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Utilization of Building Demolished Waste Aggregates in Pervious Concrete

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ABSTRACT

Everyday, around the world construction and demolition wastes is produced in large amounts. Thus it is necessary to effectively utilize these wastes in the production of new concrete. With the increasing population, there is an increasing demand on our natural resources. Thus, there is a need to conserve our natural resources and decrease environmental degradation. This is done by using demolished building coarse aggregates as a substitute to our natural aggregates in making concrete. The study aims at making pervious concrete by using building demolished aggregates and thereby note its properties for finding new applications in this field of pervious concrete based on the results. Pervious concrete is a unique, effective and environmentally friendly solution. Thus, this paper reports the results of an experimental work into the development of pervious concrete with partial replacement to natural coarse aggregates with demolished waste aggregates (DWA) for knowing their properties and effects on compressive strength and density of concrete.

Keywords: pervious concrete, DWA- demolished waste aggregates, compressive strength and density.

I. INTRODUCTION

Pervious concrete or porous concrete or no fines concrete is a concrete in which we do not use fine aggregates and if used the proportion is very less. Carefully controlled amounts of water and cementitious materials are to be used to create a paste that forms a thick coating around aggregate particles in making pervious concrete [2]. Pervious concrete contains high proportion of pores or voids which are interconnected with each other. Pervious concrete would be a natural choice for its use in many applications as it is cost effective and environmentally friendly solution. At present, there is a need to increase the awareness for conservation of nonrenewable mineral resources thus increased consideration is required to the use of pervious concrete in our country [6].

Wastes which are produced through various activities can be reused and are also usable in construction. Thus by using this waste in construction would result in a greater savings of natural materials thus addressing the issues of sustainability and environmental degradation. Due to depletion of the existing landfills and scarcity of resources for natural aggregates there is need for encouraging the use of demolished waste aggregates as a replacement to coarse aggregates in making new concrete. Due to increased amounts of demolition debris, scarcity of dumping grounds cost of disposal and transportation and due to environmental degradation the management of demolition waste is a major concern [5].This paper discusses the results of an experimental work by evaluating compressive strength and density of pervious concrete by using demolished waste aggregates (DWA). Thus, by making use of DWA in making pervious concrete we can conclude that it is an alternative to meet the economy of the project.

Applications:

Various applications of pervious concrete include drainage media for hydraulic structures, tennis courts, greenhouses, drains and drain tiles, slope stabilization, swimming pool decks, zoo areas, sidewalks, pathways, shoulders, noise barriers, parking lots and pervious base layers under heavy-duty pavements. It is also known as high porosity concrete or no fines concrete. All of the applications take advantage of the benefits of various characteristics of pervious concrete.

II. OBJECTIVES

The objectives of the study are as following:

- Evaluate the properties of DWA used in the study.
- Pervious concrete mix design proportion for 0%, 10%, 20% and 30% DWA replacements.
- Evaluate the properties like density and compressive strengths (at 7days, 14days and 28 days) of hardened pervious concrete using DWA.
- Evaluate an optimum percentage of DWA replacement in pervious concrete from the results obtained.

III. LITERATURE REVIEW

Nyok Yong Ho1; Yang Pin Kelvin Lee2; Wee Fong Lim3; TarekZayed, M.ASCE4; KeatChuan Chew5; Giau Leong Low6; and Seng Kiong Ting7 (MARCH 2013) in their work on (*Efficient Utilization of Recycled Concrete Aggregate in Structural Concrete*) conducted an in depth study to evaluate the use of RCA in structural concrete. They evaluated the properties of RCA concrete for which they conducted few tests on it and the results showed that RCA concrete can be designed to achieve compressive strength and elastic modulus comparable to NCA concrete. The properties of RCA which are evaluated in this paper are taken as reference for determining properties of DWA.

Daniel Yaw Osei, Emmanuel Nana Jackson (2012); in their work on (*Experimental Study on Palm Kernel Shells as Coarse Aggregates in Concrete*) have reported their experimental investigations on the effects on strength, density and workability of concrete by replacing natural coarse aggregate with palm kernel shells. Two controlled mixes of 1:2:4 were volume batched and weight batched. Palm kernel shells were used to replace NCA by volume and by weight by (0%, 25%, 50%, 75% and 100%) respectively. Compressive strengths and densities were evaluated at 7 days, 14days and 28 days. This paper gave me an idea of determining compressive strengths and densities at various ages of concrete and with mix proportions of various % replacements also recommended grades of concrete (BS 8110, 1997)

P. Pal, S. Shukla and A.K. Ranjan; in their work on (*Performance of pervious concrete with recycled concrete aggregates*) have presented the characteristics of pervious concrete having optimum quantity of (RCA). Six different mixes were prepared of M-15 grade of concrete with 0%, 20%, 25%, 30%, 35% and 40% of RCA for estimating compressive strength, flexural strength and permeability. This paper helped me in the mix design of pervious concrete. Also, the properties of aggregates determined are taken as reference for determining properties of DWA.

Thushara Priyadarshana Manager Research and Development, Holcim (Lanka) Limited, 413 R A De Mel Mawatha, Colombo 3, Sri Lanka, ThilakJayathunga Head of Innovation and Applications, Holcim (Lanka) Limited, 413 R A De Mel Mawatha, Colombo 3, Sri Lanka in their work on (*Pervious concrete – a sustainable choice in civil engineering and construction*) has discussed about pervious concrete, materials and possible mix proportions, properties like compressive strength, flexural strength, shrinkage, permeability, advantages, disadvantages and principal applications in Sri Lankan construction sector. This paper has briefed about the methodology to be adopted for achieving objectives of my paper and also the applications of pervious concrete are referred.

Shivakumar, M. N1, Nithin K.S2, B.M Gangadharappa3 (Jun-2014) in their paper on (*Use of building demolished waste as coarse aggregate porous concrete*) conducted an experimental study in which they have evaluated the mechanical properties of concrete for nominal mix and the mix design as per mix design codes IS 10262-2009 and IS 12727-1989. In this paper, 40:60, 50:50 and 60:40 ratio of coarse aggregates and building demolition wastes are used with w/c ratio 0.4 to 0.48. Compressive strengths for 28 days as average of three samples. By their study it is found that porous concrete results are encouraging and has been found to be comparable to the conventional concrete. This paper gives idea about the mechanical properties to be determined for my hardened pervious concrete.

IV. EXPERIMENTAL INVESTIGATIONS

4.1 Materials and mix proportion

Four concrete mixes were produced: a controlled standard pervious concrete mix and three demolished waste aggregates concretes with replacement ratios of 10%, 20% and 30%. Ordinary Portland cement (OPC) of grade 53 was used as binder material. Natural aggregates as well as building demolished waste colored coarse aggregates of size 20mm and 10mm were used in all mixes. Drinking tap water clean and free from impurities was used for mixing and curing. Table 1 show the mix design proportion and slump value of the pervious concrete used in the experimental work.

Slump test for knowing the workability of the concrete was done for all the four Mixes (0% Nominal mix, 10% DWA mix, 20% DWA mix and 30% DWA mix).

Table 1- Mix design proportion and slump value of the pervious concrete [4].

SR. NO	TYPE OF MIX	CEMENT KG	20MM NCA KG	20MM DWA KG	10MM NCA KG	10MM DWA KG	WATER KG	W/C RATIO	SLUMP VALUE MM
1	NOMINAL MIX	4.59	11.18	-	7.45	-	1.57	0.29	150
2	10% DWA	4.59	10.06	1.12	6.705	0.745	1.57	0.29	130
3	20% DWA	4.59	8.94	2.24	5.96	1.49	1.57	0.29	120
4	30% DWA	4.59	7.83	3.35	5.22	2.24	1.57	0.29	120

4.2 Concrete Mixing, Casting and Curing of the specimens

The pervious concrete mixes were produced in a tilt-drum type mixer. The natural and demolished waste 20mm and 10mm coarse aggregates and cement were dry mixed for few minutes. Then, small amounts of water were added gradually while the mixing was in progress and was continued until a uniform mix was formed. No chemical admixture was used in the concrete mixes. Immediately after mixing, slump test was carried out to know the workability of the mix and then standard specimens of 150mmx150mmx150mm steel moulds were casted for hardened concrete testing. For each mix 3 nos. of specimens were casted with well compaction. The specimens were demoulded after 24 hours and stored in water tank for curing until the day of testing. The tests were carried out on the cubes at 7days, 14days and 28 days for density and compressive strength respectively.

4.3 Methodology

Carefully controlled amounts of water and cementitious materials are to be used to create a paste that forms a thick coating around aggregate particles in making pervious concrete. Pervious concrete has no fine aggregates creating a substantial void content. Using sufficient paste to coat and bind the aggregate particles together creates a system of interconnected voids that drains quickly [3]. Demolished waste aggregates are more porous than natural coarse aggregates. The materials used for making pervious concrete was ordinary Portland cement, 20mm and 10mm natural coarse aggregates, 20mm and 10mm recycled coarse aggregates and water. The work has been divided into following phases:

- Collection of demolished waste aggregates
- Determination of properties of NCA and DWA
- Coloring the collected construction and demolition waste aggregates.
- Sieve analysis and preparation of mix design proportion for pervious concrete
- Slump test of fresh concrete
- Casting of pervious concrete done by replacing demolished waste aggregates by various percentages (0%, 10%, 20% and 30%) of natural aggregates.
- Demoulding after 24 hours and cured till the day of testing
- Determination of hardened properties of pervious concrete

The demolished waste aggregates were collected from various sites in pune like from D.Y. Patil college hostel demolished building (pimpri), from Kharabwadi residential demolished building (chakan), from residential demolished building, (Tathawade). Properties like specific gravity, water absorption, Los angels abrasion value and impact value of the collected waste aggregates was determined. These demolished waste aggregates were coloured using water insoluble stainer colour paint of Asian Paints make of Fast green colour mixed with white colour distemper to distinguish the recycled aggregates from natural aggregates when mixed and once casted. After colouring, these waste aggregates were sieved for 20mm and 10 mm coarse aggregates. Fig 1 shows sieve analysis of DWA. Fig 2 shows demolished waste coloured aggregates batched in various sizes after sieve analysis. All the materials was mixed as per the mix design and four mixes of (0% Nominal mix, 10% DWA mix, 20% DWA mix and 30% DWA mix) were prepared. The pervious concrete mixes were produced in a tilt-drum type mixer. The natural and demolished waste 20mm and 10mm coarse aggregates and cement were fry mixed for few minutes. Then, small amounts of water were added gradually while the mixing was in progress and was continued until a uniform mix was formed. No chemical admixture was used in the concrete mixes. Immediately after mixing, slump test was carried out to know the workability of the mix and then standard specimens of 150mmx150mmx150mm steel moulds were casted for hardened concrete testing. For each mix 3 nos. of specimens were casted with well compaction. The specimens were demoulded after 24 hours and stored in water tank for curing until the day of testing. The tests were carried out on the cubes at 7days, 14 days and 28 days ages for density and compressive strength respectively.

Fig 1 Sieve analysis of DWA

Fig 2 DWA batched in various sizes

In this study, the physical properties of DWA were carried out for knowing its specific gravity, water absorption, abrasion value and impact value. These properties of demolished waste aggregates are determined as per IS standards so as to compare them with the properties of natural aggregates. Also this gives an idea about their suitability for the partial replacement of natural coarse aggregates in making pervious concrete [4]. Properties of hardened concrete like density and compressive strengths are determined by knowing their weight, dimensions of the specimens, and the actual load readings on the compression test machine.

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4.4 Results and discussion

4.4.1 Properties of DWA

Table 2 presents the specific gravity, water absorption, abrasion value and impact value of both natural coarse aggregates (NCA) and demolished waste aggregates (DWA). Specific gravity is the ratio of the weight of a given volume of aggregates to the weight of an equal volume of water. The results of the test show that specific gravity of NCA is more as compared to DWA. Water absorption of aggregates is determined by increase in weight of an oven dry sample when immersed in water for 24hours. The ratio of the increase in weight to the weight of dry sample expressed in percentage is known as absorption of aggregates. The results of the test shows that water absorption of NCA is less as compared to DWA this shows that pervious concrete using DWA are more porous as compared to NCA but have less strength.

Aggregate Impact test concludes how tough our aggregates are for resisting failure by impact. It is basically the ratio of weight of fines (less than 2.36mm size) formed, to the weight of the total sample taken expressed in percentage. The results of the test show that impact value of DWA is greater than NCA.

Aggregate Abrasion test is carried out for knowing the capacity of the aggregates to resist the wear and tear. As the % abrasion increases, the compressive strength decreases depending upon the size of aggregates. Los Angels abrasion test was performed on the aggregates and the results of the test shown that the abrasion value of DWA is greater than NCA.

Table 2- Properties of natural aggregates [7] and demolished waste aggregates

SR. NO.	PARAMETERS	NATURAL COARSE AGGREGATES	DEMOLISHED WASTE COARSE AGGREGATES
1	SPECIFIC GRAVITY	2.58	2.32
2	WATER ABSORPTION	1.3%	4.58%
3	ABRASION VALUE	16%	21%
4	IMPACT VALUE	16%	19%

4.4.2 Properties of Hardened concrete

Table 3- Properties of Hardened concrete at 7days,14days and 28 days.

Sr. No.	**Type of Mix**	**Density (kg/m^3)**			**Compressive strength (Mpa)**		
		7 days	**14 days**	**28days**	**7 days**	**14 days**	**28days**
1	0% DWA Mix	2310	2315	2242	11.11	10.27	13.47
2	10% DWA Mix	2290	2250	2205	8.57	8.98	10.44
3	20% DWA Mix	2200	2247	2076	9.15	9.51	7.29
4	30% DWA Mix	2180	2220	1972	7.06	7.60	3.91

Density [3]

The densities of hardened pervious concrete were recorded after curing the specimens for 7days and 14days respectively. In this test, four specimens were measured each time (0%, 10%, 20% and 30%) DWA replaced specimens. The densities of hardened pervious concrete were calculated by the ratio of weight of the cube specimens to the volume of the specimen. Fig 3 and Fig 4 shows the graph of density and % demolished waste aggregates for 7days and 14days respectively.

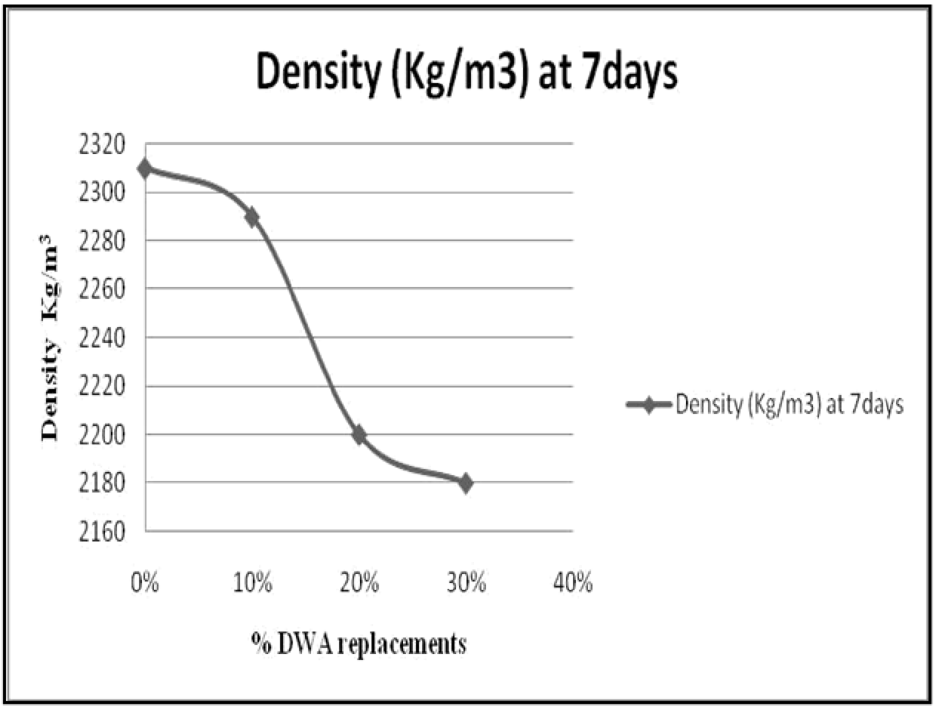

Fig: 3 shows relationship between density and % of replaced building demolished waste aggregates at 7 days

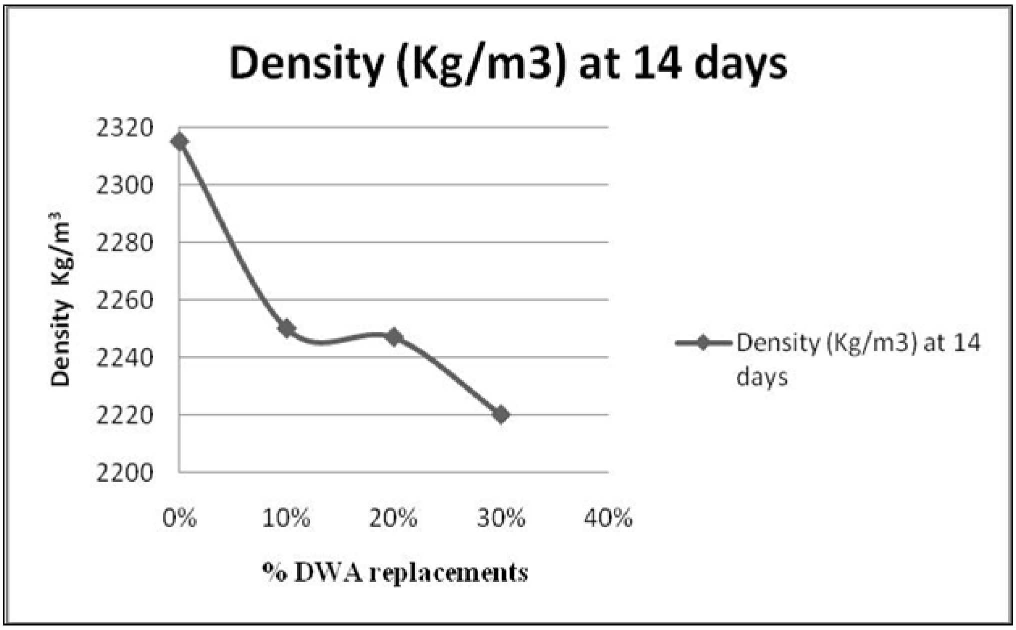

Fig: 4 shows relationship between density and % of replaced building demolished waste aggregates at 14 days

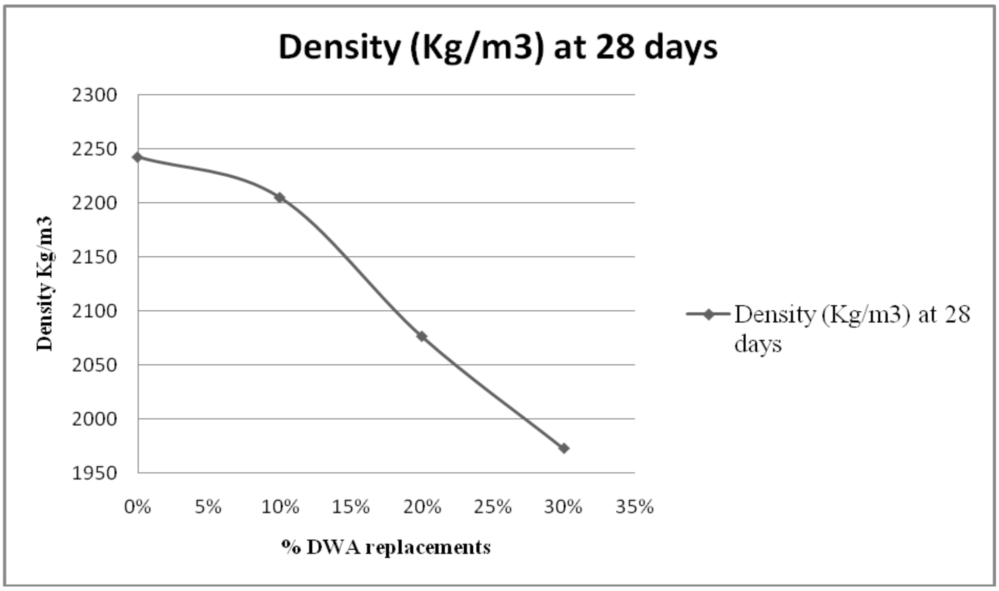

Fig: 5 shows relationship between density and % of replaced building demolished waste aggregates at 28 days

Fig 3, Fig 4 and Fig 5 shows the relationship between density and % of replaced recycled demolition waste aggregates for 7 days and 14 days respectively. Concrete containing 0% DWA is considered as reference and then this referral concrete is compared with the one having 10%, 20% and 30% DWA. It is evident from the graphs that density of pervious concrete for both 7days and 14 days decreases with increase in % DWA replacements. It is seen that the density is maximum at 0% replacement that is and is minimum for 30% replacement for both the ages.

Compressive Strength

Compressive strength is the most important test conducted on hardened concrete, because it is easy to perform and most desirable characteristic properties of concrete are qualitatively related to its compressive strength [5]. The compressive strengths of hardened pervious concrete were recorded after curing the specimens for 7days, 14days and 28 days respectively. In this test, four specimens were crushed each time (0%, 10%, 20% and 30%) DWA replaced specimens. The compressive testing machine usually shows actual applied load in KN. Compressive strength of concrete is calculated by converting the load in KN into N/mm^2.

Fig 7, Fig 8 and Fig 9 shows the graph of compressive strengths and % demolished waste aggregates for 7days, 14days and 28days respectively.

Fig 6- Compression test on DWA pervious concrete

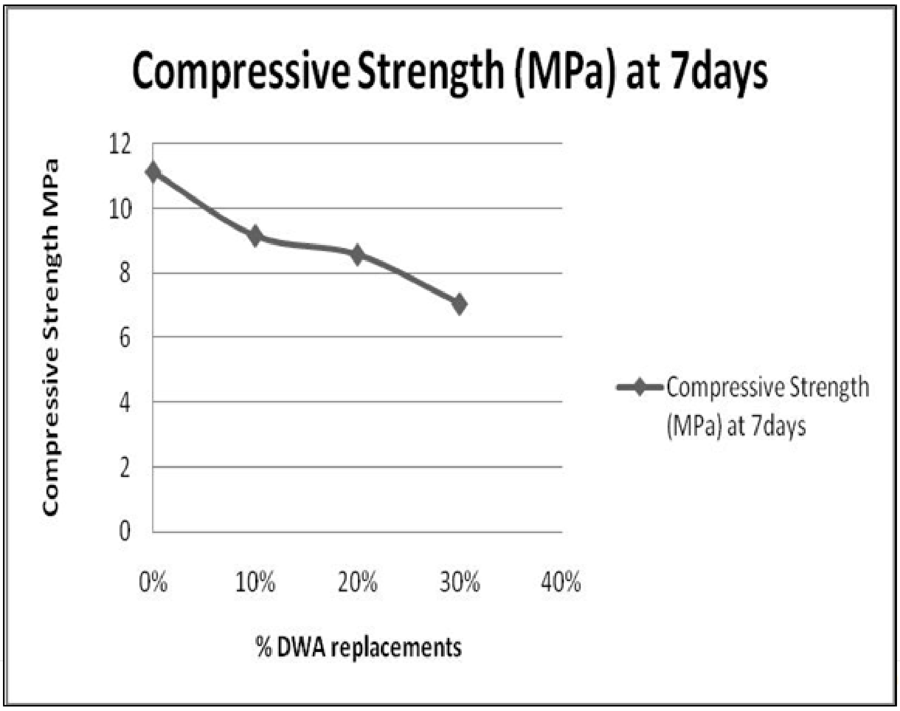

Fig 7 shows the relationship between compressive strength and % of replaced demolition waste aggregates at 7 days

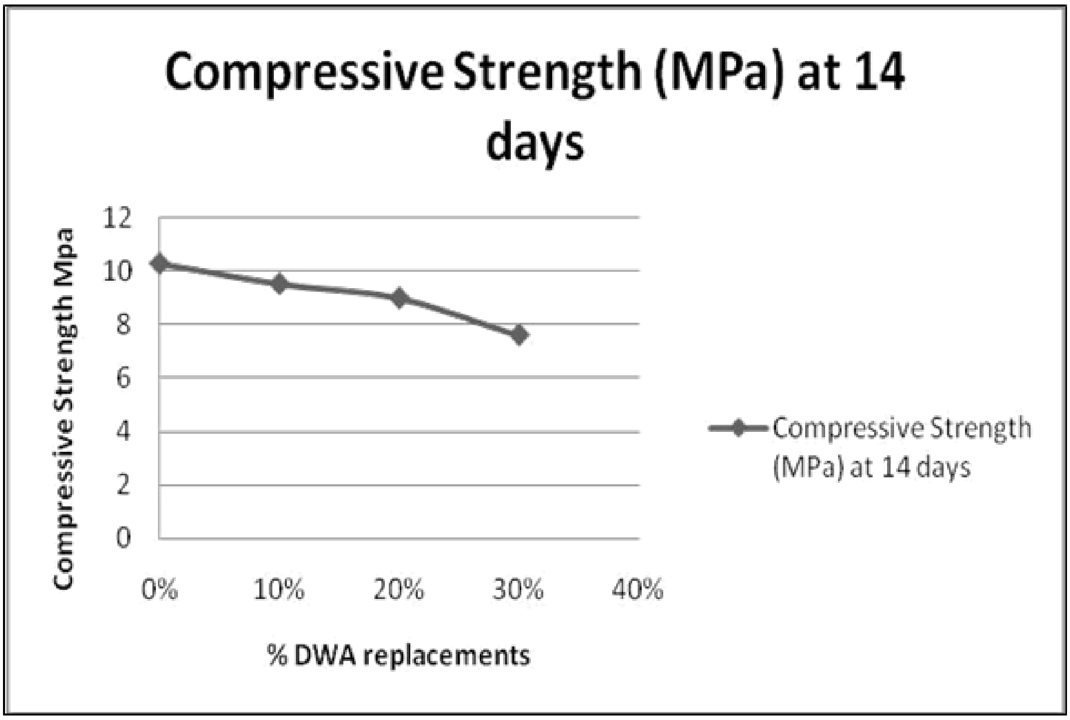

Fig 8 shows the relationship between compressive strength and % of replaced demolition waste aggregates at 14 days

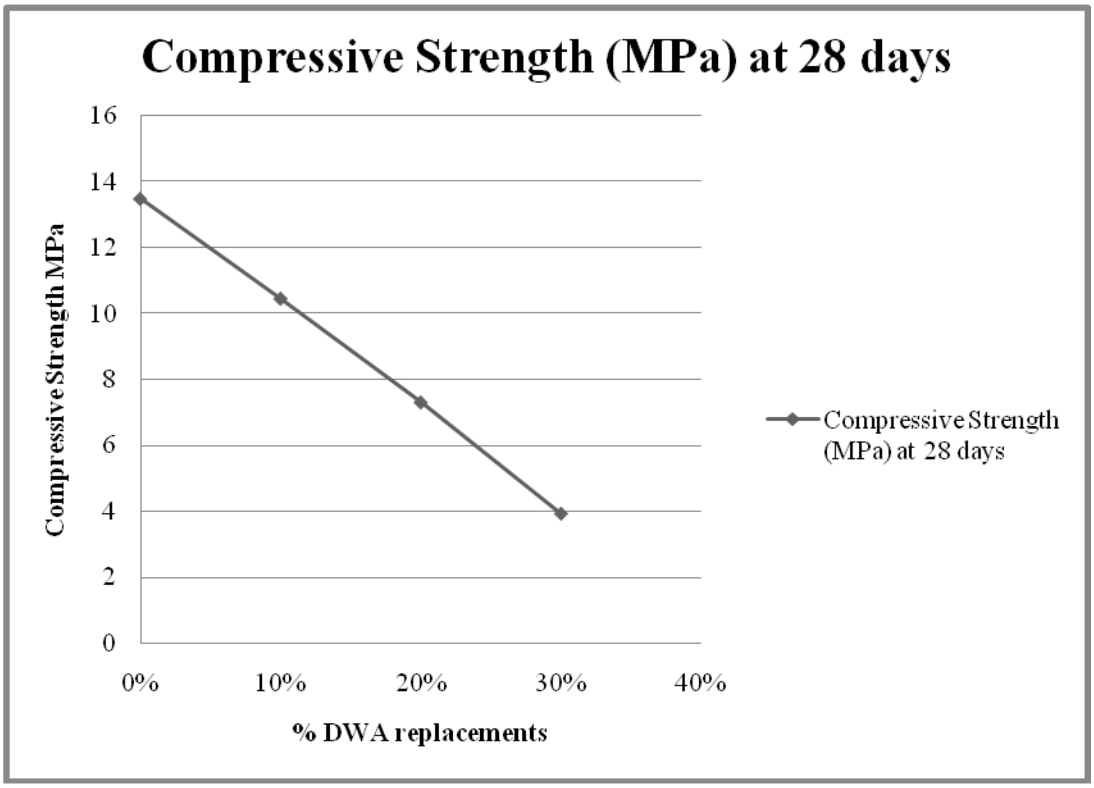

Fig 9 shows the relationship between compressive strength and % of replaced demolition waste aggregates at 28 days

Fig 7, Fig 8 and Fig 9 shows the relationship between compressive strength and % of replaced recycled demolition waste aggregates for 7 days and 14 days respectively. Concrete containing 0% DWA is considered as reference and then this referral concrete is compared with the one having 10%, 20% and 30% DWA. It is evident from the graphs that compressive strength of pervious concrete for both 7days and 14 days decreases with increase in % DWA replacements. It is seen that the density is maximum at 0% replacement that is and is minimum for 30% replacement for both the ages.

As the percentage of DWA replacement increases, the area increases, thus requiring more cement paste to bond effectively with the aggregates. As the cement content remains the same, the bonding is therefore inadequate. Strength depends to a large extent on good bonding between the cement paste and the aggregates. The compressive strength reduces as a consequence of the increase in percentage replacement of DWA.

Table 4 Recommended grades of concrete (BS 8110, 1997) [1]

GRADE	**CHARACTERISTIC STRENGTH**	**CONCRETE CLASS**
7	7	PLAIN CONCRETE
10	10	
15	15	REINFORCED CONCRETE WITH LIGHTWEIGHT AGGREGATE
20	20	REINFORCED CONCRETE WITH DENSE AGGREGATES
25	25	
30	30	CONCRETE WITH POST TENSIONED TENDONS
45	45	CONCRETE WITH PRE TENSIONED TENDONS
50	50	
60	0	

V. CONCLUSION

This paper is a approach of replacing natural coarse aggregates (NCA) with building demolished waste aggregates (DWA) in making pervious concrete and the impacts of DWA on the properties of hardened pervious concrete. Laboratory tests were performed for knowing the properties of demolished waste aggregates. It was observed that DWA had some deficient properties as compared to NCA but, yet it had the capacity to serve the purpose of replacing the natural coarse aggregates in making pervious concrete. Four pervious concrete design mixes were prepared with 0%, 10%, 20% and 30% replacement to NCA with DWA. After 7days, 14days and 28 days of curing ages, density and compressive strength of DWA replaced pervious concrete were assessed. Also I will be performing the porosity and permeability tests on pervious concrete ahead in my dissertation work.

Based on the experimental work in making pervious concrete using building demolished waste aggregates it is found that,

- The specific gravity of NCA is more as compared to DWA.
- The water absorption of NCA is less as compared to DWA this shows that pervious concrete using DWA are more porous as compared to NCA but have less strength.
- The impact value of DWA is greater than NCA and also abrasion value of DWA is greater than NCA.
- Density and compressive strength of pervious concrete was observed to be decreasing with increase in percentage of building demolished waste aggregates.
- The strength of pervious concrete with 0% DWA replacements at 7days and 14 days was 11.11 MPa and 10.27 MPa and the strength of pervious concrete with 10% DWA replacements at 7days and 14 days was 9.15 MPa and 9.51 MPa.
- Thus, we found with these characteristic strength of concrete, can be used as plain concrete or Reinforced concrete with Lightweight aggregate of M10 or M15 grade application.

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8) All the properties of natural coarse aggregates are obtained from Ms. Savita Chavan owner of Hi-tech construction material testing laboratory, Tathawade, Pune.