

Study on Effect of Grade of Concrete with Varying Percentage of Tension Reinforcement on Span to Depth Ratio for Reinforced Concrete Structure

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ABSTRACT: Deflections may be controlled by ensuring that members have sufficient stiffness to limit the deformations at the service loads. Basically, there are two approaches used to minimize the deflection within the permissible limit as described by Indian Standard code. Control is obtained by providing a suitable span to effective depth ratio for the beam which depends on support conditions, span of the beam, area and type of tension reinforcement, area of compression reinforcement as well as type of beam (rectangular or flange). Since reinforced concrete is a heterogeneous material comprising both steel and concrete. Since the quality of steel has an effect on span to effective depth ratio hence there must be an effect of quality of concrete with varying tension reinforcement also. In order to investigate whether the quality of concrete with varying percentage of tension reinforcement affects this ratio or not this project has been initiated. In this project we suggest the fourth modification factor for different of grade of concrete with varying tension reinforcement to control the deflection

KEYWORDS: Deflection control, modification factor, Span to depth ratio, flexural strength, varying grade of concrete, varying tension reinforcement.

I. INTRODUCTION

As we there are two approaches for control of deflection which is given in IS 456-2000 Clause 23.2. one is theoretical in which deflection of any structural member is calculated then compare with the permissible limit given in code which is (a), should not normally exceed span/250.(b) should not normally exceed span/350 or 20 mm whichever is less. And second is empirical method given in IS 456: 2000 Provisions for Control of Deflection

As per clause 23.2.1 of IS 456:2000 [1]

$$\text{Allowable } L/d = N \times \alpha_1 \times \alpha_2 \times \alpha_3 \geq \text{Actual } L/d$$

The modification factors given in above given equation are due to, area and type of tension reinforcement, area of compression reinforcement as well as type of beam (rectangular or flange) but there is no modification factor for grade of concrete with varying tension reinforcement which means that according to Indian standard code there is no effect of grade of concrete with varying tension reinforcement but according to these equation

$$\delta = \frac{\alpha w L^4}{E_c I_e} \quad (1)$$

Where, δ = Short-term deflection, α = Elastic deflection coefficient (=5/384) for a simply supported beam, subjected to a uniformly distributed load (w), L = Span of beam, E_c = Short term modulus of elasticity of concrete, I_e = Effective moment of inertia,

Further, Young Modulus of elasticity for concrete as per clause 6.2.3.1 of IS 456:200 is given as,

$$E_c = 5000 \times \sqrt{f_{ck}} \quad (2)$$

Where, f_{ck} is the characteristics strength of concrete at 28 days which ultimately depends on the grade of concrete.

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The above equation shows that Deflection is also depend on grade of concrete and from the Indian Standard Code we know that deflection is also depend on percentage of tension reinforcement now to investigate the another modification factor which is for grade of concrete with varying tension reinforcement this project is initiated Further after this project we suggest a modification factor for effect of grade of concrete with varying tension reinforcement as,

$$\text{Allowable } L/d = N \times \alpha_1 \times \alpha_2 \times \alpha_3 \times \alpha_4^* \geq \text{Actual } L/d$$

Where, α_4^* = Proposed modification factor corresponding to grade of concrete with varying percentage of tension reinforcement

For this investigaton we are taken four group of concrete in each group a grade of concrete with varying reinforcement sets (grade of concrete are taken in this investigation are M20,M25,M30,M35 and different sets of tension reinforcement named as A,B and C for which percentage of tension reinforcement are .50%,.793% and.723% respectively)

II. LITERATURE REVIEW

Specification Given by BS 8110-1:1997

Clause 3.4.6.3: Basic span/effective depth ratio for rectangular or flanged beams Clause 3.4.6.4 Long Span: Clause 3.4.6.5 Modification of span/depth ratios for tension reinforcement: [2].

Clause 3.4.6.6 Modification of span/depth ratios for compression reinforcement: [3].

Specification Given by EN 1992 (Euro code 2) Design of Concrete Structure

Clause 7.4 The serviceability limit state of deflection can be checked using span-effective depth ratios

Specification Given by Code of Practice for Structural Use of Concrete, 2013 (The Government of Hong Kong)

Clause 7.3.4 Limiting deflection without direct calculation (deemed-to-satisfy)

Clause 7.3.4.1 General. ,Clause 7.3.4.2 Basic span/effective depth ratio for reinforced concrete section, Clause 7.3.4.3 Long Span: .Clause 7.3.4.4 Modification of span/depth ratios for tension reinforcement ,Clause 7.3.4.5 Modification of span/depth ratios for compression reinforcement

We studied all the above literature review thoroughly there is no modification factor for different grade of concrete with varying tension reinforcement is consider in any code. In BS 8110-1:1997 and The practice code of Government of Hong Kong given the modification factor for tension reinforcement. Now on the basis of equation (1) ,(2) and different standard codes which are given the modification factor for tension reinforcement . we investigate the modification factor for different grade of concrete with varying tension reinforcement.

III. EXPERIMENTAL STUDY

Materials Used

Cement: Ordinary Portland cement, 43 Grade conforming to IS 12269 – 1987

Fine aggregate: Locally available river sand, conforming to Grading zone III of IS 383 –1970. **Coarse aggregate:** Locally available crushed blue granite stones conforming to graded aggregate of nominal size 20 mm as per IS 383 – 1970

Reinforcing Steel: Fe500 steel bars were used as main longitudinal reinforcement for both tension and compression zone. The average characteristic yield strength of longitudinal reinforcement was found to be approximately 550 MPa

Mix Proportion: The mix design has been adopted as per IS 10262-2009. There are four grade of concrete namely M20,M25,M30,M35 are designed and its characteristic strength are found in the compression test is given in table below

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TABLE Characteristic Strength for different grade of concrete

Group	Revised Grade of Concrete	Average Failure Load (KN)	Characteristic Strength (MPa)
1	M21.1	474.83	21.10
2	M25.4	571.8	25.40
3	M32.3	726.13	32.30
4	M36.0	810.3	36.00

Beam designation:

There are four group of concrete in each group a grade of concrete with varying reinforcement sets (grade of concrete are taken in this investigation are M20,M25,M30,M35 and different sets of tension reinforcement named as A,B and C for which percentage of tension reinforcement are .50%,.793% and.723%) for example one group of concrete is M21.1 for which three sets of tension reinforcement hence it is named as M21.1 A, M21.1B, M21.1C here A,B and C indicates the different sets of reinforcement. stirrups 6mm at 100mm c/c spacing upto 250mm from both edges of beam..

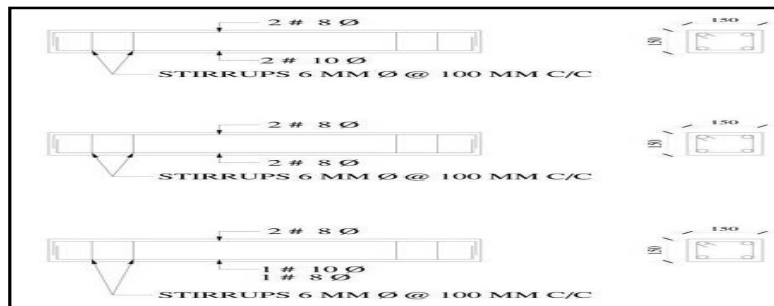


FIGURE Reinforcement detailing of beam specimen B,A,C

Description of Beam Specimens

The experimental work comprises of RC beams of rectangular cross section. All beams had the width of 150 mm, total depth of 150 mm, span length of 700 mm and effective span (i.e. c/c distance b/w two supports) of 600 mm. The dimension of all beams is shown in Fig. 4.3. Beams were designed in such a way that they would fail in flexure only under the applied monotonic load.

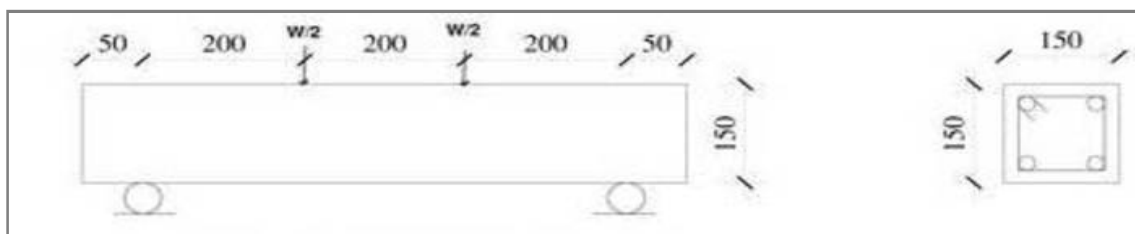


FIGURE Dimensional details of beam

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TABLE A Details of beam specimens of different groups

Details		Group 1			Group2		
Grade of Concrete		M 21.1 A	M21.1 B	M21.1 C	M 25.4 A	M25.4 B	M25.4 C
Characteristic Strength		21.1	21.1	21.1	25.4	25.4	25.4
Main R/F (HYS D)	Top	2#8	2#8	2#8	2#8	2#8	2#8
	Bottom	2#8	2#10	1#8,1#10	2#8	2#10	1#8,1#10
% of Steel		0.50	0.793	0.723	0.50	0.793	0.723
Stirrups		2 legged 6mm @100m m c/c	2 legged 6mm @100m m c/c	2 legged 6mm @100mm c/c	2 legged 6mm @100m m c/c	2 legged 6mm @100m m c/c	2 legged 6mm @100mm c/c

TABLE B Details of beam specimens of different groups

Details		Group 3			Group4		
Grade of Concrete		M 32.3 A	M32.3 B	M32.3 C	M 36 A	M36 B	M36 C
Characteristic Strength		32.3	32.3	32.3	36	36	36
Main R/F (HYS D)	Top	2#8	2#8	2#8	2#8	2#8	2#8
	Bottom	2#8	2#10	1#8,1#10	2#8	2#10	1#8,1#10
% of Steel		0.50	0.793	0.723	0.50	0.793	0.723
Stirrups		2 legged 6mm @100m m c/c	2 legged 6mm @100m m c/c	2 legged 6mm @100mm c/c	2 legged 6mm @100m m c/c	2 legged 6mm @100m m c/c	2 legged 6mm @100mm c/c

Figs. Below shows step wise procedure of concrete making i.e Formwork for the casting of specimen, Mixing of concrete, Hand compaction of beams, Water tank for curing of specimens



Formwork for the casting of specimen



Mixing of concrete

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Hand compaction of beams



Water tank for curing of specimens

Testing of Beam Specimens

The load was transmitted through the load cell of UTM (1000 KN capacity) to the beam. The beam specimen was placed over two support having 600 mm centre to centre span. Loading was done by Universal Testing Machine. Lines were marked on the beam to be tested at $L/3$ and $2L/3$ location from the left support (Where $L=600$ mm the centre to centre distance between the supports) For all beams four point bending test was performed on Universal Testing Machine (1000 KN capacity). The beams were simply supported with an effective span of 600 mm c/c. Fig. shows the set up arrangement for a beam specimen.



FIGURE Setup for beam specimen

IV. RESULTS AND DISCUSSION

Based on the study made in this dissertation, experimental findings and interpretation of results, following conclusions can be drawn,

TABLEC Experimental results of specimens

Group	Grade of Concrete	Type of reinforcement	Specimen Name	Load (KN)					
				At first Crack Deflection		At L/250 mm Deflection		At L/350 mm Deflection	
				Result	Average	Result	Average	Result	Average
1	M 21.1	A	A1	18.2	18.015	38.1	37.5	34.9	34.05
			A2	17.83		36.9		33.20	
		B	B1	19.01	18.165	39.23	38.62	35.21	34.155
			B2	17.32		38.01		33.1	
		C	C1	20.17	18.435	38.89	38.205	36.87	35.54
			C2	16.67		37.52		34.21	
2	M 25.4	A	A1	19.89	20.45	42.98	41.995	37.65	36.425
			A2	21.01		41.01		35.2	
		B	B1	18.91	20.865	44.65	43.385	40.01	38.455
			B2	22.82		42.12		36.9	

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		C	C1	18.32	19.10	43.87	42.595	38.99	39.095
			C2	19.89		41.32		39.2	
3	M 32.3	A	A1	23.12	22.45	44.9	43.83	42.5	41.15
			A2	21.78		42.76		39.8	
		B	B1	25.56	23.95	47.01	46.215	45.39	43.495
			B2	22.34		45.42		41.6	
		C	C1	24.45	24.01	46.92	46.555	43.35	42.95
			C2	23.57		46.19		42.56	
4	M 36	A	A1	25.56	25.85	45.03	44.675	43.1	42.22
			A2	26.12		44.32		41.34	
		B	B1	23.39	23.97	47.78	46.605	45.9	44.15
			B2	24.56		45.43		42.45	
		C	C1	22.90	23.38	47.4	47.76	44.1	43.33
			C2	23.87		48.12		42.56	

Generation of Modification Factor

As per the clause 6.1.2 of IS 456: 2000 minimum grade of concrete for reinforced concrete structure for mild exposure should not be less than M20. Hence by taking M21.1 as reference value, the loads for different grade of concrete have been normalized for the two deflection limits. In addition to loads, grade of concrete has also been normalized with respect to M21.1 grade and termed as *Grade Ratio*.

Modification factors for normalized grade ratio have been calculated and tabulated in Table show the graph for these modification factors and grade ratio for L/250 & L/350 mm deflection limit respectively.

Table D Modification factors for different deflections limit

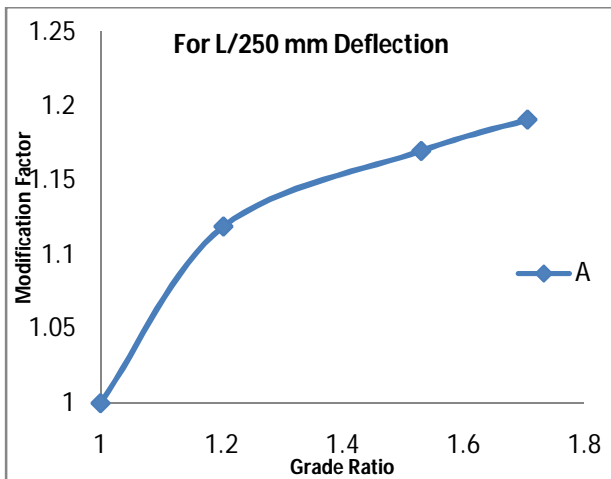
Group	Grade of Concrete	Type of Reinforcement	Grade Ratio	Modification factor	
				For L/250 mm Deflection	For L/350 mm Deflection
1	21.1	A	1.000	1.000	1.000
		B	1.000	1.000	1.000
		C	1.000	1.000	1.000
2	25.4	A	1.203	1.119	1.069
		B	1.203	1.123	1.126
		C	1.203	1.114	1.100
3	32.3	A	1.530	1.170	1.209
		B	1.530	1.197	1.273
		C	1.530	1.218	1.208
4	36	A	1.706	1.191	1.239
		B	1.706	1.206	1.292
		C	1.706	1.250	1.219

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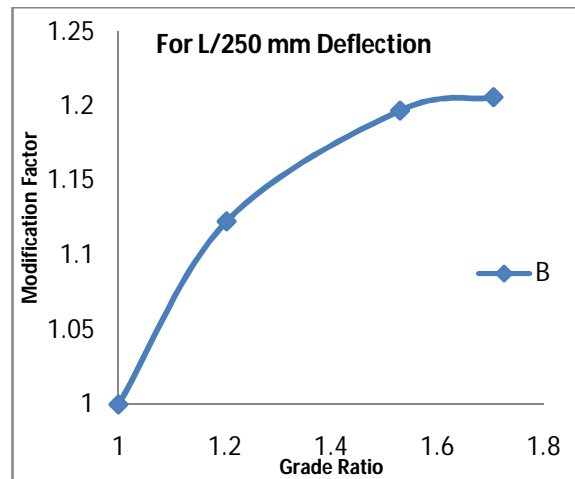
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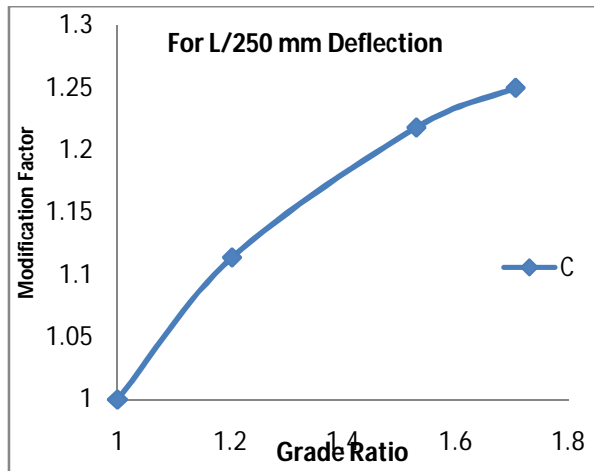
Graphical presentation of Modification Factor V/S Grade Ratio



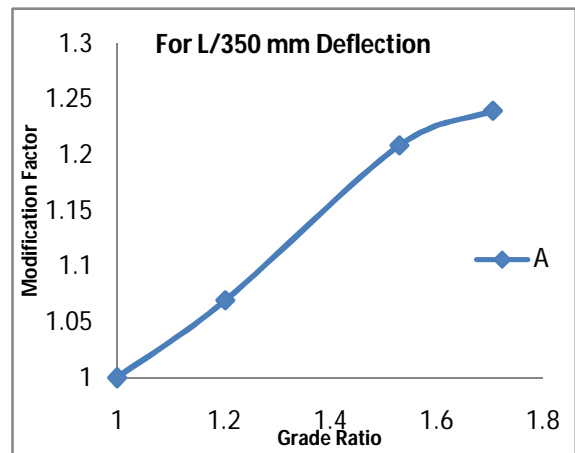
Modification Factor V/S Grade Ratio



Modification Factor V/S Grade Ratio



Modification Factor V/S Grade Ratio

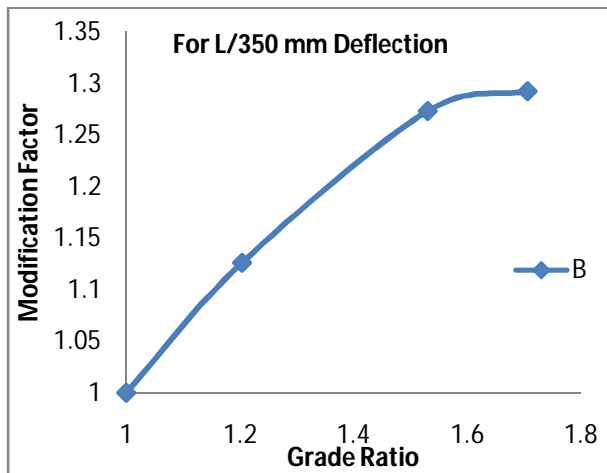


Modification Factor V/S Grade Ratio

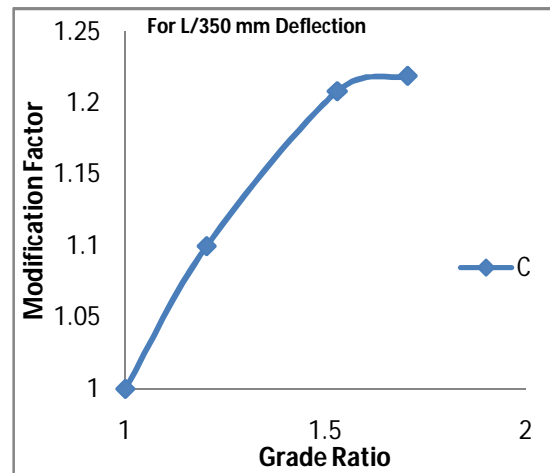
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Modification Factor V/S Grade Ratio



Modification Factor V/S Grade Ratio

On the basis of above two modification factors, the allowable span to effective depth ratio as given in clause 23.2.1 of IS 456:2000 has been further modified and can be rewritten as,

$$\text{Allowable } L/d = N \times \alpha_1 \times \alpha_2 \times \alpha_3 \times \alpha_4^* \geq \text{Actual } L/d$$

V. CONCLUSION

Based on the study made in this dissertation, experimental findings and interpretation of results, following conclusions can be drawn,

(i) It has been found that with the increase in grade of concrete with varying tension reinforcement the modification factors increases for both deflection limits as suggested in clause 23.2 of IS 456:2000 which ultimately increases the span to effective depth ratio. The suggested values of modification factors at two deflection stages are tabulated in Table A.

(ii) On the basis of above two modification factors, the allowable span to effective depth ratio as given in clause 23.2.1 of IS 456:2000 has been further modified and can be rewritten as,

$$\text{Allowable } L/d = N \times \alpha_1 \times \alpha_2 \times \alpha_3 \times \alpha_4^* \geq \text{Actual } L/d$$

Where, N = Basic value of span to effective depth ratio for different support condition as given in clause 23.2.1 of IS 456: 2000

Where, α_4^* = Proposed modification factor corresponding to grade of concrete with varying percentage of tension reinforcement.

α_1 = Modification factor for tension reinforcement

α_2 = Modification factor for compression reinforcement

α_3 = Modification factor for flanged beam

REFERENCES

- [1] Clause 23.2 of Indian Standard "Plain and reinforced concrete- code of practice (Fourth Revision), IS 456:2000 (Reaffirmed 2005).
- [2] Table 3.10 - Modification factor for tension reinforcement BS 8110-1:1997.
- [3] Table 3.11 - Modification factor for compression reinforcement BS 8110-1:1997.
- [4] Table 7.4 - Modification factor for tension reinforcement code of practice for structural use of concrete, 2013 (The Government of Hong Kong Special Administrative Region)
- [5] Table 7.5 - Modification factor for tension reinforcement code of practice for structural use of concrete, 2013 (The Government of Hong Kong Special Administrative Region).