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The Effect of Rice Field Snail Shell Powder Addition as a Fine Aggregate Substitution Material in Concrete Production

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Abstract

The increasing consumption of natural aggregates in concrete production encourages the utilization of alternative waste materials that can partially reduce dependence on conventional resources. This study investigates the effect of rice field snail shell powder as a partial substitute for fine aggregate on concrete workability, density, and compressive strength. A laboratory experimental method was conducted using five substitution levels of 0%, 2.5%, 5%, 7.5%, and 10%. The rice field snail shells were processed into powder passing the No. 100 sieve, and cylindrical concrete specimens with a diameter of 150 mm and a height of 300 mm were prepared and water-cured for 28 days. The average slump values were 165, 150, 137.5, 155, and 160 mm, respectively. The 28-day average compressive strengths were 28.26 MPa for the control concrete, 29.97 MPa at 2.5%, 22.33 MPa at 5%, 26.05 MPa at 7.5%, and 25.05 MPa at 10% substitution. The 2.5% mixture achieved the highest average compressive strength, while higher substitution levels did not consistently improve mechanical performance. The results indicate that rice field snail shell powder can partially replace fine aggregate, although its effectiveness depends on the substitution proportion and consistency of the concrete mixing process.

Keywords: *Concrete, Compressive Strength, Fine Aggregate, Rice Field Snail Shell, Waste Material.*

INTRODUCTION

Concrete remains one of the principal construction materials because its constituent materials can be combined to produce a hardened composite with substantial compressive resistance and considerable flexibility in structural applications (Sujatmiko, 2019). Its conventional composition relies on Portland cement, fine aggregate, coarse aggregate, and water, with supplementary materials incorporated when required to achieve particular fresh or hardened properties (Sujatmiko, 2019). The extensive use of concrete creates persistent demand for naturally sourced aggregates, particularly sand and crushed stone, making the development of alternative aggregate materials increasingly relevant to sustainable construction practices. Natural aggregate extraction is not only associated with material availability but also raises concerns regarding the long-term environmental consequences of continued dependence on quarrying and river-derived resources. Aggregate constitutes a substantial portion of concrete volume, and its physical characteristics, including grading, cleanliness, and particle distribution, directly influence the properties of the resulting composite (Badan Standardisasi Nasional, 1990). These conditions have encouraged recent concrete-material research to examine waste-derived resources that can partially replace conventional constituents while preserving the essential performance required for structural applications.

Previous studies have examined several forms of shell waste as alternative concrete constituents, although their reported effects vary according to shell type, particle characteristics, substitution target, and replacement proportion. Rice field snail shells are technically relevant because their chemical composition is dominated by calcium-bearing compounds, with reported contents of 61.447% CaO, 0.480% SiO_2, and 0.103% Al_2O_3, indicating their potential for application in cement-based materials (Nur Afifah et al., 2022). Research specifically employing rice field snail shells as fine-aggregate substitution has demonstrated that the material can be processed and incorporated into concrete mixtures, although its influence on compressive strength depends on the proportion used (Putra et al., 2019). At a broader level, the potential of snail shell-derived materials has been associated with their mineral composition and their capacity to reduce dependence on conventional concrete constituents (Alhassan et al., 2023). Experimental evidence from other shell wastes further indicates that selected replacement proportions may improve compressive strength, while excessive or differently configured substitution can produce adverse mechanical responses (Andika & Safarizki, 2019). These contrasting findings indicate that shell waste cannot be assumed to behave as a mechanically equivalent substitute across different concrete mixture configurations, particularly when its function changes from cement replacement to fine-aggregate replacement.

The available literature reveals a more specific limitation concerning the behavior of powdered rice field snail shells when used to replace fine aggregate at relatively small and incremental substitution levels. Studies of shell waste as fine-aggregate substitution have shown that concrete performance remains strongly dependent on the selected replacement proportion, suggesting that the relationship between shell content and mechanical performance is not necessarily linear (Rizki Abdila et al., 2023). Research involving oyster shell as a fine-aggregate substitute likewise indicates that replacing conventional fine aggregate with shell material can modify concrete properties through changes in the granular structure of the mixture (Hong & Choudhury, 2024). In contrast, several investigations of rice field snail shells have focused primarily on cement substitution, including studies examining compressive strength and elastic modulus rather than their isolated function as fine aggregate (Ridha'al Syariffudin et al., 2020). Recent research combining snail shell powder with other cement-replacement materials has also reported changes in compressive strength, but the simultaneous modification of multiple constituents makes it difficult to distinguish the specific contribution of snail shell powder (Ismawan & Munthe, 2025). Although research has begun to examine rice field conch shells in relation to both cement and fine-aggregate substitution, the available evidence does not yet establish a sufficiently consistent response for finely powdered shell material across low incremental replacement levels (Permatasari et al., 2024). This gap is particularly relevant for substitution levels of 2.5%, 5%, 7.5%, and 10%, where controlled experimental comparison can clarify whether increasing rice field snail shell powder produces a systematic improvement, deterioration, or optimum range in concrete performance.

The unresolved behavior of shell powder as a fine-aggregate substitute has both scientific and practical significance because aggregate replacement affects not only the amount of conventional material consumed but also the internal packing, workability, density, and mechanical characteristics of concrete. Fine aggregate plays an important role in distributing particles and filling voids within the concrete matrix, meaning that changes in its grading and physical condition can alter the interaction between aggregate particles and cement paste. The determination of aggregate particle-size distribution is therefore essential for establishing whether the substituted material can occupy a comparable role within the granular skeleton of concrete (Badan Standardisasi Nasional, 2012). Moisture condition must also be controlled because surface moisture in fine aggregate can alter the effective water content of the mixture and consequently influence workability and strength development (ASTM International, n.d.). Indonesian concrete standards further provide requirements concerning concrete constituents and aggregate characteristics that serve as technical references for concrete production and evaluation (Badan Standardisasi Nasional, 2002). Consequently, an assessment of shell-powder substitution should not be restricted to compressive strength alone but should relate mechanical outcomes to the physical characteristics of the constituent materials and the fresh-concrete response.

The present study positions powdered rice field snail shell as a locally available waste material and investigates its potential as a partial substitute for conventional fine aggregate in concrete production. The shells are processed into powder and passed through a No. 100 sieve before incorporation into the mixture, allowing the investigation to focus on finely divided shell particles rather than relatively coarse shell fragments. This material configuration is consistent with the broader development of shell-powder applications in concrete, where finely processed shell particles have been investigated as modified constituents capable of influencing concrete characteristics (Stel'makh et al., 2022). The experimental design employs a control mixture and four incremental substitution levels of 2.5%, 5%, 7.5%, and 10%, providing a more systematic basis for identifying changes associated with increasing shell-powder content. Aggregate bulk density, mud content, moisture content, and particle-size distribution are characterized before the concrete mixtures are evaluated, while specimen preparation and curing follow standardized laboratory procedures (Badan Standardisasi Nasional, 2011). This research framework enables the effect of shell-powder substitution to be interpreted through the combined relationship between material characteristics, fresh-concrete behavior, density, and 28-day compressive strength rather than through replacement percentage as an isolated variable.

The objective of this study is to evaluate the effect of powdered rice field snail shells used as partial fine-aggregate substitution on the characteristics and 28-day compressive strength of concrete and to identify the performance pattern associated with the investigated substitution levels. The study examines five controlled mixture conditions, consisting of conventional concrete and mixtures incorporating 2.5%, 5%, 7.5%, and 10% rice field snail shell powder as a partial replacement for fine aggregate. Its scientific contribution lies in clarifying the response of finely ground rice field snail shell material within the granular structure of concrete at relatively small incremental replacement levels, an area that remains less systematically established than cement substitution using shell-derived materials. Its methodological contribution lies in integrating aggregate characterization, fresh-concrete observations, density assessment, and compressive-strength testing within a single experimental framework so that mechanical performance can be interpreted in relation to the physical behavior of the substituted material. The study also provides a basis for determining whether a particular replacement range can maintain satisfactory concrete performance or whether increasing shell-powder content produces limitations associated with changes in aggregate packing and mixture characteristics. The resulting evidence is intended to strengthen the scientific understanding of rice field snail shell powder as an alternative fine-aggregate material while providing a practical basis for utilizing locally generated shell waste in concrete production.

RESEARCH METHODS

This study employed a laboratory experimental design to evaluate the effect of rice field snail shell powder as a partial substitute for fine aggregate in concrete. The experiment was conducted at the Structure and Building Materials Laboratory of Universitas Islam Sultan Agung, Semarang, using Type I Ordinary Portland Cement, natural fine aggregate with a particle size of 0–5 mm, crushed-stone coarse aggregate with a particle size of 5–40 mm, clean water, rice field snail shell powder obtained from small-scale enterprise waste in Semarang, and a superplasticizer. Before mixing, the fine and coarse aggregates were characterized through bulk-density, mud-content, moisture-content, and sieve-analysis tests to establish their physical properties and suitability for concrete production (Badan Standardisasi Nasional, 1990). Particle-size distribution was determined using sieve analysis in accordance with SNI ASTM C136:2012, while surface moisture of the fine aggregate was evaluated using the procedure specified in ASTM C70 (Badan Standardisasi Nasional, 2012). Aggregate cleanliness was assessed with reference to SNI S-04-1989-F, and the rice field snail shells were subsequently cleaned, dried, and mechanically ground until passing the No. 100 sieve before being incorporated into the concrete mixture (Badan Standardisasi Nasional, 1989). The resulting shell powder was used to replace fine aggregate at substitution levels of 0%, 2.5%, 5%, 7.5%, and 10%, following the approach of previous research investigating rice field snail shells as a fine-aggregate substitute in concrete (Putra et al., 2019).

The reference concrete was designed for K-250 concrete using the mixture proportions established in the experimental program, consisting of 384 kg of cement, 692 kg of fine aggregate, 1,039 kg of coarse aggregate, 215 L of water, and 2.15 L of superplasticizer per cubic metre of concrete. For each treatment, the quantity of natural fine aggregate was progressively reduced according to the prescribed substitution percentage and replaced with rice field snail shell powder. Cylindrical specimens measuring 150 mm in diameter and 300 mm in height were prepared using a concrete mixer, and the fresh concrete was subjected to slump testing before being placed into molds in three layers, with each layer compacted using 25 strokes. The specimens were demolded after 24 hours and subsequently water-cured for 28 days following the established procedure for concrete specimen preparation and curing (Badan Standardisasi Nasional, 2011). Fresh-concrete density and hardened-specimen mass were recorded as part of the physical evaluation, while compressive strength was determined after 28 days using a compression-testing machine to assess the mechanical response of each mixture. The consideration of fresh and hardened properties was important because shell-based materials have been reported to influence both workability and strength characteristics depending on their incorporation level (Imoh et al., 2025). The resulting measurements were evaluated by comparing the individual values and mean compressive strengths of the 0%, 2.5%, 5%, 7.5%, and 10% mixtures to identify the performance pattern associated with increasing rice field snail shell powder content.

RESULTS AND DISCUSSION

Aggregate Physical Characteristics and Particle Distribution

The physical characterization of the aggregates provides the initial basis for evaluating the behavior of the concrete mixtures containing rice field snail shell powder. Fine aggregate showed a clear difference between loose and compacted conditions, indicating the influence of particle rearrangement on bulk density. In the loose condition, the two measurements produced bulk densities of 1490.56 kg/m³ and 1285.21 kg/m³, with an average value reported as 1387.89 kg/m³. After compaction, the corresponding values increased to 1733.96 kg/m³ and 1724.94 kg/m³, resulting in an average of 1729.45 kg/m³. This increase reflects the reduction of interparticle voids when external compaction allows the aggregate grains to occupy the available volume more densely. Such behavior is relevant because aggregate occupies a substantial proportion of concrete volume and its physical arrangement can affect the characteristics of the resulting mixture (Sujatmiko, 2019).

Table 1. Fine Aggregate Bulk Density without Compaction

No.	Container Code	Container Weight (kg) W1	Container + Aggregate Weight (kg) W2	Aggregate Weight (kg) W3 = W2 − W1	Aggregate Bulk Density (kg/m³) W3/V Container	Average (kg/m³)
1	Sil. A	10.78	18.68	7.9	1490.56	1387.89
2	Sil. B	10.51	17.32	6.81	1285.21	

Source: Research Results, 2026

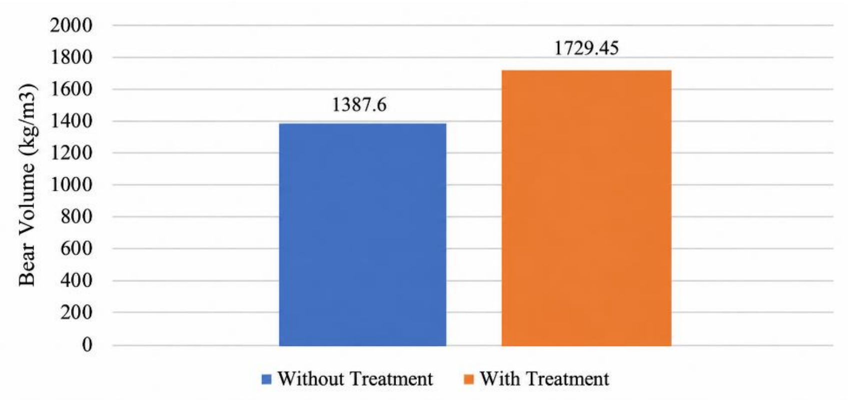

Figure 1. Fine Aggregate Bulk Density Calculation Results

The coarse aggregate exhibited a similar response to compaction, although the magnitude of the change differed from that of the fine aggregate. Under the loose condition, the reported bulk-density measurements were 1415.09 kg/m³ for Sil. A and 1336.16 kg/m³ for Sil. B, while the reported average was 1375.62 kg/m³. After compaction, the values increased to 1490.56 kg/m³ and 1556.97 kg/m³, with an average bulk density of 1523.77 kg/m³. The results indicate that compaction increased the quantity of coarse aggregate accommodated within the same test volume. Differences between loose and compacted conditions are important when characterizing aggregate because particle arrangement influences the void structure subsequently occupied by cement paste in concrete (Sujatmiko, 2019). The observed response also supports the need to maintain consistent material preparation and compaction procedures throughout concrete production.

Table 2. Coarse Aggregate Bulk Density with Compaction

No.	Container Code	Container Weight (kg) W1	Container + Aggregate Weight (kg) W2	Aggregate Weight (kg) W3 = W2 − W1	Aggregate Bulk Density (kg/m³) W3/V Container	Average (kg/m³)

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1	Sil. A	10.77	18.70	7.9	1490.56	1523.77
2	Sil. B	10.51	18.76	7.25	1556.97	

Source: Research Results, 2026

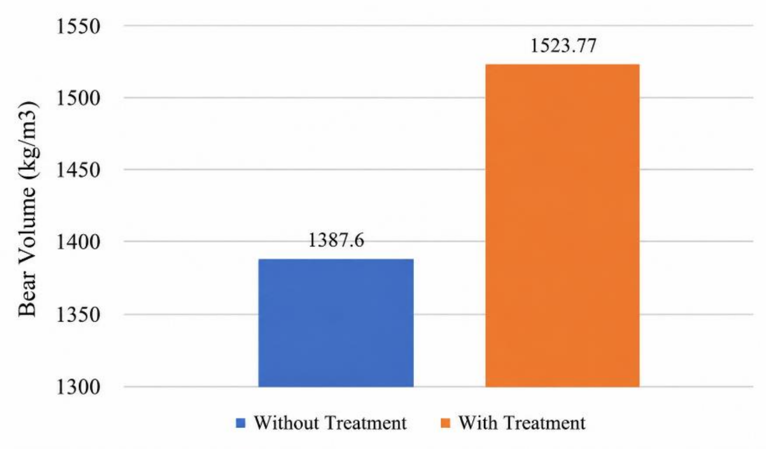

Figure 2. Coarse Aggregate Bulk Density

Aggregate cleanliness was evaluated through mud-content testing because fine contaminants can influence the quality of materials incorporated into concrete. The fine aggregate was evaluated using the sedimentation method, producing mud contents of 2% and 1.96% in the two measurements and an average value of 1.98%. The original experimental procedure referred to SNI S-04-1989-F, which specifies a maximum allowable mud content of 5% for fine aggregate. The measured fine-aggregate value was below this stated threshold. For coarse aggregate, the washing procedure produced 1.3% in both measurements, with the same value reported as the average. The original study also used SNI S-04-1989-F as the reference for evaluating the cleanliness of coarse aggregate, for which the stated mud-content requirement was stricter than that applied to fine aggregate.

Table 3. Fine Aggregate Mud Content by Sedimentation Method

Experiment	Fine Aggregate Volume (ml) V1	Mud Volume (ml) V2	Mud Content (%)	Average (%)
1	490	10	2	1.98
2	500	10	1.96	

Source: Research Results, 2026

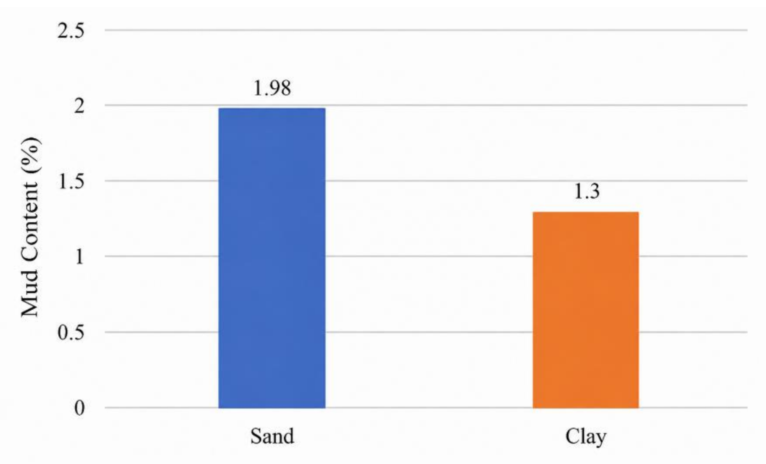

Figure 3. Aggregate Mud Content

Moisture-content testing demonstrated a substantial difference between the fine and coarse aggregates before their incorporation into the concrete mixtures. The fine aggregate produced individual moisture-content values of 2.2% and 7.2%, resulting in an average of 4.7%. The coarse aggregate yielded substantially lower values of 0.66% and 0.88%, with an average moisture content of 0.77%. Moisture determination in the experimental procedure was based on oven drying and referred to ASTM C70 as the methodological basis for evaluating moisture in aggregate. Water associated with aggregate particles is relevant to concrete production because the amount of moisture carried by aggregate forms part of the material condition encountered during mixing. The difference observed between the two aggregate fractions demonstrates that their initial moisture states were not identical, which should be retained as part of the experimental context rather than attributing later concrete behavior exclusively to the percentage of shell-powder substitution.

Table 4. Aggregate Moisture Content

Experiment	Container Weight (gram) a	Container + Aggregate before Oven Drying (gram) b	Container + Aggregate after Oven Drying (gram) c	Moisture Content (%)	Average (%)
Fine Aggregate Moisture Content					
I	46	500	490	2.2	4.7
II	54	500	470	7.2	
Coarse Aggregate Moisture Content					
I	44	500	497	0.66	0.77
II	42	500	496	0.88	

Source: Research Results, 2026

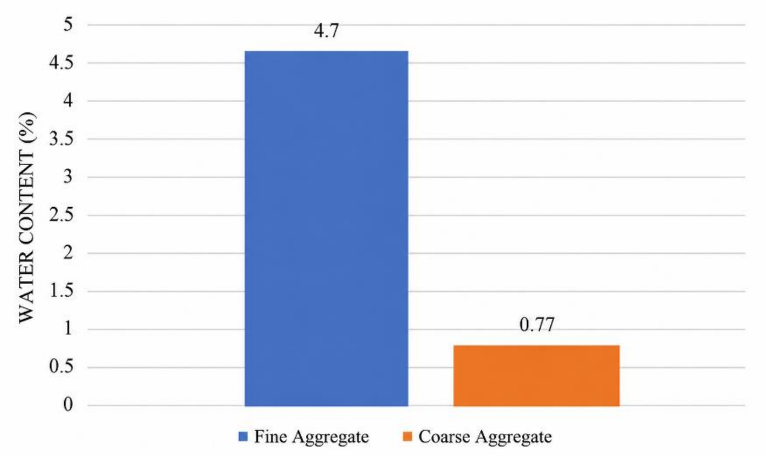

Figure 4. Aggregate Water Content

The sieve analysis of the fine aggregate provides additional evidence concerning the particle-size distribution used in the concrete mixtures. The original test began with 500 g of aggregate, while the total aggregate recovered after sieving was 440 g, corresponding to the reported material loss of 12%. The percentages passing the 3/8-inch, No. 4, No. 8, No. 16, No. 30, No. 50, and No. 100 sieves were 100%, 98.86%, 95.68%, 87.5%, 50.23%, 31.59%, and 23.18%, respectively. Comparison with the ASTM C33 specification values reproduced in the original study shows that some fractions, particularly those associated with the finer sieves, were outside the stated ranges. The resulting fineness modulus was reported as 2.13. Particle-size distribution is a relevant material parameter because aggregate grading influences the distribution and packing of particles within concrete, while the sieve-analysis procedure itself was conducted with reference to SNI ASTM C136:2012.

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Table 5. Fine Aggregate Sieve Analysis Results

No.	Sieve Size	Aggregate Weight (gram)	Retained Aggregate (%)	Cumulative Retained Aggregate (%)	Percent Finer (%)	ASTM C33 Min (%)	ASTM C33 Max (%)
1	3/8 inch	0	0	0	100	100	100
2	No. 4	5	1.14	1.14	98.86	95	100
3	No. 8	14	3.18	4.32	95.68	80	100
4	No. 16	36	8.18	12.5	87.5	50	85
5	No. 30	164	37.27	49.77	50.23	25	60
6	No. 50	82	18.64	68.41	31.59	10	30
7	No. 100	37	8.41	76.82	23.18	2	10
8	PAN	102	23.18	100	0		
	Total	**440**	**100**	**212.96**			

Source: Research Results, 2026

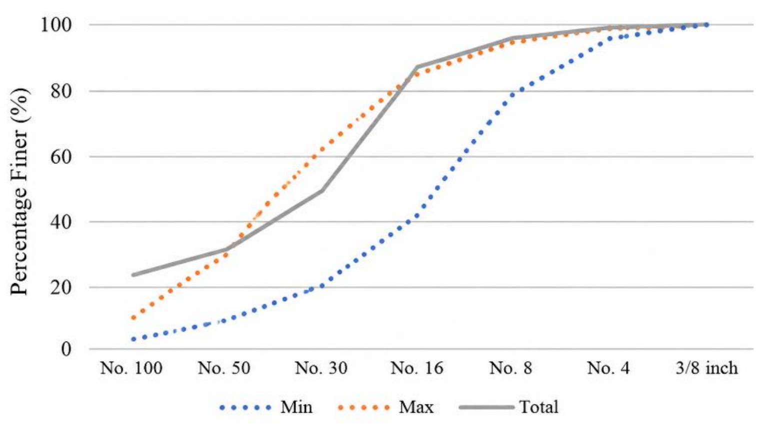

Figure 5. Fine Aggregate Sieve Analysis

The coarse-aggregate sieve analysis showed a different particle distribution from that of the fine fraction. From an initial aggregate mass of 500 g, 499 g was recovered after sieving, corresponding to the reported material loss of 0.2%. The percentages passing the 1-inch, 3/4-inch, 1/2-inch, 3/8-inch, and No. 4 sieves were 100%, 95.2%, 17.25%, 2.4%, and 0%, respectively. The original comparison with ASTM C33 showed that the 3/4-inch fraction exceeded the maximum value reproduced in the specification table, while the remaining fractions followed different positions within their reported ranges. The fineness modulus for the coarse aggregate was reported as 2.85, and this value is retained exactly as documented in the experimental results. Taken together with the moisture, mud-content, and bulk-density tests, the sieve results establish the initial physical condition of the aggregates against which the effects of rice field snail shell powder substitution should be interpreted, rather than treating substitution percentage as the only factor controlling concrete response (Putra et al., 2019).

Table 6. Coarse Aggregate Sieve Analysis Results

No.	Sieve Size	Aggregate Weight (gram)	Retained Aggregate (%)	Cumulative Retained Aggregate (%)	Percent Finer (%)	ASTM C33 Min (%)	ASTM C33 Max (%)
1	1 inch	0	0	0	100	90	100
2	3/4 inch	24	4.8	4.8	95.2	40	85
3	1/2 inch	389	77.95	82.75	17.25	10	40
4	3/8 inch	74	14.85	97.6	2.4	0	15
5	No. 4	12	2.4	100	0	0	5

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Total	**499**	**100**	**285.15**

Source: Research Results, 2026.

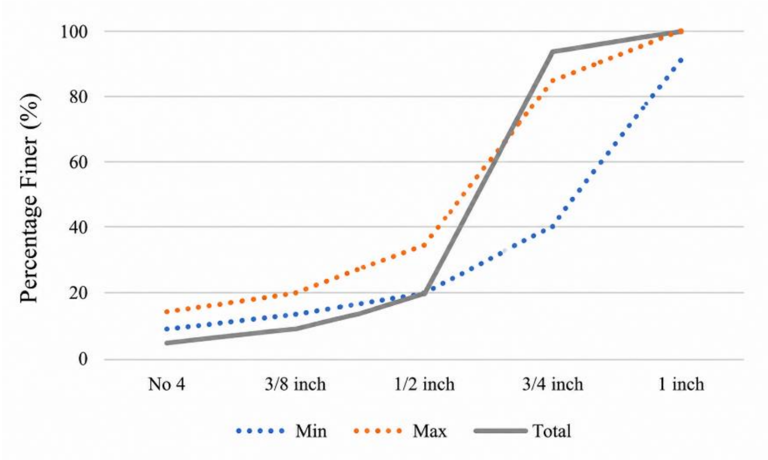

Figure 6. Coarse Aggregate Sieve Analysis

Fresh Concrete Workability and Density

The slump test was used to evaluate the workability of the fresh concrete mixtures containing different proportions of rice field snail shell powder. The control mixture, BCK 0%, produced an average slump value of 165 mm, while the BCK 2.5% mixture recorded an average of 150 mm. The lowest average slump was observed for BCK 5% at 137.5 mm, followed by an increase to 155 mm for BCK 7.5% and 160 mm for BCK 10%. These results indicate that increasing the substitution percentage did not produce a consistent linear reduction or increase in workability. The original study specifically associated the marked decrease at BCK 5% with an error in the concrete mixing procedure, meaning that this value should be interpreted within the experimental conditions rather than as an isolated material effect. Workability is influenced by water content, cement content, aggregate grading, particle shape, and the method of compaction, all of which interact within the fresh mixture (Sujatmiko, 2019).

Table 7. Slump Test

No.	Sample Name	Slump Value (mm)	Average (mm)
1	BCK 0% 1	170	165
2	BCK 0% 2	160	
3	BCK 2.5% 1	140	150
4	BCK 2.5% 2	160	
5	BCK 5% 1	135	137.5
6	BCK 5% 2	140	
7	BCK 7.5% 1	150	155
8	BCK 7.5% 2	160	
9	BCK 10% 1	150	160
10	BCK 10% 2	140	

Source: Research Results, 2026.

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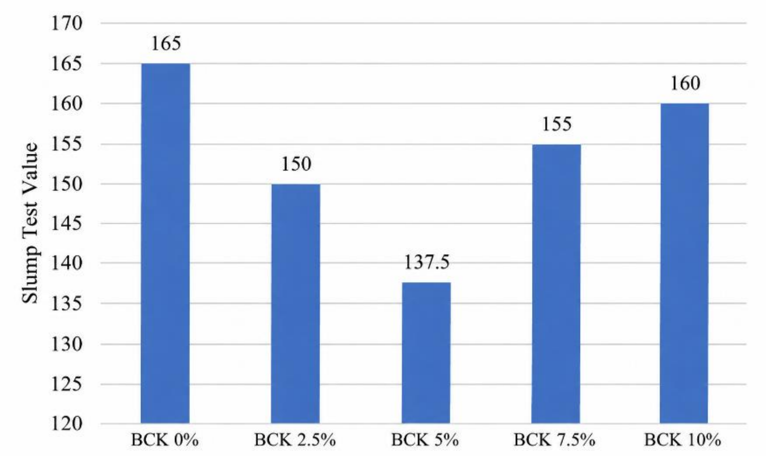

Figure 7. Slump Test

The pattern shown in Table 8 suggests that rice field snail shell powder did not produce a simple proportional effect on concrete consistency over the investigated substitution range. The reduction from 165 mm in the control mixture to 150 mm at 2.5% and 137.5 mm at 5% was followed by recovery to 155 mm and 160 mm at 7.5% and 10%, respectively. Such variation indicates that workability cannot be interpreted solely from the quantity of shell powder introduced into the mixture. The shell material used in this study passed the No. 100 sieve, which means that it introduced a very fine particle fraction into a mixture whose original fine aggregate already contained a relatively high proportion of fine particles. The original experiment also incorporated a superplasticizer to support workability across the different mixture conditions. Previous research on shell-based concrete has likewise shown that changes in shell content can affect fresh-concrete behavior differently depending on the proportion and mode of incorporation (Rizki Abdila et al., 2023).

Fresh-concrete mass measurements were subsequently used to determine the density of the specimens before hardening. The control specimens produced fresh-concrete density values of 2311.32, 2286.79, and 2292.45 kg/m³, with a reported average of 2296.86 kg/m³. For BCK 2.5%, the reported specimen densities were 2400.00 and 2307.55 kg/m³, producing an average of 2353.77 kg/m³ in the calculation table. BCK 5% produced values of 2420.75, 2171.70, and 2254.72 kg/m³, with a reported average of 2282.39 kg/m³. BCK 7.5% recorded 2298.11 and 2258.49 kg/m³ with an average of 2278.30 kg/m³, while BCK 10% recorded 2315.09, 2298.11, and 2309.43 kg/m³ with an average of 2307.55 kg/m³. These results show relatively limited changes in fresh-concrete density across the substitution levels, although individual specimens exhibited noticeable differences, particularly within the BCK 5% mixture. Concrete density is affected by the proportions and physical properties of its constituent materials, including the aggregate fractions that occupy most of the mixture volume (Sudipta et al., 2009).

Table 8. Fresh Concrete Density Calculation Results

No.	Concrete Code	Fresh Concrete Weight (kg)	Cylinder Volume (m³)	Fresh Concrete Density (kg/m³)	Average (kg/m³)
1	BCK 0%	12.25	0.0053	2311.32	2296.86
2	BCK 0%	12.12	0.0053	2286.79	
3	BCK 0%	12.15	0.0053	2292.45	
4	BCK 2.5%	12.72	0.0053	2400.00	2353.77
5	BCK 2.5%	12.23	0.0053	2307.55	
7	BCK 5%	12.83	0.0053	2420.75	2282.39
8	BCK 5%	11.51	0.0053	2171.70	
9	BCK 5%	11.95	0.0053	2254.72	
10	BCK 7.5%	12.18	0.0053	2298.11	2278.30
12	BCK 7.5%	11.97	0.0053	2258.49	
13	BCK 10%	12.27	0.0053	2315.09	2307.55

14	BCK 10%	12.18	0.0053	2298.11
15	BCK 10%	12.24	0.0053	2309.43

Source: Research Results, 2026.

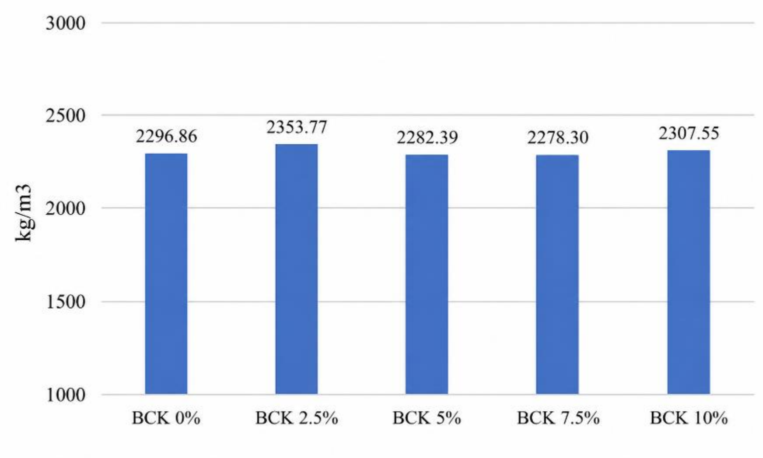

Figure 8. Fresh Concrete Density Graph

The fresh-density results do not show a monotonic relationship between increasing rice field snail shell content and concrete density. The highest reported group average in Table 9 occurred at BCK 2.5% with 2353.77 kg/m³, while the lowest reported group average occurred at BCK 7.5% with 2278.30 kg/m³. The BCK 10% mixture produced an average of 2307.55 kg/m³, which remained close to the control value of 2296.86 kg/m³. This pattern supports the observation in the original study that fresh-concrete density remained relatively stable despite minor increases and decreases among the substitution percentages. The variation among specimens indicates that the effect of shell-powder incorporation was not governed simply by the quantity of material replacing natural sand. Related shell-waste studies have similarly reported that changes in concrete properties depend on the substitution mechanism and mixture proportion rather than following a uniform response to increasing shell content (Andika & Safarizki, 2019).

After demolding and curing, the hardened specimens were weighed again to document their physical condition at 28 days. The three BCK 0% specimens weighed 12.45, 12.32, and 12.35 kg, while the BCK 2.5% specimens weighed 12.92, 12.43, and 12.02 kg. For BCK 5%, the recorded values were 13.03, 11.71, and 12.12 kg; BCK 7.5% produced 12.38, 13.03, and 12.17 kg; and BCK 10% produced 12.47, 12.38, and 12.44 kg. The values remain within a relatively narrow mass range despite the progressive replacement of fine aggregate with shell powder. The original study emphasized that curing influences the development of concrete properties because appropriate moisture conditions support cement hydration during the hardening period. This experimental procedure followed the curing approach referenced to SNI 2493:2011 and maintained the specimens under water for 28 days before subsequent mechanical evaluation.

Table 9. Hardened Concrete Weight after 28-Day Curing

No.	Specimen Code	Weight (kg)
1	BCK 0%	12.45
2	BCK 0%	12.32
3	BCK 0%	12.35
4	BCK 2.5%	12.92
5	BCK 2.5%	12.43
6	BCK 2.5%	12.02
7	BCK 5%	13.03
8	BCK 5%	11.71
9	BCK 5%	12.12
10	BCK 7.5%	12.38

11	BCK 7.5%	13.03
12	BCK 7.5%	12.17
13	BCK 10%	12.47
14	BCK 10%	12.38
15	BCK 10%	12.44

Source: Research Results, 2026.

The combined workability and density results indicate that shell-powder substitution altered fresh-concrete behavior without producing a uniform progressive trend across the investigated percentages. BCK 5% exhibited the lowest average slump and a comparatively low reported average fresh density, while the original study also documented a mixing-procedure problem for this mixture. BCK 2.5% showed a lower slump than the control but the highest reported average fresh-concrete density, demonstrating that workability and density did not change in parallel. At higher replacement levels, slump values recovered to 155 mm and 160 mm for BCK 7.5% and BCK 10%, while their fresh-density values remained within the range observed across the experimental series. These results should be interpreted together with the aggregate gradation, moisture content, and very fine particle size of the shell powder because each forms part of the mixture condition preceding mechanical testing. The fresh-concrete observations provide an important experimental basis for interpreting the compressive-strength results, especially because previous studies have shown that shell-based substitutions can produce different responses depending on percentage, material form, and replacement target (Putra et al., 2019).

Compressive Strength Performance of Rice Field Snail Shell Concrete

The 28-day compressive-strength test provided the principal mechanical indicator for assessing the effect of rice field snail shell powder as a partial substitute for fine aggregate. The control concrete, BCK 0%, produced individual compressive strengths of 28.42, 22.507, and 33.867 MPa, with a reported average of 28.26 MPa. The BCK 2.5% mixture recorded values of 31.449 and 28.508 MPa and produced the highest reported mean compressive strength of 29.97 MPa among all mixture groups. BCK 5% produced substantially lower individual strengths of 22.863, 21.948, and 22.20 MPa, resulting in an average of 22.33 MPa. The BCK 7.5% mixture recorded 25.699 and 26.409 MPa with a mean of 26.05 MPa, while BCK 10% produced 23.771, 27.381, and 24.009 MPa with a mean of 25.05 MPa. These results confirm that compressive strength did not vary linearly with increasing shell-powder content, indicating that the effect of snail shell powder is strongly dependent on its incorporation level and its interaction with the concrete matrix, as also observed in recent experimental investigations of snail shell powder-based concrete (Imoh et al., 2025).

Table 10. 28-Day Concrete Compressive Strength Results

No.	Concrete Code	Concrete Age (days)	Maximum Load (kN)	Compressive Strength (MPa)	Average (MPa)
1	BCK 0%	28	502.225	28.42	28.26
2	BCK 0%	28	397.725	22.507	
3	BCK 0%	28	598.486	33.867	
4	BCK 2.5%	28	555.751	31.449	29.97
5	BCK 2.5%	28	503.787	28.508	
7	BCK 5%	28	404.023	22.863	22.33
8	BCK 5%	28	387.856	21.948	
9	BCK 5%	28	392.315	22.20	
10	BCK 7.5%	28	454.142	25.699	26.05
12	BCK 7.5%	28	466.683	26.409	
13	BCK 10%	28	420.067	23.771	25.05
14	BCK 10%	28	483.862	27.381	
15	BCK 10%	28	424.279	24.009	

Source: Research Results, 2026.

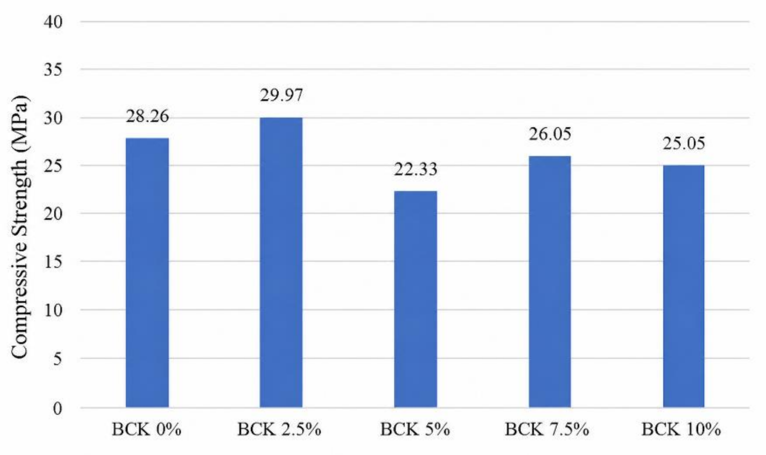

Figure 9. 28-Day Concrete Compressive Strength

The comparison between the control and BCK 2.5% indicates that a small proportion of rice field snail shell powder did not reduce the mean compressive strength under the reported experimental conditions. The average strength increased from 28.26 MPa for BCK 0% to 29.97 MPa for BCK 2.5%, corresponding to the highest mean value in Table 11. This response is consistent with previous observations that shell-based materials can produce favorable compressive-strength performance at selected low replacement levels rather than across all dosages. Nur Afifah et al. (2022), although investigating rice field snail shells as a cement substitute rather than as fine aggregate, similarly reported that the best compressive-strength result occurred at the lowest investigated replacement percentage. Andika and Safarizki (2019) also reported increased compressive strength at selected shell-waste proportions, while higher or differently applied replacement levels did not necessarily maintain the same advantage. The present result consequently supports the interpretation that the mechanical response of shell-derived material is strongly dosage-dependent and should not be extrapolated from one substitution percentage to another.

The BCK 5% mixture displayed the most pronounced reduction in compressive strength, with its mean value falling to 22.33 MPa from 29.97 MPa at BCK 2.5%. The original experimental record explicitly states that the BCK 5% mixture experienced a procedural error during mixing and that the mixture became associated with the BCK 2.5% job-mix condition; the thesis does not provide sufficient additional documentation to reconstruct the exact sequence or quantity of this error. For that reason, the lower BCK 5% strength should not be interpreted as evidence that a 5% shell-powder dosage inherently produces a compressive strength of 22.33 MPa under correctly controlled mixing conditions. The same experimental irregularity was also linked in the original study to the unusually low average slump of 137.5 mm for BCK 5%, suggesting that its fresh- and hardened-concrete results were affected by the same procedural condition. Previous shell-concrete studies have demonstrated that changes in material proportion and mixture preparation can substantially influence the resulting compressive strength (Rizki Abdila et al., 2023). The present dataset supports cautious interpretation of BCK 5% rather than an unqualified comparison of this value with the other substitution groups.

The compressive strengths at BCK 7.5% and BCK 10% were higher than that of BCK 5% but remained below the control mean and the BCK 2.5% mean. BCK 7.5% achieved 26.05 MPa, while BCK 10% achieved 25.05 MPa, compared with 28.26 MPa for BCK 0% and 29.97 MPa for BCK 2.5%. This pattern suggests that increasing the quantity of very fine shell powder beyond the lowest substitution level did not preserve the strength improvement observed at 2.5%. The shell powder used in this experiment passed the No. 100 sieve, while the fine aggregate itself already showed a relatively high proportion of particles passing the finer sieves. The original thesis attributes the reduction in strength at higher substitution levels partly to the very fine particle size of the shell material, although no microstructural or chemical test was conducted in the experiment to verify the mechanism. A declining strength response with increasing shell content has also been observed in previous research using shell waste as aggregate substitution (Zuraidah et al., 2015).

Comparison with earlier studies indicates that the present findings fall within the broad range of responses reported for shell-based concrete but should be interpreted according to the specific replacement function used here. Putra et al. (2019) investigated rice field snail shells as a substitute for fine aggregate and demonstrated that this material can be incorporated into concrete, providing the closest conceptual basis for the current experimental design. Rizki Abdila et al. (2023) likewise examined shell waste as a fine-aggregate substitute and found that compressive strength changed according to the percentage of replacement rather than following a uniform response. Vitalis et al. (2016) reported that shell incorporation influenced not only compressive strength but also splitting tensile strength and elastic modulus, emphasizing that the mechanical consequences of shell substitution depend on its proportion and treatment. Studies using shell materials as cement substitutes have produced different numerical patterns because their replacement mechanism differs from aggregate substitution (Nur Afifah et al., 2022). The present experiment adds evidence specifically for finely ground rice field snail shell powder replacing 0–10% of fine aggregate, while its results should not be directly generalized to shell material used as cement or coarse-aggregate replacement.

The variation among specimens also needs to be considered when interpreting the reported group means. The control group ranged from 22.507 to 33.867 MPa, while BCK 10% ranged from 23.771 to 27.381 MPa, showing that individual specimen values were not identical even within a single mixture condition. The original study reported only two specimens in the final compressive-strength calculation for both BCK 2.5% and BCK 7.5% because one specimen from each mixture was removed after exhibiting a difference considered too large relative to the other samples. No formal statistical outlier test, confidence interval, or inferential significance test was reported, so the article should retain these values as descriptive experimental results rather than make statistical claims that were not performed. This limitation is relevant when comparing relatively small differences between the mixture averages, especially the 1.71 MPa difference between BCK 2.5% and the control. Previous experimental studies on alternative shell materials similarly relied heavily on comparative compressive-strength measurements across mixture percentages when assessing material feasibility (Andika & Safarizki, 2019).

Based strictly on the reported compressive-strength data, BCK 2.5% produced the highest mean value at 29.97 MPa, followed by BCK 0% at 28.26 MPa, BCK 7.5% at 26.05 MPa, BCK 10% at 25.05 MPa, and BCK 5% at 22.33 MPa. The original thesis conclusion separately describes BCK 10% as the "optimal" proportion because its authors interpreted the behavior from 7.5% to 10% as relatively stable, even though the reported mean compressive strength at 10% is numerically lower than at 2.5%. For consistency with the measured data, the present discussion distinguishes these two concepts: 2.5% is the highest-performing mixture based on mean 28-day compressive strength, whereas the designation of 10% as an optimal or stable level represents the interpretation stated in the original thesis rather than the maximum-strength result. This distinction avoids modifying the experimental record while also preventing the numerical ranking in Table 11 from being misrepresented. The findings indicate that partial substitution with rice field snail shell powder is technically feasible within the investigated range, but increasing substitution content did not consistently improve compressive strength and requires careful control of mixture preparation. This interpretation is compatible with earlier shell-concrete research showing that beneficial effects are strongly dependent on dosage, replacement target, and material characteristics (Putra et al., 2019).

CONCLUSION

This study evaluated the effect of rice field snail shell powder as a partial substitute for fine aggregate on the physical properties and 28-day compressive strength of concrete. The experimental results showed that the substitution produced a non-linear response across the investigated proportions of 0%, 2.5%, 5%, 7.5%, and 10%. The control concrete achieved an average compressive strength of 28.26 MPa, while the highest mean value of 29.97 MPa was obtained at 2.5% substitution. The average compressive strength decreased to 22.33 MPa at 5%, increased to 26.05 MPa at 7.5%, and reached 25.05 MPa at 10% substitution. The comparatively low value at 5% must be interpreted cautiously because the original experiment documented a mixing-procedure error for this mixture. The results indicate that increasing the amount of rice field snail shell powder did not consistently improve concrete compressive strength. Based on the measured strength values, the 2.5% mixture demonstrated the best mechanical performance among the investigated substitution levels.

The fresh-concrete results also showed that rice field snail shell powder affected workability without producing a consistent proportional trend. Average slump values were 165, 150, 137.5, 155, and 160 mm for the 0%, 2.5%, 5%, 7.5%, and 10% mixtures, respectively, while the fresh-concrete density remained relatively stable across the experimental series. These findings indicate that partial replacement of fine aggregate with finely ground rice field snail shell waste is technically feasible within the tested range, although its effect depends on substitution proportion and consistency of the mixing process. The use of shell powder should not be assumed to improve concrete performance merely because the replacement percentage is increased. The material may provide an alternative use for rice field snail shell waste while reducing part of the conventional fine-aggregate requirement. Careful control of particle preparation, aggregate condition, mixture proportion, and mixing procedure remains necessary to obtain reliable concrete performance. Within the limitations of the present experiment, low-level substitution, particularly 2.5%, provided the most favorable compressive-strength response.

REFERENCES

Alhassan, A., Aboshio, A., & Uche, O. A. (2023). Rice husk and snail shell ash as partial replacement of ordinary Portland cement in concrete–A Review. *Nigerian Journal of Technology*, *42*(4), 425-436. https://doi.org/10.4314/njt.v42i4.2

Andika, R., & Safarizki, H. A. (2019). Pemanfaatan limbah cangkang kerang dara (*Anadara granosa*) sebagai bahan tambah dan komplemen terhadap kuat tekan beton normal. *Media Komunikasi Dunia Ilmu Sipil (MoDuluS), 1*(1), 1–6. https://doi.org/10.32585/MODULUS.V1I1.374

ASTM International. (n.d.). *ASTM C70 standard test method for surface moisture in fine aggregate*.

Badan Standardisasi Nasional. (1990). *SNI 03-1750-1990: Agregat beton, mutu dan cara uji*.

Badan Standardisasi Nasional. (2002). *SNI 03-2847-2002: Tata cara perhitungan struktur beton untuk bangunan gedung*.

Badan Standardisasi Nasional. (2011). *SNI 2493:2011: Tata cara pembuatan dan perawatan benda uji beton di laboratorium*.

Badan Standardisasi Nasional. (2012). *SNI ASTM C136:2012: Metode uji untuk analisis saringan agregat halus dan agregat kasar*.

Badan Standardisasi Nasional. (1989). *SNI S-04-1989-F: Spesifikasi bahan bangunan bagian A*.

Hong, Y. M., & Choudhury, S. R. (2024). The substitution effect of the fine aggregate in concrete with oyster shell. *Materials*, *17*(24), 6148. https://doi.org/10.3390/ma17246148

Imoh, U. U., Apata, A. C., & Movahedi Rad, M. (2025). Performance of concrete incorporating waste glass cullet and snail shell powder: workability and strength characteristics. *Buildings*, *15*(13), 2161. https://doi.org/10.3390/buildings15132161

Ismawan, D., & Munthe, A. T. (2025). Effect of Cement Substitution with Corn Stalk Ash and Addition of Snail Shell Powder on Concrete Compressive Strength. *G-Tech: Jurnal Teknologi Terapan*, *9*(2), 839-850. https://doi.org/10.70609/gtech.v9i2.6653

Nur Afifah, K., Sugiarto, A., & Qomariah. (2022). Pengaruh pemanfaatan cangkang keong sawah sebagai substitusi semen terhadap kuat tekan beton normal. *Jurnal Online Skripsi Manajemen Rekayasa Konstruksi,* *3*(3), 84–90. https://jurnal.polinema.ac.id/index.php/jos-mrk/article/view/1039

Permatasari, N., Bunyamin, B., Hady, M., Abu Hafiz, D., Lathifah, N., & Auliyah, M. H. (2024, October). Utilization of rice field conch shells as a partial substitution of cement and fine aggregate for split tensile strength of concrete. In *E3S Web of Conferences* (Vol. 476, p. 01018). EDP Sciences. https://doi.org/10.1051/e3sconf/202447601018

Putra, R., Wallah, S., & Pandaleke, R. (2019). Pengaruh pemanfaatan cangkang keong sawah sebagai substitusi agregat halus (pasir) ditinjau terhadap kuat tekan beton. *Jurnal Sipil Statik, 7*(11), 1477–1484. https://ejournal.unsrat.ac.id/index.php/jss/article/download/26069/25704

Ridha'al Syariffudin, R., Manalip, H., & Mondoringin, M. R. (2020). Pengaruh Penggunaan Serbuk Cangkang Keong Sawah Sebagai Substitusi Parsial Semen Terhadap Nilai Modulus Elastisitas. *Jurnal Sipil Statik*, *8*(5). https://ejournal.unsrat.ac.id/v3/index.php/jss/article/view/31839

Rizki Abdila, S., Zulfikar, S., & Arga, Y. P. (2023). Pengaruh limbah cangkang kerang sebagai substitusi agregat halus terhadap kuat tekan beton. *Jurnal Sipil Krisna, 9*(1), 39–48. https://doi.org/10.61488/SIPILKRISNA.V9I1.250

.

Sujatmiko, M. I. B. (2019). *Teknologi beton dan bahan bangunan*. Media Sahabat Cendekia.

Stel'makh, S. A., Shcherban', E. M., Beskopylny, A. N., Mailyan, L. R., Meskhi, B., Beskopylny, N., ... & Kotenko, M. (2022). Nanomodified concrete with enhanced characteristics based on river snail shell powder. *Applied Sciences*, *12*(15), 7839. https://doi.org/10.3390/app12157839

Tilik, L. F., Fuady, B. H., Suhadi, S., Armaini, R., Firdausa, F., Agusri, M. R., & Hartoyo, P. (2022, February). The Effect of Shell as a Substitution of Coard Aggregate with Superplasticizer Additional on the Compression Strength of Concrete. In *5th FIRST T1 T2 2021 International Conference (FIRST-T1-T2 2021)* (pp. 13-18). Atlantis Press. https://doi.org/10.2991/ahe.k.220205.003

Vitalis, V., Samsurizal, E., & Supriyadi, A. (2016). Pengaruh tambahan cangkang kerang terhadap kuat beton. *Jurnal Mahasiswa Teknik Sipil Universitas Tanjungpura, 2*(2), 191916. https://www.neliti.com/publications/191916/