"Partial replacement of cement with Metakaolin and RBI-81 in concrete"

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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May-2018

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"PARTIAL REPLACEMENT OF CEMENT WITH METAKAOLIN AND RBI-81 IN CONCRETE"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **AJAY DHIMAN(141641), PRASHANT CHANDEL(141642) ,YUGANSH TRIVEDI(141644)** during a period from July 2017 to May 2018 under the supervision of **Mr. CHANDRA PAL GAUTAM** Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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ABSTRACT

To achieve sustainability in construction world number of alternative materials is used. Metakaolin is broadly used green pozzolanas. Metakaolin is calcinied clay. There is very small emission of carbon dioxide during the production of Metakaolin as compared to cement ,saving our resources as well as keeping the production cost economical hence it is called as green pozzolanas.Earlier research also signifies,that outcome of blended Metakaolin on the properties of cement like consistency, setting time, soundness remains within the satisfact ory ranges at different standards. It also solves ecological and environmental issues as a result of cheaper production of Metakaolin and more durable.

RBI grade 81(Road Building International Grade 81) is also a environmental friendly material mostly used in soil stabilization providing drastic increase in CBR values.this material also possess some pozzolanic properties can be used as replacement material with cement.

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Chapter-1

Introduction

1.1 General introduction

To achieve sustainability in construction, the number of substitute materials is used. Metakaolin is widely used as a green pozzolan. The manufacturing of cement among all the other components of the concrete is harmful to the environment because during the production of cement there is a large emission of CO_2, i.e 3% -5%. Materials like metakaolin and RBI 81 grade have very low carbon emissions compared to cement. The additional material which are cementitious in nature are finely ground solid materials that are used as apartial replacement for concrete mixture. These supplementary materials is also naturally occurring, factory-made or manmade waste. numerous forms of pozzolanic materials that improve cement properties are utilized in cement industr y for an extended time.The Metakaolin is a dehydroxy silicate aluminum silicate. It is an amorphous non-crystallized material consisting of lamellar particles. Recent research work with Metakaolin, also show that it is a very effective pozzolanic material that effectively improves the strength parameters of concrete.

RBI Grade 81 (Road Building International Grade 81) is an extraordinary and imaginative thing that has been created to change a wide variety of soils efficiently and at low cost. Grade RBI 81 is a ground-based, , inorganic soil-based stabilizer that reacts with soil particles to form layers that are interconnected through a structure called complex structure of buried atoms.

The RBI 81 grade has shown an excellent effect in soil stabilization and we want to check its effect if mixed with cement in some proportions. Similarly, Metakaolin possess some pozzolanic properties and can be used as a replacement material for cement in some proportion that is why we want to check which proportion of cement and metakaolin will shows the reliable results for strength parameters.

1.2 Metakaolin

Fig 1.1 Metakaolin

The metakaolin is a dehydroxylated form of the kaolinitic clay mineral. The stone that is rich in kaolinite whixh is also known as Chinese clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of the Metakaolin particles is smaller than the cement particles, but it is not as fine as the silica fumes.

The Metakaolin is made of Kalonite,one of the most common mineral. When Metakaolin is used as a partial substitute for cement it combines with $Ca(OH)_2$,which is a by product of hydration reactions thus combining with extra amount of $Ca(OH)_2$ producing extra CSH gel leading to increase in the strength of concrete.

The metakaolin is formed by calcining the kalonite at a temperature of 650-800 ° C. If further heated, the structure of the Metakaolin will begin to alter.

Chemical Composition of Metakaolin

Table 1.1 chemical composition of Metakaolin{3}

Silica (SiO_2)	54.4
Alumina (Al_2O_3)	38.7
Ferric oxide (Fe_2O_3)	4.58
Calcium oxide (CaO)	0.40
Magnesium oxide (MgO)	0.07
Sodium oxide (Na_2O)	0.13

Merits of using Metakaolin

- The strength and duration of concrete increases.
- There is an increase in initial setting time.
- There is an increase in compressive strength by 20%.
- As compressive strength is increased, less amount of concrete can be used.
- Production of Metakaolin is a environmental friendly as reduction in the amount of CO_2 released in atmosphere.
- Reduces the heat of hydration therefore reduction in shrinkage and cracking.

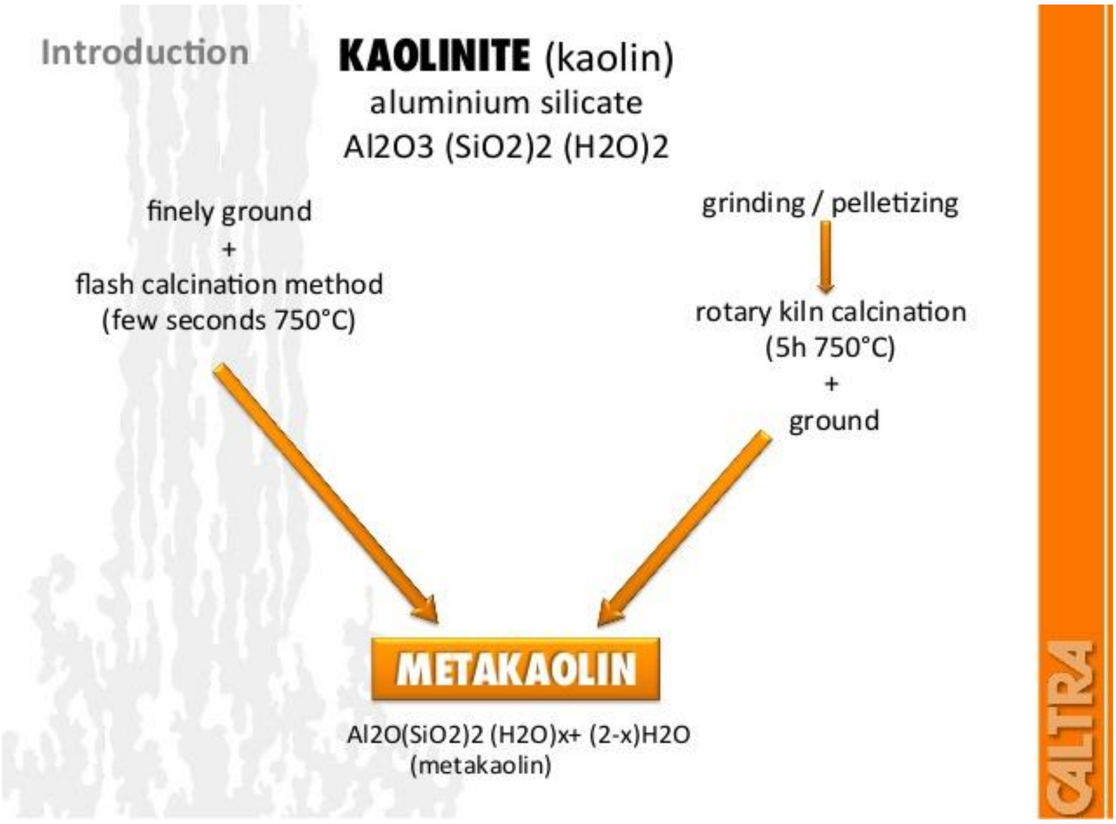

Fig 1.2 Metakaolin

1.2. RBI Grade 81

Grade 81 of the RBI (Road building internationals of grade 81) is an extraordinary and fanciful thing that has been created to change a wide variety of soils in an efficient and economic way. RBI Grade 81 is an inorganic powder based stabilizer, which reacts with the soil particles to form interconnected layers through a complex structure of a burial atom. the road can be opened to action within 24 hours of the last compaction.Gives a dust-free surface.

Fig 1.3 RBI-81

Fig 1.4 RBI-81

Fig 1.5 RBI-81

Chemical Composition of RBI Grade 81

Table 1.2.chemical composition of RBI-81{1}

Properties	**% By Mass**
Calcium Oxide (CaO)	53-56
Silicon Dioxide (SiO_2)	14-19
Sulphur TriOxide (SO_3)	9-12
Aluminium Oxide (Al_2O_3)	5-7
Iron Oxide (Fe_2O_3)	0-2
Magnesium Oxide (MgO)	0-1.1
Fibers(polypropylene)	0-1
Additives	0-4

Merits of using RBI grade 81

- Save aggregates that are used in base course.
- Saves energy and resources consumed in road construction .
- Reduces leaching and permeability of ground water.
- Reduces utilization of bitumen by diminishment of dense bituminous macadam layer.
- Makes surface impermeable and reduces soil erosion.

Chapter-2

Literature review

2.1 Literature review:

Bibha,M.et al (2015)

The objective is to study the impact of RBI Grade 81 that is mixed along withpond ash on silty and clayey soil through different proportion of RBI Grade 81 and pond ash on soils. there is reduced construction time(30 – 40%) Makes treated surface impervious to water and prevents soil erosion.

Patil,B.M et al (2013)

For the improvement of CBR value of soil, pond ash and RBI Grade 81 used for base course of flexible pavement. The CBR value of base course treated with20.1% pond ash and 5% RBI Grade 81 is increased by 124.94% as compared to untreated grade III base course.The soaked CBR value of grade-III is amplified by 170.38% compared to untreated grade-III material. Reduces the swelling characteristics of clayey soil as DFS index reduces.

Nabil, M. et al (2006)

The study investigates the effect of cement substitution with metakaolin on the durability of cement with sulphate attack. Three MK substitution levels in the study were considered 5%, 10% and 15% cement weight. As there is increase in the replacement level of Metakaolin sulphate resistance of concrete also increases . Concrete containing 10% and 15% replacement level of cement with metakao loin showed exceptional durability to sulphate attack.

Terrence, R et al (1999)

The amount of HRM required to control the expansion to < 0.05 % at 2 ye ar was found to be between 10% and 15% depending on the aggregate Assimilation of 20% metakaolin was found to significantly reduce the long-term OH^-, Na +, and K+ ion concentrations in pore solutions. The decrease in the pH and the alkalinity of pore solutions. The mechanism by which Metakaolin hold back expansion due to alkali-silica reaction appears to be by decrease in the pH of pore solutions.

Coleman,N.J et al(1996)

The concentrations of hydroxide ions of pores solutions expressed from OPC pastes containing 0,10 and 20% of metakaolin to weight of cement were determined in various stages of hydration.,it was found that the incorporation of metakaolin into the pastes causes reduction in the concentration of hydroxide ions in the solution.Metakaolin have extra tendency to bindchloride ions than OPC thus Chlorideinduced corrosion of embedded steel are expected to be affected relatively less.

Wild,S. et al (1996)

The role of MK in enhancing the strength of concrete is reviewed and the most important mechanisms identified. Metakaolin concretes with a range of MK contents (0-30%) have been cured for periods of 1 to 90 days. It gives packing effect .Accelerates the hydration process. Reaction of excess CH with Metakaolin causes reduction in formation of expansive gypsum and control cracking.

Chapter-3

Objectives

- To Study the compressive strength variation of concrete cubes (Dimension 15cm×15cm×15 cm) by partially replacing (replacement by weight) cement with Metakaolin and RBI-81.
- Replacement of cement with a eco-friendly material.

Chapter-4

Materials

Cement:

Portland Pozzolanic cement. The colour of cement was gray and it was free from lumps.

Aggregates: The sand which we used was from sand zone II and coarse aggregates used were crushed stones.

Metakaolin: Metakaolin having diameter 1μ to 13μ and obtained at the heating temperature of 750 and flash calcination was done.

RBI:RBI Grade 81 reacts with soil to form complex bury structure and hence increase its stability. It is earth friendly and inorganic in nature.

Chapter-5

Methodology

5.1.Mix Design details:

(i) Concrete Mix Design specification

(a) Characteristic compressive strength of 28 days grade - M 30

(b) Maximum nominal size of aggregates — 20 mm

(c) Shape of Coarseaggregates — Angular

(d) slump value between 50 to 100mm

(e) Quality control available at site —IS:456

(f) Condition to which structure will be exposed to (IS: 456) — Moderate

(g) Type of cement: PPC

ii) Steps for Concrete Mix Design of M25 Grade Concrete

(a) Specific gravity of cement — 3.15

(b) Specific gravity of Fine Aggregate — 2.64

(c) Specific gravity of Coarse Aggregate — 2.84

(e) Fine aggregates (Zone II from IS – 383)

Step 1 — Determination of Target mean Strength

Himsworth constant is taken as 1.65 for 5% risk factor

. Standard deviation in this case is as per IS:456 for M 25 is 4.0.

$$\mathbf{f_{target} = f_{ck} + 1.65 \times S}$$

$$\mathbf{= 25 + 1.65 \times 4.0 = 31.6\ N/mm^2}$$

Where,

S = standard deviation in N/mm^2 = 4 (as per table -1 of IS 10262- 2009)

Step 2 — Selection of water / cement ratio:-

From Table 5 of IS 456, (page no 20)

For Moderate exposure condition,maximum water-cement ratio is taken as = 0.60take water-cement ratio as 0.5.

0.5<0.6, hence OK.

Step 3 — Water Content

(Table 2 of IS 10262- 2009)

Maximum water content = 186 Kg

(for maximum nominal size of aggregate — 20 mm)

Table for Correction in water content

Calculated water content = 186+ (3/100) * 186 = 191.6 2kg /m^3

Step 4 — Selection of Cement Content

Corrected water content = 191.6 2kg /m^3

Water-cement ratio =0.5

Cement content =383kg/ m^3

(as per IS:10262-1982, page 18,table 6)

From Table 5 of IS 456,

For moderateexposure condition minimum cement content taken as = 300 kg/m^3

383 kg/m^3 >300 kg/m^3, OK.

Step 5: Estimation of CA fraction:-

From Table 3 of IS 10262,

For maximum nominal size of aggregate = 20 mm

Fine aggregate used were from zone 2

For w/c = 0.5Gross aggregate volume per unit of total aggregate volume = 0.66

Fine aggregate volume = 1 – 0.558 = 0.442

Step 6: Estimation of the mix ingredients

a) Volume of concrete = 1 m^3

b) Nominal size of aggregate is 20mm, the amount of entrapped air is 2% of volume of concrete i.e 1 m^3 (IS: 10262:1982)

$$V = \left[W + \frac{C}{S_c} + \frac{1}{p}\frac{f_a}{S_{fa}}\right] \times \frac{1}{1000}$$

$$V = \left[W + \frac{C}{S_c} + \frac{1}{1-p}\frac{C_a}{S_{ca}}\right] \times \frac{1}{1000}$$

where V = total volume of concrete= 0.98m^3

= gross volume (1m^3) subtracting the volume of entrapped air

S_c = specific gravity of cement=3.15

W = Mass of water /m^3 of concrete =191.6 kg/m^3

C = mass of cement/$m^3$of concrete, kg=383 kg/m^3

p = ratio of fine aggregate to total aggregate by total volume=0.33

f_a, C_a = total masses of fine and coarse aggregates, per cubic metre of concrete =572kg/m^3 ,1144kg/m^3

S_{fa}, S_{ca} = specific gravities of saturated surface dry fine and coarse aggregates, respectively =2.60,2.84

Table 5.1 Mix design

Water/cement	Cement	Fine aggregate	Coarse aggregate
191.58kg/m^3	383kg/m^3	572 kg/m^3	1144 kg/m^3
0.5	1	1.49	2.9

5.2 Proportion of materials:

Table .5.2Proportion of materials

Cement(%)	**Metakaolin{%}**
100	0
95	5
90	10
85	15
80	20
75	25

Table 5.3Proportion of materials

Cement	RBI grade 81 %
100	0
95	5
90	10
85	15
80	20

5.3.Casting of cubes

Standard 150×150×150 mm are casted for 28days,14 days, 7days respectively with the varying percentage of Metakaolin of total cementitious materialand kept for curing.

Fig 5.1 Casting of cubes

Fig. 5.2 casting of cubes

Fig.5.3 casting of cubes

5.4.Testing of cubes:

Compression test is performed for each cube in compression testing machine.

Fig.5.4Testing of cubes

Fig.5.5Testing of cubes

Fig.5.6Testing of cubes

Chapter-6

Test

6.1.Specific gravity of aggregates

PROCEDURE

1. About 2kg of total sample is washed , drainedand placed within the metal basket and immersed in water at the temperature between 22- 32°C and a cover of atleast 5 cm.
2. When immersed , trapped air is removed from the sample by lifting the basket 25 millimeter above the base of the tank and dropping it at a rate of regarding one drop/second. The basket and aggregate should be immersed for 24 hours.
3. Weight the basket with sample while hanging in water at a temperature of 22° – 32°Cnote the weight while hanging in water as =W1g.
4. Take the basket and aggregates from water and allowed to empty for a few minutes, transfer the aggregate to dry cloth to get rid of surface moisture. The empty basket is jolted in water for 25 times and weighed in water as=W2g.
5. Then transfer the aggregate to the another dry cloth spread in single layer and kept for 10 minutes for drying. The surface dried aggregate is then weighed as=W3
6. Place the aggregate in tray and kept in an oven for 24 hours temperature maintained at 110 ^{0}C. it's then removed from the oven,kept for cooling and weighted as=W4 g.

   Specific gravity of aggregate = (dry weight of the aggregate /Weight of equal volume of water)

   Apparent specific gravity = (dry weight of the aggregate/Weight of equal volume of water excluding air voids in aggregate)

6.2.Consistency Test of cement

1 Take 400 g of cement and place it within the tray.

2 Mix about 25th water by weight of dry cement completely to get a cement paste. Total time taken to get completely mixed water cement paste i.e. Gauging time shouldn't be over 3 to 5 minutes.

Pour the cement paste into the Vicat’s mould.

3 When filling the mould totally, smoothen the surface, making it level with high of the mould.

4 Place the total assembly,below the rod bearing plunger.

5 Place the plunger close to the surface and drop the plunger and take reading.

6 Prepare trial pastes with variable percentages of water content and follow the steps as represented above, till the depth of penetration becomes 33 to 35 millimetre.

Calculation

$$P = \frac{W}{C} \times 100$$

Where,

W=Quantity of water added

C=Quantity of cement used

Consistency of cement = 0.45

Percentage of water content for standard consistency = 0.45%

6.3 IST and FST

INITIAL SETTING TIME

1. Place the paste in the mould and resting on the non-porous plate, under the rod bearing the needle.
2. Firstly place the specimen filled with paste in contact with the needle and release the needle immediately .
3. If needle completely pierce the specimen or paste then repeat this procedure i.e .promptly releasing the needle after a gap of 2 minutes till the needle fails to sink into the specimen for about 5 mm from the bottom of the mould.

FINAL SETTING TIME

1. For determining FST time needle with annular rings is used in place of needle used in IST in vicat's apparatus .
2. When attachment fails to pierce through the test block and leaving only impression of the ring on the surface of paste, then cement is considered to reached at its FST.

6.4.Compression test:

Procedure for Cube Test

1. Take specimen from water, kept for curing and dry the cube.
2. Take the dimension of the test cube.
3. Place the cube in machine in such a manner that only smooth surface comes in contact with both the touching ends of machines.
4. Align the specimen centrally in machine.
5. Rotate the upper moveable portion of machine so that it comes in contact with the upper surface of test cube.
6. Apply the load gently make sure loading must not be impact loading,keep loading rate 140 kg/cm^2 /minute.
7. Note the maximum load on failure.

Calculation:

Compressive strength = (Load in N/ Area in $mm^{2)}$ =……………N/mm^2

Chapter-7

Result

7.1. Specific gravity of aggregates

Specific gravity of aggregates comes out to be 2.68.

Apparent specific gravity comes out to be 2.745.

Water absorption comes out to be 1.413.

7.2. Consistency of cement

Consistency of cement comes out to be 45% of weight of cement.

7.3. IST and FST of cement

Initial setting time of cement comes out to be 43 minutes.

Final setting time of cement comes out to be 7 hr 30 minutes.

7.4.Compression test

Cube dimension=150×150×150 mm

Table 7.1 Partial Replacement of cement with MK

Replacement of MK(%)	0%	5%	10%	15%	20%	25%
Cement(kg)	6	5.7	5.4	5.1	4.8	4.5
Sand(kg)	8.49	8.49	8.49	8.49	8.49	8.49
Coarse aggregate(kg)	17.4	17.4	17.4	17.4	17.4	17.4
Metakaolin(kg)	0	0.3	0.6	0.9	1.2	1.5
w/c ratio	0.5	0.5	0.5	0.5	0.5	0.5

7 days compressive strength of MK concrete

Table 7.2 7 days Compressive Strength of MK concrete

Replacement of MK(%)	Samples(S)	Area of cube(mm2)	Loading Rate(KN/s)	Force(KN)	Compressive Strength(Mpa)	Mean	Standard Deviation
0	S1	22500	4	420	18.67	18.23	0.44
	S2	22500	4	400	17.79		
5	S1	22500	4	420	18.65	18.88	0.23
	S2	22500	4	430	19.11		
10	S1	22500	4	434	19.33	19.64	0.31
	S2	22500	4	448	19.95		
15	S1	22500	4	476	21.12	20.66	0.46
	S2	22500	4	454	20.2		
20	S1	22500	4	492	21.87	21.55	0.32
	S2	22500	4	478	21.23		
25	S1	22500	4	476	21.13	20.42	0.71
	S2	22500	4	444	19.71		

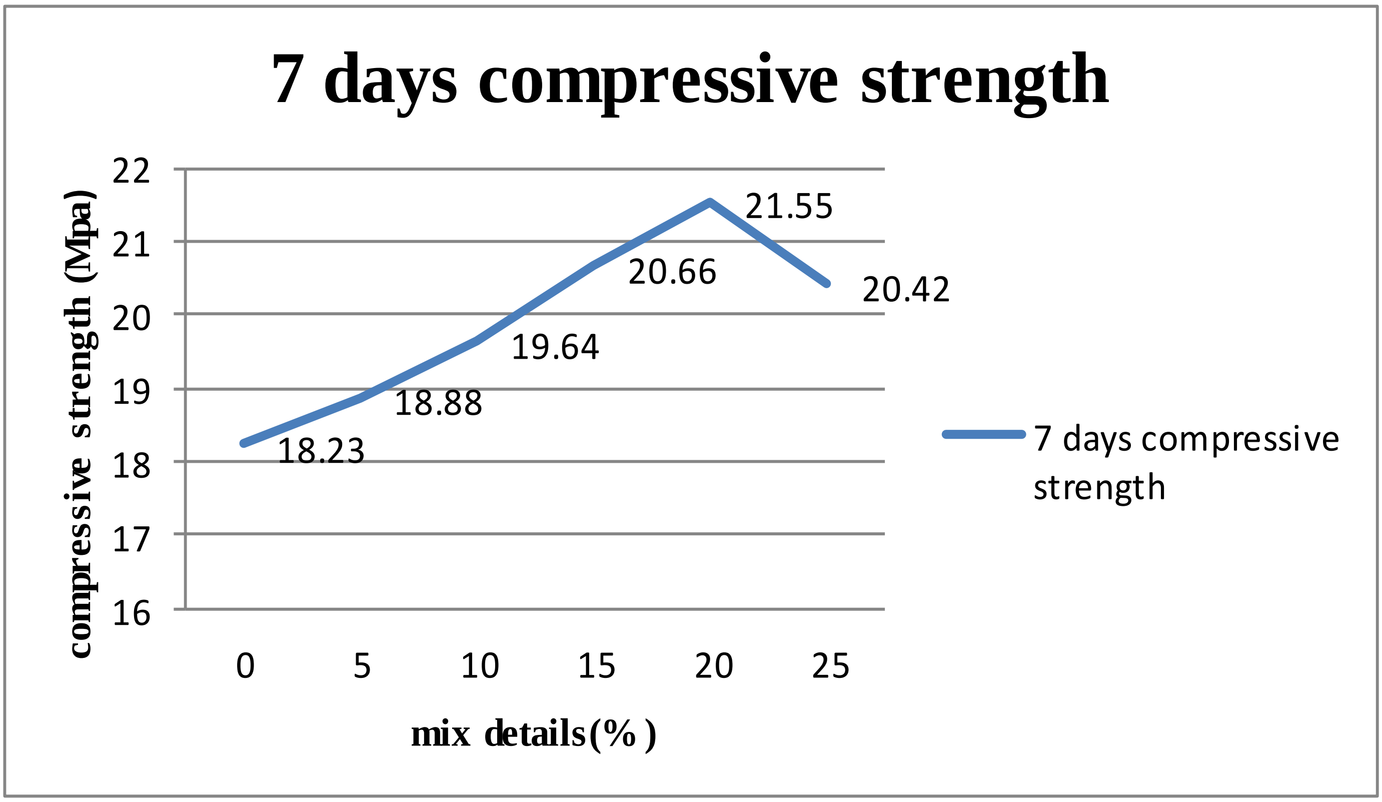

Fig 7.17 days compressive strength

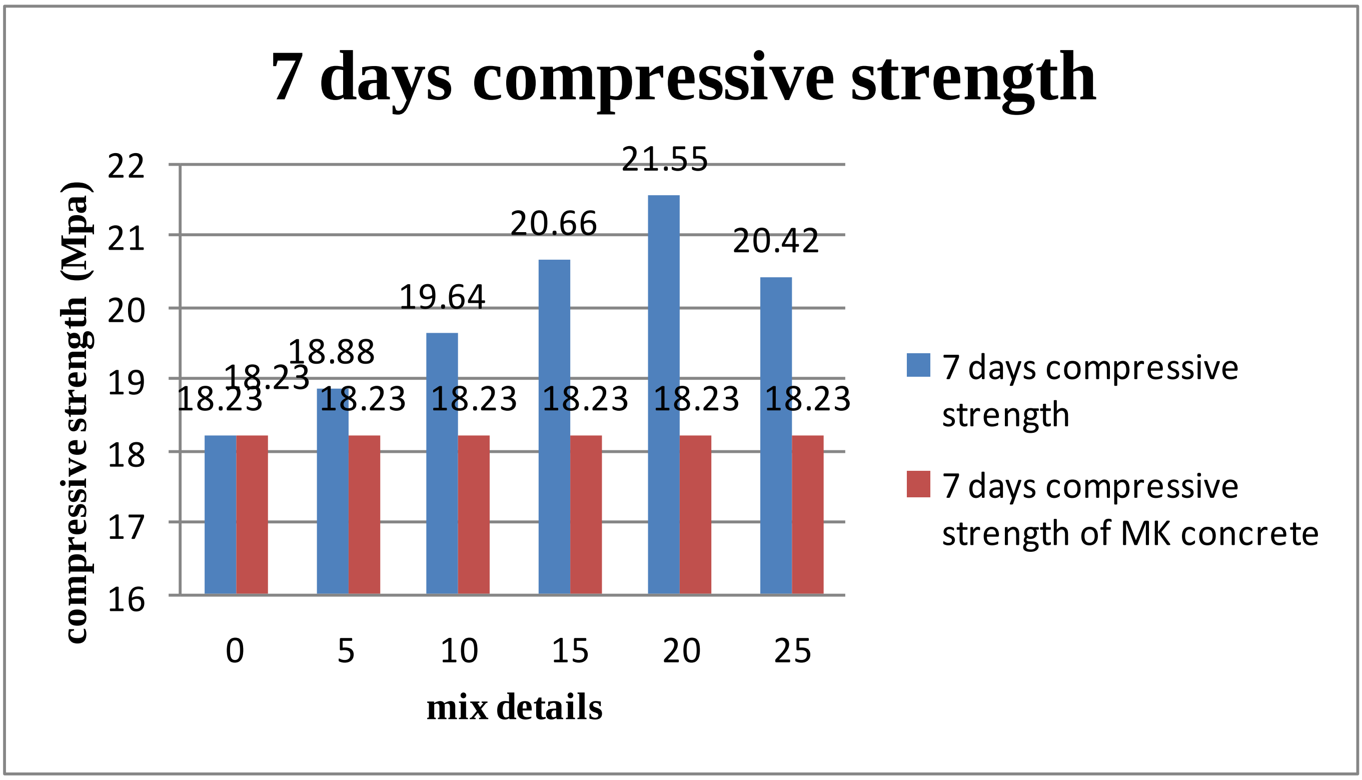

Fig 7.2 7 days compressive strength

14 days compressive strength of MK concrete

Table 7.3 14 days Compressive Strength of MK concrete

Replacement of MK(%)	Samples(S)	Area of cube(mm 2)	Loading Rate(KN /s)	Force(KN)	Compressive Strength(Mpa)	Mean	Standard Deviation
0	S1	22500	4	582	25.87	25.28	0.49887
	S2	22500	4	570	25.32		
	S3	22500	4	554	24.65		
5	S1	22500	4	584	25.97	26.22	0.47124
	S2	22500	4	580	25.81		
	S3	22500	4	604	26.88		
10	S1	22500	4	622	27.65	27.13	0.43734
	S2	22500	4	610	27.16		
	S3	22500	4	598	26.58		
15	S1	22500	4	652	28.94	28.35	0.42166
	S2	22500	4	630	27.98		
	S3	22500	4	632	28.13		
20	S1	22500	4	652	28.94	29.21	0.27
	S2	22500	4	664	29.48		
25	S1	22500	4	652	28.95	28.23	0.72
	S2	22500	4	644	27.51		

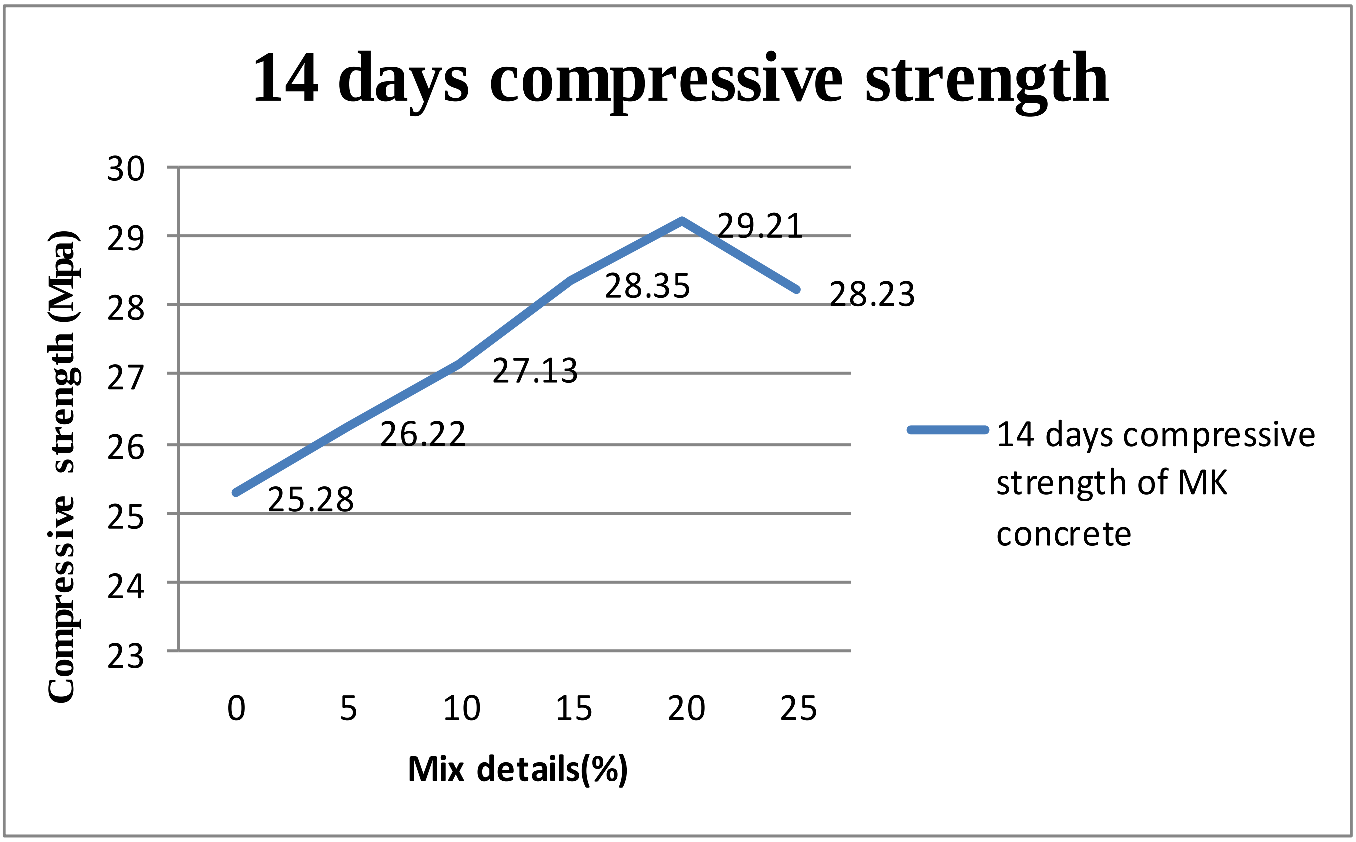

Fig 7.314 days compressive strength

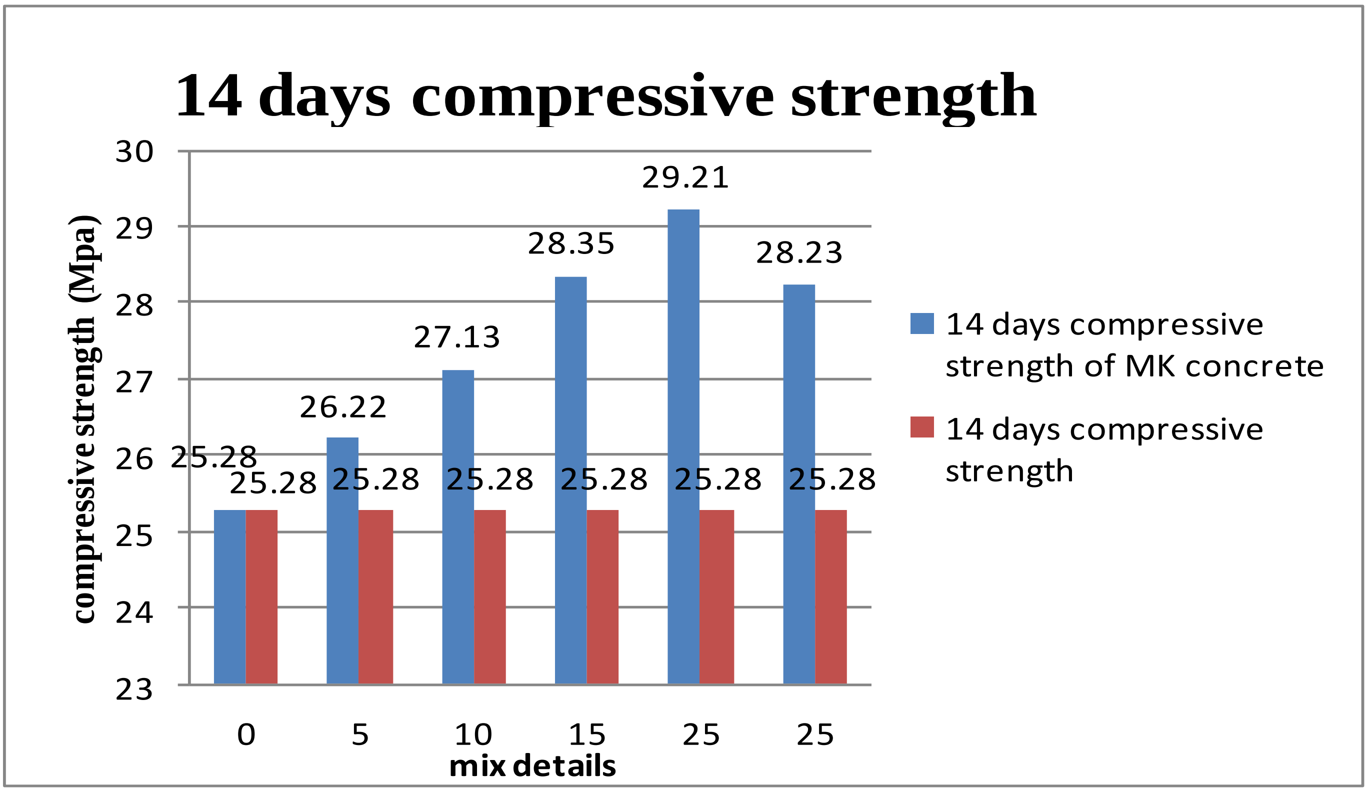

Fig 7.414 days compressive strength

28 days compressive strength of MK concrete

Table 7.4 28 days Compressive Strength of MK concrete

Replacement of MK(%)	Samples(S)	Area of cube(mm2)	Loading Rate(KN/s)	Force(KN)	Compressive Strength(Mpa)	Mean	Standard Deviation
0	S1	22500	4	644	28.66	28.52	0.28705
	S2	22500	4	632	28.12		
	S3	22500	4	648	28.78		
5	S1	22500	4	672	29.88	29.47	0.29488
	S2	22500	4	660	29.35		
	S3	22500	4	656	29.19		
10	S1	22500	4	702	31.22	31.32	0.3217
	S2	22500	4	698	30.98		
	S3	22500	4	714	31.75		
15	S1	22500	4	728	32.33	32.67	0.26587
	S2	22500	4	742	32.98		
	S3	22500	4	736	32.69		
20	S1	22500	4	772	34.31	33.92	0.31084
	S2	22500	4	754	33.55		
	S3	22500	4	762	33.89		
25	S1	22500	4	700	31.12	31.65	0.42468
	S2	22500	4	712	31.66		
	S3	22500	4	724	32.16		

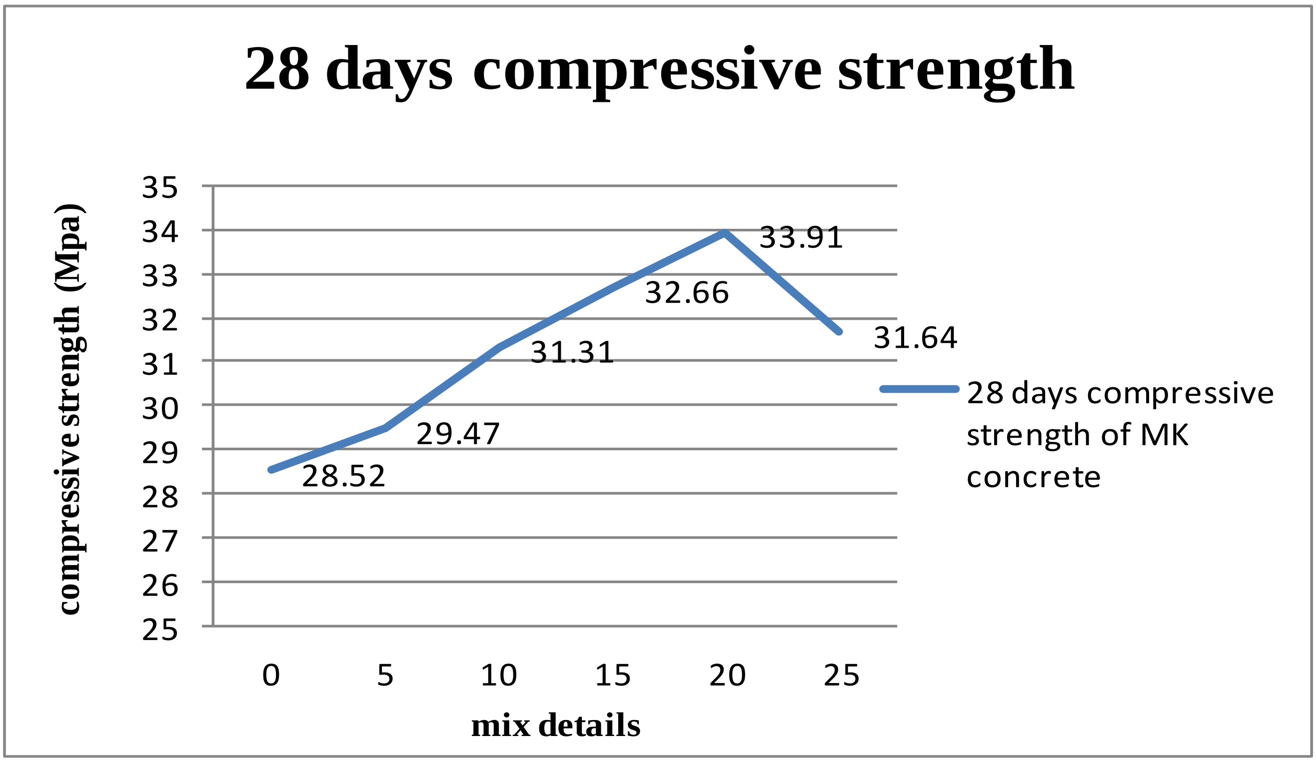

Fig 7.5 28 days compressive strength

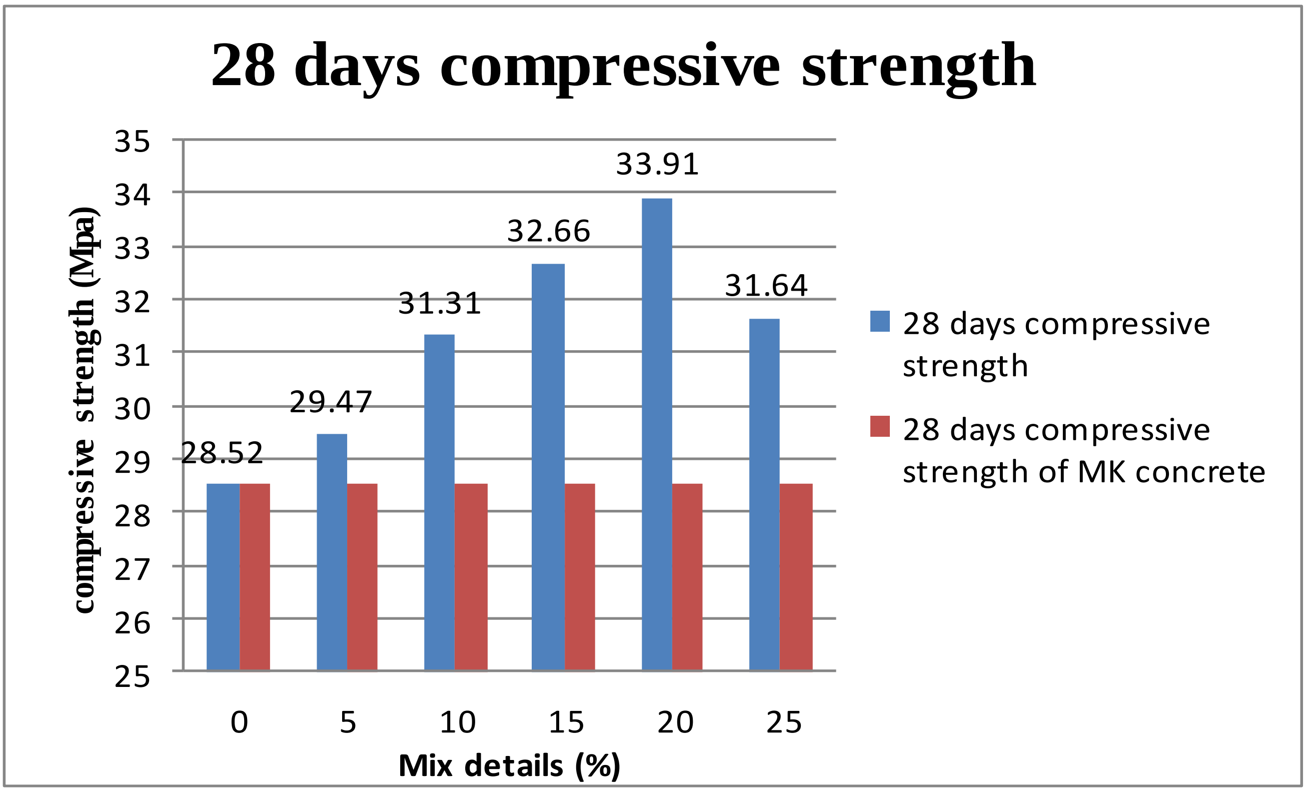

Fig 7.6 28 days compressive strength

7 days compressive strength of RBI grade 81 concrete

Table 7.5 7 days Compressive Strength of RBI grade 81 concrete

Replacement of RBI(%)	Samples(S)	Area of cube(mm2)	Loading Rate(KN/s)	Force(KN)	Compressive Strength(Mpa)	Mean	Standard Deviation
0	S1	22500	4	420	18.67	18.33	0.44
	S2	22500	4	400	17.79		
	S3	22500	4	418	18.54		
5	S1	22500	4	418	18.55	18.72	0.17
	S2	22500	4	426	18.89		
	S3	22500	4	406	18.12		
10	S1	22500	4	440	19.55	19.41	0.145
	S2	22500	4	434	19.26		
	S3	22500	4	446	19.84		
15	S1	22500	4	432	19.2	18.73	0.47
	S2	22500	4	410	18.26		
	S3	22500	4	436	19.42		
20	S1	22500	4	418	18.54	18.40	0.145
	S2	22500	4	410	18.25		
	S3	22500	4	402	17.95		
25	S1	22500	4	408	18.21	17.93	0.28
	S2	22500	4	396	17.65		
	S3	22500	4	402	17.94		

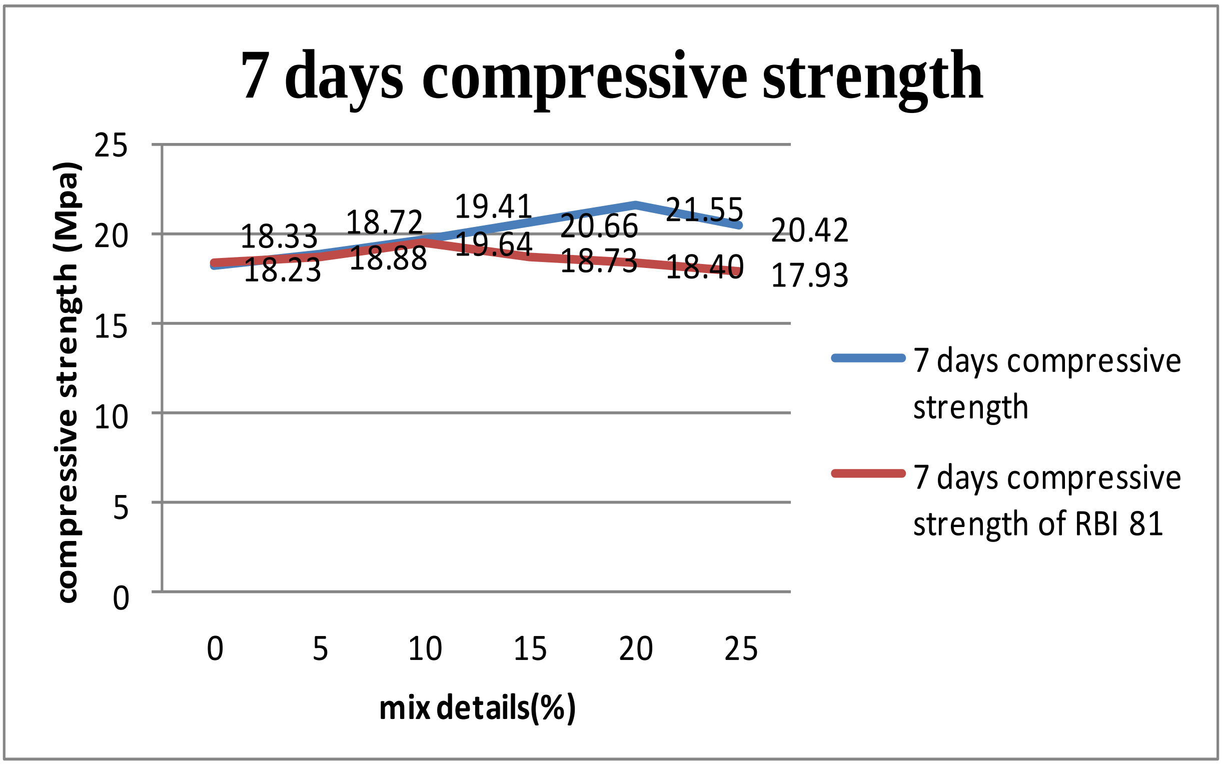

Fig 7.7 7 days compressive strength

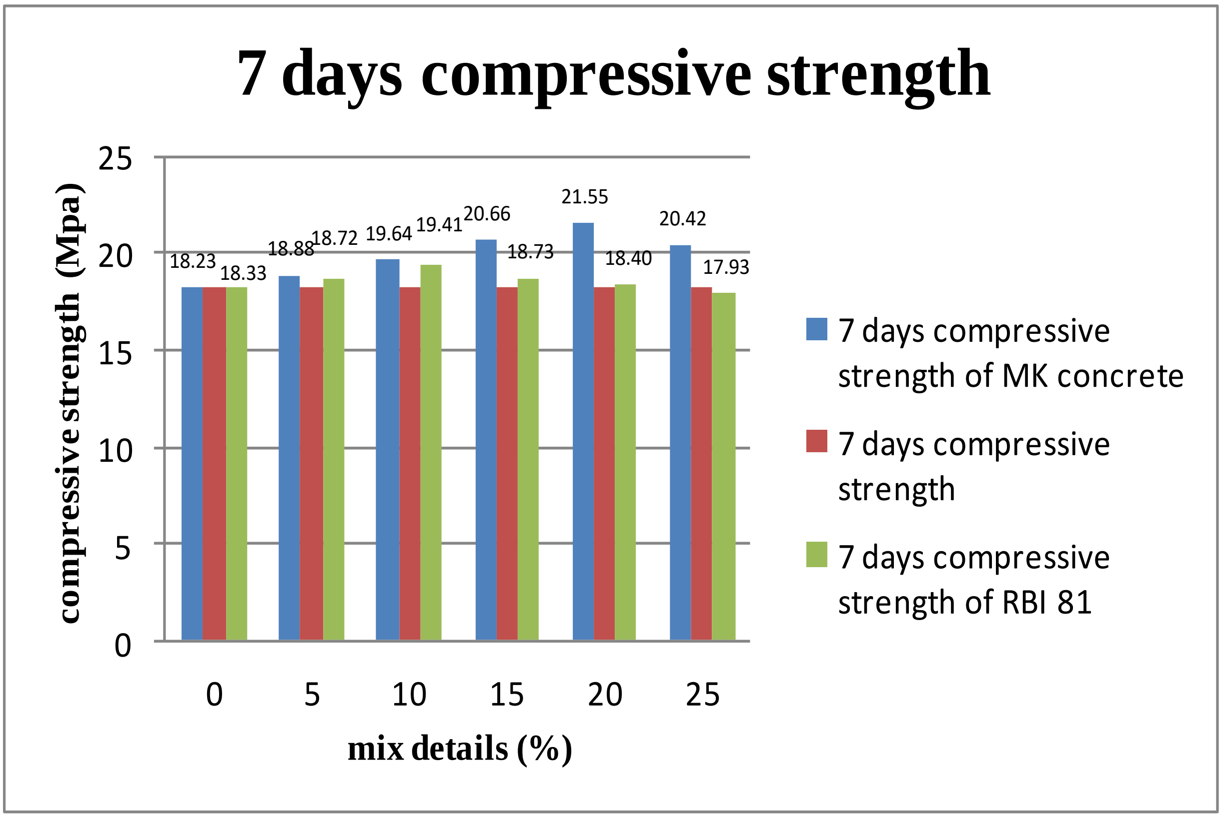

Fig 7.8 7 days compressive strength

14 days compressive strength of RBI grade 81 concrete

Table 7.6 14 days Compressive Strength of RBI grade 81 concrete

Replacement of RBI(%)	Samples(S)	Area of cube(mm2)	Loading Rate(KN/s)	Force(KN)	Compressive Strength(Mpa)	Mean	Standard Deviation
0	S1	22500	4	582	25.87	25.28	0.49887
	S2	22500	4	570	25.32		
	S3	22500	4	554	24.65		
5	S1	22500	4	598	26.58	26.31	0.19137
	S2	22500	4	588	26.14		
	S3	22500	4	590	26.22		
10	S1	22500	4	604	26.88	26.57	0.26145
	S2	22500	4	590	26.24		
	S3	22500	4	598	26.58		
15	S1	22500	4	598	26.55	26.1	0.36742
	S2	22500	4	576	25.65		
	S3	22500	4	588	26.1		
20	S1	22500	4	570	25.35	25.22	0.09741
	S2	22500	4	564	25.12		
	S3	22500	4	566	25.18		
25	S1	22500	4	566	25.19	24.99	0.29366
	S2	22500	4	564	25.12		
	S3	22500	4	554	24.65		

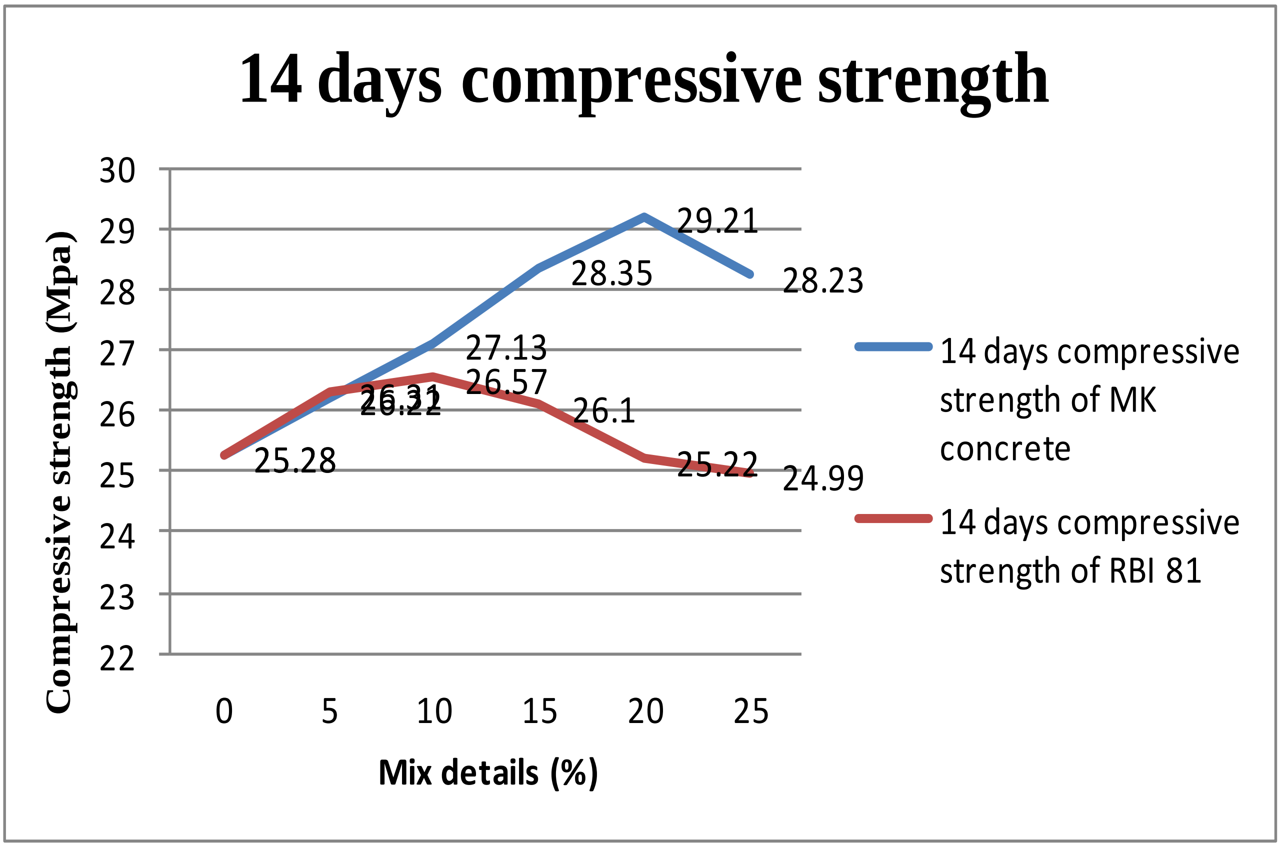

Fig 7.9 14 days compressive strength

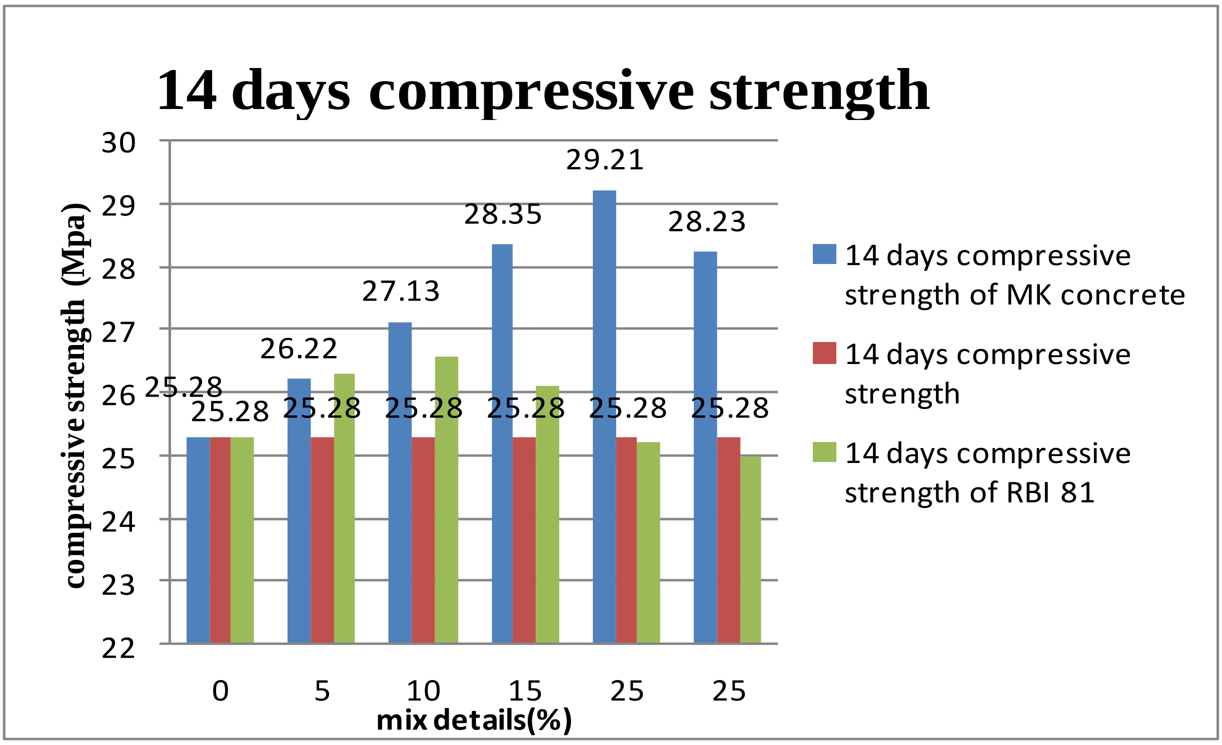

Fig 7.10 14 days compressive strength

28 days compressive strength of RBI grade 81 concrete

Table 7.7 28 days Compressive Strength of RBI grade 81 concrete

Replacement of MK(%)	Samples(S)	Area of cube(mm2)	Loading Rate(KN/s)	Force(KN)	Compressive Strength(Mpa)	Mean	Standard Deviation
0	S1	22500	4	644	28.66	28.5	0.28705
	S2	22500	4	632	28.12		
	S3	22500	4	648	28.78		
5	S1	22500	4	672	29.88	29.47	0.29488
	S2	22500	4	660	29.35		
	S3	22500	4	656	29.19		
10	S1	22500	4	702	31.22	31.32	0.3217
	S2	22500	4	698	30.98		
	S3	22500	4	714	31.75		
15	S1	22500	4	728	32.33	32.67	0.26587
	S2	22500	4	742	32.98		
	S3	22500	4	736	32.69		
20	S1	22500	4	772	34.31	33.92	0.31084
	S2	22500	4	754	33.55		
	S3	22500	4	762	33.89		
25	S1	22500	4	700	31.12	31.65	0.42468
	S2	22500	4	712	31.66		
	S3	22500	4	724	32.16		

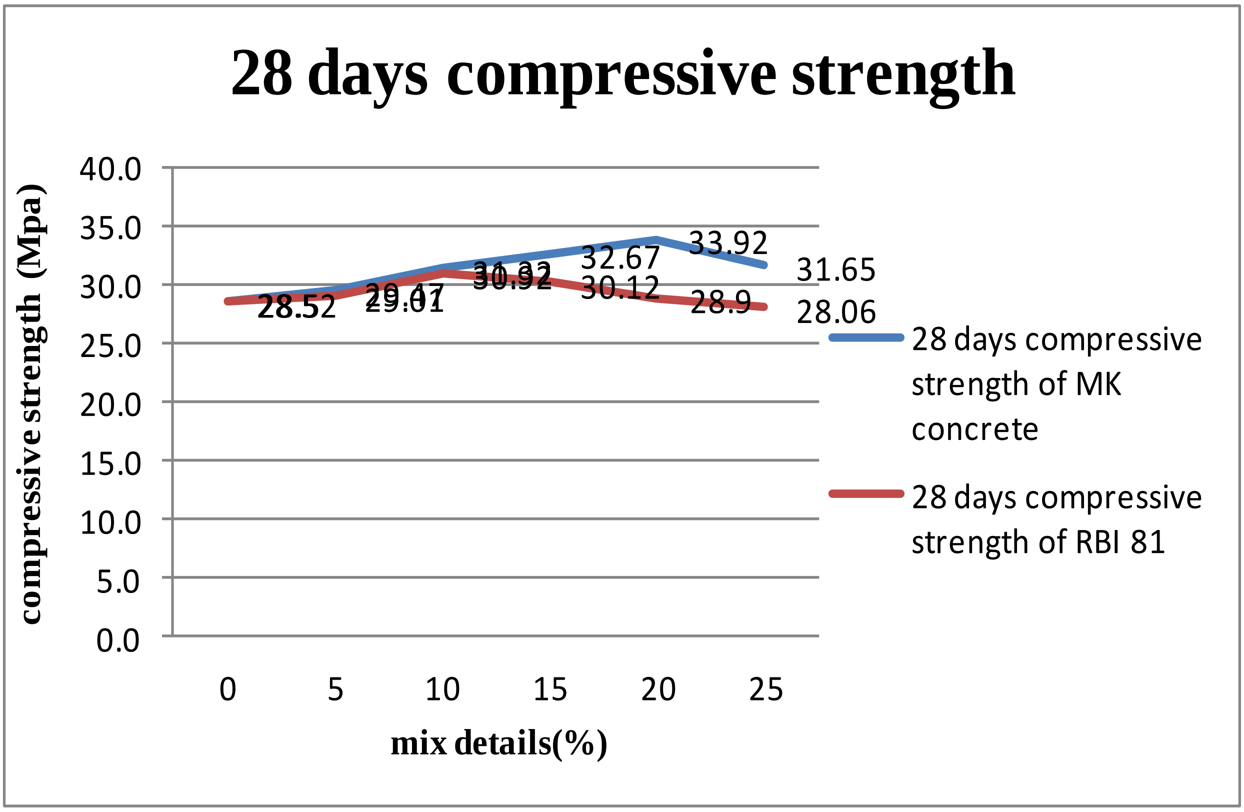

Fig 7.11 28 days compressive strength

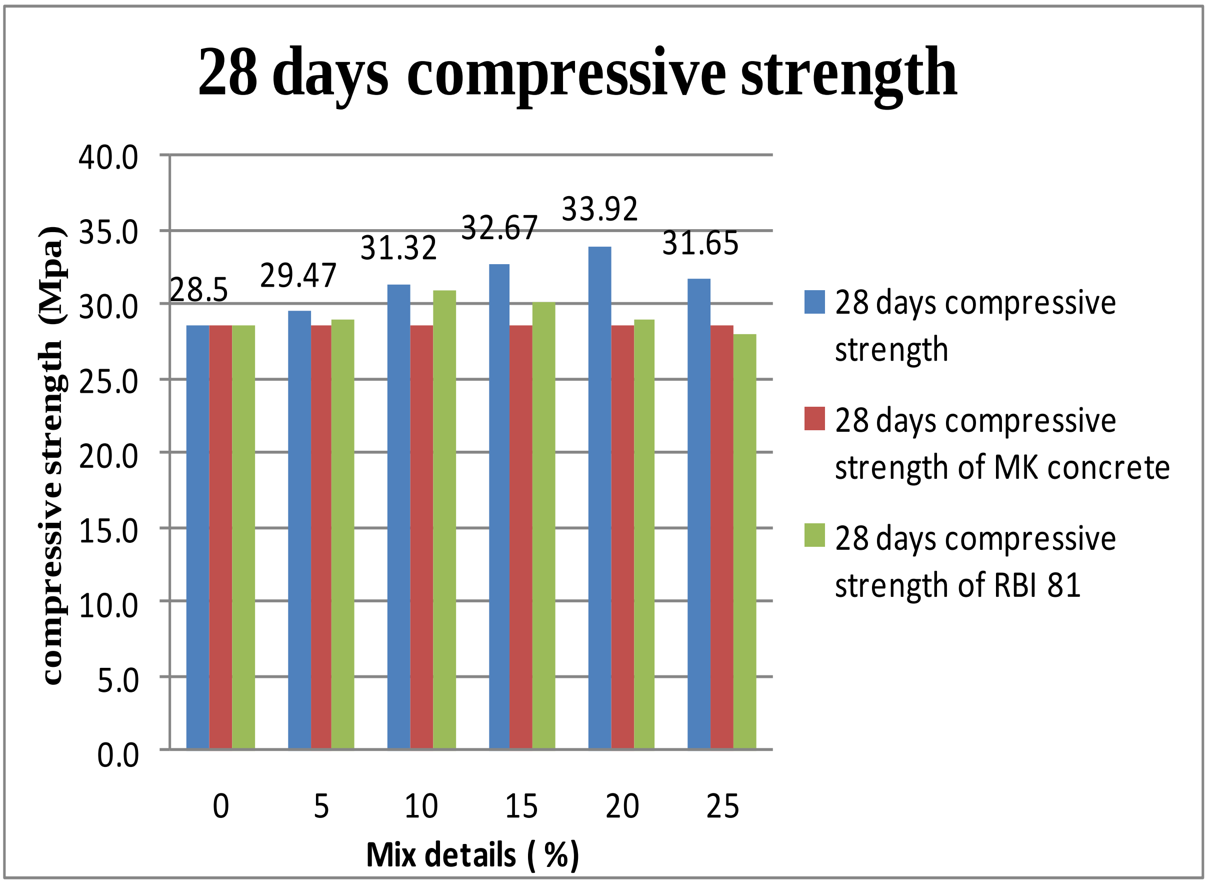

Fig 7.12 28 days compressive strength

CHAPTER-8

Conclusion

8.1 Specific gravity of aggregates

Since the acceptable limit of specific gravity of aggregates is 2.4-2.9. Hence sample lies within permissible limit.

8.2 Consistency of cement.

At 45% of water to cement ,vicat plunger penetrates the sample 5-7 mm from the bottom of vicatmould.

8.3 IST and FST of cement.

Since the permissible limit of IST and FST are 43 min. and 7 hr 30 min. respectively. Hence sample lies within permissible limit.

8.4 Compression test.

The replacement of cement with MK up to 20%, give better results from strength prospective. There is increase in compressive strength of concrete with increase in partial replacement of MK with cement till 20%, as shown in Fig 6.4.1, Fig.6.4.3 and Fig. 6.4.5.

Hence the optimized partial replacement of MK with cement as pozzolanic material is found out to be 20% and if the percentage of MK is increased above 20% there was reduction in strength of concrete was observed. Increase in the strength of concrete is due to filler effect of Metakaolin as it is more fine than cement. Metakalon is a pozzolanic material and enhance the hydration reactions of the concrete paste which is one of the reason for the increase in strength of concrete.

Early strength of concrete is found to less than 0% replacement of MK concrete strength for 7 days and 14 days because of curing conditions (water temperature is low which slow down the hydration reactions) and as portalandpozzolana cement early strength development is low in intial phases.

The replacement of cement with RBI grade 81 shows no significant increase in the strength of concrete. Compressive strength of RBI grade 81 concrete is found to be less as comparison to Metakaolin concrete.

RBI grade 81 has low silica content which imparts strength to the concrete , silica makes concrete denser by increasing dry density and increasing porosity.

RBI grade 81 cannot be used for cement replacement as increase in the concentration of RBI grade 81 show decrease or no significant change in the strength of concrete.

CHAPTER-9

FUTURE SCOPE

- Blend of Metakaolin and cement can be used for construction purposes .
- Blend of RBI-81 and cement can be used for construction of structures like boundary walls not suitable for heavy structures.
- Blend of Metakaolin with cement or RBI-81 with cement will be helpful in conservation of resources.

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