Two-Dimensional OpenSEES Numerical Models for Archetype Steel Buildings with Special Moment Frames

Prepared by

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Description of the archetype buildings:

This folder contains OpenSEES models of four archetype steel buildings designed with perimeter special moment frames (SMFs), with heights of 4, 8, 12 and 20-story. In summary, the buildings design parameters are as follows:

- Location: Downtown Los Angeles, CA (34.000º, -118.150º)
- Design codes: AISC (2010c, 2010b); ASCE (2010)
- Risk category: II (office)
- Importance factor: 1.0.
- Seismic Design Category: D_{max}
- Soil class: D
- Lateral force structural system: SMF designed with reduced-beam-section (RBS) connections as per AISC (2010a).
- Gravity framing system: the gravity columns and beams are assigned W14x90 and W24x55 sections, respectively. The interior gravity frame connections are designed as conventional single-plate shear tab beam-to-column connections.

Figure 1 below shows the typical plan view of the buildings as well as the elevation of the 4-story building. Note that the steel columns are spliced at the mid-height of odd-numbered stories except for the first-story as shown in Figure 1. Table 1 summarizes the member sizes of all four buildings.

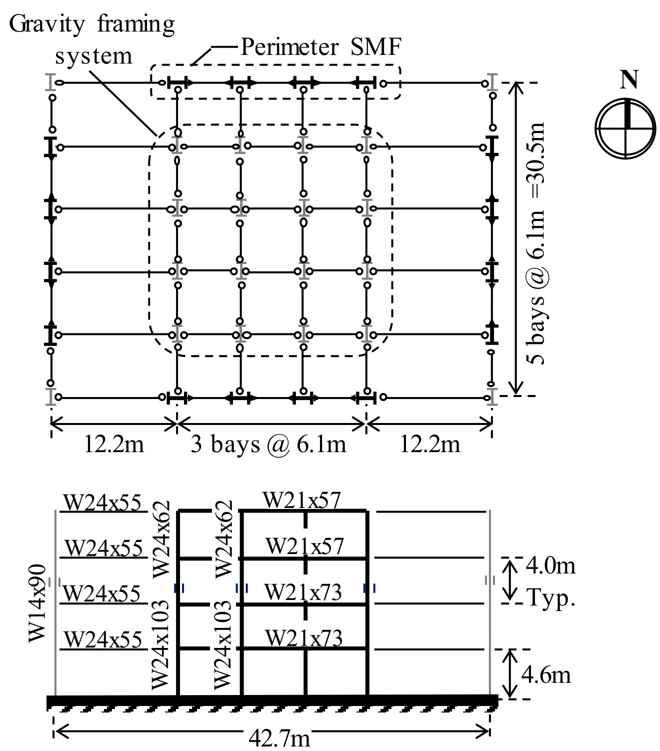

Figure 1. Typical layout of the archetype buildings

Table 1. Member sizes for the SMF of all the archetype steel frame buildings

Story	Elevation [m]	Beam size	Column size		Doubler Plate Thickness [mm]	
			Exterior	Interior	Exterior	Interior
4-Story						
4	16.3	W21x57	W24x62	W24x62	0.0	7.9
3	12.3	W21x57	W24x103	W24x103	0.0	7.9
2	8.3	W21x73	W24x103	W24x103	0.0	7.9
1	4.3	W21x73	W24x103	W24x103	0.0	7.9
8-Story						
8	32.2	W21x68	W24x94	W24x94	0.0	7.9
7	28.2	W24x84	W24x131	W24x131	0.0	14.3
6	24.2	W24x84	W24x131	W24x131	0.0	11.1
5	20.2	W27x94	W24x131	W24x176	0.0	14.3
4	16.2	W27x94	W24x131	W24x176	0.0	7.9
3	12.2	W30x116	W24x146	W24x192	1.6	15.9
2	8.2	W30x116	W24x146	W24x192	1.6	11.1
1	4.2	W30x108	W24x146	W24x192	0.0	9.5
12-Story						
12	48.2	W24x84	W24x84	W24x94	1.6	14.3
11	44.2	W24x84	W24x131	W24x131	1.6	14.3
10	40.2	W27x94	W24x131	W24x131	0.0	14.3
9	36.2	W27x94	W24x131	W24x176	0.0	14.3
8	32.2	W30x116	W24x131	W24x176	1.6	15.9
7	28.2	W30x116	W24x162	W24x207	1.6	15.9
6	24.2	W30x116	W24x162	W24x207	0.0	11.1
5	20.2	W30x116	W24x192	W24x250	0.0	11.1
4	16.2	W30x132	W24x192	W24x250	0.0	9.5
3	12.2	W30x132	W24x229	W24x279	1.6	9.5
2	8.2	W30x132	W24x229	W24x279	1.6	4.8
1	4.2	W30x124	W24x229	W24x279	0.0	1.6

Table 1. Member sizes for the SMF of all the archetype steel frame buildings (continue)

Story	**Elevation** [m]	**Beam size**	**Column size**		**Doubler Plate Thickness** [mm]	
			Exterior	**Interior**	**Exterior**	**Interior**
20-Story						
20	80.2	W24x68	W14x132	W27x129	1.6	0.0
19	76.2	W24x68	W14x193	W27x194	1.6	0.0
18	72.2	W33x130	W14x193	W27x194	25.4	25.4
17	68.2	W33x130	W14x233	W36x232	25.4	25.4
16	64.2	W33x130	W14x233	W36x232	15.9	20.6
15	60.2	W33x130	W14x283	W36x262	3.2	7.9
14	56.2	W33x152	W14x283	W36x262	0.0	9.5
13	52.2	W33x152	W14x311	W36x330	0.0	9.5
12	48.2	W33x152	W14x311	W36x330	0.0	6.4
11	44.2	W33x152	W14x370	W36x361	0.0	6.4
10	40.2	W33x152	W14x370	W36x361	0.0	3.2
9	36.2	W33x152	W14x370	W36x395	0.0	3.2
8	32.2	W33x152	W14x370	W36x395	0.0	0.0
7	28.2	W33x152	W14x455	W36x441	0.0	0.0
6	24.2	W33x141	W14x455	W36x441	0.0	0.0
5	20.2	W33x141	W14x455	W36x487	0.0	0.0
4	16.2	W33x141	W14x455	W36x487	0.0	0.0
3	12.2	W33x141	W14x500	W36x527	0.0	0.0
2	8.2	W33x130	W14x500	W36x527	0.0	0.0
1	4.2	W33x130	W14x500	W36x527	0.0	0.0

Description of OpenSEES files:

The user is provided by ready-to-run 2-dimensional OpenSEES models of four archetype steel buildings described above in the East-West direction. The names and summary descriptions of the provided files are as follows:

1) **Model Idealization and Notation.pdf**
   This file briefly describes the idealization of the SMF into a numerical model as well as employed the node and element notation.
2) **SMF[*n*]B.tcl and SMF[*n*]CG.tcl**
   These are the main TCL files of the buildings that the user would run using OpenSEES; **use OpenSEES.exe version 2.5.0 (rev 6536) or later versions**. For each *n*-story building, there are two files named SMF*n*B.tcl and SMF*n*CG.tcl. The SMF*n*B.tcl represents the bare steel building model (i.e., B models) while the SMF*n*CG.tcl represents the building model while considering the contributions of the composite action provided by the floor slab and the gravity framing system (i.e., CG models) as discussed in Elkady and Lignos (2014, 2015). Other numerical modeling guidelines for the bare steel beams and columns can be found in Lignos and Krawinkler (2011); Lignos et al. (2019). Further details can be found in Elkady (2016).
3) **Spring_***.tcl**
   These subroutines are used by the main files to create different types of zero-length springs between nodes.
4) **Construct_Panel.tcl**
   This subroutine is used by the main files to construct the nodes and elements of column-web panel zone.
5) **DynamicAnalysisCollapseSolver.tcl**
   This subroutine is used by the main files to run dynamic analysis and iterate between numerical solvers and time steps to solve convergence problems.
6) **MaxDriftTester.tcl**
   This subroutine is used by the DynamicAnalysisCollapseSolver.tcl to get the maximum drift reached in each story and check for collapse.
7) **DisplayModel3D.tcl and DisplayPlane**
   These subroutines are used by the main files to visualize the numerical model.
8) **NR94cnp.txt**
   This is only a supplemental file that contains the acceleration history for the Canoga Park record, Northridge Earthquake. This file can be used to test-run the dynamic analysis using the provided main files.

NOTE: The numerical models are creates in units of **kip** and **inches**.

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- Lignos, D. G., Hartloper, A., Elkady, A., Hamburger, R., and Deierlein, G. G. (2019). "Proposed updates to the asce 41 nonlinear modeling parameters for wide-flange steel columns in support of performance-based seismic engineering." *Journal of Structural Engineering*, 145(9), DOI: 10.1061/(ASCE)ST.1943-541X.0002353.
- Lignos, D. G., and Krawinkler, H. (2011). "Deterioration modeling of steel components in support of collapse prediction of steel moment frames under earthquake loading." *Journal of Structural Engineering*, 137(11), 1291-1302, DOI: 10.1061/(ASCE)ST.1943-541X.0000376.