add2 ICCIM LECTURE NOTES CIVIL ENGINEERING-178-189.pdf

by Yosafat Pranata

Load Transfer Shear Wall to Pile Cap Modelling Partially for Group Precast Pile

Daud Rahmat Wiyono, Roi Milyardi, Yosafat Aji Pranata, Asriwiyanti Desiani, Ginardi Husada, and Maria Christine Sutandi

Abstract Pile cap has the function to transfer the load from the upper structure to group of piles. Purpose of this research is comparing the support reaction of pile cap which loads from support reaction and loads from internal forces with pile cap modelling partially in elevator shaft. Building 14th story with shear wall frame has two model pile cap that are pile cap 1 (5 element pier with 44 piles) and pile cap 2 (11 element pier with 108 piles). The conclusion are the difference between support reaction as loads and support reaction correction are 49.10% in pile cap 1 and 56.11% in pile cap 2, and the difference between support reaction correction as loads and internal forces shear wall in 1st floor as loads are 3.86% in pile cap 1, and 3.19% in pile cap 2. With modelling pile cap partially with stiffness of piles are considered, the support reaction from support reaction correction comparing with support reaction pile cap are 3.68% in pile cap 1 and 2.51% in pile cap 2, and the support reaction from internal forces as loads comparing with support reaction pile cap are 50.11% in pile cap 1 and 69.93% in pile cap 2.

Keywords Load transfer · Shear wall · Pile cap · Stiffness

1 Introduction

In the upper structure, the location of loads from the upper structure to pile cap is important because it can give a different value of support reaction from piles modeling as support in pile cap. Loads of element shear wall are in the center of gravity of the element, and the loads from support reaction of upper structure are in the location of support in the shear wall if do not mesh in the shear wall, so the restraint is at the end of element pier [1]. Some shear walls are connected together as elevator shaft given duplicated support reaction in the joint which connected with

D. R. Wiyono (✉) · R. Milyardi · Y. A. Pranata · A. Desiani · G. Husada · M. C. Sutandi
Department of Civil Engineering, Faculty of Engineering, Universitas Kristen Maranatha, Bandung, West Java, Indonesia
e-mail: hwiesiong@gmail.com

H. A. Lie et al. (eds.), *Proceedings of the Second International Conference of Construction, Infrastructure, and Materials*, Lecture Notes in Civil Engineering 216,
https://doi.org/10.1007/978-981-16-7949-0_15

another shear wall. In modeling a partially pile cap, the support reaction depends on the position of group piles as support. SAP 2000 can provide modeling as one pile cap as block foundation to received loads from several shear walls [2]. This software can give the support reaction in piles near the actual condition by input stiffness of piles [3].

The purpose of this research is to give the difference between without modeling pile caps partially and with modeling pile caps partially as one block foundation. The variation of loads are loads from support reaction with a correction from the duplicate node at the joint between other shear walls and loads from internal forces of the shear wall at 1st story. The variation of support is by using the stiffness of piles and by restraint as usual. Focusing on supporting reaction given from modeling pile cap partially as one block foundation. To modeling, the pile cap is used a thick shell element. The difference stress from internal forces as loads and support reaction correction as loads are obtained too.

2 Literature Study

Two methods are commonly used in pile cap design. There are beam theory and truss analogy/method of strut and tie. The pile cap is designed as a beam for internal forces, which are bending and shear. Types of pile caps use in this paper are shown in the following Fig. 1.

Figure 1 has shown the position of several shear walls connected to each other. The reaction from the upper structure is not the same as the reaction from a group of

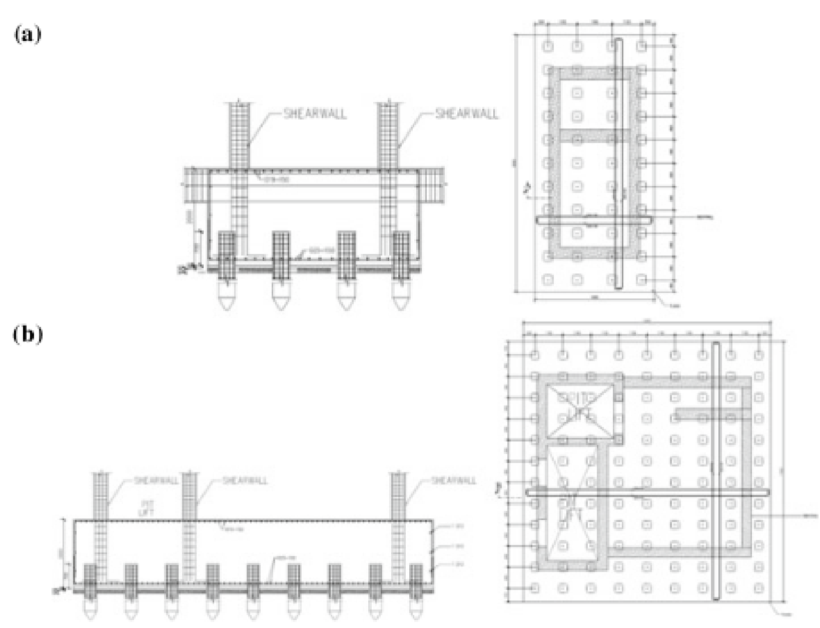

Fig. 1 Type of pile cap model **a** pile cap with 5 element pier 44 piles, **b** pile cap with 11 element piers with 108 piles

piles. That is why it can be modeling pile cap partially to obtain the reaction of group piles. Stiffness has been determined by soil investigations on the soil profile and characteristics. Pile caps design must satisfy to resist the punching shear of each pile [3]. The bearing force in the pile cap and the piles do not exceed the capacity of the element [4]. The pile cap reinforcement depends on the loading on the pile cap, the spacing of the piles, and the depth of the pile cap. To design pile foundations is done using finite element software, which is SAP2000 nonlinear, to calculate the reaction of piles. Shell thick element is used to model the pile cap element. The pile cap is assumed to be rigid, and at the top and at the bottom of the pile are pinned. The pile receives vertical load and receives force in terms proportional to the displacement [3].

3 Numerical Model

The 14th floor reinforced concrete shear wall frames building is modeling with SAP 2000 given in Fig. 2a. There are two elevator shafts on the left side and right side of the building. The elevator shaft on the left side is pile cap 1, and the elevator shaft on the right side is pile cap 2. The loads from internal forces and from support reaction are displayed in Fig. 2b–e. In Fig. 3a–d are displayed the loads from bending moment of the pile cap [4–10].

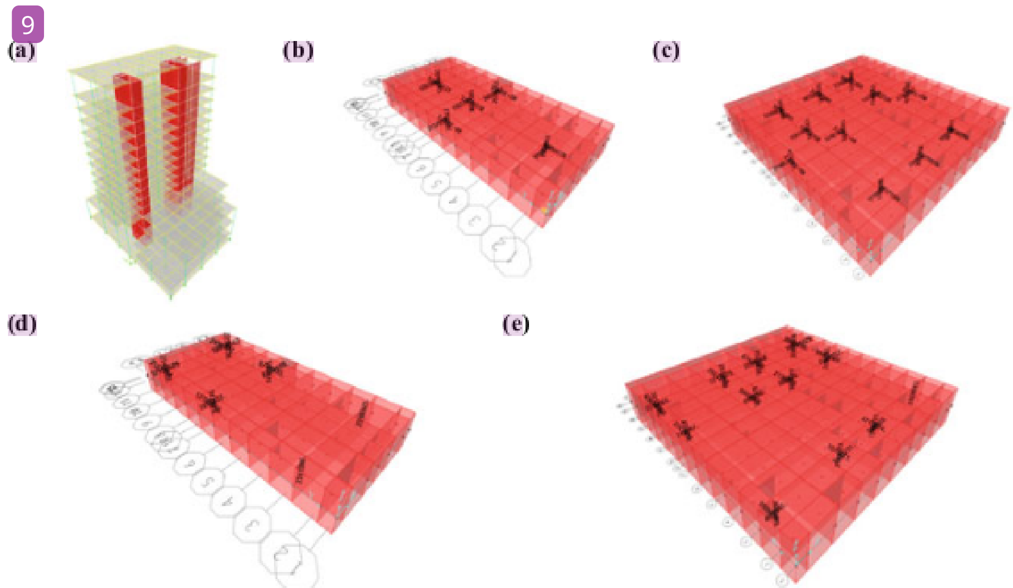

Fig. 2 Building model and loads from internal forces and loads from support reaction **a** 3D building model, **b** pile cap 1 (internal forces), **c** pile cap 2 (internal forces), **d** pile cap 1 (support reaction), **e** pile cap 2 (support reaction)

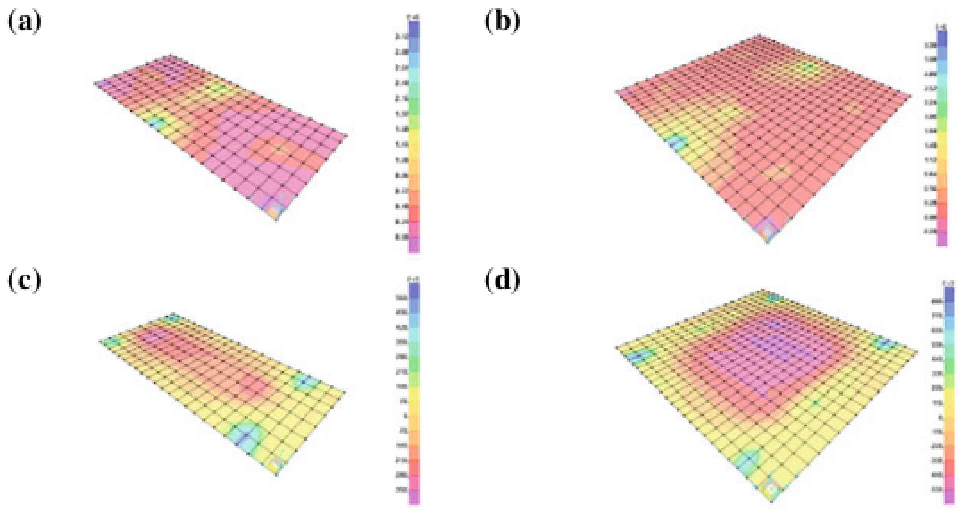

Fig. 3 Bending moment of loads from internal forces and loads from support reaction **a** pile cap 1 (internal forces), **b** pile cap 2 (internal forces), **c** pile cap 1 (support reaction), **d** pile cap 2 (support reaction)

4 Result and Discussion

Pile cap modeling as one because there are two groups of shear wall naming by pile cap with five-element pier 44 piles and pile cap with 11 element piers with 108 piles. Pile cap 1 (44 piles) without pile cap modeling partially in Tables 1, 2, and 3, and support reaction as a loads comparison, the value of support reaction correction as loads is 49.1% lower, the value of internal forces as loads is 49.1% lower, when support reaction correction as loads, the value of internal forces as loads is 3.86% higher, when support reaction as loads, the value is 57.91% lower, when support reaction correction as loads, the value of at support reaction 14.13% lower. When pile cap modeling partially and the stiffness of piles are considered in Tables 4

Table 1 Comparison loads of pile cap 1 (44 piles) without pile cap modeling partially (support reaction vs. support reaction correction)

Story name	Pier ID	P load ETABS support reaction (kN)	P load ETABS support reaction correction (kN)	Difference with support reaction (%)
Story1	P1	50,285	50,285	0.00
Story1	P2	50,569	50,569	0.00
Story1	P3	44,423	44,423	0.00
Story1	P4	45,517	45,517	0.00
Story1	P14	10,914	10,914	0.00
Total		201,708	201,708	−49.10
Story1	Other correction	0	102,854	−49.10
Total		201,708	98,854	−49.10

Table 2 Comparison loads of pile cap 1 (44 piles) without pile cap modeling partially (internal forces at internal forces location)

Story name	Pier ID	P load ETABS at internal forces Story 1 (kN)	Difference with support reaction (%)	Difference with support reaction correction (%)
Story1	P1	27,695	−44.92	
Story1	P2	25,393	−49.79	
Story1	P3	20,412	−54.05	
Story1	P4	19,090	−58.06	
Story1	P14	10,079	−7.65	
Total		102,669	−49.10	
Story1	Other correction	0	0.00	
Total		102,669	−49.10	3.86

Table 3 Comparison loads of pile cap 1 (44 piles) without pile cap modeling partially (support reaction at support reaction location)

Story name	Pier ID	P load ETABS at support reaction (kN)	Difference with support reaction (%)	Difference at support reaction correction (%)
Story1	P1	25,290	−49.71	
Story1	P2	26,857	−46.89	
Story1	P3	16,057	−63.85	
Story1	P4	9811	−78.45	
Story1	P14	6875	−37.01	
Total		84,890	−57.91	
Story1	Other correction	0		
Total		84,890	−57.91	−14.13

Table 4 Comparison support reaction of pile cap 1 (44 piles) with pile cap modeling with the stiffness of piles considered (with stiffness support reaction at support reaction location)

Story name	Pier ID	P load ETABS support reaction correction (kN)	P reaction ETABS support reaction from support reaction axial + moment stiffness = 169,600 (kN)	Difference with support reaction correction (%)
Story1	P1	50,285	25,290	
Story1	P2	50,569	26,857	
Story1	P3	44,423	16,057	
Story1	P4	45,517	6875	
Story1	P14	10,914	10,914	
Total		201,708	84,890	
Story1	Other correction	102,854	17,606	
Total		98,854	102,495	3.68

Table 5 Comparison support reaction of pile cap 1 (44 piles) with pile cap modeling with the stiffness of piles considered (with stiffness internal forces at internal forces location)

Story name	Pier ID	P load ETABS internal forces Story 1 axial + moment stiffness = 169,600 (kN)	P reaction ETABS support reaction from internal forces axial + moment stiffness = 169,600 (kN)	Difference with internal forces (%)
Story1	P1	27,695	12,811	−53.74
Story1	P2	25,393	6574	−74.11
Story1	P3	20,412	5722	−71.97
Story1	P4	19,090	4589	−75.96
Story1	P14	10,079	4205	−58.28
Total		102,669	33,901	−66.98
Story1	Other correction		17,322	16.87
Total		102,669	51,223	−50.11

and 5 and support reaction correction as a loads comparison, the value of support reaction from support reaction as loads is 57.91% lower, and when internal forces as loads comparison the value of support reaction from internal forces as loads is 66.98% lower. When the support as a restraint in Tables 6 and 7 and support reaction correction as loads comparison, the value of support reaction from support reaction as loads is 0.86% lower, and when internal forces as loads comparison the value of support reaction from internal forces as loads is 75.87% lower. For pile cap 2 (108 piles) without pile cap modeling partially in Tables 8, 9 and 10, and support reaction as loads comparison, the value of support reaction correction as loads is 56.11% lower, the value of internal forces as loads is 56.11% lower, when support reaction correction as loads, the value of internal forces as loads is 3.19% lower, when support reaction as loads, the value is 72.89% lower, when support reaction

Table 6 Comparison support reaction of pile cap 1 (44 piles) with pile cap modeling with restraint at support (with restraint support reaction at support reaction location)

Story name	Pier ID	P load ETABS support reaction correction (kN)	P reaction ETABS support reaction from support reaction axial and moment restraint (kN)	Difference with support reaction correction (%)
Story1	P1	50,285	49,652	
Story1	P2	50,569	51,935	
Story1	P3	44,423	42,863	
Story1	P4	45,517	45,662	
Story1	P14	10,914	11,098	
Total		201,708	201,209	
Story1	Other correction	102,854	−98,714	
Total		98,854	102,495	3.68

Table 7 Comparison support reaction of pile cap 1 (44 piles) with pile cap modeling with restraint at support (with restraint internal forces at internal forces location)

Story name	Pier ID	P load ETABS internal forces Story 1 axial and moment restraint (kN)	P reaction ETABS support reaction from internal forces axial + moment restraint (kN)	Difference % with internal forces (%)
Story1	P1	27,695	386	−98.61
Story1	P2	25,393	−3836	−115.11
Story1	P3	20,412	11,702	−42.67
Story1	P4	19,090	11,069	−42.01
Story1	P14	10,079	5449	−45.94
Total		102,669	24,771	−75.87
Story1	Other correction		17,322	16.87
Total		102,669	51,223	−50.11

Table 8 Comparison loads of pile cap 2 (108 piles) without pile cap modeling partially (support reaction vs. support reaction correction)

Story name	Pier ID	P load ETABS support reaction (kN)	P load ETABS support reaction correction (kN)	Difference with support reaction (%)
Story1	P5	66,543	66,543	
Story1	P6	55,937	55,937	0.00
Story1	P7	57,512	57,512	0.00
Story1	P8	51,382	51,382	0.00
Story1	P10	68,268	68,268	0.00
Story1	P11	45,831	45,831	0.00
Story1	P12	44,958	44,958	0.00
Story1	P13	13,586	13,586	0.00
Story1	P15	11,580	11,580	0.00
Story1	P16	39,215	39,215	0.00
Story1	P18	41,115	41,115	0.00
Total		495,930	495,930	−56.11
Story1	Other correction	0	271,080	−56.11
Total		495,930	224,851	−56.11

correction as loads, the value of at support reaction 40.20% lower. When pile cap modeling partially and the stiffness of piles considered in Tables 11 and 12 and support reaction correction as loads comparison, the value of support reaction from support reaction as loads is 2.51% higher, and when internal forces as loads comparison the value of support reaction from internal forces as loads is 69.93% lower. When the support as a restraint in Tables 13 and 14 and support reaction

Table 9 Comparison loads of pile cap 2 (108 piles) without pile cap modeling partially (internal forces at internal forces location)

Story name	Pier ID	P load ETABS at internal forces Story 1 (kN)	Difference with support reaction (%)	Difference with support reaction correction (%)
Story1	P5	41,105	−38.23	
Story1	P6	14,598	−73.90	
Story1	P7	18,594	−67.67	
Story1	P8	17,830	−65.30	
Story1	P10	42,577	−37.63	
Story1	P11	18,874	−58.82	
Story1	P12	16,186	−64.00	
Story1	P13	13,328	−1.90	
Story1	P15	11,407	−1.49	
Story1	P16	10,972	−72.02	
Story1	P18	12,205	−70.31	
Total		217,675	−56.11	
Story1	Other correction	0	0	
Total		217,675	−56.11	−3.19

Table 10 Comparison loads of pile cap 2 (108 piles) without pile cap modeling partially (support reaction at support reaction location)

Story name	Pier ID	P load ETABS at support reaction (kN)	Difference with support reaction (%)	Difference at support reaction correction (%)
Story1	P5	23,948	−64.01	
Story1	P6	19,113	−65.83	
Story1	P7	11,131	−80.65	
Story1	P8	8847	−82.78	
Story1	P10	23,073	−66.20	
Story1	P11	10,255	−77.63	
Story1	P12	8969	−80.05	
Story1	P13	8170	−39.87	
Story1	P15	7707	−33.45	
Story1	P16	6007	−84.68	
Story1	P18	7229	−82.42	
Total		134,450	−72.89	
Story1	Other correction	0		
Total		134,450	−72.89	−40.20

Table 11 Comparison support reaction of pile cap 2 (108 piles) with pile cap modeling with the stiffness of piles considered (with stiffness support reaction at support reaction location)

Story name	Pier ID	P load ETABS support reaction correction (kN)	P reaction ETABS support reaction from support reaction axial + moment stiffness = 169,600 (kN)	Difference with support reaction correction (%)
Story1	P5	66,543	23,948	
Story1	P6	55,937	19,113	
Story1	P7	57,512	11,131	
Story1	P8	51,382	8847	
Story1	P10	68,268	23,073	
Story1	P11	45,831	10,255	
Story1	P12	44,958	8969	
Story1	P13	13,586	8170	
Story1	P15	11,580	7707	
Story1	P16	39,215	6007	
Story1	P18	41,115	7229	
Total		495,930	134,450	
Story1	Other correction	271,080	96,055	
Total		224,851	230,505	2.51

Table 12 Comparison support reaction of pile cap 2 (108 piles) with pile cap modeling with the stiffness of piles considered (with stiffness internal forces at internal forces location)

Story name	Pier ID	P load ETABS internal forces Story 1 axial + moment stiffness = 169,600 (kN)	P reaction ETABS support reaction from internal forces axial + moment stiffness = 169,600 (kN)	Difference with internal forces (%)
Story1	P5	41,105	3936	−90.42
Story1	P6	14,598	5659	−61.23
Story1	P7	18,594	2533	−86.38
Story1	P8	17,830	1111	−93.77
Story1	P10	42,577	7255	−82.96
Story1	P11	18,874	2910	−84.58
Story1	P12	16,186	1898	−88.27
Story1	P13	13,328	2298	−82.76
Story1	P15	11,407	2303	−79.81
Story1	P16	10,972	1463	−86.66
Story1	P18	12,205	2481	−79.68
Total		217,675	33,848	−84.45
Story1	Other correction		31,602	14.49
Total		217,675	65,449	−69.93

Table 13 Comparison support reaction of pile cap 2 (108 piles) with pile cap modeling with restraint at support (with restraint support reaction at support reaction location)

Story name	Pier ID	P load ETABS support reaction correction (kN)	P reaction ETABS support reaction from support reaction axial and moment restraint (kN)	Difference with support reaction correction (%)
Story1	P5	66,543	66,375	
Story1	P6	55,937	56,524	
Story1	P7	57,512	57,689	
Story1	P8	51,382	51,436	
Story1	P10	68,268	69,847	
Story1	P11	45,831	46,179	
Story1	P12	44,958	45,193	
Story1	P13	13,586	13,792	
Story1	P15	11,580	11,867	
Story1	P16	39,215	39,341	
Story1	P18	41,115	41,334	
Total		495,930	499,577	
Story1	Other correction	271,080	269,072	
Total		224,851	230,505	2.51

Table 14 Comparison support reaction of pile cap 2 (108 piles) with pile cap modeling with restraint at support (with restraint internal forces at internal forces location)

Story name	Pier ID	P load ETABS internal forces Story 1 axial and moment restraint (kN)	P reaction ETABS support reaction from internal forces axial + moment restraint (kN)	Difference % with internal forces (%)
Story1	P5	41,105	2538	−93.83
Story1	P6	14,598	594	−95.93
Story1	P7	18,594	277	−98.51
Story1	P8	17,830	223	−98.75
Story1	P10	42,577	−1172	−102.75
Story1	P11	18,874	46,179	0.88
Story1	P12	16,186	16,354	1.04
Story1	P13	13,328	13,612	2.14
Story1	P15	11,407	11,588	1.58
Story1	P16	10,972	690	−93.71
Story1	P18	12,205	842	−93.10
Total		217,675	64,586	−70.33
Story1	Other correction		863	0.40
Total		217,675	65,449	−69.93

correction as loads comparison, the value of support reaction from support reaction as loads is 2.51% higher, the value of support reaction from internal forces as loads is 69.93% lower. The location of the higher bending moment shown in the picture is near the position of the loads.

5 Conclusion

The conclusions are:

1. Without modeling pile cap partially, the difference between support reaction as loads and support reaction correction as loads are 49.10% in pile cap 1 and 56.11% in pile cap 2, and the difference between support reaction correction as loads and internal forces shear wall in 1st floor as loads are 3.86% in pile cap 1 and 3.19% in pile cap 2.
2. With modeling pile cap partially in condition stiffness of piles is considered, the support reaction from support reaction correction compare with support reaction pile cap are 3.68% in pile cap 1 and 2.51% in pile cap 2, and the support reaction from internal forces as loads compare with support reaction pile cap are 50.11% in pile cap 1 and 69.93% in pile cap 2, 3. With modeling pile cap partially in condition restraint, the support reaction from support reaction correction compare with support reaction pile cap are 3.68% in pile cap 1 and 2.51% in pile cap 2, and the support reaction from internal forces as loads compare with support reaction pile cap are 50.11% in pile cap 1 and 69.93% in pile cap 2.

References

1. MacLeod IA (1970) Shear wall-frame interaction: a design aid. Portland Cement Association, Illinois
2. Mays TW (2015) Design guide for pile caps. Concrete Reinforcing Steel Institute, Illinois, p 156
3. Van De Graaf AV (2006) Structural design of reinforced concrete pile caps: the strut-and-tie method extended with the stringer-panel method. Graduation Report, TUDelft
4. Magade SB, Ingle RK (2020) Comparison of moments for pile-cap design. Soil Mech Found Eng 56(6):414–419. https://doi.org/10.1007/s11204-020-09624-9
5. Nageh M (2007) How to model and design high rise building using ETABS program. Scientific Book House for Publishing and Distributing, Cairo, Cairo
6. Atkins Structural Department (2007) Manual for analysis & design using ETABS. Atkins Dubai, Dubai
7. Computers and Structures Inc (2000) CSI ETABS: concrete shearwall design manual. Computers and Structures Inc., California

8. Wight JK, MacGregor JG (2012) Reinforced concrete: mechanics and design, 6th edn. Pearson Education Inc., New Jersey
9. American Concrete Institute (2011) Building code requirements for reinforced concrete (ACI 318–11). American Concrete Institute, Michigan
10. Badan Standarisasi Nasional (2012) Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan non gedung (SNI 1726:2012). Badan Standarisasi Nasional, Jakarta

add2 ICCIM LECTURE NOTES CIVIL ENGINEERING-178-189.pdf

ORIGINALITY REPORT

7%	3%	6%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Adsero, Matthew E.. "Impact of Jet Grouting on the Lateral Strength of Soil Surrounding Driven Pile Foundations.", Brigham Young University, 2021 Publication	2%
2	H. Tampubolon. "Chapter 4 Shoreline Change Cause of Abrasion in Bantan District Bengkalis Island as the Outstanding Beach Area", Springer Science and Business Media LLC, 2022 Publication	1%
3	Submitted to Universiti Teknologi Petronas Student Paper	1%
4	lintar.untar.ac.id Internet Source	1%
5	S. B. Magade, R. K. Ingle. "Comparison of Moments for Pile-Cap Design", Soil Mechanics and Foundation Engineering, 2020 Publication	1%
6	D'Souza, Clifford. "Earthquake Analysis of Three Dimensional Shear Wall-Frame Assembly on Pile Foundations considering Soil-Structure Interaction", Indian Institute of Technology, Bombay (India), 2023 Publication	1%
7	D R Wiyono, R Milyardi, Y A Pranata. " Evaluation of Internal Forces and Support Reaction of Column and Shearwall in 15	<1%

Building Design ", IOP Conference Series: Materials Science and Engineering, 2021
Publication

8	repository.maranatha.edu Internet Source	<1%
9	Daud Rahmat Wiyono, Roi Milyardi, Yosafat Aji Pranata, Anang Kristianto. "Comparison reinforcement design shear wall modelling planar and assembly in elevator shaft", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1%
10	Sushilkumar B. Magade, Ramakant K. Ingle. "Analysis methods for pile foundation: a critical review of the literature and recommended suggestions", Innovative Infrastructure Solutions, 2020 Publication	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		