EXPERIMENTAL STUDY ON THE INCREASED COVER SPECIFICATIONS IN IS 456:2000 AND THE RESULTING CRACK WIDTH IMPLICATIONS IN RC SLABS FOR MODERATE EXPOSURE

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Abstract— IS 456:2000 is the most influential and continuously used code in India, and plays a leading role related to concrete and reinforced concrete in many areas such as education, design, production, construction, infrastructure development and repair. Continuous research focuses on gaps in knowledge and the research findings renovate or alter existing codal provisions or add new provisions to raise the role of concrete industry to a higher, newer and more useful level of performance. Codes incorporate new knowledge for the betterment of users. The objective of the present research is to investigate the validity of the specified clause of the IS 456:2000 code relative to durability. Of the five environmental exposure conditions, moderate case is taken for investigation in the current research. The reported test results show that mere adoption of detailing of steel reinforcement as specified in the code ensures durability; relative to crack growth is valid.

I. INTRODUCTION

A. The main objective of the current research undertaken is stated below. The aim of the undertaken research is to investigate the validity of IS code provisions, relative durability in the case of moderate environmental exposure. Code IS 456:2000 is the most influential and extensively used code in India and plays a leading role in many ways related to concrete and reinforced concrete in the areas of education, research, design, production, construction, infrastructure projects, repair and retrofit. Continuous research focuses on gaps in knowledge, and the research findings renovate or alter existing codal provisions or add new provisions to raise the whole concrete industry to a higher, newer and useful level of performance. Although many would argue that change is counter to human nature, it is sometimes necessary to effect strategic change to make a measurable leap in efficiency and productivity. A test programme was initiated to investigate the influence of increased concrete covers in reinforced concrete slabs, stipulated in the IS 456:2000 on the development of induced crack widths when the detailing of steel reinforcement is as per codal specification. The reported results reveal that adoption of detailing of steel reinforcement as specified in the code ensures durability relative to crack growth is totally valid, in the case of moderate environmental exposure condition.

B. When tensile stress in concrete exceeds its tensile strength crack forms. There are three reasons for limiting the crack widths in structures. These are: 1.Appearance 2.Durability and 3.Liquid tightness. These three requirements are not applicable simultaneously in a particular structure. Cracks greater than 0.3mm allow ingress of moisture and chemical attack to the concrete resulting in corrosion to steel reinforcement. In different environments crack widths greater than 0.3,0.25, 0.2 and 0.1mm and less than 0.1mm cause damage as per code.

II. LITERATURE REVIEW

If the concrete is to serve for the purpose for which it is designed during its intended life time it has to be durable. Indian Standard Code of Practice for plain and reinforced concrete for general building construction was first published in 1953, and subsequently revised in 1957. The next revised code came into existence in 1964. The code was revised again and new code came in to force in 1978. The latest revision was taken up to have IS 456:2000 code, with a view to keeping abreast with the rapid development in this branch of technology. Though code in its first appearance was confirmed for building construction in subsequent revisions, scope was extended to other structures also. Crack width in RC members, such as slabs and beams, subject to flexure, direct tension, eccentric tension are influenced by a large number of factors many of which are inter-related. These include, tensile stress in steel bars, thickness of concrete cover, diameter and spacing of bars, depth of member and location of neutral axis and bond strength and tensile strength of concrete. Unfortunately many reinforced concrete structures built particularly in the not-too-distant past in adverse environments have shown signs of increased structural distress and some even collapsed mainly due to chemical attack, causing deterioration of concrete and corrosion of reinforcement. Loss of durability results in reduced life of the structure; this has agitated concrete users world over. Durability has occupied center stage in the activities of concrete technology for a few decades. Consequently it is not surprising that most of the important changes and additions made in the most recent revision (4^{th} revision) of IS 456:2000deal with cement, materials, construction and durability of concrete. The present code incorporates substantially enhanced clear covers, depending the degree of environmental exposure severity. Similar revisions happened with other countries much earlier. Concrete Covers have to be large, and simultaneously crack widths to be small for durability; these conflicting requirements are to be resolved rationally. Both the requirements of crack width and cover are to be coupled for meeting durability requirements.

III. DETAILS OF SPECIMEN AND MATERIALS

A. Of the total five, one environmental exposure condition i.e. moderate case is taken for investigation. In the experimental programme undertaken, three full scale slabs where designed to serve in moderate exposure condition and tested under simply supported and uniformly distributed load. All the slabs were identical in geometry measuring 500mm in width and 2.3m in length. The simply supported effective span was 2.0m. The overall depth of the slab varied in accordance with the exposure conditions. Moderate exposure slabs were 110mm deep. The minimum weight of the slab was 2.75kN, requiring 120kN crane for its transport. The nominal covers of the slabs were in accordance with those specified in Table 16 of the code, 30mm for moderate exposure slabs. As per Table 5 of IS 456, the properties of the concrete, the minimum cement, maximum water cement ratio and minimum grade of concrete are respectively 300kg/m^3 (3kN/m^3), 0.5 and M25 for moderate case; these values were followed in the present investigation. For each exposure condition varying percentage of steel reinforcement starting with a minimum value to a possible maximum value were adopted.

B. The percentage of flexural reinforcement varied from a maximum value, which is more than the minimum specified by the code, 0.12 percent of the total cross sectional area with high strength deformed bars to near maximum permissible value. Spacing requirement of flexural reinforcement in slabs was in compliance with codal specification. As reinforcement detailing satisfied the codal requirements, the slabs should not violate the stipulated crack width requirements. The codal Requirements for exposure conditions are tabulated in Table 1. The experimental details of the slabs adopted are furnished in Table 2. The reinforcement details of the slabs are shown in Fig 1. The distribution steel used was mild steel 6mm dia bars at 0.15 percent of the total cross section area.

IV. DETAILS OF TESTING

A. The slabs were tested in the laboratory. The load test set-up was constructed in the laboratory by erecting two pedestals of plan size 250×700mm separated by about 2.0m with a height of 750mm. The slabs were tested simply supported on an effective span of 2.0m. Total length of slabs was 2.3m. Sand bag loading was adapted as live load for testing. Sand bags each weighing 0.4 kN were laid on the top of the slab; in the span five bags were necessary touching each other.

The width of the each sand bag was 500mm occupying the whole width of the slab. Each sand bag weighed 0.4 kN, 5 bags touching each other occupied full span of 2.0m, weighed 2 kN. Each layer of sand bags with a weight of 2 kN was treated as one load stage. The slabs were instrumented for the measurement of deflection at mid-span and crack widths at each load stage. A hand held microscope with a least count of 0.1mm capable of measuring a minimum crack width of 0.05mm by judgment was used. A dial gauge was used under the slab at mid span; the least count of the dial gauge was 0.01mm. At each load stage maximum crack width, deflection and the total super imposed load on the slab were measured and noted. Cracks on both vertical side faces were marked and the maximum crack width was measured at each load stage. The slabs were tested to design ultimate load.

Table 1: Details of experimental programme

Exposure condition	Slab label	Slab depth		Nominal concrete cover (mm)	Flexural reinforcement and spacing	Slab width (mm)	Overall length of slab (m)	Effective span of slab (m)
		Over all depth (mm)	Effec tive depth (mm)					
Moderate	MO1	110	76	30	3 Nos of 8Ø - 208 c/c	500	2.3	2.0
	MO2	110	76	30	6 Nos of 8Ø - 78 c/c	500	2.3	2.0
	MO3	110	76	30	9 Nos of 8Ø - 54 c/c	500	2.3	2.0

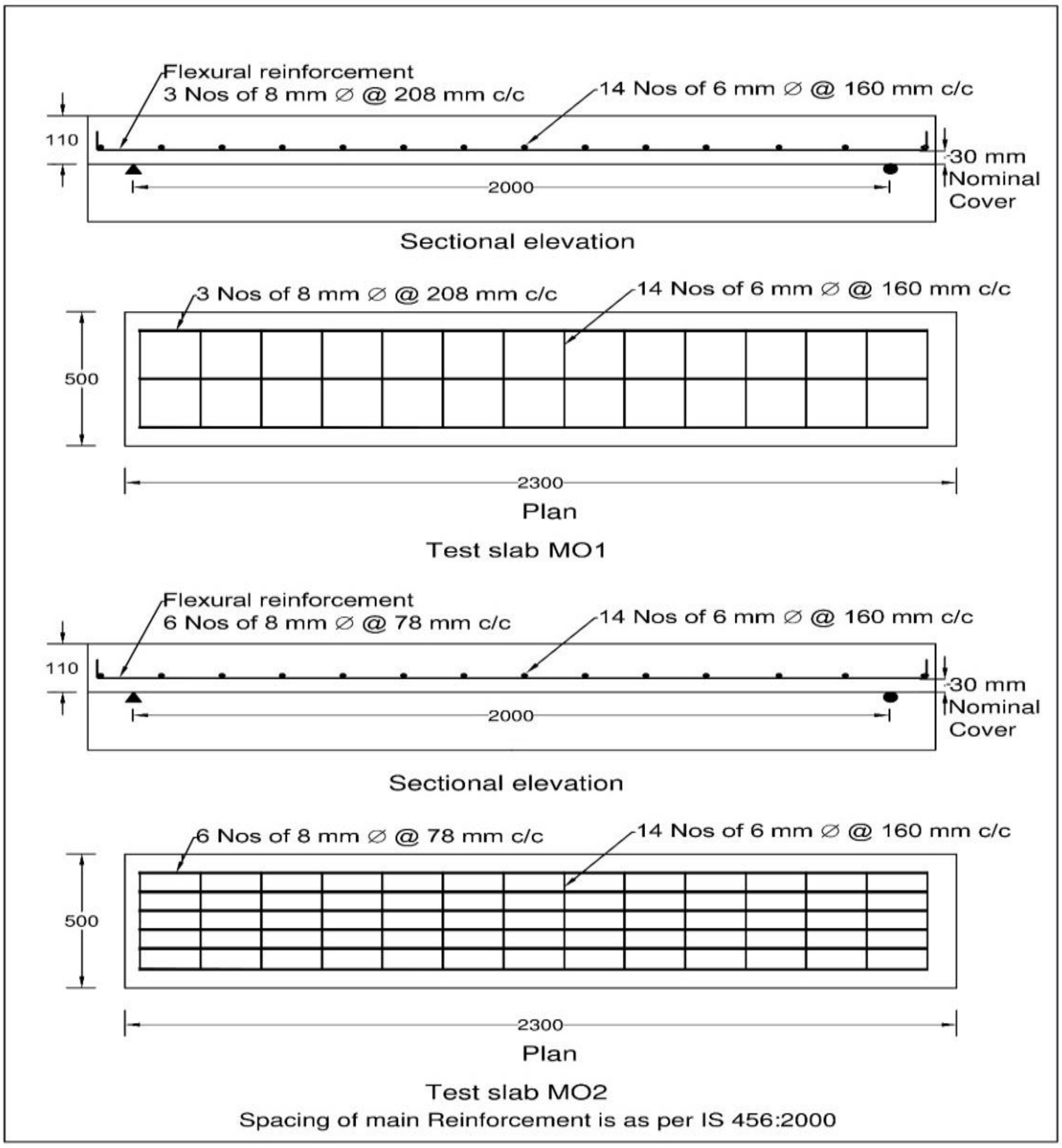

Fig. 3.1 Reinforcement details of test slabs MO1 and MO2

Figure 1: Reinforcement details of slabs MO1 and MO2

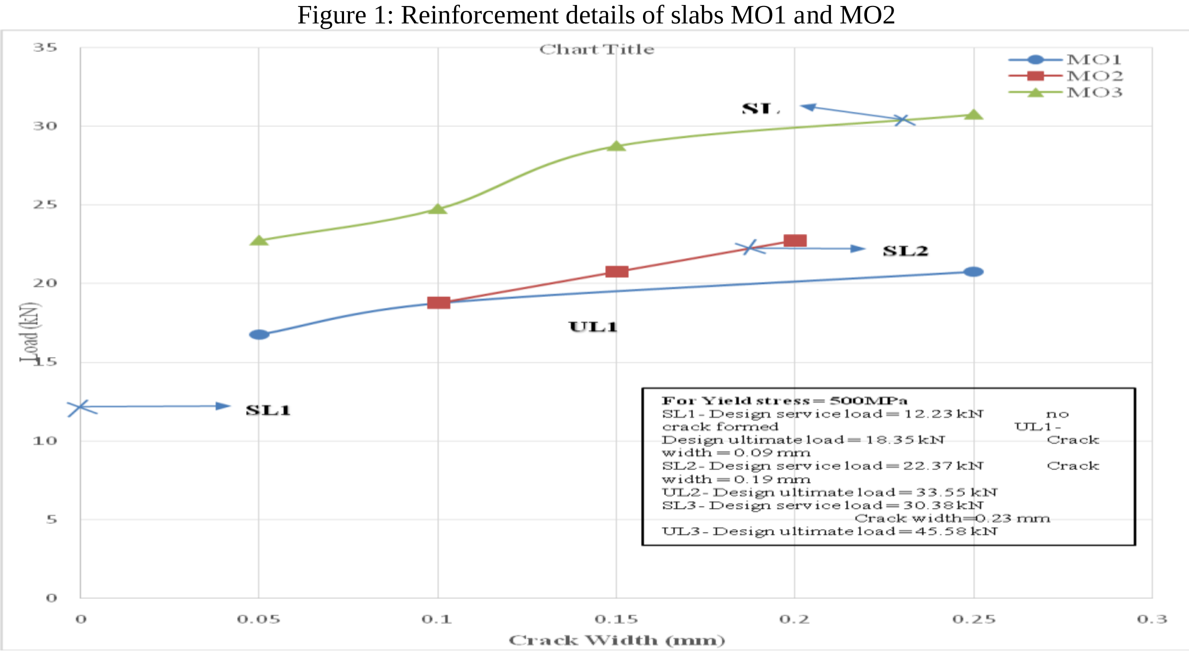

Figure 2: Combined Load – Crack width curves of moderate exposure

V. CONCLUSIONS

Based on the research conducted following conclusions are drawn

A .The experimental investigation has demonstrated that for moderate environmental exposure condition, the codal assurance that mere adaption of concrete mix design, clear cover as per Table 16 of the code, spacing of reinforcement specified in IS 456 of Cl. 26.3 is valid and would ensure durability relative to crack width as the permissible crack width is 0.25mm.

B. The deflection serviceability criteria given in IS 456:2000 is satisfied by the test slabs of this investigation.

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REFERENCES

[1] IS 456:2000 Plain and Reinforced Concrete-Code of Practice New Delhi, India: Bureau of Indian Standard.

[2] Archana Gouthaman&DevdasMenon(2001), “Increased Cover Specifications in IS 456:2000-crack width implications in RC slabs”, THE INDIAN CONCRETE JOURNAL, September.

[3] Morgan et al. (1986), “Slab reinforcement location versus code specifications”, Civil engg. Transaction, THE INSTITUTION OF ENGINEERS.

[4] Subramanian, N. &Geetha, K. (1997), “Concrete Cover for durable RC structures”, THE INDIAN CONCRETE JOURNAL, April.

[5] Tadaonishi(1982), “Outline of the studies in Japan regarding the neutralization of alkali (or carbonation) of concrete”, RILEM INTERNATIONAL SYMPOSIUM ON TESTING OF CONCRETE.

[6] Rangaswamy, N.S and others (1987), “Corrosion survey of bridges”, THE INDIAN CONCRETE JOURNAL, June.

[7] Morgan, P.R, Smith, N.M.H and Zyhajloe(1986), “Slab reinforcement location versus code specifications, Civil Engineering Transactions, The Institution Of Engineers(Australia).

[8] Schlaicill and Schaefer, K. Konstruieranimstahlbeton, BetonKalender, Part II, Wilhelm Erust&Sohn, Berlin Munich(1984).

[9] Prakash Rao, D.S.Anuradha, V.&Menzes, N. (1991), “codes of practice & construction practice-A correlation”, THE INDIAN CONCRETE JOURNAL, December.

[10] SudhirMisra(2002), “Some comments on provisions related to durability in IS456:2000”, THE INDIAN CONCRETE JOURNAL, April.