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Design of E.R. Building At Ct Arsa Palu Hospital With Liquefaction Potential

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Abstract: *This design hospital building is planned to be built in the city of Palu. Palu City has high earthquake potential, has history of liquefaction, tsunami and landslides disasters. Thorough design is needed so that this hospital building still become a place for health services after a disaster occurs. The building was designed using the Special Moment Resisting Frame Structure system based on the SNI. Earthquake load analysis uses the response spectrum method based on Earthquake Resistance Planning Procedures (SNI 1726:2019). This concept obtains structure design that meets SNI and still strong in strong earthquake and liquefaction. Analysis has been carried out and it was found that the potential for liquefaction to occur at a depth of 1.5 M to 4.5 M so that the foundation chosen was 4 piles with a diameter of 40 cm, a depth of 6 meters per pile cap. From the results of calculations, it shows that the structure of the emergency room building at CT Arsa Palu Hospital is safe from an analytical perspective.*

Keyword: *Special Moment Resisting Frame, Concrete Structure, Earthquake, Liquefaction*

INTRODUCTION

This hospital building designed in the city of Palu, Central Sulawesi, must meet the requirements set by the government and related ministries. These provisions are SNI 1726:2019, 1727:2020, SNI 2847:2019 and Indonesian Minister of Health Regulation Number 40 of 2022. The city of Palu is in the Palukoro fault area, prone to earthquakes, tsunamis and liquefaction. For this reason, adequate planning steps are needed. The planned load is according to SNI 1727:2020, for the patient room = 1.92 KN/M2 = 192 Kg/m2, the Operating Room / Lab = 2.87 KN/M2 = 287 Kg/m2, and the second floor corridor room = 3 .83 KN/m2 = 383 Kg/M2. Designed Earthquake load in accordance with SNI 1726:2019 Procedures for earthquake resistance planning for building and non-building structures. The load combination must also comply with SNI 1729-2019, 1) 1,4D, 2) 1,2 D + 1,6 L + 0,5 (Lr or R), 3) 1,2 D + 1,6 (Lr or R) + 0,5 W (L or 0,5W), 4) 1,2 D + 1,0 W+ L + 0,5 (Lr or R), 5) 0,9 D + 1,0 W, 6)

1,2 D + Ev +Eh + 0,5 L. Because this building has risk category = IV, the earthquake priority factor Ie = 1.5 (according to Table 3 & 4, (Badan Standardisasi Nasional, 2019)).

This research are part of FT Roadmap 2020-2026 and continued research after several publication about optimization (Budiarto & Ghozi, 2019), Design of genset foundation (Ghozi & Budiati, 2023), Comparison of structure due to different earthquakes (Rizaldhy & Ghozi, 2023), Steel structure (Ghozi & Budiati, 2022), Genetic algorithm for optimization (Ghozi & Budiati, 2016); (Ghozi et al., 2011). The ER Building floor design is displayed in Fig. 1.

Figure 1. ER Floor Plan

METHOD

This structure was obtained from multi-level research on concrete, loading, earthquakes and liquefaction. Preceded by a literature study on concrete, loads, earthquakes and liquefaction. Next, preliminary design and structural modelling is carried out, including load modelling. Then a structural analysis was carried out with the help of SAP2000 and the FEM support program (Eka Wati & Ghozi, 2023). After all elements are safe and in accordance with SNI, then proceed with planning the foundation by considering soil conditions/lab results, column reactions and regulations. All research stages are simplified as seen in Figure 2.

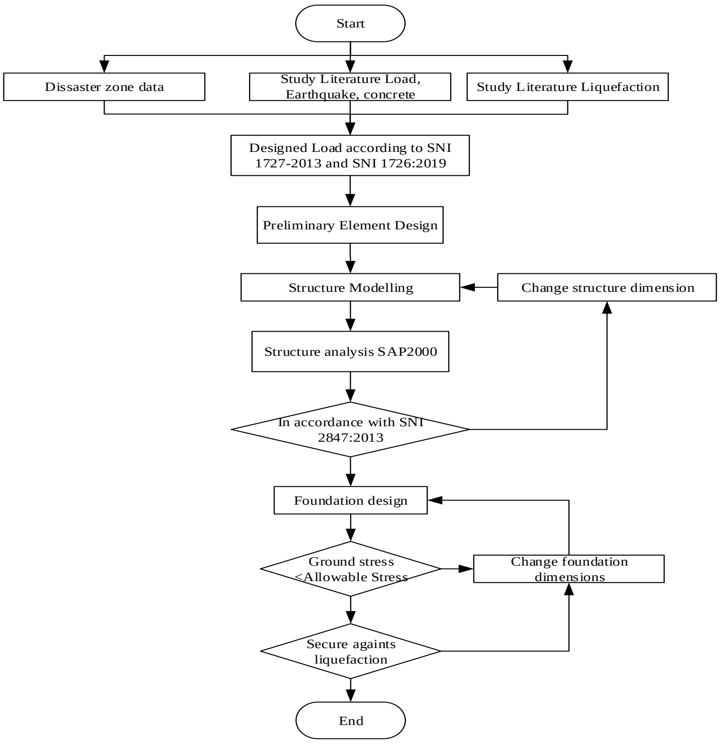

Figure 2. Research Flowchart

RESULT AND DISCUSSION

2D Structure.

The dimension of element for preliminary design is displayed in Fig. 3.

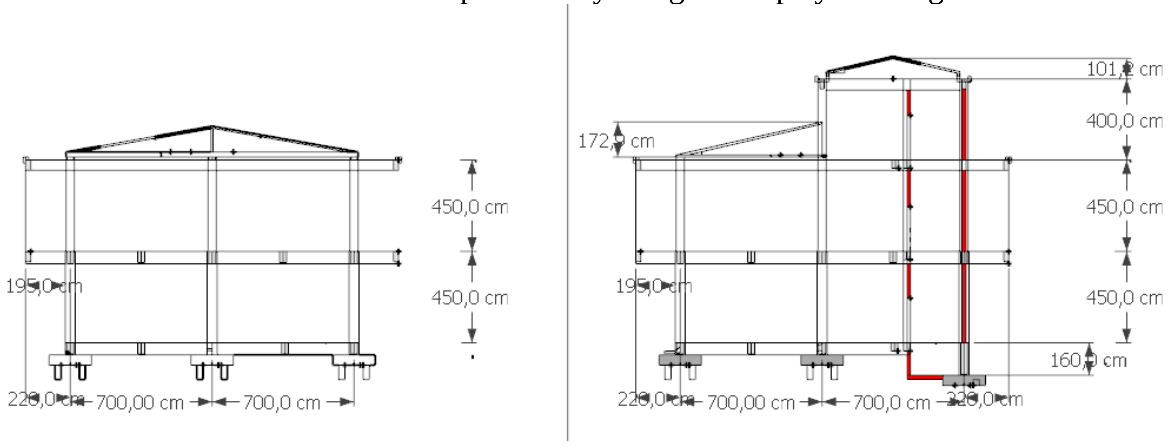

Figure 3. 2D preliminary design of structure.

Earthquake load

From the 2021 Indonesian Design Response Spectrum Application on the page https://rsa.buatkarya.pu.go.id/2021/ at coordinates -0.898724, 119.858745 Palu City, according to SNI 1726:2019, we get:

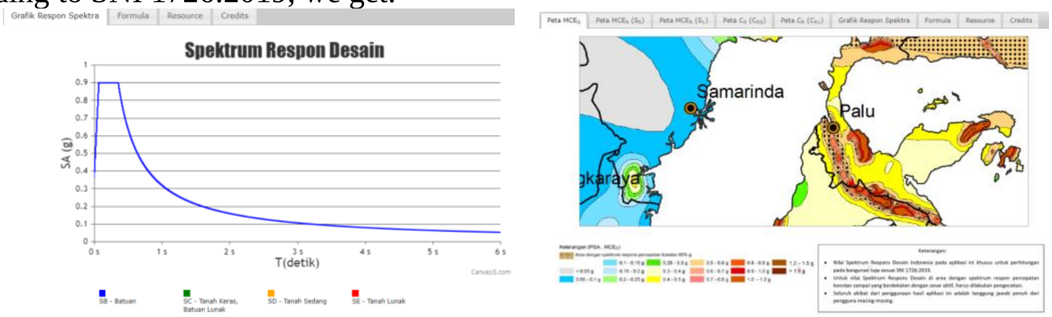

Figure 4. Spectrum Respond design and MCE_G Map

SDS = 0.9 g SD1=0.32 g
T0 = 0.07 second T1 = 0.36 second
Ct = 0.046
x = 0.9
Period, Ta = Ct × hnx= 0.046 * 9 = 0.4 second
Hn = Height
Ct,x = Parameter structure type approach
Cs= 0.05025; R=8; I=1.5;
Cs min=0.0594
W3 (roof) = 35808 kG.; W2 = 80182 kG; W1 = 129951 kG
For the floor seismic loading , it calculated :
W1+W2= 245.941,50
W = 245.941,50
V = Cs . W= 14.756,49
K=1.32

Table 1. Lateral force load every floor

Floor	H_i (M)	H_i (k)	W_i (Kg)	$w_i.h_i$(k)	F_i (kG)	
					w.h / $\sum w_i$. Hi	F_i
3	13	17,16	35.808,0	614.465,3	5.419,76	5.419,8
2	9	11,88	80.182,5	952.568,1	8.401,93	8.401,9
1	4,2	5,544	129.951,0	720.448,3	6.354,56	6.354,6
			210.133,5	1.673.016,4		

Concrete beam design

Moment and shear as result of structural analysis the displayed in Fig. 5 and Fig. 6.

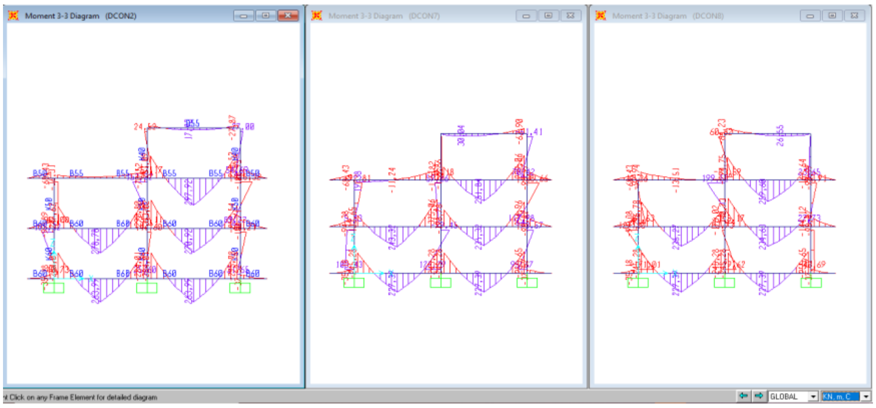

Figure 5. Moment (in KN,M)

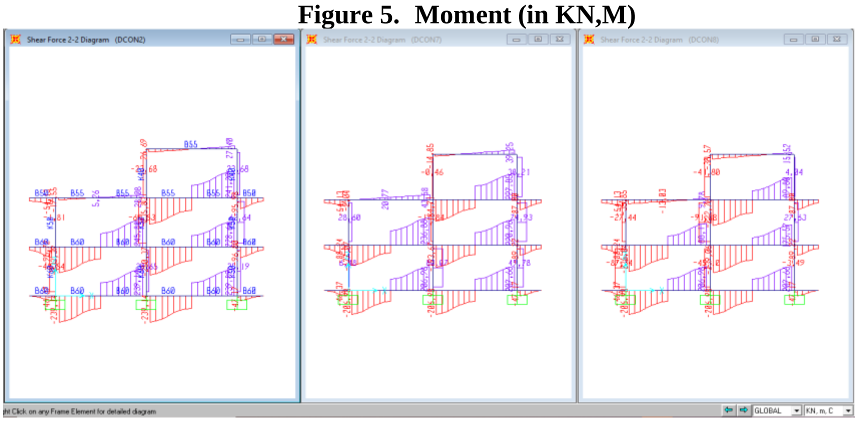

Figure 6. Shear Force (in KN-M)

Based on shear force and moment in Fig 5 and Fig. 6, design of reinforcement is then deployed. It is found that the largest moment is 449 KN-M, requiring an area of flexural reinforcement of 8D22 (3041 mm2). And for the positive moment, the largest moment is 264 KN-M, requiring an area of flexural reinforcement of 6D22 (2280 mm2). For the stirrup design, maximum shear force is Vu= 10974 Kg and it required stirrup D10-100 mm.

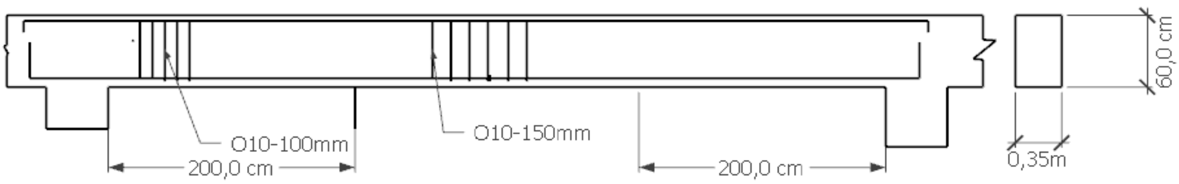

Figure 7. Detail of beam reinforcement

Column

Column axial forces due to combined loads are shown in Figure 8.

Table 2. Required bending reinforcement

Floor	cm	cm	Area req. (cm2)	Dia(mm)	n	A (cm2)	Rho
1	50	50	103,00	22	12	45,6	1,80 %
2	40	40	76,00	19	8	30,41	1,90 %

Table 3. Required shear reinforcement

Floor	cm	cm	Av (cm2/cm)	d Stirrup	Av Stirrup	S req(cm)	Space (cm)	Confinement
1	50	50	0,071	12	0,7854	11,1	10,00	6 x D13-400mm
2	40	40	0,066	10	0,7854	11,9	10,00	4 x D13-400mm

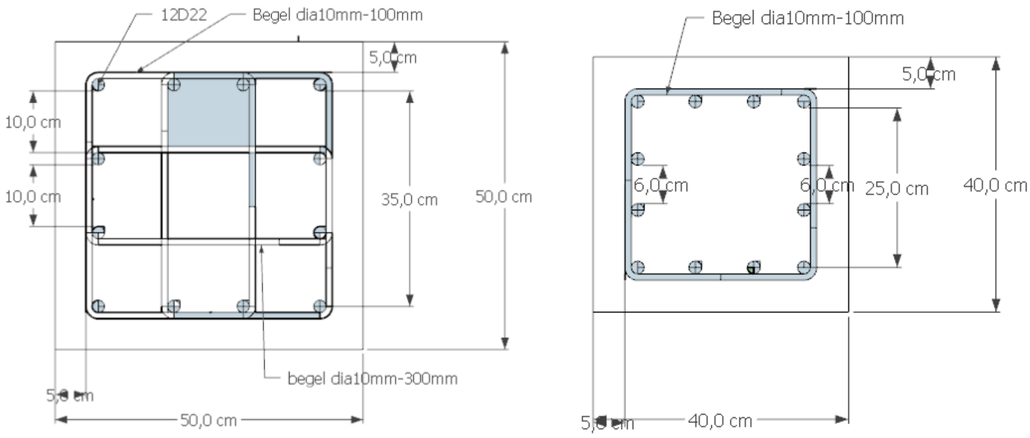

Figure 8. Column detail for K1 and K2

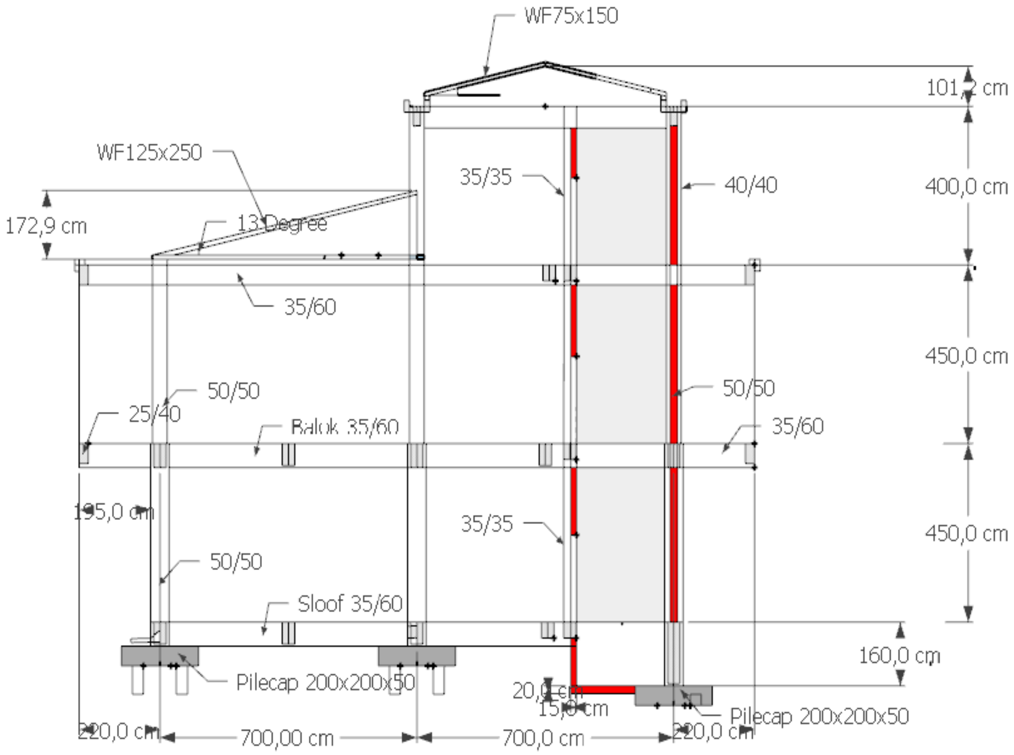

Figure 9. Portal with shear wall

Liquefaction potential

The liquefaction is already analyzed bay many researches (Allafa & Prasetya, 2019). The use of battered piles and prestressed concrete piles is not recommended on soils with high liquefaction potential (Badan Standardisasi Nasional, 2017), 12.2.4.3 Effects of liquefaction on foundation design). Liqit software is then deployed to obtain potential liquefaction in this research. Boring and SPT log as data used in Liqit software is displayed in Fig. 10. And also the result of potential liquefaction is the displayed in Fig 11.

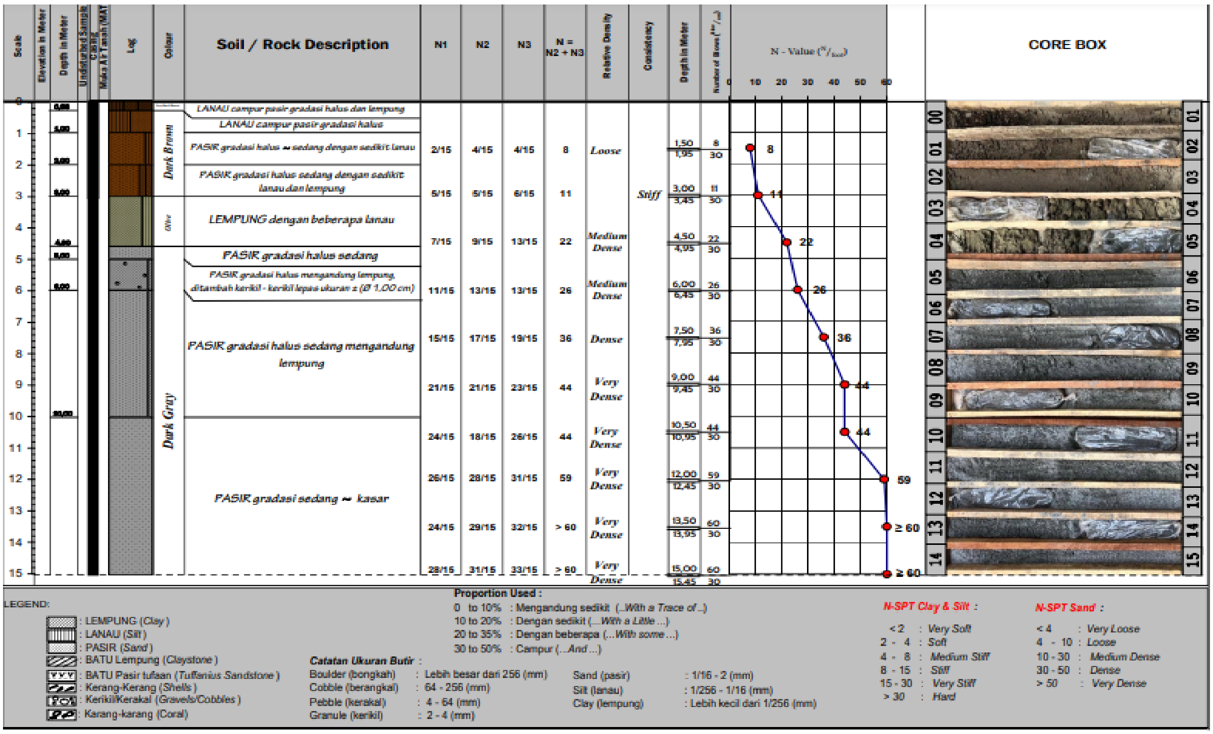

Figure 10.Boring and SPT log (Muliadi, 2023)

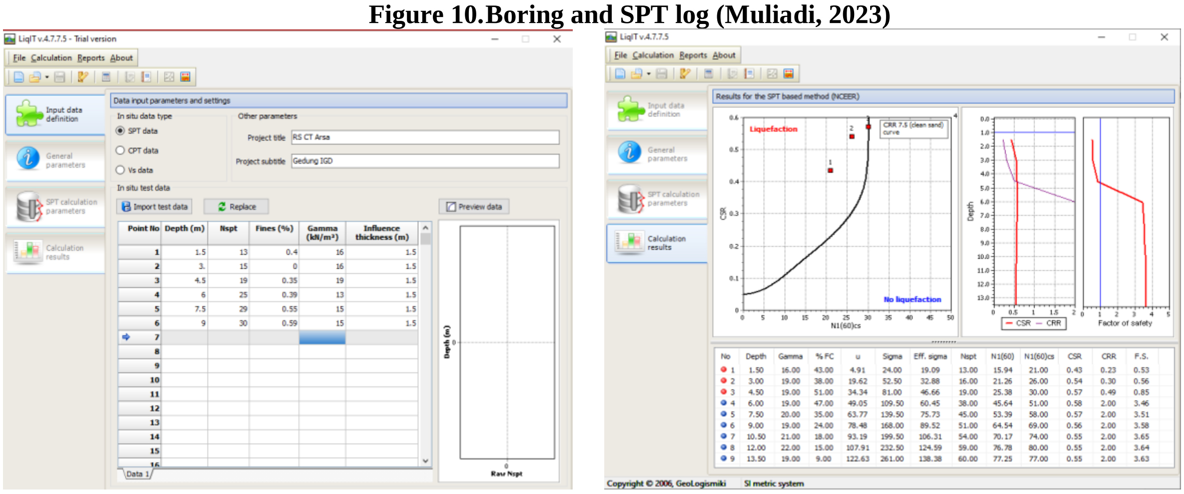

Figure 11.Liqit software and the result of liquefaction potential.

It can be concluded that liquefaction in CT Arsa Palu Hospital area (which had safety factor <1) has the potential to occur at a depth of 1.5m to 4.5m and horizontal slide 80cm which equal to 80ton force. This horizontal force can only resisted by concrete pile, not wood pile. So the concrete pile foundation base must be at a level below 4.5 meters.

Foundation and Pile Cap

Load combination consider working load (DL x 1 + LL x 1 + earthquake x 1), and also two maximum conditions (DCon 2 and DCon 7), with Axial load 182525 kG, Moment 1527000kg-cm. So it required 4 D 40 cm pile, with reinforcement D22-150mm. Because liquefaction potentially occur at depth 4.5 M so it decided that the depth of concrete pile is 6 meters. Detail of pile cap and pile is displayed as seen in Fig. 12.

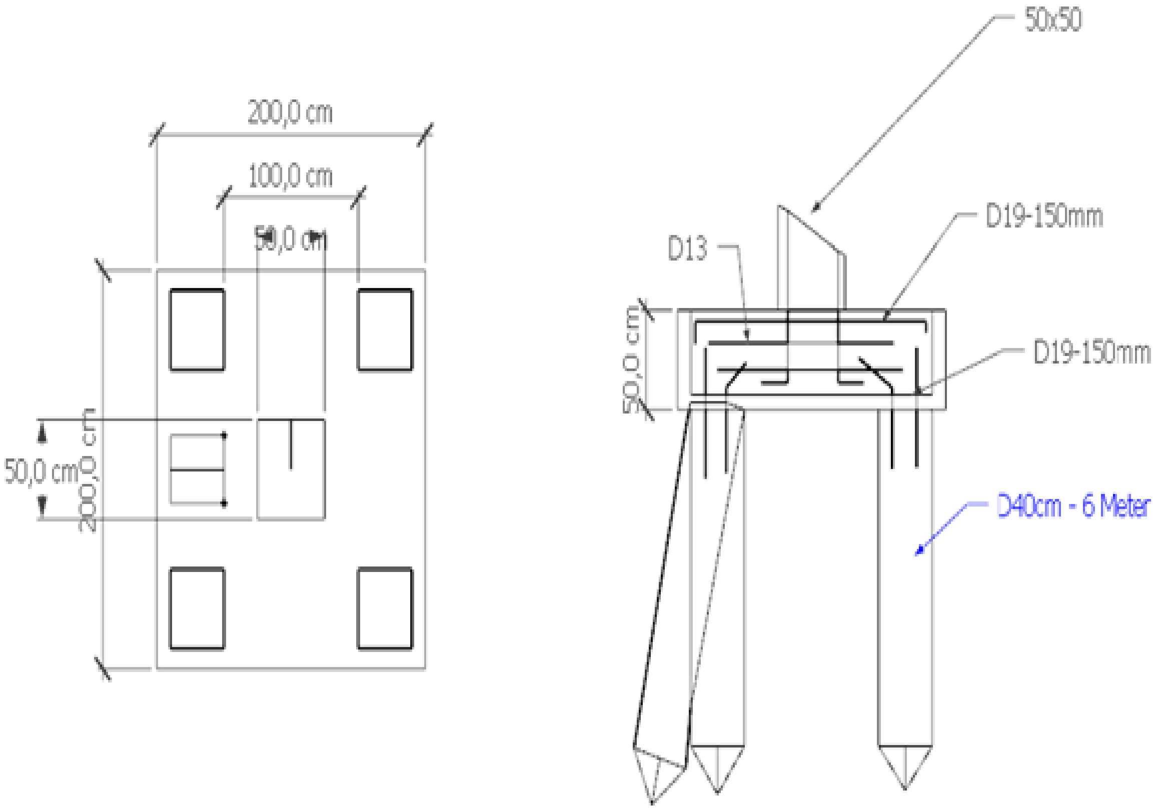

Figure 12. Detail of Pile Cap

CONCLUSION

Research has been carried out to plan the structure and foundation of the ER building at CT Arsa Palu Hospital, namely 50/50 columns on the 1st floor, 40/40 columns on the 2nd and 3rd floors, 35/60 main beams and 25/40 child beams. The danger of liquefaction has been analyzed and it was found that the potential for liquefaction to occur at a depth of 1.5 M to 4.5 M so that the foundation chosen was 4 D 40cm piles in 6 meters depth per pile cap. The pile cap obtained is 200x200x60cm in size. Overall, the dimensions of the structure are safe according to SNI 1726-2012, SNI 2847:2019, SNI 1727:2020 and SNI 8460:2017.

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