

Report On

Exploring the supply chain challenges of Coarse Aggregate (Crushed Stone)
as raw material of the Highway and Bridge Construction Projects in Roads
and Highways Department (Bangladesh)

By

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A report submitted to the BRAC Institute of Governance and Development (BIGD) in
partial fulfillment of the requirements for the degree of
Masters in Procurement and Supply Management (MPSM)

BRAC Institute of Governance and Development (BIGD)
Brac University
May 2024

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It is hereby declared that

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2. The report does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The report does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
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Letter of Transmittal

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Subject: [Type your subject here]

Dear Sir,

This is my pleasure to display my entry level position provide details regarding' Exploring the supply chain challenges of Coarse Aggregate (Crushed Stone) as raw-material of the Highway and Bridge Construction Projects in Roads and Highways Department (Bangladesh), which I was appointed by your direction.

I have attempted my best to finish the report with the essential data and recommended proposition in a significant compact and comprehensive manner as possible.

I trust that the report will meet the desires.

Sincerely yours,

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Executive Summary

The Roads and Highways Department is a government agency entitled with the responsibility to expand and maintain the National Highways of Bangladesh along with the Regional and Zilla Highways across Bangladesh. The highway networks of approximate 21000km contains numerous bridges culverts overpasses interchanges as well as flexible and rigid pavements. The construction material required for these massive infrastructures is mostly aggregate of which [75%] is coarse aggregate. With the developing trend of Communication sector of Bangladesh, the highway construction sector was given utmost priority resulting in numerous highway construction projects. To cater the demand of these highway construction projects, the capacity of the Coarse Aggregate supply chain was tested practically. Owing to the unavailability of sufficient domestic sources of the coarse aggregate, it has made this supply chain more vulnerable and price sensitive in last 10 years. The supply chain of the Coarse Aggregate is highly influential to the highway infrastructure development as well as maintenance activities of existing highways of Bangladesh. In our report, we shall focus on the overall scenario of the coarse aggregate supply specifically in Highway Construction Industry.

Keywords: Supply Chain; Coarse Aggregate; Highway and Bridge Construction; Infrastructure Project; Roads and Highways Department.

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List of Acronyms

RHD	Roads and Highways Department
PMP	Periodic Maintenance Program
GoB	Government of Bangladesh
OTM	Open Tender Method
BoQ	Bill of Quantity
ADP	Annual Development Program
MDB	Multilateral Development Bank
G2G	Government to Government
AASHTO	American Association of State Highways and Transportation Officials
US Dollar	United States Dollar
MoU	Memorandum of Understanding

Glossary

AASHTO	American Association of State Highway and Transportation Officials (AASHTO is a non-governmental organization that develops and publishes standards for the design, construction, and maintenance of transportation infrastructure in the United States. Their published standards on Transportation aspects are followed worldwide as accepted standard and criteria.
BELA	Bangladesh Environmental Lawyers Association (BELA) BELA was established in 1992 with a group of lawyers with the broad objective of promoting environmental justice and contributing to the development of sound environmental jurisprudence.
MoU	A Memorandum of Understanding (MOU) is a non-binding agreement between two or more parties that outlines their intentions, roles, and responsibilities. MOUs are often used to establish a common line of action and to facilitate communication and conflict resolution. They can be used for simple agreements that don't involve financial commitments, such as a non-financial exchange with a collaborative partner.
PESTLE Analysis	A PESTLE analysis is a strategic planning tool that helps organizations identify and analyze external factors that can impact their business. PESTLE is an acronym for the six categories of factors (Political, Economic, Social, Technological, Legal and Environmental)

Chapter 1

[Introduction]

The Roads and Highways Department (RHD) is a government agency of Bangladesh, entrusted with the responsibility of developing and maintaining the nationwide Highway and Bridge sector of Bangladesh. The departmental goal is that "The Roads and Highways Department is able to provide the People of Bangladesh with a safe, cost effective and well-maintained road network". And the purpose of the RHD is stated as "The Roads and Highways Department has a sustainable capacity to plan, manage and deliver its full range of responsibilities in respect of the main road and bridge network and to be accountable for these duties". Under the purview of its jurisdiction there are a total of 22,476.28 kilometer Highway of which 114 nos. of National Highway category contributes 4,205.16 kilometers, 152 nos. of Regional Highway contributes 5,016.27 kilometers and lastly 724 nos. of Zila Highway contributes 13,254.85 kilometers.

The massive construction and maintenance activities for the 22,476 kilometers of highways and its connecting bridges require abysmal amount of raw materials like Aggregate, Bitumen, Sand, Soil, Brick Cement Concrete etc. Among these materials the Coarse Aggregate contributes the major portion of the constituents. The objective of this report is to explore the challenges of the supply chain involved in the coarse aggregate and potential sustainable solutions to these picked out challenges for the efficient performance of the Roads and Highways Department as well as the Highway and Bridge Construction industry of Bangladesh.

Chapter 2

[Coarse Aggregate in Roads and Highways Department]

2.1 [Scope of Work of Roads and Highways Department]

The Roads and Highways Department was established along with Public Works Department (PWD) in 1962 being split from the old “Construction & Building (C&B)” organization. Long before the Liberation of Bangladesh, the Roads and Highways Department is carrying out the construction of Highways of Bangladesh. At the inception stage of RHD, the construction industry was not developed in its current state, so RHD used to procure the material and equipment itself to construct and maintain the major roads. For this purpose the RHD had to maintain colossal stackyard in the then division level and even RHD as a government agency had large number of Brick Fields owned by itself to supply the road construction materials. The RHD used to procure contractors for cash-flow of the maintenance and construction of highways. These procured contractors used to buy materials from the RHD stackyard and hire the road construction equipment from RHD mechanical section. Through this arrangement the highway sectors of Bangladesh marked its initial strides. Gradually RHD started to modernize the construction technology like use of bitumen and making flexible pavements (black pitch roads) with the economic development of the country. Along with this, the capacity of the contractor and supply chain of construction materials also exponentially improved, which enabled the contractors to procuring the construction equipment themselves and accomplishing large highway and bridge construction projects. RHD gradually gave up the micro-level management of construction, rather handled the procurement and contract management more efficiently which became its core business.

Currently, Roads and highways Department carries out maintenance work in mainly three categories, namely Periodic Maintenance Program (PMP) Major, Periodic Maintenance Program (PMP) Minor and Routine Maintenance. These maintenance programs are funded by the Government of Bangladesh (GoB) in financial year basis.

The PMP major and PMP minor is carries out by the contractor procured through national Open Tender Method (OTM). The labour, material and equipment are arranged by the contractor and after completion of the contracted construction work, the RHD pays the contractor following the quoted BoQ of the contractor.

The Routing Maintenance Program is aimed to repair and maintain the daily basis defects of the highways under the RHD district level offices lead by an executive engineer (5th Grade officer). The executive engineer of a district calls for a tender of supply of repairing materials like sand, coarse aggregate (stone size ranging from 5mm to 25mm), bricks and bitumen drums. The procured supplier, selected through competitive open bidding, supplies the procured material to the stackyard of the RHD district level office. The Executive Engineer, with the support of his subordinates and owned equipment, maintain and repair the trivial defects to avoid massive deformities in the highways under his/her jurisdiction.

For developing the new Highways or expanding the existing Highways capacity through structural strength enhancement or width increment, new projects are taken by the Roads and Highways Department through the support of the Annual Development Program (ADP) of Government of Bangladesh. Apart from the fund from the Government of Bangladesh (GoB), some Multilateral Development Banks (MDBs) like World Bank, Asian Development Bank, Asian Infrastructure Investment Bank, Islamic Development Bank come forward to provide assistance through Loan Agreement and grant to develop the highway infrastructure of Bangladesh. Besides this, some G2G initiatives like Japan International Cooperation Agency

(JICA) or Kuwait Fund for Arab Economic Development (KFAED) and international organizations like the Organization of the Petroleum Exporting Countries (OPEC) are chipping in their fund into the infrastructure development projects of Bangladesh through Roads and Highways Department. In a nutshell, the Roads and Highways Department is one of the influencing departments excelling in project implementation aimed at the massive highways as well as bridge construction in Bangladesh.

Therefore to implement those projects or maintenance program a huge amount of raw materials is required of which the Coarse Aggregate is the most critical one.

2.2 [Coarse Aggregate as a Raw Material of Highway Infrastructure development in Roads and Highways Department]

Roads and Highways Department carries out maintenance program and developing projects annually under its jurisdiction of 22476 kilometer throughout Bangladesh (source: Road Transport and Highways Division draft Annual Report 2023-24). The Coarse Aggregate is the main raw material for the highway and Bridge construction. For the Flexible Pavement (back pitch roads) coarse aggregate is used at Wearing Coarse, Binder Coarse, Base Coarse Layers predominantly and for the Rigid Pavement (concrete road) the total road layer requires coarse aggregate for concreting. For constructing the Culvert and Bridge structures a huge amount of coarse aggregate is required as well.

Concrete is made up of several different materials that combine cement, aggregate and water uniformly. Major portion of weight (70-85%) and volume (60-80%) of concrete originate from aggregate.

For Flexible Pavement highways the flakiness and shapes of the Coarse Aggregate along with its structural strength is significantly governing factors. The controlled mixture of bitumen and

coarse aggregate at maintained temperature and consistency gives the finest product as hardened flexible pavement.

The data of last five years from Fiscal Year 2019-20, 2020-21, 2021-22, 2022-23 and 2023-24 have been taken into consideration for this report. The data of development projects and Maintenance work have been collected from the Annual Report published by Road Transport and Highways Division which includes the contribution of Roads and Highways Department as well. For ease of calculation a minimum width of the road has been considered and a typical depth of reconstruction and strengthening has been considered.

SN	Demand Area	Utilization of Coarse Aggregate in Roads and Highways Department over the past 05 years (unit: cubic meter)				
		FY 2019-20	FY 2020-21	FY 2021-22	FY 2022-23	FY 2023-24
1	Development Projects	5669519.29	4453102.60	3892846.01	3191413.57	3184623.57
2	Periodic Maintenance Program	1017466.97	1259272.20	1168133.61	1156947.16	1026506.64
3	Routine Maintenance Program	37665.72	43564.74	28470.43	26898.16	48262.63
	Overall Total demand (1+2+3)	6724651.98	5755939.54	5089450.05	4375258.89	4259392.84

Table 1: Total Coarse Aggregate Utilization under different areas of Roads and Highways Department

The total requirement of Coarse Aggregate for Roads and Highways Department. last Five years ranges from 6,724,651.97 cubic meter to 4,259,392.84 cubic meter. The following graph shows the varying demand trends in each areas of the Roads and Highways Department's construction and maintenance works.

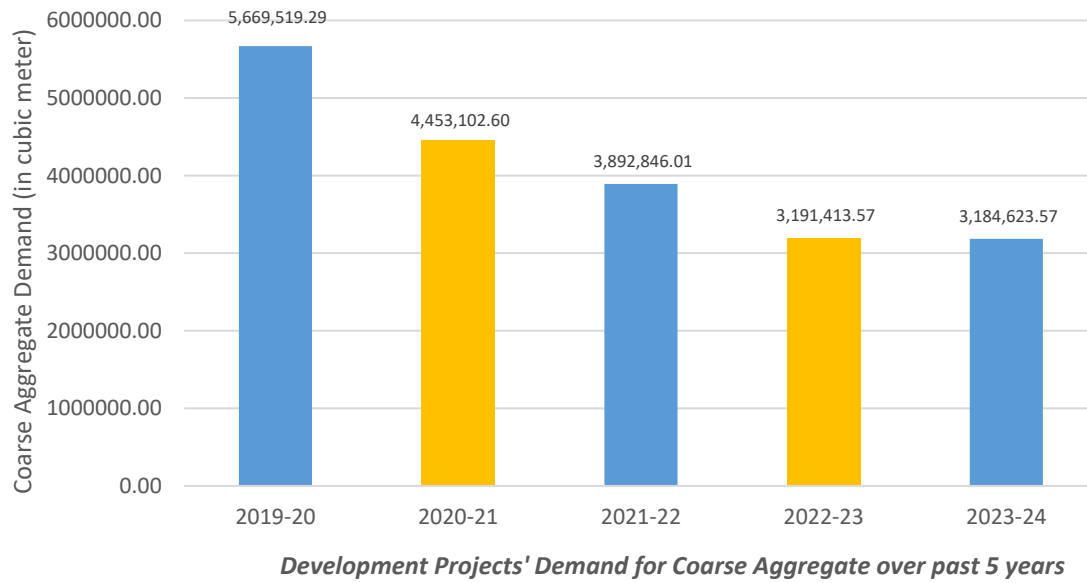


Figure 1: Demand for Coarse Aggregate in Development Projects of RHD over past 5 years

The Development Projects under the Roads and Highways has a declining trend as the number of development projects are decreasing and large project implementation is at the closing stage which contributed to the declining trend in the demand of coarse aggregate.

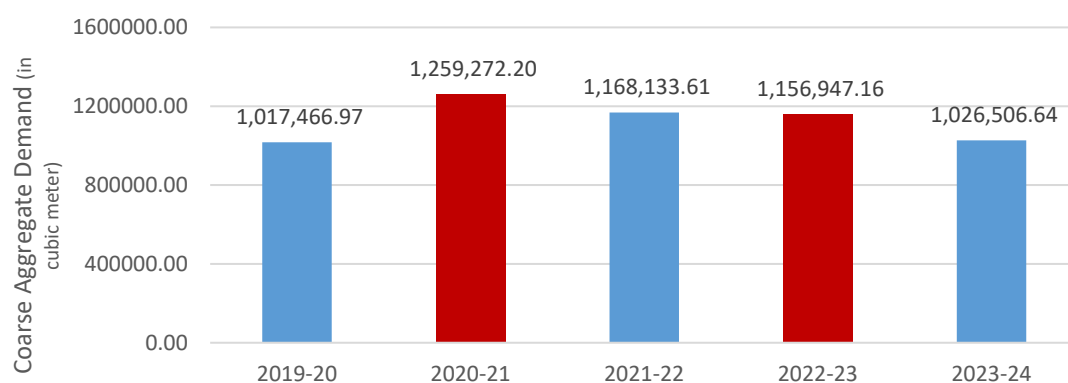


Fig: RHD Periodic Maintenance Programme Demand for Coarse Aggregate

Figure 2: Demand for Coarse Aggregate in Period Maintenance Program of RHD over past 5 years

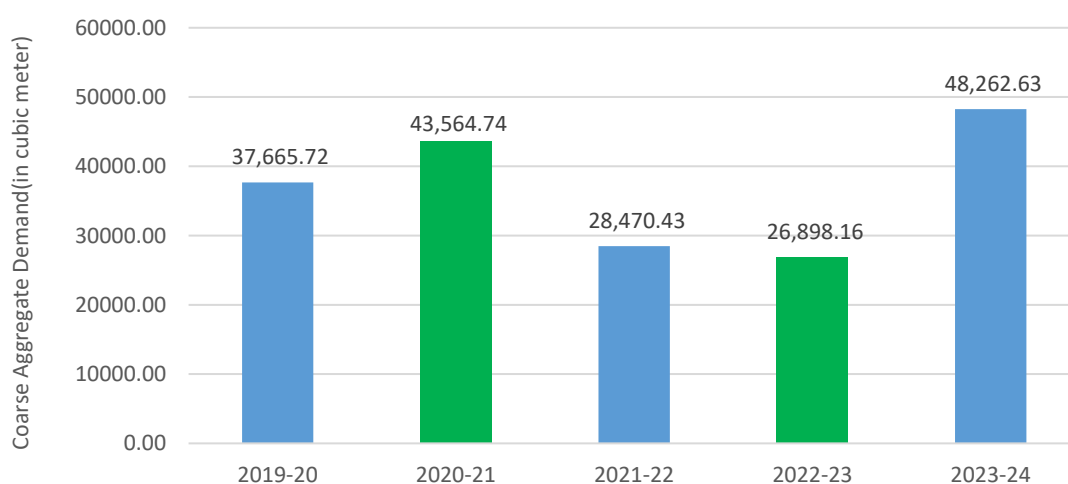


Fig: Routine Maintenance Program Demand for Coarse Aggregate

Figure 3: Demand for Coarse Aggregate in Period Maintenance Program of RHD over past 5 years

As per the data retrieved from the Annual Reports, roughly 1% Coarse Aggregate of the total demand of the Roads and Highways Department is utilized under Routine Maintenance which is procured by the Executive Engineer of the concerned Road Division. It is to be noted that the total country is divided into 65 road divisions as effective executive unit. On the other in the Periodic Maintenance Program (PMP), a variation of 15% to 26% was found out of the total demand of the RHD's Coarse Aggregate Demand. Lastly in the Development Project, the lions share of Coarse Aggregate is utilized which ranges from 75% to 84%. The Coarse Aggregate under the Periodic Maintenance Program and Development Projects are procured by the Contractors, who are selected through national competitive bidding called by the Roads

and Highways Department. The Contractor under these contract hands over the final product i.e. the well repaired or reconstructed highway to the Roads and Highways Department.

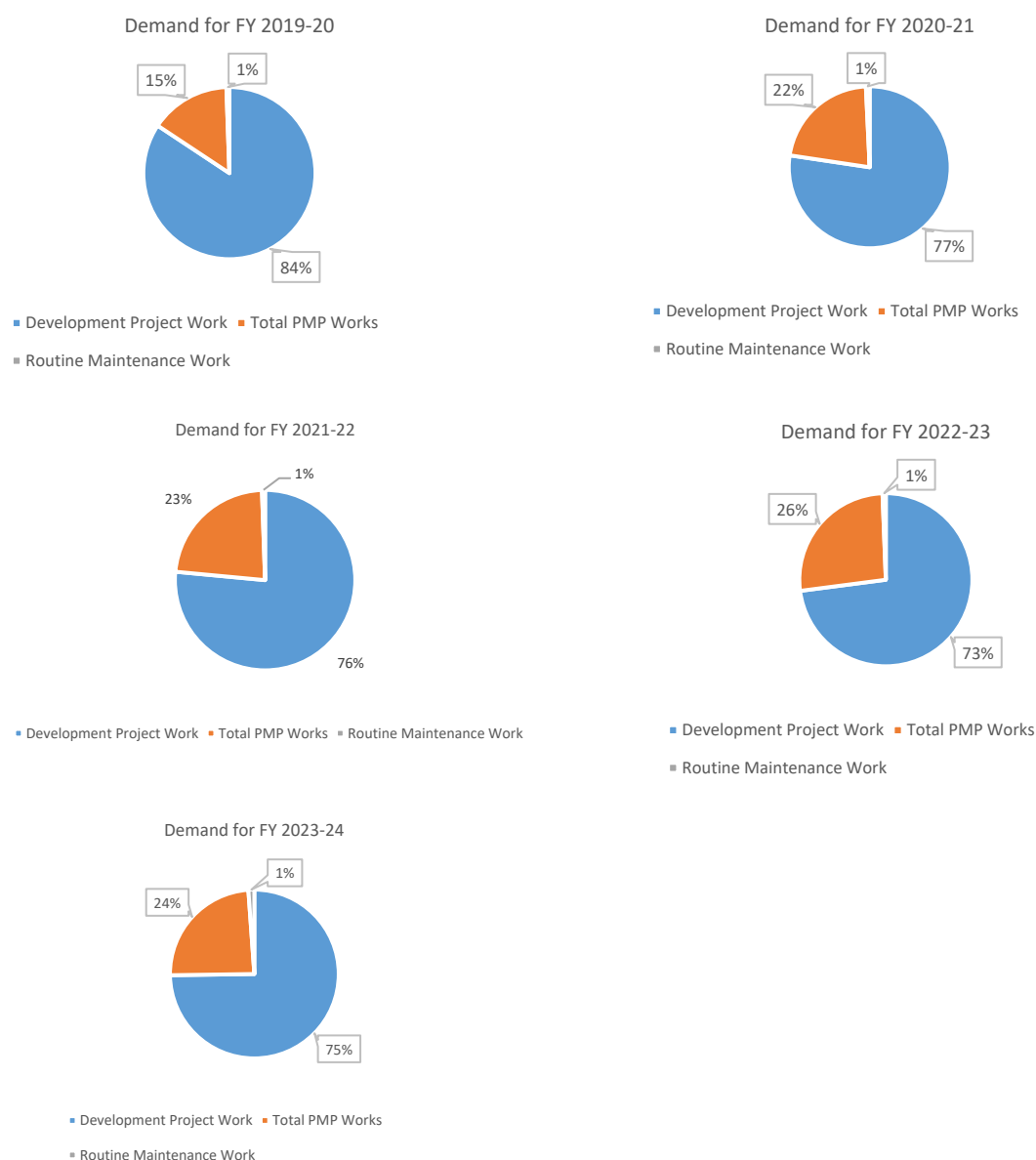


Figure 4: Contribution of different work areas to Coarse Aggregate demand of RHD over past 5 years

While observing the trend of the coarse aggregate demand we observed that there is a decline of demand as the time passes. This declining demand trend can be attributed to the reduction of the Development Projects approval and as through the last 10 years considerable number of projects have been implemented to improve the overall Highway Infrastructure of Bangladesh.

It gives a indication that in the coming years more emphasis shall be placed on repair and maintenance of the existing highways of Bangladesh.

2.3 [Demand Pattern of Coarse Aggregate for Highway and Bridge

Construction]

Straddling the Tropic of Cancer, Bangladesh has a tropical monsoon climate characterized by heavy seasonal rainfall, high temperatures, and high humidity. Natural disasters such as floods and cyclones accompanied by storm surges periodically affect the country. As the construction and maintenance work of Highways and Bridge infrastructures are done under open sky, so the rain or monsoon creates the direst challenge both at quality control and workability of working procedures. Therefore, construction and maintenance of the highways under projects or regular operation requires dry season as the suitable time. In Bangladesh, from November to May month of each year, the demand for the coarse aggregate as raw material peaks at this dry season of the year. So the challenge of the supply chain of Coarse Aggregate is to cater the total demand of the year within this 06 months. Some regions of Bangladesh like Sylhet division have only 04 months in a year as dry season making the demand peak at a very limited period.

The suppliers of the Coarse Aggregate, having limited window of supply and the scarcity of quality maintained local sources, play a monopoly in the market.

Chapter 3

[Coarse Aggregate in Bangladesh]

3.1 [What is Coarse Aggregate]

Rocks and minerals mixed to form naturally occurring aggregates. A mineral is a solid material that forms spontaneously and has an organized internal structure and chemical composition. Depending on their origin, rocks are categorized as igneous, sedimentary, or metamorphic. They are made up of a variety of minerals. Quartz, feldspar, mica, and a few other minerals are found in granite, whereas calcite, dolomite, and tiny quantities of quartz, feldspar, and clay are found in most limestone. Stone, gravel, sand, silt, and clay are produced through the weathering and erosion of rocks. The parent rock determines the quality of natural aggregate. Sand and gravel formed from igneous and metamorphic rocks, for example, is more likely to be sound than sand and gravel derived from shale and siltstone-rich rocks. Natural aggregate deposited by glaciers at higher elevations may be superior to low-lying deposits. Sand and gravel that have been smoothed by agitation in water for an extended period are typically regarded as excellent quality. The boulder are broken down rocks that is extracted from rock ore or stone ore that can be transported easily. From this boulder, Coarse Aggregate is made by using crusher machine generally having diameter size ranging from 0.2 inch to 2.0 inch. Basically, the Coarse aggregate for all types of concrete with the exception of blinding concrete shall consist of hard durable crushed or broken rock and generally conform to the requirements of AASHTO Standard Specification M 80. Coarse aggregate shall be clean, free from dust and other deleterious material.

3.2 [Sources of Coarse Aggregate in Bangladesh]

Bangladesh is a densely populated, low-lying, mainly riverine country located in South Asia with a coastline of 580 km (360 mi) on the northern littoral of the Bay of Bengal. The delta plain of the Ganges (Padma), Brahmaputra (Jamuna), and Meghna Rivers and their tributaries occupy 79 percent of the country. Four uplifted blocks (including the Madhupur and Barind Tracts in the centre and northwest) occupy 9 percent and steep hill ranges up to approximately 1,000 metres (3,300 ft) high occupy 12 percent in the southeast (the Chittagong Hill Tracts) and in the northeast. With this geographic feature, there are very limited sources of Coarse Aggregate to cater the increasing demand triggered from the highway development projects and maintenance works in Bangladesh.

The “Ordinary Stone” legend at the following map shows the potential stone quarry locations in Bangladesh.

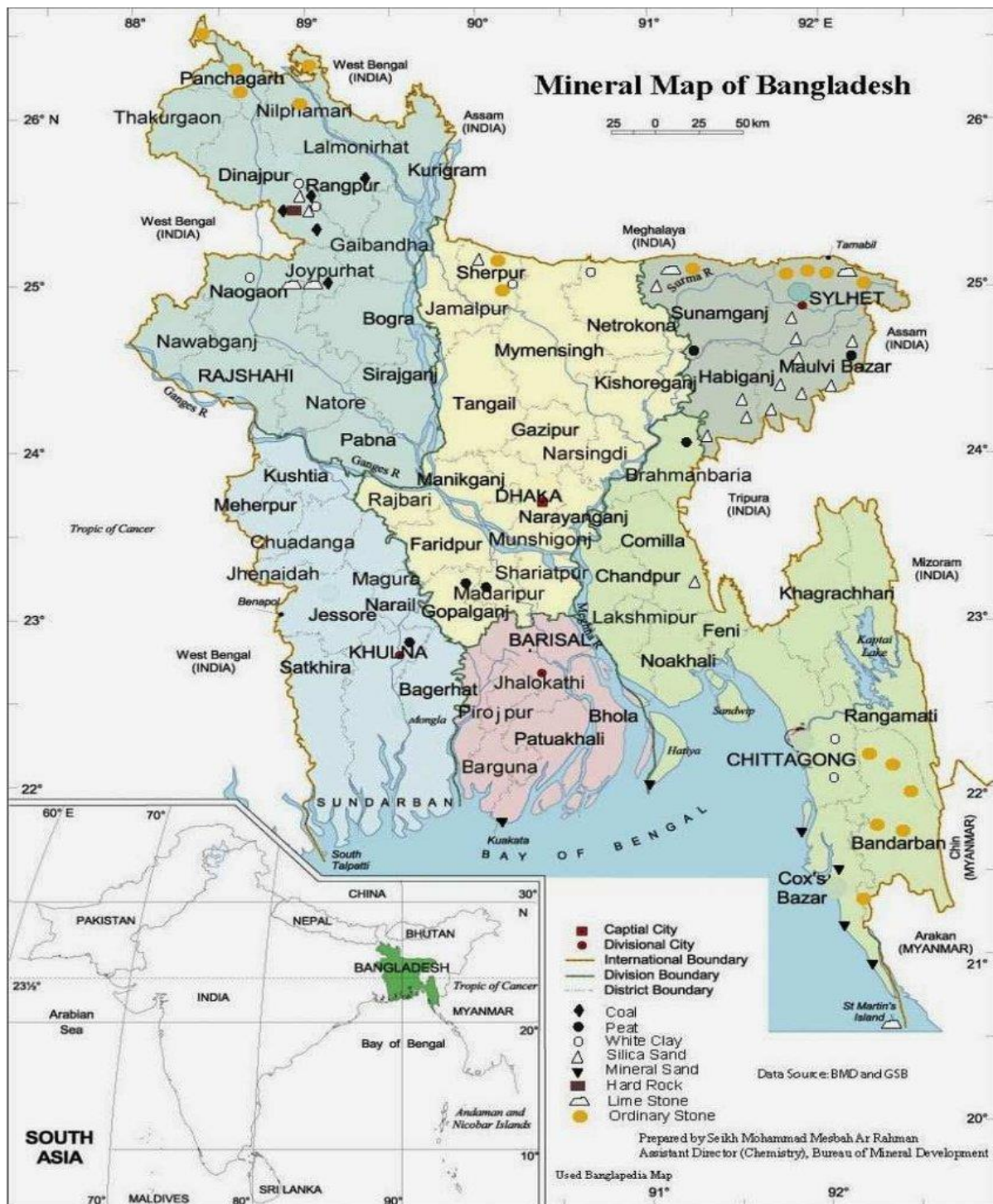


Figure 5: Mineral Map of Bangladesh (Source: Ministry of Mineral Resource)

The type and properties of the natural coarse aggregate vary depending on its source and constituents. Aggregates are mined from hard-rock quarries, natural sand-and-gravel pits, dredging submerged deposits like rivers, lakes and seabed or underground sediments. Limited

natural resources of the country can't meet the demand for coarse aggregate, and most of the natural coarse aggregate available in the local market is imported from neighboring India.

The coarse aggregate used in concrete mixing significantly affects the compressive strength of fresh and hardened concrete. Because coarse aggregates account for most of the volume in concrete, their overall properties impact the properties of concrete produced with various nominal mixes. The source, size, form, unit weight, texture, and other coarse aggregate characteristics determine their properties. The source from which coarse aggregates was collected significantly impacts their geological, mineralogical, physical, and mechanical properties. The strength, workability, and durability of concrete are all affected by variations in aggregate properties (either mechanical or physical). The overall performance and strength of concrete in both fresh and hardened stages is significantly influenced by the aggregate type by source. Different aggregate types substantially impact concrete compressive strength, with more substantial aggregate types improving total concrete strength.

Different types of natural coarse aggregate are available in the local market of Bangladesh, which are primarily imported from several regions of the neighboring country, India. There are prominently six different types of natural coarse aggregate, namely Burimari, Bhurungamari, Bholaganj, Tamabil, Jaflong, and Dinajpur Hili (Indian Black Stone), available in the local market of Bangladesh. Among these available local sources the Dinajpur Hili (Indian Black Stone) is most suitable for concreting having distinguished variation in compressive strength, splitting tensile strength and modulus of elasticity compared to other types of natural coarse aggregates.

Recently the stone from the Madhyapara Granite Mining Company Limited, being endorsed as the local source for Coarse Aggregate to reduce dependency on foreign sources, has started collecting the Coarse Aggregate and marketing to government organizations for procuring the

extracted Coarse Aggregate from their company. The Madhyapara Granite Mining Company Limited claims that they extract daily a total of 5000 Metric Ton (MT) of Granite Boulders which can be peaked to 6000 MT if required. The company claimed that the renowned testing laboratory of Bangladesh University of Engineering and Technology (BUET) has carried out the strength test and found the compressive strength of 4490 psi which is suitable for concrete construction. However, for flexible pavement construction there are available limited but better sources of Coarse Aggregate.

Chapter 4

[Challenges of Coarse Aggregate Supply chain in Roads and Highways Department]

The roads and Highways Department being crucially dependent on the supply chain of the Coarse Aggregate faces a number of challenges stemmed from both local and international factors. The challenges are listed and elaborated as follows:

4.1 [Lack of International Tender]

The local sources of coarse aggregate in Bangladesh does not have the capacity to cope up with the total demand of Roads and Highways Department. On the other hand, not all the local sources have the qualified supply of coarse aggregate to match up the required quality for the Highway and Bridge infrastructures. The procurement for the routine maintenance program is done by national competitive bidding from the local supplier directly by each local division offices, a total of 65 division offices throughout Bangladesh, of roads and highways department separately. Although The Roads and Highways Department procures only 1% of its coarse aggregate demand directly from the supplier for Routine Maintenance Program annually, but for the development projects and Periodic Maintenance Program (PMP) works coarse aggregate demand is in bulk which can be optimized for competitive international sources like Bhutan, UAE and Vietnam as well. The total demand of the Roads and Highways Department (RHD) has made it a core buyer in the industry. To ensure the quality sourcing of this huge amount of coarse aggregate can be leveraged through international competitive bidding. As the good quality sources can be availed through international competitive bidding by exploring best quality of coarse aggregate from all over the world. Besides this, the RHD can leverage a cost-effective source through international competitive bidding.

4.2 [Propensity to segregated tender through local division offices]

On the other hand, the demand of roads and highways department for coarse aggregate is the highest in Bangladesh having the bulk quantity of **22,476.28** kilometer of Highways under its jurisdiction. The tenders for the coarse aggregate are called on by the 65 division offices separately throughout Bangladesh. It inflicts the demand and supply of Roads and Highways Department segregated which lacks the opportunity of negotiation power as power and uniformity of quality. The suppliers being randomly selected add up transportation cost due to lack of prior planning. The central bidding by Roads and Highways Department (RHD) Procurement Circle can cease the opportunity of cost optimization and core buyer advantages though central bidding. The central procurement department of RHD can plan the procurement regionally to reduce the transportation cost. By accumulating the total demand of RHD for coarse aggregate in maintenance work can bring discipling and reduce wastage in the procurement as well. Instead of blindly allocating the budget in top-down approach for coarse aggregate procurement, the collection of demand requisition from all the division offices thorough the bottom-up approach can ensure the budget allocation on this purpose can be done based on equity and real time need basis. This can be facilitated through the well-planned central bidding process by the Roads and Highways Department.

4.3 [The Short Demand Period of Coarse Aggregate]

As mentioned earlier the Highway construction and maintenance works basically occurs mainly November to May month of the year, which makes the demand span only for 50% period of each year. The total supply chain remain active for the 06 months of the year and the demand of the coarse aggregate becomes more critical for this limited active period supply chain. The total demand of the coarse aggregate has to be supplied within 03 months to utilize

it within the dry season of the year. Eventually it raises the price of the coarse aggregate for demand and supply. On the other hand, the supply chain must be well planned to get the adequate supply of the coarse aggregate.

4.4 [Dependence on the monopoly foreign source of Coarse Aggregate]

The optimum supply of the qualified coarse aggregate is sourced prominently from the neighboring country India for “Pakur-Stone”. Managing the supply at bulk amount from a single foreign source makes the supply chain more vulnerable. Although in crisis moment the contractors look out for the sources of coarse aggregate at limitedly available at United Arab Emirate (UAE), Qatar and Bhutan, but these sources are not completely reliable owing to their limited supply as well as compromised quality of coarse aggregate. Furthermore, political instability or geopolitical relation with a specific source country can adversely impact the solely dependent supply chain of coarse aggregate.

4.5 [Fluctuation of International Market Rate of US Dollar]

The present economic condition of the country, owing to the geo-politics and fiscal policy of the country, is ultimately juggling with international Dollar rate. The price of the BDT currency has chute-down against the US dollar price which has impacted adversely every sector including the coarse aggregate supply chain. The suppliers have faced challenges in the arrangement of LC (Letter of Credit) issuance form the Banks which has impeded the import of the coarse aggregate from the foreign sources and ultimately the price of the available scanty amount of coarse aggregate from local sources became surprisingly high.

4.6 [Environmental of Stone Quarry extraction for Coarse Aggregate]

The coarse aggregate are collected from natural source stone ore which has an adverse impact on environment and social lives of people. The uncontrolled and unscientific extraction of

granite and boulder which is later crushed down to coarse aggregate, can lead to land slide and air pollution as well. The Jaflong area in Gowainghat Upazila is claimed to be in critical condition and is losing its appeal as a tourist spot because of the air and noise pollution emanating from the stone quarries there. In 2016, the Mineral Resources Ministry of Bangladesh banned stone extraction from five quarries from Sylhet namely– Jaflong, Bholaganj, Shah Arefin Tila, Bichhanakandi and Lovchora – to prevent environmental disasters. The High Court banned the use of stone crushers at all quarries in Sylhet based on a writ filed by Bela in 2014. These quarries were the prominent source of local coarse aggregate in Bangladesh. The lack of oversight control or supervision in the extraction can push this quarry industry to the brink of extinction, converting our local traders and suppliers towards foreign monopoly sources.

Chapter 5

[Conclusion]

The supply chain of coarse aggregate is significantly crucial for the Roads and Highways Department being the most vital raw material of Highways and Bridge Infrastructures. The challenges faced by the supply chain of coarse aggregate encompass the Political, Economic, Sociological, Legal and Environmental aspects of national as well as international arena. The challenges arguably cannot be eliminated overnight but can be mitigated to a considerable extent. In this regard, a collective approach from the suppliers, buyers and policymakers is highly required to optimize the impacts stemming from these challenges.

Chapter 6

[Recommendation]

6.1 [Multiple Sourcing of Coarse Aggregate]

In this report compared to the local sources the quality of international sources for coarse aggregate was highlighted as superior. However, the suppliers are dependent on the supply of Indian Quarries boulder for grinding to the coarse aggregate which makes the market non-competitive. Therefore, the suppliers should opt for other international sources like China which is currently third largest exporters of Stone Boulders and has a long-standing trade relation with Bangladesh can be utilized to import coarse aggregate boulders through waterways. Besides this, Bhutan, currently at second position in boulder exporting countries, had been one of the most potential source of coarse aggregate based on the requirement criteria.

6.2 [PESTLE Analysis based recommendations]

As the supply chain of coarse aggregate for Roads and Highways Department does not limit itself within that government agency rather impacts all the PESTLE aspects encompassing Political, Economic, Sociological, Legal and Environmental areas of National and International Avenue. We tried to explore the solution involving those specific areas of PESTLE spectrum.

(a) **Political:** For any trade or business political stability is a uncompromising requirement.

Although it is nearly impossible for a specific group to control the political situation, let alone the geo-political stability. From last few years the supply of coarse aggregate material (boulder) from Bhutan has reduced manifold and price of Indian Pakur stone has increased as well. Inter border relation with the neighboring countries can impact this Highway infrastructure industries significantly. The government of Bangladesh can

come up with some MoU or treaty so that these imports of coarse aggregate can be smoothen up. As part of this, on 22 March 2023 Bangladesh and Bhutan signed the "Agreement on movement of traffic-in-transit and its Protocol" on 22 March 2023 in Thimphu, for establishing arrangements for multi-modal communication channels via road, waterways, railways and airways between Bangladesh and Bhutan. Additionally, to finalize mechanism and legal basis for effective waterways connectivity with Bhutan and to ensure utilization of Bangladeshi sea ports by Bhutan, a Standard Operating Procedure (SOP) for the MoU on the Use of Inland Waterways between Bangladesh and Bhutan was signed on 15 September 2022 in Dhaka. Moreover, an MoU on the Use of Inland Waterways between Bangladesh and Bhutan was signed in 2017 and has been renewed for five years (until 2027) in September 2022.

- (b) **Economic:** The Dollar Crisis which has risen up to its peak like never before, has made every trade and business choked up. As export and import are highly impacted by the Dollar rate there were recent precedence of bilateral currency agreement for loan payment. The government can take up this initiative for the core sources of coarse aggregate to leverage the diplomatic relations with the neighboring countries. On the other hand, to mitigate the crisis for a limited period the import duty on the boulder can be readjusted to reduce the burden on the importers.
- (c) **Legal:** The government has already put restrictions on some of the stone quarry of Sylhet region. Apart from putting embargo on the coarse aggregate extraction, the traders involved in the stone quarry should be encouraged to follow scientific procedure taking into account of the environmental and social impacts of the stone quarry extraction, so that the other local sources can be utilized in an optimum manner safeguarding the national interest.

- (d) **Sociological:** The quarry of stones involves the local labour to crush the boulders to get the coarse aggregate in Bangladesh. As it involves health risks for the workers the stone quarry traders should arrange necessary health protection and insurances for the workers involved in this profession and ensure justified remuneration for them as well.
- (e) **Environmental:** The stone quarry impacts in the landscape degradation, Habitat destruction, Air and water pollution, Loss of natural carbon sinks, Eradication of biodiversity, Disruption of natural streams and springs, Lowering of the water table, Land collapse and sinkhole formation etc. The government should give importance in exploring other stone quarry sources so that the existing stone quarries can be extracted to a minimum level reducing the environmental impact. As already these environmental concerns of Stone quarry have been surfaced by the Bela foundation, proper measures should be taken to implement the restrictions. At the same time for the implementation of proper scientific technique and act upon it, the stone quarry traders should be made well informed and motivated positively.

Lastly the Roads and Highways Department (RHD) is facing currently the most critical challenges in managing its core raw material i.e. coarse aggregate which is utilized in the construction of mega projects and maintenance of existing highways under its jurisdiction. It is said that a supply chain is as strong as its weakest link. Therefore, a holistic approach from RHD, suppliers, buyers as well as Governments across the borders can bring about a sustainable solution to this critical sourcing of Coarse Aggregate for Roads and Highways Department as well as for the interest of connectivity development of the South Asian region in broader narrative.

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Appendix A.

An Example of an Appendix

Appendices should be used for supplemental information that does not form part of the main research. Remember that figures and tables in appendices should not be listed in the List of Figures or List of Tables. Refer to the Thesis Template Instructions for more information.