An Experimental Analysis of Leaching and Permeability Attributes of Crushed Concrete Waste

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***Abstract* – Demolished concrete waste forms a large proportion of the building demolition wastes and construction wastes. Large amount of production of demolition waste and lower recycling rates are making it hard to dispose construction and demolition wastes. Concrete waste (M 25 designation as per the design details) from a demolished building was analyzed in this study for its leaching and permeability properties to access its reusability. The concrete waste was crushed, graded into three samples (0-10 mm, 0-20 mm and 0.05-20) and then the samples were tested for permeability and leaching attributes. Leaching test was performed to know whether the leachate possessed excess amount of toxic elements. Tests were conducted for hydraulic gradients of 0.3 to 0.9. The results showed appreciable permeability value (1×10^{-4}m/s to 1.95×10^{-4} m/s, calculated using constant head method)) to be sufficient enough to be used as a filter layer in construction of road and hydraulic structures. The leachate of the sample did not have any excess amount of elements that can cause toxicity due to excess concentration and thus may not contribute to soil toxicity.**

Keywords— Wate concrete, leaching, leachate, recycle concrete

I. INTRODUCTION

Concrete is essential part of the construction industry. Even though steel structures have made their way in construction industry, concrete is still largely used. Every year, large quantities of demolition and construction waste is produced but the recycling rate is very low and hence disposal of such wastes is becoming an issue of concern. According to BMPTC, India; Our country produces nearly 150 million tons of construction and demolition waste each year, while recycling at just 6000 tons a year. With such rate of production and less recycling capacity, the problem of disposal of concrete has rose to alarming levels. It is estimated that the worldwide demolition waste output will increase by 2.2 billion tons per year by 2025 which is nearly double of what we have today. This increase in demolition waste accumulation is because we have not been recycling enough of concrete per year. Also, there has not been much research on the reusability of demolished concrete structure.

Demolished concrete can be crushed and turned into aggregates and can be reused in various cases. In this project we have taken demolition waste from a section of commercial building made of concrete which had been denoted M25 in the design plan.

II. LITERATURE REVIEW

A. *Some Useful Literature*

1.**Buck, Alan D. (1976).** He did research on a manufacturing aggregates by using demolition waste that consisted of concrete of various strength designations. He also predicted that there would be future rise in the need of aggregates and that shortage of fresh aggregates will be encountered if we do not learn to turn waste concrete to recycled aggregates.

2.**Marta Sánchez de Juan, Pilar Alaejos Gutiérrez (2008)** Studied that the effect of mortar still attached to demolished and crushed concrete and found out that various essential properties of aggregate had been affected due to attached mortar during construction of a concrete structure. They also suggested that the quality of recycled aggregate is not as good as that of fresh aggregate.

3. **Bozyurt et al. (2012).** An empirical relationship for resilient modulus was given by them and they related it to particle shape, binder type and aggregate mineralogy of recycled aggregate.

4.**Sherif et. al. (2015).** They worked on concrete samples made of recycled aggregates and the samples were found to inhibit acceptable compressibility, flexure and splitting tensile results. They also found that weak old mortar still adhered to surface of recycled aggregates was responsible for the loose connection between recycled concrete and the aggregate.

5.**Punitha P (2017).** Upon doing various tests she concluded that the 28 day cube strength for cubes made from Natural Aggregate and Recycled Aggregate were same and no major differences were witnessed during the work.

III. MATERIALS AND METHODOLOGY

A. *Materials Used*

The material used in this research work was M25 concrete collected from a demolished building which was crushed and graded into 3 categories; 0-10 mm, 0-20 mm and 0.05 to 20 mm. The graded samples were then tested for permeability using constant head permeability method.

B. *Methodology*

1) Constant Head Permeability Test: This test is done for coarse materials like sand, gravel etc. the head of the water at inlet and outlet is kept at a constant head difference and the measurement is performed by calculation using the formula;

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 06, June-2021

$$k = Q.L / A.h.t \quad (1)$$

where, k = permeability, Q=Volume of discharge accumulated, L= Length of Specimen, A=Area of Cross section of specimen, h=head difference, t=Time taken to collect discharge volume Q.

2) Atomic Absorption Spectrometry: This method uses EM radiations and makes them pass through liquid or solids to determine presence of various elements in the sample. The result is calibrated against standard results to know the type and concentration of the element present in the sample.

IV. Results And Discussion

After the tests were performed on the samples following results were obtained, which are presented below.

A. Hydraulic Gradient(i) vs Flux Velocity (V_f)

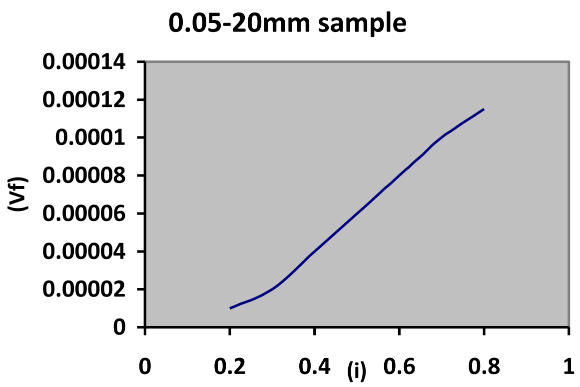

Fig. 1 Hydraulic Gradient vs Velocity of Flow for 0.05-20 mm sample.

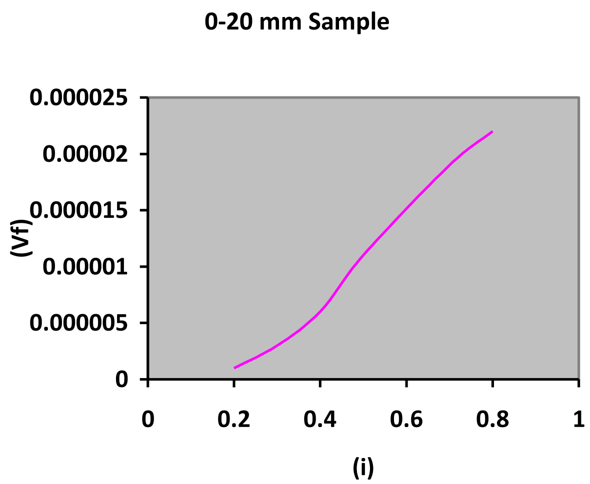

Fig. 2 Hydraulic Gradient vs Velocity of Flow for 0-20 mm sample

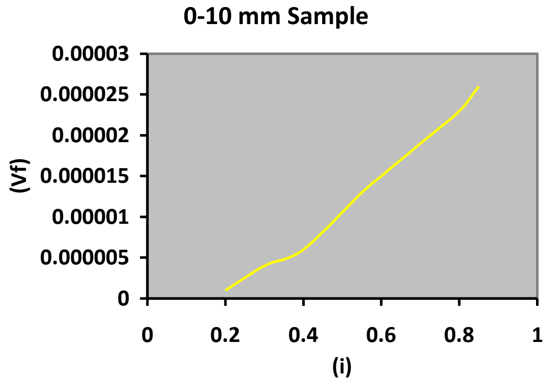

Fig. 3 Hydraulic Gradient vs Velocity of Flow for 0-10 mm sample.

In the figures 1,2 and 3, the relation was validated by

$$v = k.i.n \quad (2)$$

where, v = velocity of flow, i = hydraulic gradient and n = a factor

The value of n for the sample 0.05-20 mm is calculated as 1.62 whereas for the samples 0-20 mm and 0-10 mm, it is calculated as 1.41

B. Flux Velocity calculated by use of Hydraulic Gradient and Average Permeability

The flux velocity is calculated on the basis of Darcy's Law,

$$v = k.i \quad (3)$$

where, i = hydraulic conductivity, k = permeability coefficient, v = flux velocity

Table I Flux Velocity Calculations

	0.05-20 mm sample		0-20 mm sample		0-10 mm sample	
i	***k***	***V_f* (m/s)**	***k***	***V_f* (m/s)**	***k***	***V_f* (m/s)**
0.2		2.0×10^{-5}		3.8×10^{-6}		1.9×10^{-6}
0.3		3.1×10^{-5}		5.7×10^{-6}		6.27×10^{-6}
0.45		4.5×10^{-5}		8.6×10^{-6}		9.41×10^{-6}
0.5	1.0×10^{-4} m/s	5.0×10^{-5}	1.89×10^{-5} m/s	9.5×10^{-6}	2.09×10^{-5} m/s	1.05×10^{-5}
0.56		5.6×10^{-5}		1.06×10^{-5}		1.17×10^{-5}
0.69		6.9×10^{-5}		1.31×10^{-5}		1.44×10^{-5}
0.77		7.7×10^{-5}		1.46×10^{-5}		1.61×10^{-5}

C. Chemical Analysis of Presence Elements in the Leachate obtained from the agrregate samples

Three tests were performed for evaluation of the element concentration present in the leachate obtained from the aggregates and the average of the 3 tests and the results were obtained. The obtained results showed clearly that no values of the concentration of the elements showed values in excess to the standard concentrations of sewage that can be discharged on land or in water as given by CETPs in India.

TABLE II. MEASURED VALUES OF VARIOUS PARAMETERS

Parameter	Concentration (mg/L)	Max Concentration as Per CETPs (mg/L)
Cu	0.2	3
Ni	0.122	3
Sulphates	200	1000
Chlorides	20	600
Zn	.01	5
Pb	-	0.1

Values of pH and Conductivity were found to be 7.65 and 0.501 m-mho/cm on analysing the sample.

None of the values that are obtained exceeded the standard that have been set for the discharge of effluents into soil or water by CETPs in India and thus the leachate obained by the samples of crushed demolished concretes can be used for various applications in the field of civil engineering.

V. CONCLUSION

From the obtained results, we can conclude that the following-

1. The difference between flux velocity obtained in various blends in due to the presence of fine particles in the blends of 0-10 and 0-20 mm but absence of fine particles in 0.05 to 20 mm.
2. The obtained values of permeability are sufficient and the recycled aggregates can be thus used for construction of embankments, earthen dams etc.
3. The leachate analysis did not show any exceeded concentration of elements and thus are safe to use on soil and can be used as a filtration layer beneath structures. Nevertheless, there is a need for further tests to be done to observe if there are any elements in the leachate that may bring any harm to soil or to the organisms to the soil by exceeding their standard concentrations.

VI. FUTURE SCOPE

This work opens way for further analysis on reuse of the demolished concrete by suitable gradation. Also, suffosion analysis should be performed as per the standard to see the loss of fines that may occurr. Further research can reveal some empirical relations between the permeability parameters for flow through these type of recycled aggregates. Also, there is need for more analysis on their usability in fresh concrete placements in new constructions or wheteher they are suitable for any other purposes.

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