Numerical simulation analysis of chloride ion penetration under marine environment

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Abstract. The article gives a more effective and reasonable method for prevention of concrete structure corrosion considering both structure safety and economy by milling the core of the reinforced concrete structure and doing the silver nitrate titration experiment under marine environment . The results shows that the chloride ion content of concrete in marine splash zone is generally high in the vertical direction and the chloride ion content of concrete on the surface 1 to 3 cm of concrete structure reaches the peak then reduced quickly to stable point in the horizontal direction.

1 Introduction

The intrusion of chloride ions destroy Passive film of concrete structure since seawater contains a larger proportion of chloride salts. It makes steel exposed and occurs pitting corrosion with time flying which affects the service life of the structure even safety problem . The corrosion of concrete caused by chloride ion and how to improve corrosion of concrete by chloride has become a more and more important engineering problem.

In this paper, the law of chloride ion penetration concrete protection layer is obtained from collecting the distribution of chloride ion content in the structure by searching sample of multiple wharf structures in several different marine areas in China. It is order to further improve the corrosion resistance of concrete structures under marine environment.

2 Experiment

The full autopotentiometric titrator produced by Metrohm company in Swiss can calculate the content of chloride ion. It automatically determine the potential change of the chlorine ion in the standard

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solution of silver nitrate at first. The sudden change of the potential is the end point of the titration for the second step. At last, The content of chloride ion is worked out by the volume and concentration of the standard solution for titration.

The silver ion in the silver nitrate solution can be combined with the chloride ion in the sample solution to form a solid silver chloride. After the precipitation of all the free chloride ions, the potential of the solution will appear inflection point. Additionally, the recording instrument will record the consumed volume of the silver nitrate solution automatically at this time. Through automatic calculation, it will show the content of chloride ion in the sample solution.

2.2 Process

2.2.1 Sample preparation

In this paper, a number of regional wharf structures under marine environment are studied on the layered experiment of chloride ion. In addition, eight core samples were taken from four zones which are marine air zone, splash zone, tidal zone and full immersion zone. Furthermore, each core sample with 100mm diameter and 10mm thick for one layer is ground to 14 layers. Moreover, the ground powder sample through 0.63mm sieve is dried to a constant weight in an oven at 105 degrees centigrade. After cooling, the 20g sample is put into a triangular beaker. Then adding 200ml distilled water into the beaker and shaking several minutes, it should be static for 24 hours.

2.2.2 Titration sample powder

First of all, preparation of 0.02ml/L silver nitrate solution is added into a fully automatic potentionmetric titrator. Secondly, 20ml the sample solution, which has been soaked for 24 hours, is transferred by pipette to instrument cups in order of the ground powder for titration . Finally, the titration results are recorded and analyzed.

2.2.3 Testing results

The results are obtain by the following steps. The first step is drilling the core sample horizontally under the four marine zones which are marine air zone, splash zone, tidal zone and full immersion zone. The second step is milling the core sample into powder for each layer. The third step is doing silver nitrate titration test. The fourth step is resulting the content of chloride ion in different parts of concrete structure by numerical curve fitting of the obtained data. The result reflects that the lower content of chloride ion in sea air zone will bring less effect for the structure. In addition, two more sets of typical data results from another three regions are also recorded. The figures of their fitting curve are shown as follow.

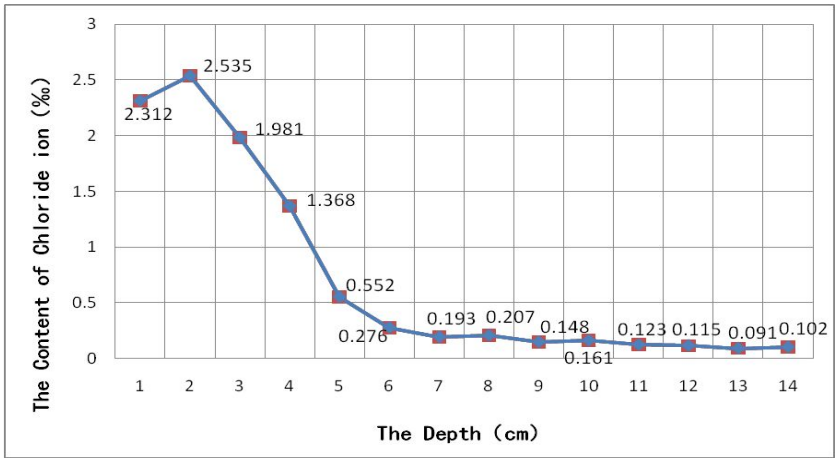

Figure 1. Group one：Relationship between Chloride Concentration and Depth in Splash Zone

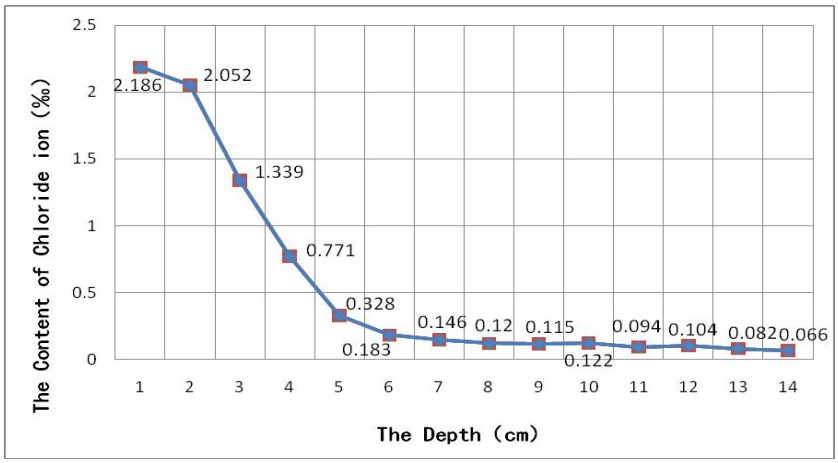

Figure 2. Group one：Relationship between Chloride Concentration and Depth in Tidal Zone

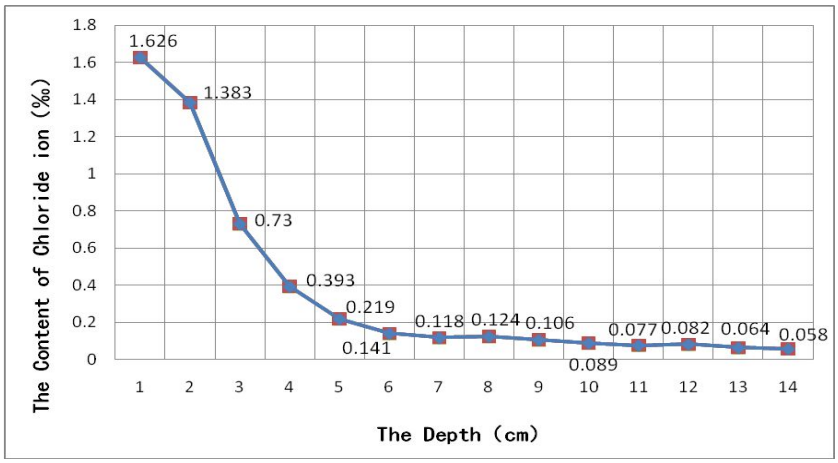

Figure 3. Group one：Relationship between Chloride Concentration and Depth in Full Immersion Zone

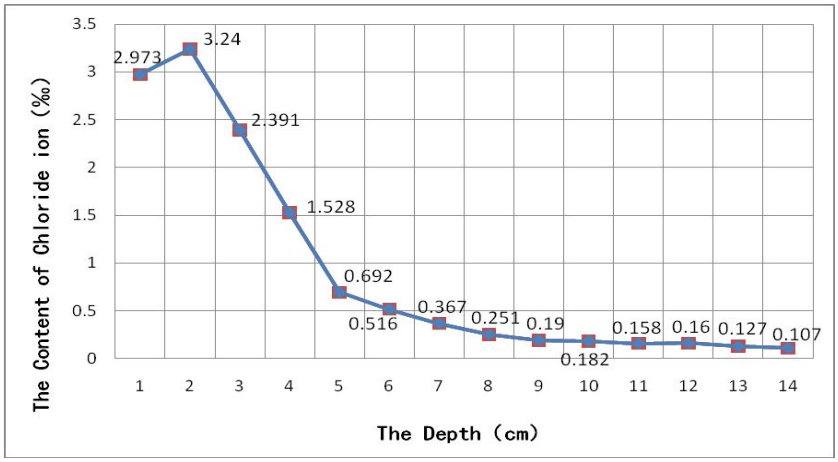

Figure 4. Group two：Relationship between Chloride Concentration and Depth in Splash Zone

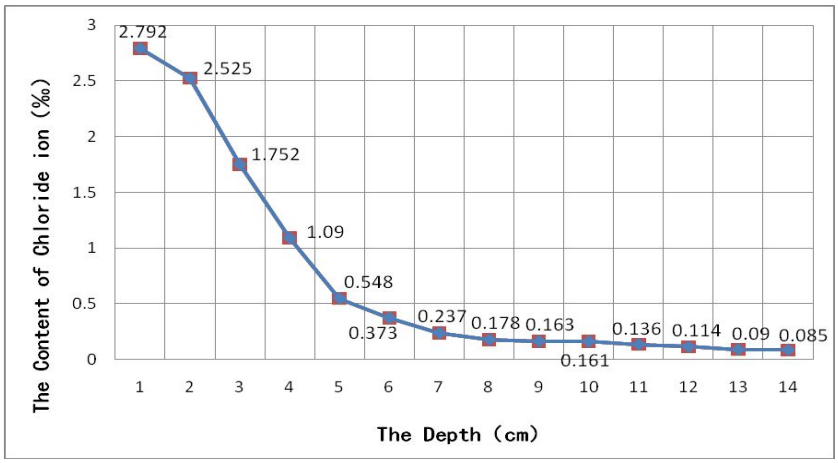

Figure 5. Group two：Relationship between Chloride Concentration and Depth in Tidal Zone

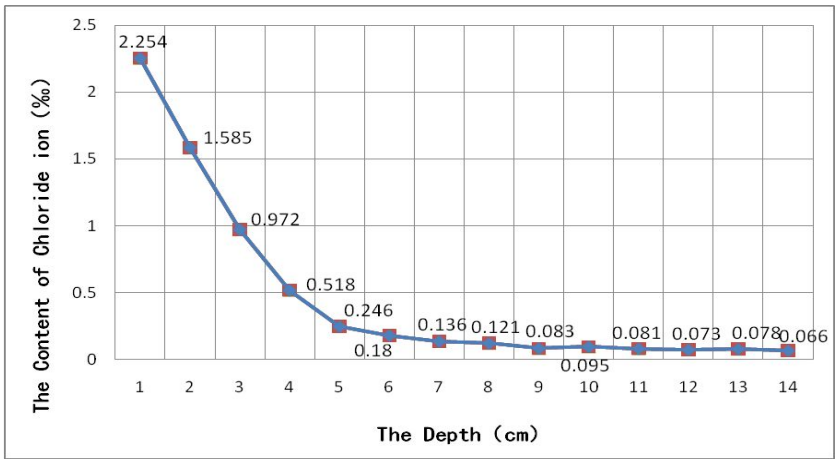

Figure 6. Group two：Relationship between Chloride Concentration and Depth in Full Immersion Zone

3. Analysis and Suggestion

According to the chart data and its analysis, the highest content of chloride ion on the surface structure is appearing in the tidal zone and immersion zone. Additionally, the content of chloride ion arrives peak at 2cm thick in the splash zone. The content of chloride ion in another three areas decreases rapidly with the depth of the protection layer and tends to be stable at last. Thus, the splash zone has the maximum area of chloride ion and should be focus on processing.

The hydraulic structure in the splash zone is in the ares of water level change and alternates wetting and drying which means it fully contacts with oxygen and UV radiation. This kind of environment is suit for chloride ion accumulation so it is important to protect the structure in this area.

For the traditional methods, strengthening the structure directly is the main manner to prevent corrosion under marine environment. There are several ways to strengthen it, which include increasing the thickness of the protective layer of the structure, reinforcing protective film, using anti-corrosion coatings and so on. Based on the analysis of obtained data, it suggests that the key parts of the structure need to be strengthened in different areas, so as to achieve a more economical and reasonable solution for the problem of corrosion protection. For example, the prefabricated structure adopts the method of lamination and subsection in order to improve the anti-corrosion ability of key areas. Meanwhile, it also can increase the thickness of concrete protective layer in the key area.

4. conclusion

The corrosion protection under marine environment has been a significant and complicated research topic, however, there is no practical method in China at present. This article represents structure corrosion mechanism more clearly and intuitively by the content of chloride ion of structure in different ocean regions.

For corrosion protection of structure under marine area, on the one hand, we should strengthen the overall anti-corrosion measure. On the other hand, we can focus on the special parts of structure to protect it. Moreover, on the basis of ensuring stability of the structure, we should make the way more economic and reasonable.

All the data and analysis mentioned above are all my understanding and summarizing from my real recorded data, please criticized the correction.

References

1. SHAO Wei and LI Jing pei. 2014. “Service Life Prediction of Reinforced Concrete Pipe Pile Due to Chloride Ion Corrosion”. JOURANAL OF TONGJI UNIVERSITY(NATURAL SCIENCE). Vol. 42, No. 12.
2. WU Jin and WU Sheng-xing. 2005. “RELIABILITY ASSESSMENT OF CONCRETE STRUCTURES WITH CORRODED REINFOR CEMENT”. ENGINEERING MECHANICS. Vol. 22, No.1.
3. LIU Jian-guo, LI Yan-tao and HOU Bao-rong. 2012. “Progress in Corrosion and Protection of Steels in Marine Splash Zone”. CORROSION AND PROTECTION. Vol. 33, No. 10.
4. WANG Jia-chun and YAN Pei-yu. 2014. “Probabilistic analysis of rebar rust in concrete under marine environment”. Journal of Jilin University(Engineering and Technology Edition). Vol 44, No.2.
5. HUANG Qin-ming. 2013. “The corrosion and anti-corrosion measures of chloride ion in the concrete reinforcement”. Supervision Test and Cost of Construction. Vol. 6, No. 2.
6. Morales, A. L.. An X-ray diffraction study of corrosion products from low carbon steel[J]. Revista de Metalurgia, 2003, 39.
7. Bastidas, D.M, Cayuela,I, Bastidas,J.M. Ant-nest corrosion of copper tubing in air-conditioning units[J]. Revista de Metalurgia, 2006, 42(5).