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Experimental Study on High Strength Concrete with Recycled Aggregate

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Abstract— The **recycling of construction and demolition waste as a source of concrete aggregates has attracted increasing interests from the construction industry. Use of waste concrete as RCA conserves natural aggregate, reduces the impact on landfills, save energy and can provide cost benefit. Recycled aggregates are the materials for the future. Recycled aggregates are consists of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. The aim for this project is to find the strength characteristic of recycled aggregates for the use in high strength structural concrete, which will give a more virtous understanding on the properties of concrete with reused aggregates, as an alternative material to coarse aggregate in structural concrete. Usually lower grade applications of recycled aggregate concrete have been reported by many researchers, but higher grade activities are seldom reported, because of its personal property on workability, strength and durability. The scope of this project is to decide and to examine the high strength concrete by using different percentage of recycled aggregates and also adding some percentage of super plasticizers to increase the workability of the concrete. Various properties like Workability, compressive strength and Split tensile Strength has to be studied and to be compared with the ordinary concrete.**

***Index Terms*— HSC, RCA, S.B.A.**

I. INTRODUCTION

1.1 General

Construction activity requires several materials such as concrete, steel, brick, stone, glass, clay, wood and mud. Nevertheless, the cement concrete continues to be the main construction element used in construction industries. For its suitability and adaptability with respect to the changing ecology, the concrete must be such that it can prevent injury to resources, guard the environment, economize and lead to proper utilization of energy [1]. To achieve this, major emphasis must be laid on the use of wastes and by products in cement and concrete used for new constructions. Thus use of Re-using the aggregate is particularly very promising as 75 per cent of concrete is made of aggregates. By reusing the aggregates from construction and demolition wastes is showing prospective application in construction as alternative to primary (natural) aggregates. Recycling is the act of processing the used material for use in creating new product. The use of natural aggregate is getting more and stronger with the advanced development in infrastructure area. In order to reduce the use of natural aggregate, once used aggregates is again used as a replacement materials. Recycled aggregate are consists of crushed, graded inorganic particles obtained from the materials that have been used in the constructions and demolition debris. These materials are usually obtained from buildings, roads, bridges, and sometimes from catastrophes such as war and seismic actions. Conventionally, the use of recycled aggregate is used as landfill. In these times, the purposes of recycled aggregate in construction areas are wide. The purposes are different from country to country. Recycled aggregate have been used as concrete kerb and gutter mix in Australia. According to Building Innovation & Construction Technology (1999), Stone says that the 10mm recycled aggregate and blended recycled sand are used for concrete kerb and gutter mix in the Lent hall Street project in Sydney. The major advantage is based on the environmental gain.

Figure 1.1: Recycled Aggregate

1.2 Historical Background

The applications of recycled aggregate in the construction areas are wide and they had been used long time ago. Wilmot and Vorobieff (1997) stated that recycled aggregate have been used in the road industry for the last 100 years in Australia [2]. They also stated that the use of recycled aggregate for the construction and rehabilitation of local government roads has a great improve in the last five years. C & D Recycling Industry (n.d.), the fact file stated that from the time of the Romans, the stones from the previous roads were reused when rebuilding their vaunted set of roads. It also stated that since the end of world war two, the recycling industry had been well established in Europe. According to Seecharan (2004), the Detroid News stated that in 1980s, the old concrete crushed into a powder was popular road filler at Michigan, USA.

1.3 High-Strength Concrete (HSC)

Concrete, a composite consisting of aggregates enclosed in a matrix of cement paste including possible pozzolans, has two major components – cement paste and aggregates. The strength of concrete depends upon the strength of these components, their distortion properties, and the bond between

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the paste and aggregate surface With most natural aggregates, it can be able to make concretes up to 120 MPa compressive strength by improving the strength of the cement paste, which can be restrained through the choice of water-content ratio and type and dosage of admixtures. However, with the recent advancement in concrete technology and the availability of various types of mineral and chemical admixtures, and super plasticizers, concrete with a compressive strength of up to 100 MPa can now be prepared. . These significant consequence have led to increased applications of high-strength concrete (HSC) all around the globe. As per Indian Standard Recommendations any concrete possesses a 28 day compressive strength more than 35 Mpa is termed as high strength concrete. But in some other places like the international forum the high strength label is applied to concrete having strength 40 Mpa or above

Figure 1.2: High Strength Concrete Bridge

1.4 Aggregates

Aggregates content is a factor which has direct & far reaching effects on the both quality & cost of concrete different from water and cement, which do not modify any specific characteristics except in the quantity in which they are utilized, the aggregate elements are infinity changeable in terms of shape & grading With fine aggregates, graded and obtained below fractions of 5 mm sieve size, the dissimilarity in particles form & surface texture affect bulk void content & fresh properties of concrete, which in turn leading to properties of the hardened concrete. Aggregates those are chemically inert materials which when bonded by cement paste to form concrete constitute the bulk of total volume of concrete & hence they influence the strength of concrete to a large extent. By relying upon their size, the aggregate are classified as the fine aggregate & coarse aggregates. The aggregate passing through 4.75 mm sieve size is called as fine aggregates. Natural sand and crushed sand usually come under fine aggregates in concrete mixes.

1.4.1 Natural Aggregate

Aggregates can come from either natural or manufactured sources. Natural aggregates originated from rock, of which they are classified again into three. Igneous rock, these rocks are primarily crystalline and are formed by the cooling of molten rock material beneath the earth's crust (magma).

Sedimentary rocks, these rocks are formed from deposited insoluble material (e.g., the remains of existing rock deposited on the bottom of an ocean or lake). This material is changed to rock by heat and pressure. Sedimentary rocks are layered in outward look and are further classified based on their predominant mineral as calcareous (limestone, chalk, etc.), siliceous (sandstone, etc.) or argillaceous (shale, etc.).

Metamorphic rock, These are igneous or sedimentary rocks that have been subjected to heat and/or pressure great enough to change their mineral structure so as to be different from the original rock. Aggregates are produced in a quarry or mine whose basic function is to convert in situ rock into aggregate with specified characteristics. Usually the rock is damned or dug from the quarry walls then reduced in size using a series of screens and crushers. Some of the quarries have the ability to washing the finished aggregate.

1.4.2 Recycled Aggregates

Construction materials are increasingly judged by their ecological characteristics. Reusing the concrete gains are importance because it protects natural resources and eliminates the need for disposal by using the readily available concrete as an aggregate source for new concrete or other applications. . The organizations that do use recycled concrete aggregate (RCA) in new concrete report that concrete with RCA performs equal to concrete with natural aggregates. Most companies mention the use of material directly in the project that is being reconstructed. Recycling of concrete is a usually a bare process. It includes removing, and crushing already present concrete into a material with a proper size and quality.

1.4.3 Aggregate Characteristics

The crushing characteristics of hardened concrete are similar to those of natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled concrete aggregates obtained from all but the poorest quality original concrete can be expected to pass the same tests. Once used concrete aggregates include not only the original aggregates, but also hydrated cement paste. Thus the concrete pastes decrease the specific gravity and increases the porosity compared to original aggregates. Higher the porosity of RCA leads to a higher absorption.

1.5 Recycling Process

Recycling plant normally located in the suburbs of cities due to the noise pollution that make by the equipment that used during recycling process. According to Aggregate and Quarry all the machinery used have to fit with the effective mufflers to reduce the noise from the processing activity [3]. The main reason that choosing the structural building as the source for recycled aggregate is because there is a huge amount of crushed demolition Portland cement concrete can be produced. The equipment that used during recycling process is various from the site conditions and also country to country. There are few dissimilar forms of equipment had been used effectively to break up the Portland cement pavement and structural building? Recycling of Portland Cement Concrete mentioned that there are few dissimilar forms of equipment had been used for crushing the Portland cement pavement. The equipment is: (a) Diesel pile – driving hammer. It is supported on a motor grader that is fixed in the Portland cement pavement on around 30cm grid pattern. (b) Rhino – horn – tooth – ripper – equipped hydraulic excavator. It is used to remove all the steel reinforcement that remaining in the Portland cement pavement.

Crushing is the initial process of producing the construction and demolition debris into recycled aggregate. The concrete debris is break down into pieces in this process. Aggregate and Quarry (2001) stated that generally the equipment used

for crushing process are either jaw or impacted mill crushers. It also mentioned that all recycling crushers have a special protection for conveyor belts to prevent damage by the reinforcement steel that in the concrete debris. They are fastened with the magnetic conveyors to remove all the scrap metal. According to Recycling of Portland Cement Concrete (n d.), the equipment used to crush and size the existing concrete have to include the jaw and cone crushers The concrete debris will break down to around 3 inches by the primary jaw crusher. It also specified that the secondary cone crushers will breaks the materials to the maximum size required which vary between ¾ and 2 inches. Screening is the process that separates the various sizes of recycled aggregate.

The cover to the plant is made up of a series of large sieves separates the materials into the size required. Recycling of Portland Cement Concrete stated that the size of screen that used to separate the coarse recycled concrete aggregate and fine recycled aggregate is 3/8 inch. The size of screen used to separate the coarse recycled aggregate can be under or over ¾ inches. It also stated that one more screen should be used to separate those particles that more than the specified size. All the recycled aggregate are stored according to the different size of aggregate. According to Recycling of Portland cement Concrete (n d.), the stockpile has to prevent from the contamination of foreign materials. It also specified that the vehicles used for stockpiling have to be kept clean of foreign materials.

1.5 Super Plasticizers

New types of admixtures known as super plasticizers have been introduced into North America within the past several years. These admixtures can enormously increase the workability of normal Portland cement concrete or greatly reduce its water content. Super plasticizers are more expensive than conventional water- reducing admixtures normally the super plasticizer is added to the truck mixer after it arrives at the jobsite and at the last convenient moment before discharge. Within 5 minutes or less the slump greatly increases and at this time the user can get the most advantage from the high fluidity of the concrete. The slump then steadily decreases during the next hour or more and it is for this reason that the super plasticizer is not added until just before use of the concrete

1.6.1 Uses

Super plasticizers are used to best advantage:

a) In areas of congested reinforcement.
b) Where a self-leveling consistence facilitates placing.
c) For high-strength concretes by decreasing the water: cement ratio as a result of reducing the water content by 15–25%.

1.6.2 Practical considerations

a) Special mixes must be designed for super plasticizers and their use must be carefully controlled.
b) The effect of a super plasticizer will last between 30 minutes to 6 hours which is depending on the type of admixture used.
c) They have a relatively high unit cost.

Figure 1.3: Super plasticizer

II. METHODOLOGY

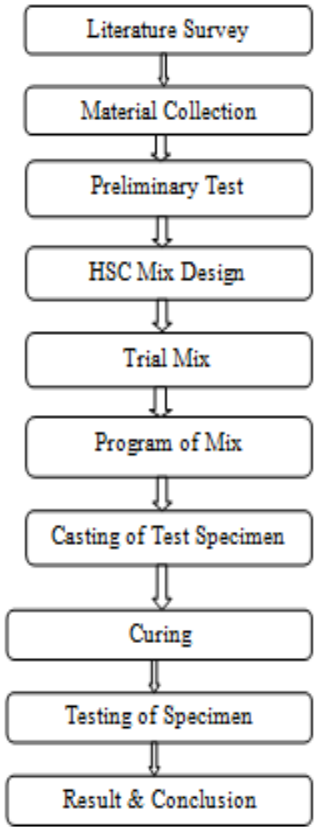

Figure 2.1: Flow chart

Figure [2.1] shows the methology which provides step by step procedures what to do next.

III. EXPERIMENTAL INVESTIGATION

Literature survey of recycled aggregate and its effects on the important properties of materials and concrete are studied. The material properties are specific gravity of fine aggregate, specific gravity of coarse aggregate, specific gravity of cement, water absorption of coarse aggregate and fine aggregate and also sieve analysis is also done, the property of concrete is also studied such as workability and strength. After the properties of the materials are obtained, mix design is done for the required grade of concrete. After that concrete samples will be prepared in laboratory. The tests will be conducted by replacing the coarse aggregates in high strength concrete mixes by recycled coarse aggregates and then tests will be conducted within estimated time. By analyzing the test

results such as compressive strength, an appropriate percentage for replacement of ordinary aggregate is selected. And with this percentage replacement concrete of recycled aggregate concrete beams are casted to find out the flexural behavior of concrete.

3.1 Mix design

3.1.1 IS Method of Design for M40 Concrete

Data:
Compressive Strength required = 40 N/mm2
Max size of Aggregate = 20 mm
Specific Gravity of cement = 3.15
Specific Gravity of Fine aggregate = 2.65
Specific Gravity of Coarse aggregate = 2.7
Degree of quality control=good
Type of exposure=mild
Water absorption of Coarse aggregate= 0.5%
Water absorption of Fine aggregate = 1%

Table 3.1: Final Mix Proportioning for 50 Kg Bag Of cement

CEMENT (KG/M^3)	WATER (KG/M^3)	F.A (KG/M^3)	C.A (KG/M^3)	W/C RATIO
50	20.005	61.61	120.395	0.40

Table [3.1] shows the mixing proportioning of cement with value specified as shown above

3.1.2 IS Method of Design for M40 Concrete with super plasticizer

Data:
Compressive Strength required = 40 N/mm2
Max size of Aggregate = 20 mm
Specific Gravity of cement = 3.15
Specific Gravity of Fine aggregate = 2.65
Specific Gravity of Coarse aggregate = 2.7
Specific Gravity of super plasticizers= 1.220

Table 3.2: Final Mix Proportioning for 50Kg Bag of Cement

CEMENT (KG/M^3)	WATER (KG/M^3)	F.A (KG/M^3)	C.A (KG/M^3)	W/C RATIO	S.P
50	17.5	75	142.5	0.35	1L

Table [3.2] shows the mixing proportioning of cement with value specified as shown above.

IV. TEST RESULTS

Table 4.1 Slump test on fresh concrete

Sl. No.	Percentage Of R.C.A	Slump (Mm)
1	0	84
2	10	81
3	20	77
4	30	74
5	40	73
6	50	72

Table 4.2 Compressive strength of concrete cubes

Sl.No.	Percentage Of R.C.A	Compressive Strength(N/Mm^2)
1	0	40
2	10	39
3	20	37
4	30	35
5	40	33
6	50	31

Table [4.1] and [4.2] shows the slump test on fresh concrete and compressive strength of concrete cube with various values.

IV. CONCLUSION

Literature survey of recycled aggregate and its effects on the important properties of materials and concrete are studied. The material properties are specific gravity of fine aggregate, specific gravity of coarse aggregate, specific gravity of cement, water absorption of coarse aggregate and fine aggregate and also sieve analysis is also done, the property of concrete is also studied such as workability and compressive strength. After the properties of the materials are obtained mix design is done for the required grade of concrete. After analyzing the concrete cubes a suitable replacement percentage is fixed (30%) by checking the factors such as economical as well as the amount of super plasticizers required. Then RCC beams are casted for this percentage to find out the flexural behavior of the concrete.

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