

STUDYING CHALLENGES OF RECYCLING BUILDING MATERIALS FOR SUSTAINABLE CONSTRUCTION IN THE CONTEXT OF BANGLADESH

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ABSTRACT

The building construction industry alone produces much amount of building wastage materials all over the world. Rapid economic growth promotes the physical development of the city to the peripheral area. For this, the manufacturing of construction materials needs more natural resources that threaten the environment and human existence. The primary reasons for the production of these bulk construction wastes are the demolition of old buildings and the effects of natural disasters on the environment. Besides the economic loss, the process obstructed achieving a sustainable built environment, particularly for developing countries. Recent developments in the building and construction professions have emphasized the adoption of environmentally friendly construction technologies as well as a study into the reusability of old, deteriorated building detritus. Many local markets have developed informally that involved the trading of recycling materials. The parties, seller, and buyer are broadly dealing for economic benefits, although it reduces the consumption of natural resources. Lack of institutional involvement and systematic exploration of the field restrict the growth of this most potential marketplace. The purpose of the study is to spell out the potentiality of building debris as alternative construction materials and bring forth the challenges of the current marketplace, moreover elaborate practical cases of how these materials have been using for construction to finishing purposes. The empirical studies and papers will be reviewed for a critical understanding of the potentiality of old materials from a methodological standpoint. Discussion with stakeholders, detailed observation, and the illustration of practical examples will help further exploration. Every year excessive use of natural resources for building construction pushes the world into destruction, while the findings could minimize this consumption and promote the trading of old building materials. Moreover, the uniqueness of the issue will inspire professionals to work with the possibilities of old building resources. According to the study, recycling building materials are not only beneficial for the economy but reduce natural resource consumption and assure environmental sustainability.

Keywords: *Environmental friendly, Recycle materials, Sustainability*

1. INTRODUCTION

The building construction industry produces a vast amount of wastage by demolishing the old buildings and infrastructural redevelopment. A large amount of building debris ignores during new construction for the sake of its quality, and the absence of a proper recycling process and guidelines requires during construction. Every year, a bulk amount of natural resources is used to produce building materials. In Bangladesh, brick is the primary building material, and every year 1-meter depth of 40km² area top layer fertile soil has taken as raw material for the production of brick. This process greatly impacted the environment and disrupted the ecological balance. Reuse of old bricks and other items could effectively reduce resource consumption and waste generation simultaneously.

Natural resource use is increasing, necessitating new approaches to reduce the dependency on virgin materials and maximize waste recycling. Sustainable construction is imperative and could be a way to

design physical development that supports human well-being and is in harmony with nature (Janssen and Hendriks 2002). Life-cycle thinking (LCA method), Design for Recycling (DFR), EVR model are some popular approaches introduced to promote sustainability in construction (Janssen and Hendriks 2002). Many materials, however, are already recycled in industry and some locally, as evidenced by research that steel recycling is most in the world. In 2014, more than 86% of steel was being recycled, and many countries are still in the early phase to adopt steel at a mass level due to climatic, soil-condition, and lack of technology (Hussain.A 2019).

In Bangladesh, 80% of steel is produced by the scraps of iron collected from old ships dismantling and building demolition (Uddin.T.M 2021). On the other hand, concrete is the most widely used construction material all over the world. A recent report found the world consumes 20 billion tonnes of concrete, which needs 14 billion tonnes of natural aggregates (Uddin.T.M 2021). For minimizing environmental impacts, it is indispensable to reuse 12 billion tonnes of demolished concrete aggregates. Many researchers have identified techniques that can improve the quality of waste concrete and take the applied structural load on it. In the sustainable era, demolished concrete is considered as key resource to achieve an environmental balance that requires a proper procedure, such as using minimum water and add-mixture during mixing. Recycled concrete is used for a variety of purposes, depending on its nature. For example, in the southern Belgian province of Namur, these are utilized for environmentally friendly road construction (Uddin.T.M 2021) in Bangladesh; floor casting with this is prevalent.

Nowadays, the green building approach instigates sustainable management of materials to use in construction. The study aims are to investigate recycling buildings' materials management process at the field level and find out challenges related to sustainable construction. Meanwhile, factors affecting the materials collection to the remanufacturing process have been identified and analysed based on filed data. The outcome will help to direct the professional and authority to work with recycling building materials constructively.

2. REUSE AND RECYCLE IN CONSTRUCTION SUSTAINABILITY

In the building construction industry, reuse and recycling are equally important in reducing the consumption of natural resources and maximizing the utilization of building waste. The reuse process is not new since 400 BC; the people preserved dilapidated/demolished materials for new products production (Petkute 2016). Over time, these procedures have evolved concerning the environment, natural resource management, and gross economy. Following this, during the modern industrial era, the availability and appeal of affordable materials have increased, and further improvement of transportation facilities instigates the use of old building materials. In the early 20th century, the industries collected iron scraps as raw materials for metal production, which were more profitable (Zimrin, 2005). The trend accelerated during World War II when purposeful demands of recycling all kinds of materials and use dramatically in high.

In early 1970, the concept was defined from an economic sustainability perspective. The use of aluminium, metal, and other costly materials turned out to be a concern, and re-using these materials was beneficial. From 1980 to 1990, shifting the public opinion and attitudes towards the waste management system had brought a new movement, where the wastage materials considered as a resource for the production of new materials. Moreover, the recent studies and works in the late 20th century have highlighted the issues of sustainability that promoted the relevant thinking of the recycling concept. The construction industry has given concern about using the materials that should reuse in the future purposefully with minimum intervention. Many developed countries already have adopted innovative measures in construction sectors under the concept 'To Build from Waste'. Figure 1 illustrates the different aspects of sustainable construction on a global and local scale. Waste generation in the construction period is vital, along with the time and cost of the project (Hussin, Rahman et al. 2013). Hussin, Rahman et al. 2013, mentioned, design change, poor material quality,

site management, and unskilled labour are some reasons responsible for on-site waste generation during construction (Hussin, Rahman et al. 2013).

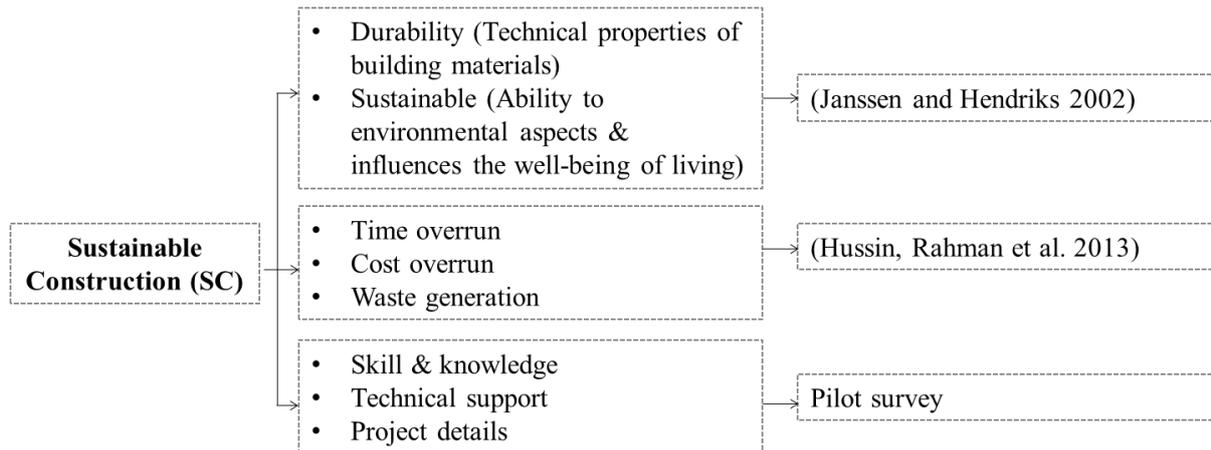


Figure 1: The conceptualization of Sustainable construction in the global and local scale (Janssen and Hendriks 2002, Hussin, Rahman et al. 2013 and Author constructed)

The construction industry is the largest consumer of natural resources and the largest producer of waste. Besides the socio-economic growth of society, it impacted on environment badly. Sustainability in this sector requires integrating all possible factors related to the environmental, economic, and social of the context. Concerning the word construction, sustainability covers two streams simultaneously, durability and sustainability. Durability refers to the technical features of materials, building sections, or construction that can withstand chemical, physical, and mechanical changes over time. On the other hand, sustainability is the general property that meets the environmental needs (air, water, and soil qualities) and influences the health and quality of liveability (Janssen and Hendriks 2002). Different approaches and tools have been developed to measure the quality of materials, such as Degradation Factor (DF), Life-cycle thinking (LCA method), Waste Management (WM), Design for Recycling (DFR), Eco-cost/ Value Ratio Model (the EVR model) and so on (Janssen and Hendriks 2002).

3. RECYCLING, SUSTAINABILITY AND BANGLADESH

In recent decades the context of Bangladesh has been experiencing extreme physical growth more than any time before, which reflects the socio-economic development and technological advancement. The acceleration of the construction industry requires more raw materials, which are natural substances and homogeneous (Janssen and Hendriks 2002). Unavailability of natural stone and inadequacy of raw materials of cement influence the brick is a widely used building material in the construction industry of Bangladesh. For making RCC and block of walls, brick is the primary material; steel and other organic materials use simultaneously. Primarily it requires the topsoil layer of the alluvial plain of Bangladesh and burns in 1100⁰ temperature, which causes massive environmental pollution.

Additionally, concrete is the second most-consumed constructions materials prepared by brick chips, cement, steel, and water in common. The cement consumption is 110 kg/capita/year that increase every year by 20-25% (Mohammed, Mahmood et al. 2016). To this end, the urgency of developing the recycling industry and adopting proper technology is needed. Many investigations and researches have recently been carried out to determine the issues associated with the recycling of organic and other materials.

The detailed investigation on recycled concrete revealed the aggregates of demolished concrete able to take and distribute the structural load. Technical illustrations of recycled concrete aggregates have

shown the load-carrying capacity almost the same as virgin aggregates. Even the results of recycled brick aggregates satisfy international standards such as ASTM C33, but it requires extra care while mixing with water (KRALJ¹ and Marič 2008). The controlled use of water and adding water-reducing admixtures can increase the usual strength and flow ability of the concrete. It is unfortunate to mention that the local market facilitates the recycling materials' business in many areas. Locally enlisted contractors, labour, shop owners, and day labour involved in repairing and manufacturing the steel, wooden, and glass items. Lack of skill during the repairing phases, apathy to work with these materials, and above all, social acceptance makes it difficult to develop it as an industry. Moreover, project and site management, types, materials, knowledge and skills of workers are necessary for sustainable construction (Gunduz and Almuajebh 2020).

4. METHODOLOGY

The research took mixed-approach to collect the primary and secondary data, and the thematic method was followed to analyse literature review and field data. Published research articles, reports, and case studies collected from websites and critically reviewed for apprehending factors and related challenges to the reuse and recycling of building construction materials. The field data were collected from two sources, firstly, from the demolition site and secondly, from the Sheikhpara marketplace. The building waste is usually being produced by new construction or through the act of reconstruction, transformation, repairing and remodelling (Hebel, Wisniewska et al.). The survey was conducted from June 2021 to November 2021, and various methods were applied to collect data from contractors, sellers, and buyers. Informal discussion, non-participant observation, and photographs used at the field level. Total 50 different shops have surveyed, and 20-25 buyers from different places participated in informal discussion. On the other hand, 25-30 daily workers participated in information sharing sessions. The study has taken Sheikhpara old materials market for the field study. For the pandemic, the field was difficult and faced challenges, which is the limitation of the study.

5. FINDING AND ANALYSIS

The Sheikhpara of Khulna city has been a marketplace for different building demolition and old ship materials for the last 2-3 decades. The field survey has identified various old buildings and broken old-ship materials, and people from outside the city area come for different products. Table 2 elaborates the detail of recycled material's sources and the overall process of recycling according to type, as well as mention the challenges based on the discussion with stakeholders. Based on the informal discussion with stakeholders, a general cyclic process has been formulated. The figure depicts the process starts collecting building waste from demolition sites by day-labourer and then sorting according to types. After that, remanufacturing is done following by displaying for selling. Finally, the materials collected by the buyer for different purposes. Figure 2 depicts the cycling-mapping of the process.

Below the ever step illustrates in details:

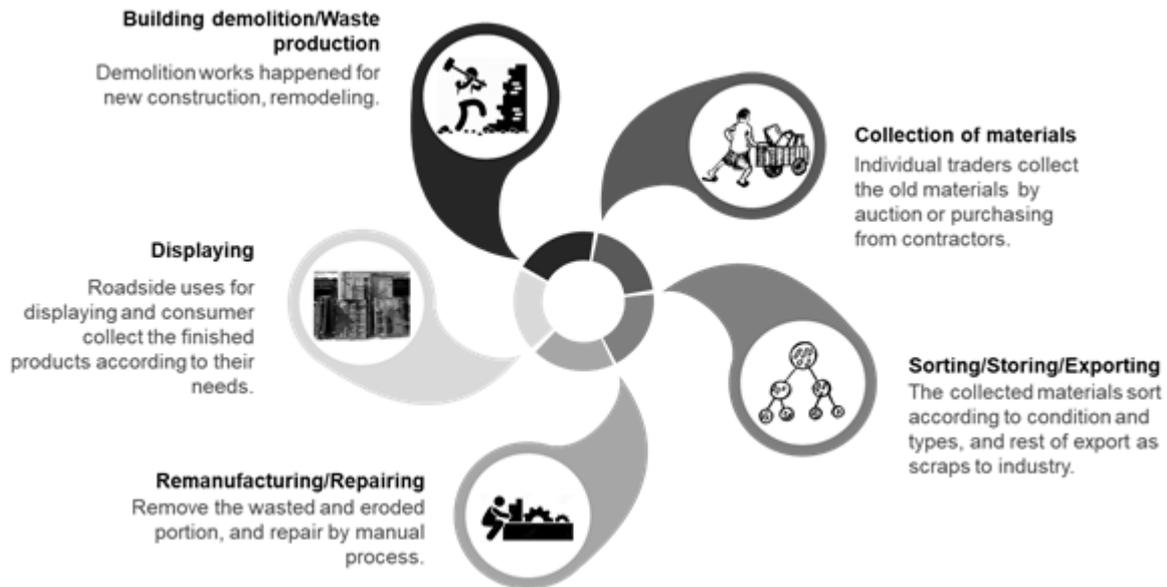


Figure 2: The Cycling-Mapping of building materials according to field survey (Author constructed based on survey).

5.1 Collection Phase

Discussions with shops owner related to these businesses mentioned three sources. Firstly, the people who take the contact of demolition of old structures; secondly, the old ship's materials collected from the Chattogram seaport area through auction; and finally, from the peddlers/hawkers who collect old materials from door to door by exchanging different offerings. Figure 2 shows the three identical recycling/remanufacturing processes.

5.1.1 Old Building Demolition

Old buildings are vital for the collection of recycled materials in the context of Bangladesh. Redevelopment, poor condition, and replacement by high-rise are the key reasons behind the demolition. The open tender, auction, and personal contact are the popular methods applying to connect with contractors for the demolition works. In general, bricks, shanks, swing windows made with glass and iron, grill, iron items (gate, door), wooden door (plank and frame), electric and plumbing items are collected after the demolition of the construction (Table 1). The demolition site is a good location for displaying brick, concrete, and other wastage Figure 3. People contact the merchant and purchase directly from the site. The iron, wooden, electrical, and plumbing items sell through the auction, where the individual traders or shop owners of Sheikhpura participate, and then display in front of the shops. The scraps items are sent to the industry for remanufacturing of new products.



Figure 3: Worker remove plaster from the brick (Left), the old gate and grills are displaying in front of the shop for selling (Captured by Author, October, 2021)

5.1.2 Old Ships Item

Broken old ships are another source of recycling or reusable building constructions materials. Bangladesh's ship dismantling industry is top in the world, where 47.2% of total ships are breaking in the Chattagram shipyard. More than 80% of recycled iron and steel is the source of this industry around Bangladesh (Hussain.A 2019). Some plastic items, such as doors, and others are also collected. Shop owners and traders have participated in open bidding arranged by authorities and importers of these old ships. After that, the materials will send to Shekhpara and other areas for further process.

5.1.3 Peddlers

Peddlers/hawkers/vendors go house to house with the mobile vehicle for collecting old materials through offering various items, such as foods, plastic products, and the cash amount. After collection from the field, they sort based on types and sell to different shops accordingly. Most of these are scraps that use as raw materials for the plastic and iron industry.

5.2 Sorting Phase

Sorting is the second phase done at the site and in the marketplace. The materials are sorted according to types and sent to different places for further processes. In Shekhpara, various shops have been developed based on material type, such as iron, steel, electrical, and plastics. Generally, a manual process uses during categorizing in part-by-part of the materials.

5.3 Recycling and Remanufacturing Phase

There have been many workshops devoted to recycling, repairing, and remanufacturing old building materials and products. Moreover, some processes are also done on a demolition site. Day labourers and available workers are involved in this process. Some products display and sell as it is for their condition, and some needs to remove and add (Figure 4). The detail is illustrated below.

Table 1: Details recycle budilg materilas sources, area of use and challanges (Author constructed based on field survey)

Building/Construction demolition (Old house, Instructional building and etc.)					
Material name	Type of use	Aggregate types	Recycling/Reuse process	Area of use	Comments/Challenges
Concrete	Construction materials	Stone/Brick chips	Crushed manually/using machine	Landfilling, floor & pathway casting	No scope to check the quality required for load-carrying.
		Steel	Manually excluding erosion and some parts, and reuse accordingly, Using as scarp for production of new steel items.	Casting, Making grill, Drain top slab, Scrap for industrial production.	Due to erosion, it's a little bit risky to use as the main portion of the construction.
Wall/Masonry	Construction materials	Brick	Manually remove plastering parts, Brick chips	Masonry work, Chips for casting	Required extra care in mixing
		Shurki/Plastering	Reuse as it is	Land development, filling	Price is very low
Wooden items	Finishing	Door & Window frame	Trimming damaged parts and adding required portion	Remaking of window and door frame, floor deck, Interior decoration	Most parts were ruined/destroyed due to climate and required good skill for remaking.
		Wooden beam			
Steel/Iron items	Finishing	Grill, Iron door, Gate	Trimming damaged parts and adding required	Grill for window and veranda, Main	Negotiate with the standard size and

			portion according to use	gate (Scissor type), Railing Door	reduce the dimension according to the product
Electric items	Finishing	Wires, Switch, Fan	Reuse as it is (Based on material condition)	Use in required location	Negotiate with the quality, but use for its cheap price
Plastic items	Finishing	Pipe			
Sanitary items	Finishing	Fixture & Fittings			
Old ships demolition items					
Steel/Iron items	Construction and finishing materials	Angle	Separate different parts manually	Structural support, Railing, Main gate, Grill	The price is comparatively high but use for the quality
		Stair	Add and remove manually according to needs	Connect two different floor (Road-side buildings, Top roof, Internal floor)	Products quality, finishing, price and lucrative
		Sheet	Separate different part manually	Gate, Railing, Roofing and casting purposes, Nails	Products quality
Plastic items	Finishing	Door , Wheels	As it is	Specific area where fit in	Products quality and price are the primary reasons
Peddlers/Hawkers (Door-to-Door collection)					
Iron and Plastic	Scrap as raw materials for recycling	Different types of chips (iron, plastic)	Proper recycling methods follow in industry	Used as new material in building construction	Without checking technical properties many ungraded scraps use for new production.



Figure 4: The grill and wooden window sell as it is from the demolition site (Left and middle), the old scissor gate displaying after remanufacturing (Captured by Author, October, 2021)

5.3.1 Brick

After the demolition of buildings, the bricks are dumped on the site, and primary cleaning, such as removing plaster, is done on-site. The buyer communicates with the contractors and collects the bricks from the site. The plastering item, Shurki, is commonly used for landfilling purposes, bricks in masonry work, and making chips for floor or roof casting.

5.3.2 Iron and Metal

The metal grills, windows, and doors decay due to climatic conditions. The deteriorate portion needs to be cut and replaced carefully. All workshops follow the manual process of repairing and remodelling the window grills and doors. Firstly, they clean by rubbing with sandpaper and washing with tarpon. After that, the broken parts are welded and add parts if needed. Finally, all the products are painted with eye-catching colours and displayed for selling. On the other hand, the old ship's iron plate was cut into pieces according to needs and followed a distinct process for making different products (Figure 5). The stair, doors, and windows require minor repairing and displaying for readymade selling.



Figure 5: The cutting process of old ship's plate for making the angle and railing(Captured by Author, October,2021)

5.4 Displaying

The road adjacent shop front is using as a display zone that ensures visibility of the products. Some products display as it is, but the majority needs to repair with the necessary adding or removing. In most cases, this occupies a portion of the road and obstructs pedestrians. The consumer does not feel comfortable when visiting the shops and checking for details.

6. DISCUSSION

The price is main reason for people to purchase the recycle building materials, moreover, quality, size according to needs and variations of materials are also important. The marketplace has developed without any authoritarian intervention and support people with different services since last 2-3 decades.

Table 2: Detail perceptions of the different stakeholders

Perception	Present challenge	Comments
Contractor's and Shop owner	Dedicated marketplace	Proper planning regarding recycling material's business (space allocation), Financial support can extend the trade.
	Financial support	
	Patronization from authority	
Worker/Day labour	Institutional knowledge	Short hands-on training, technical support and recognition from authority could instigate people to involve in the work.
	Technical support	
	High risk factor	
	Professional recognition	
Buyer	Professional support	Expertise and proper technical guidelines will be effective to work with recycle materials.
	Technical guidelines	

The Table 2 illustrates the stakeholders perception related to recycling material business. According to field study, absence of planned market area is main obstacles to extend the business, and the hazardous nature and lack of knowledge are the concern for worker. Consumer highlighted the absence of technical guidelines for minimum use of recycle building materials during constructions.

6.1 Contractor's and Shop Owner Perception

The people of Sheikpara have generally been involved in the business of old items for the last 20-30 years. The residential area has converted into a vibrant old items marketplace in Khulna city. Contractors mentioned the demand for old building materials is increasing day by day, but lack of management and inadequacy of place obstructs the expansion of the marketplace according to growing needs. That's why most of us try to sell the items in demolition sites that reduce the price. Due to climatic reasons, the old material's condition deteriorates quickly in the southern region, which requires skilled interventions for further reuse. In most cases, local re-manufacturing processes are done by local unskilled labour, which is a barrier to achieving the standard quality of the materials. A business person does not get any financial support to extend the trade or other facilities that promote the sector.

On the other hand, the shop owners emphasized space deficiency for displaying and lack business environment of the area. The shop front (roadside) uses for displaying iron/steel and wooden-related items, which is risky for pedestrians. Many times the repairing, remanufacturing, and refurbishing processes are performed on-road that causing many accidents. Residents complain to the counsellor to get the business out of here and propose a dedicated trading place.

6.2 Worker's Perception

The locals who live adjacent to Sheikpara are engaged with the recycling, restoring, repairing, and remanufacturing process. They do not have any institutional or subject-related knowledge, due to which the quality of the material cannot achieve properly. Informal discussion with workers revealed many accidents take place every day for not taking proper safety measures while working with hazardous materials. Even there is no designed place for restoring work of iron and steel, which identifies as risky for both worker and general people.

Remanufacturing, repairing, and refurbishment processes are still biased and follow orthodox practices. For remaking a product with old and new elements workers use manual processes without any technological support. For this, the finishing quality of the products does not achieve the standard.

6.3 End User's Perception

People from the peripheral area of Khulna city come to the Sheikpara for recycled iron, steel, and electric items. Discussions with the buyers bring forth some vital issues related to using these materials in building construction. Many of them mentioned the 'negotiation'; they do while using an iron grill, door, or readymade gate. Generally, the window size of the bedroom is 5'X5'/5'X6', which requires the same size as the grill, but most readymade grills (reusable) are different in dimension due to repairing purposes, such as 4'X4'-6''/5'X4'-2''. Even the local refurbishing process does not follow any standard procedures that create problems during installing time. Sometimes we pay extra for further adding or removing materials according to the functional needs.

Moreover, locally available masons have been constructed the building according to the needs and direction of the owners, and lack of professional engagement and supports makes the process critical. Masons do not follow the criteria that are required in the construction phase if recycled or reusable materials are used. Some homeowners claim the professionals are not interested in working with the old building items. Moreover, professionals state that repairing or recycling does not follow standard procedures, and the people who are not skilled enough re-manufacture the materials of the old building.

Eventually, there is no easy and constructed procedure to check the technical properties of the recycled/repairing construction materials related to materials life span. The durability of materials is the key for sustainable construction that can resist any deterioration and sustain the structure over a certain period. In Bangladesh, the recycling industry is still in the developing phase that needs the interventions of professionals from manufacturing to the implementation phase.

7. CONCLUSION

The study findings are vital for stakeholders related to the construction industry, academics, and professionals of Bangladesh, in particular, the sustainable management committee, to identify the current challenges and requirements of the recycling/reuse industry. The construction industry not only consumes a lot of natural resources like aggregates for building materials, but it also generates a lot of waste. Every year the demand for recycling construction materials is increasing in price. Many studies have shown that recycled concrete coarse aggregates can provide the same strength as new brick concrete with the same mix design (1). Additionally, this concrete mix is used for various purposes, such as landfilling, floor and road casting, but needs a proper combination of water, admixture, and materials. Many marketplaces are evolving haphazardly based on types of reusable or recycled building materials. Lack of patronization and technical supports from authorities create challenges to grow the recycling/reusable process as an industry to achieve economic and environmental sustainability. On the other hand, on-site construction waste management is a growing concern that is generated due to using unskilled workers, materials quality, poor planning, and management.

In Bangladesh, the construction industry is evolving rapidly in parts of socio-economic growth and generates implications for the environmental balance of the country. The deterioration of structures due to climate, replacement of low-rise by relatively high-rise buildings, and other structural demolitions produce a vast amount of recyclable materials. But, the industry is still young in terms of research, professional expertise, and adequate technical supports. The issue is still neglected in academic discussions and the research field, yet no expertise has developed to support the industry technically and socially. The conventional remanufacturing process does not ensure the mechanical quality of the products.

To reduce natural resource consumption and ensure environmental balance recycling, and reusing waste building materials is imperative. The approach of green architecture around the world reconfigures architectural thinking and instigates sustainable methods. Incentive and development measures of government, laws, and guidelines for using recycling materials in the construction of Development Authority, better technical supports, and training for professionals and workers could promote sustainability in Bangladesh.

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