

Experimental Investigation on Concrete Using E-Waste & Plastic Waste Partially Replaced by Coarse Aggregate

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ABSTRACT

Application of recycled materials in the building industry is essential for permanently sustainable development of each country. The use of primary sources and materials is becoming unbearable both economically and ecologically, and therefore it is necessary to seek the possibility of reuse of those materials once their durability expired

This project deals with the Comparative study of flexural behavior of fiber reinforced concrete using recycled aggregates with quarry dust replacement. Locally available waste materials such as quarry dust and recycled materials have been utilized in concrete. The aim of this project is to study enhancement of flexural strength, splitting tensile strength and modulus of elasticity due to the addition of POLYPROPYLENE fibers and recycled aggregates in concrete and the replacement of crusher dust in concrete.

The compressive strength of concrete reaches the maximum value at a replacement level of 0.5% of fibers and same behavior is observed while replacing completely with recycled aggregates and quarry dust. The split tensile strength of concrete reaches the maximum value at a replacement level of 0.5% of fibers and same behavior is observed while replacing completely with recycled aggregates and quarry dust. The flexural strength of concrete beams attains max value of 54kN ultimate load at a replacement level of 0.5% of fibers. The stiffness and energy absorption capacity at ultimate load are more in the 0.5% of fiber proportion. Hence it is concluded that recycled building waste can be effectively used as a fully replacement for natural aggregate.

Key Words: Concrete, E-waste, Plastic waste, Quarry dust, Compressive strength, Tensile strength, Flexural strength.

I. INTRODUCTION

India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures

etc., to meet the requirements of globalization in the construction of buildings and other structures concrete plays the rightful role and a large quantum of concrete is being utilized.

Recycling concrete is a viable option to decrease the demand on high quality natural resources and to limit the amount of waste that is disposed in landfills. Recycled concrete has been primarily used as a unbound material in embankments, bases, and sub-bases. Engineers have also used recycled concrete as an aggregate in the construction of new structures such as concrete pavements but with limited frequency. The use of recycled concrete in load bearing structures has not gained wide acceptance probably because of the lack of accessible information on the subject, such as expected fresh and hardened material properties.

Any construction activity requires several materials such as concrete, steel, brick, stone, glass, clay, mud, wood, and so on. However, the cement concrete remains the main construction material used in construction industries. For its suitability and adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment, economize and lead to proper utilization of energy. To achieve this, major emphasis must be laid on the use of wastes and byproducts in cement and concrete used for new constructions. The utilization of recycled aggregate is particularly very promising as 75 per cent of concrete is made of aggregates. In that case, the aggregates considered are slag, power plant wastes, recycled concrete, mining and quarrying wastes, waste glass, incinerator residue, red mud, burnt clay, sawdust, combustor ash and foundry sand. The enormous quantities of demolished concrete are available at various construction sites, which are now posing a serious problem of disposal in urban areas. This can easily be recycled as aggregate and used in concrete. Research & Development activities have been taken up all over the world for proving its feasibility, economic viability and cost effectiveness.

1.1 Objective and Scopes of Work

The main objective of this project is to study the flexural behavior of fibre reinforced concrete beam with recycled aggregates. Fibres are added at different percentages (0%, 0.5%, 1% and 1.5%) and natural aggregates are completely replaced with recycled aggregates. From the previous literature it is well understood that addition of recycled aggregates and quarry dust will ensure cost reduction in reinforced concrete. Fibres are having good tensile strength and can be used in concrete to improve its properties. The recycling and reuse of construction & demolition wastes seems feasible solution in rehabilitation and new constructions after the natural disaster or demolition of old structures. Recycling concrete is a viable option to decrease the demand on high quality natural resources and to limit the amount of waste that is disposed in landfills. Recycled concrete has been primarily used as a unbound material in embankments, bases, and sub-bases. Engineers have also used recycled concrete as an aggregate in the construction of new structures such as concrete pavements but with limited frequency. The use of recycled concrete in load bearing structures has been studied in this work.

1.2 Need for Recycled Aggregates

The main reasons for increase of volume of demolition concrete / masonry waste are as follows, Many old buildings, concrete pavements, bridges and other structures have overcome their age and limit of use due to structural deterioration beyond repairs and need to be demolished. The structures, even adequate to use are under demolition because they are not serving the needs in present scenario. New construction for better economic growth. Structures are turned into debris resulting from natural disasters like earthquake, cyclone and floods etc. Creation of building waste resulting from manmade disaster/waste

1.3 Fiber Reinforced Concrete with Recycled Aggregates

Concrete with aggregate from recycled materials, which enables saving sources of natural aggregate, is considered to have generally worse mechanical properties than common concrete. But the idea to add fibers to a concrete mixture with recycled aggregate may change material properties of such concrete, improve behavior and bring about new types of applications. Fiber reinforced concrete with recycled aggregate can be considered as optimal structural concrete for various applications. The approach to design of fiber reinforced concrete with recycled aggregate is defined by this method, or the philosophy, of the design. While in the case of

ordinary, or plain, concrete the material characteristics are defined by its application, which is reflected in the composition of fresh concrete, in the case of fiber reinforced concrete this process is its complete opposite. The composition is given in advance and subsequently its properties are proofed and its applicability in building industry sought.

1.4 MIX COMPOSITION

The general procedure of testing of composites mostly follows the economic criteria (cost minimization) with respect to simplicity of technology and possible applicability in practice, which would contribute to the building sustainability. The design can be based only on determination of the density of the compacted recycled aggregated regardless to its saturation, and the remaining components can be just added. The amount of cement should ensure the bond between the fiber and the recycled aggregate, and the amount of fibers should ensure the required uniaxial tensile strength. The amount of water should be decided according to workability requirements. The mix composition is based on the following principles,

- Recycled aggregate of wide grading curve (a single grade, e.g. 0/32 mm),
- Constant-minimum amount of binder (cement),
- Weight of fibers according to the requirement of fiber concrete properties,
- Amount of water according to required workability.

II. LITERATURE REVIEW

Jorge C. de Brito (2009): In this work, concrete has been produced with different ratios of substitution (10%, 20%, 30%, 50% and 100%) of natural sand with fine recycled concrete aggregates, has been divided in three parts: tune-fining the workability of the admixtures in order to keep it approximately constant; choosing the maximum allowable substitution ratio according to performance criteria; performing a large set of laboratory tests to compare the behaviour of concrete with that same substitution ratio of fine recycled aggregates with the behaviour of a reference concrete produced exclusively with fine natural aggregates. In all compositions, the coarse portion is made of natural limestone aggregates. The work describes the first and second parts out of above three cases and the criteria used to limit the maximum replacement ratio, based on compressive strength, short-term shrinkage and water absorption.

Gokhan Durmus (2010): In this experimental study, the effects of the recycled fine

recycled concrete aggregate (FRA) that was manufactured from concrete wastes on the concrete properties were investigated. In concrete mixtures, 0, 10, 20, 30, 40, 50 and 100% by weight FRA were used instead of river sand. Afterwards, unit weight and water absorption ratios and 28-day compressive strength were determined. According to the test results obtained, it was seen that FRA can be used up to 10 % ratio for producing C30 Concrete between 20-50% ratios for producing C25 concrete. Thus, environmental impacts and consumption of the natural resources can be significantly reduced by using recycled fine concrete aggregates in concrete applications.

Ken Watanabe (2011): The investigation concerning applicability of Ductile Fiber Reinforced Cementitious composites (DFRCC) using recycled fine aggregate was reported. DFRCCs are composites of cementitious material reinforced with fibers, which is superior to the existing fiber reinforced concrete (FRC), especially in terms of crack-dispersing. Property and mechanical ductility. Although the use of the DFRCC for actual construction work has been reported, the number of such applications is still small. In this study they have examined potential applicability of ductile fiber reinforced concrete (DFRC) using recycled aggregate. mortar using natural fine aggregate with a crushed sand and pit sand mixing ratio of 7:3 (NM); mortar using recycled fine aggregate (RM); concrete using crushed stone with maximum sizes of 10 mm and 20 mm (NC, 2NC); and concrete using recycled coarse aggregate with maximum sizes of 10 mm and 20 mm (RC, 2RC). The water-binder ratio (W/B) was 45, 50, or 55%, the sand-aggregate ratio (s/a) was 100, 80, or 60%, and the target slump test value was 18.0 cm. A mixture of PVA fiber (0.2 mm in diameter, 18 mm in length) and steel fiber (0.55 mm in diameter, 30 mm in length) was used.

V. Vytlačilova, J.Vodicka (2011): The paper presents experimental program and shows results on this composite - mechanical and physical characteristics – density, compressive strength, splitting tensile strength and flexural tensile strength and modulus of elasticity of fiber reinforced concrete. Based on a large series of acquired experimental results on different characteristics of the tested material, it can be judged on the behavior of this composite, which is sufficient enough to be used in ground structures as intended. The application of this composite material is ensured by the synthetic fibers, which along with the other components constitutes the tough structure of the composite favourable especially under tensile

loading due to its high ductility. From this paper, optimum compressive strength, split tensile strength and flexural strength are 13.75 MPA, 1.71 MPA and 2.16 MPA respectively.

Vladimira vytlačilova (2011): This paper presents an experimental investigation of fiber reinforced concrete made from construction and demolition waste – recycled concrete and masonry aggregate with and without polypropylene fibers. This work was aimed at evaluating physical – mechanical behaviour of cementitious composite first behaviour of beams in the four point bending test. From the results of analyses is obvious positive effect of fibers on the ductility of this composite material. The experimental analyses results show that recycling of inert rubble brings interesting possibilities for sustainable building. From the paper, the analysis proved positive effect of fibers on a tensile and flexural strength. The results of the experiments proved an unambiguously positive influence of the synthetic fibers on ductility and behaviour of beam after loading.

III. EXPERIMENTAL INVESTIGATION

3.1 Preparation of Recycled Aggregate



Fig 3.1 Recycled aggregates

Recycled aggregates are collected from construction sites and they were broken into pieces. Then the debris were cleaned completely and sieve analysis has been carried out.

3.2 Specific Gravity and Water Absorption

The specific gravity (saturated surface dry condition) of recycled concrete aggregate was found from 2.64 which are lower as compared to natural aggregates. Since the RCA from demolished concrete consist of crushed stone aggregate with old mortar adhering to it, the water absorption ranges from 3.05% to 7.40%, which is relatively higher than that of the natural aggregates. In general, as the water absorption characteristics of recycled aggregates are higher, it is advisable to maintain saturated surface dry (SSD) conditions of aggregate before start of the mixing operations.

3.3 Properties of the Filling Masses

Table 3.1 Properties Of The Filling Masses.

Filling mass	Bulk Density (gm/cm ³)	Particle Size (gm/cm ³)	Water absorption (gm/cm ³)
Siliceous sand (mixture NS)	2.08	2.63	1.86
Concrete recycled material	1.74	2.52	10.26
Brick recycled material	1.79	2.67	15.41
Industrial recycled material	1.55	2.76	50.43

Usually replacement of only 10% to 30% virgin sand is used for new concrete. Using 100% recycled coarse aggregate produces acceptable quality concrete. Recycled fine aggregate is angular, with a high porosity and low specific gravity. Concrete produced with recycled aggregate has lower of the strength of a comparable natural aggregate concrete.

Table 3.2 Physical Properties of Recycled Aggregates

Coarse aggregate	Density (g/cm ³)	Absorption (%)	Fineness Modulus
Natural	2.76	2.55	7.48
Recycled	2.64	6.18	7.24

3.4 Quarry Dust

Quarry dust is a residue obtained from extraction and processing of rocks which forms finer particles less than 4.75 mm. Quarry dust is used in highways as a surface finishing material. Long term growing demand for aggregates to produce concrete

has presented increased problems of supplying of sand. Besides this, environmental rules and regulations and scarcity of natural aggregates results in a continuously increasing trend towards the use of quarry dust in concrete.

Table 3.3 Physical properties of quarry rock dust and natural sand.

Property	Quarry dust	Natural sand	Test method
Specific gravity	2.54-2.60	2.60	IS 2386 (Part III) 1963
Bulk relative density (kg/m ³)	1720-1810	1460	IS 2386 (Part III) 1963
Absorption (%)	1.20-1.50	Nil	IS 2386 (Part III) 1963
Moisture content (%)	Nil	1.50	IS 2386 (Part III) 1963
Fine particles less than 0.075mm (%)	12-15	06	IS 2386 (Part I) 1963
Sieve analysis	Zone II	Zone II	IS 383 - 1970

Table 3.4 Typical Chemical Composition of Quarry Rock Dust and Natural Sand.

Constituent	Quarry rock dust (%)	Natural sand (%)	Test method
SiO ₂	62.48	80.78	IS: 4032-1968
Al ₂ O ₃	18.72	10.52	
Fe ₂ O ₃	06.54	01.75	
CaO	04.83	03.21	
MgO	02.56	00.77	
Na ₂ O	Nil	01.37	
K ₂ O	03.18	01.23	
TiO ₂	01.21	Nil	

Loss of ignition	00.48	00.37	
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Table 3.5 Particle Size Analysis of Quarry Dust

S.No	IS Sieve size	Weight retained(kg)	Cumulative weight retained(kg)	% cumulative retained(kg)	% passing
1	4.75 mm	0	0	0	100
2	2.36 mm	0.0019	0.0019	0.19	99.99
3	1.18 mm	0.0673	0.0692	6.92	93.08
4	600µm	0.1760	0.2452	24.52	75.48
5	300 µm	0.2756	0.5208	52.08	47.92
6	150 µm	0.3948	0.9159	91.56	8.44
7	75 µm	0.08	0.9959	99.59	0.41
			Total	274.86	

3.5 Polypropylene Fiber

Today it is very common to add polypropylene fibers into concrete for strengthening concrete and for protection of concrete against micro cracks. Most common count for this application is a PP with a relatively short cut of 12 mm. Other cuts used but less common are 6, 18 and 24 mm. The function of the PP fiber mixed into concrete is not to replace the steel but to avoid the creation of micro cracks in the concrete. The function of the polypropylene fiber mixed into concrete is not to replace the steel but to avoid the creation of micro cracks in the concrete. Polypropylene fibers are used in concrete to obtain a much better, more stable surface and more resistant piece of concrete. Mixing of the fibers always to be as short as possible in order not to damage the fibers. The ratio of fibers depends on the requirement. It can vary from 0.9 to 5 kg / m³ if transport from mixing plant to construction site is more than 2.5 hours then the mixing of the fiber should take place on the construction site. The more polypropylene fiber are mixed into the concrete the better the quality of the construction and reduction anti micro cracks.

- Avoid micro cracks in concrete
- Improved closed surface of concrete
- Excellent crack reduction in early-age concrete.
- Better concrete durability & reduced surface dusting.

- Improves impact and abrasion resistance.
- Improves mix cohesiveness.
- Reduces segregation of the mix.
- Significant improvement in freeze-thaw cycle resistance.
- Saves time.
- Improves water migration.
- Reduces shotcrete rebound.
- Less concrete waste.



Fig 3.5 Polypropylene Fiber

3.6 Coarse Aggregates

Locally available coarse aggregates having the maximum size of 10 to 20mm was used in this present work. The results of test conducted on coarse aggregate are given in table 5.2.

Table 5.6 Properties of Coarse Aggregate

SI.NO	Characteristics	value
1	Type	crushed
2	Specific gravity	2.76
3	Fineness modulus	7.48

4	Size	max 20mm size
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3.7 Cement: The cement used in this study is 43 grade OPC manufactured by chettinad cements.

3.8 Water: The portable water available in the college campus has been used.

3.9 Mix Proportions: Concrete mix design is a process by which the proportions of various raw materials of concrete are determined with an aim to achieve a certain minimum strength and durability, as economically as possible. The Indian standard method of mix design is used for the design of concrete mix of grade M25.

3.10 Details of Test Specimens

- C1 - 0.5% Fibre + Natural aggregates + Quarry dust.
- C2 - 1.0% Fibre + Natural aggregates +

Quarry dust.

C3 - 1.5% Fibre + Natural aggregates + Quarry dust.

C4 - 0.5% Fibre + Recycled aggregates + Quarry dust.

C5 - 1.0% Fibre + Recycled aggregates + Quarry dust.

C6 - 1.5% Fibre + Recycled aggregates + Quarry dust.

IV. RESULTS AND DISCUSSION

4.1 Compressive Strength of Cubes

The Compressive Strength Results of Concrete cube Specimens for 7 and 28 days are presented in the Table 6.1 and the comparisons of the results are shown in Figure 6.1.

Table 4.1 Compressive Strength Test Results

SPECIMENS	7 days [N / mm ²]	28 days [N / mm ²]
Control specimen	20.32	32.14
C1	29.33	33.92
C2	24.29	26.67
C3	19.26	22.82
C4	28.88	33.62
C5	24.00	27.26
C6	18.67	22.37



Figure 4.1 Compressive Strength Results

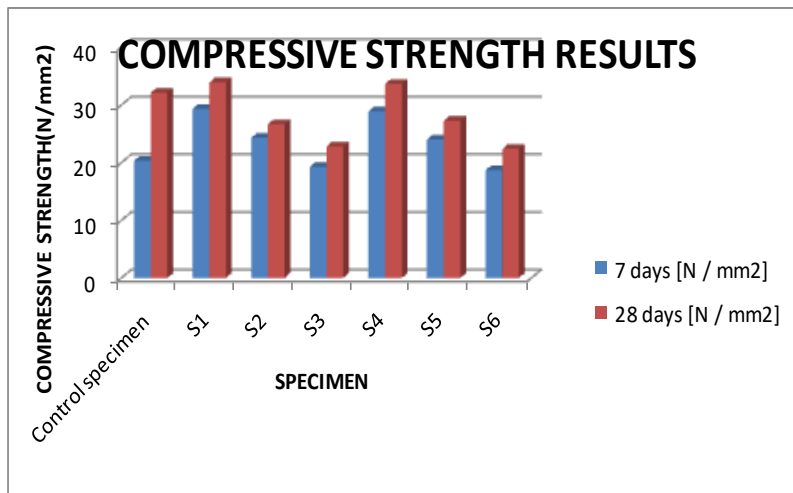


Figure 4.1 Compressive Strength Test on Concrete Cube

From the results of compressive strength it is observed that the compressive strength of concrete with recycled aggregate is same as that of natural aggregates. Hence Recycled aggregates can be used to replace natural aggregates completely.

4.2 SPLIT TENSILE STRENGTH OF CYLINDERS

The Split Tensile Strength Results of Concrete Cylinder Specimens for 28 days are presented in the Table 6.2 and comparisons of results are shown in Figure 6.2.

Table 4.2 Split Tensile Test on Cylinders

SPECIMENS	SPLIT TENSILE STRENGTH FOR 7 DAYS [N/mm ²]	SPLIT TENSILE STRENGTH FOR 28 DAYS [N/mm ²]
Control specimen	2.26	2.28
C 1	2.31	2.32
C 2	2.28	2.42
C 3	2.19	2.24
C 4	2.34	2.34
C 5	2.31	2.36
C 6	2.24	2.28



Figure 4.2 Split Tensile Test on Concrete Cylinder

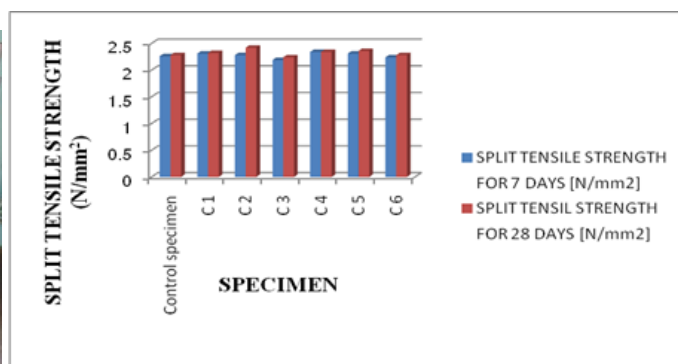
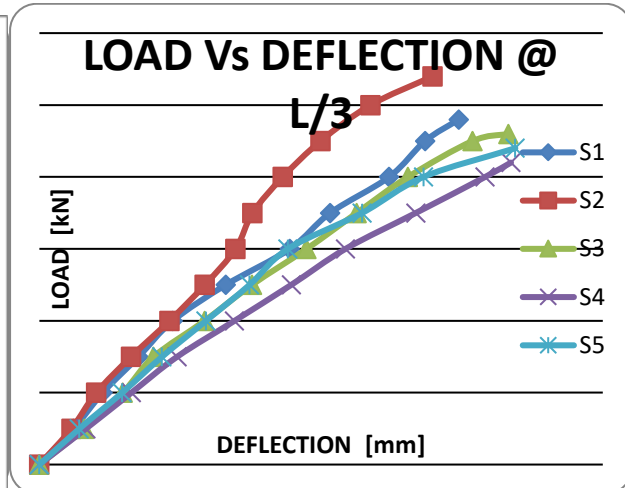
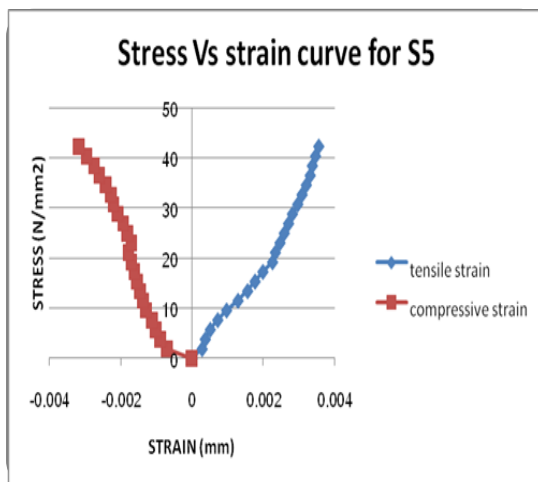


Figure 4.2 Split Tensile Test Results



From the results of split tensile strength it is observed that the split tensile strength of concrete with recycled aggregate is same as that of natural aggregates. Hence Recycled aggregates can be used to replace natural aggregates completely.

V. Conclusion:

In this project recycled aggregates are used to minimize the cost and to ensure sustainable development and also quarry dust is completely replaced with natural sand. This will suggest a suitable recycling methodology for above waste materials. Additionally polypropylene fibers are used to develop strength and ductility and the effect of replacing recycled aggregates and quarry dust on fiber reinforced concrete have been studied.

The compressive strength of concrete reaches the maximum value at a replacement level of 0.5% of fibers and same behavior is observed while replacing completely with recycled aggregates and quarry dust.

The split tensile strength of concrete reaches the maximum value at a replacement level of 0.5% of fibers and same behavior is observed while replacing completely with recycled aggregates and quarry dust.

The load deflection behavior shows a ductile behavior at 0.5% of fiber replacement level. The stiffness and energy absorption capacity at ultimate load are more in the 0.5% of fibre proportion.

Hence it is concluded that recycled building waste can be effectively used as a fully replacement for natural aggregate.

REFERENCES

- [1]. Criteria for the use of fine recycled concrete aggregates in concrete production Luis r. Evangelista, Jorge c. De Brito (2009)
- [2]. Material properties of frc with recycled aggregate Jirina Trckova and Petr Prochazka (2011)
- [3]. Ductile-fiber-reinforced concrete using recycled aggregate Masaya Nakamura, Ken Watanabe (2011)
- [4]. Effects of the fine recycled concrete aggregates on the concrete properties Hasbi Yaprak, Huseyin Yilmaz Aruntas, İlhami Demir, Osman Simsek and Gokhan (2010)
- [5]. Strength and workability characteristics of waste plastic fibre reinforced concrete produced from recycled aggregates Dr. Prahallada M.C and Dr. Prakash K.B (2010)
- [6]. Use of recycled aggregates in concrete a paradigm shift. K. Sin (2007)
- [7]. The fibre reinforced concrete using recycled aggregates Vytlačilova, J. Vodicka (2011)
- [8]. The use of manufactured quarry fines in concrete Dumitru, T. Zdrilic and G. Smorchevsky, Boral Construction Materials, Sydney, Australia (1997)
- [9]. Fracture and drying shrinkage properties of concrete containing recycled concrete aggregate Victor Cervantes, Dr. Jeffery Roesler, and Amanda (2007)
- [10]. Strength and durability properties of concrete containing quarry rock dust as fine aggregate R. Ilango Van, N. Mahendran and K. Nagamani (2006)