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PARAMETRIC STUDY OF OLD IS456:2000 AND PROPOSED IS456

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Abstract - *The aim of this paper is to compare proposed fifth revision of Indian standard code of practice for plain and reinforced concrete and old IS456:2000, Parameters like Modulus of elasticity, stress-strain curve of concrete, shear strength of concrete, P-M Interaction curve of column is changed in fifth revision of IS 456. So in this paper comparison is made on this parameters and also some design criteria which is also changed in fifth revision of IS456 and also do elementary design by both the codes and also compare the results.*

***Key Words*: Stress Strain Curve, Stress block parameters, Fulcrum point, Proposed IS 456, Robustness**

1. INTRODUCTION

Structural design is the methodical investigation of the stability, strength and rigidity of structures.IS456 2000 is the fourth revision of IS456 after that there were no such big revision in IS456 :2000 but recently in 2020 a proposed fifth revision of IS 456 is introduced. And in this proposed IS 456 major changes like modified modulus of elasticity, modified stress-strain curve of concrete, modified shear- strength of concrete, modified percentage of tensile and compression steel is introduced. Earlier we can design up to M60 grade of concrete, but now we can design up to M100 grade of concrete so design of high strength concrete is also introduced.

2. PARAMETRIC COMPARISION

2.1 STRESS STRAIN CURVE OF CONCRETE

Stress strain curve of concrete is most important in design of concrete structures. Earlier stress strain of concrete were fixed means it does not depend on grade of steel or grade of concrete. In the earlier code maximum strain is 0.0035 and parabolic portion was up to 0.002. but in proposed IS456 it is depended on grade of concrete. For different grade of concrete corresponding strain is tabulated below.

Table -1: Different grade of concrete corresponding strain

GRADE OF CONCRETE	STRAIN UP TO PARABOLIC PORTION	CONSTANT STRAIN AFTER PARABOLIC PORTION
20	0.002	0.0035
25	0.00203	0.00343
30	0.00205	0.00336
35	0.00208	0.00329
40	0.00210	0.00323
45	0.00213	0.00316
50	0.00215	0.00309
55	0.00218	0.00302
60	0.00220	0.00295
65	0.00223	0.00288
70	0.00225	0.00281
75	0.00228	0.00274
80	0.00230	0.00268
85	0.00233	0.00261
90	0.00235	0.00254
95	0.00238	0.00247
100	0.00240	0.00240

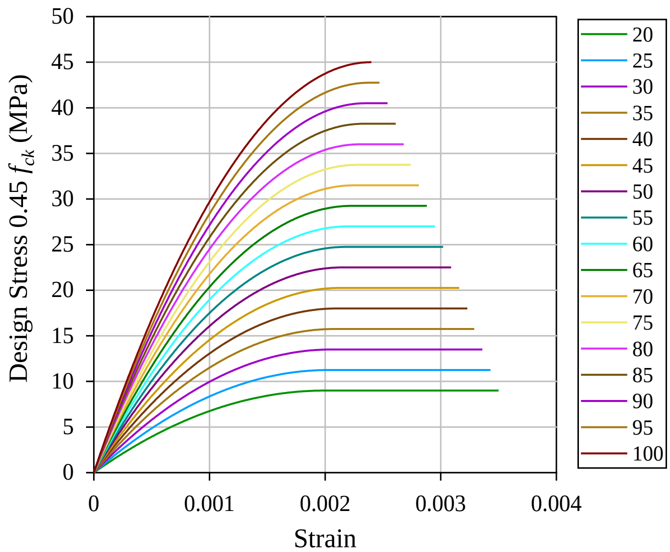
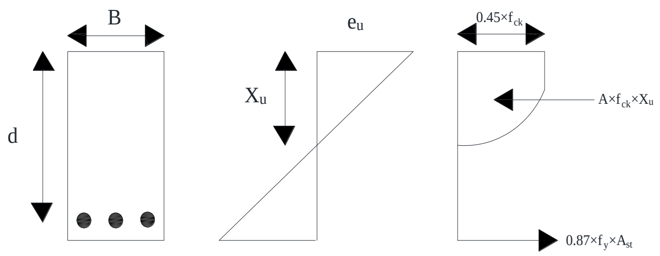


Fig -1: Graphical representation of stress-strain curve of concrete as per fifth revision

Stress block parameters



GRADE OF CONCRETE	A	B
M20	0.364	0.416

M25	0.361	0.413
M30	0.358	0.411
M35	0.355	0.409
M40	0.352	0.407
M45	0.349	0.404
M50	0.346	0.402
M55	0.342	0.399
M60	0.338	0.396
M65	0.334	0.393
M70	0.330	0.391
M75	0.325	0.388
M80	0.321	0.386
M85	0.316	0.383
M90	0.311	0.380
M95	0.305	0.377
M100	0.300	0.375

FULCRUM POINT FOR DIFFERENT GRADE OF CONCRETE

As we know P-M interaction curve is most important in design of columns, earlier there is no change in strain of concrete as the grade of concrete changes, but now P-M interaction curve as per the new standards is also depends on grade of concrete.so, from this we can also conclude that strain at highly compressed fiber is given by maximum strain in concrete minus fulcrum point multiply by least compressed fiber.

Table -2: Fulcrum point for different grade of concrete

GRADE OF CONCRETE	FULCRUM POINT	PARABOLIC PORTION
M20	3/7	4/7
M25	3/7	4/7
M30	2/5	3/5
M35	2/5	3/5
M40	3/8	5/8
M45	3/8	5/8
M50	1/3	2/3
M55	1/3	2/3
M60	1/3	2/3
M65	1/3	2/3
M70	2/7	5/7
M75	¼	3/4
M80	¼	3/4
M85	¼	3/4
M90	1/5	4/5
M95	1/5	4/5
M100	1/6	5/6

Example

Calculate strain at most compressed fiber if neutral axis is at 2 times the depth of section (grade of concrete M30)

CODE	Strain at highly compressed fibre	Strain at least compressed fibre
IS 456 (4TH REVISION)	0.0022	0.0018
IS 456 (5TH REVISION)	0.0023	0.0017

As we can see there is no big difference in strain at edges but also it can not be ignored.

2.2 MODIFIED PROPERTIES OF CONCRETE

Table -3: Properties

Properties	Old IS456	Proposed IS456
Modulus elasticity of concrete	$5000\sqrt{fck}$	$10000(fck)^{0.3}$
Shear strength of concrete	Up to grade M60 $0.631\sqrt{fck}$ Above grade M60 4.8	Up to grade M60 $0.067(fck)$ Above grade M60 4

2.3 MODIFIED DESIGN CRITERIA

Modified depth of neutral axis – As we know earlier maximum depth of neutral axis is only depend on grade of steel but now in new is456 it is also depends on grade of concrete.

Table -4: Modified $X_{u,max}/d$

f_{ck} (MPa)	$X_{u,max}/d$				
	250	415	500	550	600
20	0.531	0.479	0.456	0.443	0.432
25	0.526	0.474	0.451	0.438	0.427
30	0.521	0.469	0.446	0.433	0.422
35	0.516	0.464	0.441	0.428	0.416
40	0.511	0.459	0.436	0.424	0.412
45	0.506	0.454	0.431	0.418	0.407
50	0.500	0.448	0.425	0.413	0.401
55	0.494	0.442	0.420	0.407	0.396
60	0.489	0.437	0.414	0.402	0.390
65	0.483	0.431	0.408	0.396	0.385
70	0.476	0.425	0.402	0.390	0.379
75	0.470	0.419	0.396	0.384	0.373
80	0.465	0.413	0.391	0.379	0.368
85	0.458	0.407	0.385	0.373	0.361
90	0.451	0.400	0.378	0.366	0.355
95	0.444	0.394	0.372	0.360	0.349
100	0.437	0.387	0.365	0.353	0.342

Minimum Longitudinal Reinforcement for Beam

$$\frac{Ast,\min}{Bd} = \frac{0.25\sqrt{f_{ck}}}{f_y}$$

Minimum Longitudinal Reinforcement for Column

Grade of concrete	$\frac{Ast,min}{BD}$
M20-M40	0.008+0.00035(M-20)
M40-M60	0.015+0.00035(M-40)
M60-M80	0.022+0.00030(M-60)
M80-M100	0.028+0.00028(M-80)

Maximum Reinforcement in Slabs

$$\frac{A_{st,\max}}{Bd} = A\left(\frac{f_{ck}}{0.87\,f_y}\right)\left(\frac{x_{bal}}{d}\right) \le 0.01$$

Where, A is the stress block parameter

Maximum Reinforcement in Beams

$$\frac{A_{st,\max}}{Bd} = A\left(\frac{f_{ck}}{0.87\,f_y}\right)\left(\frac{x_{bal}}{d}\right) \le 0.02$$

2.3.1 SHEAR STRENGTH OF CONCRETE

earlier it is depends on only grade of concrete and percentage of tensile reinforcement, but as per the fifth revision it is also depends on size of the member, shape of the member and type of aggregate used.

$$\tau_c = \frac{0.36 * \lambda_a * \lambda_s * \lambda_g * (p_t f_{ck})^{1/3}}{\gamma_m}$$

Where,

$$\lambda_a = \text{Aggregate type factor} = \begin{cases} 1 \text{ for normal weight aggregate} \\ 0.75 \text{ for normal weight aggregate} \end{cases}$$

$$\lambda_s = \text{Cross section size factor} = \begin{cases} 1 \text{ for effective depth } (d) \le 400mm \\ \left(\frac{400}{d}\right)^{0.25} \text{ for effective depth } (d) > 400mm \end{cases}$$

$$\lambda_g = \text{Cross section geometry factor} = \begin{cases} 0.83 \text{ for rectangular or square cross section} \\ 0.70 \text{ for circular cross section} \end{cases}$$

$$\gamma_m = 1.5$$

2.3.2 MINIMUM TRANSVERSE REINFORCEMENT

Minimum Transverse Reinforcement in Beams

$$\frac{A_{sv,\min}}{bd} = Max\left[\frac{0.4}{f_y \frac{d}{s_v}}, \frac{0.06\sqrt{f_{ck}}}{f_y \frac{d}{s_v}}\right]$$

Minimum Transverse Reinforcement in Column

$$\frac{A_{sv,\min}}{bd} = Max\left[\frac{0.4}{f_y \frac{d}{s_v}}, \frac{0.09\sqrt{f_{ck}}}{f_y \frac{d}{s_v}}\right]$$

3 ELEMENTRY DESIGN EXAMPLE

3.1 BEAM DESIGN

Design a beam having factored moment of 350kN-m and factored shear force of 125kN (grade of concrete M20, f_y = 500, f_{ys} = 415) Assume size of beam b=300mm, D=325mm, d'= 25mm. after calculation by both the codes results are mentioned below

CODE	Percentage of tension reinforcement	Percentage of compression reinforcement	c/c spacing
OLD IS 456	3.34	2.77	Provide 2-legged 8mm dia Fe 415 @ 210 c/c
PROPOSED IS 456	REDESIGN	REDESIGN	REDESIGN

From the results as per the new proposed code we have to redesign the section so for that we have to increase depth of the beam by trial and error we obtained effective depth of beam is 400mm, After increase in depth of beam percentage of reinforcement required is tabulated below

CODE	Percentage of tension reinforcement	Percentage of compression reinforcement	c/c spacing
PROPOSED IS 456	1.90	1.20	Provide 2-legged 8mm dia Fe 415@ 225 c/c

3.2 COLUMN DESIGN

A concrete column 500mm*500mm is subjected to factored load of 3000kn and factored moment of 500knm (grade of concrete M30 and grade of steel Fe 415) Assume d'/D=0.15, Reinforcement at 4 side

CODE	PERCENTAGE OF REAINFORCEMENT
IS 456 (4th revision)	3.6
Proposed IS 456 (5th revision)	3

A concrete column 500mm*500mm is subjected to factored load of 3000kn and factored moment of 500Knm (Grade of concrete M60 and grade of steel Fe 415) Assume d'/D=0.15, Reinforcement at 2 side

CODE	PERCENTAGE OF REAINFORCEMENT
IS 456 (4th revision)	3.6
Proposed IS 456 (5th revision)	3

As we can see in second example according to 5th revision of IS 456 percentage of reinforcement is more by 1.4% this is because as per new standards minimum percentage of reinforcement is now not fixed but it is now depends on grade of concrete.

4. CONCLUSIONS

As we can see, major changes has been made in fifth revision of IS 456, for the same loading condition sizes of beams are increased around 25% as per the new standards and reinforcement required in column also increased around 0.8% and minimum percentage of reinforcement required in column also increased which is depends on grade of concrete.

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