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Study Of Productivity And Costs On The Implementation Method Of Foundation Work Using Precast Concrete Pile As A Substitute To The Use Of Wooden Pile Foundations In Low Rise Building (Housing)

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Abstract

The soil condition in Pontianak City is mostly soft soil and peat soil which causes the low bearing capacity of the soil. Various efforts have been made to increase the bearing capacity of the soil, such as the use of wooden pile (kayu cerucuk). With the limited availability of wooden pile, the use of precast piles is an alternative in increasing the bearing capacity of the soil on the foundations of buildings/housings in Pontianak City.

The purpose of this study is to compare the productivity and costs of using a wooden pile foundation measuring 12/15 cm with a length of 9-12 M against the use of a square precast concrete pile foundation measuring 15x15 cm² with a segment length of 3-4 M at a depth of 12-20 M and a size of 12-20 M. 20x20 cm² with a segment length of 6 M at a depth of 12-18 M in low-rise buildings in Pontianak City.

From the results of the study, it is known that the productivity and average cost of piling per M' in a 2-storey shophouse building with an alternative foundation using 12/15 cm cerucuk piles is 22.3 seconds/m' at a cost of Rp. 17,306.24, precast piles square 15 x 15 cm² of 111.5 seconds/m' at a cost of Rp. 144,274,439 and precast square piles of 20 x 20 cm² of 125.7 seconds/m' at a cost of Rp. 291,338,955. In a type 150 house building with an alternative foundation using 12/15 cm wooden piles of 18.05 seconds/m' at a cost of Rp. 17,185.58, precast square piles of 15 x 15 cm² of 104.67 seconds/m' at a cost of Rp. 143,890.04 and 20 x 20 cm² square precast piles of 94.66 seconds/m' with a cost of Rp. 289,724.234. The cost of foundation work with alternative foundations using precast square piles of 15 x 15 cm² is the most efficient both from the aspect of driving costs, overall costs and the cost of the unit load carried by the foundation.

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1. Introduction

The soil condition in Pontianak City is mostly soft soil and peat soil. This condition causes the low bearing capacity of the soil and has the potential to decrease the construction on it. Various efforts have been made to increase the bearing capacity of the soil, such as the use of wooden cones which can increase the bearing capacity of the main foundation for low-rise buildings (two-story buildings). With the limited availability of niches, the use of precast piles is an alternative in increasing the carrying capacity of the soil on the foundations of buildings/housings in Pontianak City.

Precast concrete can be made into piles with dimensions of 100x100 mm, 150x150 mm and 200x200 mm with segmental lengths of 3 to 5 meters. These precast piles can be staked using various kinds of piling tools that are commonly used now in Pontianak, only with a smaller capacity of the piling

tool. In this research, a comparison of productivity and cost of implementation of work using precast piles will be carried out as a substitute for wooden pile foundations in increasing the bearing capacity of the soil in Pontianak City for low-rise buildings (two-story buildings). The fixing method is to use Rigging Drop Hammer and Tripod Hammer. Piling of wooden pile uses a Tripod Hammer with a pounding weight of 250 kg, while for rectangular precast piles using a Rigging Drop Hammer with a capacity of 500 kg for a size of 15 x 15 cm² and a Rigging Drop Hammer with a capacity of 1000 kg for a size of 20 x 20 cm².

The purpose of this study was to conduct a study on the comparison of productivity and cost of using a wooden pile foundation measuring 12/15 cm with a length of 9-12 m against alternative uses of a square precast pile foundation measuring 15x15 cm² with a segment length of 3-4 m at a depth of 12-20 m. and

the size of 20x20 cm² with a segment length of 6 m at a depth of 12-18 m.

2. Literature Review

2.1. Definition of Foundation

The foundation is a lower structure that is under the ground, or a lower structure that is directly related to the ground which has a function to carry the load of the upper structure such as columns, beams, plates, etc. (Joseph E. Bowles, 1997). The function of the foundation is to lay the building and transmit the superstructure loads, both dead and live loads and external forces, to a sufficiently strong soil base. Analysis of the bearing capacity of the foundation has an important role so that this foundation work has sufficient carrying capacity to carry the load on it.

2.2. Types of Foundation

Types of foundations are divided into 2, namely shallow foundations and deep foundations:

1) Shallow foundation

Shallow foundations are foundations that are used at a depth of 0.8 – 1 meter. Because the carrying capacity of the soil is sufficient. The types of shallow foundations include brick rollag foundations, river stone foundations, well foundations, strip concrete slab foundations and mini drill foundations / strauss piles.

2) Deep foundation

In use for buildings with soft soil, wide-span buildings (having a column distance of more than 6 meters), and high-rise buildings. Inner foundations include bore piles, piles. Pile foundations or mini piles can be divided into several categories (Bowles, 1991) including: wood mini piles, concrete mini piles, steel mini piles and composite mini piles. According to the method of installation, mini pile foundations are divided into two major parts, namely: precast mini piles and cast-in-place piles. Precast mini pile is a mini pile that is formed and cast in a concrete form (formwork), then after it is strong enough it is lifted and planted. This precast mini pile according to the way of installation consists of the method of pounding, the way of vibration and the way of piling/pressure.

3) Tripod Drop Hammer and B Rig Drop Hammer.

In the installation of the pile into the ground, the pile is driven with a bat which can be a hammer, a vibrating bat or a bat that is only dropped and a hydraulic press bat.

Tripod Drop Hammer

A wooden tripod and a 250 kg hammer are commonly used in crevice driving. The tripod legs use a wooden recess which is longer than the recess to be installed, equipped with a pulley and a machine winch to pull the sling that lifts both the hammer and the recess to be installed. The wooden tripod hammer can only mount the recess in a straight line in the direction of gravity

B Rigging Drop Hammer

B Rigging Steel Pipe or B. rig is a tool commonly used for driving precast and prestressed concrete

foundations in Pontianak, with dimensions up to 32 cm in both square, triangular and round sections. The size of the steel pipe rigging itself varies and the main material can be made of steel pipe for the tool class weighing 3 Tons with a height of 8m – 11m with a hammer weight of 500 kg to 750 Kg and for the tool class weighing 1.2 Tons with a height of 6m-8m with a hammer weight of 350kg to 500 kg and for a tool class of 450 Kg with a height of 4m-5m using a hammer weighing 150-250 Kg. In terms of choosing steel pipe rigging, it is adjusted to the dimensions of the piles to be installed. Shifting and moving this tool is done manually by pushing or pulling with the help of the built-in winch.

2.3. Pile Piling Method

The stages of pile foundation work are as follows;

a) Preparatory Work

- Put a mark and date when the pile was cast.
- Lifting / moving, the pile must be moved / lifted very carefully to avoid cracking or damage
- Plan the final pile set, to determine at what depth pile driving can be stopped, based on soil data and data on the last number of strokes.
- Plan the driving sequence, taking into account the ease of maneuvering of the tool.
- Determine the stake with the Theodolite and mark it with a stake.
- Piling can be temporarily stopped for the next connection of rods if the level of the pile head has reached the ground level while the expected level of soil friction has not been reached.

b) Pole connection process:

- The mast is lifted and the head of the mast is mounted on the helmet as was done on the first rod.
- The lower end of the pile is placed above the head of the first pile so that the sides of the connecting plate of the two piles have coincided and stick together.
- Welded joints are coated with anti-corrosion
- The weld joint is coated with anti-rust.
- Finished connection, driving can be continued as was done in the first rod. Splicing can be repeated until it reaches the specified hard soil depth.
- Pile driving can be stopped when the bottom end of the pile has reached the specified hard soil layer/final set.
- Cutting the pile at the cut off level that has been determined.

c) Piling Process

- The piling tool is placed in such a way that the hammer axle falls on a predetermined stake.
- The mast is lifted at the lift point that has been provided in each hole.
- The pole is erected beside the driving lead and the head of the pole is mounted on a helmet

that has been covered with wood as a protector and handle for the head of the pole.

- The lower end of the pole is carefully positioned above the specified stake.
- The vertical adjustment of the pole is done by adjusting the length of the backstay while checking with a waterpass so that a truly vertical position is obtained. Before starting driving, the bottom of the pile is clamped with the center gate at the base of the driving lead so that the pile position does not shift during driving, especially for the first pile.
- Piling begins by lifting and dropping the hammer continuously onto the helmet mounted above the head of the pile.

d) *Quality Control*

- The entire surface of the pole is not damaged or cracked.
- The age of the concrete has met the requirements.
- The pile head must not be cracked during driving.
- The new piling can be stopped if the final set has been reached according to the calculation.

2.4. Pile Bearing Capacity From Sondir Results

Sondir or Cone Penetration Test (CPT) is highly considered the role of geotechnical because it is very fast, simple, economical and the test can be trusted in the field with continuous measurement of the subgrade surface. CPT or sondir can also classify soil layers and can estimate the strength and characteristics of the soil. In planning the mini pile foundation (pile), soil data is very necessary in planning the bearing capacity of the pile to determine the ultimate bearing capacity of the pile. The ultimate bearing capacity is determined by the following equation:

$$Q_u = Q_b + Q_s$$

$$= q_b \dots \dots \dots (2.1)$$

where:

- Qu = Pile's ultimate axial bearing capacity
- Qb = Bearing capacity at the end of the pile
- Qs = Skin resistance capacity.
- qb = Bearing capacity at the end of the pile unit area
- Ab = Area at the end of the pole.
- F = Unit of skin resistance unit area
- As = Pile skin area

In determining the ultimate axial bearing capacity (Qu) the Aoki and De Alencar methods are used. Aoki and Alencar proposed to estimate the ultimate bearing capacity from Sondir data. The end bearing capacity of the unit area (qb) is obtained as follows :

$$q_b = \frac{q_{ca} (base)}{F_b} \dots \dots \dots (2.2)$$

where :

qca (base) = The average cone resistance is 1.5D above the pile tip, 1.5D below the pile tip and Fb is an

empirical factor depending on the soil type. The skin resistance per unit area (f) is predicted as follows:

$$F = q_c (side) \frac{a_s}{F_s} \dots \dots \dots (2.3)$$

where:

- qc (side) = The average cone resistance in each layer along the pile.
- Fs = Empirical factors of skin resistance that depend on the type of soil.
- Qs = Skin resistance capacity.
- Fb = Empirical factor of pile end resistance which depends on the type of soil.

In general, the value of s for sand = 1.4 percent, the value of s for silt = 3.0 percent and the value of s for clay = 1.4 percent.

To calculate the carrying capacity of the mini pile based on the data from the sondir test, it can be done using the Meyerhoff method.

The ultimate bearing capacity of the pile foundation is expressed by the formula:

$$Q_{ult} = (q_c \times A_p) + (JHL \times K_{11}) \dots \dots \dots (2.4)$$

where:

- Qult = Carrying capacity of single mini pile.
- qc = Prisoners end sondir.
- Ap = The cross-sectional area of the pile
- JHL = The number of adhesive barriers
- K11 = Pole circumference

The bearing capacity of the foundation permit is expressed by the formula:

$$Q_{ijin} = \frac{q_c A_c}{3} + \frac{JHL \times K_{11}}{5}$$

where;

- Qjin = Carrying capacity
- JHL = Number of adhesive resistance
- K11 = Perimeter of the pile

2.5. Definition of Productivity

Productivity in construction work can be interpreted as a comparison between output (production results) to inputs (production elements: labor, materials, equipment, management and time.

$$Productivity = (output / input \times time)$$

So if the input is getting smaller and the output is getting bigger than the productivity index will be large, so the productivity is getting higher. The smaller the input and the greater the output obtained, it becomes a benchmark for productivity.

2.6. Definition of Costs in Construction Works

Cost analysis in construction projects is often referred to as work unit price analysis (AHSP) which is a method of calculating the unit price of construction work which is described in multiplying the need for building materials, work wages, and equipment with building prices, standard wages for workers and rental/purchase prices. equipment to complete per unit

of construction work. The amount of the price per unit of work depends on the unit price of materials, the unit price of wages and the unit price of tools.

2.7. Research methods

The method used in this research belongs to the type of comparative research because the results of the data processing of this research will be compared with each other to find out the advantages and disadvantages of each object to be studied according to the objectives to be achieved.

2.8. Research Location and Time

The research location is in Pontianak City, namely the Jawi River and Parit Haji Husen II. The case studies taken are foundation work on a 2-storey shophouse building located on the Jawi River and a Type 150 (two-storeys) house building located in Parit Haji Husen II. This research was conducted for 4 (four) months.

2.9. Research Stages and Procedures

The stages in this research can be seen in the following flow chart:

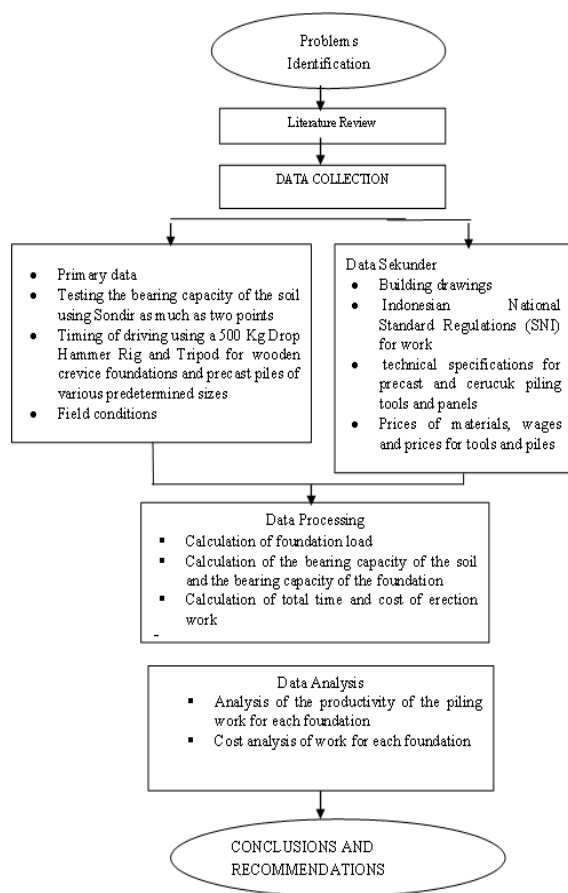


Figure 2.1. Research Flowchart

3. Results And Discussion

3.1. Productivity Analysis of Pile Piles Cerucuk and Precast Piles

The productivity of the driving time per m' pile foundation (per point of the pile group) is obtained from the total driving time per pile group divided by

the total pile length in the pile group. The productivity of the average piling time of the entire building is the total driving time of the entire pile divided by the total length of the pile. The driving time consists of tool shear time/tool preparation, penetration time and pile preparation time.

Productivity of the results of piling wooden pile foundations and precast pile foundations of various types and sizes of piles per pile group and productivity of the overall average value of pile foundations in 2-storey shop houses and type 150 houses can be seen in table 3.1 and table 3.2 below:

Table 3.1. Productivity of Cerucuk Pile and Precast Pile Per Group of Piles and Average Value per Pile in 2-Story Ruko Building Location Jawi River

No.	Building	Description		Dimension			Time amount per group	Produktivity per point Second/meter	
		Pile Cap Number	Pile Cap	Pile Number	Cross section	Length			Depth
1	Ruko 2 Lantai	10	P1	16	Dec-15	11,5 M	11,5 M	3095.27	16.82
		2	P2	20	Dec-15	11,5 M	11,5 M	3869.09	16.82
		3	P3	25	Dec-15	11,5 M	11,5 M	4836.36	16.82
		8	P4	48	10-Dec	3,6 M	3,6 M	5493.82	31.79
2	Ruko 2 Lantai	8	P1	1	□15x15	4 M	16 M	1743.27	108.95
		2	P2	2	□15x15	4 M	16 M	3486.54	108.95
		8	P3	3	□15x15	4 M	16 M	5229.81	108.95
		3	P4	4	□15x15	4 M	16 M	6973.09	108.95
3	Ruko 2 Lantai	2	P5	5	□15x15	4 M	16 M	8716.36	108.95
		8	P1	1	□20x20	6 M	18 M	1961.18	122.57
		8	P2	2	□20x20	6 M	18 M	3922.36	122.57
		4	P3	3	□20x20	6 M	18 M	5883.54	122.57
		3	P4	4	□20x20	6 M	18 M	7844.72	122.57

Table 3.2 Productivity of Cerucuk Piles and Precast Piles Per Group of Piles and Average Value per Pile in Type 150 House Buildings Locations of Parit Haji Husen II

No.	Building	Description		Dimension			Time amount Per group	Produktivity Per Point Second per meter	
		Number of Pile Cap	Pile Cap	Num. of Pile	Section	Length			Depth
1	House type 150	11	P1	4	Dec-15	11,5 M	11,5 M	773.82	16.82
		4	P2	6	Dec-15	11,5 M	11,5 M	1160.73	16.82
		6	P3	9	Dec-15	11,5 M	11,5 M	1741.09	16.82
		6	P4	12	Dec-15	11,5 M	11,5 M	2321.45	16.82
		4	P5	16	Dec-15	11,5 M	11,5 M	3095.27	16.82
		2	P6	20	Dec-15	11,5 M	11,5 M	3869.09	16.82
3	House type 150	12	P1	1	□15x15	4 M	12 M	1307.45	81.72
		2	P2	1	□15x15	4 M	16 M	1743.27	108.95
		5	P3	1	□15x15	4 M	20 M	2179.09	136.19
		5	P4	2	□15x15	4 M	16 M	3486.54	108.95
		4	P5	2	□15x15	4 M	16 M	3486.54	108.95
		1	P6	3	□15x15	4 M	20 M	6537.27	136.19
		1	P7	4	□15x15	4 M	16 M	6973.09	108.95
		2	P8	5	□15x15	4 M	12 M	6537.27	81.72
4	House type 150	19	P1	1	□20x20	6 M	12 M	1307.45	81.72
		9	P2	1	□20x20	6 M	18 M	1961.18	122.57
		4	P3	3	□20x20	6 M	12 M	3922.36	81.72

Based on the data in the table above, it is known that the average driving time productivity value is as follows:

2-storey shophouse (location of Jawi River):

- The productivity of the average piling time for a 12/15 cm cone with a driving depth of 11.5 M and a pile 10/12 cm with a depth of 3.6 M is 22.3 seconds/m'
- The productivity of the average driving time for precast square piles of 15 x 15 cm² with a driving depth of 16 M (4 pole segments @ 4M) is 111.5 seconds/m'

- Productivity of the average driving time of 20 x 20 cm² square precast piles with a driving depth of 18 M (3 pile segments @ 6M) is 125.7 seconds/m'
- Type 150 house (location of Parit Haji Husen II):
- Productivity of the average driving time for cerucuk piles is 12/15 cm with a driving depth of 11.5 M at 18.05 seconds/m'
- The average driving time productivity of 15 x 15 cm² square precast piles with a driving depth of 12 M (3 pole segments @ 4M), 16 M (4 pole segments @ 4M) and 20 M (5 pole segments @ 4M) is 104 ,67 sec/m'
- The productivity of the average driving time for precast square piles of 20 x 20 cm² at a driving depth of 12 M (2 pole segments @ 6M) , 18 M (3 pole segments @ 6M) is 94.66 seconds/m'

3.2. Calculation of Foundation Bearing Capacity and Foundation Work Cost

The type 150 house that is the reference in this study consists of 2 floors with a building area of 155.5 m² (1st floor area = 105 M² and 2nd floor area = 50.5 M²). The house is coupled to the left wall, so the load carried by the foundation is greater than the right side of the wall.

The shophouse building that is the reference in this study with a floor area of 8 x 18 m uses a slab roof. The plate is not designed to be able to carry the structural load of the next one floor building, especially at the back of the dak plate.

Through the application of Structural Analysis, with a combination of existing loads, the maximum axial pressure per tonne of each foundation point is obtained in Figure 3.1, Figure 3.2 and Figure 3.3 below:

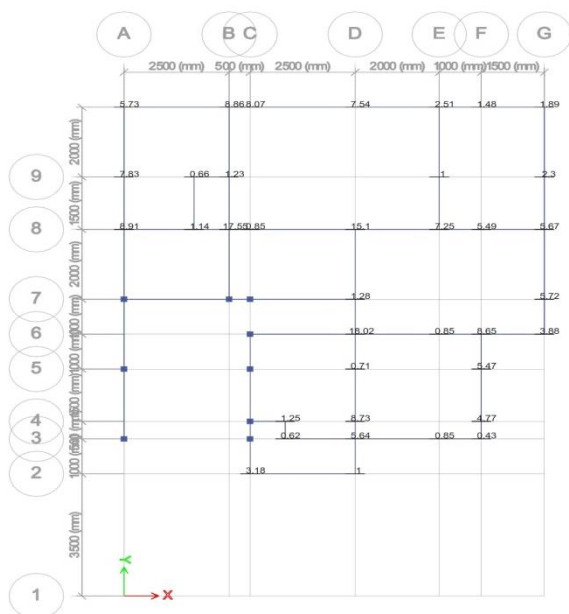
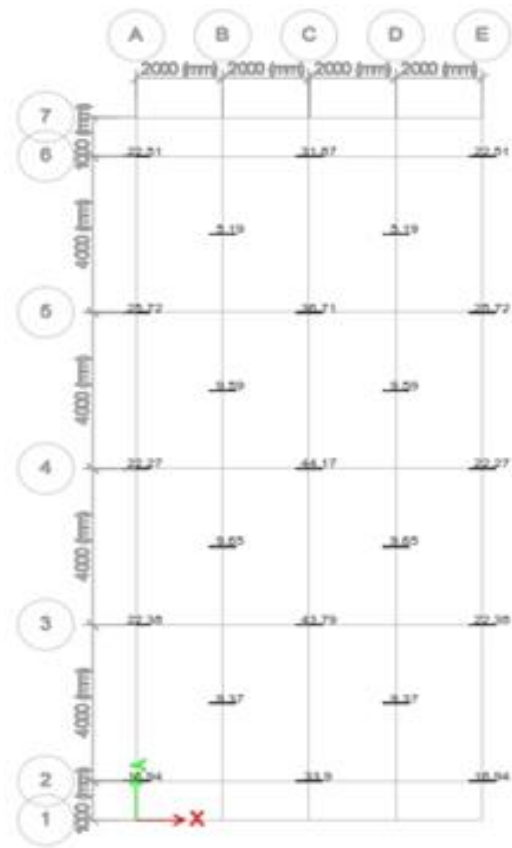
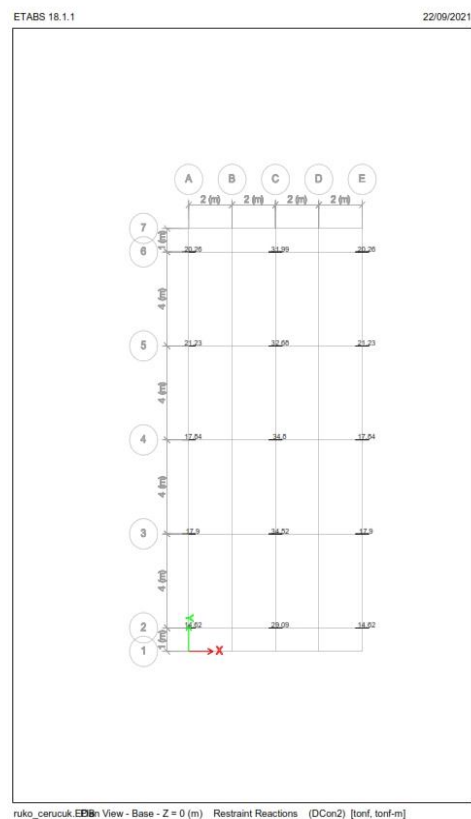


Figure 3. 1. Calculation results of the 150 type house foundation point



Plan View - Base - Z = 0 (mm) Restraint Reactions (DCon2) [tonf, tonf-mm]

Figure 3.2. Loading of Concrete Foundation



ruko_cerucuk EBView - Base - Z = 0 (m) Restraint Reactions (DCon2) [tonf, tonf-m]

Figure 3.3. Cerucuk Foundation Loading Results

Based on the structural load that occurs at the foundation point from the results of the structural analysis calculation, the foundation bearing capacity calculation with various types and sizes of foundations (piles, pile caps and pedestal columns) is calculated. The bearing capacity of the foundation is the ability of the pile group in one foundation (Pile Cap) to bear the burden of the existing building structure. The bearing capacity of the foundation is calculated based on sondir data or CPT data. Based on CPT data, it is known that the type of soil at the location of the 2-storey Ruko building on the Jawi River and Type 150 House Building in Paris II is sandy loam. The water level in the 2-storey Ruko Building on the Jawi River is quite high, ie -0.6 m from the ground level, while the water level in the Type 150 house building in Parit Haji Husen II is rather low, i.e. -1.3 m above the ground.

By knowing the number and dimensions of the foundation, the cost of foundation work can be known. The cost calculation for the foundation work as a whole consists of excavation work, embankment work, pile work (procurement of poles, rental of tools and erection work) and concrete work for Pile Cap and pedestal columns (K225 concrete work, iron work and formwork work). By dividing the cost of the foundation by the magnitude of the load carried by the foundation, it is obtained the cost of the foundation of the foundation load (Rp/kg). The results of the recapitulation of the calculation of the load and bearing capacity of the foundation and the calculation of the cost of the foundation for all alternative uses of piles can be seen in the following table:

Table 3.3. Calculation results of bearing capacity of cerucuk pile foundations and precast piles for each pile group in a 2-storey shophouse building, Jawi River location

No.	Dimension of Pile							Dimension of Pilecap (cm)			Dimension of Pedestal Column (cm)			Calculation of Design Bearing Capacity		Bearing Capacity Need			
	Pile Cap	Num. of pile	Dimension	Pile Length	Depth	Num. Segement	Pile elevation	Material	Length	Width	Height	Length	Width	Height	Pile Bearing Capacity Kg	Bearing Capacity of Pile Cap Kg	Loading Kg	Test (Max) Kg	QU
1	P1	16	Dec-15	11,5 M	11,5 M	1	-0,6 M	Wood	180	180	50	30	30	110	2286,6	36585,5	20260,0	29236,6	25%
	P2	20	Dec-15	11,5 M	11,5 M	1	-0,6 M	Wood	225	225	50	30	30	110	2286,6	45731,9	31990,0	45960,3	0%
	P3	25	Dec-15	11,5 M	11,5 M	1	-0,6 M	Wood	270	270	50	30	30	110	2286,6	57164,9	34800,0	54873,6	4%
	P4	48	10-Dec	3,6 M	3,6 M	1	-0,6 M	Wood											
2	P1	1	□15x15	4 M	16 M	4	0 M	Concrete	45	45	25	30	30	100	9665,0	9665,0	9590,0	9927,5	-3%
	P2	2	□15x15	4 M	16 M	4	0 M	Concrete	75	45	30	30	30	100	9665,0	19330,0	16940,0	17399,0	11%
	P3	3	□15x15	4 M	16 M	4	0 M	Concrete	75	75	30	30	30	100	9665,0	28995,0	25720,0	26341,0	10%
	P4	4	□15x15	4 M	16 M	4	0 M	Concrete	75	75	30	30	30	100	9665,0	38660,0	36710,0	37331,0	4%
	P5	5	□15x15	4 M	16 M	4	0 M	Concrete	75	120	30	30	30	100	9665,0	48325,0	44170,0	45034,0	7%
3	P1	1	□20x20	6 M	18 M	3	0 M	Concrete	50	50	30	30	30	100	12880,0	12880,0	9590,0	9986,0	29%
	P2	2	□20x20	6 M	18 M	3	0 M	Concrete	50	110	30	30	30	100	12880,0	25760,0	22510,0	23122,0	11%
	P3	3	□20x20	6 M	18 M	3	0 M	Concrete	110	110	30	30	30	100	12880,0	38640,0	31870,0	32957,2	17%
	P4	4	□20x20	6 M	18 M	3	0 M	Concrete	110	110	30	30	30	100	12880,0	51520,0	44170,0	45257,2	14%

Table 3.4. Results of Calculation of Bearing Capacity of Cerucuk Pile Foundations and Precast Piles in Each Group of Piles in Type 150 House Building Locations of Haji Husen II Trench

No.	Dimension of Pile							Dimension of Pilecap (cm)			Dimension of Pedestal Column (cm)			Calculation of Design Bearing Capacity		Bearing Capacity Need			
	Pile Cap	Num. of pile	Dimension	Pile Length	Depth	Num. Segement	Pile elevation	Material	Length	Width	Height	Length	Width	Height	Pile Bearing Capacity Kg	Bearing capacity of Pile Cap Kg	Loading Kg	Test (Max) Kg	QU
1	P1	4	Dec-15	11,5 M	11,5 M	1	-1,3 M	Wood	90	90	30	15	15	140	2258,6	9034,6	5274,5	7476,8	21%
	P2	6	Dec-15	11,5 M	11,5 M	1	-1,3 M	Wood	110	110	40	15	15	130	2258,6	13551,9	8269,6	11676,5	16%
	P3	9	Dec-15	11,5 M	11,5 M	1	-1,3 M	Wood	135	135	40	15	15	130	2258,6	20327,8	8852,0	13947,8	46%
	P4	12	Dec-15	11,5 M	11,5 M	1	-1,3 M	Wood	156	156	50	15	15	120	2258,6	27103,8	16492,8	23518,2	15%
	P5	16	Dec-15	11,5 M	11,5 M	1	-1,3 M	Wood	180	180	50	15	15	120	2258,6	36138,4	20241,7	29599,9	22%
	P6	20	Dec-15	11,5 M	11,5 M	1	-1,3 M	Wood	180	225	50	15	15	120	2258,6	45173,0	26613,2	38304,2	18%
2	P1	1	□15x15	4 M	12 M	3	0 M	Concrete	45	45	20	15	15	20	4810,3	4810,3	2300,0	2408,0	100%
	P2	1	□15x15	4 M	16 M	4	0 M	Concrete	45	45	20	15	15	20	6482,6	6482,6	3180,0	3288,0	97%
	P3	1	□15x15	4 M	20 M	5	0 M	Concrete	45	45	20	15	15	20	12468,0	12468,0	7990,0	8098,0	54%
	P4	2	□15x15	4 M	16 M	4	0 M	Concrete	45	90	25	15	15	15	6482,6	12965,1	9630,0	9881,1	31%
	P5	2	□15x15	4 M	16 M	4	0 M	Concrete	45	90	25	15	15	15	6482,6	12965,1	10080,0	10331,1	25%
	P6	3	□15x15	4 M	20 M	5	0 M	Concrete	90	90	25	15	15	15	12468,0	37404,0	30010	30504,1	23%
	P7	4	□15x15	4 M	16 M	4	0 M	Concrete	90	90	25	15	15	15	6482,6	25930,3	23600	24094,1	8%
	P8	5	□15x15	4 M	12 M	3	0 M	Concrete	125	90	25	15	15	15	4810,3	24051,4	21100	21783,1	10%
3	P1	1	□20x20	6 M	12 M	2	0 M	Concrete	50	50	30	15	15	10	8226,7	8226,7	6050,0	6235,4	32%
	P2	1	□20x20	6 M	18 M	3	0 M	Concrete	50	50	30	15	15	10	15573,3	15573,3	10080,0	10265,4	52%
	P3	3	□20x20	6 M	12 M	2	0 M	Concrete	110	110	30	15	15	10	8226,7	24680,0	20010,0	20886,6	18%

Table 3.5 Costs of Pile Foundation Work Cerucuk and Precast Piles With Various Dimensions and Depths of Embroidery in a 2-storey Shophouse Building, Jawi River Location and Type 150 House Building, Parit Haji Husen II Location

No	Building	Number	No.	Number of Pile	Dimension	Pile Length	Depth	Total cost of Foundation per pile group	Cost per Location	Cost per kg of foundation load
								Rp	Rp	Rp
1	2 Storeys Shophouse	10	P1	16	Dec-15	11,5 M	11,5 M	133,535	262,544,13 8.13	365
		2	P2	20	Dec-15	11,5 M	11,5 M	38,762		423,8
		3	P3	25	Dec-15	11,5 M	11,5 M	80,251		467,95
		8	P4	48	10-Dec	3,6 M	3,6 M	9,994		81,08
2	2 Storeys Shophouse	8	P1	1	□15x15	4 M	16 M	26,015	166,808,02 8.87	336,47
		2	P2	2	□15x15	4 M	16 M	11,750		303,95
		8	P3	3	□15x15	4 M	16 M	68,717		296,25
		3	P4	4	□15x15	4 M	16 M	32,693		281,89
		2	P5	5	□15x15	4 M	16 M	27,630		285,88
3	2 Storeys Shophouse	8	P1	1	□20x20	6 M	18 M	50,723	293,468,58 4.47	492,27
		8	P2	2	□20x20	6 M	18 M	97,109		471,22
		4	P3	3	□20x20	6 M	18 M	74,230		480,27
		3	P4	4	□20x20	6 M	18 M	71,405		461,99
4	House type 150	11	P1	4	Dec-15	11,5 M	11,5 M	28,289	226,243,21 9.35	343,97
		4	P2	6	Dec-15	11,5 M	11,5 M	17,507		374,84
		6	P3	9	Dec-15	11,5 M	11,5 M	38,385		458,68
		6	P4	12	Dec-15	11,5 M	11,5 M	58,542		414,87
		4	P5	16	Dec-15	11,5 M	11,5 M	51,519		435,14
		2	P6	20	Dec-15	11,5 M	11,5 M	31,999		417,7
5	House type 150	12	P1	1	□15x15	4 M	12 M	24,299	133,673,82 2.19	420,96
		2	P2	1	□15x15	4 M	16 M	5,200		401,15
		5	P3	1	□15x15	4 M	20 M	15,880		254,74
		5	P4	2	□15x15	4 M	16 M	26,296		405,65
		4	P5	2	□15x15	4 M	16 M	21,037		405,65
		1	P6	3	□15x15	4 M	20 M	9,869		263,87
		1	P7	4	□15x15	4 M	16 M	10,445		402,83
		2	P8	5	□15x15	4 M	12 M	20,644		429,17
6	House type 150	19	P1	1	□20x20	6 M	12 M	75,388	177,046,34 5.50	482,31
		9	P2	1	□20x20	6 M	18 M	51,355		366,41
		4	P3	3	□20x20	6 M	12 M	50,302		509,55

Based on the results of the calculation table above, it is known that the cost of the pile work is as follows:

2-storey shophouse (location of Jawi River):

- The amount of work costs for 12/15 cm cerucuk piles with a driving depth of 11.5 M is Rp. 199,021.72 or Rp. 17,306.24/M' and the total cost of foundation work is Rp. 262,544,138.13. The unit cost of the load is IDR 418.92 per kg
- The amount of the work cost for square precast piles of 15 x 15 cm² with a driving depth of 16 M (4 pole segments @ 4M) is Rp. 2,307,959.02 or Rp. 144,274,439/M' and the total cost of foundation work is Rp. 166,808,028.87. The cost of the unit load is IDR 300.89 per kg
- The amount of work costs for square precast piles of 20 x 20 cm² with a driving depth of 18 M (3 pole segments @ 6M) is Rp. 5,244,101.19 or Rp. 291,338,955 / M' and the total cost of foundation work is Rp. 293,468,584.47. The unit cost of the load is IDR 476.44 per kg

Type 150 house (location of Parit Haji Husen II):

- The amount of work costs for 12/15 cm cerucuk piles with a driving depth of 11.5 M is Rp. 197,634.19 or Rp. 17,185.58/M' and the total cost of foundation work is Rp. 226,243,219.35. The unit cost of the load is IDR 407.53 per kg
- The amount of work costs for precast square piles of 15 x 15 cm² at a driving depth of 12 M (3 pole segments @ 4M) is Rp 1,726,680.48, at a driving depth of 16 M (4 pile segments @ 4M) is Rp 2,302,240.65 and at a driving depth 20 M (5 pole segments @ 4M) for Rp. 2,877,800.81. The cost of pile work per M' is Rp. 143,890.04 and the total cost of foundation work is Rp. 133,673,822.19. The unit cost of the load is Rp. 373 per kg.
- The amount of work cost for square precast piles of 20 x 20 cm² at a driving depth of 12 M (2 pole segments @ 6M) is Rp. 3,476,690.81, at a driving depth of 18 M (3 pole segments @ 6M) is Rp. 5,215,036.21. The cost of pile work per M' is Rp. 289,724,234 and the total cost of foundation work is Rp. 177,046,345.50. The unit cost of the load is Rp. 452.75 per kg.

The cost of a cerucuk foundation is higher than that of precast piles due to the placement of the piles below the very low water table (-1.3 m from the surface) which causes an increase in excavation costs, fill costs and concrete costs (pile caps and pedestal columns) on pile foundations. small.

4. CONCLUSION

Based on the results of the analysis and discussion that has been carried out, the following conclusions can be drawn:

- a. The productivity of the average piling time in a 2-storey shophouse building with an alternative foundation using 12/15 cm cerucuk piles is 22.3 seconds/m' with a pile work cost per M' of Rp

17,306.24, square precast piles 15 x 15 cm² of 111.5 seconds/m' with a pile work cost per M' of Rp. 144,274.439 and a 20 x 20 cm² square precast pile of 125.7 seconds/m' with a pile work cost of Rp. 291,338,955. The productivity of the piling time in a type 150 house building with an alternative foundation using 12/15 cm cerucuk piles is 18.05 seconds/m' with a pile work cost per M' of Rp 17,185.58, precast square piles of 15 x 15 cm² of 104 ,67 seconds/m with the cost of pile work per M' of Rp. 143,890.04 and 20 x 20 cm² of square precast piles of 94.66 seconds/m' with the cost of piling work per M' of Rp 289,724,234.

- b. The productivity of the pile foundation erection time in the type 150 house building is higher than the 2-storey shophouse building. The contributing factor is the ground water level in the Type 150 House building is lower than the 2-storey Ruko building and the number of segments on the concrete piles is less so that the lifting time and connection time are faster.
- c. The total cost of foundation work on a 2-storey shophouse with an alternative foundation using 12/15 cm cerucuk piles is IDR 262,544,138.13, 15 x 15 cm² square precast piles are IDR 166,808,028.87 and 20 x 20 cm² square precast piles are 293,468,584.47. The total cost of foundation work on a type 150 house with an alternative foundation using 12/15 cm cerucuk piles is IDR 226,243,219.35, 15 x 15 cm² square precast piles of IDR 133,673,822.19 and 20 x 20 cm² square precast piles of IDR 177,046,345.50.
- d. The cost of foundation work is based on the load carried by the foundation on a 2-storey shophouse building with an alternative foundation using 12/15 cm cerucuk piles of IDR 418.92 per kg, 15 x 15 cm² square precast piles of IDR 300.89 per kg and 20 x 20 cm² square precast piles of IDR 476.41 per kg. The cost of foundation work is based on the load carried by the foundation on a type 150 house building with an alternative foundation using a 12/15 cm cerucuk pile foundation of IDR 407.53 per kg, 10 x10 cm² square precast piles of IDR 359.07 per kg, piles precast square 15 x15 cm² for IDR 373 per kg and precast square stake 20 x 20 cm² for IDR 452.75 per kg
- e. In 2-storey shop houses and type 150 house buildings, the cost of foundation work using 15 x 15 cm² square precast piles is the most efficient, both from the aspect of driving costs, overall costs and the cost of the unit load carried by the foundation. In a 2-storey shophouse building, the cost efficiency of the 12/15 cerucuk pile foundation is 37 % and that of the 20 x 20 cm² square precast pile is 43 % . In the type 150 house, the cost efficiency of the 12/15 cerucuk pile foundation is 41% and the 20 x 20 cm² square precast pile is 24.5%.

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