International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-7, Issue-6C2, April 2019

Service Life Prediction of High-Performance Concrete with Respect to Chloride Ion Penetration by Incorporated with GGBS

G. Rajesh, B. Kameswara Rao

Abstract: ***Service life prediction, this project can play out its primary function inside the required life expectancy while guaranteeing worthy support cost. In this paper, the service life of structures presented to aggressive conditions is estimated by the plausibility of splitting and spalling of concrete cover by conducting the investigation on 120 specimens (150 mm x 150 mm x 150 mm). And vary the water-cement ratios of 0.3, 0.4, and 0.5 with respective percentage of ground granulated blast furnace slag(GGBS) added in mix of W/C- 0.3 (90%, 80%, and 70%), W/C-0.4 (80%, 70%, and 60%) and W/C- 0.5 (70%, 60%, and 50%) each ratio contains 40 cubes (18 and 12-with material compressive strength and NaCl exposer, 4 and 6 without material compressive strength and NaCl exposer) compared with respective of their curing days 28 and 90. NaCl specimens are used to drill depth (5-10 mm, 10-15 mm and 15-20mm,20-25mm) and take the powder and predict the penetration depth of chemical through the specimen and compared with and without NaCl exposer specimens. The Penetration depth of chloride ion into specimen is restricted by w/c-0.3% of 90% GGBS is give better results than others.***

Index Terms: service life prediction, plain concrete, water-cement ratio, GGBS, compressive strength, NaCl expose.

I. INTRODUCTION

Chloride diffusivity is a critical property of concrete that influences the durability and administration life of a reinforced concrete structure. The correct decision of chloride diffusivity is generally given as a kind of perspective to planning cover thickness of a strengthened concrete structure. Deterioration of reinforced concrete structures because of chloride entrance pursued by support corrosion is a developing issue everywhere throughout the world. service life forecasts are of incredible significance for existing and arranged structures. Administration life might be differently characterized, however in the present paper, it is utilized to mean the time from development until the point that the penetration of chloride ion into concrete specimen are absorbed with silver nitrate (AgNo3, 1gram of it is dissolved in one liter of distilled water) titration for different depths (5 mm, 10 mm, 15mm, 20 mm, 25 mm), percentage of GGBS varying for different water cement ratios and curing period (28, 90 days) by using NaCl curing until the brick reddish color.

Revised Manuscript Received on April 15, 2019.

G. Rajesh, P. G. Student, Civil Engineering Department, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh, India.

B. Kameswara Rao, Professor, Civil Engineering Department, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh, India.

The test conducted in this study is divided into two parts. One is concerned with Cl- concentrations and other parallel compare the compressive strength of specimens.

The chloride content in the concrete by following the (UNI) Italian standard and measured the electrochemical properties of steel bars and concluded that 0.1N silver nitrate solution is suitable for the chemical analysis of chloride concentration [1]. The effect of partial replacement of ordinary Portland cement with GGBFS on compressive strength performance and done a chemical composition of GGBFS and the setting times of the cement with different replacement amount of GGBFS for 28 days and concluded that the replacement of OPC with GGBFS gives higher compressive strength and sustainability developed in concrete structures [2]. Determination of chloride ion content in concrete by analyzing the hardened concrete for chloride ion content the total procedure for the manufacturing of hardened concrete specimens and the analysis was explained and concluded that the chloride ion can easily penetrate through iron that is attached to concrete but not only through concrete [3].

II. RESEARCH SIGNIFICANCE

By concentrate every one of the written works, one thing is generally watched each structure disappointment and harms of structures before fruition of its life expectancy as it were. Since because of different impacts, for example, material properties, blend configuration, water-concrete proportion, nature of material not just these ecological effects around the structures additionally assumes a noteworthy job of basic disappointment. Concrete containing just bond, at that point it has pores, So by supplanting the concrete with fine material like GGBS it will fill the pores in cement and furthermore discover a great deal of contrast in structure. Quality, strength in the event that solidness builds, benefit life of the structure is additionally expanding both are inter linked**.**

III. MATERIALS USED

The material used for examples were Portland slag bond (OPC), coarse total, fine total, super plasticizers and faucet water and other than this solid material two additional materials are included there are granulated impact heater slag (GGBS) and silica seethe.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

IV. ADVANTAGES OF USING GGBS

GGBS is a fine material when we use in solid, it will Reduce penetrability and Pore refinement. At the point when pores are filled entrance of fluids and gases into the solid will be not exactly concrete and it will require a long investment for steel to get eroded which is available in cement [4].

- Reduction in warmth of hydration.
- Increases substance opposition.
- Reduced chloride particle infiltration.
- High obstruction of sulfate assault [5].

Figure 1: Powder of GGBS

V. EXPERIMENTAL PROCESS

A. Casting of Cubes

The cubes of dimensions 150mm☐150mm☐150mm are casted in with different variations of GGBS and water-cement ratio as shown in Table 1, plane concrete. The materials used for casting are OPC grade 53 cement.

Table I Variation in GGBS percentages

w/c ratio	0.3			0.4			0.5		
GGBS (%)	90	80	70	80	70	60	70	60	50

B. Exposure with NaCl Solution

The NaCl Solution is prepared with the mixture of NaCl and water and let the NaCl to solve in water for 1 day and then the casted cubes are placed in this solution. A total of 12 plane concrete cubes and 36 GGBS cubes are placed in the NaCl solution and let them cured for 28 days and 90 days. Figure 2 shows Cubes that are exposed to Nacl Solution.

Figure 2: Cubes Exposed to NaCl solution

C. Drilling of Cubes

The cubes Exposed to NaCl solution and Normal water are drilled after the cubes are air dried to 24 hours and at various depths and the concrete powder obtained from the cubes are used for further purpose. Figure 3 shows the cubes during and after drilling.

Figure 3: Cubes during and after drilling

D. Material Collection and Titration

The Cubes were drilled gives a 5grams of material at each successive 5mm of depth and titrated with the $AgNO_3$ solution to obtain the results. Figure 4 shows the Materials collected and Titration done.

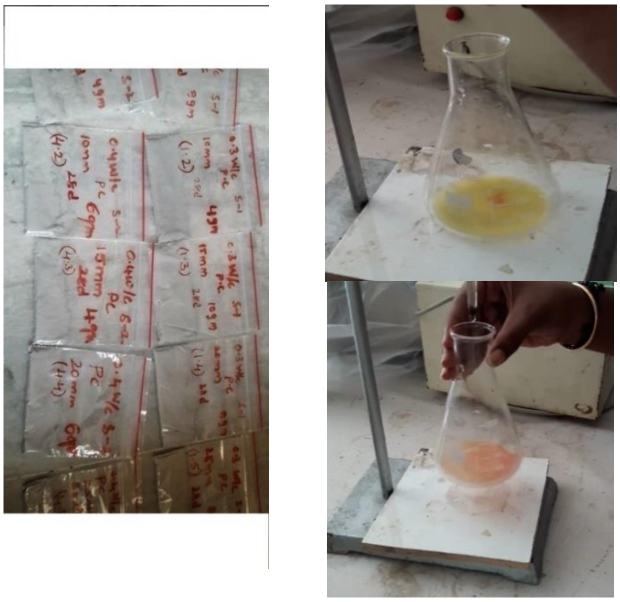

Figure 4: Materials and Titration process

*Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication*

VI. TESTS DONE FOR CUBES

A. Compressive Strength Test

Compressive strength machine is used to test the compressive forces of specimen to recover the specified compressive force which is applied manually in a period of time. The working procedure for the compression testing machine is explained as it contains 2 plates, one is fixed and the other is movable and the movable plate is used to fix the specimen cubes in the center of the loading machine and the pressure is applied manually by a pressure pump which is fixed to apply load and a dial gauge is fixed at its top to indicate the load.

Figure 5: Compressive Strength of Cubes

B. Chemical Analysis Test

The drilled concrete powder of the specimen is collected and 4grams of powder is taken in a measuring jar of 100ml and distilled with de-ionized water of 40 ml to make a solution and left free for rest to 1 hour after that 10 ml of the diluted solution is taken and 90 ml of de-ionized water is added to the above solution then again 10 ml of the solution is taken in a ml of volumetric flask. The Burette of 50ml is filled with $AgNO_3$. The volumetric flask with solution is added with 2-3 drops of potassium chromites and titrated with $AgNO_3$ then the mixture shows the pale yellow color and titrated up to end-point brick red color. The burette readings are collected.

C. Percentage of chloride ion penetration

The percentages chloride ion penetration in the concrete powder was finally calculated using the formula,

% of chloride in concrete powder $= \frac{K*N*V}{W}$

Where,

K = a constant, volume of solution taken for titration.

N = normality of AgNO3 solution, here equal to 0.01.

V = volume of AgNO3 dispended to reach the end point.

W = weight of the concrete powder.

VII. RESULTS AND DISCUSSIONS

A. Results for Compressive strength of Cubes

The cubes were cured in water for 28 days and 90 days are tested under compressive strength testing machine and the result was obtained.

Figure 6 shows the concrete compressive strength for the plain concrete for different water to cement ratio at 0.3, 0.4 and 0.5 respectively for 28 days and 90 days which shows the 90 days compressive strength as high.

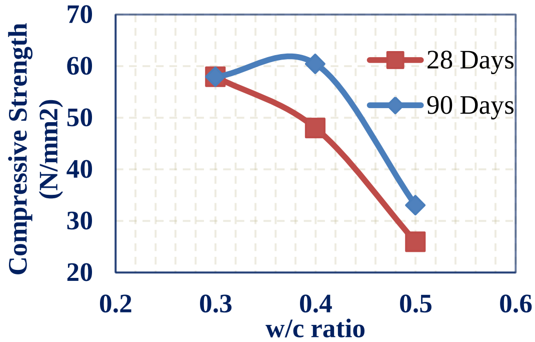

Figure 6: Compressive strength for plane concrete

Figure 7 shows the compressive strength of concrete for GGBS mixed concrete cubes for 28 days and 90 days respectively which shows the 90 days compressive strength as the highest value when compared to the plain concrete 90 days compressive strength.

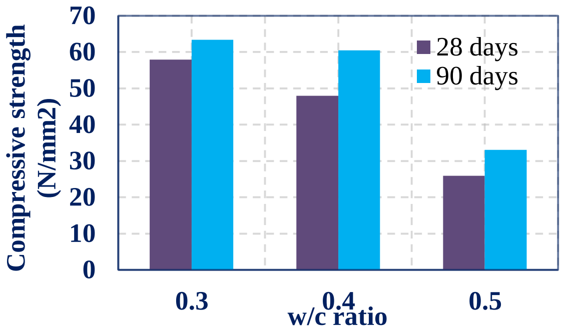

Figure 7: GGBS Concrete Compressive strength

B. Results for Exposure of NaCl solution

The specimen powder that is titrated as per the process mentioned in section V, the sample specimens gives percent of chloride ion penetration. The graphs were drawn as chloride ion penetration versus depth of penetration.

Figure 8, 9 and 10 shows the chloride ion penetration versus depth of penetration for the plain concrete with variation in water to cement ratio as 0.3, 0.4 and 0.5 respectively. The depth of penetration was observed for 28 days and 90 days and drawn in figures which show that the penetration decreases as per days increases.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

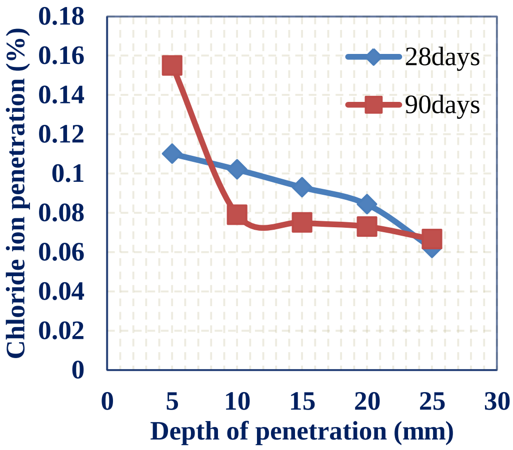

Figure 8: Plain concrete titration values

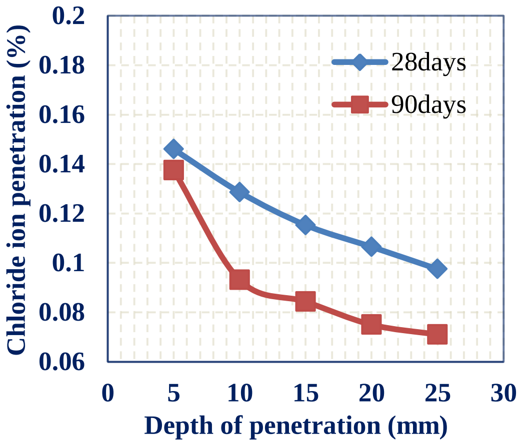

Figure 9: Plain concrete titration values

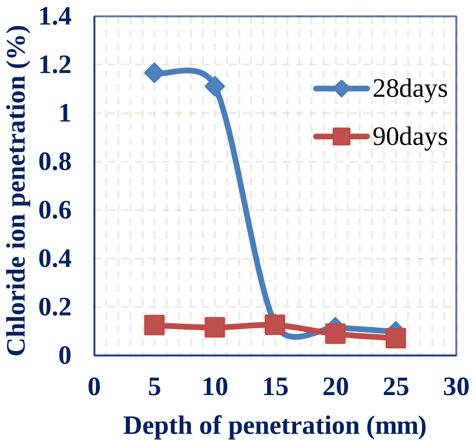

Figure 10: Plain concrete titration values

Figure 11, 12 and 13 shows that the chloride ion penetration in percent versus depth of penetration for 28 days with the variation in water to cement ratio as 0.3, 0.4 and 0.5 respectively. The figure 11 shows that the variation in GGBS percentage for 0.3 water cement ratio as 90%, 80% and 70%.

The figure 12 shows that the variation in GGBS percentage for 0.4 water cement ratio as 80%, 70% and 60%.

The figure 13 shows that the variation in GGBS percentage for 0.5 water cement ratio as 70%, 60% and 50%.

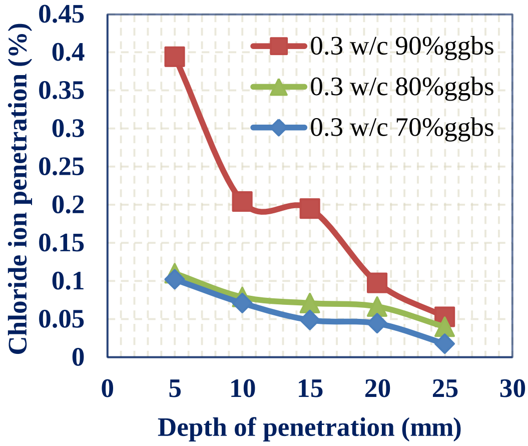

Figure 11: Chloride ion Penetration, 0.3 w/c (28days)

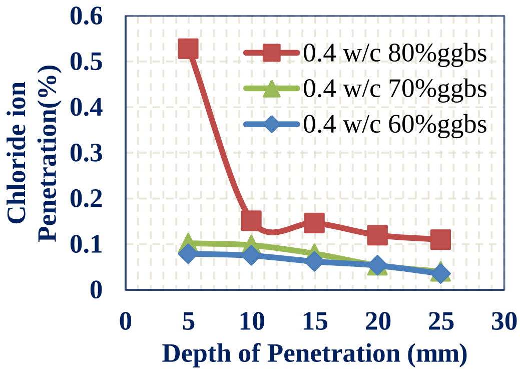

Figure 12: Chloride ion Penetration, 0.4 W/C (28 days)

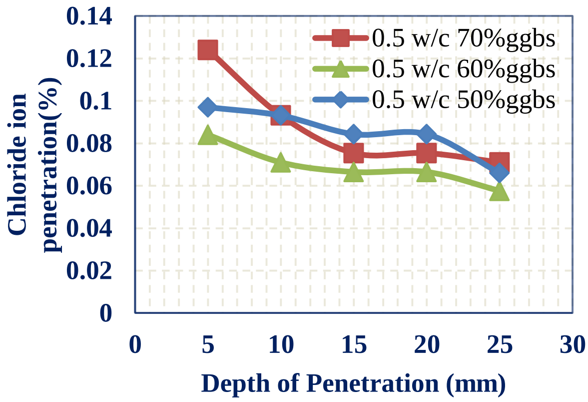

Figure 13: Chloride ion Penetration, 0.5 W/C (28 days)

Figure 14, 15 and 16 shows that the chloride ion penetration in percent versus depth of penetration for 90 days with the variation in water to cement ratio as 0.3, 0.4 and 0.5 respectively. The figure 14 shows that the variation in GGBS percentage for 0.3 water cement ratio as 90%, 80% and 70%.

The figure 15 shows that the variation in GGBS percentage for 0.4 water cement ratio as as 80%, 70% and 60%.

The figure 16 shows that the variation in GGBS percentage for 0.5 water cement ratio as 70%, 60% and 50%.

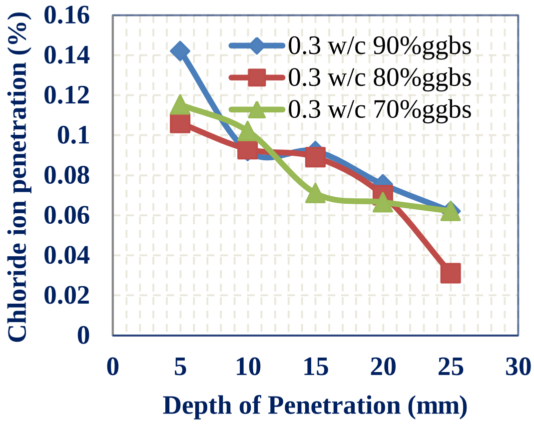

Figure 14: Chloride ion Penetration, 0.3 W/C (90 days)

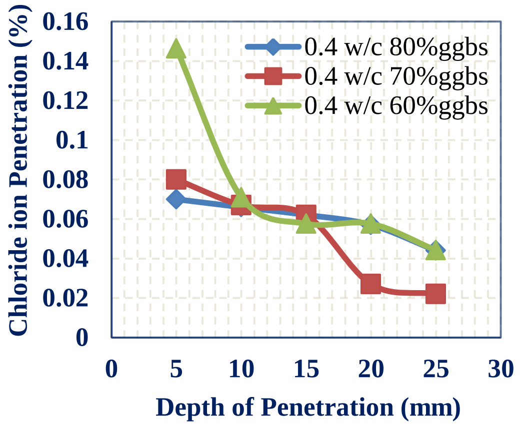

Figure 15: Chloride ion Penetration, 0.4 W/C (90 days)

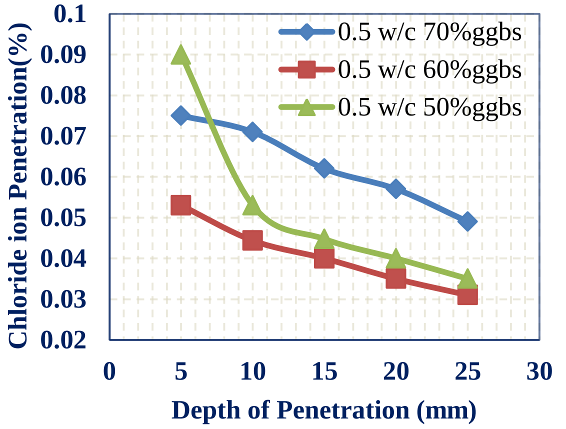

Figure 16: Chloride ion Penetration, 0.5 W/C (90 days)

Figure 17 shows the overall compressive strength for the variation in GGBS percentages replacement and in the variation in water to cement ratio.

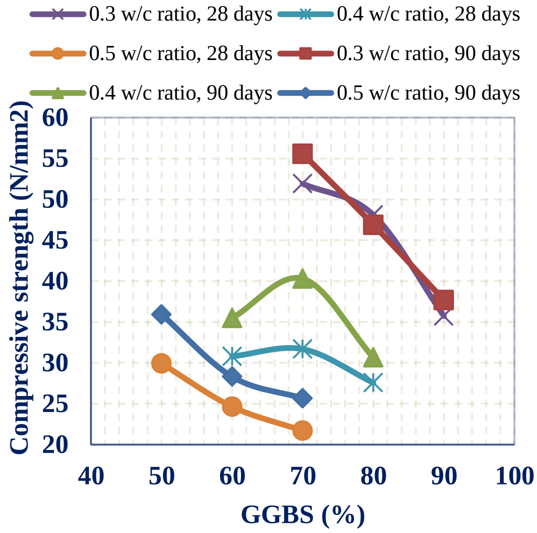

Figure 17: Overall compression values for replacement concrete

VIII. CONCLUSION

The following conclusions are drawn for the results obtained for the tests conducted for GGBS and plain concrete which includes the variation in GGBS percentage and the water cement ratio.

1. The compressive strength for the replacement of cement with GGBS gives the highest values compared to the plain concrete.
2. For plain concrete the chloride ion penetration decreases for the increase in water to cement ratio.
3. For 28 days chloride ion penetration 0.5 w/c ratio with 70% GGBS gives the highest value of penetration percentage.
4. For 90days chloride ion penetration 0.3 w/c ratio with 90% GGBS gives the highest value.

ACKNOWLEDGMENT

The authors gratefully acknowledge the Koneru Lakshmaiah Educational Foundation for the support and providing the required materials.

REFERENCES

1. Suwito, A., and Yunping Xi, "Service life of reinforced concrete structures with corrosion damage due to chloride attack," In *Life-Cycle Performance of Deteriorating Structures: Assessment, Design and Management*, 2004, pp. 207-218**.**
2. Ahmad, Shamsad, "Reinforcement corrosion in concrete structures, its monitoring and service life prediction-a review," *Cement and concrete composites*, Vol. 25, Issue 4-5, 2003, pp. 459-471.
3. Hornbostel, Karla, Claus K. Larsen, and Mette R. Geiker, "Relationship between concrete resistivity and corrosion rate– a literature review," *Cement and Concrete Composites*, Vol. 39, 2013, pp. 60-72.
4. Kumar, S., B. K. Rao, and S. Misra, "Chloride penetration resistance of concrete containing blast furnace slag," *Indian concrete journal*, Vol. 76, Issue 12, 2002, pp. 745-751.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

5. Shyam, Abhinav, Abdullah Anwar, and Syed Aqeel Ahmad, "A Literature Review on Study of Silica fume as Partial Replacement of Cement in Concrete," *International Journal of Advanced Engineering, Management and Science* 3, Issue 3 2017.
6. Chitransh, Shubham, "A Literature Review on Study of Silica fume as Partial Replacement of Cement in Concrete to reduce carbon footprint." *Journal of Structural Technology*, Vol. 2, Issue 3, 2017.
7. Cheung, Mo Shing, and B. R. Kyle, "Service life prediction of concrete structures by reliability analysis," *Construction and Building Materials*, Vol.10, Issue 1, 1996, pp. 45-55.
8. Liang, M. T., K. L. Wang, and C. H. Liang, "Service life prediction of reinforced concrete structures," *Cement and Concrete Research*, Vol. 29, Issue 9, 1999, pp. 1411-1418.
9. Song, Guangling, and Ahmad Shayan, *Service life prediction of reinforced concrete structures*. No. AP-T07/00. 2000.
10. Siemes, T., R. Polder, and H. de Vries, "Design of concrete structures for durability; example: chloride penetration in the lining of a bored tunnel." *Heron,* Vol.4, Issue *43,* 1998, pp. *227-244*.
11. VandeWater, Steve, "Why Concrete Cracks," Pdf. Internet: http://indecorativeconcrete. [March 27, 2013].
12. Martın-Pérez, B., H. Zibara, R. D. Hooton, and M. D. A. Thomas, "A study of the effect of chloride binding on service life predictions," *Cement and Concrete Research,* Vol. 30, Issue 8, 2000, pp. 1215-1223.
13. Keßler, Sylvia, Johannes Fischer, Daniel Straub, and Christoph Gehlen, "Updating of service-life prediction of reinforced concrete structures with potential mapping," *Cement and Concrete Composites,* Vol. 47, 2014, pp. 47-52.
14. Demis, Sotiris, Maria P. Efstathiou, and Vagelis G. Papadakis, "Computer-aided modeling of concrete service life." *Cement and Concrete Composites,* Vol. 47, 2014, pp. 9-18.
15. Papadakis, V. G., and S. Demis, "Estimation and validation of concrete strength and service life using software packages based on predictive models," In *Proceedings of the 12th international conference on durability of building materials and components, Porto Portugal*, 2011.
16. Vesikari, E, "Carbonation and chloride penetration in concrete with special objective of service life modelling by the Factor Approach." *VTT Technical Research Centre of Finland. VTT*, 2009.
17. Stanish, K. D., R. Douglas Hooton, and M. D. A. Thomas, *Testing the chloride penetration resistance of concrete: a literature review*. Toronto, Ontario, Canada: Department of Civil Engineering, University of Toronto, 2000.

AUTHORS PROFILE

G. Rajesh is studying Master of Technology in Structural Engineering in the department of Civil Engineering at Koneru Lakshmaiah Educational Foundation, Vaddeswaram, Guntur district, Andhra Pradesh, India. He has completed Bachelor of Technology from Srinivasa Engineering college, Razole, East Godavari District, Andhra Pradesh, India in 2014.

B. Kameswara Rao is a super annuated chief scientist from CSIR-central Building Research Institute (CBRI), Roorkee, Uttarakhand state, India. Presently he is working as a professor in the Civil Engineering Department of Koneru Lakshmaiah Education foundation, Vaddeswaram, Guntur district of Andhra Pradesh, India. He did doctorate in Structural Engineering from Indian Institute of Science (IISc), Bangalore, India in 1986.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication