International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 06| June 2021 www.irjet.net p-ISSN: 2395-0072

A PERFORMANCE APPROACH FOR DURABILITY INDEXES

Jerin Joy[1], Elson John[2]

[1]M.Tech Scholar, Dept. of Civil Engineering, Mar Athanasious College of Engineering, Kothamangalam P.O, Ernakulam, Kerala, India

[2]Professor, Dept. of Civil Engineering, Mar Athanasious College of Engineering, Kothamangalam P.O, Ernakulam, Kerala, India

---

Abstract- *By many means the concrete can degrade. The durability issues are seen in concrete structures which revealed to aggressive surroundings. These structures fail to attain desired period of service life. The structures planned with prescriptive approach of durability, fails to control the failures in concrete. The prescriptive specification is all about the methods and means of construction. Also discuss about the composition for the concrete mix. The performance requirements for the project are not clearly specified in project specifications, and so the prescriptive requirements may dispute with the intended performance. Thus nowadays the concrete construction companies are moving towards performance-based specifications rather than prescriptive. The most common method of performance approach is the durability index based which adopted on South Africa.*

Key Words: Durability, Performance approach, Prescriptive approach, Carbonation, Chloride induced corrosion

1 .INTRODUCTION

Concrete is an important component of the infrastructure and our society, including all the buildings and roads. Since the major durability related issues takes place at declining years, as when the concrete has achieved the sufficient strength. Durability is the capacity to keep going quite a while without critical decay. Depending on the surroundings of the structure to which it is revealed the durability issues are also different and need different degrees of durability. The concrete structures have to withstand against chemical attack, abrasion, weathering action and so on to continue its desired properties. The life of concrete or its durability depends on the different ingredients of the concrete, also their proportioning and interactions between them, also activities like placing and curing and service environment. Numerous normal focuses exist with respect to the affecting elements and resultant examples of deterioration processes.

Structures that complied with code requirements still fail due to excessive cracking. Approaches for durability design are; Prescriptive approach and Performance Approach. A prescriptive specification is one that includes clauses for means and methods of construction and composition of the concrete mix rather than defining performance requirements. While a performance specification is a set of instructions that outlines the functional requirements for hardened concrete depending on the application[1] [2].

2. BACK GROUND

Regarding determinations for concrete strength, a consistent change from prescriptive to performance approaches occurred early, potentially because of the fast improvement of reasonable and broadly received testing techniques. The initial strength test of cement was directed in Germany in 1836 and the cause of ASTM C39 "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens", dates from 1921. Then again, the improvement of test strategies, appropriate to measure in short-term durability of a concrete, initiated around in the 1970s. A few of the initial methods, evolved around 1980 and quiet continuing today, which include the "RILEM-Cembureau method to measure oxygen permeability, and the chloride migration test method, given now in ASTM C1202". The test strategy to gauge the diffusivity to chlorides, is still by NT Build 492, was created around 10 years after the fact.[3]

Nowadays the national standards have started to cover performance requirements along with the prescriptive ones." Canadian Standard A23.1-04/A23.2-04 includes requirements of maximum values of Coulombs (ASTM C1202) for certain exposure and service life conditions". "The Swiss Standards SIA 262 and 262/1, specify maximum values of water sorptivity or chloride diffusivity (depending on the exposure classes) for cast specimens, and of air-permeability measured on site". South

Africa follows prescriptive approach largely for the durability design, but also quality control and performance approaches have already been executed on a large scale, about 10 years ago. Besides, their "Durability Index test" methods have lately been integrated into" South African National Standards", which will soon be followed by standardised limiting values for the respective durability indicators. In numerous different places of the world, performance based techniques have been explored and grown, regularly with just restricted reasonable applications up until now.[4]

3. CONCRETE DURABILITY

A concrete structure is said to be durable only if the concrete structure is able to acquire its limits and requirements in its service environment. Also it should be able to give the designed service life without much more expense for their repair and maintenance works due to deterioration of the structure. As before the work starts the engineer who design the structure should study the environment where the project is sited and should finds the deteriorative agents at that area. Thereby engineer able create appropriate specifications for the particular work to minimize the causes of deterioration of concrete structure. The specifications for the work must include specifications that needed to minimize the effects of the deteriorative influences at the site of the work they are. The deteriorative influences are "freezing and thawing, wetting and drying, heating and cooling, loading a, cavitation, erosion, abrasion, acid attack, sulfate attack, other kinds of chemical attack, corrosion of steel, microbiological attack, penetration by marine borers, and others" [5]. The corrosion of the reinforcing steel and the resulting spalling of the concrete cover mainly because of the durability issues related with the reinforcing steel. One method to overcome durability issues is to specify the qualities like its resistance chloride attack, carbonation, water sorptivity and oxygen diffusion. Maybe depending upon the sort of structure and the climate, more than one model ought to be determined.[6]. Durability of concrete is covered with the failure of structure over the utility period of the concrete structure under a given surroundings and its not an inherent property of material. Structure which is resistant to one surrounding may not resistant to other. Durability design is about with the 'trade-off' among the quality and the quantity of the cover concrete. Additionally, the quality of the cover concrete depends on mix ingredients and proportions, but also equally importantly on method of construction, i.e. "the influences of compaction, curing, early age drying, and early penetration of aggressive environmental agents". Reinforced concrete corrosion is by the breakdown or decay of the oxide layer on the reinforcement bar. This could happen when there occurs a change in the nature of the pore solution which surrounding the bar. The main cause of this is concrete carbonation i.e the ingress of atmospheric carbon dioxide in to the concrete which lead to acidification and also chloride ingress. The chloride ingress may lead to the pitting corrosion of bar. By all these the cover layer of concrete becomes "single line of defence". As stated earlier the service life of structure depends on the cover concrete, its decay may cause deterioration of whole structure.[3]

4. CAUSES OF DETERIORATION OF CONCRETE

The access of various liquids, ions and gases from the surroundings is responsible for the decay of concrete .For example, the access of chlorides or carbon dioxide would depassivate the reinforcement bars in concrete and in the presence of water and oxygen, and bar may start corroding. Likewise, the ingress of other chemicals, such as sulfates, acids, and alkali's, also the freezing thawing action are responsible for the chemical deterioration of concrete. Some important reasons behind the deterioration of concrete are:

4.1 Carbonation

When the atmospheric carbon dioxide enters into concrete through the pores present in the concrete, in the presence of water, it may react with calcium hydroxide and forms calcium carbonate. And thus, the pH of the pore solution is lowered to below 10. The passive protective layer of the reinforcement surface will be dissolved and the corrosion of the steel will start if the carbonation progress up to the reinforcement surface of the concrete. [7].

Fig-1: Durability issue due to carbonation

4.2 Chloride Ingress And Corrosion Due To Chloride Ingress

Likewise the carbonation, the accumulation of oxides/hydroxides in the pore space of concrete results in hoop stress near the steel reinforcement bars and could end up in spalling of the concrete. This in turn results in access of moisture and chloride ions into the concrete and may result in the corrosion of reinforcement bar. The chloride induced corrosion can also be call as localized or pitting corrosion, which is more harmful than uniform corrosion. They cause the spoiling of chromium oxide layer on the rebar. The pitting corrosion spread in faster rate than other corrosions.[8]

Fig-2:Pitting corrosion

4.3 Freeze - thaw deterioration

The disintegration of concrete by the action of freezing and thawing is a very composite phenomenon. The concrete durability rapidly decreases with the expansion of freeze-thaw of concrete, and more pores and cracks are established, which may acts as passageways for chloride penetration. [7].

Fig- 3: Freeze thaw deterioration

5. PRESCRIPTIVE APPROACH

A prescriptive approach is a durability design approach where the performance requirements of the concrete is not much emphasised. While in prescriptive approach they cover the method of construction and the mix design to be used for the work and so on. And it's assumed that if all the prescriptive requirements are satisfied then the structure is having enough durability. Most of the project specification includes the prescriptive requirements; they do not focused on the performance specifications and many times the prescriptive requirements may dispute with the intentional performance.[2]

The project specifications includes outlines like; "composition of the concrete mixture such as a minimum cement content, type of cement, limits on the quantity of supplementary cementitious materials, maximum water-cementitious materials (w/cm) ratio, limits on the grading of aggregates or type used, brand of admixture and required dosage, etc". Along with these requirements they sometimes specify the compressive strength and other properties of the concrete. Sometimes these specifications may not be achieved because of the restrictions placed on the mixture composition. For each set of materials there is an extraordinary connection between the combination extents, for example, concrete substance and w/cm proportion and coming about strength and sturdiness properties. Putting inappropriate impediments on at least one of these boundaries of the concrete in a particular regularly negates the planned execution.[1]

5. PERFORMANCE APPROACH

A performance specification is a bunch of directions that form the practical prerequisites for concrete contingent upon the application. The guidelines should be clear, attainable, quantifiable and enforceable. Performance specifications should point out the test techniques and the acceptance standards that will be utilized to confirm and authorize the necessities. Also some tests are needed for pre-selection and some may be for place of work acceptance. All those specifications/ requirements should give sufficient adaptability to the engineer and to the workers to get a mix that meet the acceptance criteria. The workers should work together to get the performance criteria and the additional needs for the concrete like flow time, set time which is to ensure the work suitability depending on the mode of the work. Adaptability on mixture composition is also important to take in the source variability of ingredient materials and seasonal aspects that impact surrounding conditions during construction[1]. According to the US National Ready Mixed Concrete Association (NRMCA), "A performance specification is a set of instructions that outlines the functional requirements for hardened concrete depending on the application. The instructions should be clear, achievable, measurable and enforceable". Unlike the prescriptive approach Performance specifications keep away the specifications for methods, means and limitations on the proportions of the concrete mixture to be used in the work.[9]

The overall idea on how a performance-based specification would work on concrete are:

1. Should develop a standard system for the production of concrete and this system should be certified.

2. The specification would plainly characterize the useful necessities of the concrete.

3 Makers and temporary workers would accomplice to guarantee that the correct blend is planned, conveyed and introduced.

4. The submission would not be a definite rundown of combination ingredients, yet rather an accreditation that the mix will meet the requirements including pre-capability test results.

5 Field test are carried out after placing on the site to ensure that the concrete meets the prerequisites /requirements.

6. Instructions should be given to do what next, if the site tests on concrete fails or concrete fails to meet its specifications. [1]

6. TYPES OF PERFORMANCE TESTING

Tests can be performed at various stages in construction.

1. Pre-qualification Tests: Used by makers to show that a mixture, when put and relieved under specified or particular conditions, can meet the prerequisites and, if necessary, give input information to support life forecast. These tests regularly require huge lead time to finish and may incorporate tests required as contributions to support life models.

2. Identity Tests: test is carried out at the site before the mix is placed i.e. as soon as when the mix is delivered on the field of work. Identity test are carried out in order to determine whether to accept the mix or not. The most common test is slump test and air content test. Also the uniformity and the fresh density of concrete where tested on some places. AASHTO is a microwave test for finding the water content of the concrete which is delivered at the site. Mainly implemented on New York.

3. Quality Assurance/Quality Control Tests: In order to certify that the mix is up to the mark i.e. it satisfies the strength and other requirements of concrete specified. Also is to ensure that the correct method is followed at point of discharge of concrete mix and at the point of placing the fresh concrete.

4. In-Place Tests: Includes the non-destructive tests (NDT) and performance tests that may carry out on cores taken from the concrete specimens. This test method is to confirm that the all practices taken while the production, placing and curing have resulted in achieving the performance requirements. This is for the End Result Specifications (ERS) usually used by several North American highway agencies such as the Ministry of Transportation Ontario (MTO). Based on the results the contractors and worker are complimented if result satisfy the requirements otherwise they have to give compensation for the same.[10]

7. SOUTH AFRICAN DURABILITY STUDY

In South Africa the durability of concrete is studied based on durability index. They mainly focus on three durability index; oxygen permeability test (OPI) for permeation, water sorptivity for absorption, and chloride conductivity for diffusion. The oxygen permeability test measures the pores continuity, which may act as path way for deteriorating agents to enter into the concrete. The main reason behind it may be the bleeding or failures in compaction while concreting. In sorptivity measures the uptake of water by a dry sample by the action of capillary rise. Lesser the sorptivity index value denotes a better quality of concrete. The chloride diffusion give the quality of the cover concrete as it measures the chloride content at different layers. They performed these durability tests on the samples collected from both field and lab and prepare limiting values for each of the cases. These test values helps in mix proportioning and assessing the quality of concrete used.[9] For the performance specification they use these limiting values. The necessities associated with exposure lessons can be hooked up the usage of performance-associated layout techniques for sturdiness and can be laid out in terms of performance-associated parameters.[7]

In India the performance specifications implemented for the Delhi metro as well as for the Koodankulam power project. As the India's geographic features are relate to the South Africa we can adopt the potential of South Africa. In India adopting a performance specification includes four steps. Initially have to look on the Indian standards such as the w/c ratio, cement content and also have a study on the environmental exposure conditions based on different geographical classes. Later have to found the durability test to relate particular area. Have to find the limiting values, this step is a long processes. Final stage includes the white paper work. [9]

8. CONCLUSIONS

Insufficient durability of concrete structures is results of insufficient durability design and their execution. This is one of the reasons behind why the most seen structures are at a state of failure. Providing the concrete following code prerequisites doesn't ensure that structures in extreme conditions will be durable because durability design needs to specify other impacting issues which include the risk of cracking, and provision of sufficient curing, for the concretes that show their properties at slower rates. Under this conditions go for the performance approach for durability. Performance approaches are based on the concrete properties which may be used as input parameters to predict durability of the specific structure under consideration. Should give guide lines for construction and the guidelines should be clear, attainable, quantifiable and enforceable. One of the advantages of using performance approach for durability design is that it allows innovation in concrete construction, also contribute to effective quality control, and provide efficient means of conformity assessment for the structure.

REFERENCES

[1] C. Lobo, L. Lemay, and K. Obla, "Performance-based specifications for concrete," AEI 2006 Build. Integr. Solut. - Proc. 2006 Archit. Eng. Natl. Conf., vol. 2006, no. March, p. 45, 2006, doi: 10.1061/40798(190)45.

[2] B. Sangoju, R. Gopal, and B. Bhajantri H, "A review on performance-based specifications toward concrete durability," Struct. Concr., no. April, pp. 1–13, 2020, doi: 10.1002/suco.201900542.

[3] M. Alexander and H. Beushausen, "Durability, service life prediction, and modelling for reinforced concrete structures –

review and critique," Cem. Concr. Res., vol. 122, no. April, pp. 17–29, 2019, doi: 10.1016/j.cemconres.2019.04.018.

[4] H. Beushausen, R. Torrent, and M. G. Alexander, "Performance-based approaches for concrete durability: State of the art and future research needs," Cem. Concr. Res., vol. 119, no. July 2018, pp. 11–20, 2019, doi: 10.1016/j.cemconres.2019.01.003.

[5] B. Mather, "Concrete durability," Cem. Concr. Compos., vol. 26, no. 1, pp. 3–4, 2004, doi: 10.1016/S0958-9465(02)00122-1.

[6] D. W. S. Ho and G. J. Chirgwin, "A performance specification for durable concrete," Constr. Build. Mater., vol. 10, no. 5 SPEC. ISS., pp. 375–379, 1996, doi: 10.1016/0950-0618(95)00015-1.

[7] L. Basheer, J. Kropp, and D. J. Cleland, "Assessment of the durability of concrete from its permeation properties: A review," Constr. Build. Mater., vol. 15, no. 2–3, pp. 93–103, 2001, doi: 10.1016/S0950-0618(00)00058-1.

[8] X. Shi, N. Xie, K. Fortune, and J. Gong, "Durability of steel reinforced concrete in chloride environments: An overview," Constr. Build. Mater., vol. 30, pp. 125–138, 2012, doi: 10.1016/j.conbuildmat.2011.12.038.

[9] M. Alexander and M. Thomas, "Service life prediction and performance testing - Current developments and practical applications," Cem. Concr. Res., vol. 78, pp. 155–164, 2015, doi: 10.1016/j.cemconres.2015.05.013.

[10] R. Douglas Hooton, "Future directions for design, specification, testing, and construction of durable concrete structures," Cem. Concr. Res., vol. 124, no. July, p. 105827, 2019, doi: 10.1016/j.cemconres.2019.105827.