IMPACT AND BENEFIT ANALYSIS OF USING LIGHTWEIGHT CONCRETE BLOCKS IN BUILDING CONSTRUCTION

By

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering

Department of Civil Engineering

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147/I, Green Road, Dhaka-1215, Bangladesh

Section: 20A

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Dedicated

to

Our Honorable Supervisor

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ABSTRACT

Traditional constructions use burned clay bricks, which have drawbacks. The construction industry has grown interested in sustainable and creative building materials instead of burnt clay bricks to address environmental issues, improve construction efficiency, and improve building performance. Clay bricks are small but hefty and require a lot of concrete to unite and plaster from both sides to fill the wall surface's unevenness and improve the quality. However, lightweight concrete blocks are a viable alternative to clay bricks or standard concrete blocks due to their reduced weight and enhanced insulation. This thesis examines the advantages of lightweight concrete blocks in building construction. Lightweight blocks lowered mortar use, making them stronger, faster, and more durable than brick masonry. Due to its inexpensive cost, lightweight (about 30% less than clay bricks), and acoustic and thermal insulation, lightweight blocks are 10 times the size of clay bricks and are growing in demand. This study examines how lightweight concrete blocks affect building structures, focusing on spearing's impact on cost and weight. The study compares lightweight concrete blocks to conventional ones in mechanical, thermal, and environmental qualities. The study examines lightweight concrete blocks' structural integrity, thermal insulation, and environmental benefits through literature review and lab testing. Results show that lightweight concrete blocks have comparable mechanical strength to conventional ones, decreasing construction project carbon footprints. This thesis also investigates the economics of lightweight concrete blocks in buildings. A cost-benefit study considers material costs, construction time, energy savings, and long-term maintenance. The findings show that builders and developers can afford lightweight concrete blocks after the initial outlay. This research considers the social impact of lightweight concrete blocks in addition to the technical and economic aspects, promoting sustainable and efficient building practices and a more environmentally friendly and economically viable construction industry.

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LIST OF ABBREVIATION

AAC	:	Autoclaved Aerated Concrete
ASTM	:	American Society for Testing and Materials
BNBC	:	Bangladesh National Building Code
CKD	:	Cement Kiln Dust
CLC	:	Cellular Lightweight Concrete
FAO	:	Food and Agriculture Organization of the United Nations
FM	:	Fineness Modulus
HBRI	:	Housing and Building Research Institute
HCB	:	Hollow Concrete Block
HDPE	:	High-Density Polyethylene
LDPE	:	Low-Density Polyethylene
NAAC	:	Non-autoclaved Aerated Concrete
NILU	:	Norway-based Research Institute
PWD	:	Public Works Department
RCC	:	Reinforced Cement Concrete
SCHB	:	Sand Cement Hollow Block

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CHAPTER 1
INTRODUCTION

According to a study by the Housing and Building Research Institute (HBRI) under the Ministry of Housing and Public Works, an average of 700 acres of agricultural land is lost every day in the country, which is more than 1 percent of the total cultivable land. 20 percent of these 700 acres of land is lost due to brick kilns. In such a reality, the government made a law discouraging earth-burning brick kilns and giving priority to the use of eco-friendly concrete block bricks. Besides, plans are taken to implement the law. According to the plan, the target of using block bricks in all government development works by 2025 has been set in a step-by-step manner, moving away from the use of conventional bricks. This plan was taken in 2019. In the same year, laws were amended to regulate the manufacture of bricks and the setting up of kilns. It is known that the amended law mandates the use of block bricks instead of burnt clay bricks in all government construction, repair and expansion works and is effective from the fiscal year 2019-20.

The Ministry of Environment, Forest and Climate Change issued a notification on November 4, 2019, to implement this plan of the government. Along with government, the construction industry is also increasingly recognizing the importance of sustainable practices. Lightweight concrete blocks present an opportunity to reduce the environmental impact of construction activities. Traditional construction materials, such as standard concrete blocks, are known for their weight and resource-intensive production processes. Lightweight concrete blocks offer an alternative that can potentially address these issues. Innovations in building materials, like lightweight concrete, have gained attention due to their potential to enhance energy efficiency, reduce construction costs, and minimize the ecological footprint of buildings. Assessing the environmental impact can demonstrate the potential contribution to sustainable and eco-friendly construction.

Analyzing the impact and benefits of lightweight concrete blocks is important for influencing market trends and encouraging the adoption of sustainable construction practices by builders, architects, and developers. The viability and potential advantages of incorporating lightweight concrete blocks in building construction need a comprehensive investigation to address these challenges and provide valuable insights for sustainable and efficient construction practices. The study can also explore how the use of lightweight concrete blocks aligns with or contributes to building codes, standards, and regulations related to sustainability and environmental impact.

The study may be limited by time constraints, but the study will rely on the data accessible within the defined scope. Despite limitations, the study aims to provide valuable insights into the impact and benefits of using lightweight concrete blocks in building construction within the defined scope, offering practical recommendations for stakeholders within the construction industry.

In conclusion, the study on the impact and benefit analysis of using lightweight concrete blocks in building construction addresses a critical need in the construction industry by providing valuable insights into the environmental, economic, and structural aspects of this innovative material. The findings have the potential to inform industry practices, influence regulations, and contribute to the ongoing global effort towards sustainable and efficient construction methods.

CHAPTER 2
LITERATURE REVIEW

The report [8] provides us with a concise overview of the properties of light-weight concrete blocks, and the report [1] provides us with a comparison chart of the compressive strength of high-performance concrete blocks (HCB), which is a collaboration between the reports [2], [3], [4], [5], and [6].

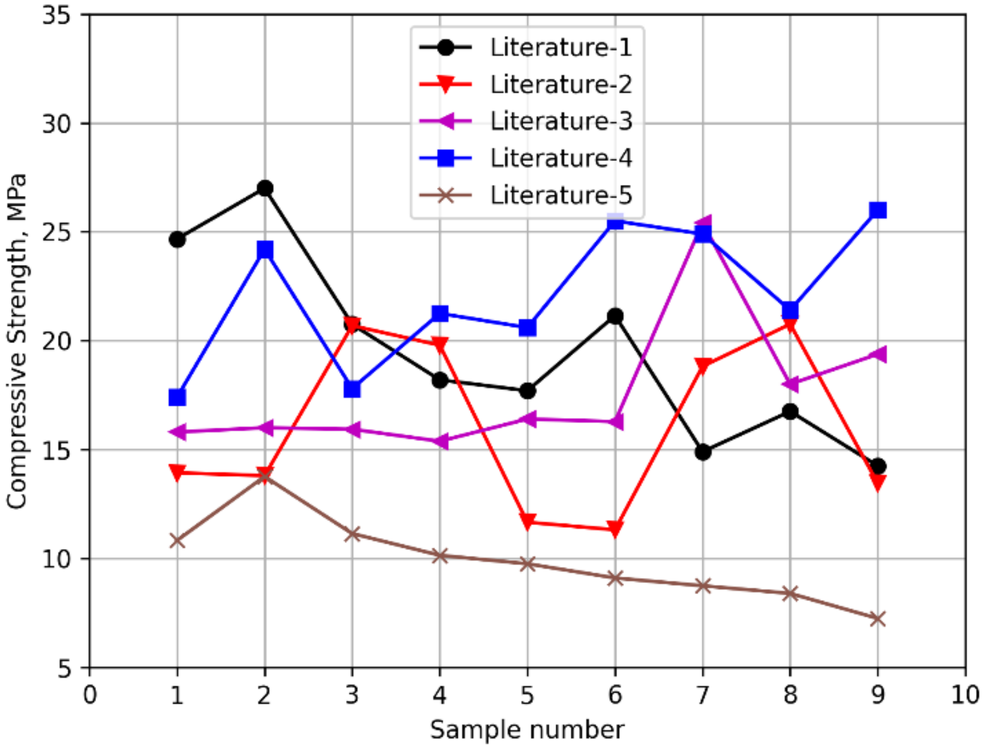

Figure 2-1: Comparison of Compressive Strength of HCB from 5 Experimental Literature [2,3-6].

A different report [7] provides us with information regarding the distinctions between clay bricks and the many kinds of lightweight concrete blocks. In addition to this, we obtain the facts and the influence that clay bricks have on the environment (particularly the pollution of the air and the land) from various newspaper stories.

Through the process of reading all these data, we are attempting to determine the real scenario of the impact of lightweight concreate block, and analysis the benefit of using lightweight concreate blocks.

CHAPTER 3
METHODOLOGY

There are many types of lightweight concrete blocks according to the method of production, manufacturing process & materials properties. Such as- Hollow Concrete Blocks (HCB), Autoclaved Aerated Concrete (AAC), Cellular Lightweight Concrete (CLC), Non-Autoclaved Aerated Concrete (NAAC). Here we mainly research on HBC in comparison to burnt clay bricks.

3.1 Composition & Manufacturing Process of Traditional Burnt Clay Bricks

Bricks are one of the oldest human made building materials. Clay is available in many places in the world it is easy to find and process. When we say clay bricks, we normally mean red, kiln fired clay bricks that are commonly available in market. These bricks gain strength and water resistance by a heat treatment process like centering. When dried clay bricks are kept for a few hours at temperatures of the order of 950 C, some constituents of the clay melt/ soften and form strong ceramic bonds. These bricks don’t have a setting time like cement bonded bricks.

However un-fired clay bricks stabilized by cement or lime have a setting time determined by the type of cement/ lime used. The setting time is greatly affected by various impurities present in the clay that may accelerate or retard setting time. Cement stabilized clay bricks may have an initial setting time from 30 minutes to a few hours. Lime stabilized bricks have a setting time of several days.

Figure 3-1: Chulli of Traditional Burnt Clay Bricks

The manufacturing process of clay brick typically involves the following steps:

1. Preparation of raw materials: The clay used in brick manufacturing is first excavated from the ground, and then screened and cleaned to remove impurities. Water is added to the clay to form a workable mixture.

2. Molding: The clay mixture is then molded into the desired shape, typically using a mold or extrusion machine. The molded clay is then left to dry in the sun or in a drying chamber for several days until it is firm enough to handle.

3. Firing: Once the clay has dried, it is fired in a kiln at temperatures between 900 and 1100 degrees Celsius. The firing process hardens the clay and transforms it into a durable ceramic material.

4. Cooling and sorting: After firing, the bricks are left to cool in the kiln before they are sorted according to their quality and size. Any defective bricks are discarded, while the high-quality bricks are packaged and ready for shipping.

5. Packaging and shipping: The finished bricks are typically packaged into stacks or pallets and then transported to construction sites or to distributors for sale.

The exact manufacturing process for clay bricks can vary depending on the type of brick being produced and the specific manufacturing methods used by different manufacturers.

3.2 Mechanical and Physical Properties of Lightweight Concrete Block

The mechanical qualities of light-weight concrete blocks are influenced by factors such as compression strength, mineral admixtures for light-weight concrete masonry, cement ratio, and the use of sludge ash particles to enhance the strength of structural components. Conducting experiments in the laboratory to establish consistent mechanical qualities has enhanced the characteristics of concrete blocks, hence enhancing their quality and usefulness as construction materials.

Nowadays, light-weight concrete blocks with 25% less cement and mineral admixtures are utilized for masonry. Substitute cement with limestone powder, fly ash, and fiber wastes to decrease the weight of construction materials. The components utilized to modify the characteristics and durability of lightweight concrete blocks consist of Portland cement, fine aggregate (river sand filtered through a 4.75 mm screen), fly ash (with a specific gravity of 2.3), and a bulk density of 98 kg/m3. Lightweight concrete blocks are employed worldwide due to their thermal qualities, low dead load, durability, toxic gas reduction, 25% cement reduction with fly ash, and other criteria. Lightweight concrete blocks can be produced using different mix proportions to manipulate their characteristics for use in building.

The density of the concrete utilized in the production of lightweight concrete blocks classifies them into three distinct categories: low-density concrete, structural, and moderately strong. Low-density concrete is mostly employed for insulating purposes, resulting in a compressive strength ranging from 0.69 MPa to 6.89 MPa. This is attributed to its lower weight unit, which is less than 800 kg/m3. Modulated concrete is employed to produce lightweight concrete blocks that exhibit favorable compressive strength (6.89–17.24 MPa) and serve as effective insulating units. Structural light-weight concrete blocks exhibit superior compression strength (exceeding 34.47 MPa) as compared to moderated concrete blocks and low-density concrete. However, they have a lower insulating effectiveness.

3.3 Composition & Manufacturing Process of HCB

Standard ingredients for hollow concrete blocks include Portland cement, aggregates, water, and other additives. Ingredients applied in the formulation and construction of hollow concrete blocks have the following. Cement: Ordinary Portland cement can produce hollow concrete blocks, and its primary function is to engage the coarse & fine aggregate particles together. Now a days Cement is widely used in all kinds of construction works nowadays, especially those that require a great deal of strength. Coarse & Fine Aggregates: Based on particle size, mineral aggregates are often classified into two distinct categories- Coarse aggregate & Fine aggregate. Concrete hollow blocks may include rough material no more than 12.5 mm in dimension. Vermiculite is a common mineral that becomes larger when heated. It has flat, mica-like structure and may be found in various locations, including South Africa, China, Brazil, and other nations. When heated to between 650 and 1000 °C, vermiculite expands by exfoliating thin plates, increasing its volume by as much as 30 times. Cement Kiln Dust (CKD) & Quarry Dust: The dry method of making cement creates a dust by-product known as cement kiln dust. Quarry dust is a by-product of granite 974 stones formed when the stones are attenuated into gritty pebbles of various sizes. This dust partially or completely replaces and produces hollow concrete blocks.

Figure 3-2: 2 Holes Hollow Blocks (390mm x 190mm x 140mm)


Figure 3-3: 2 Holes Hollow Blocks (400mm x 200mm x 100mm)

3.4 AAC (Autoclaved Aerated Concrete) Blocks

AAC blocks, or Autoclaved Aerated Concrete, are a modern type of building material. Raw materials such as quartz sand, calcined gypsum, lime, portland cement, water, and aluminum powder are combined to form AAC blocks, which are then precast as foam concrete for sustainable construction. Aluminum interacts with cement, lime, and fly ash in a calculated ratio to produce this. The robust cell structure of AAC is the result of hydrogen gas escaping and creating millions of small air cells. The air content of this sort of concrete block is around 80%. Curing it in an autoclave at high temperature and pressure is how it gets its special strength after the first mixing and shaping. AAC lightweight blocks are permeable, non-toxic, and recyclable due to their density of 550–650 kg/m3. Concrete is molded and cut into masonry blocks or planks and panels in the facility where it's made.

Invented in 1923 by Swedish architect and inventor Dr. Johan Axel Eriksson and has been around for over 90 years with being extensively in developed European countries, USA, Japan & China. AAC works effectively in high-rise structures and can withstand wide temperature fluctuations. As a result of its reduced density, AAC-built structures may use less steel and concrete for their framework. Because there are fewer seams between AAC blocks, less mortar is required during installation. The exact sizes of AAC imply less rendering material is needed. AAC manufacturers make blocks of varying sizes and strengths. However, they are often 8-9 times larger than a standard red clay brick while still having superior compressive strength and weighing only a fraction of what a standard brick would. Buildings, both indoors and out, may benefit from the versatility of AAC blocks. AAC may be utilized in structures dealing with extreme heat since it retains less heat. In addition to saving time and money, this method of construction also removes the need for additional insulating materials.

AAC blocks are a type of lightweight precast concrete building material. They are known for their exceptional thermal insulation, durability, and environmental friendliness. AAC blocks are made from a mixture of sand, cement, lime, and aluminum powder. The unique characteristic of AAC is the inclusion of aluminum powder, which reacts with lime and produces hydrogen gas, creating numerous tiny air bubbles throughout the mixture. One of the primary advantages of AAC blocks is their lightweight nature. They are about one-fifth the weight of conventional concrete blocks. This makes it easier to handle, transport, and install, reducing construction time and labor costs. AAC blocks are durable and resistant to pests and molds. They do not degrade over time, ensuring a longer lifespan for the constructed building. In summary, AAC blocks offer a range of benefits, including lightweight construction, excellent thermal and sound insulation, fire resistance, and environmental sustainability, making them a popular choice in modern construction projects.

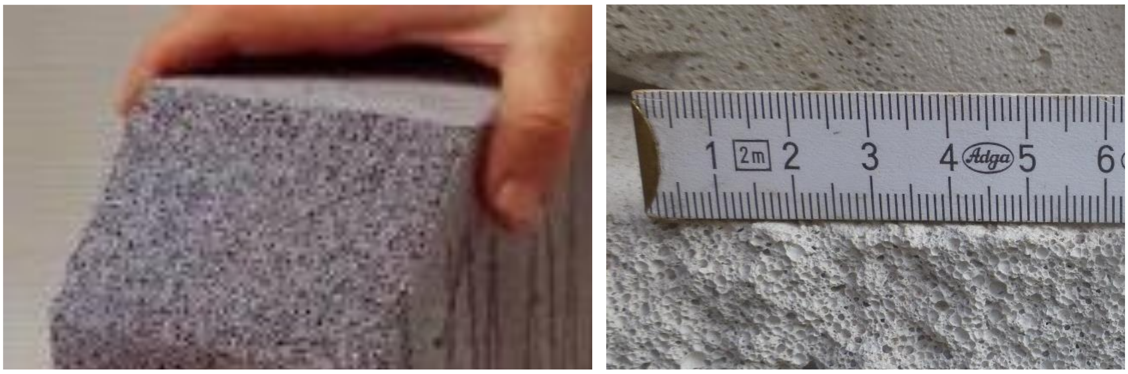

Figure 3-4: AAC Block

3.5 Comparison of Lightweight Blocks with Traditional Bricks

Table 3-1: Comparison of Bricks and Lightweight Blocks (Clay Bricks vs Lightweight Blocks)

S/N	Parameter	Red Clay Brick	Lightweight Block	
			AAC Block	Hollow Block
1	Raw Materials	Locally available clay & water	Cement, fly ash, water, and Air entraining agents	Cement, dredged sand (1:4 ratio), Admixture
2	Compressive Strength (As per IS codes)	2400 - 2800 psi	450 - 600 psi	1200 - 2200 psi
3	Dry Density (As per IS codes)	1800 kg/m3	550-650 kg/m3 It sone-third of the weight of clay brick which makes it easy to lift and transport	1400 kg/m3
4	Cost Benefit	As easily available in local market hence it is beneficiary for low rise structure.	Dead weight will be reduced for high-rise structures, saving on the amount of steel and concrete needed.	Dead weight will be reduced for high-rise structures, saving on the amount of steel and concrete needed.
5	Fire Resistance (8″ Wall)	Around 2 Hours	Up to 4 Hours	Around 4 Hours
6	Quality of End Product	Locally made product. Quality depends on various parameters like quality of raw materials used, process of manufacture etc.,	Factory made product. So, the quality of end product is consistent and good	The quality of the end product depends on the foam used and degree of quality control
7	Sound Insulation	Normal	Better Sound absorption/insulation as compared to bricks	Better Sound absorption/insulation as compared to bricks
8	Environmental Friendliness	One sq ft of cover territory with bricks walling will devour 25.5 kg of soil (approx.). It really harms condition	In AAC Block there is no topsoil utilization, and it transmits low Carbon dioxide as contrast with bricks while fabricating	In hollow Block there is no soil utilization, and it produces low Carbon dioxide as contrast with Bricks while fabricating.
9	Internal and External Plaster	Requires thick mortar surface as there are varieties in the measurements	As these blocks have dimensional precision, the inner and external mortar thickness can be lessened	As these blocks have dimensional precision, the inner and external mortar thickness can be lessened

S/N	Parameter	Red Clay Brick	Lightweight Block	
			AAC Block	**Hollow Block**
10	Cost of Construction as per PWD Rate Schd.-2022	Automatic machine-made 1st class standard brick (250mm x 115mm x115): 1 Cum cost – Tk. 4840/-	Size: 600mm x 200mm x 200mm 1 Cum costs – Tk. 3750/-	Size: 390mm x 190mm x 112mm 1 Cum costs – Tk. 4819/-
11	Cost of Masonry Wall as per PWD Rate Schd.-2022 (10 sqm)	Tk. 20,030/-	Tk. 17,283.5/-	Tk. 14,730/-
12	Joining Process	Traditional mortar needs to be used and the brick work should be cured at least for 7 days before plastering	Substance mortars can be utilized for joining the block. This diminishes the material utilization of concrete and furthermore abstains from curing process	Substance mortars can be utilized for joining the block. This diminishes the material utilization of concrete and furthermore abstains from curing process
13	Thermal Insulator	It has low thermal insulation as compared to AAC and hollow Block	AAC Blocks are great thermal insulator if cooling is a noteworthy part of any building month to month costs it will spare cost for whole lifetime	Hollow Blocks are great thermal insulator if cooling is a noteworthy part of any building month to month costs it will spare cost for whole lifetime
14	Water Absorption	Absorb 17 -20% by total volume of red clay brick	Absorb 12- 18% by total volume of AAC blocks	Absorb 12-15% of water by total volume of Block
15	Range of Application	They are useful in both load bearing and non-load baring structure	They are suitable for Non load bearing or RCC structure in partition wall	They are suitable for Non load bearing or RCC structure in partition wall

3.6 Strength Test of Clay Bricks & Lightweight Blocks

Table 3-2: Compressive Strength Test Report of Bricks

Sample Description: Red Brick

Date of Test: 05-Nov-23

Specimen No	Frog Mark	Dimension		Area	Max. Load	Com. St.		
		Top	Bottom			Load/Area	Result	
		cm	cm	cm2	Kg	Kg/cm2	Avg. Kg/cm2	Mpa
1	MRS	12.2	11.3	137.9	25500	184.9	183.6	18.00 (2611 psi)
2	MRS	12.1	11.2	135.5	24500	180.8		
3	MRS	12.2	11.1	135.4	25500	188.3		
4	MRS	12.1	11.2	135.5	25000	184.5		
5	MRS	12.2	11.1	135.4	25500	188.3		
6	MRS	12.2	11.2	136.6	25000	183.0		
7	MRS	12.1	11.3	136.7	24500	179.2		
8	MRS	12.3	11.2	137.8	25000	181.4		
9	MRS	12.2	11.1	135.4	24500	180.9		
10	MRS	12.1	11.2	135.5	25000	184.5		

Table 3-3: Compressive Strength Test Report of Hollow Blocks

Sample Description: Hollow Block

Date of Test: 06-11-2023

Specimen No	Specimen Size	Size Hole	No of Hole	Calibrated Load	Compressive Strength		Average
	mm	mm		in KN	in Mpa	in psi	psi
1	390 x 190 x 190	135 x 110 153	2	509.47	11.47	1664	1372
2	390 x 190 x 190	135 x 110 153	2	370.22	8.34	1210	
3	390 x 190 x 190	135 x 110 153	2	380.17	8.56	1242	

Table 3-4: Compressive Strength Test Report of AAC Blocks

Sample Description: AAC Block

Date of Test: 23-11 2023

Specimen No	Specimen Size	Calibrated Load	Specimen Area	Compressive Strength		Average	Water Absorption
	mm	in KN		in Mpa	in psi	psi	
1	294 x 200 x 110	191.19	58800	3.25	471	450	17.98%
2	294 x 200 x 110	193.18	58800	3.29	477		
3	294 x 200 x 110	163.34	58800	2.78	403		

3.7 Structural Effect

3.7.1 Reduced Dead Load

Lightweight blocks have a lower density compared to conventional. This results in a reduced deadload on the overall structure. The lower deadload can lead to cost savings in the foundation design and construction, as well as in the overall structural system.

3.7.2 Affordability and Sustainability

Because lightweight blocks are made entirely of natural, non-toxic materials, their manufacturing process produces very few byproducts. It's an environmentally favorable option because some of the waste and leftovers generated can be recycled and turned into aggregate. Because of its non-biodegradable makeup, the structure will last a long time and prevent harm from moisture. Lightweight blocks require less labor overall and save money because of their low weight, low energy consumption, and simplicity of installation.

3.7.3 Improved Thermal Insulation

Lightweight blocks often have better thermal insulation properties compared to regular concrete blocks. The presence of air voids in lightweight concrete contributes to its insulating capability. This can lead to energy efficiency in buildings, reducing the need for additional insulation materials and lowering heating and cooling costs.

3.7.4 Fire Resistance

Lightweight concrete blocks generally have good fire-resistant properties due to their composition. The presence of air voids and lightweight aggregates contributes to their ability to withstand high temperatures, providing an added level of safety in case of fire.

3.7.5 Acoustic Insulation

Good acoustic insulation qualities are further facilitated by the porous structure of lightweight blocks. This has the potential to improve indoor environments and make them calmer and cozier, particularly in residential and commercial structures.

3.7.6 Reduced Earthquake Loads

The reduced dead load of lightweight blocks can also be advantageous in seismic zones. The lower mass of the structure can result in lower seismic forces acting on the building during an earthquake.

Although lightweight blocks offer certain benefits, it is crucial to acknowledge that they may have limitations in terms of compressive strength when compared to conventional bricks. Hence, it is imperative to consider engineering factors in designing structures with lightweight blocks to guarantee compliance with the necessary safety and structural criteria. Furthermore, it is advisable to refer to local building standards and regulations to guarantee adherence to precise construction criteria.

3.8 Masonary Process of Bricks & Blocks

Masonry is commonly used for walls and buildings. Brick and concrete are the most broadly recognized sorts of masonry being used in industrial countries and might be either weight-bearing or a facade. Concrete blocks, mostly those with hollow cores, offer different potential effects in masonry construction. They also give extraordinary compressive strength and are most suitable to structures with light transverse loading when the cores stay blank. Filling a few or most of the cores with concrete or cement with steel fortification offers significantly more tensile and lateral strength to structures. Ease of joining of blocks, minimum plastering (6mm thick) is required to cover the faces of blocks, but in brick masonary wall minimum 12mm thick plastering is needed. So, in HCB wall, less concrete and time is used in comparison of clay bricks due to its uniform surface.

Figure 3-5: Brick Mason Thick Plastering Required

Figure 3-6: Block Mason Plastering Not Required or Thin Plastering Required

Figure 3-7: AAC Blocks Mason Plastering Not Required or Thin Plastering Required

3.9 Cost Analysis of 10 sqm Masonry Wall

Table 3-5: Cost of 125 mm (5") Brick Masonry Wall (10 sqm)

Item No.	Reference	Description of Item	Unit	Quantities	Rate in BDT	Total Amount in BDT
1.	PWD Rate Schd. - 2022 Item No. 04.15	125 mm brick work with first class bricks with cement sand (F.M. 1.2) mortar (1:6) and making bond with connected walls including necessary scaffolding, raking out joints, cleaning and soaking the bricks for at least 24 hours before use and washing of sand, curing at least for 7 days in all floors including cost of water, electricity and other charges etc. all complete and accepted by the Engineer-in-charge. (Cement: CEM-II/B-M) In ground floor	sqm	10.00	1,373.00	13,730.00
2.	PWD Rate Schd. - 2022 Item No. 15.1.1	Minimum 12 mm thick cement sand (F.M. 1.2) plaster (1:4) with fresh cement to both inner-and outer surface of wall, finishing the corner and edges including washing of sand, cleaning the surface, curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/B-M) Ground floor.	sqm	20.00	315.00	6,300.00
Total Amount of 125 mm brick wall with plaster						20,030.00

Table 3-6: Cost of 112 mm (4.4") Hollow Block Masonry Wall (10 sqm)

Item No.	Reference	Description of Item	Unit	Quantities	Rate in BDT	Total Amount in BDT
1.	PWD Rate Schd. - 2022 Item No. 30.15.1	112 mm thick partition wall with sand cement hollow block wall (SCHB) having compressive strength of not less than 10 MPa, size (390 x 190 x 112) mm, thickness of individual Block shell should not be less than 25 mm, water absorption not more than 7%, laying with specified mortar (with admixture) of cement and sand in a ratio of not less than 1:5 (sand not less than F.M = 1.2), filling the interstices with mortar and making bond with connecting walls including necessary scaffolding and curing for minimum 14 days on mortar joints by jute/ brush in wet, followed by impervious/ wet covering for another 7 days including cost of water, electricity and other charges etc. in all completed by the contractor and accepted by the Engineer-in-charge. Ground Floor	sqm	10.00	871.00	8,710.00
2.	PWD Rate Schd. - 2022 Item No. 15.5	Minimum 6 mm thick cement sand (F.M. 1.2) plaster (1:4) with fresh cement to ceiling, R.C.C. columns, beams, surface of stair case, sunshades, cornices, railings, drop wall, louvers, fins and finishing the corners and edges including washing of sand, cleaning the surface, curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/B-M) Ground floor.	sqm	20.00	301.00	6,020.00
Total Amount of 112 mm hollow block wall with plaster						14,730.00

Table 3-7: Cost of 150 mm (5.9") AAC Block Masonry Wall (10 sqm)

Item No.	Reference	Description of Item	Unit	Quantities	Rate in BDT	Total Amount in BDT
1.	PWD Rate Schd. - 2022 Item No. 30.38.3.1	150 mm thick wall in super structure with Autoclaved Aerated Concrete (AAC) Block of size (600 x 200 x 150 : L x H x W) mm having Compressive Strength not less than 6 MPa, Nominal Dry Density 850 kg/m3 and Drying Shrinkage not exceeding 0.02% conforming BNBC-2020 (ASTM C1386), laying with approved polymer modified adhesive mortar having water retention not less than 75% & average compressive strength at 28 days, min 5.2 MPa conforming ASTM C270, Splitting Tensile Strength not less than (0.40 – 0.49 MPa) conforming ASTM C1660, maintaining w/p ratio 25% - 30% and jointing adhesive mortar layer thickness of (3 mm - 4 mm), (or other binding materials which comply with BNBC-2020) filling the interstices with mortar and making bond with connecting walls/ frames including necessary scaffolding, cutting and sizing AAC blocks etc. all completed by the contractor and accepted by the Engineer-in-charge. Ground Floor	cum	1.50	7,509.00	11,263.50
2.	PWD Rate Schd. - 2022 Item No. 15.5	Minimum 6 mm thick cement sand (F.M. 1.2) plaster (1:4) with fresh cement to ceiling, R.C.C. columns, beams, surface of stair case, sunshades, cornices, railings, drop wall, louvers, fins and finishing the corners and edges including washing of sand, cleaning the surface, curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all	sqm	20.00	301.00	6,020.00

Item No.	Reference	Description of Item	Unit	Quantities	Rate in BDT	Total Amount in BDT
		complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/B-M) Ground floor.				
Total Amount of 150 mm AAC block wall						17,283.50

Table 3-8: Cost of 250 mm (10") Brick Masonry Wall (10 sqm)

Item No.	Reference	Description of Item	Unit	Quantities	Rate in BDT	Total Amount in BDT
1.	PWD Rate Schd. - 2022 Item No. 04.1	Brick works with first class bricks with cement sand (F.M. 1.2) mortar (1:6) in foundation and plinth, filling the joints/interstices fully with mortar, racking out the joints, cleaning and soaking the bricks at least for 24 hours before use and curing at least for 7 days etc. all complete including cost of water, electricity and other charges and accepted by the Engineer-in-charge.(Cement: CEM-II/B-M)	cum	2.50	9,140.00	22,850.00
2.	PWD Rate Schd. - 2022 Item No. 15.1.1	Minimum 12 mm thick cement sand (F.M. 1.2) plaster (1:4) with fresh cement to both inner-and outer surface of wall, finishing the corner and edges including washing of sand, cleaning the surface, curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/B-M) Ground floor.	sqm	20.00	315.00	6,300.00
Total Amount of 250 mm brick wall with plaster						29,150.00

Table 3-9: Cost of 240 mm (9.5") Block Masonry Wall (10 sqm)

Item No.	Reference	Description of Item	Unit	Quantities	Rate in BDT	Total Amount in BDT
1.	PWD Rate Schd. - 2022 Item No. 30.5.1	240 mm thick Exterior Wall with Concrete Hollow Block having minimum compressive strength of 15 MPa of size (390 x 190 x 240) mm, thickness of individual Block Shell should not be less than 32 mm, water absorption not more than 7%, laying with specified mortar of cement and sand in a ratio 1:4 (sand not less than F.M =1.2) and minimum thickness of 15 mm (9 mm for shell portion and 6 mm for inside hollow portion), filling the interstices with mortar and making bond with connecting walls/ frames including necessary scaffolding and curing for minimum 3 (three) days on mortar joints by jute/ brush in wet, followed by impervious/ wet covering for another 4 (four) days curing etc. all completed by contractor and accepted by the Engineer-in-charge. Ground floor	sqm	10.00	1,926.00	19,260.00
2.	PWD Rate Schd. - 2022 Item No. 15.5	Minimum 6 mm thick cement sand (F.M. 1.2) plaster (1:4) with fresh cement to ceiling, R.C.C. columns, beams, surface of stair case, sunshades, cornices, railings, drop wall, louvers, fins and finishing the corners and edges including washing of sand, cleaning the surface, curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/B-M) Ground floor.	sqm	20.00	301.00	6,020.00
Total Amount of 240 mm hollow block wall with plaster						25,280.00

Table 3-10: Cost of 240 mm (9.5") AAC Block Masonry Wall (10 sqm)

Item No.	Reference	Description of Item	Unit	Quantities	Rate in BDT	Total Amount in BDT
1.	PWD Rate Schd. - 2022 Item No. 30.38.1.1	240 mm thick wall in super structure with Autoclaved Aerated Concrete (AAC) Block of size (600 x 200 x 240 : L x H x W) mm having Compressive Strength not less than 6 MPa, Nominal Dry Density 850 kg/m3 and Drying Shrinkage not exceeding 0.02% conforming BNBC-2020 (ASTM C1386), laying with approved polymer modified adhesive mortar having water retention not less than 75% & average compressive strength at 28 days, min 5.2 MPa conforming ASTM C270, Splitting Tensile Strength not less than (0.40 – 0.49 MPa) conforming ASTM C1660, maintaining w/p ratio 25% - 30% and jointing adhesive mortar layer thickness of (3 mm - 4 mm), (or other binding materials which comply with BNBC-2020) filling the interstices with mortar and making bond with connecting walls/ frames including necessary scaffolding, cutting and sizing AAC blocks etc. all completed by the contractor and accepted by the Engineer-in-charge. Ground Floor	cum	2.40	6,124.00	14,697.60
2.	PWD Rate Schd. - 2022 Item No. 15.5	Minimum 6 mm thick cement sand (F.M. 1.2) plaster (1:4) with fresh cement to ceiling, R.C.C. columns, beams, surface of stair case, sunshades, cornices, railings, drop wall, louvers, fins and finishing the corners and edges including washing of sand, cleaning the surface, curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all	sqm	20.00	301.00	6,020.00

Item No.	Reference	Description of Item	Unit	Quantities	Rate in BDT	Total Amount in BDT
		complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/B-M) Ground floor.				
Total Amount of 240 mm AAC hollow wall with plaster						20,717.60

3.10 Environmental Affect Analysis

According to the calculations of the Ministry of Land, an average of 225 hectares of land are lost every day, and 82,000 hectares of land are lost annually. The main reason for this is the collection of soil for housing construction and brick kilns.

The owners of the brick kilns lured the farmers with a one-time small amount of money and took away the topsoil of the important agricultural land for making bricks. Large areas of arable land are used for making brick kilns. As a result, arable land is decreasing. Again, due to the heat generated in the brick kilns, crop production in the area around the kilns is greatly disrupted. Farmers produce much less than their target crops. Land is losing its productive capacity due to brick kilns on cropland and making bricks from fertile topsoil. Nutrient-rich soil is used for making bricks. Nutrients generally decrease gradually from the surface of the soil to its depth. And at a depth of 4/5 feet, the amount of nutrients is very low. Experts say that as the land is losing its productivity, if we don't stop making bricks by burning the soil, in 2040, about five crore people in the country will face a food shortage.

According to the calculations of the Department of Environment, the total number of brick kilns across the country is 8 thousand 33. Of these, 2,513 do not have environmental clearance. According to the Department of Environment last November, out of more than 3,000 illegal brick kilns in the country, there are 1,000 in 12 major cities. According to the country's Environment Protection Act (2010) and Brick Kiln Control Act (2013), no brick kiln can be constructed within one kilometer of residential areas, hills, forests, and wetlands. Even on agricultural land, no brick kiln will be considered legal.

The soil used for making bricks is very high in calcium carbonate. At high heat, calcium carbonate present in the soil breaks down to produce calcium oxide and carbon dioxide. As it turns out, every kilogram of brick-making adds about 25 grams of carbon dioxide to the atmosphere from the soil alone, which contributes to air pollution and global warming.

According to the study, about 428 kg of carbon dioxide is added to the atmosphere in the production of 1000 bricks by the fixed chimney method. According to that calculation, more than 428 grams of carbon dioxide are added to the atmosphere for each brick made, which is a very important contribution to environmental pollution. On average, 0.79 grams of suspended particulate matter, 0.45 grams of particulate matter (10), 0.45 grams of particulate matter (2.5), 1.65 grams of sulfur dioxide, and 0.052 grams of nitrogen oxide are added to the atmosphere per kg of bricks. being

On the other hand, wood is used as fuel for brick kilns, which provides 25% fuel to brick kilns in Bangladesh every year. As a result of the burning of this natural wood, many trees are destroyed on the one hand, and on the other hand, the balance of animals living in those forests is destroyed. A country needs to have 25 percent forest land to maintain overall ecological balance, but Bangladesh has only 11 percent, and that too is decreasing day by day. According to the Food and Agriculture Organization of the United Nations (FAO), the main reason behind this is the burning of wood in brick kilns. Since 1990, the country has lost at least 840,000 hectares of forest land in the last 20 years, or 42,000 hectares every year.

In collaboration with Norway-based research institute NILU (Nilu), the Department of Environment's research revealed that brick kilns are responsible for 58 percent of Dhaka's air pollution in the dry season. That means brick kilns are the largest source of greenhouse gas production in the country. Besides wood, about 5.68 million tons of coal are used as fuel in brick kilns. From which about 15.67 million tons of carbon dioxide are added to the atmosphere annually.

Excessive burning of coal releases dust, particulate carbon, carbon monoxide, oxides of sulfur, and nitrogen, which have serious effects on the eyes, lungs, and airways. According to a report by Dainik Ittefaq (2009), there are about 6,000 conventional brick kilns in the country, which emit 8.75 million tons of carbon annually.

Annual consumption of coal in brick kilns is 4.78 million metric tons; wood consumption is 1.9 metric tons; soil consumption is 2840 million CFT; and carbon emissions are 11.59 million metric tons. The result of this is global warming. Brick kilns are one of the sources of PM2.5 (particulate matter 2.5), a harmful element in the air. According to research by the "Institute of Health and Evaluate" and the "Health Effects Institute" in Boston, PM 2.5 is a harmful particle with a diameter below 2.5 micrometers. These harmful particles are easily inhaled into the lungs and are responsible for many deaths. According to the researchers, these harmful particles can cause the death of more than 1 lakh people in Dhaka.

According to a study by the Department of Environment, six pollutants are strongly associated with brick kilns. They are PM2.5, PM10, carbon dioxide, carbon monoxide, oxides of sulfur, and oxides of nitrogen. According to the research of the "US Environmental Protection Agency," if the level of PM2.5 is more than 55.4 micrometers per cubic meter, it is harmful to human health. According to the research of “The State of Global Air Report," the PM2.5 level in Dhaka was 65 in 1990, but according to the 2016 report, it reached 101, which is almost double the acceptable level. According to the World Health Organization (WHO), carbon dioxide and carbon monoxide particles cause respiratory problems and are responsible for causing lung cancer. Also, carbon dioxide inhibits oxygen uptake, and carbon monoxide is known as the silent killer. Sulfur oxides cause eye, lung, and throat problems.

Also, as carbon dioxide gas is responsible for global warming, untimely floods, sudden heavy rains, and salinity are causing crops to perish before harvest. Oxides of sulfur and nitrogen are responsible for acid rain, causing crop losses and river fish kills. Also, due to brick kilns, the number of birds and other animals in the surrounding area has decreased significantly.

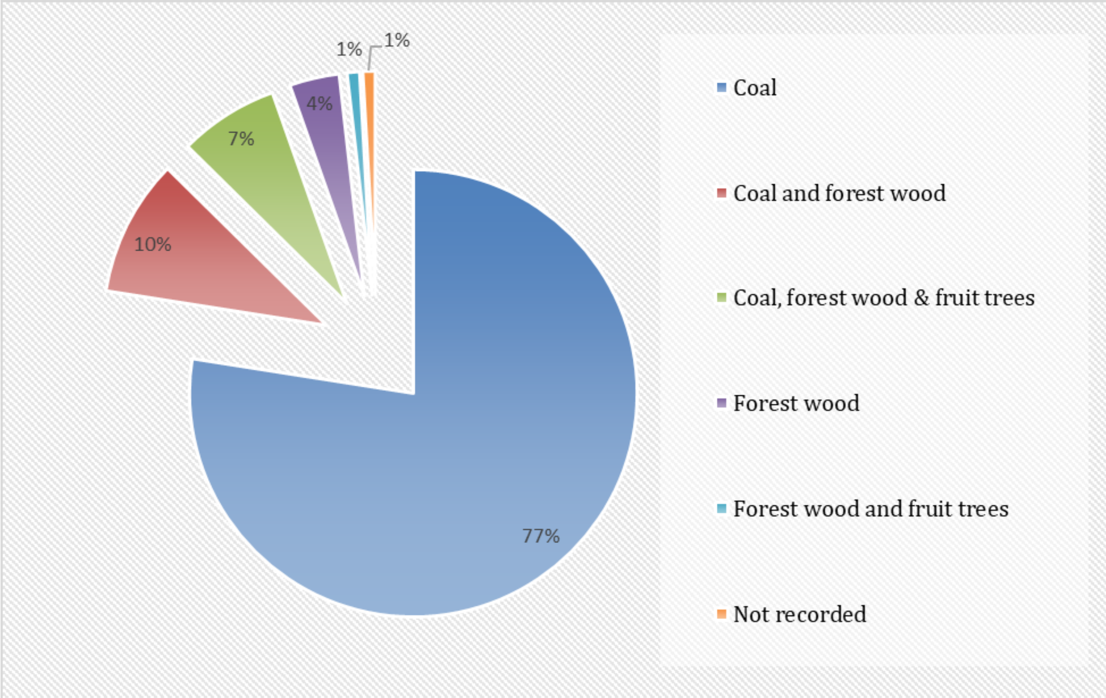

Figure 3-8: Fuels used in brick kilns

Figure 3-9: Burning of wood and trees in brick kiln

In developing countries, HCB (Hollow Concrete Block) is the material of choice for building envelope components. Hollow concrete block is the most cost-effective and environmentally friendly option for building concrete walls in a hot and dry climate because of its low heat conductivity and little material consumption. The versatility of hollow concrete blocks means they are frequently employed as walls, dividers, and structural components in building construction. Some key sustainability features are energy consumption, raw materials extraction, carbon footprint, and waste generation.

The versatility of hollow concrete blocks means they are frequently employed as walls, dividers, and structural components in building construction. Again, waste products such as extra concrete, dust, and packing debris can be created while manufacturing hollow concrete blocks. The adverse effects of these by-products on the environment can be reduced with effective waste management. Hollow concrete blocks' sustainability depends on their durability and lifespan. Concrete blocks may have a long service life with proper planning and maintenance, reducing wasteful replacements and repairs. Energy is required to create hollow concrete blocks, including mining, extraction, transportation, and manufacturing. As a result of the insulation provided by the hollow cores, less heat is transferred through the walls. This contributes to the maintenance of acceptable indoor temperatures and lessens the requirement for excessive heating or cooling, causing lower energy consumption and related greenhouse gas emissions. Buildings made of hollow concrete blocks can last longer than structures made of other materials if they are correctly designed and built.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Cost Benefit

- Unit weight of brick = 1800 kg/m^3

Unit weight of AAC block = 650 kg/m^3

= (650/1800) x 100 = 36% of brick

So, AAC block is (100-36) = 64% less weight than traditional brick.

Unit weight of HC block = 1400 kg/m^3

= (1400/1800) x 100 = 77% of brick

So, HCB is (100-77) = 23% less weight than traditional brick.

- If we use 5-inch brick masonary wall in 10 sqm area

Total dead load = 10/(0.076 x 0.254) x 3.35 kg = 1735 kg

If we use HBC (size: 400mm x 200mm x 100mm) in 10 sqm area

Total dead load = 10/(0.40 x 0.20) x 11.5 kg = 1474 kg

Dead load reduction = 100 - (1474/1735) x 100 = 15%

For high rise building, due to reduction 15% dead load. It will save the cost of concrete and steel qualities about 20%.

- As per PWD rate schedule, 2022:

Cost of 10 sqm masonary wall by brick = Tk. 20,030/-

Cost of 10 sqm masonary wall by AAC block = Tk. 17283/-

Cost save = 100 – (17283/20030) x 100 = 13% of brick masonary.

Cost of 10 sqm masonary wall by HCB = Tk. 14730/-

Cost save = 100 – (14730/20030) x 100 = 26% of brick masonary.

4.2 Environmental Effects

- The mud used in making bricks is collected from the top layer of cropland. As a result, cropland fertility is lost, crop production is reduced. On the other hand, riverbed sand is used to make blocks, so no damage is done to the crop land.

- Using lightweight concrete blocks reduces carbon emissions. Which helps to decrease air pollution. As a result, greenhouse gas production will also be reduced.

- Stop Using topsoil of cropland will increase food security and decrease soil pollution.

- It will reduce the use of wood as fuel, so deforestation will also stop.

CHAPTER 5
CONCLUSIONS

5.1 Conclusions

It is well-established that masonry walls of this building account for around 45% of the building's load. Therefore, if the weight of the blocks is lowered, the overall load of the building can also decrease.

Blocks have a weight that is one-third of bricks and one-fifth of concrete. Additionally, they come in conveniently manageable sizes. It decreases the weight of the structure, resulting in a reduction of up to 15-20% in the use of steel and concrete, leading to lower consumption and investment.

Blocks provide excellent thermal and acoustic insulation because of their minimal air infiltration. In addition, fewer joints and a more tightly packed (thin) joining mortar contribute to thermal and acoustic insulation. This results in well-insulated interiors, preventing the entry of warm air during the summer and cold air during the winter. Blocks can decrease energy expenditure by as much as 30%.

Although lightweight concrete blocks are a relatively new development in Bangladesh's construction sector, their numerous advantages make them the preferred material for upscale construction projects in a short period of time. The utilization of hollow concrete blocks in Bangladeshi construction has numerous advantages, such as enhanced thermal insulation, increased durability, resistance to pests and dampness, expedited building process, and positive contributions to sustainable development. However, there are unresolved concerns in the domains of quality control, material selection, legislation, structural design, and awareness that must be considered to ensure the safety and long-lasting nature of the final product. By intensifying research, prioritizing sustainability, embracing technological adoption, and fostering cooperation, Bangladesh has the potential to enhance the utilization of hollow concrete block construction, thereby contributing to the development of a stronger and more sustainable built environment.

The results of this effect and benefit study indicate that incorporating lightweight concrete blocks is a viable and environmentally friendly choice for constructing buildings. Stakeholders in the construction industry are advised to seriously consider using lightweight concrete blocks in their projects due to their significant advantages in terms of weight reduction, energy efficiency, and construction speed.

5.2 Limitations and Recommendations for Future Works

5.2.1 Limitations

There are also some limitations in our study. We should analysis the effect on structure due to dead load reduction. But we can't do this for our limitations. We also can't show more other kind of lightweight concrete block Cellular Lightweight Concrete (CLC) due to short of some data.

5.2.2 Recommendations for Future Works

Here, the result shows that lightweight concrete blocks are more useful, environmentally friendly, and more economical than traditional brick. So, we are recommended to use lightweight concrete blocks in building construction.

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APPENDIX

Appendix A

Figure A-1: Collecting information from HBRI Research Assistance.