Quest Journals
Journal of Architecture and Civil Engineering
Volume 11 ~ Issue 1 (January 2026) pp: 72-83
ISSN(Online): 2321-8193
www.questjournals.org

Research Paper

Comparison of RISHA Construction Costs through Precast and Cast-in-Situ Method Analysis

Nina Uskas Amin; Dwi Dinariana; Hari Nujaman
Master of Civil Engineering, Civil Engineering, Universitas Persada Indonesia YAI, Jakarta, Indonesia
Corresponding Author: Nina Uskas Amin

Abstract: *Technology of Rumah Instan Sederhana Sehat (RISHA) is an innovation in earthquake-resistant modular construction that uses a dry joint system, namely a joint without the use of adhesive materials. Although the upper components of RISHA are prefabricated, the lower structure generally still uses conventional methods (Cast-in-situ). This method has disadvantages such as long processing time, dependence on weather and the risk of wasting materials. This study aims to analyze the comparison of the using of precast foundation and the conventional foundation in RISHA type-36 structures. Three types of precast foundations were examined in this study: pocket foundations, block footings, and knockdown foundations. This study used a paralel comparative method with geothechnical, structural, and cost analyses based on Analysis of Unit Work Price based on Regulation of the Minister of Public Works and Public Housing No. 8, 2023. The analysis results indicate that precast foundations offer time and cost efficiency as well as structural performance that meets safety requirements in soft soil conditions. This study is expected to serve as a reference in accelerating post-earthquake housing development, particularly in disaster-prone areas such as Banten Province.*

Keywords: *RISHA, Precast Foundations, Cast In-Situ, Price Comparison, Geotechnical.*

Received 13 Jan., 2026; Revised 28 Jan., 2026; Accepted 30 Jan., 2026
*Published with open access at **www.questjournas.org***

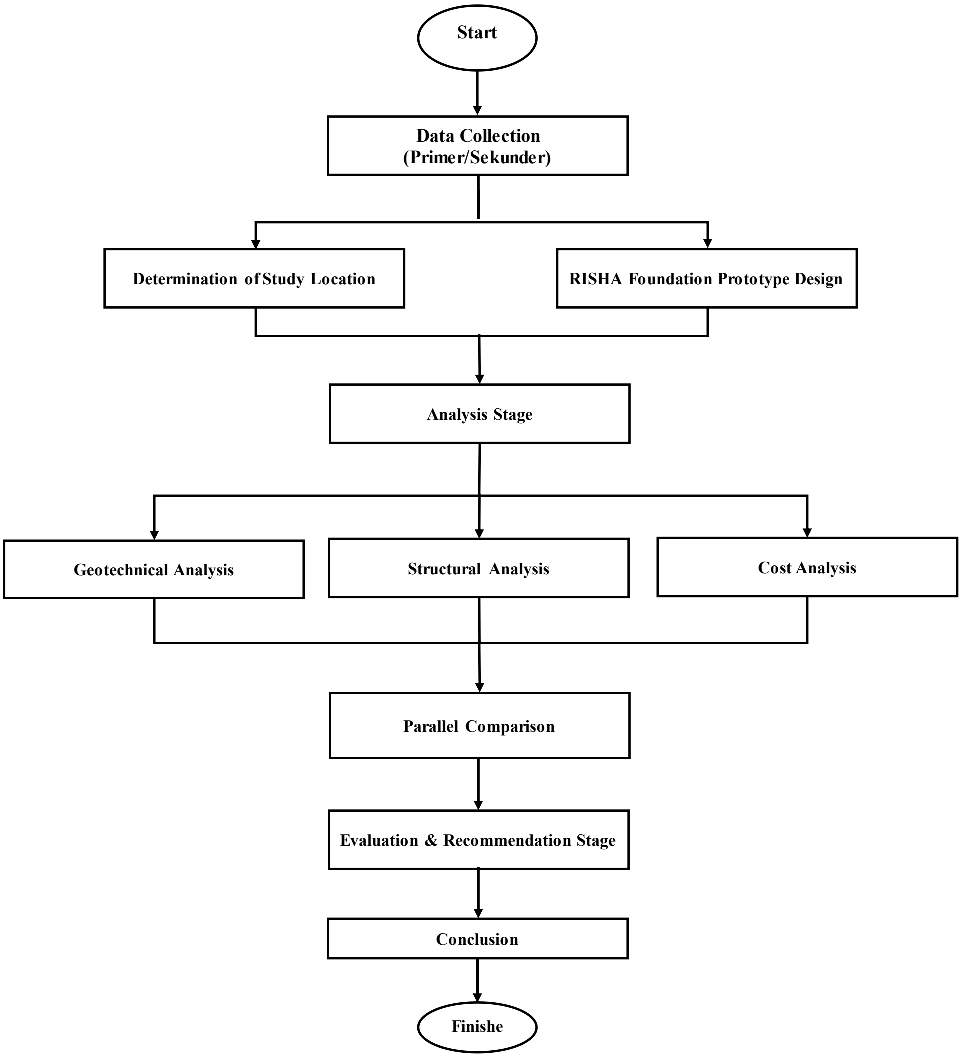
I. INTRODUCTION

Ministry of Public Works and Public Housing has released technology of RISHA in 2004. This technology is a solution of livable housing using a dismantling system (knock-down). One RISHA type 36 house unit consists of 78 P1 panels, 30 P2 panels, and 30 P3 panels. These panels are lightweightand can be assembled manually. However, the use of conventional foundations such as a split stone masonry or direct casting on site is often a barrier. This is due to the long hardening process (curing) and high labor costs. As an alternative, precast foundations are proposed to improve the efficiency of construction time, costs and quality.

This study compares the effectiveness and efficiency of using precast foundations with conventional foundations in RISHA structures, where structural performance assessments are conducted as an indicator of effectiveness, as well as assessments of time, cost, and resources as incators of foundation efficiency. To date, there has been no comprehensive study comparing the performance of precast foundations and conventional foundations in the application of RISHA. This study is expected to fill this gap. In addition, this study also aims to support quality improvement and acceleration of post-earthquake housing development in disaster-prone areas, especiallyin Banten Province.

II. METHODOLOGY

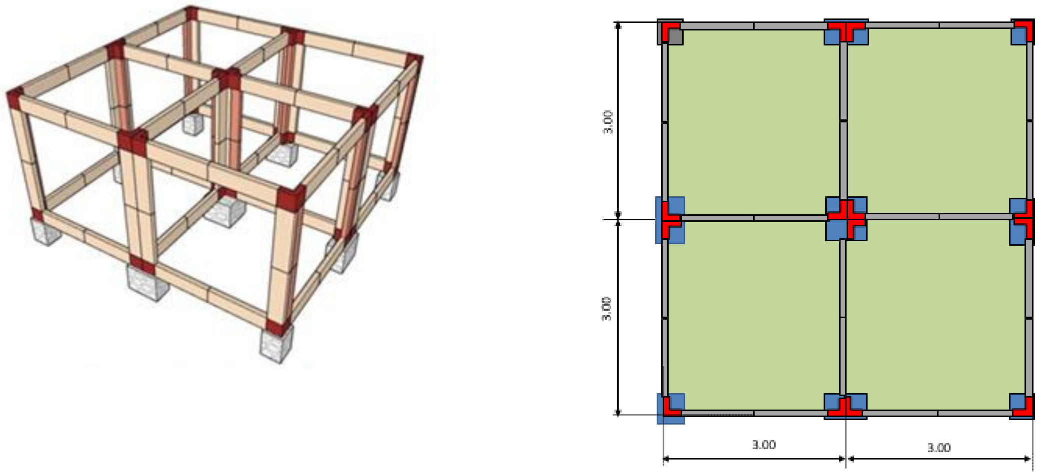
The method used in this study is the comparative parallel method with the RISHA prototype for both precast and cast-in-situ foundations on land areas with the same geothecnical conditions. This method aims to minimize distortion or errors in the data that result in inaccurate results, thus cofounding variables such as material price fluctuations or field conditions are controlled. The flowchart of the implementation method is as follows:



The RISHA house studied in this study is the standard RISHA type 36 as shown in the picture 1.1 below:

Picture 1. House Prototype of Risha Standard Type-36

The RISHA type 36 structural panel module is presented Picture 1.2 below:



Picture 2. The RISHA type 36 Structural Panel Module

Initial preparation of the study involves collecting both primary and secondary data as needed for the analysis. The analysis consist of :

Geotechnical Analysis

Filed investigation data using sounding tools and CPT (Cone Penetration Test) testing were conducted to determine the soil profile, permit bearing capacity (qi), and settlement estimates at a foundation depth of 0,5 – 1 meter. The soil investigation report was conducted by PT. Panca Guna data, soil laboratory testing from PT. Inti Teknolohi Indonesia Utama Jl. Raya Puspitek, Kp. Kademangan No. 50 Kec. Setu- South Tangerang-Banten, 15320.

Structural Analysis

This analysis aims to ensure the foundation is capable of supporting the applied loads. Furthermore, this analysis also ensures that safety requirements are met. In building planning, in addition to soil bearing capacity, allowable loads (qi), dead load (DL), and live load (LL), another important factor to consider is land settlement. It should be emphasized that the settlement analysis conducted in this study is a preliminary estimate (preliminary design) based on secondary soil parameters and correlation with field data. These calculations aim to predict and ensure that land subsidence due to strucrural loads remains within the safe limits. It is crucial to avoid cracking or stuctural failure, as required by SNI 8460:2017 and classical soil mechanics literature as Wesley (2011). Foundation dimensions are determined by comparing theoretical calculations with permissible settlement limits. The goal is to ensure the long-term stability and safety of the sturcture under specific soil conditions.

Cost Analysis

The Budget Plan is calculated using Analysis of Unit Work Price based on Regulation of the Minister of Public Works and Public Housing No. 8, 2023 and SNI 7832:2017 about Analysis of Unit Work Price of Insitu Precast Concrete for Building Construction.

III. STUDY RESULTS

This study discusses the difference in total cost between precast foundations and casi-in-situ foundations in the RISHA structure.

The precast method that has been developed 3 (three) kinds foundations for RISHA strucrures, namely:

1. Pocket Foundation

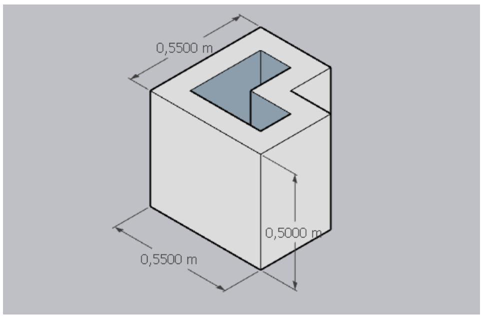
   Pocket foundations, also known as pit or shell foundations in precast contexts, are a type of shallow foundation. They are specifically designed to support prefabricated columns. Technically, their main characteristic is the pocket system (Socket). These foundations called “pocket” because they have a cavity in the center of the foundation block that serves as the placement pf the lower end of the precast column.

   Joint mechanism: After the column is inserted into the foundation cavity, the gap between the column and the foundation wall is filled with grouting material. This is in the form of high-quality concrete or a special adhesive material that produces a rigid and stable joint. In the application of RISHA technology, pocket foundation play a role in accelerating the assembly process. RISHA’s upper components are in the form of precast panels. Therefore, the use of pocket foundations allows for uniformity in the speed of construction of the lower and upper structures without waiting for the time-consuming conventional casting process.

Pocket foundations that developed for RISHA structures are three types. These type are adjusted to the foundation points of the building.

- Pocket Foundation Type 1

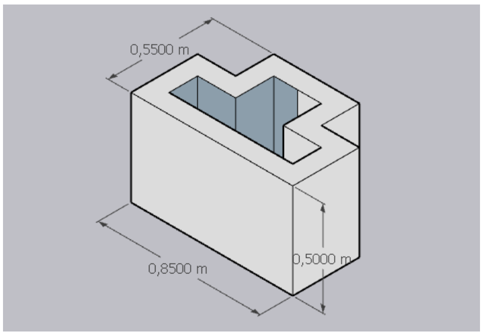
Type 1 is located at the corner of the building and serves as the main foundation point in that area. The type 1 pocket design can be seen in Picture 4 below:



Picture 3. Pocket Foundation Type 1

- Pocket Foundation Type 2

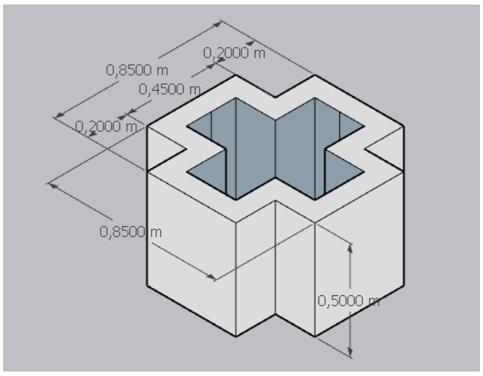
Foundation Type 2n is located at the center edge of the building, as shown at Picture 5 below:



Picture 4. Pocket Foundation Type 2

- Pocket Foundation Type 3

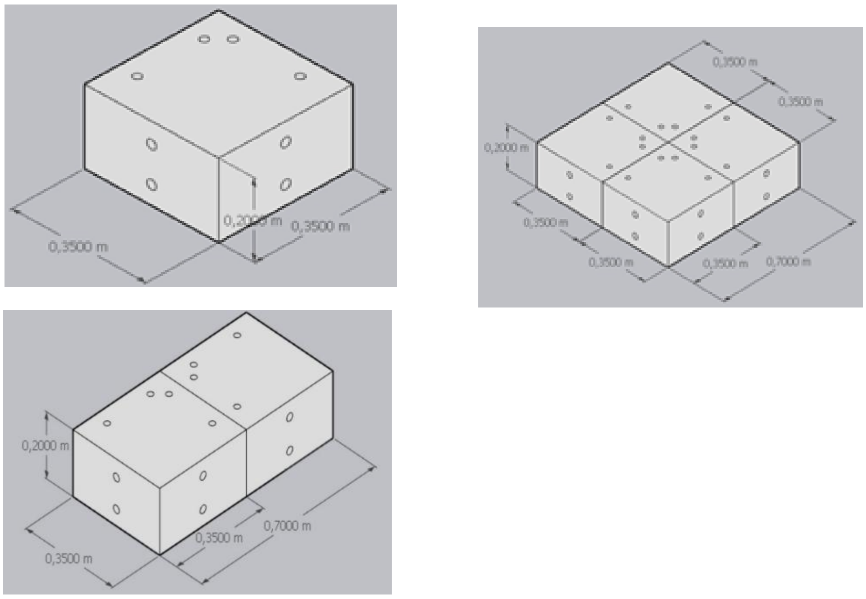
Foundation type 3 is located in the middle of the building or the core of the house as shown in Picture 6 below:



Picture 5. Pocket Foundation Type 3

2. Footing Block Foundation

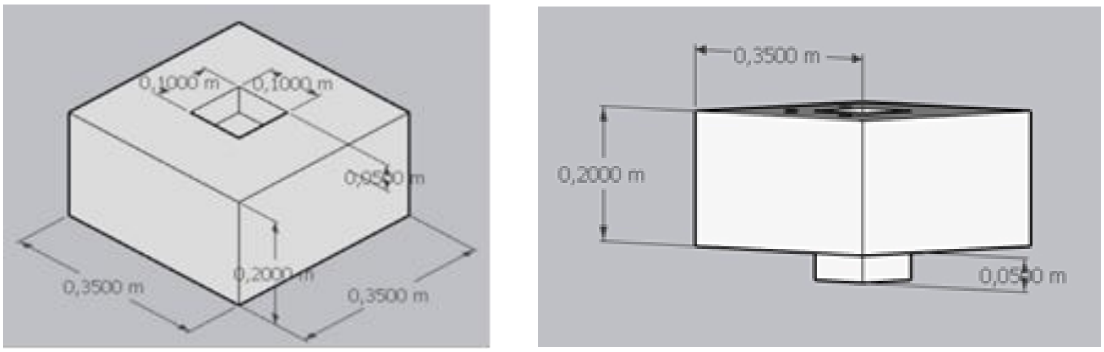
This type of foundation is a precast, square-shaped foundation measuring 40 x 40 x 20 cm, which has holes on the left and right sides as a mechanical joint between panels and joint with RISHA structure. The footing block foundation also consists of three types, just like the conventional foundation and pocket foundation that have been explained previously. Each type of foundation can be seen in Picture 7 below:



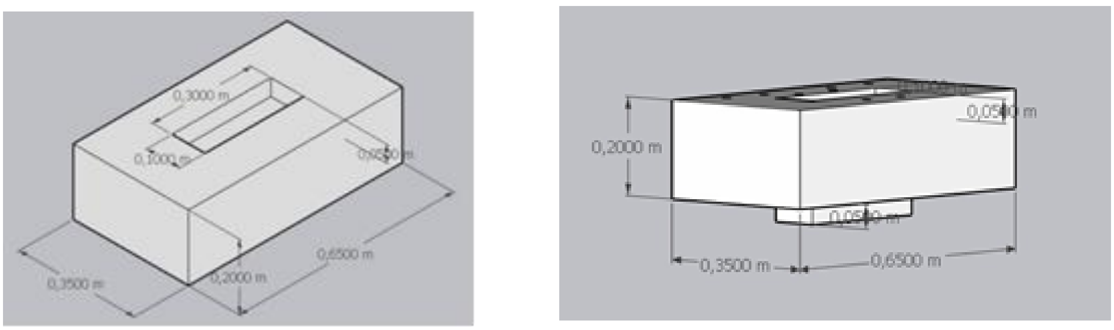
Picture 6. Footing Block Foundation Type 1, Type 2 and Type 3

3. Knock Down Foundation

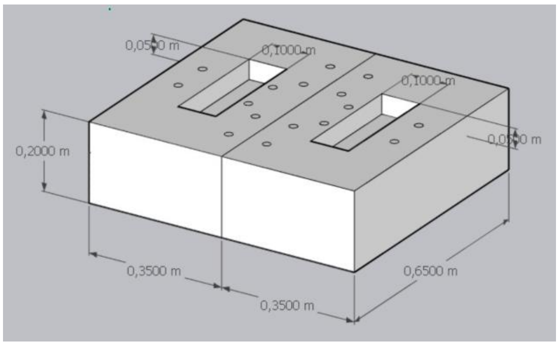
This knock down foundation consists of 3 types. Each is rectangular in shape and has a different size, corresponding to the location of the RISHA building. Each type of foundation consists of two piles, each 20 cm thick, so the depth is approximately 40 cm from the ground surface. The pupose of this design is to facilitate the mobilization process of the foundation in the field. The visualization of the foundation can be seen in the following image:

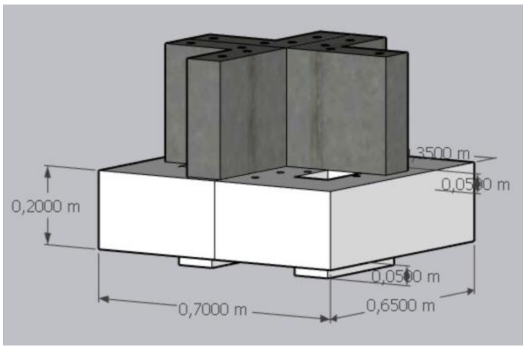


Picture 7. Knock down Foundation Type 1 (*female/male*)



Picture 11. Knock Down Foundation Type 2 (*Female/Male*)





Picture 82. Knock Down Foundation Type 3 (*female/male*)

Geotechnical Analysis

Physical Property of Land

The soil type studied in this study is soft soil. The soil investigation was conducted by PT Panca Niaga Utama at the Coretim Embung BIP project site in Serang City, Banten.

Table 1. Results of Soil Testing in the Laboratory

No	Tested Parameter	Unit	Sample
1.	Groundwater Content	%	35,04
2.	Atterberg Limits		
	- WL (Water Limit)	%	83,13
	- PL (Plastic Limit)	%	29,3
	- IP (Plastic Index)	%	53,87
3.	Soil Volume Weight (ɣ)	gr/cm³	1,83
4.	Triaxial		
	- C (Cohession)	Kg/cm³	0,32
	- Φ (intenal friction angel)	°	9,6 ≈10
	-Tangent ɸ		0,17

Structural Analysis

Because the friction angle of the soil Ø is small (< 10°) and it is assumed that the soil is less dense, the Terzaghi formula is used in this condition. "*local shear failure*"

The three types of precast foundations that have been described are all square and rectangular in shape, so the calculation of the permissible bearing capacity uses the Terzaghi formula as follows:

Where width B and lenght L satisfy B/L = 1. Therefore, the following formula is used:

$$q_u = 1{,}3\, c\, N_c + g\, D_f\, N_q + 0{,}4\, g\, B\, N_g$$

For rectangular foundation

Where width B and lenght L > 1, therefore the formula used:

$$q_u = c\, N_c S_c d_c + \gamma\, D_f\, N_q S_q\, d_y + 0{,}5\, \gamma\, B\, N\gamma\, S\gamma\, d\gamma$$

The results of the calculation of permitted bearing capacity for the proposed precast foundation type are as follows:

Table 2. Summary of Foundation Dimensions and Permitted Bearing Capacity

Parameter hasil penyelidikan tanah		
Cohesi, c	0,0320	ton/m²
Sudut Geser Dalam , Ø	10 °	
g Tanah	1,830	ton/m³

Jenis Pondasi	Dimensi Pondasi				Berat Pondasi			$q_{allowed}$	Sat
	D_f	B	L	Sat	1 bh	2 bh	Sat		
Pondasi *Pocket*									
Tipe 1	0,5	0,55	0,55	m	408	-	Kg	0,735	kg/cm²
Tipe 2	0,5	0,55	0,85	m	720	-	Kg	0,729	kg/cm²
Tipe 3	0,5	0,85	0,85	m	1032	-	Kg	0,879	kg/cm²
Pondasi *Knock Down*									
Tipe 1	0,4	0,35	0,35	m	58,8	117,6	Kg	0,605	kg/cm²
Tipe 2	0,4	0,35	0,65	m	109,2	218,4	Kg	0,596	kg/cm²
Tipe 3	0,4	0,65	0,65	m	202,8	405,6	Kg	0,623	kg/cm²
Pondasi Blok Tapak									
Tipe 1	0,2	0,35	0,35	m	58,8	-	Kg	0,368	kg/cm²
Tipe 2	0,2	0,35	0,7	m	117,6	-	Kg	0,358	kg/cm²
Tipe 3	0,2	0,7	0,7	m	235,2	-	Kg	0,238	kg/cm²
Pondasi setempat Batu Belah									
Tipe 1	0,6	0,35	0,35	m	161,7	-	Kg	0,842	kg/cm²
Tipe 2	0,6	0,35	0,65	m	300,3	-	Kg	0,832	kg/cm²
Tipe 3	0,6	0,65	0,65	m	557,7	-	Kg	0,859	kg/cm²

Bearing Capacity Correction

Based on the above data, a correction was made to the local bearing capacity at a depth of 60 m above ground level. The correction refers to the allowable stress of the landslide (laboratory test).

Table 3. Correction of Bearing Capacity of Local Foundation Permit

Types of Foundation		**Bearing Capacity Permit (q allowed)**		**Results of Bearring Capacity Permit Sondir (q*c*)**		**Remarks**
Local Split Stone Foundation	Type 1	0,842	Kg/cm²	< 6.00	Kg/cm²	ok
	Type 2	0,832	Kg/cm²	< 6.00	Kg/cm²	ok
	Type 3	0,859	Kg/cm²	< 6.00	Kg/cm²	ok

Based on the data above, a correction was made in the bearing capacity value of the pocket foundation at a depth of 50 cm below ground level against the allowable stress from the sounding results (laboratory test).

Table 4. Correction of Bearing Capacity of Pocket Foundation Permit at 50 cm Depth

Types of Foundation		**Bearing Capacity Permit (q allowed)**		**Results of Bearring Capacity Permit Sondir (q*c*)**		**Remarks**
Pocket Foundation	Type 1	0,735	Kg/cm²	< 5.00	Kg/cm²	ok
	Type 2	0,729	Kg/cm²	< 5.00	Kg/cm²	ok

	Type 3	0,879	Kg/cm²	< 5.00	Kg/cm²	ok

Based on the data above, a correction was made in the bearing capacity value of the footing block foundation at a depth of 20 cm below ground level against the allowable stress from the sounding results (laboratory test).

Table 5. Correction of Bearing Capacity of Footing Block Foundation Permit

Types of Foundation		Bearing Capacity Permit (q allowed)		Results of Bearring Capacity Permit Sondir (q*c*)		Remarks
Footing Block Foundation	Type 1	0,368	Kg/cm²	< 4.00	Kg/cm²	ok
	Type 2	0,358	Kg/cm²	< 4.00	Kg/cm²	ok
	Type 3	0,238	Kg/cm²	< 4.00	Kg/cm²	ok

Based on the data above, a correction was made in the bearing capacity value of the knock down foundation at a depth of 40 cm below ground level against the allowable stress from the sounding results (laboratory test).

Tabel 6. Correction of Bearing Capacity of Knock Down Foundation Permit

Types of Foundation		Bearing Capacity Permit (q allowed)		Results of Bearring Capacity Permit Sondir (q*c*)		Remarks
Knock Down Foundation	Type 1	0,605	Kg/cm²	< 4.00	Kg/cm²	ok
	Type 2	0,596	Kg/cm²	< 4.00	Kg/cm²	ok
	Type 3	0,623	Kg/cm²	< 4.00	Kg/cm²	ok

Load Calculation

The calculated load on the RISHA house includes the following components:

– Weight of RISHA type 36 panel
– Weight of lightweight brick wall
– Weight of foundation

The RISHA type 36 structure has been tested in the PU laboratory (test certified attached). Based on the technical assessment, the roofing materials used are asbetos and metal roof with a slope of 12,5°. This condition generates relatively small horizontal forces. The 40 cm anchors connecting the RISHA panels to the walls serve as horizontal load-bearing supports for the building. Therefore, earthquake and wind loads (horizontal forces) are negligible in a single-story house.

Live loads can be ingnored in single-story buildings because these loads are directly supported by the floor.

Table 7. Recapitulation of Load Calculation

o	Type of Foundations	Panel Load of RISHA (kg)	Brick Wall Load (kg)	Self Weight of Foundation (kg)	Total Load (kg)
1	Pocket Foundation				
	Type 1	408	576	308,4	1292,4
	Type 2	720	864	358,8	1942,8
	Type 3	1032	1152	660	2844
2	Knock Down Found.				
	Type 1	408	576	117,6	1101,6

	Type 2	720	864	218,4	1802,4
	Type 3	1032	1152	405,6	2589,6
3	Footing Block Found.				
	Type 1	408	576	58,8	1042,8
	Type 2	720	864	117,6	1701,6
	Type 3	1032	1152	235,2	2429,2
4	Local Split Stone Found.				
	Type 1	408	576	161,7	1145,7
	Type 2	720	864	300,3	1884,3
	Type 3	1032	1152	557,7	2741,7

The data shows that the loading comparison of the foundation type. Pocket foundation have a structural load-bearing capacity that increases significantly as well as the increasing of dimensions and type. Footing block foundations are more efficient for light to medium loads with simple construction. Meanwhile, knock down foundations offer modular flexibility at the expense of greater self-weight. These differences in loading characteristics are an important basis for selecting the appropriate foundation type for the building of structural RISHA needs and local soil conditions.

Land Subsidence (Settlement)

Calculation of land subsidence for each type of foundation requires the following data:

- Foundation dimensions to determine the foundation area (A) and foundation depth (Df)
- Foundation self-load (P)
- Parameters on the type of soil at the Construction Location such as cohesion value (c), friction angle Ø, and ɣ soil;

The results are in the form of working pressure on the foundation as listed in table 8 below:

Table 8. Recapitulation of Land Subsidence (*Settlement*)

No	Type of Foundations	Foundation Working Pressure (kPa)	Settlement Estimated (mm)	Correction Factor	Final Settlement (mm)
1	Pocket Foundation				
	Type 1	49,234	15,00	1,5	22,50
	Type 2	50,137	15,00		22,50
	Type 3		15,00		22,50
2	Knock Down Found.				
	Type 1	89,927	26,927	1,5	40,47
	Type 2	79,226	23,766		35,65
	Type 3	61,290	18,39		27,58
3	Footing Block Found.				
	Type 1	408	25,538	1,5	38,31
	Type 2	720	20,85		31,28
	Type 3	1032	15,00		23,00
4	Local Split Stone Found.				
	Type 1	408	28,06	1,5	42,10
	Type 2	720	27,545		41,32
	Type 3	1032	22,467		33,70

The value of land subsidence (settlement) on each foundations above are converted to millimeters (mm) by interplation. This settlement estimate uses data from the following Table 9

Table 9. Land Subsidence (*settlement*) Permit Estimation

Tekanan kerja pondasi Kpa	Tanah Kaku	Tanah sedang	Tanah Lunak
50 -100	< 5 mm	5 - 15 mm	15 - 30 mm
100 -200	5 - 10 mm	15 - 30 mm	30 - 60 mm
200 -300	10 - 20 mm	30 - 50 mm	> 60 mm

(Source: Bowles - Foundation Analysis and Design; Terzaghi & Peck, Soil Mechanics in Engineering Practice; Peck, Hanson & Thornburn, Foundation Engineering; NAVFAC DM-7 (US Marine Manuall)

Note:

The table above is not found in a single book, but it is professionally valid. It can be used for simple building designs and non-critical structures.

During the evaluation stage, additional correction factors are required for land susidence (settlement) due to field conditions. These correction factors include small local foundation (+20%), soft soil types (+20%), and precast foundation (+10%), resulting a total conservative correction of 50%. The final settlement estimate is presented in Table 10 below:

Table 9. The Final Land Subsidence (*Settlement*) Estimate

Jenis Pondasi	Foundation Work Pressure (kPa)	Penurunan (konversi) (mm)	Jenis Tanah	Estimasi *Setlement* (mm)	Catatan
Pondasi *Pocket*					
Tipe 1	49,234	22,5	Tanah Lunak	(15 - 30)	ok
Tipe 2	50,137	22,5			ok
Tipe 3	50,667	22,5			ok
Pond. *Knock Down*					
Tipe 1	89,927	40,47	Tanah Lunak	(15 - 30)	*note*
Tipe 2	79,226	35,65			*note*
Tipe 3	61,290	27,58			ok
Pond. Blok Tapak					
Tipe 1	85,127	38,31	Tanah Lunak	(15 - 30)	*note*
Tipe 2	69,453	31,28			*note*
Tipe 3	49,371	23,00			ok
Pond. setempat bt belah					
Tipe 1	93,527	42,10	Tanah Lunak	(15 - 30)	*note*
Tipe 2	82,826	41,32			*note*
Tipe 3	64,892	33,70			*note*

This table presents the performance evaluation of RISHA precast foundation in soft soil condition with a thickness of between 15-30 cm. The evaluation was conducted using working pressure, settlement, and suitability assessment parameters in the form of 'ok' or 'note' categories. All foundation types are suitable for use even though the settlement varies between 22.5 to 42.1 mm. This is consistent with the previous analysis regarding to optimizationof foundation design in a weak geotechnical condition in Serang. This data compliments the calculating settlement based on pressure anf area, which is used for geotechnical validation.

The calculation is carried out based on a simple model: settlement = SF x (pressure x soil factor), which is relevant for RISHA design optimization. Safety factor is the ratio between the ultimate capacity against the actual working load in geothecnical analysis.

Soil factor represents the specific deformation coeficient of the soil or convert pressure (kPa) into settlement (mm).

The performance of pocket foundation type 1 and 2 recorded a working pressure between 40,24 to 50,67 Kpa with a stable settlement of 22,5 mm, so it is considered completely good for shallow soft soil.

The maximum condition on this group, namely a pressure of up to 50.67 kPa and a settlement of 22.5 mm received a good rating. This confirms that the precast system is efficient in handling soft ground condition without posing significant risk.
Footing block foundation shows a higher working pressure, namely between 49.37 to 89.52 kPa. The settlement ranging between 23.0 to 38.1 mm.

Cost Comparison:
Table 10. shows the recapitulation of cost comparison of foundation for each unit.

Table 10. Recapitulation of Cost Comparison of per unit Foundation

No	Tipe Pondasi	Biaya Produksi	Biaya Erection	Biaya Joint	Total Harga
1.	**Konvensional**				Rp 1.633.674,26
					Rp 1.633.674,26
2.	***Pocket***				
	Pondasi *Pocket* T	Rp 164.187,46	Rp 32.880,00	Rp 72.819,00	Rp 269.886,46
	Pondasi *Pocket* T	Rp 226.606,26	Rp 55.660,00	Rp 145.638,00	Rp 427.904,26
	Pondasi *Pocket* T	Rp 267.394,18	Rp 65.760,00	Rp 240.325,05	Rp 573.479,23
	Lansir		Rp 871.423,20		Rp 871.423,20
					Rp 2.142.693,15
3.	**Blok Tapak**				
	Blok Tapak Tipe 1	Rp 44.280,99	Rp 9.490,75	Rp 52.101,90	Rp 105.873,64
	Blok Tapak Tipe 2	Rp 75.346,18	Rp 11.008,50	Rp 144.253,80	Rp 230.608,48
	Blok Tapak Tipe 3	Rp 136.432,68	Rp 32.408,00	Rp 318.807,60	Rp 487.648,28
	Lansir		Rp 364.207,20		Rp 364.207,20
					Rp 1.188.337,61
4.	***Knock Down***				
	***Knock Down* Tipe**	Rp 45.086,51	Rp 8.102,00	Rp 50.490,57	Rp 103.679,08
	***Knock Down* Tipe**	Rp 45.578,42	Rp 14.178,50	Rp 199.890,57	Rp 259.647,49
	***Knock Down* Tipe**	Rp 45.720,42	Rp 30.256,25	Rp 150.090,57	Rp 226.067,24
	Lansir		Rp 738.331,20		Rp 738.331,20
					Rp 1.327.725,01

The footing block foundation and knock down are very efficient in cost effective. The footing block foundation costs Rp. 1.188.337,- while knock dwon foundation Rp. 1.327.725,-. Both of these foundations can be an alternative choice for structure of RISHA.

Table 11. Shows a Recapitulation of Price Comparison of 1 unit of the House

Tipe Pondasi	Persiapan	Struktur	Arsitektur	MEP	Total Harga
Konvensional	Rp 1.480.338,50	Rp 55.937.890,67	Rp 88.843.884,98	Rp 8.320.622,00	**Rp 154.582.736,15**
Pocket	Rp 1.480.338,50	Rp 58.012.563,15	Rp 88.843.884,98	Rp 8.320.622,00	**Rp 156.657.408,63**
Blok Tapak	Rp 1.480.338,50	Rp 55.972.480,26	Rp 88.843.884,98	Rp 8.320.622,00	**Rp 154.617.325,74**
Knock Down	Rp 1.480.338,50	Rp 55.561.990,59	Rp 88.843.884,98	Rp 8.320.622,00	**Rp 154.206.836,06**

And the total cost of 1 unit RISHA house, knock down foundation is superior to other types of foundations by the value of Rp. 154.206.836,-.
This study compares conventional cast-in-situ foundation with three kinds of precast foundation (pocket, footing block, knock dwon) for the structure of RISHA on the soft soil in Serang-Banten. The study focused includes costs, implementation time, settlement, and bearing capacity. The matrix of the trade offs and discussion results are presented in Table 12 below:

Table 12. Foundation Trade-Offs Matrix

Aspek	Konvensional (*Cast-in-Situ*)	Pocket Precast	Blok Tapak Precast	Knock-Down Precast
Biaya per Unit Rumah (Rp)	154.582.736,-	156.657.408,- (lebih tinggi)	154.617.326,- (hemat Rp 965.000)	154.206.836 (hemat = Rp 1.1 jt, terbaik)
Settlement Akhir (mm, rata-rata)	23-42 (note, tertinggi)	22.5 (ok, stabil)	23-40 (note-ok)	22.5-33 (ok-note, modular)
Daya Dukung (kg/titik)	958-2406 (cukup)	408-1032 (ok)	58.8-405.6 (efisien ringan)	58.8-235.2 (fleksibel)
Waktu & Instalasi	Lama (curing, cuaca)	Cepat (fabrikasi)	Sangat cepat	Tercepat (knock-down mudah)
Kelemahan Utama	Biaya tinggi, lambat	Biaya erection tinggi	Tekanan kerja tinggi	Berat sendiri lebih besar

Data based recommendation show that konck down foundation is *superior* for large projects because it is cost-effective and fast. Meanwhile, the pocket foundation is suitable for stable soil.

CONCLUSION

The following are some ponts that can be concluded from the technical and economic analysis result of RIZHA foundation system.

1. Cost and Operational Efficiency
   The precast foundation systems, in particular, footing block and knock down, have proven to be more economical than conventional methods. Potential cost savings up to Rp. 1.1 million per housing unit. Beside in terms of financial aspects, they are superior in installation speed and ease of mobilization. Especially in the soft soil condition that has been adjusted based on the geotechincal test results.
2. Structural Performance and Bearing Capacity
   Structural evaluation ensures that all the precast foundation in this study are safe and stable in supporting the load of RISHA panels and shear forces (forces that cause shift between structural parts). The applied load on the piles is identified to range from 958 kg to 2406 kg. For large-scale project, the use of knock down system is highly recommended. This system can reduce the production and installation costs without sacrificing the quality standard of geotechnical.
3. Specific Characteristic of Each Type of Foundation
   Pocket Type Foundation has low to medium working pressure (40,24 kPa – 50,67 kPa). With estimated settlement ranging from 22.50 mm to 25.00 mm after calibration with correction factor 1.5. Thus, very suitable for hard to medium soil conditions.
   Footing block foundation has a higher working pressure, ranging from 58,92 kPa to 89,52 kPa. While, the final settlement classified as significant namely 31.70 mm to 40.47 mm.
   Note: Close supervision is required when applied to soft soil to prevent excessive deformation.

   The local foundation (footing and Type 2) have a high working pressure from 49.37 kPa to 95.26 kPa. The the final settlement reached 23.00 mm to 42.10 mm. In the critical condition, type 2 foundation shows the highest settlement at 42.10 mm, however, the design is ideal to distribute a wide load on the soft soil with RISHA precast standard foundation.

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