INFLUENCE AND EFFECT OF MARINE SALTS BEHAVIOUR AROUND THE BRIDGE SECTION

***Jayavasakan.S, ** Santosh Raja.V**

**M.Tech. Student, Department of Civil Engineering, PRIST University,*
***Assistant Professor, Department of Civil Engineering, PRIST University, Thanjavur, Tamilnadu, India.*

ABSTRACT

Concrete when exposed to seawater may deteriorate from the influence and effects of chemical and physical processes of the marine environment. The influence of marine salts and chemical ingredients in the seawater can easily corrode the concrete and steel in the bridge structures which results in reducing the strength and durability. To prevent and overcome the above damage which reduces the durability the quality requirements are studied for concrete and steel used in the bridge section. The paper presents results on the mechanical properties and durability under marine exposure of a reinforced concrete.

Keywords: M40, Durability, Salinity, Corrosion, Permeability and Seawater

INTRODUCTION

The prediction of Service life of concrete structures mainly depends on deterioration due to reinforcement corrosion. The design of the concrete structures must be based on models where deterioration is measured more accurately. In marine environment two stages are considered a) the initiation period corresponding to the critical penetration of the salts up to the level of reinforcement and b) the propagation period to the reinforcement corrosion and its effects on the bridge structure.

The ionic concentrations present in marine breeze and seawater are considered the main external agent for causing damage to reinforced concrete in marine environments. This study analyzes the changes in concrete contour on samples exposed to continuous immersed seawater, alternated wet /dry in seawater at atmosphere and continuous weathering at atmosphere.

Durability of a concrete structure depends on the marine environment in which it is exposed, as also on the time and properties of concrete. The property of Permeability is important in determining sensibility of concrete to external factors. For high Service life the concrete must be in low permeability that is strongly linked to porosity of the concrete paste. The extent of the damage depends on concrete quality.

Concrete offers corrosion protection to carbon steel. Inner causes of damage occurs due to the chemical reactions inside concrete, volume changes occur by differences in physical and chemical properties of aggregates and cement paste and particularly to its sea water permeability.

Damages on concrete induced for environment are due to the penetration across the pores in concrete, of aggressive agents as chloride (Cl^-), sulfate (SO_4) sodium (Na^+) and others ions, as well as carbon dioxide (CO2) and oxygen (O2) dissolved in sea water. When these deleterious substances reach the surface of steel reinforced, the corrosion process starts. Concrete structures such as Jetties, Wharves, Bridge structure elements, offshore platforms and retaining walls etc. are all influenced by marine environment and marine salts

AIM AND OBJECTIVES

Bridge is the only way to travel and exchange of goods in an economical way in which the area of world is covered by 70% water by seas, oceans and rivers. Bridge is the structural element which has concrete and steel. Structures located in the off shore consist of major portions of concrete and steel structures.

The salt and chemical ingredients in the seawater can easily corrode the concrete and steel in the structures which results in reducing the strength and durability. To prevent and overcome the above damage, the quality requirements are studied for concrete used in the marine structures. The influence and the effects of the penetration of the salts and salinity in concrete modals are studied.

PROPOSED SYSTEM

The durability of the concrete structures in marine environment also depends on the properties of the sea water, tides, freeze and thawing and salinity. Concrete exposed to marine environment deteriorates due to the result of combined effects of physical and chemical action of seawater. Attack on concrete due to the actions it tends to increase the permeability and not only this make the material progressively more susceptible and further action by the same destructive agent but also to other types of attacks. Thus when a concrete structure exposed to seawater the degradation is in an advanced stage. Thus concrete cubes are made in M40 mix ratio and tested for permeability and compression strength.

EXPOSURE OF STRUCTURE

Structures in marine environments can be divided into two categories of exposure such as direct and indirect. The direct exposure category includes that are partially or fully submerged, and indirect category includes structure along the coastline which does not come into direct contact with sea water. Jetties, Wharves, Bridge Substructure elements, offshore platforms and retaining walls are some examples of structures in direct exposure category, and multi-storied condominiums along the cost are example of structure in the indirect exposure category.

SALINITY

Salinity is a measurement expressed as parts per thousand (ppt) .The ratios of weight of dissolved salts to total weight is salinity. Out of the total seawater 75% has salinity between 34-35 ppt. The average salinity in the oceans is 34.7 ppt i.e., on an average there is 34.7 g of salt in every kg of seawater. Salinity in the northern Bay of Bengal can be as low as 31 ppt because the bay receives lots of freshwater due to heavy rain and from runoff of surrounding rivers (Ganga, Brahmaputra, Godavari and others rivers). Salinity near the surface in the Arabian Sea is much higher than in the Bay of Bengal because evaporation in the Arabian Sea is greater and it receives relatively less rain and runoff from rivers.

DURABILITY

The concrete in marine structures should be very low permeable. Concrete must have high resistance to freezing and thawing. There should be good resistance to deicing salts and chemicals. There should be close elastic compatibility between the aggregate and the mortar. The bond between the aggregate and cement paste should be superior. The structural reinforcement should be anti corrosive and should be protected from formation of rust

SERVICE LIFE DESIGN

Inadequate durability is the most common cause of failure of concrete structures. In design process. Generally durability is covered by prescriptive code requirements.. However, this approach is suspect when applied to new materials or to design lives longer than relevant experience. Service lives of 120 year and longer are regularly being specified, even though reinforced concrete structures did not exist 100 years ago. The penetration of salts (dissolved solids) in the models is essential for the assessment of the durability and service life of concrete structures exposed to marine environment.

METHODOLOGY

MATERIALS

CEMENT:

The cement in the concrete provides protection to the reinforcing steel against corrosion by maintaining a high PH in the order of 12.5-13 to the presence of $Ca(OH)^2$ and other alkaline materials in the hydration product of cement, and by binding a significant amount of total chlorides. OPC of 43 grades in one lot was procured and stored by air tight. The cement used was fresh, i.e., used within three months of manufacture. It should satisfy the requirement of IS 12262.

WATER:

The Ordinary drinking water available at the construction laboratory was utilized for preparation of concrete for casting all specimens of this investigation. Ordinary water available is used for the curing purpose.

FINE AGGREGATE:

Aggregates containing chloride salts cause serious corrosion problems, particularly those available near seas and those whose natural sites are in ground water containing high concentration of chloride ions. A fine aggregate got from the river is used for experimental purpose. Fine Aggregates clean from silt, organic material, salt and clay and it was clean and dry. It is of size retained in 1.19 micron sieve. Here fine aggregate is got from Kollidam River.

COARSE AGGREGATE:

The coarse aggregate should be strongest and porous component of concrete. The coarse aggregate in concrete reduces the drying shrinkage and other dimensional changes occurring on account of movement of moisture. The Coarse Aggregates is clean and dry. The Maximum size of aggregate is 20mm. The coarse aggregate used passes in sieve 19 mm and retained in sieve of size 11.4 mm sieve. It is well graded (should of different particle size and maximum dry density and minimum voids) and cubical in shape. The coarse aggregate from karur quarry is used.

WATER CEMENT RATIO:

Water cement ratio is kept low. It decreases the concrete permeability, which in turn reduces the porosity and shrinkage cracks in concrete. Water cement ratio 0.40 was used for casting all the specimens of this investigation.

DESIGN MIX FOR M40 CONCRETE

The design mix of concrete is done as per IS 10262:2009 method. The cement, Sand, Coarse aggregate and water is calculated and taken in the following quantity.

Water	Cement	Fine aggregate	Coarse aggregate
185.4 kg or ltr	463.5 kg	530.27 kg	1153.13 kg
0.40 part	1 part	1.14 part	2.49 part

Taking 50 kg of cement, the quantities of other materials are worked out and taken as below:

Cement = 50 kg

Dry Sand = 57.20 kg

Dry Coarse aggregate = 124.40 kg

Water = for w/c ratio of 0.40, quantity = 20 liters of water

WEIGH UP OF CEMENT

WEIGH UP OF COARSE AGGREGATE

WEIGH UP OF FINE AGGREGATE

MIXING OF MORTOR

LAYING OF CONCRETE IN MOULDS

CONCRETE LAID IN MOULDS

CURING IN FRESH WATER

CUBES LAID IN SEA WATER

SEA WATER

Major ions in seawater of salinity 35 are considered. Most seawater is fairly uniform in chemical composition, which has the presence of about 3.5 percent soluble salts by weight. The ionic concentrations of Cl^- and Na^+ are the highest. The pH of seawater varies between 7.5 and 8.4. The value of the seawater taken is 8.2. A quantity of 200 liters of sea water is taken for immersing of concrete cubes. The amount of dissolved solids in sea water is given below.

CHEMICAL S IN SEA WATER

Symbol	Name	% of total	mmoles	gms/kg
Cl^{-}	Chloride	55.29	546	19.353
Na^{+}	Sodium	30.74	469	10.76
Mg^{2+}	Magnesium	3.69	53	1.292
SO_4^{2-}	Sulphate	7.75	28	2.712
Ca^{2+}	Calcium	1.18	10.3	0.412
K^{+}	Potassium	1.14	10.2	0.399
Total		99.8		34.928

MAKING OF CONCRETE CUBES

The concrete cube moulds are prepared clean from dust and the sides are cleaned to have a smooth surface in which the removing of cubes casted can be easily done. The size of the mould is 150x150x150 mm. The concrete is prepared as per the design mix and laid in the moulds in three layers. Each layer is compacted using compaction rod for 30 punches. Six concrete modal cubes are prepared for the penetration test and crushing strength test. The dry weight of the concrete samples A, B & C is measured in weighing machine and the weight is given in the table.

The curing of all six concrete cubes is done by lying in fresh water for 28 days. The wet saturated weight of the concrete samples A, B & C is measured and the weight is given in the table. Then three concrete cubes A, B & C are immersed in sea water for 40 days.

The three samples D, E & F are tested for crushing strength in crushing machine and the readings are noted. From the readings the compressive strength of concrete is derived and given in the table below.

The three concrete cubes A, B & C which are immersed in sea water for 40 days is taken out and the saturated weight including the salt penetration is measured and the weight is given in the table.

WEIGHMENT OF DRY CUBE 150X150X150MM

WEIGHMENT OF CUBE DIPPING IN SEAWATER FOR 40DAYS

CONCRETE CUBE BEFORE CRUSSING 150X150X150MM

CONCRETE CUBE AFTER CRUSHING

IMPLEMENTATION & RESULTS

The results of the six sample concrete cubes are given in the tabulation below. The difference in the wet weight of concrete is derived and given in the tabulation The wight of cement is calculated for each concrete cube and given as below. The marine salt ions penetration in % with cement weight calclated and given in the tabulation. The crushing of the concrete cubes is done and the load at which the concrete cubes crushed is noted. The compressive strength of concrete cube samples is calculated dividing the crushing load obtained from the crushing machine and the area of the cube.

SAMPLE NOS	DRY WEIGHT	WET WEGHIT AFTR 28 DAYS	WET WEIGHT INCLUDING SALT PENETRATION AFTER 40 DAYS
A	8.150	8.300	8.304
B	8.120	8.280	8.287
C	8.140	8.290	8.300

WEIGH OF CONCRETE CUBE SAMPLE

SAMPLE NOS	WEIGHT OF CEMENT	DIFFERENCE IN WEGHT	SALT IONS PENETRATION IN % WITH CEMENT
A	1.760	0.004	0.227
B	1.754	0.007	0.399
C	1.758	0.006	0.341

CHLORIDE AND OTHER SALT IN % WEIGHT OF CEMENT

SAMPLE NOS	CRUSHING STRENGTH AFTER 28 DAYS FRESH WATER	CRUSHING STRENGTH AFTER 40 DAYS IN SEA WATER AFTER FRESH WATER CURING
A	--	54.21
B	--	51.57
C	--	52.10
D	48.12	--
E	47.55	--
G	49.33	--

CHLORIDE AND OTHER SALT IN % WEIGHT OF CEMENT

(IJAER) 2016, Vol. No. 11, Issue No. IV, April **e-ISSN: 2231-5152, p-ISSN: 2454-1796**

RESULTS AND DISSCUSSION

Summarizing this influence of the environmental effects is of great importance especially the micro environment in penetration of marine salts. The concrete cubes immersed in seawater increases its weight gradually after curing for 28days in fresh water beyond the strength of control cast. The compressive strength of concrete cubes cured in fresh water agrees with the value of the compressive strength of M40 mix at 28days as per IS standards. But the concrete cubes immersed in the seawater for 40 days the compressive strength is increased considerable amount. The penetration of the marine salts measured is well within the limits of IS standards. The chloride ions present will Detroit and corrode the steel reinforcement. Hence in saline environments with specific emphasis on the long term durability of concrete structures, protection measures has to be done.

CONCLUSION

It was observed that concrete cast and immersed in seawater for 40 days beyond the curing period increases its weight due to penetrating of marine salts and increases in compression strength beyond the strength of concrete cubes cured in fresh water. The fresh-salt water situation occurs when structures constructed in shores and in seas near shores. The marine salts penetrated in the concrete cause corrosion to the reinforcement and reduce the service life. To increase the service life the pH value of the concrete must be increased and preventive measures against corrosion of steel reinforcement must be taken. It is recognized that a dense and impermeable concrete can ensure long-term durability in harsh marine exposure conditions.

REFERENCES

1 Hoang Quoc Vu, Boonchai Stitmannaithum and Sugiyama Takafumi "Chloride Penetration Depth in Cracked Reinforced Concrete" ISSN 2319 – 6009 www.ijscer.com Vol. 2, No. 2, May 2013 © 2013 IJSCER

2 JoséManuelMendoza-Rangel,1 Pedro Castro-Borges,2 Patricia Quintana-Owen,2 Mercedes Balancan-Zapata,2 and Jesus Alejandro Cabrera-Madrid2 "Experimental analysis Chemical Interactions Reinforced Concrete Exposed at a Tropical Marine Environment" Hindawi Corporation Journal Volume 2015, Article ID 864872,

3 M. Sosa1, T. Pérez-López1,*, J. Reyes1, F. Corvo1, R. Camacho-Chab2, P. Quintana3, D. Aguilar3. "Influence of the Marine Environment on Reinforced Concrete Degradation Depending on Exposure Conditions" J. Electrochem. Sci., 6 (2011)

4 Senthil Kumar C1* and Naveenraj V2 "Estimation of marine salts behavior around the bridge structures" ISSN 2319 – 6009 Vol. 3, November 2014 © IJSCER.

5 Rui Miguel Ferreira, Guimaraes, "Probability Based Durability Analysis of Concrete Structures in Marine Environment" Guimaraes, Portugal © 2004 ISBN: 972 – 8692 – 16 – 1

6 P. Sandberg & Cementa AB, Lund Inst. Of Tech., Building Materials "Systematic Collection of Field Data for Service Life Prediction of Concrete Structures" HERON Vol. 52(2007) No. 4 page251-268

(IJAER) 2016, Vol. No. 11, Issue No. IV, April **e-ISSN: 2231-5152, p-ISSN: 2454-1796**

7 Bruce A. Suprenant Associate professor at the University of Colorado "Designing concrete for exposure to seawater" Publication # C910873 , 1991, The Aberdeen Group.

8 Mohammed, T., Otsuki, N., and Hamada, H. (2003). "Corrosion of Steel Bars in Cracked Concrete under Marine Environment." J. Mater. Civ. Eng., 15(5)

9 Mario Collepardi Honorary Member of the American Concrete institute. President of ENCO, Italy. "Concrete Durability in a Marine Environment"

10 Rob B. Polder and Mario R. de Rooij of Delft University of Technology, Delft, The Netherlands "Durability of marine concrete structures – field investigations and modeling" HERON, Vol. 50, No 3 (2005) page 133-153