Comparative Study of Natural and Crushed Aggregates

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Abstract: *A crucial aspect of enhancing concrete performance, particularly in terms of compressive strength, involves making sound choices regarding the sources of aggregates. This study aimed to compare the compressive strengths of concrete formulated using fine and coarse aggregates from five distinct locations. A range of physical assessments were conducted to gauge the impact of these aggregates on concrete's compressive strength. These evaluations included tests for specific gravity and absorption, sieve analysis, abrasion resistance, workability, and compressive strength. The findings highlighted that concrete crafted with fine and coarse aggregates from crushed stone sites exhibited the highest average compressive strength of 25 MPa. Following closely were the natural aggregates, yielding an average compressive strength of 24.88 MPa after a 28-day curing period. This slight variance between the two sources is attributed to their close proximity. The monitoring of compressive strengths was carried out over 7, 14, and 28 days. Overall, the research demonstrated the viability of all selected aggregate sources for use in concrete construction projects.*

Keywords: concrete, compressive strength. crushed aggregates, natural aggregates

I. INTRODUCTION

Concrete serves as a composite construction material, comprising water, fine aggregate, coarse aggregate, and cement. Our construction company primarily relies on traditional building materials like sand, granite, and cement for concrete manufacturing [9][17]. The quality of these material components—cement, aggregates, admixtures, and water—holds significant influence over the physical and strength attributes of concrete [1][23]. Aggregates, encompassing both fine and coarse varieties, act as inert fillers, constituting around 60 to 80 percent of the concrete mix and contributing to 70 to 85 percent of its overall weight. This aggregate category is bifurcated into two segments: Coarse aggregates, generally exceeding 4.75 mm in size and retained by a No. 4 sieve or larger sieve sizes; and fine aggregates, typically smaller than 4.75 mm and required to pass through a No. 4 sieve or smaller sieve sizes [8]. Within the concrete construction sector, natural or river sand and crushed sand constitute about 35% of the concrete composition [2][3][5]. Conversely, coarse aggregate occupies over one-third of the concrete volume, and any alterations in the type of coarse aggregate can influence its strength and fracture characteristics [4][19].

The mechanical attributes of high-performance concrete, including strength, stiffness, and fracture energy, are distinctly influenced by aggregates. This impact arises from the fact that, within a given water-to-cement ratio, the specific aggregate type significantly dictates these properties [7][18][20]. It is imperative to evaluate various physical attributes of aggregates, encompassing characteristics like shape, size, texture, moisture content, specific gravity, unit weight, and soundness, before their utilization in concrete production to achieve an optimal blend. The amalgamation of insights garnered from these properties, coupled with the water-to-cement ratio, enhances the precision of assessing concrete's strength, workability, and durability. Collectively, these properties wield a substantial influence over the caliber of both fresh and cured concrete [9][20].

The physical configuration and surface characteristics of aggregates have a more pronounced impact on the attributes of fresh concrete compared to matured concrete. The smoothness and circularity of the aggregate significantly influence the workability of the concrete. Concrete containing smooth and rounded aggregates tends to exhibit higher workability than that containing rough and irregularly shaped aggregates. The influence of fine aggregate fineness, physical form, and surface texture on mechanical attributes is frequently disregarded in conventional concrete practices, despite the potential increase in water requirement due to these properties. The hydrated cement paste and the region surrounding the aggregate demonstrate relative fragility in this type of concrete. Consequently, the water-to-cement (w/c) ratio becomes the key determinant of concrete's mechanical characteristics, maintaining uniform degrees of hydration [10][16].

During the selection of aggregates for concrete production, the compressive strength of the aggregates holds significant importance. The ultimate compressive strength of concrete is reliant upon a multitude of factors, including the water-to-cement ratio, the ratio of cement to aggregate, compaction level, the bonding between aggregate and mortar, the inherent strength, shape, and dimensions of the aggregates [11][12][13][22]. The kind of aggregate employed plays a pivotal role in determining the concrete's compressive strength. Among the contributing elements, fine aggregate stands out as a particularly influential material impacting concrete strength. Its combination with cement serves to fill the voids and spaces formed by coarse aggregates during the concrete manufacturing process [14][15][22].

In this study, three diverse origins of natural and crushed aggregate supplies were employed to assess the concrete's compressive strength. The objective was to identify aggregates of high quality, which are widely accessible, particularly in the Eastern Mindanao region of the Philippines, and are intended for use in constructing concrete structures.

II. MATERIALS AND METHODS

2.1 Materials

The following materials used in this research were as follows:

- Cement: Ordinary Portland Cement with a specific gravity of 3.15 was purchased from a local construction supply store in Mindanao, Philippines.
- Fine and Coarse Aggregates: Fine and coarse aggregates were gathered from distinct natural river quarry locations, as well as from three separate sources supplying crushed fine and coarse aggregates in the Mindanao region of the Philippines.
- Water: Potable water was used for concrete mixing from water supply sources.

2.2 Methods

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

- Mixture proportion: 1:2:3 (cement: fine aggregates: coarse aggregates) were used in the mix. A water-cement ratio of 0.6 was also used for the mix.

2.3 Laboratory tests

- Specific Gravity and Water Absorption Measurement: The specific gravity and water absorption values are essential characteristics of both fine and coarse aggregates, crucial for mix design calculations. The recognized ASTM C128 test method was employed to ascertain the specific gravity.
- Sieve Analysis: Fine and coarse aggregate particles were subjected to sieve analysis using the established ASTM C136 standard test method.
- Abrasion Test: The hardness of coarse aggregates was evaluated through the Los Angeles abrasion test, conducted in accordance with the established ASTM C131 standard test method.
- Slump Test: Individual slump tests were conducted for the three aggregate sources for both natural and crushed material, adhering to the prescribed ASTM C143 standard test method.
- Compressive Strength Test: The concrete's compressive strength was determined after conventional curing periods of 7, 14, and 28 days. The standardized ASTM C39 test method was employed for this assessment.

III. RESULTS AND DISCUSSION

Table 1 presents the specific gravity values of fine aggregates utilized in concrete production. Among the sources, natural fine aggregates from three different quarries exhibited the highest specific gravity, registering an average of 2.633. Following closely were the crushed aggregates with an average specific gravity of 2.625.

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TABLE 1: SPECIFIC GRAVITY OF FINE AGGREGATES

Source	**Natural Aggregates 1**	**Natural Aggregates 2**	**Natural Aggregates 3**	**Crushed Aggregates 1**	**Crushed Aggregates 2**	**Crushed Aggregates 3**
Specific Gravity	2.65	2.638	2.612	2.61	2.64	2.63

Table 2 similarly displays the specific gravity data for coarse aggregates employed in concrete manufacturing. Notably, natural coarse aggregates sourced from three river quarries exhibited the highest specific gravity, boasting an average of 2.714. This was followed by the supply of crushed stone aggregates, which had an average specific gravity of 2.640. Moreover, coarse aggregates collected from a river intermittently affected by saline water intrusion displayed a slightly lower value of 2.653. It's noteworthy that the specific gravity values for all aggregate sources fall within the standard construction range of 2.5 to 3.

TABLE 2: SPECIFIC GRAVITY OF COARSE AGGREGATES

Source	**Natural Aggregates 1**	**Natural Aggregates 2**	**Natural Aggregates 3**	**Crushed Aggregates 1**	**Crushed Aggregates 2**	**Crushed Aggregates 3**
Specific Gravity	2.70	2.73	2.714	2.68	2.643	2.637

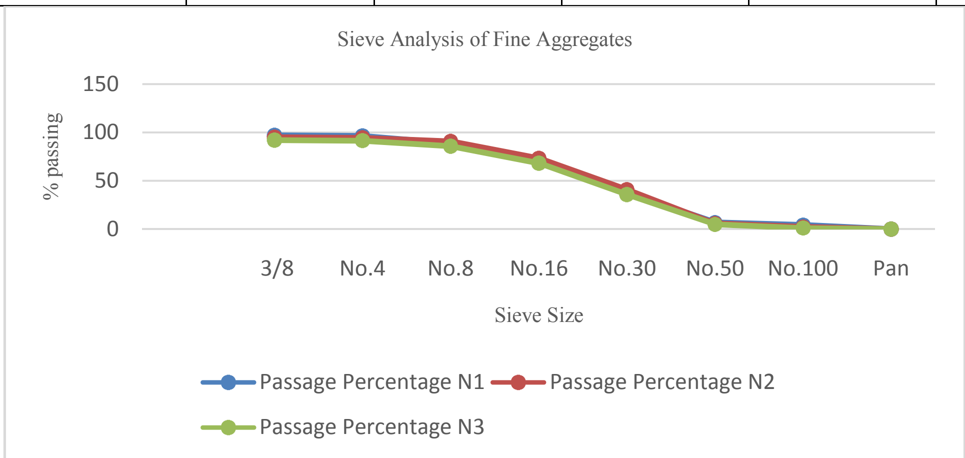

Figure 1. Sieve Analysis of Natural Fine Aggregates

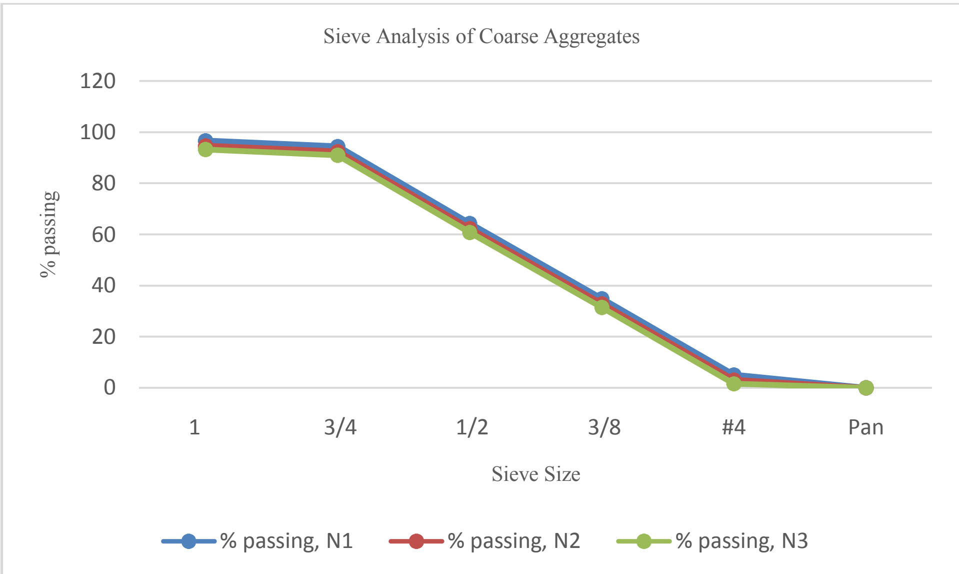

Figure 2. Sieve Analysis of Natural Coarse Aggregates

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Figure 1 and 2 depicts the particle size distribution curve for aggregates, revealing a broad dispersion of particle sizes across a wide spectrum. This scatter of particle sizes across the three sources of natural fine aggregates and crushed aggregates suggests a well-graded composition. This particular attribute of finely graded particles serves as a dependable indicator of the eventual compressive strength of concrete.

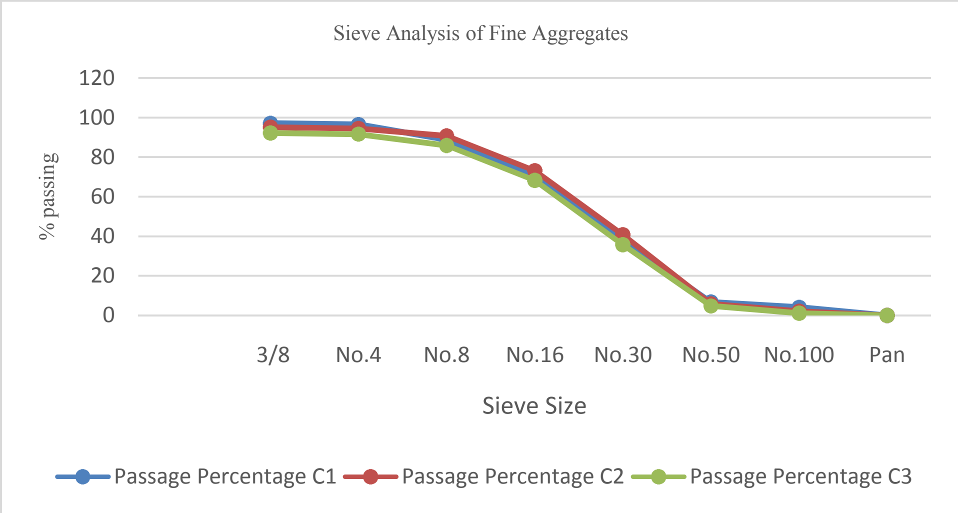

Figure 3. Sieve Analysis of Crushed Fine Aggregates

Figure 3 and 4 also illustrates the particle size distribution curve for coarse aggregates, displaying a wide scattering of particle sizes across a broad range. This distribution of particle sizes among the three sources of natural and crushed fine aggregates indicates a well-balanced mixture. This specific characteristic of well-graded particle distribution reliably signifies the potential compressive strength of concrete.

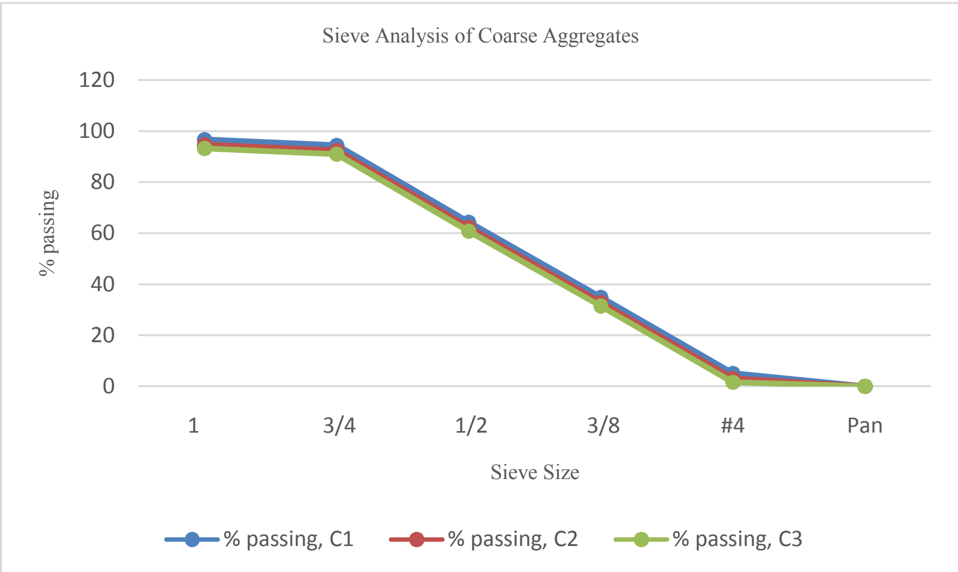

Figure 4. Sieve Analysis of Crushed Coarse Aggregates

The outcomes of the slump test are presented in Table 3. Natural aggregate sources 1, 2, and 3 exhibited an average slump of 86.33 mm, whereas crushed aggregates 1, 2, and 3 displayed a slump of 65.33 mm. This heightened slump value can be attributed to the physical attributes of the natural aggregates sourced from natural supply, which feature a smooth and rounded surface.

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TABLE 3:SLUMP TEST RESULTS

Types of Aggregates	Average Slump per Source	Average Slump
N 1	85	86.33
N 2	88	
N3	86	
C1	70	65.33
C2	66	
C3	60	

Table 4 displayed the concrete's compressive strength utilizing both fine and coarse aggregates sourced from natural source one and crushed sources. Notably, the compressive strength on the 28th day exhibited minimal disparity between these sources. This can be attributed to their geographical proximity within nearby municipalities in the Mindanao region of the Philippines. The average compressive strength across the three natural source aggregates measured at 23.73 MPa, while the three crushed source aggregates yielded an average of 24.20 MPa.

TABLE 4. COMPRESSIVE STRENGTH OF NATURAL SUPPLY AGGREGATES

fc'		Compressive Strength in MPa	
Curing Time	7 days	14 days	28 days
N1	14.71	19.03	23.76
N2	13.86	20.36	24.88
N3	14.05	17.23	22.56
Average	**14.21**	**18.87**	**23.73**
C1	14.25	20.89	24.02
C2	15.00	22.67	25.00
C3	13.98	21.50	23. 58
Average	**14.41**	**21.69**	**24.20**

Figure 5 depicted the concrete's compressive strength, employing both fine and coarse aggregates from natural source one as well as crushed sources. It is noteworthy that the compressive strength on the 28th day showed marginal variation between these sources. This can be attributed to their close geographical proximity within neighboring municipalities in the Mindanao region of the Philippines. The average compressive strength of the three aggregates from natural source 2 measured at 24.88 MPa, while among the three crushed source aggregates, source 2 demonstrated the highest strength at 25.00 MPa.

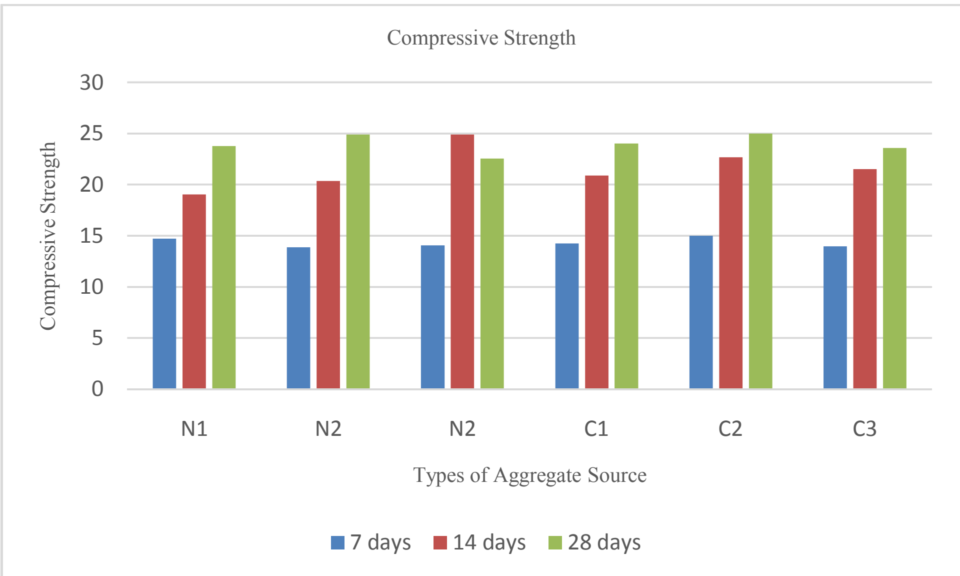

Figure 5. Compressive Test Results

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IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

- It was observed that natural supply of aggregates and crushed supply of aggregates produced almost the same compressive strength and were most workable compared.
- The physical properties of aggregates, as well as their geological nature and formation, contributed to the quality of the concrete in terms of compressive strength.
- Crushed aggregates have the highest compressive strength results; however, there is a slight difference between the two sources of aggregates in the quality of concrete, thus both sources are considered good sources for concrete construction.

4.2 Recommendation

- For the future development and betterment of this study, the researcher recommends the following:
- To develop test procedures to determine the performance of aggregates, especially the sources which is susceptible to seawater intrusion.
- To consider additional sources to be tested coming from other island areas.

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REFERENCES

[1] Ngugi, H. N., Mutuku, R. N., & Gariy, Z. A. (2014). 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.

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

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

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

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

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

[7] Wu, K-R., Chen, B., Yao, W., and Zhang, D. (1997), Effect ofCoarseAggregateTypeon Mechanical PropertiesofHigh-PerformanceConcrete.Cementand
ConcreteResearch,Vol.31,No. 10,pp. 1421-1425.

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

[9] Neville,J.B.(2000),ConcreteTechnology,Longman,England

[10] Newman,J.andChoo,B.S.(2003),AdvancedConcreteTechnology,FirstPublished,Elseviers,GreatBritain

[11] Rocco, C. and Elices, M. (2009), "Effect of Aggregate Shapeon theMechanical Properties of a Simple Concrete",Journal of Engineering FractureMechanics,Vol.76,No.2, Pp. 286– 298.

[12]Abdullahi,M.(2012),"EffectofAggregateTypeonCompressiveStrengthofConcrete",InternationalJournalforComputationalCivilandStructuralEngineering,Vol.2,No.3,Pp.791–796.

[13] Elices, M. and Rocco, C. (2008), "Effect of Aggregate size onthefractureandMechanical propertiesofaSimpleConcrete", Journal of Engineering Fracture Mechanics, Vol.75, No. 13, Pp.3829– 3851.

[14] Aziz,M.A.(1995),"EngineeringMaterials",ZandZComputerandPrinters,Dhaka,Bangladesh.

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

[16] Abbas, S.A.A. and Haider, M.A. (2012), Using different typesoffine aggregatetoproducehighstrengthconcrete.International Journal of Arts & Sciences, Vol. 5, No.7,Pp. 187–196.

[17] The Constructor: Concrete Technology.

[18] Yudong Xie, Chunxiang Qian, Yugui Xu, Ming Wei, Wenxiang Du. (20220. 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,

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

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

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

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

[23] LeBow, C. J. (2018). Effect of Cement Content on Concrete Performance. Graduate Theses and Dissertations.