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Seismic Tensile Force on Steel Girder-Concrete Wall Connections in High-Rise Composite Building Structures

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SEISMIC TENSILE FORCE ON STEEL GIRDER-CONCRETE WALL CONNECTIONS IN HIGH-RISE COMPOSITE BUILDING STRUCTURES

by

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ABSTRACT

SEISMIC TENSILE FORCE ON STEEL GIRDER-CONCRETE WALL CONNECTIONS IN HIGH-RISE COMPOSITE BUILDING STRUCTURES

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Under the Supervision of Dr. Jian Zhao

Composite steel frame – reinforced concrete (RC) core wall structures are often used in high-rise buildings. It is commonly assumed that reinforced concrete walls carry lateral loads such as earthquake loads, while steel frames carry gravity loads. As a result, lateral loads are directly applied to wall elements during a typical structural analysis. This design based on this simplification can be adequate for most structural members except the connections between steel girders and RC walls. This study focuses on the tensile loads on girder-wall connections for composite building structures in earthquakes.

Computer models were created for a 28-story composite structures recently built in Chongqing China. SAP2000 was used because detailed finite element models are available for RC shear walls and slabs without high computational costs, and a variety of earthquake analyses are available such as effective lateral load analyses and time history analyses. Different from typical analyses for design, floor slabs are modeled using shell elements such that the earthquake induced inertia force are properly positioned in the structure model. In addition, a gap is created between floor slabs and RC walls to better represent the slab-wall interfaces created by stage construction.

The analysis results indicated that 1) a significant amount (more than 50 percent) of floor inertia

forces is transferred to core walls through steel girders and girder-wall connections; 2) the total floor inertia force is directly related to the acceleration responses at floor levels; 3) the tensile forces on girder-wall connections also include that created by incompatible deformations between RC core walls and steel frames, especially at lower levels.

All previous studies on the girder-wall connections are on their load resisting capacity. This study is a demand analysis and critical step towards a reasonable safe design for composite structures. Future studies must include realistic models of the connections and other components such as embedded reinforcements. Shake table tests of building models are also critical in order to verify the demand analyses. The demand analyses will result in a set of reasonable design loads for engineers to safely design composite build structures in seismic regions.

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CHAPTER 1 INTRODUCTION

1.1 Composite Building

Composite construction is widely used in high-rise building structures, as shown in Fig. 1.1. In a composite structure, reinforced concrete (RC) shear walls provide lateral load resistance while steel frames provide gravity load resistance. Composite construction enables the use of the best properties of concrete and steel: concrete has a good plasticity of shape, good compressive strength, built-in fire protection and corrosion protection while the steel provides benefits on prefabrication, off-site labor, and high strength to weight ratio.

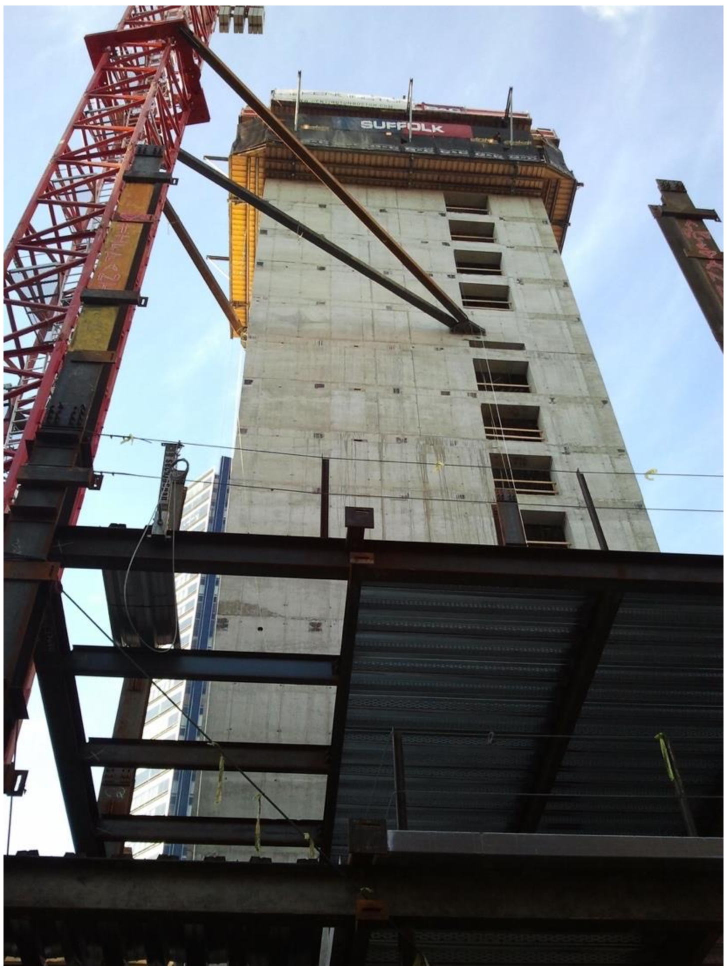


Fig. 1.1 Composite construction for high-rise building structures

1.2 Connections between Steel Girders and RC Walls

Connections are required between steel girders and RC walls in a composite high-rise building, as illustrated in Fig. 1.2, which make the shear wall and frame work together. However, there are many constraints in the design of these connections. First, during construction of a high-rise building, RC shear walls are constructed ahead of steel frames. Specifically, lifting/climbing formworks is used for the concrete shear walls with connections embedded in hardened concrete. The installation of steel frames starts after the wall reaches a certain height. Second, engineers must decide design models for the connections between steel girders and RC shear walls. Specifically, rigid connections may better engage steel frames during a lateral load event (e.g., an earthquake) than pinned connections. Meanwhile the settlement differences in RC walls and steel frames of a high-rise building structure may cause additional bending moments on the rigid connections, which are difficult to consider in design. Thus, the connections between girders and walls is often designed as pinned connections.

Fig. 1.2 Girder-wall connections in the composite building structure in Fig. 1.1

1.3 Load Transfer in Composite Building Structures Subjected to Earthquakes

The design of girder-wall connections shown in Fig. 1.2 requires proper definitions of design forces on these connections. Engineers usually obtain design forces from the results of structural analyses for a variety of loads, including gravity loads (i.e., self-weight of materials and occupants) and lateral loads (e.g., wind loads and earthquake loads). With the design tension, shear, and moment, embedded connections can be proportioned following design codes such as GB50010-2010 or ACI 318-14. Structural analyses require proper estimation of structural loads and proper definition of structural models, including the boundary conditions. Specifically, the discussion above indicates that the model of a steel girder has a pinned support at the girder-wall connection (Fig. 1.3a) rather than a fixed support (Fig. 1.3b), which will lead to a zero moment in the girder at this support in the analysis results. However, the design of embedded connections must consider a certain design moment because the actual connections, as those shown in Fig. 1.3b, may not allow completely free rotation at the girder end.

a) pinned girder-wall connection; b) rigid girder-wall connection

Fig. 1.3 Different girder-wall connections in composite building structures

Compared with the design moments, discussion on the tensile forces on the girder-wall connections is scarce. It is generally believed that the shear walls in a composite structure take the majority of the lateral loads, either from wind or an earthquake. Hence the lateral loads are often directly placed to the shear wall elements in structural analyses. For example, a girder in a composite structure is assumed to carry ZERO tension, as shown by the highlighted cells in Fig. 1.4 according to PKPM, a widely used structural analysis/design software in China. Such assumption/simplification may be reasonable for the design of lateral load resisting systems, including shear walls and columns; however, this process overlooked an important element on the path of transferring seismic loads: girder-wall connections.

CASE	M-I	M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-J	N
	V-I	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-J	T
DL	0	-45.61	-91.04	-136.16	-180.86	-225.08	-268.89	-312.39	-355.7	0
	-197.5	-196.92	-195.85	-194.3	-192.27	-190.24	-188.69	-187.62	-187.03	0
LL	0	-11.52	-22.98	-34.31	-45.46	-56.38	-67.11	-77.73	-88.28	0
	-49.86	-49.72	-49.32	-48.65	-47.72	-46.78	-46.11	-45.71	-45.58	0
EXY	-16.73	-14.64	-12.55	-10.45	-8.36	-6.27	-4.18	-2.09	0	0
	9.04	9.04	9.04	9.04	9.04	9.04	9.04	9.04	9.04	0
EXP	-2.78	-2.43	-2.08	-1.74	-1.39	-1.04	-0.69	-0.35	0	0
	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0
EXM	-2.25	-1.97	-1.69	-1.41	-1.12	-0.84	-0.56	-0.28	0	0
	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	0
EYX	-19.57	-17.13	-14.68	-12.23	-9.79	-7.34	-4.89	-2.45	0	0
	10.58	10.58	10.58	10.58	10.58	10.58	10.58	10.58	10.58	0
EYP	-19.84	-17.36	-14.88	-12.4	-9.92	-7.44	-4.96	-2.48	0	0
	10.72	10.72	10.72	10.72	10.72	10.72	10.72	10.72	10.72	0
EYM	0	2.39	4.79	7.18	9.58	11.97	14.36	16.76	19.15	0
	10.35	10.35	10.35	10.35	10.35	10.35	10.35	10.35	10.35	0
WX	0	-0.13	-0.25	-0.38	-0.51	-0.64	-0.76	-0.89	-1.02	0
	-0.55	-0.55	-0.55	-0.55	-0.55	-0.55	-0.55	-0.55	-0.55	0
WY	0	2.28	4.55	6.83	9.1	11.38	13.65	15.93	18.2	0
	9.84	9.84	9.84	9.84	9.84	9.84	9.84	9.84	9.84	0
EX	0	-2.1	-4.2	-6.3	-8.39	-10.49	-12.59	-14.69	-16.79	0
	-9.07	-9.07	-9.07	-9.07	-9.07	-9.07	-9.07	-9.07	-9.07	0
EY	0	2.46	4.93	7.39	9.85	12.32	14.78	17.25	19.71	0
	10.65	10.65	10.65	10.65	10.65	10.65	10.65	10.65	10.65	0

Fig. 1.4 PKPM analysis result of a girder in a composite structure

This design practice is originated from an assumption on rigid diaphragms, which holds true for most cast-in-place concrete floors due to their large in-plan bending stiffness. However, the lateral loads applied to shear walls are inertia forces from the floor mass in an earthquake. The inertia forces must be transferred to the walls through slab-wall connections and girder-wall connections. Due to staged construction practices, as illustrated in Fig. 1.1, RC walls may not reliably be connected to the composite floors; Hence girder-wall connections are a critical element on the load path for composite building structures in seismic zones.

1.4 Problem Statement

Failure of girder-wall connections has been observed in shake tables tests of scaled models of composite structures. For example, in a complex structure group, engineers linked a high-rise residential structure with a lower commercial structure to control the potential building collision [Gong et al., 2004]. Shake table tests indicated that the connections between the link elements and concrete could be damaged in an earthquake, as shown in Fig. 1.5a. In another test, engineers embedded the floor beams in concrete walls in the model of a 20-story building [Zhou et al., 2012]. This connection is similar to a recommended practice in the document by American Society of Civil Engineers Committee on Composite Construction. Some girder-wall connections failed during the test, as shown in Fig. 1.5b.

a) failure of connections between adjacent buildings. b) failure of girder-wall connection.

Fig. 1.5 Failure of embedded connections in shake table tests of complex structures.

Research on such embedded connections is limited compared with that on steel and concrete beam-column connections; hence, the design practice has been rather arbitrary. Although the detailed design is not completely known, and the connection performance has not been experimentally verified, it may be observed that the moment connection in Fig. 1.3b has a large embedded plate; hence, not all of the embedded anchors would be activated in tension. Meanwhile, the simple shear connections shown in Fig. 1.3a have only a few anchor bolts, which are designed with an unproven assumption that the reinforcing bars in the to-be-cast concrete slab carry the tensile force.

Laboratory tests have been conducted to investigate the behavior of embedded anchors and connections under simulated seismic loading. For example, Petersen and Zhao (2013) have observed that the shear capacity of embedded connections can be significantly reduced if the concrete cover around the connection spalls during an earthquake. In addition, Petersen et al (2018) show that the tensile behavior of embedded connections may be reliable only when special reinforcement is provided in the connection region.

This study focuses on quantifying the loads applied to the girder-wall connections in composite structures subjected to earthquake-induced loading. This aspect of structural design may have been overlooked because it is well established that lateral displacements such as story drifts control the safety of a structure in an earthquake. Hence most studies have focused on drift calculation [Li et al. 2009]. In the process, seismic shear forces are usually assigned to the lateral load resisting system, such as shear walls, directly. This practice ignored the actual transfer of earthquake-induced inertia forces from floor to the shear walls. In this study, the inertia forces are explicitly included in analyses, through which the tensile forces on girder-wall connections are examined.

1.5 Organization of Thesis

This thesis is organized as follows: a review of existing research is provided in Chapter 2. Basic concepts in seismic design of composite structures is described in Chapter 3, and the analysis program is shown in Chapter 4. The analysis results are discussed in Chapter 5. In addition to a summary and main conclusion, a series of subjects are proposed for future studies in Chapter 6. Finally, modeling procedure, procedures for obtaining analysis results, and all analyses results, in terms of tables, are included in the appendix.

CHAPTER 2 LITERATURE REVIEW

Steel-frame-RC wall composite structures have been studied extensively. The literature review below focuses on the girder-wall connections in frame-wall structures.

2.1 Studies on Composite Structures

2.1.1 Shaking Table Study on a Model of Steel-Concrete Hybrid Structure Tall Buildings by Li G., Zhou X., and Ding X.

Seismic tests were conducted on a model of typical steel-concrete hybrid tall building on shaking table. The experimental model is built after the technical center of the Shanghai-eastern Shipyard. The building has 25 floors, and a typical floor plan shown in Fig. 2.1.

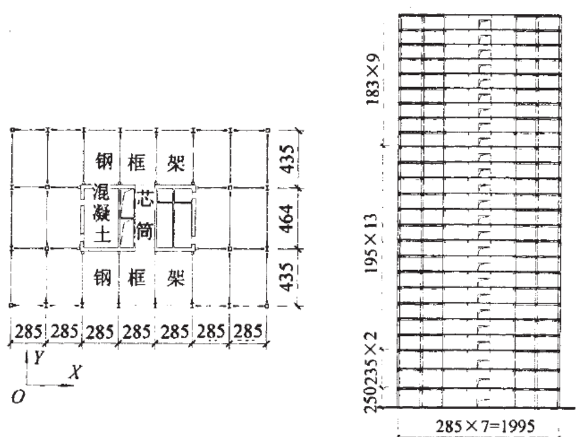


Fig. 2.1 Model structure in a shake table tests by Li et al. (2002)

Floor beams were made with GBJ Q235 steel sheets rolled into I-sections, and the shear walls C40 concrete using ultra-small aggregates. The total weight of the model was about 13.8 metric tons. Although the thickness of the floor slabs was not reported, the weight of 25 floor slabs is estimated as 3.3 tons based on an estimated concrete density and the reported scaling factors and structural dimensions. In addition, the authors added 220 kg at each floor to simulate the superimposed dead loads and partial live loads, leading to a total weight of 5.5 tons. This indicates that the weight of the shear walls is about 35% of the total building weight.

A pinned connection was used in the actual structure, as shown in Fig. 2.2. In the 1/20th-scaled model structure, the steel floor beams are connected to the shear wall through end plates glued to the concrete wall.

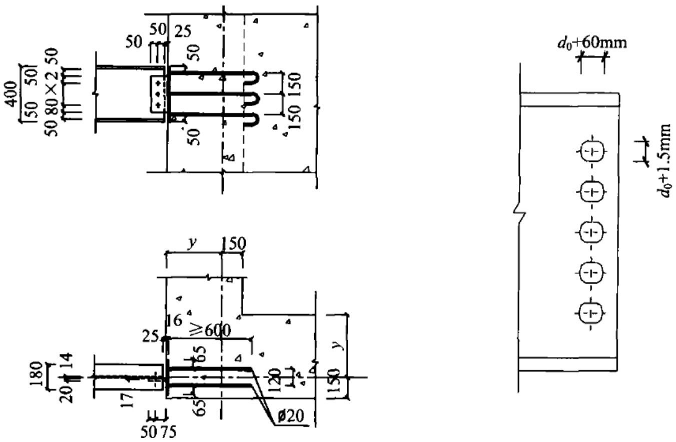


Fig. 2.2 Girder-wall connection in prototype structure by Li et al. (2002)

Concrete showed significant damage near the girder-wall connections and some glued connections failed when the model structure was subjected to seismic intensity 9 earthquakes, as shown in Fig. 2.3. No instrumentation was installed on the steel girders; hence, the actual earthquake-induced loads on these connections is unknown. The authors reported that the observed damage at girder-wall connections may have been attributed to the incompatible lateral deformation between the steel frame and the RC wall.

Fig. 2.3 Girder-wall connection failure in the model structure by Li et al. (2002)

Three earthquake records were used in the tests and the peak ground accelerations were scaled to represent a variety of seismic hazards. All accelerometers were installed at multiple floor levels and on the shake table top. The peak floor accelerations were compared to the peak ground acceleration (PGA) in Fig. 2.4. The labels in the figures shows the earthquake ground motions used in the tests and the details can be found elsewhere. The left figure shows the recorded floor accelerations when the model structure was subjected to low intensity earthquakes while the right figure high intensity earthquake (the same ground motion records with scaled-up PGA's). The authors concluded under high-intensity earthquakes, the model structure may have sustained damage and developed further damage, leading to increased fundamental vibration periods, and relatively smaller responses.

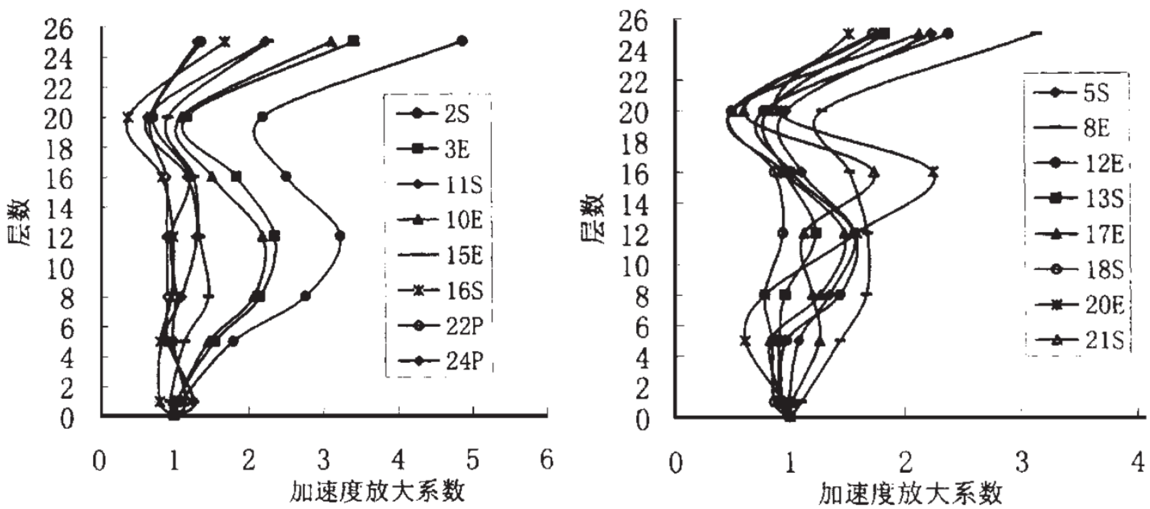


Fig. 2.4 Maximum floor acceleration observed in shake table tests by Li et al. (2012)

2.1.2 Analysis of a damaged 12-storey frame-wall concrete building during the 2010 Haiti earthquake by B. Boulanger, C. Lamarche, J. Proulx, and P. Paultre.

Boulanger et al. (2013) evaluated a 12-story reinforced concrete frame-wall structure in Port-au-Prince, Haiti, which was struck by a magnitude 7.0 earthquake on January 12, 2010. The structure behaved well during the earthquake with some damages at coupling beams, beam-column joints and columns. Importantly, the authors pointed out that the beams connecting to a U-shaped wall showed the most damage on the top four stories. This observation indicates that the beam-wall connections, especially at higher stories, were subjected to high forces during the earthquake.

Fig. 2.5 Damage to the beam near the beam-wall connection in Haiti Earthquake in 2010

2.2 Load Distribution Models

The tensile forces on girder-wall connections may be determined by considering the distribution of lateral loads among frames and shear walls. Most studies in this area focused on RC frame-RC wall structures. And the main purposes of the studies were to determine the seismic loads on the RC frames considering damage to walls during an earthquake such that the RC frames are not under-designed.

Analyses of reinforced concrete frame-wall structures have conducted extensively in the literature. Almost all studies have focused on the overall structural behaviors such as story shear, story drifts and shear wall behavior. For example, Zhong et al. (2004) pointed out that dictates the level of seismic shear carried by the frame is controlled by the relative rigidity of the frame and wall in terms of stiffness coefficient, $\lambda = H\sqrt{\frac{C_F}{EI_w}}$, where H is the total building height, C_F is the total lateral stiffness of all columns in a story, and EI_w is the shear wall stiffness. The study by Liu et al. (2007) and Lin (2012) show that the stiffness coefficient varies from 1.0 to 4.5 depending upon the total building height for typical wall-frame structures.

2.2.1 The Distribution of Seismic Shearing Force in Frame-Shear Wall Structure by Lin, S.

Stiffness coefficient is a parameter people used to consider the height of building and the ratio of the stiffness between the frame and the shear wall. It has proved that the height can be ignored. Hence, using different value of stiffness character is a typical method to find the answer.

For solving this problem, the study by Lin (2012) states that the seismic response on several buildings which have 8-frame-sheared wall structure with stiffness characteristic values arranging from 1.0 to 4.5, by the application of static elastic-plastic analysis method (Pushover) and dynamic time-history method. This study summarizes that different stiffness value of story shearing force is distributed on frame-shear wall structure under different frequency of earthquake. The influence of shear walls stiffness degradation on the distribution of story shearing force is also mentioned in this article. The formula about a frame structural story shearing force distribution is supported for further designs and studies.

2.2.2 The distribution of internal forces in reinforced concrete frame-shear wall building by Zhong, H., Yi, W., and Yuan, X.

In this paper, push-over analyses were used to study the distribution of story shear force between RC core walls and frames. The analyses indicated that the amount seismic shear force carried by the moment frames is related to the stiffness coefficient (λ), as shown in Fig. 2.6. In addition, the stiffness degradation of core walls at nonlinear stage of behavior causes significant redistribution of story shear forces: the moment frames may need to be designed for 30 percent more sotry shear forces.

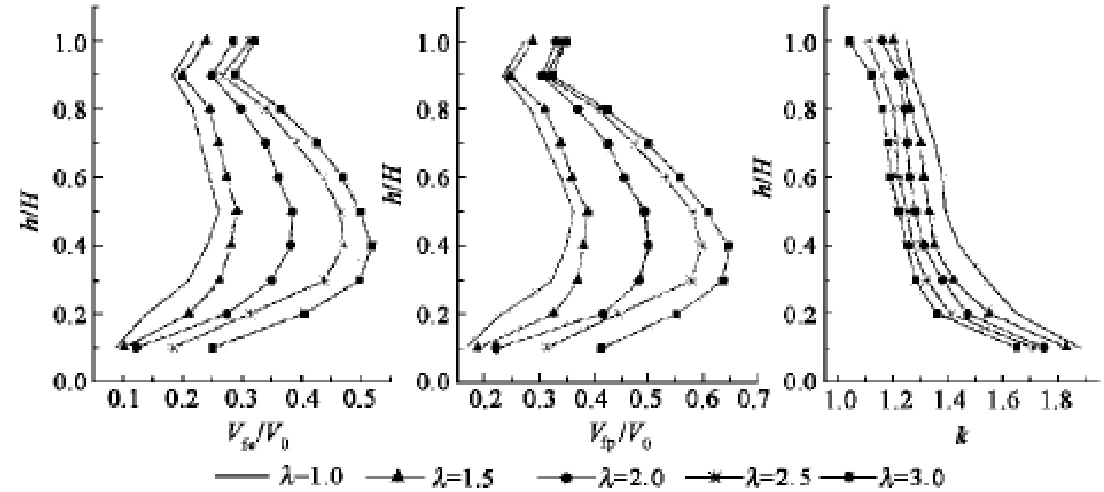


Fig. 2.6 Seismic shear force distribution in RC frame-wall structures by Zhong et al. (2012)

2.3 Embedded connections for steel girders and RC walls

2.3.1 Experiment study on seismic behavior of semi-rigid connection between steel beam and concrete wall by Liu, A. and Zhou, D.

Beam-wall connections are important in high-rise buildings because they determine how well the walls and the frames work together. In this study, an analytical model for design of the semi-rigid connections between steel beams and RC walls in high-rise hybrid buildings is proposed. Semi-rigid connections (Fig. 2.7) with embedded concrete anchors are widely used since a rigid connection requires much attention in the design and construction process. In addition, core walls and frames may have different settlement, which require that beam-wall connections have enough deformability to reduce the initial stresses.

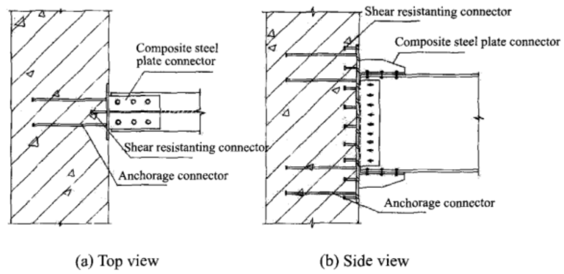


Fig. 2.7 Beam-wall semi-rigid joint design model

A general FEM program SAP84 was used to analyze a model based on a 41-story hybrid building constructed in Shanghai. The focus was on the influence of diaphragm on the connection forces. Concrete floor slabs were molded using elastic shell elements. It is show by this study that that tensile stresses of the floor slabs, which were directly connected to the shear walls in the study, reached 6-9 MPa when subjected to earthquake loads. Concrete under such tensile stresses should develop cracking, which was ignored in the analyses using elastic shell elements. Hence, most of the vertical and horizontal loads were still transferred directly to shear walls through the floor.

2.3.2 Experiments on seismic behavior of beam-wall connection by Liu, A. and Zhou, D.

Liu and Zhou (2005) continued the study using laboratory tests of beam-wall connections. A total of five model connections were tested, among which three were semi-rigid connections and two were rigid connections. The loads on connections included an axial force N and a shear force P, as shown in Fig. 2.8. Instead of tension, the connections were subjected to a compression force during the tests. High compression loads were applied to the concrete simulation axial loads on walls before stepwise incremental shear loading was applied to the connections.

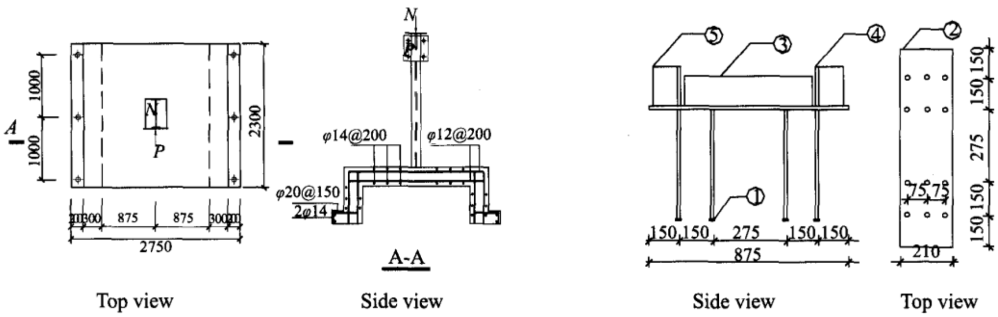


Fig. 2.8 Beam-wall connections tested by Liu and Zhou (2005)

Compared with rigid connections, the authors found that semi-rigid connections can reduce the maximum moment and shear force in steel beams. Consequently, it was derived that using semi-rigid connection, engineers may reduce the beam sections.

2.4 Steel Frame – RC Wall Structures

2.4.1 Practical calculation method research on axial tensile force transfer coefficient of steel beams at joints connecting steel frame and concrete core tube by Li, G., Li, L., and Li W.

Li et al (2010) further studied the tension loading on girder-wall connections in composite structures. Under lateral load, the composite beam helps the steel frame and the concrete wall to work together. Specifically, the steel frames develop shear deformation while RC core walls develop bending deformation. Hence, cyclic axial forces would be developed within the beam-wall connections. Finite element analyses were conducted to study the load transfer near typical girder-wall connections as shown in Fig. 2.9.

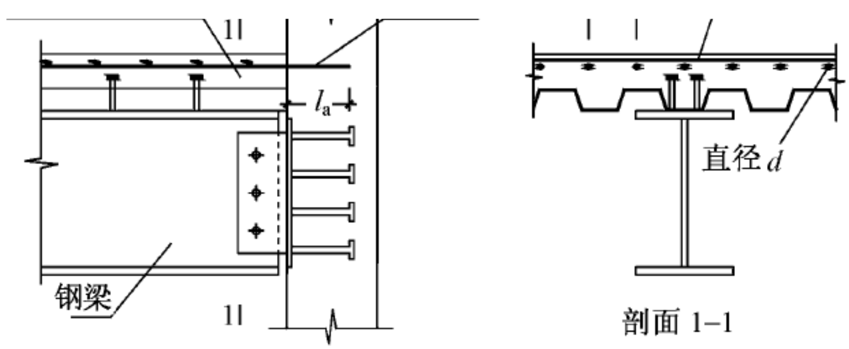


Fig. 2.9 Girder-wall connection in the analyses by Li et al.

The connections region was modeled in ANSYS as shown in Fig. 2.10. A total of six parameters were studied, which may affect the axial tensile force transfer of steel beams at the joints: 1) diameter of rebar embedded in slab (d); 2) the space between the rebars (D); 3) the width-thickness ratio of the core wall (t_w/b_w); 4) the position of the steel girder (s_w/b_w); 5) the width of the core wall (b_w); and 6) the stiffness ratio of slab to girder ($r = E_s A_s / E_c A_c$, where the subscript s represents the steel girder and c the concrete slab). The influence of these parameters to the load transfer through steel girders is shown in Fig. 2.11. The wall stiffness showed the most impact as the connections were located in the middle of the wall.

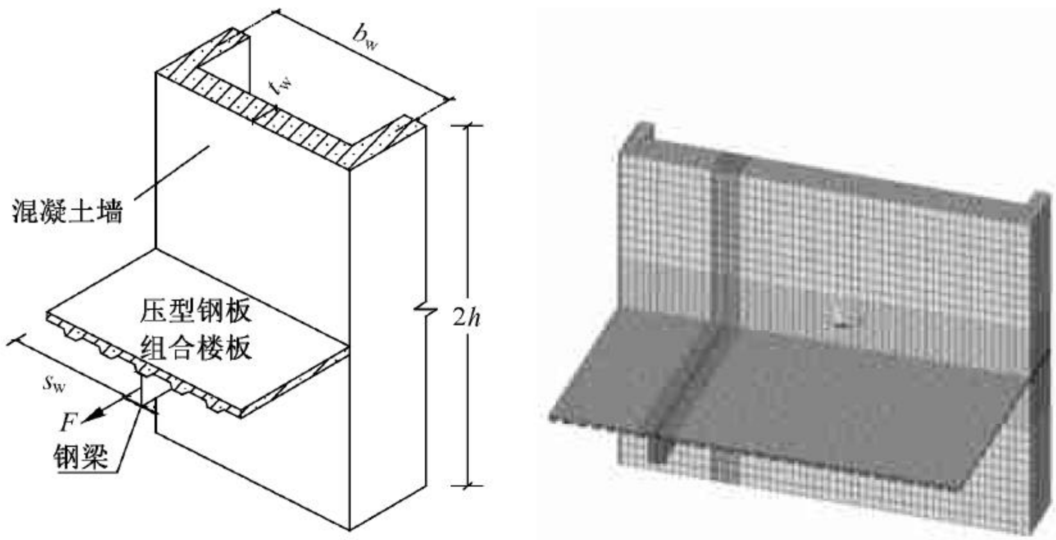


Fig. 2.10 Model of girder-wall connections by Li et al.

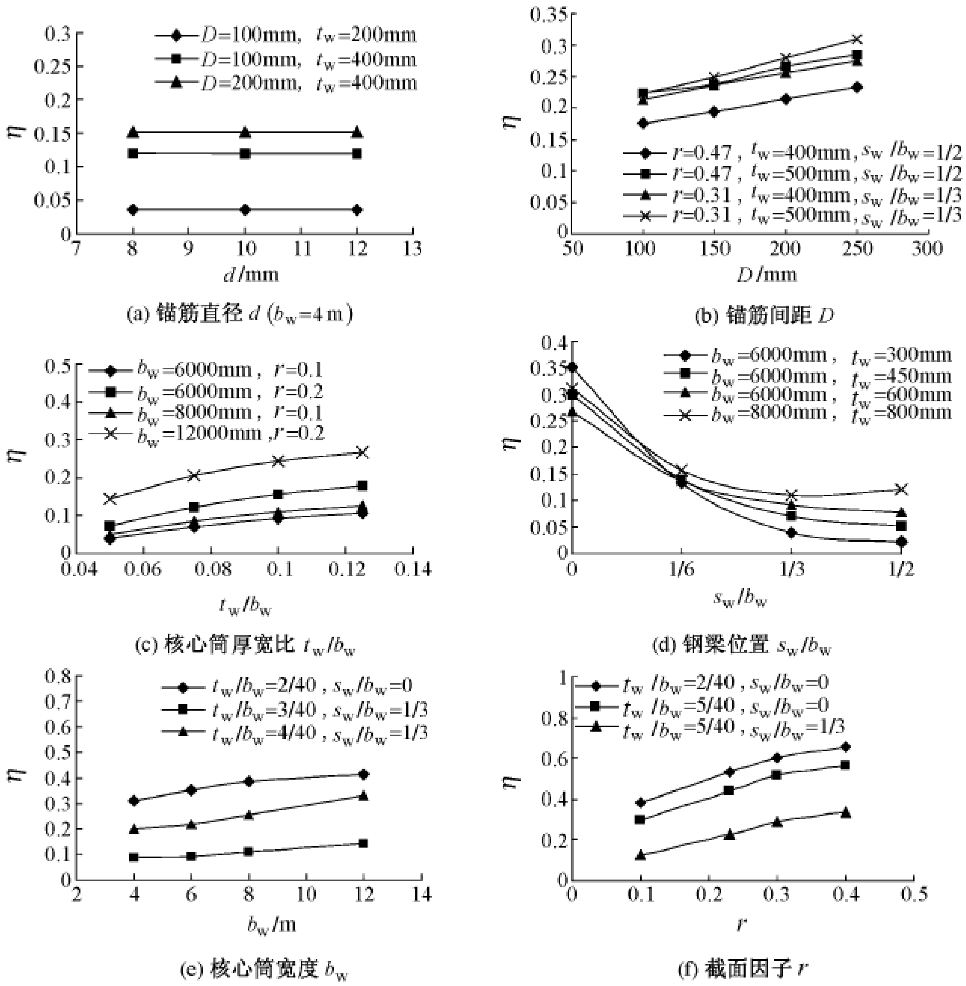


Fig. 2.11 Influence of these parameters to load transfer by Li et al.

2.4.2 Shanghai Building codes for high-rise composite building structures

The stiffness coefficient (λ) is mainly used in Shanghai code (2003) to determine the seismic shear forces carried by frames in a wall-frame structure. In the seismic design codes for high-rise composite building structures in Shanghai, this stiffness coefficient is also used to calculate the tensile forces on the girder-wall connections. The total tensile forces transferred through girders at a story *i* of a n-story composite structure (N_{Bi})is

$$N_{Bi} = 6a_1 mH \frac{1+\left(\frac{\lambda}{n}\right)^2}{n\left(1+\frac{10}{\lambda^2}\right)} \text{ for lowere levels} \tag{2.1}$$

$$N_{Bi} = 2a_1 mH\left[\frac{\lambda^2}{6n}\frac{4+\lambda^2}{2+\lambda^2}\left(1+\frac{\lambda^2}{50}\right) - 0.0471\frac{\lambda^3}{n}\right] \text{ for higher levels,} \qquad (2.2)$$

where a_1 is the base shear coefficient, mH is the total building weight, n is the total number of stories, and λ is the stiffness coefficient as defined in Section 2.2. The equations indicate that the tensile loads on girder-wall connections are mainly related to the relative stiffness of frames and core walls and the seismic base shear. The tensile forces on lower levels are higher than that of higher levels.

2.5 Models for shear walls

2.5.1 A shear wall element for nonlinear seismic analysis of super-tall buildings using OpenSees by Xinzheng, L., Linlin, X., Hong, G., Yuli. H., Xiao, L.

Elastic-plastic analysis has been widely applied in the design of tall buildings. However, most analyses are conducted by using commercial software, which limits the further in-depth research on relevant topics. In this work, a new shear wall model and a concrete constitutive model are developed based on the open source finite element code, OpenSees, by which the elastic-plastic seismic analyses of super tall RC frame-core tube structures can be performed. A series of shear walls and a 141.8m frame-core tube building are simulated. By comparison with the experimental results and the analytical results by using MSC. Marc, the rationality and reliability of the proposed element and analysis method are validated, which will provide an effective tool for further research of the seismic behavior of tall buildings based on OpenSees.

To evaluate and improve the performance-based seismic design of tall buildings, the Pacific Earthquake Engineering Research Center (PEER) launched the Tall Buildings Initiative(TBI) research program. One of the case study buildings investigated in this program is Building2A, a 42-story RC frame–core tube structure with a total above ground height of 141.8m. A three-dimension floor plan of Building 2N is shown in Fig.10. The entire model of Building2N, including 8469 nodes,9744 fiber beam elements defined by8244RC fiber sections and 4704 multi-layer shell elements defined by 177 shell sections, was initially constructed in MSC.Marc and subsequently converted to OpenSees. The OpenSees model is freely assessable, which can be conveniently shared and reused in the research community.

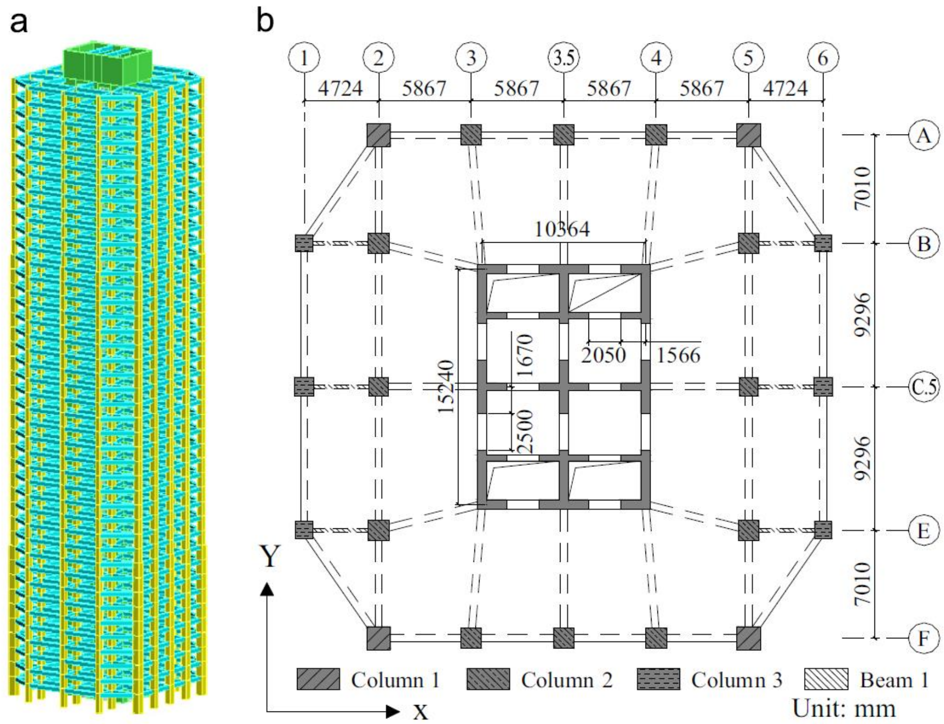


Fig. 2.12 Frame-wall structure and its model by

Many models exist for reinforced concrete shear walls as a lateral load resistant element. In the SAP2000 models shown in Chapter 4, we used solid shell elements, available in the software. Other models are briefly reviewed below.

2.5.2 Wide column analogy

Wall piers, separated by large openings (i.e., doors to elevator shafts) in the wall, can be modelled using beam-column element. The advantage of this model is its computational efficiency in a nonlinear response history analysis of large multi-story shear wall buildings. It is also easy to calculate capacity in terms of rotation or inter story drifts and to compare with available performance acceptance criteria in guidelines. Hence, this model is commonly used in exploring dynamic response of multi-story shear wall buildings in PKPM, a well-accepted design tool in China.

2.5.3 Fiber-based model

The fiber-based models are originated from the beam-column element. In a fiber model, the entries of the element stiffness matrix are calculated considering the geometry of sections along the member. For example, instead of using a user specified moment of inertia, members are discretized into several section, and the sections are discretized to many uniaxial steel and concrete fibers with their own material properties. This model enables the consideration of distributed nonlinearity in reinforced concrete members, in which nonlinear responses occur to the ends of the members while the middle portions remain linear.

Similar to the beam-column elements, this element formulation assumes that the cross-sections remain plane and normal to the reference axis after the deformation. This may not be reasonable for shear walls in low story buildings, in which shear deformation in the walls and the flexural-shear interaction may be critical.

2.6 Summary

Girder-wall connections is the basic element to make sure the steel frames and RC core walls work together. Failure of girder-wall connections have been observed in high-rise frame-wall structures in earthquakes and model structures in shake table tests. Studies have been conducted to investigate the seismic resistance of such connections while the seismic demand on such connections has not been well understood. Damage of girder-wall connections in earthquakes can be critical to the integrity of composite structures, which have become a widely accepted in high-rise buildings. This study is about the seismic demands on girder-wall connections.

CHAPTER 3 BASIC CONCEPTS IN SEISMIC ENGINEERING

3.1 Equivalent Lateral Load Analysis

This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds to earthquakes in its first vibration mode. The response is read from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code).

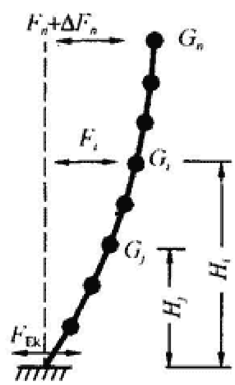


Fig. 3.1 Equivalent lateral load analysis

3.1.1 GB50011-2010

The base shear F_{Ek} is calculated as

$$F_{Ek} = \alpha_1 G_{eq}, \tag{3.1}$$

where Geq is the weight of the whole building and α_1 is the base shear coefficient, determined based on design seismic intensity. Specifically, the base shear coefficient a_1 is obtained from design spectrum, as illustrated in Fig. 3.2

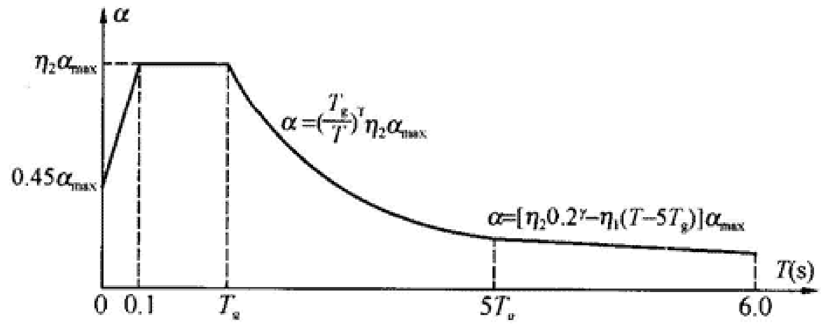


Fig. 3.2 The seismic base shear coefficient in GB50011-2010

The inertia force on each floor is calculated based on a linear distribution over the structure height,

$$F_i = \frac{G_i H_i}{\sum_{j=1}^{n} G_j H_j} F_{Ek}(1 - \delta_n), \tag{3.2}$$

where G_i is the weight of floor *i* and δ_n is calculated as additional earthquake function considering the whipping effect at the top level. The characteristic spectrum acceleration (a_{max}) is stipulated as a function of the seismic design intensity (SDI). The maximum spectrum acceleration is 0.05g, 0.10g, 0.20g and 0.40g for SDI of 6, 7, 8, and 9, respectively.

3.1.2 ASCE 7-10

The seismic design base shear is again calculated as a percentage of building weight,

$$V = C_S W, \tag{3.3}$$

where $C_S$is the seismic response coefficient, and W is the building weight, considering dead load (including operating contents) + 25% live load in some cases (storage) + some snow load.

The seismic design spectrum is shown in Fig. 3.3

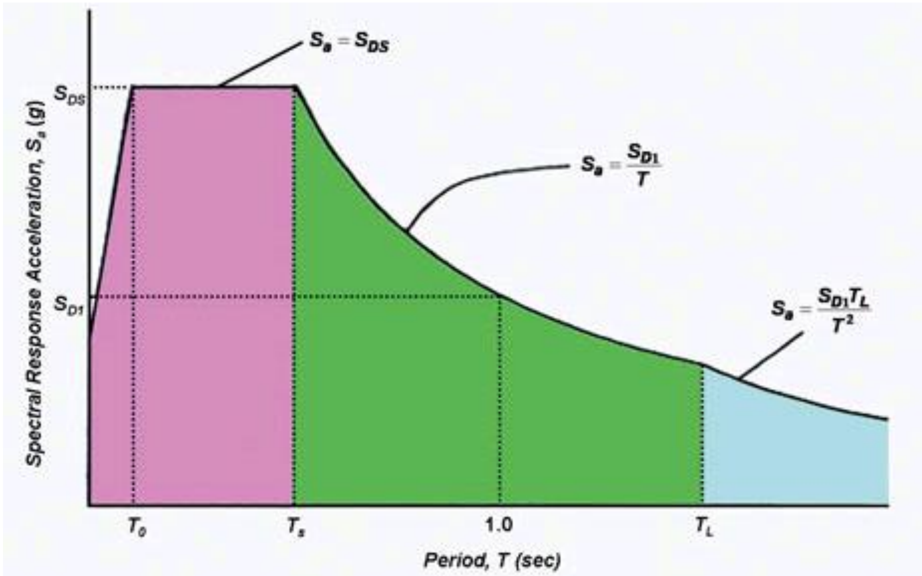


Fig. 3.3 The spectral response acceleration in ASCE 7-10

The design spectrum acceleration is related to the fundamental period of a building corresponding to the first vibration mode. The fundamental period can be estimated using

$$T_a = C_t * h_n^x, \tag{3.4}$$

Where C_t is building period coefficient, h_x is the height above the base to Level x, respectively

When the fundamental period is calculated using a computer analysis, the obtained fundamental period shall not exceed

$$T = C_u T_a, \tag{3.5}$$

The seismic base shear is distributed along the building height

$$C_{VX} = \frac{W_x h_x^k}{\sum_{i=1}^{n} W_i h_i^k}, \tag{3.6}$$

where, W_i, W_x: Portion of W assigned to level i or x, and h_i, h_x are the height of level i or x above base k sets the shape of distribution and depends on T as shown in Fig. 3.4

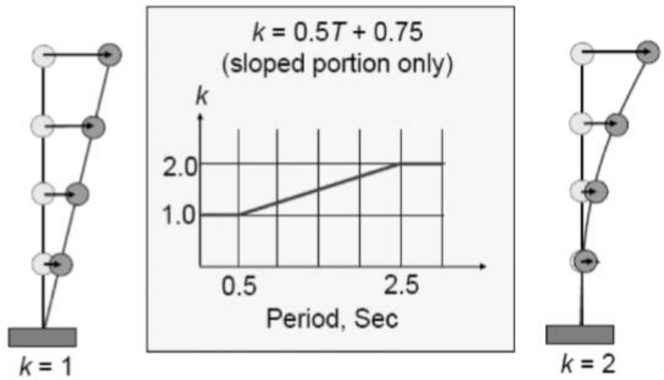


Fig. 3.4 k-factor accounts for Higher Mode Effects

3.2 Response Spectrum Analysis

A response spectrum is a plot of the peak response (that is the displacement, velocity or acceleration) of a series of single-degree-of-freedom (SDOF) systems of different natural frequencies, subjected to a certain ground motion as illustrated by Fig. 3.5. The resulting plot can then be used to obtain the response of any linear system, given its natural frequency of oscillation. One such use is in assessing the peak response of buildings to earthquakes. The response spectrum may be used to understand seismic damage to certain structures.

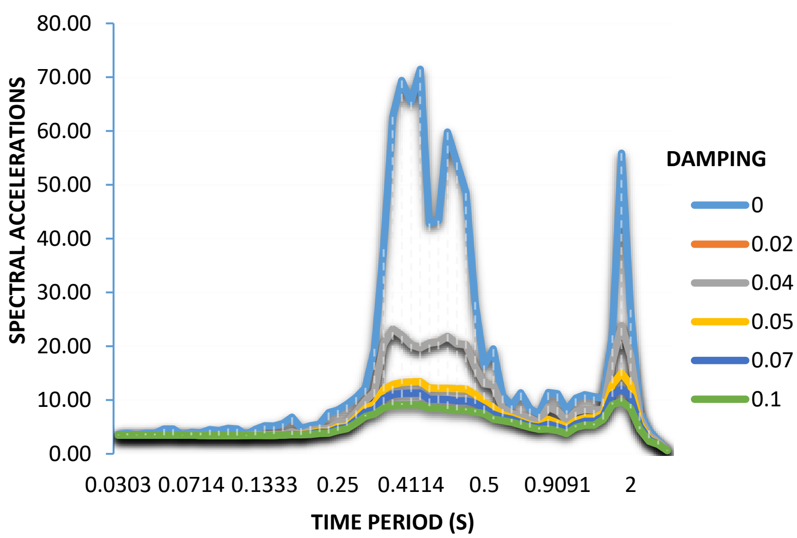


Fig. 3.5 Spectrum acceleration for El Centro earthquake

Response spectra can be used in assessing the response of multi-degree of freedom (MDOF) systems. A modal analyses is first performed to identify the vibration modes, and the response in that mode can be read from the response spectrum. These peak responses are then combined to estimate a total response. A typical combination method is the square root of the sum of the squares (SRSS) if the modal frequencies are not close. The result is different from that which would be calculated directly from a ground motion input; however, the results are generally deemed sufficient for seismic design of building structures.

The main limitation of response spectra is that they are only applicable for linear systems. Response spectra can be generated for non-linear systems but are only applicable to systems with the certain nonlinear behavior, although attempts have been made to develop non-linear seismic design spectra with wider structural application. The results of this cannot be directly combined for multi-mode response.

3.3 Time History Analyses

Time history analysis of a structure model involves a step-by-step procedure where the loading and the response is evaluated at successive time increments. During each step the response is calculated from the applied loads and the initial conditions developed at the end of the previous step (displacements and velocities). With this method the non-linear behavior may be obtained by considering the structural properties from one step to the next. Therefore, this method can be effective for the solution of non-linear response, among the many methods available. Different from the response spectrum analysis, time history analyses can provide the true structural response of a building model to a ground motion. Nevertheless, the peak responses, such as the maximum displacements and accelerations obtained from both methods, are sufficiently close to each other for design purposes [Chopra 2010].

Chapter 4 ANALYTICAL PROGRAM

4.1 Prototype Structure

This prototype building structure is located at Fuling New Zone in Chongqing, China, as a multi-use structure for business, office, and housing, as shown in Fig. 4.1. Composite construction was used in this building structure, as shown by a typical floor plan in Fig. 4.2. Specifically, the RC core walls at the center of the structure are assumed to carry the lateral loads while moment resisting frames carry the gravity loads. In addition, the perimeter columns are composite columns, made of H-shape steel members embedded in reinforced concrete, as shown in Fig. 4.3.

Fig. 4.1 Prototype structure used in the analytical program

Floor beams are composite beams, made of steel I-beams with concrete floor slabs. Shear studs are used to ensure full composite action between the slab and the beam. The steel girders have a pinned connection to the RC shear wall through embedded connections, as shown in Fig. 4.4. The steel girders have a fixed connection with the composite columns, as shown in Fig. 4.5.

The structure has two stories below the ground and 26 stories above the ground with a total height of 99.8 m. A typical floor plan is shown in Fig. 4.2, the area is 29.8×39.8 m. The core is in the center of the model. The area is 9.3 m×21.0 m. A total of five bays are used in the east-west direction (referred to as X-direction hereafter) and three bays in the north-south direction (referred to as Y-direction hereafter). The green part is the beam and the red part is the shear wall, the black lines are the secondary beams. The shear wall has a rectangular section as shown in Fig. 4.3a, the composite column has a typical section of circle as shown in Fig. 4.3b. The floor is made of concrete as shown in Fig. 4.4. The slab has a typical section of rectangular as shown in Fig. 4.5.

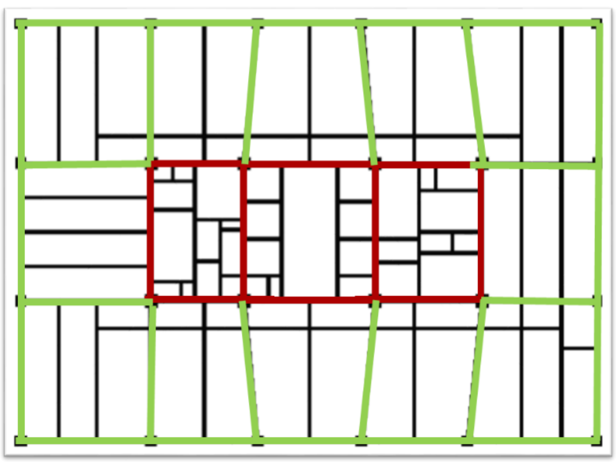
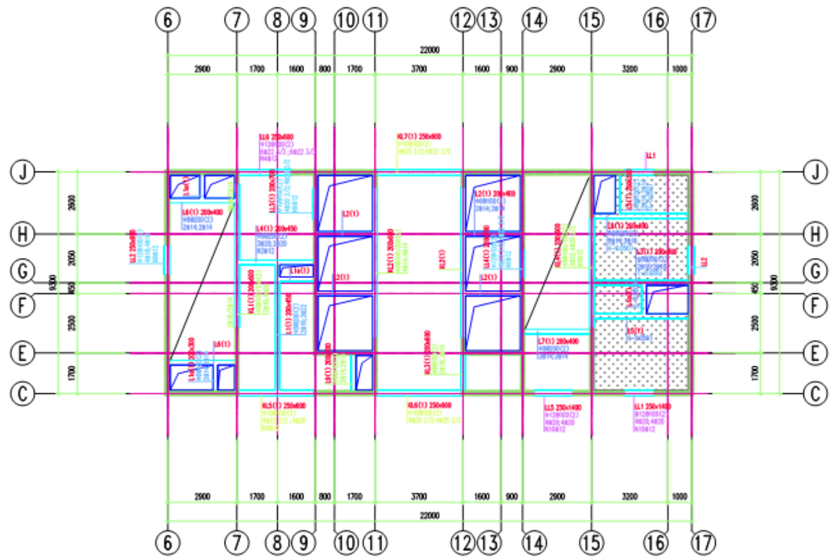
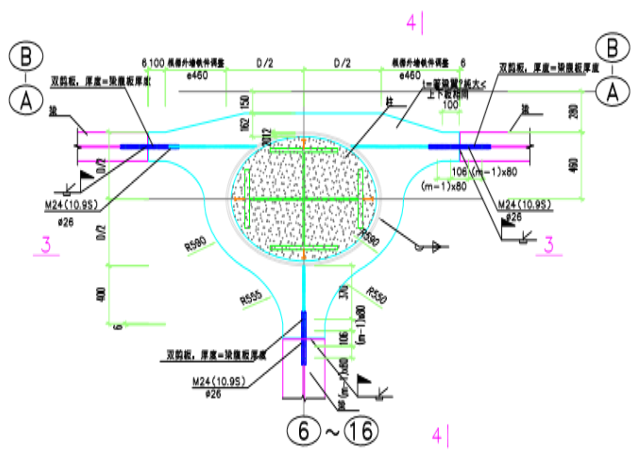


Fig. 4.2 Typical floor plan of the prototype structure



(a)



(b)

Fig. 4.3 Lateral load resisting system of the prototype structure: a) RC wall; b) composite column

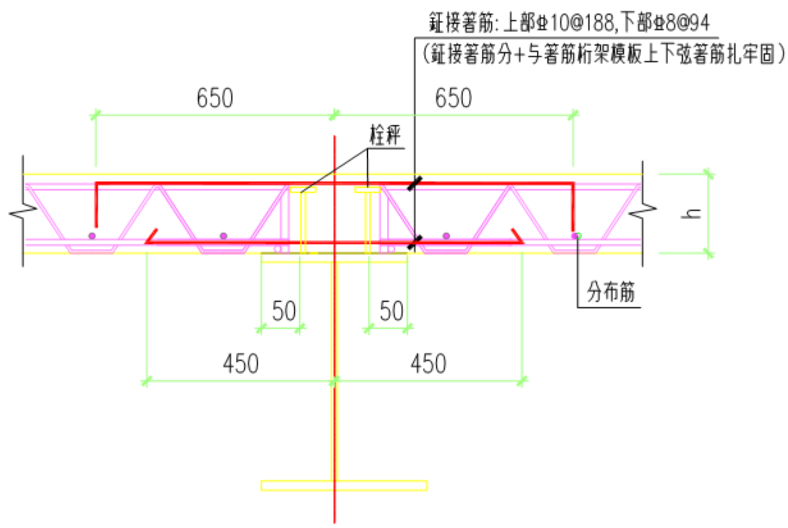


Fig.4.4 Typical composite floor slab of the prototype structure

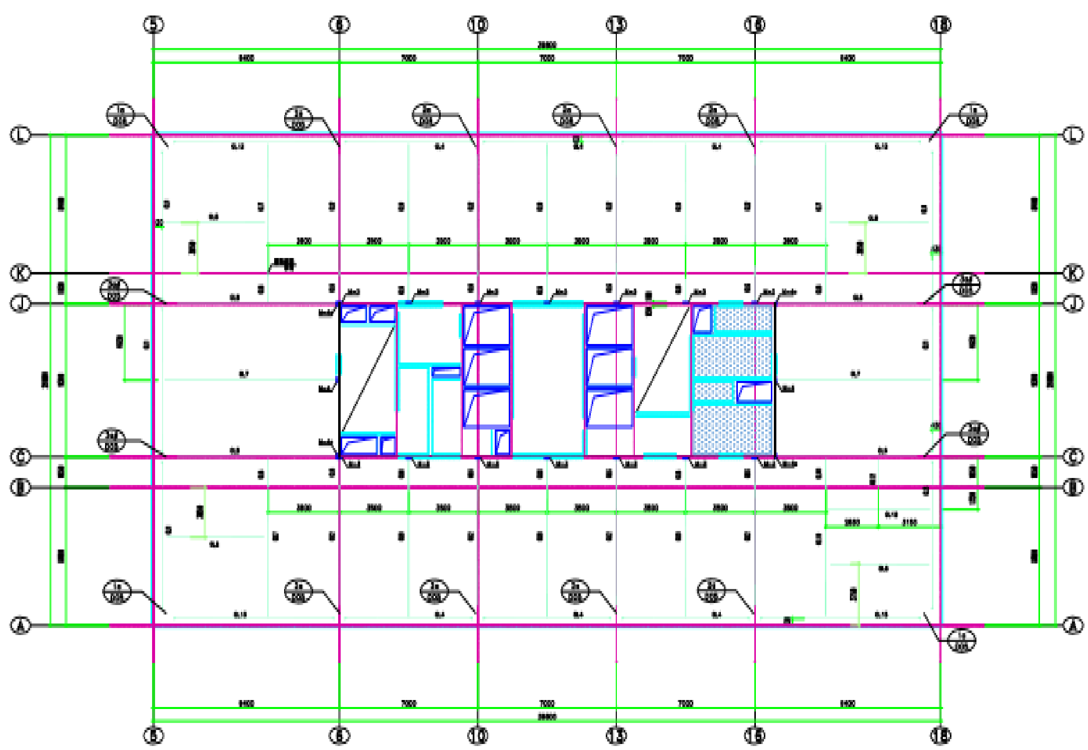


Fig.4.5 Typical floor plan of the prototype structure

The concrete material used in the construction is C30 and C45 according to GB50010-2010. The standard strength is 23.4N/mm^2 for C30 and 29.6N/mm^2 for C45. The code-specified Young's modulus of the C30 concrete is 3.00 MPa and 3.35 MPa for C45 according to GB 50010-2010.

The steel material used in the construction is Q345. The steel material has a code-specified yield strength of 345 MPa and an ultimate strength of 510 MPa.

The typical connection between steel girders and concrete is shown in Fig. 4.6. Note that the embedded connections were designed per JGJ 3-2010.

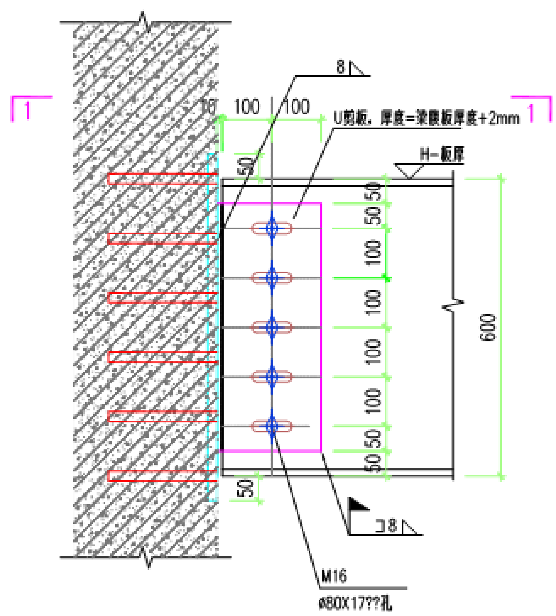


Fig.4.6 Typical girder-wall connection in the prototype structure

The building structure has been analyzed using in PKPM, a widely-used structural analysis/design software in China. The analysis indicates that

1) under dead loads, the column A-1 (axis names) at the first story are subjected to an axial load of 12,700 kN. The total building weight is estimated as 304800 kN.

2) under lateral load, the seismic load was determined according to GBJ 50011-2010. The design earthquake loads on each floor and the distribution of the load are shown in Table 4.1. Under the

lateral load, the building displacements and inter-story drifts are shown in Table 4.2 and Fig. 4.7. Hence the story stiffness can be estimated as shown in Column A-6 of Table 4.2.

Table 4.1 Shear and Percentage Under X-direction Earthquake in PKPM

Floor	Shear Force of Column	Shear Force of Shear Wall	Total Shear Force
31	75.7(90.8%)	7.7(9.2%)	83.4
30	108.6(42.2%)	148.4(57.7%)	257.4
29	183.1(46.6%)	208.2(53.0%)	392.9
28	460.5(68.4%)	425.4(63.2%)	673.2
27	354.4(38.2%)	611.9(65.9%)	927.8
26	386.4(33.4%)	809.0(69.9%)	1156.5
25	399.3(29.4%)	986.4(72.5%)	1359.8
24	413.7(26.9%)	1141.9(74.2%)	1538.6
23	428.6(25.3%)	1275.1(75.2%)	1694.9
22	441.5(24.1%)	1390.2(75.9%)	1831.1
21	454.6(23.3%)	1488.9(76.3%)	1950.4
20	464.7(22.6%)	1577.7(76.7%)	2056.6
19	475.5(22.1%)	1657.5(77.0%)	2153.5
18	483.8(21.5%)	1735.3(77.3%)	2245.2
17	492.2(21.1%)	1812.7(77.6%)	2335.5
16	497.0(20.5%)	1896.2(78.1%)	2427.1
15	502.9(19.9%)	1983.6(78.6%)	2522.3
14	505.3(19.3%)	2079.8(79.3%)	2621.7
13	508.7(18.7%)	2179.9(80.0%)	2725.1
12	502.9(17.8%)	2292.2(81.0%)	2830.9
11	511.7(17.4%)	2389.8(81.4%)	2937
10	513.4(17.1%)	2449.4(81.7%)	2997.6
9	512.3(16.8%)	2506.6(82.1%)	3054
8	498.7(16.1%)	2571.3(82.8%)	3105.4
7	480.6(15.3%)	2634.0(83.6%)	3150.8
6	459.5(14.4%)	2693.4(84.4%)	3189.7
5	442.2(13.7%)	2741.4(85.1%)	3221.6
4	220.5(6.8%)	2997.9(92.0%)	3257.9
3	381.0(11.6%)	2858.0(87.1%)	3279.7
2	663.0(19.9%)	1340.8(40.3%)	3330.3
1	104.2(3.1%)	1923.5(57.7%)	3331.8

Table 4.2 the building displacements and inter-story drifts in PKPM

Floor	Maximun Displacement	Maximum Interlayer Displacement angle
31	46.43	1/2749
30	46.06	1/3131
29	45.14	1/3177
28	44.04	1/2757
27	42.81	1/2635
26	41.52	1/2529
25	40.18	1/2425
24	38.78	1/2329
23	37.32	1/2242
22	35.81	1/2165
21	34.23	1/2097
20	32.61	1/2039
19	30.92	1/1987
18	29.19	1/1944
17	27.41	1/1907
16	25.59	1/1878
15	23.73	1/1854
14	21.85	1/1837
13	19.93	1/1826
12	18.01	1/1823
11	16.07	1/1824
10	14.13	1/1834
9	12.34	1/1871
8	10.58	1/1924
7	8.86	1/2000
6	7.22	1/2113
5	5.66	1/2295
4	4.22	1/2560
3	2.4	1/3344
2	0.75	1/8678
1	0.04	1/9999

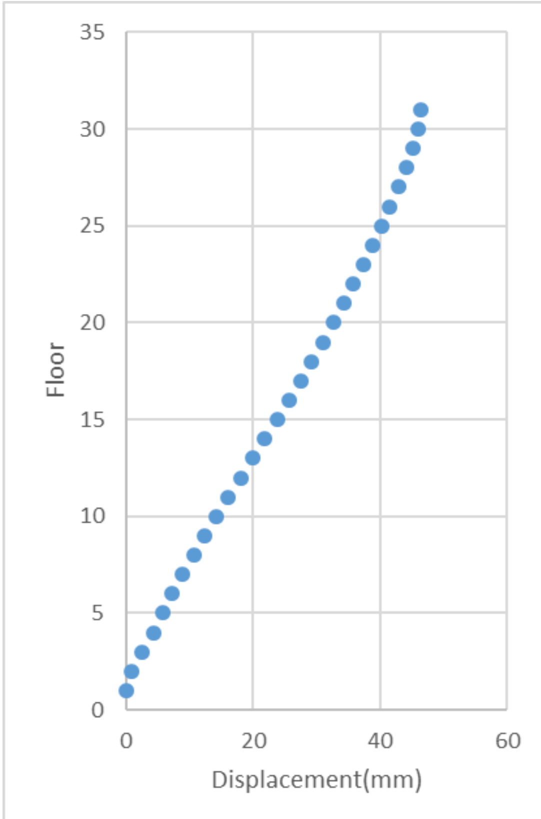


Fig. 4.7 Building displacements and inter-story drifts of the prototype structure from PKPM

3) the natural period of the structure is 3.2283 sec in X-direction and 3.9251 sec in Y-direction. The mode shapes are shown in Fig. 4.8.

MODE	PERIOD(s)	ANGLE	TYPE	TORSION PROPERTY	X PROPERTY	Y PROPERTY	LATERAL PORPERTY	DAMPING
1	3.9251	89.25	Y	0%	0%	100%	100%	4.00%
2	3.2283	178.84	X	21%	79%	0%	79%	4.00%
3	2.6816	0.95	T	79%	21%	0%	21%	4.00%
4	0.875	8.19	X	45%	54%	1%	55%	4.00%
5	0.8181	98.07	Y	0%	2%	98%	100%	4.00%
6	0.7542	8.02	T	55%	44%	1%	45%	4.00%

Fig. 4.8 Fundamental vibration modes of the prototype structure from PKPM

4) The axial load on the girder-wall connections, represented by the axial load of steel girders is ZERO in the PKPM analyses. Therefore, the embedded connections are specified as a standard connection without being proportioned to certain design forces. This design philosophy is confirmed by a design engineer (Jiang, 2018) for the project that the transfer of inertia forces from

the floor to the shear wall is assumed through the embedded bars in concrete floor/wall. Note that the bars were not proportioned to the seismic design forces either.

The connection between composite concrete floor and shear wall is shown in Fig. 4.9. Specifically, in X-direction, the inertia force from the floor mass is transferred to the shear wall through bearing along Line C, shear friction along Lone B and Line C, and embedded bars along Line G. In addition to these load paths, the connections between steel girders and concrete wall must contributed to the load transfer.

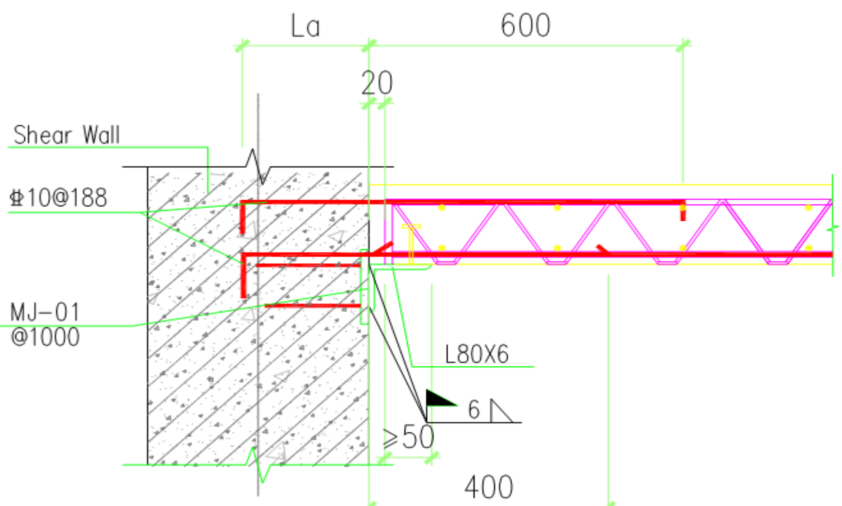


Fig. 4.9 Typical connection between composite concrete floor and shear wall of prototype structure

4.2 Analysis Software Package

SAP2000 is used in this study to quantify the loads on girder-wall connections. SAP2000 is a universal finite element analysis software developed by Professor Wilson and his students at the University of California, Berkeley, and has been popular since its inception. SAP2000 can perform static, dynamic, linear, and nonlinear finite element analyses.

4.3 Analysis Assumptions

4.3.1 Beams and girders

The 17th floor was used as a typical floor, as shown in Fig. 4.5. The building models are established by stacking the typical floor model at the actual floor heights. The girders are H600x200x14x10 selected from SAP2000 element library and the beams are H600x200x14x10. Instead of two secondary beams (Fig. 4.2), one is included in the floor model in each bay to simplify the grid of the floor slab. All girders have one end restraint, corresponding to the girder-wall connection, released as shown in Fig. 4.6. The beams have both end restraints released as they are treated as simply-supported beams.

4.3.2 Floor slabs

The floor slabs are modeled using solid shell elements in order to properly model the distributed inertia force in the seismic analyses in this study. The slab inside the shear walls is ignored to simplify the analyses. The thickness of the shell elements for the floor slabs is 0.15m, same as the actual slab. With the slab modeled using shell elements, SAP2000 automatically calculate the inertia forces generated from the acceleration of the floor. The inertia forces are applied at the common nodes of the shell elements based on the floor mass and super-imposed loads attributed to the nodes. Therefore, it is necessary to align the grids of the slab elements in adjacent bays to avoid the complex load transfer to the beam elements. In the models with slabs connected to the walls, the slab mesh must be aligned with the wall mesh.

4.3.3 Columns

The columns are composite columns with steel H-beams embedded in concrete. It is a concrete-filled steel tube column in the original structure. Knowing that this study focuses on the understanding of the load transfer from floors to shear walls, the actual composite columns are not modeled using customized elements. Instead, a generic element is used. The 900mm diameter composite column (Fig. 4.3) was convert into a reinforced concrete column with a diameter of 1200 mm. The model column has the same concrete strength and the same moment of inertia.

However the increased column size may have caused increase in column weights.

4.3.4 Walls

The actual shear walls with multiple openings, at the center of the building as shown in Fig. 4.2, was simplified in this study as a continuous element, as illustrated in Fig. 4.10. The shear walls have a thickness of 350 mm at the base and 300 mm at upper stories; hence, the shear walls are modeled using thick shell elements with a thickness of 300 mm. Note that this simplification ignores the openings in Fig. 4.3a, leading to an increased lateral stiffness of the shear wall.

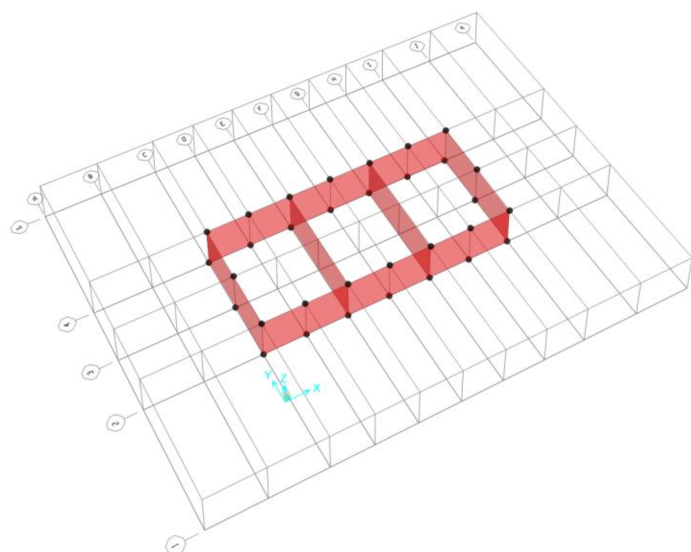


Fig. 4.10 Shear wall model in the analyses

4.3.5 Foundation

The building structure has a pile foundation below the two underground stories. Knowing that these two stories are heavily reinforced with concrete walls in the perimeter, the two underground stories are ignored in the model in this study. In order to consider the effect of the two ignored underground stories, we considered both fixed and pinned boundary conditions for the columns. The shear walls are assumed to have a fixed boundary condition at its base.

4.3.6 Beam-wall connections

The connections between the girders/beams and the RC concrete wall do provide flexural resistance to the girders. However, the design engineers assumed pinned connections; hence, the corresponding end restraints for the girders are released in the model.

4.3.7 Beam-column connections

Rigid connections are used in the structure as shown in Fig. 4.11 through welding; hence, the end restraints for the girders at the beam-column connections are maintained in the model.

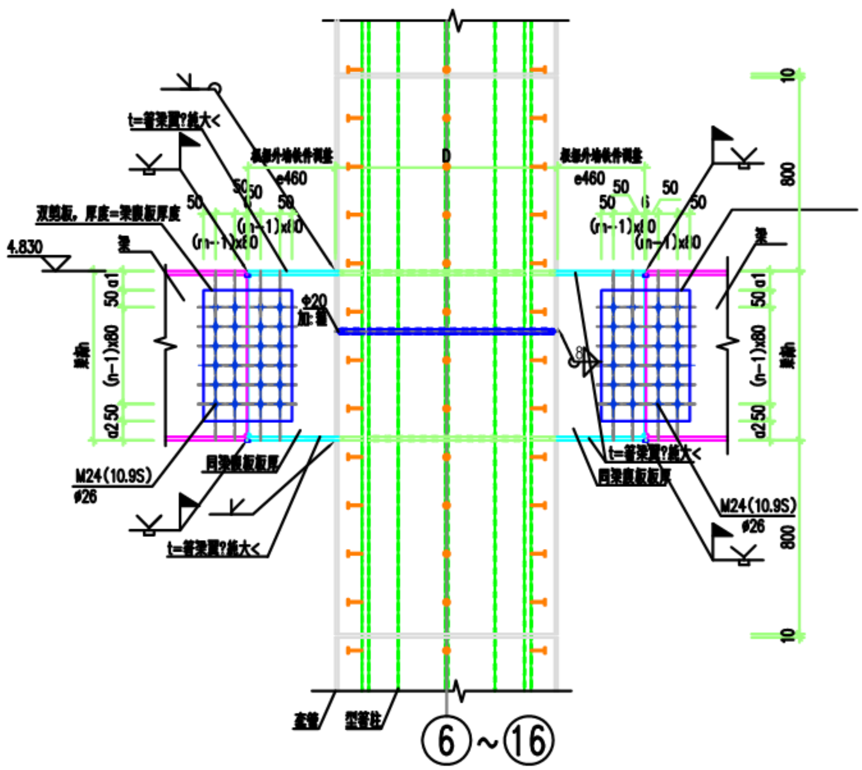


Fig. 4.11 Beam-column Connection

4.3.8 Dead load

The dead load includes the weight of the structural elements, partition walls, and the decoration. This is different from ASCE 7-10. Specifically, the partition walls and architectural elements are typically viewed as live loads. However, these components are included in the model as an equivalent area load in order to facilitate the comparison between the SAP2000 analyses with the PKPM analyses conducted by the design engineers. The dead load is 10.0 kN/m^2.

4.3.9 Live load

The live load in the design of the structure included people, furniture. The live load is 2.5 kN/m^2 in the SAP2000 model. According to GB50011-2010, half of the live load is counted in the building weight when calculating the seismic base shear.

4.3.10 Seismic loads

We use the quake load in Chinese 2010 and ASCE 7-10. When a multi-stepped load pattern is applied in a load case, the following rules govern how it will be handled:

1. In a linear static load case, the load case will internally (INSIDE) be run as a multilinear static load case, producing multiple output steps.

2. In a nonlinear static load case, the load case will internally be run as a new type of staged-construction load case, where each stage starts from the beginning of the load case, producing results similar to the multilinear static load case.

3. All other load cases (including staged-construction) are unchanged and will treat the load pattern as single-stepped, using the first step of the multi-stepped load pattern.

4. For Cases 1 and 2, if several multi-stepped load patterns are applied in a single load case, they superpose on a step-wise basis. For example, if load pattern A has 3 steps and load pattern B has five steps, the load case will apply five independent load steps: A1+B1, A2+B2, A3+B3, B4, B5. If a non-stepped load pattern is applied, such as Dead, it is applied in every load step.

4.4 Analysis cases

4.4.1 Full floor-wall connections

The shear walls and the slab share common boundaries in this analysis case, as shown in Fig. 4.12. Through the joints on the boundary lines, the wall elements and slab elements have the same deformation. Therefore, the slab can transfer both axial loads (both tension or compression) and shear to the shear wall. Note that the shear transfer is not be properly modeled in the case as slabs are NOT monolithically constructed with walls in composite structures, as shown in Fig. 1.2.

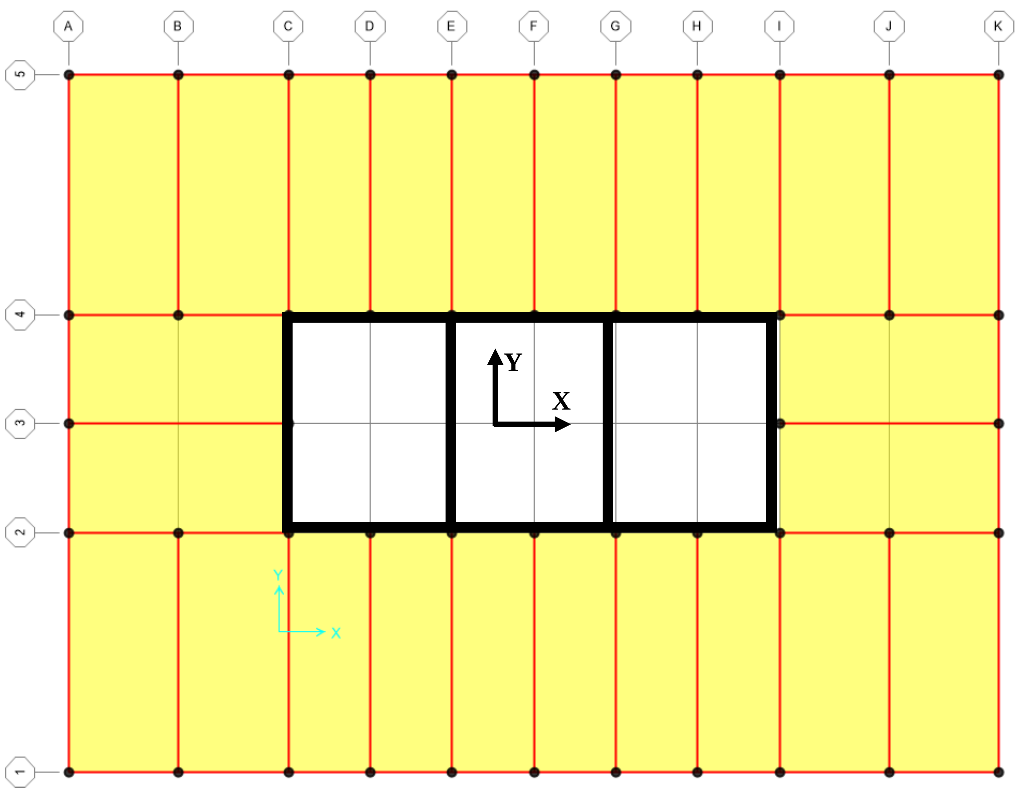


Fig. 4.12 Full floor-wall connections

4.4.2 Absent floor-wall connection

The slab is isolated from the shear wall in this case, as shown in Fig. 4.13. et al. created slits between slabs and shear walls in their study to simulate the floor-wall connections in composite construction. We created a gap in the slab in the SAP2000 model instead of slits to facilitate the observation of tensile loads in girders, which are also the loads applied to the girder-wall connections. This model better represents the shear transfer between floor slabs and shear walls. The floor beams are expected to transfer the entire inertia force form the floor, which may be viewed as an upper limit for the axial loads on girder-wall connections.

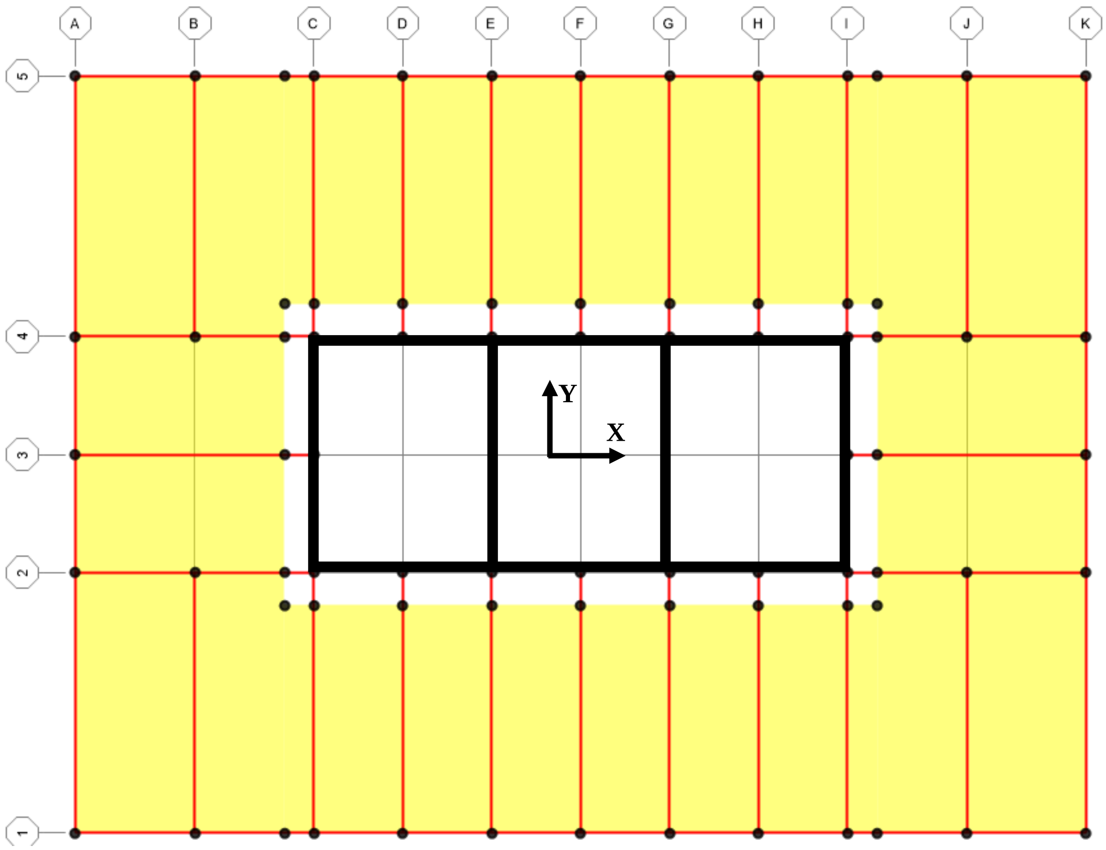
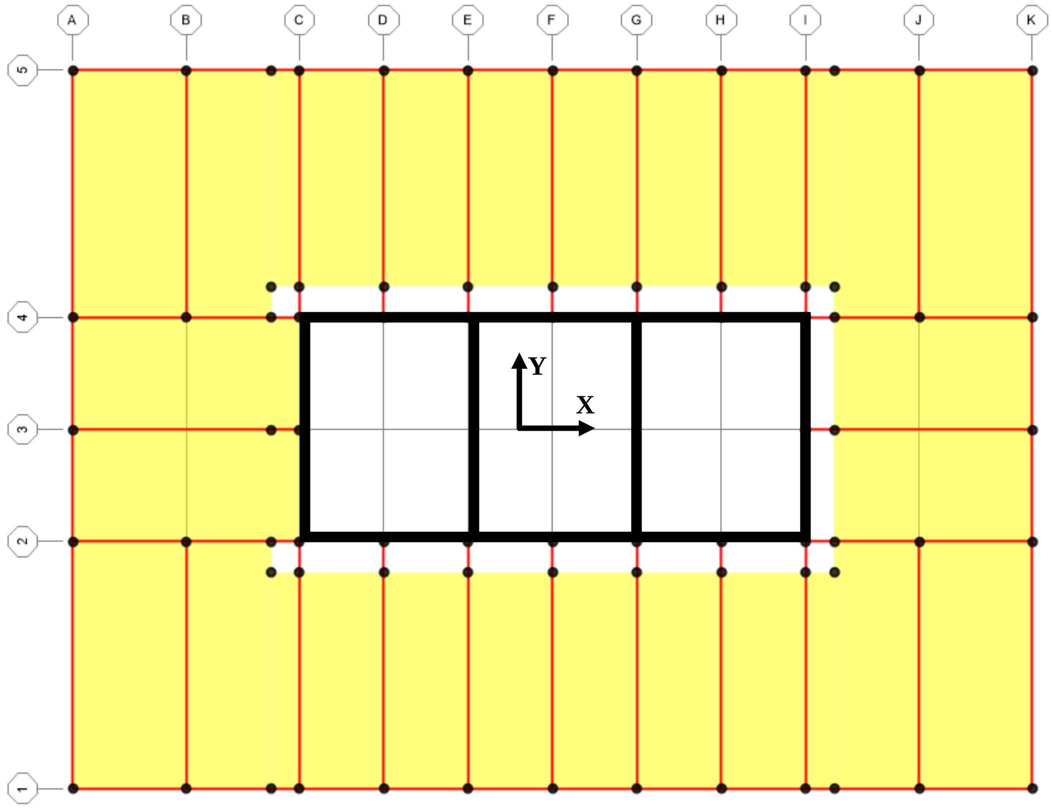


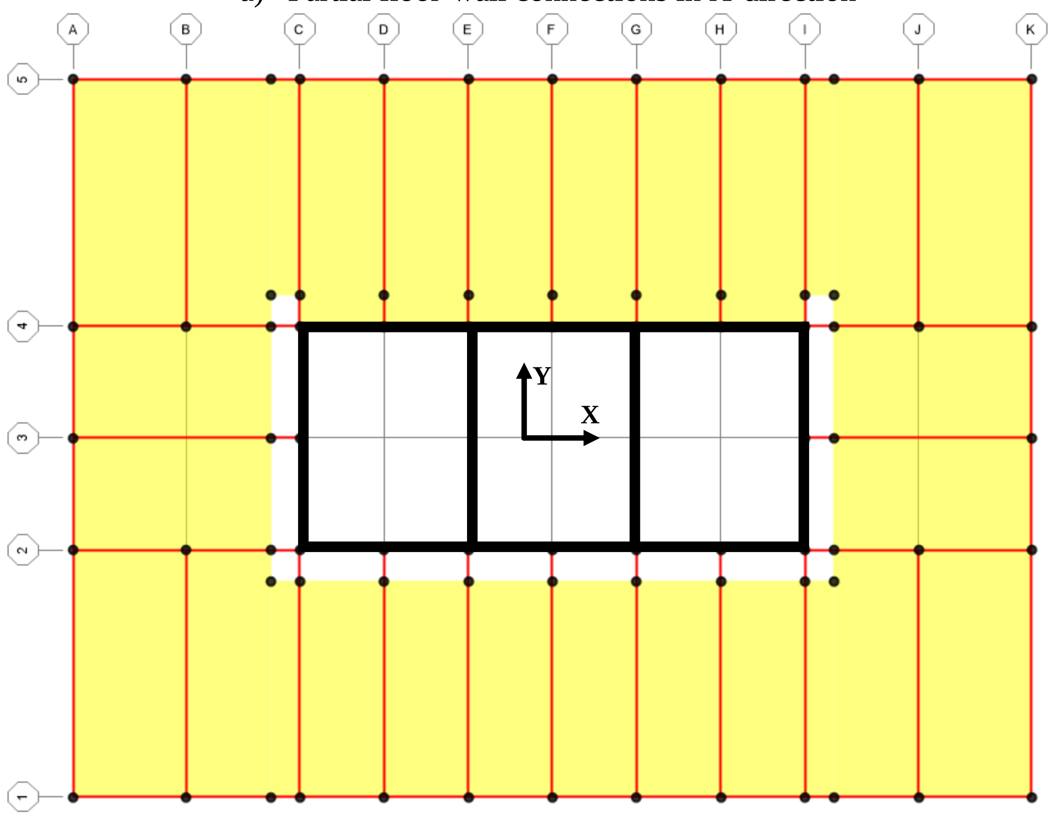
Fig. 4.13 Absent floor-wall connections

4.4.3 Partial floor-wall connections

In the third case, we included load transferring between the slabs and the walls in axial load direction, as illustrated in Fig. 4.14. Specifically, the slab is connected to the shear wall along Line C for the analyses with ground motions in X-direction, and the slab share a boundary with the walls along Line 4 for Y-direction analyses. It is expected that the connected slab will better simulate the load transfer through contact in the normal direction.



a) Partial floor-wall connections in X-direction

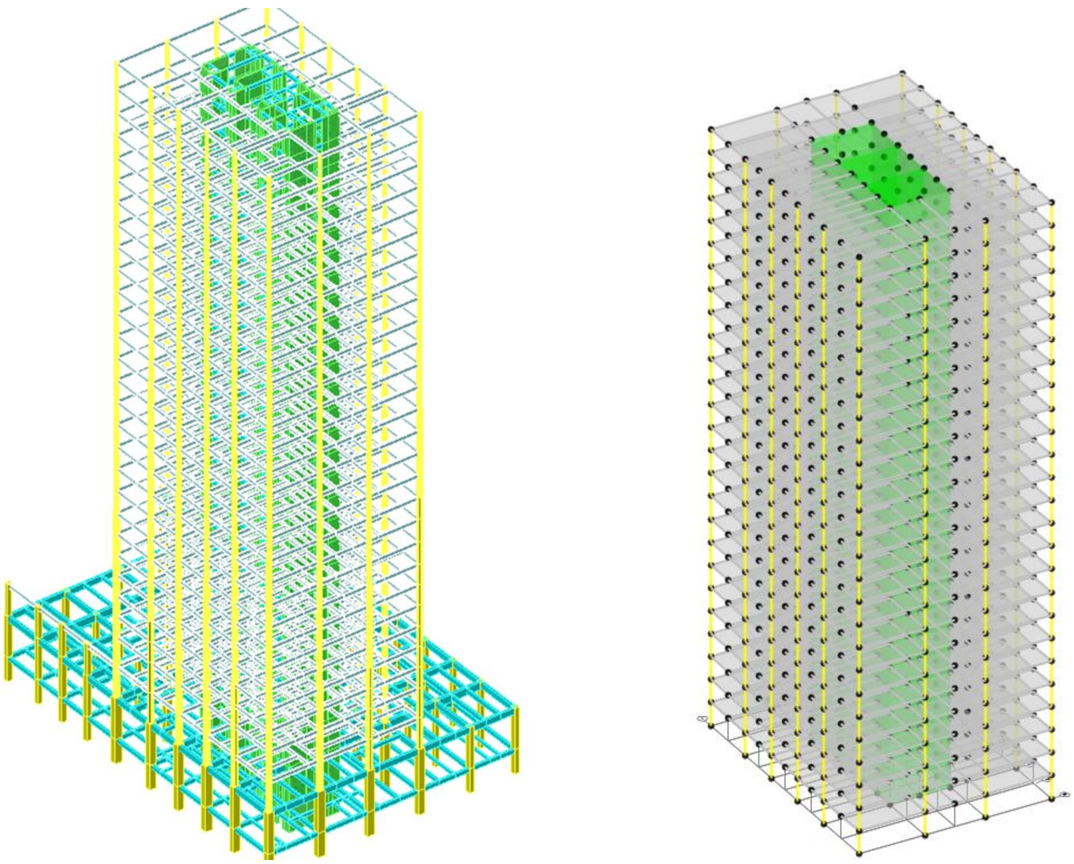


b) Partial floor-wall connections in Y-direction

Fig. 4.14 Partial floor-wall connections in Y-direction

4.5 Structural Models

The 3D model in SAP2000 of the prototype structure is shown in Fig. 4.15 along with the model built in PKPM. Specifically, Fig. 4.15a shows the model in PKPM for the design purposes while Fig. 4.16 shows the model built in SAP2000 in this study. The two underground stories are ignored, and openings in the core walls are also ignored.



a) Model in PKPM for design b) Model in SAP2000 in this study

Fig.4.15 3D Structural Models for the prototype structure

Chapter 5 ANALYSIS RESULTS

A total of thirty-two cases were conducted for the 26-story structural model as shown in Table 5.1. The procedure for reading the analysis results from SAP2000 is summarized in Appendix B. A trial analysis was conducted first for a single-story model, and the results are kept in Appendix C. The analysis results for the 26-sotry model is presented in this chapter. All analysis results are listed in Appendix D.

Table 5.1 Analysis cases for the prototype structure using equivalent lateral load method

Case	Direction	Connection	Fixity	Weight(KN)	Code	Time Period(s)	Shear Force(KN)
1	X	Full	Pinned	494640	GBJ-51000	1.8745	35761
2	X	Absent	Pinned	461363	GBJ-51000	1.8460	33828
3	X	Partial	Pinned	465887	GBJ-51000	1.8443	34190
4	X	Full	Fixed	494640	GBJ-51000	1.8743	35804
5	X	Absent	Fixed	461363	GBJ-51000	1.8445	33853
6	X	Partial	Fixed	465887	GBJ-51000	1.8428	34215
7	X	Full	Pinned	494640	ASCE7-10	1.8745	46760
8	X	Absent	Pinned	461363	ASCE7-10	1.8460	43614
9	X	Partial	Pinned	465887	ASCE7-10	1.8443	44042
10	X	Full	Fixed	494640	ASCE7-10	1.8743	46812
11	X	Absent	Fixed	461363	ASCE7-10	1.8445	43614
12	X	Partial	Fixed	465887	ASCE7-10	1.8428	44042
13	Y	Full	Pinned	494640	GBJ-51000	3.0347	30366
14	Y	Absent	Pinned	461363	GBJ-51000	3.0718	28237
15	Y	Partial	Pinned	472503	GBJ-51000	3.0440	28985
16	Y	Full	Fixed	494640	GBJ-51000	3.0343	30401
17	Y	Absent	Fixed	461363	GBJ-51000	3.0695	28242
18	Y	Partial	Fixed	472503	GBJ-51000	3.0417	28990
19	Y	Full	Pinned	494640	ASCE7-10	2.0326	46760
20	Y	Absent	Pinned	461363	ASCE7-10	2.0326	43614
21	Y	Partial	Pinned	472503	ASCE7-10	2.0326	44667
22	Y	Full	Fixed	494640	ASCE7-10	2.0326	49519
23	Y	Absent	Fixed	461363	ASCE7-10	2.0326	43614
24	Y	Partial	Fixed	472503	ASCE7-10	2.0326	44667

There are totally twelve cases in each main direction for equivalent lateral load method. They are divided by three factors: the earthquake direction, the wall-slab connections, the column base boundary condition. It is apparently that the last two factors do not affect the natural period a lot. Since the weight of the building is similar, the little difference of the period indicates similar rigidity of the structure. In conclusion, the rigidity of the base and arrangement of slab has little effect on the rigidity of the structure. The largest time period happens when the slab is connected to the shear walls.

Details on obtaining the internal forces are reported in Appendix B. The member naming conventions in these tables are as follows:

Beam 2A-C: a beam on Line 2 between Line A and Line C. For earthquake analyses in X-direction, these beams create tension/compression to the corresponding girder-wall connection.

Beam C4-5: a beam on Line C between Line 4 and Line 5. For earthquake analyses in X-direction, these beams create horizontal shear to the corresponding girder-wall connection.

Column C4: a column on the grid between Line C and Line 5. For the 26-story models, the shear forces carried by the columns is not included in the member force table because the calculated column shear includes contributions from both the inertia force at the floor of interest also the inertia forces above the floor.

Slab on Line C: the slab on Line C between Line 2 and Line 4. When connected with the core wall, the slab transfer tension/compression for earthquake analyses in X-direction.

Slab on Line 2: the slab on Line 2 between Line C and Line I. When connected with the core wall, the slab transfer shear for earthquake analyses in X-direction.

5.1 Global Structural Behavior

For the analyses of the structure model subjected to the seismic design loads corresponding to seismic design intensity 9 in the X-direction, the story forces form SAP2000 is shown in Fig. 5.2.

According to GB50011-2010, the total base shear is 30366 kN in the X-direction (with a calculated natural period of 3.0347 sec). Fig 5.1 shows the inertia forces at selected floors according to GB50011-2010 in yellow dots. The lateral loads in SAP2000 is shown in Fig. 5.2.

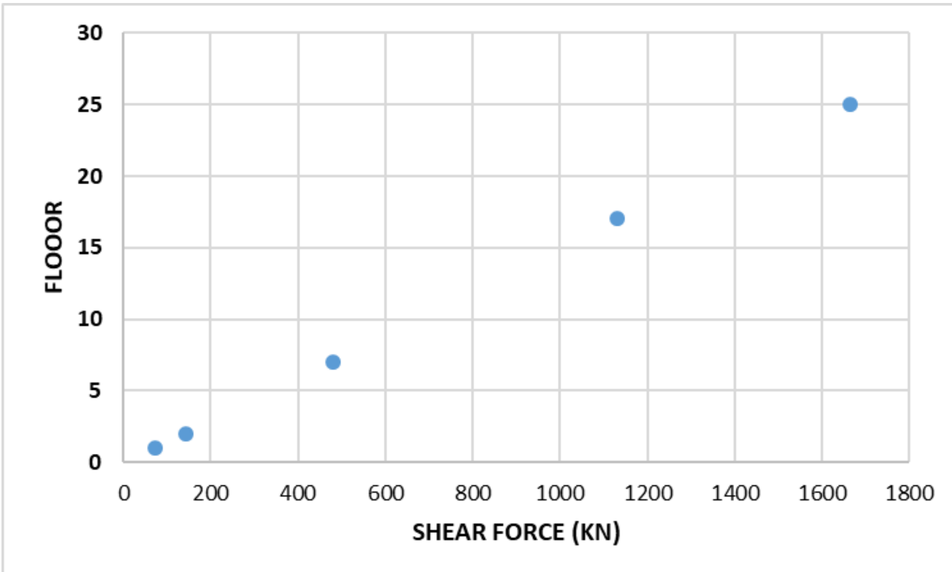


Fig. 5.1. Lateral Loads in SAP2000 According to GB50011-2010

A linear load distribution along the building height is specified in GBJ 51000-2010 as shown in Eq. 3.2. Meanwhile, ASCE 7-10 specifies a variety of functions based on the nature of the main lateral load resisting system (e.g., shear walls or moment frames). In this case, a power function with a coefficient of 1.5207 is applied, and the load distribution is shown in dashed lines in Fig. 5.2.

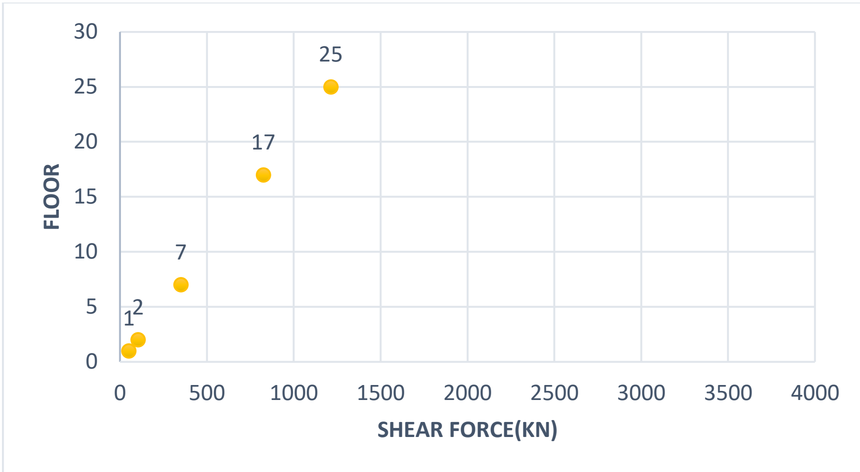


Fig. 5.2. Lateral loads in SAP2000 according to ASCE 7-10

A comparison is made on the nature period of the model. From the SAP2000, we find that the period is about 30% less than the result in PKPM. This because the shear wall is simplified which makes the rigidity higher than that of the prototype structure. However, the mode is similar in the first two cases, the first mode is Y direction and the second mode is X direction. The third mode is plane torsion.

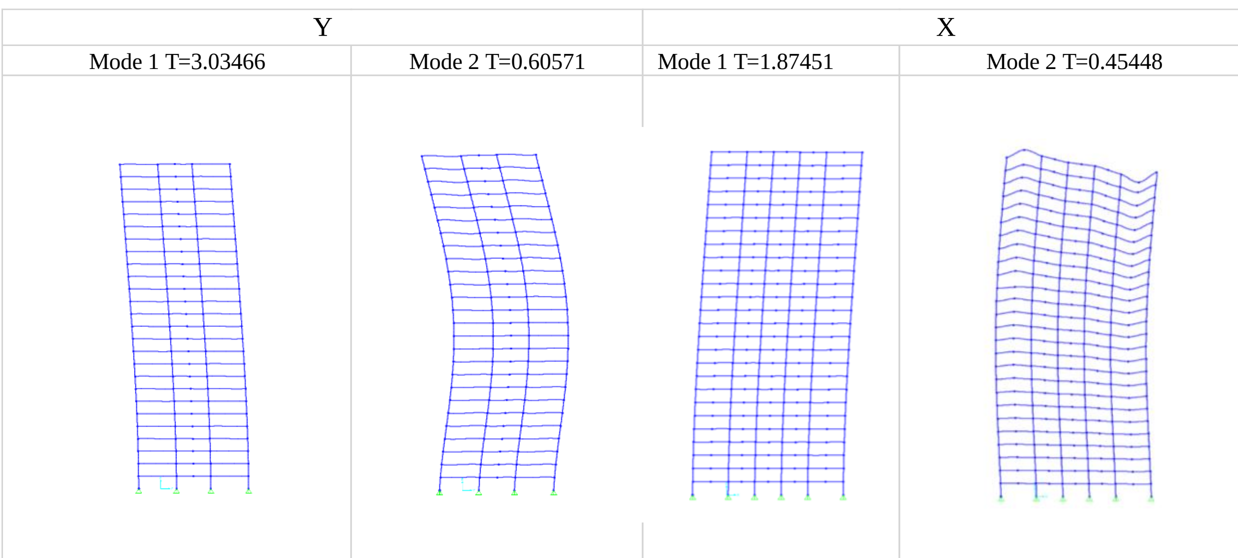


Fig. 5.3. Vibration modes from SAP2000 analyses

Table 5.2 Vibration mode in PKPM analysis

MODE	PERIOD(s)	ANGLE	TYPE	TORSION PROPERTY	X PROPERTY	Y PROPERTY	LATERAL PORPERTY	DAMPING
1	3.9251	89.25	Y	0%	0%	100%	100%	4.00%
2	3.2283	178.84	X	21%	79%	0%	79%	4.00%
3	2.6816	0.95	T	79%	21%	0%	21%	4.00%
4	0.875	8.19	X	45%	54%	1%	55%	4.00%
5	0.8181	98.07	Y	0%	2%	98%	100%	4.00%
6	0.7542	8.02	T	55%	44%	1%	45%	4.00%

5.2 Discussion of Analyses using equivalent lateral load method

5.2.1 X-Direction analysis according to GB50011-2010

SAP2000 analyses are first conducted for seismic loading according to GB50011-2010. Internal forces in members of a total of five stories were examined as shown in Tables 5.3 through 5.7: Story 1 and 2 representing lower levels, Stories 16 and 17 represents mid-height, and Story 26 the top story.

Table 5.3 contains the member internal forces for the first story of the 26-story model structures. For seismic loading in the X-direction (Fig. 4.12), the columns have a fixed base support in the first three cases while the columns have pinned base connection in the next three cases. The influence of column base conditions is negligible for Table 5.3.

The inertia force that needs to be transferred to the shear wall is from the floor mass, including the girders, beams, and columns and superimposed dead loads and live loads. The inertia force generated from the wall mass is ignored in the discussion. For a typical floor of this model structure, the weight of the floor slab including partial live load and superimposed dead load, steel beams and girders, columns, and RC walls is 10251.5 kN, 62.5 kN, 1606.0 kN, and 2108.7 kN respectively. Under an SDI-9 event, the 17th story force is 1231.9 kN in X-direction, indicating that the story acceleration is 0.069g.

Table 5.3 lists the member internal forces for three cases, as discussed in Section 4.4. The first case, in which the slab is completely separated from the core wall, shows that the majority (89.5 percent) of the floor inertia force is transferred to the wall through girder-wall connections parallel to the X-direction. On the other hand, when the slab is completely connected to the core wall (Case 3), the majority (74.4 percent) of floor inertia force is transferred to the core wall through shear in the connected slabs. Note that the shear transfer through slabs in Case 3 is not reliable because the slab is not monolithically poured with core walls in a composite building structure as shown in Fig. 1.1. Meanwhile it is also not realistic to ignore the load transfer through normal forces as assumed in Case 1. Therefore, the slab on Line C is connected to the core wall as shown in Fig. 4.14a for the analyses in X-direction. Table 5.3 indicates that the slab on Line C, along with the girders (2A-C and 4A-C) transferred about 70 percent of the inertia force while the three girders on the opposite side contributed the other 30 percent.

In all cases, a total of six girders are connected to the core wall in the X-direction, among which four are connected to a corner where the girders are in line with a long wall panel and two at the middle of a wall panel. The load transfers through the one located in the middle of a shear wall panel is negligible. This observation correlates with those observed in the finite element analyses of girder-wall subassemblies by Li et al. (2010). The observation confirms the practice in the current Shanghai code shown in Eq. 3.4, where only girders connected to the columns carry earthquake-induced inertia force. Meanwhile, the force distribution should be more related to the connecting wall rather than the columns. Further studies are needed to verify this hypothesis.

It should be noted that the story inertia force for Story 1, according to GB50011-2010, is only 72 kN for the first floor; however, the total forces transferred through all components is much higher, as shown in Table 5.3. This may have been attributed to the incompatible deformation between the core wall and the steel frame.

Table 5.3 Transfer of seismic inertia forces at <u>Story 1</u> in SAP2000 analyses according to GB50011-2010

Cases (Ex9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	75.3	75.3	-9.1	-9.1	283.0	0.4	2.6	3.4	3.7	3.4	2.6	0.4	33.3	0.0	0.0	0.0	0.0	316.3
Td=1.846	23.8%	23.8%	-2.9%	-2.9%	89.5%	0.1%	0.8%	1.1%	1.2%	1.1%	0.8%	0.1%	10.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	15.4	61.7	-13.9	-9.8	130.7	0.3	2.5	3.3	3.6	3.3	2.6	0.4	31.7	369.7	0.0	0.0	0.0	532.1
Td=1.8443	2.9%	11.6%	-2.6%	-1.8%	24.6%	0.0%	0.5%	0.6%	0.7%	0.6%	0.5%	0.1%	6.0%	69.5%	0.0%	0.0%	0.0%	100.0%
Slab connected	108.2	108.2	12.0	12.0	456.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	122.3	122.3	1017.8	1017.8	2736.9
Td=1.8755	4.0%	4.0%	0.4%	0.4%	16.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	4.5%	37.2%	37.2%	100.0%
Slab Isolated(fixed)	298.7	298.7	0.4	0.4	1195.7	-1.5	0.4	0.9	1.2	0.9	0.4	-1.5	1.4	0.0	0.0	0.0	0.0	1197.1
Td=1.8445	25.0%	25.0%	0.0%	0.0%	99.9%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	198.8	299.0	9.2	0.0	1004.9	-1.4	0.4	0.9	1.2	0.9	0.4	-1.5	1.9	58.8	0.0	0.0	0.0	1065.6
Td=1.8428	18.7%	28.1%	0.9%	0.0%	94.3%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.2%	5.5%	0.0%	0.0%	0.0%	100.0%
Slab connected	165.6	165.6	10.1	10.1	682.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	137.3	137.3	808.3	808.3	2573.5
Td=1.8743	6.4%	6.4%	0.4%	0.4%	26.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.3%	5.3%	31.4%	31.4%	100.0%

Table 5.4 Transfer of seismic inertia forces at <u>Story 2</u> in SAP2000 analyses according to GB50011-2010

Cases (Ex9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	113.5	113.5	-8.7	-8.7	436.6	0.6	2.9	4.0	4.4	4.0	2.9	0.6	39.0	0.0	0.0	0.0	0.0	475.6
Td=1.846	23.9%	23.9%	-1.8%	-1.8%	91.8%	0.1%	0.6%	0.8%	0.9%	0.8%	0.6%	0.1%	8.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	27.4	92.9	-14.9	-9.5	216.1	0.4	2.7	3.8	4.2	3.8	2.8	0.5	36.5	425.2	0.0	0.0	0.0	677.7
Td=1.8443	4.0%	13.7%	-2.2%	-1.4%	31.9%	0.1%	0.4%	0.6%	0.6%	0.6%	0.4%	0.1%	5.4%	62.7%	0.0%	0.0%	0.0%	100.0%
Slab connected	123.2	123.2	12.3	12.3	517.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	239.4	239.4	1671.9	1671.9	4339.8
Td=1.8755	2.8%	2.8%	0.3%	0.3%	11.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%	38.5%	38.5%	100.0%
Slab Isolated(fixed)	73.3	73.3	12.9	12.9	318.8	-0.4	1.7	2.6	3.0	2.6	1.7	-0.4	21.8	0.0	0.0	0.0	0.0	340.6
Td=1.8445	21.5%	21.5%	3.8%	3.8%	93.6%	-0.1%	0.5%	0.8%	0.9%	0.8%	0.5%	-0.1%	6.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	68.9	78.7	13.5	13.0	321.5	-0.4	1.7	2.6	3.0	2.6	1.7	-0.4	21.4	227.0	0.0	0.0	0.0	569.8
Td=1.8428	12.1%	13.8%	2.4%	2.3%	56.4%	-0.1%	0.3%	0.5%	0.5%	0.5%	0.3%	-0.1%	3.7%	39.8%	0.0%	0.0%	0.0%	100.0%
Slab connected	131.1	131.1	12.7	12.7	549.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	249.5	249.5	1411.2	1411.2	3871.0
Td=1.8743	3.4%	3.4%	0.3%	0.3%	14.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%	6.4%	36.5%	36.5%	100.0%

Table 5.5 Transfer of seismic inertia forces at <u>Story 16</u> in SAP2000 analyses according to GB50011-2010

Cases (Ex9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	164.6	164.6	-15.6	-15.6	626.9	0.8	1.6	2.0	2.2	2.0	1.6	0.8	21.9	0.0	0.0	0.0	0.0	648.9
Td=1.846	25.4%	25.4%	-2.4%	-2.4%	96.6%	0.1%	0.2%	0.3%	0.3%	0.3%	0.2%	0.1%	3.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	74.7	144.4	-6.1	-16.0	416.1	0.6	1.3	1.8	2.0	1.8	1.4	0.7	19.3	223.8	0.0	0.0	0.0	659.2
Td=1.8443	11.3%	21.9%	-0.9%	-2.4%	63.1%	0.1%	0.2%	0.3%	0.3%	0.3%	0.2%	0.1%	2.9%	33.9%	0.0%	0.0%	0.0%	100.0%
Slab connected	24.3	24.3	3.9	3.9	105.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.5	36.5	288.2	288.2	754.4
Td=1.8755	3.2%	3.2%	0.5%	0.5%	13.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%	4.8%	38.2%	38.2%	100.0%
Slab Isolated(fixed)	164.8	164.8	-15.6	-15.6	627.9	0.8	1.6	2.0	2.2	2.0	1.6	0.8	22.0	0.0	0.0	0.0	0.0	649.8
Td=1.8445	25.4%	25.4%	-2.4%	-2.4%	96.6%	0.1%	0.2%	0.3%	0.3%	0.3%	0.2%	0.1%	3.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	74.8	74.8	-6.1	-6.1	287.0	0.6	1.3	1.8	2.0	1.8	1.3	0.6	18.8	224.1	0.0	0.0	0.0	529.9
Td=1.8428	14.1%	14.1%	-1.1%	-1.1%	54.2%	0.1%	0.3%	0.3%	0.4%	0.3%	0.3%	0.1%	3.6%	42.3%	0.0%	0.0%	0.0%	100.0%
Slab connected	24.3	24.3	3.9	3.9	105.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.5	36.5	288.4	288.4	754.8
Td=1.8743	3.2%	3.2%	0.5%	0.5%	13.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%	4.8%	38.2%	38.2%	100.0%

Table 5.6 Transfer of seismic inertia forces at <u>Story 17</u> in SAP2000 analyses according to GB50011-2010

Cases (Ex9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	300.1	300.1	4.6	4.6	1209.6	1.6	2.4	2.8	3.0	2.8	2.4	1.6	33.1	0.0	0.0	0.0	0.0	1242.7
Td=1.846	24.1%	24.1%	0.4%	0.4%	97.3%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	153.0	273.6	-5.2	3.5	851.7	1.3	2.0	2.6	2.7	2.6	2.2	1.4	29.6	404.9	0.0	0.0	0.0	1286.1
Td=1.8443	11.9%	21.3%	-0.4%	0.3%	66.2%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	31.5%	0.0%	0.0%	0.0%	100.0%
Slab connected	0.5	0.5	2.6	2.6	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0	31.0	643.2	643.2	1355.2
Td=1.8755	0.0%	0.0%	0.2%	0.2%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	2.3%	47.5%	47.5%	100.0%
Slab Isolated(fixed)	300.3	300.3	4.6	4.6	1210.5	1.6	2.4	2.8	3.0	2.8	2.4	1.6	33.1	0.0	0.0	0.0	0.0	1243.6
Td=1.8445	24.1%	24.1%	0.4%	0.4%	97.3%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	153.2	273.9	5.2	3.5	862.7	1.3	2.0	2.6	2.7	2.6	2.2	1.4	29.6	406.9	0.0	0.0	0.0	1299.2
Td=1.8428	11.8%	21.1%	0.4%	0.3%	66.4%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	31.3%	0.0%	0.0%	0.0%	100.0%
Slab connected	0.5	0.5	2.6	2.6	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0	31.0	643.7	643.7	1356.3
Td=1.8743	0.0%	0.0%	0.2%	0.2%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	2.3%	47.5%	47.5%	100.0%

Table 5.7 Transfer of seismic inertia forces at Story 26 in SAP2000 analyses according to GB50011-2010

Cases (Ex9	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolate	1642.3	1642.3	22.9	22.9	6614.9	8.5	12.1	13.9	14.2	13.9	12.1	8.5	166.2	0.0	0.0	0.0	0.0	6781.0
Td=1.846	24.2%	24.2%	0.3%	0.3%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-si	863.3	1511.7	-3.0	19.9	4766.7	6.7	10.3	12.3	12.7	12.6	11.0	7.7	146.5	1801.6	0.0	0.0	0.0	6714.9
Td=1.8443	12.9%	22.5%	0.0%	0.3%	71.0%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	26.8%	0.0%	0.0%	0.0%	100.0%
Slab conne	133.4	133.4	10.8	10.8	555.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	156.9	156.9	2632.4	2632.4	6133.7
Td=1.8755	2.2%	2.2%	0.2%	0.2%	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	2.6%	42.9%	42.9%	100.0%
Slab Isolate	1642.9	1642.9	22.9	22.9	6617.5	8.5	12.1	13.9	14.2	13.9	12.1	8.5	166.2	0.0	0.0	0.0	0.0	6783.7
Td=1.8445	24.2%	24.2%	0.3%	0.3%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-si	863.6	1512.3	3.0	19.9	4774.6	6.7	10.3	12.3	12.7	12.6	11.0	7.7	146.6	1792.6	0.0	0.0	0.0	6713.8
Td=1.8428	12.9%	22.5%	0.0%	0.3%	71.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	26.7%	0.0%	0.0%	0.0%	100.0%
Slab conne	133.4	133.4	10.8	10.8	555.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	146.8	146.8	2633.0	2633.0	6114.9
Td=1.8743	2.2%	2.2%	0.2%	0.2%	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	2.4%	43.1%	43.1%	100.0%

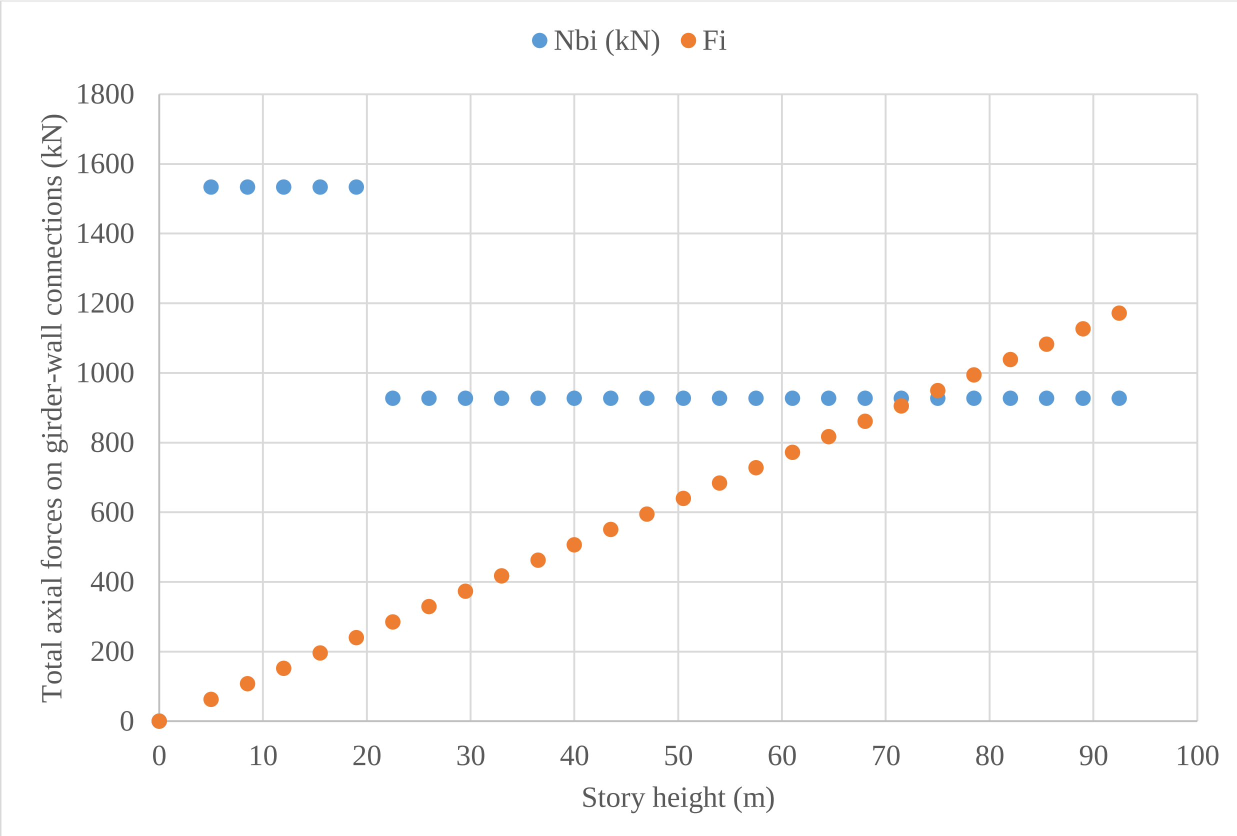


Fig. 5.4 Comparison of seismic loads on model structure

5.2.2 X-Direction analysis according to ASCE 7-10

SAP2000 analyses are also conducted for seismic loading according to ASCE 7-10. Internal forces in members of a total of five stories were examined as shown in Tables 5.8 through 5.10. For seismic loading in the X-direction (Fig. 4.12), the columns have a fixed base support in the first three cases in the tables while the columns have pinned base connection in the next three cases. The influence of column base conditions is again found negligible.

The inertia force that needs to be transferred to the shear wall is from the floor mass, including the girders, beams, and columns and superimposed dead loads and live loads. The inertia force generated from the wall mass is ignored in the discussion. For a typical floor of this model structure, the weight of the floor slab including partial live load and superimposed dead load, steel beams and girders, columns, and RC walls is 10251.5 kN, 62.5 kN, 1606.0 kN, and 2108.7 kN respectively. Under an event happened in San Francisco, the 17th story force is 1859.2 kN in X-direction, indicating that the story acceleration is 0.105 g.

Table 5.8 Transfer of seismic inertia forces at Story 1 in SAP2000 analyses according to IBC2012/ASCE7-10

Cases (AISCx9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	79.7	79.7	-11.7	-11.7	295.1	0.5	3.3	4.2	4.7	4.2	3.3	0.5	41.1	0.0	0.0	0.0	0.0	336.3
Td=1.846	23.7%	23.7%	-3.5%	-3.5%	87.8%	0.1%	1.0%	1.3%	1.4%	1.3%	1.0%	0.1%	12.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	10.9	63.7	-17.6	-12.4	119.2	0.3	3.1	4.1	4.5	4.1	3.2	0.4	39.1	456.4	0.0	0.0	0.0	614.7
Td=1.8443	1.8%	10.4%	-2.9%	-2.0%	19.4%	0.0%	0.5%	0.7%	0.7%	0.7%	0.5%	0.1%	6.4%	74.2%	0.0%	0.0%	0.0%	100.0%
Slab connected	141.7	141.7	15.5	15.5	597.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	317.3	317.3	2062.0	2062.0	5356.2
Td=1.8745	2.6%	2.6%	0.3%	0.3%	11.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.9%	5.9%	38.5%	38.5%	100.0%
Slab Isolated(fixed)	394.9	394.9	0.4	0.4	1580.2	-2.0	0.4	1.1	1.4	1.1	0.4	-2.0	0.6	0.0	0.0	0.0	0.0	1580.8
Td=1.8445	25.0%	25.0%	0.0%	0.0%	100.0%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	261.1	394.1	11.5	-0.8	1321.2	-1.8	0.5	1.1	1.4	1.1	0.4	-2.0	1.4	89.7	0.0	0.0	0.0	1412.3
Td=1.8428	18.5%	27.9%	0.8%	-0.1%	93.6%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.1%	6.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	216.3	216.3	13.0	13.0	891.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	353.1	353.1	1324.1	1324.1	4245.7
Td=1.8743	5.1%	5.1%	0.3%	0.3%	21.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	8.3%	31.2%	31.2%	100.0%

Table 5.8 lists the member internal forces in Story 1 for three cases, as discussed in Section 4.4. The first case, in which the slab is completely separated from the core wall, shows that the majority (88 percent) of the floor inertia force is transferred to the wall through girder-wall connections parallel to the X-direction. On the other hand, when the slab is completely connected to the core wall (Case 3), the majority (77 percent) of floor inertia force is transferred to the core wall through shear in the connected slabs. For Case 2, Table 5.8 indicates that the slab on Line C, along with the girders (2A-C and 4A-C) transferred about 75 percent of the inertia force while the three girders on the opposite side contributed the other 25 percent.

It should be noted that the story inertia force, according to ASCE 7-10, is only 175.2 kN for the 1st floor; however, the total forces transferred through all components is above 330 kN, as shown in Table 5.8.

Table 5.9 lists the member internal forces in Story 17 for three cases, as discussed in Section 4.4. The first case, in which the slab is completely separated from the core wall, shows that the majority (97.5 percent) of the floor inertia force is transferred to the wall through girder-wall connections parallel to the X-direction. On the other hand, when the slab is completely connected to the core wall (Case 3), the majority (94.6 percent) of floor inertia force is transferred to the core wall through shear in the connected slabs. For Case 2, Table 5.9 indicates that the slab on Line C, along with the girders (2A-C and 4A-C) transferred about 80 percent of the inertia force while the three girders on the opposite side contributed the other 201 percent.

Table 5.9 Transfer of seismic inertia forces at Story 17 in SAP2000 analyses according to IBC2012/ASCE7-10

Cases (AISCx9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	482.7	482.7	6.0	6.0	1942.7	2.5	3.5	4.2	4.4	4.2	3.5	2.5	49.6	0.0	0.0	0.0	0.0	1992.3
Td=1.846	24.2%	24.2%	0.3%	0.3%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connecte	249.2	441.0	-6.9	4.3	1377.7	2.0	3.0	3.7	4.0	3.8	3.2	2.3	44.1	599.1	0.0	0.0	0.0	2020.8
Td=1.8443	12.3%	21.8%	-0.3%	0.2%	68.2%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	29.6%	0.0%	0.0%	0.0%	100.0%
Slab connected	14.5	14.5	-2.8	-2.8	52.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.3	23.3	863.4	863.4	1825.9
Td=1.8755	0.8%	0.8%	-0.2%	-0.2%	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	1.3%	47.3%	47.3%	100.0%
Slab Isolated(fixed)	482.7	482.7	6.0	6.0	1942.7	2.5	3.5	4.2	4.4	4.2	3.5	2.5	49.6	0.0	0.0	0.0	0.0	1992.3
Td=1.8445	24.2%	24.2%	0.3%	0.3%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connecte	249.1	441.0	-6.9	4.3	1377.6	2.0	3.0	3.7	4.0	3.8	3.2	2.3	44.1	599.1	0.0	0.0	0.0	2020.8
Td=1.8428	12.3%	21.8%	-0.3%	0.2%	68.2%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	29.6%	0.0%	0.0%	0.0%	100.0%
Slab connected	14.5	14.5	-2.8	-2.8	52.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0	24.0	865.3	865.3	1831.1
Td=1.8743	0.8%	0.8%	-0.2%	-0.2%	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	1.3%	47.3%	47.3%	100.0%

It should be noted that the story inertia force, according to ASCE 7-10, is 1859 kN for the 17th floor; meanwhile the total forces transferred through all components is 1800 kN, as shown in Table 7, the huge difference between the shear force of the story and the inertia force in members does not appear again.

Table 5.10 lists the member internal forces in Story 26 for three cases, as discussed in Section 4.4. The first case, in which the slab is completely separated from the core wall, shows that the majority (97.5 percent) of the floor inertia force is transferred to the wall through girder-wall connections parallel to the X-direction. On the other hand, when the slab is completely connected to the core wall (Case 3), the majority (70.6 percent) of floor inertia force is transferred to the core wall through shear in the connected slabs. For Case 2, Table 5.10 indicates that the slab on Line C, along with the girders (2A-C and 4A-C) transferred about 54 percent of the inertia force while the three girders on the opposite side contributed the other 44.6 percent.

Table 5.10 Transfer of seismic inertia forces at <u>Story 26</u> in SAP2000 analyses according to IBC2012/ASCE7-10

Cases (AISCx9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	467.3	467.3	-16.4	-16.4	1836.4	2.4	3.3	3.9	4.0	3.9	3.3	2.4	46.2	0.0	0.0	0.0	0.0	1882.6
Td=1.846	24.8%	24.8%	-0.9%	-0.9%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	217.9	407.7	5.2	-17.0	1239.4	1.8	2.5	3.2	3.4	3.3	2.8	2.0	37.8	550.2	0.0	0.0	0.0	1827.4
Td=1.8443	11.9%	22.3%	0.3%	-0.9%	67.8%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.1%	30.1%	0.0%	0.0%	0.0%	100.0%
Slab connected	31.4	31.4	9.8	9.8	145.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	148.6	148.6	529.3	529.3	1501.0
Td=1.8755	2.1%	2.1%	0.7%	0.7%	9.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.9%	9.9%	35.3%	35.3%	100.0%
Slab Isolated(fixed)	467.4	467.4	-16.4	-16.4	1836.7	2.4	3.3	3.9	4.0	3.9	3.3	2.4	46.2	0.0	0.0	0.0	0.0	1882.9
Td=1.8445	24.8%	24.8%	-0.9%	-0.9%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	217.9	407.8	5.2	-17.0	1239.6	1.8	2.5	3.2	3.4	3.3	2.8	2.0	37.9	547.0	0.0	0.0	0.0	1824.5
Td=1.8428	11.9%	22.4%	0.3%	-0.9%	67.9%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.1%	30.0%	0.0%	0.0%	0.0%	100.0%
Slab connected	31.4	31.4	9.8	9.8	145.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	148.7	148.7	528.8	528.8	1500.2
Td=1.8743	2.1%	2.1%	0.7%	0.7%	9.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.9%	9.9%	35.2%	35.2%	100.0%

5.3 Linear Elastic Time History Analysis

5.3.1 overview of the time history analyses

The seismic analyses in Section 5.2 shows that the seismic inertia forces of a floor are related to the acceleration at the floor according to the seismic design codes. The spectrum acceleration for design is usually a fraction of actual acceleration responses observed in earthquakes. Hence, time-history analyses were conducted to examine the level of inertia forces in the structural model and the components of load transfer. Two earthquake ground motions are used:

1) Imperial Valley earthquake, occurred at 21:35 Pacific Standard Time on May 18, 1940 in Southern California. The ground acceleration is shown in Fig. 5.5.

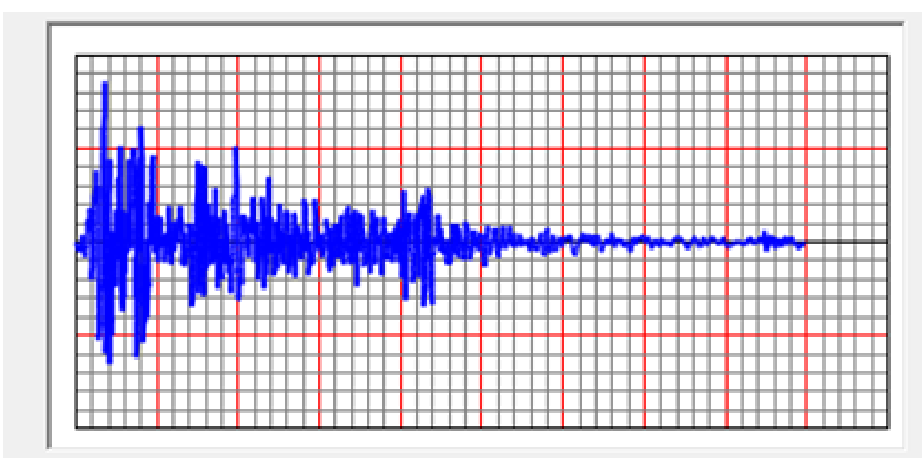


Fig. 5.5 Imperial Valley earthquake record (PGA=0.35g)

The spectrum acceleration for the ground motion is shown in Fig. 5.6. The natural period for the model structure is 3.0 sec. Correspondingly, the acceleration response for the first mode is 0.311g.

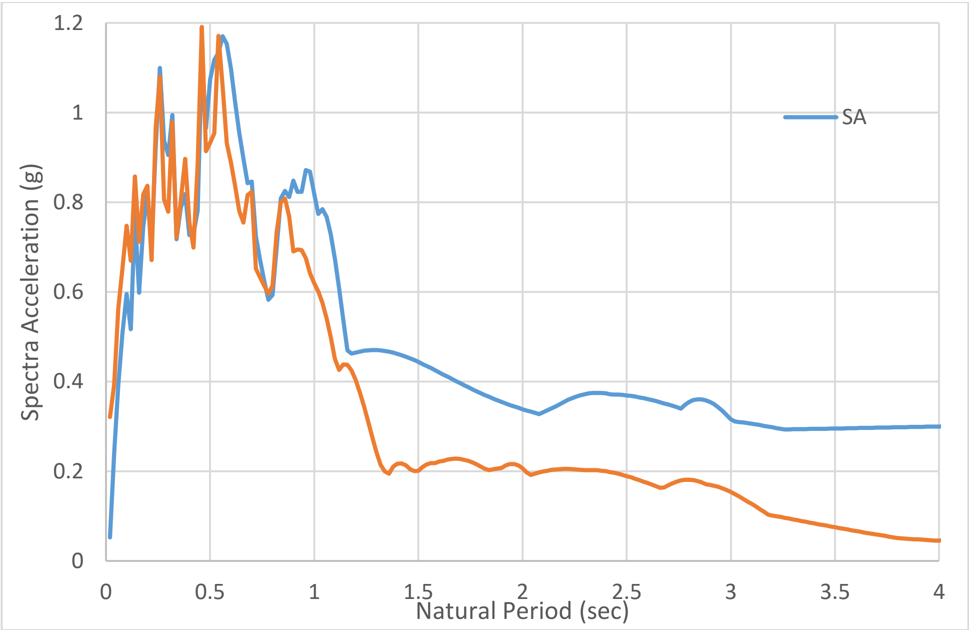


Fig. 5.6 Spectrum Acceleration for El Centro Earthquake

2) Mexico City earthquake struck in the early morning of September 19th, 1985. The earthquake had a moment magnitude of 8.0 and a Mercalli intensity of IX (Violent). The measured ground acceleration used in this study is shown in Fig. 5.7, and the spectrum acceleration is shown in Fig. 5.8. This ground acceleration records contains relatively higher components for long-period structures. Hence, the acceleration response for the first mode is 0.301g.

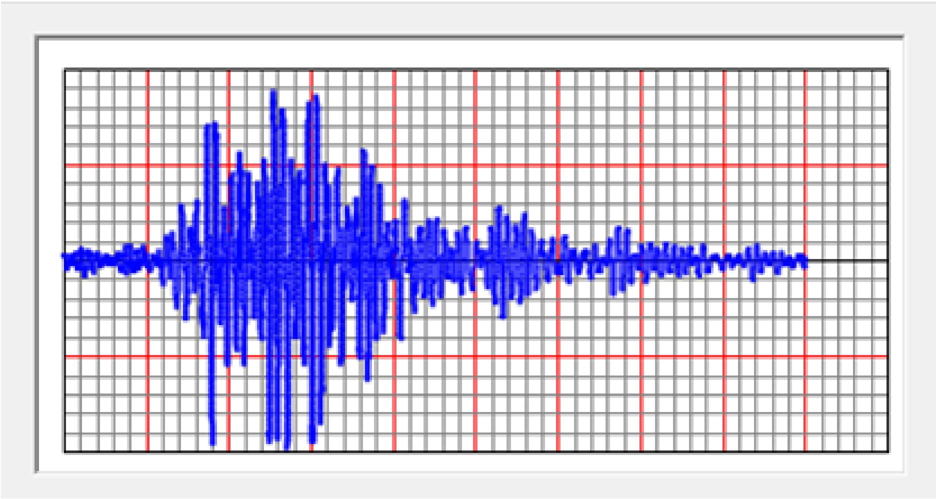


Fig. 5. 7 Mexico City earthquake record (PGA=0.10g)

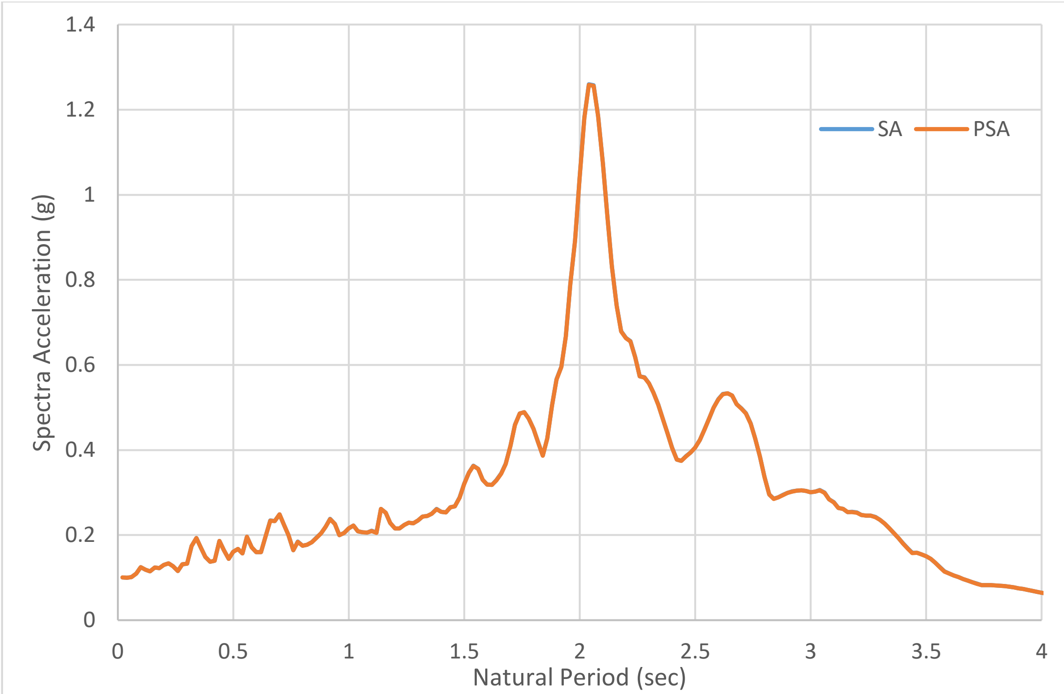


Fig. 5. 8 Spectrum Acceleration for Mexico City Earthquake

The result of the slab is an envelope so that we cannot get the force of the slab. So we use the displacement of the structure to make sure the structure is reliable.

5.3.2 Responses to the El Centro earthquake

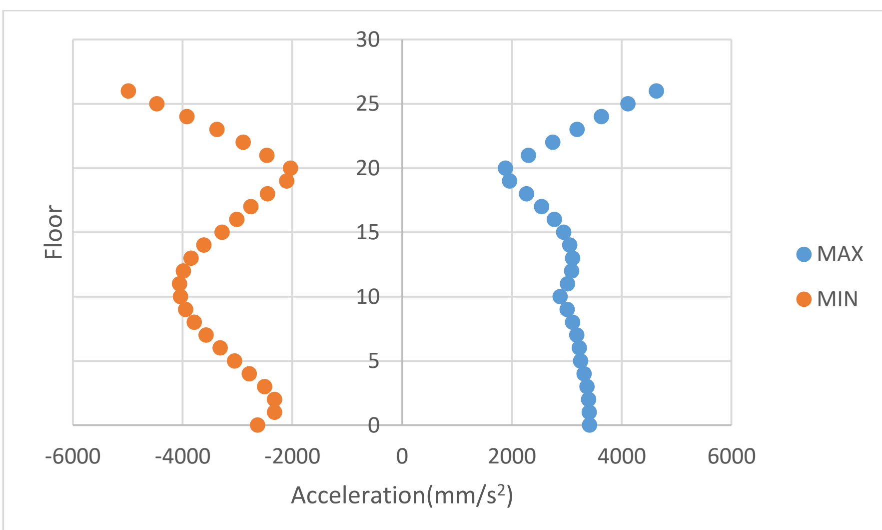


Fig. 5. 9 Responses to the El Centro Earthquake

From the figure, we can see the distribution of acceleration when the earthquake happens. As we can see, it is not a linear as we assume in the static equivalent method, the maximum acceleration happened on the top floor as well, however the acceleration is approximately 5000 mm/s^2 (0.51g). It is similar to Chinese code (0.504g), which is 0.068g in ASCE.

5.3.3 Responses to the Mexico City earthquake

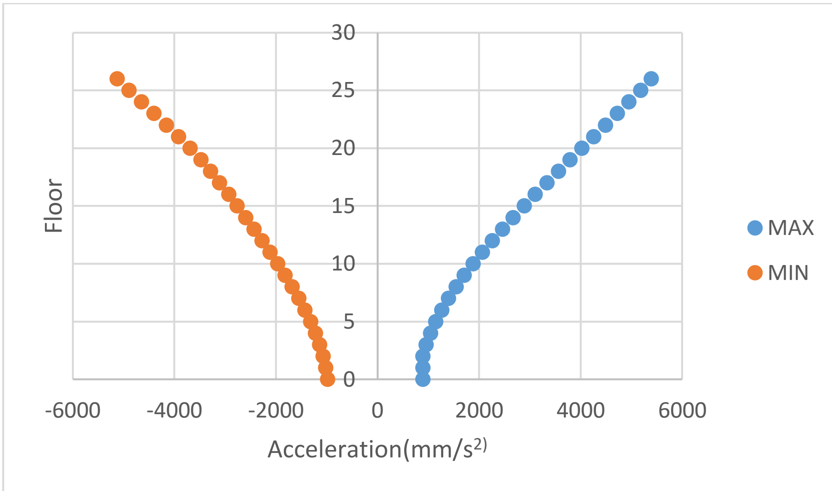


Fig. 5. 10 Responses to the Mexico City earthquake

From the table, we can see the distribution of acceleration when the Mexico City earthquake happens. As we can see, it is not a linear as we assume in the static equivalent method but it increases when the height rises up. As a result, the higher floor resists higher lateral force. It is the same as we assume in either Chinese code and American code. The maximum acceleration happened on the top floor as well, however the acceleration is approximately 5400 mm/s^2 (0.55g). It is similar to Chinese code (0.504g), which is 0.068g in ASCE. The minimum acceleration happened on the 1st floor.

5.4 Discussion of Analyses using time history method

5.4.1 X-Direction analysis according to Imperial Valley earthquake

SAP2000 analyses are conducted for seismic loading according to Imperial Valley earthquake. Table 5.11 contains the member internal forces for the first story of the 26-story model structures. For seismic loading in the X-direction (Fig. 4.12), the columns have a fixed base support in the first three cases while the columns have pinned base connection in the next three cases. The influence of column base conditions is negligible for Table 5.11.

Table 5.11 lists the member internal forces for three cases, as discussed in Section 4.4. The first case, in which the slab is completely separated from the core wall, shows that the majority (94.1 percent) of the floor inertia force is transferred to the wall through girder-wall connections parallel to the X-direction. On the other hand, when the slab is completely connected to the core wall (Case 3), the majority (70.4 percent) of floor inertia force is transferred to the core wall through shear in the connected slabs. Note that the shear transfer through slabs in Case 3 is not reliable because the slab is not monolithically poured with core walls in a composite building structure as shown in Fig. 1.1. Meanwhile it is also not realistic to ignore the load transfer through normal forces as assumed in Case 1. Therefore, the slab on Line C is connected to the core wall as shown in Fig. 4.14a for the analyses in X-direction. Table 5.11 indicates that the slab on Line C, along with the girders (2A-C and 4A-C) transferred about 65 percent of the inertia force while the three girders on the opposite side contributed the other 32 percent.

Table 5.11 Transfer of seismic inertia forces at <u>Story 1</u> in SAP2000 analyses according to time history of Imperial Valley Earthquake in 1940

Cases (IMX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	243.4	243.4	-13.8	-13.8	946.0	1.3	4.7	5.8	6.3	5.8	4.7	1.3	59.8	0.0	0.0	0.0	0.0	1005.8
	24.2%	24.2%	-1.4%	-1.4%	94.1%	0.1%	0.5%	0.6%	0.6%	0.6%	0.5%	0.1%	5.9%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	117.8	221.6	-21.8	-14.6	642.3	1.0	4.4	5.5	6.0	5.6	4.5	1.2	56.5	689.4	0.0	0.0	0.0	1388.2
	8.5%	16.0%	-1.6%	-1.1%	46.3%	0.1%	0.3%	0.4%	0.4%	0.4%	0.3%	0.1%	4.1%	49.7%	0.0%	0.0%	0.0%	100.0%
Slab connected	165.5	165.5	18.9	18.9	700.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	856.1	856.1	2875.4	2875.4	8163.0
	2.0%	2.0%	0.2%	0.2%	8.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.5%	10.5%	35.2%	35.2%	100.0%
Slab Isolated(fixed)	552.7	552.7	-6.2	-6.2	2198.1	-2.7	0.8	1.6	2.1	1.6	0.8	-2.7	2.9	0.0	0.0	0.0	0.0	2201.0
	25.1%	25.1%	-0.3%	-0.3%	99.9%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	363.5	554.6	14.1	-6.9	1843.5	-2.6	0.9	1.7	2.1	1.7	0.8	-2.7	3.8	1259.3	0.0	0.0	0.0	3106.6
	11.7%	17.9%	0.5%	-0.2%	59.3%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.1%	40.5%	0.0%	0.0%	0.0%	100.0%
Slab connected	291.2	291.2	15.2	15.2	1194.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1267.9	1267.9	2335.0	2335.0	8400.7
	3.5%	3.5%	0.2%	0.2%	14.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.1%	15.1%	27.8%	27.8%	100.0%

Table 5.12 Transfer of seismic inertia forces at <u>Story 2</u> in SAP2000 analyses according to time history of Imperial Valley Earthquake in 1940

Cases (IMX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	414.3	414.3	-13.1	-13.1	1630.9	2.2	5.5	7.2	7.8	7.2	5.5	2.2	75.2	0.0	0.0	0.0	0.0	1706.1
	24.3%	24.3%	-0.8%	-0.8%	95.6%	0.1%	0.3%	0.4%	0.5%	0.4%	0.3%	0.1%	4.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	201.9	375.0	-23.9	-14.4	1115.5	1.7	5.0	6.7	7.4	6.8	5.2	2.0	69.5	852.5	0.0	0.0	0.0	2037.6
	9.9%	18.4%	-1.2%	-0.7%	54.7%	0.1%	0.2%	0.3%	0.4%	0.3%	0.3%	0.1%	3.4%	41.8%	0.0%	0.0%	0.0%	100.0%
Slab connected	190.8	190.8	-19.4	-19.4	724.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1179.1	1179.1	3149.6	3149.6	9381.8
	2.0%	2.0%	-0.2%	-0.2%	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.6%	12.6%	33.6%	33.6%	100.0%
Slab Isolated(fixed)	213.3	213.3	20.6	20.6	894.6	1.1	2.9	4.3	4.8	4.3	2.9	1.1	42.7	0.0	0.0	0.0	0.0	937.3
	22.8%	22.8%	2.2%	2.2%	95.4%	0.1%	0.3%	0.5%	0.5%	0.5%	0.3%	0.1%	4.6%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	156.2	210.6	20.9	21.1	775.7	1.0	2.8	4.2	4.7	4.2	2.8	1.1	41.5	737.3	0.0	0.0	0.0	1554.5
	10.1%	13.5%	1.3%	1.4%	49.9%	0.1%	0.2%	0.3%	0.3%	0.3%	0.2%	0.1%	2.7%	47.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	200.6	200.6	20.3	20.3	843.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1232.7	1232.7	2642.7	2642.7	8593.9
	2.3%	2.3%	0.2%	0.2%	9.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.3%	14.3%	30.8%	30.8%	100.0%

Table 5.13 Transfer of seismic inertia forces at <u>Story 16</u> in SAP2000 analyses according to time history of Imperial Valley Earthquake in 1940

Cases (IMX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1116.3	1116.3	-28.4	-28.4	4408.2	5.8	6.2	6.9	7.1	6.9	6.2	5.8	89.9	0.0	0.0	0.0	0.0	4498.1
	24.8%	24.8%	-0.6%	-0.6%	98.0%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	623.7	1062.2	-10.5	-27.7	3333.6	4.9	5.3	6.1	6.2	6.3	5.8	5.5	79.9	1639.9	0.0	0.0	0.0	5053.4
	12.3%	21.0%	-0.2%	-0.5%	66.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.6%	32.5%	0.0%	0.0%	0.0%	100.0%
Slab connected	155.9	155.9	7.3	7.3	638.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	464.3	464.3	1602.6	1602.6	4771.9
	3.3%	3.3%	0.2%	0.2%	13.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.7%	9.7%	33.6%	33.6%	100.0%
Slab Isolated(fixed)	1108.5	1108.5	-28.4	-28.4	4377.0	5.8	6.2	6.9	7.1	6.9	6.2	5.8	89.6	0.0	0.0	0.0	0.0	4466.6
	24.8%	24.8%	-0.6%	-0.6%	98.0%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	626.3	1067.0	10.5	27.7	3424.8	4.9	5.3	6.1	6.2	6.3	5.8	5.5	80.2	1533.1	0.0	0.0	0.0	5038.1
	12.4%	21.2%	0.2%	0.6%	68.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.6%	30.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	156.4	156.4	7.2	7.2	640.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	460.1	460.1	1815.7	1815.7	5191.8
	3.0%	3.0%	0.1%	0.1%	12.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.9%	8.9%	35.0%	35.0%	100.0%

Table 5.14 Transfer of seismic inertia forces at <u>Story 17</u> in SAP2000 analyses according to time history of Imperial Valley Earthquake in 1940

Cases (IMX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1004.7	1004.7	-7.8	-7.8	4003.2	5.2	6.3	7.1	7.2	7.1	6.3	5.2	88.9	0.0	0.0	0.0	0.0	4092.1
	24.6%	24.6%	-0.2%	-0.2%	97.8%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	530.8	920.1	-8.9	5.8	2898.8	4.2	5.2	6.2	6.4	6.4	5.7	4.7	77.7	1519.4	0.0	0.0	0.0	4495.9
	11.8%	20.5%	-0.2%	0.1%	64.5%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.7%	33.8%	0.0%	0.0%	0.0%	100.0%
Slab connected	134.4	134.4	5.1	5.1	547.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	400.8	400.8	1787.3	1787.3	4923.8
	2.7%	2.7%	0.1%	0.1%	11.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.1%	8.1%	36.3%	36.3%	100.0%
Slab Isolated(fixed)	1003.4	1003.4	-7.8	-7.8	3998.1	5.2	6.3	7.1	7.2	7.1	6.3	5.2	88.9	0.0	0.0	0.0	0.0	4087.0
	24.6%	24.6%	-0.2%	-0.2%	97.8%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	529.1	917.2	-8.9	-5.8	2877.8	4.2	5.2	6.2	6.4	6.4	5.7	4.7	77.6	1530.2	0.0	0.0	0.0	4485.6
	11.8%	20.4%	-0.2%	-0.1%	64.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.7%	34.1%	0.0%	0.0%	0.0%	100.0%
Slab connected	134.8	134.8	5.1	5.1	549.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	392.2	392.2	1831.4	1831.4	4996.6
	2.7%	2.7%	0.1%	0.1%	11.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.8%	7.8%	36.7%	36.7%	100.0%

Table 5.15 Transfer of seismic inertia forces at Story 26 in SAP2000 analyses according to time history of Imperial Valley Earthquake in 1940

Cases (IMX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1465.1	1465.1	22.6	22.6	5905.7	7.6	10.9	12.6	13.0	12.6	10.9	7.6	150.4	0.0	0.0	0.0	0.0	6056.1
	24.2%	24.2%	0.4%	0.4%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	765.2	1349.0	-18.1	-23.9	4186.3	5.9	9.2	11.1	11.7	11.4	9.9	6.9	132.3	2265.7	0.0	0.0	0.0	6584.3
	11.6%	20.5%	-0.3%	-0.4%	63.6%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.0%	34.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	107.6	107.6	-14.5	-14.5	401.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	248.8	248.8	2209.7	2209.7	5318.4
	2.0%	2.0%	-0.3%	-0.3%	7.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.7%	4.7%	41.5%	41.5%	100.0%
Slab Isolated(fixed)	1454.0	1454.0	22.6	22.6	5861.2	7.6	10.8	12.5	12.9	12.5	10.8	7.6	149.2	0.0	0.0	0.0	0.0	6010.3
	24.2%	24.2%	0.4%	0.4%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	759.8	1352.6	18.1	23.9	4266.8	5.9	9.1	11.0	11.6	11.4	9.8	6.9	131.3	2237.1	0.0	0.0	0.0	6635.2
	11.5%	20.4%	0.3%	0.4%	64.3%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	33.7%	0.0%	0.0%	0.0%	100.0%
Slab connected	108.2	108.2	14.4	14.4	461.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	348.8	348.8	2096.8	2096.8	5352.8
	2.0%	2.0%	0.3%	0.3%	8.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	6.5%	39.2%	39.2%	100.0%

5.4.2 X-Direction analysis according to time history of Mexico City Earthquake

SAP2000 analyses are also conducted for seismic loading according to time history of Mexico City Earthquake. Internal forces in members of a total of five stories were examined as shown in Tables 5.16 through 5.18. For seismic loading in the X-direction (Fig. 4.12), the columns have a fixed base support in the first three cases in the tables while the columns have pinned base connection in the next three cases. The influence of column base conditions is again found negligible.

Table 5.16 Transfer of seismic inertia forces at Story 1 in SAP2000 analyses according to time history of Mexico City Earthquake

Cases (MEX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	246.8	246.8	-30.3	-30.3	926.5	1.4	8.8	11.3	12.4	11.3	8.8	1.4	111.0	0.0	0.0	0.0	0.0	1037.5
	23.8%	23.8%	-2.9%	-2.9%	89.3%	0.1%	0.8%	1.1%	1.2%	1.1%	0.8%	0.1%	10.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	51.6	201.6	-42.6	-32.3	431.6	0.8	8.3	10.9	12.0	11.0	8.5	1.1	105.3	1263.6	0.0	0.0	0.0	1800.5
	2.9%	11.2%	-2.4%	-1.8%	24.0%	0.0%	0.5%	0.6%	0.7%	0.6%	0.5%	0.1%	5.8%	70.2%	0.0%	0.0%	0.0%	100.0%
Slab connected	383.1	383.1	42.1	42.1	1616.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1742.2	1742.2	5661.0	5661.0	16422.9
	2.3%	2.3%	0.3%	0.3%	9.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.6%	10.6%	34.5%	34.5%	100.0%
Slab Isolated(fixed)	1054.6	1054.6	1.0	1.0	4220.2	5.2	-0.8	-2.6	-3.5	-2.6	-0.8	5.2	0.2	0.0	0.0	0.0	0.0	4220.4
	25.0%	25.0%	0.0%	0.0%	100.0%	0.1%	0.0%	-0.1%	-0.1%	-0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	696.9	1051.8	29.8	1.7	3528.7	-4.9	1.1	2.8	3.6	2.7	0.9	-5.2	1.9	2483.1	0.0	0.0	0.0	6013.7
	11.6%	17.5%	0.5%	0.0%	58.7%	-0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	-0.1%	0.0%	41.3%	0.0%	0.0%	0.0%	100.0%
Slab connected	593.1	593.1	35.1	35.1	2442.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1992.0	1992.0	5587.2	5587.2	17600.7
	3.4%	3.4%	0.2%	0.2%	13.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.3%	11.3%	31.7%	31.7%	100.0%

Table 5.16 lists the member internal forces in Story 1 for three cases, as discussed in Section 4.4. The first case, in which the slab is completely separated from the core wall, shows that the majority (89.3 percent) of the floor inertia force is transferred to the wall through girder-wall connections parallel to the X-direction. On the other hand, when the slab is completely connected to the core wall (Case 3), the majority (69 percent) of floor inertia force is transferred to the core wall through

shear in the connected slabs. For Case 2, Table 5.16 indicates that the slab on Line C, along with the girders (2A-C and 4A-C) transferred about 70 percent of the inertia force while the three girders on the opposite side contributed the other 30 percent.

Table 5.17 lists the member internal forces in Story 17 for three cases, as discussed in Section 4.4. The first case, in which the slab is completely separated from the core wall, shows that the majority (97.6 percent) of the floor inertia force is transferred to the wall through girder-wall connections parallel to the X-direction. On the other hand, when the slab is completely connected to the core wall (Case 3), the majority (82.8 percent) of floor inertia force is transferred to the core wall through shear in the connected slabs. For Case 2, Table 5.17 indicates that the slab on Line C, along with the girders (2A-C and 4A-C) transferred about 56 percent of the inertia force while the three girders on the opposite side contributed the other 42 percent.

Table 5.17 Transfer of seismic inertia forces at Story 17 in SAP2000 analyses according to time history of Mexico City Earthquake

Cases (MEX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1407.1	1407.1	16.2	16.2	5660.8	7.3	10.0	11.7	12.2	11.7	10.0	7.3	140.4	0.0	0.0	0.0	0.0	5801.3
	24.3%	24.3%	0.3%	0.3%	97.6%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	728.4	1284.6	-18.4	11.3	4018.8	5.8	8.5	10.4	11.0	10.7	9.1	6.6	124.1	1936.4	0.0	0.0	0.0	6079.4
	12.0%	21.1%	-0.3%	0.2%	66.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	31.9%	0.0%	0.0%	0.0%	100.0%
Slab connected	67.4	67.4	6.9	6.9	283.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	319.4	319.4	2215.1	2215.1	5352.4
	1.3%	1.3%	0.1%	0.1%	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0%	6.0%	41.4%	41.4%	100.0%
Slab Isolated(fixed)	1403.5	1403.5	16.1	16.1	5646.2	7.3	10.0	11.7	12.1	11.7	10.0	7.3	140.1	0.0	0.0	0.0	0.0	5786.3
	24.3%	24.3%	0.3%	0.3%	97.6%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	726.7	1281.6	18.4	11.3	4046.2	5.8	8.5	10.4	11.0	10.6	9.1	6.6	123.9	1910.8	0.0	0.0	0.0	6080.9
	11.9%	21.1%	0.3%	0.2%	66.5%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	31.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	67.1	67.1	6.9	6.9	282.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	428.1	428.1	2544.0	2544.0	6226.3
	1.1%	1.1%	0.1%	0.1%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.9%	6.9%	40.9%	40.9%	100.0%

It should be noted that the story inertia force, according to ASCE 7-10, is 1859 kN for the 17^{th} floor; meanwhile the total forces transferred through all components is 1800 kN, as shown in Table 7, the huge difference between the shear force of the story and the inertia force in members does not appear again.

Table 5.18 lists the member internal forces in Story 26 for three cases, as discussed in Section 4.4. The first case, in which the slab is completely separated from the core wall, shows that the majority

(97.7 percent) of the floor inertia force is transferred to the wall through girder-wall connections parallel to the X-direction. On the other hand, when the slab is completely connected to the core wall (Case 3), the majority (61.8 percent) of floor inertia force is transferred to the core wall through shear in the connected slabs. For Case 2, Table 5.18 indicates that the slab on Line C, along with the girders (2A-C and 4A-C) transferred about 54.1 percent of the inertia force while the three girders on the opposite side contributed the other 43.2 percent.

Table 5.18 Transfer of seismic inertia forces at <u>Story 26</u> in SAP2000 analyses according to time history of Mexico City Earthquake

Cases (MEX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	902.4	902.4	41.9	41.9	3693.3	4.5	6.3	7.5	7.8	7.5	6.3	4.5	88.8	0.0	0.0	0.0	0.0	3782.1
	23.9%	23.9%	1.1%	1.1%	97.7%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	408.1	775.8	-14.8	43.1	2396.1	3.3	4.7	6.0	6.4	6.2	5.3	3.8	71.3	1125.3	0.0	0.0	0.0	3592.7
	11.4%	21.6%	-0.4%	1.2%	66.7%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	31.3%	0.0%	0.0%	0.0%	100.0%
Slab connected	106.1	106.1	0.0	0.0	424.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	362.3	362.3	931.4	931.4	3011.6
	3.5%	3.5%	0.0%	0.0%	14.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0%	12.0%	30.9%	30.9%	100.0%
Slab Isolated(fixed)	903.2	903.2	41.9	41.9	3696.4	4.5	6.3	7.5	7.8	7.5	6.3	4.5	88.9	0.0	0.0	0.0	0.0	3785.3
	23.9%	23.9%	1.1%	1.1%	97.7%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	408.5	776.5	14.8	43.1	2428.0	3.3	4.7	6.0	6.4	6.2	5.3	3.8	71.4	1118.3	0.0	0.0	0.0	3617.7
	11.3%	21.5%	0.4%	1.2%	67.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	30.9%	0.0%	0.0%	0.0%	100.0%
Slab connected	61.8	61.8	24.5	24.5	296.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	361.8	361.8	1129.5	1129.5	3278.8
	1.9%	1.9%	0.7%	0.7%	9.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.0%	11.0%	34.4%	34.4%	100.0%

5.5 Summary

This study includes three types of seismic analyses: 1) code-based analyses for design purposes; 2) linear elastic time history analyses; and 3) nonlinear time-history analyses. We compared the resulted axial forces at girder ends and axial and shear forces through slab-wall boundary lines with the inertia force generated at floor levels. Note that the floor weight, including that of girders, slabs, partial live loads, and the column weights is roughly 88.1 percent of the total story weight, which also includes the weight of RC shear walls. The comparison indicates that most of the weight of the building is the slab instead of the shear wall.

1) the majority of floor inertia force is transferred to the shear walls though shear stresses in slabs

at the slab-wall boundary parallel to the seismic load directions. This misrepresents the actual shear transfer along the slab-wall boundary because the slabs are usually separated from the walls in composite structures.

2) the majority of floor inertia forces is transferred to the shear walls through axial loads at girder ends when the slab shear transfer is excluded from the model.

3) the distribution of the tensile forces at girder ends along the building height do not correspond to that of the seismic inertia forces. The inertia force is usually higher at higher levels; however the girder-end forces can be significantly higher than the floor inertia force at lower level. This may have been due to high lateral stiffness of the shear walls at lower levels in the model structure with a complete fixed base.

Chapter 6 CONCLUSIONS AND FUTURE STUDIES

6.1 Summary

Composite construction is widely used for high-rise building structures, in which concrete shear walls are designed as the main lateral load resisting element and steel frames the main gravity load resisting element. Earthquake-induced inertia forces, mainly caused by the floor masses, must be securely transferred to the shear wall. The load transfer ends at the connections between floor girders and the shear wall. Due to this commonly accepted assumption that shear walls carry the earthquake-induced lateral loads, the loads applied to the girder-wall connections are easily overlooked in design processes and steel reinforcement is used to bridge to physical gap between concrete floors and concrete walls. This practice may cause safety issues when the reinforcement become unreliable in carrying the load.

This study is a seismic demand study focusing on the axial loads on the girder-wall connections in composite structures. A 26-story building structure built in 2016 in Chongqing, China is used in the numerical study. Models are created in SAP2000, in which, concrete slabs and concrete shear walls are modeled using shell elements, and beams, girders, and columns using beam-column elements. The materials specified in the design document was used in the analysis. The analysis results corresponding to the dead leads are compared with those used in the structural design by engineers to validate the structural model. Two groups of analyses are presented in this thesis: 1) code-specific seismic analyses; and 2) elastic time-history analyses.

6.2 Conclusions

The axial forces at girder ends and axial and shear forces through slab-wall boundary lines were compared with the inertia force generated at floor levels. Note that the floor weight, including that of girders, slabs, partial live loads, and the column weights is roughly 88.1 percent of the total story weight, which also includes the weight of RC shear walls. The comparison indicates that most of the weight of the building is the slab instead of the shear wall.

1) the majority of floor inertia force is transferred to the shear walls though shear stresses in slabs at the slab-wall boundary parallel to the seismic load directions when the slab elements have a shared boundary with wall elements. This misrepresents the actual shear transfer along the slab-wall boundary because the slabs are usually separated from the walls in composite structures.

2) the majority of floor inertia forces is transferred to the shear walls through axial loads at girder ends when the slab shear transfer is excluded from the model.

3) the distribution of the tensile forces at girder ends along the building height do not correspond to that of the seismic inertia forces. The inertia force is usually higher at higher levels; however, the girder-end forces can be significantly higher than the floor inertia force at lower level. This may have been due to high lateral stiffness of the shear walls at lower levels in the model structure with a complete fixed base.

6.3 Future studies

Earthquakes are natural disasters that pose the greatest threat to high-rise structures. This study provides a better understanding of the response of composite structures under earthquakes, thereby avoiding structural insecurity caused by over-simplified assumptions in seismic design. This is critical for enhancing the society’s ability to withstand natural disasters. This study is limited in many aspects. For future studies, these subjects may be necessary:

1. non-linear analyses are needed in the future study. Meanwhile, a solid element analysis should reflect the distribution of the weight more accurately. Programs such as OpenSees

will have more flexibility in building a model, which means we can use different elements for the shear wall and column.

2. girder-wall connections need to be properly modeled along with embedded bars in future nonlinear analyses.
3. a shaking table test with proper sensors can help us understand the real load transfer in the at girder-wall connections when the earthquake happened.

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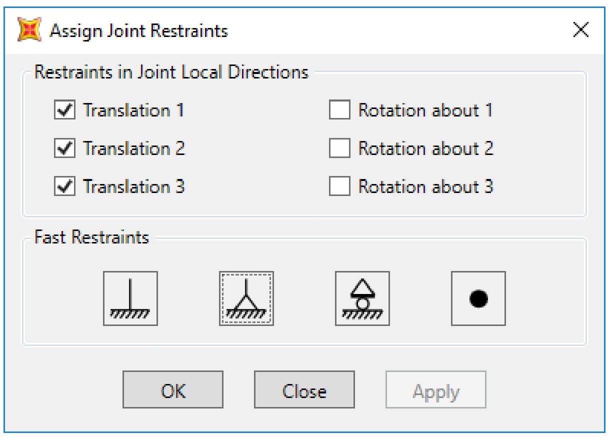
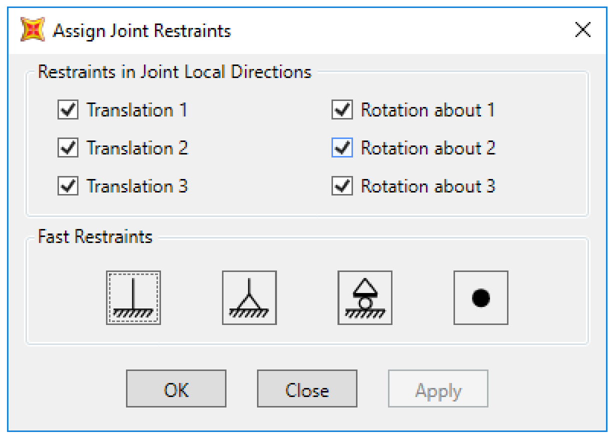
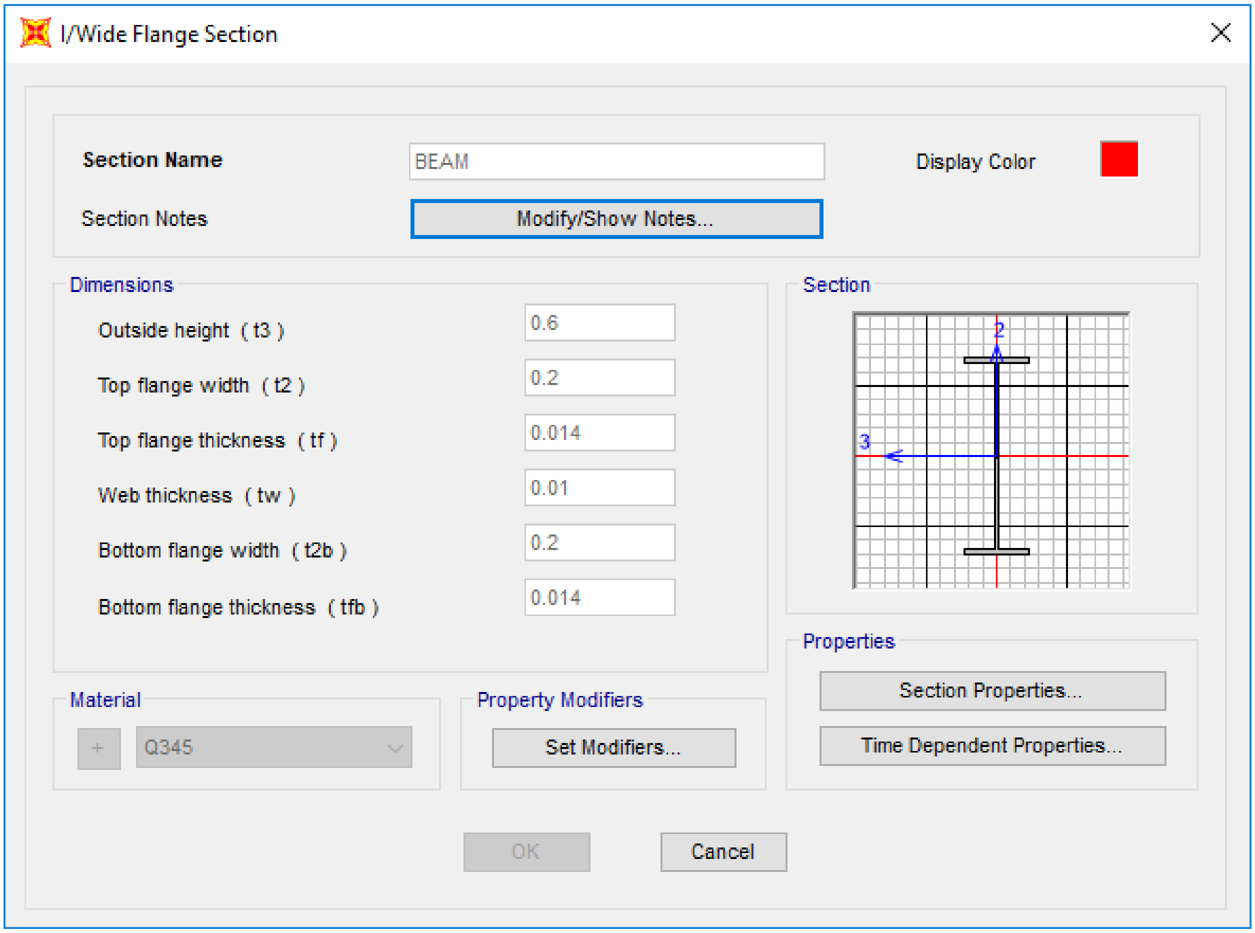
Appendix A Modeling Procedure

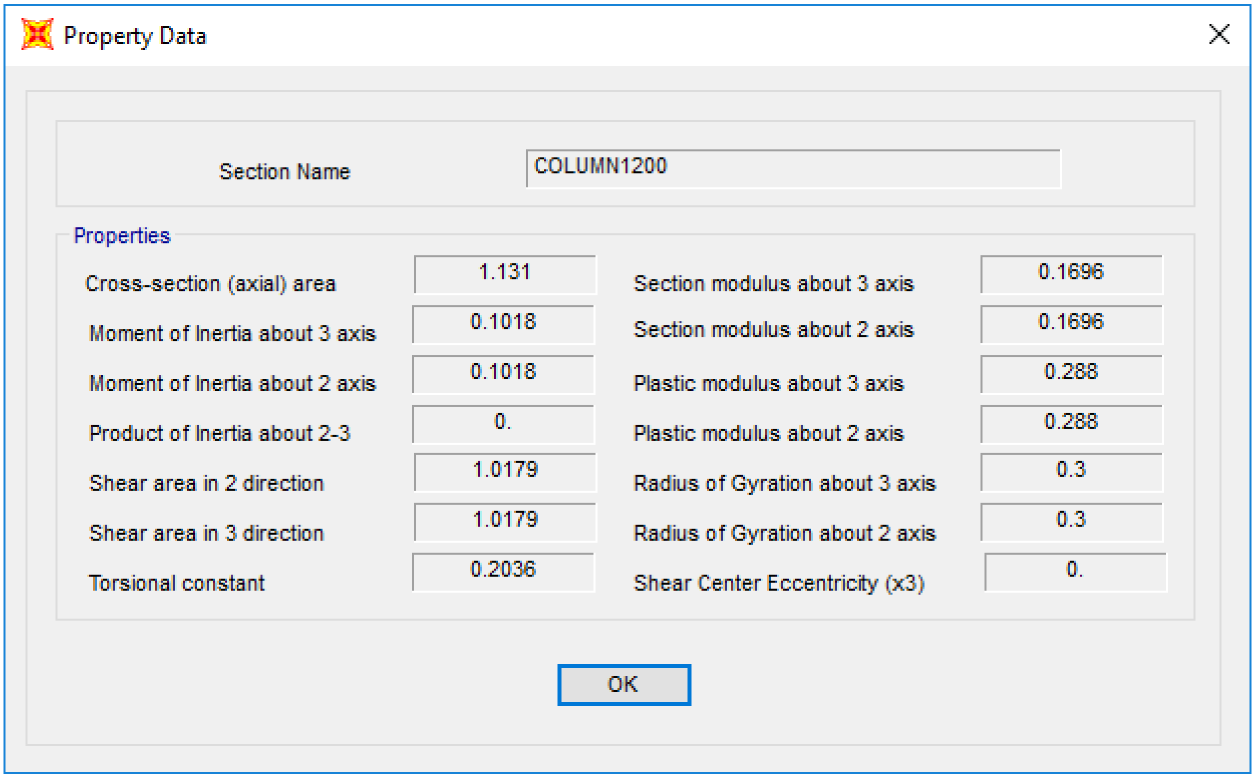
In SAP2000, I built a 26-story steel-concrete model to simulate a real high-rise structure located in Fuling City in Chongqing. Because the research focused on the beam wall axial force, I removed the two-story underground foundation and the water chamber at the top. In order to better simulate the situation in the real structure where the bottom is between the hinged and fixed base. I built two bottom fixation modes, the fixed and the hinged, thus making the real force between the two.



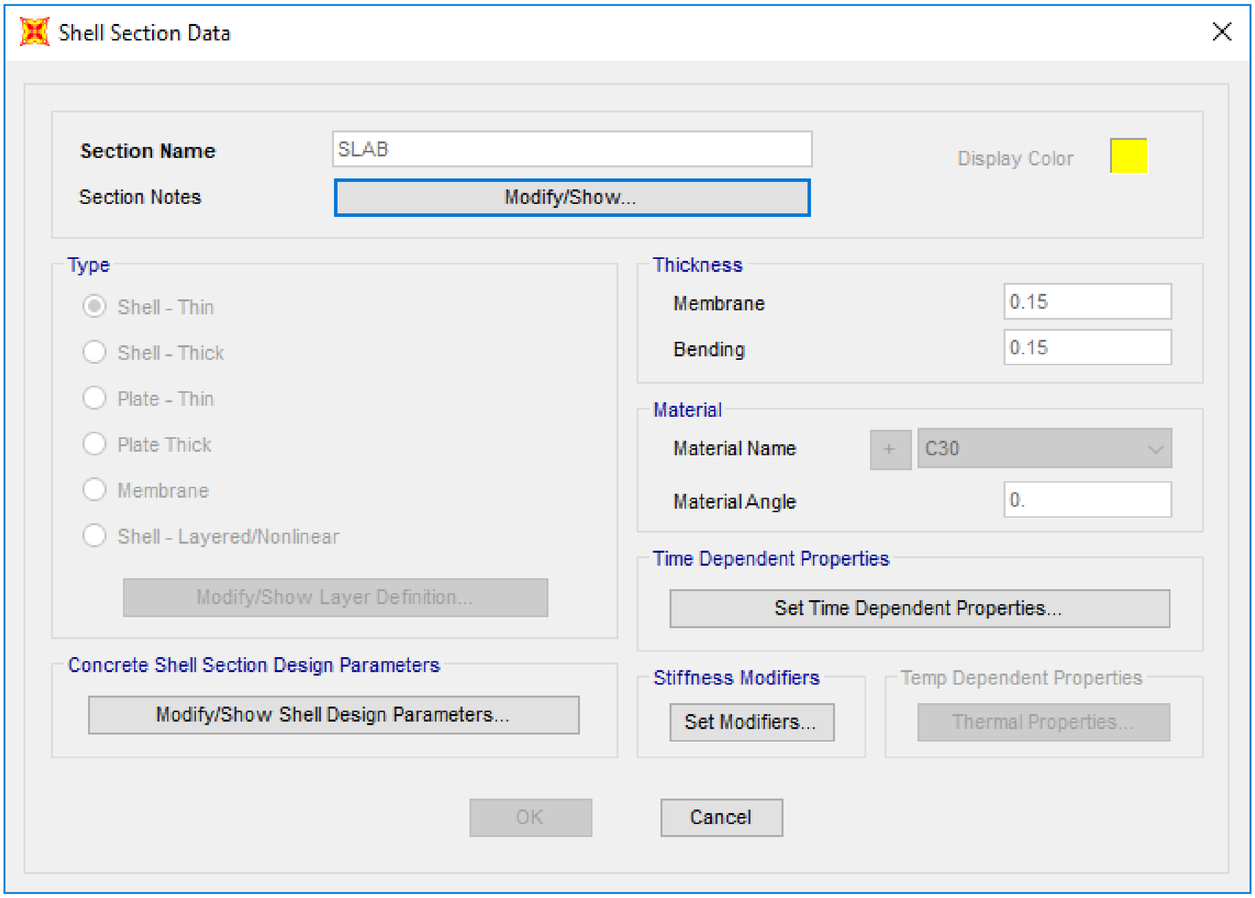




For columns, the original structure used a concrete-filled steel tube column. I used the Young's modulus to convert the original post 900 into a concrete column 1200 of equal strength, and in 7th floor, 17th floor, the section diameter changes to 0.9m and 0.6m separately. Since the rebar has little effect on the axial load in the beam, we use the 0.01 for the ratio of rebar in the column. At last the property data of the column is as followed.



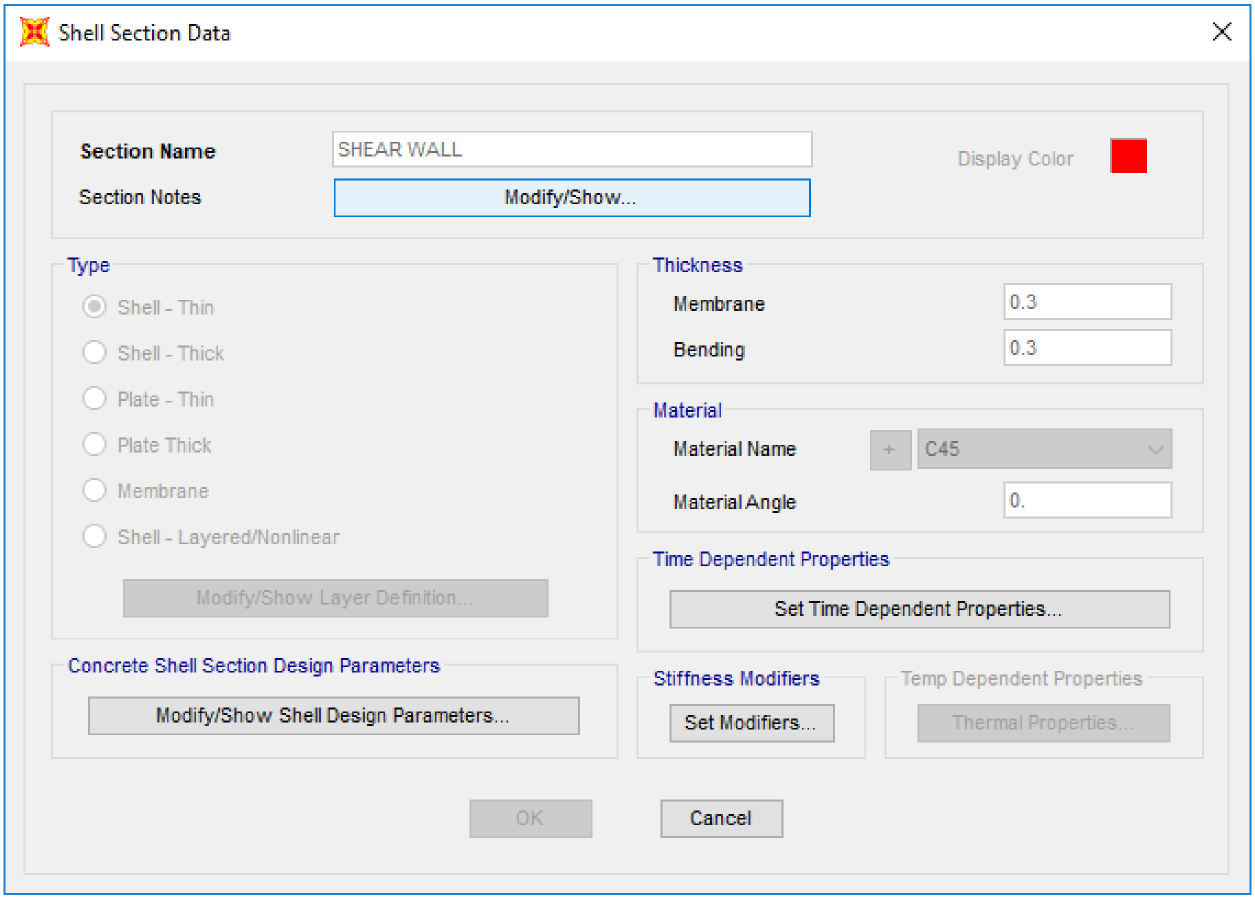
apply for the shear wall and the slab.



The inclusion of transverse shear deformation in plate-bending behavior is the main difference between thin and thick shell formulation. Thin-plate formulation follows a Kirchhoff application, which neglects transverse shear deformation, whereas thick-plate formulation follows Mindlin/Reissner, which does account for shear behavior. Thick-plate formulation has no effect upon membrane (in-plane) behavior, only plate-bending (out-of-plane) behavior.

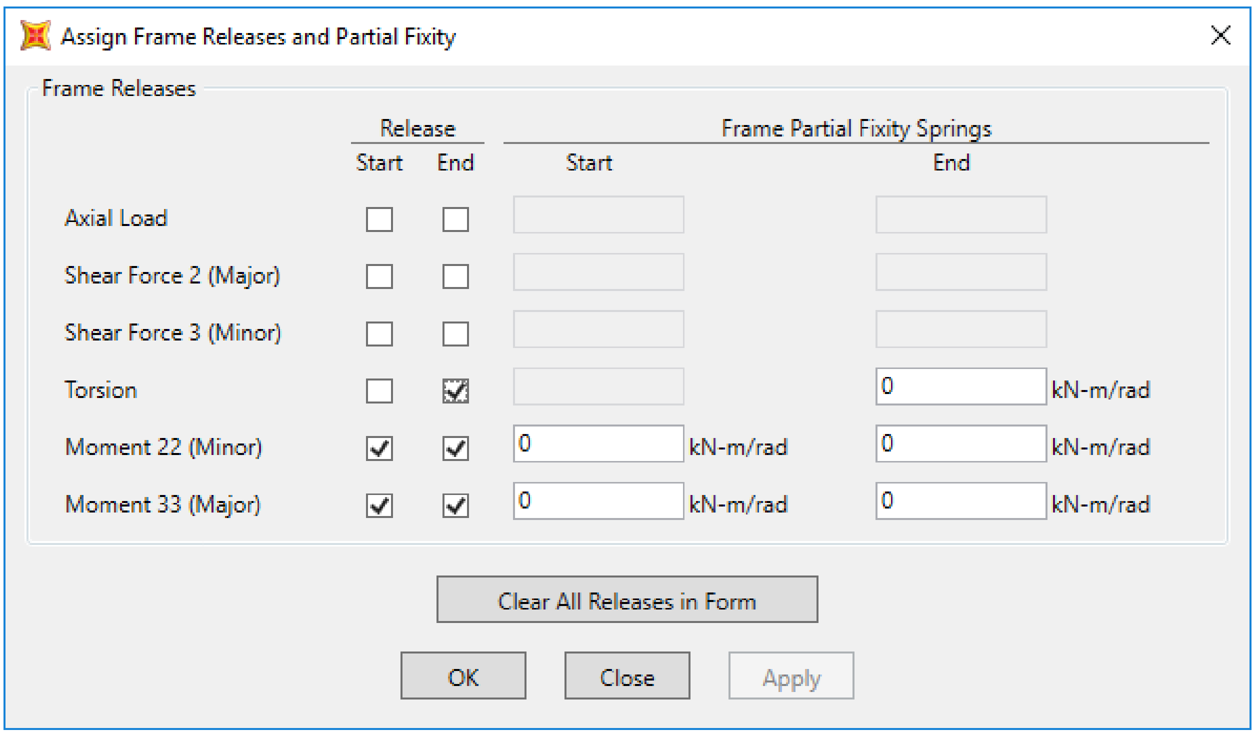
Shear deformation tends to be important when shell thickness is greater than approximately 1/5 to 1/10 of the span of plate-bending curvature. Shearing may also become significant in locations of bending-stress concentrations, which occur near sudden changes in thickness or support conditions, and near openings or re-entrant corners. Thick-plate formulation is best for such applications. As a result, in the model, the largest shell thickness is 0.0845, so thin shell model is chosen.

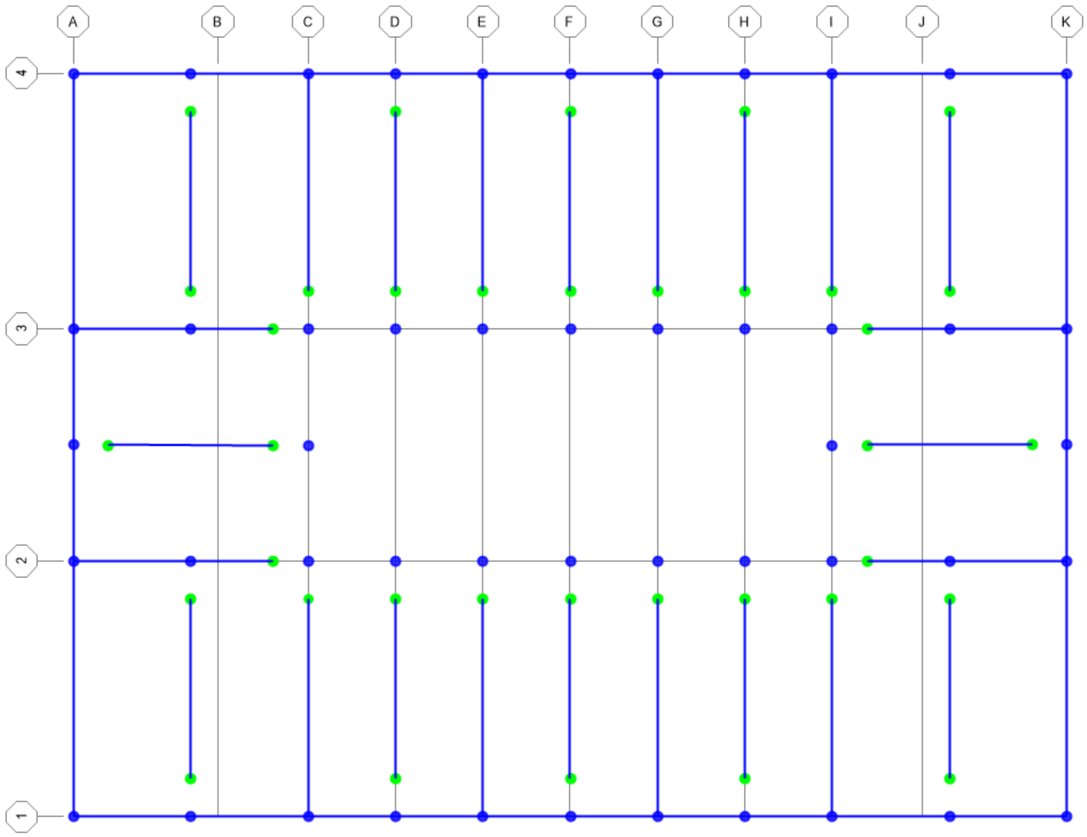
When it comes to the shear wall, since the original model has lots of thickness and different strength of concrete, I use the thickness and the material of the 17^{th} floor.



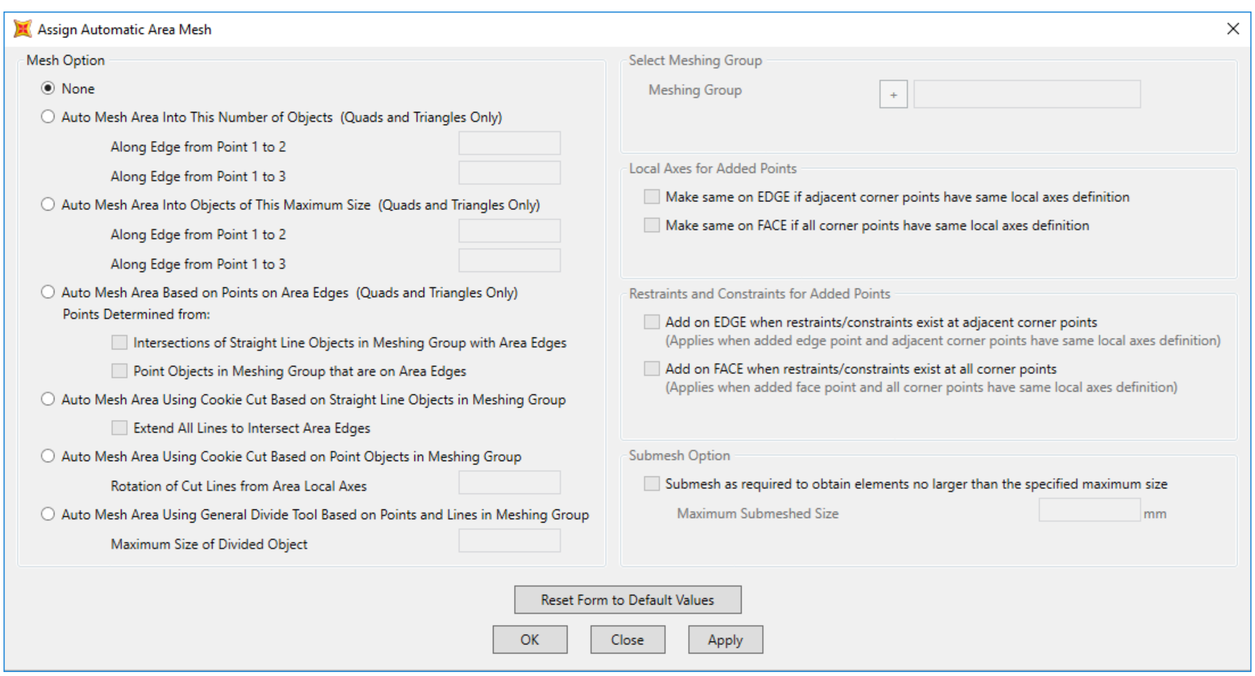
In the load calculation, we use the calculation result of PKPM, the constant load live load is distributed evenly to each floor, in which the constant load is the calculation result of removing the weight of the component in the structure. The load can be assigned to the slab in three ways. Since the steel desk slab is often considered as one-way slab. We use the uniform loads to frames, where the dead load is 11.5KN/m^2, the live load is 1.35KN/m^2 in the direction of gravity. A mesh is a network of line elements and interconnecting nodes used to model a structural system and numerically solve for its simulated behavior under applied loading. First, computational techniques create an analytical model by populating the material domain with a finite-element mesh in which each line element is assigned mathematical attributes (axial, bending, shear, and torsional stiffness, etc.) which simulate the material and geometric properties of the structural system. The system is then restrained within boundary conditions and subjected to mechanical or thermal loading. Numerical solution may then resolve structural stresses, strains, and displacement.

In this model, except the connection between the beam and the column, other connection should be hinged. Since the initial assumption for the connection is fixed, we have to release the moment and the torsion in these place.

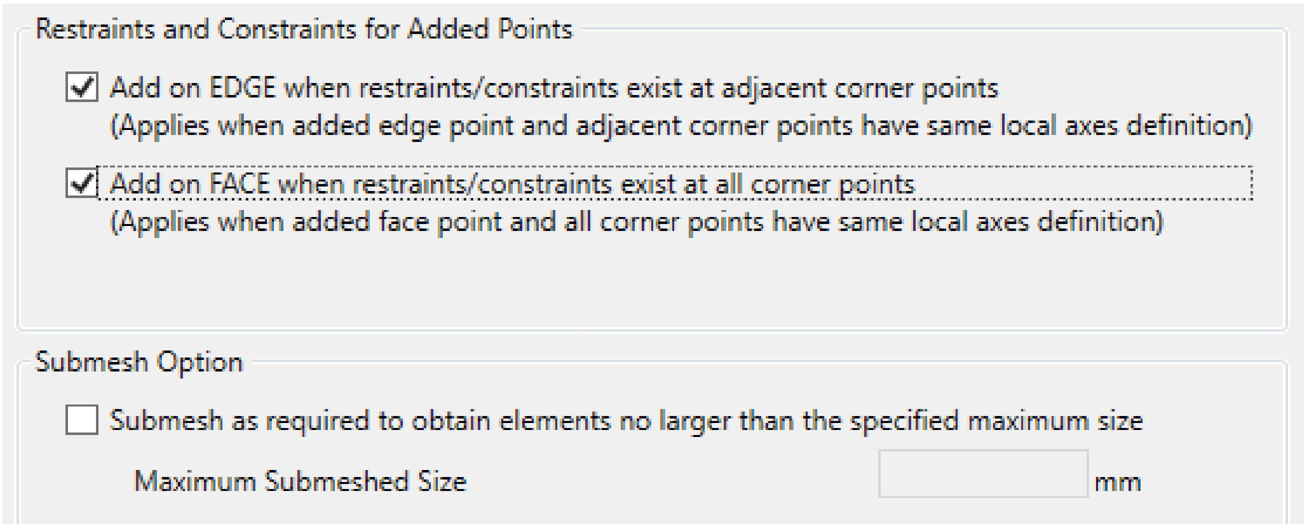




All the slab and shear wall are meshed to improve the result.



When it comes to the first floor, to make sure the shear wall confined to the ground well ,we use the restraints for the added points.



the inertial forces are concentrated at each joint of the structures and are computed as the product of the mass and accelerations, as follow:

$$\begin{Bmatrix} F_1 \\ F_2 \\ F_3 \\ M_1 \\ M_2 \\ M_3 \end{Bmatrix} = - \begin{bmatrix} \mathbf{u1} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ & \mathbf{u2} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ & & \mathbf{u3} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ & & & \mathbf{r1} & \mathbf{0} & \mathbf{0} \\ & \mathbf{sym.} & & & \mathbf{r2} & \mathbf{0} \\ & & & & & \mathbf{r3} \end{bmatrix} \begin{Bmatrix} \ddot{u}_1 \\ \ddot{u}_2 \\ \ddot{u}_3 \\ \ddot{r}_1 \\ \ddot{r}_2 \\ \ddot{r}_3 \end{Bmatrix}$$

Where the mass is computed from the density of the material and the volume of the element are automatically concentrated at each joint. Element mass and distributed loading are automatically transferred to joint locations during analysis.

And the acceleration loads (translational and rotational) that act at any point in a structure. The translational acceleration is given by the cross product of the position vector (relative to the origin of rotation) and the acceleration vector. The rotational acceleration is calculated independently from rotational inertia. This is done by applying, at the global origin, a unit rotation about the axis considered for the rotational-acceleration computation. In an earthquake, the seismic force is generated by the mass resource, which is usually 1.0D (dead load) + 0.5L (live load). In a high-rise composite structure, the shear force will be eventually transferred to columns and shear walls. The share carried by columns is relatively small because they are relatively flexible, while shear walls will carry most of the load. Therefore, the tensile force on the girder-wall connections can be significant.

Different seismic codes are applied to have a better understanding of the earthquake affect. In Chinese code, we use the highest seismic intensity to make the result more apparent. Although China and America are both country with large land and suffer a lot from the earthquake, they use different way to assess the quake. In Chinese code, we use the same seismic intensity in the same area.

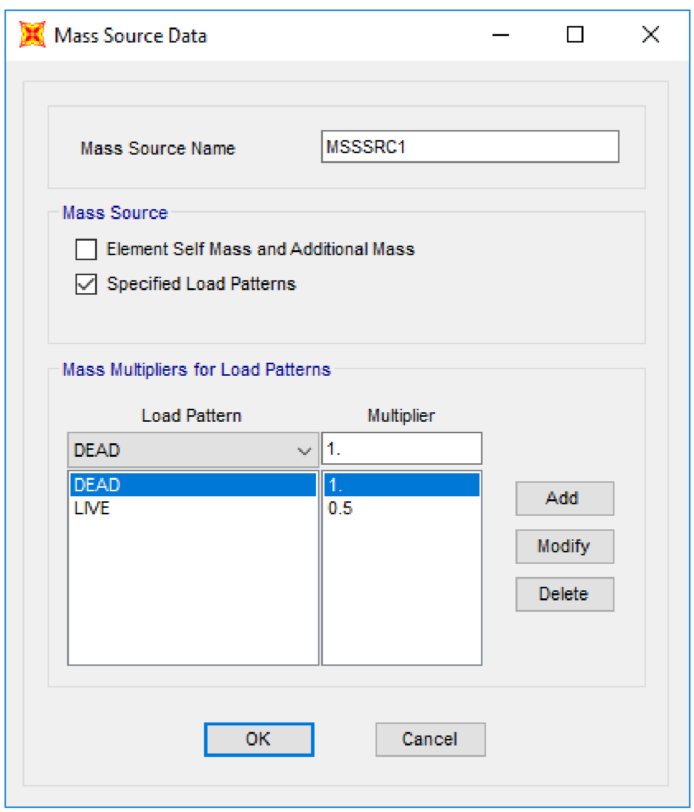


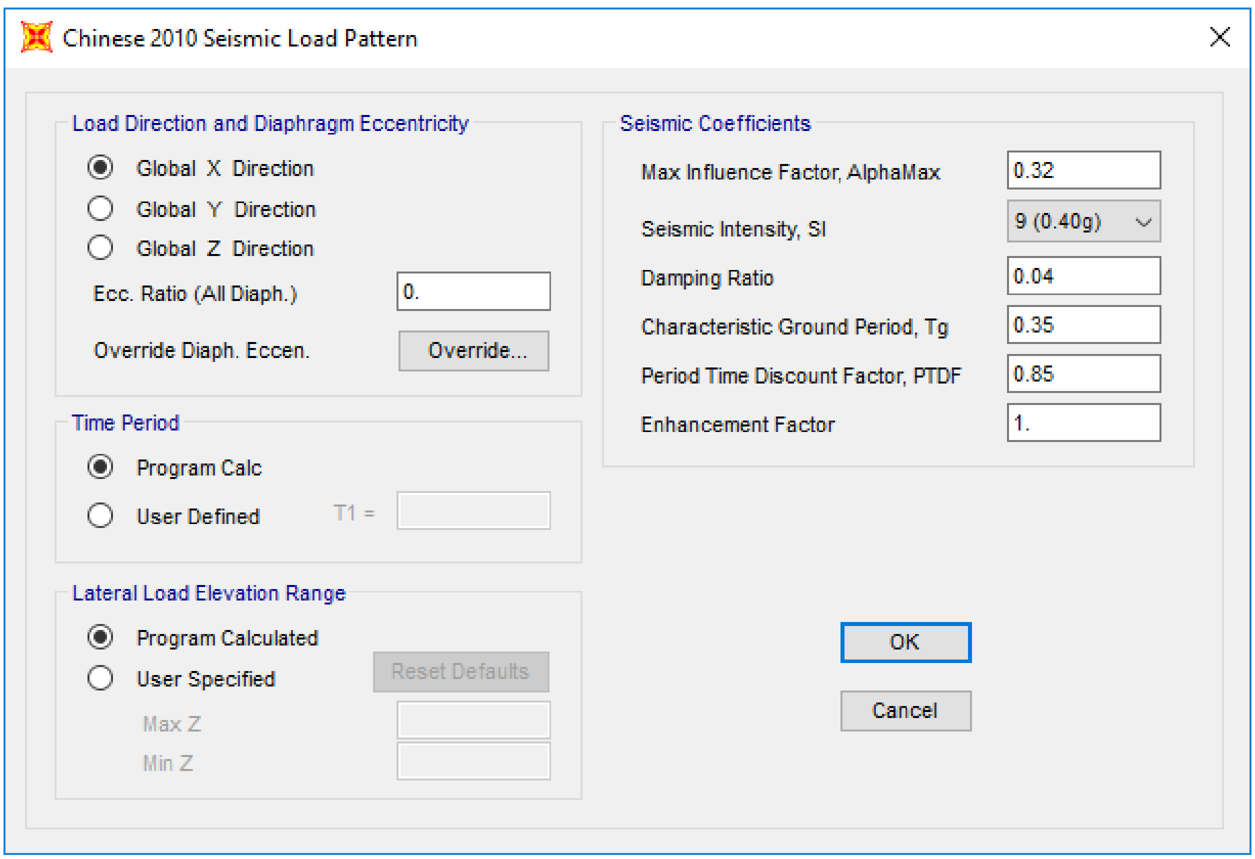
表 5.1.4-1　水平地震影响系数最大值

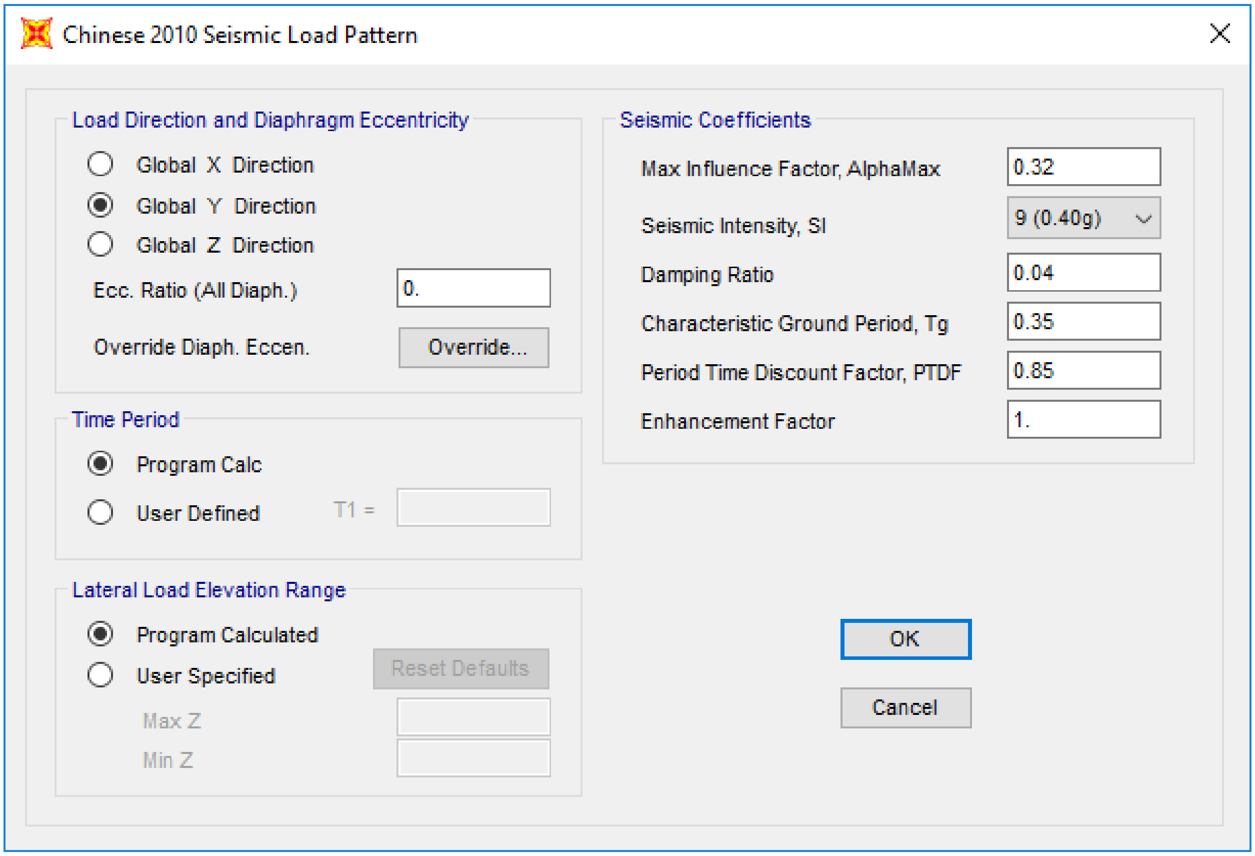
地震影响	6 度	7 度	8 度	9 度
多遇地震	0.04	0.08(0.12)	0.16(0.24)	0.32
罕遇地震	0.28	0.50(0.72)	0.90(1.20)	1.40

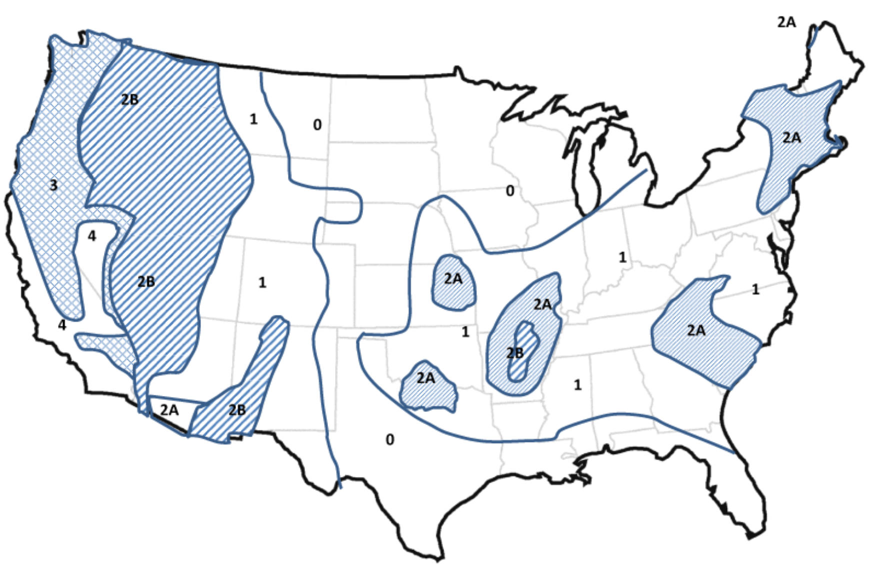
注：括号中数值分别用于设计基本地震加速度为 0.15g 和 0.30g 的地区。

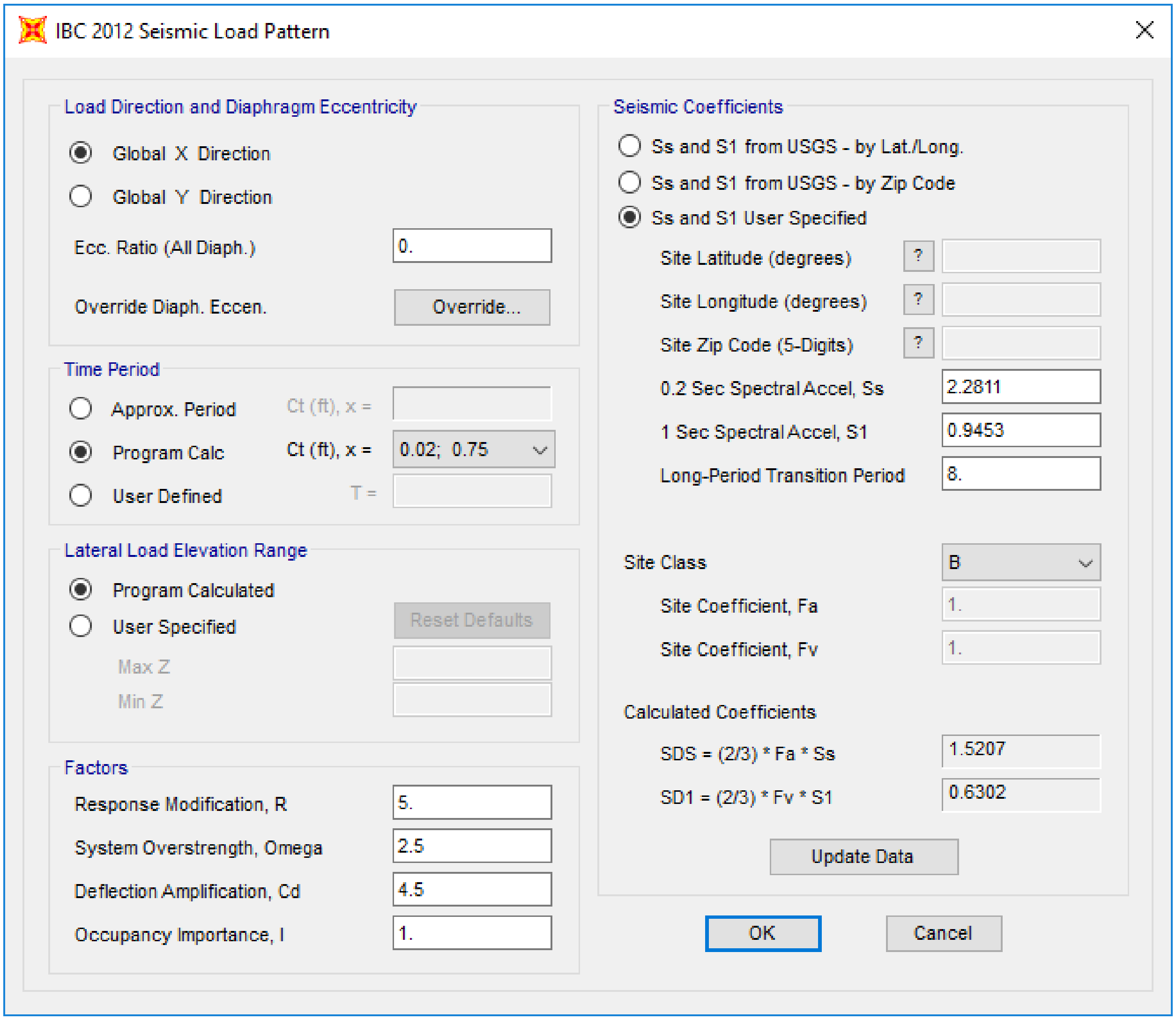
表 5.1.4-2　特征周期值(s)

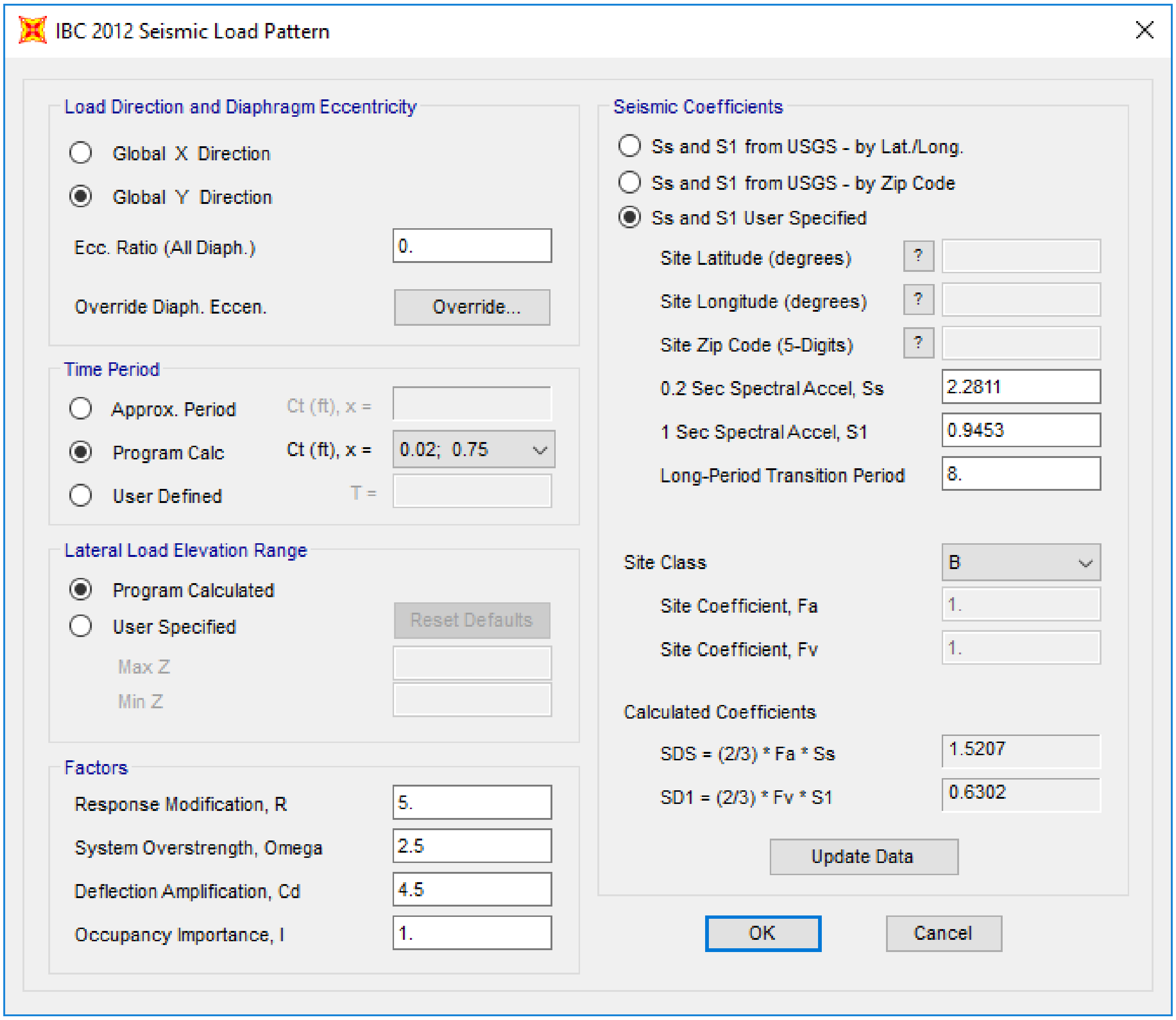
设计地震分组	场地类别				
	I_0	I_1	Ⅱ	Ⅲ	Ⅳ
第一组	0.20	0.25	0.35	0.45	0.65
第二组	0.25	0.30	0.40	0.55	0.75
第三组	0.30	0.35	0.45	0.65	0.90




Chinese 2010 Seismic Load Pattern
Load Direction and Diaphragm Eccentricity
Global X Direction
Global Y Direction
Global Z Direction
Ecc. Ratio (All Diaph.)
0.
Override Diaph. Eccen.
Override...
Time Period
Program Calc
User Defined
T1 =
Lateral Load Elevation Range
Program Calculated
User Specified
Reset Defaults
Max Z
Min Z
Seismic Coefficients
Max Influence Factor, AlphaMax
0.32
Seismic Intensity, SI
9 (0.40g)
Damping Ratio
0.04
Characteristic Ground Period, Tg
0.35
Period Time Discount Factor, PTDF
0.85
Enhancement Factor
1.
OK
Cancel


2A
2B
1
0
3
4
2A
2A
2A
2B
2A
1
0
1
1
1
0

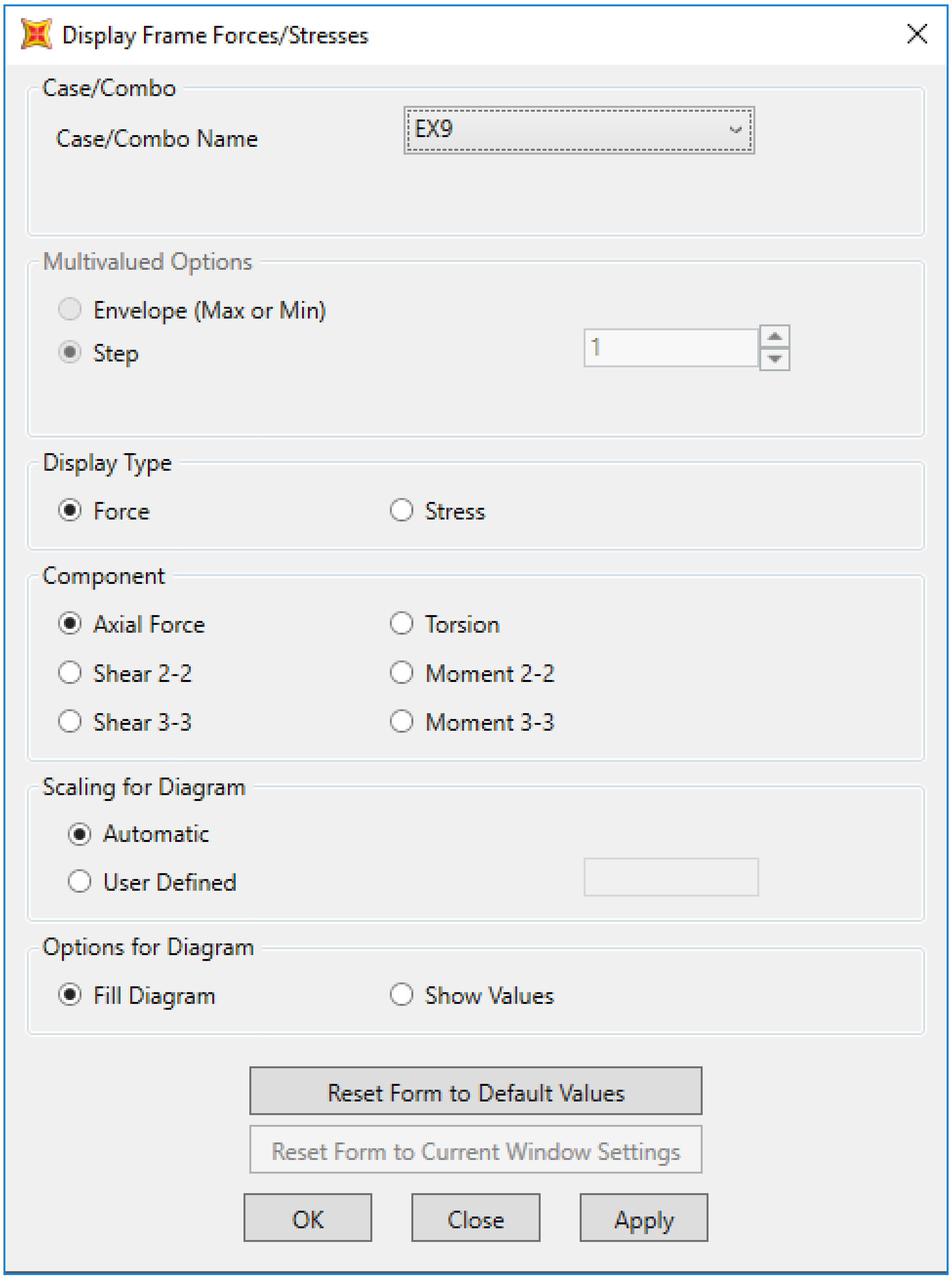

IBC 2012 Seismic Load Pattern
Load Direction and Diaphragm Eccentricity
Global X Direction
Global Y Direction
Ecc. Ratio (All Diaph.)
0.
Override Diaph. Eccen.
Override...
Time Period
Approx. Period
Ct (ft), x =
Program Calc
Ct (ft), x =
0.02; 0.75
User Defined
T =
Lateral Load Elevation Range
Program Calculated
User Specified
Reset Defaults
Max Z
Min Z
Factors
Response Modification, R
5.
System Overstrength, Omega
2.5
Deflection Amplification, Cd
4.5
Occupancy Importance, I
1.
Seismic Coefficients
Ss and S1 from USGS - by Lat./Long.
Ss and S1 from USGS - by Zip Code
Ss and S1 User Specified
Site Latitude (degrees)
Site Longitude (degrees)
Site Zip Code (5-Digits)
0.2 Sec Spectral Accel, Ss
2.2811
1 Sec Spectral Accel, S1
0.9453
Long-Period Transition Period
8.
Site Class
B
Site Coefficient, Fa
1.
Site Coefficient, Fv
1.
Calculated Coefficients
SDS = (2/3) * Fa * Ss
1.5207
SD1 = (2/3) * Fv * S1
0.6302
Update Data
OK
Cancel

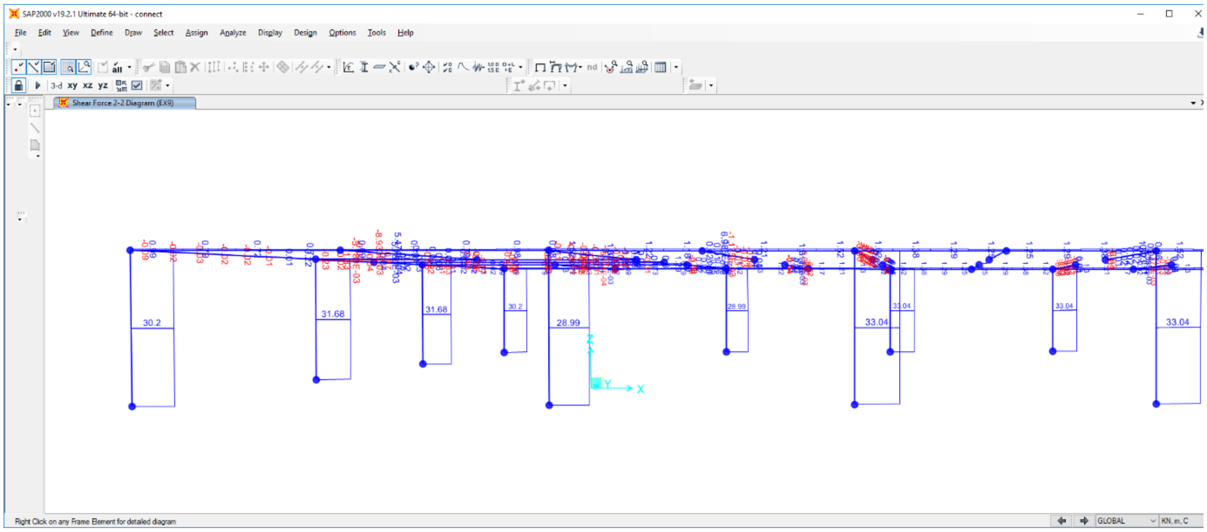


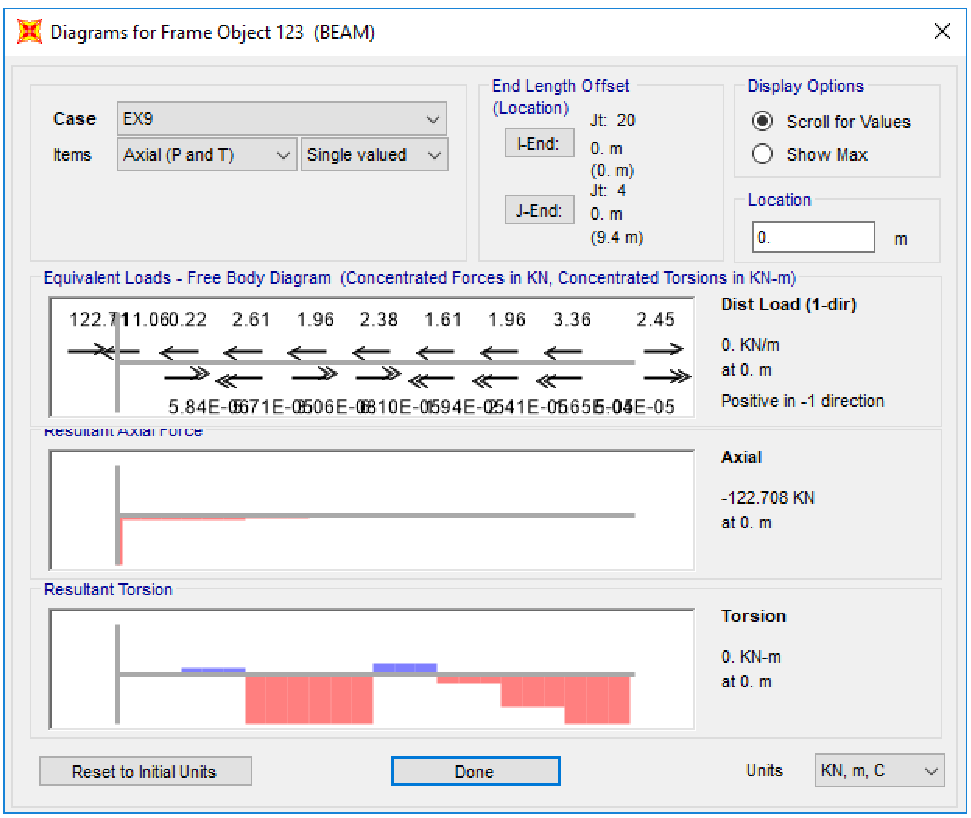
IBC 2012 Seismic Load Pattern
Load Direction and Diaphragm Eccentricity
Global X Direction
Global Y Direction
Ecc. Ratio (All Diaph.)
0.
Override Diaph. Eccen.
Override...
Time Period
Approx. Period
Ct (ft), x =
Program Calc
Ct (ft), x =
0.02; 0.75
User Defined
T =
Lateral Load Elevation Range
Program Calculated
User Specified
Reset Defaults
Max Z
Min Z
Factors
Response Modification, R
5.
System Overstrength, Omega
2.5
Deflection Amplification, Cd
4.5
Occupancy Importance, I
1.
Seismic Coefficients
Ss and S1 from USGS - by Lat./Long.
Ss and S1 from USGS - by Zip Code
Ss and S1 User Specified
Site Latitude (degrees)
Site Longitude (degrees)
Site Zip Code (5-Digits)
0.2 Sec Spectral Accel, Ss
2.2811
1 Sec Spectral Accel, S1
0.9453
Long-Period Transition Period
8.
Site Class
B
Site Coefficient, Fa
1.
Site Coefficient, Fv
1.
Calculated Coefficients
SDS = (2/3) * Fa * Ss
1.5207
SD1 = (2/3) * Fv * S1
0.6302
Update Data
OK
Cancel

Appendix B Procedures for Obtaining Analysis Results.

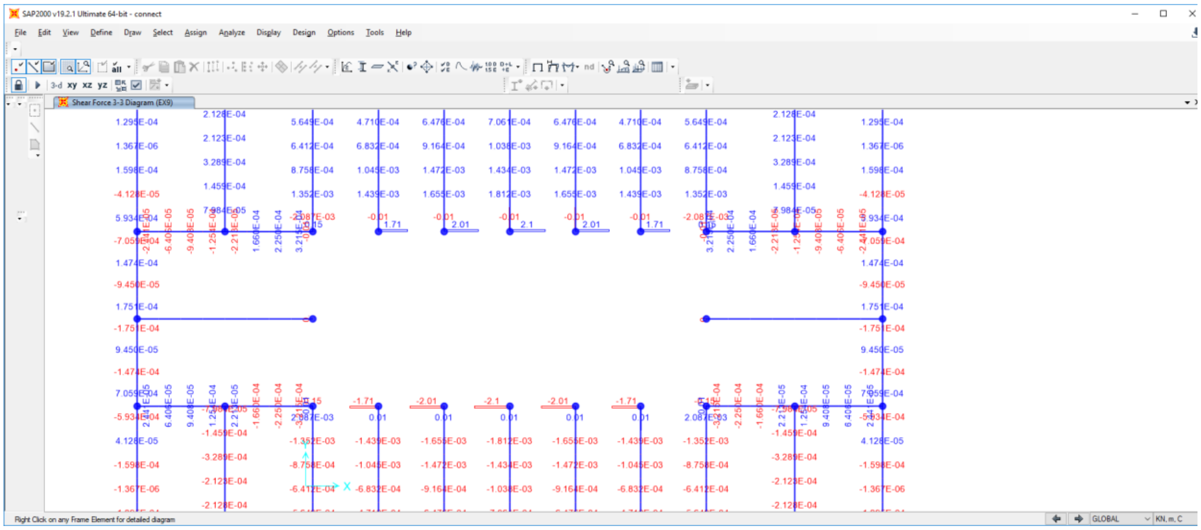
You can pick the analysis results using the output of the SAP2000.



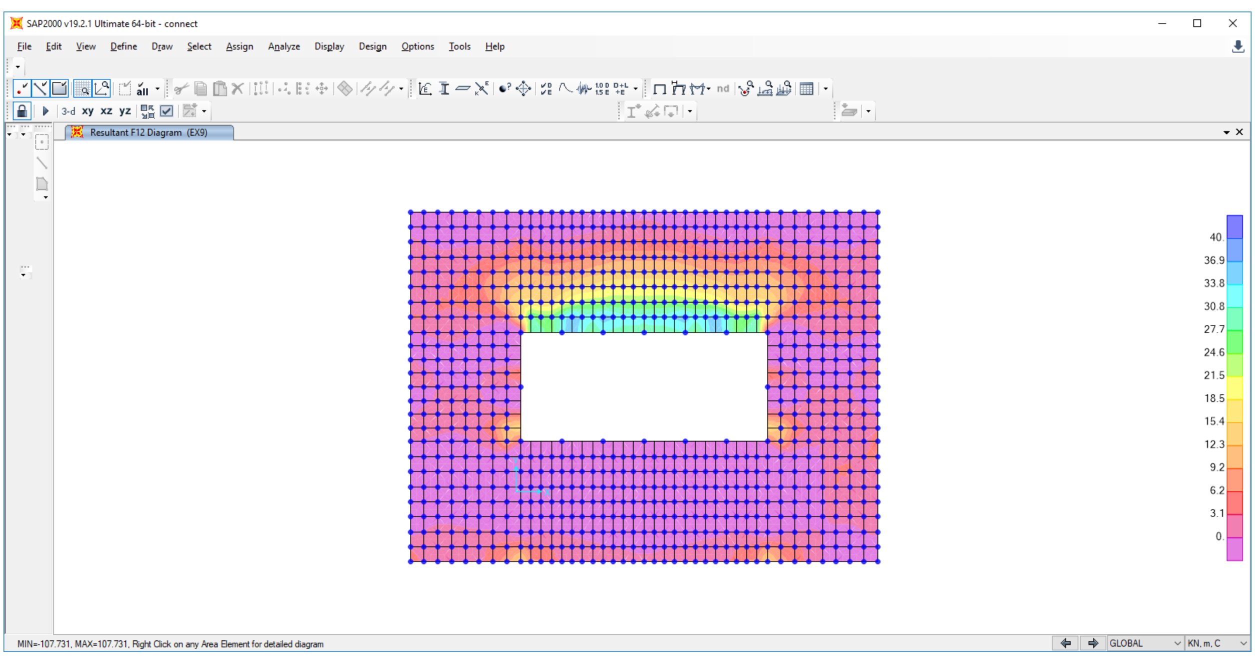




Diagrams for Frame Object 123 (BEAM)
Case
EX9
Items
Axial (P and T)
Single valued
End Length Offset
(Location)
Jt: 20
I-End:
0. m
(0. m)
Jt: 4
J-End:
0. m
(9.4 m)
Display Options
Scroll for Values
Show Max
Location
0.
m
Equivalent Loads - Free Body Diagram (Concentrated Forces in KN, Concentrated Torsions in KN-m)
Dist Load (1-dir)
0. KN/m
at 0. m
Positive in -1 direction
Resultant Axial Force
Axial
-122.708 KN
at 0. m
Resultant Torsion
Torsion
0. KN-m
at 0. m
Reset to Initial Units
Done
Units
KN, m, C

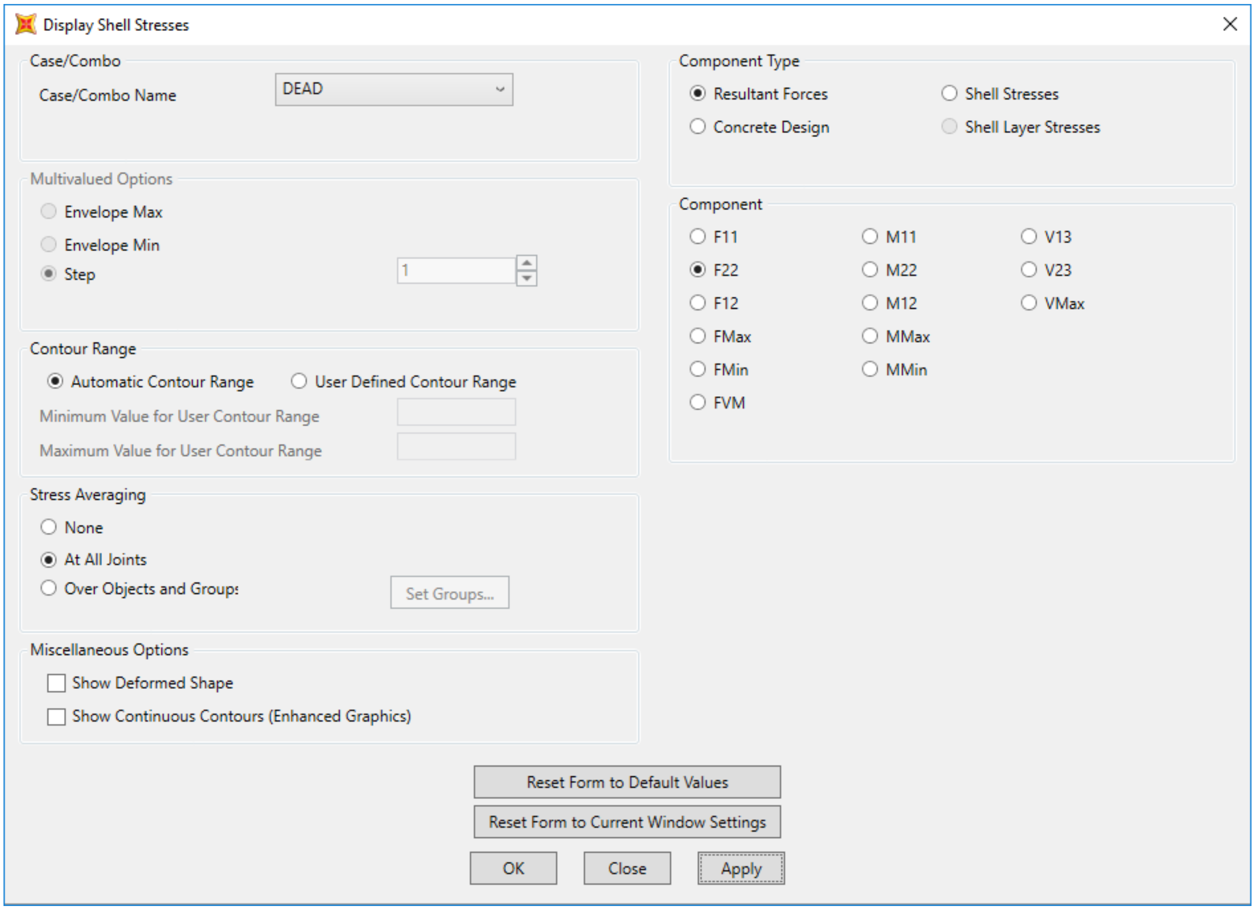


What we care about is the axial load in the beam horizon to the earthquake direction and the shear force vertical to the direction. Which means shear 3-3 is the point we want to focus on. When it comes to the slab load, we can hardly have a direct answer, so we read the result from the pattern below, we read each side interior force of a meshed slab and add them together, then we have an average force and make it multiply the length of the slab. For the edge horizontal to the earthquake load , we use the F22,to the other side, we use F12.

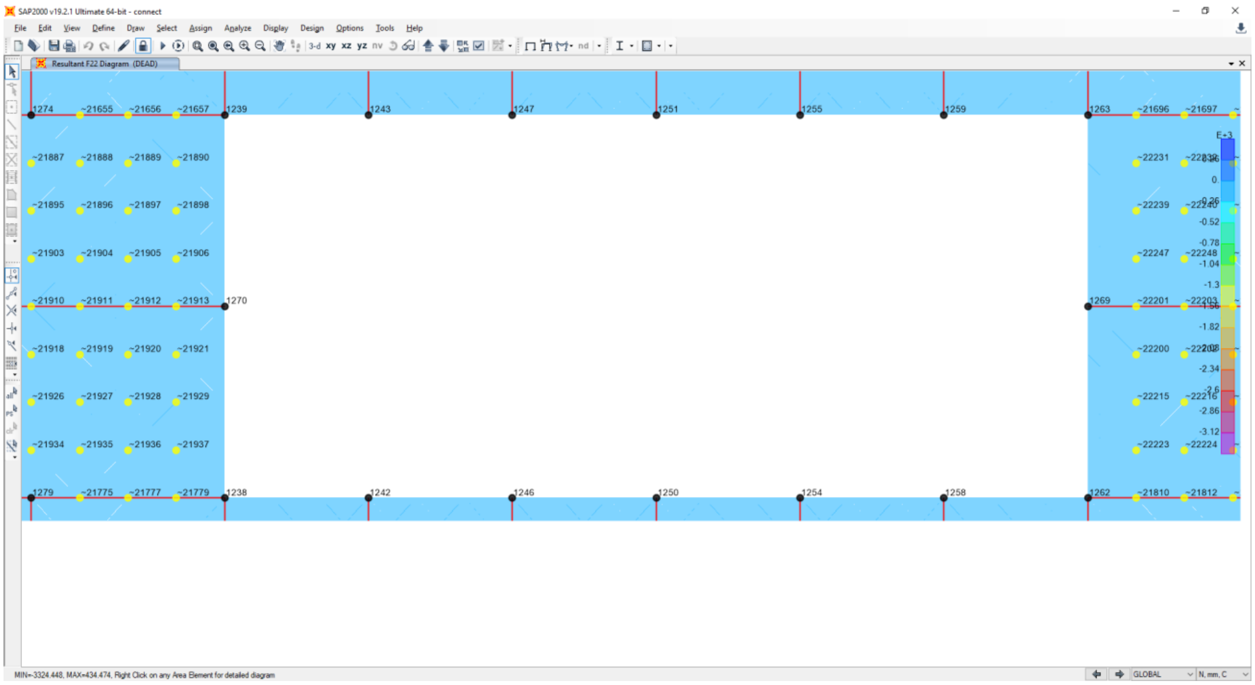


It can be found that in the case of bottom consolidation, the shear forces of beams account for a relatively large proportion of the total shear forces of the structure, at about 50%, which is mainly subject to lateral loads in practice, the steel frame mainly transmits vertical loads, and the results of hinge analysis are close to the actual comparison. At the same time, the 3-axis beam in the structure is very small, it can be found that in the case of bottom consolidation, the shear forces of beams account for a relatively large proportion of the total shear forces of the structure, at about 50%, which is mainly subject to lateral loads in practice, the steel frame mainly transmits vertical loads, and the results of hinge analysis are close to the actual comparison. At the same time, the 3-axis beam in the structure is very small.

We compared the sum of the load which includes the lateral force resisted by the column and the force lead to the shear wall with the slab shear force when earthquake happened. According the mass resource theory, it includes half of the weight of the column and shear wall in the upper and down floor. We make a calculation of the percentage of weight of the slab so that we make sure we have a true earthquake force that generated in the slab.



When it comes to the case that the slab and the shear wall are connected, we can find that this is a huge loss of the force. So we think the corner point of the shear wall also transfer a part of the load. It is marked as 1238,1239,1262,1263 in the floor below.



To find the certain data, we use the element joint force in the corner slab.

When this part is considered in the slab force, we have a better sum of the force transfer to the slab.

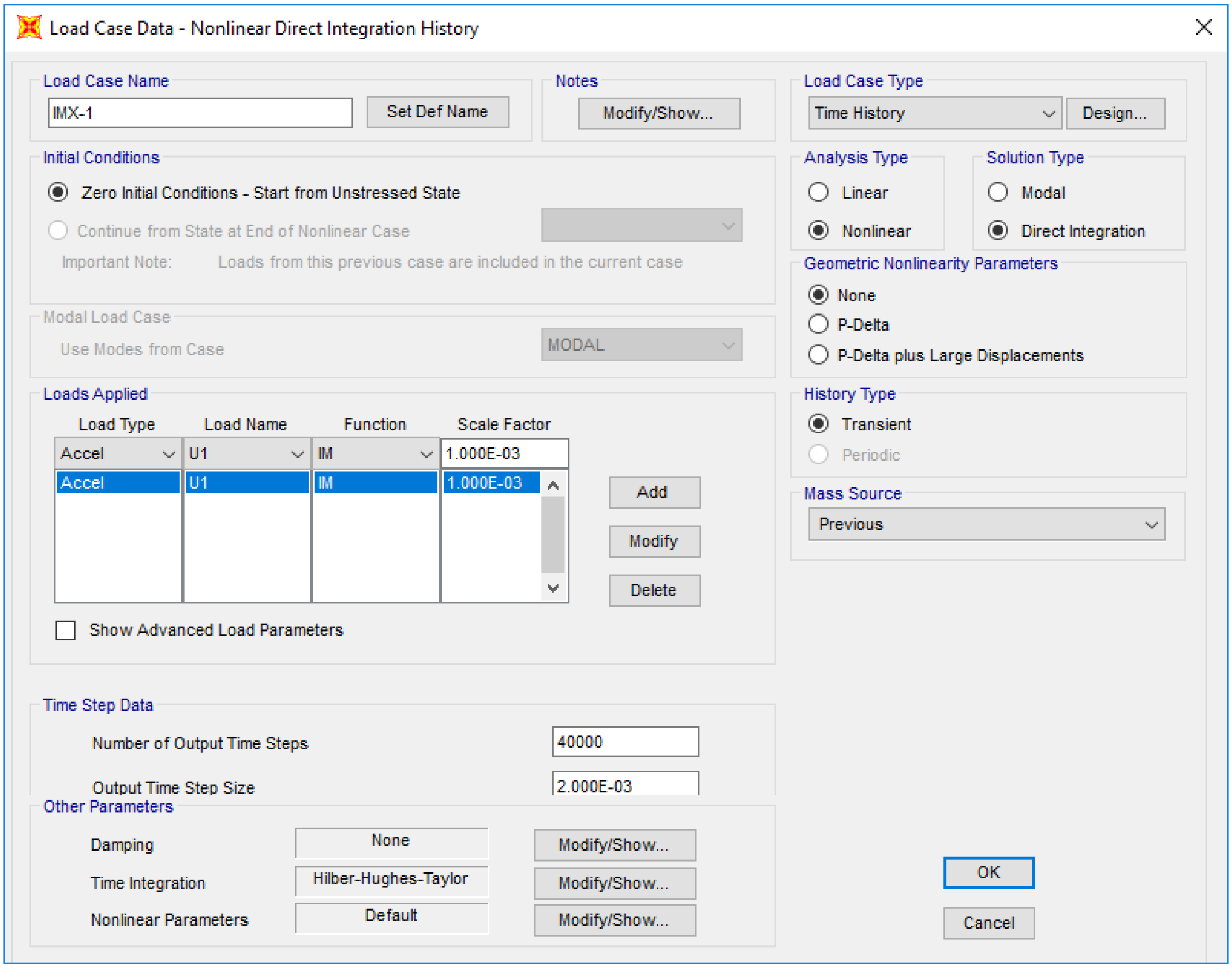
Element Joint Forces - Areas

Units: As Noted

Filter:

Area Text	AreaElem Text	Joint Text	OutputCase	CaseType Text	StepType Text	StepNum Unitless	F1 N	F2 N	F3 N	M1 N-mm
1	1-1	38	DEAD	LinStatic			-1104.17	-87792.67	-1471246.55	-25708692.6
1	1-1	~177	DEAD	LinStatic			-303.29	96302.56	-1513438.29	-8533594.84
1	1-1	~178	DEAD	LinStatic			-19.07	73993.98	1477143.18	6463133.2
1	1-1	~17	DEAD	LinStatic			1426.52	-82503.87	1517858.85	-10340736.8
1	1-1	38	MODAL	LinModal	Mode	1	0.07153	-10.07	72.79	403.79
1	1-1	~177	MODAL	LinModal	Mode	1	-0.0002043	-10.27	87.1	102.42
1	1-1	~178	MODAL	LinModal	Mode	1	-0.009689	10.53	-65.94	-139.13
1	1-1	~17	MODAL	LinModal	Mode	1	-0.06164	9.81	-93.94	163.54
1	1-1	38	MODAL	LinModal	Mode	2	1.42	5.65	58.7	98.66
1	1-1	~177	MODAL	LinModal	Mode	2	0.25	-3.19	56.23	51.61
1	1-1	~178	MODAL	LinModal	Mode	2	-0.17	-3.95	-58.48	53.39
1	1-1	~17	MODAL	LinModal	Mode	2	-1.49	1.49	-56.46	99.58
1	1-1	38	MODAL	LinModal	Mode	3	5.13	32.38	-0.98	-836.43
1	1-1	~177	MODAL	LinModal	Mode	3	-0.14	27.4	-60.94	87.83
1	1-1	~178	MODAL	LinModal	Mode	3	-0.0227	-32.43	-1.22	80.41

Record: 1 of 2186496


Load Case Data - Nonlinear Direct Integration History
Load Case Name
IMX-1
Set Def Name
Notes
Modify/Show...
Load Case Type
Time History
Design...
Initial Conditions
Zero Initial Conditions - Start from Unstressed State
Continue from State at End of Nonlinear Case
Important Note: Loads from this previous case are included in the current case
Analysis Type
Linear
Nonlinear
Solution Type
Modal
Direct Integration
Geometric Nonlinearity Parameters
None
P-Delta
P-Delta plus Large Displacements
Modal Load Case
Use Modes from Case
MODAL
Loads Applied
Load Type
Load Name
Function
Scale Factor
Accel
U1
IM
1.000E-03
Add
Modify
Delete
Show Advanced Load Parameters
History Type
Transient
Periodic
Mass Source
Previous
Time Step Data
Number of Output Time Steps
40000
Output Time Step Size
2.000E-03
Other Parameters
Damping
None
Time Integration
Hilber-Hughes-Taylor
Nonlinear Parameters
Default
Modify/Show...
OK
Cancel

Appendix C Results of one-story model structure

I first carried out a single-layer structural analysis. By observing the bending moment diagram, axial diagram, shear diagram of the structure to determine whether the structure is in line with our previous connection assumptions, we observed the beam in a single-layer situation in the United States and Chinese specifications EX, EY different operating conditions, which is mainly connected to the shear wall of the various beams, as well as the shear force of the column.

Table C.1 Transfer of seismic inertia forces according to GB50011-2010

Cases (Ex9)	Shear force in Columns (kN)									Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	A2/A3	K2/K3	A1/A5	K1/K5	C1/C5	I1/I5	E1/E5	H1/H5	Total	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated	5.4	5.4	9.0	9.0	19.7	19.7	21.1	21.1	220.3	810.5	810.5	6.2	6.2	3254.6	4.2	6.0	6.6	6.7	6.6	6.0	4.2	80.7	0.0	0.0	0.0	0.0	3555.6
Td=0.3169	0.2%	0.2%	0.3%	0.3%	0.6%	0.6%	0.6%	0.6%	6.2%	22.8%	22.8%	0.2%	0.2%	91.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	5.7	5.0	8.2	8.2	17.8	18.0	19.1	19.2	202.3	442.9	751.8	4.8	-6.2	2387.9	3.4	5.2	6.0	6.1	6.1	5.5	3.9	72.3	930.0	0.0	0.0	0.0	3592.5
Td=0.3168	0.2%	0.1%	0.2%	0.2%	0.5%	0.5%	0.5%	0.5%	5.6%	12.3%	20.9%	0.1%	-0.2%	66.5%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.0%	25.9%	0.0%	0.0%	0.0%	100.0%
Slab connected	1.8	1.8	2.0	2.0	4.2	4.2	4.6	4.6	50.4	70.6	70.6	3.3	3.3	288.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	163.0	163.0	1155.0	1155.0	2975.2
Td=0.3185	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	1.7%	2.4%	2.4%	0.1%	0.1%	9.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%	38.8%	38.8%	100.0%
Slab Isolated	106.5	106.5	118.5	118.5	134.7	134.7	132.8	132.8	1970.3	383.9	383.9	6.6	6.6	1548.8	1.9	2.7	3.0	3.0	3.0	2.7	1.9	36.5	0.0	0.0	0.0	0.0	3555.6
Td=0.3167	3.0%	3.0%	3.3%	3.3%	3.8%	3.8%	3.7%	3.7%	55.4%	10.8%	10.8%	0.2%	0.2%	43.6%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	94.3	103.8	113.7	114.6	128.5	129.8	126.7	127.3	1877.4	223.8	373.6	6.2	-2.3	1198.6	1.6	2.5	2.9	2.9	2.9	2.6	1.9	34.3	465.0	0.0	0.0	0.0	3575.3
Td=0.3167	2.6%	2.9%	3.2%	3.2%	3.6%	3.6%	3.5%	3.6%	52.5%	6.3%	10.4%	0.2%	-0.1%	33.5%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.0%	13.0%	0.0%	0.0%	0.0%	100.0%
Slab connected	46.1	46.1	45.1	45.1	50.0	50.0	51.0	51.0	768.5	57.1	57.1	0.9	0.9	230.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	110.0	110.0	945.0	945.0	3108.8
Td=0.3184	1.5%	1.5%	1.5%	1.5%	1.6%	1.6%	1.6%	1.6%	24.7%	1.8%	1.8%	0.0%	0.0%	7.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.5%	3.5%	30.4%	30.4%	100.0%

Cases (Ey9)	Shear force in Columns (kN)									Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	A2/A3	K2/K3	A1/A5	K1/K5	C1/C5	I1/I5	E1/E5	H1/H5	Total	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated	2.5	2.5	3.5	3.5	5.8	5.8	11.5	11.5	93.2	3.8	3.8	5.0	5.0	25.4	491.7	10.7	351.0	11.8	351.0	10.7	491.7	3437.2	0.0	0.0	0.0	0.0	3555.7
Td=0.2698	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.3%	2.6%	0.1%	0.1%	0.1%	0.1%	0.7%	13.8%	0.3%	9.9%	0.3%	9.9%	0.3%	13.8%	96.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	4.2	12.9	2.1	6.6	1.7	3.7	1.9	2.4	70.9	4.0	0.2	5.4	0.2	13.9	168.0	3.3	261.0	9.2	344.2	11.3	527.8	2649.6	0.0	0.0	837.0	0.0	3571.4
Td=0.2697	0.1%	0.4%	0.1%	0.2%	0.0%	0.1%	0.1%	0.1%	2.0%	0.1%	0.0%	0.2%	0.0%	0.4%	4.7%	0.1%	7.3%	0.3%	9.6%	0.3%	14.8%	74.2%	0.0%	0.0%	23.4%	0.0%	100.0%
Slab connected	4.8	4.8	2.4	2.4	1.9	1.9	1.9	1.9	43.7	0.0	0.0	0.0	0.0	0.0	70.91	2.04	79.93	1.77	79.93	2.04	70.91	615.1	698.0	698.0	341.0	341.0	2736.7
Td=0.2698	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	0.1%	2.9%	0.1%	2.9%	0.1%	2.6%	22.5%	25.5%	25.5%	12.5%	12.5%	100.0%
Slab Isolated	108.75	108.75	99.86	99.86	85.4	85.4	68.89	68.89	1451.6	2.2	2.2	0.0	0.0	8.6	283.9	7.6	227.1	7.8	227.1	7.6	283.9	2089.7	0.0	0.0	0.0	0.0	3549.9
Td=0.2697	3.1%	3.1%	2.8%	2.8%	2.4%	2.4%	1.9%	1.9%	40.9%	0.1%	0.1%	0.0%	0.0%	0.2%	8.0%	0.2%	6.4%	0.2%	6.4%	0.2%	8.0%	58.9%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	65.8	108.7	56.6	100.8	56.5	87.9	59.0	68.3	1207.3	2.2	-0.1	2.9	0.2	7.4	132.4	3.7	192.8	6.7	224.3	7.8	290.4	1716.2	0.0	0.0	651.0	0.0	3581.9
Td=0.2117	1.8%	3.0%	1.6%	2.8%	1.6%	2.5%	1.6%	1.9%	33.7%	0.1%	0.0%	0.1%	0.0%	0.2%	3.7%	0.1%	5.4%	0.2%	6.3%	0.2%	8.1%	47.9%	0.0%	0.0%	18.2%	0.0%	100.0%
Slab connected	60.5	60.5	54.3	54.3	49.7	49.7	45.4	45.4	839.2	0.0	0.0	0.0	0.0	0.0	55.75	1.79	66.06	1.6	66.1	1.8	55.8	497.5	511.0	511.0	289.0	289.0	2936.7
Td=0.2287	2.1%	2.1%	1.8%	1.8%	1.7%	1.7%	1.5%	1.5%	28.6%	0.0%	0.0%	0.0%	0.0%	0.0%	1.9%	0.1%	2.2%	0.1%	2.2%	0.1%	1.9%	16.9%	17.4%	17.4%	9.8%	9.8%	100.0%

Table C.2 Transfer of seismic inertia forces according to IBC2012/ASCE7-10

Cases (Ex9)	Shear force in Columns (kN)									Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	A2/A3	K2/K3	A1/A5	K1/K5	C1/C5	I1/I5	E1/E5	H1/H5	Total	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(p)	5.6	5.6	9.4	9.4	20.5	20.5	22.0	22.0	230.0	847.5	847.5	6.5	6.5	3403.0	4.4	6.3	6.9	7.0	6.9	6.3	4.4	84.4	0.0	0.0	0.0	0.0	3717.4
Td=0.3169	0.2%	0.2%	0.3%	0.3%	0.6%	0.6%	0.6%	0.6%	6.2%	22.8%	22.8%	0.2%	0.2%	91.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	6.0	5.2	8.5	8.6	18.6	18.8	20.0	20.1	211.6	463.1	786.0	6.5	6.1	2510.8	3.6	5.5	6.3	6.3	6.3	5.8	4.0	75.6	1162.5	0.0	0.0	0.0	3960.5
Td=0.3168	0.2%	0.1%	0.2%	0.2%	0.5%	0.5%	0.5%	0.5%	5.3%	11.7%	19.8%	0.2%	0.2%	63.4%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	1.9%	29.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	1.8	1.8	2.1	2.1	4.4	4.4	4.9	4.9	52.8	73.8	73.8	0.8	0.8	296.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	162.8	162.8	1155.0	1155.0	2985.2
Td=0.3185	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	1.8%	2.5%	2.5%	0.0%	0.0%	9.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%	38.7%	38.7%	100.0%
Slab Isolated(f)	111.4	111.4	124.0	124.0	140.8	140.8	138.9	138.9	2060.4	401.4	401.4	6.9	6.9	1619.4	2.0	2.8	3.2	3.1	3.2	2.8	2.0	38.2	0.0	0.0	0.0	0.0	3718.0
Td=0.3167	3.0%	3.0%	3.3%	3.3%	3.8%	3.8%	3.7%	3.7%	55.4%	10.8%	10.8%	0.2%	0.2%	43.6%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	98.6	108.5	118.9	119.8	134.4	135.8	132.4	133.2	1963.2	234.0	390.6	-2.4	6.5	1253.3	1.7	2.6	3.0	3.0	3.0	2.7	1.9	35.8	581.3	0.0	0.0	0.0	3833.6
Td=0.3167	2.6%	2.8%	3.1%	3.1%	3.5%	3.5%	3.5%	3.5%	51.2%	6.1%	10.2%	-0.1%	0.2%	32.7%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.9%	15.2%	0.0%	0.0%	0.0%	100.0%
Slab connected	48.2	48.2	47.1	47.1	52.2	52.2	53.3	53.3	803.2	59.7	59.7	1.0	1.0	240.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	139.5	139.5	945.0	945.0	3213.0
Td=0.3184	1.5%	1.5%	1.5%	1.5%	1.6%	1.6%	1.7%	1.7%	25.0%	1.9%	1.9%	0.0%	0.0%	7.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.3%	4.3%	29.4%	29.4%	100.0%

Cases (Ey9)	Shear force in Columns (kN)									Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	A2/A3	K2/K3	A1/A5	K1/K5	C1/C5	I1/I5	E1/E5	H1/H5	Total	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	12.0	12.0	6.1	6.1	3.6	3.6	2.6	2.6	97.2	4.0	4.0	5.3	5.3	26.6	514.1	11.2	366.9	12.4	366.9	11.2	514.1	3593.6	0.0	0.0	0.0	0.0	3717.4
Td=0.2698	0.3%	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	2.6%	0.1%	0.1%	0.1%	0.1%	0.7%	13.8%	0.3%	9.9%	0.3%	9.9%	0.3%	13.8%	96.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	10.8	10.8	5.5	5.5	3.3	3.6	2.5	2.8	89.6	3.2	3.6	4.6	4.6	22.8	270.9	0.4	119.8	6.2	348.2	9.9	471.0	2452.7	0.0	0.0	918.8	0.0	3483.9
Td=0.2697	0.3%	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	2.6%	0.1%	0.1%	0.1%	0.1%	0.7%	7.8%	0.0%	3.4%	0.2%	10.0%	0.3%	13.5%	70.4%	0.0%	0.0%	26.4%	0.0%	100.0%
Slab connected	5.0	5.0	2.5	2.5	2.0	2.0	2.0	2.0	46.0	0.0	0.0	0.0	0.0	0.0	74.15	21.14	83.57	1.85	83.57	21.14	74.15	719.1	697.5	697.5	341.3	341.3	2842.7
Td=0.2698	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	0.7%	2.9%	0.1%	2.9%	0.7%	2.6%	25.3%	24.5%	24.5%	12.0%	12.0%	100.0%
Slab Isolated(fixed)	113.7	113.7	104.41	104.41	89.29	89.29	72.03	72.03	1517.7	2.3	2.3	2.9	2.9	15.0	296.8	8.0	237.4	8.1	237.4	8.0	296.8	2185.0	0.0	0.0	0.0	0.0	3717.7
Td=0.2697	3.1%	3.1%	2.8%	2.8%	2.4%	2.4%	1.9%	1.9%	40.8%	0.1%	0.1%	0.1%	0.1%	0.4%	8.0%	0.2%	6.4%	0.2%	6.4%	0.2%	8.0%	58.8%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	106.7	107.0	98.4	98.5	85.9	76.3	70.9	57.1	1401.6	2.1	1.9	2.7	2.7	13.4	165.8	0.2	84.9	4.4	231.5	7.5	283.3	1555.2	0.0	0.0	611.6	0.0	3581.8
Td=0.2117	3.0%	3.0%	2.7%	2.8%	2.4%	2.1%	2.0%	1.6%	39.1%	0.1%	0.1%	0.1%	0.1%	0.4%	4.6%	0.0%	2.4%	0.1%	6.5%	0.2%	7.9%	43.4%	0.0%	0.0%	17.1%	0.0%	100.0%
Slab connected	63.2	63.2	56.7	56.7	52.0	52.0	47.4	47.4	877.2	0.0	0.0	0.0	0.0	0.0	58.29	1.87	69.07	1.6	69.1	1.9	58.3	520.1	349.1	349.1	558.0	558.0	3211.6
Td=0.2287	2.0%	2.0%	1.8%	1.8%	1.6%	1.6%	1.5%	1.5%	27.3%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	0.1%	2.2%	0.0%	2.2%	0.1%	1.8%	16.2%	10.9%	10.9%	17.4%	17.4%	100.0%

Appendix D Results of 26-story model structure

Floor 1

Table D.1 Transfer of seismic inertia forces at Story 1 according to GB50011-2010

Cases (Ex9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	75.3	75.3	-9.1	-9.1	283.0	0.4	2.6	3.4	3.7	3.4	2.6	0.4	33.3	0.0	0.0	0.0	0.0	316.3
Td=1.846	23.8%	23.8%	-2.9%	-2.9%	89.5%	0.1%	0.8%	1.1%	1.2%	1.1%	0.8%	0.1%	10.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	15.4	61.7	-13.9	-9.8	130.7	0.3	2.5	3.3	3.6	3.3	2.6	0.4	31.7	369.7	0.0	0.0	0.0	532.1
Td=1.8443	2.9%	11.6%	-2.6%	-1.8%	24.6%	0.0%	0.5%	0.6%	0.7%	0.6%	0.5%	0.1%	6.0%	69.5%	0.0%	0.0%	0.0%	100.0%
Slab connected	108.2	108.2	12.0	12.0	456.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	122.3	122.3	1017.8	1017.8	2736.9
Td=1.8755	4.0%	4.0%	0.4%	0.4%	16.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	4.5%	37.2%	37.2%	100.0%
Slab Isolated(fixed)	298.7	298.7	0.4	0.4	1195.7	-1.5	0.4	0.9	1.2	0.9	0.4	-1.5	1.4	0.0	0.0	0.0	0.0	1197.1
Td=1.8445	25.0%	25.0%	0.0%	0.0%	99.9%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	198.8	299.0	9.2	0.0	1004.9	-1.4	0.4	0.9	1.2	0.9	0.4	-1.5	1.9	58.8	0.0	0.0	0.0	1065.6
Td=1.8428	18.7%	28.1%	0.9%	0.0%	94.3%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.2%	5.5%	0.0%	0.0%	0.0%	100.0%
Slab connected	165.6	165.6	10.1	10.1	682.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	137.3	137.3	808.3	808.3	2573.5
Td=1.8743	6.4%	6.4%	0.4%	0.4%	26.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.3%	5.3%	31.4%	31.4%	100.0%

Cases (Ey9)	Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1.9	1.9	5.0	5.0	17.7	218.4	1.1	132.5	7.0	132.5	1.1	218.4	1422.0	0.0	0.0	0.0	0.0	1439.7
Td=3.0718	0.1%	0.1%	0.3%	0.3%	1.2%	15.2%	0.1%	9.2%	0.5%	9.2%	0.1%	15.2%	98.8%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	1.8	1.9	4.9	4.9	17.2	195.4	1.0	149.1	11.2	3.2	11.5	131.5	1006.1	0.0	0.0	820.7	0.0	1844.0
Td=3.0440	0.1%	0.1%	0.3%	0.3%	0.9%	10.6%	0.1%	8.1%	0.6%	0.2%	0.6%	7.1%	54.6%	0.0%	0.0%	44.5%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	54.89	10.73	5.52	11.74	5.52	10.73	54.89	308.0	1139.9	1139.9	69.4	69.4	2726.6
Td=3.0362	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.4%	0.2%	0.4%	0.2%	0.4%	2.0%	11.3%	41.8%	41.8%	2.5%	2.5%	100.0%
Slab Isolated(fixed)	0.9	0.9	1.7	1.7	7.1	179.6	11.8	154.7	7.7	154.7	11.8	179.6	1399.8	0.0	0.0	0.0	0.0	1406.9
Td=3.0695	0.1%	0.1%	0.1%	0.1%	0.5%	12.8%	0.8%	11.0%	0.5%	11.0%	0.8%	12.8%	99.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	0.9	0.5	1.9	1.9	6.5	188.2	10.6	133.6	8.2	92.7	7.9	91.8	1066.0	0.0	0.0	246.8	0.0	1319.2
Td=3.0417	0.1%	0.0%	0.1%	0.1%	0.5%	14.3%	0.8%	10.1%	0.6%	7.0%	0.6%	7.0%	80.8%	0.0%	0.0%	18.7%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	133.6	9.1	85.1	9.9	85.1	9.1	133.6	930.6	1074.8	1074.8	58.4	58.4	3197.0
Td=3.0343	0.0%	0.0%	0.0%	0.0%	0.0%	4.2%	0.3%	2.7%	0.3%	2.7%	0.3%	4.2%	29.1%	33.6%	33.6%	1.8%	1.8%	100.0%

Table D.2 Transfer of seismic inertia forces at Story 1 according to IBC2012/ASCE7-10

Cases (AISCx9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	79.7	79.7	-11.7	-11.7	295.1	0.5	3.3	4.2	4.7	4.2	3.3	0.5	41.1	0.0	0.0	0.0	0.0	336.3
Td=1.846	23.7%	23.7%	-3.5%	-3.5%	87.8%	0.1%	1.0%	1.3%	1.4%	1.3%	1.0%	0.1%	12.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	10.9	63.7	-17.6	-12.4	119.2	0.3	3.1	4.1	4.5	4.1	3.2	0.4	39.1	456.4	0.0	0.0	0.0	614.7
Td=1.8443	1.8%	10.4%	-2.9%	-2.0%	19.4%	0.0%	0.5%	0.7%	0.7%	0.7%	0.5%	0.1%	6.4%	74.2%	0.0%	0.0%	0.0%	100.0%
Slab connected	141.7	141.7	15.5	15.5	597.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	317.3	317.3	2062.0	2062.0	5356.2
Td=1.8745	2.6%	2.6%	0.3%	0.3%	11.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.9%	5.9%	38.5%	38.5%	100.0%
Slab Isolated(fixed)	394.9	394.9	0.4	0.4	1580.2	-2.0	0.4	1.1	1.4	1.1	0.4	-2.0	0.6	0.0	0.0	0.0	0.0	1580.8
Td=1.8445	25.0%	25.0%	0.0%	0.0%	100.0%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	261.1	394.1	11.5	-0.8	1321.2	-1.8	0.5	1.1	1.4	1.1	0.4	-2.0	1.4	89.7	0.0	0.0	0.0	1412.3
Td=1.8428	18.5%	27.9%	0.8%	-0.1%	93.6%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.1%	6.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	216.3	216.3	13.0	13.0	891.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	353.1	353.1	1324.1	1324.1	4245.7
Td=1.8743	5.1%	5.1%	0.3%	0.3%	21.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.3%	8.3%	31.2%	31.2%	100.0%

Cases (AISCy9)	Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	2.8	2.8	7.3	7.3	25.8	318.0	1.4	189.7	9.9	189.7	1.4	318.0	2056.0	0.0	0.0	0.0	0.0	2081.8
Td=2.0326	0.1%	0.1%	0.4%	0.4%	1.2%	15.3%	0.1%	9.1%	0.5%	9.1%	0.1%	15.3%	98.8%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	2.7	2.8	7.2	7.2	25.3	284.5	1.3	214.7	-3.6	2.8	-17.0	192.0	1349.5	0.0	0.0	1255.7	0.0	2630.5
Td=2.0326	0.1%	0.1%	0.3%	0.3%	1.0%	10.8%	0.1%	8.2%	-0.1%	0.1%	-0.6%	7.3%	51.3%	0.0%	0.0%	47.7%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	81.6	15.9	10.1	17.3	10.08	15.87	81.55	464.7	2862.0	2862.0	218.4	218.4	6625.5
Td=2.0326	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%	0.2%	0.2%	0.3%	0.2%	0.2%	1.2%	7.0%	43.2%	43.2%	3.3%	3.3%	100.0%
Slab Isolated(fixed)	1.5	1.5	-2.5	-2.5	0.9	278.8	17.8	241.9	12.0	241.9	17.8	278.8	2178.2	0.0	0.0	0.0	0.0	2179.1
Td=2.0326	0.1%	0.1%	-0.1%	-0.1%	0.0%	12.8%	0.8%	11.1%	0.6%	11.1%	0.8%	12.8%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	-0.4	-0.9	2.7	2.7	2.9	290.6	15.9	209.9	12.4	141.5	11.6	143.1	1649.8	0.0	0.0	409.6	0.0	2062.3
Td=2.0326	0.0%	0.0%	0.1%	0.1%	0.1%	14.1%	0.8%	10.2%	0.6%	6.9%	0.6%	6.9%	80.0%	0.0%	0.0%	19.9%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	200.1	13.4	130.1	14.6	130.1	13.4	200.1	1403.5	2348.1	2348.1	1134.5	1134.5	8368.7
Td=2.0326	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	0.2%	1.6%	0.2%	1.6%	0.2%	2.4%	16.8%	28.1%	28.1%	13.6%	13.6%	100.0%

Table D.3 Transfer of seismic inertia forces at Story 1 according to time history of Imperial Valley Earthquake in 1940

Cases (IMX)	**Force to Wall through Axial Load in Beams**					**Force to Wall through Shear load in Beams**								**Slab in Axial Load**		**Slab in Shear**		**Total**
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	243.4	243.4	-13.8	-13.8	946.0	1.3	4.7	5.8	6.3	5.8	4.7	1.3	59.8	0.0	0.0	0.0	0.0	1005.8
	24.2%	24.2%	-1.4%	-1.4%	94.1%	0.1%	0.5%	0.6%	0.6%	0.6%	0.5%	0.1%	5.9%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	117.8	221.6	-21.8	-14.6	642.3	1.0	4.4	5.5	6.0	5.6	4.5	1.2	56.5	689.4	0.0	0.0	0.0	1388.2
	8.5%	16.0%	-1.6%	-1.1%	46.3%	0.1%	0.3%	0.4%	0.4%	0.4%	0.3%	0.1%	4.1%	49.7%	0.0%	0.0%	0.0%	100.0%
Slab connected	165.5	165.5	18.9	18.9	700.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	856.1	856.1	2875.4	2875.4	8163.0
	2.0%	2.0%	0.2%	0.2%	8.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.5%	10.5%	35.2%	35.2%	100.0%
Slab Isolated(fixed)	552.7	552.7	-6.2	-6.2	2198.1	-2.7	0.8	1.6	2.1	1.6	0.8	-2.7	2.9	0.0	0.0	0.0	0.0	2201.0
	25.1%	25.1%	-0.3%	-0.3%	99.9%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	363.5	554.6	14.1	-6.9	1843.5	-2.6	0.9	1.7	2.1	1.7	0.8	-2.7	3.8	1259.3	0.0	0.0	0.0	3106.6
	11.7%	17.9%	0.5%	-0.2%	59.3%	-0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	-0.1%	0.1%	40.5%	0.0%	0.0%	0.0%	100.0%
Slab connected	291.2	291.2	15.2	15.2	1194.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1267.9	1267.9	2335.0	2335.0	8400.7
	3.5%	3.5%	0.2%	0.2%	14.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.1%	15.1%	27.8%	27.8%	100.0%

Cases (IMY)	**Force to Wall through Shear in Beams**					**Force to Wall through Axial load in Beams**								**Slab in Shear**		**Slab in Axial load**		**Total**
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	3.0	3.0	7.1	7.1	26.2	368.7	7.8	207.8	13.4	207.8	7.8	368.7	2363.8	0.0	0.0	0.0	0.0	2389.9
	0.1%	0.1%	0.3%	0.3%	1.1%	15.4%	0.3%	8.7%	0.6%	8.7%	0.3%	15.4%	98.9%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	2.9	2.9	7.0	7.0	25.7	348.8	6.7	223.9	-15.9	28.9	-16.0	217.8	1588.4	0.0	0.0	1334.6	0.0	2948.7
	0.1%	0.1%	0.2%	0.2%	0.9%	11.8%	0.2%	7.6%	-0.5%	1.0%	-0.5%	7.4%	53.9%	0.0%	0.0%	45.3%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	66.1	14.8	14.3	15.7	14.3	14.8	66.1	412.3	2634.6	2634.6	919.2	919.2	7519.9
	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	0.2%	0.2%	0.2%	0.2%	0.2%	0.9%	5.5%	35.0%	35.0%	12.2%	12.2%	100.0%
Slab Isolated(fixed)	2.6	2.6	1.8	1.8	13.9	417.3	17.0	370.1	12.6	370.1	17.0	417.3	3242.7	0.0	0.0	0.0	0.0	3256.6
	0.1%	0.1%	0.1%	0.1%	0.4%	12.8%	0.5%	11.4%	0.4%	11.4%	0.5%	12.8%	99.6%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	2.4	2.0	1.9	1.9	12.6	405.6	15.6	361.2	12.5	168.9	9.7	225.9	2398.9	0.0	0.0	2109.7	0.0	4521.2
	0.1%	0.0%	0.0%	0.0%	0.3%	9.0%	0.3%	8.0%	0.3%	3.7%	0.2%	5.0%	53.1%	0.0%	0.0%	46.7%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	209.3	11.9	155.7	12.3	155.7	11.9	209.3	1532.1	2293.3	2293.3	2278.7	2278.7	10676.1
	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.1%	1.5%	0.1%	1.5%	0.1%	2.0%	14.4%	21.5%	21.5%	21.3%	21.3%	100.0%

Table D.4 Transfer of seismic inertia forces at Story 1 according to time history of Mexico City Earthquake in 1995

Cases (MEX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	246.8	246.8	-30.3	-30.3	926.5	1.4	8.8	11.3	12.4	11.3	8.8	1.4	111.0	0.0	0.0	0.0	0.0	1037.5
	23.8%	23.8%	-2.9%	-2.9%	89.3%	0.1%	0.8%	1.1%	1.2%	1.1%	0.8%	0.1%	10.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	51.6	201.6	-42.6	-32.3	431.6	0.8	8.3	10.9	12.0	11.0	8.5	1.1	105.3	1263.6	0.0	0.0	0.0	1800.5
	2.9%	11.2%	-2.4%	-1.8%	24.0%	0.0%	0.5%	0.6%	0.7%	0.6%	0.5%	0.1%	5.8%	70.2%	0.0%	0.0%	0.0%	100.0%
Slab connected	383.1	383.1	42.1	42.1	1616.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1742.2	1742.2	5661.0	5661.0	16422.9
	2.3%	2.3%	0.3%	0.3%	9.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.6%	10.6%	34.5%	34.5%	100.0%
Slab Isolated(fixed)	1054.6	1054.6	1.0	1.0	4220.2	5.2	-0.8	-2.6	-3.5	-2.6	-0.8	5.2	0.2	0.0	0.0	0.0	0.0	4220.4
	25.0%	25.0%	0.0%	0.0%	100.0%	0.1%	0.0%	-0.1%	-0.1%	-0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	696.9	1051.8	29.8	1.7	3528.7	-4.9	1.1	2.8	3.6	2.7	0.9	-5.2	1.9	2483.1	0.0	0.0	0.0	6013.7
	11.6%	17.5%	0.5%	0.0%	58.7%	-0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	-0.1%	0.0%	41.3%	0.0%	0.0%	0.0%	100.0%
Slab connected	593.1	593.1	35.1	35.1	2442.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1992.0	1992.0	5587.2	5587.2	17600.7
	3.4%	3.4%	0.2%	0.2%	13.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.3%	11.3%	31.7%	31.7%	100.0%

Cases (MEY)	Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	3.8	3.8	10.1	10.1	35.6	437.4	-2.3	260.7	13.6	260.7	-2.3	437.4	2810.0	0.0	0.0	0.0	0.0	2845.6
	0.1%	0.1%	0.4%	0.4%	1.2%	15.4%	-0.1%	9.2%	0.5%	9.2%	-0.1%	15.4%	98.8%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	3.8	4.0	10.2	10.2	36.1	410.1	2.3	306.8	-4.2	6.1	-24.3	275.4	1944.3	0.0	0.0	1768.3	0.0	3748.7
	0.1%	0.1%	0.3%	0.3%	1.0%	10.9%	0.1%	8.2%	-0.1%	0.2%	-0.6%	7.3%	51.9%	0.0%	0.0%	47.2%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	120.4	23.0	16.1	25.2	16.1	23.0	120.4	688.7	4221.4	4221.4	1179.1	1179.1	11489.7
	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.2%	0.1%	0.2%	0.1%	0.2%	1.0%	6.0%	36.7%	36.7%	10.3%	10.3%	100.0%
Slab Isolated(fixed)	2.0	2.0	3.6	3.6	15.2	385.4	-24.7	334.6	16.6	334.6	-24.7	385.4	2814.6	0.0	0.0	0.0	0.0	2829.8
	0.1%	0.1%	0.1%	0.1%	0.5%	13.6%	-0.9%	11.8%	0.6%	11.8%	-0.9%	13.6%	99.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	2.0	1.3	3.9	3.9	14.4	422.2	22.6	308.9	18.0	204.5	16.8	209.6	2405.3	0.0	0.0	2293.5	0.0	4713.2
	0.0%	0.0%	0.1%	0.1%	0.3%	9.0%	0.5%	6.6%	0.4%	4.3%	0.4%	4.4%	51.0%	0.0%	0.0%	48.7%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	290.9	19.5	190.6	21.4	190.6	19.5	290.9	2047.0	3429.7	3429.7	2801.7	2801.7	14509.8
	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.1%	1.3%	0.1%	1.3%	0.1%	2.0%	14.1%	23.6%	23.6%	19.3%	19.3%	100.0%

Floor 2

Table D.5 Transfer of seismic inertia forces at Story 2 in SAP2000 analyses according to GB50011-2010

Cases (Ex9)	**Force to Wall through Axial Load in Beams**					**Force to Wall through Shear load in Beams**								**Slab in Axial Load**		**Slab in Shear**		**Total**
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	113.5	113.5	-8.7	-8.7	436.6	0.6	2.9	4.0	4.4	4.0	2.9	0.6	39.0	0.0	0.0	0.0	0.0	475.6
Td=1.846	23.9%	23.9%	-1.8%	-1.8%	91.8%	0.1%	0.6%	0.8%	0.9%	0.8%	0.6%	0.1%	8.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	27.4	92.9	-14.9	-9.5	216.1	0.4	2.7	3.8	4.2	3.8	2.8	0.5	36.5	425.2	0.0	0.0	0.0	677.7
Td=1.8443	4.0%	13.7%	-2.2%	-1.4%	31.9%	0.1%	0.4%	0.6%	0.6%	0.6%	0.4%	0.1%	5.4%	62.7%	0.0%	0.0%	0.0%	100.0%
Slab connected	123.2	123.2	12.3	12.3	517.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	239.4	239.4	1671.9	1671.9	4339.8
Td=1.8755	2.8%	2.8%	0.3%	0.3%	11.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	5.5%	38.5%	38.5%	100.0%
Slab Isolated(fixed)	73.3	73.3	12.9	12.9	318.8	-0.4	1.7	2.6	3.0	2.6	1.7	-0.4	21.8	0.0	0.0	0.0	0.0	340.6
Td=1.8445	21.5%	21.5%	3.8%	3.8%	93.6%	-0.1%	0.5%	0.8%	0.9%	0.8%	0.5%	-0.1%	6.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	68.9	78.7	13.5	13.0	321.5	-0.4	1.7	2.6	3.0	2.6	1.7	-0.4	21.4	227.0	0.0	0.0	0.0	569.8
Td=1.8428	12.1%	13.8%	2.4%	2.3%	56.4%	-0.1%	0.3%	0.5%	0.5%	0.5%	0.3%	-0.1%	3.7%	39.8%	0.0%	0.0%	0.0%	100.0%
Slab connected	131.1	131.1	12.7	12.7	549.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	249.5	249.5	1411.2	1411.2	3871.0
Td=1.8743	3.4%	3.4%	0.3%	0.3%	14.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%	6.4%	36.5%	36.5%	100.0%

Cases (Ey9)	**Force to Wall through Shear in Beams**					**Force to Wall through Axial load in Beams**								**Slab in Shear**		**Slab in Axial load**		**Total**
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1.6	1.6	4.6	4.6	15.4	132.7	-3.1	88.9	4.2	88.9	-3.1	132.7	882.3	0.0	0.0	0.0	0.0	897.6
Td=3.0718	0.2%	0.2%	0.5%	0.5%	1.7%	14.8%	-0.3%	9.9%	0.5%	9.9%	-0.3%	14.8%	98.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	1.5	1.7	4.5	4.5	15.4	101.7	-2.5	122.8	-5.4	-27.4	-12.6	76.8	506.9	0.0	0.0	645.5	0.0	1167.9
Td=3.0440	0.1%	0.1%	0.4%	0.4%	1.3%	8.7%	-0.2%	10.5%	-0.5%	-2.3%	-1.1%	6.6%	43.4%	0.0%	0.0%	55.3%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	109.8	11.8	24.2	16.0	24.2	11.8	109.8	615.5	1938.0	1938.0	307.0	307.0	5105.4
Td=3.0362	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	0.2%	0.5%	0.3%	0.5%	0.2%	2.2%	12.1%	38.0%	38.0%	6.0%	6.0%	100.0%
Slab Isolated(fixed)	0.4	0.4	3.2	3.2	7.8	17.4	10.6	-0.4	4.8	-0.4	10.6	17.4	119.9	0.0	0.0	0.0	0.0	127.7
Td=3.0695	0.3%	0.3%	2.5%	2.5%	6.1%	13.6%	8.3%	-0.3%	3.7%	-0.3%	8.3%	13.6%	93.9%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	0.8	0.4	3.3	3.3	8.9	34.5	9.0	-40.0	9.3	47.6	11.8	-2.7	138.9	0.0	0.0	330.0	0.0	477.8
Td=3.0417	0.2%	0.1%	0.7%	0.7%	1.9%	7.2%	1.9%	-8.4%	1.9%	10.0%	2.5%	-0.6%	29.1%	0.0%	0.0%	69.1%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	117.87	12.16	37.16	16.2	37.2	12.2	117.9	701.2	1856.2	1856.2	439.0	439.0	5291.6
Td=3.0343	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	0.2%	0.7%	0.3%	0.7%	0.2%	2.2%	13.3%	35.1%	35.1%	8.3%	8.3%	100.0%

Table D.6 Transfer of seismic inertia forces at Story 2 according to IBC2012/ASCE7-10

Cases (AISCx9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	115.0	115.0	-11.1	-11.1	437.9	0.7	3.6	4.9	5.4	4.9	3.6	0.7	47.2	0.0	0.0	0.0	0.0	485.1
Td=1.846	23.7%	23.7%	-2.3%	-2.3%	90.3%	0.1%	0.7%	1.0%	1.1%	1.0%	0.7%	0.1%	9.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	19.1	91.2	-18.8	-12.1	189.8	0.4	3.3	4.6	5.2	4.7	3.4	0.5	44.3	511.0	0.0	0.0	0.0	745.0
Td=1.8443	2.6%	12.2%	-2.5%	-1.6%	25.5%	0.1%	0.4%	0.6%	0.7%	0.6%	0.5%	0.1%	5.9%	68.6%	0.0%	0.0%	0.0%	100.0%
Slab connected	162.1	162.1	15.9	15.9	680.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	313.7	313.7	1949.3	1949.3	5206.3
Td=1.8755	3.1%	3.1%	0.3%	0.3%	13.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0%	6.0%	37.4%	37.4%	100.0%
Slab Isolated(fixed)	121.8	121.8	16.5	16.5	520.0	-0.6	2.0	3.1	3.7	3.1	2.0	-0.6	25.3	0.0	0.0	0.0	0.0	545.4
Td=1.8445	22.3%	22.3%	3.0%	3.0%	95.4%	-0.1%	0.4%	0.6%	0.7%	0.6%	0.4%	-0.1%	4.6%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	102.9	126.4	17.0	16.5	492.2	-0.6	2.0	3.1	3.6	3.1	2.0	-0.7	25.1	242.6	0.0	0.0	0.0	759.8
Td=1.8428	13.5%	16.6%	2.2%	2.2%	64.8%	-0.1%	0.3%	0.4%	0.5%	0.4%	0.3%	-0.1%	3.3%	31.9%	0.0%	0.0%	0.0%	100.0%
Slab connected	172.5	172.5	16.4	16.4	723.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	324.7	324.7	1791.7	1791.7	4955.8
Td=1.8743	3.5%	3.5%	0.3%	0.3%	14.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.6%	6.6%	36.2%	36.2%	100.0%

Cases (AISCy9)	Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	2.2	2.2	6.6	6.6	22.1	184.5	-5.1	119.2	5.2	119.2	-5.1	184.5	1204.7	0.0	0.0	0.0	0.0	1226.8
Td=3.0718	0.2%	0.2%	0.5%	0.5%	1.8%	15.0%	-0.4%	9.7%	0.4%	9.7%	-0.4%	15.0%	98.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	2.1	2.4	6.5	6.5	22.2	140.0	-4.2	170.0	-8.3	-44.3	-18.5	107.6	684.8	0.0	0.0	900.4	0.0	1607.4
Td=3.0440	0.1%	0.2%	0.4%	0.4%	1.4%	8.7%	-0.3%	10.6%	-0.5%	-2.8%	-1.2%	6.7%	42.6%	0.0%	0.0%	56.0%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	163.3	17.5	39.5	23.6	39.47	17.45	163.25	927.9	2853.1	2853.1	477.7	477.7	7589.5
Td=3.0362	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	0.2%	0.5%	0.3%	0.5%	0.2%	2.2%	12.2%	37.6%	37.6%	6.3%	6.3%	100.0%
Slab Isolated(fixed)	0.4	0.4	4.6	4.6	10.7	40.5	16.3	13.7	8.2	13.7	16.3	40.5	298.3	0.0	0.0	0.0	0.0	309.0
Td=3.0695	0.1%	0.1%	1.5%	1.5%	3.5%	13.1%	5.3%	4.4%	2.6%	4.4%	5.3%	13.1%	96.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	0.5	1.0	4.8	4.8	12.5	64.3	13.9	-45.7	14.1	74.5	17.4	3.4	283.9	0.0	0.0	464.4	0.0	760.9
Td=3.0417	0.1%	0.1%	0.6%	0.6%	1.6%	8.4%	1.8%	-6.0%	1.9%	9.8%	2.3%	0.5%	37.3%	0.0%	0.0%	61.0%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	175.4	18.0	58.9	23.9	58.9	18.0	175.4	1057.2	2731.8	2731.8	633.9	633.9	7788.6
Td=3.0343	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	0.2%	0.8%	0.3%	0.8%	0.2%	2.3%	13.6%	35.1%	35.1%	8.1%	8.1%	100.0%

Table D.7 Transfer of seismic inertia forces at <u>Story 2</u> according to time history of Imperial Valley Earthquake in 1940

Cases (IMX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	414.3	414.3	-13.1	-13.1	1630.9	2.2	5.5	7.2	7.8	7.2	5.5	2.2	75.2	0.0	0.0	0.0	0.0	1706.1
	24.3%	24.3%	-0.8%	-0.8%	95.6%	0.1%	0.3%	0.4%	0.5%	0.4%	0.3%	0.1%	4.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	201.9	375.0	-23.9	-14.4	1115.5	1.7	5.0	6.7	7.4	6.8	5.2	2.0	69.5	852.5	0.0	0.0	0.0	2037.6
	9.9%	18.4%	-1.2%	-0.7%	54.7%	0.1%	0.2%	0.3%	0.4%	0.3%	0.3%	0.1%	3.4%	41.8%	0.0%	0.0%	0.0%	100.0%
Slab connected	190.8	190.8	-19.4	-19.4	724.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1179.1	1179.1	3149.6	3149.6	9381.8
	2.0%	2.0%	-0.2%	-0.2%	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.6%	12.6%	33.6%	33.6%	100.0%
Slab Isolated(fixed)	213.3	213.3	20.6	20.6	894.6	1.1	2.9	4.3	4.8	4.3	2.9	1.1	42.7	0.0	0.0	0.0	0.0	937.3
	22.8%	22.8%	2.2%	2.2%	95.4%	0.1%	0.3%	0.5%	0.5%	0.5%	0.3%	0.1%	4.6%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	156.2	210.6	20.9	21.1	775.7	1.0	2.8	4.2	4.7	4.2	2.8	1.1	41.5	737.3	0.0	0.0	0.0	1554.5
	10.1%	13.5%	1.3%	1.4%	49.9%	0.1%	0.2%	0.3%	0.3%	0.3%	0.2%	0.1%	2.7%	47.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	200.6	200.6	20.3	20.3	843.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1232.7	1232.7	2642.7	2642.7	8593.9
	2.3%	2.3%	0.2%	0.2%	9.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.3%	14.3%	30.8%	30.8%	100.0%

Cases (IMY)	Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	3.1	3.1	6.5	6.5	25.5	339.0	-7.1	229.1	15.1	229.1	-7.1	339.0	2274.6	0.0	0.0	0.0	0.0	2300.1
	0.1%	0.1%	0.3%	0.3%	1.1%	14.7%	-0.3%	10.0%	0.7%	10.0%	-0.3%	14.7%	98.9%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	2.9	2.9	6.6	6.6	24.9	314.9	-5.5	224.6	-5.0	-42.2	-17.2	193.9	1327.1	0.0	0.0	1051.3	0.0	2403.4
	0.1%	0.1%	0.3%	0.3%	1.0%	13.1%	-0.2%	9.3%	-0.2%	-1.8%	-0.7%	8.1%	55.2%	0.0%	0.0%	43.7%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	137.8	15.8	36.3	21.1	36.3	15.8	137.8	802.1	2561.1	2561.1	1289.0	1289.0	8502.3
	0.0%	0.0%	0.0%	0.0%	0.0%	1.6%	0.2%	0.4%	0.2%	0.4%	0.2%	1.6%	9.4%	30.1%	30.1%	15.2%	15.2%	100.0%
Slab Isolated(fixed)	0.7	0.7	4.2	4.2	11.0	46.8	14.3	46.9	6.7	46.9	14.3	46.8	445.1	0.0	0.0	0.0	0.0	456.0
	0.1%	0.1%	0.9%	0.9%	2.4%	10.3%	3.1%	10.3%	1.5%	10.3%	3.1%	10.3%	97.6%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	0.8	1.0	4.5	4.5	12.7	68.4	12.9	55.3	11.0	62.0	15.9	43.7	538.3	0.0	0.0	799.9	0.0	1350.9
	0.1%	0.1%	0.3%	0.3%	0.9%	5.1%	1.0%	4.1%	0.8%	4.6%	1.2%	3.2%	39.8%	0.0%	0.0%	59.2%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	153.2	16.5	49.4	21.5	49.4	16.5	153.2	919.2	3262.6	3262.6	1328.4	1328.4	10101.2
	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.2%	0.5%	0.2%	0.5%	0.2%	1.5%	9.1%	32.3%	32.3%	13.2%	13.2%	100.0%

Table D.8 Transfer of seismic inertia forces at Story 2 according to time history of Mexico City Earthquake in 1995

Cases (MEX)	**Force to Wall through Axial Load in Beams**					**Force to Wall through Shear load in Beams**								**Slab in Axial Load**		**Slab in Shear**		**Total**
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	364.8	364.8	-28.8	-28.8	1401.4	2.1	9.7	13.2	14.6	13.2	9.7	2.1	128.9	0.0	0.0	0.0	0.0	1530.4
	23.8%	23.8%	-1.9%	-1.9%	91.6%	0.1%	0.6%	0.9%	1.0%	0.9%	0.6%	0.1%	8.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	88.6	296.0	-49.6	-31.5	688.1	1.3	8.9	12.5	14.0	12.6	9.2	1.7	120.4	1356.2	0.0	0.0	0.0	2164.7
	4.1%	13.7%	-2.3%	-1.5%	31.8%	0.1%	0.4%	0.6%	0.6%	0.6%	0.4%	0.1%	5.6%	62.7%	0.0%	0.0%	0.0%	100.0%
Slab connected	436.6	436.6	43.2	43.2	1833.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1990.8	1990.8	5539.8	5539.8	16894.2
	2.6%	2.6%	0.3%	0.3%	10.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.8%	11.8%	32.8%	32.8%	100.0%
Slab Isolated(fixed)	290.8	290.8	43.3	43.3	1250.0	1.5	5.4	8.4	9.7	8.4	5.4	1.5	80.4	0.0	0.0	0.0	0.0	1330.4
	21.9%	21.9%	3.3%	3.3%	94.0%	0.1%	0.4%	0.6%	0.7%	0.6%	0.4%	0.1%	6.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	255.0	304.8	44.6	43.5	1207.7	1.6	5.3	8.3	9.6	8.3	5.3	1.6	79.9	1359.9	0.0	0.0	0.0	2647.6
	9.6%	11.5%	1.7%	1.6%	45.6%	0.1%	0.2%	0.3%	0.4%	0.3%	0.2%	0.1%	3.0%	51.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	464.2	464.2	44.6	44.6	1946.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2621.7	2621.7	6561.3	6561.3	20312.1
	2.3%	2.3%	0.2%	0.2%	9.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.9%	12.9%	32.3%	32.3%	100.0%

Cases (MEY)	**Force to Wall through Shear in Beams**					**Force to Wall through Axial load in Beams**								**Slab in Shear**		**Slab in Axial load**		**Total**
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	3.0	3.0	9.1	9.1	30.4	255.3	7.9	164.7	-7.4	164.7	7.9	255.3	1696.7	0.0	0.0	0.0	0.0	1727.1
	0.2%	0.2%	0.5%	0.5%	1.8%	14.8%	0.5%	9.5%	-0.4%	9.5%	0.5%	14.8%	98.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	3.1	3.5	9.3	9.3	31.8	209.1	-6.5	244.9	-11.9	67.5	26.5	157.7	1374.4	0.0	0.0	1368.5	0.0	2774.7
	0.1%	0.1%	0.3%	0.3%	1.1%	7.5%	-0.2%	8.8%	-0.4%	2.4%	1.0%	5.7%	49.5%	0.0%	0.0%	49.3%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	239.9	25.4	60.1	34.4	60.1	25.4	239.9	1370.1	4197.1	4197.1	1858.7	1858.7	13481.7
	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	0.2%	0.4%	0.3%	0.4%	0.2%	1.8%	10.2%	31.1%	31.1%	13.8%	13.8%	100.0%
Slab Isolated(fixed)	0.5	0.5	6.3	6.3	14.8	62.6	22.9	25.3	11.7	25.3	22.9	62.6	466.4	0.0	0.0	0.0	0.0	481.2
	0.1%	0.1%	1.3%	1.3%	3.1%	13.0%	4.8%	5.2%	2.4%	5.2%	4.8%	13.0%	96.9%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	0.7	1.4	6.8	6.8	18.0	99.5	20.0	65.4	20.4	109.3	25.0	10.7	700.6	0.0	0.0	1265.9	0.0	1984.4
	0.0%	0.1%	0.3%	0.3%	0.9%	5.0%	1.0%	3.3%	1.0%	5.5%	1.3%	0.5%	35.3%	0.0%	0.0%	63.8%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	256.9	26.1	87.1	34.9	87.1	26.1	256.9	1550.4	4255.2	4255.2	1982.4	1982.4	14025.6
	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	0.2%	0.6%	0.2%	0.6%	0.2%	1.8%	11.1%	30.3%	30.3%	14.1%	14.1%	100.0%

Floor 16

Table D.9 Transfer of seismic inertia forces at Story 16 according to GB50011-2010

Cases (Ex9)	**Force to Wall through Axial Load in Beams**					**Force to Wall through Shear load in Beams**								**Slab in Axial Load**		**Slab in Shear**		**Total**
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	164.6	164.6	-15.6	-15.6	626.9	0.8	1.6	2.0	2.2	2.0	1.6	0.8	21.9	0.0	0.0	0.0	0.0	648.9
Td=1.846	25.4%	25.4%	-2.4%	-2.4%	96.6%	0.1%	0.2%	0.3%	0.3%	0.3%	0.2%	0.1%	3.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	74.7	144.4	-6.1	-16.0	416.1	0.6	1.3	1.8	2.0	1.8	1.4	0.7	19.3	223.8	0.0	0.0	0.0	659.2
Td=1.8443	11.3%	21.9%	-0.9%	-2.4%	63.1%	0.1%	0.2%	0.3%	0.3%	0.3%	0.2%	0.1%	2.9%	33.9%	0.0%	0.0%	0.0%	100.0%
Slab connected	24.3	24.3	3.9	3.9	105.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.5	36.5	288.2	288.2	754.4
Td=1.8755	3.2%	3.2%	0.5%	0.5%	13.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%	4.8%	38.2%	38.2%	100.0%
Slab Isolated(fixed)	164.8	164.8	-15.6	-15.6	627.9	0.8	1.6	2.0	2.2	2.0	1.6	0.8	22.0	0.0	0.0	0.0	0.0	649.8
Td=1.8445	25.4%	25.4%	-2.4%	-2.4%	96.6%	0.1%	0.2%	0.3%	0.3%	0.3%	0.2%	0.1%	3.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	74.8	74.8	-6.1	-6.1	287.0	0.6	1.3	1.8	2.0	1.8	1.3	0.6	18.8	224.1	0.0	0.0	0.0	529.9
Td=1.8428	14.1%	14.1%	-1.1%	-1.1%	54.2%	0.1%	0.3%	0.3%	0.4%	0.3%	0.3%	0.1%	3.6%	42.3%	0.0%	0.0%	0.0%	100.0%
Slab connected	24.3	24.3	3.9	3.9	105.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.5	36.5	288.4	288.4	754.8
Td=1.8743	3.2%	3.2%	0.5%	0.5%	13.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%	4.8%	38.2%	38.2%	100.0%

Cases (Ey9)	**Force to Wall through Shear in Beams**					**Force to Wall through Axial load in Beams**								**Slab in Shear**		**Slab in Axial load**		**Total**
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	0.0	0.0	0.8	0.8	1.7	31.5	16.4	-30.6	7.8	-30.6	16.4	31.5	84.6	0.0	0.0	0.0	0.0	86.3
Td=3.0718	0.0%	0.0%	0.9%	0.9%	1.9%	36.5%	18.9%	-35.5%	9.0%	-35.5%	18.9%	36.5%	98.1%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	0.0	0.1	0.8	0.8	1.8	42.6	15.3	-46.2	6.7	7.4	5.2	25.9	113.8	0.0	0.0	45.2	0.0	160.8
Td=3.0440	0.0%	0.1%	0.5%	0.5%	1.1%	26.5%	9.5%	-28.7%	4.2%	4.6%	3.2%	16.1%	70.8%	0.0%	0.0%	28.1%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	56.3	4.8	-4.1	6.3	-4.1	4.8	56.3	240.7	342.8	342.8	51.9	51.9	1030.1
Td=3.0362	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	0.5%	-0.4%	0.6%	-0.4%	0.5%	5.5%	23.4%	33.3%	33.3%	5.0%	5.0%	100.0%
Slab Isolated(fixed)	0.2	0.2	0.8	0.8	2.5	31.4	16.3	-30.7	7.8	-30.7	16.3	31.4	83.8	0.0	0.0	0.0	0.0	86.3
Td=3.0695	0.3%	0.3%	0.9%	0.9%	2.9%	36.4%	18.9%	-35.5%	9.0%	-35.5%	18.9%	36.4%	97.1%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	0.0	0.1	0.8	0.8	1.7	42.5	15.3	-46.3	6.7	7.4	5.2	25.8	113.3	0.0	0.0	45.4	0.0	160.4
Td=3.0417	0.0%	0.1%	0.5%	0.5%	1.1%	26.5%	9.5%	-28.8%	4.2%	4.6%	3.2%	16.1%	70.6%	0.0%	0.0%	28.3%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	56.26	4.83	-4.09	6.3	-4.1	4.8	56.3	240.6	342.9	342.9	51.8	51.8	1030.0
Td=3.0343	0.0%	0.0%	0.0%	0.0%	0.0%	5.5%	0.5%	-0.4%	0.6%	-0.4%	0.5%	5.5%	23.4%	33.3%	33.3%	5.0%	5.0%	100.0%

Table D.10 Transfer of seismic inertia forces at Story 16 according to IBC2012/ASCE7-10

Cases (AISCx9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	289.5	289.5	-19.4	-19.4	1119.2	1.5	2.4	3.0	3.2	3.0	2.4	1.5	33.7	0.0	0.0	0.0	0.0	1152.9
Td=1.846	25.1%	25.1%	-1.7%	-1.7%	97.1%	0.1%	0.2%	0.3%	0.3%	0.3%	0.2%	0.1%	2.9%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	138.6	257.7	-7.8	-20.0	764.8	1.1	2.0	2.6	2.9	2.7	2.2	1.3	29.6	357.0	0.0	0.0	0.0	1151.4
Td=1.8443	12.0%	22.4%	-0.7%	-1.7%	66.4%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.6%	31.0%	0.0%	0.0%	0.0%	100.0%
Slab connected	21.4	21.4	4.5	4.5	94.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.6	82.6	593.0	593.0	1445.6
Td=1.8755	1.5%	1.5%	0.3%	0.3%	6.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.7%	5.7%	41.0%	41.0%	100.0%
Slab Isolated(fixed)	289.6	289.6	-19.4	-19.4	1119.8	1.5	2.4	3.0	3.2	3.0	2.4	1.5	33.7	0.0	0.0	0.0	0.0	1153.5
Td=1.8445	25.1%	25.1%	-1.7%	-1.7%	97.1%	0.1%	0.2%	0.3%	0.3%	0.3%	0.2%	0.1%	2.9%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	138.7	257.8	-7.8	-20.0	765.2	1.1	2.0	2.6	2.9	2.7	2.2	1.3	29.6	357.1	0.0	0.0	0.0	1151.9
Td=1.8428	12.0%	22.4%	-0.7%	-1.7%	66.4%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.6%	31.0%	0.0%	0.0%	0.0%	100.0%
Slab connected	18.3	18.3	4.5	4.5	82.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	79.9	79.9	626.7	626.7	1495.6
Td=1.8743	1.2%	1.2%	0.3%	0.3%	5.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.3%	5.3%	41.9%	41.9%	100.0%

Cases (AISCy9)	Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	0.5	0.5	1.5	1.5	5.1	15.9	-19.8	112.3	-5.5	112.3	-19.8	15.9	422.6	0.0	0.0	0.0	0.0	427.7
Td=3.0718	0.1%	0.1%	0.3%	0.3%	1.2%	3.7%	-4.6%	26.3%	-1.3%	26.3%	-4.6%	3.7%	98.8%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	0.5	0.5	1.4	1.4	4.7	2.4	-18.9	119.5	-7.1	12.1	-7.1	-3.5	194.8	0.0	0.0	217.6	0.0	417.1
Td=3.0440	0.1%	0.1%	0.3%	0.3%	1.1%	0.6%	-4.5%	28.6%	-1.7%	2.9%	-1.7%	-0.8%	46.7%	0.0%	0.0%	52.2%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	65.0	6.1	-24.9	7.8	-24.85	6.11	64.98	200.6	594.0	594.0	22.2	22.2	1433.0
Td=3.0362	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	0.4%	-1.7%	0.5%	-1.7%	0.4%	4.5%	14.0%	41.5%	41.5%	1.5%	1.5%	100.0%
Slab Isolated(fixed)	0.5	0.5	1.5	1.5	5.1	16.0	-19.8	112.4	-5.5	112.4	-19.8	16.0	423.4	0.0	0.0	0.0	0.0	428.5
Td=3.0695	0.1%	0.1%	0.3%	0.3%	1.2%	3.7%	-4.6%	26.2%	-1.3%	26.2%	-4.6%	3.7%	98.8%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	0.5	0.5	1.4	1.4	4.7	2.5	-18.9	119.6	-7.1	12.1	-7.1	-3.5	195.3	0.0	0.0	220.2	0.0	420.2
Td=3.0417	0.1%	0.1%	0.3%	0.3%	1.1%	0.6%	-4.5%	28.5%	-1.7%	2.9%	-1.7%	-0.8%	46.5%	0.0%	0.0%	52.4%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	64.2	6.0	-25.6	7.8	-25.6	6.0	64.2	194.3	620.3	620.3	4.9	4.9	1444.7
Td=3.0343	0.0%	0.0%	0.0%	0.0%	0.0%	4.4%	0.4%	-1.8%	0.5%	-1.8%	0.4%	4.4%	13.5%	42.9%	42.9%	0.3%	0.3%	100.0%

Table D.11 Transfer of seismic inertia forces at Story 16 according to time history of Imperial Valley Earthquake in 1940

Cases (IMX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1116.3	1116.3	-28.4	-28.4	4408.2	5.8	6.2	6.9	7.1	6.9	6.2	5.8	89.9	0.0	0.0	0.0	0.0	4498.1
	24.8%	24.8%	-0.6%	-0.6%	98.0%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	623.7	1062.2	-10.5	-27.7	3333.6	4.9	5.3	6.1	6.2	6.3	5.8	5.5	79.9	1639.9	0.0	0.0	0.0	5053.4
	12.3%	21.0%	-0.2%	-0.5%	66.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.6%	32.5%	0.0%	0.0%	0.0%	100.0%
Slab connected	155.9	155.9	7.3	7.3	638.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	464.3	464.3	1602.6	1602.6	4771.9
	3.3%	3.3%	0.2%	0.2%	13.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.7%	9.7%	33.6%	33.6%	100.0%
Slab Isolated(fixed)	1108.5	1108.5	-28.4	-28.4	4377.0	5.8	6.2	6.9	7.1	6.9	6.2	5.8	89.6	0.0	0.0	0.0	0.0	4466.6
	24.8%	24.8%	-0.6%	-0.6%	98.0%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	626.3	1067.0	10.5	27.7	3424.8	4.9	5.3	6.1	6.2	6.3	5.8	5.5	80.2	1533.1	0.0	0.0	0.0	5038.1
	12.4%	21.2%	0.2%	0.6%	68.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.6%	30.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	156.4	156.4	7.2	7.2	640.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	460.1	460.1	1815.7	1815.7	5191.8
	3.0%	3.0%	0.1%	0.1%	12.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.9%	8.9%	35.0%	35.0%	100.0%

Cases (IMY)	Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	7.0	7.0	6.0	6.0	39.8	837.4	-48.3	855.2	69.4	855.2	-48.3	837.4	6716.1	0.0	0.0	0.0	0.0	6755.8
	0.1%	0.1%	0.1%	0.1%	0.6%	12.4%	-0.7%	12.7%	1.0%	12.7%	-0.7%	12.4%	99.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	6.2	5.4	4.9	4.9	33.0	830.7	-40.9	696.0	20.4	274.2	-6.3	449.6	4447.3	0.0	0.0	2941.8	0.0	7422.2
	0.1%	0.1%	0.1%	0.1%	0.4%	11.2%	-0.6%	9.4%	0.3%	3.7%	-0.1%	6.1%	59.9%	0.0%	0.0%	39.6%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	179.4	9.1	234.4	11.8	234.4	9.1	179.4	1715.3	891.2	891.2	1917.3	1917.3	7332.3
	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	0.1%	3.2%	0.2%	3.2%	0.1%	2.4%	23.4%	12.2%	12.2%	26.1%	26.1%	100.0%
Slab Isolated(fixed)	7.0	7.0	6.0	6.0	39.8	838.4	-48.3	856.2	69.4	856.2	-48.3	838.4	6723.8	0.0	0.0	0.0	0.0	6763.6
	0.1%	0.1%	0.1%	0.1%	0.6%	12.4%	-0.7%	12.7%	1.0%	12.7%	-0.7%	12.4%	99.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	6.2	5.4	4.9	4.9	33.1	831.8	40.9	697.3	31.5	274.5	6.3	450.2	4665.1	0.0	0.0	2943.4	0.0	7641.6
	0.1%	0.1%	0.1%	0.1%	0.4%	10.9%	0.5%	9.1%	0.4%	3.6%	0.1%	5.9%	61.0%	0.0%	0.0%	38.5%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	179.4	9.1	235.0	11.8	235.0	9.1	179.4	1717.6	1311.8	1311.8	2165.7	2165.7	8672.6
	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%	0.1%	2.7%	0.1%	2.7%	0.1%	2.1%	19.8%	15.1%	15.1%	25.0%	25.0%	100.0%

Table D.12 Transfer of seismic inertia forces at Story 16 according to time history of Mexico City Earthquake in 1995

Cases (MEX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	946.4	946.4	-48.7	-48.7	3688.3	4.9	7.3	8.9	9.3	8.9	7.3	4.9	102.6	0.0	0.0	0.0	0.0	3790.9
	25.0%	25.0%	-1.3%	-1.3%	97.3%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	463.2	846.0	-23.0	-50.9	2544.4	3.7	6.1	7.8	8.3	8.0	6.6	4.3	89.4	1289.2	0.0	0.0	0.0	3923.1
	11.8%	21.6%	-0.6%	-1.3%	64.9%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	32.9%	0.0%	0.0%	0.0%	100.0%
Slab connected	36.9	36.9	11.4	11.4	170.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1921.6	1921.6	983.1	983.1	5979.6
	0.6%	0.6%	0.2%	0.2%	2.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	32.1%	32.1%	16.4%	16.4%	100.0%
Slab Isolated(fixed)	942.9	942.9	-48.6	-48.6	3674.4	4.8	7.3	8.8	9.3	8.8	7.3	4.8	102.3	0.0	0.0	0.0	0.0	3776.7
	25.0%	25.0%	-1.3%	-1.3%	97.3%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	461.5	843.1	21.0	50.9	2681.0	3.7	6.1	7.8	8.3	8.0	6.6	4.3	89.2	1284.9	0.0	0.0	0.0	4055.1
	11.4%	20.8%	0.5%	1.3%	66.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	31.7%	0.0%	0.0%	0.0%	100.0%
Slab connected	36.7	36.7	11.4	11.4	169.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2042.3	2042.3	484.1	484.1	5222.2
	0.7%	0.7%	0.2%	0.2%	3.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.1%	39.1%	9.3%	9.3%	100.0%

Cases (MEY)	Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1.4	1.4	2.3	2.3	10.0	121.7	-32.1	214.6	16.1	214.6	-32.1	121.7	1248.8	0.0	0.0	0.0	0.0	1258.8
	0.1%	0.1%	0.2%	0.2%	0.8%	9.7%	-2.6%	17.0%	1.3%	17.0%	-2.6%	9.7%	99.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	1.2	1.2	2.2	2.2	9.3	130.4	-30.8	212.9	-1.4	44.8	-10.6	72.9	836.3	0.0	0.0	706.9	0.0	1552.5
	0.1%	0.1%	0.1%	0.1%	0.6%	8.4%	-2.0%	13.7%	-0.1%	2.9%	-0.7%	4.7%	53.9%	0.0%	0.0%	45.5%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	109.0	9.6	55.5	12.4	55.5	9.6	109.0	721.0	1359.4	1359.4	983.1	983.1	5406.0
	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.2%	1.0%	0.2%	1.0%	0.2%	2.0%	13.3%	25.1%	25.1%	18.2%	18.2%	100.0%
Slab Isolated(fixed)	1.4	1.4	2.3	2.3	10.1	121.8	-32.1	215.2	16.1	215.2	-32.1	121.8	1251.6	0.0	0.0	0.0	0.0	1261.7
	0.1%	0.1%	0.2%	0.2%	0.8%	9.7%	-2.5%	17.1%	1.3%	17.1%	-2.5%	9.7%	99.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	1.2	1.2	2.2	2.2	9.3	130.3	30.8	214.5	13.5	44.9	10.6	72.8	1035.0	0.0	0.0	716.5	0.0	1760.8
	0.1%	0.1%	0.1%	0.1%	0.5%	7.4%	1.8%	12.2%	0.8%	2.6%	0.6%	4.1%	58.8%	0.0%	0.0%	40.7%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	109.0	9.6	55.7	12.5	55.7	9.6	109.0	722.0	1169.7	1169.7	965.5	965.5	4992.4
	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%	0.2%	1.1%	0.2%	1.1%	0.2%	2.2%	14.5%	23.4%	23.4%	19.3%	19.3%	100.0%

Floor 17

Table D.13 Transfer of seismic inertia forces at Story 17 according to GB50011-2010

Cases (Ex9)	**Force to Wall through Axial Load in Beams**					**Force to Wall through Shear load in Beams**								**Slab in Axial Load**		**Slab in Shear**		**Total**
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	300.1	300.1	4.6	4.6	1209.6	1.6	2.4	2.8	3.0	2.8	2.4	1.6	33.1	0.0	0.0	0.0	0.0	1242.7
Td=1.846	24.1%	24.1%	0.4%	0.4%	97.3%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	153.0	273.6	-5.2	3.5	851.7	1.3	2.0	2.6	2.7	2.6	2.2	1.4	29.6	404.9	0.0	0.0	0.0	1286.1
Td=1.8443	11.9%	21.3%	-0.4%	0.3%	66.2%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	31.5%	0.0%	0.0%	0.0%	100.0%
Slab connected	0.5	0.5	2.6	2.6	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0	31.0	643.2	643.2	1355.2
Td=1.8755	0.0%	0.0%	0.2%	0.2%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	2.3%	47.5%	47.5%	100.0%
Slab Isolated(fixed)	300.3	300.3	4.6	4.6	1210.5	1.6	2.4	2.8	3.0	2.8	2.4	1.6	33.1	0.0	0.0	0.0	0.0	1243.6
Td=1.8445	24.1%	24.1%	0.4%	0.4%	97.3%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.7%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	153.2	273.9	5.2	3.5	862.7	1.3	2.0	2.6	2.7	2.6	2.2	1.4	29.6	406.9	0.0	0.0	0.0	1299.2
Td=1.8428	11.8%	21.1%	0.4%	0.3%	66.4%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	31.3%	0.0%	0.0%	0.0%	100.0%
Slab connected	0.5	0.5	2.6	2.6	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0	31.0	643.7	643.7	1356.3
Td=1.8743	0.0%	0.0%	0.2%	0.2%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	2.3%	47.5%	47.5%	100.0%

Cases (Ey9)	**Force to Wall through Shear in Beams**					**Force to Wall through Axial load in Beams**								**Slab in Shear**		**Slab in Axial load**		**Total**
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1.3	1.3	2.2	2.2	9.5	138.3	10.9	129.2	13.4	129.2	10.9	138.3	1140.3	0.0	0.0	0.0	0.0	1149.8
Td=3.0718	0.1%	0.1%	0.2%	0.2%	0.8%	12.0%	0.9%	11.2%	1.2%	11.2%	0.9%	12.0%	99.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	1.2	1.2	2.0	2.0	8.6	117.6	10.3	136.1	4.6	31.0	2.8	71.0	746.9	0.0	0.0	538.4	0.0	1293.9
Td=3.0440	0.1%	0.1%	0.2%	0.2%	0.7%	9.1%	0.8%	10.5%	0.4%	2.4%	0.2%	5.5%	57.7%	0.0%	0.0%	41.6%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	-16.1	-2.1	32.2	-3.7	32.15	-2.07	-16.05	48.8	574.0	574.0	196.5	196.5	1589.8
Td=3.0362	0.0%	0.0%	0.0%	0.0%	0.0%	-1.0%	-0.1%	2.0%	-0.2%	2.0%	-0.1%	-1.0%	3.1%	36.1%	36.1%	12.4%	12.4%	100.0%
Slab Isolated(fixed)	1.3	1.3	2.2	2.2	9.5	138.3	10.9	129.2	13.4	129.2	10.9	138.3	1140.5	0.0	0.0	0.0	0.0	1150.0
Td=3.0695	0.1%	0.1%	0.2%	0.2%	0.8%	12.0%	0.9%	11.2%	1.2%	11.2%	0.9%	12.0%	99.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	1.2	1.2	2.0	2.0	8.6	117.6	10.3	136.5	4.6	31.0	-2.8	71.0	736.5	0.0	0.0	538.6	0.0	1283.7
Td=3.0417	0.1%	0.1%	0.2%	0.2%	0.7%	9.2%	0.8%	10.6%	0.4%	2.4%	-0.2%	5.5%	57.4%	0.0%	0.0%	42.0%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	16.1	2.1	-32.2	3.7	-32.2	2.1	16.1	-48.8	574.2	574.2	196.6	196.6	1492.6
Td=3.0343	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.1%	-2.2%	0.2%	-2.2%	0.1%	1.1%	-3.3%	38.5%	38.5%	13.2%	13.2%	100.0%

Table D.14 Transfer of seismic inertia forces at Story 17 according to IBC2012/ASCE7-10

Cases (AISCx9)	**Force to Wall through Axial Load in Beams**					**Force to Wall through Shear load in Beams**								**Slab in Axial Load**		**Slab in Shear**		**Total**
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	482.7	482.7	6.0	6.0	1942.7	2.5	3.5	4.2	4.4	4.2	3.5	2.5	49.6	0.0	0.0	0.0	0.0	1992.3
Td=1.846	24.2%	24.2%	0.3%	0.3%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	249.2	441.0	-6.9	4.3	1377.7	2.0	3.0	3.7	4.0	3.8	3.2	2.3	44.1	599.1	0.0	0.0	0.0	2020.8
Td=1.8443	12.3%	21.8%	-0.3%	0.2%	68.2%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	29.6%	0.0%	0.0%	0.0%	100.0%
Slab connected	14.5	14.5	-2.8	-2.8	52.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.3	23.3	863.4	863.4	1825.9
Td=1.8755	0.8%	0.8%	-0.2%	-0.2%	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	1.3%	47.3%	47.3%	100.0%
Slab Isolated(fixed)	482.7	482.7	6.0	6.0	1942.7	2.5	3.5	4.2	4.4	4.2	3.5	2.5	49.6	0.0	0.0	0.0	0.0	1992.3
Td=1.8445	24.2%	24.2%	0.3%	0.3%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	249.1	441.0	-6.9	4.3	1377.6	2.0	3.0	3.7	4.0	3.8	3.2	2.3	44.1	599.1	0.0	0.0	0.0	2020.8
Td=1.8428	12.3%	21.8%	-0.3%	0.2%	68.2%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	29.6%	0.0%	0.0%	0.0%	100.0%
Slab connected	14.5	14.5	-2.8	-2.8	52.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0	24.0	865.3	865.3	1831.1
Td=1.8743	0.8%	0.8%	-0.2%	-0.2%	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	1.3%	47.3%	47.3%	100.0%

Cases (AISCy9)	**Force to Wall through Shear in Beams**					**Force to Wall through Axial load in Beams**								**Slab in Shear**		**Slab in Axial load**		**Total**
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	2.5	2.5	3.6	3.6	17.0	271.3	19.6	266.8	25.6	266.8	19.6	271.3	2282.0	0.0	0.0	0.0	0.0	2299.0
Td=3.0718	0.1%	0.1%	0.2%	0.2%	0.7%	11.8%	0.9%	11.6%	1.1%	11.6%	0.9%	11.8%	99.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	2.2	2.1	3.2	3.2	15.1	243.5	18.0	259.8	9.4	71.3	-3.7	141.5	1479.5	0.0	0.0	958.1	0.0	2452.7
Td=3.0440	0.1%	0.1%	0.1%	0.1%	0.6%	9.9%	0.7%	10.6%	0.4%	2.9%	-0.2%	5.8%	60.3%	0.0%	0.0%	39.1%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	-4.8	-2.1	69.3	-4.0	69.26	-2.08	-4.82	241.4	736.6	736.6	449.0	449.0	2612.6
Td=3.0362	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%	-0.1%	2.7%	-0.2%	2.7%	-0.1%	-0.2%	9.2%	28.2%	28.2%	17.2%	17.2%	100.0%
Slab Isolated(fixed)	2.5	2.5	3.6	3.6	17.0	271.3	19.6	266.8	25.6	266.8	19.6	271.3	2281.7	0.0	0.0	0.0	0.0	2298.6
Td=3.0695	0.1%	0.1%	0.2%	0.2%	0.7%	11.8%	0.9%	11.6%	1.1%	11.6%	0.9%	11.8%	99.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	2.1	2.1	3.2	3.2	14.9	243.4	18.0	259.8	9.4	71.3	-3.7	141.5	1479.3	0.0	0.0	958.0	0.0	2452.2
Td=3.0417	0.1%	0.1%	0.1%	0.1%	0.6%	9.9%	0.7%	10.6%	0.4%	2.9%	-0.2%	5.8%	60.3%	0.0%	0.0%	39.1%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	-5.2	-2.1	69.6	-4.0	69.6	-2.1	-5.2	241.6	740.2	740.2	449.1	449.1	2620.2
Td=3.0343	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%	-0.1%	2.7%	-0.2%	2.7%	-0.1%	-0.2%	9.2%	28.3%	28.3%	17.1%	17.1%	100.0%

Table D.15 Transfer of seismic inertia forces at Story 17 according to time history of Imperial Valley Earthquake in 1940

Cases (IMX)	**Force to Wall through Axial Load in Beams**					**Force to Wall through Shear load in Beams**								**Slab in Axial Load**		**Slab in Shear**		**Total**
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1004.7	1004.7	-7.8	-7.8	4003.2	5.2	6.3	7.1	7.2	7.1	6.3	5.2	88.9	0.0	0.0	0.0	0.0	4092.1
	24.6%	24.6%	-0.2%	-0.2%	97.8%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	530.8	920.1	-8.9	5.8	2898.8	4.2	5.2	6.2	6.4	6.4	5.7	4.7	77.7	1519.4	0.0	0.0	0.0	4495.9
	11.8%	20.5%	-0.2%	0.1%	64.5%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.7%	33.8%	0.0%	0.0%	0.0%	100.0%
Slab connected	134.4	134.4	5.1	5.1	547.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	400.8	400.8	1787.3	1787.3	4923.8
	2.7%	2.7%	0.1%	0.1%	11.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.1%	8.1%	36.3%	36.3%	100.0%
Slab Isolated(fixed)	1003.4	1003.4	-7.8	-7.8	3998.1	5.2	6.3	7.1	7.2	7.1	6.3	5.2	88.9	0.0	0.0	0.0	0.0	4087.0
	24.6%	24.6%	-0.2%	-0.2%	97.8%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	529.1	917.2	-8.9	-5.8	2877.8	4.2	5.2	6.2	6.4	6.4	5.7	4.7	77.6	1530.2	0.0	0.0	0.0	4485.6
	11.8%	20.4%	-0.2%	-0.1%	64.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.7%	34.1%	0.0%	0.0%	0.0%	100.0%
Slab connected	134.8	134.8	5.1	5.1	549.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	392.2	392.2	1831.4	1831.4	4996.6
	2.7%	2.7%	0.1%	0.1%	11.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.8%	7.8%	36.7%	36.7%	100.0%

Cases (IMY)	**Force to Wall through Shear in Beams**					**Force to Wall through Axial load in Beams**								**Slab in Shear**		**Slab in Axial load**		**Total**
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	5.6	5.6	4.6	4.6	31.7	679.4	34.5	698.6	54.7	698.6	34.5	679.4	5759.4	0.0	0.0	0.0	0.0	5791.1
	0.1%	0.1%	0.1%	0.1%	0.5%	11.7%	0.6%	12.1%	0.9%	12.1%	0.6%	11.7%	99.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	5.0	4.3	3.7	3.7	26.2	677.8	27.7	561.1	15.3	225.8	-3.6	365.6	3739.0	0.0	0.0	2320.4	0.0	6085.6
	0.1%	0.1%	0.1%	0.1%	0.4%	11.1%	0.5%	9.2%	0.3%	3.7%	-0.1%	6.0%	61.4%	0.0%	0.0%	38.1%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	148.6	-6.7	192.1	-9.5	192.1	-6.7	148.6	1316.9	1170.3	1170.3	1636.5	1636.5	6930.5
	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%	-0.1%	2.8%	-0.1%	2.8%	-0.1%	2.1%	19.0%	16.9%	16.9%	23.6%	23.6%	100.0%
Slab Isolated(fixed)	5.6	5.6	4.6	4.6	31.8	680.7	34.5	699.8	54.8	699.8	34.5	680.7	5769.8	0.0	0.0	0.0	0.0	5801.6
	0.1%	0.1%	0.1%	0.1%	0.5%	11.7%	0.6%	12.1%	0.9%	12.1%	0.6%	11.7%	99.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	5.0	4.3	3.8	3.8	26.3	679.3	27.8	562.5	24.3	226.2	3.6	366.4	3780.0	0.0	0.0	2330.6	0.0	6136.8
	0.1%	0.1%	0.1%	0.1%	0.4%	11.1%	0.5%	9.2%	0.4%	3.7%	0.1%	6.0%	61.6%	0.0%	0.0%	38.0%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	148.9	6.7	192.6	9.5	192.6	6.7	148.9	1411.6	1340.4	1340.4	1752.5	1752.5	7597.4
	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.1%	2.5%	0.1%	2.5%	0.1%	2.0%	18.6%	17.6%	17.6%	23.1%	23.1%	100.0%

Table D.16 Transfer of seismic inertia forces at Story 17 according to time history of Mexico City Earthquake in 1940

Cases (MEX)	**Force to Wall through Axial Load in Beams**					**Force to Wall through Shear load in Beams**								**Slab in Axial Load**		**Slab in Shear**		**Total**
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1407.1	1407.1	16.2	16.2	5660.8	7.3	10.0	11.7	12.2	11.7	10.0	7.3	140.4	0.0	0.0	0.0	0.0	5801.3
	24.3%	24.3%	0.3%	0.3%	97.6%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	728.4	1284.6	-18.4	11.3	4018.8	5.8	8.5	10.4	11.0	10.7	9.1	6.6	124.1	1936.4	0.0	0.0	0.0	6079.4
	12.0%	21.1%	-0.3%	0.2%	66.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	31.9%	0.0%	0.0%	0.0%	100.0%
Slab connected	67.4	67.4	6.9	6.9	283.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	319.4	319.4	2215.1	2215.1	5352.4
	1.3%	1.3%	0.1%	0.1%	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0%	6.0%	41.4%	41.4%	100.0%
Slab Isolated(fixed)	1403.5	1403.5	16.1	16.1	5646.2	7.3	10.0	11.7	12.1	11.7	10.0	7.3	140.1	0.0	0.0	0.0	0.0	5786.3
	24.3%	24.3%	0.3%	0.3%	97.6%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.4%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	726.7	1281.6	18.4	11.3	4046.2	5.8	8.5	10.4	11.0	10.6	9.1	6.6	123.9	1910.8	0.0	0.0	0.0	6080.9
	11.9%	21.1%	0.3%	0.2%	66.5%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	31.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	67.1	67.1	6.9	6.9	282.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	428.1	428.1	2544.0	2544.0	6226.3
	1.1%	1.1%	0.1%	0.1%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.9%	6.9%	40.9%	40.9%	100.0%

Cases (MEY)	**Force to Wall through Shear in Beams**					**Force to Wall through Axial load in Beams**								**Slab in Shear**		**Slab in Axial load**		**Total**
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	3.5	3.5	5.0	5.0	24.1	390.8	-27.6	385.5	-36.3	385.5	-27.6	390.8	2922.2	0.0	0.0	0.0	0.0	2946.3
	0.1%	0.1%	0.2%	0.2%	0.8%	13.3%	-0.9%	13.1%	-1.2%	13.1%	-0.9%	13.3%	99.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	3.4	3.2	4.6	4.6	22.5	381.1	26.6	395.0	13.6	113.4	-5.6	219.3	2286.6	0.0	0.0	1629.6	0.0	3938.8
	0.1%	0.1%	0.1%	0.1%	0.6%	9.7%	0.7%	10.0%	0.3%	2.9%	-0.1%	5.6%	58.1%	0.0%	0.0%	41.4%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	26.3	-3.6	109.9	-6.7	109.9	-3.6	26.3	517.0	530.2	530.2	1204.9	1204.9	3987.2
	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	-0.1%	2.8%	-0.2%	2.8%	-0.1%	0.7%	13.0%	13.3%	13.3%	30.2%	30.2%	100.0%
Slab Isolated(fixed)	3.5	3.5	5.0	5.0	24.1	392.7	-27.6	387.8	-36.4	387.8	-27.6	392.7	2938.8	0.0	0.0	0.0	0.0	2962.9
	0.1%	0.1%	0.2%	0.2%	0.8%	13.3%	-0.9%	13.1%	-1.2%	13.1%	-0.9%	13.3%	99.2%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	3.4	3.3	4.7	4.7	22.6	383.1	26.7	396.9	22.8	114.0	5.6	220.4	2338.8	0.0	0.0	1318.0	0.0	3679.5
	0.1%	0.1%	0.1%	0.1%	0.6%	10.4%	0.7%	10.8%	0.6%	3.1%	0.2%	6.0%	63.6%	0.0%	0.0%	35.8%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	26.3	3.6	110.4	6.7	110.4	3.6	26.3	574.4	1173.6	1173.6	1450.5	1450.5	5822.6
	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.1%	1.9%	0.1%	1.9%	0.1%	0.5%	9.9%	20.2%	20.2%	24.9%	24.9%	100.0%

Floor 26

Table D.17 Transfer of seismic inertia forces at Story 26 analyses according to GB50011-2010

Cases (Ex9)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1642.3	1642.3	22.9	22.9	6614.9	8.5	12.1	13.9	14.2	13.9	12.1	8.5	166.2	0.0	0.0	0.0	0.0	6781.0
Td=1.846	24.2%	24.2%	0.3%	0.3%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	863.3	1511.7	-3.0	19.9	4766.7	6.7	10.3	12.3	12.7	12.6	11.0	7.7	146.5	1801.6	0.0	0.0	0.0	6714.9
Td=1.8443	12.9%	22.5%	0.0%	0.3%	71.0%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	26.8%	0.0%	0.0%	0.0%	100.0%
Slab connected	133.4	133.4	10.8	10.8	555.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	156.9	156.9	2632.4	2632.4	6133.7
Td=1.8755	2.2%	2.2%	0.2%	0.2%	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	2.6%	42.9%	42.9%	100.0%
Slab Isolated(fixed)	1642.9	1642.9	22.9	22.9	6617.5	8.5	12.1	13.9	14.2	13.9	12.1	8.5	166.2	0.0	0.0	0.0	0.0	6783.7
Td=1.8445	24.2%	24.2%	0.3%	0.3%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	863.6	1512.3	3.0	19.9	4774.6	6.7	10.3	12.3	12.7	12.6	11.0	7.7	146.6	1792.6	0.0	0.0	0.0	6713.8
Td=1.8428	12.9%	22.5%	0.0%	0.3%	71.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.2%	26.7%	0.0%	0.0%	0.0%	100.0%
Slab connected	133.4	133.4	10.8	10.8	555.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	146.8	146.8	2633.0	2633.0	6114.9
Td=1.8743	2.2%	2.2%	0.2%	0.2%	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	2.4%	43.1%	43.1%	100.0%

Cases (Ey9)	Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	6.7	6.7	8.6	8.6	44.0	810.9	23.4	762.1	30.6	762.1	23.4	810.9	6447.0	0.0	0.0	0.0	0.0	6491.0
Td=3.0718	0.1%	0.1%	0.1%	0.1%	0.7%	12.5%	0.4%	11.7%	0.5%	11.7%	0.4%	12.5%	99.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	5.8	5.3	7.1	7.1	36.5	729.4	20.2	697.3	20.1	180.4	13.0	372.5	4065.7	0.0	0.0	2374.8	0.0	6476.9
Td=3.0440	0.1%	0.1%	0.1%	0.1%	0.6%	11.3%	0.3%	10.8%	0.3%	2.8%	0.2%	5.8%	62.8%	0.0%	0.0%	36.7%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	81.07	17.59	142.08	15.6	142.08	17.59	81.07	994.2	1080.5	1080.5	1516.0	1516.0	6187.1
Td=3.0362	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	0.3%	2.3%	0.3%	2.3%	0.3%	1.3%	16.1%	17.5%	17.5%	24.5%	24.5%	100.0%
Slab Isolated(fixed)	6.7	6.7	8.6	8.6	44.0	810.9	23.4	762.1	30.6	762.1	23.4	810.9	6447.0	0.0	0.0	0.0	0.0	6491.0
Td=3.0695	0.1%	0.1%	0.1%	0.1%	0.7%	12.5%	0.4%	11.7%	0.5%	11.7%	0.4%	12.5%	99.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	5.8	5.3	7.1	7.1	36.5	729.4	20.2	697.3	20.1	180.4	13.0	372.5	4065.7	0.0	0.0	2374.8	0.0	6476.9
Td=3.0417	0.1%	0.1%	0.1%	0.1%	0.6%	11.3%	0.3%	10.8%	0.3%	2.8%	0.2%	5.8%	62.8%	0.0%	0.0%	36.7%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	81.07	17.59	142.08	15.6	142.1	17.6	81.1	994.2	1080.5	1080.5	1516.0	1516.0	6187.1
Td=3.0343	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	0.3%	2.3%	0.3%	2.3%	0.3%	1.3%	16.1%	17.5%	17.5%	24.5%	24.5%	100.0%

Table D.18 Transfer of seismic inertia forces at <u>Story 26</u> according to IBC2012/ASCE7-10

Cases (AISCx9)	**Force to Wall through Axial Load in Beams**					**Force to Wall through Shear load in Beams**								**Slab in Axial Load**		**Slab in Shear**		**Total**
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	467.3	467.3	-16.4	-16.4	1836.4	2.4	3.3	3.9	4.0	3.9	3.3	2.4	46.2	0.0	0.0	0.0	0.0	1882.6
Td=1.846	24.8%	24.8%	-0.9%	-0.9%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	217.9	407.7	5.2	-17.0	1239.4	1.8	2.5	3.2	3.4	3.3	2.8	2.0	37.8	550.2	0.0	0.0	0.0	1827.4
Td=1.8443	11.9%	22.3%	0.3%	-0.9%	67.8%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.1%	30.1%	0.0%	0.0%	0.0%	100.0%
Slab connected	31.4	31.4	9.8	9.8	145.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	148.6	148.6	529.3	529.3	1501.0
Td=1.8755	2.1%	2.1%	0.7%	0.7%	9.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.9%	9.9%	35.3%	35.3%	100.0%
Slab Isolated(fixed)	467.4	467.4	-16.4	-16.4	1836.7	2.4	3.3	3.9	4.0	3.9	3.3	2.4	46.2	0.0	0.0	0.0	0.0	1882.9
Td=1.8445	24.8%	24.8%	-0.9%	-0.9%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	217.9	407.8	5.2	-17.0	1239.6	1.8	2.5	3.2	3.4	3.3	2.8	2.0	37.9	547.0	0.0	0.0	0.0	1824.5
Td=1.8428	11.9%	22.4%	0.3%	-0.9%	67.9%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.1%	30.0%	0.0%	0.0%	0.0%	100.0%
Slab connected	31.4	31.4	9.8	9.8	145.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	148.7	148.7	528.8	528.8	1500.2
Td=1.8743	2.1%	2.1%	0.7%	0.7%	9.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.9%	9.9%	35.2%	35.2%	100.0%

Cases (AISCy9)	**Force to Wall through Shear in Beams**					**Force to Wall through Axial load in Beams**								**Slab in Shear**		**Slab in Axial load**		**Total**
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	0.7	0.7	1.4	1.4	5.6	119.7	20.4	-50.9	11.8	-50.9	20.4	119.7	380.5	0.0	0.0	0.0	0.0	386.1
Td=3.0718	0.2%	0.2%	0.3%	0.3%	1.4%	31.0%	5.3%	-13.2%	3.1%	-13.2%	5.3%	31.0%	98.6%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	1.0	0.7	1.8	1.8	6.8	129.8	20.8	-20.0	-1.1	69.4	-16.6	131.9	628.5	0.0	0.0	147.5	0.0	782.7
Td=3.0440	0.1%	0.1%	0.2%	0.2%	0.9%	16.6%	2.7%	-2.6%	-0.1%	8.9%	-2.1%	16.8%	80.3%	0.0%	0.0%	18.8%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	47.0	17.0	-45.0	16.6	-45.0	17.0	46.99	108.9	427.1	427.1	440.0	440.0	1843.1
Td=3.0362	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%	0.9%	-2.4%	0.9%	-2.4%	0.9%	2.5%	5.9%	23.2%	23.2%	23.9%	23.9%	100.0%
Slab Isolated(fixed)	0.7	0.7	1.4	1.4	5.6	119.4	20.3	-51.1	11.8	-51.1	20.3	119.4	378.0	0.0	0.0	0.0	0.0	383.5
Td=3.0695	0.2%	0.2%	0.4%	0.4%	1.5%	31.1%	5.3%	-13.3%	3.1%	-13.3%	5.3%	31.1%	98.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	1.0	0.7	1.7	1.7	6.7	129.4	20.8	-20.3	-1.1	69.3	-16.6	131.7	626.5	0.0	0.0	177.6	0.0	810.9
Td=3.0417	0.1%	0.1%	0.2%	0.2%	0.8%	16.0%	2.6%	-2.5%	-0.1%	8.5%	-2.0%	16.2%	77.3%	0.0%	0.0%	21.9%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	47.0	-17.0	45.1	-16.6	45.1	-17.0	47.0	267.2	427.5	427.5	440.2	440.2	2002.6
Td=3.0343	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	-0.8%	2.3%	-0.8%	2.3%	-0.8%	2.3%	13.3%	21.3%	21.3%	22.0%	22.0%	100.0%

Table D.19 Transfer of seismic inertia forces at Story 26 according to time history of Imperial Valley Earthquake in 1940

Cases (IMX)	Force to Wall through Axial Load in Beams					Force to Wall through Shear load in Beams								Slab in Axial Load		Slab in Shear		Total
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1465.1	1465.1	22.6	22.6	5905.7	7.6	10.9	12.6	13.0	12.6	10.9	7.6	150.4	0.0	0.0	0.0	0.0	6056.1
	24.2%	24.2%	0.4%	0.4%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	765.2	1349.0	-18.1	-23.9	4186.3	5.9	9.2	11.1	11.7	11.4	9.9	6.9	132.3	2265.7	0.0	0.0	0.0	6584.3
	11.6%	20.5%	-0.3%	-0.4%	63.6%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%	2.0%	34.4%	0.0%	0.0%	0.0%	100.0%
Slab connected	107.6	107.6	-14.5	-14.5	401.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	248.8	248.8	2209.7	2209.7	5318.4
	2.0%	2.0%	-0.3%	-0.3%	7.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.7%	4.7%	41.5%	41.5%	100.0%
Slab Isolated(fixed)	1454.0	1454.0	22.6	22.6	5861.2	7.6	10.8	12.5	12.9	12.5	10.8	7.6	149.2	0.0	0.0	0.0	0.0	6010.3
	24.2%	24.2%	0.4%	0.4%	97.5%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.5%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	759.8	1352.6	18.1	23.9	4266.8	5.9	9.1	11.0	11.6	11.4	9.8	6.9	131.3	2237.1	0.0	0.0	0.0	6635.2
	11.5%	20.4%	0.3%	0.4%	64.3%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	33.7%	0.0%	0.0%	0.0%	100.0%
Slab connected	108.2	108.2	14.4	14.4	461.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	348.8	348.8	2096.8	2096.8	5352.8
	2.0%	2.0%	0.3%	0.3%	8.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	6.5%	39.2%	39.2%	100.0%

Cases (IMY)	Force to Wall through Shear in Beams					Force to Wall through Axial load in Beams								Slab in Shear		Slab in Axial load		Total
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	9.4	9.4	12.1	12.1	61.9	1071.3	19.1	1138.5	33.6	1138.5	19.1	1071.3	8982.7	0.0	0.0	0.0	0.0	9044.6
	0.1%	0.1%	0.1%	0.1%	0.7%	11.8%	0.2%	12.6%	0.4%	12.6%	0.2%	11.8%	99.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	8.4	7.5	10.5	10.5	53.0	995.0	19.0	1026.8	8.0	332.6	-12.9	550.0	5837.1	0.0	0.0	3939.4	0.0	9829.5
	0.1%	0.1%	0.1%	0.1%	0.5%	10.1%	0.2%	10.4%	0.1%	3.4%	-0.1%	5.6%	59.4%	0.0%	0.0%	40.1%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	84.2	-15.2	283.2	-13.8	283.2	-15.2	84.2	1381.6	1629.4	1629.4	2216.1	2216.1	9072.6
	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	-0.2%	3.1%	-0.2%	3.1%	-0.2%	0.9%	15.2%	18.0%	18.0%	24.4%	24.4%	100.0%
Slab Isolated(fixed)	9.4	9.4	12.1	12.1	61.9	1071.5	19.2	1138.5	33.6	1138.5	19.2	1071.5	8983.7	0.0	0.0	0.0	0.0	9045.6
	0.1%	0.1%	0.1%	0.1%	0.7%	11.8%	0.2%	12.6%	0.4%	12.6%	0.2%	11.8%	99.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	8.4	7.5	10.6	10.6	53.0	995.7	19.0	1027.4	20.0	332.9	12.9	550.5	5916.8	0.0	0.0	4019.2	0.0	9989.0
	0.1%	0.1%	0.1%	0.1%	0.5%	10.0%	0.2%	10.3%	0.2%	3.3%	0.1%	5.5%	59.2%	0.0%	0.0%	40.2%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	84.4	15.2	283.7	13.8	283.7	15.2	84.4	1560.7	1603.2	1603.2	2267.0	2267.0	9301.1
	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	0.2%	3.1%	0.1%	3.1%	0.2%	0.9%	16.8%	17.2%	17.2%	24.4%	24.4%	100.0%

Table D.20 Transfer of seismic inertia forces at Story 26 according to time history of Mexico City Earthquake

Cases (MEX)	**Force to Wall through Axial Load in Beams**					**Force to Wall through Shear load in Beams**								**Slab in Axial Load**		**Slab in Shear**		**Total**
Members	2A-C/4A-C	2I-K/4I-K	3A-C	3I-K	Total	C1-2/C4-5	D1-2/D4-5	E1-2/E4-5	F1-2/F4-5	G1-2/G4-5	H1-2/H4-5	I1-2/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	902.4	902.4	41.9	41.9	3693.3	4.5	6.3	7.5	7.8	7.5	6.3	4.5	88.8	0.0	0.0	0.0	0.0	3782.1
	23.9%	23.9%	1.1%	1.1%	97.7%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	408.1	775.8	-14.8	43.1	2396.1	3.3	4.7	6.0	6.4	6.2	5.3	3.8	71.3	1125.3	0.0	0.0	0.0	3592.7
	11.4%	21.6%	-0.4%	1.2%	66.7%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	31.3%	0.0%	0.0%	0.0%	100.0%
Slab connected	106.1	106.1	0.0	0.0	424.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	362.3	362.3	931.4	931.4	3011.6
	3.5%	3.5%	0.0%	0.0%	14.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0%	12.0%	30.9%	30.9%	100.0%
Slab Isolated(fixed)	903.2	903.2	41.9	41.9	3696.4	4.5	6.3	7.5	7.8	7.5	6.3	4.5	88.9	0.0	0.0	0.0	0.0	3785.3
	23.9%	23.9%	1.1%	1.1%	97.7%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	2.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	408.5	776.5	14.8	43.1	2428.0	3.3	4.7	6.0	6.4	6.2	5.3	3.8	71.4	1118.3	0.0	0.0	0.0	3617.7
	11.3%	21.5%	0.4%	1.2%	67.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	2.0%	30.9%	0.0%	0.0%	0.0%	100.0%
Slab connected	61.8	61.8	24.5	24.5	296.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	361.8	361.8	1129.5	1129.5	3278.8
	1.9%	1.9%	0.7%	0.7%	9.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.0%	11.0%	34.4%	34.4%	100.0%

Cases (MEY)	**Force to Wall through Shear in Beams**					**Force to Wall through Axial load in Beams**								**Slab in Shear**		**Slab in Axial load**		**Total**
Members	2A-C/2I-K	4A-C/4I-K	3A-C	3I-K	Total	C1-2/I1-2	D1-2/H1-2	E1-2/G1-2	F1-2/F4-5	E4-5/G4-5	D4-5/H4-5	C4-5/I4-5	Total	Line C	Line G	Line 2	Line 3	
Slab Isolated(pinned)	1.9	1.9	2.9	2.9	13.5	259.5	28.6	206.6	17.6	206.6	28.6	259.5	2014.0	0.0	0.0	0.0	0.0	2027.5
	0.1%	0.1%	0.1%	0.1%	0.7%	12.8%	1.4%	10.2%	0.9%	10.2%	1.4%	12.8%	99.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	2.1	1.7	3.3	3.3	14.2	270.2	30.4	168.2	-0.9	121.4	23.9	225.9	1678.1	0.0	0.0	2288.8	0.0	3981.0
	0.1%	0.0%	0.1%	0.1%	0.4%	6.8%	0.8%	4.2%	0.0%	3.0%	0.6%	5.7%	42.2%	0.0%	0.0%	57.5%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	73.0	-25.1	85.5	-24.3	85.5	-25.1	73.0	484.5	945.5	945.5	1622.3	1622.3	5620.1
	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	-0.4%	1.5%	-0.4%	1.5%	-0.4%	1.3%	8.6%	16.8%	16.8%	28.9%	28.9%	100.0%
Slab Isolated(fixed)	1.9	1.9	2.9	2.9	13.5	259.8	28.6	207.6	17.6	207.6	28.6	259.8	2019.1	0.0	0.0	0.0	0.0	2032.6
	0.1%	0.1%	0.1%	0.1%	0.7%	12.8%	1.4%	10.2%	0.9%	10.2%	1.4%	12.8%	99.3%	0.0%	0.0%	0.0%	0.0%	100.0%
Slab one-side connected	2.1	1.7	3.3	3.3	14.2	270.3	30.4	168.0	21.1	122.0	24.0	226.9	1725.1	0.0	0.0	2389.8	0.0	4129.1
	0.1%	0.0%	0.1%	0.1%	0.3%	6.5%	0.7%	4.1%	0.5%	3.0%	0.6%	5.5%	41.8%	0.0%	0.0%	57.9%	0.0%	100.0%
Slab connected	0.0	0.0	0.0	0.0	0.0	73.2	25.1	85.6	24.3	85.6	25.1	73.2	784.2	922.4	922.4	1580.3	1580.3	5789.6
	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	0.4%	1.5%	0.4%	1.5%	0.4%	1.3%	13.5%	15.9%	15.9%	27.3%	27.3%	100.0%