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A Sensitivity Analysis on Deflection of Simply Supported Rectangular HSSCC Two Way Slabs

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ABSTRACT

In civil engineering practice, reinforced concrete two-way slab is an important structural element. One of the major issues to be considered in the structure is deflection. Hence suitable method is required for estimating deflection. In this study, deflection is computed for simply supported reinforced concrete slab by different codes and investigation. The data used for this study was simply supported slabs subjected to uniformly distributed load. The available codal methods ACI 318-2014/15, Euro code method, IS 456 method, Bi-linear method and Desayi and Kulkarni method have been used and the prediction were compared.

KEYWORDS

Analysis, Codes, Comparison, Concrete, Deflection, HSSCC, Results, Slabs, Simply Supported.

1. INTRODUCTION

In all the branches of construction concrete and steel has attained the status of a major building material. Concrete and steel are the most important materials used in the construction of any structure. Composite of these materials, where concrete is good in compressive strength and steel yield strength are maintained for long durability of any structure. The other important structural component in civil engineering construction are reinforced concrete slabs which constitutes 40% of concrete used in any structural project.

2.SERVICEABILITY CRITERION- Deflection

One of the important serviceability limit state is the deflection that the design of a structural element based on the limit state analysis has to satisfy. It is necessary to determine deflection in design of reinforced concrete slabs.Many methods have been reported for the computation of deflection of two way reinforced concrete slabs.

1] Desayi and Kulkarni Method

2] Bi-Linear Method

3] IS Code Method

4] ACI- 318- 2014 Method

5] ACI- 318- 2015 Method

6] Euro code Method

7] Desayi and Muthu Method

But a suitable method is not available for predicting the short term deflection of HSSCC.

OBJECTIVE

1] To compute the short term deflection of HSSCC two way slabs, by available methods, using various codes of practices and also the methods suggested by other investigation.

2] A sensitivity analysis based on the predicted short term deflection at service loads.

3.EXPERIMENTAL DATA

The experimental data includes

1] Twelve reinforced concrete simply supported rectangular two way slabs of Desayi and Kulkarni's investigation [1].

2] Twenty-four rectangular HSSCC slabs of Harish investigation [8].

3.1.Desayi and Kulkarni's Investigation [1]

An experimentalprograme has been designed to cast and test 12 rectangular simply supported slabs under distributed loading. The main variables are span/depth ratio, aspect ratio and co-efficient of orthotropy.

Two different thickness of 50mm and 65mm were used such that the shorter span to depth ratio was 20 and 26. Two aspect ratio 1.25 and 1.5 were used. The reinforcement percentage was varied such that the co-efficient of orthotrophy ranges from 1 to 2.85. All the slabs were tested under uniformly distributed load and the compete load deflection behavior was reported elsewhere [1].

3.2. Experimental Investigation of Harish [8]

In this investigation a total of 24 slabs of high strength concrete and high strength self-compacting concrete were cast and tested. Slabs thicknesses of 40mm and 50mm were cast and tested. The main variable was the co-efficient of orthotropy obtained by varying the percentage of reinforcement, All the slabs were tested until failure and the load deflection plots were obtained.

4.METHOD OF ANALYSIS

The short term deflection (the deflection corresponding to the service load) were computed using thin plate theory[9] with suitable modifications at different loading stages along with suitable effective moment of inertia function. The available methods are briefly described.

1] Desayi and Kulkarni Method [1]

The analysis for the determination of load-deflection is carried out in three stages.

a) First stage ($0 < q < q_{cr}$)

$$\delta = \frac{\beta q l_x^4}{E_c Ig}$$

b) Second stage

In this second stage, the slab would have cracked at a certain location beyond the taken as $E_c I_{cr}$.

$$\delta_2 = \delta_1 + \beta \frac{(q_{cr1} - q_{cr}) lx^4}{E_c I_{cr}}$$

$$q_{cr1} = f_r bd^2 / 6 / 0.0812 l_x^4$$

c) Third stage

$$\delta_3 = \delta_2 + \beta\,(q_y - q_{cr1})\, l_x^4 / 0.5 E_c I_{cr}$$

$$q_y = M_y / 0.0368\, l_x^2$$

The load deflection plot is in the form of three straight lines

2) BI-Linear Method [2]

Deflection at working load

$\delta_w = \alpha\frac{q_w l_x^4}{E_c I_g} + \alpha\frac{(q_w - q_{cr}) l^4}{0.85\, E_c I_{cr}}$

3) IS 465: 2000 CODE Method [3]

Deflection at working load

a) $\delta_w = \frac{\alpha q_w l_x^4}{E_c I_g}$ if $M < M_{cr}$

b) b) $\delta_w = \frac{\alpha q_w l_x^4}{E_c I_{eff}}$ if $M > M_{cr}$

$I_{eff} = \frac{Icr}{1.2 - (\frac{Mcr}{m})(\frac{Z}{d})(1 - \frac{x}{d})(\frac{bw}{b})}$, $I_{cr} < I_{eff} <= I_g$

4) ACI -318-2014 Method [4]

Deflection at working load

$\delta_w = \alpha q_w l_x^4 / E_c I_{effw}$

$I_{effj} = I_{cr} + (I_g - I_{cr}) \left(\frac{M_{cr}}{M}\right)^3$

5) ACI-318- 2015 Method[5]

Deflection at working load

1) $\delta_w = \alpha q_w l_x^4 / (4733\sqrt{f'_c}) I_g$ if M<Mcr

2) $\delta_w = \alpha q_w l_x^4 / (4733\sqrt{f'_c})\, I_{eff}$ if M>Mcr

6) EURO Code Method [6]

DEFLECTION AT WORKING LOAD

a) $\delta = 0.104\, (1/r)_{un}\ l^2$ If $M < M_{cr}$

b) $\delta = 0.104\, (1/r)\ l^2$ If $M > M_{cr}$

7) Desayi and Muthu's Method [7]

Deflection at working load

$\delta_w = \delta_{cr} + \frac{\propto (q_w - q_{cr}) l_x^4}{E_c I_{eff}}$

$I_{eff} = I_g\, [1 - k_1\, \{(q_w - q_{cr}) / (q_j - q_{cr})\}^{k2}]$

Where the multiplier constant k_1 and the power co-efficient k_2 depend on the strength and sectional properties of the slab.

Table 1. Short term deflection at working load

Sl No	$\delta_j$exp(mm)	IS	Ratio of computed to experimental deflection					
			ACI 2014	ACI 2015	BI LINEAR	EURO CODE	KULKARNI &DESAYI	DESAYI &MUTHU
S1	12.7	0.76	0.28	0.64	0.62	0.53	0.93	0.58
T1	10.4	1.07	0.83	0.97	1.23	1.36	1.04	0.86
S2	12.0	0.86	0.37	0.74	0.86	1.23	1.07	0.73
T2	11.8	1.09	0.51	0.92	1.18	1.18	1.46	1.09
S3	9.9	1.07	0.85	0.91	1.17	1.22	1.52	1.24
T3	11.0	1.23	1.13	0.97	1.37	1.19	1.64	1.39
S4	8.64	0.99	0.38	0.71	0.93	1.78	0.92	0.76
T4	10.3	1.03	0.67	0.68	1.06	1.43	0.95	0.92
S5	8.46	1.33	0.44	0.67	1.07	1.75	1.32	0.89
T5	10.17	1.17	0.86	0.72	1.16	1.39	1.15	1.05
S6	9.92	0.89	0.74	0.68	1.06	1.01	1.22	1.11
T6	11.0	1.28	1.26	0.86	1.48	1.06	1.84	1.56

5.RESULT AND COMPARISION

All the thirty-six slabs test data were used for prediction of short term deflection. Table 1 gives the predictions of Desayi and Kulkarni's test data of 12 slabs. Also the load deflection behavior has been predicted of Harish Investigation. The theoretical load deflection curve has been predicted using ACI-318-2015 method.

Comparision of Load deflection curve of ACI 318 2015 and experimental values.

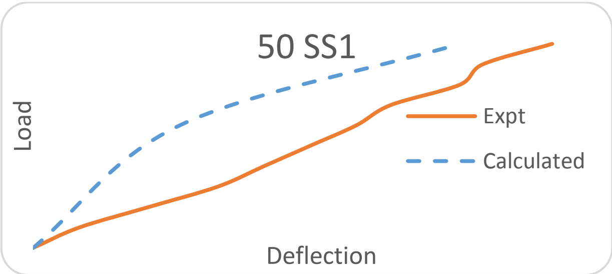

Fig 1:Comparison of Experiment vs Load deflection curve of slab 50 NS1

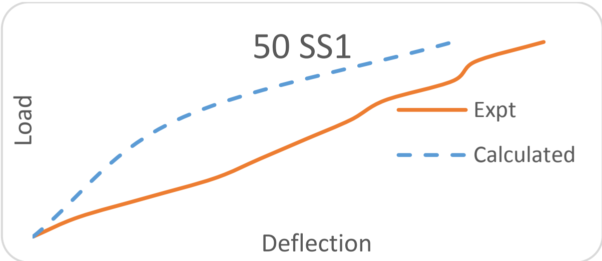

Fig 2: Comparison of Experiment vs Load deflection curve of slab 50 SS1

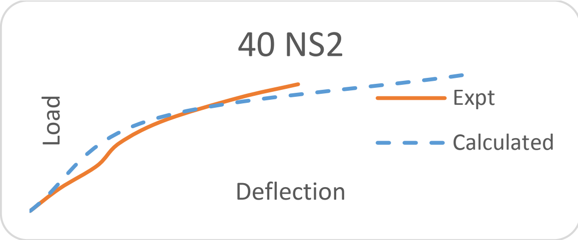

Fig 3: Comparison of Experiment vs Load deflection curve of slab 40 NS2

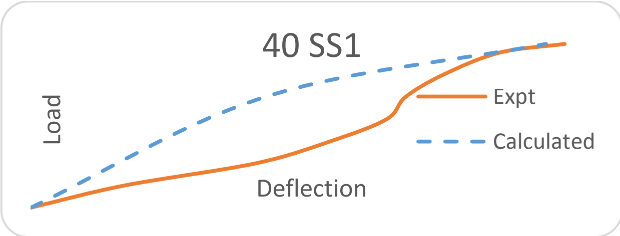

Fig 4: Comparison of Experiment vs Load deflection curve of slab 40 SS1

6. SUMMARY AND CONCLUSION

Deflection, one the important limit state to be satisfied in the limit state design of concrete structure. Both computational and control approaches are specified in various codes of practice. Based on the test data the suggested formulae are computed and the same are used for two-way slab. Hence, in this study the slabs have been examined for test data.

The test data of simply supported slabs subjected to distributed loading of Desayi and Kulkarni's and Harish investigation were used. A total of 36 slabs from both the investigations, 12 slab from the former and 24 slabs of later investigation have been used. The short term deflection were taken at working load which is the two third of Johansen's yield line load. Johansen's load was computed using the yield line theory [10].

Using the elastic deflection formula given in theory of thin plates, the deflection is calculated. The codal formula in general follow the effective moment of inertia approach are based on average curvature. In ACI 318, IS 456 codes the effective moment of inertia approach was suggested.

In Euro code the average curvature method is recommended for the computation of deflection. Also other empirical methods suggested as Bi-linear method and Desayi and Kulkarni's were used. At service load the deflection is computed. The result of Desayi and Kulkarni's method gave an average value of ratio of calculated to experimental as 0.93 to 1.06 with coefficient of variation 15%. ACI 218-2015 gave an average value of calculated to experimental as 0.64 to 1.1 with coefficient of variation 20%. IS 456-2000 method gave an average value of calculated to experimental as 0.76 to 1.5 with coefficient of variation 18%. Euro code method gave an average value of 0.53 to 1.52 with coefficient of variation 32%. ACI 318-2014 gave an average value of 0.28 to 0.56 with coefficient of variation 33%. Along with Bilinear method which gave an average value of 0.28 to 0.62 with co-efficient of variation 29%.

All the above method of analysis of various codal method indicate that a suitable method is to be developed to compute the deflection at different load levels. However, the study points out that ACI 318-2015 gave better prediction with respect to the experimental curves when compared with other available methods. This method can further be improved for better prediction with the test data.

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