ANALYSIS OF CONNECTOR BRIDGE COLUMN THAT CONNECTING TWO MULTISTORY BUILDING

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Abstract – Concrete is the most widely used construction material in the world and the main use of concrete in construction industry has more advantages compared with other materials. Nowadays, many multistory buildings are being built using concrete materials. Sometimes the neighboring multistory buildings need bridge as connector to transport people or commodities. Indonesia is located in an earthquake zone, so that such connector-bridge linking two neighboring buildings must be strong and safe during and after an earthquake. The main objective of this research is to analyze the columns of the bridge which are connected with two different bridges structure system. The first bridge (building model-1) is designed with using column-beam system with masonry-wall, while the second bridge (building model-2) is designed with using deep beam system. Structural design of this building is designed according to National Standards of Indonesia SNI 1726:2012 by using equivalent static analysis and response spectrum analysis. From the comparison of result analysis for both of the building can be concluded that bridge of building model-2 have a better result than bridge of building model-1. It is because building model-2 has a better behavior and the deep beam which is using in connector bridge for building model-2 work effectively to reduce axial force, shear force, and bending moment in bridge column.

Index Terms – Multistory building; bridge; column-beam system bridge; deep beam system bridge.

I. INTRODUCTION

Concrete is the most widely used construction material in the world (Aitcin, 2000). The main use of concrete in construction industry has more advantages compared with other materials, such as steel and wood. Nowadays, many multistory buildings are being built using concrete materials. Sometimes the neighboring multistory buildings need bridge as connector to transport people or commodities. Indonesia is located in an earthquake zone, so that such connector-bridge linking two neighboring buildings must be strong and safe during and after an earthquake (Setiawan, 2017). In previous research on 2017, Setiawan has done the research by reviewing vibration period and lateral displacement of bridge structures which connecting two multistory buildings. Therefore, this research will develop the previous research by reviewing the bridge column structure in connector bridge that connecting two neighboring multistory buildings.The main objective of this research is to analyze the columns of the bridge which are connected with two different bridges structure system. The first bridge is designed with using column-beam system with masonry-wall, while the second bridge is designed with using deep beam system. Both of these bridges are located at third floor with a fixed-roller support.

II. METHODS

The method used in this research is a simulation method which is modeling a visualization of the building using ETABS (Extended Three Dimensional Analysis of Building Systems) to analyze building structure and the connector-bridge in multistory building. Structural design of this building is designed according to National Standards of Indonesia SNI 1726:2012 by using equivalent static analysis and response spectrum analysis.

III. MODELING AND DATA OF BUILDING

The two neighboring buildings which are modeling in this research have same dimension, same height, and same number of floors. The building is modeled in three dimensional modeling in ETABS. Figure 1 shows three dimensional modeling of building model-1 which is using bridge with column-beam system and masonry-wall, while Figure 2 shows three dimensional modeling of building model-2 which is using bridge with deep beam system.

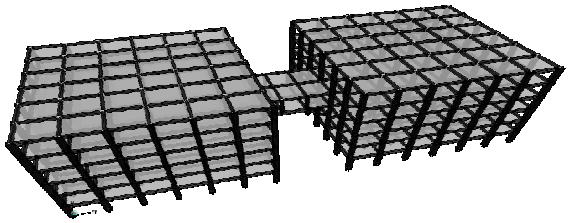


Figure 1: Three dimensional modeling of building model-1
Source: (Setiawan, 2017)

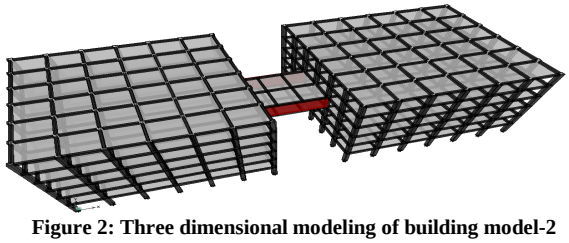


Figure 2: Three dimensional modeling of building model-2
Source: (Setiawan, 2017)

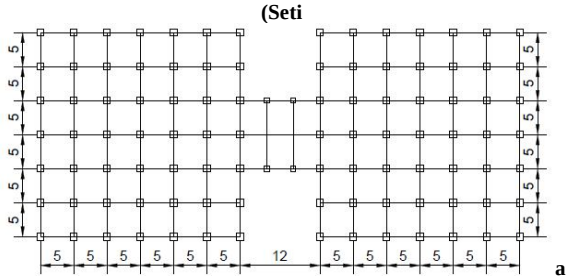
3.1. Building Data

The building which is modeling in this research is categorized as irregular building structures with column-beam system and intermediate moment frame (IMF) with Seismic Importance Factors (I) = 1.0 and response modification coefficient (R) = 5.5, this coefficient is used to calculate the reduced design seismic forces of a structural system (Varela, Tanner, & Klingner, 2004; ACI Committee 318, 2014; ACI Committee 301, 2016). The function of this building is a shopping center (mall).

3.2. Building Modeling

The building is modeled in three dimensional modeling. Floor plan for the building model-1 and model-2 are shown on Figure 3 and Figure 5, while cross section for the building model-1 and model-2 are shown on Figure 4 and Figure 6.

Figure 3: Floor plan for building model-1
Source:
(Seti



a
wan, 2017)

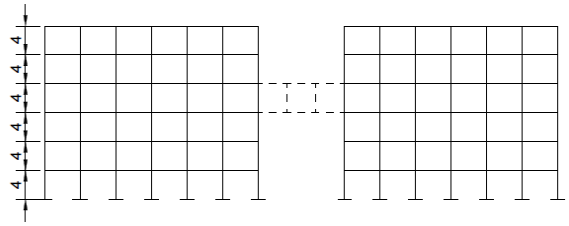


Figure 4: Cross section for building model-1
Source: (Setiawan, 2017)

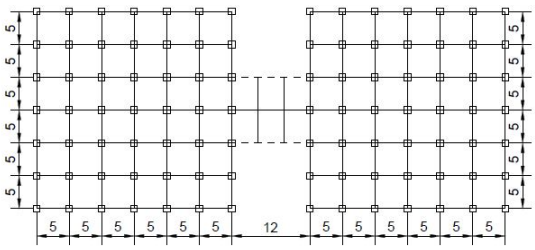


Figure 5: Floor plan for building model-2
Source: (Setiawan, 2017)

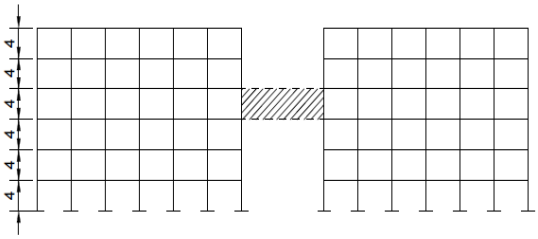


Figure 6: Cross section for building model-2
Source: (Setiawan, 2017)

3.3. Building Materials

The data of material used in this research are as follows:

Concrete : f'_c = 30 MPa

$E_c = 4700 \sqrt{f'_c}$ = 25742,96 MPa

γ_c = 2400 kg/m^3 = 23,54 kN/m^3

Rebar : f_y = 400 MPa

Stirrup : f_{ys} = 400 MPa

3.4. Data of Structure Element

Table 1 show the building element which is used for building model-1 and building model-2.

Table 1. Data of building element

Building Element	Dimension	Concrete Cover
Column	700 x 700 mm^2	40 mm
Beam	350 x 600 mm^2	40 mm
Slab	120 mm	25 mm
Bridge Column	500 x 500 mm^2	40 mm
Bridge Beam	350 x 600 mm^2	30 mm
Deep Beam	400 mm	30 mm

Source: (Setiawan, 2017)

IV. RESULT AND DISCUSSION

4.1. Analysis of Axial Force, Shear Force, and Bending Moment for Bridge Column Building Model-1

The bridge column which is analyzed for building model-1 are column number 21, 28, 35, 64, 71, 78, 99, 100, 101, and 102 on fourth floor. The location of bridge column can be seen on Figure 7.

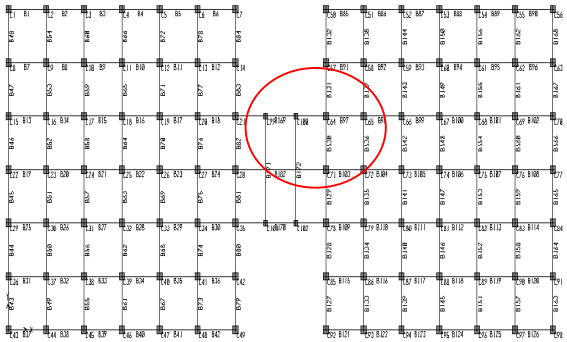


Figure 7: Location of bridge column which is analyzed for building model-1
Source: Result analysis

The columns have a maximum force on load combination COMB 18 (0,9 DEAD + 0,9 SDL – 0,3 SPEC1 – SPEC2) and the value of axial force, shear force, and bending moment are shown in Table 2, while Figure 8 to Figure 16 shows diagram of axial force, shear force, and bending moment.

Table 2. Axial force, shear force, and bending moment of bridge column building model-1

Type of Column	Column	Axial Force (N)	Shear Force (N)	Bending Moment (kN.m)
Bridge Edge Column	21	706397,00	80872,98	157,41
	28	684936,40	81111,33	155,79
	35	706397,00	80872,98	157,41
	64	38414,25	79628,98	154,66
	71	20762,28	78036,66	149,95
	78	38414,25	79628,98	154,66
Bridge Column	99	26003,12	90529,64	182,10
	100	28994,48	105098,21	210,59
	101	26003,12	90529,64	182,10
	102	28994,48	105098,21	210,59

Source: Result analysis

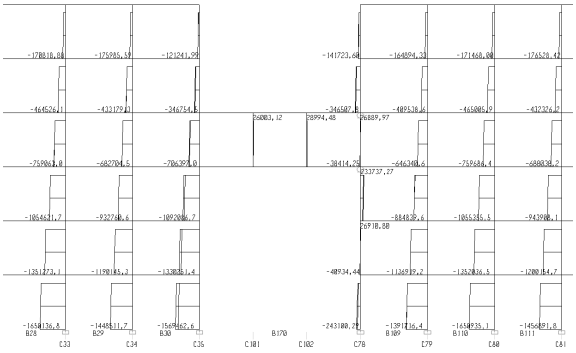


Figure 8: Diagram of axial force for bridge column building model-1 (elevation view – 3)
Source: Result analysis

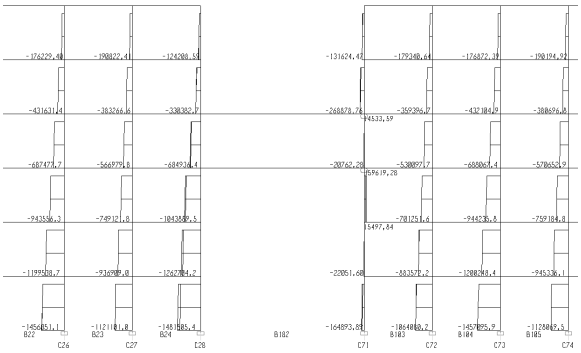


Figure 9: Diagram of axial force for bridge column building model-1 (elevation view – 4)
Source: Result analysis

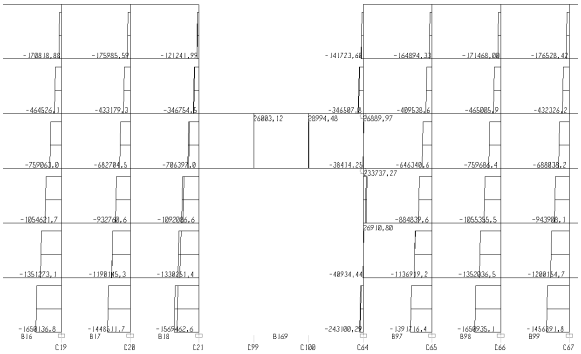


Figure 10: Diagram of axial force for bridge column building model-1 (elevation view – 5)
Source: Result analysis

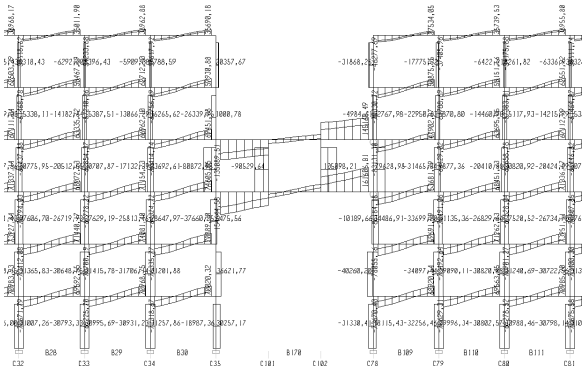


Figure 11: Diagram of shear force for bridge column building model-1 (elevation view – 3)
Source: Result analysis

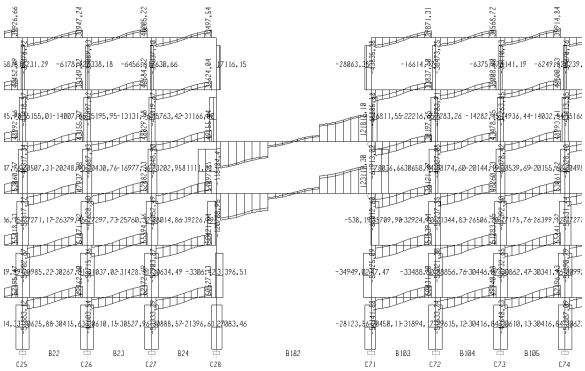


Figure 12: Diagram of shear force for bridge column building model-1 (elevation view – 4)
Source: Result analysis

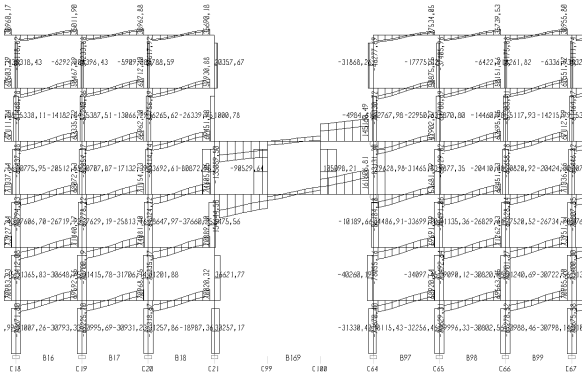


Figure 13: Diagram of shear force for bridge column building model-1 (elevation view – 5)
Source: Result analysis

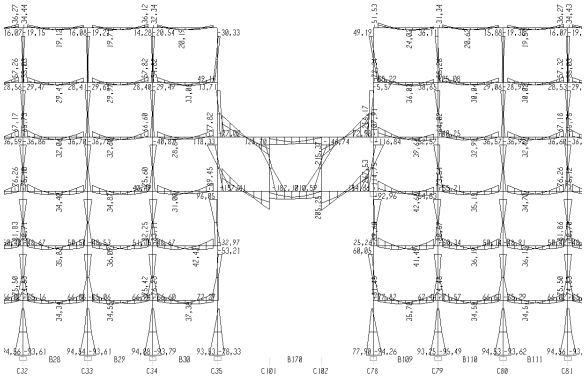


Figure 14: Diagram of bending moment for bridge column building model-1 (elevation view – 3)
Source: Result analysis

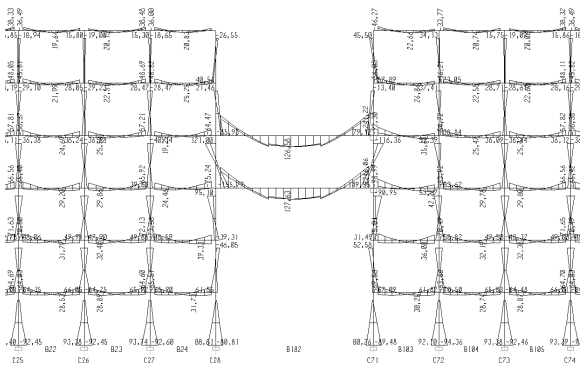


Figure 15: Diagram of bending moment for bridge column building model-1 (elevation view – 4)
Source: Result analysis

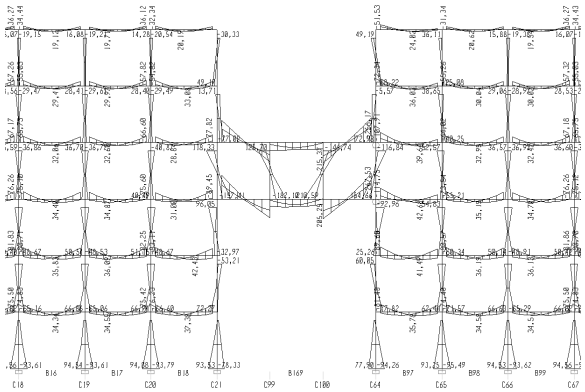


Figure 16: Diagram of bending moment for bridge column building model-1 (elevation view – 5)
Source: Result analysis

4.2. Analysis of Axial Force, Shear Force, and Bending Moment for Bridge Column Building Model-2

The bridge column which is analyzed for building model-2 are column number 21, 28, 35, 64, 71, and 78 on fourth floor. The location of bridge column can be seen on Figure 17.

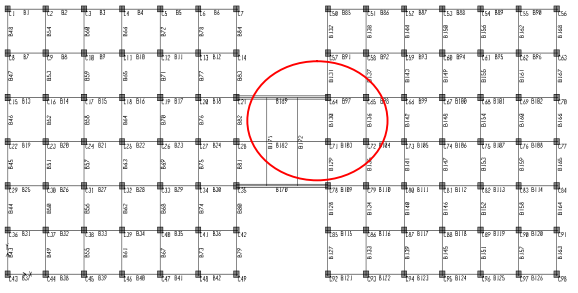


Figure 17: Location of bridge column which is analyzed for building model-2
Source: Result analysis

The columns have a maximum force on load combination COMB 18 (0,9 DEAD + 0,9 SDL – 0,3 SPEC1 – SPEC2) and the value of axial force, shear force and bending moment are shown in Table 4, while Figure 18 to Figure 26 shows diagram of axial force, shear force, and bending moment.

Table 4. Axial force, shear force, and bending moment of bridge column building model-2

Type of Column	Column	Axial Force (N)	Shear Force (N)	Bending Moment (kN.m)
Bridge Edge Column	21	242509,09	7674,20	18,67
	28	626825,90	44425,87	99,98
	35	242509,09	7674,20	18,67
	64	38414,25	9659,82	22,82
	71	20762,28	25479,19	62,29
	78	38414,25	9659,82	22,82

Source: Result analysis

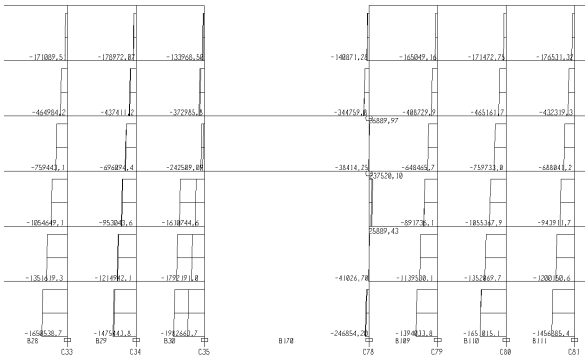


Figure 18: Diagram of axial force for bridge column building model-2 (elevation view – 3)
Source: Result analysis

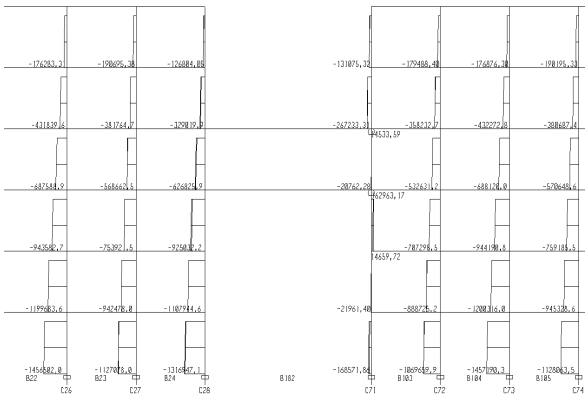


Figure 19: Diagram of axial force for bridge column building model-2 (elevation view – 4)
Source: Result analysis

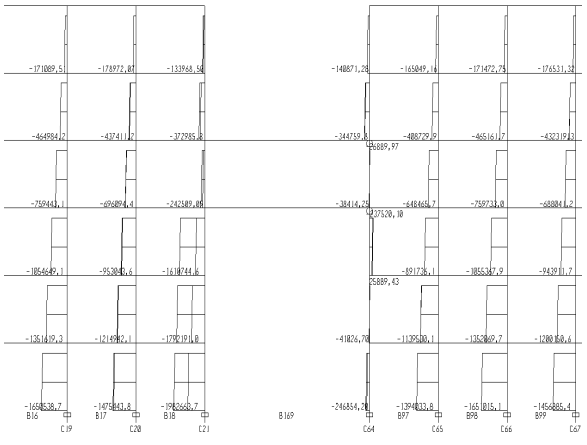


Figure 20: Diagram of axial force for bridge column building model-2 (elevation view – 5)
Source: Result analysis

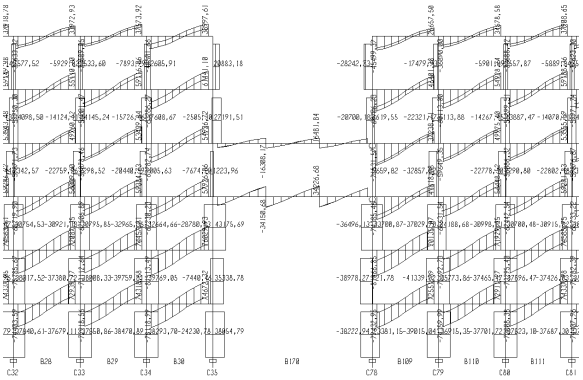


Figure 21: Diagram of shear force for bridge column building model-2 (elevation view – 3)
Source: Result analysis

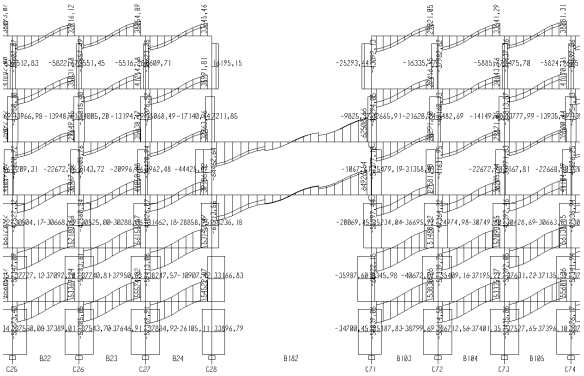


Figure 22: Diagram of shear force for bridge column building model-2 (elevation view – 4)
Source: Result analysis

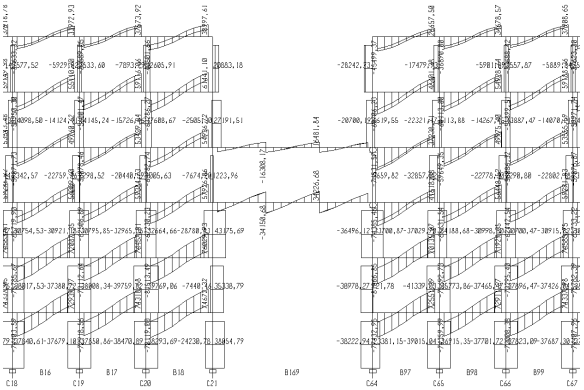


Figure 23: Diagram of shear force for bridge column building model-2 (elevation view – 5)
Source: Result analysis

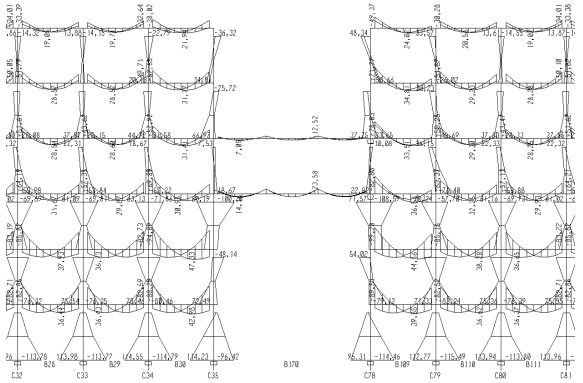


Figure 24: Diagram of bending moment for bridge column building model-2 (elevation view – 3)
Source: Result analysis

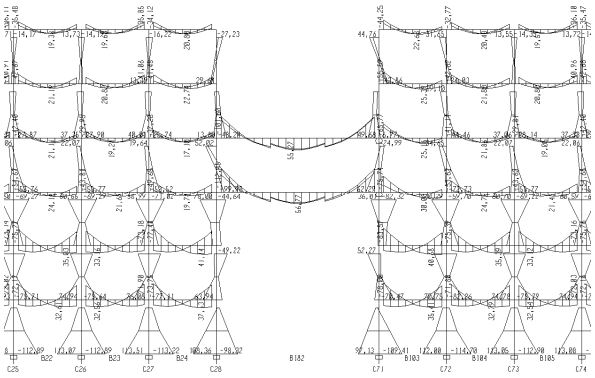


Figure 25: Diagram of bending moment for bridge column building model-2 (elevation view – 4)
Source: Result analysis

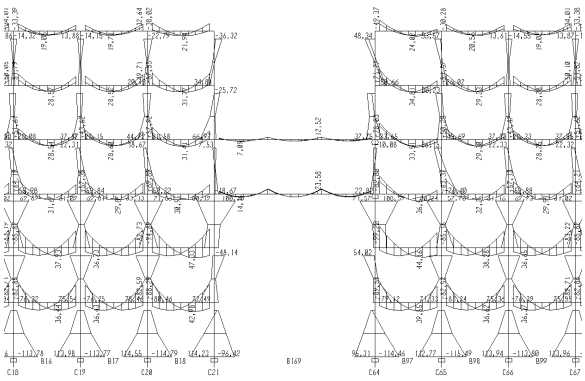


Figure 26: Diagram of bending moment for bridge column building model-2 (elevation view – 5)
Source: Result analysis

4.3. Comparison of Axial Force, Shear Force and Bending Moment for Bridge Column

The comparison result of axial force, shear force, and bending moment for bridge column building model-1 and building model-2 can be seen in Table 6 below.

Table 6. Comparison of axial force, shear force, and bending moment for bridge column building model-1 and model-2

Building	Column	Axial Force (N)	Shear Force (N)	Bending Moment (kN.m)
Model 1	21	706397,00	80872,98	157,41
	28	684936,40	81111,33	155,79
	35	706397,00	80872,98	157,41
	64	38414,25	79628,98	154,66
	71	20762,28	78036,66	149,95
	78	38414,25	79628,98	154,66
Model 2	21	242509,09	7674,20	18,67
	28	626825,90	44425,87	99,98
	35	242509,09	7674,20	18,67
	64	38414,25	9659,82	22,82
	71	20762,28	25479,19	62,29
	78	38414,25	9659,82	22,82

Source: Result analysis

From the comparison of axial force, shear force, and bending moment for bridge column, building model-1 relatively have a greater axial force, shear force, and

bending moment than building model-2. Axial force of column number 21, 28, and 35 building model-1 have a greater value than building model-2, however the axial force of column number 64, 71, and 78 have the same value for building model-1 and building model-2.

CONCLUSION

From the comparison of axial force, shear force, and bending moment for bridge column, building model-1 relatively have a greater axial force, shear force, and bending moment than building model-2. Axial force of column 21, 28, and 35 building model-1 have a greater value than building model-2, however the axial force of column 64, 71, and 78 have the same value for building model-1 and building model-2. From the comparison of result analysis for both of the building can be concluded that bridge of building model-2 which is using deep beam have a better result than bridge of building model-1 which is using masonry-wall bridge. It is because building model-2 has a better behavior and the deep beam which is using in connector bridge for building model-2 work effectively to reduce axial force, shear force, and bending moment in bridge column.

REFERENCES

[1] ACI Committee 301. (2016). 301-16 Specifications for Structural Concrete. American Concrete Institute.

[2] ACI Committee 318. (2014). 318-14: Building Code Requirements for Structural Concrete and Commentary. American Concrete Institute.

[3] Aitcin, P. C. (2000). Cements of yesterday and today: Concrete of tomorrow. Cement and Concrete Research, 1349-1359.

[4] Ezzeldin, M., El-Dakhakhni, W., & Wiebe, L. (2018, January). Reinforced Masonry Building Seismic Response Models for ASCE/SEI-41. Journal of Structural Engineering, 144(1).

[5] Kim, H. S., Lee, M. S., & Shin, Y. S. (2011). Structural Behaviors of Deep RC Beams under Combined Axial and Bending Force. Procedia Engineering, 14, 2212-2218.

[6] Minimum Design Loads and Asaociated Criteria for Buildings and Other Structures (7-16). (t.thn.). 2017: American Society of Civil Engineers.

[7] Poornima, D., Sanjay, S. J., & Yajnodbhavi , H. M. (2017). Seismic Analysis of RC Residential Multi-Storey Building for Different Locations of Shear Wall. International Journal of Science Technology & Engineering, 3(11), 54-62.

[8] Sanjeev , Lokesh, G., Patil, S., & Shastri, L. (2017). Dynamic Analysis of Multi Storied Building with and without Shear Wall and Bracing. Global Research and Development Journal for Engineering, 2(9), 44-51.

[9] Setiawan, A. F. (2017, June). Studi Analisis Jembatan Dinding Bata dan Jembatan Balok Tinggi Beton Bertulang Sebagai Penghubung Gedung Bertingkat. Engineering and Management in Construction Industry, 1, 16-28.

[10] Shedid, M. T., El-Dakhakhni, W. W., & Drysdale, R. G. (2011, April). Seismic Response Modification Factors for Reinforced Masonry Structural Walls. Journal of Performance of Constructed Facilities, 25(2).

[11] SNI 1726:2012 Tata Cara Perencanaan Ketahanan Gempa untuk Struktur Bangunan Gedung dan Non Gedung. (2012). Jakarta: Badan Standarisasi Nasional.

[12] SNI 2847:2013 Persyaratan Beton Struktural untuk Bangunan Gedung. (2013). Jakarta: Badan Standarisasi Nasional.

[13] Varela, J., Tanner, J., & Klingner, R. (2004). Development of Response Modification Coefficient and Deflection Amplification Factor for Design of AAC Structural Systems. 13th World Conference on Earthquake Engineering. Vancouver, B.C., Canada: Indian Institue of Technology, Kanpur.

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