



Analyzing the Roles of River Sharp Sand in Construction Work

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Received: 20.09.2025 | Accepted: 07.10.2025 | Published: 10.10.2025

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DOI: [10.5281/zenodo.17311218](https://doi.org/10.5281/zenodo.17311218)

Abstract

River sharp sand is a fundamental fine aggregate widely utilized in the construction industry due to its distinct physical and chemical properties. This paper provides a comprehensive analysis of the multi-faceted roles of river sharp sand in various construction applications, including concrete production, mortar and plastering, base and sub-base layers, and backfilling. It delves into the specific characteristics that make it suitable for these applications, such as its particle shape, gradation, and purity. Furthermore, the paper highlights the significant advantages of river sharp sand over land (pit) sharp sand, particularly emphasizing its natural washing process, consistent quality, and lower content of deleterious substances. While acknowledging its indispensable nature, the paper also addresses the environmental and sustainability challenges associated with its extraction, advocating for responsible resource management and the exploration of alternative materials. This analysis aims to underscore the critical importance of river sharp sand while promoting a conscientious approach to its utilization in modern construction practices.

Keywords: River sharp sand, fine aggregate, concrete, mortar, construction, aggregate properties, pit sand, sustainability.

Original Research Article

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INTRODUCTION

Aggregates constitute the largest volumetric component in most construction materials, forming the skeleton of concrete, asphalt, and masonry. Among these, sand, as a fine aggregate, plays a pivotal role in determining the strength, durability, and workability of various construction composites. Broadly classified into natural and manufactured sands, natural sands are typically sourced from riverbeds, lakes, or ancient land deposits (pits). River sharp sand, a specific type of natural sand derived from fluvial environments, is particularly prized for its superior qualities and widespread application in the global construction industry.

The unique physical characteristics of river sharp sand, shaped by the continuous processes of erosion, transportation, and deposition in river systems, render it highly suitable for demanding construction applications. These characteristics include a desirable particle shape, well-distributed gradation, and inherent purity, which collectively translate into enhanced performance in critical construction mixtures. Understanding these properties and their impact on material behavior is crucial for engineers, contractors, and material scientists alike.

This paper aims to provide a detailed academic analysis of the roles of river sharp sand in diverse construction work, illuminating the specific ways its properties contribute to structural integrity and construction efficiency. It will explore its application in concrete, mortar, road construction, and earthworks. A significant focus will be placed on articulating the advantages of river sharp sand over its counterpart, land (pit) sharp sand, by comparing their respective qualities and performance attributes. Finally, the paper will briefly touch upon the environmental implications of river sand extraction, emphasizing the need for sustainable practices and the consideration of alternative materials in the face of dwindling natural resources.

Background and Characteristics of River Sharp Sand

River sharp sand is formed through the natural weathering and erosion of rocks, followed by the transportation and deposition of these particles by flowing water. The journey downstream subjects the parent rock fragments to continuous attrition and abrasion, which refines their shape and size. As a

result, river sand particles typically exhibit a sub-angular to angular shape, often referred to as "sharp," which is a key distinguishing feature from the more rounded grains found in desert sands or some beach sands. The continuous washing action of the river naturally cleanses the sand, reducing the content of deleterious substances like clay, silt, and organic impurities.

2.1. Composition and Formation

Primarily composed of silica (quartz), river sands can also contain feldspar, mica, and other mineral fragments, depending on the geology of the source area. The dynamic fluvial environment ensures a relatively consistent and often well-graded particle size distribution. The "sharpness" arises from the fresh fracture surfaces and less extensive rounding compared to sands transported over vast distances or subjected to prolonged abrasion.

2.2. Physical Properties

- **Particle Shape and Surface Texture:** The sub-angular to angular shape of river sharp sand particles is crucial. This angularity promotes better interlocking between particles when compacted or mixed into a matrix, enhancing the shear strength and load-bearing capacity of the material. The surface texture, often slightly rough due to fresh fractures, also improves the bond with cement paste in concrete and mortar.
- **Gradation (Particle Size Distribution):** River sand typically exhibits a good, well-graded particle size distribution, meaning it contains a wide range of particle sizes from fine to coarse. This optimal gradation allows for efficient packing, minimizing voids and contributing to denser, stronger, and less permeable mixes. The fineness modulus (FM) is a common index used to describe the overall fineness or coarseness of an aggregate, and river sands often fall within an ideal range for concrete and mortar.
- **Purity and Cleanliness:** The natural washing process in rivers significantly reduces the presence of clay, silt, and organic matter. These impurities, if present in high quantities, can interfere with the hydration of cement, reduce bond strength, and lead to various defects like efflorescence, reduced strength, and increased permeability in hardened concrete.
- **Specific Gravity:** River sharp sand typically has a specific gravity ranging from 2.5 to 2.7, which is a measure of its density relative to water. This property is essential for mix design calculations.
- **Bulk Density:** The bulk density of river sand, which considers the volume of voids, is another critical factor influencing the volume of sand required for a given mix and its contribution to the overall density of the composite material.
- **Moisture Content:** River sands often come with a certain level of natural moisture content, which needs to

be accounted for in mix designs to avoid affecting the water-cement ratio.

2.3. Chemical Properties

Chemically, river sharp sand is largely inert, meaning it generally does not react with the cement paste or other components in concrete and mortar. This inertness is vital for the long-term stability and durability of construction materials. The presence of reactive silica, however, could lead to alkali-silica reaction (ASR) with highly alkaline cement, but this is less common in well-processed river sands compared to some other aggregate types.

Key Roles of River Sharp Sand in Construction

River sharp sand serves a multitude of critical functions across various construction applications, owing to its favorable physical and chemical attributes. Its roles are indispensable for achieving the desired performance of many construction composites and structures.

3.1. Concrete Production (Fine Aggregate)

In concrete mix design, river sharp sand functions as a vital fine aggregate, contributing significantly to both fresh and hardened concrete properties.

- **Filler Material and Volume Stability:** Sand fills the voids between coarse aggregate particles, creating a dense, compact matrix. This dense packing minimizes the volume of cement paste required for lubrication, making the concrete more economical. It also contributes to the overall volume stability of the concrete, reducing drying shrinkage and the propensity for cracking.
- **Workability and Cohesion:** The presence of fine aggregates like river sand improves the workability and cohesion of fresh concrete. It enhances the flowability of the mix, making it easier to transport, place, and finish without segregation. The "sharpness" also helps to prevent excessive bleeding of water to the surface.
- **Strength and Durability:** River sharp sand contributes substantially to the compressive and flexural strength of hardened concrete. Its angular particles promote mechanical interlocking within the cement matrix, forming a strong bond with both the cement paste and coarse aggregates. This interlocking action enhances the load-transfer mechanism within the concrete. Furthermore, a well-graded sand reduces permeability, making the concrete more resistant to water ingress, freeze-thaw cycles, and chemical attacks, thereby improving its durability.
- **Economic Advantage:** By replacing a portion of the more expensive cement, sand acts as an economical filler, lowering the overall cost of concrete while maintaining or enhancing its performance.

3.2. Mortar Production (Masonry, Plastering, and Rendering)

River sharp sand is an essential component in mortar, which is used for binding masonry units and for surface finishes like plastering and rendering.

- **Bonding Agent:** In masonry mortar, sand provides body and strength, ensuring a strong and durable bond between bricks, blocks, or stones. Its angularity creates mechanical keys that enhance adhesion.
- **Workability and Application:** For plastering and rendering, river sharp sand provides the necessary workability, allowing the mortar to be easily spread and manipulated to achieve smooth and even surfaces. The fineness and angularity contribute to a good "key" for subsequent coats.
- **Volume Stability in Mortar:** Similar to concrete, sand in mortar helps to control shrinkage and cracking, ensuring the long-term integrity and aesthetic appeal of plastered surfaces.

3.3. Base and Sub-base Layers in Road and Pavement Construction

In civil engineering projects, particularly road and pavement construction, river sharp sand plays a crucial role in the foundational layers.

- **Load Distribution:** As part of the base and sub-base layers, sand helps to distribute the imposed loads from traffic evenly over the subgrade, preventing localized stress concentrations and premature pavement failure.
- **Drainage Layer:** Due to its granular nature and good permeability, river sand can be used as a drainage layer beneath pavements. It prevents water accumulation, which can weaken the subgrade and lead to structural damage from frost heave or saturation.
- **Compaction and Stability:** When properly compacted, river sharp sand layers provide a stable and firm foundation, minimizing settlement and ensuring the long-term performance of the pavement structure.

3.4. Backfilling and Land Reclamation

River sharp sand is frequently employed in backfilling operations and land reclamation projects.

- **Structural Stability:** It provides a stable and compactable fill material for foundations, retaining walls, and utility trenches, ensuring structural stability and minimizing differential settlement.
- **Drainage Function:** In backfills, sand often serves a dual purpose by also facilitating the drainage of water away from structures, preventing hydrostatic pressure buildup.

- **Leveling and Grading:** It is used to create level surfaces for construction and landscaping purposes.

3.5. Filtration Systems

Due to its consistent particle size and inherent cleanliness, river sharp sand is also utilized in various filtration systems.

- **Water Treatment:** It is a common medium in slow sand filters for purifying drinking water, effectively removing suspended solids and microorganisms.
- **Drainage and Leach Fields:** In subsurface drainage systems and septic leach fields, sand acts as a filter and distribution medium.

Advantages of River Sharp Sand Over Land (Pit) Sharp Sand

While both river sand and land (pit) sand are natural aggregates, river sharp sand generally offers several distinct advantages that often make it the preferred choice for high-quality construction. These advantages primarily stem from the natural processes involved in its formation and deposition.

4.1. Natural Washing and Purity

One of the most significant advantages of river sand is its inherent cleanliness. The continuous flow of water in a river naturally washes away impurities such as clay, silt, and organic matter.

- **Lower Deleterious Substances:** River sand typically contains a much lower percentage of these deleterious substances compared to pit sand. Clay and silt can coat sand particles, inhibiting the bond between cement paste and aggregate, reducing concrete strength, and increasing water demand. Organic impurities can interfere with cement hydration, causing delayed setting and reduced strength.
- **Reduced Processing:** Because of its natural purity, river sand often requires less washing and processing before use, leading to lower production costs and reduced environmental impact associated with industrial washing. Pit sand, often extracted from ancient riverbeds or sedimentary deposits, may contain higher levels of clay, shale, and other impurities, necessitating extensive washing and screening, which consumes considerable water and energy.

4.2. Particle Shape and Surface Texture

The continuous attrition and transport in a river environment typically result in a more consistent and favorable particle shape for river sharp sand.

- **Consistent Angularity:** River sharp sand generally exhibits a more consistent sub-angular to angular particle shape. This angularity promotes superior mechanical interlocking within concrete and mortar

matrices, leading to enhanced compressive strength and improved shear resistance.

- **Improved Bond:** The slightly rougher surface texture often found on river sand particles, despite some rounding, provides a better mechanical key for bonding with cement paste compared to very smooth or highly flaky particles. Pit sand can be highly variable; some sources may yield well-shaped particles, while others might contain a higher proportion of flaky, elongated, or excessively rounded particles, which can negatively impact concrete workability and strength.

4.3. Gradation and Uniformity

Natural River processes often lead to well-graded deposits.

- **Optimal Gradation:** River sand is frequently found to be naturally well-graded, meaning it contains a balanced distribution of particle sizes. This optimal gradation minimizes voids, leading to denser concrete and mortar mixes, which in turn enhance strength, durability, and reduce permeability.
- **Greater Consistency:** River sand sources tend to offer greater consistency in gradation over time compared to diverse and often heterogeneous pit sand deposits. This consistency simplifies mix design and quality control processes. Poorly graded pit sands may require blending with other aggregate sizes or extensive screening to meet specifications, adding complexity and cost.

4.4. Lower Content of Undesirable Minerals

Due to its formation and transport mechanisms, river sand often has a lower content of certain undesirable minerals that can be present in pit sands.

- **Reduced Risk of ASR:** While not entirely immune, some pit sources might contain reactive silica forms more prone to alkali-silica reaction (ASR), which can lead to expansion and cracking in concrete. The mineralogy of river sand, shaped by its source rock and transport, often presents less risk in this regard.
- **Less Mica and Clay Lumps:** Pit sands can sometimes contain higher amounts of mica (which reduces strength and workability) or soft clay lumps (which can break down and cause pop-outs). River sand, through natural washing, typically has lower levels of these detrimental components.

4.5. Reliability and Performance

Historically, river sharp sand has established a reputation for reliability in construction due to its consistent quality.

- **Proven Performance:** Its widespread and successful use in countless projects provides a track record of proven performance in achieving durable and high-strength concrete and mortar.

- **Easier Compliance:** Meeting stringent construction specifications (e.g., ASTM, EN, IS standards) is often more straightforward with high-quality river sand due to its consistent properties and lower impurity levels.

Quality Control and Specifications

To ensure the optimal performance of river sharp sand in construction applications, rigorous quality control measures are essential. These measures involve a series of standardized tests and adherence to established specifications.

5.1. Key Quality Tests:

- **Sieve Analysis (Gradation):** Determines the particle size distribution, which is critical for mix design and workability. Standards (e.g., ASTM C136, EN 933-1) define acceptable ranges for fineness modulus and percentage passing various sieves.
- **Specific Gravity and Water Absorption:** Essential for accurate mix design calculations and understanding the aggregate's porosity. (ASTM C128, EN 1097-6).
- **Content of Deleterious Substances:** Tests for clay lumps and friable particles (ASTM C142), organic impurities (ASTM C40), and material finer than 75 μm sieve (silt and clay content) (ASTM C117, EN 933-1). These impurities can significantly impair concrete quality.
- **Soundness (Sulfate Attack):** Evaluates resistance to weathering, particularly relevant for aggregates exposed to harsh environmental conditions (ASTM C88).
- **Alkali-Silica Reactivity (ASR):** Tests (e.g., ASTM C1260, ASTM C1293) are performed to identify potentially reactive aggregates that could cause detrimental expansion in concrete.

5.2. Relevant Standards:

International and national standards such as ASTM C33 (Standard Specification for Concrete Aggregates), EN 12620 (Aggregates for Concrete), and IS 383 (Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete) provide detailed requirements for fine aggregates, including particle size limits, permissible levels of deleterious substances, and physical property thresholds. Compliance with these standards is paramount for ensuring the quality, durability, and safety of constructed elements. Non-compliance can lead to compromised structural integrity, reduced service life, increased maintenance costs, and potential safety hazards.

Environmental and Sustainability Concerns

Despite its superior qualities and indispensable roles, the extraction of river sharp sand presents significant environmental and sustainability challenges. The escalating demand for construction aggregates globally, driven by rapid urbanization and infrastructure development, has led to unsustainable levels of river sand extraction.

6.1. Environmental Impacts of Over-extraction:

- **Riverbed Degradation and Erosion:** Excessive removal of sand can lower the riverbed, increasing erosion of banks and foundations of bridges and other riverine structures.
- **Altered River Hydrology:** Lowering the riverbed changes the flow dynamics, impacting water tables in surrounding areas and potentially reducing groundwater availability.
- **Loss of Biodiversity:** Riverine ecosystems are sensitive; sand mining disrupts habitats, affects aquatic life, and can lead to a decline in biodiversity.
- **Coastal Erosion:** In coastal regions, reduced sediment supply from rivers due to upstream mining can exacerbate coastal erosion.
- **Increased Flood Risk:** Altered river morphology can sometimes increase the risk of flooding in upstream or downstream areas.

6.2. Scarcity and Economic Implications:

The finite nature of high-quality river sand sources, coupled with environmental restrictions, has led to increasing scarcity and escalating costs. This economic pressure drives the search for alternatives and highlights the need for efficient resource management.

6.3. Towards Sustainable Practices:

Addressing these concerns requires a multi-pronged approach:

- **Strict Regulation and Enforcement:** Implementing and enforcing robust regulations on sand mining to ensure sustainable extraction rates and minimize environmental damage.
- **Sustainable Sourcing:** Exploring sand deposits in less sensitive areas, such as ancient riverbeds or offshore reserves, with careful environmental impact assessments.
- **Recycling and Reuse:** Promoting the recycling of construction and demolition waste to produce recycled aggregates (e.g., recycled concrete aggregate).
- **Alternative Materials:** Investing in research and development for viable alternative fine aggregates, such as manufactured sand (M-sand) produced from crushing rocks, or industrial by-products like fly ash and ground granulated blast-furnace slag (GGBS), wherever technically and economically feasible.
- **Efficient Usage:** Optimizing mix designs to reduce the overall consumption of natural aggregates.

CONCLUSION

River sharp sand remains an indispensable fine

aggregate in the construction industry, playing critical roles in concrete, mortar, road construction, and various other civil engineering applications. Its naturally acquired characteristics – including its desirable particle shape, well-distributed gradation, and inherent purity – confer significant advantages over land (pit) sharp sand, contributing to enhanced workability, strength, and durability of construction materials. The natural washing process in rivers minimizes deleterious substances, making river sand a naturally cleaner and often more reliable choice for high-performance construction.

However, the increasing global demand for this vital natural resource has led to widespread over-extraction, posing severe environmental and ecological threats to river systems and associated ecosystems. The long-term sustainability of construction practices necessitates a paradigm shift towards responsible resource management. This includes stringent regulatory frameworks for extraction, concerted efforts in developing and utilizing alternative fine aggregates such as manufactured sand, and promoting the recycling of construction and demolition waste.

While the unique attributes of river sharp sand will likely keep it a preferred material for specific applications, the industry must progressively move towards a more sustainable model. Future research should focus on optimizing the performance of alternative materials to match or exceed the qualities of natural sand, thereby ensuring the continued progress of construction without compromising the health of our planet's invaluable river systems. The analysis of river sharp sand thus underscores both its profound utility and the urgent need for a conscientious approach to its sourcing and application in the modern world.

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