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A Comparative Study of International Structural Building Codes between IS456:2000, EC2:1992 for the Design of Concrete Structures. Design Procedure Comparison of Different Structural Elements.

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Abstract - *This research paper attempts to exhibit a comparative study for the design of reinforced concrete structures. In this research, two International structural codes have been used to analyze the different processes of strength designs., which are, IS456:2000 and Euro Code2:1992. This study elaborates the criteria of codes and exhibits the design of structures. However, the principles in these codes are the same but are different in its details. This project intends to relate IS 456-2007 and Eurocode II. The broad design standards (L/D ratio, stress-strain block parameters, load combinations and the formula compared along with the area of steel) for vital structural members to get an overview of how the codes illustrate in correspondence to each other. Emphasis will be put to the results in a tabular and graphical description for greater clarity and parallel interpretation.*

Key Words: – **Singly R/F Beam; Doubly R/F Beam**.

1.INTRODUCTION

Engineering is an art form of applying mechanics and law of physics combined to reform natural resources for the benefit of humanity. Engineering hence necessitates creative imagination to innovate useful applications in real life. Structural design is the systematic study of stability, durability and rigidity of constructions. The primary purpose of structural analysis is to design a structure competent of countering all implemented loads without collapse during its designed service life.

The fundamental part of every overall analysis requires an estimation of shear, compression and moment capacity of a structural member when designing or evaluating a collection of structural concrete sections. The research aims to compare the design criteria of the stated two design codes and calculate the area of steel for different structural members using the corresponding codes for their comparison and consequent comparative analysis.

A brief description of the Design Codes:

IS 456-2000:

The title 'Code of practice for plain and reinforced concrete for general building construction' was first published in 1953 and was revised in 1957. It was further developed in 1964 and was reissued as 'Code of practice for plain and reinforced concrete', expanding the extent of application to various structures than just general building constructions. In 1978, the third revision published included the limit state approach of design; this was the fourth revision of the standard.

IS 456-2000 is a code of practice for general structural design for plain and reinforced concrete. The latest revision of this standard was prepared in the year 2000, later reaffirmed in the year 2005. This code uses the limit state design approach written for use in India. It gives comprehensive information on the various characters of concrete.

EUROCODE 2:

The process of codifying EUROCODE II goes back to 1975 in the Treaty of Rome when the European Commission, CEN (Centre European de Normalisation) to draft the fundamental design standards. It has been updated several times since then.

1.1 AIM OF THE PROJECT

The principal purport behind this thesis is to analyze two prevailing concrete design codes concerning design and detailing of Reinforced Cement Concrete. In order to validate and support this cause, a set of spreadsheets utilized to ensure the correctness and uniformity of all computations performed; various assumptions made to reduce complexity.

Both segments focus singularly on analytical outcomes; no laboratory experiments conducted. Correlations were based on the maximum predicted permissible load, but not just confined to it. The objective of this thesis is to clarify

SL no	Country Standard	Tensile Strength of Concrete	Maximum Concrete Strain	Curing Effect on Concrete	Confined Concrete Stress-Strain Curve
1	European	Not Considered	0.003	Not Mentioned	Not Mentioned
2	Indian	Not Considered	0.0035	Not Mentioned	Not Mentioned

The differences between the two prevailing concrete design codes, IS 456, and EUROCODE II and categorize them as two major, minor, or insignificant. Comprehensive literature providing coverage of cases illustrating further inconsistencies found between IS 456 codes AND EUROCODE II.

1.2 DESIGNING PROCESS AND RESULTS

Stress-Strain Block Diagram Parameters

a. EUROCODE II

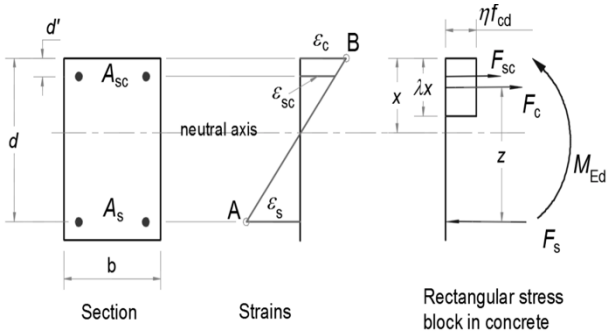

Fig -1: Stress Strain Diagram of EC II

b. IS 456:2000

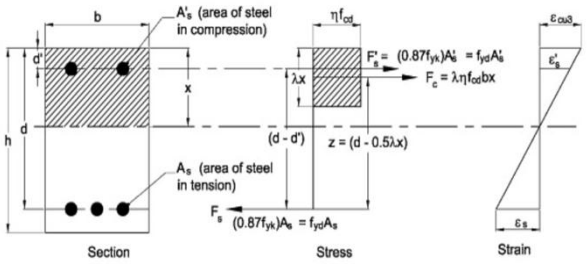

Fig -2: Stress Strain Diagram of IS 456:2000

In the Stress-Strain Diagram for EC II, it does not consider the parabolic portion of stresses; thus, this makes the calculation easier for the stress block, lever arm. Also, the lever arm in EC II is considerably higher than IS 456; hence the moment calculation is different in two codes. The parabolic portion makes the stress block and lever arm computation easier. Also, the lever arm in EC II is more significant than IS 456; hence this makes the moment calculation different in both cases.

2. Basic Design Criterions:

The distinctive design principles of both EUROCODE (EC II) and IS 456:2000 is displayed in a tabulated form for a contrasting view of the differences between the codes.

Table-1: Basic Stress Strain Parameters

SL No	Country Standards	Modulus of Elasticity	Stress Block parameters for high grade concrete	Strain Distribution (Deep Beams)
1	European	$E_c = 22{,}000\left(\frac{\sigma_B}{10}\right)^{\frac{1}{3}}$	Changes	Non - Linear
2	Indian	$E_c = 5000\sqrt{f_{ck}}$	Not Considered	Not Considered

Table-2: Elastic Modulus of Concrete

In TABLE 2. For IS 456:200, it is perceived that the code does not reflect the Stress Block parameters for high-grade concrete and Strain Distribution. In the current period, high-grade concrete has been considerably employed for various constructions, even in India. Therefore, the IS Code must acknowledge these factors to reform the missing links and hence establish the design code with the most advanced developments.

Sl No	Country Code	Load Combinations
1	EC II	a. 1.35D + 1.6L b. 1.0D + 1.5W c. 1.35D + 1.5L + 0.9W
2	IS 456:2000	a. 1.5(D + L) b. 1.2(D+L ± W) c. 1.5(D± W) d. 0.9 ± 1.5W

Table-3: Load Combinations

In TABLE 3. For IS 456:2000, the representation of load combinations available is higher in parallel relation to EC II; this diversity influences the design process, that is; loads are found to be higher than EUROCODE and consequently, the area of steel obtained.

ρ = Reinforcement Ratio = $\left(\frac{A_s}{b_w d}\right)$

Sl No	Beam Parameters (L/D)	EC II		IS 456:2000
		ρ = 1.5%	ρ = 0.5%	
1	Simply Supported	14	16	20
2	Cantilever	6	8	7
3	Continuous	18	18	26

Table-4: Beam Parameters

In TABLE 4. The L/d ratio for EC II has strict criteria than that of the IS 456:200.

3. Design Concrete Strength limits :

a. The design strength of concrete for EUROCODE II : (Min) = 12 Mpa, (Max) = 90 Mpa.

b. Indian Standard Code IS 456:2000 :
(Min) = 17Mpa, (Max) = No Limits.

Here, it is to be perceived that for IS456:2000; higher grade of concrete (more than 80Mpa) is neglected. This value of high-grade concrete can be included in upcoming revisions.

4. Design of Structural Members:

4.1 Design for Singly Reinforced Beam:

For the cause of illustration, the parameters needed for designing were taken to be same throughout the example.

Sample Question:

Dimensions of Beam:
Height of section = 500mm, Width of section = 230mm, Cover of reinforcement = 30mm, Bending Moment M = 65KNm, Cube Compressive Strength (f_{ck} = 30 N/mm^2), f_y = 550 N/mm^2, Bar diameter = 20mm, Link diameter = 10mm.

a. **By EC II** :

d = h – Cover of reinforcement – ($\frac{Bar\ Diameter}{2}$) – Link Diameter = 500 – 30 – 10 – 10 = 450 mm

K= $\frac{M}{bd^2 f_{ck}}$ = 65/(230× 450^2×30)=0.0465
∴ K < K' = 0.167 : Section is Singly Reinforced.

z = d [0.5 + $\frac{\sqrt{(0.25-K)}}{1.134}$] = 0.925d

∴ z = 0.925d < 0.95d, (OK)
z = 416.25 mm

Provide, 2T16, ($A_{s_{provided}}$ = 400 mm^2)

Min R/F : $A_{s_{provided}}$ > 0.26 ($\frac{f_{ctm}}{f_{yk}}$)bd $\not<$ 0.0013bd
Where,
0.26 ($\frac{f_{ctm}}{f_{yk}}$)bd = 107.64 mm^2, 0.0013bd = 134.55 mm^2

∴ Provided R/F is greater than the min^n area required.

Max R/F : (100$\frac{A_{s_{provided}}}{A_c}$)< 4
Where, (100$\frac{A_{s_{provided}}}{A_c}$) = 0.386 < 4 (OK)

b. **By IS 456:2000** :

M_u= BM_u = 65 KNm

M_u (lim) = 0.138f_{ck}bd^2 = 192.82 kNm

∴ M_u < M_u(lim) ; Hence, Section is Singly Reinforced.

A_{st}= 0.5($\frac{f_{ck}}{f_y}$)bd[1 – $\sqrt{1 - \frac{4.6BM_u}{f_{ck}bd^2}}$] = 304.93 mm^2

A_{st}, min = $\frac{0.85bd}{f_y}$ = 159.95 mm^2

A_{st}, max = 0.04bD = 4600 mm^2

∴ A_{st}, max < A_{st} < A_{st}, min. (OK)

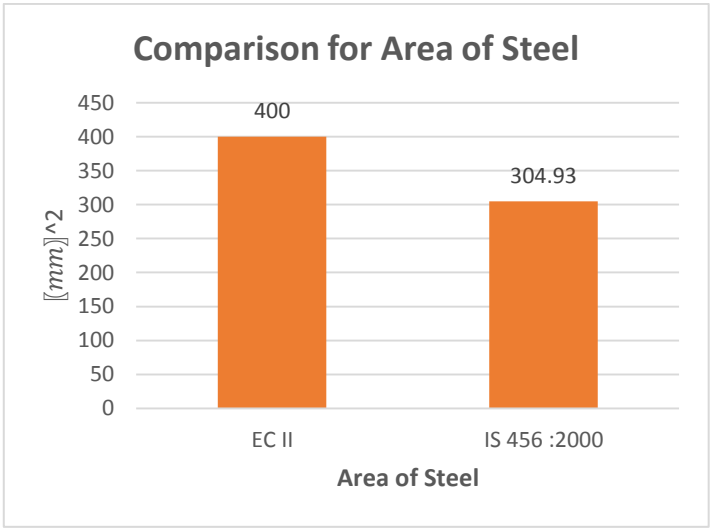

Chart-1: Area of Steel for Singly Reinforced Beam

4.2 Design for Doubly Reinforced Beam:

Sample Question:

Dimensions of Beam:
Height of section = 500mm, Width of section = 230mm, Cover of reinforcement = 20mm, Bending Moment M = 250KNm, Cube Compressive Strength (f_{ck} = 25 N/mm^2), f_y = 550 N/mm^2, Bar diameter = 20mm, Link diameter = 10mm.

a. **By EC II :**

d = h – Cover of reinforcement – ($\frac{Bar\ Diameter}{2}$) – Link Diameter
= 500 – 20 – 10 – 10 = 460 mm

d' = Cover + Link Diameter + ($\frac{Bar\ Diameter}{2}$)
= 20 + 10 + 10= 40 mm

K= $\frac{M}{bd^2 f_{ck}}$ = 250/(230× 450^2×25)=0.214

$\therefore$ K > K' = 0.167 : Section is Doubly Reinforced.

$\frac{d'}{d}$ = 0.086 < 0.171. Therefore, Compression R/F yielding.

Compressive Reinforcement Area

$A_{s'} = \frac{(K - K')\, f_{ck} b d^2}{0.87 f_y (d - d')} = 272.30\ mm^2$

z = d $[0.5 + \frac{\sqrt{(0.25 - K)}}{1.134}]$ = 0.678d
$\therefore$ z = 0.678d < 0.95d , (OK)
z = 311.88 mm

$A_s = [\frac{K' f_{ck} b d^2}{0.87 f_y (d - d')}] + A'_s = 1575\ mm^2$

Provide 2T25 + 1T16 ($A_{s_{provided}} = 1180\ mm^2$)

Min R/F : $A_{s_{provided}}$ > 0.26 ($\frac{f_{ctm}}{f_{yk}}$)bd $\not<$ 0.0013bd

Where,
0.26 ($\frac{f_{ctm}}{f_{yk}}$)bd = 107.64 mm^2, 0.0013bd = 134.55 mm^2
Where,
$\therefore$ Provided R/F is greater than the min^n area required.

Max R/F : $(100\frac{A_{s_{provided}}}{A_c})$< 4
Where, $(100\frac{A_{s_{provided}}}{A_c})$ = 1.026 < 4 (OK)

b. By IS 456:2000 :

M_u= BM_u = 250 KNm

M_u (lim) = 0.138f_{ck}bd^2 = 167.90 kNm

$\therefore$ M_u > M_u(lim) ; Hence, Section is Doubly Reinforced.

$\frac{M_u}{bd^2}$ = 5.136 N/mm^2

d' = Cover + Link Diameter + $(\frac{Bar\ Diameter}{2})$
= 20 + 10 + 10 = 40 mm

$\frac{x_u, max}{d} = (\frac{700}{1100 + 0.87 f_y}) = 0.443$

x_u, max = 203.78 mm

$p_{t,lim}$ = 0.414 $(\frac{f_{ck}}{f_y})\frac{x_u, max}{d}$ = 0.0083 = 0.833%

A_{st1} = $p_{t,lim}$bd = 878.14 mm^2

$A_{st2} = \frac{M_u - M_u\ (\lim)}{0.87 f_y (d - d')}$ = 4085.18 mm^2

A_{st} = A_{st1} + A_{st2} = 4963.32 mm^2

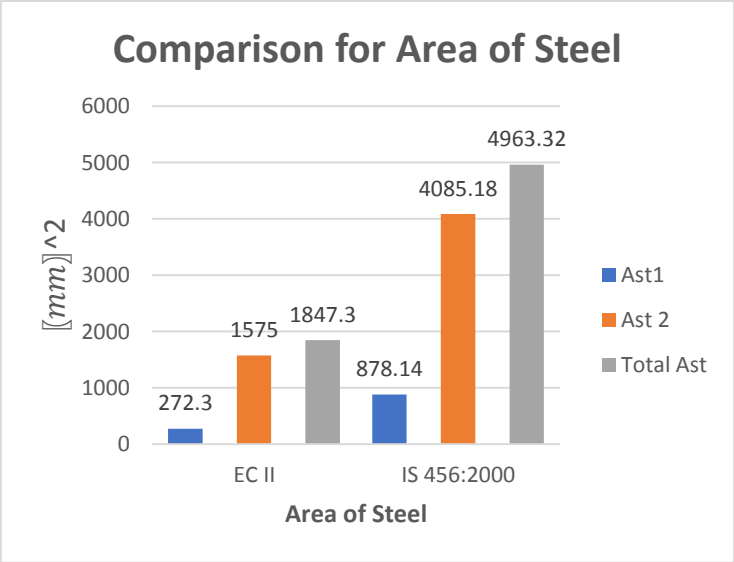

Chart-2: Area of Steel for Doubly Reinforced Beam

5. Future Scope of Work:

The BIS, which is known as the Bureau of Indian Standards that has developed IS 456:2000 the lever arm is considerably lower than EC II; hence the moment calculation is different in two codes. The parabolic portion makes the stress block and lever arm computation easier. The lever arm in EC II is more significant than IS 456; hence this makes the moment calculation different in both cases.

For IS 456:200, the code does not reflect the Stress Block parameters for high- grade concrete and Strain Distribution. In the current period, high-grade concrete has been considerably applied for many constructions, even in India. Hence, the IS Code must recognise these factors to reform the missing links and hence establish the design code with the most advanced developments.

In the era of development of new materials and different technologies, civil engineering is touching new heights. The latest innovation has brought a significant effect on the strength, durability of the structures. Innovations like Lightweight, Geo-Synthetic materials are not implemented in IS 456:2000; Hence, there is a vast field of research left in this area. It is undoubtedly beneficial if the new materials are tested and implemented onto structural designing.

IS 456 does not acknowledge characteristic concrete strength beyond M80, and this is a sphere of study one can implement and formulate for the code.

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[10] EUROCODE II.

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