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Review on Investigating Soil Stabilized Mud Blocks with Combined C&D Waste

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ABSTRACT- Buildings built by ancient civilizations like the Mesopotamians and Egyptians were made of clay and other materials, and the use of stabilized soil for construction dates to those times. On the other hand, the scientific underpinnings of soil stabilization were not established until the early 1900s. In comparison to conventional building materials, the use of stabilized soil-based construction materials, such as soil stabilized mud blocks, can offer several advantages, such as improved strength and durability, less of an adverse effect on the environment, and lower costs. The world is facing an issue that calls for the disposal of inorganic solid waste to be addressed right away. This solid waste that is produced when old buildings are demolished is frequently classified as industrial waste or C&D waste. In India alone, enormous amounts of waste are produced, very little of which is recycled. When modifying the properties of stabilized soil, this C&D waste can be used in place of soil or quarry sand. This work explores the use of a stabilizing agent in conjunction with combined C&D waste for soil sampling. The studies use combined C&D waste and soil stabilized mud blocks to test the hollow blocks' water absorption capacity and strength for various replacements. The materials needed for the study came from nearby structures that had been demolished. Using mortar, cylindrical samples for 32 different ratios of mixed construction and demolition waste with a 9% cement content were cast for various compositions. To determine whether the stabilized samples were suitable for use in construction, tests were conducted on their compressive strength and water absorption properties. Based on the least compressive values found in cylindrical samples, the C&D waste was used in ratios ranging from 0% to 100% in place of soil. Mud blocks stabilized by soil were poured and examined for durability, strength, and mechanical qualities.

In this study, an effort was made to use C&D waste—that is, brick and concrete waste—in varying amounts to create cylindrical samples that could be used to create concrete and stabilized mud blocks. In order to create cylindrical samples, different ratios of brick waste, concrete waste, and brick-concrete waste were used for 23 mix proportions. Cylindrical samples were manufactured using a cement content of 9 and 12%. These samples' mechanical and physical characteristics, such as their compressive strength, water absorption capacity, and initial rate of absorption, were investigated.

KEYWORDS- C & D Waste, Brick Waste, Concrete Waste, Compressive Strength. Scanning Electron Microscopy (SEM)

I. INTRODUCTION

Earth is the first material still used to build human civilization. Earth has always been essential to building, even for the ancient Egyptians and Mesopotamians. Mud wall constructions are widespread throughout the world. Mud is the best building material because it is easy to prepare and readily available in the area. Although it has limitations when it comes to durability, it can be thought of as an economical and energy-efficient material for low-cost and general construction. Building construction is considered a key stakeholder because of its potential to support sustainable development [1]. Uniaxial Compressive Strength, or UCS for short, is the highest compression strength a material can bear along a single axis. In UCS testing, cylindrical samples are frequently used to assess the strength characteristics of different materials, especially concrete and rocks. The origins of UCS testing can be found in the early 1900s, when scientists and engineers started investigating techniques for determining a material's composition. Uniaxial compression testing became a popular and dependable approach as the demand for standardized testing increased. Cylindrical samples were introduced into UCS testing, which has several benefits [2]. Because of the uniform distribution of stress along the axis made possible by the cylindrical shape, measuring, and controlling the applied load is made simpler. Additionally, cylindrical samples make testing and preparation easier and guarantee reliable, repeatable results. Cylindrical samples for UCS testing are usually made by coring or cutting specimens from bigger materials, like concrete buildings or rocks. These samples are meticulously formed into cylinders that have a predetermined diameter-to-height ratio, typically between 2:1 and 3:1. To guarantee uniform loading and precise measurements, the cylinder ends are frequently polished and flattened [3]. A cylindrical sample is put through testing by means of a specialized apparatus called a compression machine. Until the sample fails, the machine applies a compressive force perpendicular to it. The uniaxial compressive strength of the material can be ascertained by continuously monitoring and recording the force and the ensuing deformation. Considering the growing concern over environmentally friendly building materials and environmental issues, stabilized mud blocks provide an image of an economical, ecologically friendly, and energy-efficient building material. The stabilized mud block is the modern equivalent of the molded earth block. Stabilized soil block technology offers a high-quality, more affordable option to traditional building construction. Stabilized mud blocks are an important class of "modern construction materials" that can be used in both formal and informal sectors of structural activity because of their manufacturing flexibility [4]. This material has been developed since the early 1950s as a less costly substitute for the more costly burnt bricks and concrete blocks that are currently in use. For the most part, properly stabilized mud performs better than bricks or concrete blocks, as experience over the past three decades has shown.

II. LITERATURE REVIEW

This chapter presents an overview of mud blocks, including both soil-stabilized and concrete blocks, following a review of a few papers. They have mostly substituted coarse aggregates with C&D waste. WBP effectively replaced PPC up to a 15% replacement level, it can be concluded [15–17]. To ascertain the impact of substituting crushed brick waste for soil-sand mixture on the properties of compressed stabilized earth blocks, a comprehensive experimental study was conducted [18, 19]. The MDD decreases and the OMC increases as the amount of crushed brick waste increases. This is primarily due to the waste from crushed brick having a higher rate of water absorption and a lower density. The addition of crushed brick waste increased the flexural and compressive (wet-dry) strengths by up to 24 percent. When crushed brick waste fines smaller than 0.15 mm (CL) were used in place of sand in blocks, the results showed adverse effects even at 40% replacement [20].
In this essay, the following conclusions were reached. The maximum dry density was reached when the gravel percentage was 30 for a given 10% and 15% of fines [21]. The SLS 1382-part 1 minimum strength category for load-bearing walls was met by the 10% cement with 10% and 15% fine content as well as the compressive dry and wet strengths of mud blocks measuring 325 mm, 200 mm, and 125 mm [22–25]. Prisms' compressive strengths ranged from 14.57 MPa to 69.29 MPa for cement-sand mortar, 11.26 MPa for cement-soil mortar (1:3), and 10.35 MPa for cement-soil mortar (1:6) when the load was applied parallel to the foliation [26]. Given the strong correlation between flexural bond and block strength in multiple series, it is believed that using relatively high strength mortars with most pressed earth blocks offers little benefit [27, 28]. According to this study, cement mortar should typically be stabilized with 5% cement and based on the same soil mixture as the block. Higher cement mortars, however, might be appropriate in situations where considerable shrinkage is expected, such as in mortars made with soils that contain more than 15-20% clay [29, 30]. By altering the surface characteristics and adding surface coatings, soil-cement block masonry's shear-bond strength can be changed without affecting the mortar's characteristics. A rough texture offers superior shear-bond strength compared to a plain block surface. Applying surface coatings to the block's bed faces, such as epoxy or cement slurry coating, significantly improves the shear-bond strength [31]. An attempt to reinforce the connection is made by placing frogs on the bed faces of the block, but this method is not as effective as other ones. Bond-enhancing techniques like rough-textured bed faces and cement slurry coating are easily applied in the construction of soil-cement block masonry [32–34].
The masonry strength is more influenced by the cement content of cement-soil mortar than by the mortar's clay content. Increasing the cement percentage of a cement-soil mortar from 10% to 15% results in an approximate 20% increase in compressive strength [35, 36]. The bricks made from Accelerated Curing Mix II have a dry compression strength of 5.3 MPa since 10% cement and 10% foundry sand are used. Compared to accelerated curing bricks, normal curing bricks have a higher dry compression strength [37]. Singh et al. investigated the feasibility of using mud blocks stabilized by soil for affordable housing in India. According to the study, easily found local ingredients can be used to make soil stabilized mud bricks, an inexpensive and eco-friendly building material. The paper highlights the need for more research on the structural properties of SSMBs [38–40]. In 2020, Ravi et al. investigated the effects of different stabilizing agents, like fly ash, cement, and lime, on the durability and toughness of soil-stabilized mud bricks [41].
The thermal and acoustic properties of mud blocks stabilized by soil were investigated by Akinyemi et al. (2018). The study found that SSMBs had lower thermal conductivity and greater acoustic insulation when compared to conventional building materials. The results of the study indicate that SSMBs may be a suitable building material in hot, humid climates [42–45]. Ogunbiyi et al. (2021) examined the effects of different soil types and stabilizing agents on the compressive strength and water absorption properties of soil stabilized mud blocks. The importance of selecting the appropriate soil and stabilizing agent to produce SSMBs is emphasized in the study [46]. The wet compressive strength of the stabilized mud block and masonry prisms is less than their dry strength. The wet and dry strengths of these masonry prisms decrease with decreasing mortar strength. Stabilized mud block work exhibits a masonry efficiency of 0.52 to 0.21 in a wet state and 0.21 in a dry state. Between 0.50 and 0.36 separate the wet and dry prism strengths [47, 48]. Blocks' compressive strength value rises as cement content does. For instance, the compressive strength of the block increases by 58.3% when the cement concentration is raised from 2% to 5% [49, 50]. The blocks' compressive strength increases in tandem with the mixture's lime content. For example, increasing the amount of lime from 6% to 10% increases the compressive strength of the block by 6.33%. Considering the value of cement, that amount is meaningless. However, stiffness or young's modulus are significantly wedged. As straw fiber is produced in greater quantities, its stiffness reduces. [51].
After seven days of curing, all block samples surpassed the minimal compressive strength criterion as stated in the ABNT standard. The blocks were classified as Category C in accordance with Bolivian building material regulations after achieving a minimum strength of 4 MPa after 14 days of curing for 1.50% WTSF blocks and after 28 days for 0.75% WTSF samples. Each soil-cement block met the minimum requirements for compressive strength after 28 days. [44, 45]. This study investigates the effects of adding waste from construction and demolition on the strength and longevity of lime-stabilized soil. The author's lab tests indicate that adding C&D waste increases the toughness and firmness of the soil. Additionally, they stress how C&D waste can aid in soil stabilization for environmentally conscious building. [46-48This work examines the compressive strength and

durability of soil-stabilized blocks made from waste from construction and demolition. The author's laboratory experiments demonstrate that the addition of C&D waste improves the blocks' compressive strength and durability. They also discuss the potential application of C&D waste in the production of soil-stabilized blocks for green construction. [49–42].

III. LITERATURE REVIEW

Using combined C&D waste as a soil stabilizer during the mud block production process is the goal of the "Soil Stabilized Mud Blocks Using Combined C&D Waste" initiative. According to the authors [1], utilizing C&D waste can lessen the harmful environmental effects of waste products while improving the mechanical properties of mud blocks.

The first section of the study gives a thorough overview of every material that was used, including soil, cement, and various kinds of C&D waste. The tests that were carried out to assess the mechanical characteristics of stabilized mud blocks, including their durability, water absorption capacity, and compressive strength, are then covered by the writers [43–45]. Comparing the blocks to the control samples, there was a 67% increase in compressive strength. The blocks also demonstrated exceptional durability and resistance to water. A graph showing (figure 1) the compressive strength results for C&D waste replacements at 20%, 40%, 60%, 80%, and 100% is provided [49, 50].

According to Figure 1, there will be a slight increase in the percentage of C&D waste replacement for cement content, going from 9% to 12% and from 20% to 40%. This is because the relatively hard C&D waste particles—crushed concrete and brick waste, for example—can add additional strength and stability to the mixture. The variables that will affect the strength increase, which may or may not be significant as shown in Figure 2, include the type and quality of C&D waste material used, the properties of the soil, the amount of cement used, and the curing conditions. The investigation's findings demonstrated that the mechanical qualities of the mud blocks were enhanced by the addition of C&D waste to the soil-cement mixture. [46, 47].

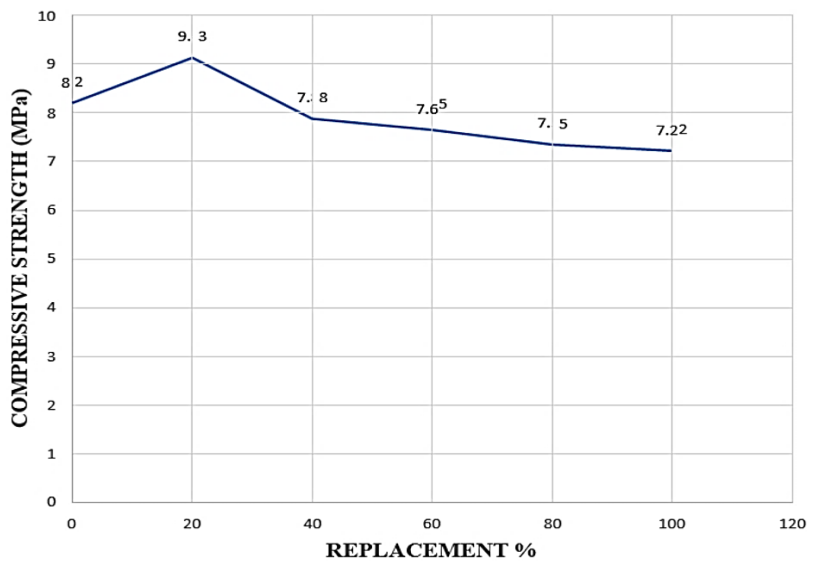

Figure 1: Compressive strength vs percentage replacement

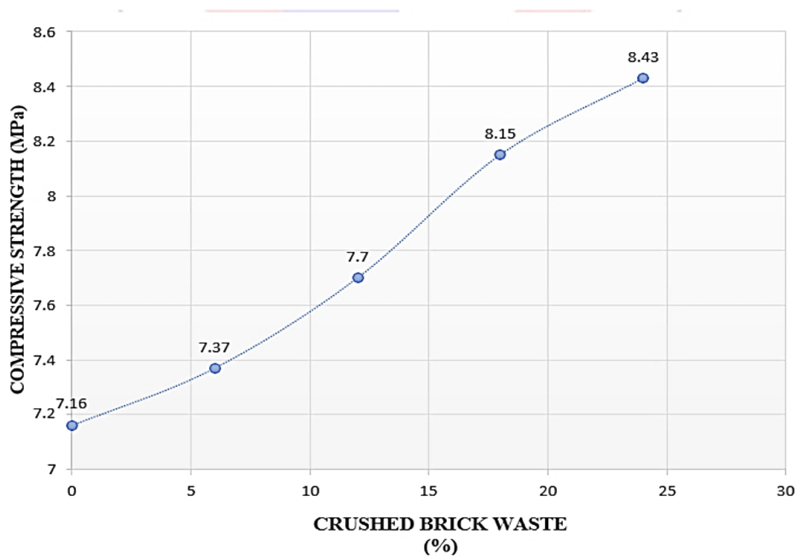

Figure 2: Compressive strength vs percentage of crushed brick waste

IV. MATERIALS

A. Soil

Four different types of material are found in soils in varying proportions: silts, clays, sands, and gravels. Each of these has a distinct behavior; for instance, some will change in volume in response to changes in humidity, while others will not. Of these material types, the first two are stable and the other two are unstable. A building material's stability—that is, its capacity to tolerate fluctuations in humidity and dryness without experiencing physical changes—is crucial. Not every soil is appropriate for every building requirement. But the fundamental ingredient needed to produce compressed stabilized earth building blocks is soil with a minimum amount of silt and clay to promote cohesiveness. The general term for the byproduct of rocks weathering is soil. Depending on the parent rock type and the kind of Hollow Stabilized Mud Blocks Department of Civil Engineering, Mohali, soil characteristics can differ significantly. climate-related factors at a specific location. In this study, red soil that was readily available locally was used. Four primary types of particles make up soils.

B. Gravel

Gravels are composed of roughly 2 to 20 mm-sized fragments of rock with varying degrees of hardness. They contribute to the soil's stability. The presence of water has no discernible effect on their mechanical characteristics.

C. Sand

The mineral particles that make up sands are typically between 0.075 and 2 mm in size. It is inert chemically and hard. Additionally, stable soil constituents have a very high degree of internal friction—that is, a very high mechanical resistance to movement between the constituent particles—but lack cohesiveness when dry. However, after being wet, they appear cohesive due to the water's surface tension filling the spaces between the particles.

D. Silt

While silt particles are far finer than sand particles, they are still quartz grains. Their sizes vary from 0.002 to 0.075 mm, and when they are dry, they do not adhere well. Silts and sand particles are nearly identical in nature, except for size. However, they have notably less internal friction than sand. When wet, they exhibit cohesiveness because their resistance to movement is generally lower than that of sands; when exposed to varying humidity levels, they swell and shrink, changing their volume noticeably. Thus, the stability of gravels, sands, and to a lesser extent silts in the presence of water characterizes them.

E. Clay

There are finer clay particles than 0.002mm. In general, a soil should have some moderate amounts of clay in it. Because they are cohesive, they give the soil some flexibility when it's wet. The thin layer of absorbed water that clings firmly to the clay layers and connects the particles is what gives the particles their plasticity. In this sense, the granular fractions of a soil that lack cohesiveness—gravel, sand, and silt—are naturally bound together by the clay minerals. This attribute is especially useful when producing Compressed SMBs. After demoulding, green blocks are still weak because the cement binder might not have had enough time to set. Department of Civil Engineering, RBU, Mohali-140301. Clay serves as a natural binder during the SMB production process, which facilitates the handling of the blocks. The clay that is preferred for using in the production of compressed SMBs gives the soil used to make the blocks its plasticity; therefore, the soil needs to be stabilized with the right admixture. Conversely, the characteristics of clay minerals are regrettably thought to be unwanted in a block. Their affinity for water is very high because they are hydrophilic. Soils that are clayey expand and contract as the soil dries. If montmorillonite clay mineral is present, this volumetric instability is more pronounced. In blocks, excessive shrinkage and swelling are undesirable characteristics. Controlling the amount of clay in soils intended for block production is advised as a result. OPC can be used to stabilize soils with less than 30% clay content, while lime is needed for soils with more than 30% clay content. It is well known that lime, via a pozzolanic reaction, can fix the clay.

F. Soil Stabilising Agents

- ***Cement***

Cement is a binder; it can bind other materials together and hardens and sets as it dries. Because it can be used alone to produce the necessary stabilizing action, it may be regarded as a primary stabilizing agent or hydraulic binder. Ordinary Portland cement of grade 53 was used in this study and was sourced locally.

- ***Brick Waste***

Several million tons of solid waste are generated worldwide from construction and demolition operations, with brick waste being one of the most notable types of waste. More studies on recycling brick wastes to create more environmentally friendly concrete have been conducted in recent years. Bricks are an item that can be recycled. Reusing brick can benefit the environment, provide financial benefits, and inspire creative ideas for remodeling projects. In the below figure 3, it is showing the demolished brick waste.

Figure 3: Demolished Brick waste (DBM).

- **CW Waste (Reinforced Concrete Waste)**

Debris produced during construction and demolition operations is categorized as waste. A significant amount of construction and demolition debris is produced each time a building or civil engineering structure is constructed, renovated, or demolished. Two methods exist for using waste in the construction industry: recycling (converting waste into raw materials used to produce building materials) and reusing (reusing components). In the below figure 4, it is showing the Recycled Concrete waste.

Figure 4: Recycled Concrete waste (RCW)

- **Soil Stabilization Techniques**

Soil stabilization is a method of refining the engineering properties of a soil by either imparting mechanical energy or mixing other substances to the soil. It is a method through which there is an increase in the bearing capacity of a soil by increasing its shear strength parameter. This involves the mixing of special soils, binders, or other chemicals additional to natural soil to improve one or extra properties. Soil stabilization techniques involve the use of stabilizers in soft soils to recover geotechnical possessions such as compressibility, strength, permeability, and durability. Generally, soil stabilization technique is divided into two groups, which are Mechanical stabilization techniques and Chemical stabilization technique. Each method has been explained in the following subheadings.

V. CONCLUSION

After examining the numerous studies, it was determined that using and producing compressed stabilized mud blocks has benefits. Compressive strength, water absorption, and the initial rate of absorption are examples of parameters that are largely dependent on the amount of stabilizer utilized. Additionally, the block parameters differ greatly depending on the amount of silt, clay, and sand used in the block's construction.

With the substantial research information available on stabilized mud blocks made with cement/ lime and soil. The cement content is suggested to be less than 9% for good strength economical blocks. Whereas the strength of blocks considerably increases when the cement content is varied from 10 -12%. It was also suggested that soil containing sand size fraction between 60-70% is suitable to manufacture dimensionally stable blocks.

To improvise physical and mechanical properties, the clay sized fraction should be in the range of 5-15%. It was also noted that no marked research was available using C&D waste using different types such as brick waste, RC waste, Mortar waste etc. and its combination.

VI. FUTURE SCOPE

- To completely comprehend the behavior of reconstituted soil when its cement content and density are changed.
- investigations into the properties of masonry under various loading scenarios.
- Research on Wallette's and walls.

The SSHB serves as evidence that it is an energy- and environmentally-friendly building material. In order to establish and sustain the recycling industry, it is recommended that a thorough and continuous investigation be conducted into the quantity and accessibility of construction and demolition (C&D) wastes across the nation. Reusing construction and demolition wastes would have a positive impact on the environment, lower the price of building supplies, create more jobs, and boost international economies.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Umer Nazir Ganie conceptualization, supervision, visualization, writing-Original Draft, Dr. Tanzeer Ahmad dar: investigation, conceptualization, validation, formal analysis, visualization, writing — review and editing; Umer Nazir Ganie, Dr. Tanzeer Ahmad Dar- review and editing.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest

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