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Salinity on Bridge Piers

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ABSTRACT : *This paper discusses the importance of chloride penetration models in assessing the service life of concrete structures in marine environments. It highlights the significance of using simple models based on Fick's 2nd law of diffusion for predicting chloride penetration. However, it emphasizes the necessity of calibrating these models with experimental data. The paper presents an experimental study where parameters for the penetration model were calibrated to predict long-term chloride content in concrete. The results suggest that current concrete cover and quality requirements outlined in existing codes may need to be increased to ensure an acceptable service life for structures in marine environments.*

KEYWORDS : *Service Life , Salinity*

1. INTRODUCTION

The paper emphasizes the increasing importance of service life prediction in concrete structure design, particularly in marine environments where reinforcement corrosion is a major concern. It highlights two key stages in the deterioration process: the initiation period, which involves critical chloride penetration up to the reinforcement level, and the propagation period, which encompasses reinforcement corrosion and its structural impacts. Due to challenges in accurately modeling corrosion effects and the typically high corrosion rates in marine settings, the focus is often on the initiation period when considering service life.

2. AIM

Bridges are crucial for land transportation and goods exchange, especially considering the vast coverage of oceans and salty water bodies worldwide. However, bridge structures face challenges such as corrosion in salty environments, particularly in columns where reinforcement corrosion can weaken them. This project aims to enhance column strength and durability by increasing concrete cover and quality requirements to prevent reinforcement corrosion. Additionally, fixed formwork in columns can aid in protection. The study focuses on assessing the strength, durability, and compressive strength of column structures to address these challenges effectively.

3.MATERIALS

Material investigation was conducted to assess various materials used in producing concrete cubes. Test results informed the design of mix ratios for these materials, guiding the preparation of concrete cubes, beams, and cylinders. Details of these investigations and test results are provided below.

3.1 CEMENT

OPC (Ordinary Portland Cement) of 43 grades was obtained in a single lot and stored in an airtight container to maintain its freshness. The cement was used within three months of its manufacture to ensure compliance with IS 12262 standards. Its properties were evaluated according to IS 4031:1968, and the results were compiled in a tabulated format for analysis and reference.

Table 1: Chemical Composition of Manufactured and Natural Sand

Constituents	Natural Sand (%)	Test Method
SiO2	80.78	IS: 4032-1968
Al2O3	10.52	
Fe2O3	1.75	
CaO	3.21	
MgO	0.77	
Na2O	1.37	
K2O	1.23	
TiO2	Nil	
Loss of ignition	0.37	

3.2 Fine Aggregate

For experimental purposes, a fine aggregate sourced from a river was utilized. The aggregate contained minimal amounts of clay and silt, both measuring less than 3% by weight. It was meticulously screened to remove any traces of silt, clay, salt, and organic materials, ensuring cleanliness and dryness. The aggregate particles were of a size that retained on a 1.19-micron sieve.

3.3 Coarse Aggregate

The coarse aggregate is a crucial component of concrete, known for its strength and porosity. Its presence helps mitigate drying shrinkage and dimensional changes caused by moisture movement. The coarse aggregate employed meets specific size criteria, passing through a 19 mm sieve and retained on an 11.4 mm sieve. It is well-graded, comprising particles of varying sizes to achieve maximum dry packing density and minimize voids. Additionally, the coarse aggregate is characterized by its cubical shape, enhancing its suitability for concrete applications.

3.4 Water

For casting all specimens in this investigation, ordinary drinking water from the construction laboratory was utilized. Water played a crucial role in the concrete mixture by aiding in dispersing the cement evenly, ensuring each aggregate particle was coated and brought into contact with the ingredients. It facilitated chemical reactions with cement, leading to setting and hardening, while also lubricating the mix for proper compaction. Potable water, devoid of impurities like oil, alkalis, acids, salts, sugar, and organic materials, was employed. The water quality met the standards outlined in IS: 456-2000, ensuring its suitability for concrete production.

4. Mix Design

4.1 General

Mix design is the process of determining the appropriate ingredients and their proportions in concrete to achieve a specified minimum strength and durability economically. Its main goal is to define minimum strength and durability requirements while understanding the relationship between aggregate and paste. In workable mixes, concrete strength decreases as the water/cement ratio increases. Thus, minimizing paste usage is crucial, emphasizing the importance of proper grading. The ratio provided, 1:1:2.18, represents the proportions of cement, fine aggregate, and coarse aggregate, respectively, in the concrete mix design.

Casting and Curing

Casting Mould Preparation : A PVC mould with a diameter of 180 mm and a height of 600 mm was positioned on a level surface. To prevent concrete from adhering to the mould, all interior faces and sides were coated with mud oil.

Mixing :

Concrete of grade M30 (with proportions 1 part cement, 1 part fine aggregate, and 2.18 parts coarse aggregate) and a water-cement ratio of 0.37 was utilized. The mixing process occurred in a roller-type mixing machine.

Placing :

Concrete was accurately positioned beneath and along the sides of the mould using a trowel .

Compaction :

Hand compaction was employed for all test cubes, followed by the use of mild steel rods with pointed ends to compact the concrete further. The compacted concrete specimens were then placed on a vibrating table to ensure thorough compaction.

Curing :
The specimens were stripped from the moulds after 24 hours. Subsequently, the test cubes underwent curing in a curing tank for a duration of 28 days. The curing process likely involved maintaining a specific environment conducive to concrete hydration and strength development. Additionally, the chloride content in the curing environment may have been monitored as part of the testing procedure.

Test of Specimen and Result Analysis :

Testing of concrete is crucial for ensuring and verifying the quality of cement concrete. Traditional columns undergo testing to assess their strength characteristics. This testing process provides valuable information about the structural integrity and performance of the concrete columns, helping to ensure they meet specified standards and requirements.

5.Testing of Specimen

5.1 Compression Test :

Cubes measuring 150 x 150 x 150 mm are positioned in a testing machine, with the load applied on the opposite side of the cubes as casted. The cubes are aligned carefully, and the load is gradually increased until the specimen breaks. The compressive strength of the concrete is calculated using the formula:

Compressive Strength = Total Failure Load / Area of the Cube

5.2 Split Tensile Test :

The test involves placing a cylinder specimen with dimensions of 150 mm in diameter and 300 mm in length horizontally between the compression testing machine's loading surface. Load is applied until failure of the cylinder along the vertical diameter, and the failure load of the specimen is recorded.

The tensile strength of the cylinder is then calculated using the formula:

Tensile strength = 2P / (3.14 * D * L)

Where:

- P represents the failure load of the specimen
- D represents the diameter of the specimen
- L represents the length of the specimen

5.3 Flexural Test :

The test is conducted to determine the flexural strength of a prism measuring 100 x 100 x 500 mm. The prism is positioned in the testing machine with the load applied to its uppermost surface as cast in the mould. Two-point loading is utilized with an effective span of 400 mm during testing. The load is applied until the prism fails. The flexural strength of the prism is calculated using the formula:

Flexural strength = (P * l) / (b * d^2)

Where:

- P is the failure load of the prism
- l is the length of the prism
- b is the breadth of the prism

- d is the depth of the prism

Table 2: Test Results			
S. No.	Specimen	Compressive Strength N/ mm ^{2}	
	Cube	7 Days	28 Days
1.	1	15.88	29.03
	2	16.20	29.06
	Cylinder	Split Tensile N/ mm ^{2}	
2	1	0.85	2.23
	2	0.83	2.39
	Prism	Flexural Test N/ mm ^{2}	
3	1	3.97	6.32
	2	3.91	6.26

5.4 Test Setup :

The column was subjected to testing in a loading frame following proper procedures. Axial load was applied gradually, and strain readings were recorded at regular intervals during loading. Loading continued until reaching the ultimate load level, and the failure pattern of the column was carefully observed and studied.

6.Conclusion

- Not using concrete proves to be more effective in penetrating concrete columns.
- Increasing the concrete cover in the column can enhance axial compressive strength, control penetration, and prevent corrosion.
- Curing in a salty solution results in a decrease in compressive strength.
- The total ultimate load carrying capacity of the specimen is significantly low, with only 240 kN compared to the ordinary capacity of about 109 kN.

7. Future Works

- Employ different sizes of cover for columns with varying mixes of column specimens subjected to different loading conditions.
- Investigate the production of various cover sizes for columns with different curing periods, such as 28 days, 54 days, and 84 days.
- Conduct experimental investigations on water permeability tests after testing the columns.

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