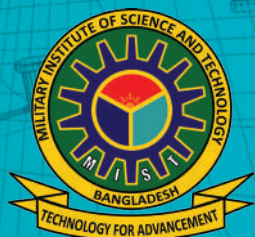
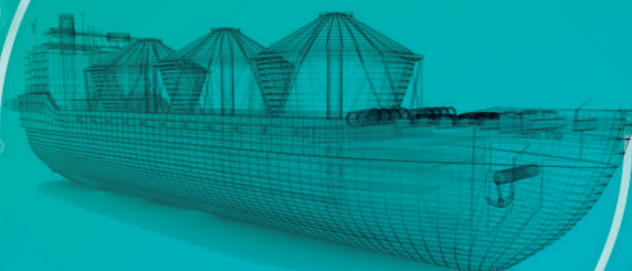


DECEMBER 2023

TECHNICAL PAPER

DEPARTMENT OF NAVAL ARCHITECTURE
AND MARINE ENGINEERING

VOLUME 02



Military Institute of Science and Technology
Dhaka, Bangladesh

With the Compliments of



Department of Naval Architecture & Marine Engineering
Military Institute of Science & Technology (MIST)

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Message from the Chief Patron

Under the esteemed leadership of Honorable Prime Minister Sheikh Hasina and in alignment with the spirit of independence, the Military Institute of Science and Technology (MIST) was envisioned and established on April 19, 1998. Going beyond its military emphasis, MIST plays a substantial role in nation-building by providing engineering education to civilian students. The concerted efforts of all the members of MIST are leading to achieve its ultimate goal in making this institute a 'Center of Excellence' in the true sense of the term.

I am delighted to know that the Naval Architecture and Marine Engineering (NAME) department is releasing the second volume of 'TECHNICAL PAPER' as part of their ongoing efforts to enhance MIST's reputation as 'Center of Excellence'. I anticipate that the contents of this technical publication will captivate the interest of scholars, students, and the general readers, inspiring them to undertake further groundbreaking research.

I am confident that the continuing efforts by NAME department for making MIST a renowned maritime platform will propel this institute even further ahead. I firmly believe that NAME department will continue expanding its horizons to reach new heights in all aspects. I extend my heartfelt best wishes for the department's future endeavors, with the anticipation of nothing but success. Together, let us continue striving for excellence and contributing to the advancement of technology on a global scale.

I wish continued success of this 'TECHNICAL PAPER' in the years to come.

A handwritten signature in black ink, appearing to read 'M. Saidul Islam', written in a cursive style.

Chief Patron
Major General Mohammed Saidul Islam, rcds, ndc, psc
Commandant
Military Institute of Science and Technology, (MIST)



Message from Editor-in Chief

With praise and gratitude to the Almighty Allah, Who guides us with His infinite mercy and wisdom, it is my great pleasure to announce the release of the second volume of our Technical Paper. I would also like to extend my heartfelt gratitude to the respected Commandant of MIST, Maj Gen Mohammed Saidul Islam, rcds, ndc, psc, for his invaluable support and guidance throughout the publication of this second volume. His unwavering commitment to academic excellence and his unique leadership have been instrumental in the success of our endeavors.

Military Institute of Science and Technology (MIST) remains an indispensable partner in Bangladesh's maritime domain. The shipbuilding and shipbreaking industries remain vital economic drivers, creating opportunities and employment for a diverse workforce. As we evolve, these sectors continue to present new potentials, opportunities and challenges, driving us to adapt and innovate. At MIST engineers, technical personnel and researchers are nurtured to be well-prepared in seizing opportunities and facing the challenges that await them. The NAME department of MIST takes pride in its legacy of graduating 266 naval architects who have carried the MIST flag high, contributing to the development of our nation and making their mark both at home and abroad.

I extend my heartfelt gratitude to the diligent researchers, participants and writers whose dedication and passion have once again brought this publication to life. It is their unwavering commitment that has allowed us to continue this journey of sharing knowledge. I must also express my sincere thanks to the companies, industries, government and private entities, seafaring professionals, researchers, academicians, professionals, stakeholders and our beloved students. Your direct and indirect contributions have been instrumental in shaping this second volume.

As we move forward with this second volume, we are not only marking our commitment to excellence but also embracing the evolving landscape of our nation. It is our hope that this paper will serve as a source of knowledge, inspiration and guidance, reflecting our dedication to progress in an ever-changing world.

Commodore A H M Rafiqul Islam, (E), NUP, psc, BN
Department of Naval Architecture and Marine Engineering (NAME), MIST

EDITORIAL

Military Institute of Science and Technology (MIST) is one of the leading Engineering institutes of Bangladesh and devoted to accelerate the nation's technological excellence with a vision to excel in the realm of engineering and technological progress. The Naval Architecture and Marine Engineering (NAME) department proudly plays a pivotal role in realizing this ambition. In the process of continuing efforts to enhance MIST's reputation as 'Center of Excellence', NAME department publishes 'TECHNICAL PAPER' and we, the all members of Editorial Board are very much proud being the part of this second volume.

Within the pages of this technical paper, one will find a compilation of technical insights contributed by esteemed experts in various maritime domains, individuals possessing extensive experience and knowledge in maritime affairs. This comprehensive paper encompasses a wide spectrum of technical topics and the latest updates on various aspects of maritime studies. Additionally, it features innovative ship designs submitted by participants for a ship design competition. The authors and ship designers have certified that their submissions have not been previously published or submitted elsewhere and are free from any security, proprietary, or copyright violations.

The publication of this technical paper was an immense undertaking that had to be completed within a very short timeframe. We must acknowledge the unwavering support of our departmental colleagues and seniors without whom achieving this level of quality would not have been possible. In this context, we would like to mention the names of Captain M Enayet Kabir, (E), psc, BN and Captain Kaosar Rashid, (E), psc, BN. Their contributions have been truly invaluable. We express our deepest gratitude to our department head, Commodore A H M Rafiqul Islam, (E), NUP, psc, BN, who served as a constant source of inspiration for all of us in the department during this monumental endeavor. We would also like to extend our thanks to Commandant Maj Gen Mohammed Saidul Islam, rcds, ndc, psc for his valuable guidance and consistent support, which played a significant role in the success of our initiative.

We trust that this technical paper will prove to be a resource for readers, offering a valuable source of technical knowledge about maritime affairs and marine technology. We hope that this publication will quench the thirst for knowledge of those engaged in the respective fields.

Editor

Lt Col Muhammad Rabiul Islam, PhD, EME

Instructor Class 'A'

NAME Department, MIST

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ARTIFICIAL INTELLIGENCE (AI) AND ROBOT: PRESENT, FUTURE AND CONSEQUENCES OF THE WORLD

Rear Admiral Khandakar Akhter Hossain^a, (E), NUP, ndc, psc, PhD, BN

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Abstract. The explosion of technology in the modern era has coincided with an equally seismic shift in how we think and talk about it. Artificial Intelligence or AI is basically simulation of human intelligence by machines, or computers or even mobile to do tasks that usually require human intelligence, like seeing, hearing, making decisions, and translating between languages. Nowadays, AI becomes a hot topic and many debates have raised many pertinent questions. It has become a crucial issue in the 21st century, as it might affect the job market and general employment. Some technology lover people think that, AI will lead to create lots of diversified and interesting jobs. However, many experts think that, it will have a big impact on the workplace and all aspect of human life in near future. In reality, AI has the ability to make jobs more creative, lucrative and flexible, and will lead definitely to a more creative and skilled economy. We must need to change the education system, including the curriculum, teaching methods, and many things that need to be done for schooling. Our mass or general education system needs to be aligned with modern and advanced technology, which will change the whole school system. National education policy and strategy must be purposeful and sustainable for the long term. This is an analytical study in which the researcher has taken all effort to evaluate the diversified use of AI and robots and the consequences for the human future, emphasizing on the global education system and 4th industrial revolution (4IR).

KEY WORDS: AI, ML, logic, algorithm, networks, robot, singularity

INTRODUCTION

A procedure or formula used to solve a problem or a series of instructions that tell a computer how to transform a data set into helpful information. All branches of information technology heavily rely on algorithms. Computer science's multidisciplinary field of artificial intelligence (AI) develops intelligent machines. AI is the replication of the human brain or intelligence by machines, like computers, to accomplish tasks requiring human aptitude or talent, such as seeing, hearing, making decisions, translating between languages, driving a vehicle or boat, operating equipment, etc. A few common and widespread uses and examples of AI are Siri by Apple [1], [2], Alexa by Amazon [3], [4], Maps by Google [5], [6], and ChatGPT by OpenAI. AI systems are getting smarter with each successful round of data processing because each communication and interface gives the system a chance to test and measure solutions and get better at the job it has been designed to do [7]. Since this can be done quickly and is far quicker than a human could [8]. AI systems are tremendously effective alternatives for any process involving intelligent decision-making and repeated tasks since they can become experts and do it much more quickly and perfectly than humans [9]. This makes AI an extremely authoritative and priceless technology because it essentially allows computers to think and behave like humans, which should be much faster and have more processing power than the human brain [10]. Again, Machine learning (ML) is the science of using machines to interpret process and analyze data in order to solve real-world and real-time problems instantly [11]. Deep Learning is an advanced

field of ML that can be used to solve more advanced problems [12]. Robotics is a branch of AI which focuses on different branches/sectors and applications of robots [13]. AI is going to dominate the car industry by creating a self-driving car in the very near future [14]. Today's AI programs are applied to practice such as diagnostics, treatment protocol development, drug development, personalized medicine, patient monitoring and any physical or mental care [15], [16].

Robotics, AI, and machine learning have advanced significantly in recent years. Automation and extensive use of AI can help organizations, companies, or industries do better in production or service by reducing errors, improving quality and speed, accuracy and integrity, and, in most cases, achieving results that are impossible for humans. Peter Norvig, Google's director of research and a pioneer of ML, the data-driven AI method behind many of the company's recent successes, says that the most important thing is to figure out how to make sure that these new systems related to AI, help society as a whole and not just those who control them. He added, 'AI has shown that it can do a lot of useful things.' From an extensive study, it has been shown that automation or the introduction of AI could boost global productivity growth by 0.8% to 1.4% per year, which is equivalent to more than 2,000 work tasks in 800 occupations. When proven technologies can only automate less than 5% of all jobs, about 60% of all jobs have at least 30% of their tasks that a machine could do. Therefore, a number of professions will experience change [17]. As a result, advances in AI and related automation technologies have led to growing fears about job losses and increasing inequality in society. This concern is widespread in high-income countries. Developing countries and emerging market economies should be even more concerned than high-income countries, as their comparative advantage in the world economy relies on abundant labour and natural resources [18]. Again, declining labour and natural resource returns, as well as the winner-take-all dynamics brought on by new information technologies, may lead to a further loss of control in the developing and labour-intensive world. This has the potential to slow the rapid progress made over the last fifty years. It may also jeopardize progress toward reducing poverty and inequality in societies around the world.

The great thinker of AI, Professor YannLeCun, said that the fear of AI being a threat to humanity is preposterously ridiculous. According to Mr. LeCun, the entire concept of AI taking over the globe is a 'projection of human nature on machines'. He wants to say that 'keeping AI research 'under lock and key' would be a 'huge mistake' [19]. According to the Meta scientist, when people express concerns about future robots working at or beyond human-level capabilities, 'they refer to artificial general intelligence (AGI) systems capable of handling a wide range of problems, similar to humans'. He emphasized that AGI development would be slow to eventually achieve a level of intelligence similar to that of a rat's brain. AI technology is becoming an increasingly important component for many products and will continue in the future; that will become a fundamental part of many people's lives. At the same time, the amount of effort AI puts into the economy will likely vary from region to region. This may depend more on the type of economic activity that is most common in a region than on the region's economic status. AI technology has the potential to give benefits to different income choices and bring significant gains to both developed and developing countries [20]. AI also has the potential to create new and innovative job opportunities, leading to a more productive and efficient economy [21]. Any technology usually eliminates employment that creates. It is the reality that, with the advancement of AI, the world will become more complex and self-centred in the future, as well as there will not be

enough jobs for all, or it will not ensure employment for everyone. So, the new generation should be educated with advanced technology and valuable skills. Therefore, the current education system must be transformed with a pragmatic solution [22].

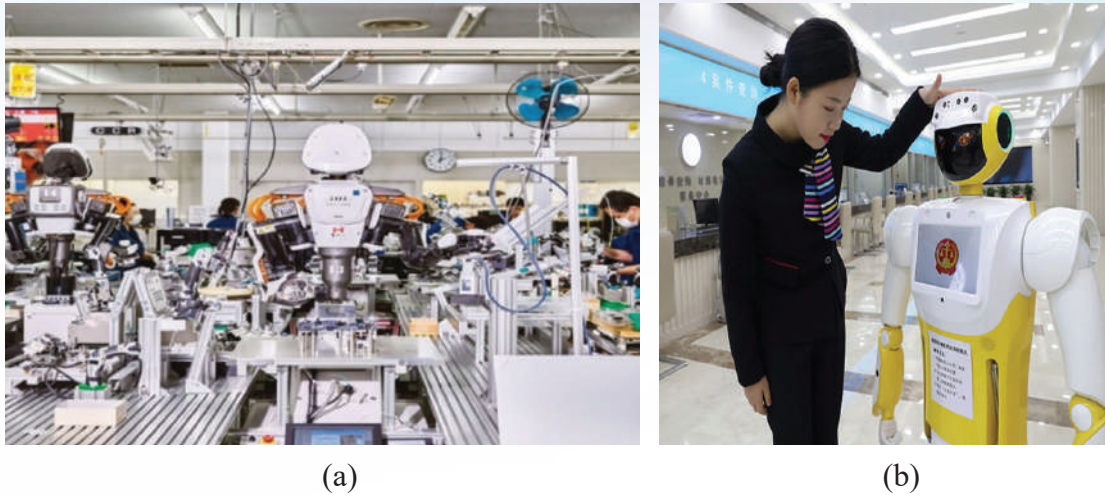


FIGURE 1. (a) In future robots will work with human [23] (b) Technological revolution relate technology and human [24]

THE IMPACT OF AI ON SOCIETY AND NEAR FUTURE

Modern AI, often referred to as 'narrow AI', predominantly utilizes data-trained models and frequently incorporates deep learning or machine learning techniques. This influence has been especially pronounced in recent years due to the surge in data collection and analysis facilitated by robust IoT connectivity, the increasing number of connected devices, and rapid advancements in computer processing. Companies are investing billions of dollars annually into AI products and services. Tech giants such as Google, Apple, Microsoft, and Amazon are at the forefront, pouring billions into the development of these AI-driven offerings. Concurrently, universities are placing greater emphasis on AI within their curricula, and the military forces of developed nations are enhancing their tactical use of AI. Andrew Ng, the former leader of Google Brain and a top scientist at Baidu, observed that many industries experience periods he describes as "winter, winter, and an eternal spring." He suggests that we might currently be in the "endless spring" phase of AI [25]. Today, some sectors are at the start of their AI journey, whereas others are expert travellers. However, both have a long way to go. Whatever impact AI is having on our present-day lives is hard to overlook. Nobody can stop or slow the very fast journey of AI. Today, AI-enabled machines can perform specific jobs better and faster than humans and imitate human actions nicely. There are four types of AI. Such as Reactive machines AI is the most superficial level of AI. Reactive machines can do basic operations. They cannot form memories or use past experiences to make decisions like IBM's Deep Blue [26]. In contrast, with limited memory, AI can store existing data and create better output using the data like Tesla's self-driving cars. Again, theory of mind AI can connect with human thoughts and interpret them better, but these are still works in improvement or progress. On the other hand, self-aware AI will have independent intelligence and make its own decisions. These machines will be smarter than human minds, and it is coming soon and will make a new history of civilization.



(a)



(b)

FIGURE 2. (a) AI and future of life [27] (b) Working relationship between human and robots [28]

Professor Klara Nahrstedt of the University of Illinois' computer science department has emphasized the importance of substantial investment in education to prepare individuals for new job opportunities, especially as AI becomes increasingly specialized and intentional in its functionalities. She believes that in the near future, learning programming will be as essential as acquiring a new language. If we delay this learning process, it could become even more challenging. Although technological advancements might render certain jobs obsolete, history has shown that new employment opportunities will emerge. This transition can be likened to America's shift from an agrarian to an industrial economy during the Industrial Revolution, which had a significant impact and played a role in the "Great Depression." The disappearance of jobs can sometimes be more abrupt than many anticipate, but new opportunities inevitably arise [29]. If we understand what the technology is capable of and the domain very well, we may start to make connections and say, 'Maybe this is an AI problem, maybe that is an AI problem. It's wise to state, 'There's a specific problem I'd like to address'.

HUMAN ERROR AND USE OF AI

While the benefits of analytics are widely recognized, such as enhancing shopping experiences, optimizing train and truck routes, identifying extraterrestrial life, and forecasting diseases, organizations globally have been confronting the challenge of human errors creeping into their analytical endeavors, sometimes leading to catastrophic results. Human error in data processing has far-reaching consequences for organizations, from crashing spacecraft to sinking ships, transferring billions of dollars to unintended recipients, and causing deaths due to pharmaceutical overdose [30]. Human mistakes in data analysis can occur for a variety of reasons, including a lack of expertise, exhaustion or loss of focus, a lack of information, or the all-too-common biases in data interpretation. On the other hand, the most prevalent human errors are related to humans reading, processing, analyzing, and interpreting data. AI can successfully tackle human mistakes by parsing, analyzing, drilling down, and dissecting enormous amounts of data. It can also do high-level arithmetic, logical, and statistical functions on a human-led scale, whereas self-service analytics cannot. AI-driven analytics has numerous advantages, from giving actionable insights in minutes to removing errors or biases in self-service analytics. We may expect to see increased adoption of AI in analytics worldwide as more business executives look to AI for insights that fuel their businesses.

AI AND FUTURE EDUCATION

AI has the potential to be tremendously beneficial in the education industry. Many learning programs benefit from using technology in their conception and implementation. It can also be used to create games and software. It is possible to revamp and overhaul the entire educational system and teaching methodologies using Artificial Intelligence. It starts with the issuance of certificates and degrees in schools and institutions. AI-based apps can help both institutions and students. It can influence the teaching and learning process by incorporating them into the educational field [31]. As a result, the procedure as a whole is benefits. It changes and adapts learning tasks to help all students become better students. AI makes sure that the needs of children with special needs are met. AI is used in education in many ways, from chatbots that help students 24/7 to personalized learning algorithms that change each student's needs. AI-powered tools are also used to do things like grade assignments and automatically give comments. AI is also being used to look at many data to find patterns and insights that can be used to help make new strategies and plans for education [32].

The condition of education and training in the Fourth Industrial Revolution (4IR) is multifaceted and complex but also offers exciting opportunities that can revolutionize society and whole nations for better health and a superior state. AI powers the 4IR, changing the workplace from being unique based on jobs to unique based on people. 4IR is making sure that people and machines can work together again. This will close the gap between the arts and social sciences and between science and technology. We need a quick response from a middle-level or higher education school because 4IR technologies can help people or damage the environment [33]. This will necessarily require much more interdisciplinary teaching, on-ground practice, research and innovation. So along with 4IR, education 4.0 is a focused, purposeful and viable approach to learning and is transforming the future of education using advanced technology and automation [34]. To stay up with the times, traditional formal educational approaches must be revisited with a future perspective. Teachers and students/learners must be familiar with the abilities required by today's rapidly evolving technology and global society. As a result, students/learners should now be led rather than directed, and material should be made available rather than given to them. However, there should be ethical internet usage and optimal use of technical advantage for humanity. The purpose and goal of both general and vocational education should be to guarantee that students/learners have the knowledge and skills necessary to compete in the global workforce [35].

Our education should have a long-term goal, and be based on what we learn. So, we need to develop outcome-based education modules to meet the accreditation needs of students and competency-based education modules to help students learn information and skills effectively. We need to build and improve the system to cut costs, be easy to use, and automate all middle- and higher-level schooling processes. Every education system and institute should have project management, reporting, and analytics tools so that we can make sure that future and modern education processes and procedures take care of things like scheduling, virtual classrooms, accreditation, strategic planning, modern learning, skill development, etc. [36]. We should adopt a strategy and formulate such a useful plan that can ensure a preferable future for today's students/learners [37]. In keeping with the changing situation of today's competitive world and the induction of super technology in every aspect of life, education curriculum formulation and development has to be prepared with supreme care and giving intense importance to technology, IT, AI, IoT, ML, big data, cloud and edge computing, social media and other knowledge and skill.



(a)



(b)

FIGURE 3. (a) AI in Education [38] (b) AI may replace academics in future [39]

INDUSTRIAL REVOLUTION, 4IR AND IMPACT OF AI

Industrial revolution is a global phenomenon and continuous process. AI is going to lead to a redefinition and a disruption of service models and products. Although the technical development leads primarily to an efficiency enhancement in the production sectors, new creative and disruptive service models will revolutionize the service sector. These are adapted with the support of big data analyses at the individual requirements of the client and not at the needs of a company.

In the field of industrial production, the term ‘automatization’ is characterized essentially by four elements: 1) the production is controlled by machines. Owing to the use of intelligent machines, production processes will be fully automated in the future, and humans will be used as a production factor only in individual cases. The so called ‘smart factory’, a production facility with few or without humans, is representative of this. 2) the real-time production is a core feature of Industry 4.0. An intelligent machine calculates the optimal utilization capacity of the production facility. Lead times are short in the production process, and standstills, except those caused by technical defects, can be avoided. Within the value creation chain, the coordination of materials, information and goods is tailored exactly to demand. Stocks are kept to a minimum, but if materials needed for production fall below a certain level, the machine orders more. The same applies to finished products; the machine produces depending on incoming orders and general demand, thus reducing storage costs. 3) the decentralization of production. The machine is essentially self-organized. This includes a network of the manufacturing units. In addition to material planning, the handling of orders is also fully automated. 4) the individualization of production even down to a batch of one unit. The machine of the future will be able to respond, within certain limits, to individual customer requests. No adjustments to the machines by humans are required. As a result, changeover times are eliminated. The smart factory adds certain components or, in a context of optimum distribution throughout the entire process, adapts individual stages of production to correspond with customer requests [40].

The term Industry 4.0 thus stands for the optimization of components involved in the production process (machines, operating resources, software, etc.) owing to their independent communication with one another via sensors and networks [41]. This is supposed to reduce production costs, particularly in the area of staff planning, giving the company a better position in international competition. Well-known examples from the field of robotics and AI are the so-called ‘smart

factories', driverless cars, delivery drones or 3D printers, which, based on an individual template, can produce highly complex things without changes in the production process or human action in any form being necessary. Well-known service models are, for example, networking platforms like Facebook or Amazon Mechanical Turk, the economy-on-demand providers Uber and Airbnb, or sharing services, such as car sharing, Spotify and Netflix. Studies show that merely due to sharing services the turnover of the sector will grow twentyfold within the next ten years. Old industry made progress by using economies of scale in an environment of mass production, but the new information economy lives on networking effects, leading to more monopolies [42].



FIGURE 4. (a) In future robot will replace teacher [43] and (b) Modern classroom [44]

FUTURE OF ROBOTICS AND ROBOTS

An algorithm is a step-by-step procedure for solving a problem or accomplishing some end.' In the field of AI, algorithms are automated instructions that tell a computer what to do. The instructions are mathematically driven and can be as simple as 'if X, then Y' actions or encompass complex mathematical layers of instructions to execute a task or find an answer to a problem [45]. The algorithm manipulates data in a variety of ways, such as sorting, inserting, replacing, or searching for a data attribute. It solves problems when it carries out the instructions. ML can be supervised, unsupervised, semi-supervised, or reinforcement learning depending on the kind of data being input into the program and the type of outputs that can be expected [46]. When we hear someone talk about a machine that learns, the machine is executing a structured set of mathematical procedures. The machine learns how to correct itself based on data used to train the application or by iterating on data used by the application once deployed. How the machine learns to correct itself depends on the mathematical models selected for the task [47]. Data scientists and ML programmers are the team members who select and adjust the mathematical models used in applications [48]. In deep learning, a set of mathematical instructions such as an algorithm, which is called a node, works like a neuron to fire the algorithm, process it as instructed, and pass its information to another node in the computer. That algorithm is then used as input by another node in the neural network. Data move through the nodes in a direction specified by the algorithm. A deep learning model can contain billions of nodes embedded in many layers.

Future robotics and automation will serve as assistants, workmates, teachers, surgeons, drivers, operators, and explorers. As engineers, technologists, and scientists continue to develop and advance

robotics, the capabilities of this technology will only increase further. Today, in many ways, robots are already an integral part of daily life. They might even assist us in expanding our horizons on our planet and beyond, helping billions of people live better lives [49]. Today, robots have become human friends and have been among us for quite some time and are used to separate humans from dull, automated, dangerous or dirty jobs or tasks in warehouses and factories at the workplace. Safety is perhaps one of the most important factors when we are talking about replacing humans with robots. Robots injuring or, even worse, killing their human colleagues are becoming even bigger as the use of advanced AI increases or automation rises and many more factories are adopting automation. Forbes published an interesting story about the incident in which a semi-autonomous driving Tesla car [50] collided with a tractor-trailer in Florida and subsequently killed its driver in 2016 [51]. Again in 2015 when an industrial robot killed a German factory employee and in 2017, another killed a Michigan worker. However, in the Future of Jobs Report, more than 80% of business executives said that they are accelerating plans to digitize work processes and deploy new technologies [52]. And 50% of employers expect to increase the speed of the automation of some roles in their companies. So, in the age of AI, the McKinsey Global Institute declared that workforce transitions in a time of automation estimate that as many as 375 million workers, or roughly 14% of the global labor force, may need to re-skill in digitization, automation and AI by 2030 [53], in their report, 'Jobs lost, jobs gained [54].'

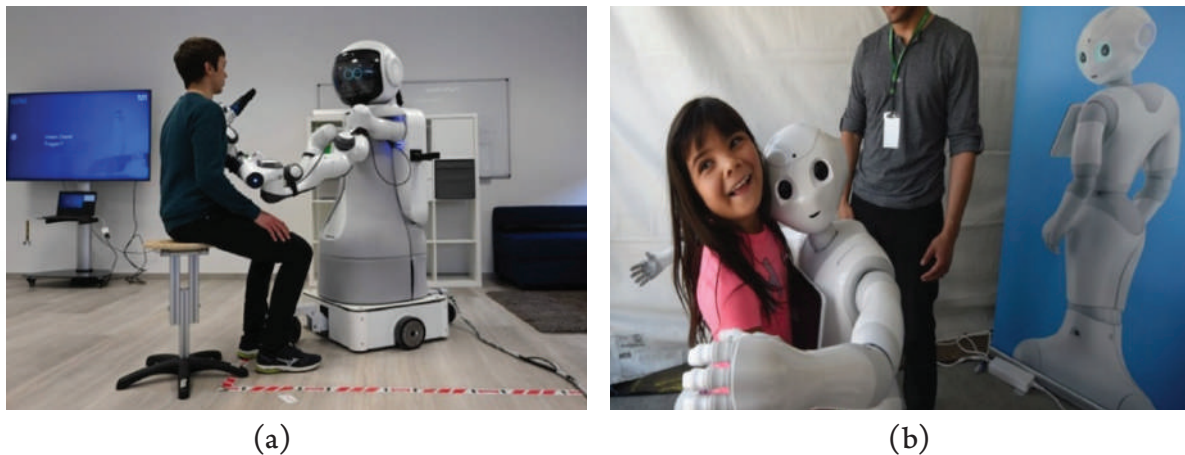


FIGURE 5. Example of few modern robots ((a) Healthcare robot, (b) Emotional robot) [55], [56]

PREPARATION TO MITIGATE THE FUTURE CHALLENGES

The development of every nation is dependent on the proper utilization of people and physical resources, which is dependent on manpower training and skill development. Actually, technical education is all about developing skills. Skilled labor can undoubtedly boost production. Technical education teaches people skills and knowledge that are necessary for society and industry. Japan's rapid industrialization is attributed to the collection of technical skills, knowledge, and know-how, as well as its strong dedication to education, particularly technical professional training. Technical education not only increases analytical and functional abilities, but it also improves efficiency, skills, knowledge, and profitability, all of which are critical for any country's economic success. AI may now maximize profit while also accelerating inclusive growth. To decide which entrepreneurs and small firms are positioned to win, AI helps investment decisions by utilizing data rather than heuristics [Gunning 2019]. Understanding the technologies themselves, in all their richness and complexity, and how they work, the limits of what they can do, what they were designed to do, and

how they are actually used, is a critical part of understanding how technology has caused global change and, in turn, how global changes have influenced the development of new technologies (Oberdiek 1995).

Technical education is information about finer skills in life that provide pupils with an advantage over traditional schooling. Audio editing, video editing, voice modulation, recorded coddling, little programming, and so on are fascinating skill sets that necessitate a finer and more nuanced understanding. These abilities are typically found in students who are imaginative or have a gentler side to their academic personality, allowing them to experiment and explore rather than obey the rules and stay between the lines. Today's students and youth are rejecting traditional career paths such as manager, accountant, doctor, lawyer, or administrator in favor of jobs that require far more technical knowledge and skill, such as digital sound or video editing, AI, ML, or IoT specialist, robot or data scientist, technologist, or engineer. We need to remember that, future world needs technician or engineer or technologist in advanced digital and smart knowledge, skills, expertise and capabilities. So, our education and skill development system and human resource development program should be along with such purposeful curriculum and syllabus which is able to prepare our new generation accordingly.

UNESCO and ILO at Geneva in 2002 have declared that, technical and vocational education as well as training is the prime-mover of a developing nation in the 21st century. Earlier formal education was mostly associated either with humanities or with fields like engineering, medicine, and mathematics. An educated person usually involved somebody sitting in an office somewhere and doing purely intellectual work. On the other hand, technical education is the education which involved direct physical labor and practical application of one's skills. Modern society literally cannot exist without skilled labor force (Issey 2016). World's socioeconomic landscape keeps changing. So, the importance of technical education steadily grows and it will continue. Both students and educational institutions now understand it. Computing Power, Smarter Devices, Datafication (such as coding), AI and Machine Learning (ML), Extended Reality, Digital Trust, 3D Printing, Genomics, New Energy Solutions, Robotic Process Automation (RPA), Edge Computing, Quantum Computing, Virtual Reality and Augmented Reality, Blockchain, Internet of Things (IoT), 5G, Cyber Security, and other emerging technology trends are on the horizon (Simplilearn 2023).

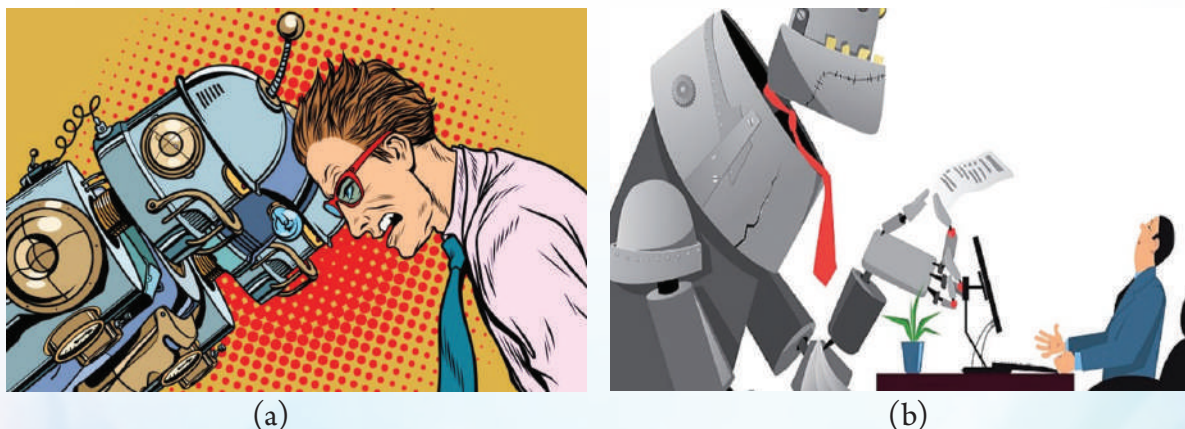


FIGURE 6. (a) Machine vs human- who is winning? [57] (b) Robot will outsmart human in near future [58]

AI AND NEXT GLOBAL CONSEQUENCE

With every new use of AI comes the scary question of whether or not robots will put people out of work. The judges have yet to make up their minds. Some experts strongly disagree that AI will automate so many jobs that millions will be out of work. On the other hand, other experts see this as a serious issue. Social experts and people who think about AI thought that the organization of the workforce was changing and that AI was taking over jobs. It lets us build a market based on knowledge and use that to improve automation for a better way of life. It might be abstract, but we should be worried about AI and robots taking our jobs [59]. However, some experts speculated that algorithms are to blame for losing white-collar jobs like business analysts, hedge fund managers, and lawyers. Again, there is some disagreement on how the rise of AI will affect the workforce, but experts agree on several themes to look for. On the other hand, some experts feel that when AI is integrated into the working, it will create more jobs, at least in the medium term. Wilson believes the change to AI-based systems will cause the economy to add occupations to help transition. The changes will be felt subliminally and will not be visible.

CONCLUSIONS

Today, AI robots are already very close to being real. Things that normally need human intelligence are now within the capabilities of machines. ML and deep learning are only two examples of AI techniques that can simplify any task. Data has the same value for computers as experience does for humans. There is a great deal we can do using AI to improve the quality of our service and the success of our company. If AI is deployed properly, it will allow us to maximize productivity across all departments, boost sales and customer happiness, and better use our resources. This is why AI is using every sector or business or organization. Future dangers from AI may be very significant. AI, IoT, ML, and automation will reduce the need for human workers and the size of the global economy. However, there is a high degree of uncertainty regarding the conceivable technological development scenarios and their effects. So, substantial potential weaknesses and risks cannot be ignored.

REFERENCES

1. <https://www.apple.com/siri/>, accessed on 21 Jul 2023
2. Bosker, Biance (January 24, 2013). "SIRI RISING: The Inside Story Of Siri's Origins – And Why She Could Overshadow The iPhone". Huffington Post, accessed on 21 Jul 2023
3. <https://alexa.amazon.com/>, accessed on 21 Jul 2023
4. Donnelly, Grace (May 9, 2018). "Amazon Alexa Will Come Built- In to All New Homes From Lennar". Fortune, accessed on 21 Jul 2023
5. Google Company: Our history in depth". google.co.uk. Archived from the original on April 6, 2016, accessed on 21 Jul 2023
6. Ray Bill, (November 29, 2007), "Google Maps Mobile knows where you are", The Register, Situation Publishing, Archived from the original on October 25, 2020, accessed on 21 Jul
7. <https://csuglobal.edu/blog/why-ai-important>, accessed on 21 Jul 2023

8. <https://cloud.google.com/learn/what-is-artificial-intelligence>, accessed on 17 June 2023
9. Luger George, et al, (2004), *Artificial Intelligence: Structures and Strategies for Complex Problem Solving* (5th ed.), Benjamin/Cummings, ISBN 978-0-8053-4780-7
10. Dreyfus Hubert, et al, (1986), *Mind over Machine: The Power of Human Intuition and Expertise in the Era of the Computer*. Oxford, UK: Blackwell. ISBN 978-0-02-908060-3
11. <https://www.edureka.co/blog/top-machine-learning-tools/>, accessed on 17 June 2023
12. <https://www.sciencedirect.com/science/article/abs/pii/S138650561730446X>, accessed on 17 June 2023
13. <https://www.tandfonline.com/doi/10.1080/20479700.2018.1498220>, accessed on 17 June 2023
14. <https://dataconomy.com/2022/12/28/artificial-intelligence-and-self-driving/#>, accessed on 17 June 2023
15. Hu Liangyuan, et al, (2022-12-01), "Using Tree-Based Machine Learning for Health Studies: Literature Review and Case Series", *International Journal of Environmental Research and Public Health*, 19 (23), ISSN 1660-4601
16. Mullainathan Sendhil, (May 2022), "Solving medicine's data bottleneck: Nightingale Open Science", *Nature Medicine*, 28 (5): 897–899, doi:10.1038/s41591-022-01804-4. ISSN 1546-170X
17. Johnny ChLok · 2019, *Artificial Intelligence Future Ten Development Stages*, Independently Published, ISBN:9781671040670, 1671040678
18. Korinek, Anton and Joseph E. Stiglitz (2019), "Artificial Intelligence and Its Implications for Income Distribution and Unemployment," in Agrawal et al.: *The Economics of Artificial Intelligence*, NBER and University of Chicago Press
19. <https://nagalandpost.com/index.php/meta-scientist-yann-lecun-dismisses-ai-threat-to-humanity/>, accessed on 17 June 2023
20. Johnny ChLok · 2020, *Artificial Intelligence How Impacts Global Economy*, Independently Published, ISBN:9781661685263, 1661685269
21. Pablo Padula · 2023, *Are You Going to Lose Your Job to Artificial Intelligence?*, Amazon Digital Services LLC - Kdp, ISBN:9798391007401
22. Alexander J. Means, Michael A. Peters, Petar Jandrić, *Education and Technological Unemployment*, Springer Nature Singapore, ISBN:9789811362255, 9811362254
23. <https://www.wired.co.uk/article/robots-in-the-workplace>, accessed on 17 Aug 2023
24. https://www.chinadaily.com.cn/opinion/2017-10/31/content_33921693.htm, accessed on 17 Aug 2023
25. <https://builtin.com/artificial-intelligence/artificial-intelligence-future>, accessed on 17 June 2023

26. <https://www.firstindia.co.in/>, accessed on 17 June 2023
27. <https://futureoflife.org/cause-area/artificial-intelligence/>, accessed on 07 Oct 2023
28. <https://www.shutterstock.com/search/robot-human-working-together>, accessed on 21 Sep 2023
29. Nilsson, Nils (1998), *Artificial Intelligence: A New Synthesis*, Morgan Kaufmann Publishers, ISBN 978-1-55860-467-4 <https://en.wikipedia.org/wiki/Special:BookSources/978-1-55860-467-4>
30. Albert, E.T. (2019), "AI in talent acquisition: a review of AI-applications used in recruitment and selection", *Strategic HR Review*, Vol. 18 No. 5
31. <https://www.javatpoint.com/artificial-intelligence-in-education>, accessed on 29 June 2023
32. <https://www.questionpro.com/blog/ai-in-education/>, accessed on 29 June 2023
33. Dua, D.; Graff, C. *UCI Machine Learning Repository*; University of California: Irvine, CA, USA, 2017
34. Dao L.T., (2023), Abibliometric analysis of Research on Education 4.0 during the 2017–2021 period. *Education and Information Technologies*, 28(3)
35. López-Pérez M. V., et al, (2011). Blended learning in higher education: Students' perceptions and their relation to outcomes. *Computers & Education*, 56(3)
36. Maguire M., et al, (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. *AISHE-J*, 8(3)
37. Adams Becker, S., et al, (2017), *NMC horizon report: 2017 higher Education Edition*. Austin, Texas: The New Media Consortium
38. <https://www.thedailystar.net/campus/news/exploring-avenues-ai-education-3434681>, accessed on 22 Jul 2023
39. <https://www.timeshighereducation.com/opinion/ai-will-replace-academics-unless-our-teaching-challenges-students-again>, accessed on 22 Jul 2023
40. Hossain K A, (2023), Analysis of Present and Future Use of Artificial Intelligence (AI) in Line of 4th industrial Revolution (4IR), *Scientific Research Journal* 11 (8), ISSN: 2201-2796, Aug 2023, accessed on 14 Aug 2023
41. Sandro Panagl, (2015), 'Digitalisierung der Wirtschaft - Bedeutung Chancen und Herausforderungen', *Austrian Economic Chambers* 5, accessed on 15 Aug 2023
42. Bloomberg, (2016), available at: www.bloomberg.com/news/videos/2016-05-20/forward-thinking-march-of-the-machines, accessed on 15 Aug 2023
43. <https://www.notredamecoll.ac.uk/news/will-robots-replace-teachers-zufar-hussain>, accessed on 29 Sep 2023
44. <https://www.youtube.com/watch?v=1n1mzVoivL8>, accessed on 03 Oct 2023

45. Castellanos S. What exactly is artificial intelligence, The Wall Street Journal, 2018, accessed on 22 Jul 2023
46. Fumo D. Types of machine learning algorithms you should know. Towards Data Science, 2017, accessed on 22 Jul 2023
47. Menzies T. 21st-century AI: proud, not smug. IEEE Intell Syst. 2003;18(3):18–24
48. Schatsky D, Muraskin C, Gurumurthy R. Demystifying artificial intelligence: what business leaders need to know about cognitive technologies. Deloitte Insights, 2014
49. <https://www.knowledgehut.com/blog/data-science/future-of-robotics>, accessed on 16 June 2023
50. https://www.tesla.com/en_eu, accessed on 16 June 2023
51. <https://www.forbes.com/?sh=12c92a752254>, accessed on 16 June 2023
52. <https://www.weforum.org/reports/the-future-of-jobs-report-2020>, accessed on 26 June 2023
53. <https://www.mckinsey.com/mgi/overview>, accessed on 26 June 2023
54. James Bessen, Learning by doing: The real connection between innovation, wages, and wealth, Yale University Press, 2015
55. <https://www.japantimes.co.jp/news/2023/03/20/world/germany-taps-robots-elderly-care/>, accessed on 17 Sep 2023
56. <https://edition.cnn.com/2015/06/22/tech/pepper-robot-sold-out/index.html>, accessed on 18 Sep 2023
57. <https://bdtechtalks.com/2018/08/30/race-between-humans-and-artificial-intelligence/>, accessed on 23 Sep 2023
58. https://www.business-standard.com/article/current-affairs/robots-will-outsmart-humans-by-2029-11-yearsearlier-than-expected-hp-cto-117091300177_1.html, accessed on 23 Sep 2023
59. Müller, Vincent C., et al, (2016), "Future Progress in Artificial Intelligence: A Survey of Expert Opinion". In Müller, Vincent C. (ed.), Fundamental Issues of Artificial Intelligence. Springer

Author's Brief Biography



Rear Admiral Khandakar Akhter Hossain, NUP, ndc, psc, PhD was commissioned in the Engineering Branch of Bangladesh Navy on 01 January 1991. He has completed his BSc and MSc Engineering in Naval Architecture and Marine Engineering with distinct result from Bangladesh University of Engineering and Technology (BUET). He has also completed MBA from reputed public university. He did Shipbuilding and Shipyard Management Course both from China and from USA. He has achieved prestigious Doctor of Philosophy (PhD) degree from both BUET (On shipbuilding /recycling) and California, USA (On advanced engineering management). He has served as Engineer Officer onboard different war ships including BNS UMAR FAROOQ, BNS ALI HAIDER, BNS BANGABANDHU and BNS SHADHINOTA. He has also served as Deputy Director/Director at NHQ. He successfully participated in UN peacekeeping mission in Sudan. He was the project chief Naval Architecture/Engineer of state of Art warship Shadhinota Class Missile Corvette project in China. He has also served as GM (Shipbuilding), GM (Production) and GM (Planning and Marketing) in all BN owned shipyards. He has served as member engineering in Chittagong Port Authority. He has successfully performed the duty of Managing Director (MD) in all three shipyards run by BN and has contributed remarkably in national shipbuilding industry. Before joining here, he has performed his duties as Commodore Superintendent of Dockyard (CSD). He has performed various instructional duties in Naval Academy, Marine Academy, NIT and MIST. He was also the Dean/Head (On NAME department/ME Faculty) at Military Institute of Science and Technology (MIST). He is the fellow of prestigious institutes like IEB (BD), RINA (UK) and IAMSP (USA). He has more than one hundred International publications/papers on shipbuilding, ship recycling, energy solution, human management diversification, port operation, AI, IoT and advanced technology in diversified international technical journals. Presently he is serving as Assistant Chief of Naval Staff (Materiel) at Naval Headquarters. He is happily married with Dr. Sharmin and blessed with twin daughters and two sons.

SELECTION OF STEEL FOR SUBMARINE HULL

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Abstract. The operational requirement of submarine needs tremendous focus in submarine construction and structural strength. Selection of appropriate material thus became a determinant of the greater strength of submarines. This paper will analyze the critical requirements to enhance the capability of submarine in reaching greater depth and the importance of material for achieving the capability. In particular, this paper will analyze the feasibility of steel as a material for submarine hull construction.

INTRODUCTION

Submarines are underwater self-propelled crafts that are designed and built to perform underwater operations for a stipulated amount of time. The submarine design consists of a single, mixed or double-hull system that houses all the necessary systems and manpower required for completion of its mission.

The submarine design process is extremely difficult. Approximately 40% of the focus and priority in the entire submarine design process is given to its structural design [1]. The full process of designing its structure also takes up majority of the time, as it is not only related to strength factors but also to a nexus of functional aspects that are interrelated to it.

HISTORY OF SUBMERSIBLE CRAFT

The concept of underwater combat has roots deep in antiquity. There are images of men using hollow sticks to breathe underwater for hunting at the temples at Thebes, but the first known military use occurred during the siege of Syracuse [2]. Later legends from Alexandria, Egypt from the 12th century AD, suggested that Alexander conducted reconnaissance, using a primitive submersible in the form of a diving bell, as depicted in a 16th-century Islamic painting.

The first serious discussion of a “submarine” - a craft designed to be navigated underwater, appeared in 1578 from the pen of William Bourne, a British mathematician and writer on naval subjects [3]. Bourne proposed a completely enclosed boat that could be submerged and rowed underwater. Bourne did not actually construct his boat. Dutch inventor Cornelius van Drebel is usually credited with building the first submarine.

The submarine was first used as an offensive weapon in naval warfare during the American war of independence (1775–83). The Turtle, a one-man craft invented by David Bushnell, a student at Yale, was built of wood in the shape of a walnut standing on end [4]. During WW-1 and WW-2 submarines proved its worth in military use and went through many modifications and modernization. Present day submarines are propelled by nuclear power, diesel-electric or air independent propulsion system.

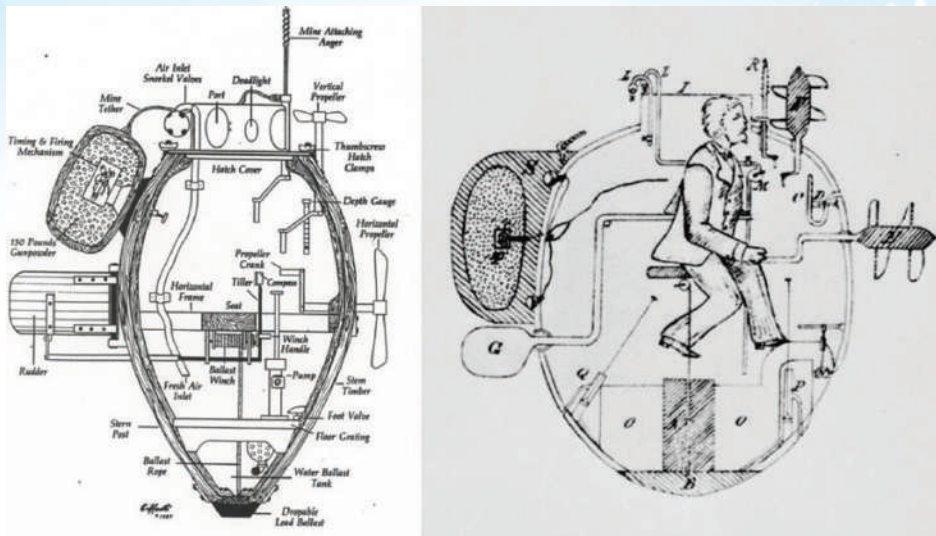


FIGURE 1. The design of Turtle

BASIC UNDERSTANDING OF SUBMARINE HULL

Parts of a Submarine

The basic parts of a submarine are as follows:

1. **Pressure Hull.** Pressure hull is designed to withstand the hydrostatic pressure at the maximum operable depth of the submarine. It houses the important machinery and crew accommodations.
2. **Non-pressure Hull.** The pressure hull is housed inside the non- pressure hull, which does not withstand pressure.
3. **Main Ballast Tanks (MBT).** The “floodable” spaces are compartmentalized into tanks, which in submarine terminology, are called Main Ballast Tanks.

CHARACTERISTICS OF PRESSURE HULL

The pressure hull of submarine must have two basic characteristics. These are great strength and ability to maintain its original shape under pressure. Considering these two factors and economy shape of pressure hull is determined to be circular cross section.

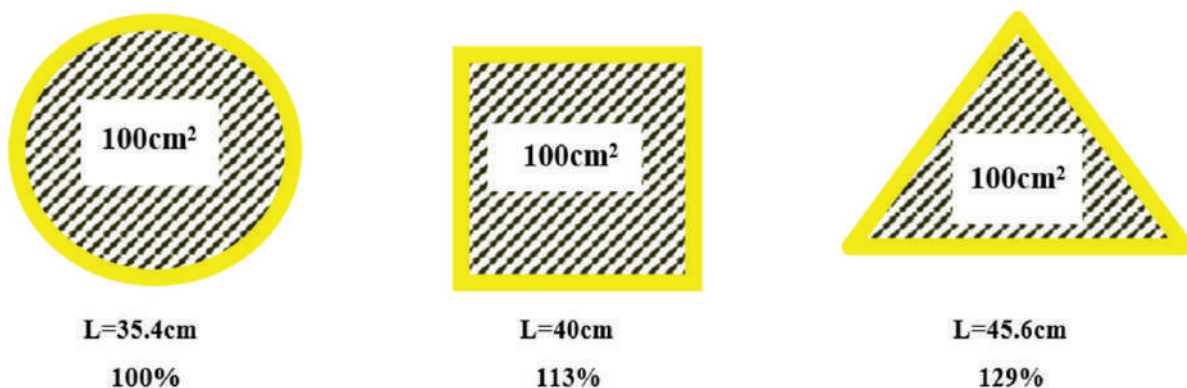


FIGURE 2. Deformation and Area vs material cost in various hull form

DEPTH VS WATER PRESSURE ON PRESSURE HULL

The density of water causes ambient pressures that increase dramatically with depth [5]. At about 10 m below the surface, the water exerts twice the pressure (2 atmospheres or 200 kPa) as air at surface level. And for every further 10 m depth the water pressure increased by 1 atmosphere.

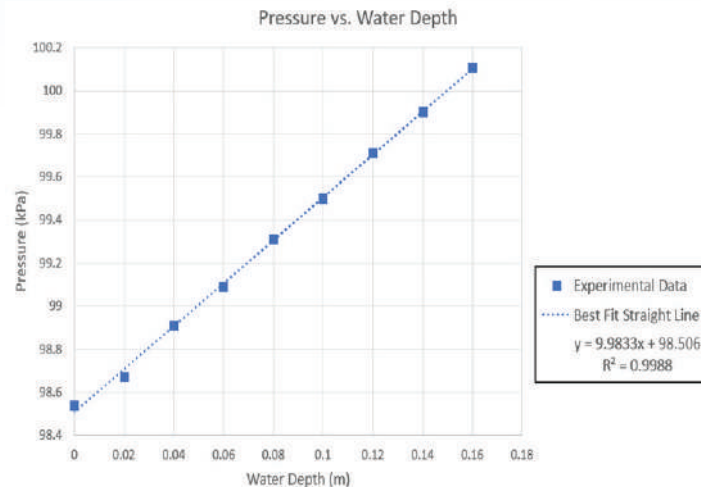


FIGURE 3. Depth vs pressure underwater

SUBMARINE HULL MATERIAL SELECTION CRITERIA

Depth

Depth is one of the most important and deciding structural design criteria. The pressure hull is the primary structural element of the submarine, and is designed to be able to withstand the external hydrostatic pressure. Following depth parameter are considered during selection of hull material.

- Depth Rating
- Design Depth
- Test Depth
- Maximum Operating Depth
- Crush Depth

Shock Load

A submarine is designed to withstand the loads generated by underwater detonations (for example, mine explosions, pressures generated by bursting of large underwater gas bubbles).

Other Factors

Following other properties of hull material are also considered in selecting a submarine hull material:

- Corrosion Resistance
- Resistance to Stress-corrosion and Cracking
- Resistance to Low Cycle Fatigue
- Creep Resistance

- e. Stress Relief Embrittlement
- f. Resistance to Brittle Fractures
- g. High Strength to Density Ratio
- h. High Ductility
- i. Fracture Toughness
- j. Weldability
- k. Malleability

SUBMARINE PRESSURE HULL MATERIAL USED WORLD-WIDE

Submarine pressure hulls are usually made of steel, aluminum, titanium, acrylic plastic and glass. Aluminum is generally considered unacceptable as a pressure hull material because it is not weldable and is subject to stress-corrosion cracking. Pure titanium is too susceptible to stress-corrosion at high tensile stress levels, but titanium graphite alloys do not exhibit this problem [6].

Basing on the above criteria various navies worldwide selected various hull materials suitable for their submarines.

USA

USA use HY80, HY100, HY130 grade material where the number represents the strength in square inch per kilo lb and HY represents High Yield.

- 1. HY80: Strength 552MPa (80ksi)
- 2. HY100: Strength 690MPa (100ksi)
- 3. HY130: Strength 890MPa (130ksi)

Germany

Submarine steel (U-Boot-Stahl) is available in 1.3813, 1.3952, 1.3964 and 1.3974 category.

- 1. 1.3964: Strength 560MPa-ship 212A (214), 206, 205, Dolphin class.
- 2. 1.3974: Is the strength around HY90 class (620-640MPa)

China

Following types of material are used:

- 1. 980 steel: Yield Strength 784MPa – Used in Type 093, Type 094 submarines.
- 2. 921A steel: Yield Strength 590MPa (60kgf/mm²) – Used in Type 039 submarines.
- 3. TA5-A Titanium alloy: Yield Strength 588MPa (60kgf/mm²).

YS = Yield Strength or proof stress. HY = High Yield

YS 	 US	 UK	 France	 Germany	 China	 Russia and India	 Japan	 Australia	 Sweden
550M Pa	HY80	Q1N		1.3964		India DMR-292 #	* 1) NS56		
590M Pa			60HLES		921A TA5-A	AK-25 48-OT3			
630M Pa				1.3974					
690M Pa	HY100	Q2N				AB-2	* 2) NS70		
700M Pa			80HLES					BIS812 EMA	Weldox 700
785M Pa					980	AK-29	NS80		
890M Pa	HY130		100HLES		*4) Ti80	AB-3?	NS90		Weldox 900
980M Pa						AK-33			
1075 MPa						AK- ??			
1178 MPa	HY156						* 3) NS110		

- * 1) steel of 550MPa and NS56 is equivalent to HY80 grade steel.
 * 2) steel of 690MPa and NS70 is equivalent to HY100 grade steel.
 * 3) steel 1078MPa and NS110 is equivalent to the HY156 grade steel.
 * 4) Ti80 Titanium alloy under development 880MPa equivalent to NS90 or HY128 steel - source.

FIGURE 4. Pressure hull Material for Submarine Used Worldwide

PARTICULARS OF SAMPLE HULL MATERIAL

To further compare the characteristic of pressure hull material German 1.3964 type steel which is Austenitic chromium-nickel stainless steel stabilized with niobium for use in non-magnetic applications can be taken as example. The material composition of 1.3964 type steel is X2CrNiMnMoNb21-16-5-3 which is illustrated in following table:

Table 1. The physical properties of the material

Properties	Typical Value	Remarks
Yield strength	560 N/mm ²	
Tensile strength	890N/mm ²	
Corrosion Resistance		Very Good
Weldability		Good
Density	09 kg/dm ³	
Thermal Conductivity	14 W/m K	at 20 °C
Thermal Expansion	15.7 x 10-6 K-1	20 – 100 °C:
	17.0 x 10-6K-1	20 – 200 °C:
	17.5 x 10-6K-1	20 – 300 °C:
	17.8 x 10-6K-1	20 – 400 °C:

DEDUCTION

Basing on the study of requirements of structural strength for submarine to operate at greater depth is highly influenced by the materials used for construction of hull. Moreover, the design of the hull has also some contribution to the strength of the structure. Finally, the workmanship and industrial capability determines maintenance of uniform strength throughout the hull. In general hull thickness, strength of material, design and size etc. are the prime factors for the structural strength of a submarine hull. In this regard steel alloys are a brilliant choice.

CONCLUSION

Selection of hull materials of a submarine depends on various criteria. These include the operational requirement of the submarine such as the depth. In addition, the corrosion resistance, material quality, yield strength, weight of material etc. are intrinsic particulars to be considered for hull construction. Material strength is a significant factor when the required operational depth of submarine increases. In this aspect most of the modern countries use alloys which provide better corrosion resistance, greater strength and superior strength to weight ratio. The percentage of carbon in material plays a determining role in increasing strength.

However, to achieve the required combination the design and industrial process is a determinant of success. The survivability of the submarine depends on the uniform strength throughout the hull. To achieve this thickness of submarine pressure hull is of paramount importance. Nonetheless, it is the strength of the material which ultimately decides the survivability of the submarine underwater. In this regard the selection of material and composition of alloys are important.

REFERENCE

1. <https://www.marineinsight.com/naval-architecture/submarine-design-structure-of-a-submarine/> accessed on 17 June 2021.
2. <https://www.marineinsight.com/naval-architecture/submarine-design-structure-of-a-submarine/> accessed on 17 June 2021.
3. <http://www.madehow.com/Volume-5/Nuclear-Submarine.html> accessed on 17 June 2021.
4. <https://www.sciencedirect.com/topics/engineering/pressure-hull> accessed on 18 June 2021.
5. <http://naval-architect-jobs.blogspot.com/2011/11/submarine-hull-strength.html> accessed on 18 June 2021.
6. <https://www.marineinsight.com/naval-architecture/understanding-stability-submarine/> accessed on 15 June 2021.

Author's Brief Biography



Commodore A H M Rafiqul Islam, (E), NUP, psc, BN completed his graduation in Naval Architecture and Marine Engineering from BUET in 1999. Since then, the officer has served in various capacities of Bangladesh Navy. During his last illustrious career of thirty years in Bangladesh Navy, the individual served as Project Engineer Officer of Submarine Project in China. Thereafter, submarine became a point of interest for the officer where he served for long time. Presently, the officer is pursuing his Master's degree and acting as the Head of the Department of Naval Architecture and Marine Engineering at MIST.

STUDY ON IMPROVEMENT OF EXISTING WATER CIRCULAR TRANSPORTATION SYSTEM BETWEEN GABTOLI AND SADARGHAT

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Abstract. In modern electronic packaging industries, plastic ball grid array (PBGA) has been widely used as the microprocessor components. Upon thermal cycling due to the generation of thermal stresses, the PBGA package may undergo fatigue failure in the solder balls and thus it became a matter of interest for researchers to model the PBGA package to calculate its thermal cycling life. This study aims in 3D finite element modeling of the slice model of a PBGA package to calculate the accumulated plastic dissipation energy per cycle in the solder joint, which is often considered as an indication of damage accumulation in the solder joint of the PBGA package. The thermal cycling simulation is performed between -40 to 125 oC and the associated life to failure is predicted using obtained finite element results and life prediction theory. As researchers have already showed, the failure of the solder joint usually starts at the corner of the solder-copper interface layer and then it propagates along the interface or through the body of the solder depending on the mechanical properties and shape of the solder ball. Traditionally, a flat interface layer is always maintained in the manufacturing of the PBGA packages. For the first time, this research focuses on the effects of the interface geometry on the damage accumulation in the critical solder joint hence the life for crack initiation as well as crack propagation of the package. Instead of a flat circular solder-copper interface layer, a wavy patterned interface layer is considered in the simulation. Finite element analysis results show that thermal life and crack propagation in the solder ball greatly depends on the geometry of the solder joints. The volume averaged plastic energy dissipation accumulated per cycle is reduced when a wavy patterned interface layer is considered which may be due to the fact that more surfaces come in contact with each other reducing stress and therefore the no. of cycles before failure increased in case of wavy patterned interface layer.

INTRODUCTION

In Bangladesh's capital city of Dhaka, the Gabtoli-Sadarghat water circle transportation system is a significant type of public transportation. For commuters, especially those from the western part of the city who must travel to the central and eastern sectors, it offers a practical and affordable form of transportation. The system does, however, suffer a lot of challenges and constraints that have a detrimental effect on both its economic viability and ridership. These issues include a lack of safety safeguards, poor boat quality, inadequate infrastructure, and infrequent service. A comprehensive investigation is needed to identify the difficulties and suggest workable and sustainable introducing new technologies, and all of the above are examples of feasible initiatives. By putting these tactics into practice, the city and its residents could benefit from a more effective, secure, and appealing water circle transit system. It is crucial to prioritize and invest in enhancing the transportation

infrastructure as Dhaka's population expands to provide all inhabitants with a reliable and secure mode of transportation. solutions in order to address these concerns and enhance the current water circular transportation system. Creating a policy framework, raising public awareness, boosting safety and security measures, upgrading infrastructure and boats.

ROUTE ANALYSIS

Two significant places in Dhaka, the capital city of Bangladesh, are Gabtoli and Sadarghat. The waterways route is one of the most convenient and well-liked ways to get between these two destinations, which are separated by a distance of roughly 16 kilo meters. The city's northern and southern regions are connected by a waterways route, which offers an alternative to the typically congested road transit system. The route was selected because it satisfied the essential physical requirements and provided several chances for the transportation sector to prosper in the future by obtaining the required level of precision.

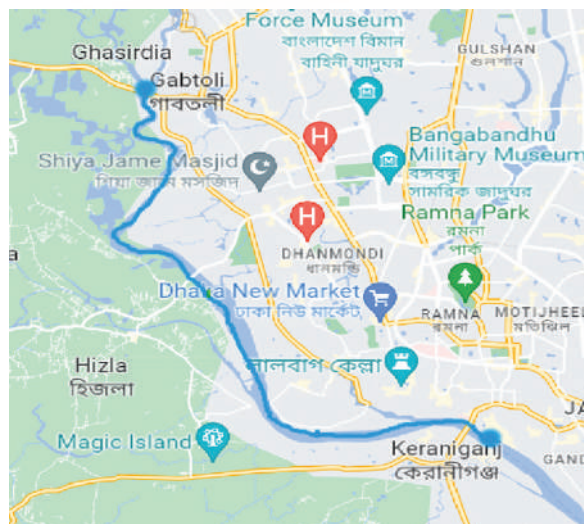


FIGURE 1: Map showing location of the study area (Satellite View)

PROBLEMS AND PROPOSED SOLUTION FOR THE ROUTE

A. Problems on the route

A significant variety of problems with the Gabtoli-Sadarghat water circle transportation system in Dhaka, including a lack of outside frequency and slower pace. Low boat frequency causes lengthy wait times between boats, which deters commuters from using the system. The boats' attraction is further diminished by the fact they move at a slower speed than other forms of transportation. Existing loads on this route are also problematic for the system, which may cause crowding and discomfort for passengers. Safety and security pose a serious problem as well because passengers' lives are at stake when safety procedures like life jackets and safety warnings aren't used. Further, there is a low level of ridership due to the lack of passenger awareness about the system. The city and its residents will profit if the frequency and speed of the boats are increased, security and stability measures are implemented, and public awareness is risen. This would make the water circle transit system a more practical, efficient, and fascinating means of transportation improving infrastructure, modernizing transportation modes, and integrating different transportation modes are critical for

the development of Bangladesh's inland transportation sector. To achieve this, the government should prioritize investment in infrastructure development and maintenance, promote the use of technology, and regulate and standardize different aspects of the transportation sector. The government should also take steps to tackle corruption, improve logistics management, enhance safety and security measures, promote environmental sustainability, and encourage skilled labour development. Additionally, political stability and increased investment in the sector should be ensured. The government could also consider privatization and public-private partnerships to leverage the strengths of both sectors. Lastly, international cooperation should be explored to enhance regional integration and the development of regional transportation networks

B. Types of Water Vessel Functioning On The Route

In Bangladesh, the waterways route between Gabtoli and Sadarghat is primarily serviced by motorized passenger boats or ferries that can carry both people and cargo. Depending on demand and route requirements, these diesel-powered boats come in a variety of sizes and are composed of steel or wood. As part of the circular canal system, the Bangladesh Inland Water Transport Company (BIWTC) launched a water bus service between Sadarghat and Gabtoli in 2004, but it was a failure due to poor frequency and intermodal facilities. The service was restarted in 2010 after a six-year break, but was quickly suspended once more due to a lack of landing facilities, subpar journeys, and increasing rates. The Bangladesh Inland Water Transport Authority (BIWTA) dredged the river to ensure a constant water flow while the BIWTC chose to expand the service frequency by introducing four new water buses with 81 seats each. The service was restarted by BIWTA in July 2013 with six water buses, with rates ranging from 10 to 40 taka.

BIWTC intends to increase the number of water buses to twelve by the end of the year despite suffering a financial loss as a result of the low passenger volume. It is intended that this increase in frequency would make the water bus service more well-liked and lucrative in the future, along with advancements in landing areas and prices.

C. Speedboat Service on Dhaka Circular Waterway

In September 2022, a private enterprise introduced a high-speed watercraft service using five swift speedboats on two routes of the Dhaka circular waterway. The Koddha-Gabtali and Gabtali-Sadarghat routes will be introduced later in response to passenger demand. The Tongi, Abdullahpur-Koddha and Tongi/Abdullahpur (Gazipur)-Ulukhul (Kaliganj) routes were offered for Tk150 and Tk120, respectively. State ministers Khalid Mahmud Chowdhury and Zahid Ahsan Russell, who stressed the value of safeguarding waterways and asked business owners not to harm the environment by depositing trash in the river, launched the Tongi River Port. In order to reduce road congestion and establish effective passenger and cargo transportation systems via waterways, the high-speed watercraft service was introduced.

PROPOSED SUBSTATION

A. Substation at Thota:

There may be a substation for travelers heading from and toward this location called Thota close to Sadarghat (2.2 kilometers down the waterway). Although there are many ghats seen here, the ghats (stations) are solely for local boats. inadequate or completely unavailable amenities The water route from Thota to the Kamrangir char region can also be used.

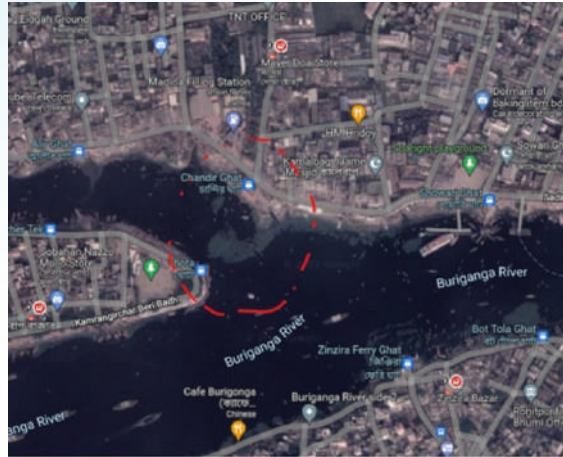


Figure 2: Substation at Thota (Satellite View)

Substation Near Dhanmondi Model Town (Bosila):

This substation enables the connection of a new water channel passing through Bosila in the route, in addition to offering local residents with access to water transportation facilities.



Figure 3: Substation at Bosila (Satellite View)

On the proposed substation area, there is also a stream through that area might be helpful. The region is densely populated.

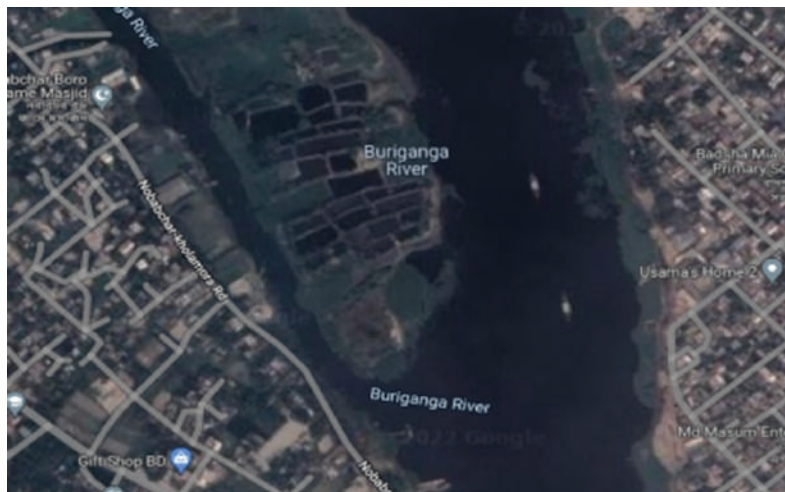


Figure 4: Substation at Nobabchar area (Satellite View)

B. Preliminary Design of a Vessel

A preliminary Catamaran vessel design that could be launched along on the route has been designed, and the probability of sustainability has been evaluated using net present value calculations.

Reason for Catamaran design instead of monohull

Due to their stability, shallow draft, roomy interiors, and faster speed when compared to monohulls, catamarans are typically chosen for carrying passengers. For people who are prone to motion sickness, they provide a gentler ride in choppy waters. They have additional options for itineraries and destinations because they can access beaches and shallow waters. They provide a more pleasant and delightful trip since they offer more space for passengers and amenities. Also, because of their greater speed, they provide speedy and effective transit, which benefits ferry services and vacation operators. Generally, catamarans are preferred over monohulls for passenger transport due to their many advantages.

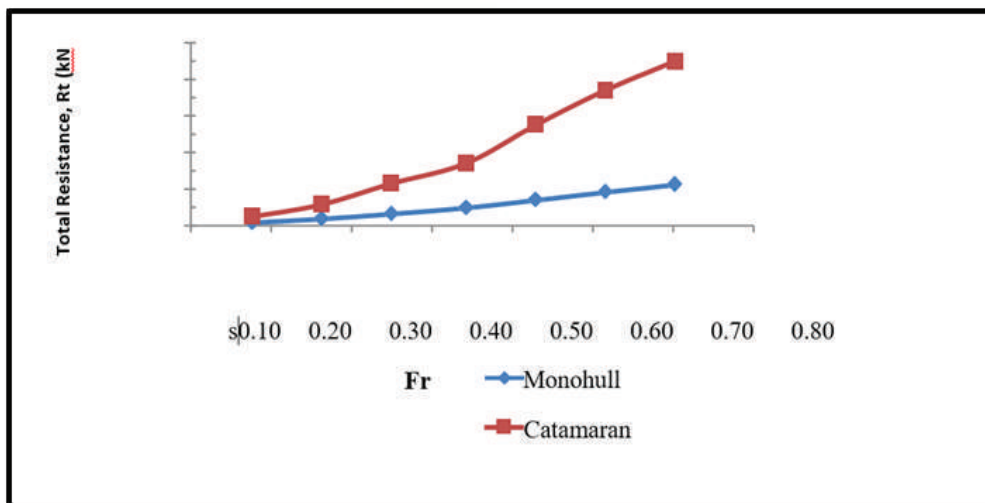


Figure 5: Comparison of Monohull and Catamaran vessel resistance

Rhino 3D design

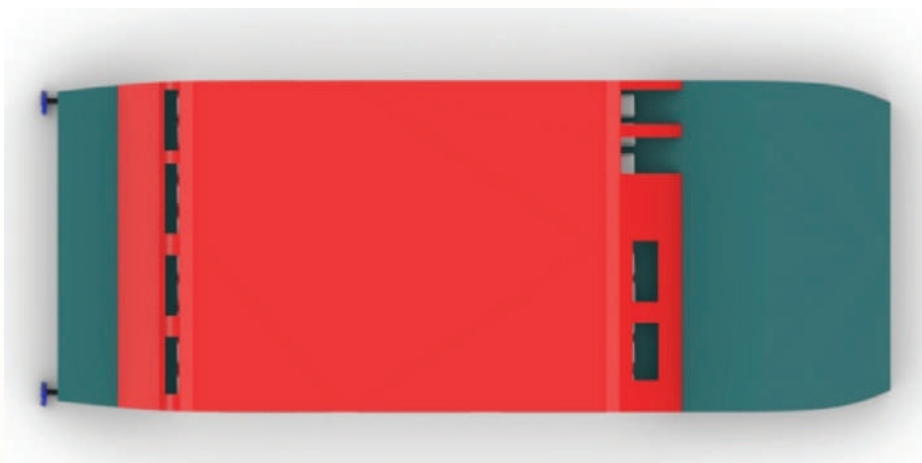


Figure 6: Top view

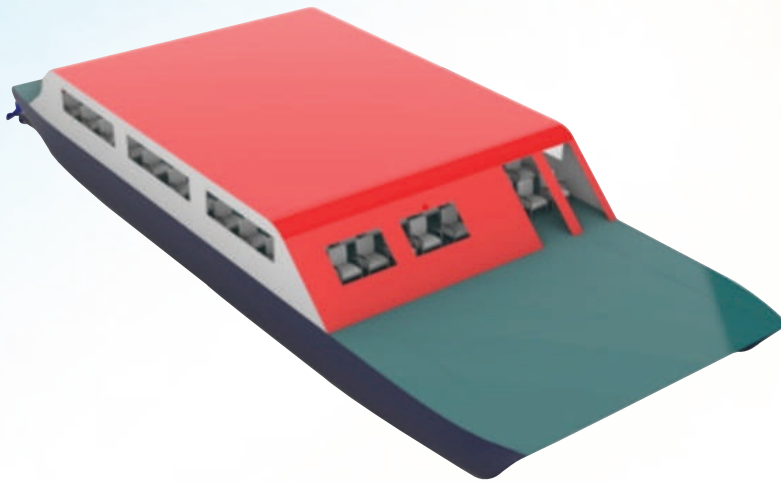


Figure 7: Perspective view



Figure 8: Right view

C. Dimensions

Length overall-24 meters

Breadth-9.5 meters

Draft-1.5 meters

Depth-1.7 meters

Displacement-72 tonne

D. Estimated Total Capital cost

Engine cost	1768200
Steel cost	1170000
Generator cost	1500000
Accommodation and interior costs	4561800
Shipyard costs	3000000
Other machinery costs	3000000
Total Capital cost	15000000

Table 1: Capital cost for Catamaran vessel

E. NET PRESENT VALUE ANALYSIS

Fare per trip=300x3=9000 taka

Fare per day=3x9000=27000 taka

Maintenance day per year=15 days

Working day per year=350 days

Fare per year=27000x50 =9450000taka

Expense per year-

Salary of 1 skipper 4 crew=200000x12=2400000tk

Fuel consumption=On 50% load 5.7 liter per hour

Operating hour 6 hours

Fuel cost per year=6x5.7x109x12 =450000taka

Lubricating oil cost=100000 taka

Maintenance per year=1500000tk

Other costs=450000taka

On the boat capacity =160 passengers

Considering 150 passengers will travel on per trip

Office hour=10 am to 4.30 pm

Minimum trip per day =3 days

Table 2: Net Present Value Calculation

YE R	CASH INFLO W BEFORE TAX	EXPENS E	Depreciati on	TAXABL E INFLOW	TAX 30%	CASH INFLO W AFTER TAX	PW 8%	DCF
0	-20000000						1	- 2000000 0
1	9450000	4800000		4650000	1395000	8055000	0.92592 6	7458333.
2	9922500	5040000	1052631.57 9	3829868.4 21	1148960. 5	8773539. 47	0.85733 9	7521896
3	10418625	5292000	1052631.57 9	4073993.4 21	1222198	9196426. 97	0.79383 2	7300420.
4	10939556. 25	5556600	1578947.36 8	3804008.8 82	1141202. 7	9798353. 59	0.73503	7202082. 4
5	11486534. 06	5834430	1578947.36 8	4073156.6 95	1221947	10264587 .1	0.68058 3	6985905. 5
							NPV	1646863 7

Launching a catamaran on the route between Gabtoli and Sadarghat Water should be profitable since the NPV is positive and has a corresponding value. Since the NPV was estimated over a period of five years, the investment will be recovered in under five years with a substantial profit margin. This NPV ought to draw investors and businessmen.

F. DISCUSSION and RECOMMENDATION

A. Infrastructure Development

The growth of Bangladesh's inland transportation industry depends on the infrastructure, including roads, bridges, and ports, being improved. To make sure that the transportation system can handle the growing volume of traffic, the government should prioritize investments in infrastructure development and upkeep.

B. Modernization of Transportation Modes

The government ought to make investments in the modernisation of the rail network, including modernizing the machinery and technologies in use. This will increase the railway system's effectiveness and dependability, making it a more desirable alternative for both enterprises and individuals.

C. Integration of Diverse Modes of Transportation

The government ought to try to integrate various means of transportation, including those involving the road, rail, water, and air. By doing this, efficient and effective transportation of both people and products will be possible.

D. Corruption

Government should take action to combat corruption in the inland transportation industry. Anti-Corruption Measures This can entail bolstering anti-corruption legislation and rules, boosting accountability, and improving transparency.

E. Improved logistic management

For Bangladesh's inland transportation industry to operate effectively and efficiently, improved logistics management is essential. To guarantee that commodities are carried in a timely and economical way, the government should seek to improve coordination and planning amongst various parties.

F. Steps to Improve Safety and Security

The government needs to take action to improve safety and security in the inland transportation industry. This can entail hiring more security guards, upgrading security tools and technology, and putting safety precautions in place to stop theft and hijacking.

G. Sustainability in the environment

The government needs to take action to solve environmental problems in the inland transportation industry. This could entail encouraging the use of eco-friendly transportation options, such as electric or hybrid cars, and making the necessary investments in waste management and disposal systems.

H. Political Stability

The government should take action to maintain political stability in the nation, which will lessen the impact of strikes and protests on transportation.

I. Increased Investment

By fostering a welcoming investment environment and decreasing the risks connected with the industry, the government should promote more investment in the inland transportation sector.

J. Development of Skilled Labour

The government ought to make investments in the inland transportation industry's need for skilled workers. This can entail offering chances for education and training as well as encouraging the growth of practical skills.

K. Increase efficiency and cut costs

The government may want to privatize various facets of the inland transportation industry, such as the operation of ports and railroads.

L. Public-Private Partnerships:

To take advantage of the strengths of both the public and private sectors, the government might promote the growth of PPPs in the inland transportation industry.

M. Usage of Technology

To increase effectiveness and lower costs, the government should encourage the use of technology in the inland transportation industry, including the use of GPS, real-time monitoring, and automated systems.

N. Regulation and Standardization

To provide a level playing field for all stakeholders in the inland transportation industry, the government should regulate and standardize many areas of the industry, such as tariffs.

O. International Cooperation

In the inland transportation industry, the government should look at prospects for international cooperation, such as regional integration and the creation of regional transportation networks.

CONCLUSIONS

A review of the Gabtoli to Sadarghat water circle transportation system reveals serious issues, including traffic, delays, and safety worries, which have an adverse effect on Dhaka citizens. Increasing the number of vessels, expanding infrastructure, setting safety measures in place, and better stakeholder collaboration are all suggestions for how to improve this system. To satisfy the growing demand and shorten wait times, more boats should be deployed. New jetties and repairs to the infrastructure will increase accessibility and safety. Implementing safety precautions like life jackets, boater education, and emergency supplies is a good idea. A more effective and dependable network of water transportation depends on greater stakeholder cooperation and communication. These adjustments attempt to increase capacity, reduce travel times, and improve mobility, but they necessitate cooperation from the public, transport providers, and the government.

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REFERENCES

1. Circular Water Transport System of Dhaka City: Analysis of Existing Condition, 6. Inherent Problems and Future Prospects – thesis published by S. M. Nawshad Hossain, Sania Sifat Miti, Md. Lutfur Rahman
2. Reviving The Inland Waterways Of Dhaka: A morphological approach towards an integrated transportation system; thesis published by Amreen Shajahan (BUET), Farida Nilufar (BUET)
3. THE Circular Waterway In Dhaka: Enhancing Recreation and Place Making by Jesmin-Nahar- Sultana (BUET)
4. Buriganga River Pollution: Its Causes and Impacts by M. G. Kibria, M. N. Kadir and S. Alam
5. An Investigation Into The Water Quality Of Buriganga - A River Running Through Dhaka Shaikh Sayed Ahammed, Sadia Tasfina, K. Ayaz Rabbani, Md. Adbul Khaleque
6. Bangladesh Inland Water Transport Authority (BIWTA)
7. Bangladesh Inland Water Transport Corporation (BIWTC)

Author's Brief Biography



Capt Kaosar Rashid, (E), psc, BN, is a proud alumnus of Bangladesh University of Engineering and Technology (BUET), where he earned both his BSc and MSc degrees in Naval Architecture and Marine Engineering. He did Marine Engineering Specialization (Bangladesh and India), Marine Engine Simulator Course (India), Post graduate Diploma in Marine Engineering, Junior Staff Course, Naval Staff Course (DSCSC, Mirpur) and Masters in Defense Studies (Bangladesh University of Professionals (BUP). He served as Deputy General Manager in Khulna Shipyard Ltd, Khulna, Engineering Officer (EO) onboard Naval ships (Small, Medium, large), Staff Officer (plans) at NHQ, Dhaka and OIC in Khulna Shipyard, Dockyard & Engineering Workshop Limited. He also worked as Instructor Class 'A' in NAME dept. and Instructor Class 'B' in Mechanical Engineering dept. in MIST, Engineering Instructor in Bangladesh Marine Academy and Instructor in Engineering Training School of BNS SHAHEED MOAZZAM. He has also served as the Head of the Naval Architecture and Marine Engineering (NAME) Department at MIST. Currently, he holds the prestigious position of Director of Students' Welfare (DSW) and Senior Instructor in the Department of Naval Architecture and Marine Engineering at the Military Institute of Science and Technology. His teaching and research interest include Environmental Pollution by Marine Vehicles, Control of Marine Accidents, Propulsion Efficiency, and Offshore Structure Analysis.

Shipping Beyond Boundary

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Abstract. This comprehensive article explores the potential of the shipping industry in Bangladesh and outlines strategic initiatives to harness this potential for economic growth. Bangladesh, strategically located in South Asia with access to the Bay of Bengal, stands as a natural trade gateway connecting various regions. The nation's growing economy, driven by industries such as textiles, demands efficient shipping services. Despite challenges like infrastructure limitations and complex regulations, the shipping sector in Bangladesh exhibits resilience and adaptability. The article emphasizes the need for strategic steps such as facilitating capital access, attracting investments, simplifying foreign transactions, offering sector-specific incentives, and ensuring tax exemptions. These measures, coupled with the development of supporting industries, can elevate Bangladesh as a prominent player in the global shipping arena, contributing significantly to the nation's economic prosperity.

INTRODUCTION

Bangladesh annually exports goods worth 56 billion dollars and imports goods worth 92 billion dollars. The transportation sector accounts for a significant portion of the expenses in this import export business. In the fiscal year 22-23, Bangladesh incurred a cost of 34 billion dollars in freight charges paid to foreign companies. According to the Flag protection Act of 2019 in Bangladesh, shipping of imported cargo is mandated to be done by Bangladeshi shipping companies. However, due to the lack of domestic shipping lines, foreign shipping companies are doing business by getting waiver from department of shipping. If Bangladesh had the capacity to handle these shipments, it could potentially earn 15 billion dollars in freight revenue.

According to UNCTAD regulations, a country can carry 50% of its total import-export cargo through its own carriers. Currently, Bangladesh has the potential for a 17-billion-dollar business. Additionally, the neighboring states like Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Tripura, Uttar Pradesh, Jharkhand, and West Bengal collectively have a 31-billion-dollar business potential. India, with its 400-billion-dollar industry, hires various shipping companies every year. This suggests a substantial opportunity for Bangladesh and its neighboring states to tap into the shipping industry and significantly enhance their economic prospects.

Moreover, there exists a lucrative opportunity worth \$25 billion in the neighboring Seven Sisters states, namely Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, and Tripura, as well as in Uttar Pradesh, Jharkhand, and West Bengal. India, boasting a 400-billion-dollar market, consistently attracts a wide array of shipping companies each year.

To bolster our economy, given our limited resources and a burgeoning population, a strategic focus on the service sector is imperative. Countries such as Canada, Switzerland, Germany, and South Korea have achieved prosperity by emphasizing the service industry. Germany, for instance, generates \$1.2 trillion from its service sector, while South Korea earns \$500 billion.

Shipping stands out prominently within the service sector. The advantage of this business lies in its independence from land; it can operate globally with skilled manpower. By nurturing our shipping sector, we have the potential to make a significant 100% contribution to our GDP. For instance, a Danish company called APM contributes a remarkable 110% to its country's GDP.

Switzerland, a landlocked country with no seaports or maritime boundaries, is home to the world's largest shipping company. This fact underscores the urgency for the development of shipping companies in our region, making it a necessity of the present moment.

OBJECTIVE

By developing a shipping service right from our own home base, we're not only meeting our own logistical needs but also tapping into a thriving global demand and earning foreign currency. This is the way to emerge as an economically strongest nation of the region:

WHY SHIPPING BUSINESS

Strategic Location

Situated strategically in South Asia and blessed with access to the Bay of Bengal, Bangladesh functions as a natural trade gateway connecting South Asia, Southeast Asia, and the global market. This geographical positioning elevates its significance as a pivotal hub for shipping and logistics operations.

The geographical location of Bangladesh is unique as it connects the Northeastern states of India, Nepal, Bhutan, entire West Bengal as well as Myanmar, which is paving the way for Chittagong Port to function as a region's main transshipment hub.

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FIGURE 1. The Geographical location of Bangladesh

Growing Economy

In recent years, Bangladesh has witnessed a remarkable and consistent upswing in its economic growth. The nation's Gross Domestic Product (GDP) has been on a steady rise, positioning it as one of the globe's fastest-growing economies. This robust economic expansion has naturally spurred a heightened demand for shipping services, driven by the need to efficiently transport a wide array of goods and raw materials. As industries flourish and trade networks expand, the reliance on reliable and efficient shipping solutions has become paramount, underlining the pivotal role played by the shipping sector in fueling Bangladesh's burgeoning economy.

Export Import-Driven Economy

The thriving textile industry in Bangladesh presents a significant opportunity for the shipping business. As a major exporter of textiles, ready-made garments, and agricultural products, Bangladesh relies heavily on seamless shipping and logistics services to ensure the swift and efficient delivery of its products to international markets. With the textile sector being one of the country's economic pillars, the demand for reliable shipping solutions is ever-increasing. This presents a lucrative prospect for shipping companies to capitalize on this demand, offering tailored services that cater to the specific needs of the textile industry. By providing efficient cargo handling, timely deliveries, and cost-effective transportation solutions, shipping businesses can play a pivotal role in further boosting Bangladesh's textile exports. Embracing this opportunity not only strengthens the shipping sector but also contributes significantly to the country's economic growth and global trade footprint.

A detailed statistics of our economy can reflect the nature of this industry. Following table will highlight the nature of the shipping industry of Bangladesh.

TABLE 1. Trade Statistics

Details	Quantity	Units
Total Cargo Handled by Chittagong Port	117	Million MT
Import	94	Million MT
Export	23	Million MT
In 2021 - Container Handled	3,214,548	TEUs
Import	1,649,459	TEUs
Export – Laden	837,751	TEUs
Export – Empty	739,337	TEUs

TABLE 2. Regional Cargo

Details	Quantity	Units	Import Value Per MT	Total Import Value (Millions-USD)	Freight Revenue
Total Cargo handled by Kolkata Port	64	Million MT		18,800	
Import	42	Million MT	250	10,400	2,704
Export	22	Million MT	375	8,400	1,512
In 2019-20 (Container Handled)	8,44,762	TEUs			

Details	Quantity	Units	Import Value Per MT	Total Import Value (Millions-USD)	Freight Revenue
Import	4,22,381	TEUs	44,000	18,585	1,774
Export - Empty	1,68,952	TEUs			42
Export - Laden	2,53,429	TEUs	19,500	4,942	558
Sub Total					
Nepal Bound Cargo	13	Million MT			4,550
Nepal Bound Container	1,80,000	TEUs			
Bhutan Bound container	85,000	TEUs			

TABLE 3. Volume of the Freight Market

Expenses related to Foreign Trade related transport cost	Bangladesh Amount (USD)	Rest of Bay of Bengal Amount (USD)
Total Merchandise Import Value	92,364,800,000.00	63,36,48,00,000
Total Merchandise Export Value	56,342,300,000.00	42,34,23,00,000
Total Merchandise Trade Value	148,707,100,000.00	1,05,70,71,00,000
Freight and related other charges (BD)	34,712,130,000.00	31712130000
Nepal Bound Cargo		4,591,000,000.00
Bhutan Bound Cargo		136,160,925.73
Total Freight Market	USD (Billion)	66.42

Freight Market in Bay of Bengal: 101.113 USD (Billion)

Expanding Port Infrastructure

Bangladesh has been investing in expanding and modernizing its port infrastructure. Major ports like Chittagong, Payra Port and Mongla Port have undergone significant upgrades to handle larger cargo volumes efficiently. Also, Matarbari deep sea port will open very soon.

Connectivity Initiatives

Bangladesh has been investing in expanding and modernizing its port infrastructure. Major ports like Chittagong, Payra Port and Mongla Port have undergone significant upgrades to handle larger cargo volumes efficiently. Also, Matarbari deep sea port will open very soon.

Increasing Trade Volume

The trade volume of Bangladesh has been steadily increasing, with imports of raw materials and exports of finished products. This trend creates opportunities for shipping companies to expand their operations and services.

Rise In Shipping Technology

The adoption of modern shipping technology, such as containerization and tracking systems, has improved the efficiency and competitiveness of the shipping industry in Bangladesh.

Regional Trade Agreements

Bangladesh is a member of various regional trade agreements, such as SAARC and BIMSTEC. These agreements promote trade and economic cooperation among member countries, further boosting the shipping industry's prospects.

OPPORTUNITIES OF SHIPPING BEYOND NATIONAL BOUNDARIES

International shipping and global trade present substantial prospects for Bangladesh, underscoring the country's strategic positioning and its access to the Bay of Bengal as pivotal advantages. These factors position Bangladesh as a promising hub for international shipping and trade. Within this context, the nation can tap into a diverse range of boundless opportunities:

1. **Export and Import Expansion:** Bangladesh can broaden its export-import activities, venturing into global markets and diversifying beyond its strong textile sector to include electronics, pharmaceuticals, and agro-products.
2. **Transshipment Excellence:** Due to its proximity to major global markets, Bangladesh can establish itself as a transshipment hub. This involves efficient handling and transfer of cargo from large vessels to smaller ones, facilitating seamless distribution across various regional destinations.
3. **Container Shipping Enhancement:** Active participation in the global supply chain necessitates investment in container shipping services. Establishing container shipping lines connecting Bangladeshi ports with international counterparts is crucial for seamless global connectivity.
4. **Efficient Logistics and Freight Forwarding:** As global trade rises, the demand for efficient logistics and freight forwarding services grows. Specialized companies coordinating the movement of goods between countries can flourish in this dynamic environment.
5. **Free Trade Zones Establishment:** Creating special economic zones or free trade zones within Bangladesh attracts foreign investments. These zones serve as attractive hubs for foreign entities aiming to set up manufacturing or distribution facilities, ensuring effortless access to international markets.
6. **E-commerce Facilitation:** The surging growth of e-commerce offers opportunities for cross-border trade. Bangladesh can streamline customs procedures, enhance international shipping services, and bolster support for e-commerce platforms, fostering seamless online trade.
7. **Maritime Support Services Development:** Establishing maritime services like ship bunkering, ship agency, and maritime consultancy contributes significantly to the shipping industry's growth. These services ensure efficient vessel operations and services, bolstering the sector.
8. **Cold Chain Logistics Implementation:** Responding to the global demand for perishable goods, Bangladesh can establish a robust cold chain logistics network. This infrastructure enables the country to export agricultural products such as fruits and vegetables to international markets, meeting stringent quality standards.

9. **Investment in Marine Technology:** Strategic investments in marine technology research and development can lead to innovations in ship design, navigation systems, and safety measures. These advancements enhance Bangladesh's competitiveness in the global shipping industry.
10. **Tailored Shipping Finance and Insurance Services:** Offering financial and insurance services customized to international shipping and trade needs can attract foreign investors and traders. Tailored solutions enhance confidence and facilitate smoother transactions in the shipping business.
11. **Environmental Compliance and Sustainable Practices:** In light of tightening global regulations on emissions and environmental sustainability, businesses focusing on clean shipping and sustainable practices are poised to thrive. Complying with these standards ensures environmental responsibility and industry competitiveness.
12. **Promotion of International Collaboration:** Building robust international partnerships and agreements with other countries creates avenues for joint ventures, trade agreements, and cooperative efforts within the shipping and trade sector. Collaborative initiatives foster knowledge exchange and mutual growth, expanding opportunities for all stakeholders involved.

CHALLENGES

The shipping business in Bangladesh faces several challenges, both internal and external, that can impact its efficiency, profitability, and competitiveness. Here are some of the key challenges faced by the shipping industry in Bangladesh:

1. **Infrastructure Limitations:** Limited port capacity: The major ports in Bangladesh, such as Chittagong Port, experience congestion and limited handling capacity, leading to delays in cargo processing. Inadequate road and rail connectivity: Insufficient Road and rail infrastructure connecting ports to industrial zones can cause bottlenecks in cargo transportation.
2. **Complex Customs Procedures:** Cumbersome and time-consuming customs clearance processes can hinder the smooth flow of goods. Inconsistent regulations: Frequent changes in regulations and compliance requirements can create uncertainty for businesses.
3. **Inconsistent Regulations:** Frequent changes in regulations and compliance requirements can create uncertainty for businesses.
4. **Environmental Challenges:** Vulnerability to climate change: Bangladesh's low-lying coastal areas are highly susceptible to sea-level rise and extreme weather events, posing risks to port operations and shipping routes. Pollution concerns: Environmental regulations related to emissions and ballast water management are increasingly stringent, requiring compliance measures and investments in cleaner technologies.
5. **Piracy and Maritime Security:** The presence of pirates in the Bay of Bengal and concerns related to maritime security can increase risks for vessels operating in the region.
6. **Outdated Technology:** Insufficient investment in modern technology and automation can lead to inefficiencies in cargo handling and logistics.

7. **Competition with Neighboring Ports:** Nearby ports in India and Myanmar can pose competitive challenges, especially if they offer more efficient services or lower costs.
8. **Political Instability:** Periodic political unrest and strikes can disrupt business operations and hinder trade.
9. **Exchange Rate Fluctuations:** Currency exchange rate volatility can impact the costs and profitability of international shipping operations.
10. **Inadequate Investment:** Limited investment in port infrastructure and logistics: The shipping sector may not receive adequate funding for necessary upgrades and expansions.
11. **Bureaucracy and Corruption:** Bureaucratic red tape and corruption can slow down business processes and increase costs.
12. **Security and Safety Regulations:** Compliance with international security and safety regulations, such as the International Ship and Port Facility Security (ISPS) Code, requires resources and expertise.
13. **Risk Management:** Cargo damage, accidents, and liability risks require meticulous management through insurance and safety protocols.

Despite these challenges, the shipping industry in Bangladesh has displayed resilience and adaptability. Ongoing efforts by the government and industry stakeholders to improve infrastructure, streamline regulations, and enhance competitiveness aim to position Bangladesh as a key player in global trade and shipping.

DEVELOPMENT OF SHIPPING SUPPORTING INDUSTRY

The shipping industry relies on a wide range of supporting industries and services to function effectively. These supporting industries play crucial roles in various aspects of the shipping business. Here are some key supporting industries in the shipping sector will be developed along with shipping business.

1. **Port Operations:** Ports are the primary points of entry and exit for cargo in the shipping industry. Port operations include cargo handling, container terminal management, stevedoring, and customs clearance.
2. **Shipbuilding and Repair:** The shipbuilding industry produces vessels, while ship repair facilities maintain and repair ships to ensure they remain seaworthy and compliant with safety and environmental standards.
3. **Marine Insurance:** Marine insurance companies provide coverage for cargo, vessels, and liability risks associated with shipping. This is essential for mitigating potential financial losses.
4. **Freight Forwarding:** Freight forwarders act as intermediaries between shippers and carriers, coordinating transportation and logistics services, handling documentation, and ensuring cargo moves efficiently.
5. **Customs Brokerage:** Customs brokers assist with customs clearance procedures, import/export documentation, and compliance with customs regulations at ports of entry and exit.

6. **Logistics and Supply Chain Management:** Companies specializing in logistics and supply chain management offer services such as inventory management, transportation planning, and distribution to optimize the flow of goods.
7. **Container Manufacturing:** The production of shipping containers, including standard dry containers, refrigerated containers (reefers), and specialized containers, is crucial for cargo transportation.
8. **Navigation and Communication Technology:** Providers of navigation systems, communication equipment, and satellite tracking play a vital role in ensuring safe and efficient navigation for vessels.
9. **Environmental Services:** Companies offering environmental services help the shipping industry comply with environmental regulations, such as ballast water management, emissions reduction, and waste disposal.
10. **Maritime Security:** Maritime security firms help protect vessels and cargo from threats such as piracy, theft, and terrorism. They provide armed guards, security assessments, and security equipment.
11. **Crewing and Manning Agencies:** These agencies recruit and manage crews for ships, including captains, officers, engineers, and deckhands. They ensure that vessels are adequately staffed with qualified personnel.
12. **Port Infrastructure Development:** Companies involved in the planning, design, and construction of port infrastructure, including piers, terminals, and container yards, support the growth and efficiency of ports.
13. **Bunker Fuel Supply:** Suppliers of bunker fuel provide the fuel required to power ships. With increasing environmental regulations, there is a growing demand for cleaner and more efficient fuels.
14. **Container Leasing and Management:** Container leasing companies provide containers to shipping lines and logistics providers on lease, and they manage container fleets.
15. **Cargo Surveying and Inspection:** Cargo surveyors inspect and assess the condition of cargo before and after shipment, ensuring it meets quality and safety standards.
16. **Trade Finance and Banking:** Banks and financial institutions offer trade finance solutions, letters of credit, and other financial instruments to facilitate international trade and shipping transactions.
17. **Maritime Education and Training:** Institutions and training centers provide education and training for individuals pursuing careers in the maritime industry.

These supporting industries may generate job opportunities, earn foreign currency and create resonance to the overall economy and its worth will be not less than 50 USD(billion)

STEPS REQUIRED FOR THE SHIPPING BUSINESS DEVELOPMENT IN BANGLADESH

In order to achieve a sustainable outcome from Shipping Business, Bangladesh can take following steps. Although this steps alone cannot sufficiently determine the outcome of the shipping industries development in Bangladesh but for a sustainable growth of this industry following steps is absolutely necessary to achieve the goal.

1. **Facilitate Capital Access:** To fuel the growth of the shipping industry, entrepreneurs should be encouraged with streamlined processes to secure capital easily from banks, specifically earmarked for ship acquisitions.
2. **Simplify Foreign Currency Loans:** Policies should be revised to simplify the process for entrepreneurs seeking foreign currency loans from abroad for ship acquisitions, promoting international investments in the industry.
3. **Attract Investments:** To attract investments, favorable policies should be created, encouraging insurance and pension funds from various countries to invest in the shipping sector, boosting financial inflows.
4. **Ensure Efficient Foreign Transactions:** For effective management of shipping businesses, facilitate the establishment of foreign currency and instant payment gateways. Shipping companies should be authorized to transfer 85% of their foreign expenses in foreign currency, especially for essential needs like fuel, repairs, and crew salaries, ensuring smooth operations.
5. **Offer Sector-Specific Incentives:** Introduce incentives tailored to the shipping sector, akin to those provided for imports. By encouraging export-oriented industries, such incentives would stimulate growth and investment in the shipping industry.
6. **Tax Exemptions and Growth Projections:** Waive all VAT and taxes related to earnings in foreign currency. These initiatives have the potential to yield substantial annual earnings, aiming for an impressive target of 100 billion foreign currencies within the next 5 years. Furthermore, Bangladesh could earn an additional 50 billion dollars through associated businesses, propelling the sector's growth at an annual rate of 15%. These steps are vital for the burgeoning success of the shipping industries in Bangladesh.
7. **Policy of Opening Letters of Credit (LC) in FOB Terms to Facilitate Local Shipping Lines:** OB terms mean that the seller is responsible for delivering the goods to the port or vessel and covering all costs associated with the delivery to the agreed point. Once the goods are on board, the risk and costs transfer to the buyer. I am recommending that countries open Letters of Credit in FOB terms can significantly benefit local shipping lines and foster economic growth. FOB terms streamline the trade process, reduce costs, and mitigate risks for all parties involved. Furthermore, they position a country as an attractive destination for international trade and investment. By adopting this approach, countries can enhance their competitiveness and positively impact their domestic economies.

CONCLUSION

Bangladesh stands at a pivotal moment, poised to harness the vast potential within its shipping industry to bolster its economy and emerge as a global player. With an annual export value of \$56

billion and an import value of \$92 billion, the transportation sector plays a significant role in the country's trade dynamics. However, challenges such as limited port capacity, complex customs procedures, environmental vulnerabilities, and political instability have hindered the shipping sector's full potential.

Addressing these challenges demands a strategic approach and coordinated efforts from various stakeholders. Streamlining capital access, simplifying foreign currency loans, and attracting investments are critical steps to empower entrepreneurs and enhance the industry's financial stability. Facilitating efficient foreign transactions, offering sector-specific incentives, and projecting growth through tax exemptions can stimulate business activities, encouraging innovation and expansion.

The potential for the shipping industry's growth is underscored by its interconnection with supporting sectors like port operations, shipbuilding, marine insurance, logistics, and technology. Investment in these areas is not only essential for the shipping industry's development but also for generating employment opportunities and foreign currency inflows.

Bangladesh's strategic location as a trade gateway connecting South Asia, Southeast Asia, and the global market provides a unique advantage. By capitalizing on this geographical positioning, Bangladesh can expand its export-import activities, diversify into electronics, pharmaceuticals, and agro-products, and establish itself as a transshipment hub, efficiently transferring cargo to various regional destinations.

Moreover, embracing technological advancements, complying with international security and safety regulations, and promoting maritime education and training will enhance the industry's competitiveness. Collaboration with neighboring states, involvement in regional trade agreements, and participation in global trade events will further position Bangladesh as a key player in the international shipping arena.

In conclusion, a comprehensive strategy encompassing financial facilitation, technological integration, regulatory compliance, and international collaboration is crucial for Bangladesh to unlock the vast potential within its shipping industry. By surmounting challenges, fostering innovation, and nurturing a conducive business environment, Bangladesh can not only meet its domestic logistical needs but also tap into a thriving global demand, earning foreign currency and emerging as the economic powerhouse of the region. The path to economic strength lies in strategic investments, robust policies, and a collective commitment to the growth of the shipping industry, steering Bangladesh toward unparalleled prosperity in the global trade landscape.

Author's Brief Biography



Md. Shamsul Alam pursued his B.Sc. in Naval Architecture & Marine Engineering from Bangladesh University of Engineering & Technology (BUET) in Dhaka, Bangladesh in June 2002. His dedication to the field of naval architecture extends to his involvement in professional associations. He holds esteemed memberships in renowned organizations, including "The Royal Institution of Naval Architects (RINA)" in London, United Kingdom, and the "Society of Naval Architects & Marine Engineers (SNAME)" in the USA. Additionally, he proudly serves as a "Life Member" of the "Association of Naval Architects & Marine Engineers (ANAME)" in Dhaka, Bangladesh, and "The Institution of Engineers, Bangladesh (IEB)" in Dhaka. He completed training on various aspects of naval architecture, including towing tank experiments, ship design, seakeeping, stability, and structural analysis. His career journey has seen him contribute his skills and knowledge to a range of esteemed organizations. His current role as the Managing Director of Marine House ltd in Dhaka, Bangladesh. He had also held consulting positions with Sea Fishers Dockyard in Chittagong, Bangladesh, Dhaka Dockyard & Engineering Works in Dhaka, and B.F. Internationals in Dhaka. He also has collaborated with prominent entities, including the Mongla Port Authority, the Bangladesh Inland Water Transport Corporation, and the Pyra Port Authority, Bangladesh Shipping corporation etc. providing valuable insights and expertise in naval architecture and marine engineering.

POSSIBILITY OF USING NATURAL FIBER AS STRUCTURAL STRENGTHING MEMBER

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Abstract. Natural fiber composites (NFC) are made of natural resources thus possesses environmentally beneficial properties such as biodegradability. With its natural characteristics, NFC is obtaining more attention in recent years in various application including automotive, merchandise, structural and infrastructure. Several studies have shown that NFC can be developed into a load-bearing structural member for applications in structural and infrastructure application. Natural fibers exhibit many advantageous properties as reinforcement for composites. They are a low-density material, yielding relatively lightweight composites with high specific properties. Natural fibers also offer significant cost advantages and benefits associated with processing, as compared to synthetic fibers. The challenge in working with NFC is the large variation in properties and characteristics. The properties of NFC to a large extent influenced by the type of fibers, environmental condition where the plant fibers are sourced and the type of fiber treatments. However, with their unique and wide range of variability, natural fiber composites could emerge as a new alternative engineering material which can substitute the use of synthetic fiber composites. Finally, the study will conclude with the prospects of NFC applications and the emerging trends in novel bio-composites for future structural applications.

KEYWORDS:

Natural fiber; structural application; fiber composites.

INTRODUCTION

Application of natural fibers as a construction material is not new. The use of natural fibers in composites dates back to three thousand years ago in ancient Egypt where straw and clay were combined to build walls. These peoples, however, had no idea how they could systematically study the fundamental mechanisms and processes involved in the reinforcing effect of natural fibers and what could be done to maximize their performance in strengthening structures [2].

The meritorious services of the artificial Fiber Reinforced Polymer (FRP) composites in construction industry are already encouraging since last few decades. The most common synthetic fibers in practice are glass, carbon, and aramid. It has been concluded that the synthetic FRP composites are capable to upgrade the stiffness, durability, ultimate load-carrying capacity, and retard the cracks propagation of structures. However, such material does not address the issues of sustainability of the non-renewable sources and imposes a higher cost during manufacturing. In addition, the human health will be affected adversely especially in skin and respiratory system. Thus, the research community had given more attention to natural fibers as an alternative to the artificial fibers [3].

The growing environmental awareness worldwide has led to an increasing interest in natural fibers and their applications so that their study is nowadays considered an important field. There exists a wide variety of natural fibers that can be employed as reinforcement or fillers. Fiber composites composed of natural fibers offer such advantages as high strength, lightweight, and high durability as well as resistance to water, chemical attacks, electric current, fire, and corrosion. Moreover, they have proved cost effective in most applications as the properties of fiber composites can be engineered to match the requirements of each specific application. Therefore, interest in natural fiber-reinforced composites (NFRCs) composites is growing rapidly in the transportation sector, aerospace, marine, construction, and automotive industry [2].

The difficulty, however, lies in the evaluation of the quality of natural fibers for use in such applications. The real challenge in this regard lies in the development of a general relation capable of capturing and predicting the structural and mechanical properties of NFRCs since large variations are typically observed in their properties and characteristics [2]. It is important to note that natural fibers have some disadvantages, such as low thermal stability (likely to degrade at 220–250°C). Hydrophilic nature of natural fibers results very poor interface and poor resistance to moisture absorption. The lack of good adhesion between natural fibers and polymeric matrix materials, as well as the high moisture absorption of natural fibers, negatively affect the mechanical properties. To develop composites with better mechanical properties and environmental performance, it is necessary to enhance the hydrophobicity of flax fibers by treating them with appropriate coupling agents or coating them with appropriate resins [2].

This paper aims to investigate the possibility of use of natural fiber composites in structural and infrastructure applications.

NATURAL FIBER

Natural fibers in simple definition are fibers that are not synthetic or manmade. They can be sourced from plants or animals. Hence, these fibers are actually in abundance stock around the world. Several plants from which fibers can be sourced are Sisal (*Agave sisalana*), Hemp (*Cannabis sativa*), Bamboo, Coconut (*Cocos nucifera*), Flax (*Linum usitatissimum*), Kenaf (*Hibiscus cannabinus*), Jute (*Corchorus capsularis*) and Ramie (*Boehmeria nivea*). Fibers from animals are for example wool (Sheep) and feathers (Chicken) [1] etc.

From part of the plant where the fibers are sourced, the fibers can be classified into bast fibers (jute, flax, hemp, ramie and kenaf), leaf fibers (banana, sisal, agave and pineapple), seed fibers (coir, cotton and kapok), core fibers (kenaf, hemp and jute), grass and reed (wheat, corn and rice), and other types of fibers [4].

Traditionally, especially in rural developing countries, natural fibers have been cultivated and used extensively for non-structural applications such as multipurpose rope, bag, broom, fish net and filters. The fibers have also been used for applications in housing as roof material and wall insulation. In the composites industry, natural fibers are often referred to as vegetable fibers. Plant fibers derived from bast (stem, soft tissues, or sclerenchyma); plant leaf, seed, fruit, and wood; or cereal and grass straw are generally the most popular of natural fibers used as reinforcement in fiber-reinforced composites [2]. Figure 2 shows the life cycle of natural fibers composites.

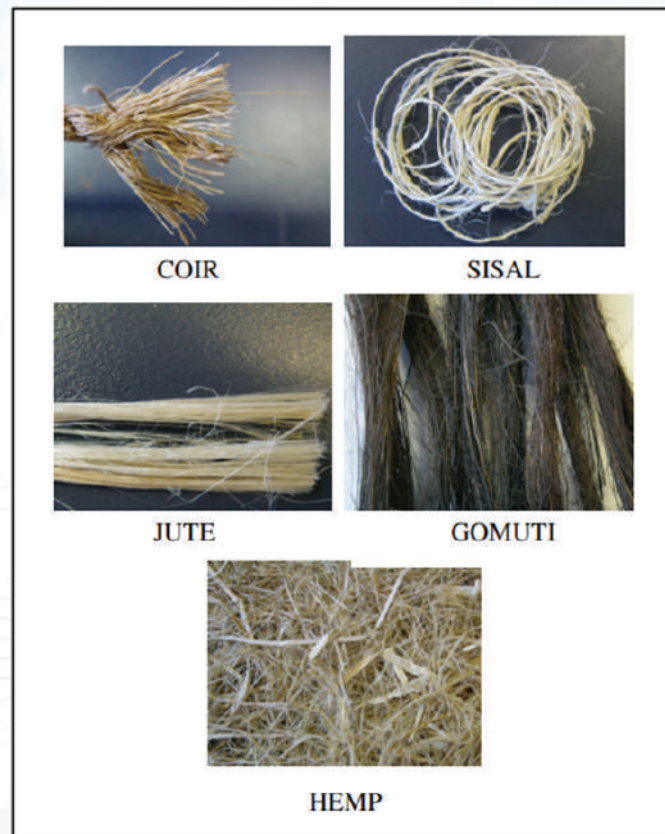


FIGURE 1. Pictures of several natural fibers [1]

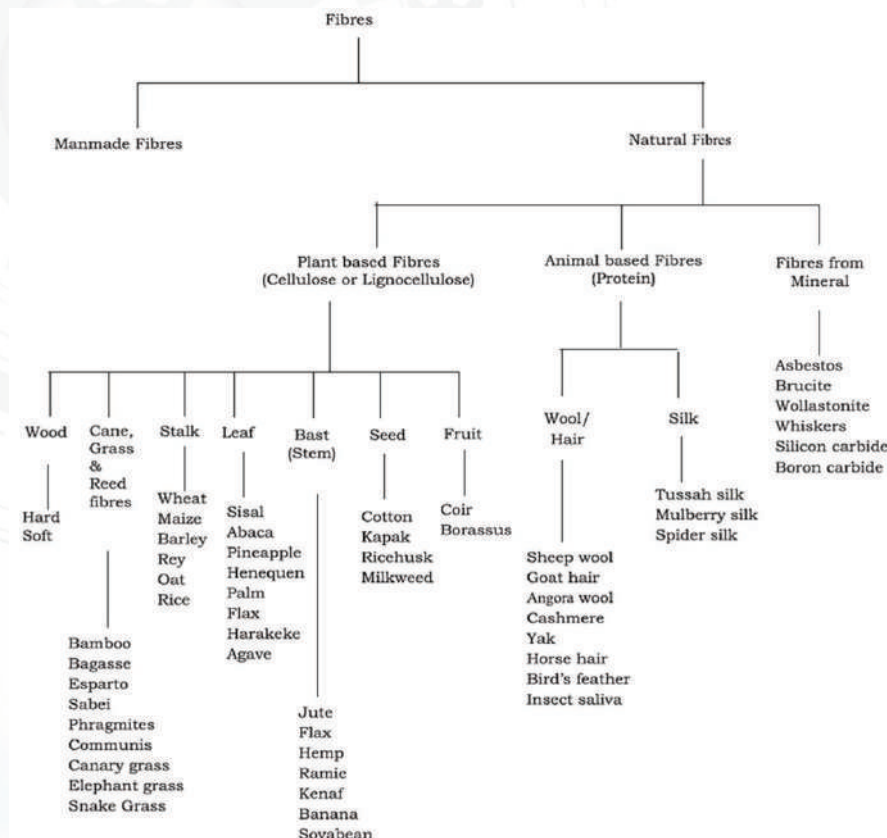


FIGURE 2. Classification of natural fibers [5]



FIGURE 3. Life Cycle of Natural fiber reinforced composites [7]

PROPERTIES OF NATURAL FIBERS

CHEMICAL PROPERTIES

Cellulose is the major component in the natural fiber that develop the stability and strength of the cell as well as fiber. The amount of percentage of cellulose in the fiber influence the mechanical properties, economic of fiber production and usage of fiber in various type of application. Hemicellulose is lightly crosslinked when compared to cellulose and it is the combination of multi-polysaccharide polymer with the degree of polymerization and orientation is less than the cellulose. Lignin is a highly cross-linked molecular complex and act like glue between fibril which form the cell wall. Lignin provide the strength and stiffness of the cell wall and it protect carbohydrate from physical and chemical attack [8].

Table 1. Chemical Composition of Natural fibers [7]

Fiber type	Chemical composition percentage (%)					
	Cellulose	Hemicellulose	Lignin	Pectin	Waxes	Moisture
Flax	64.1	16.7	2	1.8	1.5	10
Hemp	55-80.2	12-22.4	2.6-13	0.9-3	0.2	6.5
Jute	64.4	12	0.2	11.8	0.5	10
Remie	68.9	13.1	0.6	1.9	0.3	10
Kenaf	37-49	18-24	15-21	8.9	0.5	-
Sisal	65	12	9.9	0.8	0.3	10
Cabuya	68-77	4-8	13	-	2	-
Abacca	56-63	15-17	7-10	-	3	-
Coir	19.9-36.7	11.9-15.4	32.7-53.3	4.7-7.0	-	0.2-0.5
Banana	48-60	10.2-15.9	14.4-21.6	2.1-4.1	3-5	2-3
Betelnut	35-64.8	29-33.1	13-26	9.2-15.4	0.5-0.7	-
Rice	28-48	23-28	14	-	20	-
Wheat	29-51	26-32	16-21	-	7	-
Oat	31-48	27-38	16-19	-	7.5	-
Sea grass	57	38	5	10	-	-
Bagasse	28.3-55	20-36.3	21.2-24	-	0.9	-
Bamboo	48.2-73.8	12.5-73.3	10.2-21.4	0.37	-	11.7

MECHANICAL PROPERTIES

Generally, the type of fiber is based on its source: animal plant or mineral. Cellulose is the main constituent of the fiber and protein is the main constituent in animal fiber. Due to the higher strength and stiffness, the plant fibers are used over the animal fiber. Mechanical properties of natural fibers composite are affected by some factors, these are listed below:

- Selecting fibers (type, harvest time, treatment and fiber content)
- Resin type
- Stacking sequence of fibers
- Interfacial strength
- Manufacturing process Cellulose is the major

Table 2. Mechanical Properties of Fibers [9]

Fiber	Density (g/cm ³)	Length (mm)	Failure strain (%)	Tensile strength (MPa)	Stiffness/young's modules (GPa)	Specific tensile strength (MPa/cm ³)	Specific young's modules
Ramie	1.5	900-1200	2.0-3.8	400-938	44-128	270-620	29-85
Flax	1.5	5-900	1.2-3.2	345-1830	27-80	230-1220	18-53
Hemp	1.5	5-55	1.6	550-1110	58-70	370-740	39-47
Jute	1.3-1.5	1.5-120	1.5-1.8	393-800	10-55	300-610	7.1-39
Harakeke	1.3	4-5	4.2-5.8	440-990	14-33	388-761	11-25
Sisal	1.3-1.5	900	2.0-2.5	507-855	9.4-28	362-610	6.7-20
Alfa	1.4	350	1.5-2.4	188-308	18-25	134-220	13-18
Cotton	1.5-1.6	10-60	3.0-10	287-800	5.5-13	190-530	3.7-8.4
Coir	1.2	20-150	15-30	131-220	4-6	110-180	3.3-5
Silk	1.3	Continuous	15-60	100-1500	5-25	100-1500	4-20
Feather	0.9	10-30	6.9	100-203	3-10	112-226	3.3-11
Wool	1.3	38-152	13.2-35	50-315	2.3-5	38-242	1.8-3.8
E - glass	2.5	Continuous	2.5	2000-3000	70	800-1400	29

POTENTIAL NATURAL FIBER FOR STRENGTHING STRUCTURE

Natural fibers as construction materials are not entirely new; in fact, they have been used since the early seventies. In Bangladesh, primary schools were constructed using jute fiber reinforced polyester in 1972–1973 as the first natural fiber composite material to be used in a developing country [6].

Various researchers have shown the feasibility of the usage of natural fiber composites in various civil engineering applications including roofing and bridges. The all-natural composites which are composites made of natural fibers and biodegradable resins are an important development that shows feasibility not only for non-load bearing construction elements but also for structural elements.

Rao (et al. 2008] aims at introducing new natural fibers used as fillers in a polymeric matrix enabling production of economical and lightweight composites for load carrying structures. An investigation of the extraction procedures of vakka, date and bamboo fibers has been undertaken.

The cross-sectional shape, the density and tensile properties of these fibers, along with established fibers like sisal, banana, coconut and palm, are determined experimentally under similar conditions and compared. The fibers introduced in the present study could be used as an effective reinforcement for making composites, which have an added advantage of being lightweight [9].

F. S. Tong (et al. 2017) present a paper reviewing the natural fibers such as jute, kenaf, sisal, and silk as current reinforcement in Polymer Matrix Composite (PMC) for strengthening of Reinforced Concrete (RC) structural members externally in building industry. They found that among the natural fibers, bamboo fiber is considered as the most potential fiber due to its lighter specific density and rapid growth rate. The BFRC possessed higher mechanical properties than kenaf, jute, and sisal fiber-based composite. Bamboo fiber is believed to be a nearly inexhaustible root of raw material for the raising demand for biocompatible products, environmentally friendly and have achieved the criterion of structural upgradation material [3].

Very few examples have been so far developed of bio-composites used as infrastructure components. One example is the pedestrian bridge made by the Eindhoven University of Technology in 2019 in which the girder is a bio-composite of hemp and flax fibers attached to a polylactic acid (PLA)-based foam core. Three alternatives are traditionally in use for bridge building in the Netherlands, namely concrete, steel, and composites. Even if environmental concerns are not the most important factor, composites often come in as the winning solution. A composite bridge requires hardly any maintenance, while a steel bridge has to be painted every 5 years. From a building cost viewpoint, concrete is usually the cheapest alternative albeit a concrete bridge is impossible in some locations because of its high weight while it also occupies more space and takes more time to construct. In such cases, a steel bridge might be preferred but only at a higher cost. It follows that a composite bridge stands as the really most economical solution. Moreover, a bio-composite bridge will reasonably be the winner if environmental concerns are the main factor to consider [11].

CONCLUSION

Application of natural fibers is on the rise and will continue to dominate the market for the years to come. In real life situations, natural fibers will carry on to be new materials used to make reinforced composites for different structural applications. Bio-composites or biodegradable materials (like wood) are characterized by shorter life-spans and require more safety provisions to account for rotting and aging. A long-lasting, load-bearing product is highly unlikely to be biodegradable because any biodegradable material might encounter problems of moisture penetration in the long run. The presently available mathematical and numerical models for predicting the properties of natural fiber-reinforced composites are not always accurate enough due to the nonavailability of reliable input data. These considerations require an enormous amount of research in future as many of the issues raised in previous works still await reasonable and convincing answers in order to guarantee the reliability of natural fiber composites for different applications.

REFERENCE

1. Ticoalu, A., Aravinthan, T. and Cardona, F., 2010, January. A review of current development in natural fiber composites for structural and infrastructure applications. In Proceedings of the southern region engineering conference (SREC 2010).
2. Abdollahiparsa, H., Shahmirzaloo, A., Teuffel, P. and Blok, R., 2023. A review of recent developments in structural applications of natural fiber-Reinforced composites (NFRCS). *Composites and Advanced Materials*,
3. F. S. Tong, S. C. Chin, S. I. Doh and J. Gimbun, Natural Fiber Composites as Potential External Strengthening Material – A Review, *Indian Journal of Science and Technology*, 10(2) 1–5 2017.
4. R. M. Rowell, "Natural fibers: types and properties," in *Properties and performance of natural-fiber composites*, K. Pickering, Ed., ed Cambridge: Woodhead Publishing Limited, 2008.
5. Ramesh M. Kenaf (*Hibiscus cannabinus* L.) fibre based bio-materials: a review on processing and properties. *Progress in Materials Science* 2016; 78: 1–92.
6. Abiola OS. Natural fibre cement composites. In: *Advanced High Strength Natural Fibre Composites in Construction*. London: Woodhead Publishing, 2017, pp. 205–214.
7. Khan T, Hameed Sultan MTB, Ariffin AH. The challenges of natural fiber in manufacturing, material selection, and technology application: A review. *Journal of Reinforced Plastics and Composites* 2018; 37(11):770–779.
8. Sankar, P. Siva, and S. B. Singh. "A Review of Natural Fiber Composites for Structural, Infrastructural and Ballistic Applications." *Emerging Trends of Advanced Composite Materials in Structural Applications*. Springer Singapore, Singapore (2021): 353-373.
9. Pickering KL, Efendy MGA, Le TM. A review of recent developments in natural fiber composites and their mechanical performance. *Composites Part A: Applied Science and Manufacturing* 2016; 83: 98–112.
10. K. Murali Mohan Rao, K. Mohana Rao, Extraction and tensile properties of natural fibers: Vakka, date and bamboo *Composite Structures* 77 (2007) 288–295
11. Rijk Blok R, Joris Smits J, Gkaidatzis R, et al. Rafail Gkaidatzis MSc & Patrick Teuffel Prof. Dr-ingbio-based composite footbridge: design, production and in situ monitoring. *Structural Engineering International* 2019; 29(3): 453–465.

Author's Brief Biography



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He is a Quality driven professional with a 20-year experience in maritime field and 13 years as an exclusive surveyor of a classification society DNVGL. He was serving multiple professions such as Surveyor Trainee for Protection & Indemnity (P&I) condition Survey, cargo related casualty and other surveys, Senior Naval Architect, Senior Surveyor and Project Manager and Technical Director. He started the business in SEASHORE Maritime Services and Engineering Management as part time to offer quality consultancy service in maritime field based on his knowledge & experience. From 2023, it became his full-time business. He is a Member (M/00322611) of Royal Institute of Naval Architects (RINA) UK since 2010, Life Fellow (F/12291) in Institute of Engineers, Bangladesh (IEB) since 2007 and Life Member (LM106081) & current Organizing Secretary of Association of Naval Architects and Marine Engineers, Bangladesh (ANAMEB) 2021-2023. He has successfully completed more than 200 web and classroom professional training organized by employers and renowned institutions of South Korea, Germany, Singapore, India, China, Sri Lanka and Philippines. Singapore from Mar 30 to Sept 15, 2008.

CAUSES OF POLLUTION OF BURIGANGA RIVER AND ITS FEASIBLE MITIGATION PROCESS

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INTRODUCTION

The Buriganga River flows through the southwest part of Dhaka and known as the life this city. The flow of this river is influenced by rivers like Jamuna, Turag and Dhaleswari. This river is economically very important to Dhaka, it was once the main source of drinking water for this city. The Buriganga river is one of the most important rivers in the country in respect to irrigation, fisheries, transportation, recreational uses and so on. The water of Buriganga river is undergoing continuous changes in terms of quality. The degradation of water quality of Buriganga has aggravated at an alarming rate because of increasing industrialization, urbanization, and development activities. Buriganga river receives millions of litters of sewage, domestic waste, industrial and agricultural effluents. The Buriganga river is choked with industrial effluent and untreated sewage through numerous outfalls. Thousands of industrial units and sewerage lines dumping huge volumes of toxic wastes into Buriganga river increasingly polluting the water (1). Ainun Nisat a leading environmental expert expressed, "Much of the Buriganga is now gone, having fallen to ever insatiable land grabbers and industries dumping untreated effluents into the river. The water of the Buriganga is now so polluted that all fish have died and increasing filth and human waste have turned it like a black gel. Even rowing across the river is now difficult for it smells so badly." Today the Buriganga River is one of the most polluted rivers of Bangladesh. The most common pollutants of this river are chemical waste from factories, household waste, medical waste, sewage, tannery waste, plastics and oil. The city of Dhaka discharges about 4500 tons of solid waste and most of it is released into the river. Around 21,000 cubic meters of toxic water are released into the river by tanneries every day, according to the Department of Environment. Dhaka is a city of more than 15 million people, and its human waste is responsible for 60% of pollution in the river, industrial waste of 30% and the rest is solid waste. This pollution ends the river into a dying river which causes natural calamities and hazard. So, the aim is to find out the causes of pollution and suggest some feasible mitigation process of the pollution and save the river and its ecosystem.

RIVER POLLUTION AROUND DHAKA CITY

Dhaka is surrounded by six rivers. River Balu and Shitalakhya are on the eastern side. Turag and Buriganga on the western side. Tongi khal to the north and Dhaleshwari to the south. Dhaka is one of the congested cities in the world. The rivers surrounding it are an advantage to it and essential for the survival of this mega city as these rivers provide drainage system, drinking water, different kinds of fishes, and waterways for travelling.

Major industrialization has been observed in Dhaka, especially dyeing, washing, and textile sectors. Estimation reveals that there are over 7000 industries in Dhaka metropolitan area located in mostly three clusters, namely, Hazaribagh, Tejgaon, Dhaka-Narayanganj- Demra area (2). However, among all these industries dyeing factories and tanneries are the main polluters of the rivers. Waste from these industries is usually connected to the sewerage system that directly follows to the rivers around the city. The rivers have become a dumping ground of all kinds of solid, liquid, and other chemical waste.

Polluted water of Buriganga, Turag, Balu, Shitalakhya, Narai flowing around the greater Dhaka city is posing a serious threat to public life as the water is unfit for human use. People living near these polluted rivers, having no other alternatives, are forced to use this polluted water which results in skin disease and water-borne disease.



Figure 1: River pollution around Dhaka city

SOURCES OF WATER QUALITY PARAMETER

Water quality parameters include chemical, physical, and biological properties and can be tested or monitored based on the desired water parameters of concern. The parameters that are frequently sampled or monitored for water quality include temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), sodium (Na), potassium (K), iron (Fe), arsenic (As) and manganese (Mn) content etc. Water Quality parameters are basic to life within aquatic systems. Impairments of these can be observed as impacts to the flora and or fauna with a given water body. It has been observed several time that Most of the measured water quality parameters and concentration of heavy metals exceeded the standard level set by Department of Engineering (DoE). Among heavy metal concentration, level of chromium and cadmium were much higher than the standard drinking level, these results indicate that surrounding industrial wastewater discharging from textile and tannery industries, which pollute the Buriganga river water most.

CAUSES OF POLLUTION

Buriganga river is one of the most polluted rivers in Bangladesh. The water is pitch black in color in dry season, the smell is unbearable. A large portion of the total population, about 150 million people, rely on the river for living and for transportation. Dhaka is not a planned city and much of its urbanization is linked to its industrial development, which over time has resulted in decreased water quality. Inadequate sewage and inefficient waste management contribute to the water pollution, resulting in water quality in the river to parameters far below the critical limit. Moreover, untreated industrial waste and household sewage are discharged into the river system, leading to the extinction

of aquatic life and the failure of ecosystems. To evaluate the current situation of the Buriganga River, it is essential to understand the volume, variety and types of dumping the river is receiving. The average depth of the river is 7.6 m with a maximum depth of 18 m (3). More than 249 tanneries are located on the bank of the Buriganga River and most of these industries do not have any effluent treatment plants (4). As a consequence, every day the river receives approximately 22,000 m³ of liquid waste containing chromium, lead, ammonium, sulfur and other chemicals. In addition, other industries such as fertilizer industries, dyeing industries, aluminum, iron and steel workshops, plastic, pharmaceuticals, battery manufacturing, washing, hardware and cold storage units discharge around 3,500 m³ of liquid wastes every day into the Buriganga River (5). Furthermore, industrial effluents have damaged land fertility around Buriganga and affected agriculture. The accumulation of waste has also reduced the navigability of the river, adversely affecting the water transportation system. This is now one of the most polluted rivers in Bangladesh due to extensive dumping of industrial and human waste.

SOURCES OF POLLUTION

Due to poor revenue sources of the city governments, the sewerage network is absent in some locations, so sewage is connected with the storm water lines there. The disposal of untreated industrial and chemical waste into storm sewer lines ultimately contaminates the river water. Other causes of pollution include the solid waste dumping points besides the river, lack of sanitary latrine facilities for the poor living nearby, obstruction of the natural flow of water due to engrossments, pollutants at the Sewerage Treatment Plant at Pagla (PSTP), and absence of a sanitary sewage system alongside the Buriganga river (6).

POINT SOURCES

The point sources of pollution of the Buriganga are identified as:

Group 1: Sluice gates alongside the Dhaka Integrated Flood Protection (DIFP)

Group 2: City drains along the Buriganga, including the Dholai Khal

Group 3: Outfall from the PSTP. These sources largely make the river water contaminated and the worst quality for human usage and underwater microorganisms (7).

GROUP 1

The sluice gate along the Dhaka Integrated Flood Protection (DIFP) Embankment: Eleven sluice gates are found alongside the DIFP embankment. Sluice gate S-6 mainly drains out storm water and sewage from Mohammadpur, Kallyanpur, and adjoining areas through Kallyanpur Khal and part of Ramchandrapur Khal. During high-flow seasons, it washes all small-industrial waste and household waste into the Buriganga, while S-7 drains out the toxic ternary waste from Hazaribagh, which largely contributes to the pollution of the Buriganga. Along with the tannery waste, it discharges household waste from the neighboring areas through Kantasur Khal. A part of Ramchandrapur Khal drains out dark and toxic wastewater through S-7. Household waste from Rayerbazar, Nimtala, Sultanganj, Zigatala, Nawabgonj, Gajmahal, Kantasur, and West Dhanmondi is discharged to Buriganga through S-7, which also carries the tannery waste from Nimtala Beel to Buriganga. S-8 also carries tannery waste from Borhanpur, Kanipara, and Battola areas, which is later discharged into the Buriganga river. Both sources pollute the water of the Buriganga, while S-9 drains out wastewater from Pilkhana, Enayetgonj, Ganaktuly, Azimpur, Bhagalpur, and Nawabgonj, and S-10 drains out wastewater from Shahidnagar, Balughat, and Amligola into the Buriganga.

GROUP 2

Municipal drains: 41 drains in Dholai Khal area carry municipal wastewater into Buriganga. Mostly earthen canals pass over Postagola-Shashan Ghat to Balubazar. In the Dholai Khal area, one of the major channels of water pollution of the river Buriganga, 40% of the total pollutants is discharged at these points (Bhuiyan, Rakib, Dampare, Ganyaglo, & Suzuki, 2011). Gerani Khal, connected with Dholai Khal, discharges wastewater from part of Narinda, Saidabad, Farashganj, and the adjoining area of Hrishikesh-Dash Road. Untreated wastewater through these channels flows directly into the Buriganga river and deteriorates its water quality.

GROUP 3

The Pagla Sewerage Treatment Plant (PSTP): The PSTP is the only point where municipal wastewater is treated before falling into the Buriganga. This plant is located at S-7 and Dholai Khal, which controls the pollution level of wastewater at that point. As such, the level of pollution is less at S-7 and Dholai Khal, compared to that of other sluice gates alongside the Buriganga river. However, the PSTP treats a lower volume of wastewater than its capacity due to the low flow of wastewater during dry seasons (approximately 48,000 m³ /day), and such plants are absent at points of other sluice gates alongside the Buriganga river. The following Figure 2 demonstrates the dark wastewater, which directly falls into the Buriganga in the absence of the Sewerage Treatment Plant at the points of all sluice gates except S-7 and pollutes the river water.

NON-POINT SOURCES

Numerous non-point sources of domestic and industrial waste also contribute to water pollution of the Buriganga. Significant domestic wastewater is discharged into the Buriganga water from the Lalbagh area throughout the Babubazar area. The indiscriminate release of wastewater deteriorates the quality of water, particularly in the dry season when the volume of water is lower, resulting in the river water becoming darker with a pungent smell. Moreover, industrial wastewater from the densely populated Zinzira to Keraniganj significantly contaminates the Buriganga water. Oil spillage is one of the main sources of water pollution in Buriganga river. Oil spillage from boats and other sources hampers riverine life and ecosystem. River dumping or waste dumping from boats and ships in the river, especially plastic substances crush water life and enough plastic waste can slow the flow of the river. Groundwater pollution is another major non-point source. Buriganga receives a high amount of garbage, plastic, clinical waste, domestic waste everyday by the people living along side.

POSSIBLE MITIGATION PROCESS FOR REDUCING POLLUTION LEVEL

Pollution in the Buriganga River has reached such a level that mitigation and prevention of pollution alone cannot bring it back to life. A restoration plan must be followed in order to revitalize the river. The possible mitigation measures that must be undertaken include the following.

PUBLIC AWARENESS TO CONTROL TO POPULATION

The huge population explosion of Dhaka is one of the main reasons for Buriganga river pollution. According to several studies, each day about 900 cubic meters untreated domestic and industrial effluents are discharged into the Buriganga-Turag system. An individual person means an extra number

of pollutants. So, to prevent the Buriganga river pollution we should make public awareness not to dump in river and stop population growth of Dhaka city.

INCREASE WATER FLOW OF BURIGANGA

During the dry season, the river has a flow of only 50 cubic metre per second (cumec). One solution is to connect the rivers of Dhaka with the Jamuna River which has a minimum dry season flow of around 3500 cumec. This will not only improve the water quality of the peripheral rivers of Dhaka but also will benefit water supply, agriculture irrigation, fisheries, and navigation. This is an ideal case of integrated water resources management.

CONTROLLED DISPOSAL OF SOLID WASTES

To control disposal of solid wastes into river Dhaka City Corporation (DCC) and BIWTA should work together. BIWTA must force the owners of the vessels and traders on the bank of the river to dump the solid wastes at the fixed places provided by DCC. For any type of construction work within 50 meters of the riverbank, clearance from BIWTA should be mandatory. All structures, especially brick fields within 200 meters from the riverbank should be demolished.

RIVER DREDGING

The government must allocate a budget so that BIWTA can buy sufficient dredgers for routine dredging of the riverbed for smooth navigation. River pollution cleanup solutions like river dredging and debris containment river boom, will attempt to curb some of the pollutants in the water.

MOVING TANNERY FROM HAZARIBAGH

The Ministry of Industries must take initiatives to shift the leather tanneries from Hazaribagh to Hemayetpur, Savar with Common Effluent Treatment Plant (CETP) facilities, which was supposed to be done in 2006, under the recommendation of a task force on Buriganga formed by the government in 2003.

MITIGATING MARINE POLLUTION

CONTROLLED DISPOSAL OF BALLAST WATER

The discharge of ballast water from ships is a major cause of river pollution. The huge amount of ballast water being disposed in the river. Around 1000 metric tons of ballast water discharged every year. 'Ballast Water Management Plant' should be implemented under IMO rules and regulations on almost all types of ships. Most of the ballast water treatment systems use 2-3 disinfectant methods together, divided into different stages. A general ballast water treatment plant comprises two stages with one stage using physical separation while the second stage employing some disinfectant technology. The choice of treatment system used in combination depends on a variety of factors such as type of ship, space available on the ship, and cost limitations as mentioned before.

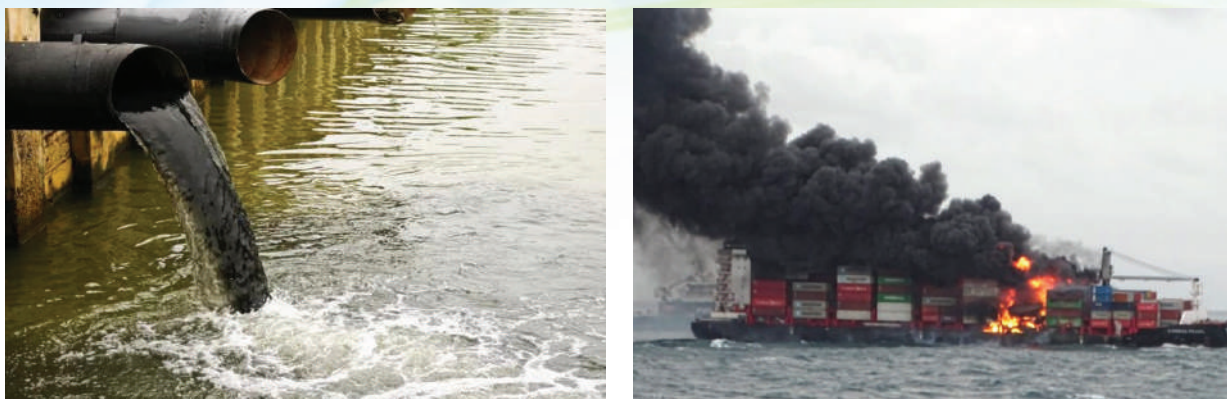


Figure 2: Pollution from ship

CONTROLLED DISPOSAL OF GREY AND BLACK (SEWAGE) WATER

The discharge of grey and black water directly into the river needs to be controlled. Sewage treatment plants are used for treating gray and black water. The Sewage treatment plant must be installed onboard ship to reduce the pollution caused by grey water from sinks, laundries, showers and galleys and Black water or sewage water.

CONTROLLED DISPOSAL OF TOXIC CHEMICALS AND OTHER SOURCES

Toxic chemicals should be discharged under strict rules as per IMO and inland rules to reduce pollution due to chemicals. These chemicals should be treated before discharging.

CONTROLLED DISPOSAL OF BILGE OIL

Right after an oil spill, the immediate concern is to prevent the oil from spreading and contaminating the adjacent areas. While mechanical methods like using oil booms effectively contain the oil, they have certain limitations to their use. Experts have recently been using compounds like 'Elastol', which is basically poly iso-butylene (PIB) in a white powdered form, to confine oil spills. The compound gelatinizes or solidifies the oil on the water surface, thus preventing it from spreading or escaping. In addition, the gelatin is easy to retrieve, and this makes the process highly efficient.

CONTROLLED DISPOSAL OF SOLID WASTE

IMO conventions such as MARPOL Annex 5- Garbage from Ships and other related guidelines have to some extent been able to streamline the waste and garbage management onboard marine vessels by implementing methods such as Garbage Management Plan for Ships. This also makes it vital for the vessels' waste management teams to work together in order to understand and comply with waste reduction, recycling and management. The waste and Garbage generated onboard ships which contribute to river pollution comprise of chiefly plastics, dunnage and packing material, cleaning material and rags, paper products, food waste, remains of paints, solvents, and chemicals. Proper handling of these waste products is critical to prevent marine pollution. Maximum efforts should be put into waste reduction and management to permit a safe and healthy work environment onboard as well as preserving a pollution free River Buriganga.

CONCLUSION

The Buriganga River represents a good case study about the emerging problems and threats that the rivers in Bangladesh are now facing. The problems related to environmental degradation are widely observed recognized and discussed, but the key issue is to take some initiatives for the ecological restoration of the riverine environment. The cost involved in mitigation, restoration, and protection programs of the Buriganga River can be justified by the resulting benefits that the people of Dhaka expect from the river, which is inextricably linked with the history and development of Dhaka. It has been found that the Buriganga river is strongly polluted and unsuitable for drinking and irrigational purposes. Proper care should be taken when disposing of industrial effluent, sewage water and sludge to protect aquatic environment as well as existence of lives. Again, to control marine pollution ships need to follow the IMO rule. Proper sewage treatment plants, chemical plants, and oil treatment systems need to be installed onboard the ship. Ship owners and service providers should be liable for strict compliance with IMO standard on installation of various treatment plant onboard ship. The overall general people awareness needs to be developed against pollution of water of Buriganga river.

RECOMMENDATIONS

The following recommendations should be followed:

1. Definite measures should be taken against the effluents from the industries discharged directly to the Buriganga river without any proper treatment.
2. Strict rule should be imposed for ensuring use of proper Sewage and Chemical treatment plant onboard ships to minimize marine pollution.

REFERENCES

1. Islam, M. M.; Akhtar, M. K. and Masud, M. S. 2006. Prediction of environmental flow to improve the water quality in the river Buriganga. Proceedings of the 17th IASTED International Conference on Modelling and Simulation, Montreal, QC, Canada.
2. Alam, T. and Hasan, M. 2021. study on the pollution intensity level of Buriganga river and its viable mitigation process, thesis NAME department, Military Institute of Science and Technology.
3. Investigation of Some Water Quality Parameters of the Buriganga River. Article in Journal of Environmental Science and Natural Resources · December 2012
4. Hossain, M. S. 2005. 'Save Buriganga Movement', The NARBO (Network of Asian River Basin Organizations) Newsletter, 5th issue, spring 2005
5. Gain, S. Moral and P. Raj. 1998. 'Industrialization and Industrial Pollution' in Gain, P., Moral, S. and Raj, P. (eds.), Bangladesh Environment: facing the 21st century, pp. 165-185, Society for Environment and Human Development (SEHD), Dhaka.
6. Bashar, T. and Fung, I. W. H. Water Pollution in a Densely Populated Megapolis, Dhaka: Water 2020 J. Bangladesh Inst. Plan. July, 2020
7. Water Pollution in a Densely Populated Megapolis, Dhaka Bashar T and Ivan W.H. Fung 21 Institute for Social Policy, Housing & Equalities Research, Heriot Watt University.

Author's Brief Biography



Cdr Tasnuva Anan, (E), psc, BN was born on 16 December 1982 at Khulna. She was commissioned from Bangladesh Naval Academy (BNA) on 21 December 2001 as one of the pioneer female officers of Bangladesh Armed Forces. She completed her BSc (Engg) and MSc (Engg) in Naval Architecture and Marine Engineering from Bangladesh University of Engineering and Technology (BUET). He served as Engineering Officer (EO) on board BNS SOMUDRA AVIJAN. Other than the mandatory courses for her professional career, she attended Ship Design course at Wuchang Shipyard, China. Presently, she is serving as instructor of NAME department in MIST. She is happily married and blessed with a daughter.

Comparison of Corrosive Nature of Shipbuilding Plates in Fresh Water & Sea Water

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Abstract. There are a number of distinct meanings for the term "corrosion." Some definitions are extremely specific, addressing only a single type of corrosion, whereas others are extremely general, encompassing a wide range of deterioration. This study examines the corrosive behavior of 5mm and 6mm shipbuilding plates in freshwater and saltwater. The primary focus was on the effects of corrosion and the changes in mechanical properties of Mild steel induced by corrosion, as well as the necessity of understanding how materials corrode. To complete the investigation and collect the necessary data, several tests were conducted. Samples of precisely machined mild steel were submerged in saltwater and freshwater for four months. The samples were removed from the water and weighed several times over the course of a few days to ascertain the rate of weight loss and corrosion. To gain a greater understanding of the variation in mechanical properties and surface morphology, tensile tests, hardness tests, and microscopic observation were conducted. Weight loss and corrosion rate curves were plotted to make the comparison more visible. For shipbuilding purposes, it is essential to comprehend how corrosion can disrupt ship operations and eventually contribute to the ship's premature failure. This study's findings can be used to choose the finest materials for applications with a high rate of corrosion.

INTRODUCTION

Almost every manufacturing or manufacturing-related application makes use of mild steel. It is a category of low carbon steels characterized by high tensile strength, plasticity, and affordability, and has a carbon content between 0.15 and 0.3 percent. Carburizing also increases its surface hardness. In addition to being the most cost-effective form of steel, its weldability, strength, and hardness make it ideal for usage in a broad range of steel products.

Although it contains very little carbon, mild steel is nonetheless considered to have rather robust mechanical qualities. Mild steel's superior tensile and impact strength over High Carbon Steel is due to the fact that it may be readily bent at room temperature. Mild steel may be bent or deformed when pressured, however high carbon steel cracks or breaks under the same conditions. Weldability, processability, high ductility, and excellent stiffness [8] were just a few of mild steel's benefits in the building business.

Materials including fiber-reinforced polymers (FRP), nonferrous metals, and polymers are used in the construction of ships. However, marine steels make up over 90% of all materials used in maritime engineering. Carbon and mild steel kinds with high tensile strengths and outstanding workability are among the requirements of master shipbuilders. Timber and wrought iron remained the most common materials in marine applications for decades after steel became increasingly prevalent in shipbuilding in the late 1800s. Before World War II, steel was used almost exclusively in

the construction of large boats like cargo freighters and war ships because it was stronger and lighter than wrought iron, enabling for quicker and more durable vessels to be created for crowded battlegrounds. Due to its lower initial cost and lighter overall weight, steel quickly replaced iron in the shipbuilding industry after World War II. The use of prefabricated steel components in block construction heralded the beginning of a new era in shipbuilding. These days, ships' superstructures are made almost entirely out of steel. When one or more electrons are lost in the bulk of a metal due to corrosion, the binding energy of that metal decreases, and the metal oxidizes. Corrosion resistance is an essential property since it determines how reactive a metal or alloy will be in a certain setting. The expanding usage of this metal in manufacturing and construction sectors presents a number of challenges, one of the most significant being the control of corrosion when exposed to a variety of corrosive environments [10]. The rate of corrosion of steel structures in hostile marine and offshore settings impacts the economic interests of offshore structures because steel loss may have a substantial influence on structural safety and performance. More and more people are interested in delaying the expense of replacing existing structures by estimating the corrosion rate at a specific site for a given amount of exposure once the protective coating or cathodic protection has been removed [9].

2. RESEARCH METHODOLOGY

To acquire results, this study employs the following methodology:

- Collection of uncoated mild steel plates
- Collection of saltwater and freshwater [Figures 1(a, b)]
- Cut steel plates to the specified dimensions using a CNC machine from Machine Tools Lab [Figure 1(c, d, e)]
- Acquiring the essential supplies and apparatus for the experimental arrangement
- Establishing the experimental arrangement at the Hydrodynamics Lab on the ground floor of tower 4
- Necessary experiments were conducted, and based on experimental data, conclusions were drawn.

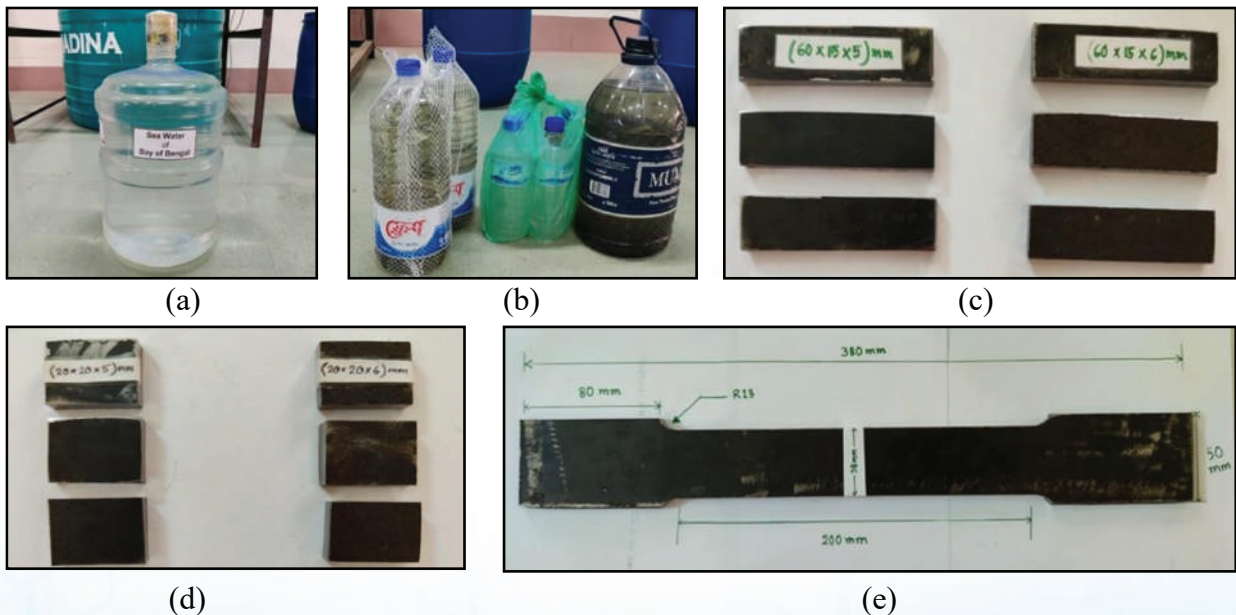


FIGURE 1. (a) Sea water. (b) Fresh Water. (c) Samples for weight loss & corrosion rate calculation. (d) Samples for hardness test. (e) Sample for tensile strength test

3. SAMPLE COLLECTION & PREPARATION

Water and steel plate samples were collected. Samples have been prepared according to the required size, which is shown above.

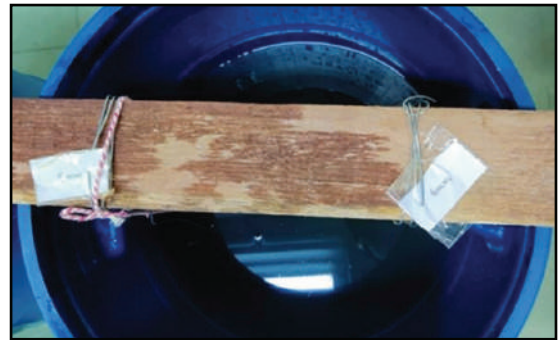
4. EXPERIMENTAL SETUP

In The Hydrodynamics Lab Of The Name Department At MIST, The Following Components Were Assembled For An Experiment:

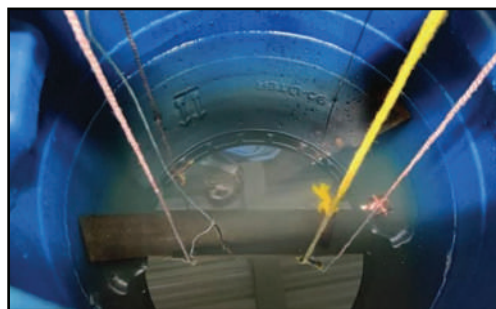
- Two 40-Liter Containers Were Carried, With One Containing Pure Water And The Other Containing Salt Water [Figure 2(a)].
- A Piece Of Wood Was Placed Atop The Containers, And Samples Were Suspended From It Using Fine Threads [Figure 2(b)].
- Barrels And Samples Were Plainly Labelled To Prevent Error During The Reading Procedure, And Samples Were Submerged In Water [Figure 3(c)].



(a)



(b)



(c)

FIGURE 2. (a) Barrels of fresh water & sea water. (b) Piece of wood placed on top. (c) Samples immersed in water.

5. EXPERIMENT

To conclude the investigation, a total of five experiments were conducted.

- Weight loss calculation
- Corrosion rate calculation
- Hardness test

- Tensile strength test
- Microscopic examination

6. RESULT & DISCUSSION

6.1 Weight Loss Calculation

6.1.1 Weight Loss in Fresh Water

When both samples [5mm, 6mm] are submerged in fresh water for the first few days, weight loss increases dramatically, indicating the corrosion assault is at its height. The first-day weight loss for 5mm and 6mm samples were 0.036 and 0.1. The sample materials lose less weight as immersion duration increases, reaching 0.001 and 0.02 respectively. Lower weight loss over several days may indicate that protective coatings produced during the preceding days lower corrosion attack rates by inhibiting sample-corroding medium contact. The quick weight loss during submersion may be related to the time needed for the exposed surface to form a protective coating on the samples.

TABLE 1. Data for 5mm & 6mm samples in freshwater

Days	Weight Loss, ΔW (gm/mm ²) 5mm	Weight Loss, ΔW (gm/mm ²) 6mm
2	0.036	0.1
4	0.027	0.08
6	0.023	0.056
9	0.02	0.054
15	0.02	0.032
30	0.005	0.03
45	0.003	0.028
60	0.001	0.025
75	0.001	0.0248
90	0.001	0.0242
105	0.001	0.0235
120	0.001	0.02

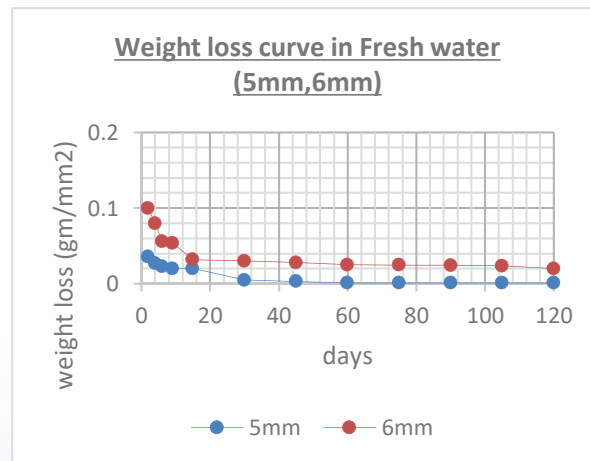


FIGURE 3. Weight loss curve in fresh water (5mm, 6mm)

6.1.2 Weight Loss in Sea Water

Again, in the case of samples [5mm,6mm] immersed in seawater, a similar trajectory is obtained in which a greater quantity of weight loss is observed during the first few days, but weight loss is observed to decrease with increasing immersion time [Table 2]. The same explanation applies to this phenomenon as it did to fresh water.

TABLE 2. Data for 5mm & 6mm samples in seawater

Days	Weight Loss, ΔW (gm/mm ²) 5mm	Weight Loss, ΔW (gm/mm ²) 6mm
2	0.148	0.248
4	0.432	0.532
6	0.425	0.526
9	0.25	0.264
15	0.151	0.228
30	0.238	0.153
45	0.224	0.139
60	0.189	0.125
75	0.156	0.173
90	0.148	0.098
105	0.14	0.095
120	0.12	0.085

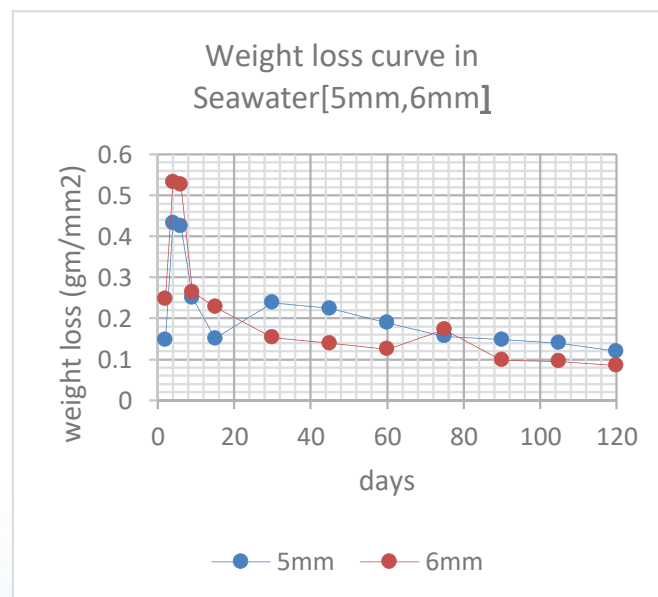


FIGURE 4. Data for 5mm & 6mm samples in seawater

6.2 Corrosion Rate Calculation

Variable corrosion rate is also associated with progressive weight loss. Using the following equations, the corrosion rate was computed for each reading.

$$R_{\text{corrosion}} = ((K \times \Delta W)) / ((\rho \times T))$$

ΔW = Weight loss per exposed surface area (gm/ cm²)

W_o = Initial weight (gm);

W_f = Weight after designated period (gm);

A = Exposed surface area (cm²);

$R_{\text{corrosion}}$ = Corrosion Rate (mm/year);

K = Unit conversion factor;

ρ = Density of metal (gm/ cm³);

T = Exposed time (hour)

6.2.1 Corrosion Rate in Fresh Water

Low corrosion rates observed after many days are probable indications that protective coatings (corrosion products) developed over the previous days tend to reduce corrosion attack rates by preventing sufficient interaction between samples and corrosive media. On the last day of immersion, the corrosion rate for 5mm and 6mm samples decreased to 0.00015 and 0.002 respectively, whereas on the first day it was 0.32 and 0.86.

TABLE 3. Data for 5mm & 6mm samples in freshwater

Days	Corrosion Rate, Cr (mm/year)	Corrosion Rate, Cr (mm/year)
	5mm	6mm
2	0.328212814	0.861052135
4	0.123079805	0.344420854
6	0.069897173	0.160729732
9	0.0405201	0.103326256
15	0.01215603	0.036738224
30	0.003039008	0.017221043
45	0.001215603	0.010715315
60	0.000303901	0.007175434
75	0.000243121	0.005694425
90	0.000202601	0.004630547
105	0.000173658	0.003854233
120	0.00015195	0.002870174

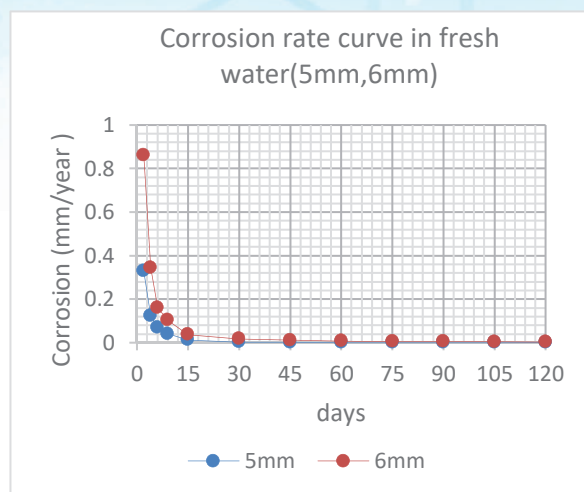


FIGURE 5. Corrosion rate curve in fresh water (5mm, 6mm)

6.2.2 Corrosion Rate in Sea Water

After ten days of exposure, the corrosion rate of the initial phase has significantly increased. When the plates are immersed in seawater, the corrosion rate is initially sluggish and then becomes rapid between the second and fifteenth day as the passive coatings that formed between the second and fifteenth day disintegrate, allowing corrosion to commence. Oxygen and chloride participate in electrochemical reactions in seawater, which accelerates the corrosion rate. After the initial phase, the rate of corrosion decreases progressively for both types of water until approximately 110 days of exposure; after 120 days, it approaches "0" [Table 4]. Due to the increased presence of dissolved ions, sea water exhibits the greatest quantity of weight loss, and thus the highest corrosion rate, when compared with pure water.

TABLE 4. Data for 5mm & 6mm samples in seawater

Days	Corrosion Rate, Cr (mm/year)	
	5mm	6mm
2	1.349319346	2.135409295
4	1.969276883	2.290398679
6	1.291578202	1.50971141
9	0.506501256	0.505150586
15	0.183556055	0.261759849
30	0.144656759	0.087827318
45	0.090765025	0.053193887
60	0.057437242	0.035877172
75	0.037926814	0.039723205
90	0.029984874	0.018751802
105	0.02431206	0.015580943
120	0.018234045	0.012198239

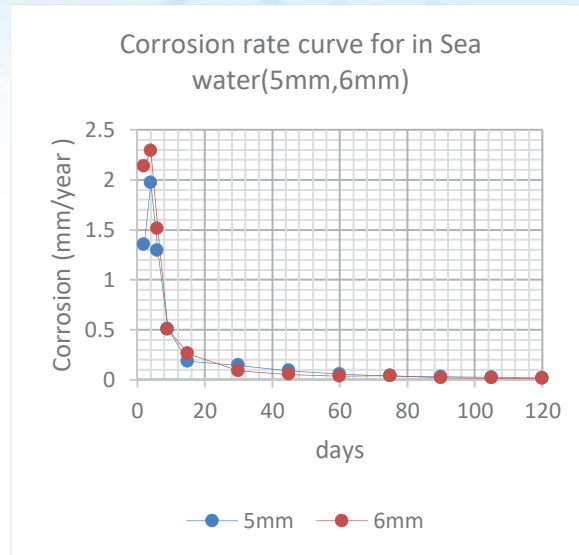


FIGURE 6. Corrosion rate curve in sea water (5mm, 6mm)

6.3 Tensile Strength Test by UTM

Overall, corrosion has had a significant impact on the yield strength of the immersed samples, as evidenced by the incremental decrease in load in both bodies of water [Figures 7, 8, and 9]. Consequently, corroded samples require less force to begin plastic deformation. This means that corroded materials fail with minimal force and in a relatively shorter amount of time. [Tables 5, 6, and 7] All corroded samples had higher ultimate tensile strength than non-corroded samples. This may be due to the different deformation properties of the samples and the cross-section utilized in the stress calculation.

TABLE 5. Data from UTM for samples (without immersion)

Specimen[mm]	Load at Tensile strength [kN]	Tensile extension at Tensile strength [mm]	Tensile stress at Maximum Load [MPa]
5	93.615	38.734	461.67566
6	109.159	37.901	448.01569

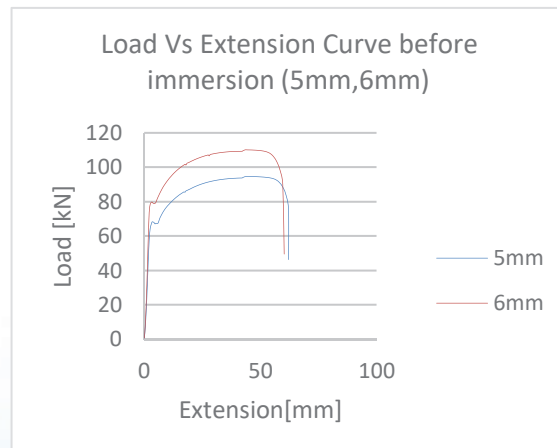
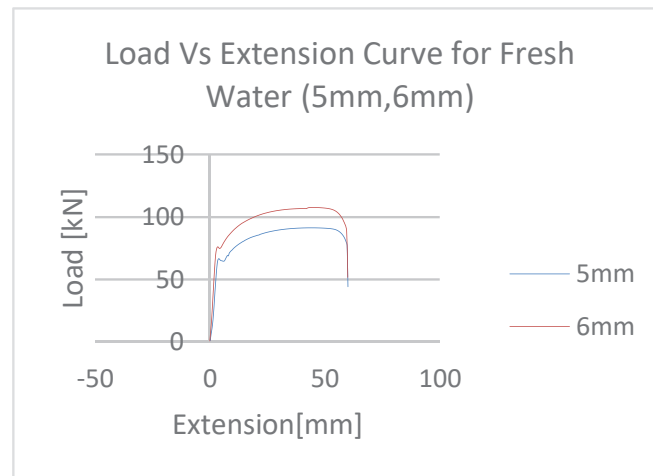


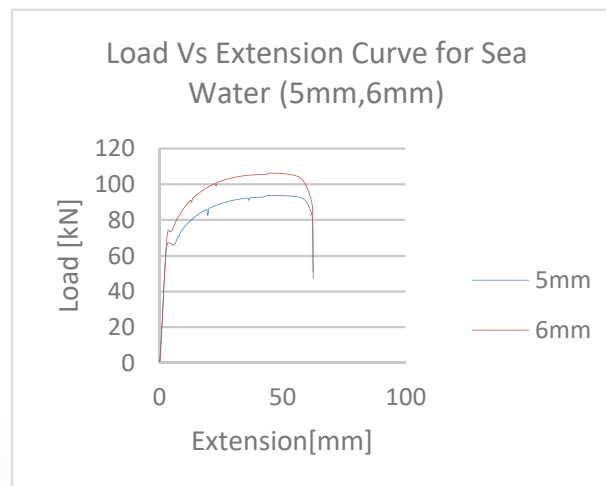
FIGURE 7. Load vs. Extension Curve before immersion (5mm, 6mm)

TABLE 6. Load vs. Extension Curve before immersion (5mm, 6mm)

Specimen[mm]	Load at Tensile strength [kN]	Tensile extension at Tensile strength [mm]	Tensile stress at Maximum Load [MPa]
5	93.71	47.034	483.14221
6	105.377	39.56	471.00

**FIGURE 8.** Load vs. Extension Curve in fresh water (5mm, 6mm)**TABLE 7.** Data from UTM for 5mm sample in sea water

Specimen[mm]	Load at Tensile strength [kN]	Tensile extension at Tensile strength [mm]	Tensile stress at Maximum Load [MPa]
5	106.571	37.903	554.45856
6	91.27	43.729	470.55963

**FIGURE 9.** Load vs. Extension Curve in sea water (5mm, 6mm)

6.4 Hardness Test

6.4.1 Samples before immersion

TABLE 8. Vickers & Rockwell Hardness Values for samples before immersion

5mm		6mm	
HV	HRA	HV	HRA
151.1	49.6	151.1	49.6
138.8	47.2	153.6	50.1
148.9	49.2	150.8	49.2
145.7	48.6	148.1	49.6
148.0	49.1	149.9	49.1
141.6	48.0	153.0	49.4
143.7	48.3	148.9	50.0
146.5	48.8	152.7	49.2
144.5	48.4	151.9	49.9
152.0	49.8	147.6	49.0
Avg	146.08	150.75	49.57

6.4.2 Samples immersed in fresh water

When 6mm samples are submerged in fresh water, a decrease in hardness value is observed. For example, the HV value for a 6mm sample fell to 147.36 and the HRA value fell to 48.74 [Table 9], whereas the initial HV and HRA values were 150.75 and 49.57 [Table 8] respectively. However, there is a minor increase in the case of 5mm specimens. HV and HRA values increased from 146.08 and 48.7 [Table 8] to 147.67 and 48.91 [Table 9], indicating that wear resistance increases with increasing hardness.

TABLE 9. Vickers & Rockwell Hardness Values for samples in fresh water

5mm		6mm	
HV	HRA	HV	HRA
149.2	149.2	147.4	48.9
149.7	149.7	152.7	49.9
148.6	148.6	140.9	47.8
149.8	149.8	150.2	49.5
141.7	141.7	147.4	48.9
146.3	146.3	149.5	49.4
151.6	151.6	145.5	48.6

	150.8	150.8	148.5	49.2
	148.7	49.6	144.2	48.4
	140.3	49.6	137.2	46.8
Avg	147.67	48.91	147.36	48.74

6.4.3 Samples immersed in sea water

If we compare the values of the corroded samples in sea water to their initial values, we can conclude that the hardness values for both samples have decreased as a result of an increase in immersion time [Table 10]. This happens when the specimen is immersed for an extended period of time and exposed to ion chlorides for a longer period of time. As the sodium content percentage increases, the hardness value falls. This is due to the presence of additional chloride ions in the saline water, which accelerates the decomposition of the passive layer and decreases corrosion resistance.

TABLE 10. Vickers & Rockwell Hardness Values for samples in sea water

5mm		6mm	
HV	HRA	HV	HRA
145.3	48.6	152.2	49.8
140.3	47.6	148.1	49.1
150.0	49.5	146.7	48.8
143.5	48.3	152.1	49.8
139.4	47.4	149.1	49.3
142.6	48.1	152.9	49.9
138.1	47.0	150.0	49.5
HV	HRA	152.6	49.9
145.7	48.6	153.4	50.0
137.7	46.8	148.5	49.2
Avg	142.07	150.56	49.53

6.5 Microscopic view observation

Observations at the microscopic level indicate that samples prior to immersion have a smooth, line-like surface with no holes. [Figures 10(a), 11(a)] The micrographs of the sample materials reveal new refining traces and a complete absence of grain boundaries. After 120 days of immersion in pure water, the specimens exhibit severe surface damage, indicating that the surface has been severely corroded. [Figures 10(c), 11(c)] The uneven, pitted, and fissured surface of the corroded sample indicates uniform corrosion. In the case of seawater, the corrosion morphologies are relatively homogenous, although pitting corrosion occurs on a small portion of the surface [Figures 10(b), 11(b)].

6.5.1 5mm sample

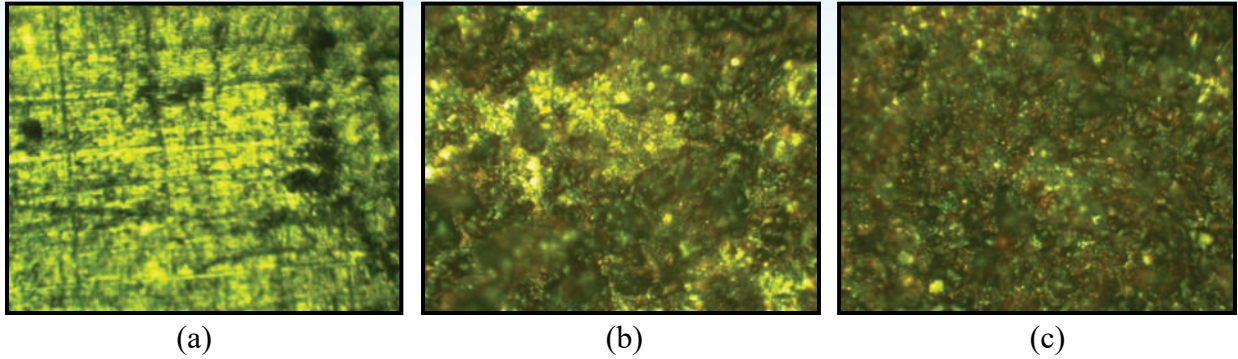


FIGURE 10. Microstructure of 5mm sample (a) before corrosion. (b) after corrosion in sea water (c) after corrosion in fresh water.

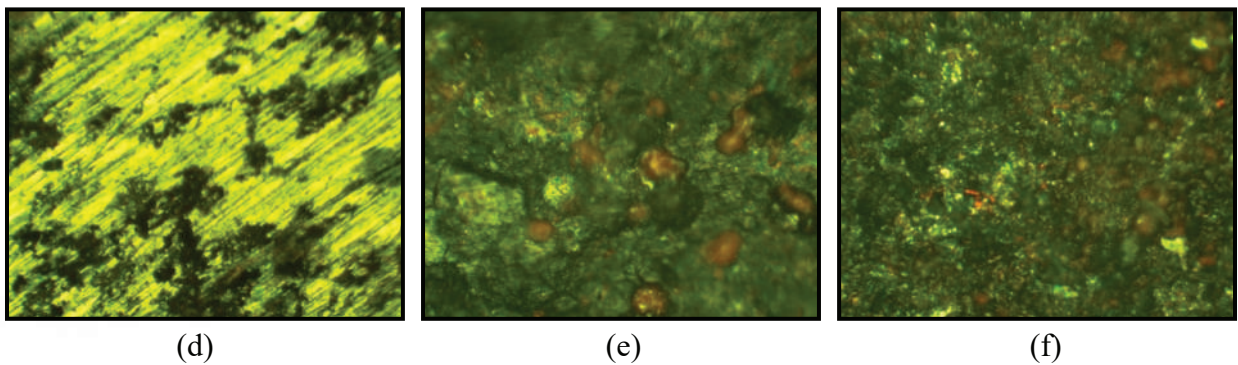


FIGURE 11. Microstructure of 5mm sample (a) before corrosion. (b) after corrosion in sea water (c) after corrosion in fresh water.

CONCLUSIONS

Within the limits of experimental error, conclusions drawn based on observations and results of the research are stated below:

- Based on the data and analysis, mild steel has a high corrosion resistance, as it is evident from the graphs that even as the number of days of exposure increased, both weight loss and corrosion rate progressively decreased. For instance, the corrosion rate of 5mm and 6mm samples in pure water was observed to be 0.000151 and 0.00287 per day on the 120th day, respectively. In the first few days, both samples exhibited a degree of corrosion, with 0.328 and 0.861, respectively, for the same samples in fresh water at their apex.
- Initial immersion period weight loss and corrosion rates were greatest, then progressively dropped to stable levels. The protective films (corrosion products) made in the preceding days reduce corrosion attack rates by restricting sample-corroding medium contact.
- Due to the higher concentration of dissolved ions in sea water compared to fresh water in the experiment, sea water had the greatest propensity to corrode. Saltwater's chloride content has the ability to dissolve oxide deposits on metal surfaces and form complexes with metal ions that, when hydrolyzed, release hydrogen ions, increasing the water's acidity and

enhancing local mild steel corrosion. Ions may be deposited on metal by salt spray and salt water in the air.

- Of the two samples, the sample immersed in seawater for six millimetres experienced the greatest weight loss and corrosion rate.
- Of the two specimens, the 5mm specimen immersed in seawater demonstrates the lowest Vickers and Rockwell hardness values.
- Optical microscope photos reveal uniformly distributed corrosion in both corrosive media. Micrographs reveal that fresh water-corroded samples had fewer, shallower pits than seawater-corroded ones. Greater pits mean greater weight loss and quicker material degradation.

REFERENCES

1. A Royani, S Prifiharni, L Nuraini, G Priyotomo, Sundjono, I Purawiardi and H Gunawan, Corrosion of carbon steel after exposure in the river of Sukabumi, West Java, IOP Conf. Series: Materials Science and Engineering 541 (2019) 012031 doi:10.1088/1757-899X/541/1/012031
2. Augustine Uzorh(2013).Corrosion Properties of Plain Carbon Steels, International Journal Of Engineering And Science (IJES),November 2013,Nigeria,Volume 2,Issue,11,2013, pp.-18-24,ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805
3. D.de la Fuente, I. Díaz, J. Simancas, B. Chico and M. M o r c i l l o , L O N G - T E R M ATMOSPHERIC CORROSION OF MILD STEEL, National Centre for Metallurgical Research (CENIM-CSIC), Avda. Gregorio del Amo,8, 28040-Madrid, Spain, pp -4-5
4. Garbatov, Yordan & Parunov, Joško & Kodvanj, Janos & Eldeen, Saad & Guedes Soares, Carlos. (2016). Experimental assessment of tensile strength of corroded steel specimens subjected to sandblast and sandpaper cleaning. Marine Structures.49.18-
5. Marhamati, F., Mahdavian, M. & Bazgir, S. Corrosion mitigation of mild steel in hydrochloric acid solution using grape seed extract. Sci Rep 11, 18374 (2021).
6. Md. Moniruzzaman, Md. Mohar Ali Bepari, M. Merajul Haque and S. Alam Limon, CORROSION OF GALVANIZED STEEL AND COPPER IN AQUEOUS ENVIRONMENTS, Journal of Mechanical Engineering, Vol. ME 43, No. 2, December 2013,pp -61
7. Naja'atu Auwal Usman, Usman Muhammad Tukur, Bishir Usman, Comparative study on the corrosion behavior of mild steel in effluents, sea and fresh water, Bayero journal of pure and Applied Sciences, 12(1): 280 – 284
8. Ojo Sunday Isaac Fayomi and Abimbola Patricia Idowu Popoola (2019).Corrosion propagation challenges of mild steel in industrial operations and response to problem

definition, International Conf. on Engineering for Sustainable World, December 2019, Nigeria, 1378 (2019) 022006, doi:10.1088/1742-6596/1378/2/022006.

9. Ting, Ong Shiou ; Potty, Narayanan Sambu ; Liew, Mohd. Shahir, Marine corrosion of mild steel at Lumut, Pera, International Conference on Fundamental and Applied Sciences, 2012
10. Umeozokwere Anthony O1, Mbabuikwe Ikenna U2, Oreko Benjamin Ufuma3, Ezemuo DT, Corrosion Rates and its Impact on Mild Steel in Some Selected Environments, Journal of Scientific and Engineering Research, 2016, 3(1):34-43

Author's Brief Biography



Zarin Tahsin has been graduated from the department of Naval Architecture and Marine Engineering, MIST on 22 May 2022. She consistently ranked in the top five of her class during all eight semesters, and as a result, the institution recognized her academic achievement by presenting her a merit scholarship. Besides, she was awarded the dean's list for outstanding performance during 2018-19 with a CGPA of 3.77. She is working as a Teaching Assistant in the same department since 01 November 2022. Her research interest lies in the areas of, Materials Science, Strength Analysis of Corroded Plates etc.

Effect of Bilge Keel on Roll Oscillation Characteristics of Bangladesh Inland Passenger Vessel

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Abstract. Vessel accident in Bangladesh inland water is a recurrent phenomenon and most of accidents taken place in stormy weather. If strong wind sustains for a long time, wind generated surface waves generate and it may roll a vessel beyond the limit. Bilge keel is the most prominent roll damper for a vessel. Currently there is no provision in statutory rules of Bangladesh for fitting bilge keel in inland vessels. This study has investigated the effect of bilge keel of different sizes on the rolling characteristics of a sample Bangladesh inland passenger vessel. Both the ship rolling in calm water (without wind and wave) and rolling due to combined action of wind and wave have been investigated. Wind velocity corresponding to Bangladesh River Danger Signal - III is considered for both wind and wave action. In inland waterways, waves are wind generated surface waves. Damping amplitude has been estimated by well-known Ikeda method. International Maritime Organization (IMO) has proposed a method to estimate roll damping coefficients from equivalent linear damping coefficients by simplified Ikeda method. The characteristics of roll motion (due to combined influence of wind and wave) namely standard deviation, zero crossing frequency and zero crossing period could be estimated from the estimated roll motion spectrum which is a function of the total moment spectrum of wind and wave.

Key words: bilge keel, roll motion, Ikeda method, damping coefficients, Bangladesh inland vessel.

INTRODUCTION

International Maritime Organization (IMO) has developed 'Interim Guidelines on the Second Generation Intact Stability Criteria' and circulated by MSC. 1/Circ. 1627 [1]. The 'Explanatory Notes' to the guideline was approved and circulated by MSC. 1/Circ. 1652 [2] in very recent time. Series of program by committee and subcommittee were held and lots of working paper were dealt with before the development and approval. The second generation stability criteria are formulated from the understanding of vessels vulnerability to 05 different identified stability failure modes. Intact Stability Code (IS Code), 2008 [3] is the mandatory criteria of IMO for ensuring the minimum stability requirement of a vessel. From the very beginning of adoption of the IS Code 2008, it was felt by researchers and other stake holders that the criteria are not sufficient to address the wide variety of vessel types, sizes, operational profiles and environmental conditions. Finally, the second generation criteria are finalized as complementary measures to mandatory 2008 code. Accidents involving passenger vessels are a recurring issue within the inland waterways of Bangladesh, resulting in the tragic loss of thousands of lives. In their study, Iqbal et. al. [4] examined 25 years' worth of data on accidents involving passenger vessels in Bangladesh's inland waterways. The analysis revealed that in 49% of the cases, the accidents were attributed to a loss of intact

stability. Excessive rolling beyond the limit due to unfavorable environmental condition can rationally be said as the main reason for stability loss. Analysis shows that, stormy weather that causes adverse external/environmental loads are behind 60% of intact ship accidents. With this understanding, this study aims to analyze the roll motion of a sample passenger vessel. Bangladesh River Danger Signal No – III is considered as the adverse environment. The wind velocity corresponding to this signal is 20.83 m/s [5].

If a vessel is fitted with Bilge Keel, the roll motion characteristics of the vessel will be changed with the effect of probable damping. A bilge keel is a flat bar that is fitted longitudinally along some part of ship at the location of bilge plate (curved plate that connects side shell plate with bottom plate) and acts as a roll damper (Figure - 1). A bilge keel can reduce the rolling amplitude by damping the roll motion and the amplitude of damping will depend on geometrical parameters of bilge keel. Bilge keel is the most popular roll mitigation device for vessels. Literature shows that, a series of research had been conducted addressing the efficiency of bilge keel as a roll mitigation device [6]. Though inland vessels are failing by losing stability recurrently in Bangladesh and excessive rolling is the rationally identified cause, surprisingly there is no provision or mandatory rule of fitting bilge keel in Bangladesh inland vessels. This study has investigated the effect of bilge keel on roll motion of a sample Bangladesh Inland Passenger vessel. IMO 'Explanatory Notes' [2] recommend several methods for estimating damping data. The simplified Ikeda method [7] is the remarkable one among them. Ikeda method has been simplified by a number of empirical formula using regression analysis where a large number of coefficients and coefficients values have been defined.

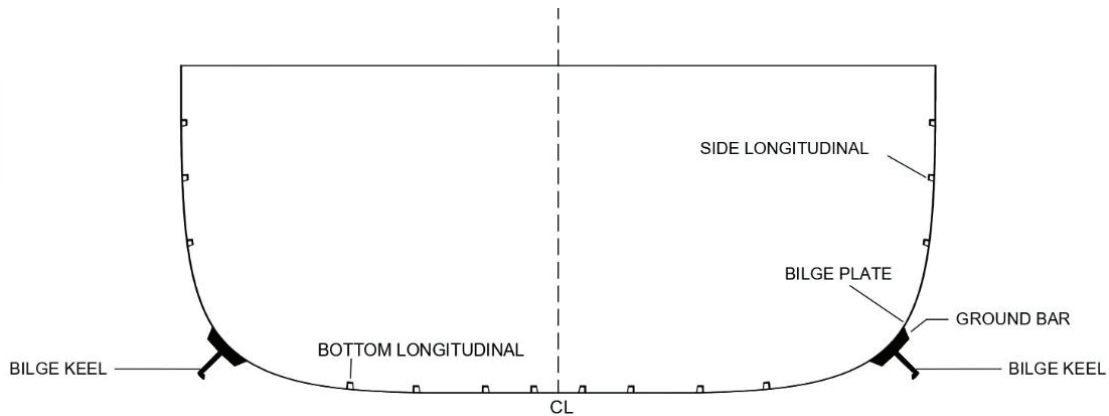


Figure 1. Vessel mid-ship section fitted with Bilge Keel

MODEL OF SHIP ROLL MOTION

Ship roll motion of two models have been considered in this study, namely ship roll motion in calm water without any wind force (Model - 1) [2] and ship roll motion under combined action of wind and wave (Model - 2) [8]. The effect of bilge keel for both of the models have been investigated.

Model – 1

The equation of motion in calm water is as follows:

$$(I_{xx} + A_{44})\ddot{\phi} + (I_{xx} + A_{44})(\delta_0\dot{\phi} + \delta_1\dot{\phi}^2 + \delta_2\dot{\phi}^3) + WGM_{\phi} = 0 \quad (1)$$

where, $\ddot{\phi}$ is the roll angular acceleration, $\dot{\phi}$ is the roll angular velocity, W the ship weight, GM the metacentric height, I_{xx} the transverse moment of inertia of ship, A_{44} the added mass, δ_0 , δ_1 and δ_2 are

linear, quadratic and cubic roll damping coefficients respectively. Introducing the equivalent linear damping coefficient $B_{44}(\varphi_a)$ as a function of rolling amplitude φ_a , Equation – 1 can be written as:

$$(I_{xx} + A_{44})\ddot{\varphi} + B_{44}(\varphi_a)\dot{\varphi} + WGM_\varphi = 0 \quad (2)$$

Equation – 2 gets the following form where

$$\alpha_e = B_{44}(\varphi_a)/2(I_{xx} + A_{44}) \text{ and } \omega_r = \sqrt{WGM/(I_{xx} + A_{44})}: \\ \ddot{\varphi} + 2\alpha_e\dot{\varphi} + \omega_r^2\varphi = 0 \quad (3)$$

The solution of Equation – 3 is given by $\varphi = \varphi_a e^{-\alpha_e t} \cos(\omega_r t - \varepsilon)$. In this study, the I_{xx} and A_{44} are estimated from the relationships, $I_{xx} = \rho \nabla r_x^2$ and $A_{44} = 0.25 I_{xx}$ respectively where radius of gyration (r_x) is considered as 40% of ship moulded breadth.

Model – 2

This is the model for assessing short-term rolling motion characteristics by considering a vessel is heeled due to the influence of the average wind and rolling at that position under action of beam waves and gusty wind. This study assumes wind generated surface waves in Bangladesh inland waterways in River Danger Signal – III (wind velocity 20.83 m/s). Following is the linear equation of motion:

$$\ddot{\varphi} + 2\delta_e(\sigma_\varphi)\dot{\varphi} + \omega_{0,e}^2(\varphi_s)\varphi = \omega_0^2.m(t) \quad (4)$$

In Equation – 4, $\delta_e(\sigma_\varphi) = \delta_0 + \sqrt{(2/\pi)} \cdot \delta_1 \cdot \sigma_\varphi + 1.5\delta_2\sigma_\varphi^2$ and $m(t) = M(t)/W.GM$ with $\delta_e(\sigma_\varphi)$ is the equivalent linear roll damping coefficient (a function of σ_φ) and ω_0 is the upright ship roll natural frequency. The standard deviation of the roll velocity, σ_φ has the following relationship:

$$\sigma_\varphi^2 = \int_0^\infty \frac{\omega^2 \cdot \omega_0^4}{(\omega_{0,e}^2(\varphi_s) - \omega^2)^2 + (2\delta_e(\sigma_\varphi) \cdot \omega)^2} \cdot \frac{S_M(\omega)}{(W.GM)^2} d\omega \quad (5)$$

Here $\omega_{0,e}$ is an equivalent roll natural frequency and holds the relationship $\omega_{0,e}(\varphi_s) = \omega_0 \cdot \sqrt{GM_{res}(\varphi_s)/GM}$ where $GM_{res}(\varphi_s)$ stands for residual metacentric height at the initial heeling angle (φ_s) due to mean wind. The roll damping coefficients (δ_0 , δ_1 and δ_2) can be estimated from equivalent linear damping coefficient $B_{44}(\varphi_a)$ (a function of rolling amplitude φ_a) by the following relationship:

$$\frac{B_{44}(\varphi_a) \cdot \omega_0^2}{2W.GM} = \delta_0 + \frac{4}{3\pi} \cdot \delta_1 \cdot \omega_0 \varphi_a + \frac{3}{8} \delta_2 \omega_0^2 \varphi_a^2 \quad (6)$$

The roll motion spectrum in this model:

$$S_\varphi(\omega) = \frac{\omega_0^4}{(\omega_{0,e}^2(\varphi_s) - \omega^2)^2 + (2\delta_e(\omega))^2} \cdot \frac{S_M(\omega)}{(W.GM)^2} \quad (7)$$

In Equation – 7, ω is the wave circular frequency and $S_M(\omega)$ is the spectrum of total moment due to the combined influence of waves and gust. The roll motion governing parameters can be estimated by using the spectrum ($S_\varphi(\omega)$) (of the roll motion as follows with $m_0 = \int_0^\infty S_\varphi(\omega) d\omega$ and $m_2 = \int_0^\infty \omega^2 \cdot S_\varphi(\omega) d\omega$:

Roll standard deviation (rad): $\sigma_\varphi = \sqrt{m_0}$;

Roll zero crossing frequency (rad/sec):

$$\omega_{z,\varphi} = \sqrt{m_2/m_0} ;$$

Roll zero crossing period (sec):

$$T_{z,\varphi} = 2\pi/(\sqrt{m_2/m_0}).$$

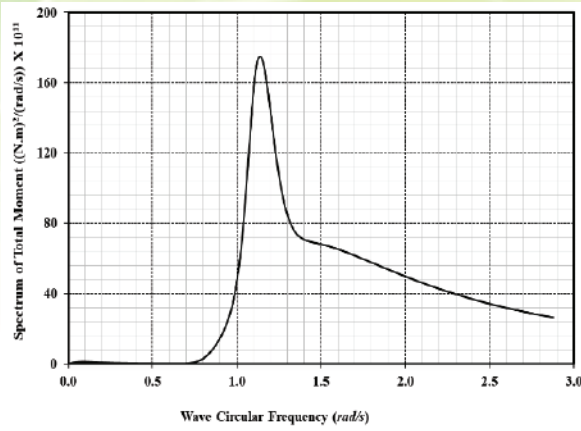


Figure 2. Regenerated result of Abdee et.al. [9]

Total Roll Moment of a Bangladesh inland passenger vessel (Figure - 2) due to the wind generated waves and gust that was estimated in another study [9] has been considered for this investigation and the same vessel (Table – 1) has been taken as the sample vessel.

TABLE 1. Principal, Hydrostatic and Relevant Particulars of the considered Bangladesh inland passenger vessel

Length (overall)	70.50 (m)
Length (in waterline)	68.00 (m)
Length between perpendiculars	66.70 (m)
Breadth (moulded)	10.60 (m)
Depth (moulded)	2.60 (m)
Draft (full load condition)	1.80(m)
Coefficient (block)	0.63
Coefficient (midship)	0.956
Displacement (mass)	819 (ton)
KG (keel to center of gravity)	2.60 (m)
KM (transverse)	7.08 (m)
Windage Area (lateral)	525 (m ²)
distance from the center of lateral windage area to the center of the underwater lateral area	4.80 (m)
Vessel Speed	5.14 m/s

EQUIVALENT LINEAR DAMPING COEFFICIENT BY SIMPLIFIED IKEDA METHOD

IMO has proposed the simplified Ikeda Method in absence of sufficient information. In the method, equivalent linear damping coefficient $B_{44}(\varphi_a)$ and the circular roll frequency is non-dimensionalized by water density ρ , ship volume displacement ∇ , breadth B and gravitational acceleration g as follows:

$$\widehat{B}_{44} = \frac{B_{44}}{\rho \nabla B^2} \sqrt{\frac{B}{2g}}; \quad \widehat{\omega} = \omega \sqrt{\frac{B}{2g}} \quad (8)$$

Here, the total roll damping (B_{44}) consists of five damping components, namely the skin-friction damping component (B_F), the wave-making damping component (B_w), the eddy-making damping (B_E), the bilge keel damping component (B_{BK}) and the lift component (B_L). The method is simplified with a number of empirical formula by regression analysis and by introducing a lots of coefficients. Only the governing variables of each damping component have been shown below:

$B_F = f$ (water density, length between perpendiculars, draught, block coefficient, breadth, center of gravity, rolling period, dynamic viscosity, roll amplitude, roll frequency);

$B_w = f$ (roll frequency, breadth, draught, block coefficient, mid-ship section coefficient, center of gravity);

$B_E = f$ (roll frequency, roll amplitude, breadth, draught, block coefficient, mid-ship section coefficient);

$B_{BK} = f$ (roll frequency, breadth, draught, block coefficient, mid-ship section coefficient, roll amplitude, bilge keel dimensions (length, breadth));

$B_L = f$ (length between perpendiculars, breadth, draught, vessel speed, mid-ship section coefficient, center of gravity, displacement).

Once the equivalent linear damping coefficient $B_{44}(\varphi_a)$ is estimated for some specific roll amplitude φ_a the roll damping coefficients (δ_0 , δ_1 and δ_2) and can be estimated from Equation – 6 by least square method.

RESULTS AND ANALYSIS

Bilge keel is a flat bar that is welded to bilge plate (curved plate between shell plate and bottom plate) to damp the roll motion. Naturally, it's dimension specially the surface area influences the amplitude of roll damping. Effect of bilge keel with different surface area on a sample Bangladesh passenger vessel with traditional shape, geometry and principal particulars has been studied. Figure – 3 shows influence of bilge keel surface area (length x breadth) on values of equivalent linear damping coefficient $B_{44}(\varphi_a)$ with different roll amplitudes. The rate of increase in coefficient value increases with the increase of rolling amplitude. Figure – 4 shows the roll motion simulation results in calm water for different rolling amplitude.

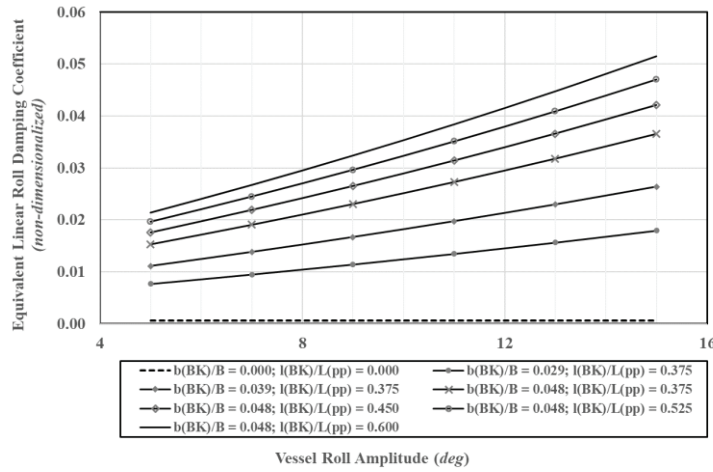


Figure 3. Variation of non-dimensionalized equivalent linear damping coefficient $B_{44}(\varphi_a)$ with the variation of bilge keel dimensions and roll amplitude

Figure – 5 shows the simulation results of roll motion due to combined effect of wind and wave. It is observed that roll damping increases drastically in presence of bilge keel. Variation in bilge keel breadth has higher influence on roll damping than the variation of bilge keel length. Figure – 6 shows the variation in roll motion spectrum with the variation of bilge keel dimensions. It is observed that, resonant roll motion may occur for the wave periods close to the ship natural period without fitting of a bilge keel. This situation is a great threat to a vessel from stability point of view and also vessel maneuvering will be very difficult during the situation. This dangerous scenario can be avoided by fitting bilge keels. Finally, the estimated values of roll motion (due to combined effect of wind and wave) governing parameters and the change in values with the change of bilge keel dimension is shown in Table – 2.

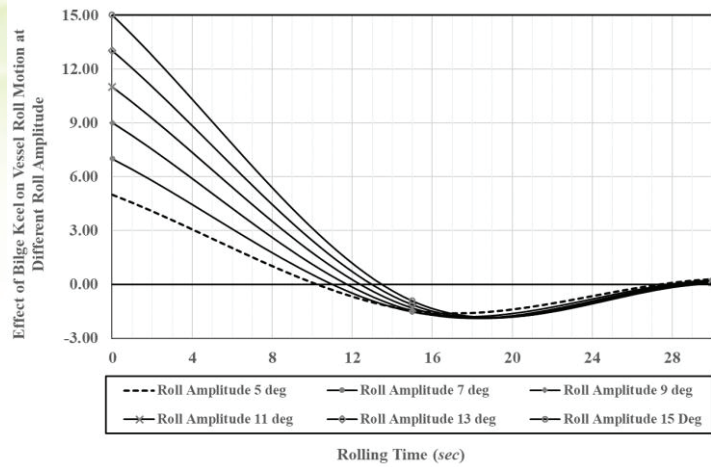


Figure 4. Roll damping by bilge keel ($b(BK)/B = 0.048$; $l(BK)/L_{pp} = 0.600$) with time for different roll amplitude (ϕ_a) in calm water (Model - 1)

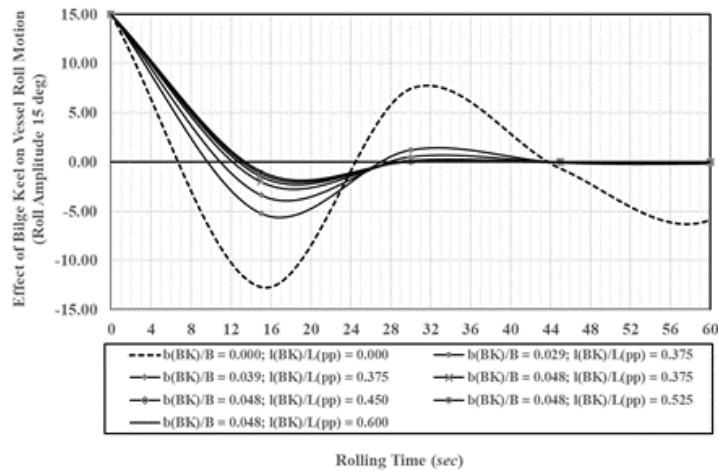


Figure 5. Roll damping (for roll amplitude 15 degree) by bilge keel with time for different bilge keel dimensions (Model - 2)

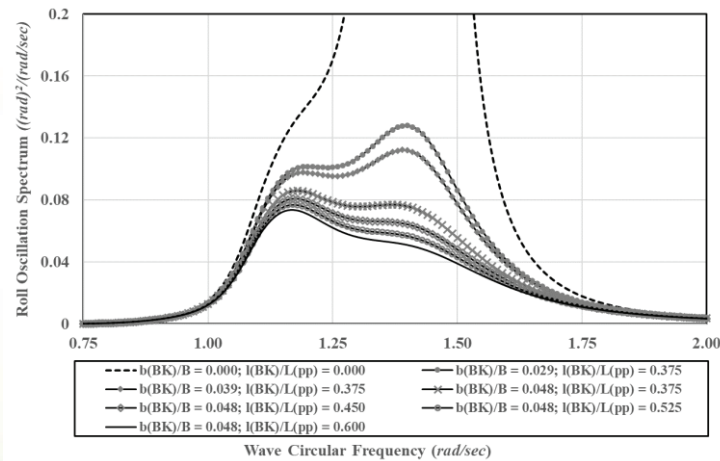


Figure 6. Variation in roll motion spectrum ($S_\phi(\omega)$) with the variation of bilge keel dimensions (Model - 2)

Table 2. Values of roll motion parameters (due to combined influence of wind and wave) for different Bilge Keel dimensions

Size of Bilge Keel	Roll Standard Deviation (σ_ϕ) (rad)	Roll Zero Crossing Frequency ($\omega_{z,\phi}$) (rad/sec)	Roll Zero Crossing Period ($T_{z,\phi}$) (sec)
b(BK)/B = 0.000; l(BK)/L(pp) = 0.000	2.817	1.420	4.424
b(BK)/B = 0.029; l(BK)/L(pp) = 0.375	0.244	1.385	4.533
b(BK)/B = 0.039; l(BK)/L(pp) = 0.375	0.235	1.384	4.537
b(BK)/B = 0.048; l(BK)/L(pp) = 0.375	0.211	1.382	4.545
b(BK)/B = 0.048; l(BK)/L(pp) = 0.450	0.201	1.381	4.548
b(BK)/B = 0.048; l(BK)/L(pp) = 0.525	0.194	1.381	4.549
b(BK)/B = 0.048; l(BK)/L(pp) = 0.600	0.187	1.380	4.550

CONCLUSIONS

Losing stability by rolling beyond the limit due to influence of adverse environmental load is the main reason of many Bangladesh inland vessels accidents. A vessel may roll in calm water due to inertia force or a vessel may roll due to combined effect of wind and wave. Bilge keel, the prominent roll damper for vessels reduces the rolling amplitude remarkably. Effect of bilge keel on a passenger vessel's rolling motion has been studied. It is observed that the rolling amplitude reduced drastically with bilge keel fitting. The breadth of bilge keel has more effect than length on roll damping. Fitting of bilge keels in a vessel may avoid the resonant scenario where large amplitude roll may occur due to wave period close to ship natural period. Nothing is mentioned in current statutory rules of Bangladesh regarding the fitting of bilge keel in inland vessels. This study proves the necessity of fitting bilge keel at least in Bangladesh inland passenger vessels and the rules may be modified accordingly.

REFERENCES

1. IMO, "Interim Guidelines on the Second Generation Intact Stability Criteria" (MSC. 1/Circ. 1627 (2020)).
2. IMO, "Explanatory Notes to the Interim Guidelines on the Second Generation Intact Stability Criteria" (MSC. 1/Circ. 1652 (2023)).
3. IMO, "Adoption of the International Code on Intact Stability, 2008 (Resolution MSC.267 (85) (2008)).
4. K. S. Iqbal, G. Bulian, K. Hasegawa, M. M. Karim, Z. I. Awal, "A rational analysis of intact stability hazards involving small inland passenger ferries in Bangladesh" (Journal of marine science and technology, 13(3), (2008)) pp; 270-281.
5. M. R. Islam, M. H. Akib, F Tabassum, KA Hossain, "On the Investigation of Wind Generated Waves in Bangladesh Rivers for the Assessment of Stability Requirements in Inland Vessel Design" (Brodogradnja: Teorija i praksa brodogradnje i pomorske tehnike 72 (3) (2021)) pp: 45-59.

6. M. A. R. Irfan, S. Nallayarasu, S. K. Bhattacharyya, "Numerical prediction of roll damping of ships with and without bilge keel", (Ocean Engineering 179 (2019)) pp: 226-245.
7. Y. Kawahara, K. Maekawa, Y. Ikeda, "A Simple Prediction Formula of Roll Damping of Conventional Cargo Ships on the Basis of Ikeda's Method and Its Limitation", (Chapter 26 of Contemporary Ideas on Ship Stability and Capsizing in Waves, Neves, M.A.S., Belenky V.L., de Kat, J.O., Spyrou, K. and Umeda, N., eds., Springer, ISBN 978-94-007-1481-6 (2011) pp: 465-486.
8. IMO, "Finalization of Second Generation Intact Stability Criteria, Report of the Correspondance Group (part 4) Submitted by Japan" (SDC 4/5/1 Add. 3 (2016)).
9. S. M. S. R. Abdee, A. M. A. Wahid, A. K. M. S. H. Barnil, M. R. Islam, "Total Roll Moment of Bangladesh Inland Vessel Due to the Wind Generated Waves and Gust", (submitted for publication).

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Design of an Efficient and Economic Bilge Water Management System in Inland Waterway Vessels of Bangladesh

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Abstract. Bilge water is one of the main causes of marine pollution in Bangladesh, where dumping of untreated bilge water, containing mainly oil, poses serious threat to both human lives and aquatic ecosystems. Due to high capital expenditure of a bilge water treatment system, inland waterway vessels of Bangladesh are seldom seen to be fitted with such system. This research is focused on the development of an indigenous, cost-efficient and affordable solution for the inland waterway vessels of Bangladesh so water can be separated from the bilge water part and discharged overboard, while the volume reduced oily sludge can be stored and sold separately. A set up is proposed to determine the optimum sizing of gravity filtration for maximizing the free oil removal so the emulsified oil can be removed from the water stream with optimum sized slow sand filter only. Finally, oil content is determined to find out the oil removal rate from the discharged water to determine the social and environmental benefits of the system.

INTRODUCTION

Marine pollution is one of the most critical issues in today's world. With rapid increase in marine transport system, pollution is also increasing simultaneously. To maintain a ship's stability and safety, collected bilge water must be discharged. But accumulated bilge water shouldn't be discharged without treatment. Therefore, a feasible oil-water separator must be introduced to reduce the water and environment pollution. By observing various techniques and methods "Slow Sand Filtration (SSF)" along with the Gravity Separation is found to cost friendly and effective for inland vessels. Its low budget and easy installation will attract the shipping industries as well as the ship owners. Though commercial OWS (Oily Water Separator) is available for this purpose, its complicated installation and high maintenance cost makes it very unpopular in Bangladeshi inland shipping industry. Separator, dust filter, probe, pump, heating device etc. are needed to set up an OWS system whether slow sand filtration system only needs some valves, SSF unit, gravity separation unit, filter and bilge pump which are economically available and easy to maintain.

LITERATURE REVIEW

Discharges of oily water into the sea can affect the reproduction and growth of marine organisms. Volatile Organic Compounds (VOCs), Polycyclic Aromatic Hydrocarbons (PAHs) and other poisonous & harmful significance comprise in oil products [1-2]. Vessels are identified as the main reason for marine pollution [3]. Specifically, it can be said that human activities are the main reasons to pollute the marine environment. Massive industrialization with globalization has a great impact on water pollution. In Bangladesh, threat of oil pollution from marine vessels is a matter of concern in coastal and port state areas [4]. By study and analysis of various cases some mentionable issues came up for Bangladesh's perspective regarding this pollution which are poor enforcement of laws,

uncontrolled actions of great number of inland and merchant shipping vessels and negligence of infrastructure by the governments. Moreover, there is no legal and written policy of the protection of the coastal areas currently. Bangladesh has 230 rivers which pass through about 710 kilometers. Ships and aircrafts are notified about 33% of marine pollution (Alam and Faruk, 2014) [5]. The Sundarbans which is the largest mangrove forest of the world, is a part of the delta formed by the rivers Ganges, Brahmaputra and Meghna. Various water vessels use this route and causes water pollution but there are less studies and cases regarding this issue. An oil tanker accident on December 9, 2014 on this route and then there was all over spilled oil. This causes a huge impact on environment of the mangrove forest and human being [6]. Another incident took place on October 25, 2019 when about 10,000 liters of heavy fuel oil spilled into Karnaphuli River in Bangladesh. This oil was spread over more than 16 kilometers and causes significant threat to the hundreds of fish species, affected a breeding ground of the Ganges dolphins and damaged the food chain of the river [7]. After these incidents, everyone is aware about the harmful effects of contamination of oil. But discharging of bilge water and others hazardous substances throwing into water is not reducing. Bangladesh has given consent to most of the international convention and laws of marine pollution but the country has no national policies of its own to protect the marine environment [8].

To reduce this pollution, the MARPOL 73/78 convention imposed a standard limit set to discharge oil/grease (<15 mg/L) into the sea [9]. With the advent of the International Convention for the Prevention of Marine Pollution from Ships (MARPOL), Marine Environmental Protection Committee (MEPC), the Department of Environment (DOE), more and more regulations are coming into place [10-11]. However, it is a matter of sorrow that inland waterway vessels of Bangladesh seldom comply with these pollution requirements. These vessels discharge huge amount of waste materials into the rivers. Due to lack of knowledge about the bilge handling and large capital expenditure to set up a commercial bilge water treatment unit, the ship owners are also inclined to comply with these. Hence, this paper is focused on designing an efficient and economic bilge water management system. There are various types of oily water separation techniques, namely physical treatment (gravity, coagulation, filtration), chemical treatment (adsorption, electrochemical), biological treatment (microbial metabolism, activated sludge, biofilm), combined treatment [12]. But here an ancient technique called “slow sand filtration” is introduced along with the gravity separation method. This system has the advantage of easy installation, operation and maintenance, high effluent quality, and low cost [13].

DESIGN ASSUMPTION

According to the particulars of a typical inland cargo vessel the equipment of bilge management system is consummated.

According to DNV-RU-SHIP part-4, chapter-6, section-4 the minimum bilge well capacity shall be 0.15 m^3 . Also, according to SOLAS there shall be at least 2 power pumps, one of which may be driven by propulsion machinery. In the considered cargo vessel, a maximum of 3.7 m^3 bilge water is considered in a particular day [14]. If the Daily Bilge Pump capacity is taken as $3.7 \text{ m}^3/\text{h}$, it will take 1 hour to transfer all these bilge water to the gravity separation unit. At this rate, emptying a bilge well of 0.15 m^3 will take 146 second. According to DNV-RU-SHIP part-4, chapter-6, section-4 the Main Bilge Pump capacity is $45.5 \text{ m}^3/\text{hour}$.

Main bilge line sizing is calculated as per SOLAS. Inner diameter of Main Bilge Line, d is calculated as 75.3mm and bilge water velocity is found as more than 2 m/s. The Inner diameter of Branch Bilge Line, d_1 is calculated as 52.1mm.

According to DNV minimum capacity of the Bilge holding Tank is taken as 4m^3 . The sludge tank capacity, V is taken as 0.225 m^3 as per MARPOL Annex I. An Average of 0.67m^3 bilge water produced per day [15]. If 20% design margin considered, then the capacity of gravity separation tank and buffer tank will be 0.8m^3 . The oil content in the gravity separation tank is 40L, considering 50 ppm oil content in the bilge water.

The filtration rate of slow sand filter is taken as $100\text{ L/m}^2/\text{h}$ and minimum height of slow sand filter is 750mm. So, the size of the slow sand filter is 6m^3 . Pipe wall thickness is calculated as per ASME B31.3. For 3" and 3.5" pipes, SCH STD has been considered.

SCHEMATIC AND DESCRIPTION

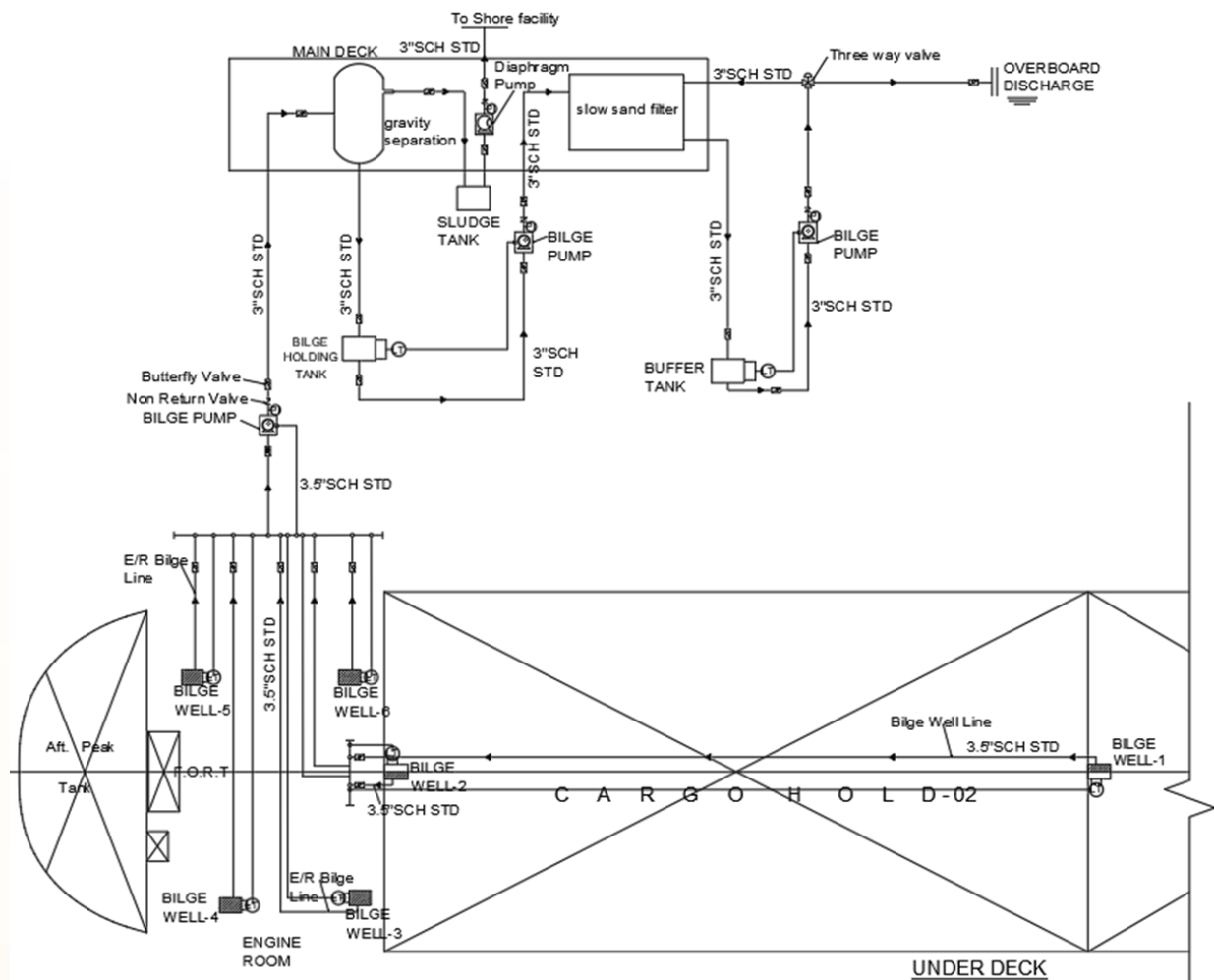


FIGURE 1. Schematic diagram of system.

DESCRIPTION OF SYSTEM

Bilge wells will collect the bilge water from different lines of machineries. These will be operated through level transmitters. When one of the bilge wells fills up, a centrifugal pump will start pumping the bilge water to the gravity separation tank. Then with the help of pump, bilge suction will be started and move it to the gravity separation unit. The bilge water will stay for a while in this unit to separate the mixture of oil and water by gravitational force. Then the oil will be floated and the contaminated water will be remained under the layer of oil. More than one gravity unit will be installed to get better performance.

Separation of fluid by gravity settling is calculated from 3 different formula under 3 different conditions (Newton's Law, Intermediate Law, Stoke's Law). Terminal velocity, $V_t = 0.0008175 \text{ m/s}$. For oil-water mixture height of 0.6m the settling time = 733.94 s = 12 min 23s. If there is no stirring up (by discharging to the settling) within this 12 min 23s time period, oil will be precipitated and can be transferred to the holding tank.

After that an isolation valve will be opened to let the oil into sludge tank and contaminated water will flow to bilge holding tank by gravity. Then the contaminated water will be transferred into the slow sand filtration unit by pump. In this unit, fine sand and gravel will be provided to carry out the process of filtration. The treated water will be carried out into the buffer tank. This tank will be used as a storage tank. A pump will be installed to discharge the treated water overboard. A three-way control valve will be placed at this discharge point with oil content ppm meter. If oil content is less than 15ppm, then water will be discharged from the ship and if it is greater than 15ppm, the water will go again into the slow sand filtration unit and will repeat the filtration process.

Due to impurities in oil, the slow sand filter can be clogged. Sometimes it blocks the pores which may resist the efficient work of this filter. Necessary steps should be kept maintain and clean the SSF unit such as –

- Minimum sand layer (2.5 to 3 cm) should be scrapped from the surface of the bed when it is full of clogs and clean sand should be replaced to that place.[16]
- All the valves installed, should be checked in every few months by opening and closing them to ensure that it's not becoming stuck or leaks.
- Backwashing is a good option to remove dirt and other debris. This process is mainly reverse water flow which passes through the filter of sand. Depending on working condition backwashing should be introduced several times such as every month or between 2 to 3 months or yearly.
- If valve leaking, valve failure, tank failure, dirty sand filter and other disturbance and issues occur then immediately these things must be fixed to operate the SSF properly.
- It is worth mentioning that use of the correct quantity of sand to operate the filter properly otherwise the filter will not perform efficiently.[17]

Maintenance of Pump

Pump maintenance should also be considered along with maintenance of SSF. Proper maintenance of pump includes:

1. Routine based maintenance
2. Overhaul or repair operations [18]

Pumps play a vital role to transfer fluid and carry out debris from slow sand filtration unit and discharge it from ship. So, it's maintenance must be a top prior. [19]

For daily check schedule:

- If noise occurs, check bearings and cavitation.
- Check temperature of bearings.
- Review all pump bearings and oil rings by the help of filling ports.
- Gaskets and pressure casing should be monitored if any oil leakage happens.
- Check pump's indicator and needle valve are working properly.
- Check cracks in pipes/hoses.
- Check inlet pressure and outlet pressure.[20-21]

For monthly check schedule:

- Need to put oil in bearing reservoirs if necessary.
- Oiler bulbs and level windows must be cleaned if needed.
- From bearing brackets, scrap must be cleaned out. Make sure that drain hole must remain free.
- Power piston, fittings and leaks should be checked by overhauling if required.
- If any parts need to change or replace then it must be done.[21-22]

For yearly check schedule:

- Check coupling alignment, axial float and driver shaft by using an indicator.
- By overhauling, every valves and linkages should be cleaned and checked properly.
- If corrosion occurs to any parts then necessary measurements should be kept to solve this problem.

Governor, spring, bearing, plunger etc. should be inspected to get optimum performance from the pump.[21-22]

SOCIAL & ENVIRONMENTAL COST

In a case study of pollution by oil, it came up that 1(one) liter of oil can pollute 1(one) million liters of water.[23] In Bangladesh, price of each unit (1,000 liters) of water is Tk 15.18 for residential use and Tk 42 for commercial use[24]. So, 1(one) liter of oil can loss water of net worth Tk ($1000 \times 15.18 = 15180$) for residential and Tk ($1000 \times 42 = 42000$) for commercial use respectively. From the design assumption, it is calculated that 40L oil will be recovered from total bilge in a single voyage. So, 40L of oil can save water of net worth Tk ($4000 \times 15.18 = 60720$) for residential use and Tk ($4000 \times 42 = 168000$) for commercial use respectively. A ship typically does 20 trip in a year. So, the minimum annual value of saving water is TK ($60720 \times 20 = 1214400$). Moreover, oily water

pollution has one of the most dangerous effects on the water environment. It creates a thin layer so that sunlight and oxygen can't get into the water. For this, plants and animals under water can't live.

Oil doesn't affect only wild life as well as it has great impact on human life too. Discharge oil pollutes water then this polluted water hampers irrigation and can damage the plants of water treatment. It can be said that oil spills are difficult to clean up and cleaning process is also very costly. So, treatment of this oil contamination before discharging into water is very important.

CONCLUSIONS

Slow Sand Filtration (SSF) along with gravity separation unit will have a great impact on Bangladesh's shipping industries, transportation of marine vessel and marine environment. Implementation of this cost effective concept will reduce water pollution, resulting in a significant social and environmental cost benefit.

REFERENCES

10. Buskey, E.J.; White, H.K.; Esbaugh, A.J. Impact of oil spills on marine life in the Gulf of Mexico: Effect on plankton, nekton, and deep-sea benthos *Oceanography* 2016, 29, 174–181. [CrossRef].
11. Beyer, J.; Trannum, H.C.; Bakke, T.; Hodson, P.V.; Collier, T.K. Environmental effects of the Deep water Horizon oil spill: A review. *Mar. Pollut. Bull.* 2016, 110, 28–51. [CrossRef].
12. Artut, K. Sintine Suyunun Elektrokimyasal Yontemlerle Arastirilmasi. Master's Thesis, Mersin University, Mersin, Turkey, June 2008.
13. Protection of Bangladesh waters against accidental oil pollution from ships, Khondaker Md. Asaduzzaman.
14. Marine pollution in Bangladesh: Its causes and impacts on the environment, Kudrat-E-Khuda and Rumana Sharmin Barsha.
15. Impact of oil spill in the Bangladesh Sundarbans.
16. Dolphins threatened by Bangladesh oil spill.
17. Protecting the environment from marine pollution in Bangladesh: A brief in legal aspects with response to national and international cooperation's.
18. Ministry of Ecology and Environment. General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, Discharge Standard for Water Pollutants from Ships: GB 3552-2018; Environmental Science Press: Beijing, China, 2018.
19. Office of Water, EPA. Cruise Ship Discharge Assessment Report, December 29, 2008. Washington, D.C: US Environmental Protection Agency; 2008.
20. Office of Enforcement and Compliance Assurance, EPA. A Guide for Ship Scrappers: Tips for Regulatory Compliance. Washington, D.C: US Environmental Protection Agency; 2000. pp. 4.1-4.42.

21. Research progress and prospects of marine oily wastewater treatment: A review M Han, J Zhang, W Chu, J Chen, G Zhou - Water, 2019 - mdpi.com
22. 255.1 BSSL Slow sand filtration: A low cost treatment for water supplies in developing countries.
23. An Analysis of Ship-Source and Marine Pollution in Nigeria Sea sports: D. E. Onwuegbuchunam 1,*, T. E. Ebe 2, L. I. Okoroji 3 and A. E. Essien 4 ,23 august 2017.
24. The Management of Ship-Generated Waste On-board Ships: Deflt, CE Deflt, January 2017.
25. Viden-io-cleaning of slow sand filter and rapid sand filter.
26. Slow sand filtration |SSWM-find tools for sustainable sanitation and water management.
27. Maintenance and trouble-shooting of centrifugal pumps, Namitha M R 2015664502
28. Pump maintenance 101, Daniel P. Duffy
29. HVAC, Preventative Maintenance, Centrifugal pump maintenance, Ryan Waldron September 22, 2020
30. Maintenance and trouble-shooting of centrifugal pumps, Namitha M R 2015664502
31. Marine bilge pumps, the ultimate guide for ships
32. The impact of oil on the environment – Oil care

Author's Brief Biography



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COMPARATIVE STUDY OF USED AND UNUSED PLATES IN BANGLADESH SHIP BUILDING INDUSTRY

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Abstract. The progressive deterioration of structures caused by operational use and environmental influences is known as ship aging. It may cause structural deformation and cracking on the ship structure as a result of changes in the structure's properties. Damage can be assessed using various strength tests, such as tension, impact, and hardness tests. In this paper, tensile, hardness, and impact tests are performed on two different types of plates (new and used). The results provide the maximum elongation, area reduction, and ultimate tensile strength, and thus aid in the material selection for shipbuilding.

INTRODUCTION

Since ancient times, ships have played a pivotal role in the people of this country's trade affairs. According to the accounts of the 14th century Moroccan traveler IBN Batuta, there used to large fleets of warships docked in various ports of the country. Fraser (1983) conducted a thorough parametric study based on finite element analysis of beam and plate elements and proposed a few empirical equations for determining effective beam stiffness. The effective width of the slab is expressed as a function of column size and span for flat plate floors. The column zone in the finite element model of floors was assumed rigid in this parametric study. Other structural parameters, such as slab thickness, floor height by width, and so on, do not appear to be taken into account. Based on the findings of the experimental results, Lue et al (1994) studied the response of flat plate buildings and conducted extensive experimental investigations on plate column, sub-assemble, and proposed an effective slab width concept to be used for hysteretic static analysis to repress type loading. They proposed using some constant factors in their hysteretic model.

Ship building traditionally uses structural steel plate to fabricate ship hulls. Modern steel plates have much higher tensile strengths than their predecessors, making them much better suited to the efficient construction of ships. For different location of a ship hull, the thickness can be different. For example, side shell plating is the shell plating on the sides of the ship that forms the watertight skin along the ship side which are usually 6mm to 8mm thick. Whereas, keel is the steel plate with slightly more thickness than other adjoining plates on its sides. The area needs more strengthening because the ship sits on this area on the blocks, during construction as well as during dry docks.

This paper deals with tension, impact and hardness test on collected shipbuilding plates. The comparison of the results unveils the strength of the material on different aspects which may help in selection of material for ship construction.

THEORETICAL BACKGROUND

Despite the usage of a great variety of materials like composites and aluminum alloys, various types of steels are still utilized for shipbuilding industry [1]. Tensile test

Tensile and yield strength are determined by pulling a standardized machined sample in a special hydraulic press and recording the pulling force at increasing elongations until the sample breaks. The elongation at this point, and the way the fracture looks, are good indications of the steel's ductility [2]. Properties that are directly measured via a tensile test are

1. Ultimate tensile strength breaking strength.
2. Maximum elongation and reduction in area.

Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. The test process involves placing the test specimen in the testing machine and slowly extending it until it fractures. During this process, the elongation of the gauge section is recorded against the applied force. The data is manipulated so that it is not specific to the geometry of the test sample. The elongation measurement is used to calculate the engineering strain, E , using the following equation:

Where,

ΔL is the change in gauge length, L_0 is the initial gauge length, and L is the final length. The force measurement is used to calculate the engineering stress, σ , using the following equation:

$$\sigma = F/A \quad (3)$$

Where,

F is the tensile force and A is the nominal cross-section of the specimen. The machine does these calculations as the force increases, so that the data points can be graphed into a stress-strain curve.

Impact Test

Impact test signifies toughness of material that is the ability of material to absorb energy during plastic deformation. Toughness takes into account both the strength and ductility of the material. [3]

To perform this test the sample is placed into a holding fixture with the geometry and orientation determined by the type of test that is used and then a known weight generally but not always in the shape of a pendulum is released from a known height so that it collides with the specimen with a sudden force. This collision between the weight and specimen generally results in the destruction of the specimen but the transfer of energy between the two is used to determine the fracture mechanics of the material. This energy may be used to determine the Toughness [4].

These values are important for the selection of materials that will be used in applications that require the material to undergo very rapid loading processes such as in vehicular.

Impact test can be done in either Charpy or Izod method. In Charpy impact test, the column of the machine is positioned at a 140-degree angle with the striker and the pendulum hammer, whereas, the pendulum hammer is set with the column of the machine at a 90-degree angle with the striker [5].



Fig. 1. Impact testing machine

For both the methods, the following equation is used.

$$\text{Notch of impact} = \frac{\text{Energy absorbed}}{\text{Cross - section area}} \quad (4)$$

Hardness Test

Hardness tests are extensively used to characterize a certain material and to identify if it is appropriate for its intended purpose which involve the utilization of a particularly shaped indenter that is harder than the material under testing. The indenter is pressed onto the test surface with the use of a certain amount of force. The size of the depth of the indent is measured in order to determine the hardness value [6].

The Brinell hardness test method as used to determine Brinell hardness, is defined in ASTM E10. Brinell testing often use a very high-test load (3000 kgf) and a 10mm diameter indenter so that the resulting indentation averages out most surface and sub-surface inconsistencies [7].

The diameter of the impression is the average of two readings at right angles and the use of a Brinell hardness number table can simplify the determination of the Brinell hardness.

$$BHN = \frac{2F}{\pi D(D - \sqrt{D^2 - d^2})} \quad (5)$$

Where, BHN=Brinell hardness number.

F=Force applied.

D=Diameter of indenter.

d=Diameter of indentation.

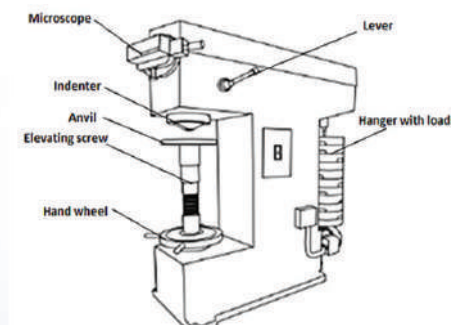


Fig. 2. Hardness testing machine

EXPERIMENTAL PROCEDURE

Sample Collection and Preparation

Three types of plates were collected of three different thickness 6mm, 8mm and 10 mm from different shipyard (Fig). Two of them are used plates (China classification society approved plates and vhatiry plates) and unused one was collected from local shipyard of Bangladesh. For tensile test, the samples were prepared following ASTM-A370 Code (Fig). It is usually a standardized sample cross-section.

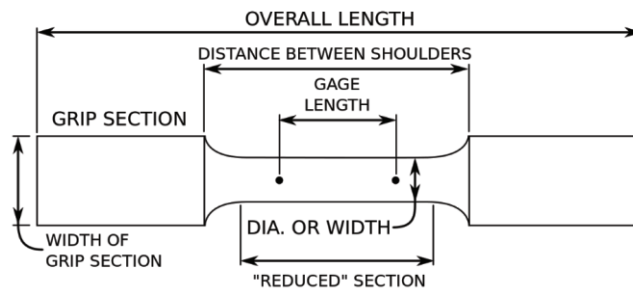


Fig. 3. Standardized sample cross section



(a)



(b)



(c)

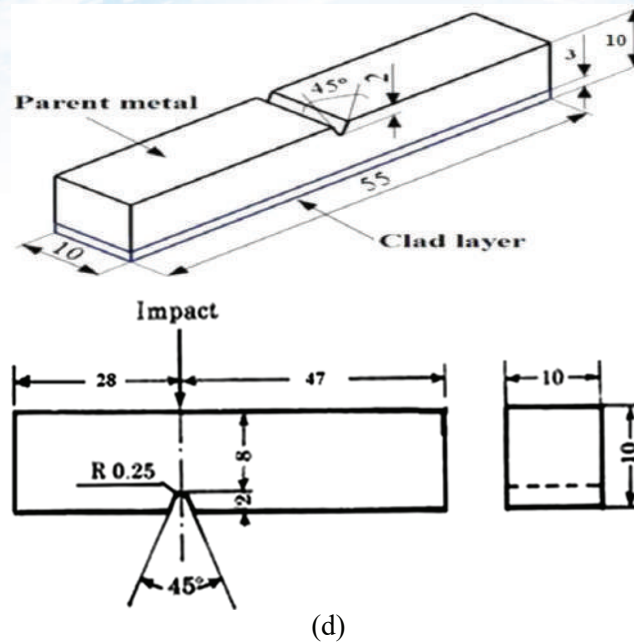


Fig. 4. (a) Sample collection, (b), (c), (d) sample preparation

Experimental Setup

By applying tension along the sample's axial axis, the length increased and the cross-sectional area decreased.

The Engineering stress, σ from the ratio of force (F) applied to the corresponding cross-sectional area (A). hence the strain is also calculated using the (1) and (2).



Fig. 5. Tensile test

For impact test, the sample pieces were prepared individually for both types of method. The sample pieces of Charpy were about 10mm in breadth and 55 mm in length. For testing the impact of the sample a v-notch was grooved at the middle position of the sample with a 45 degree angling and 2mm of depth.

On the other hand, the sample pieces of izod were about 10mm in breadth and 75mm in length. A v-notch was grooved at the 28mm distance from one end of the sample with a 45 degree angling and 2mm of depth. During test, the sample pieces were set as the notch was in the middle of the support. The hammer was set with the striker with 1400 and 900 for Charpy and Izod test

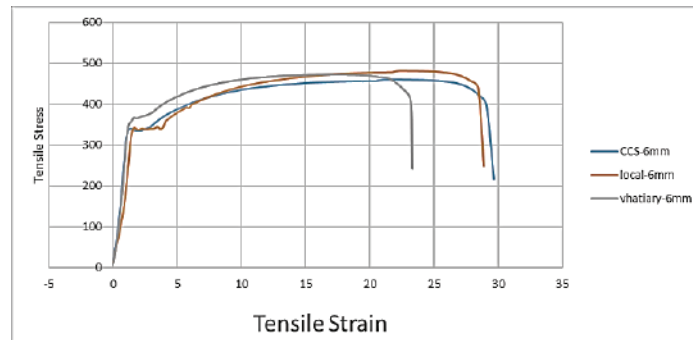
respectively [5]. So that samples could absorb the impact of the hammer on that particular portion. Equation (3) is used to calculate the notch of impact. For Brinell hardness test the samples were placed on the table and applied a force of 187.5 kg with an indenter of 2.4 mm for 30 seconds. Using (4) BHN is calculated. The overall results are summarized in next section along with the graphs.

RESULT AND DISCUSSION

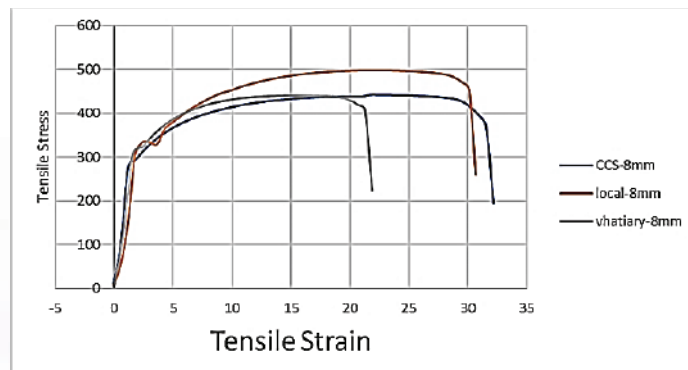
TABLE 1 RESULT FROM TENSILE, IMPACT AND HARDNESS TEST

TENSILE TEST		Old plate (CCS)		Old plate (Vhatiary)		New plate	
	Thickness	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)
	6 mm	345	450	347	472	348	460
	8 mm	275	435	308	441	350	500
	10 mm	332	479	310.7	459	320	482
IMPACT TEST	Thickness	Izod (j/m ²)	Charpy (j/m ²)	Izod (j/m ²)	Charpy (j/m ²)	Izod (j/m ²)	Charpy (j/m ²)
	6 mm	1604167	2145833	1208333	1395833	791667	1000000
	8 mm	1859375	2703125	546875	312500	781250	625000
	10 mm	1562500	2262500	1612500	2175000	675000	625000
	Thickness	BHN (kgf)		BHN (kgf)		BHN (kgf)	
HARDNESS TEST	6 mm	162.77		187.23		187.23	
	8 mm	167.33		167.3		170	
	10 mm	140		155.61		229	
	Thickness	BHN (kgf)		BHN (kgf)		BHN (kgf)	

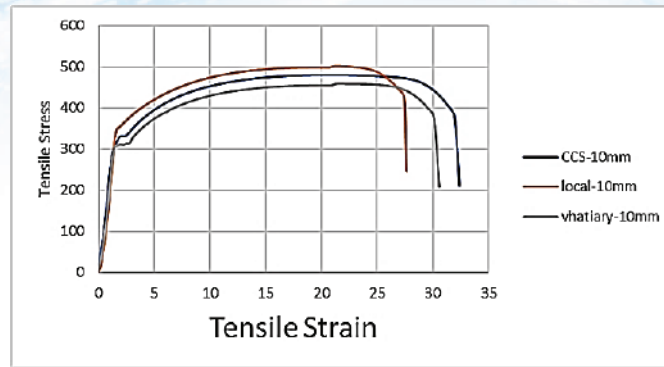
The stress strain curve obtained from the tensile test is also attached here.



(a)



(b)



(c)

Fig. 6. Stress-strain curve for (a) 6mm plates, (b) 8mm plates, (c) 10mm plates

In terms of tensile strength, unused/new plate with an 8mm thickness outpaces others. It exhibits the maximum tensile and ultimate strength comparing to the other variations. In terms of hardness, the unused plate of 10mm thickness showing the highest Brinell Hardness Number reveals that it can resist loading better than the plates of other variations.

Amongst used plates, old plates (CCS) with 8mm thickness, appear to withstand more impact force than other in both Izod and Charpy test but the other one surpassed in the tensile and impact test.

Therefore, the plates of 8mm thickness, possess better impact and tensile strength than 6mm and 10 mm thick plate. Overall, the experimental findings indicate that the use of locally sourced unused plates in the construction of various ship components could be a viable option because they are stronger than the other two varieties.

CONCLUSION

Different types of plates with different thicknesses exhibit varying levels of strength, impact resistance, and hardness, as demonstrated by the results presented. Consequently, by comparing the results, a suitable plate for the construction of a new ship can be selected based on its above mentioned properties.

In this study, the plates of three different thickness were collected from three different sources. The plates were undergone strength testing and the results showed that local unused plates yield more tensile strength and hardness. Although used vhatlary plates may absorb more impact force than others, it is preferable to use class approved plates when tensile strength and hardness are important factors to consider.

REFERENCES

- [1] F. Hayat and H. Uzun, "Effect of heat treatment on microstructure, mechanical properties and fracture behaviour of ship and dual phase steels," J. Iron Steel Res. Int 18(8), 2011, pp. 65-72.
- [2] <https://www.britannica.com/technology/steel/Testing-of-properties>.
- [3] <https://www.pcepurnia.org/wp-content/uploads/2020/03/impact-test-IZOD.pdf>.
- [4] T. A. Siewert and M. P., Pendulum impact testing, Manahan editor, 2000.

- [5] C. J. G. a. M. R. ADAMS, "The utility of impact testing as a measure of toughness, "SPE journal, pp. 12-13.
- [6] <https://www.hardnesstesters.com/test-types/brinell-hardness-testing>.
- [7] <https://www.corrosionpedia.com/definition/621/hardness-test-material-science>.

Author's Brief Biography



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Comparative Analysis on Deterioration of Mild Steel in Distinctive Water Samples in The Influence of Fluid Flow Velocity

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Abstract. The ship hull usually constitutes of steel which operates in an environment of air and water which stimulates corrosion of the ship plating. There are ship plating of different thickness among them plates of 5mm, 6mm are mostly used in case of construction and are vulnerable to corrosion. Previously corrosion loss and its rate, structural and mechanical properties have been estimated in a static condition and significant outcomes observed. Here, along with the statistical estimations in static condition the corrosion properties in a dynamic condition caused by the plate velocity influenced fluid flow has been calculated. A standard weight loss method has been adopted and using a DC motor the plate rotated at a constant speed and weight loss corrosion rate reading were taken for 120 days at a 15 days interval in 2 water samples. Besides mechanical properties and micrographic views were observed before and after corrosion. It has been found the weight loss increased in terms of exposure period and corrosion rate decayed exponentially though in case of salt water solution corrosion rate increased for 3 weeks caused by the presence of ions. There is significant reduction in the tensile strength of the material and hardness has decreased in case of salt water solution. Hence it can be stated that sea water is the most corrosive environment on the influence of motion

Keywords: Deterioration, Corrosion rate, Weight loss.

INTRODUCTION

At present the need for ships & marine vehicles has flourished rapidly. For this purpose, the body/ship hull mostly constructed using mild steel & its alloy. Since low carbon steel contains carbon content not much than 0.3 % by measurement as a result are worthy for machining purposes & other mechanical/physical properties such as high tensile strength, welding-control, ease in heat treatment which makes it a commonly used shipbuilding material. There are various material available used for shipbuilding which includes Glass Reinforced Plastic/Fiber Reinforced Plastic, ferrous & non-ferrous metals, plastics & wood. Although the significant material for the purpose of shipbuilding is plain carbon steel/carbon steel almost 90% nearly. Steel for shipbuilding must first be certified by one or more classification societies, such as the Lloyd's Register of Shipping (LR, UK), Bureau Veritas (BV, France), Det Norske Veritas Germanischer Lloyd (DNV GL, Germany)[1]. Now a days it is scarcely seen hull made without steel. Although scenario was quite opposite 100 years ago. The event could not be avoided was iron joints were found in historic wooden build ships & this continued for many centuries. In addition these were restricted by Mid Age steel producers could not assure enough volumes of hot metal & mild steel smelting. First ever

steel ship hull was constructed at the end of 1800 century. It was a barge type vessel. Steels provided strength as well as less weight in comparison to wrought iron during World War 2. Hence steel took place of iron in ship construction owing to its cost efficiency & lighter weight. Which initiates an new era of ship construction. operation & maintenance of the ship structure.

RESEARCH SCHEME & EXPERIMENTAL ARRANGEMENT

According to the objectives to achieve the final outcome which depend on the acquisition of marine grade steel plates .Acquisition of Experimental sample waters. Employing a cutting machine automobile shop to chop the plates to the required dimension. Procuring fundamental stores and instruments to conduct the experiment. As experimental arrangement, a truss having inclined steel rods, single phase DC motor, water reservoir for both sample to be immersed in water were used.

WEIGHT LOSS ESTIMATION

To determine the weight loss, specimens were quantified by an acute accuracy scale measuring instrument prior to thons soaking in the experimental waters. The initial experimental measurement was observed within specimens were exposed to water about 2 days (48 hours). Weight loss was determined within span of 15 days and hence the data were correlated in order to evaluate the deviation in the result in different erosive medium as in static condition. Following formulae was utilized to estimate the weight loss.

W_i = Initial weight (g) W_1 = Weight after the allocated time interval (g)

$$\Delta W = \frac{(W_i - W_1)}{a} \text{ (g per mm}^2 \text{)}$$

Where, a= Surface area of per specimen

CORROSION RATE ESTIMATION

Allied with spontaneous weight loss as well as corrosion rate fluctuates. Rate of decay along with loss of weight was estimated and the outcomes were compared with respect to the experiment conducted in static condition. We have determined rate of corrosion/decay for each observed value by virtue of the formulae mentioned below:

$$R_{decay} = \frac{k \times \Delta W}{d \times a \times t}$$

ΔW = Weight loss per revealed surface area, (g/cm²) , R_{decay} = Corrosion rate, (mm/year)

W_i =Initial weight, (g) , W_f = Weight observed after required time interval, (g)

a = Revealed Surface area, (cm²) , d = Density of mild steel, (g/cm³) = 7.85 g/cm³

t = Reveal period (hour) , k = Unit conversion factor= 87600

TENSILE STRENGTH ANALYSIS

The strength of the metal was acutely affected by the immersion on the presence of fluid motion. The most vulnerable specimen susceptible to corrosion was 5mm plate in sea water. It can be observed from load-extension curve the gradual decrement of load was much significant in dynamic corrosion. It indicates that the decayed element losses it's capability to withstand the minimum

load. Both unblemished and submerged specimens were assessed utilizing Universal Testing Machine. The data acquired by the means of UTM were contrasted to distinguish the divergence of tensile strength of each specimen both in static and dynamic condition

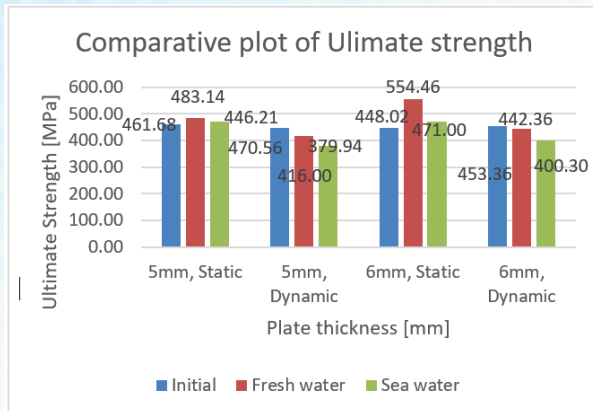


FIGURE 1. Comparative Illustration of Ultimate Strength

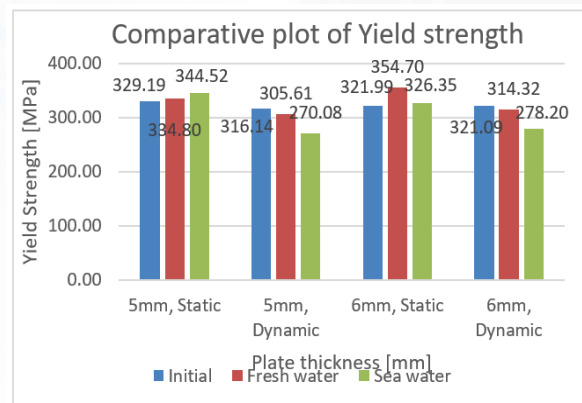


FIGURE 2. Comparative Illustration of Yield Strength

HARDNESS TEST

Hardness test was performed prior to samples were submersed in sample waters, the initial & final reading was observed. The submersed specimens were washed prior to test in order to eliminate the corrosion product from the exterior hence so indentation was visible. Both Vickers and Rockwell hardness test were performed and was compared with the outcomes in static condition.

MICROGRAPH INSPECTION

In fresh water at the end of a week the specimen submersed in sample water was encompassed by a slender coating of ferric oxide. Reddish colors the sample water which signifies that corrosion actions took place. After washing the specimen the rust went away and progressively turned into blackish color with a significant weight loss at that time. Brownish residue is termed as Ferric Hydroxide. In sea water, Glowing crimson wear showing areas of ash and blackish layer on the metal periphery. (Emmanuel Chuka et al., 2014). Within the 2nd to 4th week, 60-85% of the metallic periphery evolved into pitted surface in conjunction with stiff brown abrasive elements. When the surface is cleaned increased amounts of black pits appeared on the metallic surface. Just before the completion of the experiment spherical degrades were molded on the periphery and when cleaned off revealed spherical hollows underneath. The pitted surface was grey in color and the rest of the surface was black. Approximately at the 5th week the sample solution turned into deep yellow brown. A Scanning Electron Microscope was utilized to perform high capable micrographic analysis at different magnification as required for the steel plate after immersion test. This analysis has been performed to observe if therein a scrap of changes in the surface fundamentals of the eroded surfaces provoked by the sample waters. Moreover, the decayed specimens occupied with irregular edges along with different pit holes after the complete immersion test of 120 days.

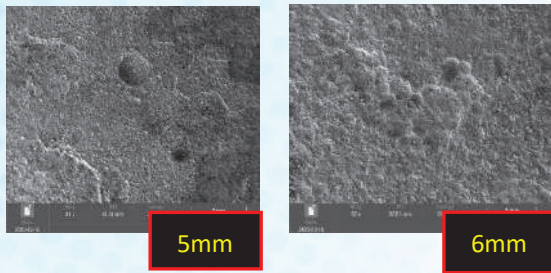


FIGURE 3. SEM image of corroded surface of specimens in Fresh water

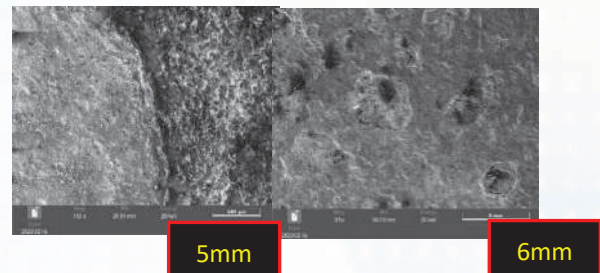


FIGURE 4. SEM image of corroded surface of specimens in Sea water

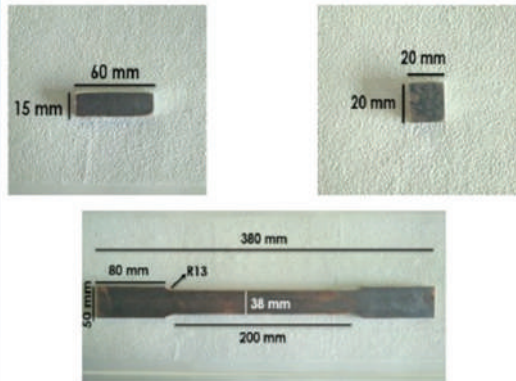


FIGURE 5. Sample Preparation



FIGURE 6. Complete Arrangement

TABLE 1. Initial Hardness Readings

Before immersion			
Plate thickness			
6mm		5mm	
131.4		119.1	
123.7		118.7	
123		120.1	
123.8		120.4	
125.4		119.2	
123.8		119.3	
126.4		120.7	
122.9		117.8	
119.9		117.6	
122.3		119	
Avg	124.26	Avg	119.19

TABLE 2. Hardness after Fresh water immersion

Comparative final Reading after Fresh water immersion			
5mm plate		6mm plate	
Dynamic Corrosion	Static Corrosion	Dynamic Corrosion	Static Corrosion
125.3	149.2	121.8	149.2
126.5	149.7	123.02	149.7
124.5	148.6	122.5	148.6
124.7	149.8	124.3	149.8
124.8	141.7	123.2	141.7
122.3	146.3	128.8	146.3
125.9	151.6	126.4	151.6
117.4	150.8	125.7	150.8
118.3	148.7	127.1	148.7
120.1	140.3	127.4	140.3
Avg:	Avg:	Avg:	Avg:
122.98	147.67	125.022	147.67

TABLE 3. Hardness after sea water

Comparative final Reading after Fresh water immersion			
5mm plate		6mm plate	
Dynamic Corrosion	Static Corrosion	Dynamic Corrosion	Static Corrosion
121.2	145.3	120.2	152.2
123	140.3	124.9	148.1
119.2	150	123.2	146.1
119.7	143.5	119.1	152.1
116.1	139.4	117.8	149.1
117.4	142.6	119.5	152.9
119.2	138.1	121.8	150
117.8	145.7	121.6	152.6
117.9	137.7	122.6	153.4
121.6	140.3	123.8	148.5
Avg:	Avg:	Avg:	Avg:
119.31	142.1	121.41	150.5

RESULTS AND DISCUSSION

Sharp increment in weight loss in the wake of 20th day prior to immersion which raised exponentially at 80th day in comparison to static condition caused by the metabolic stage of decay in results into the formation of regional pit holes effected by bio-mechanics of molecular organisms also defined as “Biological Corrosion.” (R E Melchers, 2005; Robert E. Melchers, 2005). By noticing the weight loss curve in comparison to static condition, considerable weight decrement takes place from 90 days to 120 days. Although the deuteration rate was diminishing from the very beginning. (Vukelic et al.,

2021). After exposure of 2 weeks of the weight loss in dynamic corrosion was 0.4 g and in static condition it was 0.2 g averagely, so corrosion effect in the fluence of flow velocity weight loss has been linearly doubled. In short term exposure from 14 to 20 days, weight loss curve varies linearly with respect to exposure time, marking the initiating stage of corrosion (Melchers, 2003). The initial stage of decay was linear with respect to exposed days it is governed by 3 parameters such as thermal reading of the sample water, degree of dissolved oxygen and pH. (Javed et al., 2014). Declining nature of weight lost per day from 20 to 40 days followed by a linear rise as a consequence of formidable molarity of Carbonate salt and hence obstructed disintegration. (AYOOLA et al., 2022) In comparison to static condition the weight loss was significant and has increased quite in exponential from after 45 days to total exposure time. Gradually developing weight loss is characterized by biologically influenced corrosion. Exposure about a year could result in a better rate of corrosion, the impact of ionic bonds of salts it destructs any outer films formed as well as hinders it building on the plate periphery. In comparison with corrosion curve of static vs dynamic, decay rate of mild steel rises up to 0.8 mm/year on the starting week. (Royani et al., 2019) Gradual exponential falling down of corrosion rate from the first week to 0.4 mm/year and hence steadied subsequently at then end of experiment. Higher corrosion rate at the initial stage from 2 to 3 weeks which dropped frequently and approached at a static rate of corrosion in both static and dynamic condition. Inferior proportion of ionic charges in the sample water is the influencing factor due to the availability of air and the media may constitute a decay sealing. The rate of deuteration is almost the same at the final week of exposure both in relative to the stated condition. This is caused by protective oxide film.

In Sea water Immersion, Intense ascend in the rate of decay all through initial 10 days nearly and reached the peak. And accompanied by a progressive fall down of corrosion rate all through the rest of the experimental immersion in sea water. The corrosion curve in seawater is characterized by heterogeneous and discrepancy in corrosion composites. (Ejenike Ogagorojo Ovri, Igwemezie and OOVri, 2013) Chlorine Ions displace the metallic ions aggregated on the anode through the formation of compound solution that stimulates electro synthetic actions and deuteration rates appreciably on low carbon steel. The decrement in rate of decay was influenced by the constitution of iron oxides within the decaying medium because the corrosion product would be ferric ions and carbonate salts. (Stephen et al., 2019) In seawater both for static and dynamic condition the rate of corrosion is affected by the concentration of chlorine ions and presence of oxygen. The considerable rise in corrosion rate is higher in strong chloride solution rather than usual salt water. Hence there is an acute acid contamination which trend is to rise the corrosion rate before the formation of resistive oxide layer. (Revie and Uhlig, no date b; Ismail and Adan, 2014). The strength of the metal was acutely affected by the immersion on the presence of fluid motion. The most vulnerable specimen susceptible to corrosion was 5mm plate in sea water. It can be observed from load-extension curve the gradual decrement of load was much significant in dynamic corrosion. It indicates that the decayed element losses its capability to withstand the minimum load. After fresh water immersion in velocity influenced media hardness of the material depends on Critical Scale Thickness. The decrement in hardness in case of 5mm plate is prominent it has reduced to 122.98, though in static condition there is not much variation in the hardness of the of the material. after Sea water Immersion in Comparison with the decayed specimen in sea water with their initial reading we can see that hardness for both the condition of corrosion has decreased with respect to the time of immersion. It is caused by a prolonged period of immersion and presence of salt ions. Magnitude of the reading reduces as a

percent of salt constituents increases. This is caused by the impact of greater degree of chlorine ion in the sample water, which stimulates the attack on oxide film and hence decrease corrosion safeguard. After exposure to 6mm plate, in sea water Regional pits indicating high molar concentration of chloride ions and an acidic media. Cavities on the surface were constituted on account of the cathodic actions to constitute iron chloride (FeCl_3) such settled the synthesis to propagate Iron Oxy Hydroxide (HFeO_2). (Parapurath et al., 2022). Various sized holes at the eroded periphery. Presence of smooth cavities reduce the risk of ruptures which could lead to the catastrophe of the structure. In Fresh water, morphologies of the rust composites derived from the immersion experiment at the end of 120 days were observed with different magnification. The sample exhibited a condensed wear product covering within uniform layer on top of the metallic periphery all through the experiment.

The rust products constituted a slender and continuous exterior, layers the region of carbon steel distributed precisely. Negligible alterations in periphery elements evolved over periods. After exposure to 5mm plate, in sea water, Extreme surface disfigurement referring to the intensely rusted surface. The degraded specimen's irregular periphery herewith holes and fractures symbolize that consistent decay of the metallic surface. Few areas illustrate a regional attack, which is defined as a chloride strike. In the inhabitation of formidable chlorine ions, the exposed laminas of remote oxide coatings are dissociated because of influencing Ferric Ion, Fe^{3+} composition whereas the double staged synthesis eventuated surrounded by transitional prolonged stabled of Iron Oxychloride (FeOCl). (Popov, 2015). It indicates the salty region FeOCl was freely adhered to the metal exterior, hence wouldn't shield it from anymore corrosive strikes. Oxychloride works like an influential catalyst part (anode), such layer breaks down and dissociates the steel plating. In Fresh water, in Chloride-free medium rust composites assumed to be granular alike constitution, combination of iron and oxygen with very less amount of salty solution and Sulphur. (Tang et al., 2014). Accompanied by negligible section of the periphery where pitting corrosion took place. It is evidently observable on the decayed surface of 5mm plate. Additionally, occupied by blackish cavities, which indicates the specimen's exteriors have suffered pitting deuteration. Within Fresh water specimens ruptures are barely noticed in comparison with seawater surface morphologies. Finally, it is to be mentioned that compared to the sample submersed in fresh water, the surface of the sample submersed in sea water has an increased degree of pits or cavities. Defined by significant figure of cavities indicates greater mass loss and a quicker decay rate of the metallic surface.

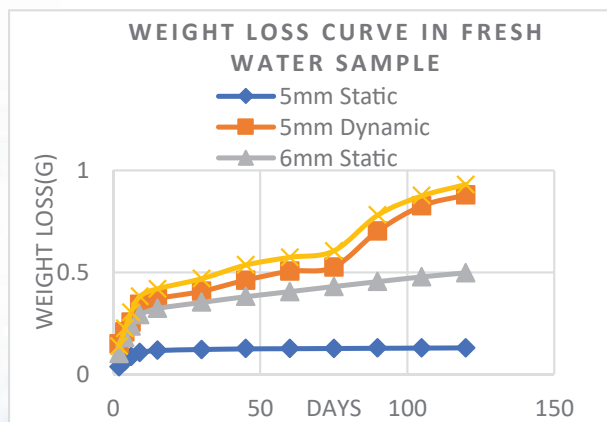


FIGURE 7. Weight Loss curve in Fresh water

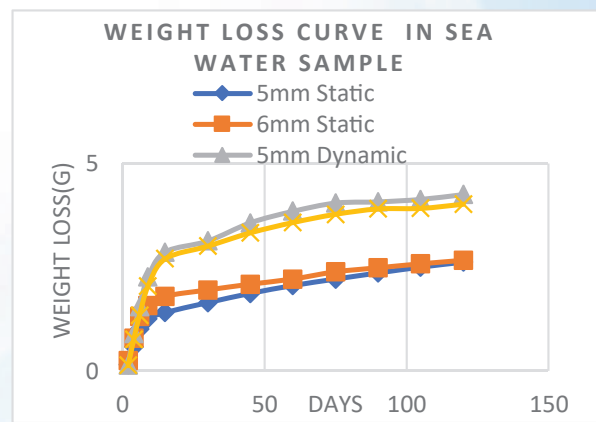


FIGURE 8. Weight Loss curve in Sea water

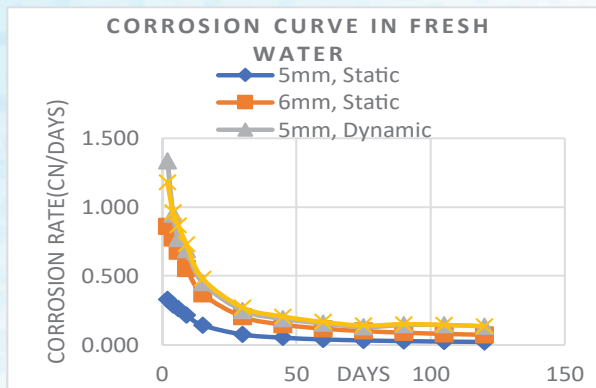


FIGURE 9. Corrosion curve in Fresh water

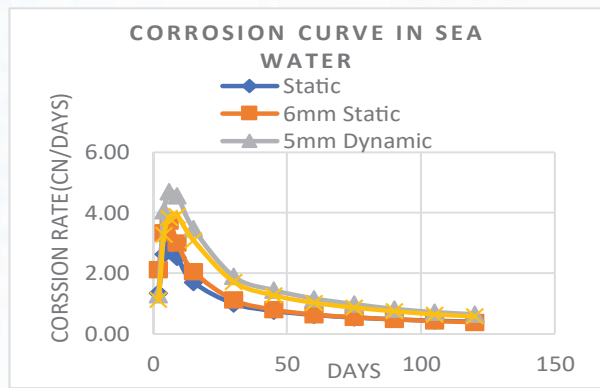


FIGURE 10. Corrosion curve in Sea water

CONCLUSIONS

On the basis of the results and analysis in comparison in static condition weight loss and corrosion was significant on the influence of flow velocity. In relation with static corrosion, weight loss curve was increasing exponentially with respect to exposure time. Weight loss curve for corrosion in dynamic condition was linearly doubled to that of static condition. Amidst the two specimens, the utmost weight loss and corrosion rate is identified as 6mm plate immersed in sea water at dynamic condition. It is stimulated by the presence of chloride ions, exposure period and flow velocity. Linear increment in rate of decay at sea water was due to the heterogeneous and discrepancy in corrosion composites. The tensile strength of the specimen is governed by its'Plate thickness, and the fluid motion which tends to decrease the range of elasticity of the material and stimulates plastic deformation. Increment in hardness of the metal is influenced by critical scale thickness. SEM micrographs indicates that in fresh water corrosion is most likely uniform over the surface and due to the impact of chloride attack pitting and regional corrosion occurs.

REFERENCES

1. Melchers, R E (2005) Statistical Characterization of Pitting Corrosion— Part 1: Data Analysis, CORROSION SCIENCE SECTION CORROSION.
Melchers, Robert E. (2005) 'The effect of corrosion on the structural reliability of steel offshore structures', in Corrosion Science, pp. 2391–2410. Available at: <https://doi.org/10.1016/j.corsci.2005.04.004>.
2. Vukelic, G. et al. (2021) 'Long-term marine environment exposure effect on butt-welded shipbuilding steel', Journal of Marine Science and Engineering, 9(5). Available at: <https://doi.org/10.3390/jmse9050491>.
Melchers, R.E. (2003) CORROSION SCIENCE SECTION Modeling of Marine Immersion Corrosion for Mild and Low-Alloy Steels-Part 2: Uncertainty Estimation.
3. Javed, Muhammad Awais et al. (2014) Comparison of the corrosion of carbon steel in natural seawaters-Evidence of MIC? Mapping the thermotolerant proteases in UHT milk using molecular techniques View project Effect of testing parameters on microbiologically influenced corrosion laboratory test outcomes View project COMPARISON OF THE CORROSION OF CARBON STEEL IN NATURAL SEAWATERS-EVIDENCE OF MIC? Available at: <https://www.researchgate.net/publication/258565854>.
4. AYOOLA, W. et al. (2022) 'CORROSIVE INFLUENCE OF VARIED SALT SOLUTIONS CONCENTRATION ON MILD STEEL', Usak University Journal of Engineering Sciences [Preprint]. Available at: <https://doi.org/10.47137/uujes.1073121>.

5. Royani, A. et al. (2019) 'Corrosion of carbon steel in synthetic freshwater for water distribution systems', in IOP Conference Series: Earth and Environmental Science. Institute of Physics Publishing. Available at: <https://doi.org/10.1088/1755-1315/399/1/012089>.
6. Ejenike Ogagorojo Ovri, J., Igwemezie, V.C. and OOvri, J.E. (2013) Investigation into the Effects of Microstructure on the Corrosion Susceptibility of Medium Carbon Steel. Available at: www.theijes.com.
7. Stephen, Joseph Temitope et al. (2019) 'Corrosion Inhibition of Alkaline Solution on Low Carbon Steel In Local Water (Oku River)', International Journal of Scientific and Technical Research in Engineering (IJSTRE) www.ijstre.com, 14. Available at: www.ijstre.com.
8. Revie, R.W. and Uhlig, H.H. (no date b) CORROSION AND CORROSION CONTROL An Introduction to Corrosion Science and Engineering FOURTH EDITION.
9. Ismail, A. and Adan, N.H. (2014) 'Effect of Oxygen Concentration on Corrosion Rate of Carbon Steel in Seawater', American Journal of Engineering Research (AJER), 03, pp. 64–67. Available at: www.ajer.org.
10. Emmanuel Chuka, C. et al. (2014) 'Investigation Of The Effect Of Corrosion On Mild Steel In Five Different Environments', INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH, 3(7). Available at: www.ijstr.org.
11. Parapurath, S. et al. (2022) 'Effect of Microstructure on Electrochemical Properties of the EN S275 Mild Steel under Chlorine-Rich and Chlorine-Free Media at Different pHs', Metals, 12(8). Available at: <https://doi.org/10.3390/met12081386>.
12. Popov, B.N. (2015) Corrosion engineering : principles and solved problems. Elsevier.
13. Tang, Y. et al. (2014) 'The corrosion behavior of pure iron under solid Na₂SO₄ deposit in wet oxygen flow at 500 °C', Materials, 7(9), pp. 6144–6157. Available at: <https://doi.org/10.3390/ma7096144>.

Author's Brief Biography



MD. Rejwan Al Foysal completed his B.Sc. in Naval Architecture and Marine Engineering from MIST. He is pursuing M.Sc. in Naval Architecture and Marine Engineering from BUET. At present, he is an Asst. Naval Architect in SeaBeach77 Ltd. He has participated in design consultancy of “LCT Building Project by Bangladesh Army”. His research interests include corrosion analysis, ship performance, and production.

SHIP DESIGN COMPETITION



The poster is for a 3D Ship Design Competition organized by the Military Institute of Science & Technology (MIST), Bangladesh. It features a teal background with a compass rose and a ship. The text is arranged in a circular flow, with icons for each point: a book for students, an envelope for submission, a medal for prizes, a ship for vessel types, and gears for software. The submission deadline is 21st August, 2022, and contact information for Dr. S M Ikhtiar Mahmud is provided at the bottom.

 **MILITARY INSTITUTE OF SCIENCE
& TECHNOLOGY (MIST), BANGLADESH**

**3D SHIP DESIGN
COMPETITION**

 Organized by : Department of Naval Architecture & Marine Engineering

 Students from any discipline, any university/institute around the world can participate

 Send design to
namedept@gmail.com
ikhtiar@name.mist.ac.bd

 Certificate and attractive prize for winners

 Any type of vessel

 Size : 24m to 200 m

 Use any suitable software

Submission Deadline : 21st August, 2022

**For any queries ,
Contact : Dr. S M Ikhtiar Mahmud**
 **01716444110**

Made with PosterMyWall.com

Figure: Poster of 3-D Ship Design Competition

3-D Ship Design Competition

Dr. S M Ikhtiar Mahmud

In order to promote naval architecture and the shipbuilding industry in Bangladesh, the Department of Naval Architecture and Marine Engineering (NAME) at the Military Institute of Science and Technology (MIST) held a 3-D Ship Design competition for students worldwide on World Maritime Day 2022. Students were introduced to engineering, design, drawing, and project planning through the competition, which also stimulated their creativity. Students who took part could choose to design a ship individually or in small groups. The panel of judges for thorough documentation, decisions, proper drawing and calculation accuracy evaluated the designs. This competition mainly emphasized and promoted the significance of design in marine sector by bringing together young dynamic designers interested in this sector and contributing to education via creative learning.

Ship design used to be an evolutionary process in which a new design was based on an existing, similar ship design that was modified to meet specific needs. The advent of modern analysis tools, software and powerful computers gave students the opportunity for innovation. Because ships are complicated, designing them requires a methodical approach. The lack of a prototype or basis ship gave the students the freedom to be innovative and inventive. This innovative thinking leads to the capability of a ship to float, move and trade. A solid understanding of the relationships between equipment and systems is vital for effective functionality.

The title of this competition was 3-D Ship Design Competition. The Ship Design Competition was arranged to develop ship design skills in students from various universities and institutions over the world. The design criteria were set as follows:

- Length of the ship shall be between 24m to 200m.
- Any hull shape shall be acceptable as long as it does not violate the design parameters.
- Ships shall be able to adequately and reliably accommodate and secure the steering assembly and propulsion equipment.
- Ships shall be able to carry the arranged payload and remain within these design parameters.
- Ships shall be unique and must not be copies of past submittals.
- Calculations shall be made as per maritime rules, regulations and guidelines.
- Final design package shall be submitted before end-of-day on date specified.

Assessments of the ship's characteristics such as stability, structural integrity, powering, maneuverability and motions were the main targets of the competition. The design must also be cost-effective, environment friendly and require minimum manning. The safety of the ship, the people on board and the environment in which it sails are all-important. Ship design is iterative in nature so students should know how to follow the design spiral and understand the effect of this spiral during project planning. Inferences to be drawn from the illustrations are those among the interlocking constraints, which must be satisfied.

The overall design, feasibility and efficiency served as the three main factors for evaluation of designs. According to the judges, the competition was extremely challenging and all the designs

were of the highest quality submitted for a student competition. The awardees were invited to present their designs on 21 August 2022 at MIST.

Winners were selected by a panel of judges evaluating the following criteria:

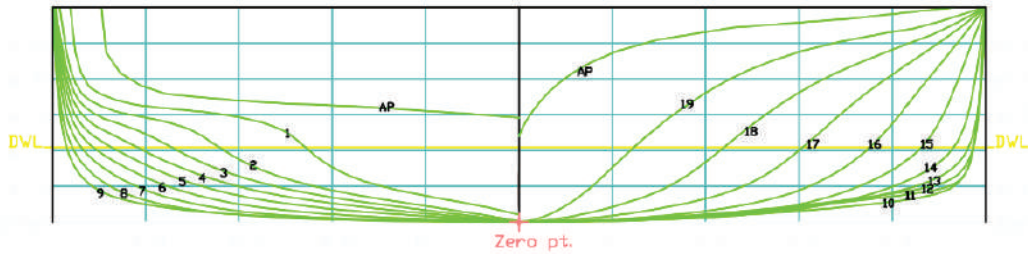
- Principal characteristics
- Concept selection/initial definition and sizing/Parameters ratio
- Hull form development
- General arrangements
- Forward and Aft part of the vessel (Tank, BHD)
- Capacity (Cargo, passenger etc.)
- Outfitting items
- Completeness
- Text and graphics (figures)
- Overall Quality and Originality

All the participants displayed good design skills and professionalism. Amongst them 10 (ten) were selected as finalists and received remuneration and prizes for their excellent submissions. The winners were from Military Institute of Science and Technology (MIST), Bangabandhu Sheikh Mujibur Rahman Maritime University (BSMRMU) and Sonargaon University (SU). Ships design is an amalgamation of art, technology, innovation and environment. A process brings together a wide range of disciplines and analysis procedures. The objectives of this 3-D Ship Design Competition for the students were to create awareness about the significance of ship design on the eve of World Maritime Day 2022, to incorporate all the latest technologies concerning navigation, propulsion, and cargo handling equipment and to optimize ship speed with maximum bearable cargo weight. The competition was successfully completed with tremendous support from all the stakeholders and fulfilled the requirements set up by the Department.

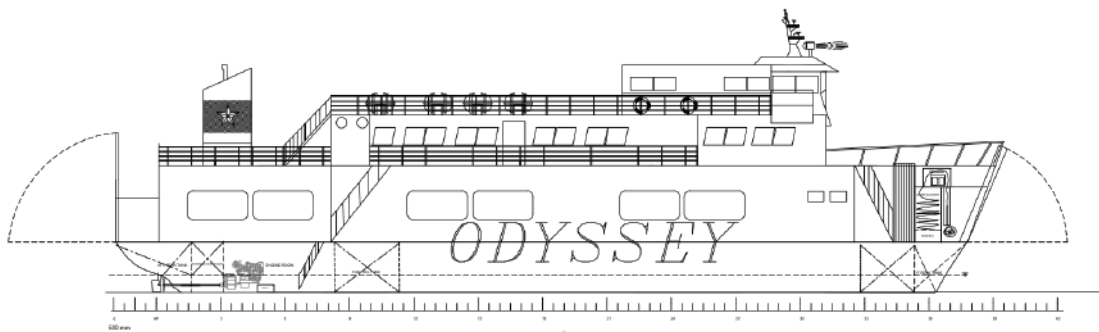
The following participants have been declared as winners by the panel of judges:

Position	Name of the Participant	University/ Institute	Type of Ship	Prizes
1 st	Md. Emam Hossain Emon Shah Md Newaz Sharif Ahad	MIST	Inland Ro- Pax Ferry	Crest, Certificate
2 nd	Nahid Hossain Rony Saiful Islam	MIST	Container Ship	Crest, Certificate
3 rd	S.M Fahad Hossen Munna Zamiul Alam	MIST	Ro-Pax Ferry	Crest, Certificate
4 th	Md. Mijanur Rahman Kaniz Farzana Zinia	SU	Passenger Vessel	Crest, Certificate
5 th	Md. Rabbi Raihan Imon B M Faysal	BSMRMU	Fishing Boat	Crest, Certificate

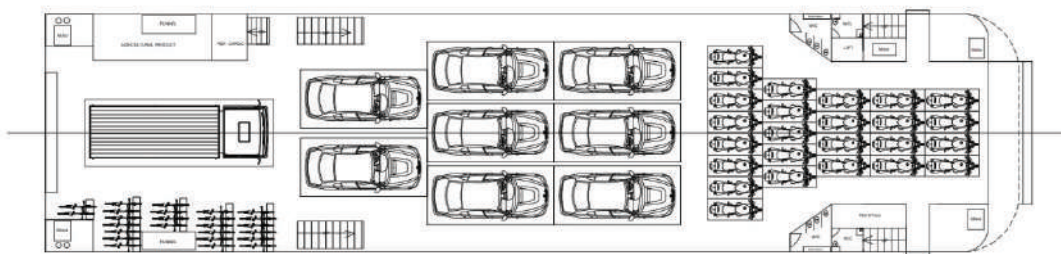
Inland Ro-Pax Ferry



BODY PLAN



PROFILE



MAIN DECK

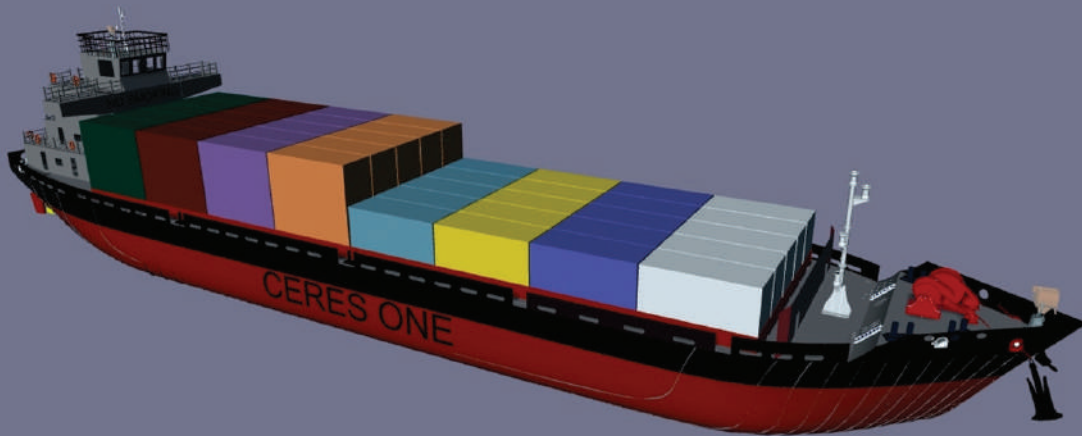
Principal Particulars:

LOA = 42m
LBP = 36.50m
Breadth = 10m
Draft = 0.8m
Speed = 12knot

Designed by:

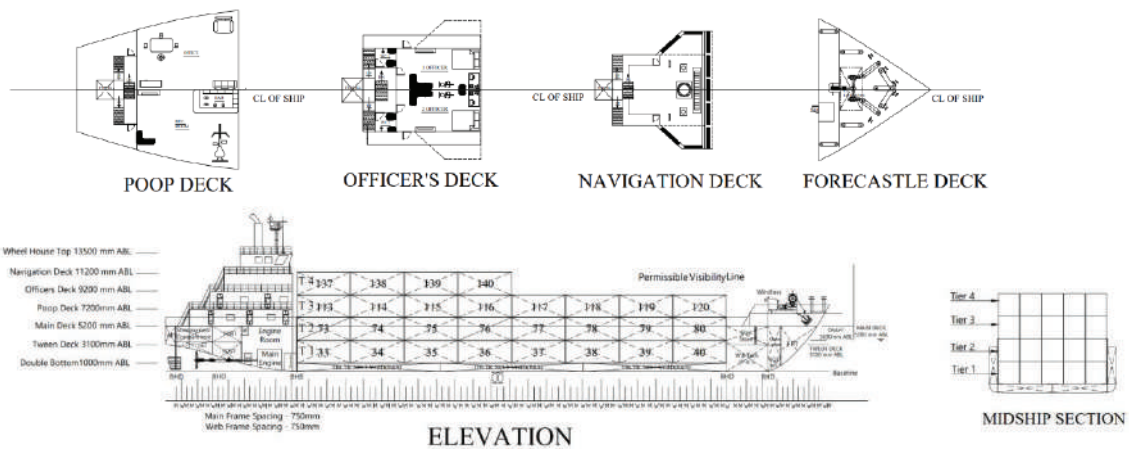
Md. Emam Hossain Emon
Shah Md Newaz Sharif Ahad
Organization: MIST

Container Ship



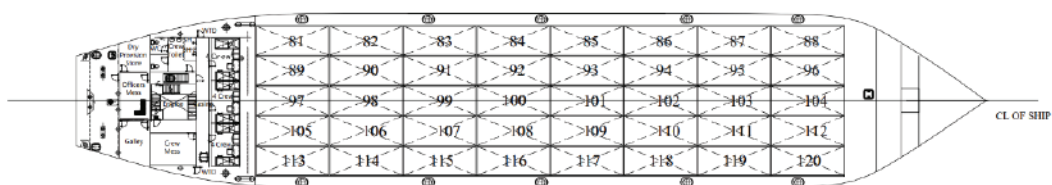
ELEVATION

GENERAL ARRANGEMENT DRAWING of a 140 TEU's CONTAINER SHIP



ELEVATION

MIDSHIP SECTION



MAIN DECK

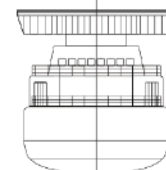
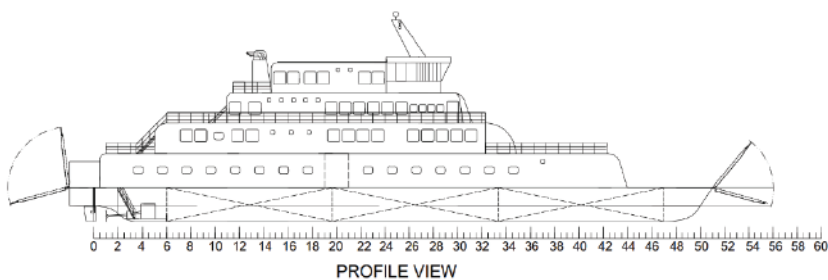
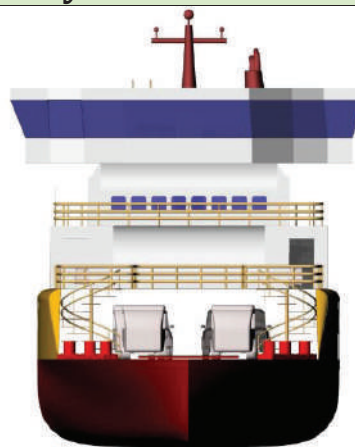
Principal Particulars:

LOA = 77.83m
 Breadth = 14.65m
 Draft = 3.60m
 Cb = 0.78

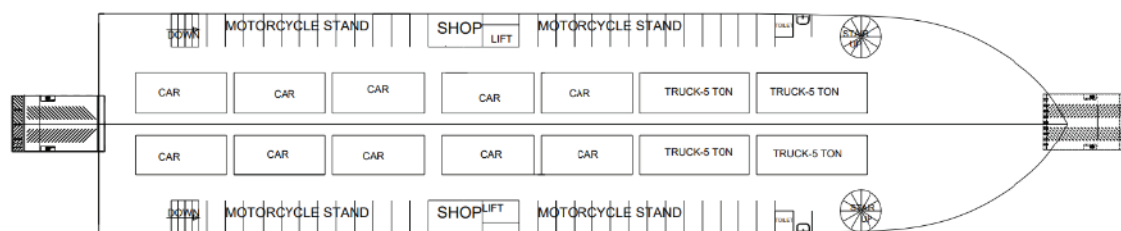
Designed by:

Md. Nahid Hossain
 Md. Saiful Islam
 Organization: MIST

Ro-Pax Ferry



FRONT VIEW



MAIN DECK



PASSENGER DECK

Principal Particulars:

LOA = 53m

LBP = 50m

Breadth = 12m

Draft = 1.27m

Displacement = 517ton

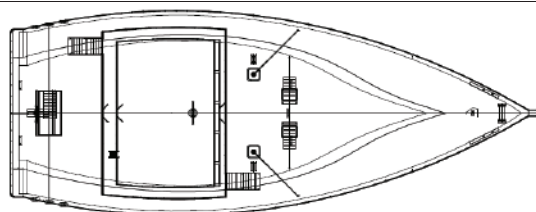
Designed by:

S.M Fahad Hossen Munna

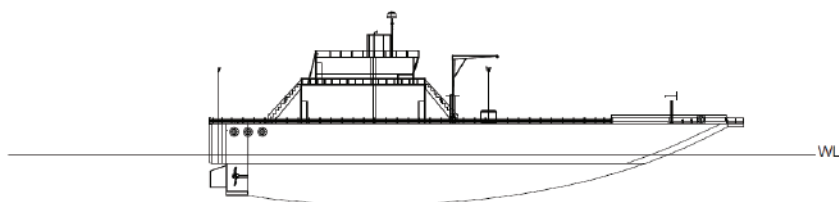
Zamiul Alam

Organization: MIST

Fishing Boat



Top view



Elevation

Principal Particulars:

LOA = 48.45m
LBP = 40.08m
Breadth = 18.288m
Draft = 4.45m

Designed by:

Md. Rabbi Raihan Imon
B M Faysal
Organization: Bangabandhu Sheikh Mujibur
Rahman Maritime University, BSMRMU

ACKNOWLEDGEMENT







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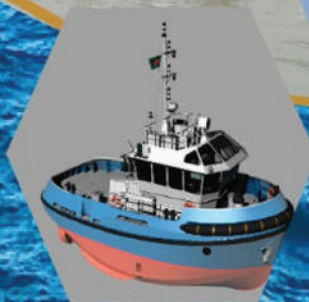
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Kabir Steel Limited, a concern of Kabir Ship Recycling Facilities, has been a leader in ship recycling since 1985. We've recycled over 3,800,000 LDT from 163 types of ships, boasting an annual capacity of 150,000+ tons. Our commitment to excellence is evident in our compliance with HKC 2009 standards, recognized by BV, IRS and ClassNK, as we strive to be the world's most trusted green ship recycler.

Our synchronized system, skilled workforce and top-notch equipment, including barge-mounted cranes, excavators and a Negative Pressure Unit for ACM handling, ensure efficient operations. We prioritize worker well-being with an in-house medical center, accommodations, meals and recreational facilities.

Environmental responsibility is paramount. Our cutting-edge containment system and rigorous monitoring guarantee minimal impact. We adhere to a zero-discharge policy by treating oily water through Oil Water Separators. Additionally, our circular economy approach connects ship recycling with our steel mill, oxygen plant, shipbuilding yard and a fleet of bulk carriers in Bangladesh.

Our UNIQUE advantage/s over others in this area;

- Exclusive direct access road from the main highway guarantees unimpeded evacuation routes during emergencies, free from interference by local neighborhoods or activities.
- Our yard features a distinctive hydraulic shearing machine, a rarity in the recycling industry. This advanced equipment enables us to downsize ultimate melting steel for steel mills with precision, eliminating the need for manual gas cutting before leaving our premises.
- We take pride in having the largest fleet of sea-going ships in Bangladesh where we are reusing store items under IMO HazMat Part III.
- Our NPU unit incorporates cutting-edge technology for efficient operations of ACM handling.
- Our management team comprises highly qualified permanent employees with marine backgrounds, including sailing engineers and class surveyors, ensuring technical expertise and operational efficiency.

Collaboration with the IMO SENSREC Project and partnerships with universities drive continuous improvement in the ship recycling industry, solidifying our commitment to sustainability.



Kabir Steel Limited



Shitalpur, Sitakunda, Chattogram, Bangladesh



info@kabirshiprecycling.com



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<https://kabirshiprecycling.com>



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যাত্রীদের প্রতি

জরুরী প্রয়োজনে যোগাযোগ হটলাইন: ১৬৩১৩

- নৌ যাত্রাকালে অবৈধ, রেজিস্ট্রেশন/ সার্ভে (ফিটনেস) সনদ/ রুটপারমিট/ সময়সূচি বিহীন ও ঝুঁকিপূর্ণ নৌযান (লঞ্চ, ট্রলার, স্পীডবোট ও অন্যান্য) পরিহার করুন।
- ছোট নৌযানে (স্পীডবোট ও ট্রলার) ভ্রমণকালে লাইফ জ্যাকেট পরিধান করুন।
- অতিরিক্ত যাত্রী হয়ে লঞ্চ ভ্রমণ করবেন না, লঞ্চের ছাদে উঠবেন না।
- আবহাওয়ার পূর্বাভাস জেনে যাত্রা করুন। দূর্যোগপূর্ণ আবহাওয়া/ খারাপ আবহাওয়ায় নৌযানে যাত্রা করবেন না।
- দূর্যোগপূর্ণ আবহাওয়া দেখা দিলে আপনার যাত্রা বাতিল করুন। কোন অবস্থায় জীবনের ঝুঁকি নিবেন না।
- পথিমধ্যে হঠাৎ দূর্যোগপূর্ণ আবহাওয়া শুরু হলে লঞ্চ ছুটছুটি না করে জীবন রক্ষাকারী সরঞ্জামাদি হাতের নাগালে রেখে সতর্কবস্থায় থাকুন। এ সময় নৌযানের চালককে উদ্ভুক্ত বা চাপ প্রয়োগ না করে ধীরস্থির ও শান্তভাবে পরিস্থিতি মোকাবেলা করুন।

চালকদের প্রতি

জরুরী প্রয়োজনে যোগাযোগ হটলাইন: ১৬৩১৩

- অভ্যন্তরীণ নৌপথে অবৈধ, রেজিস্ট্রেশন/ সার্ভে (ফিটনেস) সনদ/ রুটপারমিট/ সময়সূচি বিহীন ও ঝুঁকিপূর্ণ নৌযান (লঞ্চ, ট্রলার, স্পীডবোট, কার্গো, বাল্কহেড ও অন্যান্য নৌযান) পরিচালনা করবেন না।
- নৌযানে (লঞ্চ, ট্রলার, স্পীডবোট, কার্গো, বাল্কহেড ও অন্যান্য নৌযান) ধারণ ক্ষমতার অতিরিক্ত যাত্রী ও মালামাল বহন করবেন না।
- দূর্যোগপূর্ণ আবহাওয়ায় নৌযান (লঞ্চ, ট্রলার, স্পীডবোট, কার্গো, বাল্কহেড ও অন্যান্য নৌযান) পরিচালনা করবেন না।
- স্পীডবোট ও ছোট নৌযান পরিচালনাকালে যাত্রীদের লাইফ জ্যাকেট পরিধান নিশ্চিত করুন।
- যাত্রার পূর্বে ইঞ্জিন, নেভিগেশনাল লাইট, ফায়ার পাম্প, অগ্নিনির্বাপক যন্ত্রপাতি এবং অন্যান্য সরঞ্জামাদি ভালোভাবে পরীক্ষা করুন এবং হ্যাচকভার পানিরোধক করে ভালোভাবে বন্ধ করুন।
- আবহাওয়া অধিদপ্তর হতে আবহাওয়া সংকেত/ বার্তা জেনে নৌযান পরিচালনা করুন।
- নৌযানের সার্ভে (ফিটনেস) সনদে উল্লেখিত সংখ্যক জীবন রক্ষাকারী সরঞ্জামাদি (লাইফ জ্যাকেট, লাইফ বয়া ও অগ্নিনির্বাপক সরঞ্জামাদি ইত্যাদি) রাখুন। মাঝ নদীতে রেখে নৌকায় করে যাত্রী উঠা-নামা করবেন না।
- পথিমধ্যে বাড়ের/ দূর্যোগপূর্ণ আবহাওয়ার আশংকা দেখা দিলে নৌযান দ্রুত নিকটবর্তী নিরাপদ স্থানে সরিয়ে নিন বা নদীর তীরে ভিড়িয়ে রাখুন।

মালিকদের প্রতি

জরুরী প্রয়োজনে যোগাযোগ হটলাইন: ১৬৩১৩

- অনুগ্রহ করে নৌযান নিবন্ধন (রেজিস্ট্রেশন ও সার্ভে) করুন। নিবন্ধনের জন্য নৌপরিবহন অধিদপ্তর/নিকটস্থ নদী বন্দর কার্যালয়ে যোগাযোগ করুন।
- অনুগ্রহ করে নৌযানের রুটপারমিট এবং প্রয়োজন অনুযায়ী সময়সূচি গ্রহণ করুন। রুটপারমিট ও সময়সূচির জন্য বিআইডব্লিউটিএ'র প্রধান কার্যালয়ে/ নিকটস্থ নদী বন্দর কার্যালয়ে যোগাযোগ করুন।
- অবৈধ, রেজিস্ট্রেশন/ সার্ভে (ফিটনেস) সনদ/ রুটপারমিট/ সময়সূচি বিহীন ঝুঁকিপূর্ণ নৌযান (লঞ্চ, ট্রলার, স্পীডবোট, কার্গো, বাল্কহেড ও অন্যান্য) পরিচালনা করবেন না।
- যাত্রী সাধারণের জানমালের নিরাপত্তা বিধান করা আপনার নৈতিক দায়িত্ব ও কর্তব্য। তাই উপযুক্ত সনদধারী এবং নির্ধারিত সংখ্যক মাস্টার, ড্রাইভার দ্বারা নৌযান পরিচালনা করুন।
- নৌযানে যাতে অতিরিক্ত যাত্রী ও মালামাল পরিবহন না করা হয় সে লক্ষ্যে নিজ নিজ নৌযানের প্রতি সতর্ক দৃষ্টি রাখুন।
- নৌযানের সার্ভে (ফিটনেস) সনদে উল্লেখিত সংখ্যক জীবনরক্ষাকারী সরঞ্জামাদি (লাইফ জ্যাকেট, লাইফ বয়া, অগ্নিনির্বাপক সরঞ্জামাদি ইত্যাদি) মজুদ রাখুন।
- প্রতিটি নৌযানে রেডিও ও মোবাইল ফোন সরবরাহ করুন। দূর্যোগপূর্ণ আবহাওয়ায় নৌযানের মাস্টারের পুনঃপুনঃ যোগাযোগ রক্ষা করে সার্বিক বিষয় কঠোরভাবে মনিটর করুন।



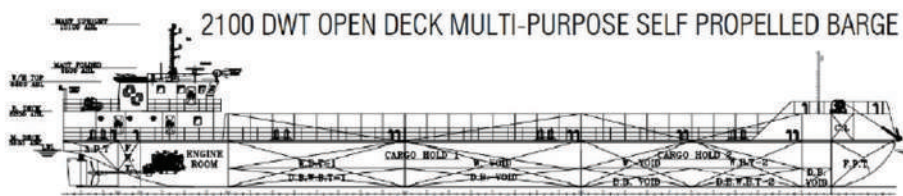
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- চাঁদপুর-শরীয়তপুর-চাঁদপুর
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- লাহারহাট-ভেদুরিয়া-লাহারহাট
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অভ্যন্তরীণ যাত্রীবাহী সার্ভিস

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- চট্টগ্রাম-হাতিয়া
- কক্সবাজার-সেন্টমার্টিন (পর্যটন সার্ভিস) শান্ত মৌসুমে চলাচল করে
- টেকনাফ-সেন্টমার্টিন (পর্যটন সার্ভিস) শান্ত মৌসুমে চলাচল করে

উপকূলীয় যাত্রীবাহী সি-ট্রাক সার্ভিস

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- মজুচৌধুরীরহাট-ইলিশা
- ইলিশা-মজুচৌধুরীরহাট
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- বয়ারচর-ভাষানচর
- আলেকজান্ডার (লক্ষ্মীপুর)-মীর্জাকালু (ভোলা)



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ওয়াটার বাস



উপকূলীয় যাত্রীবাহী জাহাজ 'এম ভি তাজউদ্দিন আহমদ'



উপকূলীয় যাত্রীবাহী সি-ট্রাক

এছাড়াও কার্গো সার্ভিস ইউনিটের অধীন ০৪ টি কন্টেইনারবাহী জাহাজ ও কোস্টার জাহাজ দ্বারা কন্টেইনার ও মালামাল পরিবহন করা হয়।



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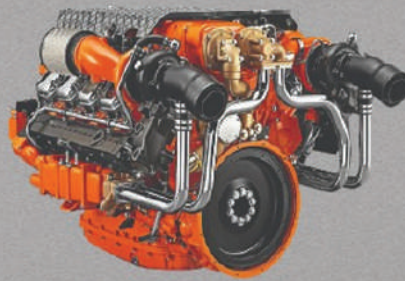
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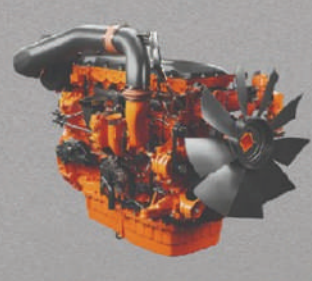
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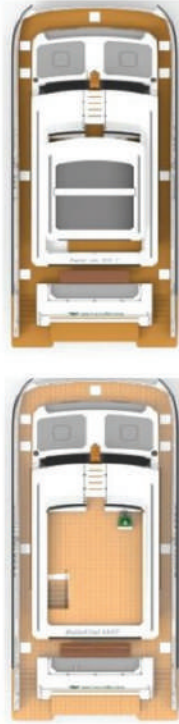
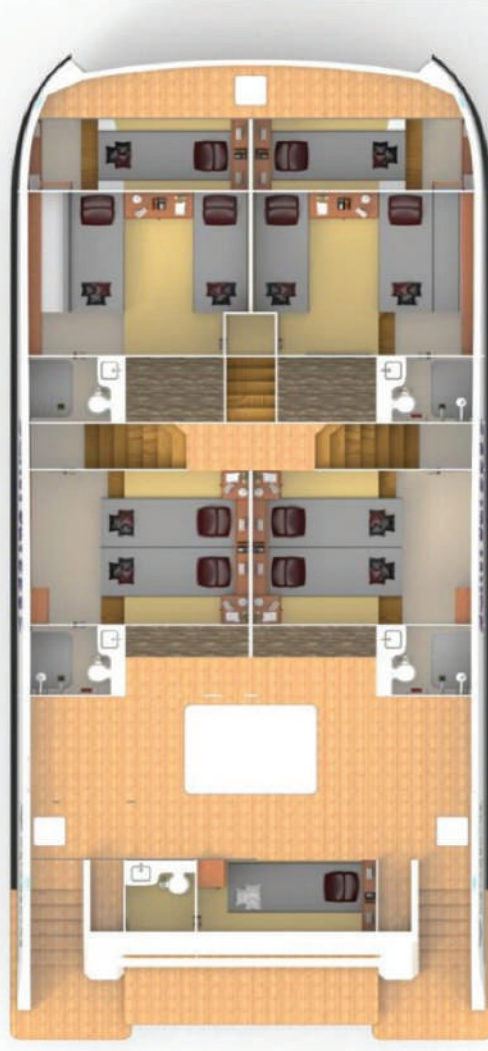
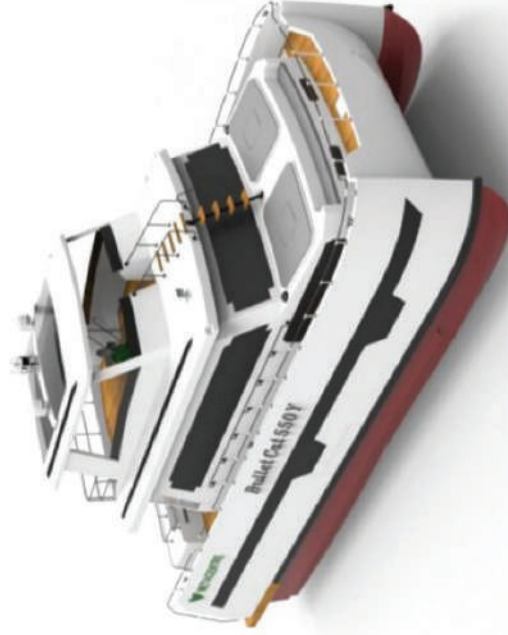
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Please Contact: Bipul Kanti Das, Mobile: +8801711521010, E-mail: bipul@europowerbd.com



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Principal Particulars

Length (OA)

:16.25 M

Breadth

:07.00 M

Depth

:03.00 M

VIP Saloon with Galley: 01Nos

VIP With Attach Toilet :04Nos

Guest+Crew With Toilet:03+1Nos

Material

:GRP/FRP

BULLET CAT 550Y



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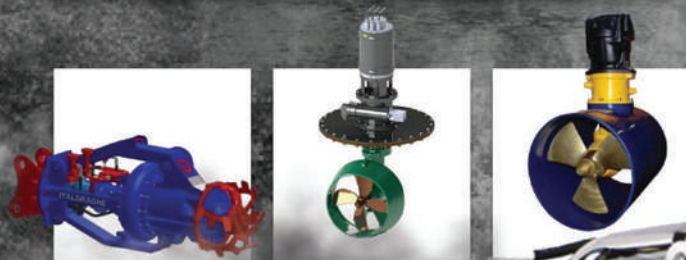


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- * জাহাজ তৈরিতে আমাদের রয়েছে সুদীর্ঘ ৬৫ বছরের অভিজ্ঞতা।
- * আমাদের রয়েছে ১৬৫০ জন দক্ষ প্রকৌশলী, টেকনিশিয়ান ও শ্রমিক।
- * আমরা ইতিমধ্যে ৮০০ নতুন জাহাজ তৈরী এবং ৩৫০০ জাহাজ মেরামত সম্পন্ন করেছি।
- * আমরা প্রতিযোগিতামূলক মূল্যে ক্লাস ভেসেল নির্মাণ করে থাকি।
- * বাংলাদেশে আমাদের রয়েছে বিশ্ব মানের একমাত্র রাবার ফ্যাক্টরী।
- * খুলনা শিপইয়ার্ডের মাধ্যমে জাহাজ তৈরী করে আপনার বিনিয়োগ সুরক্ষিত করুন।



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