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Naveed Anjum, Muhammad Ashikur Rahman, Md. Mynul Islam, Md. Munir Hasan
Bangabandhu Sheikh Mujibur Rahman Maritime University, Bangladesh

OVERVIEW OF POPULAR RAW MATERIALS IN SHIP BUILDING AND A SUSTAINABLE APPROACH FOR THIS INDUSTRY IN BANGLADESH

Abstract

One of the key driving factors of Human development has been our ability to traverse and conquer new ground. The Shipbuilding industry has played a significant role in this aspect by providing the aptest mode of transportation, our floating vessels, which has served us well throughout history and partaken in many revolutions. The materials for building such vessels have seen many variations and iterations stretching from Tree barks & wood to the modern use of Alloy and other synthetic materials. Many supplementary materials are also used nowadays for building a well-functioning vessel and the trade of these materials among various nations also plays a key part in moving its industry forward.

The prices of these materials also see many variations, as many contributing factors allocate in their procurement and handling. But, the recent outbreak of the Corona virus pandemic has created many implications with the shipbuilding industry also being largely affected in many ways. In these trying times, Bangladesh has remained strong with a solid base and good initiatives could play a significant role in further enhancing this country's shipbuilding industry. This paper tries to highlight the popular trends in the Shipbuilding market and plot a series of sustainable approaches which could ensure Bangladesh's progress in the long run.

Keywords: shipbuilding, raw materials, COVID pandemic, price trends, Bangladesh.

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Навид Анджум, Мухаммад Ашикур Рахман, Майнул Ислам, Мунир Хасан
Морской университет Бангабандху Шейха Муджибура Рахмана, Бангладеш

ОБЗОР ПОПУЛЯРНЫХ СЫРЬЕВЫХ МАТЕРИАЛОВ В СУДОСТРОЕНИИ И УСТОЙЧИВЫЙ ПОДХОД В ДАННОЙ ОТРАСЛИ В БАНГЛАДЕШ

Аннотация

Одним из движущих ключевых факторов человеческого развития была наша способность проходить и завоевывать новые территории. Судостроительная промышленность сыграла здесь значительную роль, предоставив самый подходящий вид транспорта – плавсредства, которые хорошо служили нам на протяжении всей истории и участвовали во многих революциях. Материалы для изготовления таких судов претерпели множество изменений и повторных циклов разработок, начиная от древесной коры и дерева и заканчивая современным использованием сплавов и других синтетических материалов. Также в настоящее время для строительства хорошо функционирующего судна используются многие дополнительные материалы, и торговля этими материалами между различными странами также играет ключевую роль в продвижении судостроительной промышленности.

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Для цитирования: Навид Анджум, Мухаммад Ашикур Рахман, Майнул Ислам, Мунир Хасан. Обзор популярных сырьевых материалов в судостроении и устойчивый подход в данной отрасли в Бангладеш. Труды Крыловского государственного научного центра. 2022; 4(402): 161–172.

Цены на данные материалы также очень различаются, чему способствуют многие возникающие при закупке и обработке данных материалов факторы. Но недавняя вспышка пандемии коронавируса (COVID) привела к многочисленным последствиям, и судостроительная промышленность также во многом пострадала. В эти трудные времена Бангладеш остается сильной страной с прочной базой, и удачные начинания могут сыграть значительную роль в дальнейшем развитии судостроительной промышленности страны. В данном документе предпринята попытка выделить популярные тенденции на рынке судостроения и наметить ряд устойчивых подходов, которые могли бы обеспечить прогресс Бангладеш в долгосрочной перспективе.

Ключевые слова: судостроение, сырьевые материалы, пандемия коронавируса (COVID), тенденция изменения цен, Бангладеш.

Авторы заявляют об отсутствии возможных конфликтов интересов.

Introduction

Введение

Developments in the Shipbuilding and vessel building industry have been a constant feature of progression and sustenance for civilizations throughout history. Most historians believe it began as early as 4000 B. C. supported by an Abydos boat of Ancient Egypt which is currently considered the oldest ship in existence having been recovered from Abydos and carbon-dated approximately 5000 years old.

Large Ships began to be built during the Roman Empire and pieces of evidence of ancient large ships have been found in Asia in China, as well as Nordic Scandinavian Viking Ships of Europe. But it wasn't until the middle ages that Shipbuilding became an integral part of the World Economy. Sailing ships became viable means of long distance transport by around 1450 AD during which phase historians believe it gained proper economic and strategic importance having become a labor-intensive assembly operation carried out on a seasonal basis during a phase where France, Britain, Holland, Spain, and Baltic ports became major shipbuilding centers.

The British influence throughout the 1800's provided access to improved technology and building practices in the early stages of the industry. (President, 1996), thus beginning an era for major shifts for advanced materials and technological advancements in this industry. In 1913 U.K. yards produced 58 % of world output. Germany ranked next, accounting for 14 %; who built very large vessels and would go on to develop the revolutionary diesel engine in 1914 (Bullers, 2014) and after 1945, international trade increased at an unprecedented rate, causing the world's fleet to double in size (Staniforth & Shefi, 2014). American Shipbuilding specialized in the construction of large ships exceeding 5,000 tons and would go on to become the major shipbuilders of the latter half of the 20th century. (Thompson, 2005) Overseas shipbuilding in the Early Modern period carried major implications for European powers. But, in later years, the shift of

power for this ever-developing industry became transitional and is nowadays passed around according to the extent of potentiality for success.

The world went from wooden ships to modern-day alloy-infused ships but did see many shifts and variations. With the advent of material technology came the advent of competition in the material market. In the early stages, ships of Antiquity were assembled by the mortise and tenon fashion. Different types of wood were used for different specified parts of ships. Until the Middle Ages, all Nordic ships had inbuilt clinkers using the shell-first method. In the Nordic countries, where wood is abundant, commercial wooden shipbuilding ceased to exist only recently. Wooden ships were constructed on a building berth, around which timbers and planking were cut and shaped, then fitted together on the berth to form the hull; a similar practice which was followed up by iron vessels and, later, with the earlier steel ship models, as these tended to be replicas of the older solid wooden hulls (Tsoumis, 2013).

Iron gradually came into more effective use in its own right, rather than be termed a substitute for timber/Lumber. Iron was used previously only for components such as anchors. Popular consensus is such that most of this ironwork was present in 1805, though it is completely hypothetical. Economic difficulties during the First World War obliged the Allied governments to cooperate for improving their supply capacities. As the historian, Georges-Henri Soutou wrote: "Within the summer of 1917, the problem of raw materials came at the first plan of the Allied concerns. The war drastically altered the structure of global trade and led to a "Decentralization of the international economy". Prior to 1914, Europe and North America were the industrial leaders that made the highest added-value products, whereas the other continents supplied them with cheap raw materials. This "centre-periphery" pattern changed during the war. (Peters, 2006) The USA, Eastern Asia, and the dominions witnessed a broad industrial growth at the downfall of Western European markets. The European countries imported more manufactured goods and saw their raw material import levels fall by almost 50 %.

On the contrary, Far East Asia had a different outcome. Europe's decline helped their industry to be developed at an exponential rate, especially in Japan. The exports of raw materials also increased in order to supply new industries with natural and manufactured resources being acquired both from nearby and further afield, as was labor. Vessels continued to be constructed in both Tasmania and South Australia up until the 1940's and regular ketch services to outposts in South Australia continued into the 1960's. (Bullers, 2006) Japan used its steel shipbuilding techniques in the 1950's and 1960's to rebuild their industrial structure; South Korea started to make steel shipbuilding a strategic industry in the 1970's. Thus, throughout the next few decades and into the turn of the century, the Raw Material market shifted towards the Heavier Steel Commodity. Now-a-days, this industry primarily focuses on expansion and conservation with profiteering being a key influence.

The ongoing Covid pandemic has significantly impacted all worldwide industries and the Shipbuilding raw material market is no exception. The accounted number of sustainability measures available for quantifying development is overwhelming to planners, scientists, and policymakers. Hence, clarification of interrelationships, redundancy, and spatial distributions is needed. (Shaker, 2015) Professor Gunter Pauli's use of the term "BLUE ECONOMY" in his book "The Blue Economy: 10 years, 100 innovations, 100 million jobs" probably was a wealth invention strategy through nature inspired derivatives based on environmental correctness.

But its implications were solid enough for World leaders to focus a huge portion of their attention on the Maritime sector and the Shipbuilding industry as a whole. The increasing focus on Globalization demands a swift and widely accessible ability to move raw materials, components and finished products across our worlds' waterways. The Shipbuilding industry makes it possible in a mature and fairly stable way. (Of et al., 2015) Considering this attribute, the government of Bangladesh is considering projects and policies which could help its shipbuilding and raw material industry eclipse into newer horizons and concurrently improve its trade relations with leading nations.

Prior to Covid, Bangladesh had a highly progressive Shipbuilding industry and a good trade system that saw Raw materials get shipped swiftly and efficiently to firms and investors. Though predominantly an Importing nation, new archaeological discoveries are helping the nation overcome many chasms and debts that may prove to be more sustainable than most

nations, especially those affected by the Covid crisis. As a result, many more sustainable approaches can be entertained as mentioned in the latter part of this paper and, based on the data represented could serve as proper recommendations for our industry moving forward.

Methodology

Метод

The subject of the Empirical study was the result of archival research and secondary data collection of the related field from previously cited documents and surveys collected through different portals. The author applied Statistical evaluations to the collected Data and represented them through tables & Illustrations. The aim of the research was to highlight key information from the sources and clarify its stance in establishing the justification of the research topic. A recommendation model was then added in the latter part of this paper to enhance the clarity of the aimed research.

Popular Ship Building Raw Materials

Популярные сырьевые материалы в судостроении

The Materials used for Shipbuilding are similar to most other construction projects. They include but are not limited to Iron, Steel, Aluminium, plastics, and so forth. Even these diverse materials have some common factors in terms of their properties (Toughness, Ductility & Malleability) which make them useful for the task. Apart from these, some necessary factors contribute to the selection of materials as-well. Illustrated below is a diagram highlighting requirements for proper shipbuilding (fig. 1, *see the plate*).

It is no surprise that the Shipbuilding industry needs constant expenditure in the workforce and raw material procurement. Hence, the pricing of Raw materials & the availability of these materials also plays an important role in the projects related to the industry. Below we will see some of the popular Ship Building Raw Materials and get a brief insight about them (table 1).

The Price trend of these materials is shown below (fig. 2, *see the plate*).

We applied a Standard Deviation on calculated prices and derived the probable range of the aforementioned Raw materials on a global scale through the use of Standard Bell Curves. The Price Deviations of these Materials are shown below (table 2).

Table 1. General Overview of Popular Shipbuilding Raw Materials. (Authors interpretation from Market research)

Таблица 1. Общий обзор популярных судостроительных сырьевых материалов (интерпретация авторов на основе исследования рынка)

Raw Material	Popular Types Used in Shipbuilding	Ship Parts Used In	General Advantages	General Disadvantages	Leading Exporter
Wood	1. Oak 2. Cedar 3. Ash	1. Ship Apron 2. Beams 3. Classical Boat Stem, Deck, Hulls & Spar Construction	1. Buoyant 2. Properly dried timber is Climate Resistant 3. Was abundant during the early middle ages	1. Unfit for Modern-day heavy construction for many reasons 2. Aids in the cause of Deforestation	Canada
Iron Ore	1. Wrought 2. Cast	1. Hulls 2. Plates 3. Lesser Fittings	1. Directly helps in Steel Production 2. Was Ideal during Industrial revolution and throughout Middle age Shipbuilding 3. Helps strengthen overall construction of Ship 4. Abundant in Mines and Naturally 5. Easy to extract	1. Is Gradually gaining Price due to ongoing pandemic 2. Releases Toxins in the air during extraction	Australia
Steel	1. Mild Steel (Grade-A, B, C, D, E) 2. Medium Carbon Steel (0.3–0.5 % Carbon) 3. High Carbon Steel (0.5–0.7 % Carbon) 4. Stainless	1. Overall Construction of Ship (Plates, Beams, Bars, Billets etc. to name a few) 2. Utilities and Structures aboard 3. Derrick Booms, Strakes, Keel, Crosstrees, Mast Tables	1. Superior Tensile Strength, Hardness, Bending capabilities. 2. Superior resistance in Impact & Fatigue 3. Ideal for Modern Shipbuilding	1. Has high corrosive properties in comparison to alternatives 2. Genuine Heat Conductor, causing discomfort to crew on sunny days	China & Indonesia
Alloys	1. Aluminum 2. Titanium 3. Zinc 4. Copper/Nickel	1. Hot Rolled Plates & Ballast Tanks 2. Hull Alternates & Undersea parts of a vessel 3. Rudder & Propeller Parts	1. Lighter than Steel by almost 60 % 2. Superior Corrosion-resistant & reduced Hull Breach 3. Non-magnetic & Low maintenance Cost 4. Allows design of narrower ships which increases Fuel Efficiency & Ship stability 5. Best Insulators in terms of Metalloid	1. High Initial costs (10 times that of steel) 2. Requires Great skill set for production and promulgation 3. Requires substantial amount of Time for project applications	Canada USA Chile South Korea
Ceramics & Glass	1. Ceramic Paint 2. Insulator parts 3. Resins 4. Glass Fiber	1. Sandwich Structures 2. Electromagnetic Shielding 3. Onboard Structure Joints 4. Ship Hull Coating	1. Non-magnetic and Light-weight 2. Ideal insulators, corrosion resistive & Viscous in Sea-water 3. Fire and Shock Resistant	1. Low Tensile Strength 2. Very Stiff 3. Not recommended for Heavy Construction	Spain & China

Table 1. Continuation
Таблица 1. Продолжение

Raw Material	Popular Types Used in Shipbuilding	Ship Parts Used In	General Advantages	General Disadvantages	Leading Exporter
CFRP	1. Carbon Composite 2. Polyacrylonitrile (PAN) 3. Foils	1. Propellers 2. Hulls for Smaller vessels (Boats, Kayaks) 3. Special Ships (Fiber Ships)	1. Non-magnetic & Light-weight 2. Flexible & functional for multiple purposes 3. Ideal for Collision & Impact Resistance 4. Cheaper in comparison to others 5. Makes vehicles faster and more efficient 6. Heat resistant 7. High corrosion & Fatigue durability	1. Environment Deterrent 2. Requires expert skill set for handling 3. Unfit for Heavy construction	USA
Rubber	1. Chlorinated 2. Natural	1. Fenders 2. Airbags 3. Coating 4. Gaskets 5. Onboard Pipes and other small materials	1. Ideal for Collision & Impact Resistance 2. Non-magnetic & Light-weight 3. Flexible & functional for multiple purposes	1. Unfit for Heavy construction 2. Requires expert skill set for different uses	Thailand

Table 2. Standard Deviation among the popular Raw Materials in the past 5 years (authors' calculations)

Таблица 2. Стандартное отступление от норм, стандартов и т.д. среди популярных видов сырьевых материалов за последние 5 лет (расчеты авторов)

Raw Material	Using 68–95–99.7 % Rule (Price Range in USD)		Current Global Price
	68 %	95 %	
Wood	340.68–1368.35	–170.7–1874.7	\$806/MBF
Iron Ore	76.02–186.76	20.65–242.15	\$127/Ton
Steels	Steel		\$4901/Ton (Approximate Combined Weighted Average)
	658.1855–864.8745	554.8409–968.2191	
	Stainless Steel		
	600.13–1118.23	341.08–1377.28	
Alloys	Aluminum		\$4650/Ton (Approximate Combined Weighted average)
	2503.478–3000.77	2254.834–3249.41	
	Titanium		
	3090.655–3631.151	2820.407–3901.399	
	Zinc		
	2903.438–3722.262	2494.025–4131.675	
	Copper/Nickel		
	6262.308–9547.592	4619.665–11 190.23	
Ceramics & Glass	Ceramics		\$6821.2/Ton (Approximate Combined Weighted Average)
	3102.85–3153.55	2942.5–3223.9	
	Glass		
	9019.1–10 330.68	8363.31–10 986.47	
CFRP	8837.68–16 762.32	4875.36–20 724.64	\$21 500/Ton (Approximately)
Rubber	1.85–2.71	1.42–3.14	\$2.12/kg

Comparison among Leading Exporters

Сравнение ведущих экспортеров

From Different sources and Calculations we determined that the USA, Germany, China, and Japan had the best grip over the Shipbuilding Raw Materials Trade market. The table below (table 3) highlights the exports of these nations and sets up the comparison (the export values are in USD Billion).

The table highlights that the Asian market dominates the Shipbuilding Raw material market and China is the leader economically and trade-wise the USA tops the charts. Even the Corona-virus pandemic couldn't halt most of their progress and research shows that they have the upper-hand in the overall Raw Material market in the Worlds Shipbuilding sector.

Effect of COVID pandemic on Ship-building industry and procurement of Raw Materials

Влияние пандемии COVID на судостроительную промышленность и закупки сырьевых материалов

The outbreak of the COVID-19 pandemic has sparked many urgent questions about the impact of pandemics and its effects on our real economy. As Shipbuilding is now often considered a key contributor to the World Economy, failure to cope up with the outbreak has also resulted in huge losses for the sector. As the COVID crisis engulfed investors, predictable consequences came into play primarily through chaos, followed by a huge loss of perspective which left most unbalanced. As market stocks dropped from COVID effects, global indices around the world were down substantially. Every equity index was substantially between February 14 and March 23, 2020; which has been termed the melt-down phase of the crisis (Damodaran, 2021). While

every index did recover in the following months, some didn't bode better than most. Oil Prices were down to below 0\$ to -37.63\$ per barrel.

This caused a massive plummet in the production & Collection of Crude oil, Shale oil & Fuel, which are essential commodities in the Shipping industry. This up-rift caused massive shifts in the Supply Chain of the industry and also managed to affect the project flow in the industry. Supply chain network design (SCND) which determines the structure of a chain and affects its costs and performance, deals with a variety of decisions such as determining the number, size, and location of facilities in a supply chain and may include tactical decisions as well as operational decisions. (Farahani et al., 2014) were in shambles due to lack of manpower and execution.

Thus, it created a massive up-rift on the global scale. The Shipbuilding and maritime transport industries which are separate industries but inextricably linked and mutually dependent through the degrees of vertical and horizontal integration are high were also largely affected. This principally occurs into two main forms: supplies and subcontracts (Balance, 2014) but, were disrupted by the crisis where an overload of projects and inability to provide labor-force combined to bring the industry to virtual collapse. Thus, the effect on the World Economy was seen clearly in this industry as a whole and this is supported by narrative evidence from contemporary newspapers, which report significant declines in output and sales across several industries due to labor shortages and falling demand. (Correia et al., 1918)

Affected by the Covid-19 pandemic, analysts in 2020 concluded that, the global new shipbuilding market remained constantly sluggish. They also mentioned that pessimistic expectations in the global shipbuilding would still gradually increase throughout 2021. New ship transactions would decrease significantly, and the number of new ship orders received by major ship-

Table 3. Rank Comparison and Economic comparison of Leading Shipbuilding raw material exporters

Таблица 3. Ранжирование и экономическое сравнение ведущих экспортеров судостроительных сырьевых материалов

Country	Material							Rank Quotient (Average)	Rank	GDP Growth Rate
	Wood	Iron Ore	Steel	Alloy	Ceramics and Glass	CFRP	Rubber			
USA	2.804	0.847	12.127	3.4	2.59	45.3	0.0641	0.863	1	5.7 %
Germany	2.294	0.117	22	4.37	3.38	8.67	0.088	0.835	2	4.56 %
China	4.486	1.6	33.8	6.434	9.32	17.3	0.022	0.814	3	9.16 %
Japan	0.054	0.0066	23.4	3.36	1.59	27.1	0.007	0.767	4	3.4 %

building countries would also decline constantly (Jiang & Hansen, 2013). Between January to November of 2020, China received several orders for new ships of 22.52 million DWT, which was a significant decrease of 8.7 % from the year prior. Orders for exportable ships were 19.77 million DWT, seeing a huge year-on-year decrease of 13.5 % while, export orders accounted for only 87.8 %.

In the same period, Japan's orders for new ships/vessels also dropped by a staggering 66.7 %, and South Korea's orders also dropped by 8.4 % as per year-on-year accounts. In this period as-well, China's shipbuilding completions, new orders, and hand-held orders accounted for 40.4 %, 50.8 %, and 46.9 % of the global market, respectively which were all significant losses. As a necessary counter-measure, on November 15, 2020, the ten ASEAN countries formally signed the Regional Comprehensive Economic Partnership Agreement (RCEP) which currently is the world's largest free-trade zone. The establishment of the RCEP free trade zone means that almost one-third of the world's economy will become an integrated market with 90 % of good trade achieving zero tariffs and achieving zero tax in 10 years.

According to the analysis, the RECP taking effect will greatly promote the exchange trade between the contracting states, thereby promoting the rapid development of intra-regional and external maritime trade. But, if the pandemic continues, the global shipbuilding industry will continue to incur losses in 2021 and may not gradually recover until the end of 2022 with the Raw Material Shipping trade being one of the most affected. It is therefore important that both shipyards and buyers carefully consider their legal position under their obligations and agreed contracts, while further ensuring that their position regarding any delays to vessel construction is efficiently protected and maintained.

Shipbuilding Raw Material Industry In Bangladesh

Сырьевая промышленность судостроения в Бангладеш

At present Bangladesh has been identified as one of the most notable nations that could capture that Maritime dream. Gimenez, et al. (2014) stated that the vision 2021 plan and the associated perspective plans for 2010–2021, adopted by the Government of Bangladesh laid out a series of development targets for 2021. As Bangladesh has been sited as the world's largest delta, for obvious reasons more than 90 % of its trade is transported by its sea and rivers. Pre-

Covid, the Dry docks of Bangladesh were mending about 15 ships annually while earning foreign exchange. (M.R. Rahman, 2017)

At present, ships built in Bangladesh are exported to around 12 countries in Asia, Africa, and Europe. The Bangladeshi shipbuilding industry has been exploring export market opportunities in the niche segment of small vessels (below 12,000 dwt). Annual market value of local shipbuilding currently reaches about \$1 billion, and the demand growth has been forecasted to remain progressive. The World Bank Group estimates that Bangladeshi shipbuilding grows at 10–15 % per annum on average for the next decade. Over 80 % of materials and components are imported for either export or ocean-going vessels, while vessels for inland waters has broadened local supply basis more up to 50 to 60 %.

This industry not only earns foreign exchange but also saves a huge sum; whereas in road and rail transportation about 100 % of transport vehicles/rolling stocks need to be imported from abroad. (M.R. Rahman, 2017). Considering that the average import growth rate is 15.79 % (last 10 years) and the export growth rate is 15.43 % (last 10 years), the projected value of freights in the next ten years could be around USD 435 billion. There are more than 300 shipyards and Workshops in Bangladesh along with an almost 100 % of the required marine vehicles being built by these yards.

Bangladeshi shipbuilding can enjoy labor cost competitiveness of 20 to 30 % relative to other countries, according to a local trade body and has competitively-priced skilled engineers and semi-skilled workers. Tailor-made training opportunity for shipbuilding is also available under the cooperation between the government and industry association, which generates 6,000 workers every year and matches over 70 % of them with job opportunities in the industry. Thus, there are many reasons why Bangladesh's shipbuilding industry is now often considered its primary source of international investment.

Bangladesh is predominantly an importing nation. Due to a lack of discovered resources, Bangladesh mainly relies on its business with the trading nations. As a result of this we often see our country's marine resources hugely unexploited. Bangladesh's major trading partners for both imports and exports are the USA, India, Japan, China, Australia, South Korea, Hong Kong, Malaysia, Indonesia, Taiwan, Saudi Arabia, UAE, and other European countries. As per 2019 reports, Bangladesh imported a reported US\$50 Billion worth of commodities in the world. Its top imports are summarized below (fig. 3, *see the plate*).

The chart initially highlights that around 40% of the top imports are directly integrated with the Shipbuilding industry and 32 % are directly interlinked in the Raw Material Trade for this industry as-well. The corresponding extension of the chart further highlights that 39 % of Bangladesh’s imports come from top Shipbuilding nations and China already being established as the Leader in the industry also predominantly encompasses 21 % (\$17.3 Billion) of their overall trade.

Metals used in the Shipbuilding industry have attributed to a massive \$5.22 Billion in imports which was also dominated by Scrap Iron (21 %), Flat Rolled Steel (5.53 %) and, Aluminium (4.69 %) which are the basic materials for Ship Hull Construction. Rubbers, Glass, Plastics, and Ceramics which are used for insulation in the Ships body accounted for over \$3 Billion in trades as- well with Rubber Tires, Glass Fibers and CFRP combining over \$400 Million alone. Hence, Bangladesh is certainly trying to invest in its Shipbuilding industry which highlights proper intent.

Only as recent as 2019 did Bangladesh discover an Iron Ore Mine in Dinajpur. As reports suggest it has a 400 foot Thick Iron Layer and covers an area between 6–10 Square Kilometers. Thus Post Pandemic phase, if proper work is initiated in similar excavations like this, Bangladesh can start its own export for Raw Materials and also tone down on the imports. But already Bangladesh earns a huge sum from the Metals, Rubber & Fiber industry with revenue-generating at \$124 Million, \$129 Million and \$61.3 Million respectively from the export of these industries alone.

Bangladesh’s exports are predominantly lead by the American and European markets with the USA (\$6.86 Billion) and Germany (\$6.69 Billion) alone. As previously stated these nations are also top in the Raw Material Trade for the Shipbuilding industry and hence, Bangladesh’s connections with the industry are fully integrated as all OEC trends suggest. Thus, this industry only requires care and proper implementation to fully reach its designated potential.

A Comparison of most used materials in Bangladesh

Сравнение наиболее часто используемых материалов в Бангладеш

Bangladesh has a rich history in building ships for Royalty but is only now learning the benefits of modernization. As a result, heavy metals such as steel are still their go-to material for the overall basis of the ships. Though they entertain the idea of using other materials in ship construction, many factors contribute in the selection of basis material. Below is a comparison of basis Raw Materials in Bangladesh (table 4).

Thus, for many reasons, Steel is the most used material for the construction of Ships Hull and the overall body of ships in Bangladesh. Other materials such as Rubber, Ceramics & Glass attribute in creating the minor but essential touches in the overall construction of a ship. Bangladesh is mainly preferred for its budget in Ship construction and low labor costs aid in that aspect. Hence cost is a huge criterion in the procurement of basis material in the shipbuilding industry of Bangladesh. But, overall labor costs for maintenance over an extensive period also contribute in selection of metals, which is why, Alloys are ideal for the long-term plans. But, as previously mentioned, Bangladesh is a developing nation in Shipbuilding aspects and the Covid Pandemic has changed the economic perception. Hence, the selection of Steel is justified at the moment.

A Sustainable Approach for this Industry in Bangladesh

Устойчивый подход в данной отрасли в Бангладеш

The terms “sustainability” and “green” being often used “interchangeably”, have gained due recognition in the architecture, engineering, and construction issues over the past few decades. The World Commis-

Table 4. Comparison of strengths of primary building materials

Таблица 4. Сравнение прочности основных строительных материалов

Material	Tensile Strength (σ) In Mpa	Youngs Modulus (E) In Mpa	Fracture Toughness (K) In Mpa	Cost In USD/tonnes
Steels (Estimated Averages)	2693	200	175	4901
CFRP	1100	180	70	21 500
Alloys (Estimated Averages)	850	86	76	4650
Wood	83	11	41	806

sion on Environment and Development in 1987 defined sustainability as “the project to meet present needs without compromising the ability of future generations to meet their needs”. However, sustainability is not just about the cause, it also offers equally economic, environmental, and societal benefits. In other words, the concept of sustainability can be as a functional engine whose gears are environment, economy, and society. The Diagram below depicts the authors’ ideas (fig. 4, *see the plate*).

Bangladesh’s Ship building industry is on the brink of global expansion and the opportunity to implement a sustainable base for promulgation is its biggest benefit. As the world reels from the impact of various environmental breakdowns, industries are required to play their role to reduce the negative impacts and disturbances to nature. (A. Rahman & Karim, 2015) The Covid Pandemic highlighted our nation’s cracks in its approaches for sustainability and thus it is high time rectifications came into play. The points below can be considered the authors’ perception into the matter.

- Implementation of a green Supply chain in the Shipbuilding industry can be the ideal initiative. In the Automotive industry, demand for greener products has remained since the 1970’s and 1980’s. Contrastingly, the shipbuilding market sets it apart through industrial customers but ultimately lags behind in comparison to other more consumer-oriented industries which apply green technologies and work approaches. Ship firms usually exploit their ships for delivering cargo. Ship-owners nowadays request shipbuilders to offer environmentally friendly ships, and employ sustainable production processes, as the ship-owners themselves are experiencing pressure from government agencies to comply with environmental rules and regulations.

Conditions like these ensure shipbuilding firms & their material suppliers to participate in green activities and adopt proactive environmental management practices that improve the environmental performance of the entire chain. Governmental involvement can influence company initiatives by offering capital remuneration for purchasing environmental products, or by indirect encouragement/discouragement via varying tax rates. Competitive advantage by going green and social responsibility, have shown to have significant influence on the willingness to participate in Green Supply Chain Management (GrSCM).

Therefore, focal companies should identify suppliers with a powerful financial and human resources

allocation to properly ensure compliance with their requirements. Companies could start training their workforce (those who especially deal with purchasers) to apply environmental tools such as designs for environmental layout, life-cycle analysis, recycling, and other environmentally proactive practices in order to create environmental awareness inside the focal company as well as in the supplier companies, which will consequently benefit their GrSCM schemes and practices. They can reach out to support suppliers in a proactive and collaborative manner. (Caniëls et al., 2016) This is because suppliers were found to be more responsive to their customer environmental performance necessities where increasing levels of relationship-specific investments were conjured. Thus, ensuring a secure trading system.

- To prosper into new ventures, first our nation must solidify its own basis. Price swings throughout the raw materials sector have placed a renewed & profound spotlight on the repercussions that raw materials can have on a firm and supply chain operations. Irrespective of specific businesses, such shifts can lead to incurable economic harm. Unfortunately, the post facto responses available to firms are limited by the over-reaching effects of materials. Materials simply are not just a bundle of characteristics/traits that translate into product performance. Instead, on the operational side, materials establish a class of appropriate production based technologies and, by extension, possible product devise and architecture.

Availability of these raw materials limits recycling rate if the amount of metals reaching their end-of-life is diminished than demands for that metal. In the end, materials with high levels of concentration during primary productions should be less prone to scarcity arising from institutional inefficiency if there is an active secondary recovery industry. Metrics at best should be used to assess vulnerability rather than predict scarcity since, over the prolonged tenure, market forces and technological components will effectively ensure that responses such as substitution and recycling will occur as per instructions.

Firms need to start considering their options in regards to materials availability, identifying their dependency on materials with high vulnerability. For this purpose, the authors would propose, a conjectural strategy for evaluating the gravity of depleting index screens. In particular, the reserve-based screen should be compared against industry rules of thumb for standard reserve capacity. A resilient supply

chain must have a strategy that includes “what-if” scenarios for unprecedented disruptions.

Knowledge of government action, in particular for Military & defense applications can be critical. Knowledge, planning, and flexibility are three broad measures to reducing supply chain risks. Although, institutional inefficiency is the more acknowledged type of “materials availability” problem for the supply chain in the near term, each of these measures can also prepare supply chains for long-term risks of physical constraints.

- Workplace safety is one of the major concerns nowadays in workplace of any kind. Intending to find major and serious issues related to workplace safety in an active shipyard, relevant well organized measures should be undertaken. Moreover, consciousness and efforts of all level of the workforce is necessary to well develop a safe working environment. Implementing safety rules and conducting primary safety training is very necessary in reducing workplace accidents. Below is an illustration of primary measures that should be ensured (fig. 6, *see the plate*).
- Steel Prices took a huge slump in 2020 due to the pandemic with a downfall by almost 50 %. Bangladesh’s structural steel industry incurred almost a loss of \$1.1 Billion. Production costs increased by almost 40 % but sales dropped by 46 % in the last fiscal year. As 95 % of Steel raw materials are imported with 65 % imposed tax which directly correlates to the Ship industry, the Government should take necessary steps to minimize the matter.
- The Industry 4.0 is strategic initiative representing the synonym for the evolution of today’s factories into Smart Factories capable of overcoming the challenges of the efficient product lifecycle, highly customized products and to stay in the race with omnipresent competitors. Its whole concept is based upon the Cyber-Physical Production System (CPPS), Internet of Things, Big Data and Internet of Services and interaction among real and virtual worlds. It presents development changing the overall traditional industry layouts and includes design, technology and innovation cycles which are seen as an important strategy to tackle competition in the future. Smart products from these smart factories will allow the “last minute” changes according to the customer requirements. (Kagermann et al., 2013) As the Industry 4.0 concept generated by Japan and shown succession by Croatia, strongly impacts on the worldwide industries

and all the aspects of Civil Human Society, its implementation into Bangladesh’s Shipbuilding industry would undoubtedly be fruitful.

The shipbuilding industry has special attention from the governments, especially considering the naval shipbuilding aspects, as the leader of the reorganizations and implementation improvements are firmly driven by the Shipbuilding 4.0 ideas. The Naval industry is the driving force of national development and innovations. For the overall success of the project, good cooperation between shipbuilders and Ship-owners is crucial, bringing several benefits: lean, flat point of contact, minimization of the coordination, conflicts and the disagreements are simplified, the risk of loss of the profit is ultimately reduced (Hadjina & Matulja, 2018).

- Investment in our sea-ports and supplementary projects could serve our nation’s future economy well and plans are already in effect. Recently the government requested \$500 Million from Worldbank for solidifying the annual budget. As per Business standard reports, a good portion of that budget may be contributed into the Maritime & Shipbuilding sector. The Payra port coalition with India has seen a massive \$2 Billion in investments with \$650 Million added annually for further developments. The proposed Gazaria River port will cost around \$3 Billion and will be on par with the Matabori Deep sea port which could earn huge trade values. Vehicle imports at Benapole stood at \$131.7 Million in 2020 are yet to reach ideal numbers but it is still seeing 15–20 % increase per annum. The Karnaphuly dredging project which would cost around \$519 Million (approximately) could in-tune draw better trade deals as that would allow for smoother shipping and a more eco-friendly approach. Finally maintaining proper quality control & assurance in said projects and adding timely observations and investments will certainly help the industry and raw material trade in the long run. Etc. Thus, if some of these recommendations are entertained in the slightest, then, the foundation for sustainability in the industries can certainly be achieved.

Conclusion

Закключение

The Shipbuilding industry has witnessed many changes throughout history and is currently facing one of its biggest challenges. The halt of proper trade facilities for Raw materials is no new phenomenon but at an age

where progression and economic stability is the only goal, obstruction to such propagation has created massive disruptions to the flow of business and the industry overall. As highlighted by the data on this paper, the author tries to establish that these external factors are truly affecting the overall trend of the industry and unless sustainable measures are taken, the industry will see another collapse.

But, such scenarios have also opened the market wide open, with Bangladesh being in the situation to claim it. Effective measures as stated by the Author's compilation could help promote the cause and to some extent help our nation gets the proper recognition it deserves. Hence, the author feels that the research is causal and needs to be further continued. The presented results are certainly not exhaustive, but they can be useful sources of profound knowledge. Only time will tell on whether we truly can achieve the sustainability that has been stated.

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About the authors

Naveed Anjum, Undergraduate Student, Department of Naval Architecture and Offshore Engineering, Bangabandhu Sheikh Mujibur Rahman Maritime University. Address: #14/06–14/23, Pallabi, Mirpur-12, Dhaka-1216, Bangladesh. Tel.: +880-1712-158477. E-mail: Naoe18006.naveed@bsmrmu.edu.bd.

Muhammad Ashikur Rahman, Undergraduate Student, Department of Naval Architecture and Offshore Engi-

neering, Bangabandhu Sheikh Mujibur Rahman Maritime University. Address: #14/06–14/23, Pallabi, Mirpur-12, Dhaka-1216, Bangladesh. Tel.: +880-1683-294473. E-mail: Naoe18007.ashikur@bsmrmu.edu.bd.

Md. Mynul Islam, Undergraduate Student, Department of Naval Architecture and Offshore Engineering, Bangabandhu Sheikh Mujibur Rahman Maritime University. Address: #14/06–14/23, Pallabi, Mirpur-12, Dhaka-1216, Bangladesh. Tel.: +880-1845-265501. E-mail: Naoe18003.mynul@bsmrmu.edu.bd.

Md. Munir Hasan, Commodore (Retd.), B.Sc, M.Sc in Naval Architecture and Marine Engineering, PhD in Mechanical Engineering, Faculty of Engineering and Technology, Department of Naval Architecture and Offshore Engineering, Bangabandhu Sheikh Mujibur Rahman Maritime University. Address: #14/06–14/23, Pallabi, Mirpur-12, Dhaka-1216, Bangladesh. Tel.: +880-1678-034496. E-mail: munhas2007@yahoo.com, munir.naoe@bsmrmu.edu.bd.

Сведения об авторах

Навид Анджум, студент факультета военно-морской архитектуры и шельфовой техники Морского университета Бангабандху Шейха Муджибура Рахмана. Адрес: #14/06–14/23, Паллаби, Мирпур-12, Дакка-1216, Бангладеш. Тел.: +880-1712-158477. E-mail: Naoe18006.naveed@bsmrmu.edu.bd.

Мухаммад Ашикур Рахман, студент факультета кораблестроения и шельфовой техники Морского университета Бангабандху Шейха Муджибура Рахмана. Адрес: #14/06–14/23, Паллаби, Мирпур-12, Дакка-1216, Бангладеш. Тел.: +880-1683-294473. E-mail: Naoe18007.ashikur@bsmrmu.edu.bd.

Майнул Ислам, студент факультета кораблестроения и шельфовой техники Морского университета Бангабандху Шейха Муджибура Рахмана. Адрес: #14/06–14/23, Паллаби, Мирпур-12, Дакка-1216, Бангладеш. Тел.: +880-1845-265501. E-mail: Naoe18003.mynul@bsmrmu.edu.bd.

Мунир Хасан, коммодор (в отставке), бакалавр, магистр в области кораблестроения и морской техники, доктор наук в области машиностроения на инженерно-технологическом факультете кафедры кораблестроения и шельфовой техники Морского университета Бангабандху Шейха Муджибура Рахмана. Адрес: #14/06–14/23, Паллаби, Мирпур-12, Дакка-1216, Бангладеш. Тел.: +880-1678-034496. E-mail: munhas2007@yahoo.com, munir.naoe@bsmrmu.edu.bd.

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Fig. 1. Criterion in the selection of Raw Materials for Ship construction. (Authors Interpretation)

Рис. 1. Критерий при выборе сырьевых материалов для судостроения (авторская интерпретация)

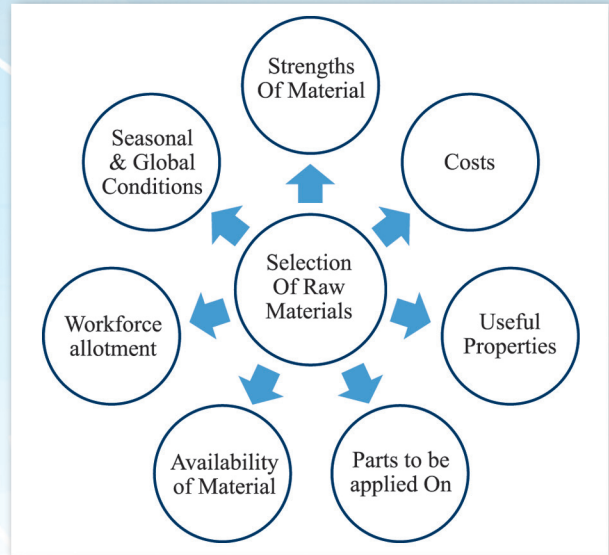
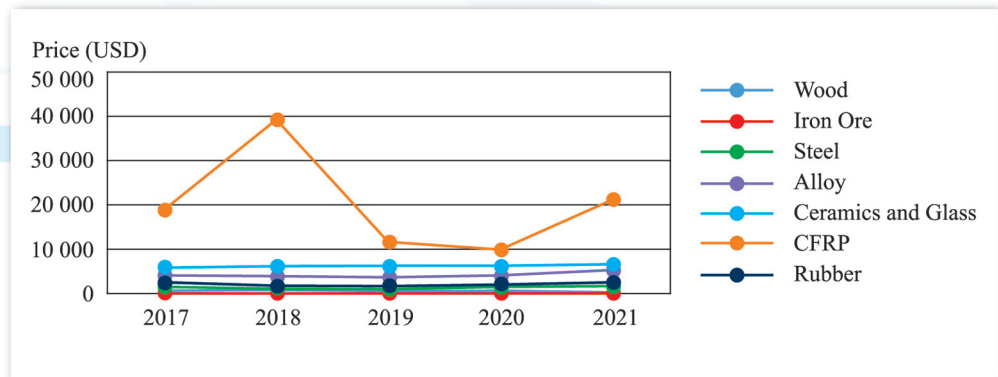
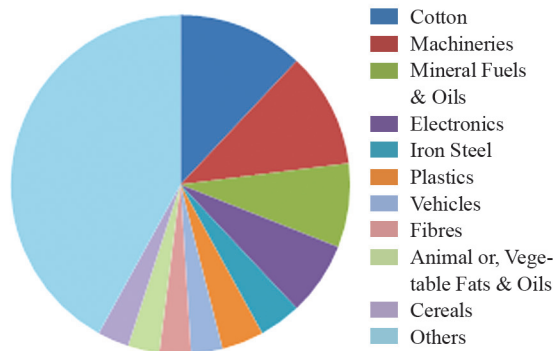


Fig. 2. Price Trend of Popular Shipbuilding Raw Materials (2017–2021)

Рис. 2. Динамика цен на популярные судостроительные сырьевые материалы (2017–2021 гг.)



Percentage chart of Top imports of Bangladesh



Percentage Chart of Top Importing nations for Bangladesh

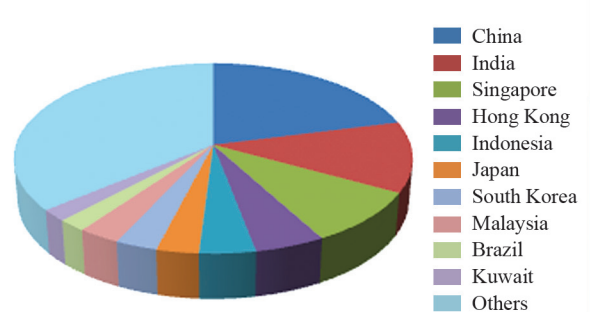


Fig. 3. Top Imports and Importing nations of Bangladesh (Exportgenius.in)

Рис. 3. Основные статьи импорта и страны-импортеры Бангладеш (сайт Exportgenius.in)

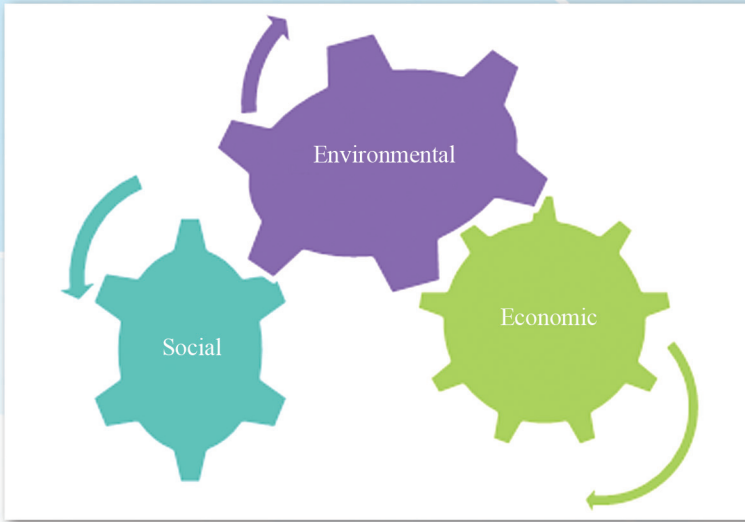


Fig. 4. Authors' interpretation of gears for Sustainability (Neyestani, 2017)

Рис. 4. Авторская интерпретация механизмов устойчивого развития (Нейестани, 2017)

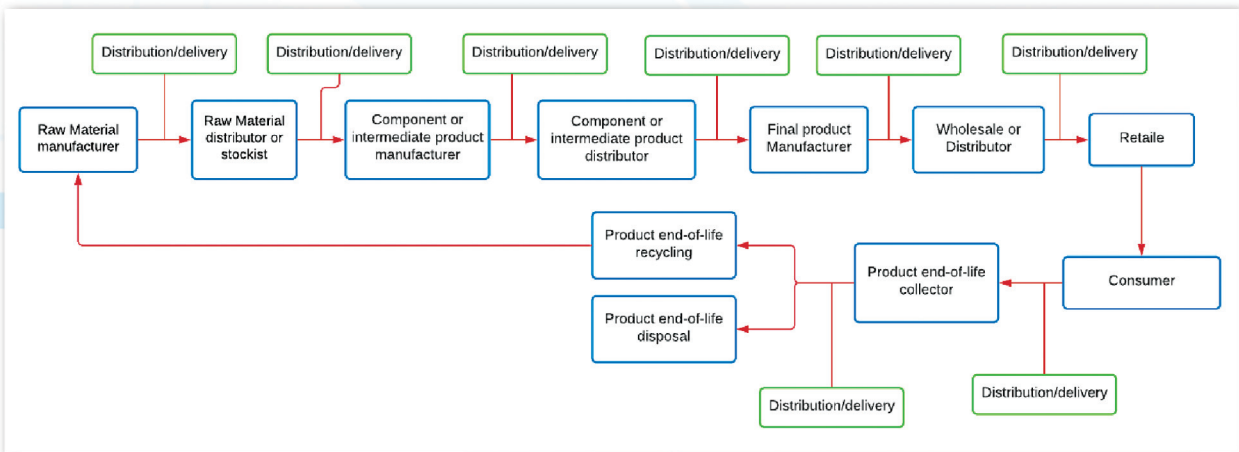


Fig. 5. Green Supply Chain Diagram from upstream raw material manufacturer to downstream retail and reverse supply chain which includes disposal and recycling (Alonso et al., 2007)

Рис. 5. Схема экологичной цепочки поставок от добывающего производителя сырьевых материалов до розничной торговли и обратной цепочки поставок, включающей утилизацию и переработку (Алонсо и др., 2007)



Fig. 6. Measures of Hazard Prevention (Hossain et al., 2016)

Рис. 6. Меры по предотвращению опасности (Хоссейн и др., 2016)