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Study on Mechanical Properties of Concrete with Partial Replacement of Cement By China Clay

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Abstract - *In construction industry cement is having higher demand. Higher consumption of cement in construction industry leads to higher pollution. The cement content in high strength concrete is very high which increases the shrinkage and evolution of heat of hydration in concrete and also it is very uneconomical to use cement in construction industry. In order to make economic aspects in construction industry and protecting the environment from pollution partial replacement of cement by china clay in concrete is the best option .This research aims at studying the mechanical properties of concrete by replacing cement with china clay by 5%, 10% and 15%.Better result in mechanical properties is obtained when10% of cement is replaced with china clay in concrete.*

Key Words: **China clay, compressive strength, split tensile strength, flexural strength**…

1. INTRODUCTION

Concrete is an important material used in construction industry. Production of concrete involves two different activities. One is related to material and another is processes. The material part is generally taken by everybody, but the processes in manufacturing concrete are often neglected. Therefore no wonder that it is the 'process which is responsible for quality of concrete whether good or bad [1]. If we take care of processes, the quality of concrete will be improved automatically without a large expenditure as the major part of expenditure has already been made in procurement of material. The main content in china clay is kaolinite a clay mineral and it is a thin small flocky crystals [2]. China clay occur in the form of loose or dense fine flaky and earthy aggregates Here in china clay more silica content and less lime content when compared to ordinary Portland cement[3]. Since silica content were more in china clay ,silica were able to act as a nanofiller and recover the pore structure of concrete by decreasing harmful pores in concrete[4]. Usually the colour of the china clay powder is white but impurities present in it make its colour change. Silica content could accelerate C-S-H gel formation as a result of increase the strength of the concrete. China clay is a soft, earthy, white colour mineral and hydrated Aluminium Silicate [5].

1.1 China clay

China clay is a soft, earthy, white colour mineral and hydrated Aluminium Silicate .The main content in china clay is kaolinite a clay mineral which is very thin small flocky crystals. China clay occur in the form of loose or dense fine flaky and earthy aggregates .Usually the colour of the china clay powder is white but impurities present in it make its colour change China clay is obtained in opencast mining under rocks in Trivandrum and it is obtained as lumps and this lumps are break down into china clay powder. China clay is mainly used as fillers in concrete. It is mainly used in bricks and manufacturing of white cement. China clay is also used in many industries e.g. as filler in paper production, as pigments and brighteners in plastic paints and rubber industry. In highway construction china clay was used as a fine aggregate replacement in bituminous concrete.

2. EXPERIMENTAL INVESTIGATION

2.1 Mix Design

A total of four mix are used in the thesis for casting the specimens. They are M30 and M30 with 5%, 10% and 15% replacement of OPC. Mix design was done for M30 mix and the proportioning was obtained as 1:1.6:2.9 at w/c ratio of 0.38 and addition of super plasticizer at 0.35%. The mix design was done according to IS 10262:2009 and IS 456:2000.The strength was ascertained by checking the control cubes for compressive strength.

Table -1: mix proportions

Sl no	Mix	Cement	Fine aggregate	Coarse aggregate	W/C ratio	Super-plasticizer
1	M30	1	1.6	2.9	0.38	0.35%
2	CC (5%)	1	1.68	3.05	0.38	0.5%
3	CC (10%)	1	1.8	3.28	0.38	0.35%
4	CC (15%)	1	1.8	3.72	0.38	0.3%

Table -2: mix proportions per m^3

ingredients	Control (kg/m^3)	Cc5% (kg/m^3)	Cc10% (kg/m^3)	Cc15% (kg/m^3)
cement	414.73	394	373.25	352.52
Water	157.16	157.16	157.16	157.16
sand	696.6	662.88	675.99	660.07
Coarse aggregate	1205.41	1203.71	1227.51	1198.61
China clay		20.73	41.473	62.21

2.2 Preparation of test specimen

Mixing was done on the basis of mix proportions. Mixing was done manually. Mixing was continued until a workable concrete is obtained and slump is checked for a particular mix. Then the concrete were placed in a particular mould by giving proper compaction or by giving proper tamping .After that the specimens was demoulded after 24hrs and were kept in water tank for curing. Standard moulds used for specimen were 150 mm x 150 mm x150 mm cubes, 150mm x300 mm cylinders100mmx500mm beams.

Table -3: mix proportions per m^3

SI NO	Specimen	Size (cm)	Number
1	Cubes	(150mmx150mm)	52
2	Cylinders	(150mmx300mm)	20
3	Beams	(100mmX500mm)	12

3. EXPERIMENTAL TEST AND RESULTS

3.1 Compressive strength

According to IS 516-1959 compressive strength was done on 150 mm × 150 mm × 150mm control and partially replaced cement concrete cubes. All specimens were loaded in axial compression, using a Compression Testing Machine (CTM) of capacity 2000 kN. The load was applied until the resistance of the specimen to the load decreases and finally breaks down and no greater load can be sustained. From the results when cement is replaced with china clay compressive strength increases and optimum is obtained at 10% and beyond 10% compressive strength decreases. There is an increase of 75 % compressive strength in 7th day and 7.86% compressive strength in 28th day in china clay replaced concrete when compared with M30 OPC concrete.

Table -4: Compressive strength test result

Mix Id	Binder composition	Fine aggregate	Compressive strength	
			7th day	28th day
M 30	OPC	100%M-sand	19.11N/mm^2	35.3 N/mm^2
CC5%	95%Opc+5%china clay	100%M-sand	26.88N/mm^2	37.55N/mm^2
CC10%	90%Opc+10%china clay	100%M-sand	33.49N/mm^2	8.11N/mm^2
CC15%	85%Opc+15%china clay	100%M-sand	21.33N/mm^2	23.3 N/mm^2

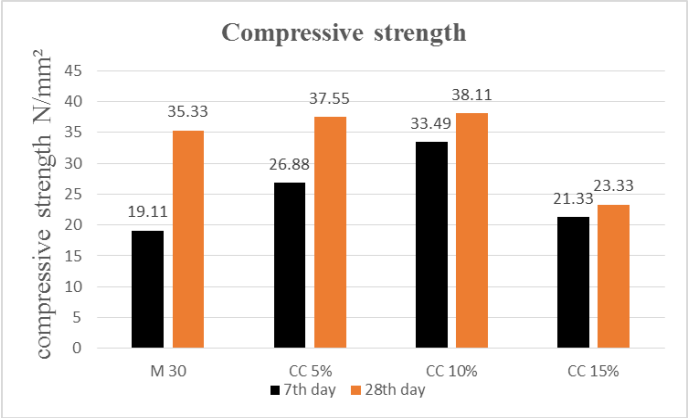

Chart -1: Compressive strength for different mix

Fig -1: compression test setup

3.2 Split tensile strength

According to IS 5816-1999 the split tensile strength was done on 150× 300mm control and partially replaced cement concrete cylinders. All specimens were loaded in axial compression, using a Compression Testing Machine (CTM) of capacity 2000 KN.

The test specimen was placed in the centering jig by positioning correctly along the top and bottom of the plane of loading of the specimen. According to the central position of the specimen the jig was placed in the machine. The load was applied continuously at a nominal rate until failure. The splitting tensile strength of the specimen shall be computed using the formula:

$$fct=2P/\pi dl$$

Where P= maximum load in Newton applied to the specimen

l = specimen length (in mm),

d = cross sectional dimension of the specimen (in mm)

From the test results it can be seen that when cement is replaced with china clay the split tensile strength is increasing. There is an increase of 22.9 % split tensile strength in 7th day and 31.7 % split tensile strength in 28th day in china clay replaced concrete when compared with M30 concrete

Table -5: Split tensile strength test result

Mix Id	Binder composition	Fine aggregate	Split tensile strength	
			7th day	28th day
M 30	Opc	100%M-sand	1.84N/mm²	2.68N/mm²
CC10	90%Opc+10%china clay	100%M-sand	2.26N/mm²	3.53N/mm²

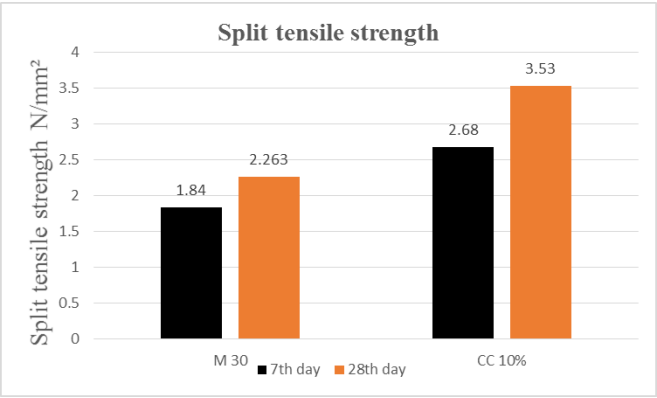

Chart -2: Split tensile strength for different mix

Fig -2: Split tensile test setup

3.3 Flexural strength

According to IS 516-1959 the flexural strength was done on 500 × 100 × 100mm control and partially replaced cement concrete beams. Testing was done on flexural testing machine. The specimen was placed in the machine in such a manner that 2.5cm marked from the two extreme edges of the specimen should coincide with the support of the machine. The axis of the specimen should be carefully aligned with the loading device axis. The load was applied continuously so that the extreme fibre stress increases at approximately 7 kg/cm²/min.

The flexural strength of the specimen is expressed as the $fb= pl/bd^2$

When 'a', the measured distance between fracture line and the nearer support, in cm, another formulae for flexural strength is $fb=3pa/bd^2$,When 'a' is less than 13.3 cm. From the test results it can be seen that when cement is replaced with china clay the split tensile strength is increasing. There is an increase of 27.4 % flexural strength in 7th day and 5.15 % flexural strength in 28th day when compared with M30 concrete

Table -6: Flexural strength test result

Mix Id	Binder composition	Fine aggregate	Flexural strength	
			7th day	28th day
M 30	Opc	100%M-sand	5 N/ mm²	7.37 N/ mm²
CC10	90%Opc+10% china clay	100%M-sand	6.37N/mm²	7.75 N/ mm²

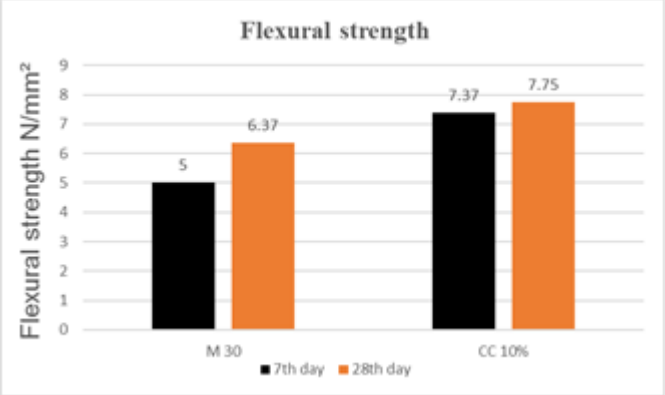

Chart -3: Flexural strength for different mix

Fig -3: Flexural test setup

3.4 Modulus of Elasticity

According to IS 516-1959 Modulus of elasticity test was conducted on 150 × 300mm control and partially replaced cement concrete cylinders. All specimens were loaded in compression machine of capacity 2000KN.Longitudinal compressometer comprises of two set of screws. Two spots were marked 5cm from top and bottom of the specimens. Cylinder specimen is placed inside the compressometer and bottom and top screw is placed on the spots and made to tight. Now dial gauge is set to zero position. Place specimen with compressometer in compression testing machine and load is applied at a certain interval and deflection is noted in dialguage and at the same time corresponding load is noted and finally stress strain graph is plotted. From the test results it can be seen that when cement is replaced with china clay modulus of elasticity is increased. There is an increase of 8.34 % modulus of elasticity in 28th day when compared with M30 concrete. From the combined stress strain graph it can be concluded that stress strain behavior of control and china clay replaced concrete were found to be similar.

Table -7: Modulus of elasticity test result

Mix Id	Binder composition	Fine aggregate	Modulus of elasticity
M 30	OPC	100%M-sand	27868.74N/mm²
CC10	90%Opc+10% china clay	100%M-sand	30200 N/mm²

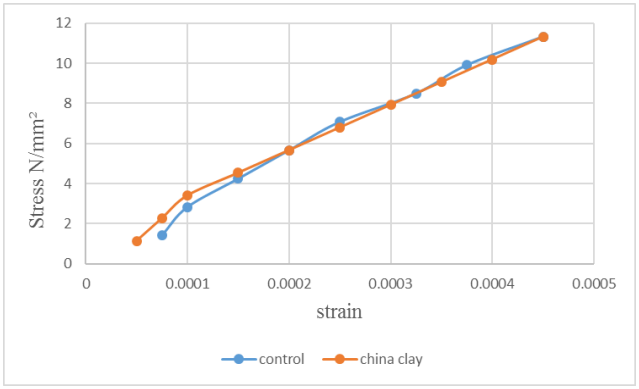

Chart -4: Combined stress strain curve for control and china clay

Fig -4: Modulus of elasticity test setup

4. CONCLUSIONS

- When cement is replaced with china clay the compressive strength is increasing and at 10% of replacement with cement by china clay it was found to be 75% increase in 7th day and 7.86% increase in 28th day strength when compared with conventional concrete
- The results shows that the average split tensile strength of the cement replaced concrete will be higher. The split tensile strength of china clay replaced concrete was found to be 22.9% and 31.7% increase in 7th day and 28th day compared to M30 concrete.
- Better result in flexural strength when cement is replaced with china clay.27.4% and 5.15% increase in flexural strength of china clay concrete
- The stress strain curve of replaced and conventional concrete were found to be similar in modulus of elasticity test. 8.34 % increase in young's modulus when compared with M30 concrete

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