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Study on the Reliability of Materials and Structures of Simple Pre-cast Modular Houses (Case Study: RUCAST Technology)

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Abstract

RUCAST (PreCAST Concrete Main Frame) is a precast concrete housing system developed to provide more flexible and affordable landed houses. Unlike many existing precast technologies that have rigid panel sizes and limited floor-plan flexibility, RUCAST allows flexible beam-column positioning and flat wall columns, resulting in more efficient space usage and adaptable interior layouts. RUCAST is designed as a confined masonry structural system, where the walls carry structural loads while beams and columns function mainly as wall restraints. The system uses a concrete mix ratio of 1:2:3 (cement:fine aggregate:coarse aggregate) to ensure practical construction and consistent field quality. Beam and column dimensions are 100 × 100 mm^2, with mechanical connections using steel threads and plates, making the frame unsuitable as a moment-resisting system. The study evaluated material properties, structural components, structural behavior, and production costs. Tests included concrete compressive strength, reinforcing steel strength, mortar strength, masonry bond strength, flexural testing of structural components, and cyclic testing of wall systems. Results indicate that RUCAST can be applied in 37 of Indonesia's 38 provincial capitals for hard, medium, and soft soil conditions, with adequate performance for areas having $S_{DS} \leq 1.38g$. RUCAST production costs are also approximately 25.28% lower than comparable precast housing technologies.

Keywords: Confined masonry, 1:2:3 concrete mix, earthquake resistant house, precast landed house, RUCAST.

Abstrak

RUCAST (Rangka Utama beton preCAST) merupakan teknologi rumah sederhana pracetak yang dikembangkan untuk memberikan fleksibilitas desain dan biaya yang lebih ekonomis dibandingkan teknologi rumah pracetak yang sudah ada. Berbeda dengan sistem pracetak konvensional yang memiliki keterbatasan akibat ukuran panel yang kaku, RUCAST memungkinkan fleksibilitas posisi kolom–balok dan penggunaan kolom rata dinding sehingga tata ruang menjadi lebih efisien, luas, dan mudah disesuaikan dengan kebutuhan pengguna. RUCAST dirancang sebagai sistem struktur dinding terkekang, di mana dinding berfungsi menerima beban struktur, sedangkan balok dan kolom hanya berperan sebagai pengekang dinding. Material beton menggunakan campuran volumetrik 1:2:3 untuk mempermudah pelaksanaan di lapangan dan menjaga kualitas konstruksi. Dimensi balok dan kolom sebesar 100 × 100 mm^2 *dengan sambungan mekanik sederhana menyebabkan sistem ini tidak direkomendasikan sebagai portal pemikul momen. Penelitian mencakup pengujian material, komponen struktur, perilaku struktur, dan analisis biaya produksi. Hasil penelitian menunjukkan bahwa RUCAST mampu diterapkan pada 37 dari 38 ibu kota provinsi di Indonesia dengan kapasitas gempa memadai untuk lokasi dengan* $S_{DS} \leq 1{,}38g$*. Selain itu, biaya produksi RUCAST sekitar 25,28% lebih murah dibandingkan teknologi rumah pracetak sejenis.*

Kata Kunci: *Pasangan dinding pengekang, beton campuran 1:2:3, rumah tahan gempa, rumah tapak pracetak, RUCAST.*

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INTRODUCTION

The rapid growth of the urban population has led to a high demand for housing, yet this demand is not matched by the pace of landed house construction, thereby increasing the housing backlog in Indonesia. According to data from the Central Bureau of Statistics in 2025, the housing backlog has reached 15 million units, up from 9.9 million units previously (Bahfein and Alexander, 2025). In an effort to reduce this backlog, the Ministry of Public Works has developed simple landed houses using precast structural systems, with various technologies introduced from the era of the Building Research Institute (LPMB) to the Center for Research and Development of Housing and Settlements (Puskim) (Direktorat Bina Teknik Permukiman dan Perumahan, 2018). However, further innovations are still needed to meet market demands, as previous systems are considered too costly and offer limited design flexibility due to the rigid dimensions of their structural panels.

According to SNI 1979-1990 on Spatial Specifications for Residential Houses, the standard space requirement for housing is 9 m^2 per person. However, when observing the current earthquake-resistant precast houses available on the market, such as RISHA (Direktorat Bina Teknik Permukiman dan Perumahan, 2021), although they provide a floor area of 9 m^2, the net usable area is only 7.84 m^2.

In addition, the layout of the type-36 houses offered by existing simple precast housing systems still appears rigid, as they typically adopt a rectangular configuration divided into four rooms of uniform size. Therefore, future precast housing systems need to be developed to meet the required housing space standards while also offering more flexible interior layouts.

Another challenge in developing simple precast housing in Indonesia is the uneven quality of building materials, especially in remote and hard-to-reach areas. The distribution of materials to frontier, remote, underdeveloped, and outermost regions still depends on long and complex sea and land routes, with minimal intermodal integration and limited infrastructure such as unloading ports, storage warehouses, and local distribution fleets (Berlianto et al., 2025).

This situation results in inconsistent availability of standard materials in the field, making it necessary to formulate precast component materials that are more adaptive and easier to obtain across various production locations. In response to these market challenges, we have developed a new simple precast housing system that we call RUCAST.

RUCAST (Rangka Utama Beton preCAST) is a simple housing system that uses precast reinforced concrete as its structural framework and is designed as a one-story landed house. RUCAST consists of beam and column components made of reinforced concrete with dimensions of 100 × 100 mm^2, incorporating a mechanical connection system using steel plates and anchor bolts.

The RUCAST beam has a length of 1400 mm, reinforced with 4Ø8 main bars and Ø8-100 stirrups, and is referred to as Beam B140. The RUCAST column has a length of 3150 mm, reinforced with 4Ø10 main bars and Ø8-100 stirrups, and is referred to as Column K315. The mechanical connection in RUCAST uses a UNP 75.40.5.7 steel profile welded to Ø10 reinforcement embedded in the beam. A detailed illustration of the building unit and the structural component design of the RUCAST system can be seen in Figure 1.

RUCAST is designed as a structure with a confined masonry system, in which the wall elements are restrained by horizontal and vertical confining members on all four sides (Schacher and Hart, 2015). The vertical confining elements in this system are the K315 Columns, while the horizontal confining elements are the B140 Beams. The K315 Columns and B140 Beams are intended to behave monolithically with the wall; therefore, their connections are designed using Ø10 reinforcement bars embedded between the wall and the columns. The wall component in this system uses lightweight concrete blocks with a thickness of 100 mm.

The concrete materials used in the RUCAST system are designed with a volumetric mix ratio of 1:2:3 for cement, sand, and aggregate, respectively, to ensure that the formulation is easy to apply in the field. In addition, this study is limited to the use of lightweight concrete blocks and instant mortar adhesive, considering that modern housing construction is now more familiar with these materials. These limitations also allow the research to focus on evaluating the structural performance and production costs of precast houses in a manner that is realistic and relevant to current construction practices.

To meet diverse floor plan needs tailored to the owner's wishes, RUCAST is present with the flexibility of column and beam positions, as the distance between columns is 1.5 meters. Thus, in addition to the typical 6x6 m floor plan, the house floor plans using RUCAST technology will be more varied according to the user's needs. However, it is still necessary to comply with the structural irregularity rules that refer to SNI 1726:2019 article 7.3.2. Figure 2 shows a comparison of a typical landed house floor plan with a variation floor plan that can be applied using RUCAST tecnology.

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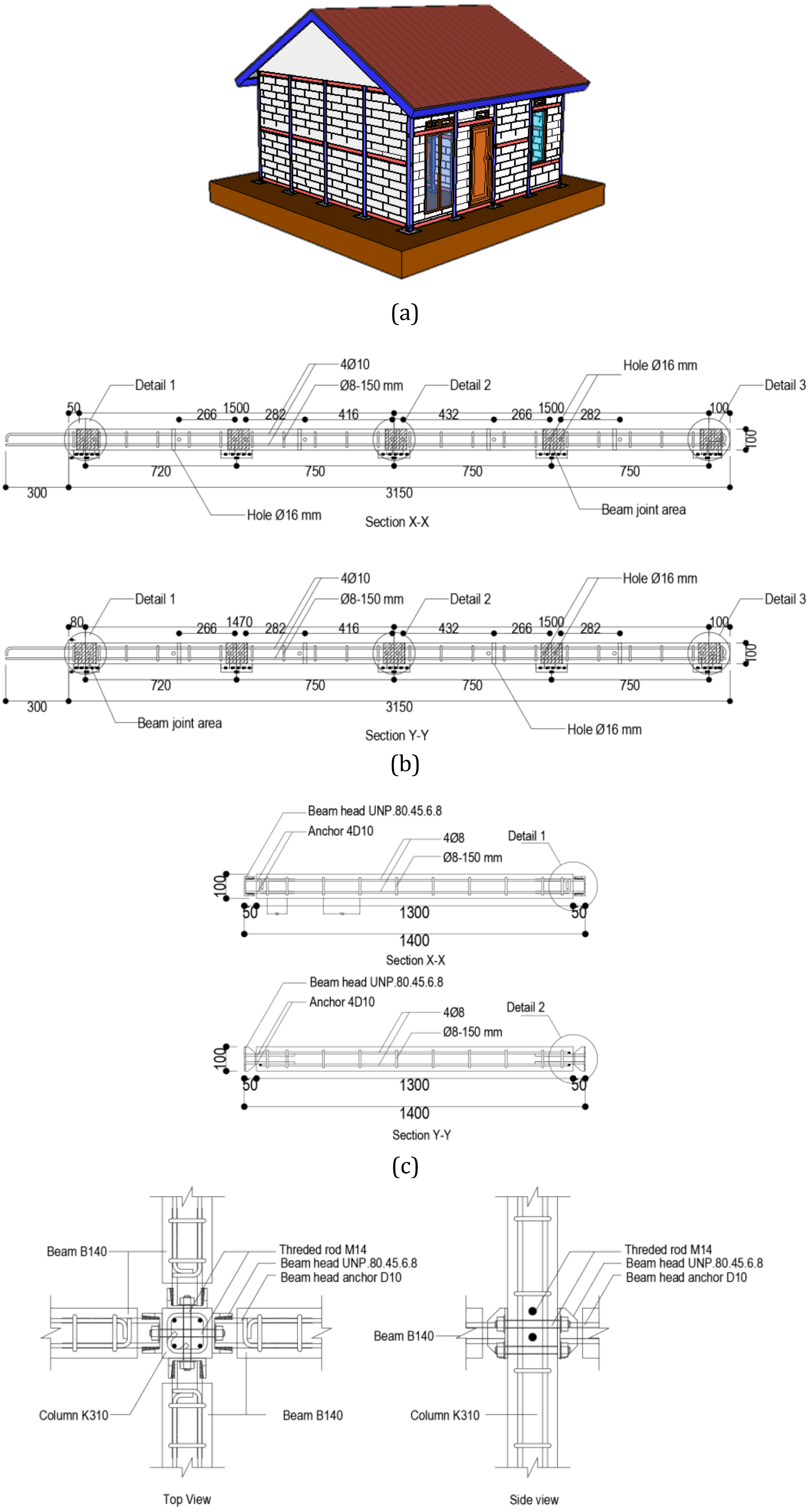

(a)

(b)

(c)

(d)

Figure 1 Sketch of The RUCAST Unit and Confining Element Components (a) Building Unit (b) K315 Column (c) B140 Beam (d) Beam–Column Connection System.

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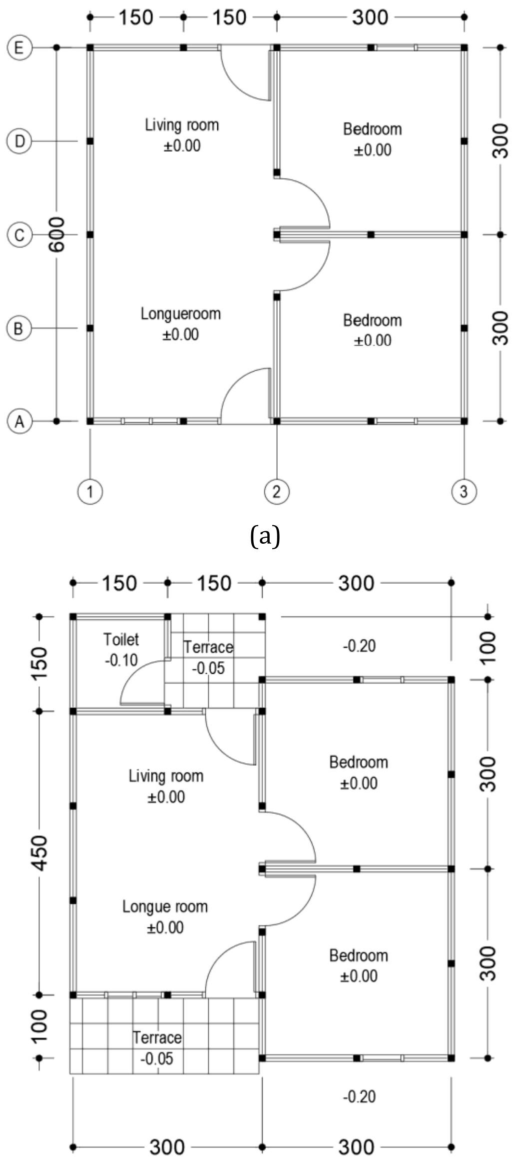

(a)

(b)

Figure 2 Simple House Floor Plan (a) Typical Floor Plan (b) Variation Floor Plan .

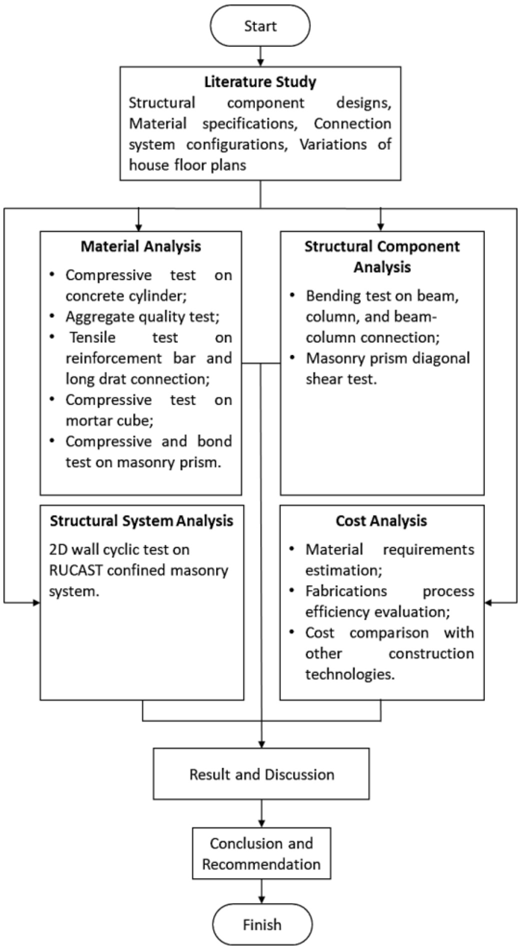

Figure 3 Research Methodology Workflow.

METHOD

This research specifically focuses on evaluating the performance of the RUCAST structural system, demonstrated through experimental testing in the form of a two-dimensional cyclic wall test to assess the structural response and capacity under repeated lateral loading as a simulation of earthquake forces. Furthermore, capacity tests of beam, column, joint, and wall shear components were conducted to verify that these elements cannot act independently, but instead function as confinement elements within a confined masonry system, where the primary structural component is the wall. This verification is essential to ensure that the RUCAST system adheres to the working principles of a reliable confined masonry structure under lateral loads. In addition, this study includes a series of material quality tests such as concrete compressive strength, reinforcing-steel tensile strength, and mortar compressive and adhesion tests to demonstrate that the RUCAST system can be produced using simple materials that are readily available on site. The research also encompasses an analysis of production costs, including material requirement estimation, fabrication-process efficiency evaluation, and cost comparison with other construction technologies to assess the system's economic viability. Thus, this research not only evaluates structural performance but also establishes technical feasibility, the availability of local materials, and cost efficiency as a foundation for the broader application of RUCAST technology.

The initial stage of this research began with a literature study to identify the innovation needs for precast simple-housing systems. This stage resulted in the establishment of the preliminary RUCAST system design, covering structural-component dimensions, material specifications, joint-system configurations, and possible variations of housing layouts. After the basic design was determined, a material-aspect analysis was conducted through a series of experimental tests, including concrete cylinder compressive strength tests, aggregate quality tests, tensile tests on reinforcement and threaded connectors, mortar adhesion tests on lightweight brick masonry, and compressive tests on lightweight brick mortar joints.

The next stage involved analyzing the structural-component aspects through flexural testing of B140 beams, K315 columns, beam–column joints, and diagonal shear-strength testing of lightweight brick walls. Subsequently, a structural-system analysis was carried out through cyclic testing of two-dimensional (2D) walls to evaluate the overall structural performance under repeated lateral loading. The final stage of the research comprised a production-cost analysis, including material requirement estimation, fabrication-process efficiency assessment, and cost comparison with other construction technologies. Overall, the research methodology workflow can be seen in Figure 3.

Material Analysis

The analysis of material aspects was carried out through a series of tests, including the compressive strength test of concrete cylinders. The concrete compressive strength value was obtained using the following equation.

$$f_c' = \frac{P}{A} \tag{1}$$

Where P is the compressive load applied by the esting machine and A is the cross-sectional area of the concrete specimen. The compressive test specimens were concrete cylinders with a diameter of 150 mm and a height of 300 mm. Two variations of concrete mix proportions were used in this study, namely 1:2:3 and 2:3:5 for cement, fine aggregate, and coarse aggregate. Each mix was prepared with three different water contents determined by water–cement ratios of w/c = 0.5 according to SNI 2847:2019, w/c = 0.6, and a slump value of ±12 cm. The number of specimens was set at 5 variations with concrete ages of 7, 14, 28, and 56 days, where each variation and age consisted of 5 specimens. In total, 120 concrete cylinders were tested.

In addition, an analysis of the characteristics of coarse and fine aggregates was carried out. The tests included determination of moisture content (SNI 1971:2011), specific gravity and water absorption (SNI 1970:2016 and SNI 1969:2016), as well as gradation analysis using sieve tests (SNI C136:2012), which were evaluated against ASTM C33 aggregate-quality requirements. Each test was performed in triplicate to obtain representative and consistent values, ensuring that the aggregates met quality standards and reflected actual field conditions.

Simultaneously, tensile tests were also performed on reinforcing steel bars and threaded steel used in the beam–column connection of RUCAST reinforced-concrete components. These tests aimed to determine the actual characteristics of the reinforcing steel and threaded rods used in beams, columns, and beam–column joints. The reinforcing bars used were plain bars with diameters of 10 mm (for column K315) and 8 mm (for beam B140), while the threaded rods used in beam–column connections had a diameter of 13 mm. Each reinforcing bar and threaded rod specimen was prepared at a length of 500 mm, and each test was performed in triplicate to obtain representative results.

In addition, to determine the average quality of the mortar used in lightweight brick masonry, a compressive strength test was conducted. This test used three types of instant mortar commonly available on the market Mortar A, Mortar B, and Mortar C. The purpose was to assess the extent of compressive-strength differences among the three products. The testing method referred to SNI 6825:2002 and ASTM C109-02. The water content used followed the usage instructions for each mortar type (Mortar A = 425 ml/2 kg; Mortar B = 437.5 ml/2 kg; Mortar C = 462.5 ml/2 kg). The specimens were cast in cube form with dimensions of 50 × 50 mm and tested using a compression machine at the age of 28 days. A total of 5 specimens were prepared for each type of instant mortar, resulting in 15 specimens overall.

To determine the compressive strength and bond strength of brick masonry prism components, tests were conducted using specimens consisting of three stacked lightweight bricks measuring 200 mm in length, 200 mm in width, and 100 mm in thickness, with a 3 mm layer of mortar between them. Two types of lightweight bricks (Brick 1 and Brick 2) and three types of instant mortar (Mortar A, Mortar B, and Mortar C) were used in the testing, resulting in six specimen variations. The purpose was to identify the potential quality levels of masonry constructed from various material combinations commonly found in the field. Each variation was tested in triplicate, resulting in a total of 36 specimens. The compressive and adhesion strength test of brick masonry prism documentation can be seen in Figure 8.

Structural Component Analysis

The structural component analysis was conducted to determine the characteristics and capacities of each structural component in the RUCAST system, namely the B140 beam, K315 column, beam–column joint, and masonry wall. The tests performed on the B140 beam, K315 column, and

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beam–column joint were flexural tests. The testing referred to SNI 4431:2011, in which the specimen is placed transversely on two simple supports and then loaded with a compressive force applied through a load spreader consisting of two rollers, as shown in Figure 4. Two specimens were tested for each of the B140 beams, K315 columns, and beam–column joints. The calculation of the flexural strength of the beam component (M) is presented in the following equation.

$$M = 0.5 \times (P + W) \times x \tag{2}$$

where:
P = Force (kN)
W = specimen + load spreader + load cell (kN)
x = length of support to load roll (m)

The RUCAST component connection, which is a mechanical joint using a UNP 80.45.6.8 profile on the B140 Beam and connected with a 13 mm diameter threaded steel rod, is expected to exhibit semi-rigid behavior that can be analyzed through the joint rotation value (ϕ) at the beam–column connection, as shown in Figure 5. Joint rotation is defined as the slope of the deflection curve relative to the load-arm length (Görgün, 1997). The joint rotation value can be calculated using the following equation.

$$\phi = \delta / L \tag{3}$$

where:
ϕ = joint rotation
δ = deflection at the load point
L = load arm length

From the joint rotation results, the Secant Stiffness (K_s) can be calculated. According to AISC 360-16, K_s is the joint stiffness determined from the service

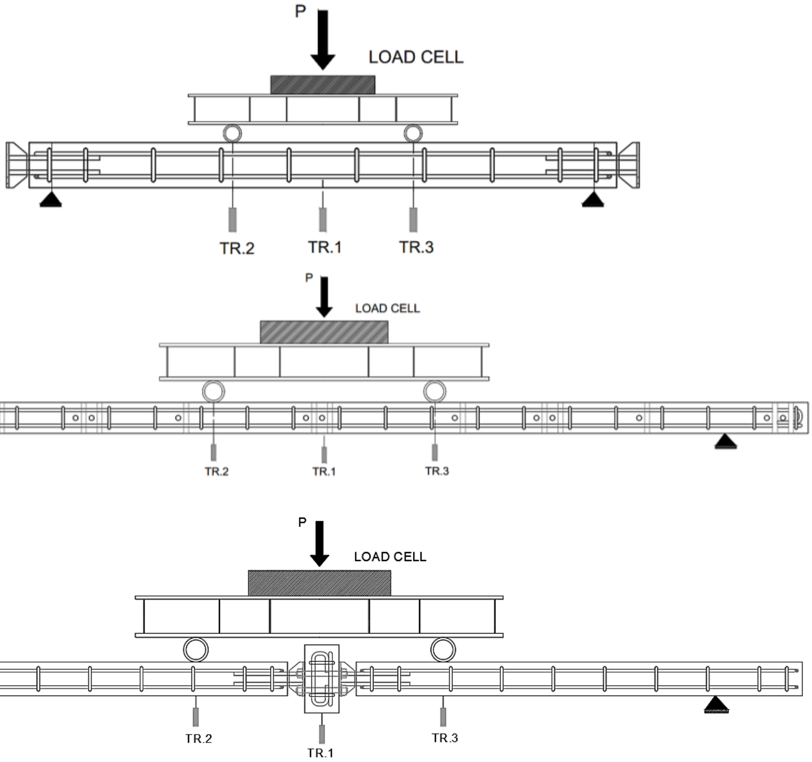

Figure 4 Flexural Test of Structural Component in Laboratory.

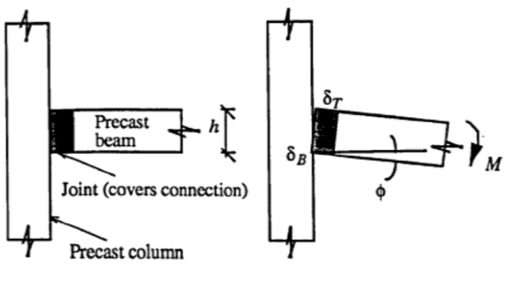

Figure 5 Illustration of Joint Rotation Values at Component Connection. (Source: Görgün, 1997)

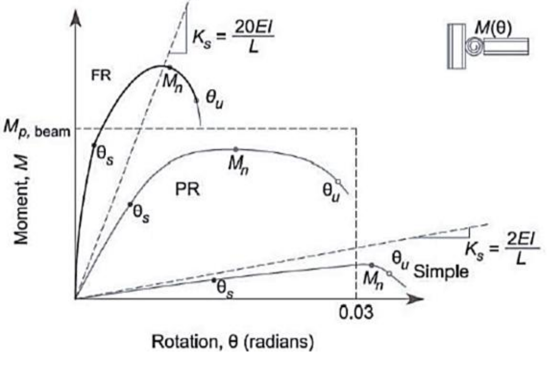

Figure 6 Rigidity Connection Classification Curve. (Source: AISC 360-16, 2016)

load divided by the resulting joint rotation ($K_s = M_s/Ø_s$). If $K_sL/EI \geq 20$, the joint can be classified as fully restrained (FR), meaning it can maintain rotational compatibility between components. If $K_sL/EI \leq 2$, the joint is classified as a pin connection (a joint that rotates without contributing to moment resistance). Joint stiffness values falling between these limits are categorized as partially restrained (PR), as shown in Figure 6. This analysis was conducted to evaluate the behavior of the beam–column connection in the RUCAST system.

The final variable in the structural component analysis is the diagonal shear capacity testing of lightweight brick masonry wall components, using an analytical method referring to NTC-M 2004. This test was conducted to determine the shear capacity and vertical shear failure pattern of lightweight masonry walls as one of the components of the RUCAST system. The analysis was performed by applying a diagonal compressive load to the lightweight brick masonry wall partition specimen (Meli et al., 2011), as shown in Figure 7. The bricks used in the specimens were lightweight bricks of types 1 and 2, measuring 60 × 20 × 10 cm, while the mortar used was instant mortar type A with a joint thickness of 3 mm (according to manufacturer specifications).

The diagonal shear strength (v_m) was analyzed from the results of the diagonal compression test on square masonry wall specimens, which were then loaded monotonically along their diagonal axis. Essentially, vm is influenced by the type of wall material and the mortar used. The shear strength of the wall (v) has acceptance criteria referring to NTC-M 2004, using the following equation.

$$v = (0.5v_m + 0.3\sigma) \leq 1.5v_m \qquad (4)$$

where:
v_m = diagonal shear strength obtained from laboratory testing
σ = wall compressive stress

$$\sigma = \frac{W_T}{\Sigma A_w} \qquad (5)$$

where:
W_T = total building weight
A_w = cross-sectional area of a wall on a floor

Structural System Analysis

The structural analysis conducted was a two-dimensional cyclic wall test using materials and structural components that had been previously analyzed. This analysis aimed to determine the performance and behavior of the prototype specimen particularly the two-dimensional wall in the in-plane direction under cyclic lateral loading as a simulation of earthquake-induced lateral forces, using a hydraulic jack as the mechanical instrument to apply the load, as shown in Figure 8. Referring to SNI 7834:2012 and ASTM E2126-11, a displacement-control loading protocol consisting of cyclic lateral loads was applied in both push and pull directions with progressively increasing displacement targets. For the initial loading cycles, small displacement targets were used to observe the behavior of the wall within the elastic range, as illustrated in Figure 9.

The cyclic test was carried out using one RUCAST

confined masonry specimen. The specimen details can be seen in Figure 10 along with the construction specifications as follows.

1. Confining frame consists of K315 and B140 elements, each with dimensions of 100 × 100 mm^2. The column has a length of 3150 mm with main reinforcement of 4Ø10 and stirrups of Ø8-100. The beam has a length of 1400 mm with main reinforcement of 4Ø8 and stirrups of Ø8-100. Both are made from a 1:2:3 mix concrete with 0.5 w/c ratio.
2. The RUCAST system connection uses a mechanical joint consisting of a UNP 80.45.6.8 steel profile welded to Ø10 reinforcement bars embedded at both ends of the B140 beam. The UNP steel profile is connected to the column using a 13 mm diameter threaded steel rod.
3. The wall is constructed from lightweight bricks of Type 2 with dimensions of 60 × 20 × 10 cm. The adhesive between the bricks uses instant mortar Type A with a thickness of 3 mm. The wall surface is finished with a plaster layer made of a 1:3 cement-to-fine aggregate mixture with a thickness of 3 mm.
4. The anchor at the connection between column K315 and the specimen foundation uses Ø10 reinforcement with a depth of 300 mm, which is the main continuous column reinforcement embedded into the foundation. Meanwhile, the anchor between the column and the wall is connected using Ø8 reinforcement with a depth of 300 mm, installed during the lightweight brick masonry construction process.

The RUCAST structure, which is a confined masonry system, has its performance predominantly governed by strength. Strength verification is carried out by comparing the lateral resistance capacity ($V_{capacity}$) with the seismic base shear (V), which is calculated based on the design earthquake specified in SNI 1726:2019 using the following equation.

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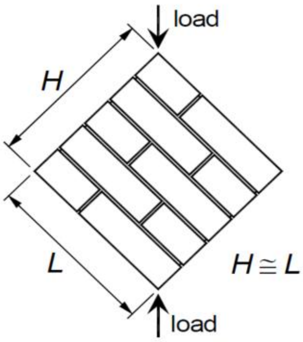

Figure 7 Illustration of Diagonal Shear Strength Test of a Masonry Wall. (Source: Seismic Design Guide for Low-Rise Confined Masonry Buildings, 2011)

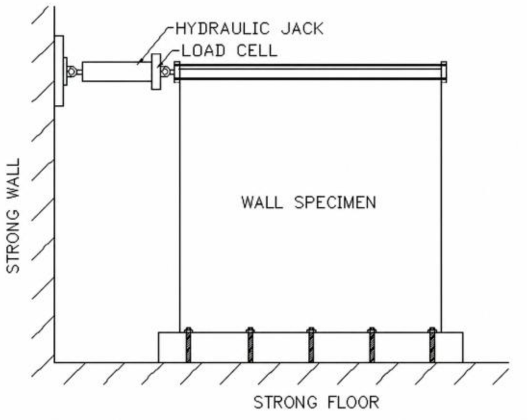

Figure 8 Typical 2D Wall Cyclic Testing.

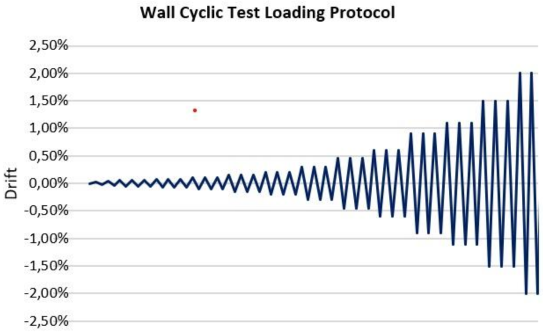

Figure 9 Cyclic Wall Test Loading Graph

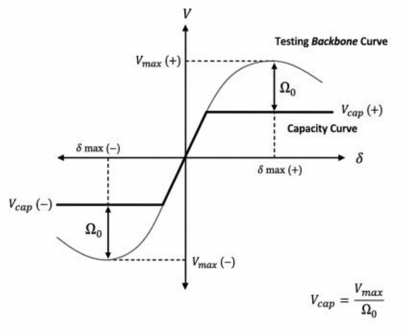

Figure 11 Backbone Curve Testing in Determining Structural Capacity.

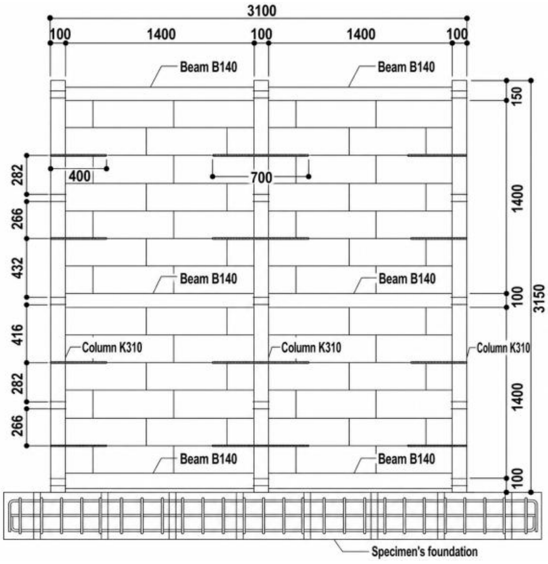

Figure 10 RUCAST Cyclic Wall Test Specimen.

$$V = C_s \times W \tag{6}$$

where:

C_s = seismic response coefficient

W = effective seismic weight

The effective seismic weight (W) consists of the structure's self-weight, dead loads, and other applicable loads in accordance with the provisions of SNI 1726:2019 Section 7.7.2. The seismic coefficient (C_s) is influenced by the design earthquake acceleration parameters (S_{DS} dan S_{D1}), the response modification factor (R), the importance factor (I), and the structural period (T), as specified in SNI 1726:2019 Section 7.8.1.1.

The lateral resistance capacity ($V_{capacity}$) is calculated based on the backbone curve obtained

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from the cyclic test, using an offset equal to the maximum push–pull lateral load (V_{max}) that the structure can withstand before failure, divided by the structural overstrength factor (Ω_0), as illustrated in Figure 11. The lateral capacity of the structure used for evaluation is the smaller value between the push and pull capacities. The structural system is considered adequate to resist seismic loads if its capacity exceeds the demand or the induced earthquake load, which can be expressed mathematically as follows.

Cost Analysis

Production cost analysis was carried out to accurately estimate budget requirements, minimize the risk of cost overruns, and improve the efficiency of fabrication and construction processes. This analysis method includes identifying all production cost components required for manufacturing RUCAST precast elements, including material, labor, equipment, and fabrication processes. In addition, an evaluation of mass construction costs was conducted to assess the economies of scale that could be achieved if the RUCAST system is implemented on a large scale. The analysis also includes a cost comparison between using timber and steel formwork to determine the most economical and sustainable option. Finally, RUCAST production costs were compared with those of other precast technologies to evaluate the economic competitiveness of this system relative to existing alternatives.

RESULTS AND DISCUSSION

Material Aspect

The quality of concrete on site is influenced by the composition of cement, fine aggregates, coarse aggregates, and water content. To anicipate factors that may cause the concrete quality to fall below standards and to ensure ease of implementation in the field, this study used simplified concrete mix proportions of 1:2:3 and 2:3:5 with water–cement ratios of 0.5 and 0.6, as well as a slump value of ±12 cm. Each variation was tested at concrete ages of 7, 14, 28, and 56 days. The concrete cylinder compressive strength test was conducted according to SNI 1974:2023 using cylindrical molds with a diameter of 15 cm and a height of 30 cm. The compressive strength results for each mix variation can be seen in Table 1 and Figure 12.

The curve shows that the 2:3:5 mix with 0.5 w/c ratio has higher compressive strength compared to the other mixes. However, at 56 days, the 1:2:3 mix with 0.5 w/c ratio exhibits a capacity nearly equal to that of the 2:3:5 mix with the same w/c ratio. Therefore, the 1:2:3 mix with 0.5 w/c ratio is selected as the concrete material for the RUCAST components, due to the 1:2:3 mix is more commonly used in construction on site.

To determine the material characteristics of the concrete mixture used in RUCAST, tests on coarse and fine aggregates were conducted based on SNI ASTM C136:2012, with the results presented in Table 2 and Figure 13. Based on the analysis of moisture content, silt content, specific gravity, and bulk density, both coarse and fine aggregates were found to not meet the acceptance criteria for concrete aggregates according to ASTM C33/C33M-13. The sieve analysis results show a similar issue: both the coarse and fine aggregates exhibit uniform gradation and do not meet the requirements for concrete aggregates. These conditions have the potential to reduce the compressive strength and durability of the concrete. Overall, this negatively affects the quality and production efficiency of RUCAST concrete. Therefore, further technical actions are necessary in the research, such as adjusting the mix design, improving aggregate quality, or evaluating alternative material sources, to ensure the required performance of RUCAST concrete can be achieved.

The tensile strength of reinforcement steel for beam component B140, column component K315, and threaded steel rod used in the beam–column connection was analyzed in the laboratory to determine the actual characteristics of the reinforcement steel according to the SNI 8389:2017method. The results of the tensile strength analysis for the reinforcement steel and threaded steel can be seen in Table 3 and Figure 14. Based on the analysis, the average tensile strength of the reinforcement steel with an 8 mm diameter is 495 MPa, and for a 10 mm diameter is 598 MPa. Meanwhile, the average tensile strength of the 13 mm threaded steel is 535 MPa. Referring to SNI 2052:2024, the reinforcement used for the B140 beam component and K315 column component meets the minimum tensile strength specification of 350 MPa. Similarly, the threaded steel meets the factory specification with a minimum tensile strength of 460 MPThe results of the mortar compressive strength analysis are presented in Figure 15. Based on the test results, it can be observed that there is a significant difference among the mortars. A notable difference is seen between Mortar type A (7.83 MPa) and type B (2.03 MPa), which have a disparity of 74%. These results indicate substantial variability in material quality, which will affect the consistency of construction work in the field, increase the risk of bond failure in lightweight brick masonry, and ultimately reduce the overall performance of the structural system.

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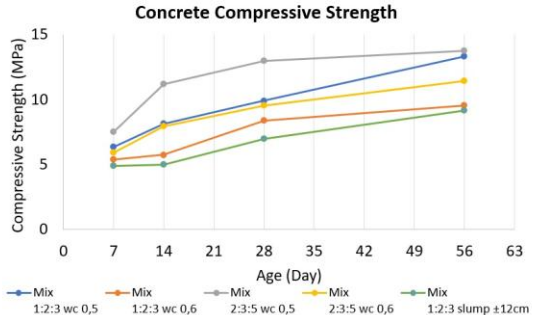

Figure 12 Concrete Compressive Strength Curve Based on Age.

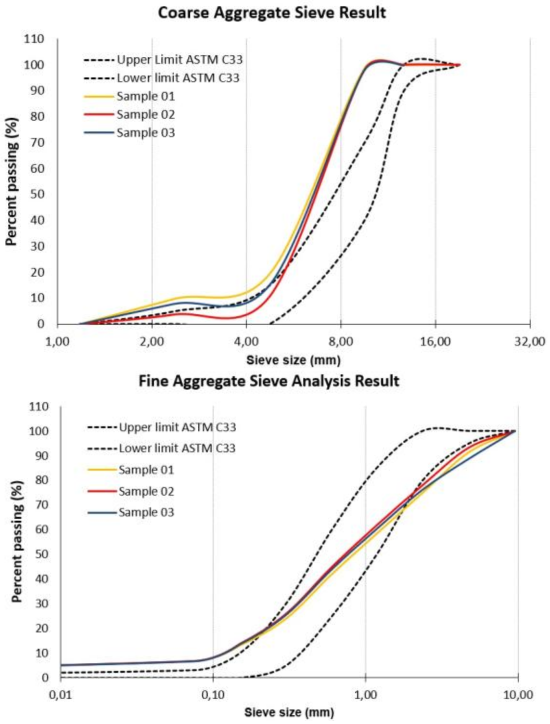

Figure 13 Sieve Analysis Graphs (a) Coarse Aggregate (b) Fine Aggregate.

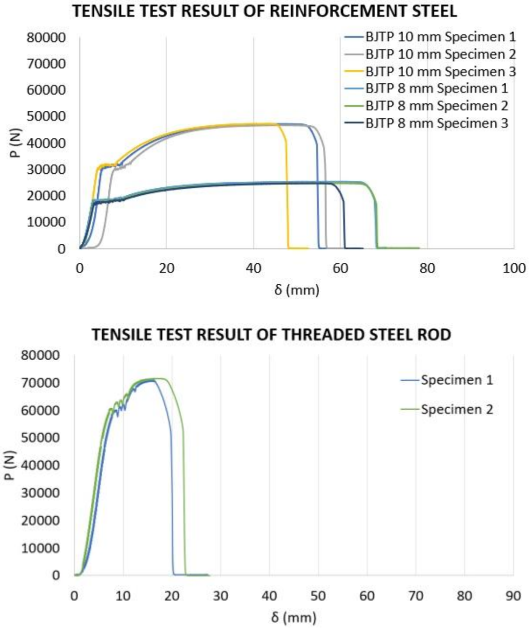

Figure 14 Tensile Test Result Graphs (a) Reinforcement Steel (b) Threaded Steel Rod Joints.

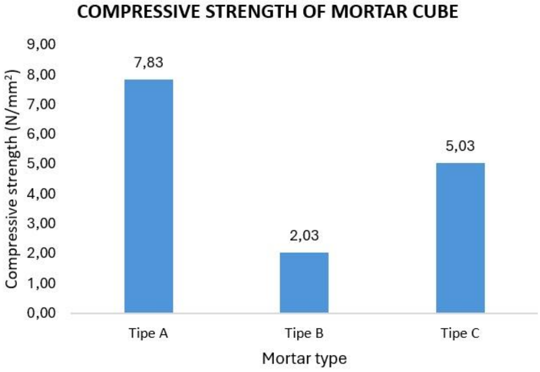

Figure 15 Mortar Compressive Strength Graph.

Table 1 Compressive strength analysis result

No	Mix variation	Mix ratio	Age (days)	Comp. strength (MPa)	Standard deviation
1	Mix of 1:2:3 w/c 0,5	8 cement + 16 fine ag. + 24 coarse ag. + 4 water	7	6,34	0,92
			14	8,12	0,69
			28	9,88	0,96
			56	13,29	0,30
2	Mix of 1:2:3 w/c 0,6	8 cement + 16 fine ag. + 24 coarse ag. + 6 water	7	5,34	0,33
			14	5,72	0,28
			28	8,35	0,28
			56	9,54	0,48
3	Mix of 2:3:5 w/c 0,5	cement + 15 fine ag. + 25 coarse ag. + 5 water	7	7,50	0,76
			14	11,18	0,92
			28	12,98	0,94
			56	13,72	0,93
4	Mix of 2:3:5 w/c 0,6	8 cement + 12 fine ag. + 20 coarse ag. + 4 water	7	5,89	0,38
			14	7,92	0,37
			28	9,53	0,69
			56	11,39	0,49
5	Mix of 1:2:3 slump ±12 cm	8 cement + 16 fine ag. + 24 coarse ag. + 4 water	7	4,87	0,27
			14	4,96	0,97
			28	6,97	0,72
			56	9,16	0,97

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In the long term, this inconsistency may also masonry components. The strength of lightweight brick masonry prism is evaluated based on its compressive strength and bond strength characteristics, as shown in the graphs in Figure 16. Based on these graphs, lightweight brick masonry prism using brick type 2 demonstrate higher average compressive and bond strength compared to brick type 1. The graphs also show that although mortar B does not exhibit higher compressive strength than mortar A, mortar B actually provides better bond strength. This finding indicates that mortar B has more effective adhesion properties, contributing more to the bonding capacity and stability of the masonry wall than to its ability to resist compressive loads. This enhanced adhesion plays a more dominant role in maintaining wall performance under service conditions than its ability to resist compressive loads alone.

Structural Component Aspect

Flexural strength analysis was conducted on Column K315 and Beam B140, with the results presented in Table 4 and Figure 17. Based on these data, it is known that Beam B140 and Column K315 have relatively small moment capacities, with values of 1.83 kNm and 2.34 kNm, respectively. This finding indicates that these two elements are not designed to carry large flexural loads but instead function as components that do not resist significant moments. Therefore, Beam B140 and Column K315 cannot be used as standalone structural elements, they must be applied as wall-confined components in the RUCAST system.

Based on the results of the RUCAST connection system analysis presented in Table 5, secant stiffness (Ks) values of 6.84 and 5.66 were obtained. Referring to AISC 360-16, these values satisfy the 2 ≤ KsL/EI ≤ 20 criteria, so that the RUCAST connection can be categorized as semi-rigid or partially restrained. The relatively low stiffness shows that the connection behavior tends to be as a hinge, meaning its moment-resisting capacity is limited. This condition affects the lateral stability of the system because the connection is unable to provide adequate moment resistance against significant seismic. Therefore, RUCAST should not be used as a standalone structural element but instead must be supported by lightweight brick masonry as infill walls within the beam–column frame. The results of the diagonal shear strength test of the lightweight masonry wall can be seen in Table 6 Based on these results, the wall component

Table 2 Analysis of aggregate material characteristics

No.	Description		Coarse Aggregate Test Result	Coarse Aggregate Quality Requirement	Coarse Aggregate Remarks	Fine Aggregate Test Result	Fine Aggregate Quality Requirement	Fine Aggregate Remarks
1	Moisture content	%	7.75	Max 1	NOT OK	4.58	Max 3	NOT OK
2	Silt content	%	8.63	Max 1	NOT OK	25.87	Max 3	NOT OK
3	Bulk density							
	- Loose condition	kg/L	1.96	Min 3	NOT OK	2.34	Min 1.2	OK
	- Compacted condition	kg/L	2.04	Min 3	NOT OK	2.47	Min 1.2	OK
4	Specific gravity and water absorption							
	- Oven dry specific gravity	gr/cc	1.55	Min 2,5	NOT OK	2.39	Min 2.5	NOT OK
	- SSD specific gravity	gr/cc	1.79	Min 2,5	NOT OK	2.49	Min 2.5	NOT OK
	- Apparent specific gravity	gr/cc	1.86	Min 2,5	NOT OK	2.66	Min 2.5	NOT OK
	- Water absorption	%	5.37	Min 2,5	OK	4.21	Min 2.5	OK

Table 3 Result of tensile strength analysis of reinforcement steel and threaded steel rod joints

No	Specimen Length (mm)	Diameter (mm)	Tensile Force (N)	Yield Stress (MPa)	Tensile Stress (MPa)
	BJTP 10 mm				
1	499	10	47162	392	600
2	498	10	46712	383	594
3	500	10	47228	386	601
	BJTP 8 mm				
4	498	8	25330	361	503
5	498	8	24780	346	492
6	499	8	24716	346	491
	THREADED STEEL ROD				
7	495	13	70703	467,41	532,68
8	497	13	71492	456,17	538,62

Table 4 Beam and column flexural strength analysis result

No	Component	P (kN)	W (kN)	x (m)	M (kNm)
1	Beam B140	10.54	0.99	0.33	1.92
2	Beam B140	9.46	0.99	0.33	1.74
3	Column K315	3.72	1.39	0.9	2.30
4	Column K315	3.96	1.36	0.9	2.39

Table 5 Semi-rigid connection analysis

No	P (kN)	W (kN)	M (kN.m)	L (m)	δ (m)	$\phi = \delta/L$	Ks = M/Ø
1	0,86	1,37	0,89	0,4	0,052	0,13	6,84
2	0,75	1,37	0,85	0,4	0,059	0,15	5,66

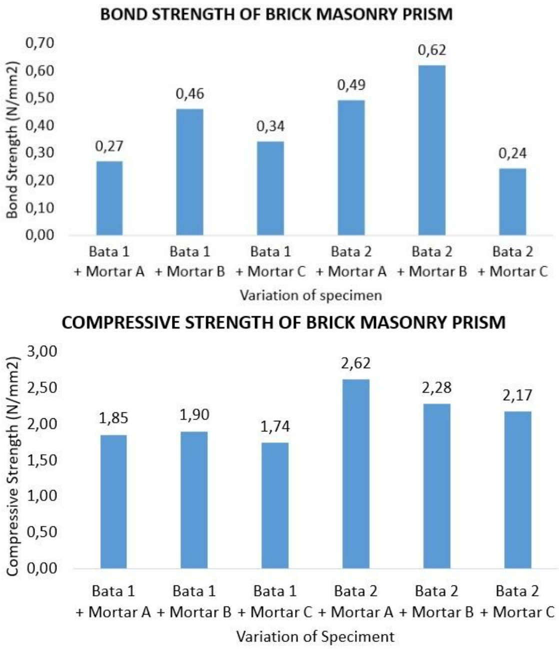

Figure 16 Brick Masonry Prism Test Result Graph (a) Compressive Strength (b) Bond Strength.

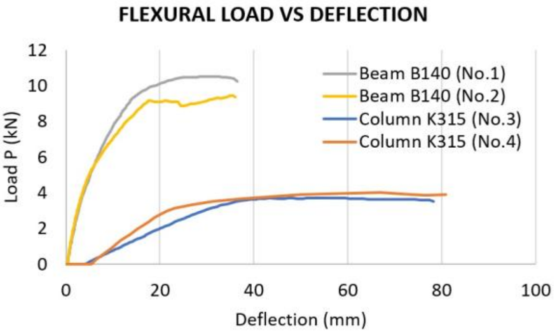

Figure 17 Beam B140 and Column K315 Flexural Strength Comparison Graph.

Table 6 Diagonal shear strength analysis of masonry wall

No	Condition	Specimen 1	Specimen 2
1	Weight (kg)	55	60
2	Height (m)	1.2	1.2
3	Width (m)	1.2	1.2
4	Thickness (m)	0.099	0.099
5	Density (kg/m^3)	385.8	420.9
6	P max (kN)	32.8	23.2
7	Area (m^2)	0.1188	0.1188
8	v_m (6/7) (MPa)	0.276	0.195
9	A_w (m^2)	3.3	3.3
10	W_T (kN)	108.2	108.2
11	σ (10/9) (MPa)	0.033	0.033
12	v	0.148	0.107
13	1.5 v_m	0.414	0.293
	Cek v < 1.5v_m	**OK**	**OK**

Figure 18 RUCAST 2D Wall Cyclic Test Setup.

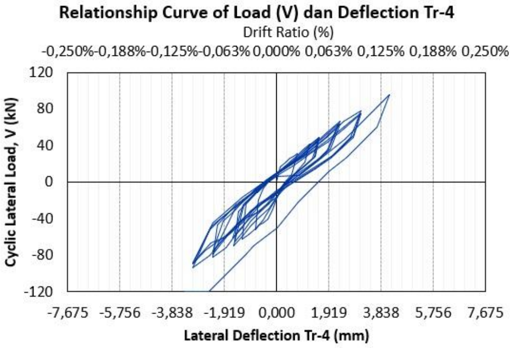

Figure 19 Hysteretic Curve.

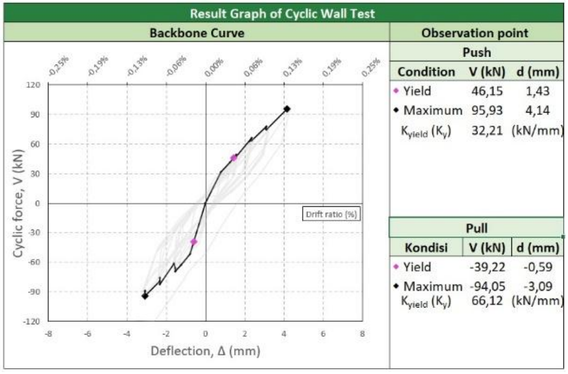

Figure 20 Backbone Curve.

Table 7 Seismic weight calculation

No	Component	Tributary area weight (kN)
1	Roof component	1.05
2	Masonry component	15.86
3	Column component	3.71
4	Beam component	5.44
5	Non-structural accessories	0.99
	TOTAL	**27.05**

has an average diagonal shear stress capacity (v_m) of 0.23 MPa. This value meets the acceptance criteria of NTC-M 2004, namely $v \leq 1.5v_m$, indicating that the wall has sufficient shear capacity to resist the diagonal shear forces that occur without experiencing premature failure.

Structural System Aspect

The RUCAST structural system is a confined masonry system applied to both the interior and exterior walls of the building. The cyclic test results of the 2D wall specimen are presented in the form of a hysteresis curve (hysteretic loop), which illustrates the relationship between the load and deformation experienced by the specimen during cyclic loading, observed at a specific measurement point. In this test, the observation point was taken from transducer TR-4, as shown in Figure 18. The resulting hysteresis curve, shown in Figure 19, is then used for structural capacity analysis. Furthermore, the hysteresis curve is used to determine the backbone curve based on key points such as the yield point and maximum load point, as illustrated in Figure 20. This backbone curve represents the strength and stiffness behavior of the RUCAST structural system.

Based on the obtained backbone curve, as well as the yield and maximum points in both tension and compression (push and pull conditions), the RUCAST confined masonry structure demonstrates a maximum push capacity of 95.93 kN and a maximum pull capacity of 94.05 kN. In determining the design seismic capacity ($V_{capacity}$), the smaller value from both maximum capacity must be divided by an overstrength factor (Ω_0), which value is taken from SNI 1729:2019 Section 7.2.2, namely 2.5 (for bearing wall systems). Thus, the seismic capacity of the RUCAST structural system is 37.62 kN which is subsequently referred to as $V_{capacity}$.

Push lateral capacity:

$$V_{capacity+} = \frac{V_{max+}}{\Omega_0} = \frac{95{,}93}{2{,}5} = 38{,}37\ kN \qquad (7)$$

Pull lateral capacity:

$$V_{capacity-} = \frac{V_{max-}}{\Omega_0} = \frac{94{,}05}{2{,}5} = 37{,}62\ kN \qquad (8)$$

According to SNI 1726:2019 Section 7.7.2, the calculation of the effective seismic weight (W) consists of the self-weight of the structure and the

Table 8 Demand vs capacity (DCR) evaluation of 38 provincial capital locations in Indonesia

No	Location	SS	S1	Site Class SC						Site Class SD						Site Class SE					
				S_{DS}	KDS	Cs	V (kN)	DCR	Status	S_{DS}	KDS	Cs	V (kN)	DCR	Status	S_{DS}	KDS	Cs	V (kN)	DCR	Status
1	Merauke	0.03	0.04	0.03	A	0.03	0.81	0.02	OK	0.03	A	0.03	0.81	0.02	OK	0.05	A	0.05	1.35	0.04	OK
2	Palangka-raya	0.05	0.04	0.04	A	0.04	1.08	0.03	OK	0.05	A	0.05	1.35	0.04	OK	0.08	A	0.08	2.16	0.06	OK
3	Tanjung pinang	0.07	0.11	0.06	A	0.06	1.62	0.04	OK	0.08	A	0.08	2.16	0.06	OK	0.11	A	0.11	2.98	0.08	OK
4	Banjar baru	0.12	0.05	0.05	B	0.05	1.35	0.04	OK	0.09	B	0.09	2.43	0.06	OK	0.19	B	0.19	5.14	0.14	OK
5	Samarinda	0.12	0.10	0.11	B	0.11	2.98	0.08	OK	0.13	B	0.13	3.52	0.09	OK	0.19	B	0.19	5.14	0.14	OK
6	Pangkal-pinang	0.14	0.13	0.12	B	0.12	3.25	0.09	OK	0.15	B	0.15	4.06	0.11	OK	0.23	B	0.23	6.22	0.17	OK
7	Pontianak	0.18	0.05	0.15	B	0.15	4.06	0.11	OK	0.19	B	0.19	5.14	0.14	OK	0.28	B	0.28	7.57	0.20	OK
8	Makassar	0.22	0.11	0.19	B	0.19	5.14	0.14	OK	0.24	B	0.24	6.49	0.17	OK	0.36	C	0.36	9.74	0.26	OK
9	Palembang	0.29	0.25	0.25	B	0.25	6.76	0.18	OK	0.31	B	0.31	8.39	0.22	OK	0.44	C	0.44	11.90	0.32	OK
10	Tanjung selor	0.32	0.14	0.27	B	0.27	7.30	0.19	OK	0.33	C	0.33	8.93	0.24	OK	0.47	C	0.47	12.71	0.34	OK
11	Jambi	0.33	0.26	0.29	B	0.29	7.84	0.21	OK	0.34	C	0.34	9.20	0.24	OK	0.48	C	0.48	12.98	0.35	OK
12	Pekanbaru	0.38	0.30	0.33	C	0.33	8.93	0.24	OK	0.37	C	0.37	10.01	0.27	OK	0.51	D	0.51	13.80	0.37	OK
13	Medan	0.66	0.36	0.54	D	0.54	14.61	0.39	OK	0.56	D	0.56	15.15	0.40	OK	0.63	D	0.63	17.04	0.45	OK
14	Surabaya	0.68	0.30	0.55	D	0.55	14.88	0.40	OK	0.57	D	0.57	15.42	0.41	OK	0.64	D	0.64	17.31	0.46	OK
15	Mamuju	0.69	0.25	0.56	D	0.56	15.15	0.40	OK	0.57	D	0.57	15.42	0.41	OK	0.64	D	0.64	17.31	0.46	OK
16	Kendari	0.70	0.20	0.57	D	0.57	15.42	0.41	OK	0.58	D	0.58	15.69	0.42	OK	0.67	D	0.67	18.12	0.48	OK
17	Jakarta	0.78	0.38	0.63	D	0.63	17.04	0.45	OK	0.62	D	0.62	16.77	0.45	OK	0.67	D	0.67	18.12	0.48	OK
18	Bandar lampung	0.87	0.43	0.70	D	0.70	18.93	0.50	OK	0.67	D	0.67	18.12	0.48	OK	0.70	D	0.70	18.93	0.50	OK
19	Serang	0.89	0.44	0.71	D	0.71	19.21	0.51	OK	0.68	D	0.68	18.39	0.49	OK	0.71	D	0.71	19.21	0.51	OK
20	Semarang	0.91	0.39	0.73	D	0.73	19.75	0.52	OK	0.69	D	0.69	18.66	0.50	OK	0.71	D	0.71	19.21	0.51	OK
21	Denpasar	0.96	0.40	0.77	D	0.77	20.83	0.55	OK	0.71	D	0.71	19.21	0.51	OK	0.73	D	0.73	19.75	0.52	OK
22	Kupang	1.04	0.37	0.83	D	0.83	22.45	0.60	OK	0.75	D	0.75	20.29	0.54	OK	0.74	D	0.74	20.02	0.53	OK
23	Manado	1.03	0.46	0.83	D	0.83	22.45	0.60	OK	0.75	D	0.75	20.29	0.54	OK	0.74	D	0.74	20.02	0.53	OK
24	Mataram	1.03	0.40	0.83	D	0.83	22.45	0.60	OK	0.75	D	0.75	20.29	0.54	OK	0.74	D	0.74	20.02	0.53	OK
25	Sofifi	1.06	0.45	0.85	D	0.85	22.99	0.61	OK	0.76	D	0.76	20.56	0.55	OK	0.75	D	0.75	20.29	0.54	OK
26	Ambon	1.08	0.39	0.87	D	0.87	23.53	0.63	OK	0.77	D	0.77	20.83	0.55	OK	0.75	D	0.75	20.29	0.54	OK
27	Yogyakarta	1.11	0.51	0.89	D	0.89	24.07	0.64	OK	0.78	D	0.78	21.10	0.56	OK	0.75	D	0.75	20.29	0.54	OK
28	Bandung	1.12	0.49	0.90	D	0.90	24.34	0.65	OK	0.79	D	0.79	21.37	0.57	OK	0.75	D	0.75	20.29	0.54	OK
29	Padang	1.12	0.57	0.90	D	0.90	24.34	0.65	OK	0.79	D	0.79	21.37	0.57	OK	0.75	D	0.75	20.29	0.54	OK
30	Banda aceh	1.43	0.56	1.17	D	1.17	31.65	0.84	OK	0.98	D	0.98	26.51	0.70	OK	0.79	D	0.79	21.37	0.57	OK
31	Nabire	1.49	0.60	1.19	D	1.19	32.19	0.86	OK	0.99	D	0.99	26.78	0.71	OK	0.80	D	0.80	21.64	0.58	OK
32	Bengkulu	1.50	0.60	1.20	D	1.20	32.46	0.86	OK	1.00	D	1.00	27.05	0.72	OK	0.80	D	0.80	21.64	0.58	OK
33	Gorontalo	1.50	0.60	1.20	D	1.20	32.46	0.86	OK	1.00	D	1.00	27.05	0.72	OK	0.80	D	0.80	21.64	0.58	OK
34	Jayawijaya	1.50	0.60	1.20	D	1.20	32.46	0.86	OK	1.00	D	1.00	27.05	0.72	OK	0.80	D	0.80	21.64	0.58	OK
35	Jayapura	1.50	0.62	1.20	D	1.20	32.46	0.86	OK	1.00	D	1.00	27.05	0.72	OK	0.80	D	0.80	21.64	0.58	OK
36	Palu	1.50	0.60	1.20	D	1.20	32.46	0.86	OK	1.00	D	1.00	27.05	0.72	OK	0.80	D	0.80	21.64	0.58	OK
37	Sorong	1.60	0.65	1.28	D	1.28	34.62	0.92	OK	1.07	D	1.07	28.94	0.77	OK	0.85	D	0.85	22.99	0.61	OK
38	Manokwari	2.51	0.85	2.01	E	2.01	54.37	1.45	**Not OK**	1.67	E	1.67	45.17	1.20	**Not OK**	1.34	E	1.34	36.25	0.96	OK

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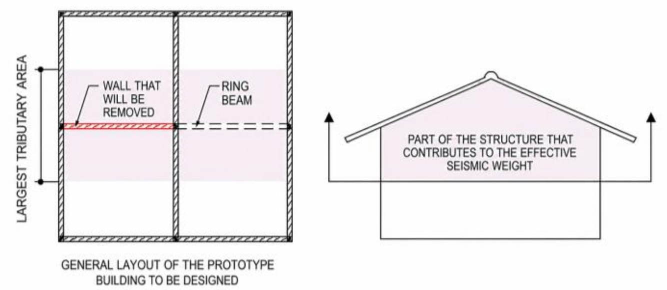

Figure 21 Illustration of Tributary Area In Effective Seismic Weight Calculation.

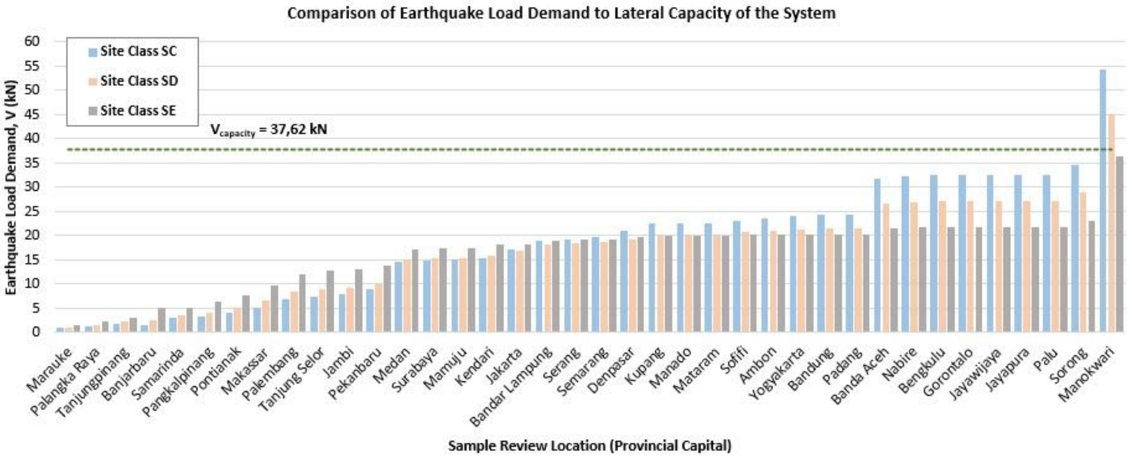

Figure 22 Graphical presentation of demand vs capacity check

weight of secondary components attached to the structure. Since the test specimen used is a wall segment, the structural weight considered is adjusted based on the tributary area carried by the wall. The illustration and calculation of tributary area is shown in Figure 21 and Table 7.

The structural strength assessment of the RUCAST system was carried out using a Demand vs Capacity Ratio (DCR) analysis. The analysis was performed by comparing the capacity ($V_{capacity}$) with the design earthquake load (V), represented as an equivalent static seismic force calculated using the equation $V = C_s \times W$. In this study, the sample locations used for calculating V included 38 provincial capital cities, considering soil site classes hard soil (SC), medium soil (SD), and soft soil (SE). RUCAST wall structural system will be considered to have adequate in-plane shear (earhquake force) resistance if $V_{capacity} \geq V$ or if the DCR value is less than 1. The DCR calculation results for the sampled locations are presented in Table 8, while Figure 22 shows the graphical evaluation of the DCR values. Based on the analysis, it can be concluded that RUCAST possesses sufficient seismic capacity for 37 out of 38 provincial capital locations in Indonesia,for soil site classes SC, SD, and SE. The RUCAST wall structural system is adequate for locations with $S_{DS} \leq 1.38g$.

Deformation and damage occurring during the testing process were continuously monitored. As shown in Figure 23, the wall damage pattern is marked with blue lines (tension cracks) and black lines (compression cracks). The first crack appeared at the interface between the bottom tie beam (sloof) and the foundation. This occurred because no anchor connection was provided between the bottom tie beam and the foundation. This was followed by minor cracking in the hydraulic jack area during the pushing phase due to the weak confinement of the column–beam assembly in resisting localized loads. Subsequently, horizontal (sliding) and diagonal (shear) cracks appeared on the lower right and left sides of the wall, followed by cracking in the upper area that was not in contact with the hydraulic jack. These observations reinforce the hypothesis that when a 3 × 3 m confined masonry wall panel is subdivided by a central column and beam, shear cracking patterns will form in each of the four smaller wall segments created by the column–beam partition.

As loading increased, at a drift of 0.15%, localized damage around the hydraulic jack grew more severe, causing the tie strap to detach from the wall and forcing the test to be stopped. Based on these observations, the RUCAST wall structure exhibited the expected damage pattern shear cracking across the wall panel, characterized by diagonal cracks forming an angle of approximately 45°. Although the crack widths were not large, these diagonal cracks were visible in all four smaller wall segments separated by the column and beam in the middle of the 3 × 3 m wall panel.

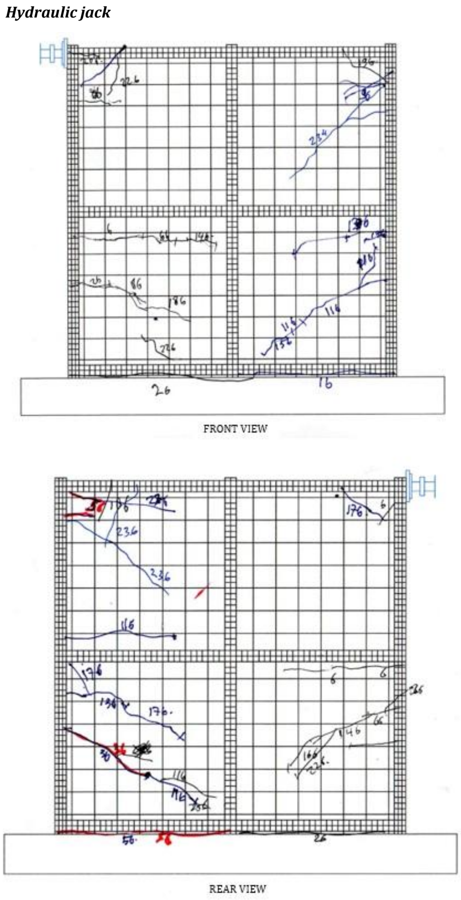

Figure 23 Damage Patterns on Wall Specimen.

Cost Aspect

The comparison between steel and timber formwork for optimizing mass production of the RUCAST system has been carried out in this study. Based on the construction cost calculations, the cost of RUCAST using steel formwork is Rp. 2.042.938,- per square meter, while using timber formwork results in a cost of Rp. 1.968.763,- per square meter.

Table 9 shows the most efficient number of steel panel molds required to produce RUCAST components in each production cycle. If the number of formwork molds used is lower than this efficient amount, the construction cost of RUCAST will likely increase due to reduced work productivity. Conversely, if the number of molds exceeds the efficient amount, the construction cost will also.increase because of the higher quantity of formwork materials. Table 9 also indicates that timber formwork is cheaper than steel formwork when producing a single RUCAST unit. However, for producing more than five units, steel formwork becomes more cost-effective compared to timber. The more units constructed, the more efficient and economical steel formwork becomes.

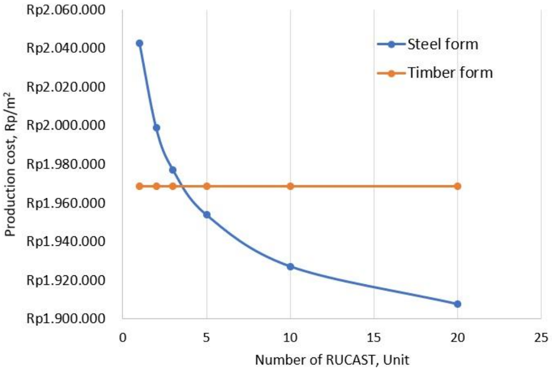

Figure 24 Diagram of Relationship between the number of units and RUCAST production cost

Table 9 Comparison of RUCAST construction costs based on steel and wood formwork

Number of units	Number of B140 form	Number of K315 form	cost/m² for steel form (IDR)	cost/m² for timber form (IDR)
1	10	3	2.042.938	1.968.763
2	10	3	1.998.777	1.968.763
3	12	3	1.977.174	1.968.763
5	17	5	1.953.859	1.968.763
10	20	6	1.927.133	1.968.763
20	27	8	1.907.587	1.968.763

The unit–cost relationship chart in Figure 24 illustrates that for the construction of five RUCAST units, steel formwork becomes 1% cheaper than timber formwork, with the cost advantage increasing as the number of RUCAST units grows. A comparative cost analysis was carried out between RUCAST production and an existing similar technology, RISHA, using steel formwork and the same layout, as shown in Table 10. Based on the analysis results, the cost of constructing one unit of RISHA is Rp. 98.474.027,- while for one unit of RUCAST requires Rp. 73.582.241,-. Therefore, in general, the budget required to produce one RUCAST unit is lower than that of one RISHA unit.

CONCLUSION

This study demonstrates that the RUCAST structural system, with its slender beam–column components and a column spacing of 1.5 meters, is capable of providing flexible floor plans and spatial aesthetic advantages. Although the resulting concrete strength is low due to substandard aggregate quality, the reinforcing steel and mechanical connections meet SNI requirements. The performance of mortar and lightweight brick

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Table 10 Comparation of RUCAST with RISHA Construction Cost

Construction Stage	Unit	Volume	Rucast Unit Price (Rp)	Rucast Total Price (Rp)	Risha Unit Price (Rp)	Risha Total Price (Rp)
A. PREPARATION STAGE						
A.1. Site cleaning	m^2	36.0	15,000.00	540,000.00	15,000.00	540,000.00
A.2. Measurement and installation of batter boards	m'	24.0	82,910.00	1,989,840.00	82,910.00	1,989,840.00
B. EARTHWORK						
B.1. Excavation	m^3	1.9	60,750.00	116,640.00	60,750.00	214,326.00
B.2. Stands backfill	m^3	0.4	305,142.86	123,033.60	305,142.86	123,033.60
C. FOUNDATION STRUCTURE WORK						
C.1. Working floor K-100	m^3	1.8	810,419.00	1,458,754.20	810,419.00	1,458,754.20
C.2. Stone foundation	m^3	1.9	711,978.57	1,366,998.86	711,978.57	2,511,860.40
D. SUPERSTRUCTURE WORK						
D.1. Panel B140/Panel 1	buah	68.0	140,105.82	9,527,195.58	258,137.38	20,134,715.70
D.2. Panel K310/Panel 2	buah	20.0	249,708.62	4,994,172.45	373,568.58	11,207,057.35
D.3. Panel P3 (RISHA)					227,627.79	6,828,833.77
E. ROOF WORK						
E.1. Roof frame installation	m^2	50.4	146,531.67	7,380,800.05	146,531.67	7,380,800.05
E.2. Roof covering installation	m^2	50.4	36,515.00	1,839,260.55	36,515.00	1,839,260.55
E.3. Roof tile installation	m^2	50.4	124,875.00	6,289,953.75	124,875.00	6,289,953.75
F. ARCHITECTURAL WORK						
F.1. Wall work						
F.1.1. Brick installation	m^2	79.2	151,278.57	11,981,262.86	151,278.57	11,981,262.86
F.1.2. Plastering	m^2	158.4	37,489.54	5,938,343.59	37,489.54	5,938,343.59
F.1.3. Smoothing/Acian	m^2	158.4	21,050.00	3,334,320.00	21,050.00	3,334,320.00
F.1.4. Painting	m^2	158.4	14,640.00	2,318,976.00	14,640.00	2,318,976.00
F.2. Ceiling work						
F.2.1. Ceiling frame installation	m^2	36.0	186,900.00	6,728,400.00	186,900.00	6,728,400.00
F.2.2. Gypsum installation	m^2	36.0	27,597.00	993,492.00	27,597.00	993,492.00
F.2.3. Ceiling painting	m^2	36.0	14,640.00	527,040.00	14,640.00	527,040.00
F.3. Flooring work	m^2	36.0	140,248.57	5,048,948.57	140,248.57	5,048,948.57
G. MECHANICAL, ELECTRICAL, AND PLUMBING WORK						
G.1. Lamp instalation	point	4.0	271,202.31	1,084,809.23	271,202.31	1,084,809.23
TOTAL				**73,582,241.29**	**TOTAL**	**98,474,027.62**
TOTAL/m^2				**2,043,951.15**	**TOTAL/m^2**	**2,735,389.66**

masonry is considered adequate based on compressive strength, bond strength, and shear strength, all of which remain within the acceptable limits of NTC-M 2004. Flexural analysis indicates that RUCAST beams and columns are not effective as moment-resisting elements, making them more suitable as wall-restraining components. Its mechanical connections are categorized as semi-rigid and require the support of masonry walls to improve system stiffness.

Overall, the shear wall capacity of RUCAST is deemed suitable for application in nearly all provincial capitals in Indonesia, with damage patterns aligning with expectations. From a cost perspective, mass production of RUCAST using steel molds proves more economical, up to 25.28% cheaper than comparable precast technologies such as RISHA. Considering these findings, it is recommended that variations in house layouts comply with the irregularity provisions of SNI 1726:2019 Article 7.3.2. Additional, in developing RUCAST housing typologies, structural analysis software can be utilized to refine calculations and increase safety factors to accommodate variability in concrete quality in real-field conditions. To prevent failure in field implementation, guidelines and manuals for RUCAST design and construction should be prepared.

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