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Experimental study on the Strength Behaviour of Brick bat aggregate as Partial Replacement of normal granite Aggregate in concrete

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Abstract
In an effort to find an alternative material in concrete, much work has been focused to use brick bat aggregate in producing normal strength or even high strength concrete. At the same time, population and economic growth is forcing the demolition of many old structures. Therefore, there is a huge flow of construction and demolition waste and thereby it is necessary to recycle the waste to overcome the problem of occupying the landfill sites This research describes an experimental investigation carried on recycled brick bat aggregates were collected from the various demolished building sites and their physical and mechanical performance were then compared with the concrete made from normal brick bat aggregates. It is found that the mechanical properties of recycled brick concrete are comparable to that of normal brick bat aggregate at medium strength level.

Keywords: brick bat aggregates, recycled concrete, Mechanical properties, compressive strength, water-cement ratio.

INTRODUCTION

The protection of the environment should be promoted by the reuse or recycling of waste materials. In many cases, recycled materials must compete with low-cost products. In general aggregates are collected by cutting mountains or breaking river gravels or boulders, or by breaking clay bricks. At present especially in the developing country faces the scarcity of stone chips or aggregates construction works are obstructed day by day. A significant amount of natural resource can be saved if the demolished concrete is recycled for new constructions. Clay is burnt in form of brick, and when crushed, form aggregates which are known as brick bat aggregate. Brick bat aggregate products made from primary materials, and reduce the environmental costs of waste disposal. Demolition of old and deteriorated buildings and traffic infrastructure, and their substitution with new ones, is a frequent observable fact today in a large part of the world. The main reasons for this situation are changes of purpose, structural deterioration, rearrangement of a city, expansion of traffic directions and increasing traffic load, natural disasters. This type of aggregates has been extensively used in concrete in many places of the world especially in the some part of Asian country, where source of natural aggregate is limited. However, these aggregates are porous and light weight, and also have high water absorption capacity than virgin natural aggregates. Porosity of brick bat aggregate leads towards its low compressive strength and high abrasion value. Despite of all these shortcomings, brick bat aggregate has been used in making concretes for many years. Light weight concrete has tremendous advantages such as lower density and thermal insulation property and also strong enough to be used for structural purposes. If we used brick bat aggregate as recycled aggregates to stone chips we can reduce the bad effect of dust on environment & increase the salvage value. If the properties of recycled aggregates remain close enough compared to fresh aggregate, then recycled aggregates can widely used. This study investigates the properties of normal and recycled brick bat aggregates to produce structural concrete. As it is well known that the volumetric stability of concrete mainly comes from the

aggregates where stone chips are commonly used as coarse aggregates in concrete. In India the guideline and its standard procedure of brick bat aggregate concrete still not properly available. In this research were useful to expected and its results will useful for developing standard procedure of code.

AIM AND OBJECTIVE OF THE STUDY

The global demand for construction aggregates exceeds 30 billion tons per year.
The annual amount of construction and demolition waste (CDW) in sub-continent is 4.3 million tons.
While the current method of managing such waste is through disposal in landfills causing huge deposits of construction Demolition waste (CDW) and becoming an environmental problem.
One of the possible solutions to these problems is to recycle construction and demolition concrete waste to produce an alternative aggregate for structural concrete.

Literature Review

Collins RJ et al.,(1992)A possible solution to these problems is to recycle demolished concrete and produce an alternative aggregate for structural concrete in this way. Recycling of demolished building rubble is not a new concept, as several countries have been crushing rubbles to aggregate for a number of years but the aggregate produced has mainly been limited to low level uses such as pipe bedding, site fill, sub-base or as a capping layer. Bektas et al. found that up to 30% replacement of natural sand with crushed fine brick bat aggregates increases the alkali-silica reaction (ASR), i.e., higher expansion in concrete. However, for the same mix composition, expansion was reduced for a further replacement of 50% and 100% natural sand with crushed brick. At 100% brick bat aggregate replacement, almost similar expansion was found in concrete with 100% natural sand. Buck AD et al,(.1977) ,Hansen TC et al, (1984) and Khalaf FM et al. (2004), studied the mechanical properties and the durability characteristics of Recycled Aggregate Concrete must be investigated to ensure proper use of the recycled material. There have been numerous studies concerned with the mechanical and durability properties of Recycled Aggregate Concrete. Tests have shown that the mechanical properties depend on the properties of the recycled concrete used to produce the aggregate and on the percentage replacement of coarse aggregates in the new concrete. Chopra et al., (2007) studied Pervious concrete is a special type of concrete obtained by omitting fine aggregates from the mix design. Thus the name no fine concretes is also applied, which is agglomeration of coarse aggregate particles surrounded by a coating of cement paste. Absences of fine particles introduce a high percentage of voids in concrete, which leads to its low compressive strength. However, these voids are large in size resulting in very low capillary movement of water, and high permeability. Comparing to conventional concrete which has a void ratio of about 3-5%, pervious concrete possesses void ratio as high as 15-40% depending on its application. This high percentage of void ratio results of its low unit weight of about 70% that of conventional concrete. Mansur et al. (1999) studied the properties of stone aggregate concrete with those of brick bat aggregate concrete by replacing equal amount of stone with brick. All the above mentioned studies were for normal strength concrete; however, attempts have also been made to produce high strength concrete using brick bats as coarse aggregate (Rashid et al., 2008). Brick bat aggregate concrete also performs well or even better than natural aggregate concrete under high temperature (Fouad et al., 2004). All these studies justified the use of crushed brick as an alternative source of coarse aggregate in concrete. Yanagibashi et al.(2002) studied Sixty to 70 percent of demolished concrete is used as subbase aggregate for road construction.

EXPERIMENTAL INVESTIGATION

The materials used in this research work were cement, natural sand, coarse aggregate, brick bat aggregate and water. The properties of theses materials were found from the laboratory test.

Ordinary Portland Cement (OPC)

Ordinary Portland cement is hydraulic cement. Locally available 53 grade of cement used for this research work and their physical properties are presented in Table 1.

Table 1: Properties of Cement

S.No	Description	Values
1	Consistency	32%
2	Initial setting time	45 minutes
3	Final setting time	190 minutes
4	Specific gravity	3.2
5	Fineness of Cement	3%

Fine Aggregate(FA)

Locally available free of debris and nearly riverbed sand is used as fine aggregate.
The physical properties are tested in the laboratory and presented in Table 2.

Table 2: physical properties of sand

Sl.No	Description	Values
1	Water absorption	19.3%
2	Specific gravity	1.95
3	Bulk density(kg/m^3)	1085
4	Particle size gradation	Graded

Coarse Aggregate(CA)

Coarse aggregate were obtained in crushed form were of granite-type from the near by quarry mines. The natural coarse aggregate is of angular shaped crushed granite with maximum size of 20mm and its specific gravity is 2.77 respectively. The physical properties are presented in Table 3.

Table 3:Physical properties of Coarse aggregate

S.No	Description	Values
1	Fineness modulus	3.9
2	Specific gravity	2.60
3	Bulk density	1.43
4	Water absorption	0.55%

Brick bat Aggregate(BA)

Broken bricks chips are again crushed in to 20 mm size and are used as coarse aggregate in concrete as the partial or full replacement of coarse aggregrte with brick bat aggregate was considered in this study. Its physical properties are tabled in Table :4.

S.No	Description	Values
1	Fineness modulus	3.9
2	Specific gravity	2.60
3	Bulk density	1.43

Table :4 physical properties brick bat aggregate

Figure 1: Brick bat aggregate

Water

Fresh water used available laboratory with pH value of 7 for mixing and curing of the mixes in this investigation.

METHODOLOGY

In this research work, an experimental work was carried out to test various cube specimens, cylindrical specimens and beam specimens of brick bat aggregate concrete to determine compressive strength, splitting tensile strength, flexural strength and modulus of elasticity, were determined as the mechanical properties of concrete made with brick bat aggregate by replacing stone chips. Concrete grade M 20 was proportioned according to the procedure as mentioned in the code. The mix proportioning procedure for the concrete was done according to IS 10262: 2009. The experimental work was carried out into stages. In the First stage, properties of materials were determined and in Second stages specimens were prepared and tested. In this study of research work 0%, 25%, 50% ,75% and 100% brick bat coarse aggregate have been used replacing crushed chips for the research works with a Water cement ratio was kept as 0.45 throughout the work.

Results and Discussion

Workability of Concrete

The workability of concrete prepared with recycled brick bat aggregate as well as natural granite course aggregate. The variation of proportion of Brick bat aggregate and natural granite coarse aggregate concrete for a constant water cement ratio of 0.45 and mixed design was prepared. It has been observed that the workability has been reduced by increasing the ratio of Brick bat aggregate and natural granite coarse aggregate concrete.

Table 5: Slump value of brick bat concrete

Sl.No	Specimen	Slump (mm)
1	NMC	50
2	BA25	48
3	BA50	46
4	BA75	45
5	BA100	40

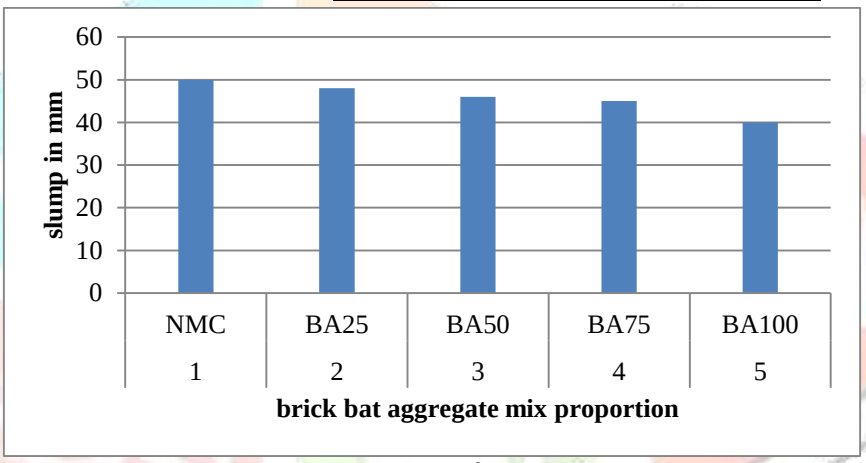

Figure 2 : Slump value of brick bat concrete

Water Absorption

The water absorption test was carried out for both Brick bat Aggregate and normal granite aggregate in accordance with IS 2386 (Part3) – 19637 . The water absorption of aggregate is found by measuring the increase in mass of an oven-dried sample when immersed in water for 24 hours. The ratio of the increase in mass to the mass of the dry sample, expressed as a percentage, is termed as absorption . The water absorption results were shown in Table.3 and 4. The water absorption in RBA was found to be 19.30%. This value was higher than that of Granite Aggregate, of which absorption wasonly 0.55%. The higher water absorption was due to the presence of more pores in Brick bat Aggregate.

Compressive Strength of Concrete

Compression test is the common test conducted on to find hardened concrete. In this research study cubel specimens were used. The size of the cube specimens were 150mm X150mm and 150mm, Universal testing machine was used to loading. Capacity of the testing machine 4000 kN and rate of loading was 250 KN/minute. The test method conforms to the ISI standard requirements. The compressive strength of concrete at 7, 14 and 28 days is shown in Table no:1 for an W/C = 0.45, a reduction in strength of concrete is found for recycled brick bat aggregate concrete compared with the natural granite aggregate concrete. The addition of brick bat concrete(BAC) results in reduction in the compressive strength .At the age of 7 ,14 and 28 days it observed that 5%, 28% and 31% of strength reduction was observed when compared to NMC of BAC25 mix concrete. When compared to NMC with BA50 it was observed that at 9%, 31% and 51% is lower strength was observed at 7,14 and 28 days. An strength of 28%, 51% and 52% was reduced was observed at 7,14 and 28 days ofBAC75 when compared to NMC. The maximum reduction in the compressive strength was found that in the BA100 concrete mix is equal to 33% ,

41% and 40.5% an age of 7,14 and 28 days respectively. The BAC was weaker aggregate when compared to normal granite aggregate hence the initial cracks appear easily on the BCA concrete specimen.

Table 6 : Compressive strength at 7 days and 28 days of Brick bat aggregate concrete

Sl.No	Mix Designation	Compressive Strength N/mm^2		
		7 days	14 days	28 days
1	NMC	15.0	17.3	25.7
2	BA25	14.3	12.5	20.5
3	BA50	13.7	12.1	13.7
4	BA75	9.3	8.5	12.5
5	BA100	7.5	7.1	10.4

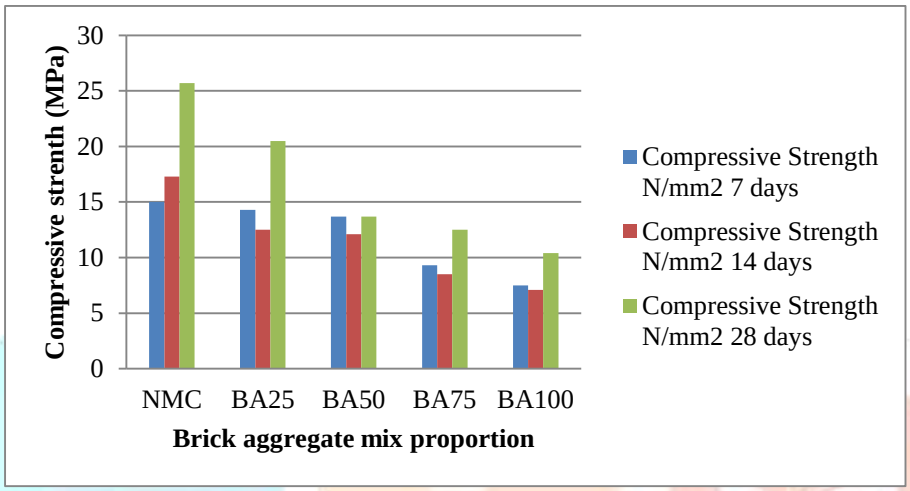

Figure 3: Compressive strength of brick bat aggregate concrete

Split Tensile Strength of Concrete

In general concrete is not normally designed to resist direct tension. While tensile strength is estimating the load under which cracking will develop. The strength reduction of 8%, 2% and 2% was observed of BA25 with NMA concrete of 7,14 and 28 days strength. An average strength of 34%,15% and 15% for 7,14 and 28 days strength was reduced for BA50 with NMA concrete. Also 47%,33% and 36% of BA75 when compared to NMA concrete of 7,14 and 28 days strength. It is observed that the reduction of strength of difference in percentage of BA100 with compared with NMC is 15%,15% and 36% at an age of 7,14 and 28 days. It was observed almost same strength of difference in percentage for all the mix proportion of BCA with normal aggregate concrete. At BA50 concrete is reduced most strength when compared to NMA concrete.

Table 7 : Split Tensile strength at 7 days and 28 days of Brick bat aggregate concrete

Sl.No	Mix Designation	Split Tensile Strength N/mm^2		
		7 days	14 days	28 days
1	NMC	11.3	10.45	12.20
2	BA25	10.43	10.34	12.00
3	BA50	7.50	8.98	10.37
4	BA75	6.10	7.01	7.87
5	BA100	3.77	4.20	5.23

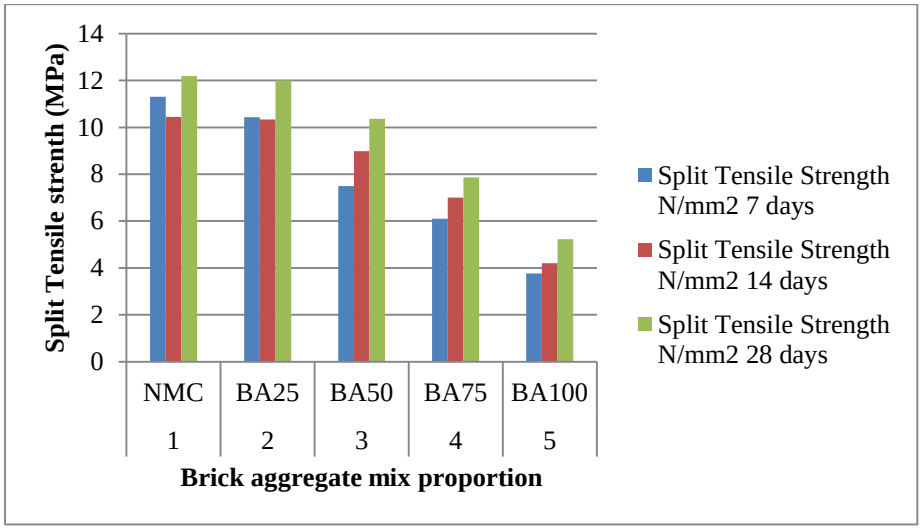

Figure 4:Split Tensile strength at 7 days and 28 days of Brick bat aggregate concrete

Conclusion

From the research it was observed that;

It has been seen that 50% percent replacement of recycled brick bat aggregate give optimum value of mechanical properties which indicate recycled brick bat aggregate can widely used for construction works.

The RCBA (Recycled brick bat aggregate) are less weight aggregates but not light weight aggregates.

For 25% is found to be better substitute for concrete with respect to strength.

The 25% replacement of RCBA is considered as the best in view of strength and economy, hence we use it in moderately loaded structures.

50% replacement of RCBA can be used wherever load coming chances are less.

When RCBA (Recycled brick bat aggregate) waste is used in concrete it shows less cost in non-structural concrete works also the cost of production will be economical. Hence, overall cost of the project will come down.

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