The Effect of Seismic Masses in Calculation of a 17 Multi-story Concrete Structure

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Keywords: Mass Source, Self and Specified Mass, from Loads, Equivalent Lateral Force, Story Shear, Story Drift.

Abstract: The seismic weight according to code will be used for seismic calculation and defined by mass source. The application in ETABS has a 3-ways to define seismic mass: 1. From self and specified mass, 2. From loads. 3. From self and specified mass and loads. If the mass source is not defined properly, seismic forces will not be calculated correctly and so the base shear value will also be incorrect. The purpose of this article is to obtain the mass source from 3-ways in ETABS which is near to the manually calculated Mass and its effects. The case study is a 17 multi-story building, and from the results of the analysis and discussion it is concluded that: the lowest time period, equivalent lateral force, story shear, story drift are the 'From self and specified mass', followed by the 'From load with DL+0.5 LL'. Next is the 'Self and specified mass and load with DL+0.5 LL', and the last is 'Self and specified mass and load with DL+ LL'. The value of 'From load with DL+0.5 LL' is near to the manually calculated Mass with 'DL+LL', and thus corresponds to the recommendation by ASCE 7–10.

1 INTRODUCTION

Mass source is a seismic weight according to code and performed for seismic analysis. ASCE 7–10 requires the effective seismic weight including dead load and other load, in this case other load is LL reduction, so the value of reduction factor f is for LL is determined. The load here will be used for seismic calculations. In the application of software ETABS there are 3 ways to define seismic mass: 1. From self and specified mass, 2. From loads. 3. From self and specified mass and loads.

Each choice has different consequences in inputting Self weight, Dead load and Live load. For example if From loads is chosen then the load S can be assigned that refer to dead weight type (self-weight included) and also the live load cases as per code with the appropriate factor based on governing condition (Computers and Structures Inc., n.d.).

The purpose of this article is to obtain the mass source with a near to mass calculated manual from 3-ways option in ETABS. The case study is a 17 multi-story building where until the 10th story, the mass becomes one mass and from the 11th to the 17th story, the mass becomes 2-tower and the structure will be a dual system.

ASCE 7–10 use 'DL + 0.25 LL' for seismic masses, which LL for gravity combination can reduce with factor 0.5. The seismic weight/mass that is calculated using ETABS is then verified using an analytical method which is called Mass calculated manual. Self-weight has default of 'DL + f LL', Specified Load patterns must select 'DL + f LL', and additional mass due to surface loads line loads.

In ETABS consider full (100%) of dead load and 25% of live load (less than 3kN/m^2), and if the live load exceeds 3kN/m^2 then the mass source will be full (100 %) of dead load and 50 % of live load. Usually only full of dead load is enough for normal buildings, but needed to consider all the Live loads and Dead loads that are permanent. For example permanent mechanical equipment as live load then consider

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them in mass source too. If a portion of live load is assumed to be sustained for example where LL is heavy like in malls, a portion of LL should also be considered. So, any load that is deemed to be permanent needs to be considered in seismic calculation (Akis, 2004; Nageh, 2007).

These 3-ways choices each have the purpose to input the load cases in each choice. Everyone can use each 3-way choice with different load cases. The load option is the one generally recommended by people familiar with ETABS. The reason is because the default "From self and specified mass" option means that additional mass has to be manually assigned, and that involves unit conversion for mass assignments.

The third option "From self and specified mass and loads" is dangerous because many users tend to include the dead self-weight in that list, thereby double counting self-weight in the mass model. The users can detect it in the warning while checking the model showing the sentence "Mass source has both element self-mass and a load pattern with a self-weight multiplier greater than zero. This may result in duplicated self-mass. If it is true, while checking the model it will show the sentence "Model has been checked", and no warning messages were generated.

2 LITERATURE STUDY

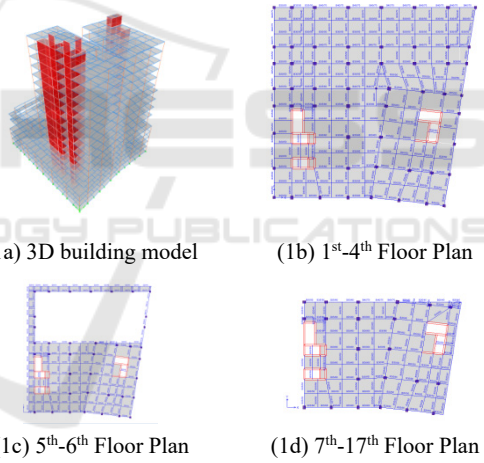
Mass values consist of structural elements which have volume and material density. In dynamic analysis, mass translation and rotation with acceleration to create inertial forces. For the purpose of estimating seismic loads standard ASCE 7-10 requires calculating the effective seismic weight which includes dead load, partitions and permanent equipment, plus 25% of the floor live load in areas used for storage (MacLeod, 1970; Somers, 2012; Wight & MacGregor, 2012).

This contribution of live load as inertia seems to be correlated with the low likelihood that live load objects be present at the time of the designed earthquake. However, for storage and some commercial facilities live loads may continuously be present and even exceed the dead load. Seismic mass source is a parameter that used both for calculation of seismic loads using Equivalent Lateral Force Method and Responses Spectrum Analysis (American Society of Civil Engineering, 2010; Atkins Structural Department, 2007; Budiono & Supriatna, 2011; Wiyono, R.D., Roi, C. M., & Lesmana, 2018).

Mass source is the structural weight and the seismic loads are calculated based on the specified mass of the building. ASCE 7/IBC requires for another load as storage which is 0.25LL (not be included in the effective seismic weight if increasing of storage loads adds no more than 0.05, garages and parking need not be included in the effective seismic weight. Partition weight (10 psf) is required and the weight of operation of permanent equipment. The loading combination of 1.2D + E + 0.5L + 0.25S for all occupancies in accordance with Table 4-1 ASCE 7–10 less than or equal to 4,79kN/m^2.

3 ANALYTICAL MODEL

In this case study, a 17 multi-story building with two elevator shafts in the left side and the right side of floor plan building load has been calculated from the code (American Society of Civil Engineering, 2010; Badan Standarisasi Nasional, 2012). The mass source until the 10th story is one mass. After that from the 11th to the 17th floor, the mass will become two towers. The 3D structure given in Figure 1 shows the plan of each floor.



(1a) 3D building model (1b) 1st-4th Floor Plan

(1c) 5th-6th Floor Plan (1d) 7th-17th Floor Plan

Figure 1: Building model and floor plane data.

4 RESULTS AND DISCUSSION

Table 1 shows the manually calculated Mass and in Table 2 is shown the time periods. The lowest time period is 'From self and specified mass', after that 'From load with DL + 0.5 LL', next is the 'Self and specified mass and load with DL + 0.5 LL', and the last is 'Self and specified mass and load with 1 LL'. From this table can be seen that the period of Mass calculated manual DL + LL is near to From load with DL + 0.5 LL.

Table 1: Manual Calculation of Mass.

Floor	Self-Weight (DL) (kg/m^2)	SDL (kg/m^2)	LL (kg/m^2)	Total Area (m^2)	Total Weight (kg)
17	27072	150	250	94	64672
16	65952	150	250	229	157552
15	222912	150	250	774	532512
14	222912	150	250	774	532512
13	222912	150	250	774	532512
12	222912	150	250	774	532512
11	222912	150	250	774	532512
10	222912	150	250	774	532512
9	273600	150	250	950	653600
8	269856	150	250	937	644656
7	269856	150	250	937	644656
6	269856	150	250	937	644656
5	338112	150	500	1174	1101212
4	522144	150	500	1813	1700594
3	360864	150	500	1253	1175314
2	262368	150	500	911	854518
1	608904	0	500	1933	1575404
0	642132	0	500	1836.2	1560232

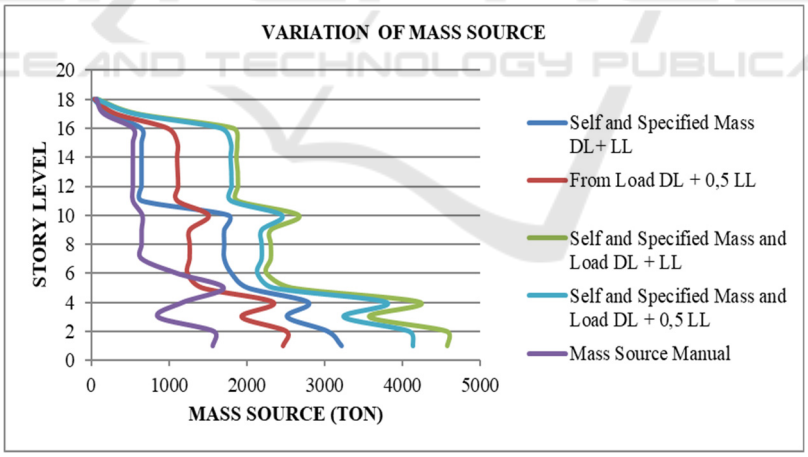


Figure 2: Variation of mass source.

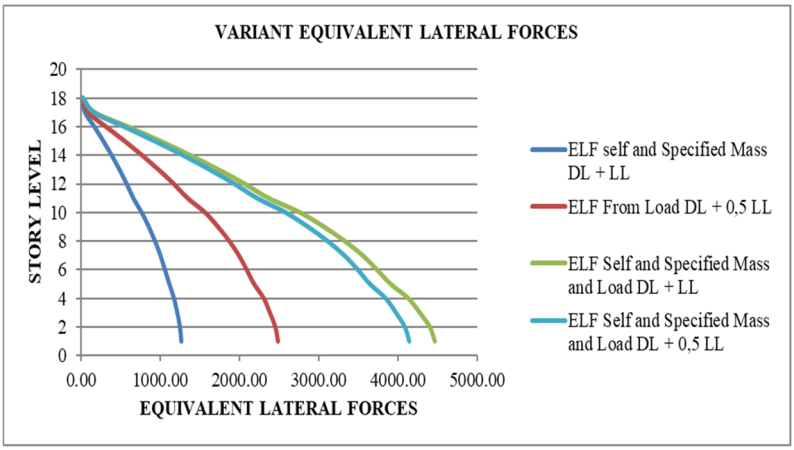


Figure 3: Variation ofequivalent lateral forces.

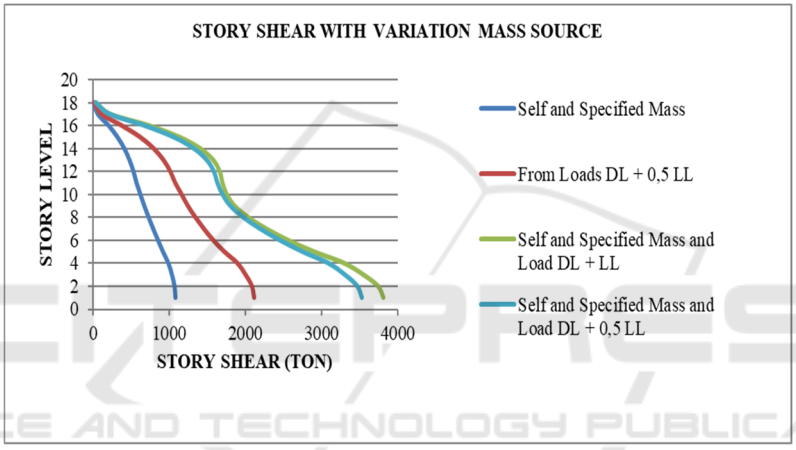


Figure 4: Story shear with variation mass source.

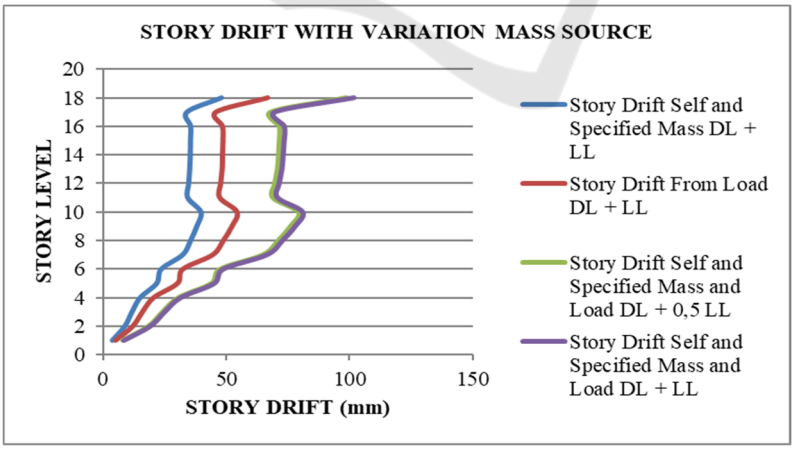


Figure 5: Story drift with variation mass source.

Table 2: Time Period from Varian Masses.

Mode / Mass Source Condition	1	2	3
Self and Specified Mass Default DL + LL	1.411	1.048	0.74
From Loads DL + 0.5 LL	1.732	1.302	0.89
Self and Specified Mass and Loads DL + 0.5 LL	2.234	1.67	1.16
Self and Specified Mass and Loads DL + LL	2.298	1.72	1.19
Mass Source Manual DL + LL	1.7		

Figure 2 shows the mass sources. The mass is calculated manually as a comparison. So, from the value of 'Self and specified', the mass is 22.10% lower. The value of 'From load with DL + 0.5 LL' is 2.75% bigger than the value of 'Self and specified' mass. The 'load with DL + 0.5 LL' is 72.43% and the 'Self and specified mass and load with DL + LL' is 84.42%.

Figure 3 shows the Equivalent Lateral Load. The mass is manually calculated as comparison. The value of 'From self and specified mass' is 47.28% lower. The value of 'From load with DL + 0.5 LL' is 2.11% bigger. The value of 'Self and specified mass and load with DL + 0.5 LL' is 71.57% and the value of 'Self and specified mass and load with DL + LL' is 84.19%.

Figure 4 shows the story shear. Because the value of 'Mass manually calculated Dl + LL' is near to the value of 'From load with DL + 0.5 LL', so it is assumed that the value of Story shear of 'From load' is the same as the comparison. And thus, the value of 'From self and specified mass' is 28,56 % lower. The value of 'Self and specified mass and load with DL + 0.5 LL' is 64,16% and finally the value of 'Self and specified mass and load with DL + LL' is 72,75%.

Figure 5 shows the story drift. Because the 'Mass calculated manual DL + LL' is near to the 'From load with DL + 0.5 LL', it is assumed that the value of 'Story drift From load with DL + LL' is the same as the comparison. So, the value of 'From self and specified mass' is 27,25% lower, then the value of 'Self and specified mass and load with DL + 0.5 LL' is 47,64%. And finally the value of 'Self and specified mass and load with DL + LL' is 51,94%.

4 CONCLUSIONS

From the results of the analysis and discussion it is concluded that:

1. The lowest time period is 'From self' and 'specified mass', after that 'From load with DL +0.5 LL', next is the 'Self and specified mass and load with DL + 0.5 LL', the last is 'Self and specified mass and load with DL + LL'. From Table 2 can be seen that the period of 'Mass calculated manual DL + LL' is near to 'From load with DL + 0.5 LL'.
2. Based on the Chosen Mass which is manually calculated 'DL + LL' as the comparison, the value of 'From self and specified' mass is 22.10% lower, then the value of 'From load with DL + 0.5 LL' is bigger 2.75%, followed by the 'Self and specified mass and load with DL + 0.5 LL' which is 72.43 % and finally the value of 'Self and specified mass and load with DL + LL', which is 84.42%.
3. If the Mass is manually calculated 'DL + LL' as a comparison of the Equivalent Lateral Force, the value of 'From self and specified mass' is 47.28% lower, then the 'From load with DL + 0.5 LL', which is 2.11% bigger/. Followed by the value of 'Self and specified mass and load with DL + 0.5 LL', which is 71.57% and finally the value of 'Self and specified mass and load with DL + LL' which is 84.19%.
4. Because the Mass which is manually calculated 'DL + LL' is near to the value of 'From load with DL + 0.5 LL', it is assumed that the value of 'Story shear of the From load is the same as the comparison. The value of 'Self and specified mass' is 28.56% lower, followed then by the value of 'Self and specified mass and load with DL + 0.5 LL' which is 64.16% and finally the value of 'Self and specified mass and load with DL + LL', which is 72.75%.
5. Because the Mass which is manually calculated 'DL + LL' is near to the value of 'From load with DL + 0.5 LL', it is assumed that the value of Story drift of 'From load' is the same and as the comparison. The value of 'Self and specified mass' is 27.25% lower, followed then by 'Self and specified mass and load with DL + 0.5 LL', which is 47.64 %, and finally the value of 'Self and specified mass and load with DL + LL', which is 51.94%.
6. Since the model calculation of 'Load with DL + 0.5 LL' is near to Mass which is manually calculated with 'DL + LL', it corresponds to the recommendation of ASCE 7–10.

REFERENCES

Akis, T. (2004). *Lateral Load Analysis of Shear Wall - Frame Structures.* The Middle East Technical University.

American Society of Civil Engineering. (2010). *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7–10)*. American Society of Civil Engineering.

Atkins Structural Department. (2007). *Manual For Analysis & Design Using ETABS.*

Badan Standardisasi Nasional. (2012). *Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan non gedung (SNI 1726:2012)*. Badan Standardisasi Nasional (BSN).

Budiono, B; Supriatna, L. (2011). *Studi Komparasi Desain Bangunan Tahan Gempa dengan Menggunakan SNI 03-1726-2002 dan RSNI 03-1726-201X*. Penerbit ITB.

Computers and Structures Inc. (n.d.). *CSI ETABS, Concrete Shearwall Design Manual*. University Avenue.

MacLeod, A. (1970). *Shear Wall-Frame Interaction A DESIGN AID*.

Nageh, M. (2007). *How to Model and Design High Rise Building Using ETABS Program*. Scientific Book House For Publishing and Distributing.

Somers, P. (2012). *Reinforced Concrete-Instructional Materials Complementing FEMA P-751, Design Examples*. FEMA.

Wight, J. K. & MacGregor, J. G. (2012). *Reinforced Concrete: Mechanics and Design, 6th Edition*. Pearson Education, Inc.

Wiyono, R.D., Roi, C. M., & Lesmana. (2018). The Effect of Shear Wall Configuration on Seismic Performance in the Hotel Building. *The 2nd International Joint Conference on Advanced Engineering and Technology (IJCAET 2017) and International Symposium on Advanced Mechanical and Power Engineering (ISAMPE 2017*.