IOSR Journal of Engineering (IOSR JEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 01-08

An Experimental Study on Deterioration of Concrete in Puducherry Coastal Region

K.Srinivasan[1], Dr.S.Jayakumar[2], P.Harishkumar[3], K.Mohamed Nasim[4]
[1,]*(Assistant Professor, Department of Civil Engineering, Sri Manakula Vinayagar Engineering College, Pondicherry-605107*
[2]*(Professor and Head, Department of Civil Engineering, Sri Manakula Vinayagar Engineering College, Pondicherry-605107)*
[3.4]*(UG Student, Department of Civil Engineering, Sri Manakula Vinayagar Engineering College, Pondicherry-605107*

Abstract: *The aim of this research work is to study the behavior of concert in marine environment for study period of three month along the Puducherry coast. The concrete cubes of both conventional and epoxy coated are kept at various exposure conditions like fully submerged (F.S), partly submerged (P.S) and atmospheric conditions (A.C) along the Puducherry coast. Carbonation depth, Chloride Test, Compressive strength and pH test were conducted for the samples at end of each month. The mineralogical compositions of all exposure condition to synthetic seawater for 3 months at the surface layer and at the core of tested specimens were investigated by X-ray diffraction (XRD).After 3 months of testing, concrete degradation occurred in the external surface of the samples. The most aggressive conditions are found on the partly submerged (P.S) followed by fully submerged (F.S) non-coated samples. The coated samples for all the exposure conditions were found to be unaffected during the study period.*

Keywords: *Carbonation depth, Chloride Test, Compressive strength and pH Test*

I. Introduction

The coastal morphological change in the near shore zone are induced by natural activities such as wind, wave, storm, and tides etc., which abide to seasonal. Tsunami, sea level rise. Construction of groin, breakwater, seawall, dredging and beach nourishment which are the prime response for an unstable coastal zone. Therefore, understanding the beach morphological changes in this zone is necessary and important for coastal engineering projects, *e.g.,* constructing harbors, maintaining navigation channels, and protecting the beach against erosion.

1.1 Orgin Of The Research Problem

The union territory of Pondicherry ,located on the south East Coast of India facing Bay of Bengal at latitude of 11º 56' N and Longitude of 79º 50' E. The region experiences an average of 2 to 3 cyclones annually. The wave height in the nearshore of this coast ranges between 1.0 m to 1.5 m with a wave period ranging between 7.0 sec to 9.0sec. The wave climate is very severe during monsoon with significant wave heights ranging from 4.0 to 6.0 m and wave period from 10.0 sec to 15.0 sec.

Acknowledging the elevation of the Puducherry shore line, settlement on this coast dates back to 18th century by the French .The French colony was established on a sand dune of 15 mts high, and 250 mts wide which spans along the eastern coastal stretch of South India till Cape Comarine . The coast has lost a sandy beach of nearly 1km in width two century back after the settlements and left out with 25 meters of beach opposite to the white town spanning around 3.7Km, which was evident till 1986. The construction of Groynes at the tidal inlet of the artificial fishing harbor at Veerampattinam as aggravated the situation and had led to severe erosion problem and the consequences are propagation of shore line towards in land. This phenomenon has lead to sweeping of houses which are constructed along the coast on the Northern side of the Groyne thereby affecting the coastal community.

Moreover, in order to protect the upland from severe erosion, the coast opposite to the white town of Puducherry was armored with random rubble mound seawall. Since the predominant movement of sediment is Northerly, this activity has extended the problem of erosion further in the Northern side of the coast thereby causing severe damages to coastal Hamlet villages. This study focus on the various technical aspects to safeguard the remaining beach and win back the lost beach by adopting a proper scientific approach , which could help the coastal engineers to understand and implement the coastal related activities .

Both hard solution and soft solution methods were followed in puducherry coastal region which to protect the coastal form of erosion. The hard solution are groyne, breakwater, seawall etc. Soft solution are artificial beach nourishment using river sand. The main aim of this paper is to find a suitable local substitute for

the high density iron ore. High density concrete observes neutrons which are accurate construction material which protects from irradiated rays and causing harmful effects to environment and living things, another important aspect is resistant against freeze and thawing cycles and weathering effects. High density concrete or heavy weight concrete is concrete should have density greater than 2600kg/m^3.

High density concrete can be made from natural heavy weight aggregates are commonly used having specific gravity ranging from barites (2.5 - 3.5), magnetite (3.5 - 4.0) and hematite (4.0 – 4.5) occasionally. the portion of either coarse aggregate or fine aggregate, these give even greater densities of 5900kg/m^3 for iron. And also 50% of replacing the Hematite. the portion of either coarse aggregate or fine aggregate, these give even greater densities of 5900kg/m^3 for iron. XRD analysis have many applications in concrete such measurement of glass content in pozzolanic material, degree of hydration, and also in predicting the strength of slag cements.

High volume blended concrete specimens were analysed using XRD after 365 days of drying and also for few concrete speciemens after 180 day if dring using two w/b ratios of 0.38 and 0.48. the mix design of the high strength concrete (HSC) concrete with specified characterised compressive strength of 50N/mm2, The hematite are partially replaced a fine aggregate. High strength concrete gives strength and durability than the ordinary concrete. Ordinary concrete and Standard concrete may as with specified characteristic compressive strength of 150 mm cube at 28 days between 10 to 20 N/mm^2 25 to 55 N/mm^2 respectively. The High strength concrete may as with specified characteristic compressive strength 150N/mm cube at 28 days between 60 to 80 N/mm2. Hematite aggregates are partially replaced in high strength concrete by 0%, 10%, 20%, and 30% of weight of natural coarse aggregate used.

II. Materials and Mix Proportion

2.1 Cement

In order to withstand the chemical attack of coastal environment, Ordinary Portland cement is selected. Ordinary Portland cement is tested as per IS1489 (Part 2). The total quantity of cement required is approximately estimated. The physical properties of material such as consistency, initial and final setting time and specific gravity were tested in accordance with IS 4031-1968.

2.2 Fine Aggregate

Locally available river sand was used in this investigation as fine sand. Fine aggregate was tested for physical properties such as gravity, density, fines modulus and water absorption as per IS:2386-1963. Sieve analysis of fine aggregate was done and presented in the table 1. Gradation curve is shown in the Figure 1 respectively.

Table-1: Sieve Analysis of Fine Aggregate

Is sieve	weight retained(g)	Weight retained (%)	Cumulative % of weight retained	Cumulative passing (%)
4.75	0.017	1.17	1.7	98.3
2.36	0.044	4.4	6.1	93.9
1.18	0.200	20	26.1	73.9
0.600	0.386	38.6	64.7	35.3
0.300	0.140	14.0	78.7	21.3
0.150	0.186	18.6	97.3	2.7
0.075	0.010	1.0	98.3	1.7
Remaining	0.001	0.1	99.3	0.7

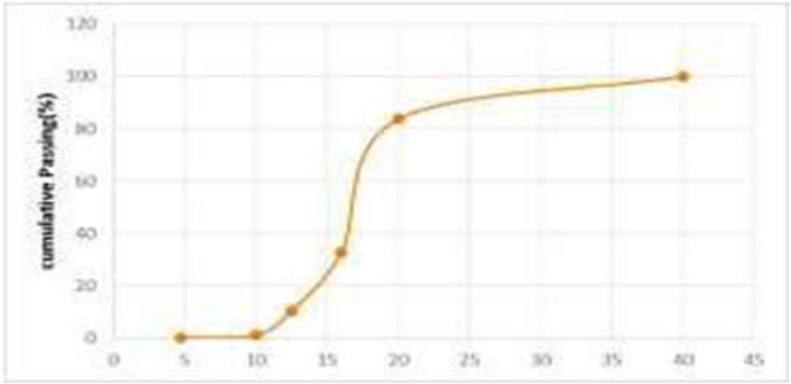

Fig 01.graduation curve of fine aggregates

2.3 Coarse Aggregate

Locally available coarse aggregate are used for the test. The natural aggregate was tested for the physical and mechanical properties like sieve analysis, specific gravity, water absorption and density as per IS: 2386-1963. The sieve analysis and gradation curve of coarse aggregate was presented in table 2 and figure 2 respectively.

Table-2: Sieve Analysis of Coarse Aggregate

Is seive size	Weight retained (gm)	Weight retained (%)	Cumulative % of weight retained	Cumulative passing %
40	0	0	0	100
20	1.623	16.23	16.23	83.7
16	5.123	51.23	67.48	32.52
12.5	2.226	22.26	89.74	10.26
10	0.923	9.23	98.97	1.03
4.75	0.089	0.89	99.86	0.14

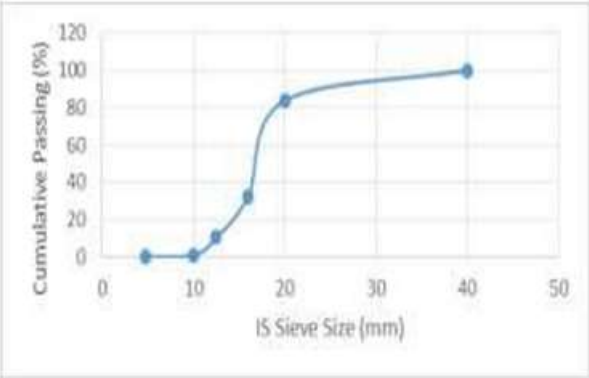

Fig 2 gradation curve of coarse aggregate

2.4 Concrete Mix Design

Concrete mix design is made in accordance with IS 10262– 2009 for the M 50grade concrete. For 1 cum of concrete and water / cement ratio = 0.40

Table-3: Mix Proportion for M 35 grade concrete

Material	Quantity
Cement	422 kg
Fine Aggregate	703 kg
Coarse Aggregate	1264 kg
Water	151 kg
Chemical Admixtures	7 kg

III. Specimen Preparation and Test Method

The specimens were casted in cubes of size 150 mm lengths, 150mm breadth and a height of 150 mm in two layers each layer being consolidated using a vibrating table. Total no of cube casted was 98. Mixing was according to IS 10262 – 2009. Coarse aggregate was first added to the mixer, followed by approximately one third of mixing water, and then the mixer was started. Fine aggregate, cement and the remaining water were added to the running mixer in a gradual manner. Fresh mixes were tested for workability by slump in accordance with IS: 1199 (1989).Following the casting concrete specimen was covered with wet gunny bags and kept in laboratory at a room temperature of 24 hours. After demolding, specimens were placed in curing tank for 28 days. Curing was done according to IS: 9013-1978.Special care was taken not to dry out the specimens prior to testing. After curing period the cubes were taken and 21 no of cubes out of 42 were painted with epoxy and then it was transferred to its respective location and exposure condition.

Table-4: Number of cubes and their location

	Pondicherry Beach		Verampattinam		Total
Exposure Condition	**Coated**	**Non Coated**	**Coated**	**Non Coated**	**no of Cubes**
Atmosphere	3	3	3	3	12
Partly Submerged	3	3	3	3	12
Fully Submerged	3	3	3	3	12

3.1 Test Method

3.1.1 Compressive strength

The concrete cubes of size 150x150x150 mm were tested after the samples being brought from the site in accordance with IS:516-1969 using compressive testing machine .

3.1.2 Water Soluble Chloride Content

This test is done as per IS: 14959 (Part II) - 2001. Samples are collected from hardened concrete specimen at 1 and 2 cm from the surface by chiselling process. Sieve the crushed samples through 850µm IS sieve. Thoroughly blend the material. Weigh 1000±5 g of the pulverized concrete sample in a 2 litre capacity beaker and add 1000 ml of distilled water (chloride free). Stir the mixture vigorously and warm gently for 15 minutes. After that allow the mixture to stand for 24 hour for settling. To prepare chromate indicator dissolve 5 of potassium indicator in 100 ml of distilled water. To prepare standard silver nitrate solution (0.014) dissolve 1.698 gm of silver nitrate in distilled water and dilute to 1 litre.

Take about 200 ml of the supernatant solution into a clean dry 250 ml capacity beaker. Immediately, filter the and collect the filtrate. Pipette 50ml of filtrate in a conical flask. Add 2 drops of potassium chromate which acts as an indicator. Titrate this solution against silver nitrate solution till yellow colour of the solution turns brick red which shows the end point. From this value the amount of chloride penetrated can be determined.

Chloride in mg/l = (A–B) x AgNO3 x 35.43 x 1000 x 0.05

Where A= Volume of Silver Nitrate consumed for sample

B = Volume of Silver Nitrate consumed for distilled water.

3.1.3 X-Ray Diffraction Test

Concrete powder was extracted by using a chisel from the specimen surface. The samples obtained were grinded and sieved up to 200 mesh. Samples were kept under dry conditions until XRD analysis was carried out. A portion of each sample (0.1 g) was introduced in a Bragg-Brentano Geometry X-ray diffract meter (Siemens D5000). The equipment operated with a CuKα radiation (λ = 1.5416 Å °), with a step size of 0.01° (2θ) every 5 seconds. This X- Ray Diffraction test gives the Dolomite, calcite and quartz content in the sample which can be compared with ICDD (International Centre for diffraction data).

3.1.4 Carbonation Depth

The carbonation depth is measured by using phenolphthalein indicator. The phenolphthalein indicator is made by diluting 1 g of phenolphthalein powder in 90 percent ethanol solution. This phenolphthalein solution when sprayed over the concrete surface shows pink colour when not affected by carbonation and colourless when affected by carbonation which shows the surface penetration of CO_2.

3.1.5 pH Test

The pH test can be determined by using either litmus paper or electronic pH meter. Initially the basic nature of the sample is determined by using litmus paper in which the colour change of the paper is noted. Later the crushed samples from the surface of concrete are immersed in water for a period of 24 hours and later tested using pH meter.

3.1.6 Chloride Visual Test

Presence of chloride over the surface can be determined by using silver nitrate solution. Silver Nitrate when sprayed over the surface reacts with chloride to form silver chloride which is white precipitate. In absence of chloride silver reacts with hydroxide and forms a brown precipitate.

IV. Result and Conclusion

A total of 42 cubes were casted which includes both conventional cubes and epoxy coated cubes were placed at various harbour and coastal environmental condition such as fully submerged, partly submerged and

atmospheric conditions. The following tests were conducted to determine the condition of the cubes at various exposure conditions as discussed below.

4.1 Compressive strength

The compressive strength of the cubes were tested and it is found to be in accordance to M55 grade concrete. The compressive strength of the cubes does not vary much. The tables 5 and 6 and figures 3 and 4 indicates the values of compressive strength and it's comparison respectively.

Table 5: Compressive Strength Values of Veerampatinam site.

Exposure Condition	First Month (N/mm^2)	Second Month (N/mm^2)	Third Month (N/mm^2)
Atmosphere	50.40	49.8	51.43
Partly Submerge	48.37	46.53	43.77
Fully Submerged	50.2	49.6	48.75

Table 6: Compressive strength Values at Beach site

Exposure Condition	First month(N/mm^2)	Second Month (N/mm^2)	Third month (N/mm^2)
Atmosphere	49.76	51.8	53.2
Partly Submerge	48.77	47.2	45.6
Fully Submerged	51.15	50.82	50.62

4.2 Chloride Content

The chloride content were estimated by using titration process. It was found that maximum chloride content is for partially submerged samples and they are 0.3759 and 0.3666 percentage by weight of cement for beach and verampattinam sites respectively. The figure 5 to 10 shows the comparison of chloride content in concrete cubes under various exposure conditions.

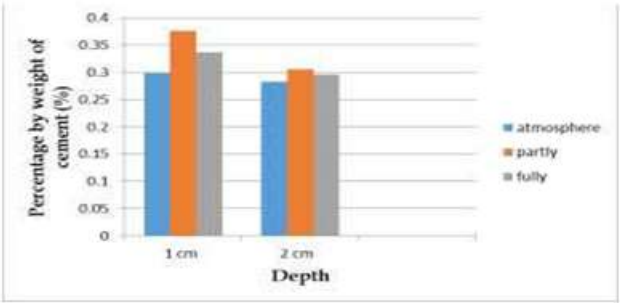

Fig 4: chloride content of first month in veerampattinam site

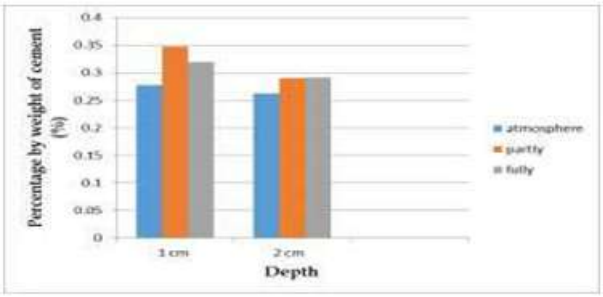

Fig.5: chloride content of second month in veerampattinam Site

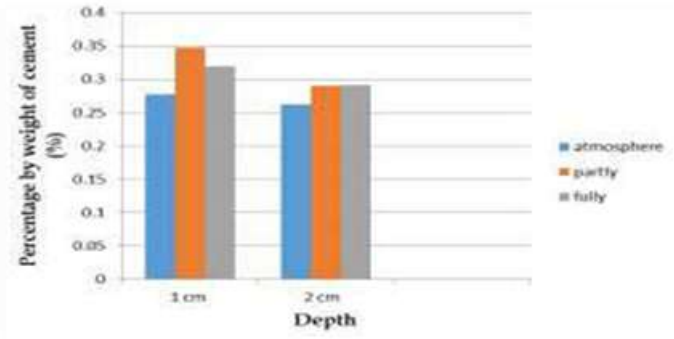

Fig.06: Chloride content of Third month in Veerampattinam Site

4.3 X-Ray Diffraction

The x-ray diffraction test were conducted for samples exposed to various conditions such as Partly submerged – Harbour, Partly submerged-Beach , Fully submerged – Harbour ,Fully submerged-Beach and Atmosphere condition to determine the elemental analysis .The concrete samples were chiselled out from the surface of cube to a depth of 5 mm and tested for the mineral content. The calcite and quartz content were found to be high for atmosphere samples. For fully and partly submerged samples the mineral content over the surface have been eroded and washed away thereby reducing the mineral content. The figure 11, 12 shows the graphs for calcite and quartz under various exposure conditions in non-coated samples.

4.4 Carbonated Depth

Phenolphthalein indicator was used to determine the carbonated effect on the cubes. It was found that the partially submerged non-coated cubes at both harbour and beach site was found to be affected by carbonates over the surface, when analysed for three months of exposure condition. Traces of carbonation were found in the cubes at fully submerged conditions on the third month. There were no traces of carbonate for cube at atmospheric condition. The coated cubes when tested for carbonation was found to be unaffected by all three exposure conditions for both harbour and beach site. The figures 13,14,15 shows the samples tested for carbonated depth.

4.5 pH Values

The pH of the concrete samples are measured by using electric pH meter. The pH of the atmospheric samples is found to be around 12.4. But for partly and fully submerged samples its pH ranges from 11.5 to 12.2. For all other exposure conditions and coated cubes, pH was found to around 12.5 which is as same as that for ordinary concrete. The table 7 shows

Table 7: pH values at the surface of samples

		Exposure Conditions		
Months	**Exposure Conditions**	**Atmospheric**	**Partly-submerged**	**Fully-submerged**
1.	Harbour	12.28	11.8	11.92
2.	Harbour	12.4	11.9	12.1
3	Harbour	12.31	11.5	11.8

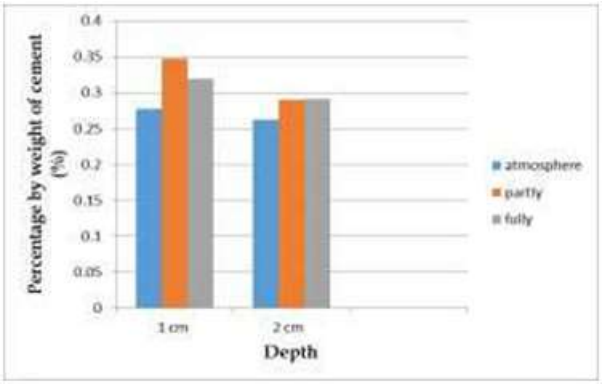

Fig.07: pH values at the surface of samples

4.6 Chloride Visual Testing

Silver nitrate solution was sprayed over the surface of concrete cubes in order to indicate the presence of chloride. The partly submerged and fully submerged uncoated cubes are influenced by the presence of chloride. The visual chloride observation shows that the uncoated cubes exposed to atmosphere and coated cubes for all exposure condition were not affected by chloride attack. The figure 16 shows the cube tested for chloride.

Fig.8: Attacked surface

4.7 Weight Comparison In Percentage

The weight comparisons of partly submerged and fully submerged samples are as shown below. In epoxy coated cubes the weight loss is minimal of nearly 0.005 percentage by weight of concrete which is mainly due to the wave actions. The figures 5.9, 5.10 shows the comparison of weight loss in different samples.

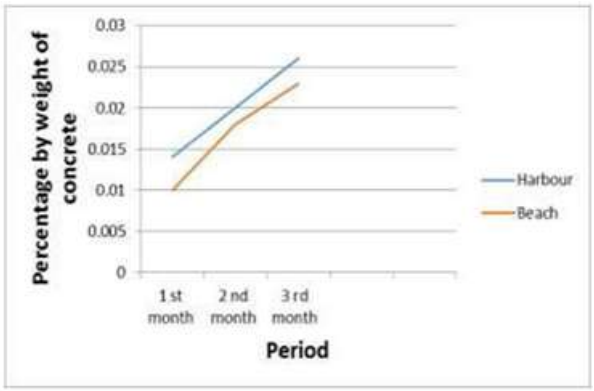

Fig.9: Comparison of weight loss in partly submerged Samples

V. Conclusion

After 3 months of testing, concrete degradation occurred in the external surface of the samples. The most aggressive conditions are found on the partly submerged (P.S) followed by fully submerged (F.S) non-coated samples. The atmospheric samples for all the exposure conditions were found to be unaffected during the study period.

- The influence of carbonation is found only on the surface of the atmospheric sample for all the three exposure conditions which shows the sign of surface penetration of CO_2 leading to initial deterioration. No significant influence of carbonation is in epoxy coated cubes.

- The chloride was found to be more in partly submerged samples compared to fully submerged sample which are the primary agents of deterioration.

- Physical test (compression test &loss of weight) results shows that partly submerged samples have more weight loss when compared to other conditions. This is mainly due to impact of waves.

- The minerals such as Quartz and calcite are found to be very less for partly submerged samples due to the eroding action of waves.

- From the research, it was found that there is an increase in the rate of deterioration of concrete cubes under partially submerged condition when compared with fully submerged and atmospheric conditions. Hence the surface exposed to alternate wetting and drying of the coastal structures can be coated with epoxy coating so as to minimize the deterioration process.

Acknowledgment

I would like to thank my guide Mr.K.Srinivasan , Assistant professor, Department of Civil Engineering for his support, valuable advices, suggestions and tremendous help in carrying out the study successfully. I would like to thank Dr.S.Jayakumar, Professor and Head, Department of Civil Engineering, Sri Manakula Vinayagar engineering College, Pondicherry for his continual support, constant encouragement and incalculable help for conducting the study. I am intended to thank as he has been a great source of inspiration for us. I would like to express our heartfelt gratitude to our director cum principal, Dr.V.S.K.Venkatachalapathy, Sri Manakula Vinayagar engineering College for providing us a well-equipped laboratory facility to carry out this research work.

References

[1]. Neelamani and sundarvadivelu 2006. Investigation on the reasons for erosion of Pondicherry Coast, South East Coast of India; Journal of Coastal Research, SI 39 (Proceedings of the 8th International Coastal Symposium), 880 - 883. Itajaí, SC, Brazil, ISSN 0749-0208.

[2]. Nam, P.T., Larson, M., Hanson, H., Hoan, L.X., 2009. A numerical model of near shore waves, currents, and sediment transport In: Coastal Engineering, Vol. 56, 1084-1096.

[3]. Nam, P.T., Larson, M., 2010. Model of near shore waves and wave induced current around a detached In: Journal of Waterway, Port, Coastal, and Ocean Engineering, Vol. 136, No. 3, 156-176.

[4]. Larson, M., Camenen, B., Nam, P.T., 2010. A unified sediment transport model for inlet application Submitted to: Journal of Coastal Research (in press).

[5]. Rajalakshmi P.R. and Usha Natesan, 'Dynamics of Pulicat mouth', November 2006, Accepted in the Journal of Engineering today.

[6]. Wasim Khaliq, Muhammad Basit Ehsan, Crack healing in concrete using various bio influenced self-healing techniques, Construction and Building Materials 102 (2016) 349–357.

[7]. Nasiru Zakari Muhammad, Arezou Shafaghat, Ali Keyvanfar, Muhd Zaimi Abd. Majid, S.K. Ghoshal, Seyed Esmaeil Mohammadyan Yasouj, Abideen Adekunle Ganiyu, Mostafa Samadi Kouchaksaraei, Hesam Kamya, Mohammad Mahdi Taheri, Mostafa Rezazadeh Shirdar, Ronald McCaffer, Tests and methods of evaluating the self-healing efficiency of concrete: A review, Construction and Building Materials 112 (2016) 1123–1132.

[8]. Mian Luo, Chun-xiang Qian, Rui-yang Li, Factors affecting crack repairing capacity of bacteria-based self-healing concrete, Construction and Building Materials 87 (2015) 1–7.

[9]. Y. C. Guo, X. Wang, Z. Yan & H. Zhong, Current progress on biological self-healing concrete, ISSN: 1432-8917 (Print) 1433-075X.

[10]. S.Krishnapriya , D.L.Venkatesh Babu, G.Prince Arulraj, Isolation and identification of bacteria to improve the strength of concrete, Microbiological Research S0944-5013(15)00050-6.