

Sustainable Design of Ship Breaking Industry in Developing Countries

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Abstract: Ship breaking industry is one of the important industries for developing economies. It provides employment, economic prosperity and much needed re-useable materials for country's economic development. Ship breaking industry is green *per se* as it allows using scrap metals and other machineries for vertical and horizontal recycling. It provides raw materials for national economic activities including industrialization, construction, and building and infrastructure development. Ship breaking is crucial especially for Bangladesh as it does not have any natural resources including iron ore except the natural gas. Although ship breaking is economically beneficial but it comes with a huge environmental and occupational health and safety cost. Ship breaking industries have been developed through unplanned and unscientific ways in most developing countries. In this study, a systematic and sustainable approach to ship breaking activities has been proposed. With proper implementation, it will not only safeguard the environment and occupational health and safety but also improve productivity, profit margin and national economic prosperity. The proposed approach can be replicated in most developing countries with little or no modification.

Key words: Sustainable design, ship breaking, environment, developing countries, Bangladesh.

Introduction

In general, the ship breaking industry is involved with the dismantling of the ship and a great source of supplying reusable metal, parts and machineries. Prior to 1980s, the practice of ship breaking was mainly concentrated in the industrialized developed nations such as the US and Europe. But due to high labour and operating costs, this work has shifted to developing countries, especially China, India, Bangladesh, Pakistan, The Philippines, Vietnam and so on. This trend started in the 1980s. There are several reasons for this ship breaking industry's move. First, the labour cost in present ship breaking countries is cheaper. Ship owner and ship breaking business people found it lucrative and commercially profitable. Second, ship breaking requires less sophisticated machineries and

technology. Third, it provides reusable and less carbon footprint resources especially for developing countries where no such resources are available or expensive to extract or acquire. Additionally, the environmental regulations, occupational health and safety policies are poorly regulated and are hardly implanted and practiced. Due to high environmental concern and safety regulations in industrialized developed nations, it is difficult for ship owners to dismantle ships in compliance with existing environmental rules and regulations. Unlike many North Asian countries (Japan, Taiwan, South Korea), ship breaking work was started in 1969 in today's Bangladesh by dismantling of a Greek ship named as 'M V Alpine' stuck by cyclone (Hossain and Islam, 2006). Ship breaking industry began to flourish from the 1980s. There are several reasons for the development of ship breaking

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industry in Bangladesh. The country has a long, flat inter tidal zone along with an extended beach with tidal difference of six metres. There is a huge local demand for scrap iron and steel, reusable parts and machineries as the country does not have any natural resources except natural gas and also does not have financial capability to import these materials and machineries. Furthermore, the scrap iron and steel have become primary raw materials for re-rolling steel industries. Moreover, there is less awareness of environmental concern and abundant cheap labour. In 2005, there were 24 ship breaking yards along the 14 km long coastal area from Fouzdarhat to Kumira in the outskirts of the port city of Chittagong. In 2008, the number of ship breaking yards reached to 36, and in 2010 it peaked to 100 along 20 km long coastal area in contrast to 14 km in 2005. The industry has expanded a lot so do the environmental effects due to industrial

pollution. Poor personal safety for workers and environmental pollution caused damages to biodiversity of adjacent area. A series of explosions during ship dismantling caused deaths of several workers due to poor training, safety protection and lack of use of modern machinery in dismantling work. Docking and ship dismantling processes under the open sky in the coastal beach is shown in Figures 1 and 2. The docking process is very primitive.

Due to the unplanned ship dismantling process, the ship breaking industry creates environmental and occupational hazards. Recently, various government and judicial authorities of developing countries especially Bangladesh have imposed restrictions on ship breaking activities upon raising concerns from various environmental organizations and workers' unions. On the other hand, ship breaking industry is a major source of



Figure 1: Ship breaking activities in Bangladesh.



Figure 2: Hazardous working environment in ship breaking yard.

employment, economic activities and raw materials for industrial and construction sectors for developing countries. Therefore, sudden restrictions on ship breaking activities can cause serious consequences in this vital recycling industry. It can make thousands of people jobless, affect economic progress, and increase greenhouse gas emission. By considering this dilemma, an optimal and sustainable solution for a ship breaking industry is urgently needed. Therefore, the primary objective of this paper is to develop a sustainable and occupational safe yard design, operation procedure and required infrastructure for ship breaking industry.

Global Ship Breaking Activities

In the 1970s and first half of 1980s some European countries such as Spain, Italy and Croatia had significant ship breaking activities. However, these activities reduced gradually from later half of 1980s. In 1977, ship breaking activity was generally concentrated in Taiwan with over 50% of world total ship breaking activities. The world's major ship breaking activities from 1977 to 2010 are shown in Figure 3. Till 1985, Taiwan was one of the major ship breaking countries in the world. However, the activity has drastically reduced to two ships in 1990 compared to 7822 ships in 1985. A similar trend was also noted for South Korea. Its ship breaking dropped from 2551 ships in 1985 to four ships in 1990. The fall in ship breaking activities in Taiwan and South Korea was primarily due to the rise of labour cost and stringent environmental and safety regulations. This has ushered in new opportunities for less developed countries with abundance of cheap labour such as China, India, Pakistan and Bangladesh. As mentioned earlier, the commercial ship breaking activity began in Bangladesh in 1985. Although the ship

breaking industry started to shape up in Bangladesh during this time (1980s and early 1990s), India became one of the leading nations in the world in ship braking surpassing China. The coastal area 'Alang ship breaking yard' of the India's State of Gujarat became world famous location in the world. In 1990s Pakistan was also very active in ship breaking activities but in later half of 2000s the ship breaking activity has reduced notably. During this period, Bangladesh gradually increased its ship breaking activities from later half of 1990s. The upward trend continued and in 2005 it became one of the largest ship breaking countries in the world (see Figure 3). In 2008, the number has doubled and it still accounts for half of the world total ship breaking. The number of ship breaking has reduced drastically in 2009 and 2010, mainly due to the global economic recession, rise in transportation cost and sudden imposition of government restrictions. In the same period, certain embargo is in place by the country's higher court expressing concerns that most ship breaking yards might not follow the country's environment protection laws and occupational health and safety. The sudden imposition of law did not allow local ship braking yards and ship owners to prepare themselves to comply with relatively stringent government rules and regulations. However, the situation has started to improve since the beginning of 2011 as the country's higher court has lifted the ban on import of ships for dismantling in Bangladesh on certain preconditions related to occupational health and safety, and environmental protection. Figure 4 describes the percentage of ship breaking activities of different countries from 2000 to 2010. Figure 5 illustrates the percentage of total world ship breaking in Bangladesh from 1985 to 2010.

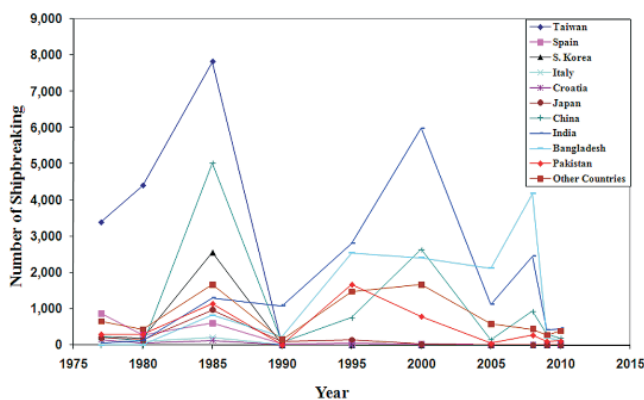


Figure 3: Ship breaking activities around the globe from 1977 to 2010. Adapted from The Shipbuilders Association of Japan, 2010; Abdullah, Mahboob and Biruni, 2011.

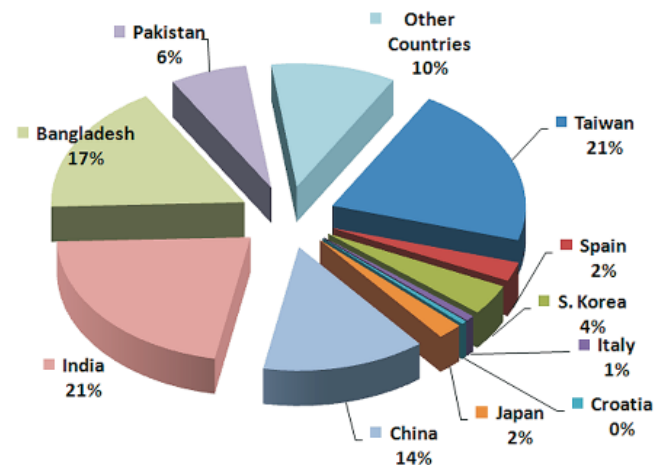


Figure 4: Percentage of ship breaking activities of different countries from 2000 to 2010. Adapted from The Shipbuilders Association of Japan, 2010; Abdullah, Mahboob and Biruni, 2011.

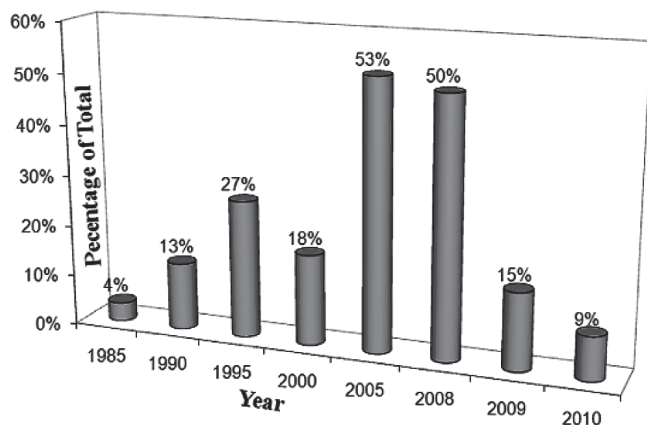


Figure 5: Percentage of total world ship breaking in Bangladesh from 1985 to 2010. Adapted from The Shipbuilders Association of Japan, 2010; Abdullah, Mahboob and Biruni, 2011.

Impact of Ship Breaking on Environment and Occupational Health and Safety

Ship breaking and ship recycling is a complex and hazardous process as it contains harmful chemicals, oils, and other hazardous materials. The exposure of these materials to human and surrounding environment can have detrimental effect. Unfortunately, in most ship breaking yards in developing nations due to lack of awareness, employee training, protective equipment, loose regulations and cost savings, no systematic, organised and scientific method are being used in ship breaking. As a result, frequent explosions, accidents and environmental pollution often take place in most ship breaking yards. For example, 95% of a typical empty ship (mass varies between 5000 tonnes to 40,000 tonnes) is steel and coated with 10 to 100 tonnes of paint containing lead, cadmium, arsenic, zinc and chromium (Hossain and Islam, 2006). Furthermore, scrap ship may contain hazardous asbestos, several thousand litres of oil consisting of engine oil, bilge oil, various hydraulic oil, greases, etc. Oil tanker contains additional residual oil up to thousand cubic metres. Most of these items are defined as hazardous material according to Basel Convention (2003). However, most left over petrochemical product can be recycled and reprocessed for commercial uses if appropriate recycling process along with safe removal process can be established. Hence environmental and health damages can be significantly reduced, and profit margin from ship breaking can also be increased. The major ship breaking hazards are briefly described in the following subsections.

Oil Pollution

There is a significant portion of oil leakage to surrounding water and soil in every ship breaking yard in developing countries. The spilled oil mix with water and wash away to the sea and adjacent soil. This makes serious risk on fragile ecosystems especially on marine flora and fauna. Sea birds, fish, turtle, various sea mammals – all are directly affected due to pollution and their life cycles are shortened notably. In addition, marine vegetation and coral life are under direct threat of oil pollution. In most developing countries including Bangladesh, fish is one of the important sources of protein. The shortage of fish due to water pollution in the coastal regions can make the entire population of a country malnourished.

Impact on Biodiversity in Water and Soil

The oil and various harmful chemicals (e.g., spillage, floatable grease balls, ammonia and metal rust) can damage the soil fertility enormously. The pH level of soil can easily go up which is a severe threat to many plants and vegetation. In addition, the binding properties of surrounding soil reduce appreciably due to soil contamination, mechanical and excessive human activities. Therefore, the soil erosion in the coastal area increases notably. Furthermore, oil spilling may cause serious damage by reduction of light intensity, inhibiting the exchange of oxygen and carbon dioxide across the air-sea water interface and by acute toxicity. This may cause serious damage on the growth on abundant marine organisms, especially plankton and fishes. A study undertaken by Islam and Hossain (1986) on soil and seawater pollution from Fouzdarhat to Cumira coastal area near Chittagong, reported a high ammonia toxic in beach soil and water with increased pH. In another recent study conducted by Siddiquee, Parween, Quddus and Barua (2009), they found some traces of elements including Mn, Zn, Pb, Cu, Cd and Hg.

Carbon Footprint of Ship Breaking Industries

In terms of carbon footprint, ship breaking industry is green and sustainable industry. It makes scrapped material into reusable form. Based on world steel data collection and methodology for calculating the life cycle index (LCI) for steel products, steel production from ingot produce emissions of 1.987 tonnes of CO₂/tonne of steel, whereas steel production from scrap steel in re-rolling mills produce emissions of 0.357 tonnes of CO₂/tonne of steel. As mentioned earlier ship breaking industry is vital and lifeline for many developing countries especially Bangladesh economy, as it does not

have any iron ore deposits. An estimated eight million tonnes of steel is required each year for Bangladesh. Ship breaking industry supplies 80% of this (i.e. 6.4 million tonnes). The 6.4 million tonnes of steel produce emission of 2.29 million tonnes of CO₂. If Bangladesh fully imports these steel requirements or produces it from iron ingot, it would produce 12.72 million tonnes of CO₂. So the ship recycling saves CO₂ emissions $(12.72 - 2.29) = 10.43$ million tonnes each year of world total CO₂ emissions. It is a huge saving for the global environment. The ship breaking industry is not only supplying reusable material and machines but also help in reducing the impact of climate change by reducing the CO₂ emission. Thanks to ship breaking industry, hundreds of small and medium re-rolling and steel processing plants across Bangladesh convert scrap metals into various vital metal products employing over half a million people.

Role of Government and Ship Breaking Industry in Bangladesh

Until recently, the Bangladesh government did not have any industrial policy on ship breaking as it was not considered country's main industrial thrust. Due to lack of policy, regulation and policing, the ship breaking industry was not developed in an organised way while other industrial sectors such as garments and textiles, pharmaceuticals, ship building, have grown. As mentioned earlier, there were reports that many ship breaking yards did not follow basic protections for their employees and surrounding environments. As a result, a series of accidents occurred in ship breaking yards where sizeable human casualties were reported. Environmental damages due to pollution have also occurred. Some ship breaking industries were taken to court by the country's environmental non-government organisations and some victims. Demaria (2010) has given a brief picture of controversy at the Indian Supreme Court in 2006 over the dismantling of the ocean liner 'Blue Lady'. On 17 March 2010, the High Court of Bangladesh gave several directions to ship breaking industry for sustainable and safe dismantling of ships where it said that before entering the Bangladesh territorial water, the imported ship must be cleaned. It also directed the Ministry of Shipping to ensure that the ship must obtain the Department of Environment's certification. Unfortunately, many ship owners did not comply with the High Court's directives. As a result, on 15 December 2010, the High Court imposed ban temporarily on importing of ships for recycling purposes. In April 2011, the Government of Bangladesh formulated new law for ship breaking

industry and also declared ship breaking a major industry. According to the legislation, all ships for dismantling purpose brought to Bangladesh must have certificates from the registered country that the ships are free of toxic substances. By this new legislation the responsibility was shifted to the government of the country of the owner of the ship. No ship can enter Bangladesh territorial water without certification that it has been detoxified in the exporting country. This sudden step has made the Bangladesh ship breaking industry vulnerable. Clearly the reason for this amendment is for the protection of environment. The government has transferred the policy formulation responsibilities to the Ministry of Industry for better managing this emerging industrial sector. As a result, the ship breaking industry will now be able to get financial and mentoring supports from the government. Also the industry has to comply with the Ministry of Industry's policies and regulations in this regard. In March 2011, the High Court of Bangladesh has also issued some directives on employees' occupational health and safety related matter. Some key points of these directives are as follows.

- Import of scrap ship will be based on ensuring public and workers' safety and environmental protection.
- No ship can be dismantled without cleaning toxic gas.
- Untrained (unqualified) employees and employees under 18 years cannot be engaged in ship dismantling process.
- All employees for ship dismantling must undergo a formal safety and professional training at an institute funded by the owners of shipyard under the direction and supervision of Bangladesh Marine Academy.
- A qualified marine engineer needs to be present at each ship breaking yard during dismantling.
- The entire ship breaking process must be monitored by a special team comprising a qualified naval architect of Marine Academy nominated by Bangladesh University of Engineering and Technology (BUET), a chemical engineer nominated by BUET, a representative from Department of Environment (DoE) and a representative of Waste Concerned and a representative of a non-government environmental organization. The team will submit reports on the records of the working condition to the Directorate of Labour on a regular basis.
- A separate facility will have to be created within ship breaking yard for workers dining and recreation.
- No ship breaking work will be allowed after dusk.
- No ship will enter the country without a pre-cleaning and environmental certificate.

Future of Ship Breaking Industry in Bangladesh

Ship breaking industry has a great future and become an integral part of Bangladesh economy by creating direct and indirect jobs for millions of people across the country and it is one of the driving forces for the country's economic development. Every piece of a scrapped ship is being converted into a reusable item. Therefore, the ship breaking industry in Bangladesh can be termed as a sustainable and green industry. As identified in Hossain and Islam (2006), practically 100% of the ship is recycled. In order to have reduced global environment pollution, the recycling process from scrapped ships should be continued.

As mentioned earlier, Bangladesh does not have any iron-ore deposit. It fully relies on import of this mineral. On the other hand, importing iron-ore mineral from other countries will significantly affect country's economic growth and prosperity as it will cost heavily on country's exchequer. It is no doubt that ship breaking/dismantling provides Bangladesh with almost 90% of its steel product needs and saves huge hard earned foreign exchange and accelerates country's overall economic development. Country's several thousand steel re-rolling industries fully depend on scrap metals from ship dismantling. According to Young Power in Social Action (2005), the Bangladesh government earns revenue over US\$100 million from ship breaking each year (7.5% as import duties, 2.5% as yards tax). More than 25,000 people are directly employed in ship breaking yards and over half a million in other related activities across the country. Additionally, the ship breaking is a great source of various used and affordable materials for local use. Many items including lathe machine, shaper machine, drill machine, hydraulic press, motor, pump, engine, boiler, heat exchanger, generator, compressor from medium to large size, electrical cable, circuit, electronic devices, electrical appliances, various steel parts such as anchor, chains, ventilation parts, pipes and pipe fittings, valves; sanitary equipment, furniture (beds, sofa, chairs, tables), batteries, insulation material, engine oil, fuel oil, hydraulic oil, and so on are readily obtained for local use from ship dismantling.

The ship breaking industry in Bangladesh is likely to gain momentum in the next 10 years with the European Union's proposed accelerated phase-out of single-hull tankers (20,000 to 30,000 DWT – dead weight tonnage). Recent study shows there are more than 2250 single-hull tankers of 5000 DWT (till January 2014), which have to be scrapped. This is 25%–30% higher than the

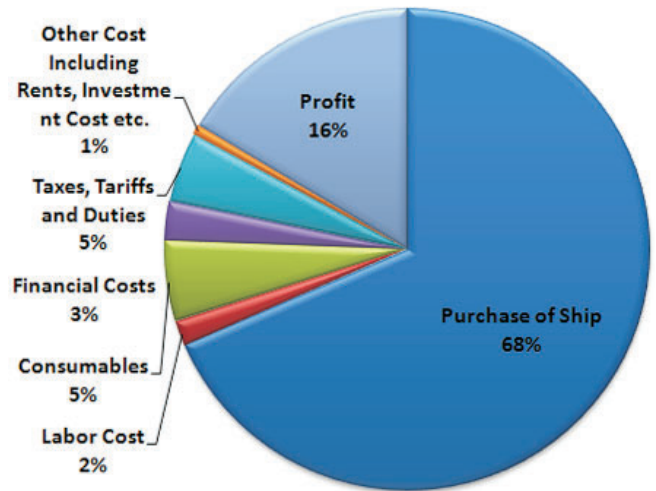


Figure 6: Cost and profit of ship breaking activity per ship. Adapted from Sarraf et al., 2010.

estimate of peak volume of 2015. New regulations put a ban on carrying heavy grades of oil in single-hull tankers. European Commission (EC) has set strict time-tables to withdraw these single hull tankers between 2010 and 2015. The EU Parliament and council amended regulation 417/2002 to phase out single-hull tankers. Many of these ship breaking activities will be conducted in Bangladesh, India, China and Pakistan. Therefore, Bangladesh has a great prospect to gain economic benefit through ship breaking industry.

Figure 6 describes various costs associated with ship breaking industry. It illustrates profit margin of the ship breaking industry. From the figure, it is evident that a net profit of 16% and/or more can be achieved from a single ship dismantling process.

Sustainable Solutions for Ship Breaking Industry in Bangladesh

In order to develop a sustainable, environmentally and occupationally safe ship breaking industry, we propose a methodology. A flow chart of the methodology is shown in Figure 7. It consists of three steps: Phase 1, Phase 2 and Phase 3. Each of these three phases is described in the following subsections.

Phase 1: Pre-dismantle Preparation

In Phase 1, we identified the key pre-inspection and pre-cleaning features. This is the most important phase for ensuring environmental hazard-free ship breaking. When an imported ship enters the coastal area, a detailed inspection should be required. The inspection group can be made of representatives from Mercantile Marine

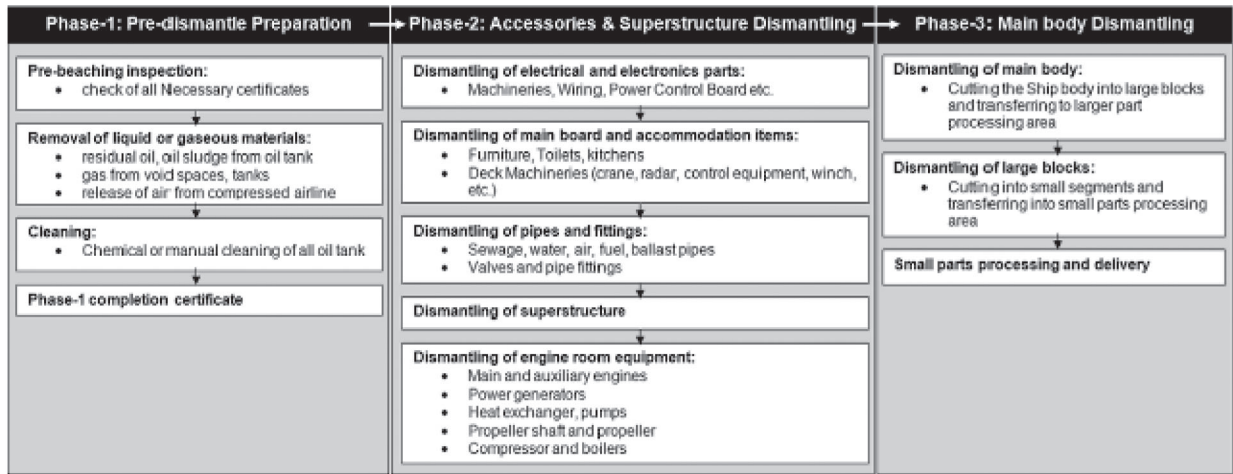


Figure 7: Step-by-step procedure for ship breaking.

Department, Department of Environment, Port Authority and Independent Environmental Monitoring Organization. The team will inspect all the necessary certificates and documentations. In this phase, all fuel, residual oil and oil sludge from the tanks must be removed safely. Nothing should be discharged to the sea and the atmosphere. The inspection body will also ensure the gas-free certification, release of gas from cargo holds, void spaces and tanks. Toilet sewage, waste water, and so on should also be removed. Ballast water and fresh water should be tested whether they can be discharged in the sea without affecting the bio-diversity of the sea. The temperature of the hot water should be lowered before discharging into the sea. A specific guideline and test method should be implemented by the inspection authority. A specified amount of fuel oil should be left in the ship to drive the ship to yard dismantling area. After the docking of the ship on the beach, the residual fuel oil should be removed before beginning any work. This should also be monitored by the inspection authority.

Phase 2: Accessories and Superstructure Dismantle

In Phase 2, the dismantling of ship begins. In this phase, all parts and machineries are removed from the ship. Electrical wiring is a major source of accident. Initially, all electrical wiring, power control board and electrical machineries are removed. Subsequently, all the furniture from living room, dining place, kitchen appliances, toilet items are removed. Then the main deck machineries, such as crane, winch, capstan, bollard, pump, valve, life boat, radar, control equipment, navigation equipment, HVAC systems, and hatch cover should be removed. Later, all the pipelines such as sewage line, fresh water line, hot water line, bilge and ballast line, compressed air line,

fuel oil line, lubrication oil line, sea water line, and so on, are removed. All valves, pipe fittings and pipe instruments should also be removed. After the completion of all the activities as mentioned above, the cutting and removal of the superstructure should be finished. The super structure cutting includes the area from control room to accommodation and poop deck. The removal of super structure will open the top side of ship and allow taking away all the equipment from engine room (i.e., main and auxiliary engine, power generators, heat exchanger, pumps, compressor and boiler). The propeller shaft, steering arrangement and propeller can also be detached from the ship. At the end of Phase 2, the only the main steel structural body of the ship will be left.

Phase 3: Main Body Dismantle

Phase 3 is the final stage of a complete dismantling process of the ship. It involves cutting and dismantling of the main body of the ship. The main body needs to be cut block by block in segments. At first, the cutting is done on fore peak and bow block. When the bow and fore peak blocks are removed, the wing tank or the left and right body of the cargo hold should be cut. Successive cutting should begin to the bottom tank. Cutting should be sequential from forepeak to aft peak of the ship. During cutting each block area should be clearly specified. A thorough cutting plan should be devised and followed. During cutting, each block should be properly hoisted and well balanced by hanging from overhead crane, gantry crane or mobile crane. Each block should be shifted to large parts processing area. In large parts processing area, the block should be cut into pieces and shifted to small parts processing area. In the small parts processing area, further processing should be done

according to customer needs and delivered to the adjacent transport bay. By following these processes, an organized and efficient way of cutting the ship can be ensured. It will ensure safety of workers, surrounding environment, and increase productivity, efficiency and profit margin.

Additionally, we also propose a Centralised Waste Management Centre in ship breaking yard. It can be managed by ship breaking yards, governments and/or public–private partnership. The purpose of the centre should be to control and manage the waste in the ship breaking yard. There can be a central effluent treatment plant in the ship breaking zone to which all the ship breaking yard should be linked.

There are many hazardous substances in the ship which are dangerous to human health. This material needs careful handling. In shipyards there is no awareness in handling hazardous materials. Asbestos is the most harmful material found in the ship. When a ship is dismantled a huge amount of asbestos is released. In ship breaking yards in most developing nations including Bangladesh, air quality and exposure to harmful elements are rampant. For example, the air is filled with asbestos fibre and flocks as they are removed without any precaution by the workers without any individual safety protection. Moreover, workers are exposed to the asbestos insulation materials as they are dried in open sky for reselling purpose. Unfortunately, asbestos are not banned in most developing countries. Used oil can be reprocessed and refined for further use. A safe removal of used and other harmful chemicals from ships and yard must be planned and done with utmost care. The Waste Management Centre in a ship breaking yard will oversee a safe procedure for asbestos, hazardous material, and harmful chemicals handling, proper documentation, and individual and collective protection of workers.

The ongoing occupational health and safety of workers, and environmental pollution monitoring facility in the ship breaking yard area is paramount. Although some regulations and laws have been enacted on occupational health and safety (OHS) and environmental protection (EP) by the government, it has not been implemented properly especially in ship breaking industry. There is a lacking in proper enforcement of OHS and environmental laws and regulations in ship breaking yard. In order to improve and properly implement the OHS and other laws, a series of regular short courses and briefing for employees is needed as many incidents and accidents generally occur due to lack of knowledge and/or awareness. Ongoing safety and environmental awareness must be monitored to have maximum effect. The process will not only minimise or eliminate accidents

but also increase productivity and profit margin. A proper incident and accident reporting systems and actions taken against the reports must be recorded, monitored and analysed for further improvements. With a small investment, ship breaking companies will be able to reap rich returns.

Design Layout of Ship Breaking Yard

One of the main reasons for environmental pollution, infringement of OHS and other incidents is the unplanned ship breaking in unconstrained beach area. In order to minimise or fully eliminate these concerns, a well-designed and planned ship breaking yard with required infrastructure must be developed. It will also increase productivity and reduce pilferage significantly. A good cooperation between government and ship breaking yards is needed to develop specialised zones in the coastal area for ship breaking activities by allocating land not more than minimum requirement under stringent OHS and environmental conditions. In order to develop a sustainable ship breaking yard, several layouts have been designed. These layouts are shown in Figures 8, 9 and 10. The layouts should include the following.

- The entire ship breaking region must be subdivided into multiple plots and individual plot will be a ship breaking yard. Each yard must be separated from adjacent yards by using appropriate boundary wall. All the ship breaking activities must be contained within the plot.
- Safe transportation of dismantled parts, machineries, steel plates and other commodities to and from the

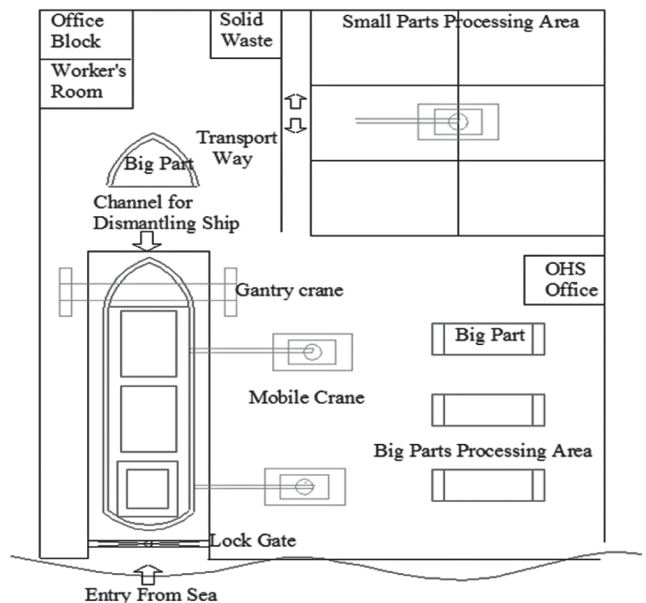


Figure 8: Layout of a sustainable ship breaking yard.

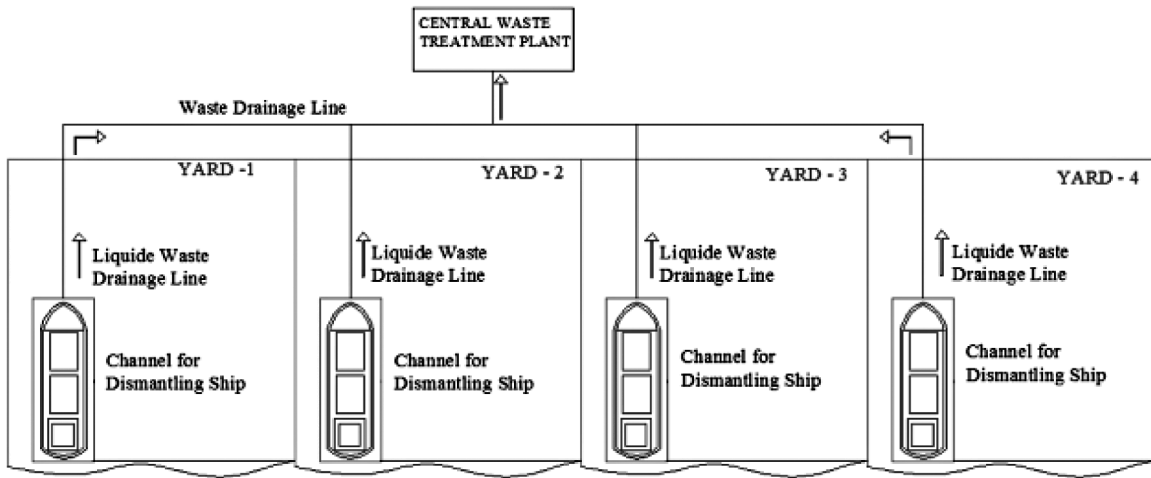


Figure 9: Block diagram of a sustainable ship breaking zone with central waste treatment plant and single channel ship breaking yard.

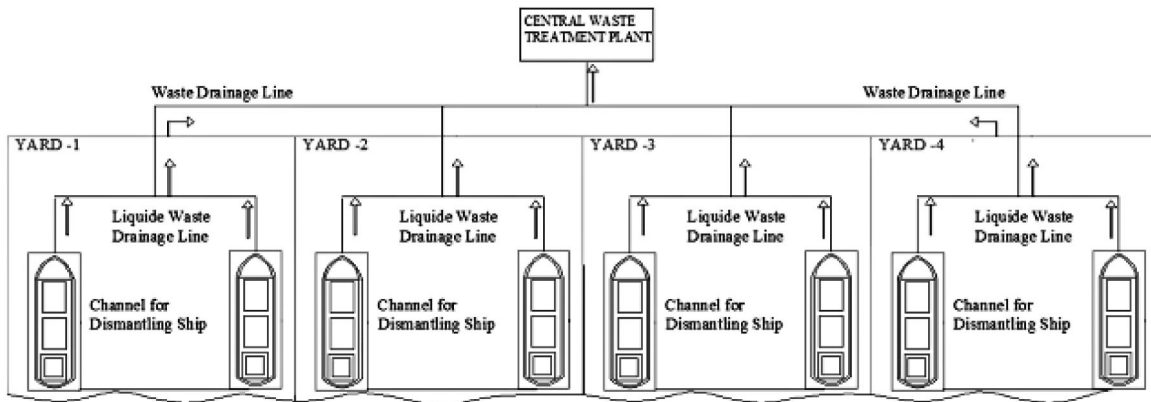


Figure 10: Block diagram of a sustainable ship breaking zone with central waste treatment plant and double channel ship breaking yard.

ship breaking yard zone must be ensured. Each and every individual ship breaking yard must have easy access to nearby main highway and rail network.

- (c) Each ship breaking yard must be connected to the central waste management plant (mentioned earlier) as shown in Figures 9 and 10. The figures represent block diagrams of the central waste management. A drainage line from each channel is drawn, which flows to central waste treatment plant. Each yard must also have a solid waste area. The solid waste should be carried to the central waste management plant.
- (d) A safe handling centre for asbestos and hazardous materials is also required in each ship breaking yard.
- (e) In order to improve workers' occupational health and safety, productivity and well-being, leisure and

recreational centre must be incorporated in the ship breaking yard.

- (f) Appropriate materials handling equipment including overhead crane and gantry crane must be available in each yard. In ship breaking yards of most developing countries especially in Bangladesh, one of the main reasons for serious accidents and work related deaths is the lack of mechanized materials handling facility. Most work is done manually without using safety gears (helmet, boots, cloths, gloves, goggles, etc.). It is not only dangerous but also less productive. The Gantry Crane, Overhead Crane, Mobile Crane and Hauling Winch should be used for handling of the large to medium parts and machineries. A layout for this equipment is shown in Figure 8.

- (g) The individual ship breaking yard should not destabilise the surrounding flora and fauna. Green vegetation must be developed around the ship breaking zone. Additionally, the yard must be protected from sudden sea surge especially during tropical cyclones and storms by enacting a safety barrier.
- (h) Instead of breaking the ship directly on the beach, there should be a dry-dock or a channel type platform in the mouth of the sea-shore in each ship breaking yard, where the ship will enter during high tide. A lock gate can be provided in the channel. In Figure 8, the proposed channel for ship breaking is shown. When the ship enters in the channel the lock gate closes the channel and water is pumped out and the ship stands on the platform. Large parts of the ship can be dismantled here and the dismantled parts can later be moved to the designated place for further dismantling. This layout design will be effective and provide much needed sustainable ship breaking in most developing countries with Bangladesh type geographical layout. The design can be modified to fit other countries' ship breaking activities in accordance with their geographical and environmental needs.
- (i) In each ship breaking yard there should be an OHS office. The office will look after the occupational health and safety related activities undertaken in the yard. The location of the OHS office is shown in Figure 8. It will ensure whether the workers are working with proper safety equipment/gadgets and all work is undertaken in accordance with safety procedure or not. Additionally, it will ensure safe handling of equipment and parts, certification of handling equipment, fire and emergency system, accident and injury handling, etc.

Integration of Ship Breaking Industry with Coastal Zone Management Plan

In Bangladesh, ship breaking industry is not integrated with coastal zone management plan. Government needs to formulate an appropriate ship breaking industry plan and its integration with the coastal zone management. There should be a suitable zone selection and management and its linkage to the inland infrastructure. For example, the Fouzdarhat area of Chittagong is marked as recreational area in the Master Plan of Chittagong whereas it has now become hazardous ship breaking area. The Coastal Zone Management Plan should develop suitable shore site for the expansion of ship breaking industry in consultation with concerned stakeholders. The

Department of Environment should work hand in glove with the ship breaking industry to ensure environmental protection in the coastal area of ship breaking yards. The department should also establish onsite monitoring to address environmental concerns. Most ship breaking industries are ignorant of relevant government rules and regulations. They should be actively engaged and consulted in policy formation by the government departments. The department should also work to ensure application of Basel Convention (2003) and ILO (2003), that identifies the guideline for safe and sustainable ship breaking activity both for environment and worker. In the study undertaken by Naser, Unsalan, Tekogul and Stuer-Lauridsen (2008), it is reported how the Turkish Government implemented the OHS laws and regulations, and made ship breaking activity at Aliaya ship breaking yards in Turkey as premier green ship recycling industry. This example can be used to ensure the policy implementation at the grass root levels. One of the major concerns related to deforestation by the ship breaking yards which might have caused adverse effects on environment and livelihoods of many surrounding population. The Department of Forestry should make a clear policy and supervise to save the trees in the coastal areas adjacent to ship breaking yards.

Conclusion and Recommendation

The scale and importance of ship breaking industry for developing nations especially Bangladesh is enormous. A sustainable and well planned ship breaking industry will not only generate employment and economic growth, but also significantly reduce greenhouse gas emission. A close cooperation between the government and ship breaking industry is extremely important and needed to tap the huge potentials of the industry. A modern and scientific approach is required for ship dismantling process in order to improve the occupational health and safety of workers, productivity, profit margin and environmental protection of surrounding flora and fauna. Bangladesh ship breaking can be the world's leading green ship dismantling industry if the proposed design plan and procedures are implemented.

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