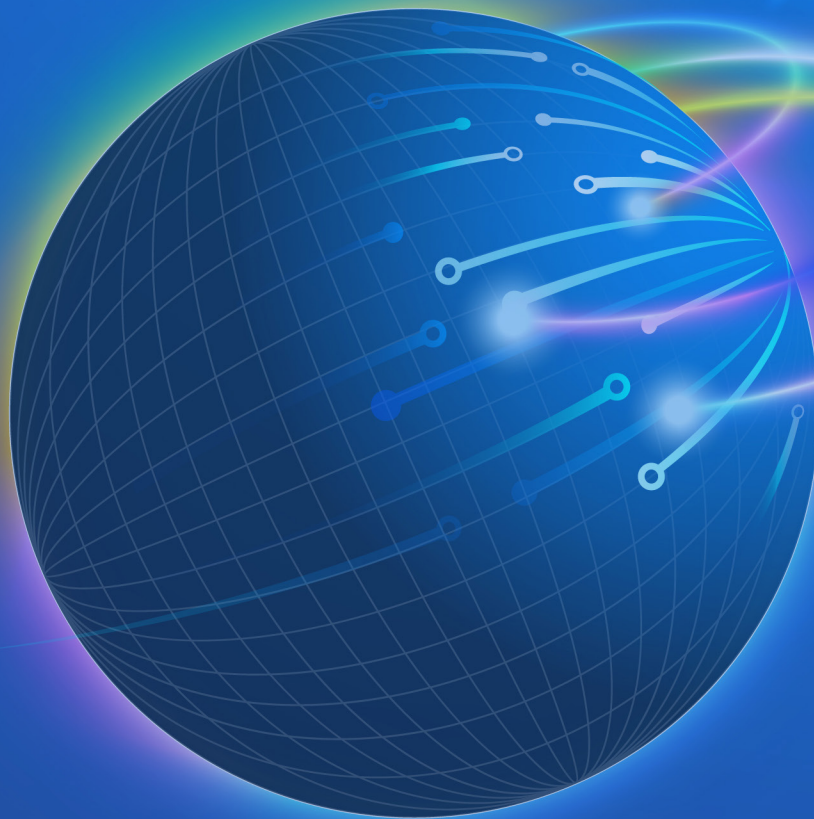




AMERICAN JOURNAL OF **GEOSPATIAL TECHNOLOGY (AJGT)**

ISSN: 2833-8006 (ONLINE)

VOLUME 3 ISSUE 1 (2024)



PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

Properties Evaluation and Suitability Assessment for Construction Applications of Sand of Kirtankhola River in Bangladesh

Tarun Debnath^{1*}, M. A. Rob¹, Sanjoy Bhowal Pranta¹, Md. Liton Rabbani¹

Article Information

Received: August 20, 2024

Accepted: September 24, 2024

Published: September 27, 2024

Keywords

River Sand, Kirtankhola River, Physical and Chemical Properties, Construction Materials

ABSTRACT

The availability of high-quality construction materials is a critical factor in ensuring the durability and structural integrity of construction projects. River sand is often considered a suitable material for construction due to its quality and performance characteristics when combined with coarse aggregate and binding materials, such as cement in concrete. Additionally, the Kirtankhola River in Barishal, Bangladesh, is known to be a less polluted river. We have selected several locations along this river to collect sand samples for further study regarding this natural resource. This study focuses on the assessment of river sand sourced from the Kirtankhola River, with a primary objective to evaluate its suitability for construction applications. The research employs a comprehensive approach, encompassing field sampling, laboratory testing, and analysis of the physical and chemical properties of the Kirtankhola river sand. Various tests, including gradation analysis, moisture content determination, fineness modulus calculation, Particle size distribution curve, specific gravity measurement, Unit weight, Dry Density and assessment of silt and clay content, are conducted to provide a thorough understanding of the sand's characteristics. The study also examines the potential presence of organic impurities and assesses the chemical composition of the river sand. Local construction standards and guidelines are taken into account to establish whether the Kirtankhola River sand meets the necessary specifications for use in concrete and mortar. The findings from this research aim to provide valuable insights for construction professionals and decision-makers, aiding in responsible sourcing and usage of construction materials while ensuring the quality and performance of construction projects in the region.

INTRODUCTION

Sand, a fundamental component of concrete is a crucial ingredient in construction, acting like the “glue” that holds structures together. The Kirtankhola River could be a valuable source of construction sand. (Rahman, 2013) (Islam, 2014) (Siddique, 2016) To ensure sustainable and reliable construction practices, it's essential to understand the quality of sand from this river. This study aims to thoroughly evaluate the quality and suitability for construction applications. (Hussain, 2015) (Chowdhury, 2017) As the demand for construction materials rises, assessing the potential of local resources becomes imperative. (Fahad *et al.*, 2021) Soil analysis in Barisal City Corporation shows 68.43% sand and 31.65% silt and clay, indicating suitability for high-rise construction. (Rabbani *et al.*, 2023) Brick kilns significantly reduce organic matter and nutrients in the soil, with burnt soil showing lower OM (0.51%) and nutrients but higher pH and EC compared to unburned soil, indicating deteriorated soil quality. (Debnath *et al.*, 2023) The suitability of Kirtankhola River water for irrigation is determined by chemical composition and physical parameters, which are generally within standard limits, though nitrate and ammonia levels require government action to control industrial effluents. By focusing on Kirtankhola River sand, this research seeks to provide valuable insights into its availability and adequacy for construction in the Barishal region. (Rahman, 2013) (Siddique, 2016) (Robiul

Hasan, 2019) The study analyzed various properties of Kirtankhola River sand whose findings is valuable for construction projects in the region. However, it's important to acknowledge certain limitations, such as potential sand quality variations across different river locations. When we build houses, bridges or roads, the quality of materials especially river sand is crucial for strength, durability, and workability. Imagine living near the Kirtankhola River, it's not just a waterway but a potential source of sand for building. Before using the sand, this study will closely examine its quality to ensure it meets construction standards in the area. Construction is booming and the demand for good-quality materials like sand keeps growing. By studying Kirtankhola River sand, we can determine if it meets the standards needed for building strong and safe structures in this community. It's like checking if the ingredients we have are right for a recipe – in this case, the recipe for sturdy buildings. With its well-graded particle size distribution, round shape, and natural composition, river sand has been favored for construction. (Robiul Hasan, 2019) However, increasing demand, environmental concerns, and sand mining restrictions prompt a thorough assessment of alternative sources, including local river sands like those from the Kirtankhola River. The Kirtankhola River, situated in the Barishal region, is a crucial watercourse with sedimentary deposits, particularly sand, that could significantly contribute to the construction sector. Using local resources

¹ Barishal Engineering College, Bangladesh

* Corresponding author's e-mail: tarundebnath75@gmail.com

like Kirtankhola River sand aligns with sustainable development goals, offering positive environmental and economic impacts. (Chowdhury, 2017) (Siddique, 2016) Utilizing nearby materials reduces transportation costs, lowers the carbon footprint associated with transport, and supports regional economies. A quick method was developed to find fineness modulus of sand by using image processing method (Fahad, A., Nayem, N.H., Hossain, M.N. *et al.*, 2024). Rabbani, M. L. (2017) examined on low cost roofing system. In this studied they used wash local sand with fineness modulus of 1.25.

Rabbani, M. L., Sazzad, G., Miah, R., & Islam, T. (2023) studied soil quality. In this research they investigated various soil quality. However, the feasibility of such utilization depends on a thorough understanding of the quality and appropriateness of local materials.

MATERIALS AND METHODS

Study Area

The study was conducted between the Char Kawa Ferry Ghat, Barishal River Port Terminal, 30 Godown, Dapdapia Bridge Area, Char Monai Ferry Ghat.



Figure 1: Geological Map

GPS Location of Sampling Points

Table 1: Location

Serial Number	Sample Location	GPS Co-ordinates	
		Latitude	Longitude
1	Char Kawa Ferry Ghat	22°41'49.6"N	90°22'42.7"E
2	Barisal Muktijoddha Park	22°41'43.3"N	90°22'25.8"E
3	30 Godown	22°40'42.8"N	90°21'54.5"E
4	Dapdapia Bridge Area	22°39'45.4"N	90°21'24.9"E
5	Char Monai Ferry Ghat	22°43'07.4"N	90°23'31.3"E

Sample Collection Process

We collected 500 grams of sand from each location using an excavator. These samples were then transferred to cloth bags and labeled accordingly. Additionally, a separate sample of any surface crust was collected. Each sample was labeled with information such as area name and field location. Subsequently, the samples were dried

in the shade and sent, along with an information sheet, to our sand testing laboratory for comprehensive analysis. This meticulous sand sampling process aims to provide an accurate understanding of the sand composition in the Kirtankhola River region, facilitating effective reclamation strategies and supporting sustainable sand practices.



Figure 2: Sand Samples

Testing of Sample

Several tests were performed on the collected sample. These were:

1. Moisture Content:
2. Dry Density:
3. pH:
4. Unit Weight:
5. Specific Gravity Procedure:

6. Sieve analysis process:
 7. Fineness Modulus:
 8. Hydrometer Analysis of fine-grained soil/Evaluate the silt and clay content in a soil sample:
 9. Particle Size Analysis:
 10. Permeability
- All the test were performed according to standard test methods. Some of the figures of the tests are given below.



Figure 3: Drying in Oven



Figure 4: Weight Determination



Figure 5: Sieve Analysis

RESULTS AND DISCUSSION

The main aspect of this research paper is to deliver several quality full details about the different parameters of Kirtonkhola River sand. Which can be useable to construct any type of construction by using this river sand. Here are the results of our applied test:

Moisture Content

The moisture content of Kirtonkhola River sand varied across the different locations, ranging from 8.33% at Char Monai Ferry Ghat to 15.02% at Char Kawa Ferry Ghat. The average moisture content of the sand was 11.77%. Char Kawa Ferry Ghat exhibited the highest moisture

content, likely due to factors such as its proximity to the river or a higher concentration of fine particles that retain water. Char Monai Ferry Ghat displayed the lowest moisture content, potentially linked to its location or the presence of coarser sand particles that drain water more readily. The moisture content of sand significantly impacts its engineering and construction properties. Higher moisture content can lead to reduced strength, increased workability, and potential instability. Conversely, lower moisture content can increase strength but reduce workability and may require additional water

for compaction. Understanding the variations in moisture content across different locations within the Kirtonkhola River is crucial for various applications, including:

1. Selecting appropriate sand types and adjusting construction methods based on the anticipated moisture content.
2. Implementing appropriate drainage measures and potentially adjusting the sand content in asphalt mixes.
3. Identifying areas more susceptible to erosion due to higher moisture content and implementing targeted mitigation strategies.

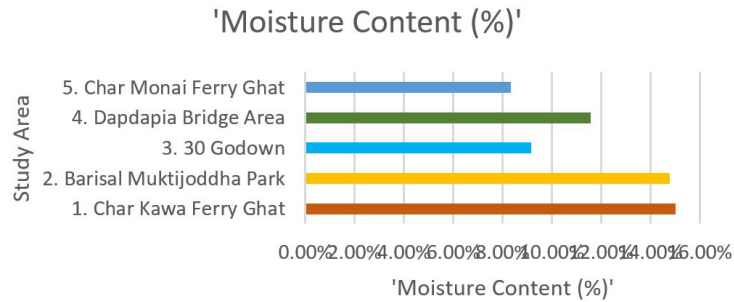


Figure 6: Moisture Content Values According to Different Locations

Dry Density

The dry density of Kirtonkhola River sand exhibits significant variation across the different locations. The highest dry density was observed at Char Monai Ferry Ghat with a value of 2.76 g/cm³, while the lowest value was recorded at Dapdapia Bridge Area with 1.91 g/cm³. This difference suggests potential variations in the sand composition and packing density at these locations. The overall dry density range of Kirtonkhola River sand falls

between 1.91 g/cm³ and 2.76 g/cm³. The average dry density of Kirtonkhola river sand across all locations is 2.216 g/cm³. This range is comparable to the typical range reported for river sands in general, which typically falls between 1.5 g/cm³ and 2.8 g/cm³. Several factors could contribute to the observed variations in dry density, including grain size distribution and the presence of organic matter or other impurities.

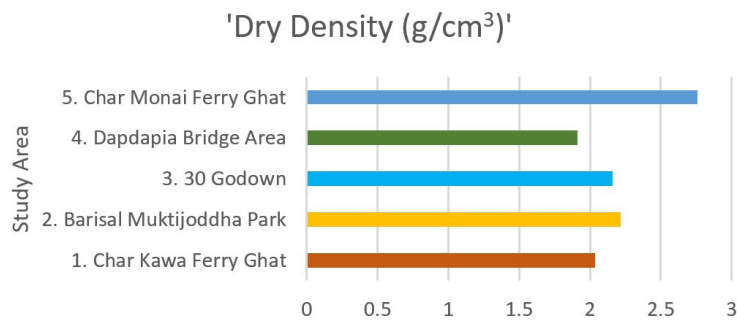


Figure 7: Dry Density Values According to Different Locations

The dry density of Kirtonkhola River sand exhibits significant variation across the different locations. The highest dry density was observed at Char Monai Ferry Ghat with a value of 2.76 g/cm³, while the lowest value was recorded at Dapdapia Bridge Area with 1.91 g/cm³. This difference suggests potential variations in the sand composition and packing density at these locations. The overall dry density range of Kirtonkhola River sand falls between 1.91 g/cm³ and 2.76 g/cm³. The average dry density of Kirtonkhola river sand across all locations is 2.216 g/cm³. This range is comparable to the typical range reported for river sands in general, which typically falls between 1.5 g/cm³ and 2.8

g/cm³. Several factors could contribute to the observed variations in dry density, including grain size distribution and the presence of organic matter or other impurities.

pH

The pH of Kirtonkhola River sand displayed a slightly alkaline range across the different locations, with values ranging from 7.3 at Dapdapia Bridge Area to 7.8 at Char Kawa Ferry Ghat. The average pH of the sand was 7.54. All measured pH values fall within the neutral to slightly alkaline range (pH 6.5 - 8.5), indicating that the sand is not likely to pose any significant environmental concerns.

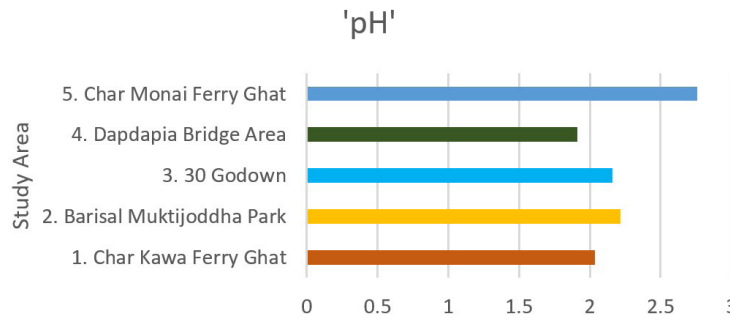


Figure 8: pH Values According to Different Locations

Unit Weight

The unit weight of Kirtonkhola River sand exhibited significant variations across the different locations, ranging from 18.731 kN/m³ at Dapdapia Bridge Area to 27.066 kN/m³ at Char Monai Ferry Ghat. The average unit weight of the sand was 21.533 kN/m³. Char Monai

Ferry Ghat displayed the highest unit weight, potentially due to factors such as the presence of coarser sand particles or a higher degree of compaction. Dapdapia Bridge Area exhibited the lowest unit weight, potentially linked to a higher proportion of finer sand particles or less compaction.

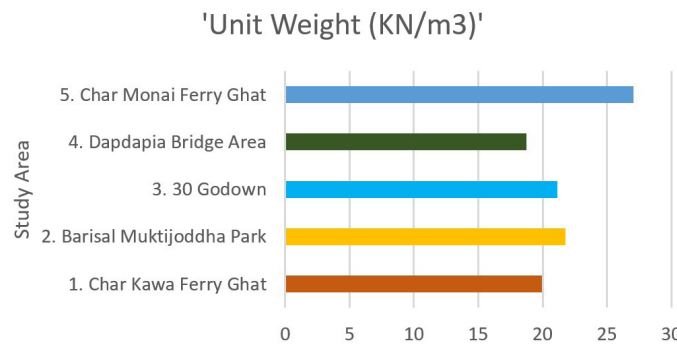


Figure 9: Unit Weight Values According to Different Locations

Specific Gravity

The diverse specific gravity values observed along the Kirtankhola River, ranging from 2.107 to 2.647, highlight significant variations in soil density and composition at distinct locations. The higher specific gravity values at Chor Monai Ferry Ghat, Dapdapia Bridge Area, and 30 Godown suggest denser materials, potentially influencing load-bearing capacities and foundation design. Conversely, lower specific gravity values at Muktijoddha

Park and Char Kawa Ferry Ghat imply lighter, potentially more porous soils. Integrating these specific gravity findings with permeability and other geotechnical data is crucial for a comprehensive understanding of subsurface conditions. Such insights are instrumental in guiding informed decisions for construction, infrastructure planning, and environmental management along the riverbank, ensuring the development's sustainability and resilience

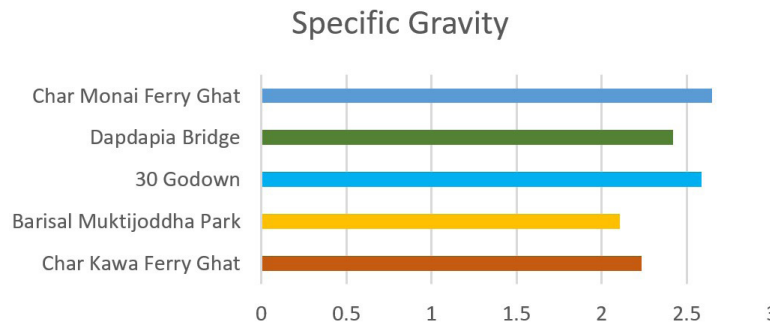


Figure 10: Specific Gravity Values According to Different Locations

Sieve Analysis

From the sieve analysis, key parameters have been calculated for each sample, including the uniformity coefficient (Cu), coefficient of curvature (Cc), effective

size D10, D30, D60, and percentages of sand, gravel, and finer particles. These parameters serve as critical indicators of the particle size distribution and granular characteristics.

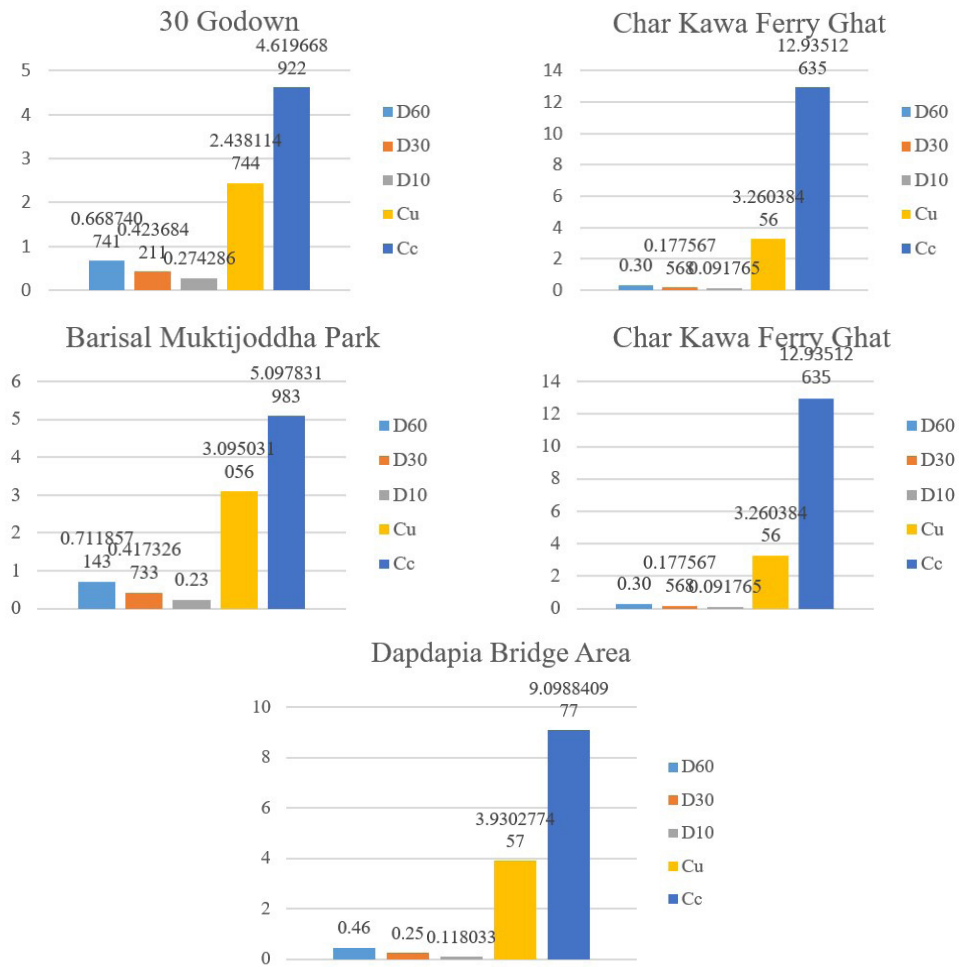


Figure 11: Sieve Analysis Values According to Different Location

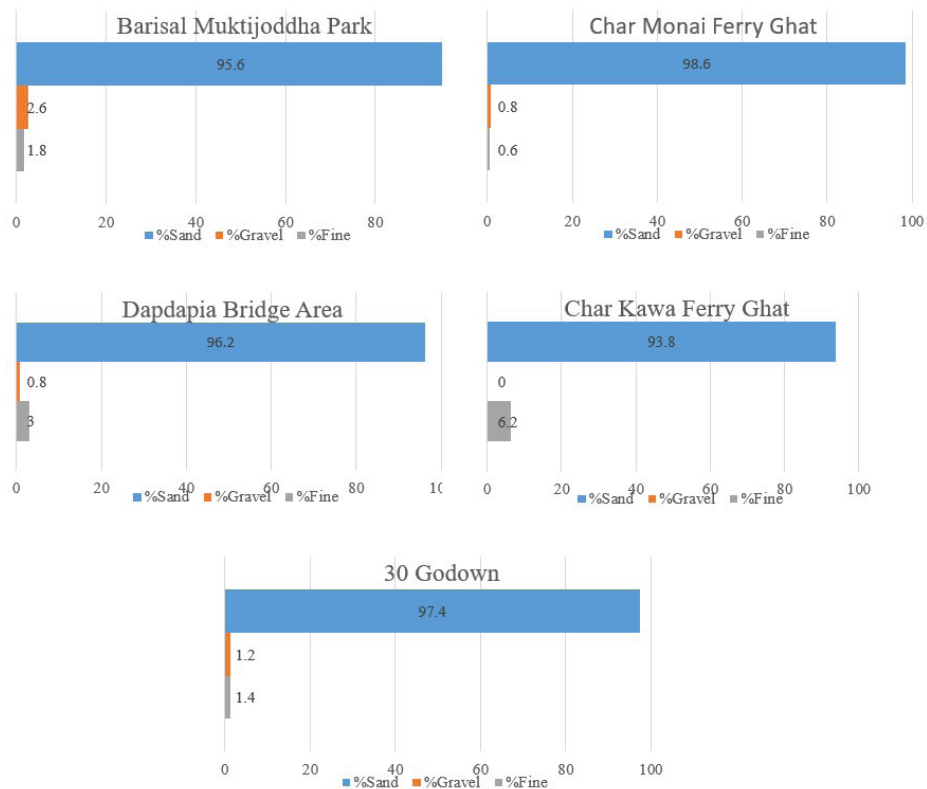


Figure 12: Percentage of Sand, Gravel and Fine Values According to Different Location

Fineness Modulus

Optimizing Fineness Modulus is crucial in concrete mix design, demanding a thorough evaluation of aggregate characteristics. (Neville, 2011) Calculated through systematic sieve analysis, the Fineness Modulus serves as a key determinant. Increasing values, signaling coarser aggregates, potentially enhance strength but compromise workability. Conversely, lower values denote finer

aggregates, improving workability at the possible expense of strength. (211, 2019) Engineers must precisely calculate the Fineness Modulus within a specified range to strike the right balance, tailoring fine aggregates for project needs. This numerical representation of particle size distribution guides the adjustment within a defined range, ensuring a dense matrix for enhanced strength and durability.

Table 2: Sand Quality According to Fineness Modulus

Type of Sand	Fineness Modulus
Fine Sand	2.2-2.6
Medium Sand	2.6-2.9
Coarse Sand	2.9-3.2

In summary, a precise calculation and adherence to an appropriate fineness Modulus range enable engineers to navigate the workability-strength trade-off, creating a customized concrete mix for diverse construction projects. (Mehta, 2014) Further exploration holds potential for refining concrete engineering practices. The Finess

Modulus of Kirtonkhola river sand is varies in different location. A study carried out on low-cost roofing, here a washed sand of fineness modulus 1.5 was used as fine aggregate (Rabbani, A study on low cost roof (Masonry Slab, 2017)). Here are the values of our finding,

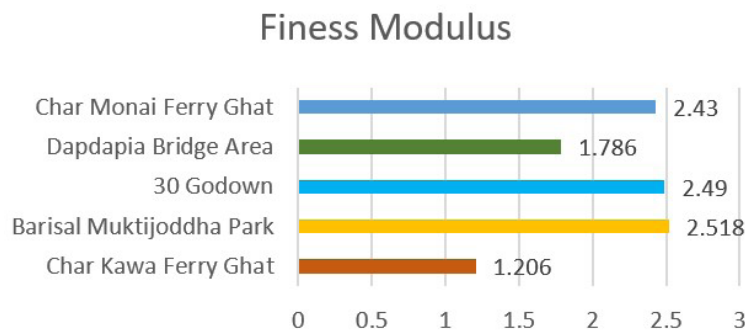
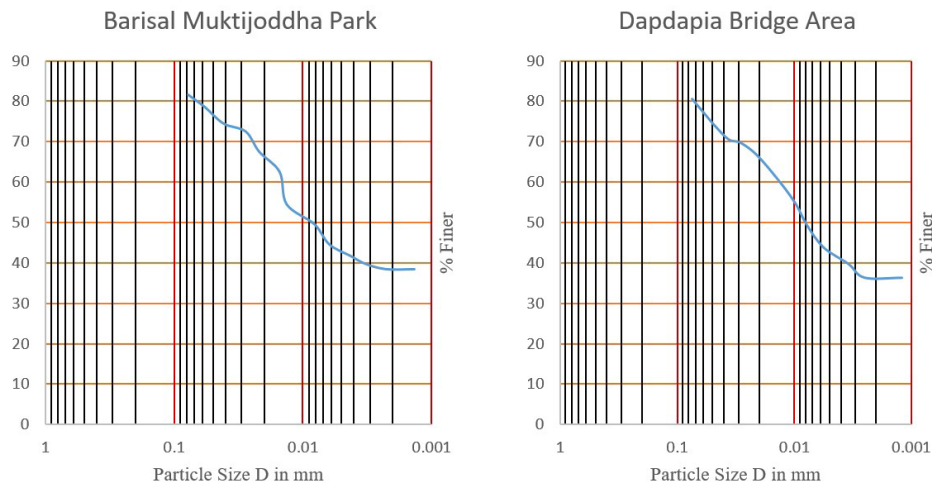


Figure 13: Fineness Modulus Values According to Different Locations

Hydrometer Analysis of Fine-Grained Soil

A hydrometer reading vs. diameter graph visually represents soil particle settling in water. It aids in determining particle size distribution, highlighting quicker settling of larger particles with higher initial hydrometer readings. Smaller particles, like clay and silt, settle more

slowly, leading to a gradual decrease in readings over time. In the specific samples discussed, Char Kawa Ferry Ghat displays a prominent peak, indicating higher silt and clay content, while Char Monai Ferry Ghat shows a less prominent peak, suggesting lower concentrations of finer particles



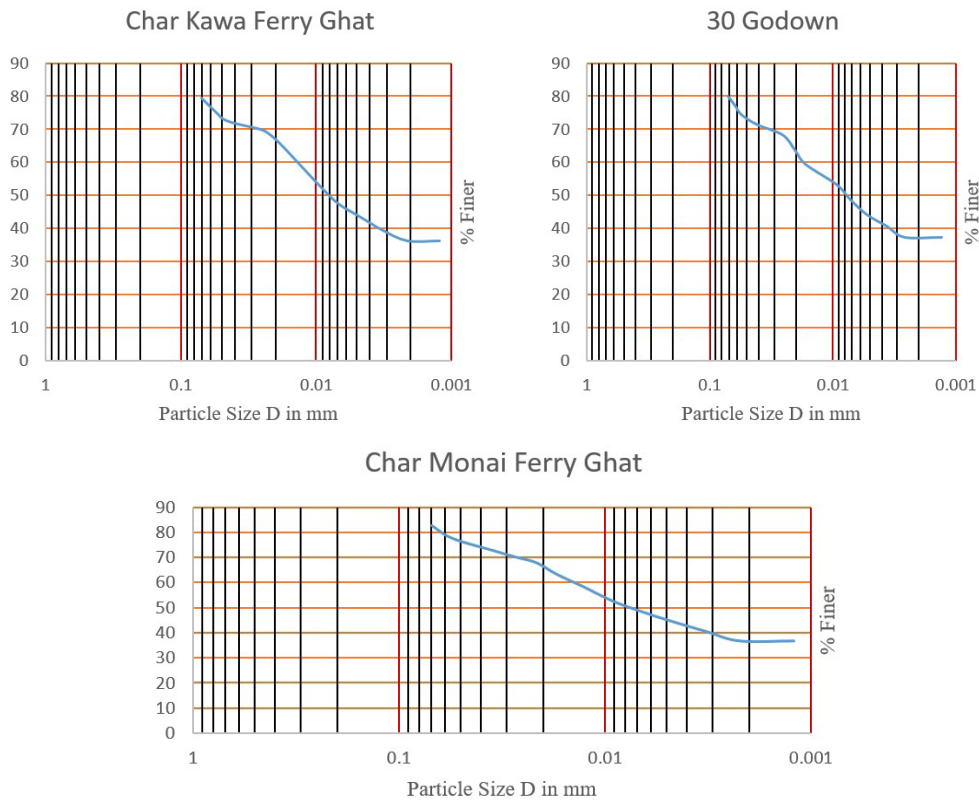
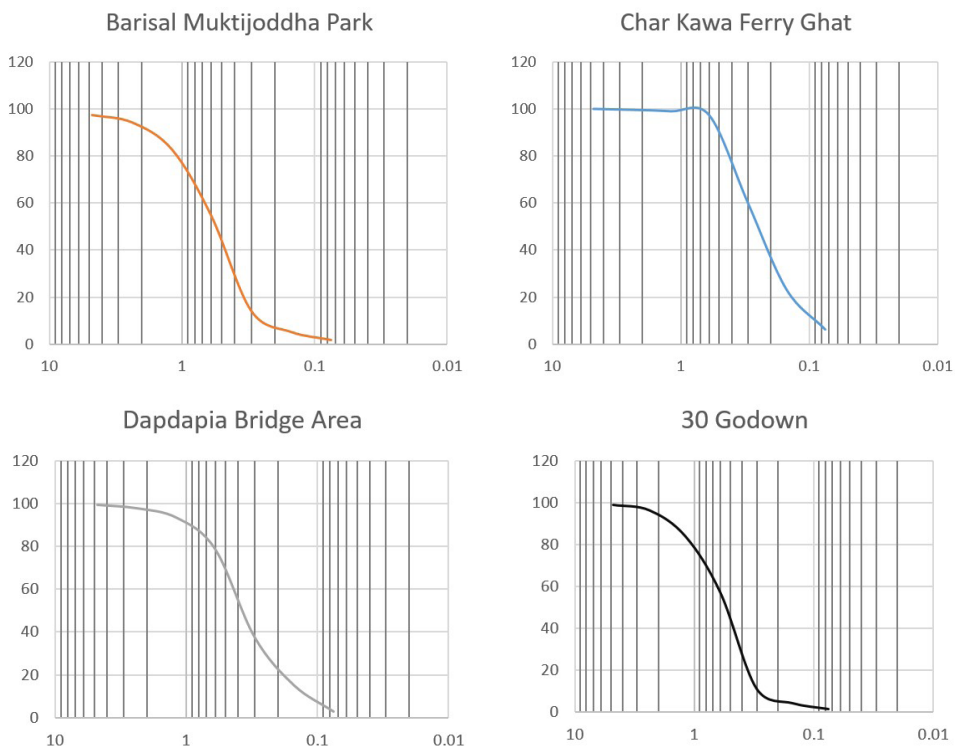


Figure 14: Hydrometer reading vs. Diameter Graph According to Different Location

Particle Size Analysis

By analyzing the particle size distribution curve for each sample, we distinguished and understood the unique characteristics of sand in each sample based on size. This provided a clear scenario of the particle size distribution, allowing us to identify the optimal sand for specific

applications. (Craig, 2004) The information gleaned from the analysis helped in selecting the best sand from the samples, considering factors such as uniformity, gradation, and particle size composition. This ensured informed decision-making in utilizing the most suitable sand for desired engineering or construction purposes.



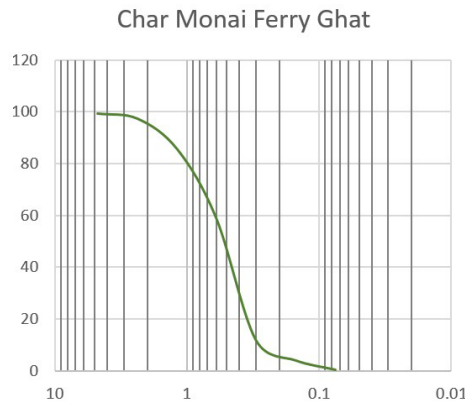


Figure 15: Particle Size Distribution Curve According to Different Location

Permeability

The permeability coefficient results, ranging from 4 to 8 $\times 10^{-3}$ cm/sec along different locations of the Kirtankhola River, signify notable spatial heterogeneity in subsurface characteristics. Higher coefficients in areas like Dapdapia Bridge, 30 Godown, and Muktijuddha Park suggest increased soil permeability, potentially influencing water flow and drainage dynamics. (Freeze, 1979) The relatively lower coefficients at Chor Monai and Char Kawa Ferry

Ghat areas indicate less permeable soils. These findings hold significance for geotechnical and environmental considerations, impacting construction feasibility, flood risk assessments, and infrastructure planning. It is crucial to benchmark these results against industry standards and conduct further investigations to enhance the reliability of the data for informed decision-making in the development and management of the riverine environment.

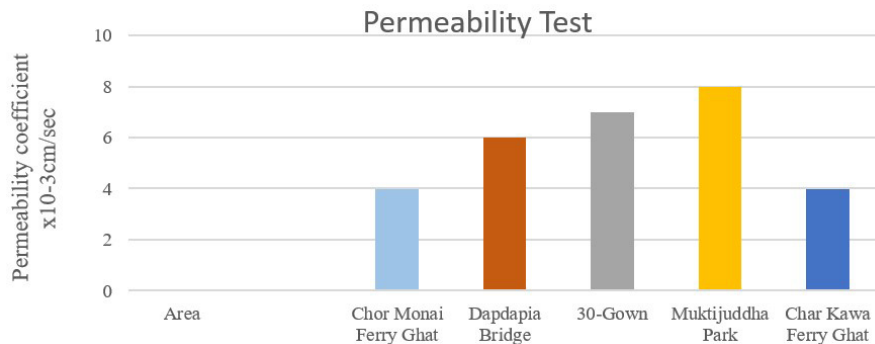


Figure 16: Permeability test values According to Different Locations

CONCLUSION

In conclusion, the comprehensive quality evaluation and suitability assessment of Kirtonkhola River sand for construction applications provide a robust foundation for informed decision-making. The examination of key properties such as dry density, pH, unit weight, permeability, Finess Modulus, and moisture content across various locations revealed a range of characteristics that align with industry standards. The observed variations in these properties underscore the importance of considering local factors that influence the engineering properties of the sand. (Holtz, 1981) The slightly alkaline pH range (7.3 to 7.8) indicates that the sand is not likely to pose significant environmental concerns, contributing to its overall suitability for construction applications. The unit weight variations from 18.731 kN/m^3 to 27.066 kN/m^3 highlight the importance of understanding local factors influencing this property, aiding in the selection of sand with appropriate stability and compaction

characteristics. Furthermore, the moisture content variations from 8.33% to 15.02% emphasize the need for tailored construction methods and considerations, acknowledging the impact of moisture on strength, workability, and stability. (Tiwari, 2016) Sand is used in almost 80 percent of the construction industry. It is, therefore, very important to understand the properties of sand that influence the compressive strength of concrete. Thus, it is undeniable that sand is an important construction material. (FAHAD *et al.*, 2023) This study provides valuable insights that can guide the selection of Kirtonkhola River sand for construction projects. However, ongoing monitoring and further investigations are recommended to refine our understanding of the sand's properties and ensure its optimal utilization in various construction applications. The findings contribute to a more nuanced understanding of the material, fostering sustainable and effective construction practices in the region. (Bingöl, 2012)

REFERENCES

- A. C. (2019). Standard practice for selecting proportions for normal, heavyweight, and mass concrete (ACI 211.1-19). *American Concrete Institute*.
- Bear, J. (1972). *Dynamics of fluids in porous media*. Dover Publications.
- Bingöl, A. Ö. (2012). Investigation of some geotechnical properties of Çanakkale gravel-sand mixture as a construction material. *International Journal of Engineering and Technology*, 33–40.
- Brady, N. C. (2016). *The nature and properties of soils* (15th ed.). Pearson.
- Campbell, G. S. (1998). *An introduction to environmental biophysics*. Springer Science & Business Media.
- Chowdhury, M. R. (2017). The impact of using local river sand on the construction industry in Bangladesh. *Journal of Bangladesh Institute of Engineers*, 41(3), 203–212.
- Craig, R. F. (2004). *Craig's soil mechanics* (7th ed.). Spon Press.
- Das, B. M. (2019). *Principles of geotechnical engineering* (9th ed.). Cengage Learning.
- Debnath, T., Ridoy, M. R., Soyeb, M. H., & Rabbani, M. L. (2023). Investigation of some selected water quality parameters of the Kirtankhola River, Bangladesh. *American Journal of Engineering Research (AJER)*, 12(6), 10–24.
- Fahad, A., Nayem, N. H., Hossain, M. N., et al. (2024). Sand fineness modulus prediction in the construction sector using convolutional neural networks. *Asian Journal of Civil Engineering*, 25, 443–450. <https://doi.org/10.1007/s42107-023-00786-z>
- Fahad, A., Nayem, N. H., Hossain, N., & Rabbani, M. L. (2021). A study of subsoil investigations in Barishal City Corporation, Bangladesh. *International Research Journal of Engineering and Technology (IRJET)*, 08(12).
- Freeze, R. A. (1979). *Groundwater* (1st ed.). Prentice-Hall.
- Head, K. H. (2014). *Manual of soil laboratory testing* (Vol. 2). CRC Press.
- Hillel, D. (2004). *Introduction to environmental soil physics*. Elsevier Academic Press.
- Holtz, R. D. (1981). *An introduction to geotechnical engineering*. Prentice-Hall.
- Hussain, M. (2015). Evaluation of the quality of river sand for sustainable construction in Bangladesh. *International Journal of Sustainable Built Environment*, 4(1), 51–62.
- Islam, M. S. (2014). Properties of river sand from the Barishal region of Bangladesh and their suitability for construction. *Construction and Building Materials*, 66, 504–512.
- Lambe, T. W. (1969). *Soil mechanics*. John Wiley & Sons.
- Leshchinsky, D. A. (1992). Particle size distribution and its influence on permeability of granular soils. *Canadian Geotechnical Journal*, 29(4), 579–587.
- Mehta, P. K. (2014). *Concrete: Microstructure, properties, and materials* (4th ed.). McGraw-Hill Education.
- Neville, A. M. (2011). *Properties of concrete* (5th ed.). Pearson Education.
- Schofield, A. W. (1955). The measurement of soil pH. *Soil Science Society of America Journal*, 19(2), 164–167.
- Rabbani, M. L. (2017). A study on low cost roof (masonry slab). *American Journal of Engineering Research (AJER)*, 6(3), 32–36.
- Rabbani, M. L., Sazzad, G., Miah, R., & Islam, T. (2023). The effects of brick kiln activity on the deterioration of agricultural soil quality: A study at Barishal Sadar Upazila, Bangladesh. *JETIR*, 10(9).
- Rahman, M. M. (2013). Assessment of the suitability of river sand for construction purposes in Chittagong, Bangladesh. *Journal of Civil Engineering (Nepal)*, 30(1), 1–10.
- Robiul Hasan, N. D. (2019). Environmental impact assessment of Dutta Residential Area Project at Kornokathi, Barisal, Bangladesh. *ResearchGate*, 1–43.
- Siddique, R. (2016). River sand mining in Bangladesh: Environmental impacts and mitigation measures. *Journal of Environmental Management*, 177, 342–353.
- Tiwari, A. K. (2016). Sustainability in the construction industry: A review of practices and concepts. *Australasian Journal of Construction Economics and Building*, 16(4), 40–57.
- Uchimura, C. P. (2010). Effects of dry density and grain size distribution on soil-water characteristic curves of sandy soils. *Soils and Foundations*, 50(1), 161–172.
- Wang, Q. W. (2019). Effects of fineness modulus of recycled aggregate on mechanical properties of concrete. *Construction and Building Materials*, 204, 439–449.