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Assessment of Fresh Properties of Pond Ash SCC

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Abstract: ***Self compacting concrete mixes were prepared by replacing fine aggregates i.e natural sand by pond ash thermal power plant waste at different replacement levels like 10, 20, 30, 40, 50, 60, 70 percent by keeping cementatious content constant as 600kg/m3 and water content 180liter polycarboxylic based superplasticizer was used to enhance workability of the concrete mixes. Fresh state properties of SCC like flow property, filling property, passing ability and segregation resistances of the mixes were checked by conducting inverted slump flow test, T500mm flow, V-shaped funnel test, V-shaped funnel test at T5min test, L-Box test method, U-Box test method were carried out according to EFNARC guidelines. Test results obtained for all the mixes were satisfying to the EFNARC specifications. Due to the porous nature of pond ash absorption of mixing water was initially high later some amount of water was released to the concrete mix by pond ash with increase in time of mixing. Upto 60% replacement levels test results were satisfactory, for 70% replacement level additional water was added to achieve the required mix.***

Keywords: self compacting concrete, fly ash, pond ash, admixture, fresh properties etc

1. Introduction

General

India is developing at faster rate, industrial sector, construction sector and agriculture sector are expanding day by day and modern methodologies are introduced for expansion and improvement. In present scenario electricity has become the need of hour, for every activity we need electricity; electricity has become inseparable part of our lives this intern has led to increase in the power generation.

In India electricity is generated by wind mills, solar power plants, hydro electric power plants, coal fired power plants(thermal power plants), nuclear power plants etc, since power generated by wind mills, hydro electric power stations and solar plants is less and power generation by nuclear power plants is not safe greater importance is given on power generation by coal fired power stations as coal is available abundantly in our country, thus coal fired power plants(thermal power plants) are the main power generation centers, but the problem with these power plants is the disposal of ccp's (coal combustion products) which requires large land area, water, energy for their disposal since these particles are very fine if not properly managed will travel through air and disturbs the ecology and are harmful to the people dwelling in the surroundings. Disposal of ccp's is the most debated issue in the recent past.

Coal combustion products comprises of fly ash, bottom ash (pond ash), cenospheres, conditioned ash and flue gas de-sulfurisation. Mainly ccp's comprises of fly ash and pond ash about 90%(fly ash 75-80% and pond ash 15-20%) other products are in traces.

Powdered coal when burnt in power plants produces fly ash, when coal is burnt at high temperature clay particles present in coal powder fuses to fine particles containing aluminum silicate and other chemicals. Fly ash is differentiated in two categories i.e. class C fly ash and class F fly ash based on chemical composition which mainly depends upon ignitition and performance of furnaces.

The coarser porus ash which falls to the bottom of furnave is called bottom ash or pond ash it is transported to the ash pond by water so it is also called wet bottom ash. This ash is crystalline in nature. These coal combustion products posses pozzolonic property and this property of fly ash and pond ash has led to greater research in making use of fly ash and pond ash in construction industry.

Self compacting concrete:

Self compacting concrete is a special concrete that has the ability to flow under its own weight main characteristics of SCC are passing ability, filling property and resistance segregation. In SCC powder content is high and in total aggregate volume fine aggregate volume is higher than coarse aggregate volume usually fine aggregate volume to coarse aggregate volume ratio is taken as 60:40 this is because as finer particles increases flow property of concrete increases coarser particles block the flow of concrete.

The idea of SCC was first developed by Japanese to meet adversities of site conditions and scarcity of labors this concrete flows on its own in the areas of dense reinforcement where vibration of concrete is not possible. Addition of super plasticizer is necessary to this concrete to increase the flow of concrete in some cases VMA may also be used to maintain homogeneity of the concrete. SCC also acts as environment friendly concrete by reducing the noise pollution and safety of labors at site and surroundings is maintained.

2. Literature Review

Lee bong chun, Kim jin sung, Kim tae sang, Chae seong tae- 2008 [1]

In this paper mechanical properties and durability properties of the concrete were analysed by replacing pond ash a part of fine aggregate in 10, 20, 30% by weight.

For the present investigation pond ash was collected from three different pits and mixes were prepared. Physical and chemical properties of samples were checked by various tests, SEM analysis showed that, fineness modulus of pond ash varied from 2.19-3.26, absolute volume varied from 50.34-62.25%, surface dry density and unit volume of pond ash varies from 1.85-2.27 and 0.93-1.342 g/cm3, absorptiveness of pond ash was in range between 3.77 and 5.78% due to porous nature. Pond ash concrete was lighter than normal concrete and workability of pond ash incorporated concrete was low at 30% pond ash content.

Compressive strength and tensile strength increased with increase in pond ash content it was explained that this might be because of less w/c ratio which is caused by absorption of mixing water by pond ash

XRD test on pond ash showed that, pond ash has major crystalloids as quartz and mullite. Pond ash has high chloride content and need to be removed to use in concrete.

Freezing and thawing resistance of concrete decreased with increases in pond ash content it aws explained that this was because of air content and water absorption of pond ash.

LB Andrade, JC Rocha, M cheriaf-2006[2]

In this paper moisture movement was studied to know whether pond ash was suitable to replace as suitable as fine aggregate and evaluation of behavior of concrete using bottom ash as replacement to natural sand was done.

Five blends with 0%, 25%, 50%, 75% and 100% replacement to natural sand by bottom ash were prepared; two concrete mix proportions were made CRT3 and CRT4. CRT3 mixes with considering water content in the bottom ash at the time of concrete production, CRT4 with discounting the water content and considering all contents as solid materials. Capillary absorption: increase in final water content was directly dependent on increase in pond ash content, porosity of pond ash results in greater capillary absorption this is also influenced by absorption of bottom ash particles itself. Final moisture content was almost triple for 50% increase in porosity of blend. Grain size of bottom ash also adds to increase in moisture content. Bleeding: CRT3 and CRT4 mixes had almost same water loss. Since pond ash absorbed more water loss of water from mixes was also directly dependent on pond ash content.

Water loss through air drying: when samples were kept to dry water was lost from samples water loss increased with increase in pond ash content of the mixes.

Bharatiganesh, H Sharadabai, R Nagendra-2009[3]

In this paper workability and strength properties of M20 concrete with various levels of replacement to fine aggregates by pond ash is studied. Five mixes were designed M20 NC, M20 12.5%, M20 25%, M20 37.5%, M20 50%.

M20 NC represents normal concrete with 0% replacement to natural sand.

M20 12.5% represents concrete mix with replacement to natural sand by pond ash of 12.5%.

M20 25% represents concrete mix with replacement to natural sand by pond ash of 25%.

M20 37.5% represents concrete mix with replacement to natural sand by pond ash of 37.5%.

M20 50% represents concrete mix with replacement to natural sand by pond ash of 50%.

The results show that as the quantity of pond ash or replacement level increases mix becomes harsh, slump decreases and admixture dosage also increases. Compressive strength of M20 25% was found to be maximum and compressive strength of M20 50% decreases by 0.92 times to that of M20m NC. 25% replacement level was found to be optimum. Split tensile strength of M20 12.5%, M20 25%, M20 37.5%, was found to be higher than that of M20 NC but split tensile strength of M20 50% was less than M20 NC. Flexural strength of M20 12.5%, M20 25%, M20 37.5% was found to be more than that of M20 NC and was found maximum at 25% replacement level.

Bharatiganesh, Dr. R. Nagendra, Dr. H. Sharadabai, MR Suresh, Harisha C, Krishna KL-2009[4]

In this paper self compacting concrete with cementatious material 400kg/m3 and fine aggregate i.e. manufactured sand was replaced with pond ash for different steps i.e. 10%, 20%, 30%, 40%, 50% and fresh properties were studied.

Results showed that slump flows were comparable with that of normal self compacting concrete, no specific pattern was observed in T50 sec but satisfied EFNARC specifications. V-funnel time increased with increase in replacement levels of pond ash, paper states that this effect may be the result of finer particles in pond ash. L-box test results for all replacement level were satisfying to EFNARC specification.

In this paper it is also explained that pond ash replaced SCC was found viscous with higher replacement levels, this property of pond ash SCC was related to the fineness of pond ash particles and vesicular texture of pond ash particles. Compressive strength of the mixes reduced with increase in replacement level for 50% replacement level 25% reduction in strength was observed for same curing period.

SM Waysal, PD Dhake, MP Kadam[5]

In this paper experiment was conducted by replacing natural sand with pond ash by weight at various steps of replacement. Cement content was kept constant as 400kg/m3 and water content 192 liters. Mechanical properties were checked.

Results of the test showed that at 20% replacement of sand compressive strength increased as that of normal concrete up to 40% thereafter compressive strength decreased. Paper also states that strength gain in pond ash concrete is slow. Split tensile strength of 7 days increases for 20% to 40% replacement levels and after those strength decreases, for 28 days strength increased for 20% replacement and then decreased with increase in percentage of replacement. Flexural strength also increased for 20% replacement level and thereafter decreased. Modulus of elasticity increased up to 20% replacement later it decreased.

Debashis Das, V.K Gupta, S.K Kaushik[6]

In this paper 12 mixes are prepared, 4 mixes with 10mm maximum size of coarse aggregates, 4 mixes with 12.5mm as maximum size of aggregates and 4 mixes with 20mm as maximum size of aggregates, all the parameters were kept constant other than coarse aggregate and fine aggregate, initially coarse aggregate were taken 60% of total aggregate and after that coarse aggregate was replaced by sand in step of 15%.

Results of the test showed that mixes with 60% coarse aggregate showed unsatisfactory slump and high segregation. Later to reduce segregation and improve workability one fourth of coarse aggregate was replaced with fine aggregates with maximum size of coarse as 10mm and 12mm flow ability and segregation resistance improved. In second step two parts of coarse aggregate was replaced with sand, the ratio CA: FA was 30:70 flow was uniform without segregation. In third step two third parts of coarse aggregate was replaced with fine aggregate flow was uniform without segregation but flow diameter was only 60cm, from above results it showed that for 30% coarse aggregate by weight results were quite good.

3. Objective of the Project

Due to concentrated efforts on utilization of fly ash has increased the usage of fly ash in construction industry, agriculture, construction of road embankments, dumping, pavements etc. But the utilization rate of pond ash is pretty less, even though many researches are done on use of pond ash as alternative to cement and fine aggregates in cement concrete production but its in use actual practice is not done. The present investigation is about utilization of pond ash as a replacement to fine aggregates and to determine what maximum replacement can be done in self compacting concrete.

In recent years natural sand has become a rare resource due to increase infrastructural developments in cities need for natural river sand has increased to meet the increasing demand natural river sand is mined from the river beds extensive mining of sand from river beds depletes the source and greatly disturbs the river water ecosystem.

As the resource is getting depleted it is our duty to find an alternative to natural sand for using in constructional practices, in recent years civil engineers have come up with manufactured sand to replace Natural River sand, even manufactured sand requires large amount of water and energy for production. So by using of pond ash as fine aggregate in concrete production not only reduces the demand for natural sand but also solves the problem of its disposal and saves large amount of energy and protects environment. Greater knowledge and research on pond ash do this.

3.1 Scope of work

Scope of the present experimental work is.
1) Collection of sample of materials used for the experimental work on SCC.
2) Characterization of fly ash, pond ash and other materials according to code of practice.
3) Mix designing SCC by absolute volume method according to EFNARC guidelines. Total cementatious content is fixed as 600kg/m3 and 30% of total cementatious content is replaced by fly ash.
4) Seven design mixes are prepared by replacing fine aggregates by pond ash in increasing order up to 70%.
5) Fresh properties of scc mixes are checked, to asses the fresh properties inverted slump flow, T50cm flow, v-shaped funnel test, v-shaped funnel test at 5min, l-box test, u-box method are performed to check flow property, filling property, passing ability and segregation resistance.
6) Results are recorded and compared with standard requirements to be fulfilled according to EFNARC specifications.
7) Based on comparison of results conclusion is drawn.

Materials Used and Methods

Materials used for the present investigation on self compacting concrete are.
1) Cement (opc 43 grade).
2) Fly ash (Class f).
3) Natural river sand.
4) Pond ash.
5) Coarse aggregates (10mm and down).
6) Super plasticizer (master glenium).
7) Water.

Cement: Ordinary Portland cement (OPC) 43 grade JK cement confirming to IS 12269:1987 was taken from CASHUTEC, properties of which were tested in the laboratory are given in Table

Table 1: Physical properties of cement

Brand of cement	Jk cement
Type of cement used	43grade , OPC
Normal consistency	32%
Initial setting time	45 minutes
Final setting time	400 minutes
Fineness (sieve analysis)	8.50%
Compressive strength(Mpa)	
3days	19.38 Mpa
7days	27.50 Mpa

Fly ash (class F): The fly ash is obtained from RTPS confirming to specification IS 3812 Part 1 and 2-2003. The various tests are done confirming to IS 1727-1967 and are used as fines which contribute to powder content in SCC.

Table 2: Physical properties of fly ash

Colour	Whitish grey
Form	Powder
Specific gravity	2.08
Moisture	0.30%
Residue on 45 micron seive	15.70%
Fineness (m^2/kg)	349

Super plasticizer: super plasticizers reduce the water to cement ratio and increase the workability of the concrete. Poly carboxylic based super plasticizer **Master Glenium** of BASF chemicals is used for the study of SCC. Dosage of admixture was fixed by various trails.

Water: Clean and portable water satisfying to IS 456:2000 is used for preparing concrete.

Pond ash: Pond ash is procured from RTPS. The physical properties of are pond ash listed in table 3. The tests were conducted according to IS: 1727-1967(reaffirmed 2008).

Table 3: Physical properties of pond ash

Colour	Grey
Form	Crystalline
Specific gravity	1.99
Water absorption	20%
Residue on 45 micron seive	79%
Fineness(m^2/kg)	164

Natural river sand: Natural river sand satisfying to specifications of IS: 383-1970 (zone II) with specific gravity 2.60 is used. Natural river sand was taken from Krishna river bed near Kadlur Raichur. Tests on natural river sand were conducted in cashutec laboratory.

Table 4: Characteristics of fine aggregates

Specific gravity	2.6
Water absorption	5%
sieve analysis	
Sieve sizes	Percentage passing
4.75mm	98.8
2.36mm	95.6
1.18mm	68.2
600 microns	42.4
300microns	2.2
150 microns	0

Coarse aggregates (10mm and down): size of coarse aggregates greatly influences the flow properties of self compacting concrete. As the maximum size of aggregates increases obstruction to the flow increases, segregation increases so to get good flow ability and passing ability maximum size of coarse aggregates was taken 10mm.Coarse aggregates were taken from Guddeballur quarry. The tests were conducted in cashutec laboratory.

Table 5: Characteristics of coarse aggregates

Specific gravity	2.66
Water absorption	0.90%
Sieve analysis	
Sieve sizes	Percentage passing
40.00mm	100
20.00mm	100
12.5mm	80
10.00mm	25
4.75mm	0

Fresh state properties of self compacting concrete test methods

Properties	Test methods(laboratory)
Filling ability	Slump flow
	T_{50cm} slump flow
	V-funnel
Passing ability	L-box
	U-box
Segregation resistance	V-funnel at 5mins

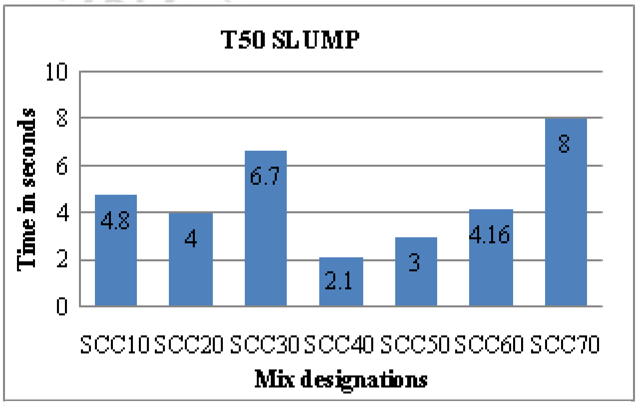
Mix calculation details

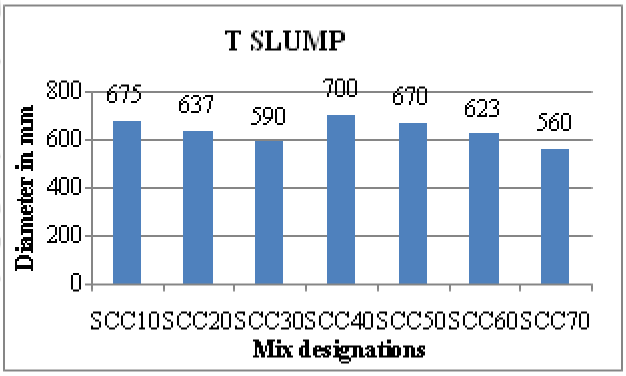
Materials	Replacement levels						
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**
Cement	420	420	420	420	420	420	420
fly ash	180	180	180	180	180	180	180
Water	180	180	180	180	180	180	180
Pond ash	69.16	138.33	207.499	276.66	345.83	414.99	484.165
Coarse aggregates	616.36	616.36	616.36	616.36	616.36	616.36	616.36
Sand	813.31	722.94	632.57	542.20	451.841	361.47	271.10

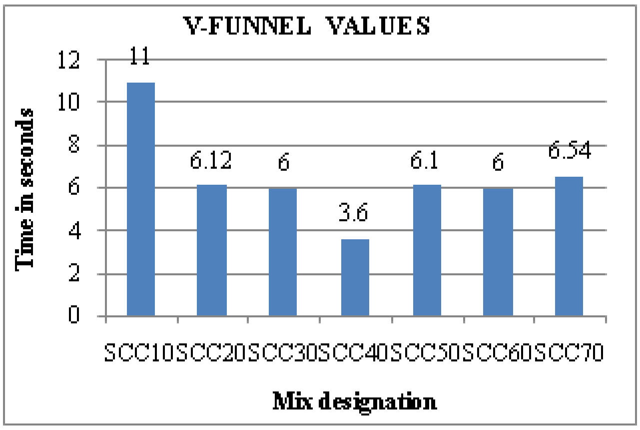
Mix designation details

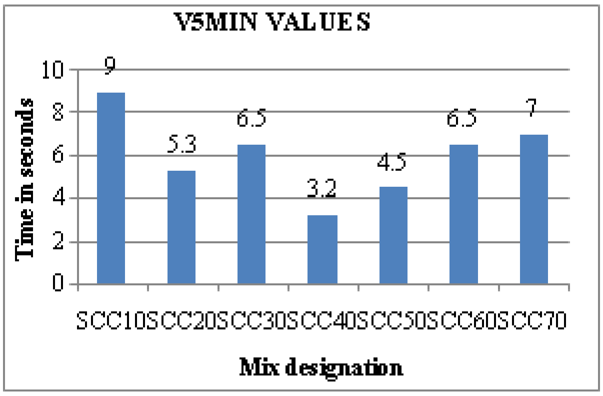
Scc10	Scc with 10% replacement to fine aggregates by pond ash.
Scc20	Scc with 20% replacement to fine aggregates by pond ash.
Scc30	Scc with 30% replacement to fine aggregates by pond ash.
Scc40	Scc with 40% replacement to fine aggregates by pond ash.
Scc50	Scc with 50% replacement to fine aggregates by pond ash.
Scc60	Scc with 60% replacement to fine aggregates by pond ash.
Scc70	Scc with 70% replacement to fine aggregates by pond ash.

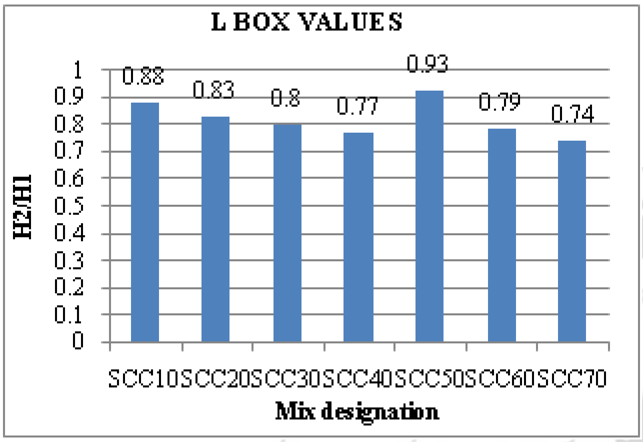
4. Results and Discussions

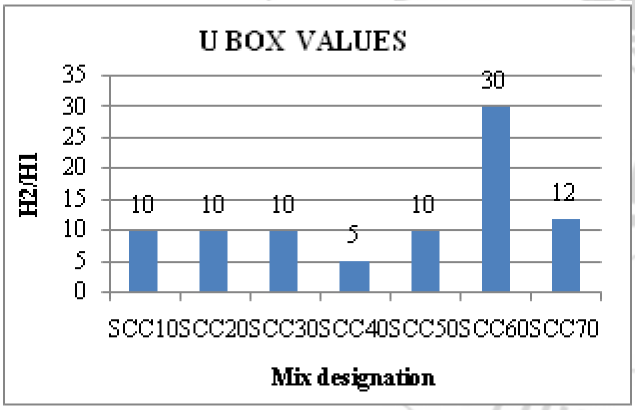












Discussion of results of inverted slump flow test:
According to EFNARC specifications minimum value of slump flow is 650mm and maximum value of slump flow is 800mm all the concrete mixes except for scc30 and scc70 satisfy to the specification there is no clear variation in slump flow of the mixes but after 40% replacement level slump flow gradually decreases.

Discussion of results of T50cm flow:
According to EFNARC specifications minimum value of T50cm slump flow is 2sec and maximum value is 5sec all the mixes except for scc30 and scc70 satisfies to the specifications. There is no clear relation in mixes for T50cm slump flow time.
For scc10, scc20, scc40, scc50 and scc60 time was within 5sec indicating good flow ability.

Discussion of results of V-shaped funnel test:
All the values for V-funnel test are within the limits. V-funnel time decreased with increases in replacement level and for scc40 it was found to be 3.6sec which is very less indicating increased filling ability of the concrete mixes. Due to high percentage of fine particles in pond ash has resulted in good filling and flow ability of concrete.

Discussion of results of V-shaped funnel test at T5min:
All the values for V-funnel at T5min were satisfying to the EFNARC specifications, ranging from 3 to 9sec indicating all the mixes were stable and there was no segregation of concrete. This is may be because pond ash did not release the water and water added to the mix was sufficient. For scc70 mix while carrying out slump flow test small quantity of water came out of the mix and distance measured was 0.9cm indicating that extra water added to scc70 was more than required to achieve fresh properties.

Discussion of results of L-box test:
L- Box test results were ranging from 0.7 to 1 which was within the requirements according to EFNARC specifications. This indicates that all the mixes had good passing ability this may be because 10mm and down size coarse aggregates were used in the mix.

Discussion of results of U-box test:
All the values for U-box test were within the requirements indicating good passing ability of the mixes.

5. Conclusions

From the results and discussions of the previous chapter it can be concluded that pond ash can be replaced to fine aggregates in self compacting concrete up to 70% as the fresh properties are satisfied by the mixes according to EFNARC specification.

1) Up to 60% pond ash can be replaced to fine aggregates in self compacting concrete with further replacements after 60% segregation of concrete takes place.
2) Super plasticizers greatly improve the workability of concrete but dosage of admixture is to be determined by carrying out various trials.
3) Up to 50% replacement level self compacting concrete can be easily handled at further replacement concrete becomes harsh this may be because coarse texture of pond ash.
4) Large scale utilization of pond ash can be done in concrete production as a replacement to natural river sand which can reduce depletion of natural river sand and can save large area of land, water resource used for dumping of pond ash which also helps create good ecosystem.
5) Great knowledge and vast research work is helpful to control to control the behavior of pond ash in concrete system.
6) It was observed while carrying out experiments that initially pond ash absorbs large quantity of water added to the mix later it releases some quantity of water back to the mix.
7) Absorption of water by pond ash greatly influences the behavior of the mix so it is important to initially determine the absorption of water by pond ash.
8) SCC mix with 80% replacement to fine aggregates by pond ash was designed and water quantity designed was less initially and extra water was added to the mix to

achieve fresh properties but we did not achieve the slump required and mix released the water after some time leading to segregation.

9) In pond ash SCC maximum size of coarse aggregates play important role in determining the passing ability of concrete. Due to high fine aggregate volume and vesicular texture of pond ash coarse aggregates get locked into fine aggregates, if coarse aggregates size increases passing ability of concrete may decrease. Coarse aggregates of size 10mm can be used to get good passing ability.

6. Scope for Future Study

1) Study of fresh properties of SCC with pond ash replaced to fine aggregates using viscosity modifying agent.
2) Studying the fresh properties of SCC with pond ash replaced to fine aggregate by varying the sizes of coarse aggregates due to higher fines content in pond ash.
3) Study of fresh properties of pond ash SCC by varying the coarse aggregate to fine aggregate ratio.
4) Study of behavior of pond ash in SCC.

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