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Assessment of Concrete Compressive Strength with the Incorporation of Recycled Coarse Aggregates Across Varied Curing Periods

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Abstract: *One of the most crucial factors in optimizing the compressive strength of concrete is the assessment of aggregate supply quality. However, due to scarcity and local regulations limiting quarrying, making the most of available supply becomes essential. In this study, the compressive strengths of concrete were compared using recycled aggregates from three different sources and cured for 60 days. Various tests, including specific gravity and absorption, sieve analysis, abrasion test, workability test, and compressive strength test, were conducted to evaluate the suitability of these recycled aggregates for concrete applications. The study's specific findings revealed that with an increasing number of curing days, using the ponding method up to 28 days and the moist method beyond 28 days, the compressive strengths of the five different concrete mixtures also increased. Moreover, employing the three sources of recycled aggregates showed a comparable rise in concrete's compressive strength. Remarkably, the compressive strength achieved in one concrete mixture at the 28-day curing period could be attained by another mixture at specific curing periods. Adequate curing of concrete specimens through ponding at the required temperature demonstrated a significant enhancement in the compressive strength of concrete. Overall, the study concluded that the compressive strengths of the five different concrete mixtures varied and could be properly addressed through correct proportioning, handling, and proper mixing. Utilizing recycled aggregates from three different sources and varying the water-cement ratio for each mixture yielded positive outcomes. Furthermore, the research revealed that all selected recycled aggregate sources were suitable for concrete construction in the area and could be blended to maximize usage volume without significantly affecting quality.*

Keywords: Concrete, Coarse Aggregates, Curing Periods, Compressive Strength, Recycled Aggregates

I. INTRODUCTION

The selection of aggregates for concrete takes into consideration the compressive strength of the aggregate. Several factors, including the water-to-cement ratio, cement-to-aggregate ratio, degree of compaction, aggregate-to-mortar bond, aggregate strength, form, and size, influence the compressive strength of concrete [1][2][3][4][23]. The type of aggregate used plays a vital role in determining the concrete's compressive strength. Of all these factors, the fine aggregate's significance stands out as it fills the voids left by coarse aggregate during concrete batching, ultimately impacting the strength of the concrete [5][6][4][24][25][27].

Aggregates significantly influence the mechanical properties, including strength and durability, of high-performance concrete. The specific type of aggregate employed impacts the stiffness and fracture energy of concrete for a given water/cement ratio [7][8][9][26]. Before utilizing aggregates in concrete production, various physical parameters such as shape, size, texture, moisture levels, specific gravity, unit weight, and soundness must be evaluated to ensure an acceptable mixture. Combining this information with the water/cement ratio allows for more accurate estimations of the concrete's strength, workability, and durability, all of which play a pivotal role in determining the overall quality of the concrete [10][11].

The physical shape and texture of aggregates have a more significant impact on the qualities of fresh concrete compared to hardened concrete. Workability is influenced by the smoothness and roundness of the aggregate, with rough and

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irregular-shaped aggregates resulting in less workable concrete than smooth and round ones. In the design mix of concrete, fine aggregate fineness, physical shape, surface texture, and mechanical properties are carefully considered, as these properties can affect water consumption during mixing, consequently influencing the overall quality [14][15][16]. The mechanical properties of concrete are also influenced by the degree of hydration and the water/cement (w/c) ratio [12][13].Furthermore, proper curing of concrete plays a crucial role in determining its compressive strength. Various curing methods, such as air curing, water-submerged curing, spray curing, polythene curing, moist sand curing, and burlap curing, are employed until testing ages of 3, 7, 14, 21, and 28 days for normal curing periods [17][18][19][20][21]. These methods ensure that the concrete develops its desired strength and durability.

The utilization of recycled aggregates in concrete is of paramount importance nowadays as it provides a viable solution to address the scarcity of natural aggregate supply. As construction activities continue to grow and the demand for aggregates rises, traditional sources of natural aggregates may become depleted or restricted due to environmental concerns or regulations. By incorporating recycled aggregates, which are derived from the processing of construction and demolition waste, into concrete production, we can significantly reduce the strain on natural resources. Overall, the adoption of recycled aggregates in concrete offers a sustainable and eco-friendly solution to overcome the scarcity of natural aggregate supply, contributing to more responsible and resource-efficient construction practices.

In this study, the researcher utilized natural fine aggregates and recycled coarse aggregates from various sources to create five distinct concrete design mixes. With the growing construction sector in the Philippines, concrete cylinder samples were cured for 60 days to assess the variation in compressive strengths when these aggregates were combined to optimize their utilization.

II. MATERIALS AND METHODS

2.1 Materials

The following materials used in this research were as follows:

2.1.1 Cement: Ordinary Portland Cement was acquired from a nearby construction supply store in the Philippines.

2.1.2 Fine and Coarse Aggregates: For the mixtures, regular fine sand and recycled coarse concrete waste were employed. Additionally, potable water sourced from the local water utility was used for concrete mixing.

2.2 Methods

The following methods were adopted in this research were as follows:

2.2.1 Mixture proportion: Five different concrete mixtures were used in determining the quantities of ingredients of the concrete mix.

2.2.2 Laboratory tests: Specific gravity and the amount of water absorption: One of the most essential features of fine and coarse aggregates in the computation of mix design is specific gravity. The standard test method ASTM C128 was used in the determination of the specific gravity.

- Sieve Analysis: Standard test method ASTM C136 was used for sieve analysis of blended fine and coarse aggregates.
- Abrasion Test: The hardness of the blended coarse aggregates was determined by the Los Angeles abrasion test. Standard test method ASTM C131 was used in the test.
- Curing: Standard test method ASTM C31 was used for curing of test specimens and curing by ponding at standard temperature and moist methods were used.
- Slump Test: Separate test of a slump for the concrete mixtures using the natural fine sand and recycled coarse aggregates. Standard test method ASTM C143 was used for the test.
- Compressive Strength Test: Compressive strength of concrete was determined under a normal curing period of 7 days, 14 days, 28 days, 35 days, 40 days, 50 days and 60 days. Standard test method ASTM C39 was used for the test.

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III. RESULTS AND DISCUSSION

Table 1 displays the material ratios necessary to produce one cubic unit of the concrete mixture. In the case of concrete mixture 2, the proportions are as follows: 1-part cement, 1.3 parts natural fine aggregates, and 2.0 parts coarse recycled aggregates. It is important to emphasize that all concrete materials for each mix will be measured uniformly.

TABLE 1: PROPORTIONS OF CONCRETE MIXTURES

Concrete Mixture	Mixture Proportion
1	1:1: 1.5
2	1: 1.3 :2.0
3	1: 1.6: 2.5
4	1: 1.8: 3
5	1: 2.0: 3.5

In Table 2, the results of the average slump test with recycled waste coarse aggregates from source A are presented. Mixture 1 displayed an average slump of 116.70 mm, and this value progressively increased up to mixture 5. The noticeable increase in slump can be attributed to the higher water-cement ratio and the utilization of recycled coarse aggregates sourced from a demolished construction site 1.

TABLE 2: SLUMP TEST RESULTS PER CONCRETE MIXTURE, SOURCE A

Concrete Mixture	Average Slump, mm
1	116.70
2	135.45
3	157.94
4	172.98
5	192.35

Table 3 presents the water-cement (W/C) ratios of five different concrete mixtures along with the required compressive strength for a 28-day curing period. The water-cement ratios were determined using the absolute volume formula in concrete material proportioning calculations. Additionally, the table illustrates that as the water-cement ratio increases, there is a corresponding decrease in the compressive strength of the specimens during the 28-day curing period using aggregates source A.

TABLE 3: WATER-CEMENT RATIO AND COMPRESSIVE STRENGTH, SOURCE A

Concrete Mixtures	Water-Cement Ratio by Weight	Ave. Compressive Strength, fc'(28-day)
1	0.50	25.19 MPa
2	0.55	24.20 MPa
3	0.60	23.10 MPa
4	0.65	22.08 MPa
5	0.70	21.04 MPa

In Table 4, the results of the average slump test with recycled waste coarse aggregates from source B are presented. Mixture 3 displayed an average slump of 159.98 mm, and this value progressively increased up to mixture 5. The noticeable increase in slump can be attributed to the higher water-cement ratio and the utilization of recycled coarse aggregates sourced from a demolished construction site 2.

TABLE 4: SLUMP TEST RESULTS PER CONCRETE MIXTURE, SOURCE B

Concrete Mixture	Average Slump, mm
1	118.90
2	137.65
3	159.98
4	175.18
5	194.55

Table 5 presents the water-cement (W/C) ratios of five different concrete mixtures along with the required compressive strength for a 28-day curing period. The water-cement ratios were determined using the absolute volume formula in concrete material proportioning calculations. Additionally, the table illustrates that as the water-cement ratio increases,

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there is a corresponding decrease in the compressive strength of the specimens during the 28-day curing period using aggregates source B.

TABLE 5: WATER-CEMENT RATIO AND COMPRESSIVE STRENGTH, SOURCE B

Concrete Mixtures	Water-Cement Ratio by Weight	Ave. Compressive Strength, fc'(28-day)
1	0.50	20.98 MPa
2	0.55	20.00 MPa
3	0.60	19.00 MPa
4	0.65	18.00 MPa
5	0.70	17.00 MPa

In Table 6, the results of the slump test with recycled waste coarse aggregates from source C are presented. Mixture 4 displayed an average slump of 173.27 mm, and this value progressively increased up to mixture 6. The noticeable increase in slump can be attributed to the higher water-cement ratio and the utilization of recycled coarse aggregates sourced from a demolished construction site 3.

TABLE 6: SLUMP TEST RESULTS PER CONCRETE MIXTURE, SOURCE C

Concrete Mixture	Average Slump, mm
1	115.80
2	135.78
3	156.18
4	173.27
5	191.44

Table 7 presents the water-cement (W/C) ratios of five different concrete mixtures along with the required compressive strength for a 28-day curing period. The water-cement ratios were determined using the absolute volume formula in concrete material proportioning calculations. Additionally, the table illustrates that as the water-cement ratio increases, there is a corresponding decrease in the compressive strength of the specimens during the 28-day curing period using aggregates source C.

TABLE 7: WATER-CEMENT RATIO AND COMPRESSIVE STRENGTH, SOURCE C

Concrete Mixtures	Water-Cement Ratio by Weight	Ave. Compressive Strength, fc'(28-day)
1	0.50	26.54 MPa
2	0.55	24.52 MPa
3	0.60	23.52 MPa
4	0.65	22.42 MPa
5	0.70	21.32 MPa

In Table 8, the compressive strengths of concrete specimens from various sources are recorded using a concrete testing equipment, with curing periods ranging from 3 days to 60 days, measured in MPa (N/mm2). The results demonstrate a consistent increase in compressive strength for all five concrete mixtures from the 3-day to the 60-day curing duration, utilizing both ponding and moist methods. Notably, a substantial increase in strength is clearly observed throughout the entire curing period, with ponding employed from 3 to 28 days and moist methods used thereafter beyond the 28-day period.

TABLE 8: CURING PERIOD AND COMPRESSIVE STRENGTH

Curing Period (Days)	Mix. 1 A	Mix. 1 B	Mix 1 C	Mix. 2 A	Mix. 2 B	Mix 2 C	Mix. 3 A	Mix. 3 B	Mix 3 C	Mix. 4 A	Mix. 4 B	Mix 4 C	Mix. 5 A	Mix. 5 B	Mix 5 C
3	12.82	10.65	13.54	11.83	10.45	12.44	10.73	9.45	11.44	9.72	8.35	10.34	8.63	7.35	9.24
7	18.26	14.78	19.22	17.28	14.24	17.12	16.18	13.95	16.12	15.16	12.85	15.02	14.06	11.85	14.02
14	22.30	18.09	23.22	21.32	18.27	22.32	20.22	17.27	21.32	18.20	16.17	20.24	17.18	15.17	19.14
28	25.19	20.98	26.54	24.20	20.00	24.52	23.10	19.00	23.52	22.08	18.00	22.42	21.04	17.00	21.32
35	26.34	21.72	26.88	25.45	21.52	24.66	24.35	20.52	23.67	23.33	19.42	22.47	22.22	18.42	21.37
40	26.54	22.34	26.90	25.36	22.02	25.93	24.26	21.02	24.20	23.43	20.00	23.10	22.44	19.00	22.02
50	27.03	23.22	27.95	26.13	23.12	26.85	25.03	22.12	24.25	24.00	21.06	23.15	23.00	20.06	22.11

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60	27.35	24.00	28.04	26.46	23.65	26.88	25.36	22.65	24.85	24.18	21.38	23.65	23.07	20.38	22.55

Table 9 reveals a consistent pattern where the compressive strength of concrete mixtures increases with longer curing periods using recycled coarse aggregates from source A. Mixture 1, for instance, exhibited an 18.11% relative increase in compressive strength from the 7-day to the 14-day curing period. Subsequently, the strength continued to rise in the subsequent curing intervals, but the increments were smaller compared to the previous ones. A similar trend was observed for Mixtures 2 to 5, with their compressive strengths increasing at each curing interval but gradually decreasing as the curing period extended. The percentage increase in compressive strengths of all five concrete mixtures per curing interval demonstrated a constant or uniform rise. However, the average increase in compressive strengths decreased over time, with only a minor discrepancy noticed in the 35-day to 40-day interval. From the 40-day to 60-day interval, the results indicated a further decrease in percentage increase. Moreover, the study shows that concrete mixtures with larger proportions exhibit lesser strength, as evident in the compressive strength results. Larger proportions lead to greater volume but diminished strength, while lesser proportions yield higher strength levels.

TABLE 9: PERCENT INCREASE OF COMPRESSIVE STRENGTH PER CURING PERIOD, SOURCE A

Curing Period (Days)	**Mix. 1**	**Mix. 2**	**Mix. 3**	**Mix. 4**	**Mix. 5**
3-7	29.79	31.53	33.68	35.88	38.62
7-14	18.11	18.94	19.98	16.70	18.16
14-28	11.47	11.90	12.47	17.57	18.35
28-35	4.36	4.91	5.13	5.36	5.31
35-40	0.7	-0.35	-0.37	0.43	0.98
40-50	1.81	2.94	3.08	2.38	2.43
50-60	1.17	1.24	1.30	0.74	0.30

Table 10 reveals a consistent pattern where the compressive strength of concrete mixtures increases with longer curing periods using recycled coarse aggregates from source B. Mixture 1, for instance, exhibited an 18.30% relative increase in compressive strength from the 7-day to the 14-day curing period. Subsequently, the strength continued to rise in the subsequent curing intervals, but the increments were smaller compared to the previous ones. A similar trend was observed for Mixtures 2 to 5, with their compressive strengths increasing at each curing interval but gradually decreasing as the curing period extended. The percentage increase in compressive strengths of all five concrete mixtures per curing interval demonstrated a constant or uniform rise. However, the average increase in compressive strengths decreased over time, with only a minor discrepancy noticed in the 35-day to 40-day interval. From the 40-day to 60-day interval, the results indicated a further decrease in percentage increase. Moreover, the study shows that concrete mixtures with larger proportions exhibit lesser strength, as evident in the compressive strength results. Larger proportions lead to greater volume but diminished strength, while lesser proportions yield higher strength levels.

TABLE 10: PERCENT INCREASE OF COMPRESSIVE STRENGTH PER CURING PERIOD, SOURCE B

Curing Period (Days)	**Mix. 1**	**Mix. 2**	**Mix. 3**	**Mix. 4**	**Mix. 5**
3-7	31.33	26.62	32.26	35.02	37.97
7-14	18.30	22.06	19.22	20.53	21.89
14-28	13.78	8.65	9.11	10.17	10.76
28-35	3.41	7.06	7.41	7.31	7.71
35-40	2.78	2.27	2.38	2.90	3.05
40-50	3.79	4.76	4.97	5.03	5.28
50-60	3.25	2.24	2.34	1.50	1.57

Table 11 exhibits a consistent trend where the compressive strength of concrete mixtures increases with longer curing periods using recycled coarse aggregates from source C. Mixture 1, for example, demonstrated a relative increase of 17.23% in compressive strength from the 7-day to the 14-day curing period. Subsequently, the strength continued to rise in the following curing intervals, albeit with smaller increments compared to the earlier stages. A similar pattern was observed for Mixtures 2 to 5, with their compressive strengths increasing at each curing interval but gradually declining as the curing period extended. The percentage increase in compressive strengths for all five concrete mixtures per curing interval indicated a constant or uniform ascent. However, the average increase in compressive strengths decreased over time, with only a minor discrepancy noticed in the 35-day to 40-day interval. From the 40-day to 60-day interval, the results indicated a further decrease in percentage increase. Furthermore, the study demonstrates that concrete mixtures with larger proportions exhibit lower strength, as evidenced by the compressive strength results. Larger proportions lead to greater volume but diminished strength, whereas smaller proportions yield higher strength levels.

TABLE 11: PERCENT INCREASE OF COMPRESSIVE STRENGTH PER CURING PERIOD, SOURCE C

Curing Period (Days)	**Mix. 1**	**Mix. 2**	**Mix. 3**	**Mix. 4**	**Mix. 5**
3-7	29.55	27.34	29.03	31.16	34.09
7-14	17.23	23.30	24.39	25.79	26.75
14-28	12.51	8.97	9.35	9.72	10.23
28-35	1.26	0.57	0.63	0.22	0.23
35-40	0.07	4.90	2.19	2.73	2.95
40-50	3.76	3.43	0.21	0.22	0.41
50-60	0.32	0.11	2.41	2.11	1.95

Table 12 presents the percentage difference in compressive strengths of concrete proportions for each design mixture, utilizing recycled coarse aggregates from source A. Notably, when comparing mixtures 4 and 5, mixture 5 exhibits lower compressive strength than mixture 4, as evidenced by the preceding tables on compressive strengths of concrete. The percent difference in compressive strength during the 3-day curing period is 7.72%, 5.37% at the 7-day period, 4.39% at the 14-day period, 3.93% at the 28-day period, 3.38% at the 35-day period, 4.45% at the 40-day period, 3.33% at the 50-day period, and 3.25% at the 60-day curing period, all using waste aggregates from source A. Remarkably, a consistent and significant increase in compressive strength is observed for both mixtures throughout each curing interval.

TABLE 12: PERCENT DIFFERENCE OF COMPRESSIVE STRENGTHS OF CONCRETE PROPORTIONS, SOURCE A

Curing Period (Days)	**Mix 1-2**	**Mix 2-3**	**Mix 3-4**	**Mix 4-5**
3	7.72	1.88	9.41	11.21
7	5.37	3.65	6.30	7.26
14	4.39	-1.00	9.99	5.60
28	3.93	4.67	4.42	4.71
35	3.38	0.92	4.19	4.76
40	4.45	1.43	3.42	4.23
50	3.33	0.43	4.12	4.17
60	3.25	1.46	4.65	4.59

Table 13 below presents the percent difference of compressive strengths for concrete mixtures during each curing interval using recycled aggregates from source B. Notably, mixtures 3 and 4 yield lower compressive strengths compared to mixture 1 and 2, as evident in the preceding tables showcasing the compressive strengths of concrete. The percent difference in compressive strength for mixture 3 and 4, using recycled aggregates from source B, is as follows: 11.64% at the 3-day curing period, 7.89% at the 7-day period, 6.37% at the 14-day period, 5.26% at the 28-day period, 5.36% at the 35-day period, 4.85% at the 40-day period, 4.79% at the 50-day period, and 5.61% at the 60-day curing period. Remarkably, both mixtures 3 and 4 display a consistent and significant increase in compressive strength throughout each curing interval as also shown in the preceding table of compressive strengths.

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TABLE 13: PERCENT DIFFERENCE OF COMPRESSIVE STRENGTHS OF CONCRETE PROPORTIONS, SOURCE B

Curing Period (Days)	Mix 1-2	Mix 2-3	Mix 3-4	Mix 4-5
3	1.88	9.57	11.64	11.98
7	3.65	2.04	7.89	7.78
14	-1.00	5.47	6.37	6.18
28	4.67	5.00	5.26	5.56
35	0.92	4.65	5.36	5.15
40	1.43	4.54	4.85	5.00
50	0.43	4.33	4.79	4.75
60	1.46	4.23	5.61	4.68

Table 14 below presents the percent difference of compressive strengths for concrete mixtures during each curing interval. Notably, mixtures 4 and 5 yield lower compressive strengths compared to mixture 3 and 4, as evident in the preceding tables showcasing the compressive strengths of concrete. The percent difference in compressive strength for mixture 4 and 5, using waste aggregates from source C, is as follows: 10.64% at the 3-day curing period, 6.66% at the 7-day period, 5.43% at the 14-day period, 4.91% at the 28-day period, 4.90% at the 35-day period, 4.68% at the 40-day period, 4.49% at the 50-day period, and 4.65% at the 60-day curing period. Remarkably, both mixtures 4 and 5 display a consistent and significant increase in compressive strength throughout each curing interval.

TABLE 14: PERCENT DIFFERENCE OF COMPRESSIVE STRENGTHS OF CONCRETE PROPORTIONS, SOURCE C

Curing Period (Days)	Mix 1-2	Mix 2-3	Mix 3-4	Mix 4-5
3	8.12	8.04	9.62	10.64
7	10.93	5.84	6.82	6.66
14	3.88	4.48	5.07	5.43
28	7.61	4.08	4.68	4.91
35	8.26	4.01	5.07	4.90
40	3.61	6.67	4.55	4.68
50	3.94	9.68	4.54	4.49
60	4.14	7.55	4.83	4.65

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

- The compressive strengths of the five different concrete mixtures exhibit a consistent increase with an extended number of curing days, utilizing both ponding and moist methods of curing, even when incorporating recycled coarse aggregates.
- The compressive strengths of the concrete mixtures demonstrate an increase as the quantities of concrete materials decrease, even when using recycled coarse aggregates sourced from different sites. A concrete mixture ratio of 1:1:1.5 yields greater compressive strength compared to a concrete mixture ratio of 1:1.3:2.0.
- The compressive strength of a concrete mixture at the 28-day curing period can be achieved by another concrete mixture at either a longer or shorter curing period. For instance, the compressive strength of mixture 1 during the 28-day curing period can be attained by mixture 2 during the 35-day curing period.
- Recycled coarse aggregates can be blended together and utilized as aggregates in concrete, resulting in the production of high-quality concrete products.

4.2 Recommendation

For the future development and betterment of this study, the researcher recommends the following:

- To test recycled aggregates properties coming from several other sources outside the areas of study for more blending processes.
- Based on the conclusions, the recycled coarse supplies of aggregates from three sourcesare of good quality and to maximize its use, it is recommended that blended aggregates is suitable for concrete work production.

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REFERENCES

[1] C. Rocco and M. Elices, “Effect of Aggregate Shape on the Mechanical Properties of a Simple Concrete”, Journal of Engineering Fracture Mechanics, Vol. 76, No.2, Pp. 286 – 298, (2009).

[2] M. Abdullahi, “Effect of Aggregate Type on Compressive Strength of Concrete”, International Journal for Computational Civil and Structural Engineering, Vol. 2, No. 3, Pp. 791 – 796, (2012).

[3] C. Rocco and M. Elices, “Effect of Aggregate size on the fracture and Mechanical properties of a Simple Concrete”, Journal of Engineering Fracture Mechanics, Vol. 75, No. 13, Pp. 3829 – 3851, (2008).

[4] S. Ahmad, S.A. Alghamdi, A Study on Effect of Coarse Aggregate Type on Concrete Performance. *Arab J Sci Eng* **37,** 1777–1786. (2012).

[5] M.A. Aziz, “Engineering Materials”, Z and Z Computer and Printers, Dhaka, Bangladesh, (1995).

[6] R. Sharmin, M. Ahmed, A. Mohiuddin, & A. L. Forhat, Comparison of strength performance of concrete with uncrushed or crushed coarse aggregate. *ARPN J. Eng. Appl. Sci*, *1*(2), 1-4, (2006).

[7] Wu, K-R., Chen, B., Yao, W., and Zhang, D., Effect of Coarse Aggregate Type on Mechanical Properties of High-Performance Concrete. Cement and Concrete Research, Vol. 31, No. 10, pp. 1421-1425, (1997).

[8] Yudong Xie, Chunxiang Qian, Yugui Xu, Ming Wei, Wenxiang Du, Effect of fine aggregate type on early-age performance, cracking analysis and engineering applications of C50 concrete, Construction and Building Materials, Volume 323, 126633, ISSN 0950-0618, (2020).

[9] Shatha Deyaa Mohammed, Influence of Water Source on the Compressive Strength of High Strength Concrete. *Diyala Journal of Engineering Sciences*, *10*(1), 31–38, (2017).

[10] J. B. Neville, Concrete Technology, Longman, England, (2000).

[11] C. J. LeBow, Effect of Cement Content on Concrete Performance. Graduate Theses and Dissertations

[12] J. Newman and B. S. Choo, Advanced Concrete Technology, First Published, Elseviers, Great Britain, (2003).

[13] S.A.A Abbas. and M.A. Haider, Using different types of fine aggregate to produce high strength concrete. *International Journal of Arts & Sciences,* Vol. 5, No.7, Pp. 187–196, (2012).

[14] H. N. Ngugi, R. N. Mutuku, & Z. A. Gariy, Effects of sand quality on bond strength of concrete: a case study in Nairobi City County and Its Environs, Kenya. *Int J Civil Struct Eng Res*, *2*(1), 119-129, (2014).

[15] The Constructor: Concrete Technology.

[16] Kosalya Sundaralingam, Arvinthan Peiris, Arulanantham Anburuvel, Navaratnarajah Sathiparan, Quarry dust as river sand replacement in cement masonry blocks: Effect on mechanical and durability characteristics, Materialia, Volume 21,101324, ISSN 2589-1529, (2022).

[17] A. A. Raheem, A. A. Soyingbe, & A. J. Emenike, Effect of curing methods on density and compressive strength of concrete. *International Journal of Applied Science and Technology*, *3*(4), (2013).

[18] L. Siekmann, M. Plotz, & C. Krischek, Alternative curing methods. *Current Clinical Microbiology Reports*, *8*(2), 40-48, (2021).

[19] Al-Gahtani, A. S Al-Gahtani, Effect of curing methods on the properties of plain and blended cement concretes. *Construction and Building Materials*, *24*(3), 308-314, (2010).

[20] Y. Nahata, N. Kholia, & T. G. Tank, Effect of curing methods on efficiency of curing of cement mortar. *APCBEE procedia*, *9*, 222-229, (2014).

[21] M. Safiuddin, S. N. Raman, & M. F. M. Zain, Effect of different curing methods on the properties of microsilica concrete. *Australian Journal of Basic and Applied Sciences*, *1*(2), 87-95, (2007).

[22] D. F. Orchard, Concrete technology, properties of material, Fourth Edition ed., vol. Volume 1, London: Applied Science Publishers ltd, 1979, pp. PP 139-150

[23] J. Quayson & Zakari Mustapha, Impact Of Coarse Aggregate On Compressive Strength Of Concrete. 49-58, (2019).

[24] A. F. Mnse, A. O. Coren, O. A. Ayegbusi, & S. A. Oderinde, Comparison of the Compressive Strength of Concrete Produced using Sand from Different Sources, (2015).

[25] M. Abdullahi, Effect of aggregate type on compressive strength of concrete. *International Journal of Civil and structural engineering*, *2*(3), 782, (2012).

[26] L. Mahr(2014). Aggregate Testing Standards: Aggregate Quality and Use, (2014).

[27] H. O. Ozioko, & E. E. Ohazurike, Effect of Fine Aggregate Types on the Compressive Strength of Concrete. *Nigerian Journal of Engineering*, *27*(2), (2020).