Experimental Investigation on Self Compacting Self Curing Concrete with Limestone Powder and Steel Fibers

S. Divya*, R. Ramasubramani, D. Madhu

Department of Civil Engineering, Faculty of Engineering and Technology
SRM University, Kattankulathur, TamilNadu, India.

Abstract: **Self-Compacting concrete is a type of concrete that gets compacted under its self-weight. It's commonly abbreviated as SCC and defined as the concrete which can placed and compacted into every corner of a formwork; purely means of its self-weight by eliminating the need of either external energy input from vibrators or any type of compacting effort. In this study, the effect of replacing the cement by limestone powder with (5%,10%,20%) respectively and steel fibers (2%) their combinations of various proportions on the properties of Self compacting concrete has been compared. Properties of compressive strength, split tensile strength and flexural strength of Concrete were determined. However, the results of this study suggest that limestone powder (10%),steel fibers (2%) combinations can improve the workability of Self compacting concrete, more than conventional concrete and while their using separate. Limestone powder can have a positive influence on the mechanical performance at early strength development while Steel fibers can improve more strength avoid cracking. Rapid chloride permeability test for conventional concrete and optimum one i.e. of replacement of cement by Limestone powder (10%) and steel fibers (2%) with self compacting self curing concrete gets moderately so results suggest that we can use for construction purpose. For slab self-curing is more workable than normal curing.**

Key Words: Lime stone powder; steel fibers;Super plasticizer; CeraHyperplastxr – 40; Self-compacting concrete;

I. INTRODUCTION

1.1 General

Self-compacting concrete was first developed by okamura in 1988, in order to achieve durable concrete structures. Since then, various investigations have been carried out and mainly large construction companies have used the concrete in practical structures in all over the world. Investigations for establishing a rational mix-design method and Self-compact ability testing methods have been carried out to make the concrete the standard one.

1.2 Development of self compactingconcrete

A several years before in 1983, the problem of the durability of concrete structures was a major topic of interest in all over the world. To make durable concrete structures, sufficient compaction by skilled workers were required. However, the gradual reduction in the number of skilled workers in Japan's construction industry has led to a similar reduction in the quality of construction work. One solution for the achievement of durable concrete structures independent of the quality of construction work is the employment of self-compacting concrete, which can be compacted into every corner of a formwork, purely by means of its own weight and without the need for vibrating compaction

The necessity of this type of concrete was proposed by Okamura of japanin 1986. Studies to develop self-compacting concrete, including a fundamental study on the workability of concrete, have been carried out by Ozawaand Maekawaat the University of Tokyo. The prototype of self compacting concrete was first completed in 1988 using materials already on the market. The prototype performedsatisfactorily with regard to drying and hardening shrinkage, heat of hydration after
Densenes Hardening, and other properties. This concrete was named "High Performance Concrete." and was defined in three stages of concrete namely Fresh: self-compactable, Early age: avoidance of initial defects and After hardening: protection against external factors

1.3 Need for this study

The results of this study suggest that certain Limestone Powder, steel fibers combinations can improve the workability of Self compacting concrete more than conventional one.Good strength concrete can be prepared by replacement of cement with limestone powder to the self compacting self curing concrete mix.Superplasticizer, Viscosity Modifying Agent, self curing agents are so Economical for preparing Self compacting self curing concrete. Limestone powder used as Mineral admixture to improve the strength properties. Durability characteristics are found for concrete by rapid chloride permeability test.

II. LIME STONE POWDER

The use of Portland cement containing limestone filler is a common practice in European countries, especially in France. This type of cement is formulated to achieve certain goals in the technical, economic, and ecological fields. Among the technical benefits are the increase of early strength, the control of bleeding in concrete with low cement content and the low sensitibility to the lack of curing.
The addition of limestone powder reduces the initial and final setting time, as well as porosity, whereas free lime and combined water increase with increasing limestone content. The quality of the limestone filler affects the performance of the cement in concrete and the water

demand of the cement. In general limestone powder filler in cement and concrete effects acceleration of hydration, dilution of cement paste, increase of effective *w/c,* ratio and increases the strength at early ages. The addition of limestone powder filler to fine cement pastes and mortars reduces the diffusion coefficient of chloride ions. The lime stone powder is shown Fig 1.

Fig. 1 lime stone powder

2.1 Steel fibers

Steel fiber is one of the most commonly used fiber. Generally round fibers are used, the steel fibers usually get rusted and lose some of its strength. Butinvestigations showrustlings happens at surface only. Use of steel fibers makes significant improvement in flexural, impact strength of concrete. Fig 2 shows the steel fibers of 30mm length and 0.60 diameter and the fiber is in the shape of crimpled one. It is available in the market easily.

Fig. 2steel fibers

2.2 Chemical admixtures

Superplasticizers or high range water reducing admixtures are an essential component of Self compacting concrete. Cerahyperplast xr-w40 was used as super plasticizer and Glenium stream 2 was used as viscosity modifying agent and Cerapolycure-w was used as self curing admixture.

2.2.1 CeraHyperplastxr - 40

CeraHyperplastxr– 40 is a polycarboxylate ether based new range water reducing admixture. It helps in the production of self - compacting concrete. It improves pump ability at low water - cement ratios and low cement contents. It also achieves a higher slump than normal plasticizer and it retain slumps to extend than the normal superplasticizer.Fig. 4 shows that 10 liters cane of super plasticizer based on polycarboxylate ether and viscosity modifying agent of 1 liter bottle.

Fig. 4Superplastizier and viscositymodifying agent

Table 1 shows that properties of cerahyperplastxr(superplastizier)

Table 1 Properties of cerahyperplastxr -w40

Properties	**Description**
Appearance	Liquid
Color	Beige
Chemical Composition	Poly carboxylate Ether
Active Ingredients	40%
Specific gravity	1.06 - 1.22
Ph	6 – 8
Chloride content	Nil

2.2.2 Cerapolycure - w

It is a wax based curing compound which when applied on concrete forms a seamless film and it prevents the evaporation of water from the capillaries of Concrete. Fig 5 shows that 10 liters cane of cera polycure-w which was used for curing of specimens of concrete. The cost of one litrecerapolycure – w is 45/- and one liter of cerapolycure – w is used for 3.5 to 4.5 m^2 of concrete.

Fig. 5 cerapolycure-w

It eliminates hessian or polyethylene film completely with use of water. No risk of erratic or poor curing and ensure that the cement hydrate efficiently. It has excellent solar reflectance, which keeps the concrete temperature low, especially helpful during the early stages of concrete hydration. Its easy to apply and saves labor cost. It does not have any contaminants like chloride etc.., and will not affect the setting time of concrete. Table2 shows that properties of cerapolycure-w i.e. curing compound

Table 2 properties of cerapolycure– w(self curing admixture)

Properties	**Description**
Water loss after 72 hrs	Not more than 0.55 kg/m^2
Appearance	Translucent White
Dry film color	White
Reflectance	More than 60% than that of Mgo
Min. application temp	4^0c

2.2.3 Glenium Stream 2

The new technology of self-compacting concretewas found in which it allows concrete to compact without vibration, even with stronglyreinforced structures.A self-compacting mix should have a highworkability and high viscosity.The fluidity of the mix is guaranteed when thereis no friction between the internal particles and theconcrete can flow freely; segregation occurs when the components of the concrete separate out intomortar and large aggregates.Reaching the right balance between fluidity andresistance to segregation - apparently opposingproperties - is essential for this type of mix. Thisbalance is lacking when the fluidity of the concreteis obtained by adding water. Although asuperplasticizer admixture gives high fluidity, aloneit does not guarantee the necessary properties toensure a good degree of self-compacting. That is why glenium stream 2 is a fundamentaladmixture when making Self-compacting Concrete. Table 3.3 shows that properties of viscosity modifying agent.

Table 3 shows the properties of glenium stream 2 (viscosity modifying agent)

Table 3 properties of glenium stream 2(viscosity modifying agent)

Properties	**Description**
Aspect	Color free flowing liquid
Relative density	1.01±0.01 at 25°C
P_h	> 6
Chloride Ion Content	< 0.2%

III. SELF COMPACTABILITY (OR) FRESH CONCRETE

The method for achieving self-compactability involves not only high deformability of paste or mortar, but also resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of reinforcing bars. Okamura and Ozawahave employed the following methods to achieve self-compactability.

- Limited aggregate content
- Low water-powder ratio
- Use of super plasticizer

The frequency of collisionand contact between aggregate particles can increase as the relative distance between the particles decreases and then internal stress can increase when concrete is deformed, particularly near obstacles. It has been revealed that the energy required for flowing is consumed by the increased internal stress, resulting in blockage of aggregate particles. Limiting the coarse aggregate content, whose energy consumption is particularly intense, to a level lower than normal proportions is effective in avoiding this kind of blockage. Highly viscous paste is also required to avoid the blockage of coarse aggregate when concrete flows through obstacles .When concrete is deformed, paste with a high viscosity also prevents localized increases in the internal stress due to the approach of coarse aggregate particles. High deformability can be achieved only by the employment of a superplasticizer, keeping the water-powder ratio to be very low value. The mix-proportioning of the self-compacting concrete is shown and compared with those of normal concrete and RCD (Roller Compacted concrete for Dam) concrete. The aggregate content is smaller than conventional concrete which requires vibrating compaction. The degree of packing of coarse aggregate in SCC is around 50% so that the interaction between coarse aggregate particles when the concrete deforms may become small. In addition, The ratios the fine aggregate volume to its solid volume in the mortar.

The degree of packing of fine aggregate in Selfcompacting concrete Mortar is around 60% so that the shear deformability when the concrete deforms may be limited. On the other hand, the viscosity of the paste in Selfcompacting concrete is the highest of the other types of concrete due to the lowest water-powder ratio. That is effective in inhibiting segregation

3.1 Self curing

Self curing concrete is the which can itself by retaining its moisture content. A concrete can be made to self cure either by adding curing admixtures or by the application of curing compounds Various admixtures used Are concur WB, conplast NC, conplast C N and conplast S D 110 etc.... The admixtures used for curing concrete certain chloride which will lead to corrosion of reinforcement. Hence its use is restricted only within plain concrete. Curing compounds available are wax based and resin based. The curing compound applied on concrete acts as a protective layer increase as the relative and seals the moisture content within the concrete. The curing compounds available are concurewb ,concurelp etc…Here the "external self curing" is adopted. External self curing concrete is the one which can cure itself by retaining its moisture content within the concrete by the application of curing compounds on the surface of the concrete.

Spray is applied on the membrane to retain moisture in concrete for effective curing. It is suitable for all general concreting applications and it is applied for large area concrete surfaces, such as airport runways, roads and bridgeworks.It is also suitable for piece works, where the curing is difficult. It is also suitable for tunnel lining work.

The advantage of doing external self curing can improve curing of concrete which enhances cement hydration and provides a more durable concrete. It can control moisture loss and improves surface quality. It reduces permeability and minimizes surface cracking and shrinkage. The fugitive color provides visual guide during application and increases early age strength. Spray application reduces labor costs and eliminates the need for alternative curing systems.

IV. EXPERIMENTAL INVESTIGATION

4.1General

The project deals with the comparing the conventional concrete withself-compacting self curing concrete and also replacing lime stone powder with different percentages instead of cement. The steel fibers areadded to strengthen the concrete.

Before doing testing the compressive strength, split tensile, flexural strength the fresh properties of concrete were conducted. The self-compacting property is identified by the result of slump cone, v-funnel, L-box, U-box tests. This can identify the flow ability, filling ability and passing ability of concrete by acceptance limit. Table 4 shows fresh properties of concrete should satisfy the acceptance criteria for self compacting concrete based on European guide lines.Table 5 shows that test results for self-compacting concrete that which should satisfy the acceptance criteria of specification

Table 4 Acceptance criteria for Self Compacting concrete

S.No	**Method**	**Units**	**Minimum**	**Maximum**
1	Slump cone	mm	650	800
2	V-funnel	Sec	6	12
3	L-box	(h2/h1)	0.8	1
4	U-box	(h2/h1)	0	30

Table 5 Tests results for Self-compacting concrete

S.No	Method	Trail 1	Trail 2	Trail 3
1	Slump cone	495	550	655
2	V-funnel	55	40	14
3	L-box	0.11	0.56	0.93
4	U-box	0	2.2	4.3

4.2 Curing of specimens

The specimens were casted and left for self curing by applying polycure on specimens for three different curing periods. The specimens were cured for 3 days, 7 days and 28 days. The curing of specimens by self curing process is shown in Fig6.showsself curing of cubes, cylinders, beams

Fig.6 curing of specimens (self curing)

4.3 Conduct of experiment

The concrete cubes, cylinders and beams were tested for compressive strength, split tensile and flexural test respectively. The test was conducted for the curing period of 3, 7 and 28 days. The strength was compared for conventional and lime stone powder concrete with different percentages (5%, 10%, and 20%). Along with this 2% of steel fibers were added. These concrete are added up with self curing and self compacting agents. The test is carried out for 100x100x100 mm size cubes, 100 x 200 mm cylinders and 100 x 100 x 750 mm beams. Fig 7 shows the compressive strength test, split tensile and flexural beam test for cubes, cylinders and beams respectively.

Fig. 7 compressive test, split tensile and flexural test

4.4 Rapid chloride permeability test

The primary cause of corrosion is due to the permeation of moisture, chloride ions and oxygen into concrete and this is aided by the inherent porosity hydrated paste, micro cracks both present in the cement paste. Since chloride ions affect the protective oxide film of steel, so it is very important property to determine the chloride ion intrusion in the concrete.

In this test a thin disc of concrete having 100mm diameter and 50mm thick is introduced in between the two chambers of diffusion cell which are filled with sodium hydroxide (0.3N) in the positive terminal and sodium chloride (3N) in the negative terminal. To accelerate the rate of diffusion of chloride ions through the concrete, this test was adopted by ASTM C-1202 and AASHTO T-227. The migration of ions takes place in an externally applied electric field of 60 volts. An appraisal on chloride permeability of concrete can be obtained by measuring the electric current passing through the concrete specimen at every 30 minutes over a period of 6 hours and the resistance of the specimen to chloride ion penetration is estimated from the total charge passed. The electric charge passed is calculated as charge passed (Q) in coulombs. Here the test is carried for optimum strength obtained lime stone powder concrete and conventional concrete along with steel fibers

$$\mathbf{Q = 900\,[(I_0 + I_{360}) + 2(I_{30} + I_{60} + I_{90} + I_{120} + I_{150} + I_{180} + I_{210} + I_{240} + I_{270} + I_{300} + I_{330})]} \;\ldots\ldots\; (4.1)$$

Where,

I_0 = Initial current passed.

I_{30}, I_{60}, I_{90} ………I_{360} = Current at the end of every 30 minutes.

The concrete is given a quantitative rating based on the charge passed with respect to the chloride permeability according to ASTM C-1202 as given below in

Table 6 shows chloride permeability range.

Table6 Chloride Permeability Range

Charge passed in coulombs	Chloride permeability
>4000	High
2000 to 4000	Moderate
1000 to 2000	Low
100 to 1000	Very low
<100	Negligible

Fig 8 shows the testing apparatus of rapid chloride permeability test(RCPT)

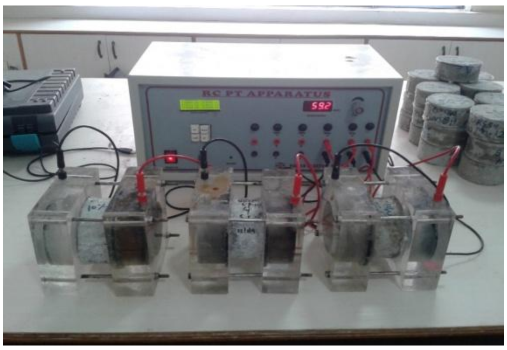

Fig. 8 Rapid chloride permeability test apparatus

4.5 Deflection test for slab

Here the test is carried for optimum strength obtained lime stone powder concrete and conventional concrete along with steel fibres. The dimension of the slab is 850 mm x 540 mm. The maximum capacity of load applied was 40 tones based on the frame. The least count of the dial gauge is 0.01 and least count of proving ring is 0.001, jack capacity is 25 tones. Slab is placed on frame and the deflection test was carried out. The deflection test and the experimental set up of the frame is shown in Fig 9. The cracks the noticed and marked finally.

Fig. 9deflection test for slab

V. RESULTS AND DISCUSSION

The results of compressive test split tensile test, flexural test, RCPT and deflection test and analayised and discussed in below.

5.1Acceptance criteria for self-compacting concrete

The following table 7 gives the acceptance criteria for self-compactingconcrete. The table 8 shows the result of self-compacting concrete for M25 grade

Table 7 Acceptance criteria forTable 8 Test results for Self-compactingconcreteself-compacting concrete

S.No	Method	Units	Minimum	Maximum
1	Slump cone	Mm	650	800
2	V- funnel	Sec	6	12
3	L- box	(h2/h1)	0.8	1
4	U-box	(h2/h1)	0	30

S.No	Method	Trail 1	Trail 2	Trail 3
1	Slump cone	495	550	655
2	V- funnel	55	40	14
3	L- box	0.11	0.56	0.93
4	U-box	0	2.2	4.3

5.2 compressive strength test

The compressive strength of m25 grade of concrete was tested for both conventional concrete and self compacting, self curing concrete under 5, 10 and 20% of lime stone powder with 2% of steel fibers The compressive strength was identified high at 10% lime stone powder containing self-compacting self-curing concrete (32.3mpa). The result is shown in table 9.

Table 9 Average compressive strength in Mpa

S.No	Type of concrete	3 days (Mpa)			7 days (Mpa)			28 days (Mpa)		
1	Conventional concrete	11.3			17.5			26.3		
2	Conventional concrete + fiber (2%)	15.2			18.1			27.1		
3	Self compacting self curing + fiber (2%)	15.0			17.5			30.1		
4	Lime stone powder (5%, 10%, 20%) replacement of cement curing in water	11.1	11.0	9.5	15.1	17.0	18.0	24.3	27.3	25.6
5	Lime stone powder (5%, 10%, 20%) and steel fibers 2% curing in water	12.3	15.5	11.3	16.3	19.8	17.9	28.1	29.6	22.3
6	Lime stone powder (5%, 10%, 20%) and steel fibers 2% with self compacting self curing concrete	17.1	19.3	8.0	20.5	22.1	12.5	27.9	**32.3**	20.2

5.3 split tensile test

The split tensile strength of m25 grade of concrete was tested for both conventional concrete and self compacting, self curing concrete under 5, 10 and 20% of lime stone powder with 2% of steel fibers. The split tensile strength was identified high at 10% lime stone under 28 days of water curing (4.20mpa) whereas self compacting self curing concrete had a small variation (4.14mpa). The result is shown in table 10.

Table 10 Average split tensile strength in Mpa

S.No	Type of concrete	3 days (Mpa)			7 days (Mpa)			28 days (Mpa)		
1	Conventional concrete	1.2			2.33			3.0		
2	Conventional concrete + fiber (2%)	1.5			2.66			3.2		
3	Self compacting self curing + fiber (2%)	1.5			2.38			4.07		
4	Lime stone powder (5%, 10%, 20%) replacement of cement curing in water	1.87	1.75	1.65	2.64	2.89	2.51	3.78	4.07	3.37
5	Lime stone powder (5%, 10%, 20%) and steel fibers 2% curing in water	1.84	1.75	1.75	2.65	2.7	2.32	3.98	**4.20**	2.32
6	Lime stone powder (5%, 10%, 20%) and steel fibers 2% with self compacting self curing concrete	1.65	1.75	1.30	2.57	2.80	2.51	4.01	**4.14**	3.50

5.4 flexural strength test

The flexural strength of m25 grade of concrete was tested for both conventional concrete and self compacting, self curing concrete under 5, 10 and 20% of lime stone powder with 2% of steel fibres. The flexural strength was higher at 10% limestone under 28 days of water curing (5.0mpa) whereas self compacting self curing concrete had a small variation (4.5mpa). The result is shown in table 11.

Table 11 Average flexural strength in Mpa

S.No	Type of concrete	3 days (Mpa)			7 days (Mpa)			28 days (Mpa)		
1	Conventional concrete	1.0			2.0			4.0		
2	Conventional concrete + fiber (2%)	0.5			2.0			4.5		
3	Self compacting self curing + fiber (2%)	0.5			1.0			4.0		
4	Lime stone powder (5%, 10%, 20%) replacement of cement curing in water	1.0	2.5	1.0	2.5	3.0	3.0	4.5	4.0	4.0
5	Lime stone powder (5%, 10%, 20%) and steel fibers 2% curing in water	1.5	1.0	1.0	3.0	2.5	2.5	4.5	**5.0**	4.0
6	Lime stone powder (5%, 10%, 20%) and steel fibers 2% with self compacting self curing concrete	0.5	0.5	1.0	2.5	2.0	1.0	4.0	**4.5**	2.5

5.5 Rapid chloride permeability test

The RCPT test is done for conventional concrete and concrete having 10% of lime stone powder + 2% of steel fibers under self compacting and self curing Table

Table 12 Rcpt values for conventional concrete

Interval (30 min)	Current passed I
I0	96
I30	114
I60	117
I90	121
I120	124
I150	126
I180	129
I210	131
I240	133
I270	133
I300	134
I330	133
I360	137

Charge passed (Q) = 900 x [(I0 + I360) + 2 x(I30XI60XI90XI120XI150XI180XI210X240XI270XI300XI330XO370)]

Io = initial current passed

I30,I60.I90………..I360 = current at the end of every 30 minutes

Q = 2720.7 (coulomb's)

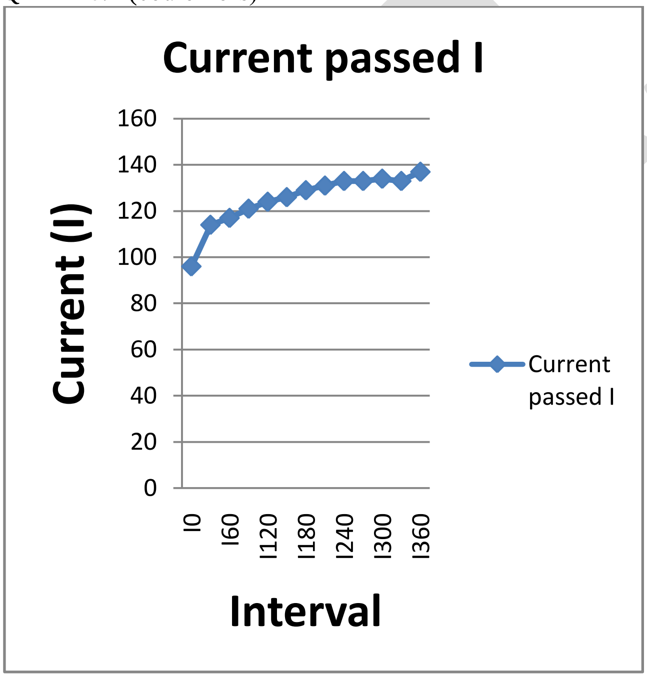

Fig. 10 chloride conducted Vs time (conventional concrete)

An appraisal chloride permeability of concrete can be obtained by measuring the electric current passing through the concrete specimen at every 30 minutes over a period of 6 hours and resistance of the specimen to chloride ion penetration is estimated from the total charge passed. The electric charge passed is calculated as charge passed (Q) in coulombs

Table 13 Rcpt values for concrete with optimum one

Interval (30 min)	Current passed I
I0	16
I30	91
I60	106
I90	121
I120	139
I150	151
I180	168
I210	185
I240	217
I270	246
I300	259
I330	275
I360	296

Charge passed (Q) = 900 x [(I0 + I360) + 2 x(I30XI60XI90XI120XI150XI180XI210X240XI270XI300XI330XO370)]

Io = initial current passed

I30,I60.I90………..I360 = current at the end of every 30 minutes

Q = 3805.2 ampiers (moderate permeability)

Rcpt for conventional and optimum is having moderate permeability , so we can use in construction purpose .

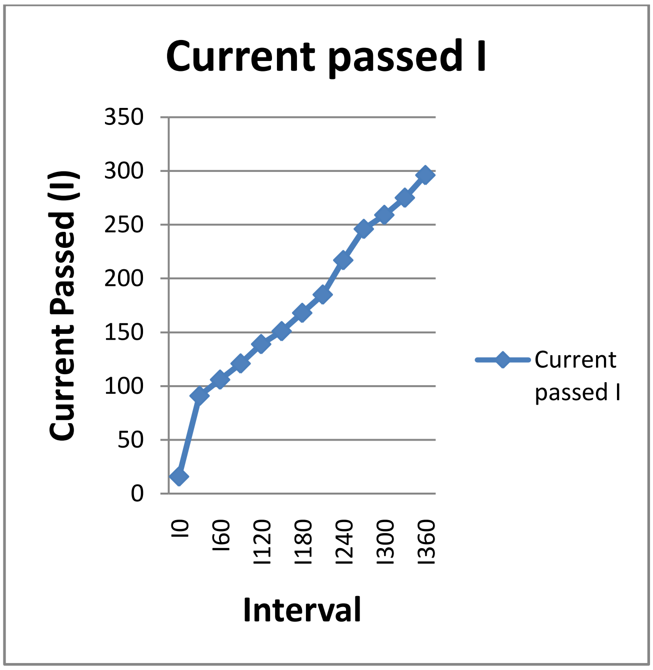

Fig. 11 chloride conducted Vs time (10% L.P+2%steel fiber)

Table 14 Load Vs deflection (conventional concrete)

Load (tones)	Deflection (mm)
0.5	0.05
1.0	0.78
1.5	1.32
2.0	1.92
2.5	2.48
3.0	3.07
3.5	3.65
4.0	4.11
4.5	4.62
5.0	5.15
5.5	5.38
6.0	6.18
6.5	6.40
7.0	6.98
7.5	7.38
8.0	7.90

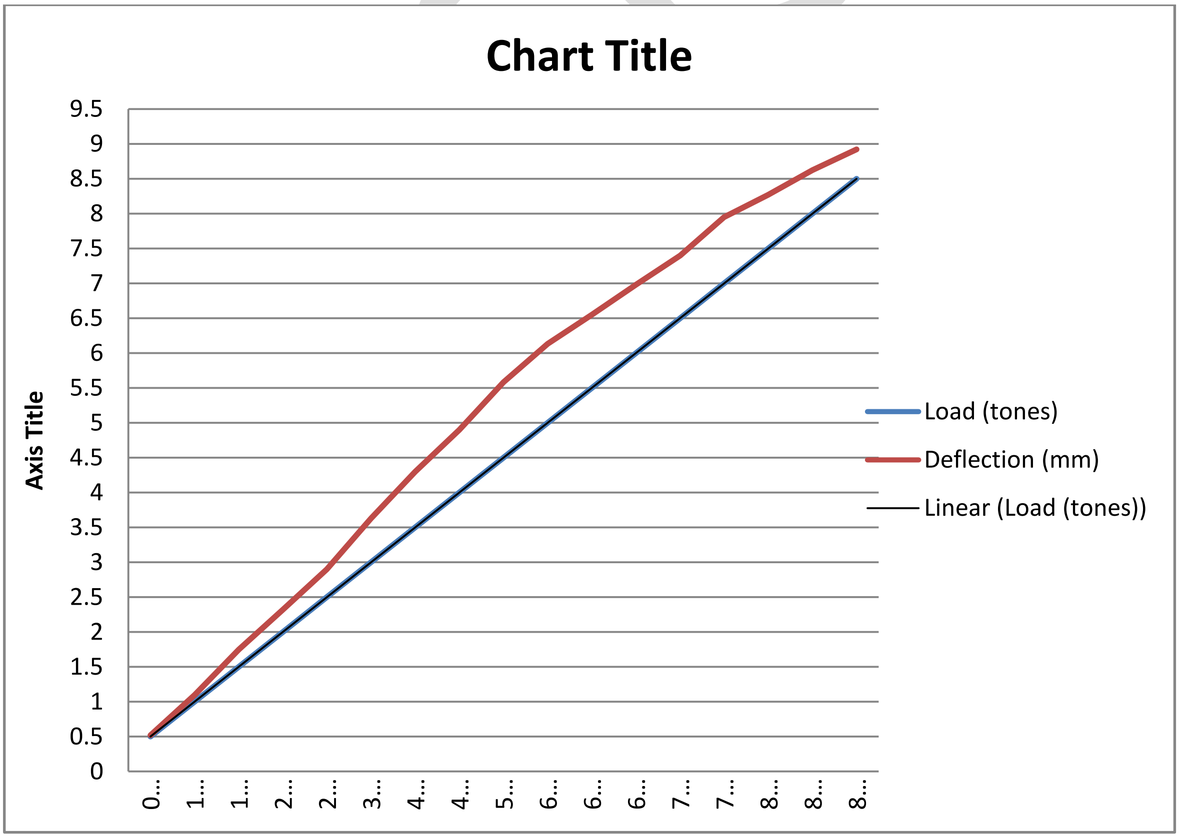

Fig. 12 Load Vs deflection curve (conventional concrete)

Table 15 Load Vs deflection (10% L.P+2%steel fiber)

Load (tones)	Deflection (mm)
0.5	0.52
1.0	1.1
1.5	1.75
2.0	2.32
2.5	2.90
3.0	3.63
3.5	4.30
4.0	4.90
4.5	5.58
5.0	6.13
5.5	6.55
6.0	6.98
6.5	7.40
7.0	7.95
7.5	8.27
8.0	8.62
8.5	8.92

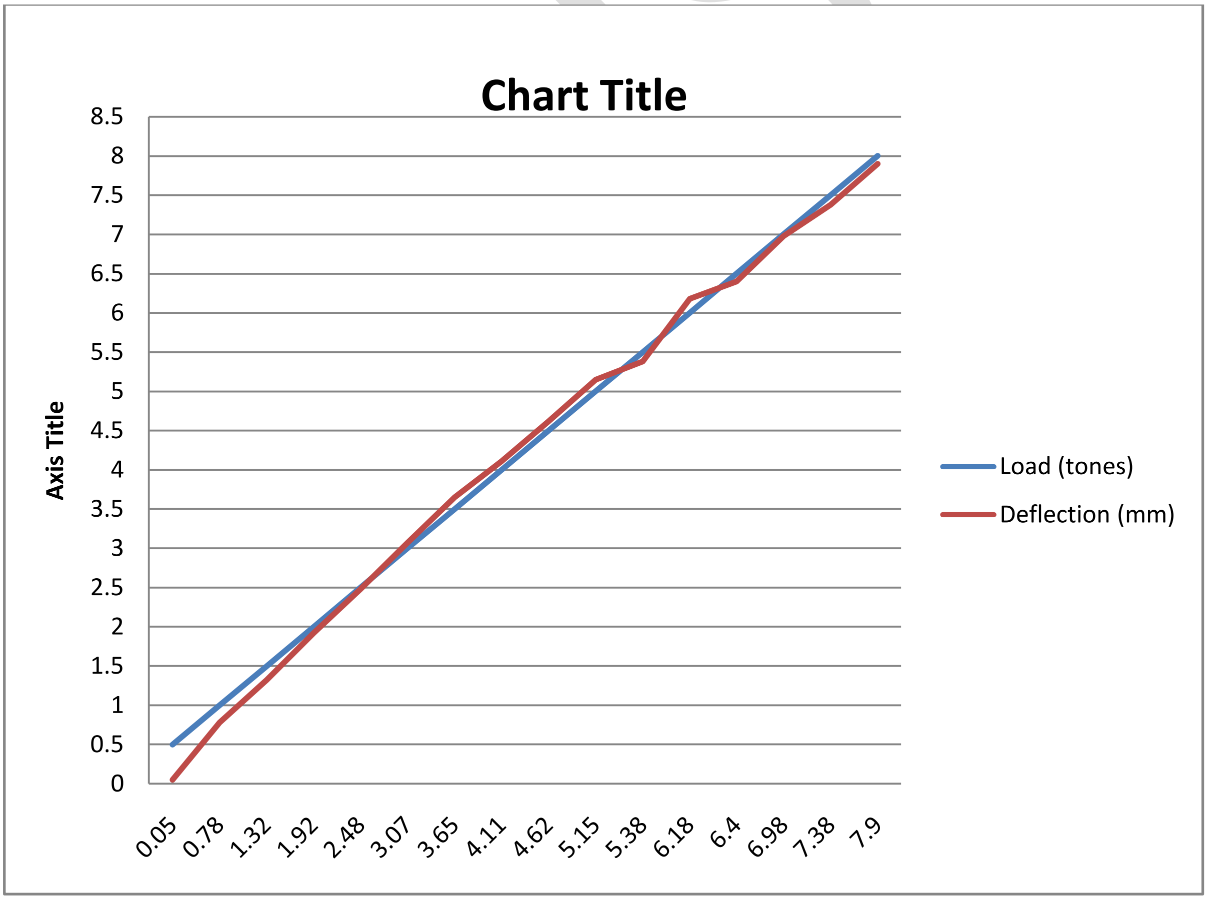

Fig. 12 Load Vs deflection curve (10% L.P+2%steel fiber)

VI. CONCLUSIONS

During the experimental program the lime stone powder had good role in concrete strength. In replacement of cement by Lime stone powder some limited percentage shown a reasonable change in compressive strength, split tensile strength and flexural strength

Based on the investigation carried out on Lime stone powder and steel fibers with Self compacting self curing concrete compare with the normal concrete. Following conclusions made

Compressive strength Comparing from conventional concrete and limestone powder and steel fibers with self-compacting self-curing concrete gives better strength, so we can use combination without using separate separately. Compressive strength is 6% more when comparing to conventional by lime stone powder 10% and steel fibers 2% with self-compacting self-curing concrete.Morely limestone powder gives compressive strength. Tensile strength under Lime stone powder (10%) replacement of cement and steel fibers 2% curing under water gives more tensile strength while comparing to conventional concrete. Flexural strength is same as conventional concrete and gives almost same result, so self-curing agent is more workable. Rcpt For conventional and optimum get moderate permeability, so we can use construction purpose.Self curing can be achieved for various purposes in construction engineering.

ACKNOWLEDGEMENT

The authors wish to thank the SRM University Management, for their support to complete this study and those who were directly or indirectly involved in this study. Also thanks **Dr. K. S. Satyanarayanan, Professor, Civil**, SRM University for his help in reviews of this research works during its progress.

REFERENCES

[1]. Alperen yurtseven (2005), "Workability of hybrid fiber reinforced self-compacting concrete" material management, Vol. 4, pp. 423-431.
[2]. Amal francis (2013), "Mechanical properties of self curing", Indian journal of emerjing trends in engineering and development, vol. 2 pp. 641 - 647.
[3]. ACI 308-92, Standard practice for curing concrete" Bureau of Indian Standards, New Delhi, India.
[4]. EFNARC, (2006), "Specification and Guidelines for Self-Compacting concrete", EFNARC (European Federation of Producers and Applicators of Specialist Products for Structures)EN 1992-1-1 Design of concrete structures (Eurocode 2), Scc 028.
[5]. Jagannadha Kumar (2012),"Mechanical properties of self curing concrete",indian jouranal, Vol. 1, pp. 51-57.
[6]. Liberato ferrara (2012) "A comprehensive methodology to test the performance of Steel Fibre Reinforced Self-Compacting Concrete (SFR-SCC)" Vol. 39, pp. 406–42.
[7]. Ravikumar MS, Selvamony, Kennan SU, Basil Gnanappa S. (2009) 'Behavior of self-compacted self curing kiln ash concrete with various admixtures', ARPN J Eng,
[8]. Vol. 5, pp. 63-68.
[9]. Saharan , Christianson, Yamane, 2006, 'The effect of chemical admixtures and mineral additives on the properties of self-compacting mortars', Cement and Concrete Composites, Vol. 28, pp.432-440.
[10]. Ravikumar MS, Selvamony, Kennan SU, Basil Gnanappa S. (2009), "Development of high strength self compacted self curing concrete with mineral admixtures", ARPN J Eng, Vol. 3, pp. 103-108.
[11]. T. Ponikiewski (2013) "Flexural behaviour of self-compacting concrete reinforced with different types of steel fibers" Construction and Building Materials Vol. 47 pp. 397–408.
[12]. Yamane, (2006), 'The effect of chemical admixtures and mineral additives on the properties of self-compacting mortars', Cement and Concrete Composites, Vol. 28, pp.432-440.