SALINE WATER PURIFICATION TECHNOLOGY AT HOUSEHOLD LEVEL AND LOW-COST DURABLE HOUSING TECHNOLOGY FOR COASTAL AREAS OF BANGLADESH

Fact Finding Report

Low-cost housing technology solutions

KICT

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1. BACKGROUND

Bangladesh is one of the most vulnerable countries on Earth, and due to its unique geographical location in the tropical monsoon area, people suffer from frequent natural disasters affecting lives, land, property and livelihoods. Monsoon is defined as a seasonal reversing wind circulation between summer and winter, the northeast wind in the winter and the southwest wind blows in the summer. It is caused by the temperature difference between the continent and the ocean, which brings heavy rain to Bangladesh.

The most prominent climate features of Bangladesh are high temperature, heavy rainfall, excessive humidity and seasonal changes. Three distinct dominant seasons can be recognized in Bangladesh, which are, cool dry season from November to February, hot summer season from March to May and heavy rainy monsoon season from June to October. March can be considered as the spring season, from October to November may call as autumn season and the dry season starts from December to March. In general, the temperature in January is the coldest, the highest reaches in April, and the temperature slightly drops down from April and the rainy season begins from this time. The most dominant factor in the climate of Bangladesh is humidity and rainfall. March and April are the least humid months over most of the western part of the country and the least humid months in the eastern area are January to March. In addition, the relative humidity exceeds 80% anywhere from June to September. It is very dry in winter, around 2-4% of annual rainfall. Strong heat and humidity from Bengal Bay, which increases 10% -25% of the annual precipitation in the summer, and rainfall in the rainy season represents a total of 70-90 % annually.

1.1 GEO-CLIMATIC CONTEXT OF BANGLADESH

1.1.1 SATKHIRA DISTRICT

Satkhira is a district in South-Western Bangladesh and is part of Khulna Division. It lies along the border with West Bengal, India. Satkhira also has a tropical climate. Satkhira has annual average temperature of 26.2°C and maximum temperature reaches 35.1°C in April, minimum temperature is 12.3 °C in January. There is much less rainfall in winter than in summer. Approximately

1,655 millimeters of precipitation falls annually and 90% of annual rainfall occurs in between May and October.

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	19.1	22	26.8	29.6	30.2	29.5	28.8	28.8	28.9	27.7	23.7	19.8
Min. Temperature (°C)	12.3	15.3	20.3	24.1	25.5	26.1	26	26	25.8	23.7	18.1	13.2
Max. Temperature (°C)	25.9	28.8	33.3	35.1	34.9	33	31.6	31.7	32	31.7	29.4	26.5
Avg. Temperature (°F)	66.4	71.6	80.2	85.3	86.4	85.1	83.8	83.8	84.0	81.9	74.7	67.6
Min. Temperature (°F)	54.1	59.5	68.5	75.4	77.9	79.0	78.8	78.8	78.4	74.7	64.6	55.8
Max. Temperature (°F)	78.6	83.8	91.9	95.2	94.8	91.4	88.9	89.1	89.6	89.1	84.9	79.7
Precipitation / Rainfall (mm)	11	17	28	63	132	296	347	320	271	136	28	6

FIGURE 1 SATKHIRA DISTRICT CLIMATE TABLE[1]

A. Temperature

The annual average temperature of the Satkhira region is 26.2°C, with a monthly maximum of 35.1°C in April and monthly minimum of 12.3° in January.

B. Humidity

Although the humidity of Satkhira area is comparatively high with annual mean of 83%. The maximum monthly relative humidity is 89% in February and the minimum monthly relative humidity 75% in May.

C. Wind speed

[1] Last visited, 05/04/2018, Climate-Data.ORG, https://en.climate-data.org/asia/bangladesh/khulna-division/satkhira-59286/

The annual mean wind speed is 4.3 m/s. Daily high wind velocity was shown as 7.7m/s during May to July and minimum wind speed of less than1 m/s occurs in July to September.

D. Precipitation

Annual precipitation is 1,655mm. Maximum rainfall of Satkhira is 347mm which occurs during summer in July, and minimum rainfall 6mm occurs in December. The difference in precipitation is 341mm throughout the year.

1.1.2 BAGERHAT DISTRICT

Bagerhat District is a district in South-Western Bangladesh, lies East of Khulna, West of Pirojpur. It is a part of the Khulna Division. Bagerhat has annual average temperature of 26.04°C and maximum temperature reaches 34.6°C in May, minimum temperature is 12.4 °C in January. Approximately 1934 millimeters of precipitation falls annually and 90% of annual rainfall occurs in between May and October.

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	19.1	21.8	26.5	28.9	29.8	28.9	28.4	28.4	28.7	27.7	24.2	20.1
Min. Temperature (°C)	12.4	15.1	20.1	23.7	25.1	25.8	25.8	25.9	25.8	24	19	13.8
Max. Temperature (°C)	25.9	28.6	32.9	34.1	34.6	32.1	31.1	31	31.7	31.5	29.4	26.4
Avg. Temperature (°F)	66.4	71.2	79.7	84.0	85.6	84.0	83.1	83.1	83.7	81.9	75.6	68.2
Min. Temperature (°F)	54.3	59.2	68.2	74.7	77.2	78.4	78.4	78.6	78.4	75.2	66.2	56.8
Max. Temperature (°F)	78.6	83.5	91.2	93.4	94.3	89.8	88.0	87.8	89.1	88.7	84.9	79.5
Precipitation / Rainfall (mm)	12	21	43	90	190	371	404	349	254	158	34	8

FIGURE 2 BAGERHAT DISTRICT CLIMATE TABLE[2]

[2] Last visited, 05/04/2018, Climate-Data.ORG, https://en.climate-data.org/asia/bangladesh/khulna-division/bagerhat-56261/

A. Temperature

The annual average temperature of the Bagerhat region is 26.04°C, with a monthly maximum of 34.6°C in May and monthly minimum of 12.4°C in January.

B. Humidity

Although the humidity of Bagerhat area is comparatively high with annual mean of 74%. The maximum monthly relative humidity is 84% in August and the minimum monthly relative humidity 62% in March.

C. Wind speed

The annual mean wind speed is 3.5 m/s. Daily high wind velocity was shown as 9 m/s during August and minimum wind speed of 1 m/s occurs in October to November.

D. Precipitation

Annual precipitation is 1,934mm. Maximum rainfall of Bagerhat is 404 mm which occurs during summer in July, and minimum rainfall 8 mm occurs in December. The difference in precipitation is 396mm throughout the year.

1.2 CURRENT STATUS OF HOUSING IN COASTAL AREAS

1.2.1 HOUSING-RELATED CHALLENGES

Bangladesh is one of the world's most populous countries, with more than 1,100 people living on a square kilometer. A third of the 160 million people live below the poverty line, and most people live in slums or are without any proper shelter. Due to the natural disasters such as cyclones, floods and erosion, which brings the result of unemployment, lack of education opportunities. For economic reasons, more than 26% of coastal area people are trying to avoid this phenomenon and are migrating to North-West, such as Dhaka city. These problems increase the Dhaka's density, house prices and poverty rate. Figure 3 and 4 shows the regional poverty rate and migration rate in Bangladesh, which explains that coastal areas generally have higher rates of poverty and migration than other regions. In Figure 3, the areas marked with dark brown color show areas with more than 44% people living under extreme poverty and the bright red

color indicates areas where 33%- 43% of people live in extreme poverty. In addition, Figure 4 shows the migration rates caused by natural disaster in 2012. The red bar graph shows the population proportion of the migration out of the region and the green bar graph is the proportion of the migration into the region. From this map study, most of coastal area is shown as dark brown and bright red color with red bar graph, which means that people who lives in this coastal area, moved to the capital city such as Dhaka, to survive natural disasters and the economic problems. Figure 5 explains how people migrate due to the natural disaster.

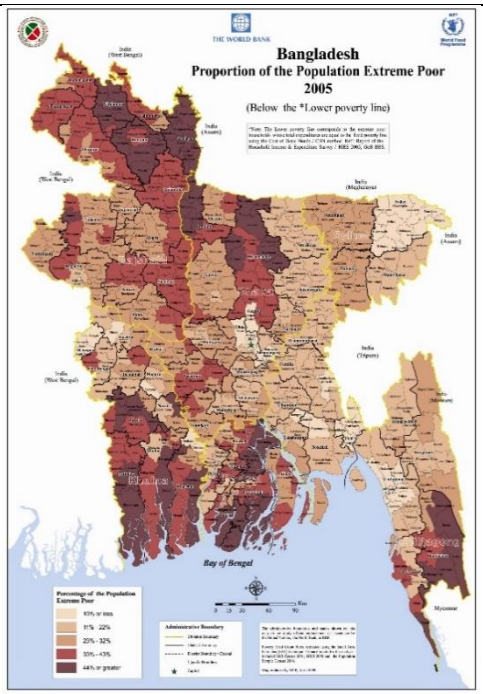


FIGURE 3 PROPORTION OF THE POPULATION EXTREME POOR 2005[3]

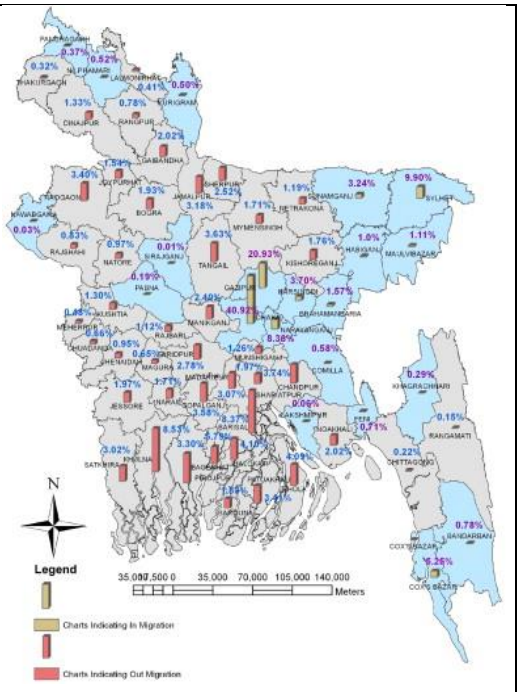


FIGURE 4 MIGRATION RATES BY NATURAL DISASTER 2012[4]

[3] NGO Forum, http://ngof.org/wdb_new/sites/default/files/Upazila%20based%20Poverty.jpg ,visited on 7th of September, 2017

[4] Hassan, M, 2012, Mapping the Effects of Natural Disaster on Human Displacement and Migration in Bangladesh: Special Focus on their Spatial Distribution in Dhaka

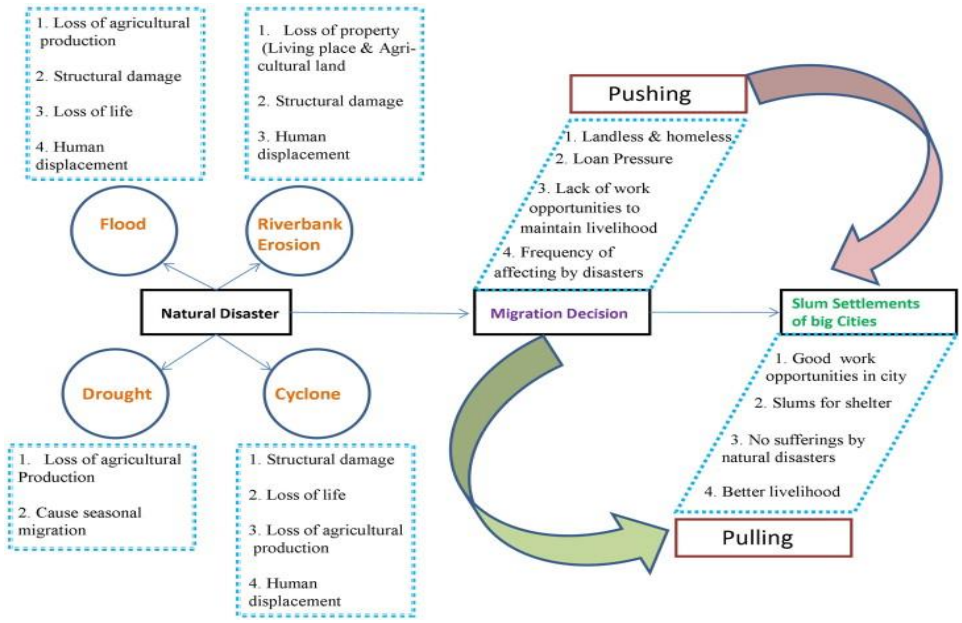


FIGURE 5 DISASTER INDUCED HUMAN MIGRATION[5]

The Bangladesh coastal zone is the lowest lying zone in Bangladesh where 37 million people are living within one-meter elevation from high tide level. Most of coastal area is based on acid sulphate soil, grey floodplain soil and grey piedmont soil, which means that the land is not hard enough to stand for natural disaster especially on Monsoon season. Due to flood related increase of groundwater and salt infiltration, clean coastal urban drinking supply for more than 11million coastal people is a major problem. Salinity of water and soil is seen as a risk factor in many parts of the coastal area, especially where more than 60% of the total population depend on agriculture for livelihood.

[5] Hassan, M, 2012, Mapping the Effects of Natural Disaster on Human Displacement and Migration in Bangladesh: Special Focus on their Spatial Distribution in Dhaka

Name of the City	City Area (km^2)	Area affected by salinity (%)	Name of the City	City Area (km^2)	Area affected by salinity (%)
Barguna	15.57	46	Botiaghata	8.30	69
Mathbaria	15.92	65	Dumuria	6.39	68
Pathorghata	18.31	68	Rupsha	2.30	45
Galachipa	9.60	72	Mongla	17.79	78
Kalapara	19.49	74	Paikgacha	2.12	81
Munchiganj	2.10	88	Bagherhat	7.53	56
Kaliganj	7.96	77	Morelganj	15.36	65
Ashasuni	6.81	85	Koira	10.06	81
Sathkhira	27.84	45			

FIGURE 6 COASTAL ZONE AFFECTED BY SALINITY (SOURCE: ISLAM AND GNAUCK 2010)[6]

Around 80% of the residential houses in coast area built with straw or bamboo walls and reeds or straw woven roofs. Around 20% of the residential houses built with mud brick walls. In the case of straw or bamboo houses, the floor is elevated for flood reason but also for allowing ventilation through the floor area. The high steep pitched roof is for ventilation purpose with long eaves that shadow and protect the walls from rain. During the rainfall monsoon season, there were various housing problems such as collapsing walls and leaking water from the roof and these problems exacerbate during natural disasters. As mentioned above, coastal area people live below the poverty line and do not have the ability to repair their residential houses.

[6] Islam, S.N., Gnauck, A., 2010. Climate Change versus urban drinking water supply and management: a case analysis on the coastal towns of Bangladesh, Germany

FIGURE 7 CURRENT RESIDENTIAL STATUS IN COASTAL ZONE IN BANGLADESH[7]

1.3 CURRENT BUILDING METHODS AND MATERIALS[8]

Coastal houses are mainly made of indigenous materials locally available, such as, bamboo, straw, grass, jute stick, golpata' [golpata] (Nipa fruiticans), mud and Corrugated Iron sheets. In Southern region and the Southern coastal tract of Chittagong district the roofs of the houses are normally thatched with CI sheet; with Son' [Shon] grass golpata leaves in. Shapes are predominantly rectangular. A small verandah' [baranda] with straw or bamboo support is a common design. Wattle and daub walls with plaited bamboo dubbed on with a thick layer of mud used for the wall is found in the housing construction in South-Western parts of Northern Bangladesh. Wattle and daub walls are also common in the islands and the coastal regions of Chittagong, especially on the South of Sitakunda.

Some of the rural houses in disaster-prone areas have constructed with kutcha construction using natural organic materials. These have shorter life span, which easily destroyed by high flood, moderate storm or cyclone. Houses in floodplain

[7] Displacement solutions & YPSA, 2014, Bangladesh Housing land and property (HLP) Rights Initiative – Climate Displacement in Bangladesh Stakeholders, laws and policies -,mapping the existing insititutional framework, Bangladesh

[8] Housing and Building Research Institute (HBRI) (2018), *Standard Guideline for rural housing in disaster prone area of Bangladesh*, Bangladesh

areas are normally located above the seasonal flood level; however, they go under water during high flooding of storm surges.

Therefore, structures in the coastal region demand the use of alternative appropriate materials and technologies for withstanding severe loads emanating from cyclones, tidal surges and earthquakes. Also, people with disabilities face many challenges due to the normal construction of houses and their special housing needs to be ensured.[9]

FIGURE 8 BAMBOO LEAVES WALL STRUCTURE

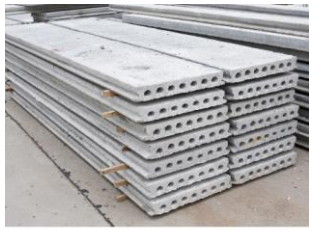
FIGURE 9 GOL PATA ROOF AND BAMBOO WALL CONFIGURATIONS

[9] Shahrom, S. K., & Zainol, R. 2015, 42 Journal of Design and Built Environment Vol. 15 (1)

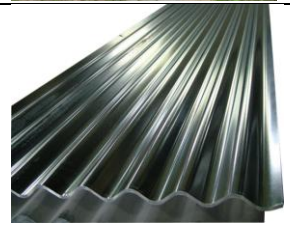
2. MATERIAL STUDY[10]

Material	Description	Image
Ferro cement	• Ferrocement is ideally suited for thin wall structures as the uniform distribution and dispersion of reinforcement provide better crack resistance, higher tensile strength to-weight ratio, ductility and impact resistance. • Ferrocement elements can be divided into two categories based on the construction procedure	
Cast-in-situ	• Cast in situ ferrocement includes the procedure of constructing the element in the particular site. • It is difficult to maintain the size, shape and thickness of the element. • Labor charge is high. • Assembling cost is high in this type of construction. • Cost per unit = 135 Tk/sft	

[10] Housing and Building Research Institute (HBRI) (2018), *Standard Guideline for rural housing in disaster prone area of Bangladesh*, Bangladesh

Pre- Cast	• Ferrocement pre-cast element can be constructed at convenient places (e.g. factory, workshops) and transported to the sites. • It is easy to move from the place of manufacturing to the construction site. • Labor charge is comparatively low. • Less efforts are required to maintain the size, shape and thickness of the element. • In order to avoid the issues related to salinity in coastal areas pre cast ferrocement elements can be proved to be more preferable. • Cost per unit = 120 Tk/sft	
3D Panel	• 3D panel is a prefabricated panel, which consists of a super-insulated core of rigid expanded polystyrene, sandwiched between two sheets of steel welded wire fabric mesh. • 2.5 mm diameter galvanized steel truss wire is pierced through the polystyrene core at offset angles for superior strength and integrity and welded to each of the outer layer sheets of eleven-gauge steel welded wire fabric mesh. • Cost per unit =182 Tk/sft	

Sandwich Panel	• The sandwich panels are consisted of two thin ferrocement layers, reinforced with one layer of iron wire mesh, with core (middle part) made of Expanded Polystyrene Sheet • Cost per unit = 135 Tk/sft	
Compressed Stabilized Earth Block (CSEB)	• Compressed stabilized earth block (CSEB) or a compressed soil block, is a building material made • primarily from dredged soil compressed at high pressure to form blocks. • The dredged soil is being collected from Kapatakha, Shurma and Feni river • Cost per unit =3,282 Tk/ Cum	
Thermal Block	• Thermal block is the composition of Expanded Polystyrene Sheet and Mortar (Cement and Sand). • Commonly used as facade material. • Improves the thermal property of indoor environment. Can be used in frame structures. • Lightweight though reduces overall mass of the structure • Cost per unit =135 Tk/sft	

CLC Block	• Cellular Light Weight Concrete (CLC) is a version of light weight concrete that is produced like normal concrete under ambient conditions. • It is 50% Lighter than normal brick • Cost per unit = 5,768.82 Tk/cum	
CGI Sheet	• CGI or Corrugated Galvanized Iron is a building material composed of sheets of hot-deep galvanized mild steel, cold-rolled to produce a linear corrugated pattern in them. The corrugations increase the bending strength of the sheet in the direction perpendicular to the corrugations, but not parallel to them. Normally each sheet is manufactured longer in its strong direction. CGI is lightweight and easily transported. Corrugated iron is equivalent to tin roof • Cost per unit = 127 Tk/sft	
Sand Cement Hollow Block	• These blocks are produced by combining sand and cement. Low Maintenance, Color and brilliance of masonry withstands outdoor elements. • Strength can be specified as per the requirement. • Reduce in total cost of project by being less in dead load of walls • Cost per unit = 60 Tk/sft	

Poly block with EPS Bubble	• Made from sand, cement, EPS bubble and foaming agent. • Reduce in total cost of project: - Being less dead load of walls. • Reduce in total cost of project: - Being less dead load of walls • Cost per unit = 60 Tk/sft	
Interlocking Block	• Interlocking blocks are like 2 adjoining pieces of a jigsaw puzzle. Each block has a projection at one end and a depression at the other. The projection of one block fits in to the depression of the next so that they always align perfectly. • Cost per unit =30.00 Tk/sft	
Aerated Concrete Block	• Autoclaved cellular concrete (ACC) is made with fine aggregate, cement, and an expansion agent that causes the fresh mixture to rise like bread dough. • ACC materials use thin bed mortar in thicknesses around ⅛ inch, depending on the national building codes. • Lighter in weight than normal brick • Cost per unit =25 Tk/sft	

3. FIELD SURVEY

In order to investigate status of the Southern coast area of Bangladesh, such as residential living conditions of the residents, local construction materials availability, local material infrastructure status, transportation status, KICT had performed and surveyed six various regions in the southern coast. Based on the field survey data, KICT derived three recommended models of construction materials that can be utilized through various field surveys such as coastal areas, inland plains, and hilly areas.

3.1 FIELD STUDY

3.1.1 SOUTHERN COASTAL REGION OF BANGLADESH

Adjacent to Bangor Bay, the southern coastal region of Bangladesh lies below 22° north latitudes. It is designated as the Sunda Burns National Park and Protected Forest, as it is located near the coast. It is a non-residential area with the majority of people living above 22.2 to 22.5° north latitude. KICT conducted a study in the area. This study analyzes the districts of Satkhira, Bagerhat, and Khulna, where the durability of buildings is low due to the climatic environment. In particular, KICT investigated the local climatic environment, topographic characteristics, building structure types, major constituent materials, and the state of disaster prevention facilities, focusing on villages adjacent to inland rivers. In addition, this study derives the imperative factors and presents building materials optimized for these areas. Finally, based on the findings, this study proposes a housing model.

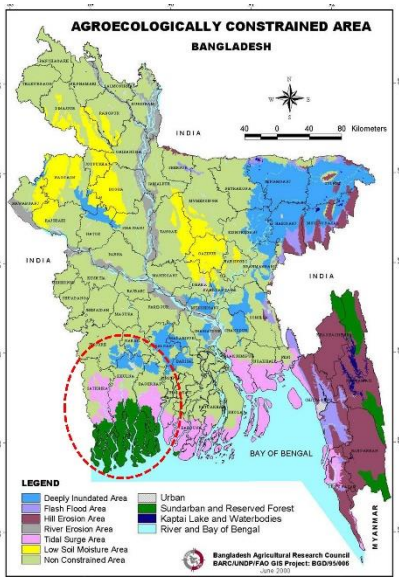


FIGURE 10 FIELD SURVEY AREA

A closer look at the topographic characteristics of the area reveals that the latitude is in the range of 22.27° to 22.49° north, while the longitude is in the range of 89.19° to 89.59° east. It features a rainy season from May to September and a dry season from October to April. Generally, it has a humid climate, wherein the humidity level is always above 85% during the

rainy season and above 70% during the dry season. From May to September, which is the rainy season, the peak temperature can reach 35°C; during the night, the temperature is about 10°C cooler, hovering around 25°C. During the dry season, in the winter, the peak temperature can reach 25°C and drops to 12°C at night.

During the rainy season, precipitation is most intense between June and August, and the monthly precipitation level is around 300 to 3500mm. The northern mountainous area is classified as earthquake prone, while the southern coastal region has geographic features that are relatively stable to earthquakes.

According to a survey by the Bangladesh government, the Sunda Burns National Park and the forest reserve area are highly affected by cyclones. The area in the latitudes of 22.27° to 22.49° north, which is the survey area, is classified as a danger zone, and Khulna, Satkhira, and Bagerhat, which make up most of the surveyed area, are classified as strong wind zones.

Interestingly, the survey indicates that areas around the river in the northern region are more vulnerable to flooding than the southern coastal region. An alleged reason for this is that, in the southern region, the wetland area blocks flooding at the lower end, making the region relatively stable to flooding. Even if there is a flood, the water will only reach the predictable level, making disaster management relatively easy.

Conversely, in the northern region by the river, areas that are not properly equipped with disaster prevention facilities or levees are even more vulnerable to flooding when there is heavy rainfall.

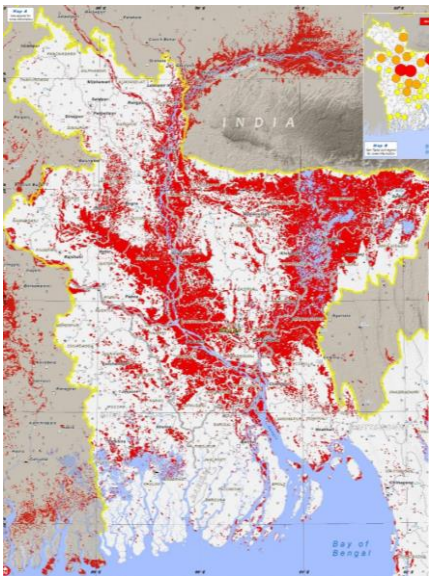


FIGURE 11 FLOODED AREA DURING RAINFALL SEASON

As shown in Figure 11, the areas surrounding the rivers and lakes in the central and northwestern regions are very vulnerable to flooding. In fact, flood damage in Bangladesh, which occurs every year, is mainly caused by floods in the urban areas around the river in the northern region. In other words, the southern coastal region is relatively stable in terms of flood damage caused by heavy rainfall.

3.1.2 SECURING HOUSING DURABILITY

The structures can be classified by structural type and materials used. The structural types of houses in the southern coastal region of Bangladesh can be classified into bamboo, masonry, and reinforced concrete buildings. The main constituent materials of the walls are brick, bamboo, soil, wood, stone, and golpata, while the roofs are mainly composed of SGI sheet, golpata, slate, and straw. Factors that affect the durability of houses are water, wind, and vibration. If there is salinity in the water or wind, in the case of reinforced concrete structures, durability can be compromised quickly, and the corrosion of metal roofs, such as tiles, can progress rapidly. The main components used in the region are SRC, brick, timber, and bamboo. The durability and economy of each material are classified as follows.

First, factors that affect durability include salinity in the air or water, CO_2 concentration in the air, high humidity, high temperature, wind, and the physical factor of earthquakes. The influence of each factor can be classified according to a five-level scale. Reinforced concrete structures have strong resistance to wind, earthquake, temperature, and humidity, but are vulnerable to high concentrations of salinity or CO_2 in the air. In particular, the deterioration and peeling of old building surfaces can be vulnerable to weakening of its concrete structure due to neutralization. Therefore, they deteriorate further, affected by expansion due to infiltration of water.

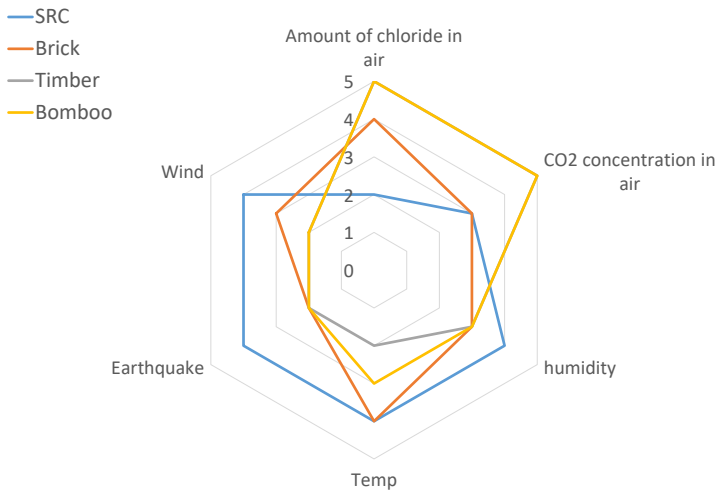


FIGURE 12 FACTORS AFFECTING THE DURABILITY OF HOUSING CONSTRUCTION

When comparing the economic efficiency of buildings according to the structural type, the economy can be categorized by the price of materials, construction method, construction technology, construction period, ease of supply of materials, and supply conditions, transportation, among others.

The material is composed of reinforced steel and cement concrete of SRC structure, forming a relatively high price structure. From a materials perspective, building SRC structures in non-urban areas is inefficient for several reasons. First, cement is sourced by importing clinker from India to be crushed, although there are many cement companies in Bangladesh. Due to the lack of infrastructure required to transport cement and the lack of plants for its production, the applicability of SRC structures is considerably low. Moreover, there are many difficulties in supplying rebar.

Timber and bamboo, which are widely used as wall and roof materials in the region, can be obtained locally, and have the advantage of having accumulated technology in accordance with their long history of usage and shortening the construction periods. In particular, using bamboo or timber as roof or wall and having a SRC structure can be advantageous in preparing against the effects of strong winds and ensuring a pleasant climate space.

Bangladesh has many burned brick factories, and the bricks produced in the country are crushed and used as course aggregate or flooding materials. However, its use as a raw material is expected to result in the construction of durable housing. For this, it is necessary to provide infrastructure in the region to enable its transportation, such as roads. Individually, it is believed that the use of bricks for construction of houses in areas surrounding the river will be feasible if the bricks are transported using waterways.

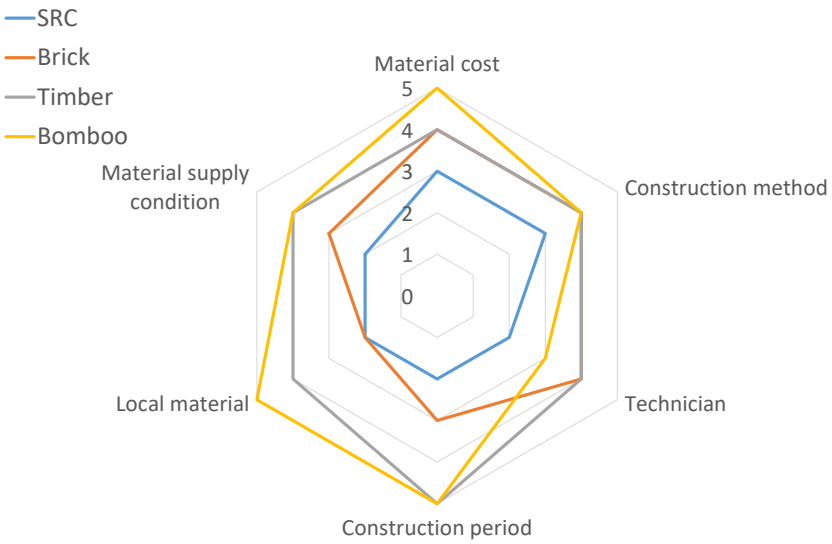


FIGURE 13 ECONOMIC FACTORS OF HOUSING CONSTRUCTION

3.2 FIRST FIELD SURVEY

Satkhira, Bagerhat, and Khulna were selected for the local residential environment survey at the request of the Ministry of Environment of Bangladesh. The main objective of the survey was to investigate the local environment for durable housing construction. The local environmental survey was conducted to examine various factors that can affect the durability of buildings, such as climatic and geographical conditions, current residential environment, preferred residential environment, and locally available construction materials and supply infrastructure. Survey lists in Table 2 were used to determine the requisite elements for the construction of houses that meet the durable housing guideline of the Bangladesh government as described above.

The village survey was conducted in at least six regions, and at least three villages were surveyed in each target region. The selected villages in each region were divided into the coastal or riverside areas, the isolated areas, and the hilly areas. The residents of the villages were initially expected to comprise between 50-100 households numbering over 200 people. After the local survey, however, it was found that the population density of the rural villages was so high that the survey was conducted in villages with at least 1,000 residents.

The reasons for classifying the villages from the coastal, remote, and hilly areas are as follows: 1) the factors affecting the results during rainfall can vary, 2) the shape of the ground in coastal or riverside areas is different from that of hilly areas, and 3) the content of sodium in groundwater may vary. The number of households was set to include between 50-100 to ensure appropriate representation of the average type of housing in the area.

TABLE 1 SELECTION CRITERIA FOR LOCAL SURVEY AREA

	Selection Criteria
Location of Target Villages	- Three villages in each target area in Bagerhat, Satkhira - Three different types of regions: coastal wetlands, flat land, and hilly land - Must investigate at least six villages in two regions
Scale of Surveyed Villages	- Household unit : 50-100 households - Population requirement : more than 200 people ※ It may not be possible to identify the structure of the village in the target area, but the smallest unit of village type should be selected. However, the composition of the housing should be in the form of villages, and the houses separated by a large distance should be excluded.

In the survey of the residential environment conducted during an on-site visit, the substandard level of infrastructure, such as the village size and roads, the composition of major soils, the salinity of soils and water quality, and the pH and salinity of the drinking water were measured.

In the case of the housing structure, the main structural components, wall materials, roof materials, and the size of the distributed houses were surveyed. The distance between houses, the accessible pathways, and the current status of prevention measures protecting against disasters such as floods and cyclones, were surveyed.

A survey was conducted to determine the location of restrooms, their distances from central buildings, and their effects on rivers or groundwater near the village.

TABLE 2 LOCAL HOUSING SURVEY LISTS

	Village Name
Village size	- Classification by population and household number
Accessibility of the village	- The distance from the nearest road upon which cars can may travel, to the center of the village
Composition of soils in the village area	- Major soil composition for local materials utilization
Salinity of soil and water	- Salinity of soils - Salinity of rivers and groundwater near the village
pH of drinking water and other water	- Salinity of stored water for drinking purposes (rainwater and groundwater)
system (Status of drinking water management)	- Storage method and management status of drinking water
Structure of housing	- Status of the main structure, wall, roof, and floor materials
Housing types	- House size (number of total rooms and living rooms)
Residential amenities	- Accessibility, individual drinking water supply system, etc.
Disaster prevention systems	- Status of disaster prevention systems against floods and wind for both houses and villages
Restroom	- Status of utilization and management of individual restrooms

3.2.1 VILLAGE KAYA BUNIA UNDER CHADPAI UNION, MONGLA UPAZILA, BAGERHAT-COASTAL AREA

- **Population and Number of Households**

The villages are sparsely located and separated from each other, and fisheries and aquaculture businesses are found along the rivers. They comprise a population of about 200 people and 30 to 40 households.

- **Accessibility of the Village**

Kaya bunia Village, which is located along the riverside of the Ruspa River, is more easily accessible via boat than land. Mongla Port, one of the largest ports in Bangladesh, is in the neighboring area, and various factories are nearby due to the deep river. However, this village is a relatively low-access village located over 30 minutes by boat from the factories.

Even when accessing the village using the river, there is no stable docking system. Although each individual household is adjacent to the river, when getting on and off the boat, there is considerable risk. The results from the analysis of accessibility, which used a satellite map, suggested that transporting materials by land is an option because there is a road between Mongla and Joymoni located 800m from the village; an unpaved road is located towards the rear portion of the village. However, since the roads are not in good condition, transporting materials via the water route is considered the most convenient approach in contrast to that by land.

Location of the village

Village gathering status

Houses near riverside

FIGURE 14 KAYA BUNIA VILLAGE

- **Capability of Utilizing Construction Materials Available Around the Village**

The materials for home improvement and new constructions can be supplied by either bringing them in from outside or by manufacturing and supplying them directly on-site using local materials. Typical locally available materials include mud for making bricks, rice straw for roofing and walls, Gol pata, and bamboo.

The area is near a river. In the marsh area, the main occupation is shrimp culture farming, and obtaining materials, such as rice straw and Gol pata, is difficult. Thus, it is not easy to build houses using materials obtained directly from the local area.

	
Aquaculture around the village	Submerged villages

FIGURE 15 VICINITY OF THE VILLAGE

- **Salinity and pH of Drinking Water / Rainwater Storage System**

The drinking water in the area comes from rainwater, which is contained in a storage device (a large jar) buried in the ground for each household. There is no separate water treatment system, and the average salinity is 0.01% with a pH in the range of 7.42 to 7.68, which is seemingly an acceptable range for drinking water.

	
Rainwater storage system	pH and salinity measurements

FIGURE 16 DRINKING WATER STORAGE SYSTEM AND SALINITY MEASUREMENTS

- **Structure and Form of Housing**

Most houses near rivers have roofs and walls made of rice straw and Gol pata. For structures that must withstand considerable force, bamboo is used. The houses in the inner areas located far from the rivers use SGI sheet and tin-based roofing materials; they are partially in

significant corrosion. The structure of the housing itself is not deliberate or a specific type, but rather takes the form of a temporary dwelling.

	
Condition of roofs and walls of housing	Composite wall structure

FIGURE 17 MAJOR STRUCTURE OF HOUSING AND UTILIZATION OF GOL PATA

- **Amenities**

The distance between houses is considerable, and some parts of the area are paved with bricks. However, the roads connecting the houses to the main road are in bad condition and are sometimes filled with water. Drinking water is contained in separate storage systems for individual households, and electricity is not supplied. Therefore, houses are powered by separate photovoltaic systems.

	
Passage between houses (brick pavement)	Integrated solar panel

FIGURE 18 STATUS OF WALKING PATHS AND AMENITIES (SOLAR PANELS)

- **Disaster Prevention Systems**

While this area is near the river, the risk of flooding and inundation is not high. Therefore, it takes the housing form against typhoons nearby water.

- **Restrooms**

Toilets drain directly into the river and are separate from the main structures.

Restroom configuration

FIGURE 19 ISOLATED RESTROOMS

3.2.2 VILLAGE SHALABUNIA UNDER CHADPAI UNION, MONGLA UPAZILA, BAGERHAT – COASTAL AREA

- **Population and Number of Households**

A collection of households forms a village near a river. The village type is separated from the main village. Fisheries and aquaculture businesses are located along the river and contain a population of about 200 to 300 people and 30 to 40 households.

- **Accessibility of the Village**

Shalabunia Village, located along the bank of the Ruspa River, is more easily accessible by boat than by land. The Bangladeshi coast guard, a gas reservoir, and a cement factory are distributed in the neighboring area. The inner section of the village is comprised of rice paddy fields. The main transportation method is by land using a road behind the village, and not by boat. It is possible to transport materials via the land route owing to the unpaved roads just behind the village. However, since the roads are not in good condition, transporting materials via the water route is considered the most convenient approach in contrast to that by land.

Location of the village

Village gathering status

	
Village docking system	Cement factory nearby

FIGURE 20 LOCATION AND VICINITY OF SHALABUNIAY

- **Capability of Utilizing Construction Materials Available Around the Village**

The rear section of the village is involved in rice and dry-field farming, and sands are extracted in the nearby cement factory area. In addition, many palm trees around the village provide Gol pata, and rice straw can be acquired after the rice has been harvested. During the visit, it was found that many houses had a Gol pata roof.

	
Houses in the village	Gol pata roof and bamboo wall configurations

FIGURE 21 VILLAGE HOUSING CONFIGURATION STATUS

- **Salinity and pH of Drinking Water / Rainwater Storage System**

Drinking water in the area comes from rainwater collected on the roofs. There were no purification processes or treatments for the water. The pH and salinity of the water were measured as 6.98 to 7.12 and less than 200ppm, respectively.

The salinity of the reservoirs in the village was found to be as high as 2,900ppm. Thus, using groundwater for drinking may have a detrimental effect on health.

	
Rainwater storage system	pH and salinity measurements

FIGURE 22 RAINWATER STORAGE SYSTEM AND THE HIGH SALINITY OF GROUNDWATER

- **Structure and Form of Housing**

More than 70% of the houses have roofs made of Gol pata, and zinc and slate roofs are also found. There are various types of housing structures. In the case of slate and zinc roofs, the indoor ceiling is either finished or substituted with a cloth. The purpose of these ceilings is to reduce the indoor heat in the zinc and slate structures, which have lower heat shielding ability compared to Gol pata.

	
Indoor ceiling structure of zinc roof	Gol pata roof structure

FIGURE 23 INTERIOR AND EXTERIOR STRUCTURES OF A HOUSE CEILING

- **Amenities**

The rainwater storage system is as large as $2m^3$, and the rainwater from the roof is automatically collected. Electricity is supplied and no photovoltaic power system is used. The indoor floors are relatively safely constructed; thus, there is no noticeable problem in commuting between houses.

	
Ceiling fan	Gol pata finish

FIGURE 24 INDOOR VENTILATION AND TEMPERATURE CONTROL SYSTEM AND ROOF PROTECTION

- **Disaster Prevention Systems**

The docking system for the waterways comprises a dam to prevent the flooding of rivers. The water level (height of the river) and the height of the village are the same and are separated by the dam.

- **Restrooms**

Restrooms are configured as individual restrooms.

3.2.3 VILLAGE KAMAL KATHI UNDER CHADPAI UNION, MONGLA UPAZILA, BAGERHAT – HILLY AREA

- **Population and Number of Households**

The village is located over 20 minutes away from the riverbank by car and its central area is accessible to vehicles. The village is not paved but the condition of the soil on the road is fairly good. The village population is about 2,500 people, and more than 100 households comprise the village. The main business is shrimp culture farming. A village hall and a local administrative unit are also included in the village.

- **Accessibility of the Village**

The road approaching the village has a width of 1.5 lines, so two vehicles from the opposite direction may pass each other at reduced speeds. The village is connected to the unpaved road about 10 minutes past the point at which the asphalt pavement ends, and both sides of the village access road comprise farms.

There are small reservoirs that can be used for drinking water in the center of the village, and houses are arranged around this reservoir. The roads in this area are composed of brick pavement.

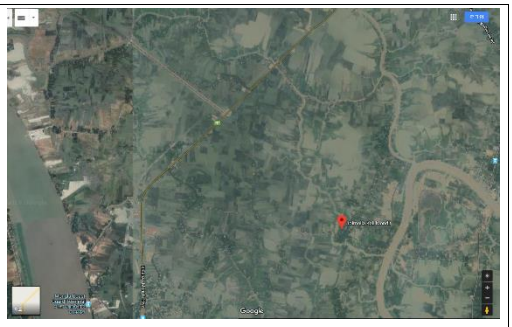
	
Location of the village	Village gathering status
	
Village entrance road	Central roads of the village

FIGURE 25 LOCATION AND ENTRANCE ROADS OF KAMAL KATHI VILLAGE

- **Capability of Utilizing Construction Materials Available Around the Village**

Most of the rear area of the village is used as an aquafarm, and other types of farming are not conducted. Palm trees and lush Gol pata trees are found in the village. While soil is easily found throughout the village, the organic contents are too high for its use in construction.

	
Soils in the village	Major housing configurations

FIGURE 26 SOIL TYPES IN THE VILLAGE AND MAJOR HOUSING CONFIGURATIONS

- **Salinity and pH of Drinking Water / Rainwater Storage System**

This village is unique in that it utilizes community drinking water. There is a reservoir storage container in the central part of the village that is shared by residents. The chloride content in the reservoir is measured as 900 to 1200ppm, which is drinkable, but has a higher content of chloride compared to general rainwater. The pH of the reservoir water is between

6.89 and 7.31. While this reservoir is a collection of rainwater for the community in the village, the reservoir has a relatively high chloride content due to the salinity of the soil. The salinity of reservoirs in the village was found to be as high as 2,900ppm. Thus, using the groundwater for drinking could have a detrimental effect on health.

	
Conversation with village residents	Village reservoir

FIGURE 27 DIALOGUE WITH VILLAGE RESIDENTS ABOUT THE SUPPLY SYSTEM FOR DRINKING WATER

- **Structure and Form of Housing**

Houses are made of a variety of materials. They use Gol pata, zinc, and slate for roofs, and Gol pata, masonry, and zinc for walls. They are composed of a greater variety of materials compared to other areas because cars can reach the central portion of the village.

	
The condition of the roof and walls of a house	Interior eaves and structure

FIGURE 28 IMPROVED HOUSE STRUCTURE AND COMPOSITION

- **Amenities**

One of the amenities, the artificial lake in the central part of the village, was installed by a foreign NGO organization. Rainwater is stored in this lake for later use. Although the water is stored for a long time, and the temperature and humidity are relatively high such that organic matters may grow, the residents were found to be using this water without a separate filtration system. Electricity is supplied to all regions in the village.

	
Passage between houses (brick pavement)	Solar integrated panel

FIGURE 29 IMPROVED EAVES AND MASONRY BRICK HOUSE

- **Disaster Prevention Systems**

Since the village was far away from the river, it was first thought that there would be no flooding. Surprisingly, however, the village receives a significant amount of water during the rainy season. Most of the houses in the village are built on a soil foundation 60-100 cm high to prevent water from flooding the house. Some houses are built on a concrete foundation. The houses built on a soil foundation have a vinyl finish on the outside to prevent its degradation.

	
Mud foundation with vinyl protection	Concrete foundation (disaster prevention)

FIGURE 30 CURRENT STATUS OF DISASTER PREVENTION SYSTEMS AGAINST THE FLOODING OF HOUSES

- **Restrooms**

Restrooms are configured as individual restrooms.


Restroom configuration

FIGURE 31 ISOLATED RESTROOM

3.2.4 VILLAGE KAMAL KATHI UNDER PABMAPUKUR UNION OF SHYAMNAGAR UPAZILA OF SATKHIRA - FLAT AREA

- **Population and Number of Households**

The village is located on the banks of the Kholpetua River, along which dozens of villages are located. About 200 to 300 people live in the village in approximately 60 households. They are engaged in fisheries and aquaculture as their main business. The village consists of independent buildings, such as a village hall, and is clean overall.

- **Accessibility of the Village**

The village is located between the Kholpetua and Kopothakho Rivers. Access to the central part of the village, Shyamnagr, must be achieved by boat, not by land; the latter is currently impossible due to the presence of rivers on either side of the land. The Kholpetua Riverbank consists of concrete revetment block, but many blocks are missing.

There are no difficulties with the berthing of a boat, but the facilities that people use to get on and off are very dangerous. It is connected to the villages along the river via the riverbank road, the height of which is estimated to be more than 2m. The roads in the village are not paved but do not interfere with commuting.

Location of the village

Village gathering status

Village entrance road

Central roads of the village

FIGURE 32 CURRENT STATUS OF KAMAL KATHI VILLAGE

■ **Capability of Utilizing Construction Materials Available Around the Village**

The rear area of the village is used as an aquafarm, and no other types of farming, such as rice paddy or field farming, are conducted. There are no soils in the village that can be used as a construction material, and bamboo, palm trees, and rice straws are not used either. In comparison to other villages, the composition ratio of slate and SGI sheet is higher.

	
Fishery	Cement mortar-finish wall

FIGURE 33 DAILY JOBS AND HOUSING STATUS IN THE VILLAGE

■ **Salinity and pH of Drinking Water / Rainwater Storage System**

There is no rainwater collection mechanism for individual households, and rainwater is not used for drinking. Groundwater is pumped from 70m underground and is used for drinking. The salinity of the water is 1700 to 4200 ppm, which is relatively high. The pH is 7.95 to 8.04, which is higher than previous Mongla villages. Based on drinking water standards, the alkaline level is slightly high.

	
Structure of slate ceiling	Dirt-finish floor

FIGURE 34 STATUS OF INDOOR CEILING AND FLOOR STRUCTURES

■ **Structure and Form of Housing**

A variety of materials, such as Gol pata, slate, zinc, and slabs, are combined and used for different roof structures. The wall structure is also varied, and structures comprising woven bamboo, cement mortar finish, soil finish, and brick masonry are found.

Some houses have wall cladding comprised of mud mixed with rice straw and leaves, as well as a double roof structure made of bamboo and Gol pata. The roofs made of slate, tin-plate, or SGI sheet have a ceiling with a cloth or a board, which is intended to block the heat.

	
Gol pata roof eaves	Slate roof eaves

FIGURE 35 CONFIGURATION OF EAVES ACCORDING TO MATERIAL TYPES

- **Amenities**

There is a village community building just below the riverfront docking system, and a riverbank that allows commuting between neighboring villages. Although commuting by car is not possible, the operation of motorcycles and bicycles is an option. Electricity is supplied, and some households have a ceiling fan to control heat.

	
Village community space (village hall)	Ceiling fan

FIGURE 36 RESIDENTIAL AMENITIES

- **Disaster Prevention Systems**

To prevent the flooding of the Kholpetua River, a dam was constructed. However, the revetment blocks have collapsed and are not functioning. They are composed of rectangular blocks, rather than those which interlock; thus, when the lower blocks are lost in the river, the upper blocks also collapse. The house has a soil foundation of 80 ~ 100cm and the floor inside the house is mostly soil.

	
Status of revetment block	Condition of soil foundation for flood prevention

FIGURE 37 STATUS OF THE DISASTER PREVENTION SYSTEMS OF THE VILLAGE AND INDIVIDUAL HOUSES

- **Restrooms**

Restrooms are configured as individual restrooms, and each household has one restroom.

Restroom configuration

FIGURE 38 ISOLATED RESTROOM

3.2.5 VILLAGE NORTH JHAPA UNDER PABMAPUKUR UNION OF SHYAMNAGAR UPAZILA OF SATKHIRA – FLAT AREA

- **Population and Number of Households**

The village is located on the banks of the Kholpetua River, along which dozens of villages are located. About 1,000 people live in the village, comprising approximately 200 households. They are engaged in fisheries and aquaculture as their main business. They have a more organized layout compared to other villages.

- **Accessibility of the Village**

The village is located between the Kholpetua and Kopothakho Rivers. To access Shyamnagr, which is the central part of the village, a boat must be used, as it is impossible to get there by land due to the presence of a river on either side of the land.

Difficulty is expected when berthing the boat, and for those who are not accustomed to getting on and off the boat, they run the risk of falling off. It is connected to the villages along the river via the riverbank road. The height of the riverbank is 2m or higher. The roads in the village are not paved but do not interfere with commuting.

It connects the villages along the riverbank in the village, and the height of the riverbank is estimated to be over 2m. The roads in the village are not paved but do not interfere with commuting.

Location of the village

Village gathering satus

Village entrance road

Village dock

FIGURE 39 CURRENT STATUS OF KAMAL KATHI VILLAGE

- **Capability of Utilizing Construction Materials Available Around the Village**

In the central part of the village, Gol pata can be acquired from many trees. Since most of the rear area conducts aquaculture, it is difficult to obtain soil. Bamboo, palm trees, and rice straws are not used either. In comparison to other villages, the composition ratio of slate and SGI sheet is higher.

	
Slate roof	Roads inside the village

FIGURE 40 MAIN CONSTRUCTION MATERIALS IN THE VILLAGE

- **Salinity and pH of Drinking Water / Rainwater Storage System**

This village has a community water treatment system, known as a RO-System, installed in the central part of the village to purify the groundwater for drinking. As there is no separate supply system, drinking water is transported by individuals. Water quality management is regularly conducted by NGOs, and the salinity level at the last visit was in the range of 500 to 1500 ppm; the pH was stable at 6.74 to 6.95.

	
Clay wall using rice straw	Baked tile roof

FIGURE 41 MAIN CONSTRUCTION MATERIALS OF HOUSES

- **Structure and Form of Housing**

There are a variety of housing forms throughout the village, including bricks, reinforced concrete structure, slate structure, and masonry. A variety of roofing materials are also available, such as burned tiles, slate, Gol pata, and concrete tile. Houses throughout the village are well-maintained. The walls are made of clay, and some sections are missing. However, houses in the village are in overall good condition.

	
Status of well-maintained village housing	Concrete houses

FIGURE 42 STRUCTURE OF THE VILLAGE

- **Amenities**

The foremost amenity of the village is its water treatment system. An NGO installed the system and has been conducting proper management of the water quality and pH level on a regular basis. However, since there is no separate supply system, individuals bring water in and fill the storage container. Electricity is supplied.

	
Community water treatment plant	Water treatment system

FIGURE 43 STATUS OF THE COMMUNITY WATER TREATMENT SYSTEM

- **Disaster Prevention Systems**

Revetment blocks near the river are washed out. The height of the soil intended for flood prevention is as low as 30 cm.

	
Internal water discharge system	Status of soil blocks against flooding

FIGURE 44 CURRENT STATUS OF DISASTER PREVENTION SYSTEMS OF THE VILLAGE AND INDIVIDUAL HOUSES

- **Restrooms**

Restrooms are separated from one another, and one toilet is used for each house.

3.2.6 VILLAGE DURGABATI UNDER BURIGOALINI UNION OF SHYAMNAGARUPAZILA OF SATKHIRA - COASTAL AREA

- **Population and Number of Households**

The village is located on the banks of the Kholpetua River. Unlike the previous two villages, it is connected to other areas by land. The village is relatively more accessible and has roads that allow cars to reach the village entrance. There are more than 1,500 people living in the village, comprising of more than 200 households.

- **Accessibility of the Village**

The Kholpetua River dock is in very dangerous condition due to the loss of the surrounding revetment blocks. The loss of blocks is very severe, and the surface is too smooth to allow for safety when walking. However, the rear area of the village is well-maintained owing to the road to Shyamnagr, and the road condition is good enough to allow a small truck to operate. The road conditions in the village are stable, and people traveling on foot and via motorcycle can be easily found.

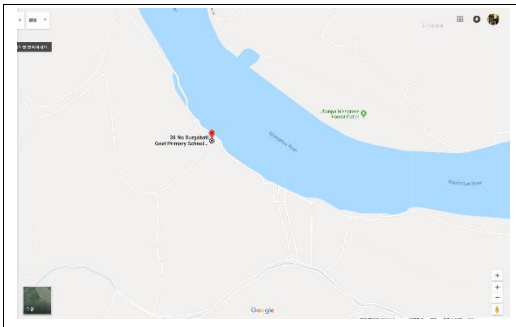
	
Location of the village	Village gathering status
	
Hindu temple	Village hall

FIGURE 45 CURRENT STATUS OF DURGABATI VILLAGE

- **Capability of Utilizing Construction Materials Available Around the Village**

Except for the central part of the village, obtaining soil is difficult because aquafarms are operated, similar to other areas. It is not possible to obtain rice straw, trees, Gol pata, or bamboo locally. Due to the good road connections, however, bringing materials into the village from the outside can be easily accomplished.

	
Masonry and slate structure	Status of wall composition

FIGURE 46 STATUS OF MAJOR HOUSES OF THE VILLAGE

- **Salinity and pH of Drinking Water / Rainwater Storage System**

To obtain drinking water, rainwater is stored using a scientific system. The pH of the water ranges between 6.56 and 6.72, and salinity is under 100ppm, which is harmless. Individual houses have their own rainwater storage.

	
Rainwater storage system	Rainwater storage system

FIGURE 47 RAINWATER STORAGE SYSTEM FOR INDIVIDUAL HOUSES

- **Structure and Form of Housing**

Housing in this village is composed of various forms and materials and features some interesting types of structures: there is a two-story reinforced concrete building, and a variety of structure types—including brick, masonry, and wood—for houses. Roof materials used in the area include zinc and slate. Other materials, such as Gol pata, which are easily found in other villages, are not available here.

	
Structure of a wall	Again of red bricks and pillars

FIGURE 48 STRUCTURE AND FORM OF HOUSING

■ **Amenities**

Electricity is supplied, and rainwater is stored and utilized. Moreover, there is a manual pumping system to draw groundwater.

	
Indoor ceiling structure	Village hall

FIGURE 49 INDIVIDUAL HOUSING AND VILLAGE COMMUNITY AMENITIES

■ **Disaster Prevention Systems**

Revetment blocks near the river are washed out. The height of the soil for flood prevention is as low as 30 cm.

	
Collapsed revetment blocks	A pond next to a house

FIGURE 50 AGING OF THE DISASTER PREVENTION SYSTEMS

■ **Restrooms**

Restrooms are separated from one another, and one toilet is used for each house.

3.3 FIELD STUDY – LOCAL INFRASTRUCTURE CONSTRUCTION MATERIALS

The materials required for housing construction can be divided into two types according to their supply: self-supply using local materials, and supply through the external construction materials market. As housing construction in the Southern coastal region of Bangladesh is not active and most of the construction is on a low-income housing scale, there is no market available at present for the supply of various construction materials. However, many of the sintering burned brick factories scattered throughout Bangladesh are located in the region, and high-quality bricks are produced in cement brick factories in the Khulna area, which can be considered the heart of the region.

Priority should be given to the construction of road infrastructure to facilitate the supply of construction materials, although the region is scarcely accessible, with the exception of some areas.

3.3.1 CITY TILES AND THE CITY CERAMIC COMPANY

In Southern Bangladesh, the supply infrastructure is not fluid due to the lack of demand for construction materials. In particular, Bagerhat and Satkhira are close to the southern coast; in this area, housing is not built using industrialized construction materials, but rather using local materials, such as golpata, bamboo, and straw. The most commonly used industrial products are SGI sheet, slate, and brick.

The cement brick factory in the Khulna region has produced various types of cement secondary products, such as cement bricks, regular blocks, and interlocking blocks. In addition, it produced the wall finishing material and floor material using cement paste alone, while maintaining good product quality.

- **Cement Secondary Products**

Cement bricks and blocks typically have the dimensions of the international standard. The factory was producing the same cement bricks and perforated bricks as Korea and other countries, as well as the same type of interlocking blocks as Korea.

It is common to use cement and fine aggregates for cement bricks. This particular factory uses cement, sand, and crushed stone powder instead of fine aggregates. The Khulna University inspects the quality of the product in order to manage its compressive strength.

There are many cement manufacturers in Bangladesh, but they all assume the role of suppliers by importing clinker from foreign countries and then pulverizing it. Although the

four main cement manufacturers of the world have entered this market, cement prices are still higher in comparison with other countries and the national income. Cement prices exceed 100 dollars per ton, and the prices of bricks and blocks produced are higher than in other countries (the price of perforated block is 42 taka per unit, the price of cement brick is 12 taka per unit, and the price of interlocking block is 22 taka per unit).

Due to the nature of cement products, logistics costs are also high. Therefore, it is impossible to use cement bricks for the expansion of contraction of full-income households. However, since the cost of labor is relatively low, most construction costs are offset by the cost of construction labor. In metropolitan areas such as Dhaka, constructions using brick masonry have been common due to these reasons.

The City Tiles & City Ceramic Company, which has been visited by the research group, are capable of producing various products related to cement secondary products and of various types and designs, as well as have inventories of various molds. The company uses vibrational molding machines in the process of producing cement blocks, although products such as floor finishes are mainly produced by manual work.

FIGURE 51 BRICK MANUFACTURING PROCESS

FIGURE 52 BRICK MANUFACTURING PROCESS BY VIBRATIONAL MOLDING

FIGURE 53 SOLID BRICK PRODUCTION

FIGURE 54 BRICK FORMING MOLD

FIGURE 55 FLOOR MOLDING RESIN

FIGURE 56 MOLDED PRODUCT

FIGURE 57 VARIOUS MOLDING PRODUCTS

3.3.2 VISIT TO THE LOCAL FACTORY OF SINTERED BRICK AND ROOF TILES IN THE SATKHIRA REGION

There are several brick factories across Bangladesh, most of which produce sintered bricks and is considered the main cause of environmental pollution, as such factories use coal or wood materials as fuel. As Bangladesh's atmospheric conditions are the worst in the world, the number of factories is beginning to decline gradually, starting with factories near the capital Dhaka.

The reason for the abundance of sintering brick factories in Bangladesh is the use of sintered bricks as an alternative to the scarcity of coarse aggregate. The sintered brick crushed in 25 to 45mm aggregate is used as substitute for coarse aggregate.

The research group has also visited many sintering brick factories in the Bagerhat and Satkhria regions, where it was common to see piles of bricks on the streets.

- **Flooring and Sintered Roof Tile Production Plants**

There are many factories of sintering brick between Satkhria and Jessore. Among the many factories, KICT visited a factory specializing in roof tiles and flooring materials, in addition to sintered bricks. This factory uses local clay to produce a variety of flooring, tiles, and other interior building materials.

FIGURE 58 SITE OF PLASTIC ROOF MATERIALS

FIGURE 59 COAL-FIRED POWER BRICK PLANT

Professional factories produce roof tiles and other products using coal, which is the same form as ordinary sintered bricks, while factories specializing in small roof tiles and flooring materials produce products by hand. A compact manual press is used to mold the product by putting the clay that has been assembled into a particular mold frame in advance, and the product is fired in a kiln (firing furnace) using wood. The mold used to shape the roof tiles was a wooden frame, and the tiles were fired for six hours in a furnace after 24 hours of drying indoors, following the press molding.

FIGURE 60 CURING AFTER MOLDING (LEFT AT ROOM TEMPERATURE FOR TWO DAYS)

FIGURE 61 MOLDING PRESS (MANUAL WORK)

The factory produces various types of products for flooring and walls. For flooring, various interlocking products are made. Although the productivity is not high as the overall process is done through manual labor, the factory has a competitive edge due to low labor costs, ease of supply of raw materials, and availability of wood to be used as fuel.

Almost all brick factories in the surrounding areas merely produce bricks. However, this factory produces a variety of products that can be used from Satkhria to Jessore, thus showing competitiveness.

FIGURE 62 FUEL FOR FIRING (WOOD)

FIGURE 63 COLOR OF BRICK BEFORE AND AFTER FIRING

The visit to the cement brick factory in the Khulna region and the sintering production factory in the Satkhria region revealed that they are producing basic products for housing construction using local materials. We were also informed that there are many other similar factories scattered throughout the region.

In other words, as the surveyed products are not used as high-grade building materials but rather as materials for general housing construction, it is believed that they can be used for home improvements in the visited area by using the products produced locally.

Particularly, in the case of the Hurka area of the Khulna region and the Durgabati area of the Satkhria region, considering that cars can enter the village, it is believed that basic housing construction is available using these locally produced materials.

3.4 SECOND FIELD TRIP SURVEY[11]

The purpose of this field survey is to understand of the characteristics and problems of local housing structures, investigation of residential environmental conditions such as local

[11] Friendship, Feasibility study report, 2018

temperature, humidity and soil etc., Investigation of infrastructure for building improvement, direction of residential improvement through this study.

Table 3 summarizes the field survey information and sources:

TABLE 3 SUMMARY OF THE FEASIBILITY SURVEY INFORMATION AND SOURCES

Evaluation Question	**Information area/Indicators**	**Source**
Understand, analyze, and report the feasibility study	Main structural type of housing (wood, masonry, soil erection etc.) - Analysis of the major causes of aging housing (analysis of causes e.g. Salt and weathering etc.) - Analysis of aging type (size and shape of cracks, size and shape of exfoliations etc.) - Current status and maintenance of old structure - Status of internal space division (average area and number of rooms) - Presence of floor and ceiling (ceiling finish) - Difference in heights between the main building and the ground (presence of canopy) -Average number of residents (survey on family composition) - Fuel usage patterns for meals - Exhaust and ventilation methods - Configuration and materials of windows and doors - Sleeping type (floor, bed, etc.) - Indoor finishing (cement, soil, wood, tree branches, etc.) - Indoor floor finishing (soil, cement, wood, board, tile, etc.)	- Villagers (who belongs there more than 10 years) - Local leaders like elected public representative -Expert on Housing of Southern Bangladesh (academician, researcher, engineer etc.)

	-Use of water (water supply or direct use of underground water) - Electricity supply (voltage and main use electrical appliances) - Location and type of toilet (indoor, outdoor)	

GEOGRAPHIC LOCATION

Three locations (three villages) on each district of Bagerhat and Satkhira, which were pre-visited jointly by the KICT and Friendship team were included in this survey. These areas belong to southern coastal part of Bangladesh. Every location was tracked through GPS.

SITE SELECTION

Simple random selection technique was used for selecting the villagers and their houses from the respective villages. For each village 100 villagers and their houses were selected, so total 600 hundred villagers were through this simple random sampling.

TABLE 4 VILLAGE PROFILE

Village Name	**Uttar Japa**	**Durgabati**	**Kamalkathi**	**Hurka**	**Keyabunia**	**Selabunia**
Union	Poddopukur	Buri Goyalinoi	Poddopukur	Hurka	Chila	Burirvanga
Upazila	Shyamnagar	Shyamnagar	Shyamnagar	Rampal	Mongla	Mongla
District	Satkhira	Satkhira	Satkhira	Bagerhat	Bagerhat	Bagerhat
GPS_E	89.21326	89.22946	89.21326	89.63467	89.61796	89.57381
GPS_N	22.33638	22.28128	22.33638	22.566	22.4207	22.54982
Households	450	469	420	230	150	153
Population	2600	2700	2450	1060	650	1000
Shelter	Yes	Yes	No	No	No	Yes
Shelter Capacity	500	400				
Mobile Accessibility	No	Yes	No	No	No	No

Mode of easy Accessibility	By Road and water way	By Road and water way	By Road and water way	By Road	By Road and water way	By Road and water way
Distance from main road {in KM}	3	3	2	7	5	3
Road Pavement	Yes	Yes	Yes	Yes	Yes	Yes
Approach road width {in Meter}	3	4	1.8	3.7	1.2	1.8
Average width of main road {in Meter}	9	9	9	8	7	8

Cyclone Shelter

In a total of six villages in the study area only three villages (Uttar Japa, Durgabati, Selabunia) have a cyclone shelter.

Mobile and Mode of Easy Accessibility

Among the six other villages only Durgabati has a mobile network accessibility. The mode of accessibility of every village is mainly by road and water. Hurka of Bagerhat district has road access only. It is observed that every village has a pavement.

Village Distance from the main road in KM

On an average approximate driving distance between Villages and Main Road is 3.8 kms. Maximum distance between Hurka village and the main road is 7 kms. Travel time refers to the time taken if the distance is covered by a car or a boat.

Approach road width:

Approach road width is differed village to village, maximum approach road width is 4 meters in Durgabati village and minimum approach road width is 1.2 meters in Keyabunia village.

Average width of main road:

The average width of the main road in meter gets presented in the table. The height, width of the road is 9 meters observed in three areas, which are Durgabati, Uttar Japa and Kamalkathi.

Family Profile:

TABLE 5 FAMILY PROFILE

Profile	Average	Maximum	Minimum
Family Size	4.19	10	1
Male child	1.35	7	1
Female child	1.45	5	1
Yearly Income	82556 BDT	180000	3600

According to the 2011 national census, the average household size is 4.4 in Bangladesh. The average household size in the survey area is 4.19 which were less than the national average. The average female child size is 1.45 whereas male child size is 1.35.

In survey analysis, it is noticed that the surveyed household average yearly income (considering Farming, non-farm and both farming and non-farming) is about BDT 82556.00.

Housing Area:

Most of the survey dwellers live in a small area. The mean housing area of the survey area was 95.75 square meters and the median was 82.11 square meters.

House Structure Type:

TABLE 6 HOUSE STRUCTURE TYPE

Type	Frequency (N)	Percent (%)
Bamboo	26	4.3
Bamboo and Golpata	19	3.2
Bamboo and Mud	2	0.3
Bamboo and Tin	10	1.7
Bamboo, Mud and Golpata	5	0.8
Bamboo, Mud and Tin	3	0.5

Brick	28	4.7
Brick and Asbestos	1	0.2
Brick and Bamboo	1	0.2
Brick and Mud	3	0.5
Brick and Tin	1	0.2
Brick and Wood	2	0.3
Brick, Wood and Tin	3	0.5
Concrete	45	7.5
Concrete and Bamboo	3	0.5
Concrete and Brick	6	1.0
Concrete and Mud	2	0.3
Concrete and Tin	1	0.2
Concrete and Wood	16	2.7
Concrete, Brick and Asbestos	1	0.2
Concrete, Brick and Wood	1	0.2
Concrete, Wood and Mud	1	0.2
Golpata	2	0.3
Mud and Golpata	58	9.7
Mud and Tin	6	1.0
Tin	20	3.3
Wood	88	14.7
Wood and Bamboo	13	2.2
Wood and Golpata	18	3.0
Wood and Mud	11	1.8
Wood and Tin	81	13.5
Wood, Bamboo and Asbestos	1	0.2
Wood, Bamboo and Golpata	19	3.2
Wood, Bamboo and Mud	19	3.2
Wood, Bamboo and Tin	72	12.0
Wood, Mud and Asbestos	1	0.2
Wood, Mud and Golpata	2	0.3
Wood, Mud and Tin	8	1.3
Wood, Tin and Golpata	1	0.2
Total	**600**	**100.0**

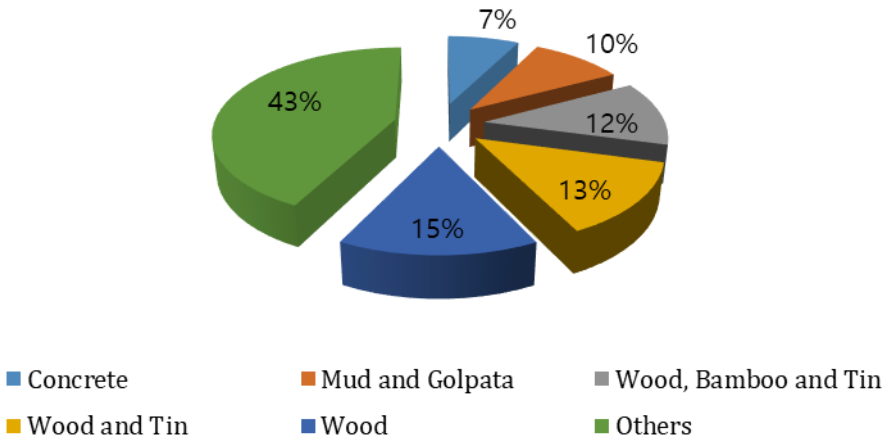


FIGURE 64 HOUSE STRUCTURE TYPE

In the survey area the basic form of the house was a cluster of small 'shelters' of, huts around a central yard, locally called the 'Uthan'. The huts are usually single roomed, detached and loosely spaced around the central courtyard. Usually kitchen is not attached to house. From the table it can been noticed that the dwellers of the area used different type material to build the basic structure of their houses, such as Golpata leaves, brick, bamboo, wood, mud, asbestos, concrete and corrugated iron sheets as roofs. Among the 600 house 88 (14.7%) house's structure were made of wood, 81 (13.3%) made of both wood and tin, and 72 (12%) made of bamboo, wood and tin.

Room Number Excluding the Kitchen:

TABLE 7 ROOM NUMBER EXCLUDING THE KITCHEN

Room Number	**Frequency (N)**	**Percent (%)**
1	424	70.7
2	134	22.3
3	34	5.7
4	6	1.0
5	2	0.3
Total	600	100.0

It has been noticed that 70.7% of dwellings had one room (Table 7). 22.3% of respondents had two rooms in their houses.

Number of Window in the House:

TABLE 8 NUMBER OF WINDOW IN THE HOUSE

Number of Window	Frequency (N)	Percent (%)
0	128	21.3
1	39	6.5
2	132	22.0
3	71	11.8
4	130	21.7
5	33	5.5
6	35	5.8
7	8	1.3
8	9	1.5
9	4	0.7
10	6	1.0
11	1	0.2
12	3	0.5
15	1	0.2
Total	600	100.0

It has been noticed that 21.3% of houses did not have any window in their houses (Table 8). 22% of houses had two windows in their house and 21.7% of houses had 4 windows in their house. It is also found that 11.8% of houses had 3 windows.

Total Window Area

TABLE 9 TOTAL WINDOW AREA

Total Window area (Square meter), N= 600	
Mean	6.94
Median	4.88

The mean and median for the window area were 6.94 square meters and 4.88 meters respectively.

Way of closing the window:

TABLE 10 WAY OF CLOSING THE WINDOW

Methods	Frequency (N)	Percent (%)
Hinge (Kopat)	160	33.9
Open and Tied up	184	39.0
Scatter (Chitkani)	122	25.8
Other	6	1.3
Total	472	100.0

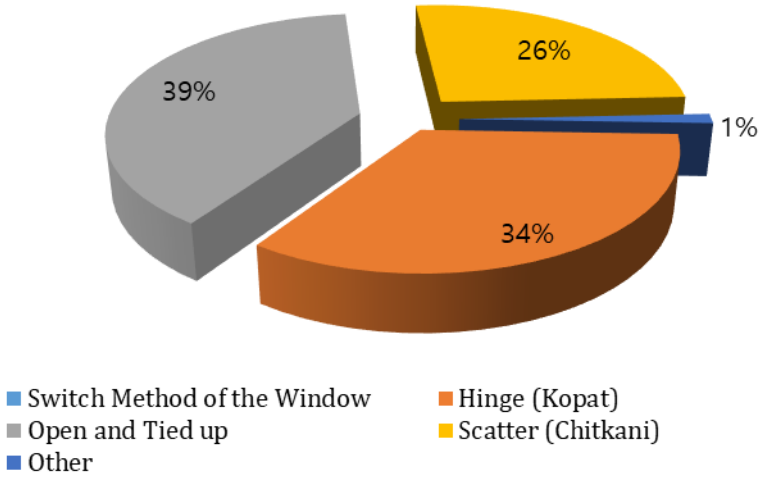


FIGURE 65 WAY OF CLOSING THE WINDOW

Different types of switch method of the window were observed in the study area. About 34% of dwellings used Hinge to lock windows whereas 39% of dwellings used the facility of Open and Tied up for their window. 26% of respondents used scatter for the window to lock or unlock windows.

Ground to Floor (Plinth of House) Height:

TABLE 11 GROUND TO FLOOR (PLINTH OF HOUSE) HEIGHT

House to floor (plinth) height (in meter), N= 600	
Mean	0.64
Median	0.61

Regarding the height of the plinth of respondent houses, the average of plinth height was 0.64 meters.

Position of Kitchen

It is found that 62.2% of dwellings had detached kitchens and 37.8% of dwellings had attached Kitchen.

TABLE 12 POSITION OF KITCHEN

Position	Frequency (N)	Percent (%)
Attached	227	37.8
Detached	373	62.2
Total	600	100.0

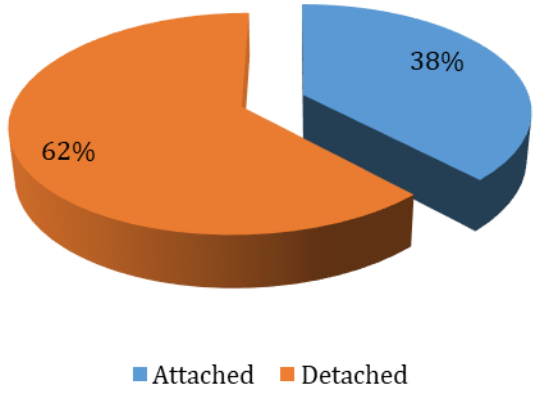


FIGURE 66 POSITION OF KITCHEN

Facade of the House:

TABLE 13 FACADE OF THE HOUSE

Facing	Frequency (N)	Percent (%)
North	39	6.5
South	395	65.8
East	121	20.2
West	45	7.5
Total	600	100

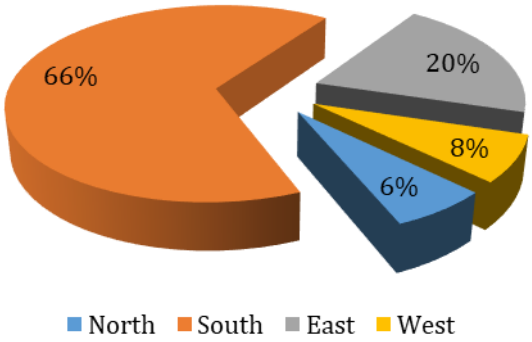


FIGURE 67 FAÇADE OF HOUSE

It is observed that 65.8% of dwellings faced to the South, and 20.2% of dwellings faced to the East. 7.5% and 6.5% of dwellings faced to the West and the North respectively.

Ventilation:

TABLE 14 VENTILATION

Passage for Ventilation	Frequency (N)	Percent (%)
Yes	420	70
No	178	29.7
No response	2	0.3
Total	600	100

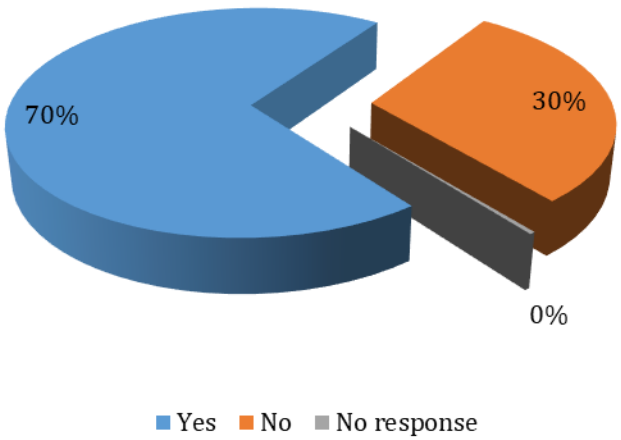


FIGURE 68 VENTILATION

Regarding enough passes for ventilation, most of the participants, which correspond 420 (70%) dwellings, mentioned about existence of enough passes for ventilation.

Use of Technology for ventilation:

TABLE 15 USE OF TECHNOLOGY FOR VENTILATION

Technology	Frequency (N)	Percent (%)
Electric Fan	5	0.8
Nothing	588	98.0
Others	7	1.2
Total	600	100.0

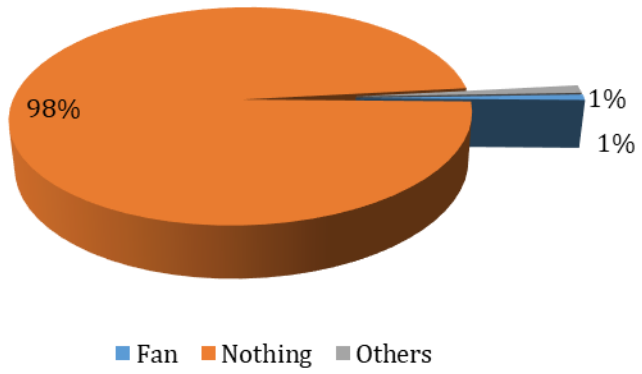


FIGURE 69 USE OF TECHNOLOGY FOR VENTILATION

Almost no one uses mechanical ventilation during hot days. People depended on natural ventilation as 98.0% of the respondents mentioned that they didn't use any ventilation technology. 1.2 % of the respondents mentioned that they used other options for the ventilation like handmade fans. 0.8% of the respondents mentioned electric fans as a technology for ventilation.

Materials of Roofs of houses:

TABLE 16 MATERIALS OF ROOFS OF HOUSES

Materials	Frequency (N)	Percent (%)
Asbestos	112	18.7

Asbestos and Tali	1	0.2
Asbestos and Tin	1	0.2
Bamboo	9	1.5
Bamboo and Tin	8	1.3
Concrete	28	4.7
Concrete and Tin	4	0.7
Concrete and Wood	1	0.2
Conctrete and Tali	1	0.2
Golpata/Straw	107	17.8
Golpata/Straw and Asbestos	16	2.7
Golpata/Straw and Bamboo	15	2.5
Golpata/Straw and Tali	2	0.3
Golpata/Straw and Tin	15	2.5
Golpata/Straw and Wood	8	1.3
Golpata/Straw, Bamboo and Tin	3	0.5
Golpata/Straw, Wood and Bamboo	2	0.3
Golpata/Straw, Wood and Tin	2	0.3
Tali	12	2.0
Tali and Tin	1	0.2
Tin	122	20.3
Wood	28	4.7
Wood and Asbestos	1	0.2
Wood and Bamboo	3	0.5
Wood and Tali	3	0.5
Wood and Tin	39	6.5
Wood, Bamboo and Tin	56	9.3
Total	600	100.0

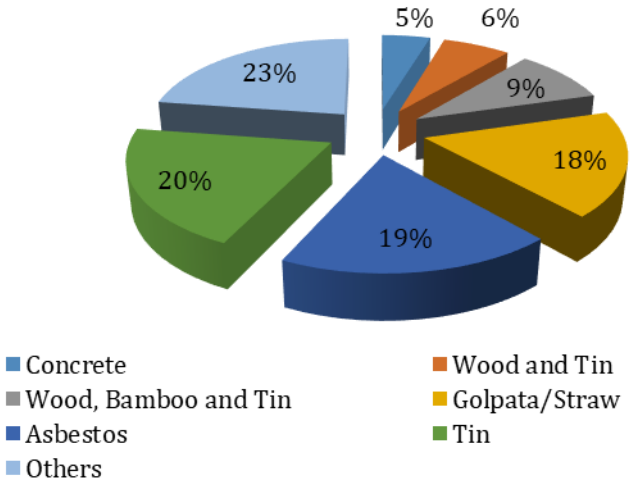


FIGURE 70 MATERIALS OF ROOFS OF HOUSES

It can be noticed that the dwellers of the area used different types of materials to build the roof of the house, such as Golpata leaves/straw, brick, bamboo, wood, mud, asbestos, concrete and corrugated iron sheets (Table 16). Among the 600 houses, 122 (20.3%) dwelling roofs were made of tin, 112 (18.7%) dwelling roofs were made of asbestos and 107 (17.8%) dwelling roofs were made of Golpata /straw.

Materials of the Floors of the houses:

TABLE 17 MATERIALS OF THE FLOORS OF THE HOUSES

Materials	Frequency (N)	Percent (%)
Brick	15	2.5
Concrete	45	7.5
Mud	540	90
Total	600	100.0

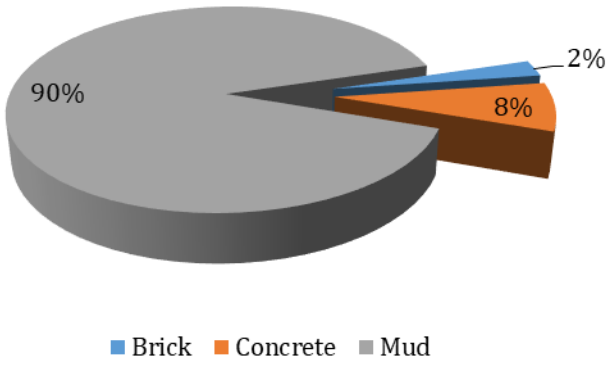


FIGURE 71 MATERIALS OF THE FLOORS OF HOUSES

90% of the respondents had house floors built with mud whereas 7.5% were with concrete and 2.5% were with bricks.

Materials of Inner Walls of Houses:

TABLE 18 MATERIALS OF INNER WALLS OF HOUSES

Materials	Frequency (N)	Percent (%)
Bamboo	45	7.5
Brick	16	2.7
Concrete	37	6.2
Concrete and Brick	1	0.2
Concrete and Tin	1	0.2
Golpata	9	1.5

Mud	127	21.2
Mud and Bamboo	26	4.3
Mud and Brick	1	0.2
Mud and Golpata	2	0.3
Mud and Tin	4	0.7
Mud and Wood	16	2.7
Tin	49	8.2
Tin and Bamboo	3	0.5
Tin and Golpata	45	7.5
Wood	75	12.5
Wood and Bamboo	10	1.7
Wood and Brick	1	0.2
Wood and Golpata	16	2.7
Wood and Tin	116	19.3
Total	600	100.0

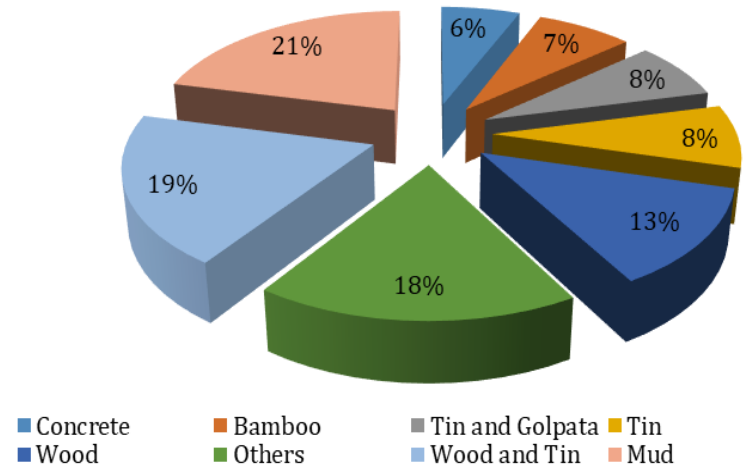


FIGURE 72 MATERIALS OF INNER WALLS OF HOUSES

As can be seen from houses' structural materials, dwellers in the survey used different types of materials for the inner walls of their houses. Observed materials are Bamboo, Brick, Concrete, Golpata, Mud, Brick, Tin, Golpata and so on. Among these mentioned items mud was the most commonly used for the inside walls.

Window Materials:

Approximately 87.3% of the window frames of dwellings were made of wood whereas approximately 8.5% of window frames were made of Bamboo. The composition of bamboo and wood is used in 1.5% of window frames of houses.

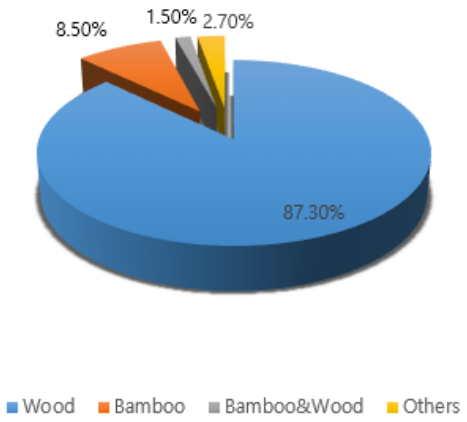


FIGURE 73 WINDOW MATERIALS

Cracks in Roofs:

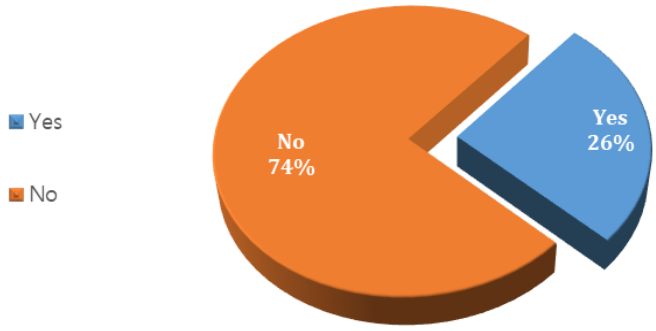


FIGURE 74 CRACKS IN ROOFS

It is found that 74% of roofs of houses were not in good condition, which means that there are cracks in the roof causing leakages. The rest of the roofs of houses were free from cracks, damage and leakages.

Number of Cracks in Roof:

About 37% of dwellings had one crack in their roof and 16.1% of dwellings had two cracks in their roof. The rest of the houses had three to fifty cracks.

TABLE 19 NUMBER OF CRACKS IN ROOF

Number of Cracks	Frequency (N)	Percent (%)
1	57	36.8
2	25	16.1
3	28	18.1
4	11	7.1

5	3	1.9
6	4	2.6
7	6	3.9
8	1	0.6
9	3	1.9
10	3	1.9
12	1	0.6
20	3	1.9
20	1	0.6
22	1	0.6
25	4	2.6
30	1	0.6
50	3	1.9

Reasons of Cracks in the roofs

Figure 75 presents the reasons for the cracks in the roof. The highest number of respondents (41.3%) indicated that decay was the reason for cracks whereas 38.7%, 30.3%, 23.2%, 0.6% were due to salinity, cyclones, the use of low quality materials and tidal-surges respectively. The rest of the respondents (5.2%) indicated other reasons.

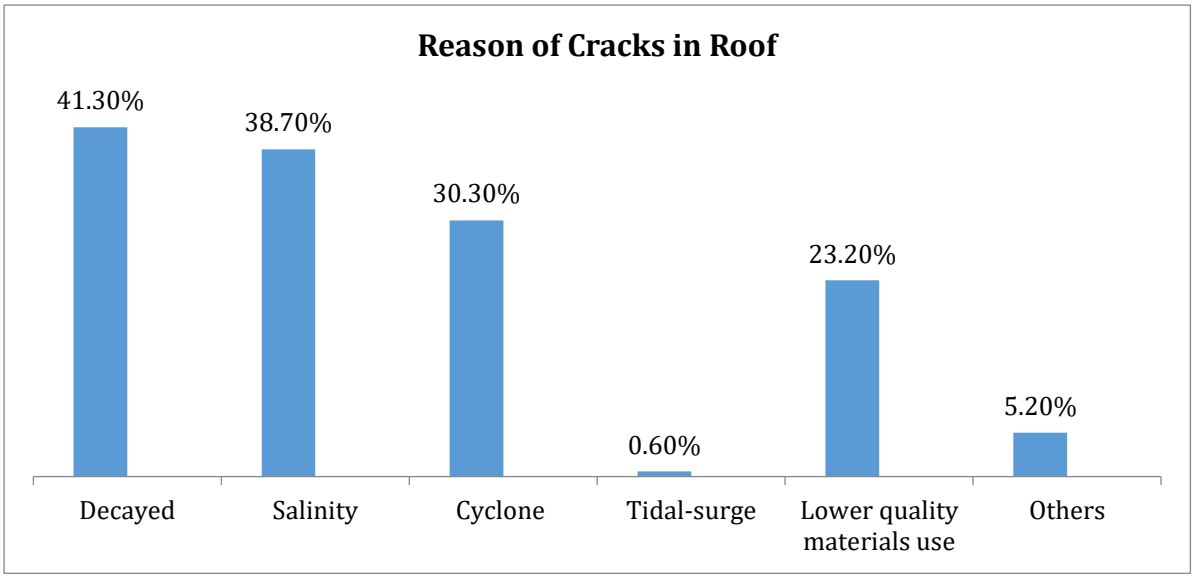


FIGURE 75 REASON OF CRACKS IN ROOF

Cracks in the Walls:

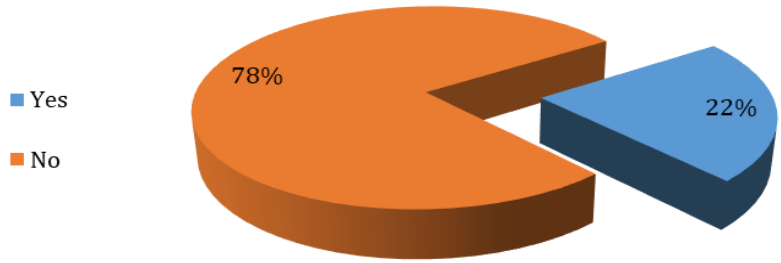


FIGURE 76 CRACK IN THE WALLS

It is found that 78% of the surveyed dwellings did not have any cracks in the walls. 22% dwellings had cracks in the walls.

Number of Cracks in a Wall:

Maximum number of dwellings (24.4%) had one cracks at their wall. 19.3% of dwellings had 2 cracks whereas 14.8% of dwellings had three cracks at their wall.

TABLE 20 NUMBER OF CRACKS IN A WALL

Number of Cracks	Frequency (N)	Percent (%)
1	33	24.4
2	26	19.3
3	20	14.8
4	10	7.4
5	11	8.1
6	3	2.2
7	4	3.0
8	5	3.7
10	2	1.5
12	4	3.0
13	1	0.7
14	1	0.7
15	2	1.5
20	3	2.2
25	2	1.5
30	1	0.7
Total	135	100

Reason of the cracks in Wall:

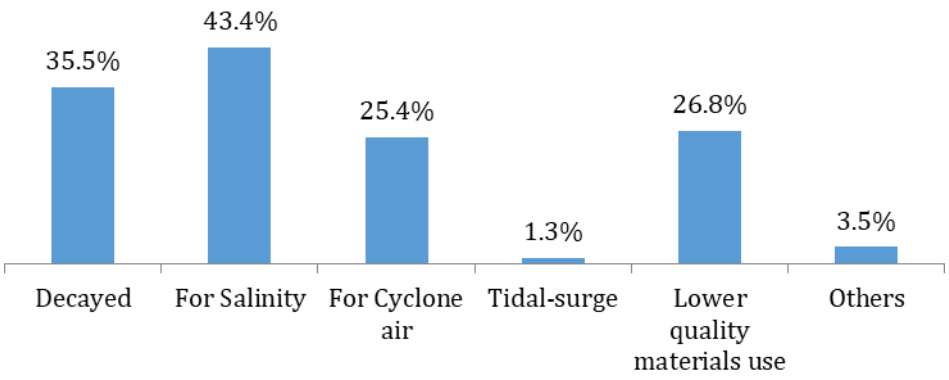


FIGURE 77 REASON OF THE CRACKS IN WALL

Respondents mentioned many reasons for the cracks in the walls as follow: 43.4% due to salinity, 35.5% due to decay, 26,8% due to the use of low quality building materials, 25.4 due to cyclones, 1.3% due to tidal surge and 3.5% due to other reasons.

Status of the Last Five Years Rebuild/Repair House:

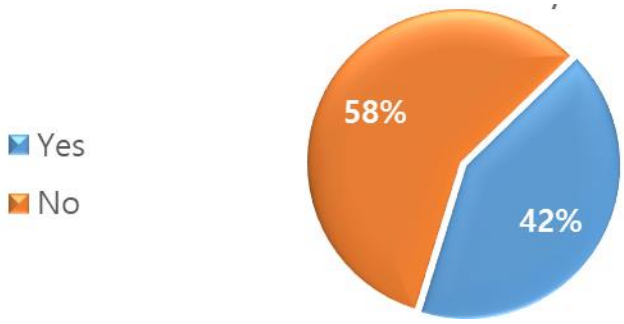


FIGURE 78 STATUS OF THE LAST FIVE YEARS REBUILD/REPAIR HOUSE

The surveyed 600 house owners were asked about their experiences with rebuilding and repairing their houses in the last five years: 42% of respondents had such experiences whereas 58% of respondents did not make any changes.

Average Expenditure for House Repairs:

According to the statement of dwellers, an average expenditure of house repair was BDT 47932.54, which was BDT 25000.00 in median value.

TABLE 21 AVERAGE EXPENDITURE FOR HOUSE REPAIRS

Expenses for repairing in BDT	
Mean	47932.54
Median	25000.00

Main Fuel for Cooking:

TABLE 22 MAIN FUEL FOR COOKING

Fuel Type	**Frequency (N)**	**Percent (%)**
Carosine	10	1.7
Wood	560	93.3
Hay/husk	14	2.3
Cow dung	10	1.7
Leaf	6	1.0
Total	600	100.0

It was found that different types of traditional fuels were consumed in the community. The Table 22 shows that the most commonly used traditional fuel was wood (93.3%) followed by hay/husk (2.3%). A cow dung was also used for fuel (1.7%).

Daily Average Fuel Cost in BDT:

The daily fuel cost of 600 respondents has been calculated in a mean and a median value. The mean value for the daily fuel cost was 16.60 BDT and the median value was 15.00 BDT.

Sleeping Arrangement:

Sleeping agreements were divided into categories “Bed”, “Floor” and “Bed and Floor”. Most commonly mentioned sleeping agreement was “Bed, (84.3%), followed by “Floor” (11.8%), and the rest 3.8% mentioned “Bed and Floor”.

Main Source of Water:

TABLE 23 MAIN SOURCE OF WATER

Source of water	**Frequency (N)**	**Percent (%)**

Groundwater (Self)	69	11.5
Combined Supply water	22	3.7
Rain water	416	69.3
River Water	12	2.0
Pond Water	26	4.3
Others Tube Well	36	6.0
Sold Water	19	3.2
Total	600	100.0

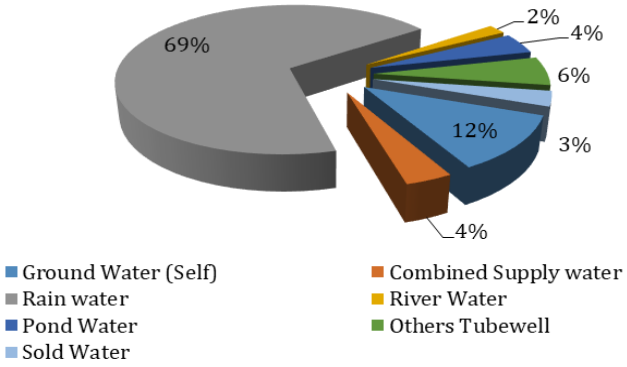


FIGURE 79 MAIN SOURCE OF WATER

The main sources of the water in the study areas were Ground water, Combined Supply water, Rain, Water, River water, Pond water, Sold water and Other tube wells. More than half of the respondents, which corresponds 69.3% of the 600 respondents, mentioned Rain Water as their main source of water. The second most mentioned water source was groundwater, which was mentioned by 11.5% respondents.

Bath and Other Usable Water Sources:

Considering the bath and other usable water sources, more than half of the respondents (58.3%) of the total respondents mentioned pond water. 23.8 % of respondents mentioned river water whereas 9.3% of respondents mentioned groundwater.

TABLE 24 BATH AND OTHER USABLE WATER SOURCES

Source of Water	**Frequency (N)**	**Percent (%)**
Groundwater (Self)	56	9.3
Combined Supply water	7	1.2
Rain water	34	5.7
River Water	143	23.8

Pond Water	350	58.3
Others Tube Well	10	1.7
Total	600	100.0

Types of Toilet:

89.3% of respondents mentioned that they used a ring-slab toilet. 4.7% of the respondents mentioned not to have a toilet while 5.5% of the respondents used toilet without using ring-slab.

TABLE 25 TYPES OF TOILET

Types of toilet	Frequency (N)	Percent (%)
Open Field	28	4.7
Latrine with Ring (for pit) & slab	536	89.3
Latrine without Ring (for pit) & slab	33	5.5
Latrine using pit (with cover)	1	0.2
Others	2	0.3
Total	600	100.0

Conform of the Building Code for Construction:

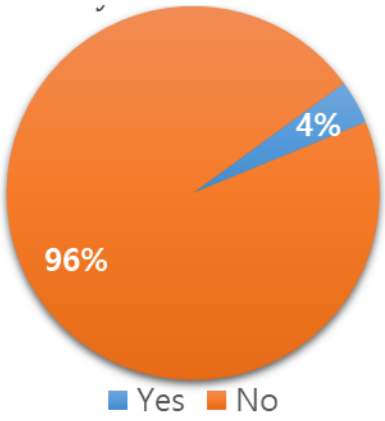


FIGURE 80 CONFORM OF THE BUILDING CODE FOR CONSTRUCTION

Only 4% of respondents were following building codes for construction whereas 96% of respondents did not follow building codes for the construction of their houses.

4. DESCRIPTION OF TECHNOLOGY OPTIONS

4.1 MATERIALS

4.1.1 USE OF CURRENT MATERIALS FOR DURABLE HOUSING CONSTRUCTION

The factors for the construction of durable housing were reviewed. The Bangladesh government has already established relevant standards for durable housing and its maintenance in the Bangladesh Building Code. In particular, guidelines for the construction of durable housing are provided separately by region, taking into account the different environmental characteristics of the southern coastal region, such as geography and climate. The eight elements required for housing construction presented by the Housing and Building Research Institute (HBRI) guidelines are as follows.

STANDARD GUIDELINES FOR RURAL HOUSING IN DISASTER-PRONE AREAS OF BANGLADESH[12]

- **Standard 1:** Security of tenure must be guaranteed for a set period of time of at least 30 years.

- The current situation of tenure must be assessed; - Where security of tenure is absent, it must be obtained for at least 30 years (through relocation, owner deeds, or rental agreements within the means of the household or otherwise); - Proof and documentation of security of tenure must be provided to inhabitants.

According to the above, it is necessary to define the minimum tenure once the construction is complete, and proof must be provided to the building owner. Although many countries do not prescribe the life span of a house, they require performance standards of at least 30 years in terms of building value and resource utilization. The southern coastal region of Bangladesh faces many difficulties in ensuring durability of housing due to high humidity and strong winds. However, the use of inorganic materials, such as cement and clay, as well as adequate

[12] Housing and Building Research Institute (HBRI) (2018), *Standard Guideline for rural housing in disaster prone area of Bangladesh*, Bangladesh

maintenance and management will be sufficient to meet the minimum required life span criteria.

- **Standard 2:** Access to safe water and sanitation solutions must be provided.

- One up to the standard toilet is to be provided per household; - Ample access to safe water must be provided within 300 meters from the house site; - The construction of toilet and water supply solutions must respect the same hazard resilience measures applied in housing.

The above is concerned with preventing sources of pollution of the drinking water used in residential facilities, and is a regulation to prevent the use of water with high salinity or contamination. As most of the region uses groundwater, this standard regulates the use of barrier-type septic tanks, which prevent contamination from penetrating the soil, in case of private toilets. In addition, regulations on the minimum distance ensure that drinking water is provided smoothly. In the southern coastal regions, there are areas wherein most households use toilets without separate septic tanks or use groundwater with high salinity. Prior to the improvement of housing, it is considered that water purification facilities and improvement of toilets are a priority in these regions.

- **Standard 3:** All housing must be built with materials and techniques that allow easy maintenance, repair, and duplication.

- Preference to local, well-known, and available materials; - Focus on local techniques and tricks, and the improvement thereof; - Accompany the introduction of new materials and techniques with extensive training and follow-up; - Look into options to produce new materials locally; - The expected repair and maintenance cost and time must remain within the budget of the household and limited to what households can do in combination with their other activities.

The durability of a building is not maintained to the level of performance at the time of construction and can be altered by continuous maintenance and management. In the same way people can be treated at the hospital when sick, buildings must be repaired or improved if they are damaged or if their function is compromised. Maintenance and repair should be

easy and affordable. Costly and complex methods can lead to maintenance abandonment and ultimately to a decline in housing longevity. A new construction should consider future maintenance and management, use materials that can be easily obtained in the field, and make it easy for the owner and inhabitants of the building to make repairs. In addition, training systems for easy acquisition of related technologies and a system for sharing methods and equipment are needed.

- **Standard 4:** All housing and sites must be adapted to the local hazard profile to resist recurrent disasters over 30 years.

- For the implementation area: identify threats to which sites and houses are exposed, and establish which hazard profile is to be taken into account in the design of the house; - For the individual house/site: identify which additional location/site specific threats are to be taken into account – lack of protective vegetation, proximity to a river edge, and communal plinth of insufficient height, among others; - All houses must be built in accordance with the minimum technical standards set out in these guidelines for the different hazards.

One of the main functions of a building is to protect the inhabitants from external environmental changes. For this, new constructions should begin by eliminating risk factors from the beginning stages. They must comply with the minimum safety standards set by the State and the safety standards of the individual home and area in which it is located.

Part 7 of the Bangladesh Building Code has all regulations governing safety in the construction phase, including constructional responsibility and practices, storage, stacking and handling practices, safety during construction, demolition work, maintenance management, repairs, retrofitting, and building strengthening, among others.

- **Standard 5:** All housing must offer a comfortable and healthy internal climate.

- The dimension of the smallest house module should not be lesser than 10'-0"X12'-0" for a family of 2 to 3 members (minimum approximate of 3.6 sqm per person);

- Cross-ventilation must be provided by placing at least two windows on opposite sides of the house, being one in the main room, and at least one additional window in each additional space;

- All windows must be fitted with a system for partial or full blinding, in accordance with local practices;

- Additional ventilation openings are foreseen in cooking areas and under the roof in areas where heat builds up inside the house.

Housing should provide a basic space for people to have a comfortable rest and to lead a stable life. Therefore, it is necessary to maintain environmentally and hygienically pleasant conditions during residence. To this end, light, air, and temperature should be appropriate, and factors that may put health at risk should be removed.

In many houses in the southern region of Bangladesh, fuel is used indoors, which causes smoke to build up inside as there is no proper ventilation. In such cases, the ambient air deteriorates can be a cause of various diseases. Therefore, this regulation stipulates proper indoor lighting parameters, window types, and opening sizes.

▪ **Standard 6:** All housing must be adapted to the special and specific needs of its inhabitants.

- 5% to 10% of the housing budget must be allocated to adapt standard house designs to the specific needs of individual households (access ramp, additional internal separations, and storage room among others), and takes into account the various needs of different members of a household (women and men of all ages);

- This amount can also be spent on site organization, to be decided in discussion with the individual household.

Dwellings cluster to form a village and, when a village expands, it becomes a city. Currently, many households are arranged in the form of residential villages. Thus, a connection system and a space for cultural activities within the communities are needed. In addition, the need for appropriate community space for each group – men, women, children, and the elderly – is increasing. This regulation recommends the use of at least 5% to 10% of the total budget for the formation of such communal spaces.

As society develops, the function of housing as the minimal unit of social life, rather than its traditional role, is becoming more important. Housing can serve as a member of the community rather than an independent entity.

■ **Standard 7:** All housing must be functional, culturally appropriate, and adaptable.

- If necessary, each house should be provided with two doors: one as the main entry and other as secondary exit;
- In discussion with communities and households, standard designs must be adapted to cultural practices;
- If uncommon types of houses are built, awareness is to be raised as to the reasons, the community acceptance should be obtained, and additional training on repair and maintenance should be conducted;
- The house must be adapted to the functional needs of the household (see also Standard 6);
- Each house must be built so that it can be easily adapted or expanded upon (easy to make qualitative connections, preference of local materials, among others);
- Training must be provided on how safe extensions and adaptations can be made.

It presents criteria for the minimum level of cultural elements and performance elements that should be structured in the individual housing and village community stages. As for individual houses, it is necessary to build the main entrance and side entrance so that they can be accessed freely and used in emergencies. At the village level, it is important to provide the space necessary for education. Thus, this standard provides criteria for such requirements. As proposed in Standard 4 above, it is necessary to provide a space for training village members to conduct building maintenance.

■ **Standard 8:** All housing should be situated as close as possible to employment and education opportunities, as well as to medical and other social services.

- Accessibility to housing sites must be guaranteed;
- In case of relocation projects, sites must be chosen to allow households to access livelihood opportunities and services.

Housing should be provided in connection with the spaces where people work. Therefore, houses and villages should be accessible and be built so as to have easy access to medical facilities for health care and education facilities for children.

4.1.2 PROPOSAL OF CONSTRUCTION MATERIALS TO SECURE ECONOMIC EFFICIENCY AND DURABILITY

1. Low income (Type-A)

- Basic concept:

> Development of building wall using local materials

> Improvement of durability in existing system

> Compose wall materials which are available from Southern coast area

> Wall material price should not exceed USD 3/m2

Raw Materials	Additives	Descriptions	Specifications
Straw, Soil	Cement, Lime, resin	- Local soil is used for main material, and straw is used to enhance reinforcement. - Exterior walls are reinforced by mixing resin. - For interior materials, use only cement or sodium silicate to improve the humidity. - Produce in various brick shapes such as 300 * 300 * 150mm, 300 * 150 * 150mm - Intermediate hollow structure to prevent crack breakage. - Variable adjustment on length of straw	- Density: 1.0~1.2 g/cm3 - Compressive strength: 10~15MPa - Additive content: >10% - Resin content: >5%

Forming process:

Preparation of soil (Sieving after drying as certain powder) → Preparation of straw (cut to a certain length after drying, within 100mm) → Preparation of additive → Mixing of binders (soil: total amount of additive = 80:20) → Mixing with straw [Within 2% of binding material (by weight)] → Mixing of water (within 30% of total weight) → Casting a mold (pressurizing mold) → Natural curing after de-molding

2. Low - Middle income (Type-B)

- Basic concept:

> Development of building wall using local raw materials

> Replacement of cement brick etc.

> Allow simple process of molding method and composition of materials

> Wall material price should not exceed USD 5/m2

Raw Materials	Additives	Descriptions	Specifications
Ash, Clay, Bamboo	Cement, Sodium Silicate, Al powder	- Main materials are Fly ash, clay and cement - form of foam structure to give light weight - Foaming uses Al powder or hydrogen peroxide. - Water repellent to improve water resistance for exterior material - Molded up to 500 * 500 * 100mm - No extra reinforcing fiber. - Partially mixed with cement to improve the hardness of the product - The structure of the wall is stacking into bamboo molding frame.	- Density: < 0.5 g/cm3 - Compressive strength: < 5MPa - Water absorption: < 15%

Forming process:

Preparation of raw materials (Fly ash with high content of CaO, Clay, Cement) Sieving after drying as certain powder → Preparation of foaming agent (Al powder or hydrogen peroxide)

→ Preparation of a mold → Mixing of binders (Ash : Clay : Cement = 50 : 30 : 20) → Mixing of foaming agent (Al powder mixing is in advance, Hydrogen peroxide mixing is less than 1% of mixing water) → Insert into a mold → De-molding → Insert into a bamboo mold

3. Above middle income (Type-C)

- Basic concept:

> Materials that can ensure durability, has high corrosion resistance to seawater

> Wall panel that can be easily assembled and assembled locally

> Partially replaceable material

> Approx. wall material price - USD 20~30/m2

Raw Materials	Additives	Descriptions	Specifications
Cement , Silica powder	Cellulose fiber Methylcellulose powder	- Cement extrusion molding - Using large-scale facilities - Use 40 ~ 50% of cement as main raw material (smooth cement supply in Bangladesh) - High density and water resistant - Excellent UV resistance - High bending strength and compressive strength - Straw can be used as reinforcing fiber	- Density: > 1.5 g/cm3 - Flexural strength: > 14MPa -Water absorption : < 15%

Forming process:

Preparation of raw materials (Cement, silica powder, fiber, additives) → Mixing of binders → Extrusion molding → 1st curing (curing at 65 ℃ for 8 hours) → 2nd curing (curing at 180 ℃ for 8 hours) → cutting → construction

4.2 PROPOSAL

The main goal is to design several optimum housing prototypes which can be affordable and durable for Southern coastal areas of Bangladesh. Through this project, KICT has outlined 3 different types of housing proposals depending on income level, building area, resident's living area, price etc. of the residents of Southern Bangladesh. To minimize the maintenance cost of residential living environment, all 3 housing proposals are recommended to apply the rainwater recycling system and solar system.

Housing type

1) Type A: Durable housing design for low income residents in Southern coastal area of Bangladesh

2) Type B: Durable housing design for low-middle income residents in Southern coastal area of Bangladesh

3) Type C: Durable housing design for middle income residents in Southern coastal area and urban area of Bangladesh

Main materials

1) Low income (Type-A):

- Local materials (Gol-pata, Bamboo, lightweight foam blocks, etc.)
- Utilization of solar system
- Utilization of rainwater storage
- Lightweight foam blocks and general cement brick

2) Low-Middle income (Type-B)

- Lightweight foam blocks, general cement brick and extruded concrete panel (Byucksan)
- Utilization of solar system
- Utilization of rainwater storage
- Lightweight foam blocks and general cement brick

3) Middle income or urban area residents (Type-C)

- Extruded concrete panel (Byucksan)

- Utilization of solar system

- Utilization of rainwater storage

Building area

1) Low income class (Type-A) - Area of 50 ㎡ ~60 ㎡

2) Low-Middle income class (Type-B) - Area of 50 ㎡ ~60 ㎡

3) Middle income class or urban area residents (Type-C) - Area of 70 ㎡~80 ㎡

House division

1) Low income (A type)

- 2 bedroom, living, dining, toilet, shower, kitchen

2) Low-Middle income (B type)

- 2 bedroom, living, dining, toilet, shower, kitchen.

3) Middle income or urban area residents (C type)

- 2 bedroom, living, dining, toilet, shower, kitchen, Verandah, open entrance terrace

Summary of 3 housing proposals

	Type-A	**Type-B**	**Type-C**
Number of floors	1 floor	1 floor	1 floor
Area	572sft/53 ㎡	572sft/53 ㎡	758sft/70.1 ㎡
Main Material	Light weight foam block/Local brick	Light weight foam block/ Cement brick	Extruded concrete panel
Wall structure	Cement hollow Block	Cement brick	Concrete panel
Roof structure	G.I steel gable roof	G.I steel gable roof	G.I steel gable roof

Division	Room(1,2), Living & Dining, Kitchen, Toilet, Shower	Room(1,2), Living & Dining, Kitchen, Toilet, Shower	Room(1,2), Living & Dining, Kitchen, Toilet, Shower, Verandah, Open terrace
Price / household	USD 10,990	USD 12,570	USD19,770
Price /㎡	USD 207	USD 237	USD 282
Solar system	3KW	3KW	3KW
Rainwater tank	1TON	1TON	1TON

TYPE-A

ROOM	UNITS	AREA
BED ROOM-1	12’-0”X14’-0”	168sft/15.6m2
BED ROOM-2	12’-0”X14’-0”	168sft/15.6m2
LIVING & DINING	10’-0”X14’-0”	140sft/13m2
KITCHEN	8’-0”X6’-0”	48sft/4.4m2
SHOWER	4’-0”X6’-0”	24sft/2.2m2
TOILET	4’-0”X6’-0”	24sft/2.2m2
TOTAL AREA		**572sft/53m2**

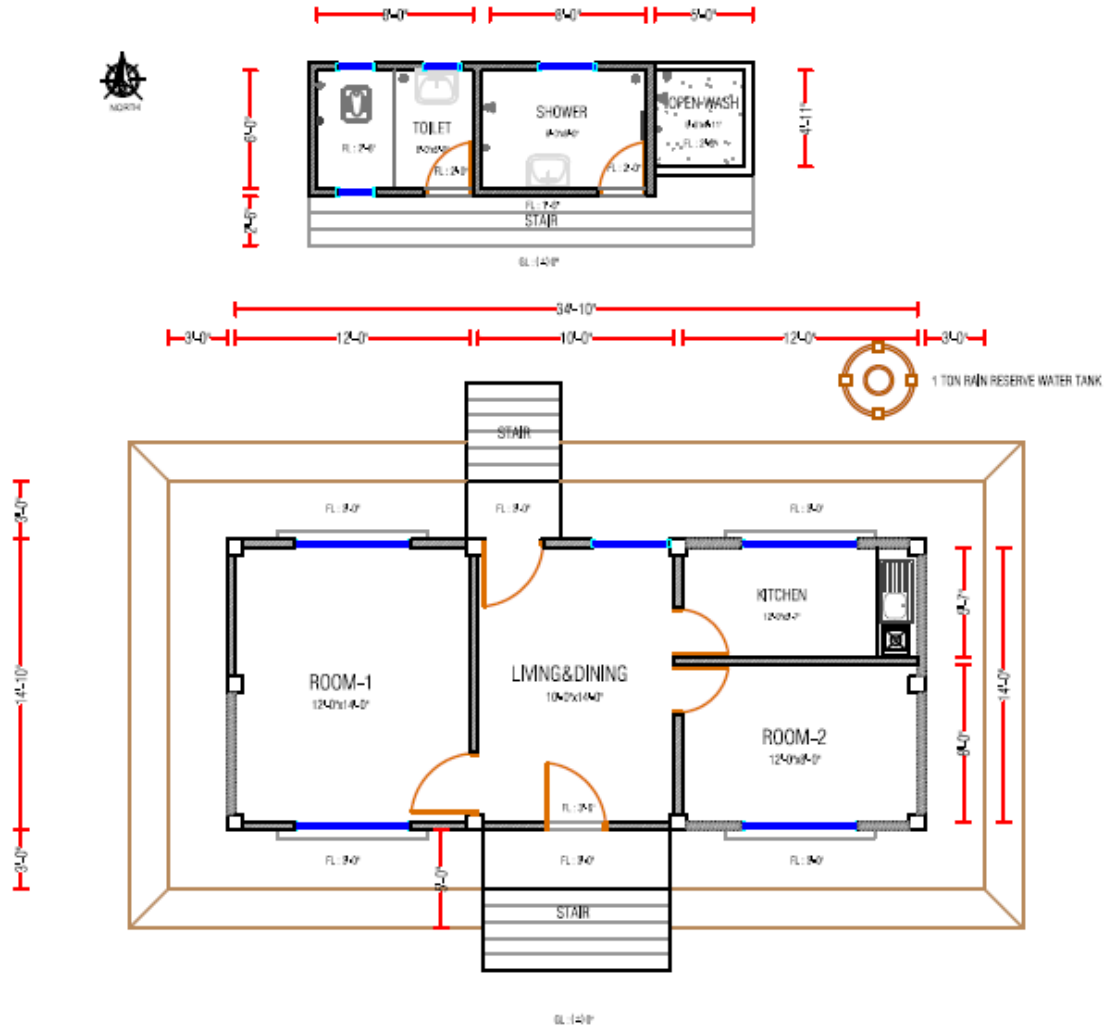


FIGURE 81 FLOOR PLAN

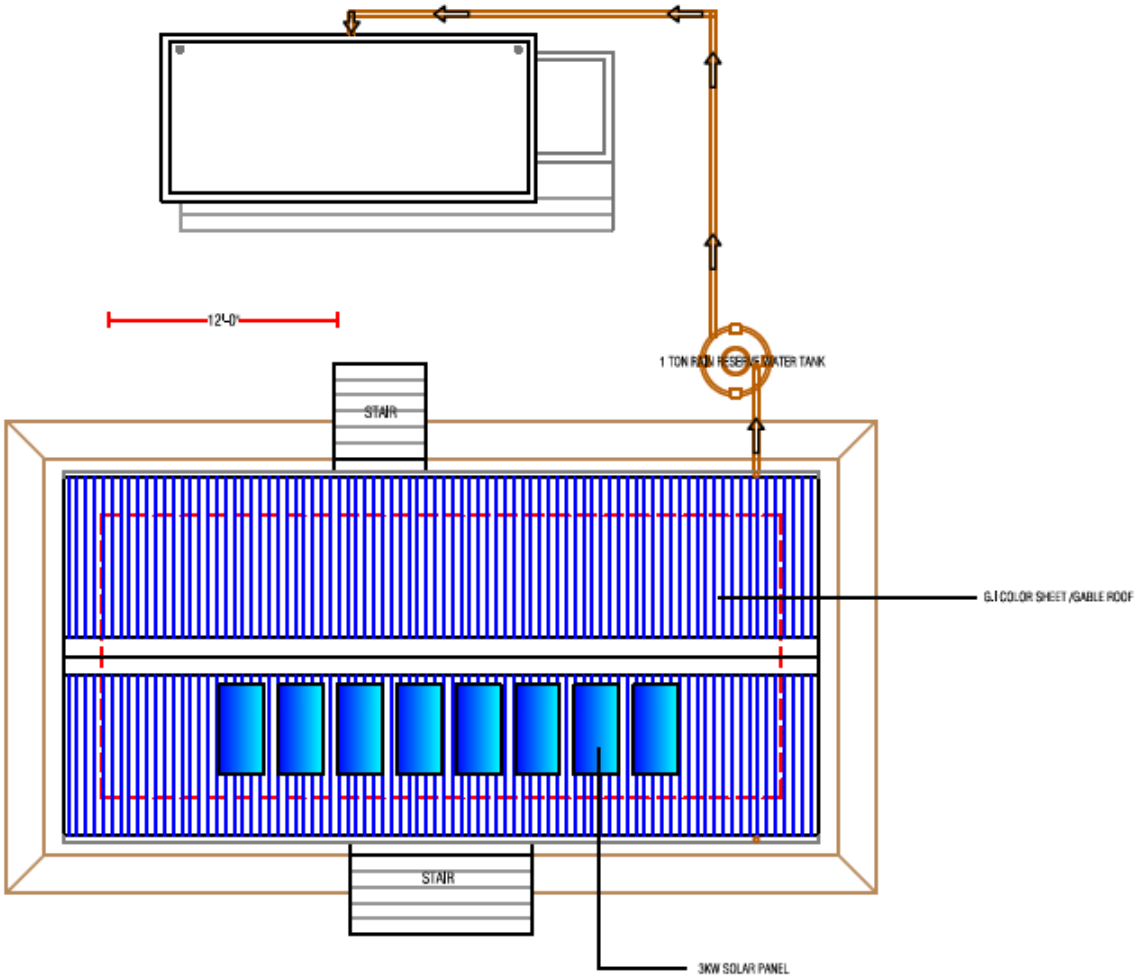


FIGURE 82 ROOF PLAN

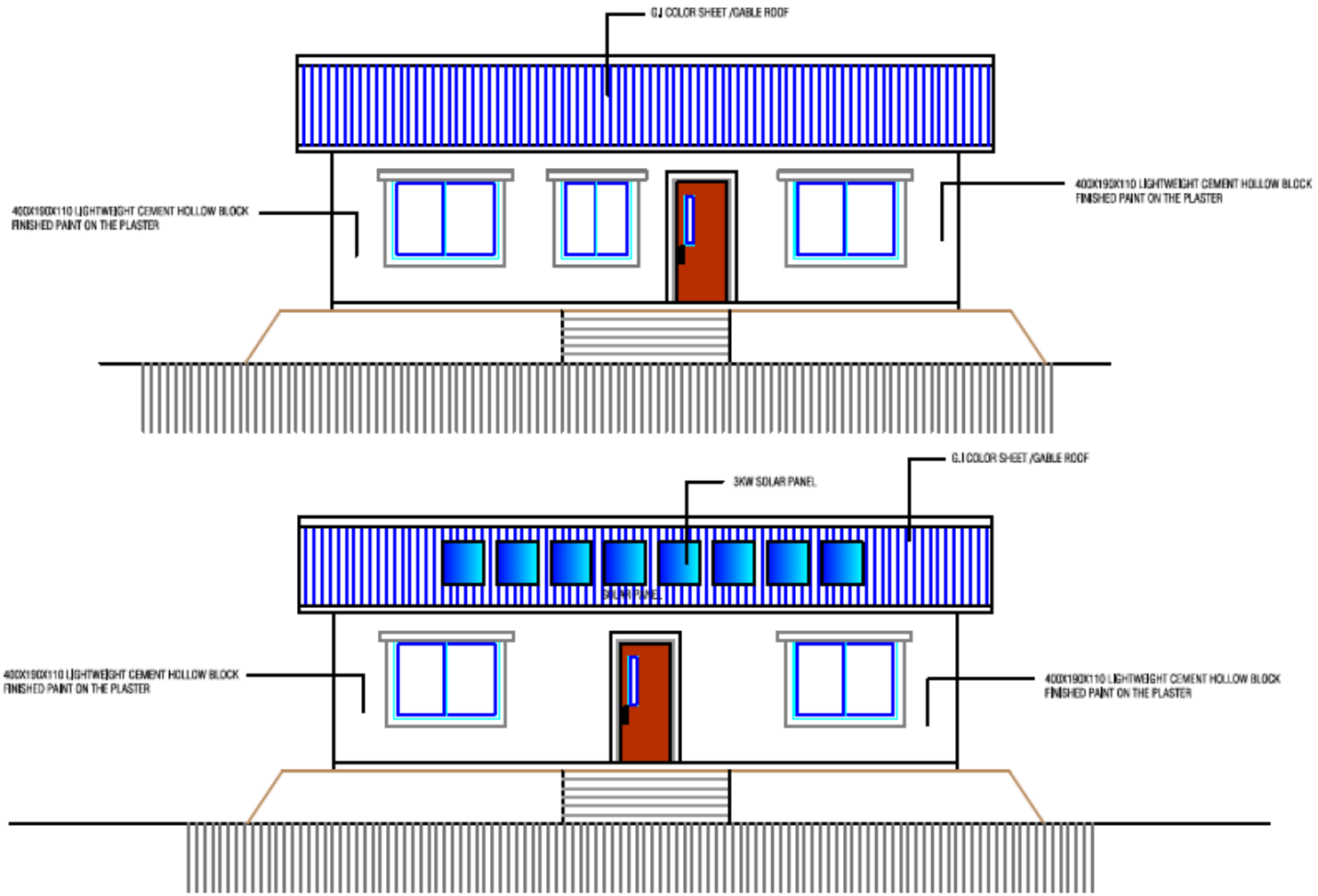


FIGURE 83 NORTH & SOUTH ELEVATION

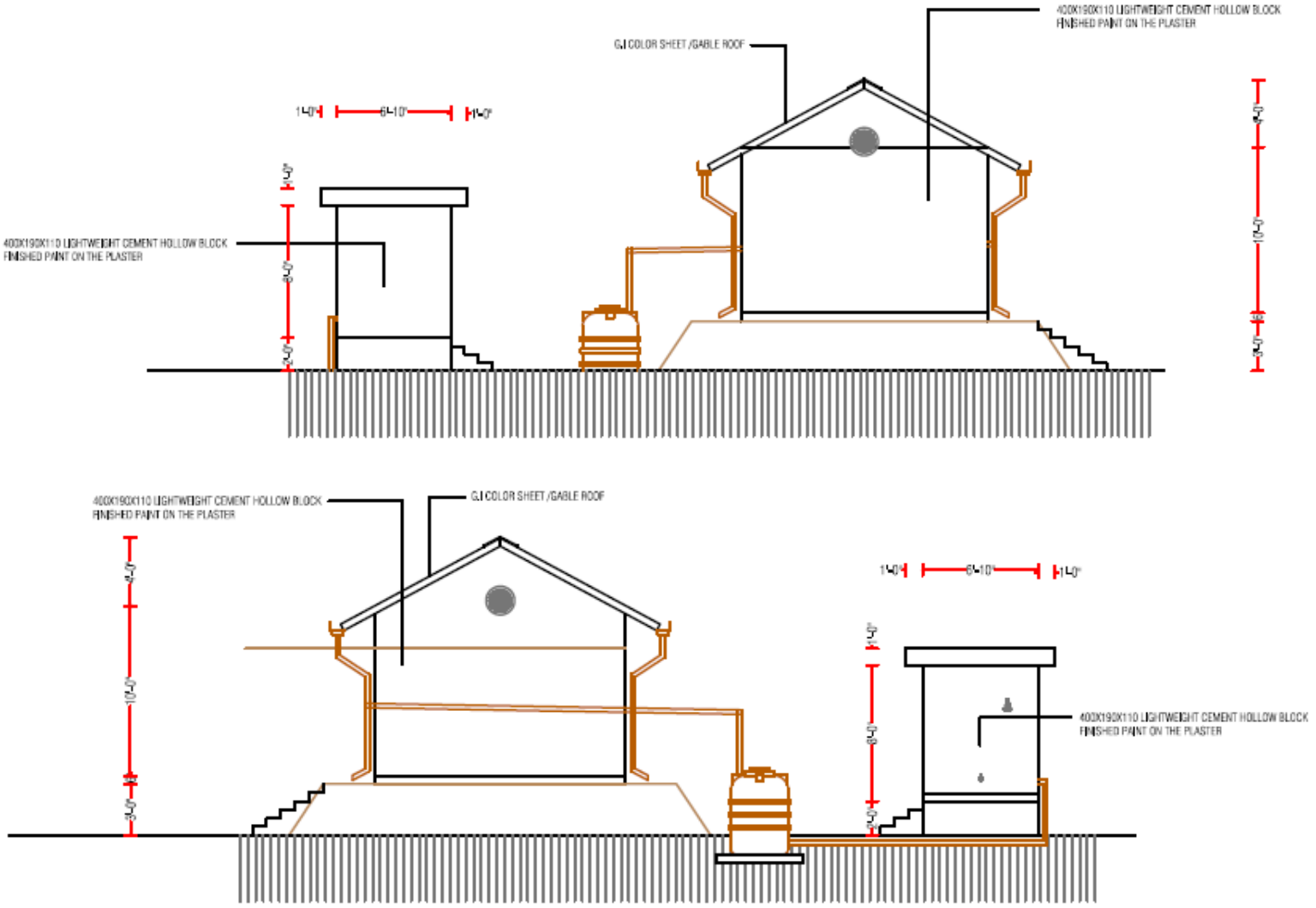


FIGURE 84 WEST & EAST ELEVATION

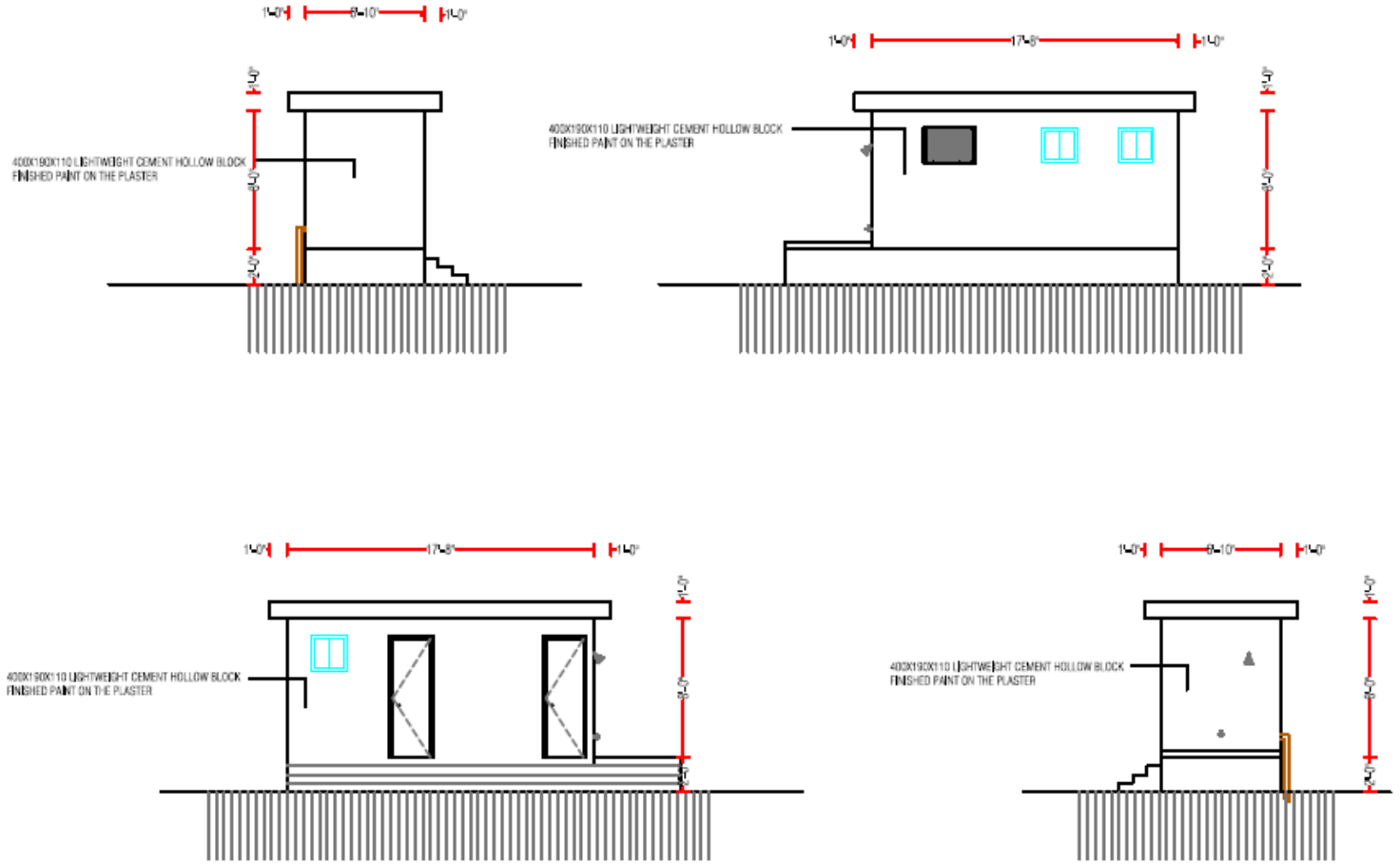


FIGURE 85 ANNEX BUILDING ELEVATION

TYPE-B

ROOM	UNITS	AREA
BED ROOM-1	12’-0”X14’-0”	168sft/15.6m2
BED ROOM-2	12’-0”X14’-0”	168sft/15.6m2
LIVING & DINING	10’-0”X14’-0”	140sft/13m2
KITCHEN	8’-0”X6’-0”	48sft/4.4m2
SHOWER	4’-0”X6’-0”	24sft/2.2m2
TOILET	4’-0”X6’-0”	24sft/2.2m2
TOTAL AREA		**572sft/53m2**

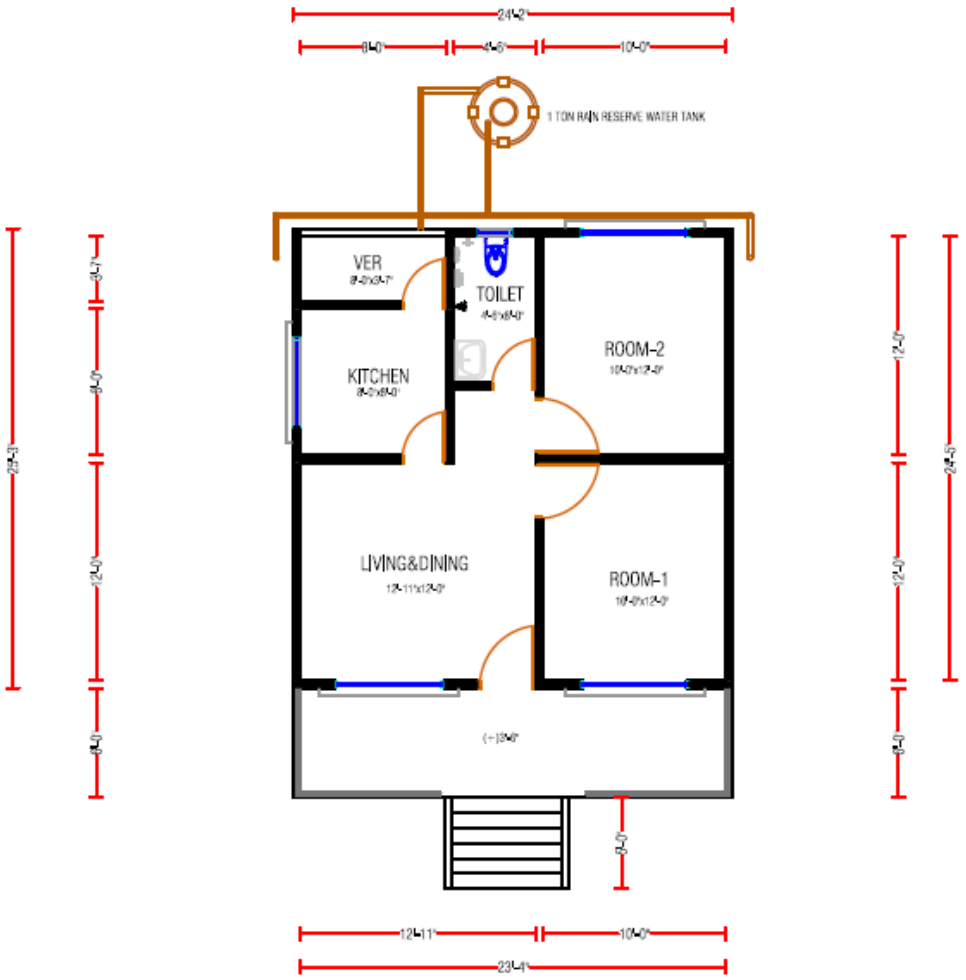


FIGURE 86 FLOOR PLAN

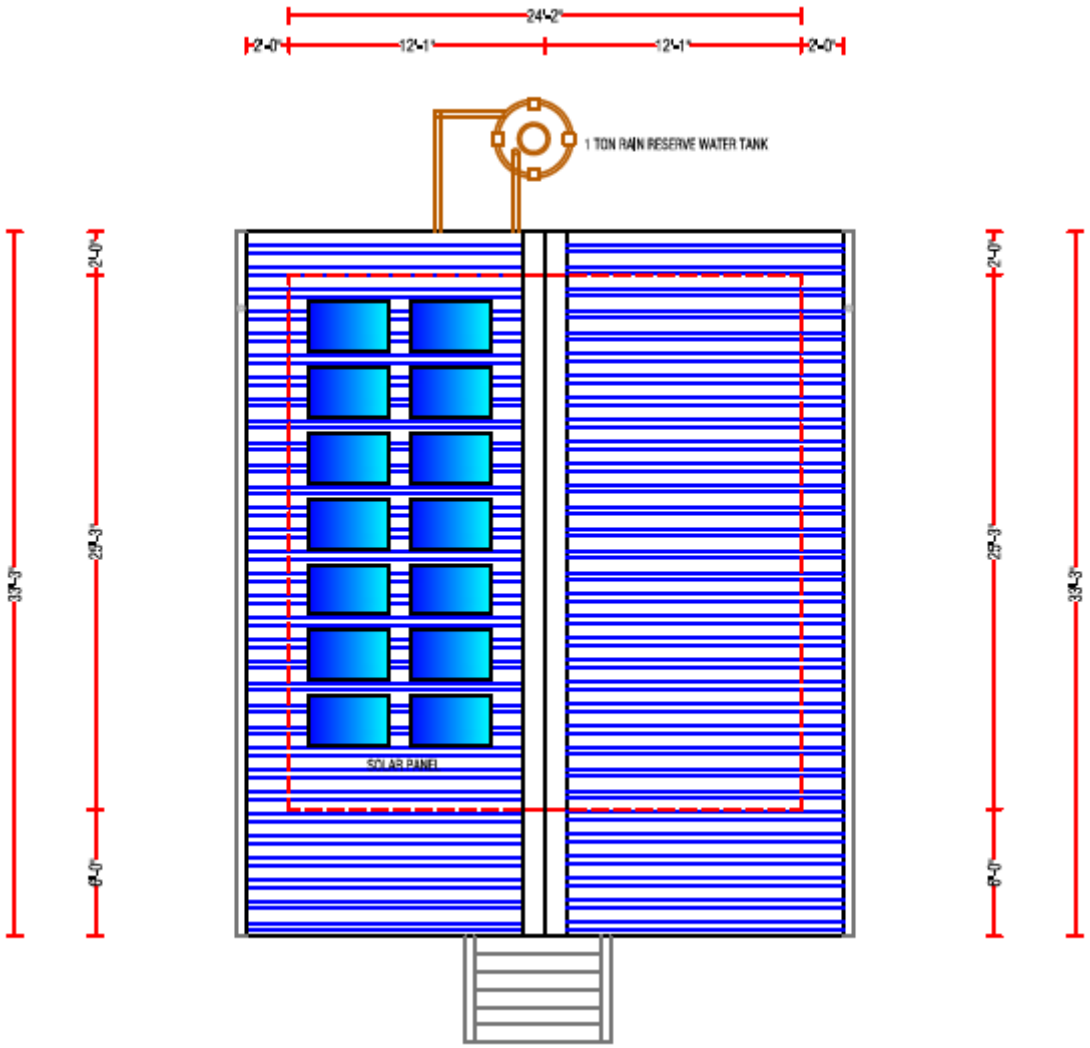


FIGURE 87 ROOF PLAN

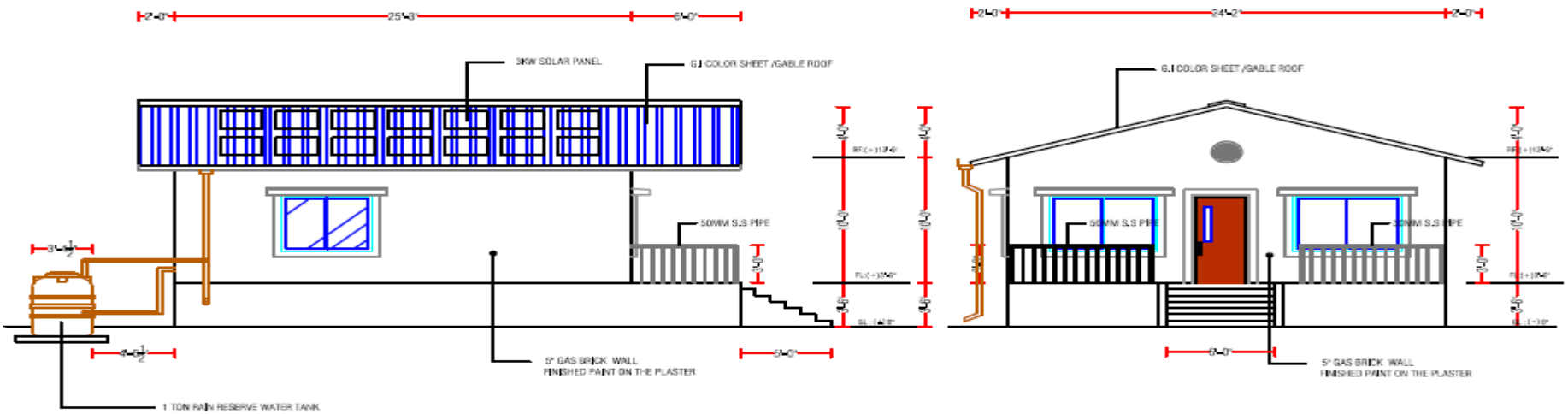


FIGURE 88 FRONT & LEFT ELEVATION

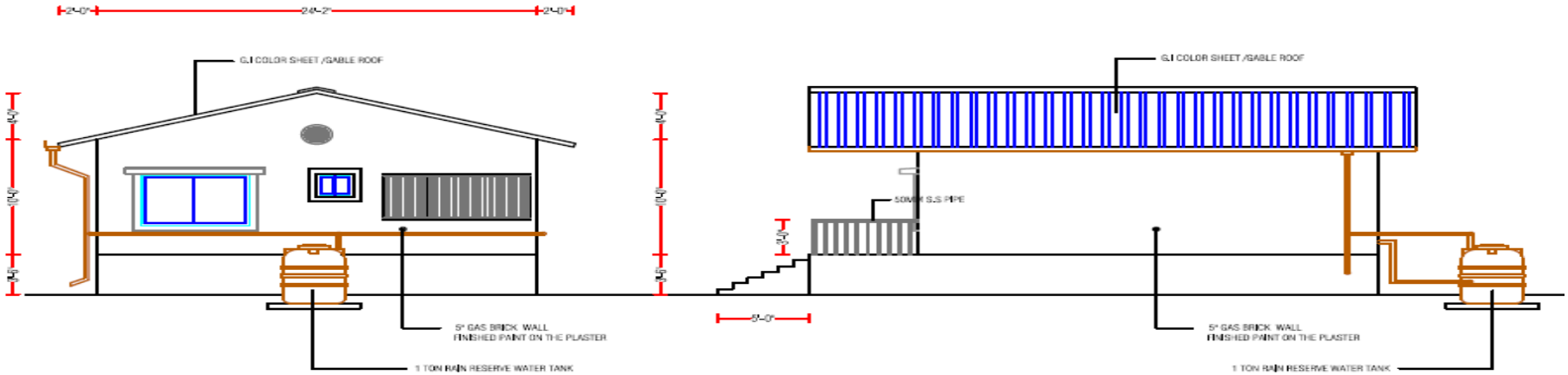


FIGURE 89 BACK & RIGHT ELEVATION

TYPE-C

ROOM	UNITS	AREA
BED ROOM-1	12’-0” X 14’-0”	168sft/15.6m^2
BED ROOM-2	12’-0” X 12’-0”	144sft/13.3m^2
LIVING & DINING	13’-5”X 14’-0”	256sft/23.7 m^2
KITCHEN	10’-0” X 12’-0”	120sft/11.1 m^2
TOILET	5’-0’ X 7’-0”	35sft/3.2 m^2
VERANDAH	3’-0” X 4’-0” 5’-0” X 3”-7”	35sft/3.2m2
TOTAL AREA		**758sft/70.1m2**

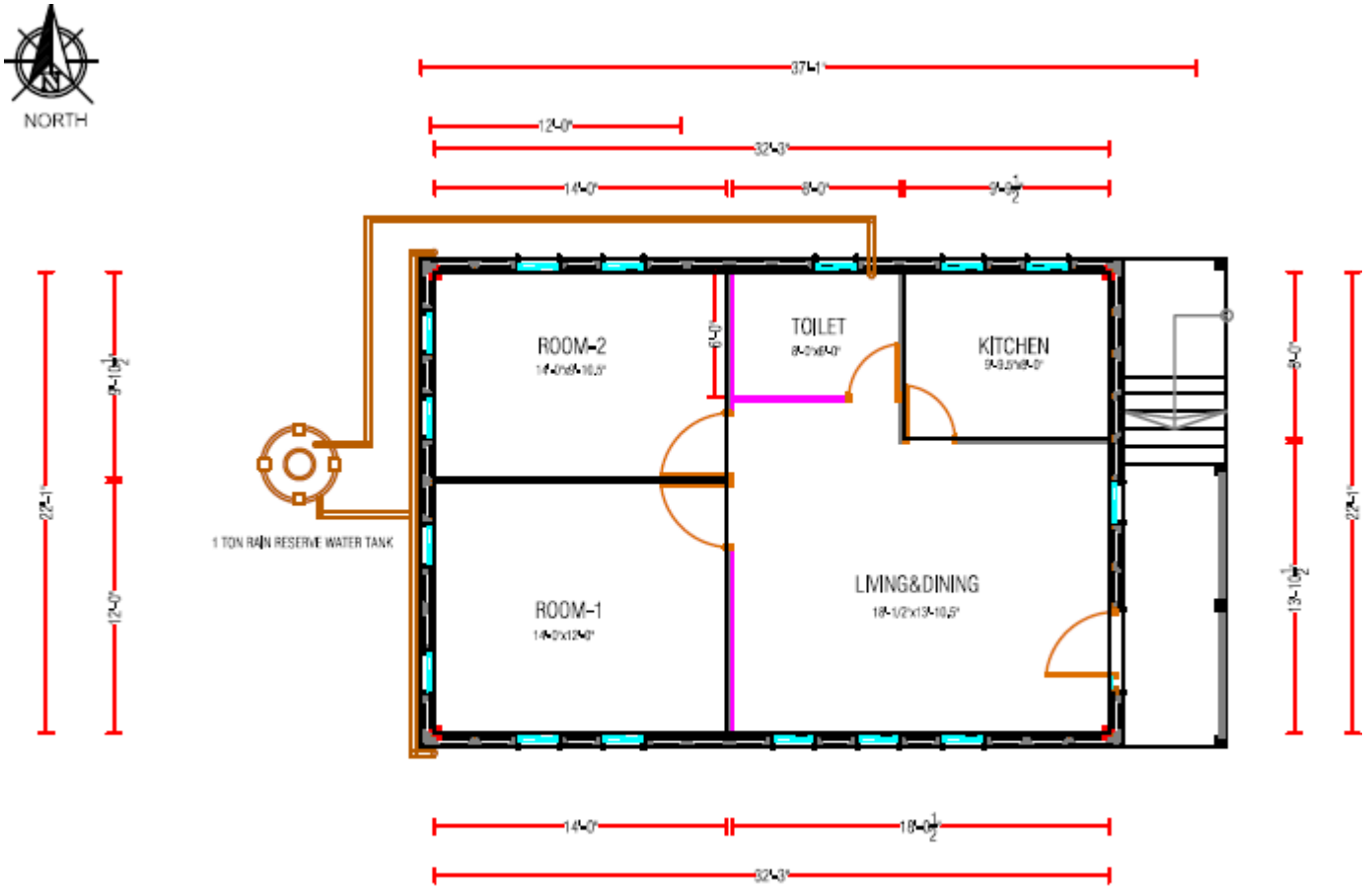


FIGURE 90 FLOOR PLAN

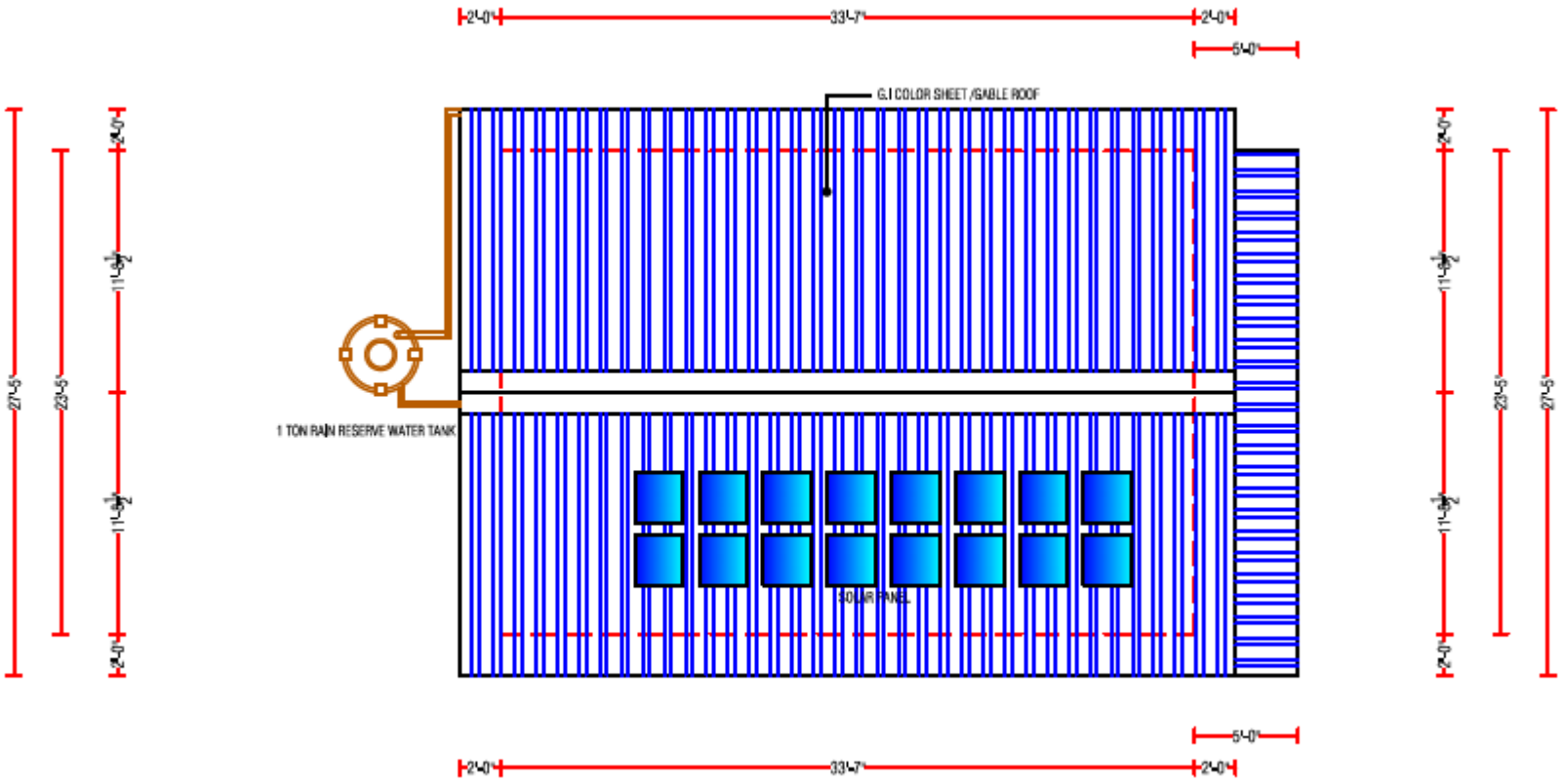


FIGURE 91 ROOF PLAN

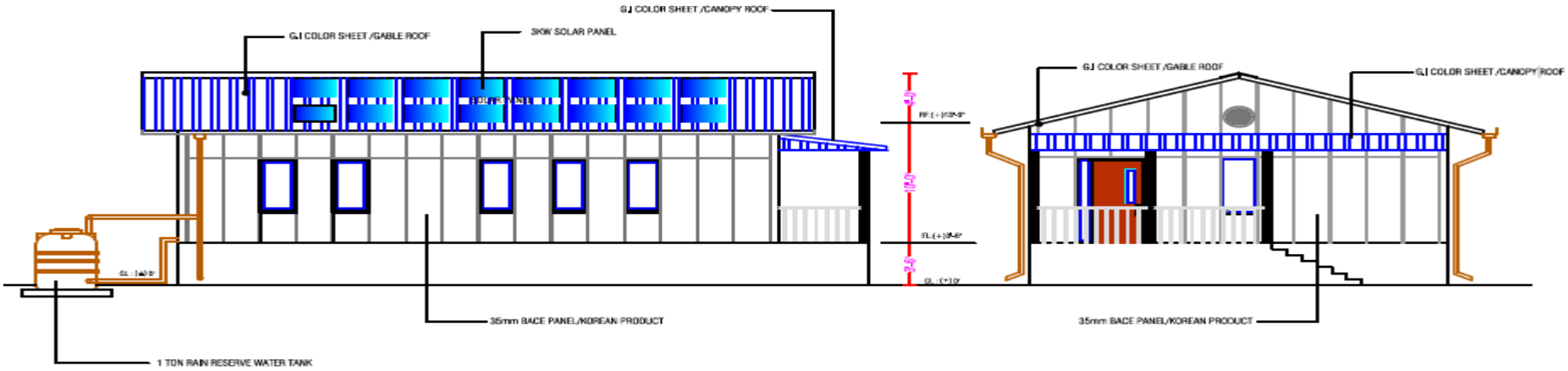


FIGURE 92 FRONT & RIGHT ELEVATION

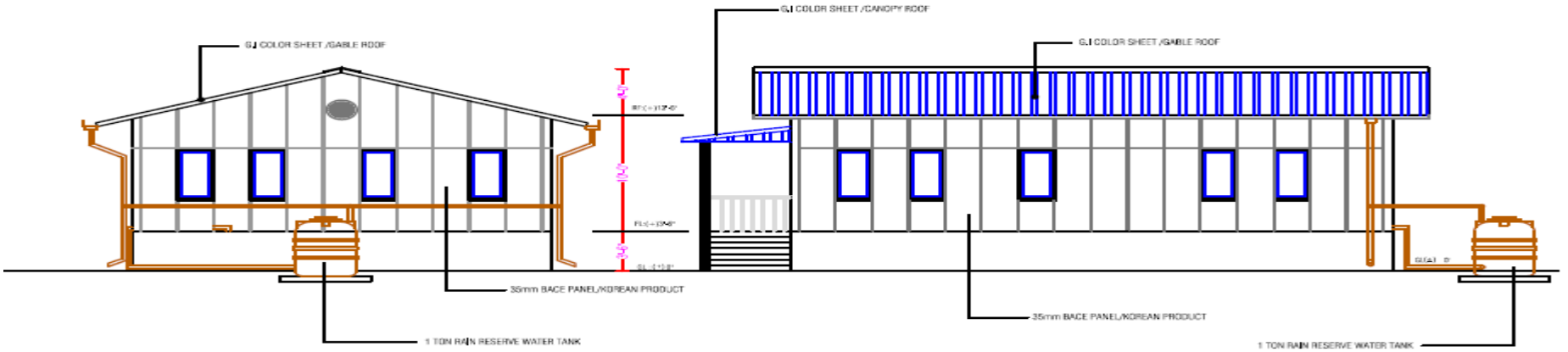


FIGURE 93 LEFT & BACK ELEVATION

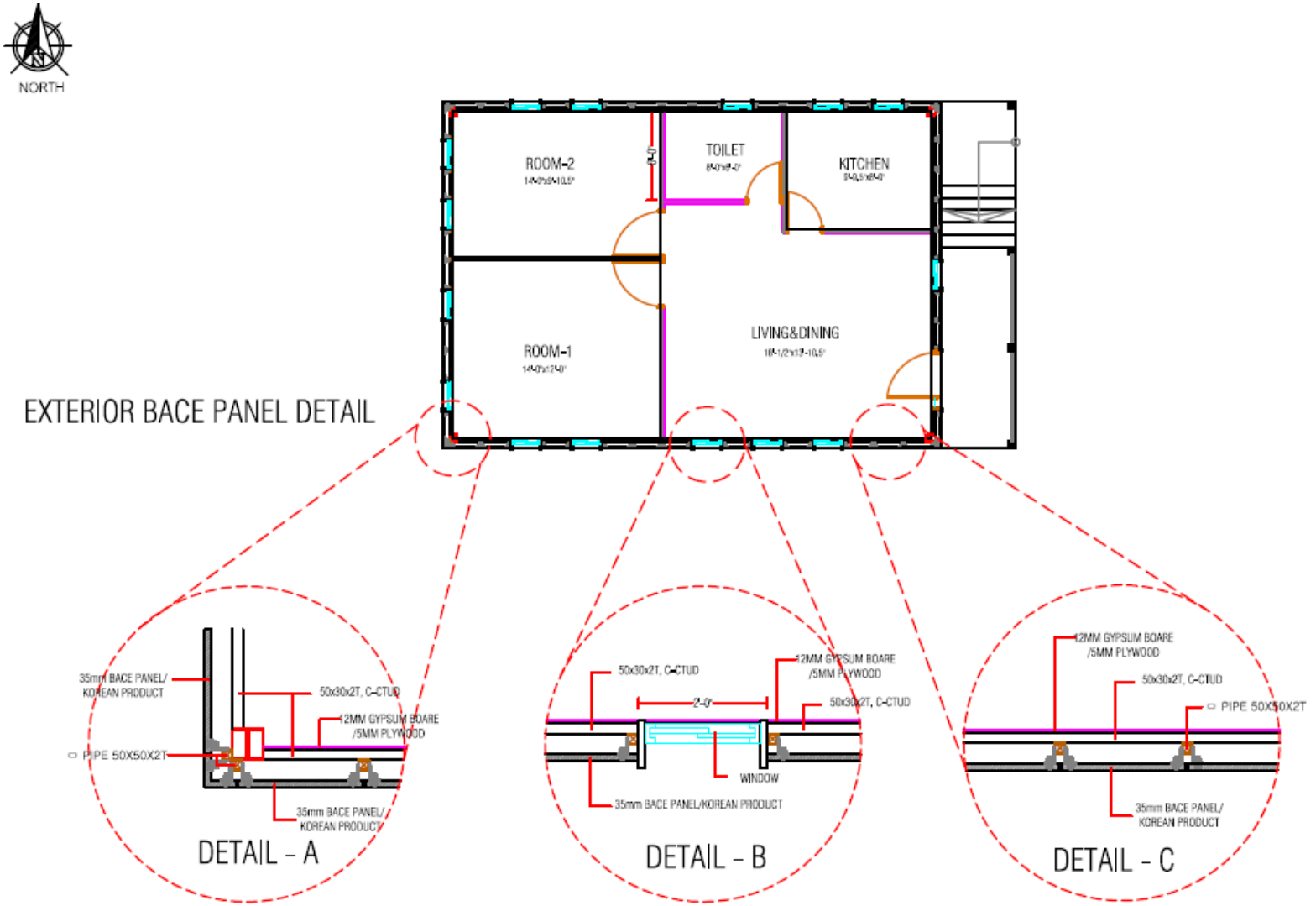
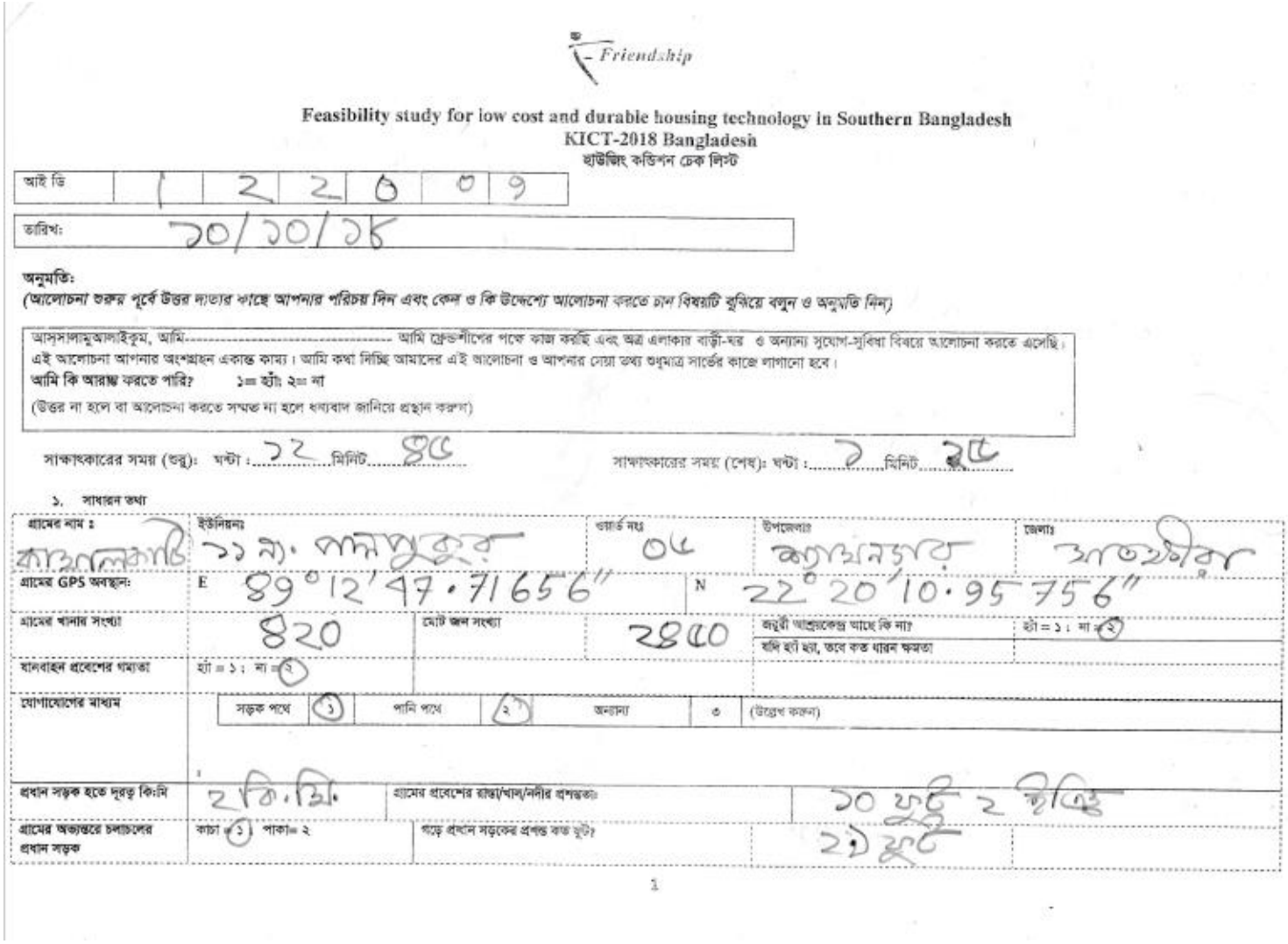


FIGURE 94 DETAIL PLAN (EXTRUDED CONCRETE BASE PANEL - BYUCKSAN)

5. APPENDIX – FIELD SURVEY CHECKLIST



Friendship

Feasibility study for low cost and durable housing technology in Southern Bangladesh
KICT-2018 Bangladesh
হাউজিং কন্ডিশন চেক লিস্ট

আই ডি	১	২	২	০	০	৯

তারিখ: ২০/১০/১৮

অনুমতি:
(আলোচনা শুরুর পূর্বে উত্তর দাতার কাছে আপনার পরিচয় দিন এবং কেন ও কি উদ্দেশ্যে আলোচনা করতে চান বিষয়টি বুঝিয়ে বলুন ও অনুমতি নিন)

আস্সালামুআলাইকুম, আমি----------আমি ফ্রেন্ডশীপের পক্ষে কাজ করছি এবং অত্র এলাকার বাড়ী-ঘর ও অন্যান্য সুযোগ-সুবিধা বিষয়ে আলোচনা করতে এসেছি। এই আলোচনা আপনার অংশগ্রহন একান্ত কাম্য। আমি কথা দিচ্ছি আমাদের এই আলোচনা ও আপনার দেয়া তথ্য শুধুমাত্র সার্ভের কাজে লাগানো হবে।
আমি কি আরম্ভ করতে পারি? ১= হ্যাঁ; ২= না
(উত্তর না হলে বা আলোচনা করতে সম্মত না হলে ধন্যবাদ জানিয়ে প্রস্থান করুন)

সাক্ষাৎকারের সময় (শুরু): ঘন্টা : ১২ মিনিট ৪৫ সাক্ষাৎকারের সময় (শেষ): ঘন্টা : ১ মিনিট ২৫

১. সাধারন তথ্য

গ্রামের নাম : কাজলকাটি	ইউনিয়ন: ১১ নং পানখালী	ওয়ার্ড নং: ০৬	উপজেলা: কচুখালী	জেলা: সাতক্ষীরা
গ্রামের GPS অবস্থান:	E 89°12'47.71656"		N 22°20'10.95756"	
গ্রামের খানার সংখ্যা	৪২০	মোট জন সংখ্যা ২৪৫০	জরুরী আশ্রয়কেন্দ্র আছে কি না?	হ্যাঁ = ১; না = ২
			যদি হ্যাঁ হয়, তবে কত ধারন ক্ষমতা	
যানবাহন প্রবেশের গম্যতা	হ্যাঁ = ১; না = ২			
যোগাযোগের মাধ্যম	সড়ক পথে ১	পানি পথে ২	অন্যান্য ৩	(উল্লেখ করুন)
প্রধান সড়ক হতে দূরত্ব কি:মি	২ কি.মি.	গ্রামের প্রবেশের রাস্তা/খাল/নদীর প্রশস্ততা:	১০ ফুট ২ ইঞ্চি	
গ্রামের অভ্যন্তরে চলাচলের প্রধান সড়ক	কাচা = ১ পাকা= ২	গড়ে প্রধান সড়কের প্রশস্ত কত ফুট?	২১ ফুট	

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উত্তরদাতার নামঃ দেবব্রত মন্ডল

মোবাইল নম্বরঃ ০১৯১১-১৫৭৩২৭

বয়সঃ ২৫ বছর মাস ☑ পুরুষ ☐ নারী

২. বাড়ীর কাঠামো ও এর ক্ষয়-ক্ষতি [নিম্নক্ত প্রশ্নসমূহ (প্রযোজ্য ক্ষেত্রে) আপনার পর্যবেক্ষনের ভিত্তিতে উত্তর নিয়ে আসতে হবে]

২.১ বাড়ীর কাঠামো কী দিয়ে তৈরি? (একাধিক উত্তর হতে পারে)

কনক্রিট	১	ইট	২	কাঠ	৩	বাঁশ	(৪)	কাঁদা-মাটি	৫	অন্যান্য (উল্লেখ করুন)	৬

২.১.১ মোট বসত-বাড়ির আয়তন-(বর্গফুট) ১৩৬.৭৫

২.১.২ কক্ষ সংখ্যা -(রান্নাঘর বাদে) ২

২.২ বাড়ীর ছাদ কী দিয়ে তৈরি? (একাধিক উত্তর হতে পারে)

কনক্রিট	১	খড়/গোলপাতা	(২)	কাঠ	৩	বাঁশ	৪	টালি	৫	অন্যান্য (উল্লেখ করুন)	৬

২.২.১ ভিটা থেকে ছাদের উচ্চতা - ফুট ৭ ফুট

২.২.২ ছাদ সম্পূর্ণ ঠিক আছে? হ্যাঁ = (১) না = ২

২.৩ ভূমি থেকে বাড়ীর উচ্চতা - ফুট ৩.৫৭ ফুট

২.৪ প্রবেশ বারান্দা আছে কি না হ্যাঁ = (১) না = ২

২.৫ জানালা সংখ্যা ৫

২.৫.১ মোট জানালার আয়তন - (বর্গফুট) ৬.১৪

২.৫.২ জানালা কী দিয়ে তৈরি? (একাধিক উত্তর হতে পারে)

কনক্রিট	১	ইট	২	কাঠ	(৩)	বাঁশ	৪	অন্যান্য (উল্লেখ করুন)	৫

২.৬.১ বাড়ী তৈরির ব্যবহৃত জিনিস-পত্র কোথা থেকে সংগ্রহ করেছেন? নওয়াবেকী

২.৬.২উক্ত ছাদের পুরুত্ব কত? ২ মি.মি

২.৭.১ গত ৫ বছরে বসত-বাড়ি মেরামত/ পুনরায় তৈরি করতে হয়েছে? হ্যাঁ = (১) না = ২

২.৭.২ হ্যাঁ হলে কতবার? ২

২.৭.৩ এতে কত খরচ হয়েছে? ৫ হাজার টাকা

২.৮.১ গত ৫ বছরে বসত-বাড়ি স্থানান্তর করতে হয়েছে কি? হ্যাঁ = ১ , না = (২)

২.৮.২ হ্যাঁ হলে কতবার?

২.৮.৩ কত খরচ হয়েছে?

২.৯.১ বাড়ীর দেয়াল এ ফাটল/ভাংগা আছে কি? হ্যাঁ = ১ ; না = (২)

২.৯.২ হ্যাঁ হলে ফাটলের মাপ- (ইঞ্চি)

২.৯.৩ হ্যাঁ হলে ফাটল কয়টি (সংখ্যা)

২.৯.৪ বাড়ীর ছাদে/চালে ফাটল/ ভাংগা আছে কি? হ্যাঁ = ১ ; না = (২)

২.৯.৫ হ্যাঁ হলে ফাটলের মাপ- (ইঞ্চি)

২.৯.৬ হ্যাঁ হলে ফাটল কয়টি (সংখ্যা)

২.৯.৭ ফাটলের প্রধান কারণ কী কী (একাধিক উত্তর হতে পারে)

ক্ষয়প্রাপ্ত হওয়া	১	লবনাক্ততার জন্য	২	ঘূর্নিঝড়ের বাতাসের জন্য	৩	জলোচ্ছাসের জন্য	৪	নিম্নমানের মালামাল ব্যবহার	৫	অন্যান্য) (উল্লেখ করুন	৬

২.১০ বাড়ীর মুখ

উত্তর	১	দক্ষিণ	২	পূর্ব	(৩)	পশ্চিম	৪

২.১১ বাড়িতে পর্যাপ্ত বাতাস আসা যাওয়ার ব্যবস্থ আছে কি? (উত্তরের সাথে আপনার পর্যবেক্ষণ মিলিয়ে সঠিক উত্তর বেছে নিন) হ্যাঁ = ১ ; না = (২)

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২.১২ বাড়ীতে উঠোন আছে কি?	হ্যাঁ = ১ ; না = ২		২.১৩ নিকটবর্তী পুকুর আছে কি?	হ্যাঁ = ১ ; না = ২	
২.১৪.১ বাড়িতে পানি উঠে কি ?	হ্যাঁ = ১ ; না = ২	২.১৪.২ কিসের পানি ?		২.৪.৩ কখন এই পানি উঠেছিল? (বছর)	
২.১৪.৪ এই পানি কতদিন অবস্থান করেছিল?		২.১৪.৫ উঠানে কত ফুট পানি উঠেছিল			

৩. ব্যবহার ও মালামাল:

৩.১ পরিবারের সদস্য সংখ্যা:											
৩.২ বাড়ীর ছেলে সন্তানের সংখ্যা:						৩.৩ বাড়ীর মেয়ে সন্তানের সংখ্যা:					
৩.৩.১ বাড়ীর বৃদ্ধের সংখ্যা:		৩.৩.২ বাড়ীর প্রতিবন্ধীর সংখ্যা:				৩.৩.৩ বাড়ীর প্রতিবন্ধীর ধরন:	শ্রবণ প্রতিবন্ধী = ০১, বাক প্রতিবন্ধী = ০২, দৃষ্টি প্রতিবন্ধী = ০৩, শারীরিক প্রতিবন্ধী = ০৪, একাধিক প্রতিবন্ধকতা = ০৫, মানসিক প্রতিবন্ধী = ০৬, অন্যান্য = ০৭				
৩.৪ পরিবারের বাৎসরিক আয়: (টাকায়)						৩.৫ রান্না ঘরের অবস্থান কোথায়	ভিতর (সংযুক্ত)	১	বাহির (আলাদা)	২	
৩.৬ রান্নার জ্বালানি: (একাধিক উত্তর হতে পারে)	কেরোসিন	১	কাঠ	২	খড়	৩	অন্যান্য (উল্লেখ করুন)	৪			
৩.৭ বায়ুচলাচল ব্যবস্থা (গরম বাতাস বাহির হওয়ার বিশেষ ব্যবস্থা)	চিমনি	১	পাখা	২	নাই	৩	অন্যান্য (উল্লেখ করুন)		৪		
৩.৮ প্রধান প্রবেশ বারান্দার আয়তন: বর্গফুট						৩.৯ প্রধান প্রবেশ বারান্দার তৈরি উপাদান:					
৩.১০ জানালা কি মালামাল দিয়ে তৈরি? (একাধিক উত্তর হতে পারে)	কাঠ	১	লোহা	২	টালি	৩	অন্যান্য (উল্লেখ করুন)		৬		
৩.১১ জানালা আটকানোর পদ্ধতি:	ছিটকিনি	১	কপাট	২	বেধে রাখা ও খোলা	৩	অন্যান্য (উল্লেখ করুন		৪		
৩.১২ ঘুমানোর ব্যবস্থা:	মেঝে	১	খাটি/বিছানা	২	অন্যান্য (উল্লেখ করুন)				৩		
৩.১৩ ঘরের মেঝে তৈরির উপাদান: (একাধিক উত্তর হতে পারে)	মাটি /কাদা	১	কনক্রিট	২	ইট	৩	টাইল	৪	কাঠ	৫	অন্যান্য (উল্লেখ করুন)	৬
৩.১৪ ঘরের ভিতর দেয়ালের তৈরি উপাদান (একাধিক উত্তর হতে পারে)	মাটি /কাদা	১	কনক্রিট	২	টালি	৩	টাইল	৪	কাঠ	৫	অন্যান্য (উল্লেখ করুন)	৬

৪. সুযোগ-সুবিধা

৪.১ খাবার পানির উৎস। (একাধিক উত্তর হতে পারে)	মাটির নিচের পানি (নিরাপদ) ১ ; সৌদি সাপ্লাই পানি ২ ; বৃষ্টির পানি ৩ ; নদীর পানি ৪ ; পুকুরের/দীঘির পানি ৫ ; অন্যান্য (উল্লেখ করুন) ৬ — ৩কি.মি. দূর থেকে আনায় হয়
৪.২ গোসল ও অন্যান্য কাজে ব্যবহৃত পানি: (একাধিক উত্তর হতে পারে)	মাটির নিচের পানি (নিরাপদ) ১ ; সৌদি সাপ্লাই পানি ২ ; বৃষ্টির পানি ৩ ; নদীর পানি ৪ ; পুকুরের পানি ৫ ; অন্যান্য (উল্লেখ করুন) ৬
৪.৩: বৈদ্যুতিক সংযোগ আছে কি?	হ্যাঁ = ১ ; না = ২ — ৪.৪ না হলে, ঘরে আলোর ব্যবস্থা: কুপি/হারিকেন ১ ; সোলার ২ ; অন্যান্য ৩ (উল্লেখ করুন)
৪.৫ পায়খানার ধরণ:	খোলা মাঠে/ঝোপঝাড়ে ১ ; রিং স্লোপ সহ পায়খানা ২ ; রিং স্লোপ ছাড়া পায়খানা ৩ ; ঢাকনা যুক্ত গর্ত ৪ ; অন্যান্য ৫ (উল্লেখ করুন)
৪.৬.১ বৃষ্টির পানির জন্য বাড়ীর ছাদ পেয়ার করেন কি?	হ্যাঁ = ১ ; না = ২ — ৪.৬.২ হ্যাঁ হলে, কতজন মিলে বাড়ীর ছাদ পেয়ার করেন? — ৪.৬.৩ বৃষ্টির পানি পরিবারের কতদিন চলে? ২০ দিন
৪.৬.৪ খাবার পানির কি কিনতে হয়?	হ্যাঁ = ১ ; না = ২ — ৪.৬.৫ হ্যাঁ হলে, গতবছরে বাড়ি নিজের জন্য কিনতে হয়েছিল কি? — ৪.৬.৬ গড়ে প্রতিদিন কত খরচ হয়েছিল কি?

৫. অন্যান্য

৫.১ স্থানীয় সরকার সম্পর্কে এর দূরত্ব:	৩কি.মি. — ৫.২ যেখানে কোনো বাড়ী নির্মাণ বীতিমালা আছে? হ্যাঁ = ১ ; না = ২
৫.৩ আপনার বাড়ী তৈরীতে যে সাহায্য করেছে? (কারিগরি)	নিজে ১ ; আত্মীয়-স্বজন দিয়ে ২ ; ঠিকাদার দিয়ে ৩ ; অন্যান্য (উল্লেখ করুন) ৪ — মিস্ত্রী
৫.৩ আপনার বাড়ী তৈরীতে কে সাহায্য করেছে?- (আর্থিক)	নিজে ১ ; সরকার ২ ; NGO ৩ ; প্রতিবেশী ৪ ; অন্যান্য (উল্লেখ করুন) ৫

উত্তরদাতার স্বাক্ষর	দেবব্রত মন্ডল

৬. ডাটা এডিটর / ডাটা এন্ট্রি অপারেটরের পরিচিতি:

৬.১	সাক্ষাৎকার গ্রহণকারীর নাম	বি.এম. কামরুল হাসান	৬.৫	সাক্ষাৎকার গ্রহনে তারিখ	২০/১০/১৮
৬.২	সুপারভাইজার এর নাম		৬.৬	চেক করার তারিখ	২৩.১০.১৮
৬.৩	কাজ সঠিক ভাবে করা হয়েছে (কোডে)		৬.৭	এন্ট্রি করার তারিখ	

কোড: সম্পূর্ণ সঠিক পাওয়া গেছে = ১, মোটামুটি সঠিক পাওয়া গেছে = ২, সঠিক পাওয়া যায়নি = ৩