

## SURAT - TUGAS

Nomor: 214-D/1005/FT-UNTAR/II/2021

Dekan Fakultas Teknik Universitas Tarumanagara, dengan ini menugaskan kepada Saudara:

**Ir. Sunarjo Leman, M.T.**

Untuk melaksanakan **Mempresentasikan Hasil Penelitian** dengan data sebagai berikut:

Judul Makalah : The Effect of Using Composite Column for Enhancing Structural Stiffness  
Nama Seminar : The 3 rd Tarumanagara International Conference on the Applications of Technology and Engineering (TICATE) 2020  
Penyelenggara : Universitas Tarumanagara  
Peran : Pemakalah (Presenter)  
Waktu Pelaksanaan : 03 - 04 Agustus 2020

Demikian Surat Tugas ini dibuat, untuk dilaksanakan dengan sebaik-baiknya dan melaporkan hasil penugasan tersebut kepada Dekan Fakultas Teknik Universitas Tarumanagara.

18 Februari 2021

Dekan



Harto Tanujaya, S.I., M.T., Ph.D.

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**Tarumanagara International Conference  
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*for the contribution as*

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*Paper Title :*

The Effect of Using Composite Column for Enhancing Structural Stiffness

August 3<sup>rd</sup> - 4<sup>th</sup>, 2020

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To cite this article: Christian Juniarto and Sunarjo Leman 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **1007** 012049

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# The Effect of Using Composite Column for Enhancing Structural Stiffness

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**Abstract.** The aims from this study is to determine which story has the greatest effect on the structure by using a structural column from composite material that is consist of steel and concrete combined together. Using the help of MIDAS GEN software to do the structural analysis. 5 models were made to capture the lateral displacement due to earthquake loading using linear dynamic procedure. Model 1 is a steel only structure followed by next model using composite materials starting from the bottom 2 floors (model 2) , 4 floors (model 3), 6 floor (model 4), all floors (model 5). From all of the models that is used, we can conclude that the bottom 2 story is the one that has greatest impact in lowering the lateral displacement.

## 1. Introduction

By combining 2 or more materials we can make a new one called composite materials. In civil engineering it's quite usual for combine steel and concrete together to take advantages of the two, because they have their own weakness such as lack of stiffness for steel structure moment frame, meanwhile for reinforce concrete, it's usually take much more space because concrete as a material has a lower capacity than steel. But sometimes we don't really have to use composite structure especially column in all story of the buildings. It can be used in the lower portion of the buildings, because the lower story will tend to have more capacity and stiffness demand than the upper one.

## 2. Material

Steel materials that is used refer to ASTM standard with A572-50 grade, the specification for A572-50 type is 345 Mpa for  $F_y$  and 450 Mpa for  $F_u$ , with modulus of elasticity ( $E_s$ ) 200000 Mpa. For concrete, this study use  $F'_c$  30 with compression stress up to 30 Mpa and modulus of elasticity ( $E_c$ ) 25643 Mpa.

## 3. Structure Modelling

In this study, the buildings consist of 8 story located in Serang, with soft soil classification. The story height is 3.5 m high, the loading type is dead load, live load, and earthquake load. The boundary condition at the base is taken as hinge that restraint 3 degree of freedom (translation in x, y, and z direction). The beam and column connection is assume as rigid connection.



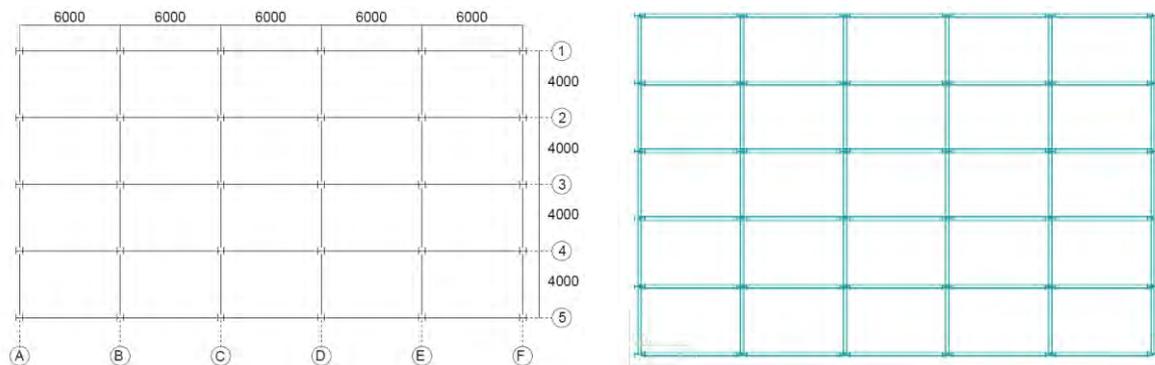


Figure 1. Floor Plan and Midas Gen Model

3.1. Member dimension

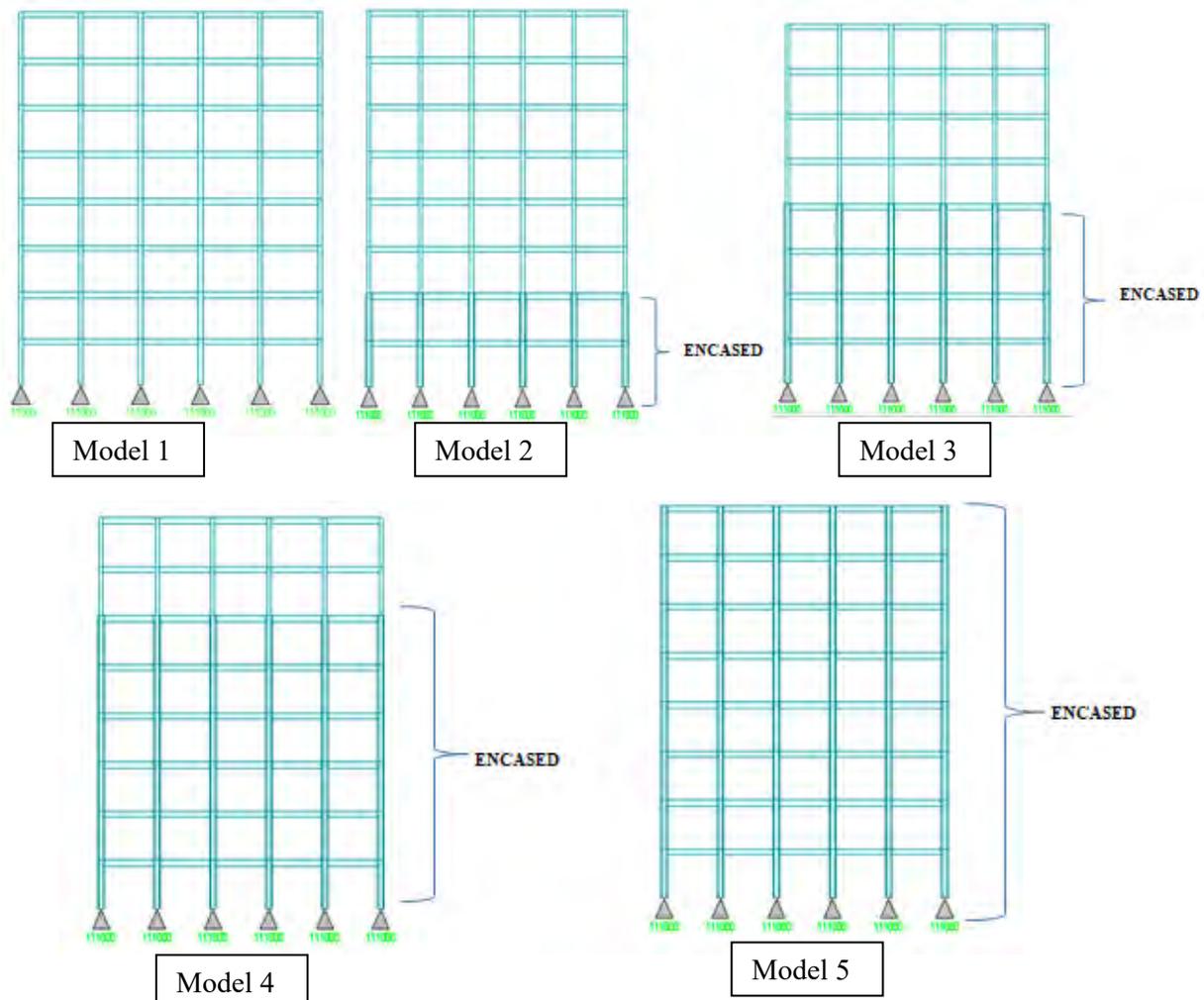
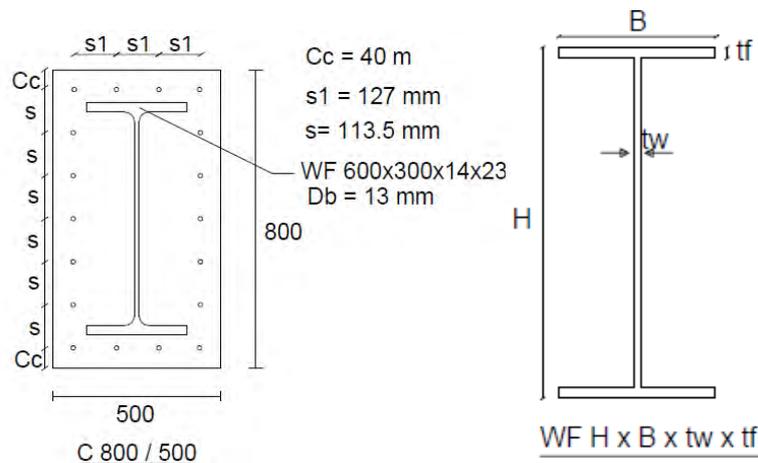


Figure 2. 5 models of structure

In **Figure 2.** 5 models of structure it's shown all the models of the structure, for the steel profile the author assign WF 450x200x09x14 for beams, meanwhile for the steel columns the author assign WF 600x300x14x23, and last for encased composite column the structure models use C 800/500, the section for the profile member is shown in **Figure 3.** Member Dimension.



**Figure 3.** Member Dimension

### 3.2. Gravity Load and Seismic Load

The gravity loading consist of live load base on rooms and corridors type of loading, and dead load plus superimposed dead load that work on whole floor plan in the structure and present in **Table 1.** Gravity Load. For seismic load, the author input the parameter to the MIDAS GEN and the force result from the analysis is on **Table 2.** Story Forces (kN).

**Table 1.** Gravity Load

Story	Live Load
2	Room 1.92 kN/m <sup>2</sup>
	Corridor 4.8 kN/m <sup>2</sup>
3-8	Room 1.92 kN/m <sup>2</sup>
	Corridor 4.8 kN/m <sup>2</sup>
Dead Load	
wall	2.5 kN/m <sup>2</sup>
Slab	4.32 kN/m <sup>2</sup>
SDL	
ceramic	1.1 kN/m <sup>2</sup>
Mechanical	0.19 kN/m <sup>2</sup>
Ceiling	0.1 kN/m <sup>2</sup>
Hanger	0.05 kN/m <sup>2</sup>
SDL Total	1.44 kN/m <sup>2</sup>

(Sumber: ASCE 7-10, 2010)

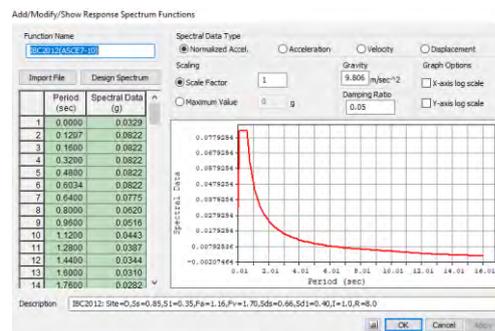


Figure 4. Design Spectrum Input Data

Table 2. Story Forces (kN)

Story	Model 1		Model 2		Model 3		Model 4		Model 5	
	Ex	Ey								
8	282.83	134.02	298.35	228.62	302	230.72	299.38	233.73	310.33	227.63
7	219.74	116.89	229.7	176.8	233.19	184.57	228.42	179.75	254.76	208.01
6	158.1	97.15	162.03	122.29	165.26	141.11	173.48	139.45	179.55	164.72
5	121.52	83.75	122.32	91.54	123.75	106.39	144.89	136.3	135.84	132.61
4	103.39	73.98	103.09	76.67	111.22	88.03	123.04	121.73	114.96	111.3
3	97.2	67.01	96.61	69.41	115.48	98.15	114.59	109.49	108.86	101.47
2	97.52	62.41	107	73.27	117.9	97.17	114.4	100.25	111.1	97.46
1	67.3	52.45	81.6	76.86	81.5	77.76	79.2	78.2	78.1	79.1

#### 4. Lateral Displacement

Lateral displacement is computed on x direction due to seismic loading on the x direction (Ex), and also displacement on y direction due to seismic load Ey acting on y axes. The author taking the values of lateral displacement on the center of mass of structure due to the simetrical configuration. The lateral displacement is calculated using respons spectrum load with dead load, SDL, and 50% of live load is present as an assumption for the load case. The lateral displacement is calculated by equation [1]:

$$\delta_i = \delta_{ei} C_d / I_e \quad (1)$$

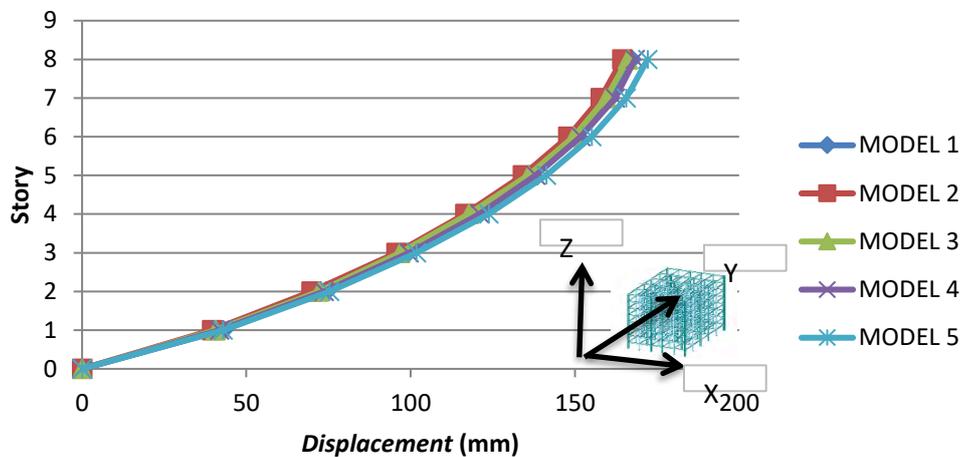
with  $\delta_i$  = Lateral displacement at story i,  $C_d$  = Amplification factor for deflection,  $I_e$  = Importance factor.

##### 4.1. Lateral displacement on x direction

The values for the lateral displacement in x direction due to Ex is on **Table 3**. Lateral Displacement on x Direction, and the graph of the lateral displacement is on **Figure 5**. Lateral displacement on x direction graph.

**Table 3.** Lateral Displacement on x Direction

Story	Model 1	Model 2	Model 3	Model 4	Model 5
8	167.2	164.45	166.1	168.3	172.15
7	160.6	157.85	159.5	162.25	165.55
6	150.7	147.95	149.6	151.8	155.1
5	136.95	134.2	135.85	138.05	141.35
4	119.9	116.6	117.7	121	123.75
3	99.55	95.7	96.8	99.55	101.75
2	74.25	69.85	72.05	73.7	75.35
1	42.9	39.6	40.7	41.8	42.9

**Figure 5.** Lateral displacement on x direction graph

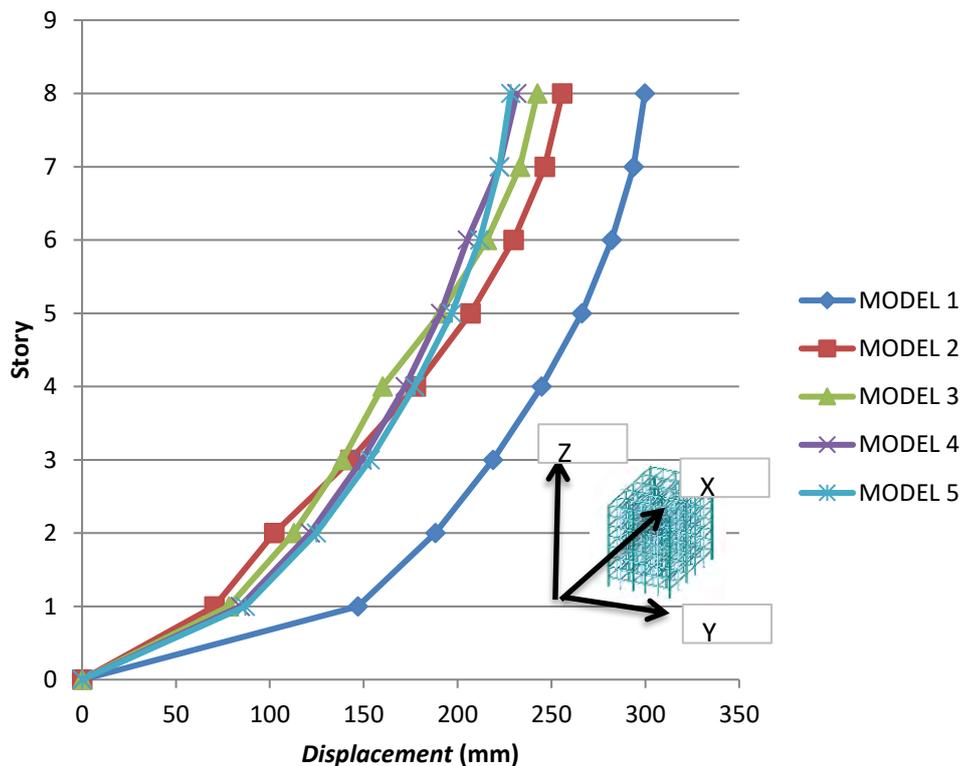
Shown in the **Figure 5**. Lateral displacement on x direction graph there is no significant changes in 5 models. If we choose roof displacement as the target point, we can see that the lowest value is reach on the 2<sup>nd</sup> model that is 164.46 mm.

#### 4.2. Lateral displacement on y direction

The values for the lateral displacement in x direction due to  $E_x$  is **Table 4**. Lateral Displacement on y Direction, and the graph of the lateral displacement is on **Figure 5**. Lateral displacement on x direction graph.

**Table 4.** Lateral Displacement on y Direction

Story	Model 1	Model 2	Model 3	Model 4	Model 5
8	271.7	218.9	209.55	200.2	196.9
7	266.2	211.2	201.3	191.95	191.95
6	256.3	196.9	185.9	177.1	183.15
5	242	177.1	164.45	165	169.95
4	223.3	151.8	137.5	149.05	153.45
3	200.2	121.55	119.35	129.25	133.1
2	173.8	86.9	97.9	106.15	108.9
1	138.05	61.05	68.75	74.8	77



**Figure 6.** Lateral displacement on x direction graph.

In y direction, the biggest lateral displacement on the target point is 271.7 mm located in model 1, and the lowest is 196.6 mm in model 5. The most significant change happens in model 2 compared to model 1, there is a reduction in the target point displacement from 271.7 to 218.9. Meanwhile the other models do not really have a significant impact in reducing the displacement.

## 5. Conclusion

It is shown that even if we choose a higher stiffness member, it won't really mean that the lateral displacement will always be smaller. Because the mass also participates in the dynamic characteristic of structures. And from this study, we can conclude that the lowest 2<sup>nd</sup> story is the one that has the greatest impact on lowering the lateral displacement for a structural building in an 8-story tall building.

## References

- [1] Badan Standardisasi Nasional *SNI 1726:2012 Tata Cara Ketahanan Gempa untuk Bangunan Gedung dan Non Gedung* (Jakarta: BSN)
- [2] *ASCE 7-10, Minimum Design Load for Buildings and Other Structures*. (Reston Virginia: American Society of civil engineers)