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# Performance Analysis of Locally Sourced Aggregates in Concrete Compressive Strength

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**Abstract:** Different varieties of natural coarse aggregate are available in the Bangladeshi market, most of which are imported from various parts of the neighbouring nation, India. The purpose of this article is to identify the optimum mechanically strong locally accessible natural coarse aggregate for concrete preparation. It also focuses on the findings of an experiment inquiry into the impacts of three distinct types of natural coarse aggregate accessible in the Bangladeshi market, namely Bholaganj, Tamabil, and Panchagarh, on the mechanical characteristics of concrete. Each kind of natural coarse aggregate was used to make concrete cylinder specimens measuring 150mm X 150mm while the other materials remained constant. The study's concrete mix ratio and water/cement ratio were 1:1.5:3 and 0.52, respectively. At 7, 14, and 28 days of curing age, the compressive strength, splitting tensile strength, and modulus of elasticity were measured. The results revealed that Panchagarh is best suited for concreting, with significant differences in compressive strength, splitting tensile strength, and modulus of elasticity when compared to other types of natural coarse aggregates employed in the study.

## Introduction

Concrete is a composite material generated by the homogeneous mixing of water, cement, and (fine and coarse) aggregates in a predetermined ratio. The most desired quality of excellent concrete is its strength. It must be sufficiently hardened to withstand the numerous stresses to which it will be subjected. The value of test strength below which a set percentage of the test results should not fall is hence the value of concrete's compressive strength (A. M. Neville, 1981). The significant strength difference between concrete and mortar with the same cement/aggregate ratio implies that coarse particles are essential to the growth of concrete strength. Depending on the mix percentage chosen, which in turn depends on the anticipated compressive strength, the coarse aggregates can make up to 60% of the weight or volume of the concrete. Aggregate, which makes up 60 to 80 % of the volume and 70 to 85 % of the weight of concrete, is frequently thought of as inert filler. Although aggregate is regarded as inert filler, it is an essential element that determines the thermal and elastic characteristics as well as the dimensional stability of the concrete. There are two categories of aggregate: coarse and fine. Fine aggregate typically measures less than 4.75 mm and passes through a No. 4 sieve, whereas coarse aggregate often measures higher than 4.75 mm and is kept on a No. 4 filter. When choosing an aggregate, compressive aggregate strength is a crucial consideration. The majorities of concrete aggregates are much stronger than the other concrete ingredients and are thus not taken into consideration when calculating the strength of regular strength concrete. The compressive strength of the aggregates may have a greater impact on lightweight aggregate concrete than other factors (Report Civil 2011).

The type of coarse aggregate that is used in concrete mixing has a significant impact on the compressive strength of both freshly mixed concrete and concrete that has hardened. Since coarse aggregate makes up the majority of the volume in concrete, the general characteristics of coarse aggregates influence the characteristics of concrete produced with various nominal mixes. The source, size, shape, unit weight, texture, and other characteristics of coarse aggregate determine its characteristics. The source from which they have been retrieved has a significant impact on the geological, physical, and mechanical characteristics of coarse aggregates. The mechanical or physical variations in aggregate qualities have an impact on the strength, workability, and durability of concrete. Bangladesh has many sources of stone chips in varied sizes. Boulder stone chips are big stone chips that are taken from quarries or riverbeds. Boulder stone chips are used for foundations, retaining walls, and breakwaters. Shingles are medium-sized stone chips that range in size from 10mm to 20mm. They are frequently utilised in concrete manufacturing, road building, and other construction projects. Coarse stone chips are 20mm to 40mm aggregates. Road construction and heavy-duty concrete employ them. Fine stone chips, also known as sand-sized aggregates or screenings, are smaller-sized particulates, typically spanning in size from 0.1mm to 10mm. They are utilised in concrete, plastering, and other building applications requiring finer aggregates. Sylhet has an abundance of stone chip resources. It is the stone chip capital of Bangladesh. The area is well-known for its high-quality boulder stone chips, which are used in large construction projects. Stone chips are obtained in a variety of sites across Sylhet, notably along the Surma River and its tributaries. Comilla, in eastern Bangladesh, also provides stone chips. It generates shingles as well as coarse and fine stone chips. Stone chips are in great demand in Dhaka due to construction. This region is covered with shingles and gritty stone chips. Stone chips may also be found in Chittagong, Rajshahi, and the Rangpur region of Bangladesh. The characteristics of natural coarse aggregate can vary based on its source and composition. It is obtained from various places such as hard-rock quarries, natural sand-and-gravel pits, submerged deposits like rivers, lakes, and seabeds, or underground sediments. Due to limited natural resources, the demand for coarse aggregate in the country is often met through imports from neighboring India. Naturally occurring aggregates are formed by the combination of different rocks and minerals. Concrete is a widely utilised material in civil construction projects in Bangladesh, including buildings, dams, bridges, roads, retaining walls, irrigation canals, etc. At the moment, nominal mix concrete of various grades is made in building construction projects using a variety of coarse aggregates from diverse sources. As concrete's physical or mechanical properties affect its performance both fresh and hardened. The major focus of this topic is thus on the evaluation and analysis of coarse aggregate sources with regard to the compressive strength of the concrete.

**Review of Past Works**

The primary quality of concrete is strength. According to Neville (1981), aggregates are inert elements scattered throughout cement paste, whose strength is primarily influenced by its form, surface roughness, and cleanliness. He reported that completely smooth coarse particles reduced concrete strength by 10% as compared to when the aggregates were roughened. In addition, smooth, rounded aggregates were easier to work with but produced a lower compressive strength in the matrix than irregular aggregates with a rough surface roughness, according to Young and Sam, 2008 (https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Performance+of+Concrete+ Containing+Engine++Oil&btnG=). They also believed that a thin layer of contaminants, such as silt, on the surface of the aggregate may prevent the formation of a strong link, which would reduce the strength of concrete made with the aggregates. The results of the test conducted by Soroka in 1993 showed differences in the compressive strengths of concrete constructed with crushed stone and uncrushed stone. With the crushed stone as opposed to the uncrushed stone, he was able to attain a higher compressive strength. Multiple parameters, including the water/cement ratio, grading, surface texture, shape, strength, and stiffness of the aggregates employed, contributed to this strength performance.

The impact of form, surface roughness, fine coatings, and aggregate size maximum on the water demand and strength of concrete was also explored by (D. L. B. and R. D. Gaynor) According to the study, irregularly shaped smaller-sized aggregates without coatings outperformed smooth, spherical large-sized aggregates in terms of strength at an equivalent water/cement ratio. Additionally, they said that certain aggregate qualities and the extent of the size variation may cause an increase or decrease in concrete strength at a constant cement concentration. According to Stanon and Bloem, 1960 multiple strength levels exist for certain aggregate maximum sizes at various water/cement ratios. They found that, with the same water/cement ratio, the strength of concrete consistently decreases as the maximum size of aggregate increases. The establishment of aggregate-cement bonding is inhibited by the presence of clay, silt, crush dust, and all other types of overcoating, which lowers the strength of concrete. Since aggregates are thought of as the skeleton of concrete, Chen and Liu and Rao and Prasad (2002) both came to the conclusion that all types of coatings should be avoided in order to produce high-quality concrete. Failure may start in the aggregates, the matrix, or the contact between the aggregate and the matrix when a concrete mass is under stress. The contact between the aggregate and matrix has a significant role in influencing the strength of concrete.

The surface roughness of concrete is often taken into account when determining the concrete's flexural strengths. Raju, 1988 emphasised the need of employing a variety of aggregates, including crushed rock that is typically angular in shape or gravel that is rounded and irregular. Concrete and steel are two of the most frequently utilised structural materials, as correctly noted by Neville in 1981 [8]. The choice of a more suitable economic mix is made possible by understanding of the characteristics of concrete. The fundamental strength of the concrete is its durability. According to Jackson and Ravindra (1996), it is the maximum load (stress) that concrete can support. The other characteristics of concrete often get better as its strength does. It is simple to conduct strength tests, especially compression tests; the compressive strength of concrete is frequently utilised in the construction industry for quality control and specification purposes. The engineer would state his desired flexural strength in terms of compressive strength as he is aware of his goal value. The concrete's compressive strength is influenced by a number of elements. The coarse aggregate, which makes up the majority of the concrete, needs to be given careful thought since it will undoubtedly have a significant impact on how strong the concrete becomes.

## Materials and Method

### Cement

In this work, Portland Composite Cement (PCC) with a 42.5 N strength class was used. PCC is made up of 70-79% clinker, 21-30% slag, fly ash, limestone, and 0-5% gypsum and has a specific gravity of 3.11. This cement took 151 minutes to set initially, and 403 minutes to set completely. It had an initial strength of 21.7 MPa after three days.

**Fine Aggregate**

The fine aggregate in this investigation was made from locally available coarse sand (Sylhet Sand). The physical properties of fine aggregate are shown in Table 1.

**Table 1: Physical Properties of Fine Aggregate**

| Fine Aggregate Type | Fineness Modulus (FM) | Unit Weight (kg/m3) | Absorption Capacity % | Bulk Specific Gravity (OD) |
|---|---|---|---|---|
| Coarse Sand | 2.54 | 1479 | 1.34 | 2.54 |

**Coarse Aggregate**

For this investigation, three distinct types of natural coarse aggregate (Figure 1) were gathered from Panchagarh and Sylhet districts. Several experiments were subsequently performed to evaluate the physical characteristics of the natural aggregates, as indicated in Table 2. Figure 2 depicts particle size distributions (ASTM C136/136M-19).

| (a) Tamabil | (b) Bholaganj | (c) Panchagarh |
|---|---|---|

**Figure 1: Different types of natural coarse aggregates from several locations: (a) Tamabil, (b) Bholaganj, (c) Panchagarh**

**Table 2: Physical Properties of Different Types of Natural Coarse Aggregate**

| Types/ Source of Natural Aggregate | Fineness Modulus (FM) | Unit weight (kg/m3) | % Void | Apparent Specific Gravity | Bulk Specific Gravity | Absorption Capacity (%) |
|---|---|---|---|---|---|---|
| Tamabil | 7.57 | 1880 | 44 | 2.65 | 2.62 | 0.67 |
| Bholaganj | 7.41 | 1800 | 41 | 2.73 | 2.69 | 0.97 |
| Panchagarh | 7. | 1737 | 42 | 2.91 | 2.79 | 2.22 |

**Concrete Mix Proportion**

For the investigation, the concrete mix ratio and water/cement ratio were 1:1.5:3 and 0.52, respectively. The trial mixes were created with the goal of achieving a strength of 20 MPa after 28 days and a slump value of 75-100 mm. Three distinct types of concrete were then made by altering simply the coarse aggregate type. A total of 36 concrete cylinders of 150 mm x 150 mm were prepared to evaluate compressive strength (ASTM C39/39M-09a) at 7, 14, and 28 days.

**Results and Discussion**

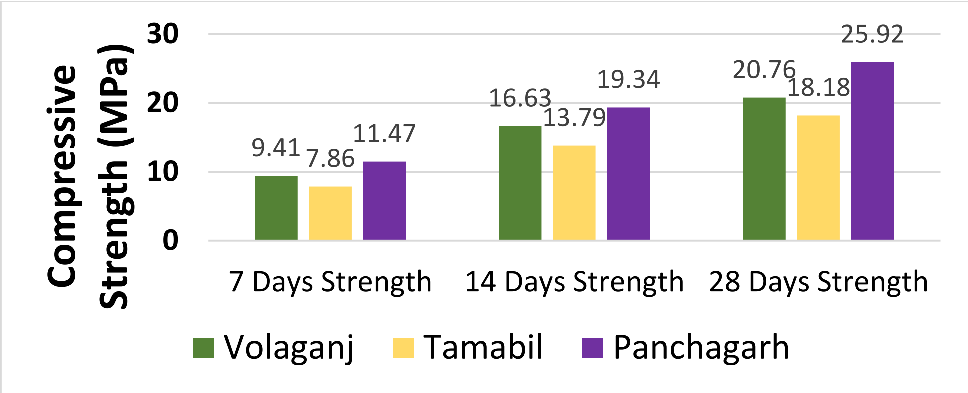


**Figure 2: Comparison of Compressive Strength**

The highest strength was found for Panchagarh and lowest for Tamabil. It is due to the angular shape, gradation.

**Conclusion**

The primary goal of this research is to identify the best natural coarse aggregate for building projects in terms of mechanical strength of concrete among locally accessible resources. Three distinct varieties of natural coarse aggregate were gathered for this purpose, all of which are largely accessible in the Bangladeshi market. The natural coarse aggregate type was varied to create concrete cylindrical examples. After that, the samples were evaluated in terms of compressive strength, splitting tensile strength, and modulus of elasticity. The results suggest that Panchagarh, commonly known as Indian Black Stone, performed better than the other types of aggregate employed in the study. Panchagarh had the highest compressive strength and cracking tensile strength, whereas Bholaganj had the highest modulus of elasticity.

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