International Journal For Technological Research In Engineering
Volume 2, Issue 7, March-2015 *ISSN (Online): 2347 - 4718*

PREDICTION OF MECHANICAL PROPERTIES OF CONCRETE USING ADMIXTURES AND WITH DIFFERENT CURING CONDITIONS

Suryateja M[1], Dr. D Neeraja[2]
[2]Associate Professor, Structural Department
School of Mechanical and Building Sciences, VIT University Vellore - 632014, Tamil Nadu.

Abstract: The aim of this paper is to find the effective curing for normal concrete and the concrete with different admixtures such as Micro silica and GGBS. The different Percentage of admixtures chosen for the study are 3%,6%,9% for silica fume and 10%,20%,30% for Ground Granulated Blast Furnace Slag (GGBS) and optimum Micro silica with different GGBS percents were also used. Cubes and Beams were casted for all the different mixes including Normal mix and were kept in three different curings i.e., Water curing, Lime curing, and Resin based curing compound. The mechanical properties of concrete such as compression and flexural strength were determined for the specimens. The specimens were cured for 7, 28, 56 day curing before they were subjected to the tests. Finally it was observed that the specimens with Micro Silica6%+ GGBS10% (SG10) had the highest Compressive, Flexural Strength and UPV values. The results also show significant increase in Mechanical properties of concrete by adding the Micro silica. From the results, it is evident that curing plays a significant role in strength development and Lime curing is proven to be very effective for the concrete with and without admixtures and showing an increase of strength from 4% to 15%. However the Resin based curing compound had only little applications.

I. INTRODUCTION

Concrete is the world's most widely used construction material. It has the applications ranging from a small cube that can be caste in a mould to the construction of Mega Dams and Skyscrapers. The most important properties of the concrete were compressive and flexural strength. The addition of mineral admixtures has become very common in modern concrete technology because of technical requirement, economic and environmental reasons. The use of Micro silica enhances the mechanical properties, durability and construction ability in concrete and it is very reactive and effective pozzolanic material due to its fine particle size and high purity of SiO2 (99.88%) content. It is used in the production of high strength and high performance concrete. GGBS is used to make durable concrete structures in combination with ordinary Portland cement. GGBS has been widely used for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years. Curing is the process which allows the concrete for continuous hydration for attaining its maximum strength. The curing technique should ensure that there is uninterrupted hydration throughout the hydration. Along with the maximum strength gain, curing also ensures durability, minimize creep, reduces plastic shrinkage, water tightness etc. The curing should start immediately after the final setting of the concrete to avoid plastic shrinkage. Different curings should be adopted based on the mineral admixtures used in concrete, various locations, climatic conditions and availability of water. Curing is important aspect for micro silica concrete as the material undergoes zero bleeding. The rate of evaporation from the surface is faster than the rate of migration of water from interior to surface in micro silica concrete. It causes plastic shrinkage in concrete. So the early curing by the way of membrane curing is essential. This research effort is aimed at investigating and comparing the compressive and flexural strength development of concrete cured by immersion in potable water, immersion in lime water, and using Resin Based Curing Compound for 7, 28 and 56 days curing periods.

II. Materials and Experimental procedure

A. Materials:

1. Cement:

OPC 53 grade cement used for casting specimens and all the physical and chemical properties of the cement were satisfied with IS 12269:1987. Locally available natural river sand (Palar River sand, Tamil Nadu, India) and the coarse aggregates with maximum size of 20 mm were used. Normal tap water is used for concrete mixing.

2. Micro Silica:

Micro Silica is a very reactive and effective pozzolanic material due to its fineness. The purity of Micro Silica used is 99.5%. The specific Gravity of Micro Silica is 2.63 and is odourless and pure white in colour. The physical properties and chemical composition of Micro Silica are shown in Table-1 and Table-2 respectively.

Table-1

Physical properties	Results
Appearance	White Colour Powder
Physical State	Micronized Powder
Pack Density	0.76gm/cc
pH of 5% Solution	6.90
Specific Gravity	2.63
Moisture	0.058%

Table-2

Silica (SIO2)	99.886%
Alumina (AL2O3)	0.043%
Ferric Oxide(Fe2O3)	0.040%

Calcium Oxide (CaO)	0.001%
Titanium Oxide (TiO2)	0.001%
Sodium Oxide (Na2O)	0.003%

3. Ground Granulated Blast Furnace Slag (GGBS):

GGBS comprises mainly of CaO, SiO2, Al2O3, MgO, it contains less than 1% crystalline silica. It has the same main chemical constituents as ordinary Portland cement, but in different proportions. GGBS is used to make durable concrete structures in combination with ordinary Portland cement. GGBS has been widely used for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years. It is used as a binder in this work and its specific gravity is 2.85. It provides higher resistance to chloride ingress reducing the risk of reinforcement corrosion and provides higher resistance to attacks by sulphate and other chemicals. The chemical composition is shown in Table-3.

Table-3

Calcium Oxide (CaO)	39%
Silica (SIO2)	34%
Alumina (AL2O3)	10%
Magnesium Oxide (MgO)	8%

4 Super Plasticizer:

In order to have proper workability Super Plasticizer named Conplast SP430 is used. It has the specific gravity of 1.22. Conplast SP430(G) complies with IS:9103:1999 and BS:5075 Part 3 and ASTM-C-494 Type 'F' as a high range water reducing admixture and Type G at high dosage. It is dark brown in colour with neutral pH ranging from 6-9%. Based on trails the 0.72Lit per 100Kg of cement is used of super plasticizer is used.

B. Mix Proportions:

The Normal Mix is designed for M40 grade of concrete and the cement is replaced by various proportions of Micro Silica and GGBS for different mixes. Micro Silica is used in 3%, 6%, 9% and GGBS in 10%, 20%, 40% proportions and based on test results, the optimum percent of Micro Silica was chosen. The combination of GGBS at different percentages and optimum percentage of Micro Silica was also considered to compute mechanical properties. Table-4 shows different mixes for which Cubes and Beams were casted for all the mixes to find the Compression and Flexural Strengths for all the three different types of curings and also to find strengths at 7day, 28day and 56 day.

Table-4:

Mix Name	Cement (Kg/m3)	Micro Silica (Kg/m3)	GGBS (Kg/m3)
Normal Concrete(NC)	370.0	_	_
Micro Silica 3% (S 3)	358.9	11.1	_
Micro Silica 6% (S 6)	347.8	22.2	_
Micro Silica 9% (S 9)	336.7	33.3	_
GGBS 10% (G 10)	333	_	37
GGBS 20% (G 20)	296	_	74
GGBS 40% (G 40)	222	_	148
Micro Silica6%+ GGBS10% (SG10)	310.8	22.2	37
Micro Silica6%+ GGBS20% (SG20)	273.8	22.2	74
Micro Silica6%+ GGBS40% (SG40)	199.8	22.2	148

C. Curing Methods:

The different curing methods adopted in this experimental study are Normal Water Curing, Membrane Curing using Resin based Curing compound and Lime curing. Normal Water Curing is immersing the specimens in water for 7, 28, 56 days respectively.

1. Resin Based Curing Compound:

Curing is important aspect for micro silica concrete as the material undergoes zero bleeding. The rate of evaporation from the surface is faster than the rate of migration of water from interior to surface .It causes plastic shrinkage in concrete. So the early curing by the way of membrane curing is essential. The commercial name of curing compound used is CERAPOLYCURE-R and it is a Petro resin based aluminium pigmented curing compound. Commercially preferred and generally used equipment is a knapsack sprayer of the type commonly used in horticulture or pest control. But for experimental purpose Brush is used for applying Curing Compound.

2. Lime curing:

Lime curing is immersing the specimens in Lime saturated Water (i.e. Lime is added to the water till the excess lime settles in the bottom tub). In this experimental study 5% W/W of lime is added to the water.

3. Tests for Concrete:

Cubes of dimension (100*100*100 mm) and Beams (100*100*500 mm) were casted and the specimens were demoulded after 24 hours and placed in curing. Compressive strength for 7days, 28days, 56days and 28days for Flexure strength were taken. In addition to Compressive and Flexure, Ultra sonic pulse velocity (UPV) values were also taken.

III. RESULTS AND DISCUSSION

A. Compressive strength:

In this study cubes and beams were casted for 10 mixes and placed in three different curing conditions and tested for Compressive and Flexure at 7,28,56 days. The optimum

percentage for Micro silica is observed at 6% and at 56 days and this mix (SF 6%) has shown a compressive strength of 46.9Mpa which is 14.66% more compared to normal concrete. And the optimum value for GGBS is 42.8Mpa and has shown an increase of 6% with Normal concrete. For Normal concrete (NC) the lime curing has shown a maximum 40.9Mpa which is 9% increase in strength with Normal concrete at 56 day strength. But at 7 day Lime curing got strength increase of about 35% and this suggests that Lime curing can be used as an accelerated curing method.

B. Resin Cured Concrete:

Resin curing has good results with Micro silica concrete with maximum strength loss of 10% and average loss of 4% but this curing is not suitable with GGBS concrete since the maximum strength loss is 48% and average strength loss is about 20%. However the 7 day strength of Resin cured concrete is more than Lime and Water cured concrete in Normal concrete mix but the strength of Resin concrete is reduced at 28 and 56 days.

C. Lime Cured Concrete:

The strength of all different types of concretes were increased by Lime curing and it also accelerating the curing process. It is because the lime particles are penetrating through the pores of concrete and making the concrete more dense and it found by visual observation of tested specimens. The optimum mix in lime concrete is Micro silica 6% + GGBS 10% with compressive strength value of 48.1Mpa.

By using the above mix and Lime curing the strength is increased by 30% of which 10% is due to Admixtures and 20% is due to lime curing. The Compressive strengths of different Mixes at different curings are shown in the following Fig 1-3. The highest compressive strength at 7 day is observed at Micro silica 6% which is lime cured and the strength is 37Mpa shown in Fig-1. Similarly the highest compressive strength at 28 day and 56 day were observed at Micro Silica6%+ GGBS10% (SG10) mix which is lime cured and observed the maximum compressive strengths of 40.5Mpa and 48.1Mpa respectively which can be observed from Fig-2, Fig-3. It is observed that Compressive strength for (S 6) and (SG10) were high compared to all other mixes.

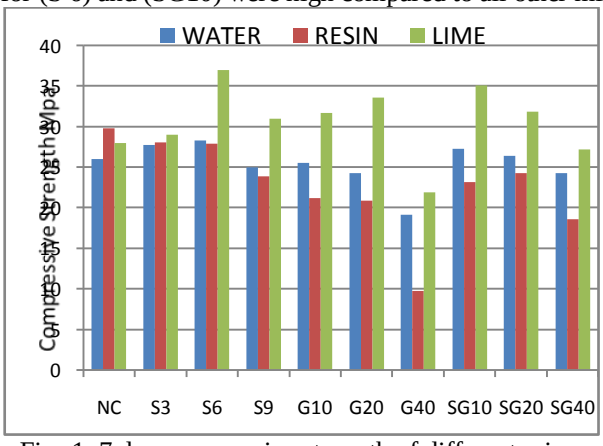

Fig -1: 7 day compressive strength of different mixes with different Curings

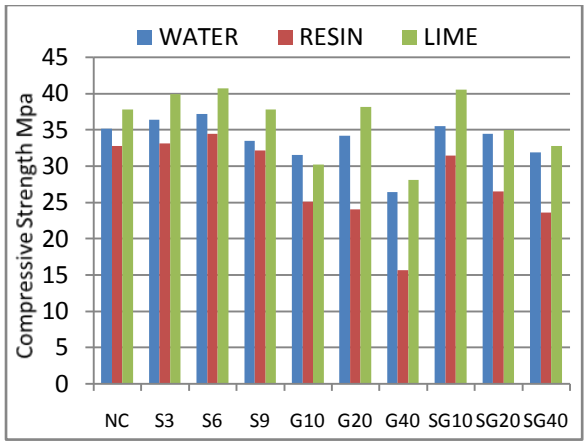

Fig -2: 28 day compressive strength of different mixes with different Curings

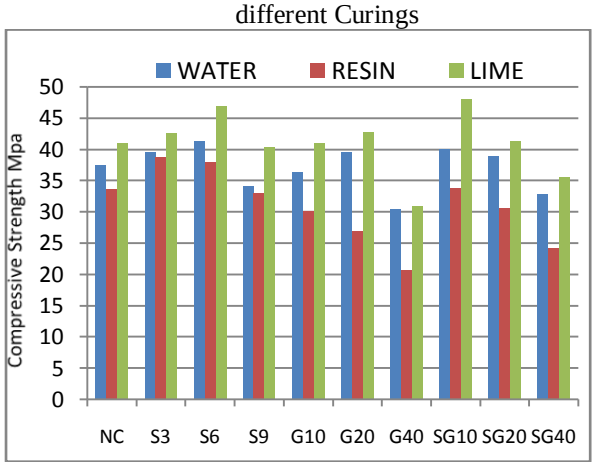

Fig -3: 56 day compressive strength of different mixes with different Curings

D. Flexural strength:

Flexural strength is the most important parameter for concrete after Compression. Beams (500*100*100mm) were casted to find the Flexural strength of all the mixes of different Curings. It is observed that in Normal concrete Flexural strength was increased in Lime cured concrete and decreased in Resin cured concrete compared with normal Water cured concrete. But by adding Micro silica the strength was decreased for both the Lime and Resin cured concrete compared with Water cured concrete. However the overall strength of concrete is increased with the addition of Micro silica. By adding GGBS strength was slightly increased with Normal concrete for 10% and 20% replacement but for 40% replacement sharp strength reduction is observed. At 10% replacement of GGBS there is slight increase of strength in Lime cured concrete compared with Normal water cured concrete. But in other cases strength was decreased by Lime and Resin curing. The 7 day strengths for Resin cured concrete were high compared other cured concretes but after 28 days Lime and Normal cured concretes was proven better. In concrete with both Micro silica and GGBS showed the best results compared with all other mixes. Concrete with 10%GGBS & 6% Micro silica showed the highest strength of 7.03Mpa and in this particular mix Lime and Resin showed higher strengths compared with

Water cured. The maximum Flexural strength at 7 day is at (S3) and is 7.11Mpa. At 28 days the maximum Flexure is observed at Micro Silica6%+ GGBS10% (SG10) 7.03Mpa. It is observed that the flexural strength is slightly decreased from 7 days to 28 days in Resin curing or Membrane curing. The Flexural strengths of all mixes at different curings were shown in the Fig-4, Fig-5.

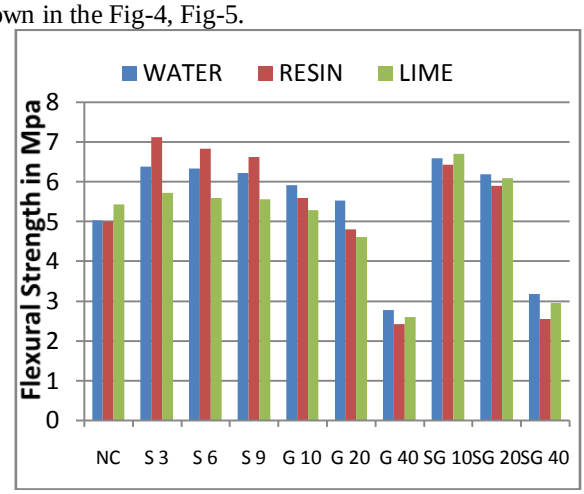

Fig -4: 7 day Flexural strengths of different mixes with different Curings

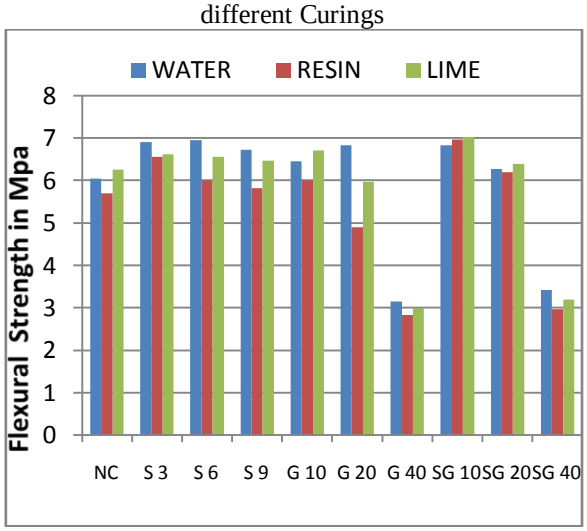

Fig -5: 28 day Flexural strengths of different mixes with different Curing

E. Ultrasonic Pulse Velocity:

It one of the reliable Non Destructive testing methods in which we get Pulse velocity by cross probing in km/sec. Table-5 Indicates the quality of concrete for particular Pulse velocity.

Pulse velocity(km/sec)	Concrete quality grading
1 Above 4.5	Excellent
2 3.5 to 4.5	Good
3 3.0 to 3.5	Medium
4 Below 3.0	Doubtful

The values of UPV is shown in the Fig 11 and it clearly shows that Lime cured concrete has very high UPV values and it indicates quality of the concrete

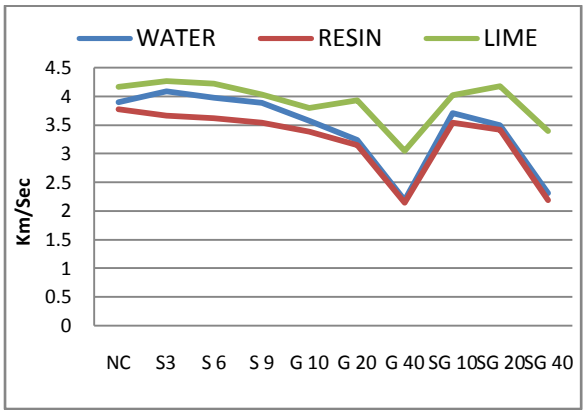

Fig-6: UPV values for different curings and different mixes at 56days.

IV. CONCLUSION

The results obtained in the research allow presenting as following:

1. The highest Compressive strength obtained is attributed to Micro Silica6% + GGBS10% (SG10) as 48.1 Mpa with Lime curing at 56 days.
2. The addition of Micro silica increased the strength of concrete by more than 10%. The optimum percent of micro silica is 6%.
3. Lime curing is very effective for all mixes of concrete and the Compressive strength is increased to a maximum of 20% compared with Normal Water cured concrete.
4. There is a sharp increase of strength in Lime cured concrete and is acting like Accelerated curing.
5. For Micro silica Resin curing is effective with very little strength loss. But it is not recommended for GGBS concrete due to significant strength loss.
6. The concrete with both Micro silica and GGBS (SG10, SG20) got good Compressive and Flexural strengths values and showed improvement in strength with Lime and Resin curings.
7. The UPV values for all Lime cured concretes were greater than Normal and Resin cured concretes which indicate the decrease of voids and denser Matrix.
8. The optimum percent of GGBS is 20% and showed slight increase in strength at 20% replacement and slight decrease in strength at 10% replacement and significant strength loss at 40%. However it is known that GGBS concrete gains strength with time.

REFERENCES

[1] Influence of silica fume on the tensile strength of concrete S.Bhanjaa, B. Senguptab, Department of Civil Engineering, Bengal Engineering College (D.U.), Howrah, West Bengal, 711103, India.
[2] Effects of Curing Condition and Curing Period on the Compressive Strength Development of Plain Concrete Akinwumi, I.I.*, Gbadamosi, Z.O. Department of Civil Engineering, Covenant University, P. M. B. 1023, Ota, Nigeria.
[3] The influence of curing conditions on strength

properties and maturity development of concrete Scott a. newbolds1, special projects engineer Indiana department of transportation.

[4] Effect of curing regime and temperature on the compressive strength of cement-slag mortars, Fathollah Sajedi Department of Civil Engineering, Islamic Azad University, Ahvaz Branch, and Ahvaz, Iran.

[5] Influence of curing regimes on compressive strength of ultra High performance concrete, Prabhat ranjan prem, B Bharatkumar and Nagesh CSIR-Structural Engineering Research Centre, CSIR Campus, Taramani, Chennai 600113, India.

[6] IS.383.1970 coarse and fine aggregates from natural sources for concrete

[7] IS.9103.1999 Admixtures Indian Standard concrete admixtures – specification

[8] IS.10262.2009 Concrete mix proportioning – guidelines.

[9] IS.12089.1987 GGBS Specifications for Granulated slag for manufacture if Portland slag cement

[10] IS.15388.2003 silica fume Specifications

[11] ASTM C 31

