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A STUDY ON PROPERTIES OF CONCRETE WITH REJECTION COAL PARTIAL REPLACED AS COARSE AGGREGATE

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ABSTRACT

Around 67% of power created in India is by burning of coal. The aggregate assessed stores of coal in world are evaluated to be 6,641,200 million tones and for India the same is assessed to be 106,260 million tones. The utilization of coal is required to increment at speedier rate than it had been in the past due to the expansion in the cost of rough and normal gas. The interest of coal amid the primary portion of a century ago stayed pretty much consistent and now it is required to increment in this century. It has the most elevated forward linkage impact with thermal power, railroads trains, manures industry, concrete, steel, electric force and various different commercial ventures. India keeps on being the 6th biggest maker of coal with its yearly generation of almost 100 million tones. The stores of high positioning coal i.e. anthracite and coking bituminous coals are less when contrasted with the low positioning bituminous and lignite coals.

Then again, the interest of high rank coals is more for metallurgical use and for use as fuel. As the development industry is the plausible application to reuse waste materials, this examination is mostly planned to acquaint CWR as an option with coarse aggregates and study the mechanical properties durable properties of CWR based concrete. In this study, coarse aggregates are partially replaced by CWR at different levels (0% - 40%). The Compressive strength , Split tensile strength ,Bond, and. Durable properties RCPT, Drying shrinkage, Water absorption, porosity, of concrete were resolved at various curing periods and contrasted with M25 evaluation of conventional concrete (CC).

INTRODUCTION

1.1 GENERAL

Research concerning the utilization of by-products and modern squanders to enlarge the properties of concrete has been continuing for a long time. In the late decade, the endeavors have been made to utilize industry by-products, for example, fly ash, silica fume, ground granulated blast furnace slag (GGBFS), glass cullet, and so on., in the common developments. The potential use of modern by-products in concrete as incomplete aggregate substitution or as halfway cement substitution, contingent upon their synthetic organization and molecule size. The utilization of these materials in concrete emerges because of natural requirements, in the sheltered transfer of these by products.

Huge consideration is being centered around the earth and protecting of regular assets and reusing of squanders materials. Really numerous industries are delivering a noteworthy number of items which join scrap (buildups). In the most recent 20 years, a ton of works concerning the utilization of a few sorts of urban squanders in building materials industrials process have been distributed. Numerous specialists have been reached out to concentrate new sorts of squanders to explore profoundly specific viewpoints. The expansion of squanders, aside from the natural advantages, likewise creates great consequences for the properties of definite items.

Aggregates are the primary element of cement involving around 70-80% of its volume and straightforwardly influencing the fresh and hard properties. The accessibility of good quality totals is draining step by step because of colossal development in Indian development industry.

Concrete being the biggest man made material utilized on earth is ceaselessly requiring great nature of totals in vast volumes. A need was felt to recognize potential option wellspring of total to satisfy the future development desire of Indian development industry.

Critical examination is made on the utilization of a wide range of materials as aggregate substitutes, for example, coal powder, blast furnace slag, fiber glass waste materials, waste plastics, elastic waste, sintered muck pellets and others. The utilization of waste materials can be expanded complex if these are utilized as total into cement mortar and concrete. This kind of utilization of a waste material can take care of issues of absence of total in different development destinations and decrease natural issues identified with aggregates mining and waste transfer. As the aggregates can altogether control the properties of concrete, the properties of the aggregates have an extraordinary significance. In this way a careful assessment is important before utilizing any waste material as aggregates in concrete.

1.2 COAL WASHRY REJECTS

Around 67% of power created in India is by burning of coal. The aggregate assessed stores of coal in world are evaluated to be 6,641,200 million tones and for India the same is assessed to be 106,260 million tones. The utilization of coal is required to increment at speedier rate than it had been in the past due to the expansion in the cost of rough and normal gas. The interest of coal amid the primary portion of a century ago stayed pretty much consistent and now it is required to increment in this century. It has the most elevated forward linkage impact with thermal power, railroads trains, manures industry, concrete, steel, electric force and various different commercial ventures. India keeps on being the 6th biggest maker of coal with its yearly generation of almost 100 million tones. The stores of high positioning coal i.e. anthracite and coking bituminous coals are less when contrasted with the low positioning bituminous and lignite coals. Then again, the interest of high rank coals is more for metallurgical use and for use as fuel.

Coal is a weak, firm, sedimentary, flammable rock got from vegetable trash which has experienced numerous physical and substance changes amid the long course of a large number of years. It comprises fundamentally of essential carbon. The nature of coal shifts with rank from peat to lignite, from lignite to bituminous, from bituminous to semi-anthracite and from semi-anthracite to anthracite.

The coal as it originates from mines comprise of numerous pollutions, for example, magnesium sulfate, sulfur in type of pyrites, slate and fire mud. These substances have higher particular gravity than unadulterated coal and henceforth, it requires coal washing strategy to clean coal before utilizing. Particular gravity of immaculate coal is 1.2 to 1.7 and for debased coal is 1.7 to 4.9. In this manner, coal must be screened to size and it must be cleaned by jigging or by overwhelming media division. Indeed, even as interest develops, society expects cleaner vitality with less contamination and an expanding accentuation on ecological manageability. The coal business remembers it must meet the test of natural supportability and specifically it must decrease its nursery gas emanations on the off chance that it is to remain a part of a manageable vitality future. The nature of coal should be surveyed at exactly that point it can be reasonably utilized as a part of various commercial ventures.

Indian coal is thought to be of low quality since it contains fiery remains as high as 45%, high dampness content (4–20%), low sulfur content (0.2–0.7%), and low calorific qualities (between 2500–5000 kcal/kg) (IEA, 2002). High slag content in the coal supplied to the force pants postures natural issues as well as results in poor plant execution and high cost for Operation and Maintenance and fiery debris transfer. In this manner, coal washing is essential from monetary and environment perspective. The present introduced limit of washeries for coal is around 131.24 million-tons per annum for both coking and non-coking coal (Energy Statistics, 2013).

The normal coal-washing forms impact a division amongst coal and debasement as a result of the distinction in particular gravities of these segments. In considering the potential outcomes of enhancing a coal by washing, it has subsequently long been basic practice to isolate the crude coal blend into coal and polluting influence by drenching it in an answer with particular gravity halfway between that coal and debasement. The segment of the example with particular gravity not as much as that of the arrangement skims and the segment with the particular gravity more than that of the arrangement sink. Gotten coal completed by the water stream over a weir and the decline sinks at the base. Reject is expelled time to time from the washer and put away in dugout stockpiling. This deny which is put away in shelter stockpiling is called coal washry rejects (CWR).

1.3 AIMS AND SCOPE OF THE PROJECT

As the development industry is the plausible application to reuse waste materials, this examination is mostly planned to acquaint CWR as an option with coarse aggregates and study the mechanical properties durable properties of CWR based concrete. In this study, coarse aggregates are partially replaced by CWR at different levels (0% - 40%). The Compressive strength , Split tensile strength ,Bond, and. Durable properties RCPT, Drying shrinkage, Water absorption, porosity, of concrete were resolved at various curing periods and contrasted with M25 evaluation of conventional concrete (CC).

LITERATURE REVIEW

2.1 GENERAL

This section talks about the examination work completed on solid utilizing different modern by-items and squanders materials. This section gives a far reaching audit of the work did by different specialists in the field of reusing the mechanical by-items and squanders materials in concrete as full or halfway substitution of totals.

The quick improvement of the development business and utilization of common assets and decay of the earth in a few rising economies have brought about an unsustainable advancement of the development business. Therefore, utilizing the mechanical by-items and waste materials is a basic stride in natural manageability. Total regularly represents 65–80% of the solid volume and it assumes a significant part in solid properties, for example, workability, quality, dimensional security, and solidness. The utilization of waste materials as total in solid arrangement can devour tremendous measures of waste materials. This can take care of issues of absence of total on development destinations and diminish natural issues identified with total mining and waste transfer. There is a developing enthusiasm for utilizing waste materials as total and extensive examination has been embraced on the utilization of a wide range of materials as total substitutes.

Compelling examination is being made on the utilization of numerous materials as total substitutes, for example, coal fiery remains, impact heater slag, fiber glass waste materials, waste plastics, elastic waste, sintered slime pellets and others.

2.2 MECHANICAL WASTE AGGREGATES

A wide order of modern waste total can be made relying upon the compound way of squanders. Some waste totals originate from creation and utilization of natural materials. Plastics, elastic, calfskin and some nourishment commercial enterprises squanders are natural squanders. Then again, modern slags, mining squanders, coal industry squanders and others are inorganic squanders. Glass fortified plastics and some modern slime may contain both natural and inorganic materials. Another arrangement of modern waste total should be possible relying upon the heaviness of waste totals. A few totals are lightweight by nature. Plastics, elastic, most nourishment and farming commercial ventures squanders and coal base powder are of this kind. Then again, the majority of the modern slags are heavier than customary totals.

2.3 COAL ASH AS AN AGGREGATE IN CONCRETE

Blazing of coal produces two sorts of waste materials: fly fiery debris and base powder. There are two sorts of base cinders, wet base evaporator slag and dry base fiery debris relying upon both the kettle sort and its configuration. Coal fly powder, otherwise called pummeled fuel fiery remains, is the finest part of these cinders, which are discharged from burning chamber and transported by vent gasses. Fly cinder contains the non-flammable matter in coal alongside a little measure of carbon that remaining parts from fragmented coal burning. Fly fiery remains comprises generally of sediment measured and mud estimated shiny circles. Base slag is delivered as a granular material and expelled from the base of dry boilers. Evaporator slag, a coarse grained item, is delivered from two sorts of wet base boilers, slag-tap and tornado boilers. The slag-tap evaporator blazes pounded coal while the violent wind heater smolders smashed coal. Both evaporator sorts have a strong base with a hole that can be opened to permit liquid fiery remains to stream into a container, which contains extinguishing water. At the point when the liquid slag interacts with the extinguishing water, the fiery remains cracks in a flash, takes shape, and structures pellets. High weight water planes wash the kettle slag from the container into a sluiceway, which then transmits the cinder to accumulation bowls for dewatering and further handling. Kettle slag is a coarse, rakish, smooth, dark material. At the point when pounded coal is smoldered in a slag-tap heater, as much as 50 % of the powder is held in the heater as evaporator slag. In a violent wind heater, which smolders smashed coal, 70–85 % of the fiery remains is held as evaporator slag. Properties of coal fiery remains rely on upon coal sort, pummeling framework, burning conditions, temperature, kind of heater, minerals in coals and processing framework. In spite of the fact that a critical number of references are accessible on the properties and utilization of fly cinder as a mineral expansion in typical Portland bond, very little writing exists on the utilization of fly fiery debris, coal base powder (CBA) and heater slag as a granular added substance into cement. Again contrasted with CBA, almost no work has been done on the utilization of other two fiery debris as total in cement. The properties of these fiery debris will be examined independently.

2.4 INDUSTRIAL SLAG

Slag is an in part vitreous by-result of purifying mineral because of isolating of the metal division from the useless portion. It can be viewed as a blend of metal oxides; be that as it may, slags can contain metal sulfides and metal molecules in the basic structure.

2.4.1 FERROUS SLAG

Ferrous slag is delivered amid the generation of iron utilizing impact heater (impact heater slag) and in the partition of the liquid steel from polluting influences in steel-production heaters (steel slag).

EXPERIMENTAL PROGRAM

3.1. MATERIALS

Constituent materials used to make concrete can affect the properties of the solid. The accompanying segments talk about constituent materials utilized for assembling of both conventional concrete (CC) and coal washry rejects (CWR) based concrete. Concoction and physical properties of the constituent materials are introduced in this segment.

3.1.1 Cement

Ordinary Portland Cement 53 grade (Penna) was used corresponding to IS 12269 (1987). The chemical properties of the cement as obtained by the manufacturer are presented in the

Summary of physical properties and various tests conducted on cement as per IS 4031(1988) are presented in the Table 3.2

3.1.2. Coarse aggregate

Crushed granite stones of size 20 mm and 10 mm are used as coarse aggregate. The bulk specific gravity in oven dry condition and water absorption of the coarse aggregate 20 mm and 10mm as per IS 2386 (Part III, 1963) are 2.6 and 0.3% respectively. The bulk density, impact strength and crushing strength values of 20 mm aggregate are 1580 kg/m^3, 17.9% and 22.8% respectively. The gradation of the coarse aggregate was determined by sieve analysis as per IS 383 (1970) and presented in the Tables 3.3 and 3.4. The grading curves of the coarse aggregates as per IS 383 (1970) are shown in Figs. 3.1 and 3.2

3.1.2. Fine aggregate

Natural river sand is used as fine aggregate. The bulk specific gravity in oven dry condition and water absorption of the sand as per IS 2386 (Part III, 1963) are 2.6 and 1% respectively. The gradation of the sand was determined by sieve analysis as per IS 383 (1970) and presented in the Table 3.5. The grading curve of the fine aggregate as per IS 383 (1970) is shown in Fig. 3.3. Fineness modulus of sand is 2.26.

3.1.2. Water

Generally, water that is suitable for drinking is satisfactory for use in concrete. When it is suspected that water may contain sewage, mine water, or wastes from industrial plants or canneries, it should not be used in concrete unless tests indicate that it is satisfactory. Water from such sources should be avoided.

TEST METHODS

This section describes about the test methods which are utilized for testing the hardened properties of concrete.

TESTS ON FRESH CONCRETE

Slump cone Test

Definition

- Slump is a measurement of concrete's workability, or fluidity.
- It's an indirect measurement of concrete consistency or stiffness.

A slump test is a strategy used to decide the consistency of concrete. The consistency, or stiffness, demonstrates how much water has been utilized as a part of the mix. The solidness of the concrete mix ought to be coordinated to the necessities for the completed item quality

Concrete Slump Test

The concrete slump test is utilized for the estimation of a property of new concrete. The test is an exact test that measures the workability of new concrete. All the more particularly, it gauges consistency between clumps. The test is famous because of the effortlessness of device utilized and basic strategy.

Apparatus

- Slump cone,
- Scale for measurement,
- Temping rod (steel)

Procedure of Concrete Slump test:

1. The mold for the slump test is a frustum of a cone, 300 mm (12 in) of tallness. The base is 200 mm (8in) in distance across and it has a littler opening at the highest point of 100 mm (4 in).
2. The base is put on a smooth surface and the holder is loaded with cement in three layers, whose workability is to be tried.
3. Each layer is temped 25 times with a standard 16 mm (5/8 in) distance across steel rod, adjusted toward the end.
4. When the mold is totally loaded with cement, the top surface is struck off (leveled with mold top opening) by method for screening and moving movement of the temping pole.
5. The mold must be solidly held against its base amid the whole operation so it couldn't move because of the pouring of concrete and this should be possible by method for handles or foot - rests brazed to the mold.
6. Immediately in the wake of filling is finished and the concrete is leveled, the cone is gradually and painstakingly lifted vertically, an unsupported solid will now droop.
7. The abatement in the stature of the focal point of the slumped concrete is called slump.
8. The slump is measured by putting the cone just close to the droop concrete and the temping bar is put over the cone so it ought to likewise come over the region of slumped concrete.
9. The reduction in stature of cement to that of mold is noted with scale. (generally measured to the closest 5 mm (1/4 in).

Types of Slump

The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as;

1. Collapse Slump
2. Shear Slump
3. True Slump

Collapse Slump

In a collapse slump the concrete collapses completely. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which slump test is not appropriate.

Shear Slump

In a shear slump the top portion of the concrete shears off and slips sideways.

OR

If one-half of the cone slides down an inclined plane, the slump is said to be a shear slump.

1. If a shear or collapse slump is achieved, a fresh sample should be taken and the test is repeated.
2. If the shear slump persists, as may the case with harsh mixes, this is an indication of lack of cohesion of the mix.

True Slump

In a true slump the concrete simply subsides, keeping more or less to shape

1. This is the only slump which is used in various tests.
2. Mixes of stiff consistence have a Zero slump, so that in the rather dry range no variation can be detected between mixes of different workability.

3.

3.3MIX DESIGN

Coarse aggregate particles of size 20 mm and 10 mm were used with regards to adequate bond with the reinforcement in the building structures. 20 mm and 10 mm coarse aggregate particles were blended in 60:40 proportion by percentage weight of total aggregate. 20 mm coarse aggregate was replaced by 20 mm CWR at 0%, 20%, 30%, 40% and 50%.M 25 grade of conventional concrete (CC) has been designed as per IS 10262:2009 [19] and IS 456:2000 [20]. Mix proportions of constituent materials are shown in Table .

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter discuss about the results of the test which are made on concrete .This test results covers the properties of the concrete made by using coal washry rejects(CWR). This replacement done as partial replacement in concrete of coarse aggregates at levels of 0% and 30% .The strength properties containing compressive strength , spilt tensile strength, bond strength ,Modulus of elasticity of the concrete (MOE) and durable properties including, Rapid chloride permeability(RCPT), Water absorption , porosity , drying shrinkage .These tests are conducted at the curing periods of 28,56,and 90days.

4.2.1. COMPRESSIVE STRENGTH

This Chapter section discusses the mechanical properties of the CC (CWR_0) and CWR based concrete mixes at different curing periods.

4.2.2. SPLITTING TENSILE STRENGTH

This chapter discuss about the splitting tensile strength of the concrete based on coal washry rejects (CWR).

4.2.3. BOND STRENGTH

This testconducts on concrete to determine the bonding strength between concrete and reinforcement. This chapter discuss about the bond strength of the concrete made with replacement of coal washry rejects at different curing periods.

4.3 DURABLE PROPERTIES OF CONCRETE

4.3.1 RAPID CHLORIDE PERMEABILITY TEST (RCPT)

This chapter discuss about the permeability test conducted on the coal washry reject based concrete.

4.3.2WATER ABSORPTION

This chapter discuss about the water absorption test conducted on the coal washry reject based concrete at the different curing

POROSITY OF CONCRETE

This chapter discuss about the porosity test conducted on the coal washry reject based concrete at the different curing levels.

4.3.3 DRYING SHRINKAGE OF CONCRETE

This chapter discuss about the drying shrinkage test conducted on the coal washry reject based concrete at the different curing levels.

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TABLE 3.1 PROPERTIES OF CEMENT

Particulars	Test result	Requirement as per IS:12269-1987
Chemical Composition		
% Silica(SiO_2)	**19.79**	
% Alumina(Al_2O_3)	**5.67**	
% Iron Oxide(Fe_2O_3)	**4.68**	
% Lime(CaO)	**61.81**	
% Magnesia(MgO)	**0.84**	Not more Than 6.0%
% Sulphuric Anhydride (SO_3)	**2.48**	Max. 3.0% when $C_3A>5.0$ Max. 2.5% when $C_3A<5.0$
% Chloride content	**0.003**	Max. 0.1%
Lime Saturation Factor CaO-0.7SO_3/2.8SiO_2+1.2Al_2O_3+0.65Fe_2O_3	**0.92**	0.80 to 1.02
Ratio of Alumina/Iron Oxide	**1.21**	Min. 0.66

TABLE 3.2 PHYSICAL PROPERTIES OF CEMENT

Physical properties	Test result	Test method/ Remarks	Requirement as per IS 12269 (1987)
Specific gravity	3.15	IS 4031(1988) – part 11	-
Fineness (m^2/Kg)	311.5	Manufacturer data	Min 225 m^2/kg
Normal consistency	30%	IS 4031 (1988)- part 4	-
Initial setting time (min)	90	IS 4031 (1988)- part 5	Min. 30 min
Final setting time (min)	220	IS 4031 (1988)- part 5	Max. 600 min
Soundness Lechatelier Expansion (mm) Autoclave Expansion (%)	0.8 0.01	Manufacturer data	Max. 10 mm Max. 0.8%
Compressive strength (MPa) 3 days 7 days 28 days	25 39 57	IS 4031 (1988)- part 6	27 MPa 37 MPa 53 MPa
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Compressive strength (MPa) 3 days 7 days 28 days	25 39 57	IS 4031 (1988)- part 6	27 MPa 37 MPa 53 MPa

TABLE 3.3 SIEVE ANALYSIS OF 20 MM COARSE AGGREGATE

Sieve size	Cumulative percent passing	
	20 mm	**IS 383 (1970) limits**
20 mm	100	85-100
16 mm	56.17	N/A
12.5 mm	22.32	N/A
10 mm	5.29	0-20
4.75 mm	0	0-5

TABLE 3.4 SIEVE ANALYSIS OF 10 MM COARSE AGGREGATE

Sieve size	Cumulative percent passing	
	10 mm	IS 383 (1970) limits
10 mm	99.68	85-100
4.75 mm	8.76	0-20
2.36 mm	2.4	0-5

TABLE 3.5 SIEVE ANALYSIS OF FINE AGGREGATE

Sieve No.	Cumulative percent passing	
	Fine aggregate	IS: 383-1970 – Zone III requirement
3/8" (10mm)	100	100
No.4 (4.75mm)	100	90-100
No.8 (2.36mm)	100	85-100
No.16 (1.18mm)	99.25	75-100
No.30 (600µm)	65.08	60-79
No.50 (300µm)	7.4	12-40
No.100 (150µm)	1.9	0-10

TABLE 3.6 PHYSICAL PROPERTIES OF COAL WASHERY REJECTS

S.NO	Name of the property	Mill Rejected Coal
1	Relative density	0.48%
2	Specific gravity	2.06
3	Water absorption	0.26%
4	Bulk Density(kg/cum)	1431
5	Impact strength(percentage by weight)	19.5%
6	Crushing strength.	26.8%

TABLE 3.7 RCPT RATINGS AS PER ASTM C1202.

Charge Passing (Coulombs)	Charge Passing (Coulombs)
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very Low
<100	Negligible

TABLE M: MIX PROPORTIONS OF CONSTITUENT MATERIALS OF CONCRETE MIXES

Mix type	Cement kg/m³	Water l/m³	20 mm kg/m³	10 mm kg/m³	CWR 20 mm kg/m³	Sand kg/m³
CWR_0	384	192	683	456	0	636
CWR_10	384	192	615	456	68.5	636
CWR_20	384	192	546	456	137	636
CWR_30	384	192	478	456	205	636

TABLE 4.1 SLUMP CONE VALUES

Mix	Slump in mm
M1	68
M2	74
M3	76
M4	85
M5	91
M6	102

TABLE 4.2COMPACTION FACTOR TEST

Mix	Compaction factor
M1	0.92
M2	0.95
M3	0.92
M4	0.92
M5	0.92

TABLE 4.3 COMPRESSIVE STRENGTH OF CONCRETE

MIX TYPE	COMPRESSIVE STRENGTH(MPa)		
	28days	56 days	90days
CWR-0	34.12	36.02	38.72
CWR-10	33.41	35.89	38.69
CWR-20	33.07	35.87	38.65
CWR-30	32.98	35.86	38.64
CWR-40	28.65	30.81	32.16

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FIG. 3.1 GRADING CURVE OF 20 MM COARSE AGGREGATE

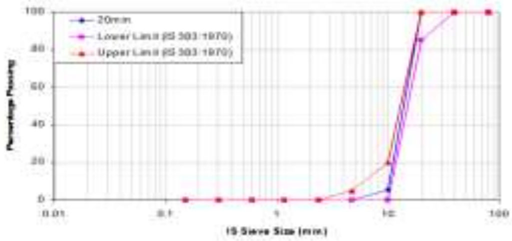


FIG. 3.2 GRADING CURVE OF 10 MM COARSE AGGREGATE

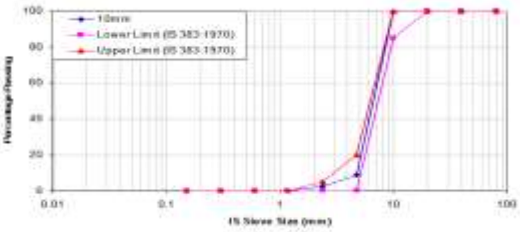


FIG. 3.3 GRADING CURVE OF FINE AGGREGATE

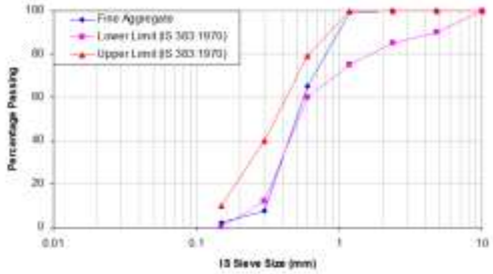


FIG .4.1 COMPRESSIVE STRENGTH V/S AGE

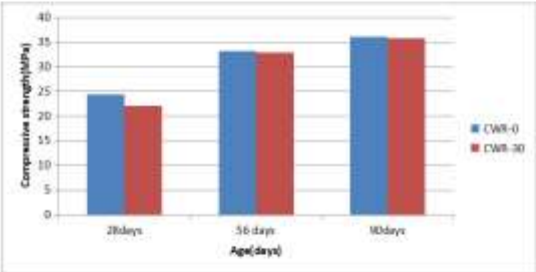
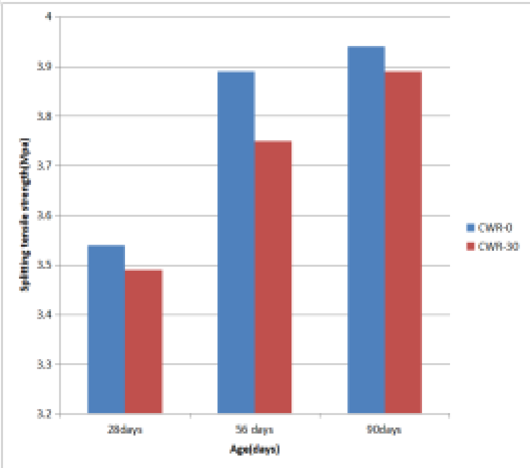


FIG 4.2 SPLIT TENSILE STRENGTH V/S. AGE



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CONCLUSION

This chapter summarizes the overall conclusions drawn from the investigation of concrete using coal washry rejects as partial replacement of coarse aggregate.

5.1. CONCLUSIONS

Based on the test results, the following conclusions are drawn:

1.From the results it is seen that the concrete mixes with partial replacement of CWR have attained lower values of compressive, splitting tensile, bond strength, and MOE properties at all ages as compared to that of conventional concrete.

2.The lower value of crushing and impact strength of CWR is mainly attributed to the decrease in compressive, splitting tensile and Bond and MOE properties of CWR based concrete mixes.

3.It is observed that the strength properties have been decreased marginally for the concrete mixes CWR_20 and CWR_30. The 28 day compressive strength of the concrete mixes CWR_20 and CWR_30 are comparable to that of M 25 grade of CC.

4.The further increase in replacement of CWR decreased the strength properties significantly as in the case of the concrete mixes CWR_40 and CWR_50.

5.Hence, it can be recommended to use CWR at 30% partial replacement of coarse aggregate in order to attain the desired values of CC.

6.It is observed that from the durable properties, the values of RCPT (Rapid chloride permeability test) is observed MODERATE compared with conventional concrete.

7.It is observed that, The values of water absorption is less when compared with conventional concrete at all ages of the curing periods.

8.From the results of porosity it is observed that the porosity values are little more when compared with conventional concrete.

9.From the drying shrinkage values it is observed that the values of drying shrinkage is less when compared with the **conventional concrete.**

5.2. FUTURE WORK

Based on the investigation of this project, the future work includes:

●Study on durability properties of CWR based concrete mixes.

●Keeping in view of the availability of natural resources and environmental aspects, it is recommended to replace some percentage of sand with bottom ash CWR based concrete mixes and study all hardened and durability properties.

●Study on micro level properties of CWR based concrete mixes.

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