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Reuse of Brick Waste in the Construction Industry

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Abstract

Demolition work produces a lot of waste or demolition waste made up of different materials like concrete, wood, metals, bricks, glass, plastics and asphalt. To maintain environmental sustainability this waste must be managed. This study offers a sustainable solution for the construction industry by providing a thorough analysis of demolition waste management with a focus on the reuse of brick aggregate and brick dust. Samples from a controlled demolition site were collected for the study. The brick samples from the demolition site were found through laboratory testing to have greater compressive strength than regular bricks, making them an acceptable building material. Brick dust was also discovered to be a superior void filler. These waste materials were used to create lean concrete, which was stronger than regular concrete and thus suitable for building. Cost comparisons revealed significant cost savings, making this strategy appealing from an economic standpoint. The study emphasises how using bricks made from demolition debris could lower carbon emissions. Responsible demolition waste management can also prevent priceless land resources from being turned into landfills, enhance soil quality and advance in building a circular economy. In conclusion, improving demolition waste management, particularly by recycling brick waste, offers a long-term solution for the building sector. It contributes to a greener and more sustainable future by minimising environmental impact, conserving resources, lowering construction costs and promoting a circular economy.

Keywords: *Brick Aggregate Reuse, Demolition Waste Management, Sustainable Construction*

1.0 Introduction

The debris, rubble and waste materials that result from the process of demolishing or dismantling constructions such as buildings, bridges, roads and other infrastructure are referred to as demolition waste[1]. As societies grow and develop, urban renewal programs, maintenance and the necessity for new development frequently demand the demolition and replacement of existing structures. As a result, demolition activities generate a substantial amount of garbage that must be carefully managed and disposed of. A variety of materials, including concrete, wood, metals, bricks, glass, plastics, asphalt and more can be found in demolition waste. Depending on the type of structure being destroyed and the demolition techniques employed, the composition of demolition waste may change[2]. While some materials might be repurposed for recycling or reuse, a sizable portion ends up as waste that needs to be properly managed to reduce environmental impact and encourage sustainability[3]. Managing demolition waste involves several difficulties. Firstly, improper waste management could put a strain on landfill capacity due to the sheer volume of waste produced[4]. Second, due to the potential health and environmental risks associated with some demolition waste components like asbestos, lead-based paint and other hazardous materials, they must be handled and disposed of in a specific way[5]. The demand for virgin resources must be decreased and the carbon footprint associated with new construction projects must be reduced by recycling and reusing demolition waste

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materials[3]. Sustainable waste management techniques such as the efficient handling and processing of demolition waste, have received more attention in recent years. Governments, environmental groups and the construction sector have been working to create policies and guidelines that support ethical waste management, encourage recycling and reclamation and lessen the negative environmental effects of demolition activities[6]. In the current scenarios of sustainable development, the use of demolition waste should be explored in different fields including improving soil strength[7,8] and incorporating the demolition waste in the construction of green buildings[9]. Utilising cutting-edge methods like selective demolition, deconstruction and sophisticated sorting technologies will increase the number of valuable materials recovered from demolition waste and prevent them from ending up in landfills[10]. Additionally, fostering a culture of responsible demolition waste management can be accomplished by raising awareness and educating stakeholders, such as contractors, architects and the general public. Overall, managing demolition waste is a critical component of environmental stewardship and sustainable development[10]. We can lessen our impact on the environment, save resources and advance the circular economy in the construction sector by putting good waste management practices into practice. Therefore, the objective of this study is to find any suitable mechanism to reuse the demolition waste generated by the construction industry.

2.0 Classification of Demolition Waste

Demolition waste can be defined as waste formed by the activity of knocking something down or destroying it during construction work. The type of demolition waste depends on the planning, management, environmental and risk control. It can be broadly classified as uncontrolled demolition waste and controlled demolition waste[11]. Controlled demolition waste may be broadly defined as demolition waste where different type of waste products is sorted and separated. In this type of demolition waste the composition of demolition waste may be of different types like brick walls with plastering, brick wall and concrete, wood products, glass, aluminium, plastic and hydrocarbon waste[12]. Even though all of these types of composition are formed from the demolished site, the materials of different types are not mixed up and are sorted for further steps to be taken. Controlled demolition waste is mostly available in the demolition of structures like buildings, bridges, etc. where demolition takes place due to development, faulty design and when the building exceeds its estimated planning life[3,10]. Uncontrolled demolition wastes are the type of demolition waste where all the composition of demolition waste is mixed up which need to be sorted and separated for further steps to be taken. The demolition waste can consist of brick walls with plastering, brick walls and concrete, wood products, glass, brick waste in the construction industry, aluminium, plastic and hydrocarbon waste etc. This type of demolition waste is produced mainly due to natural disasters like earthquakes, landslides, natural calamities etc[13]. In most cases, alumina, steel, glass, wood etc. are recycled. But brick walls with plastering, brick aggregates and brick dust are generally disposed of for landfill. This increases the chances of contamination of the adjoining soil and reduces the fertility of the soil. Therefore, the brick walls with plastering, brick aggregate and brick dust are major demolition waste components of concern.

3.0 Potential Re-Use of Demolition Waste

A major portion of the demolition waste is brick aggregate and brick dust. Table 1 indicates the potential uses of these types of waste.

4.0 Sample Collection

Demolished structural material samples were collected from the controlled demolished site at Bamunimaidam, Guwahati, Assam and several samples of local normal bricks were collected from Assam Down Town University. The demolished building was a commercial building. The samples collected were demolished bricks with plastering. Demolished samples of brick with mortar were collected carefully and transported to Assam Down Town University campus by a mini truck for different types of laboratory tests. The collected sample is used to prepare Brick Aggregate Concrete (BAC).

Table 1. Potential uses of demolition waste

Sl. No	Components of Demolition Waste	Potential Use
1.	Brick wall with plastering	Wick drains: Uses of brick dust and brick aggregates from demolition waste in the foundation of buildings as a vertical filter media Ground improvement work: In this case, brick dust and brick aggregate from demolition waste can be used as a vertical filter media as well as for densification of soil in the foundation of building construction Lean concrete: Use of brick aggregate as material for concrete with a strength of M: 15 grade for lean concrete like lintels, etc Lean RCC: Use of brick aggregate in reinforced cement concrete in M: 15 grade with Fe 415 steel bars for low load-bearing structure Wall: This can be varied from M: 10 to M: 15 where brick aggregate is used as a wall structure material. Plastering: In this case, brick dust can be used with a mixture of lime and cement or brick dust mixed with stone dust or natural sand for plastering
2.	Brick dust and brick aggregate	Wick drains: The use of brick dust and brick aggregate in road works is almost similar to that of building construction, while in this case it is used as a longitudinal filter media as the road is on longitudinal alignment Ground stabilisation: The use of brick dust and brick aggregate for ground stabilisation is applicable as a longitudinal central filter media as well as for densification Cut-off wall: This one is similar to ground stabilisation which is used as longitudinal edge filter media and for densification for the foundation along the road Sub-base layer: For the sub-base layer certain amount of requirement is laid as per IS code for the strength of the material. In this case, brick dust as well as brick aggregate is planned to be used as a bearing layer with specific grading of the material Base course for low-volume roads: The function of this course is similar to that of the sub-base layer which is applicable for low-traffic volume roads Bitumen modifier: Using brick dust of different fineness and different penetration grades of bitumen in the surface layer of road construction

The brick wall with plastering from the demolition site consists of both crushed bricks and plastering mortar. It is difficult to separate brick and plaster mortar if the waste is in bulk and large quantity. This impact load test is done in a sample of plastering mortars from the demolition site. The value of the impact load test results in an average of 40.82%. Due to this, for laboratory tests, plastering mortar is neglected and removed as much as possible, although some amount of plastering is attached to the brick surface which is subject to further tests. A brick wall with plastering consists of brick as well as plastering mortar. Due to this a mathematical calculation is done as per the size of the brick and the thickness of plastering (i.e., mortar). Assuming a brick wall with the plastering of 5 meters in length, 2 meters in height and 130 mm in thickness, considering the brick to be of a non-modular size of 230x 110 x70 mm having a plastering thickness of 10 mm approximately. The composition ratio of brick with respect to plastering mortar in terms of volume can be calculated as 65% brick composition and 35% plastering mortar. Similarly, Brick dust found from the site was used as fine aggregate in this study.

The composition of BAC can be of various mix ratios depending on the various ways of approach. Here are some of the various mix ratios and methods for brick aggregate concrete which can be practically applied and practised in this research work:

- Brick aggregate + Natural sand + Cement
- Brick aggregate + Stone dust + Cement
- Brick aggregate + Brick dust and Stone dust + Cement
- Brick aggregate + Natural sand + Cement (varying w/c ratio)
- Brick aggregate + Natural sand + Cement (aggregate surface area factor)

Using this mix ratio, this research aims to find out the maximum outcomes for brick aggregate concrete so that it can be used as a replacement for conventional brick walls. Using an alternative mix ratio, the research aims to acquire target strength for brick aggregate concrete which can be applicable in today's constructions.

5.0 Laboratory Tests and Results

Different laboratory tests were conducted to estimate the strength of brick with plastering found from the demolition site, brick dust and ultimately concrete made up of brick aggregates found from the demolition site.

5.1 Brick with Plastering

Comparison of compressive strength between a single brick sample and a sample from the demolition site. A compressive test is done on bricks of different samples to find out the performance of the brick against compression and how much load it can withstand. For performing this test IS: 3495-1992 is referred. The test results are shown in Table 2. Thirty samples from each category as mentioned in Table 2 were tested to get the results mentioned in Table 2. The above test results show that the compressive strength of the brick sample from the demolition site possesses more strength as compared to normal bricks. This outcome can be due to the constant load taken by the brick from the structure before it is demolished.

5.2 Brick Dust and Aggregate

The Brick Masonry collected from the demolished site is not in an appropriate state to be used as an aggregate. So, it has to be converted to a suitable size and shape. For this purpose, stimulated crushing of brick masonry is done in the lab to get the required size of the aggregate. The size of the aggregate is selected based on the Clause-5.3.3 of IS: 456-2000. The broken pieces produce 2 types of aggregates. The aggregate which passes the IS sieve 20 mm

Table 2. Compressive strength comparison of brick

Serial No	Sample	Average Compressive Strength
1.	Brick collected from demolition site	13 N/Sq. mm
2.	Normal Brick	6.96 N/Sq. mm

and is retained on the IS sieve 4.75 mm is taken as coarse aggregate. On the other hand, the quantity which passes the 4.75 mm IS sieve is taken as fine aggregate i.e. brick dust. From this crushing of brick walls with plastering, the amount of brick composition as well as plastering materials are calculated and separated. However, it cannot be fully separated as some plastering materials are intact with the brick surface. Mathematical calculations for the composition of bricks and plastering materials are done in which from the total quantity, approximately 35% are composed of plastering materials. Laboratory tests for crushing strength for plastering materials are performed and found that they have lower strength than brick aggregates, due to this reason maximum amount of these plastering materials are removed from the test samples for laboratory tests as they possess lower strength than brick aggregate. The remaining quantity of plastering materials is mostly turned into dust while crushing of materials is done for the preparation of aggregate. Brick dusts are subjected to sieve analysis and the results are compared with the normal sand to have some insight about the brick dust. From the analysis, it was found that the size of brick dust is small and can be used as a filler material for another fine aggregate.

The suitability of the brick aggregates is checked using the crushing strength test of aggregates. This test is performed to check the performance of aggregates against crushing under loads. The aggregate strength of coarse aggregate must be known for different constructions like buildings, roads, etc. to find out whether it is reliable as a construction material. By performing aggregate tests like impact tests and crushing value tests, we can find out the strength of the aggregate and whether it is suitable for different types of constructions. The crushing value of the normal brick aggregate is found to be 2.63% whereas the crushing value of the demolished brick aggregate was found to be 2.89%. It indicates that the demolished brick wastes have higher crushing strength than the normal brick aggregate.

5.3 Preparation of Lean Concrete

Several samples of lean concrete are prepared using the conventional method (i.e., a mixture of cement + natural sand + brick aggregate) and using the wastes collected from demolition waste. Several water-cement ratios were adopted to find the optimum strength for different categories of materials. Ultimately based on this trial-and-error method, optimum water-cement ratio was found for different samples and the test results are shown in Table 3.

From Table 3 it can be said that the demolished brick aggregate and brick dust can be used as natural replacements for sand and brick aggregate to have higher strength parameters. But as the use of brick dust increases the water-cement ratio, therefore, it can be used until a limited strength gain.

6.0 Discussion

Re-engineering bricks from demolition waste can greatly increase different ways of protecting the environment In India, 100,000 brick kilns, produce 200,000,000,000 bricks annually. The average total Carbon Footprint of the bricks produced in the Fixed Chimney Bull’s Trench

Table 3. Compressive strength of lean concrete

Sl. No	Sample Composition	Tested Samples in Numbers	Compressive Strength Concrete (N/mm sq)	w/c Ratio
1.	Cement + Natural sand + Brick aggregate	30	3.95	0.55
2.	Cement + Brick dust + Brick aggregate	30	3.98	0.70
3.	Cement + Stone dust+ Brick aggregate	30	4.06	0.67

Kilns (FCBTK's) is predicted to be 427.985 kg CO_2/1000 bricks. So India produced around 85,597,000,000 kg of CO_2 annually from FCBTK's. Reduction of a minimum of 30% of this much carbon dioxide will greatly improve the environment around us and this can be pointed out as the main advantage. If all this waste from demolition sites is used as a landfill which is practised in today's world, it will not only affect the environment but also geotechnical studies which will decrease the quality of soil and result in a larger demand for soil stabilisation. Secondly, due to the transportation of these brick manufacturing industries, a huge amount of carbon dioxide is produced every day which results in environmental pollution. This can be reduced if re-engineering of bricks can be applied and practised overall. Globally most of all the waste from demolition sites is used as landfills which is a common practice in today's world. If we can find a way to re-engineer and reuse at least 20% of it, we would be able to save millions of waste which is thrown away in landfills and also save large acres of land. This will affect not only the environment but also geotechnical studies which will increase the quality of soil and result in a larger demand for soil stabilisation. As per PWD SOR (2018), conventional brick wall construction costs Rs.8139/- per cubic meter which can be reduced by replacing them with brick aggregate concrete, brick aggregate concrete can be constructed for around Rs.5000 - 6000/- per cubic meter. This results in reducing the cost at around 30 to 40 % of the original cost which will have a great impact relating to the cost and volume of construction. Sourcing brick material from the demolition site will further reduce the cost. Due to these reasons, brick aggregate concrete is beneficial for construction materials economically.

7.0 Conclusion

From the laboratory test, it is found that lean concrete prepared using waste material possesses higher strength than traditional lean concrete. Therefore, it is highly recommended to use this brick waste in construction for lean concrete structures. As manual crushing of brick masonry takes lots of manpower and time, so, the use of suitable crushing machines is recommended. Brick dust is found to be a better void filler than stone dust and natural sand. Due to the smaller particles of brick dust, further testing on brick dust is recommended to examine its suitability as a fine aggregate or for marginal index soil. A cost comparison is made between the BAC and conventional brick masonry where the former is found to be about 35% less than that of the latter. The BAC is found to be a suitable replacement for conventional brick masonry and lean concrete, saving considerable money and protecting the environment.

To reduce the negative effects on the environment and support sustainable development, demolition waste management is essential. Concrete, wood, metals, bricks, glass, plastics and asphalt are just a few of the materials that make up demolition waste which can be either controlled or uncontrolled. Controlled demolition waste is waste that has undergone sorting and separation to enable recycling and reuse. On the other hand, uncontrolled demolition waste is made up of a variety of materials that must be sorted and processed separately. Effective waste management practices and careful handling of hazardous materials are crucial to reducing the burden on landfill capacity and avoiding risks to the environment and human health. It is possible to lessen the need for virgin resources and the carbon footprint associated with new construction projects by recycling and reusing demolition waste materials. Advanced sorting technologies, selective demolition and deconstruction can all help to recover more valuable materials from demolition waste. Raising awareness and educating stakeholders about ethical waste practices are essential for fostering a culture of responsible demolition waste management. Governments, environmental organisations and the building industry all contribute significantly to the development of laws and regulations that support efforts at sustainable waste management, recycling and reclamation. There are several opportunities for the potential reuse of demolition waste, particularly brick aggregate and brick dust. Vertical filter media, ground improvement work, lean concrete, reinforced cement concrete for low load-bearing structures and wall and plastering materials can all be used in foundation construction. The maximum strength that brick aggregate concrete can achieve can be found by investigating different mix ratios and performing laboratory tests, making it appropriate for use as a substitute for conventional brick walls. The strength of demolition waste materials was found to be higher in laboratory tests than that of regular bricks, indicating their potential as dependable building materials. To optimise strength parameters, the water-cement ratio should be strictly controlled. We can lessen our impact on the environment, conserve resources and advance a circular economy in the construction sector by efficiently managing demolition waste and utilising its reusability potential. This study emphasises how crucial it is to develop appropriate strategies for recycling demolition waste back into the building sector, which supports sustainable development.

8.0 Future Scope

There are several potential future scopes in the field of reusing brick waste in the construction industry. The use of brick dust and brick aggregates from demolition waste can be explored as a vertical filter media in foundation construction. This may help improve ground conditions and enhance the stability of buildings. The way using brick dust and brick aggregates as a material for ground improvement techniques can also be explored. This can help enhance the load-bearing capacity of the soil, improve overall construction quality and minimise the cost. The use of brick waste can also be explored in the production of reinforced cement concrete for low-load-bearing structures. This can provide a sustainable alternative to conventional construction materials and help reduce the environmental impact of construction activities. The potential future opportunities in reusing brick waste in the construction industry offer a sustainable solution for waste management, resource conservation and environmental protection.

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