Comparative Study Of IS 456:2000 & Eurocode 2: EN 1992-1-1 For Design Of R.C.C Beam

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Abstract : The reinforced concrete structures must be designed and constructed according to the provisions of a design code. A design code a document that establishes the for the design of a structure. Each country has their own geographical, topographical and climatic conditions. These conditions leads each country to establish their own criteria for the design of reinforced concrete structures.Design codes are the most important and basic tools for structural designer engineers. The design codes do not give design procedures, but specify the design requirement and constraints that must be satisfied.. The diversity of the provision of codes for countries worldwide becomes a problem when engineers have to move from one country to another. Thus, the study of main features commonalities and differences of the various codes of practice is necessary to form a common platform for structural design throughout the world. This paper constitutes a comparative study of the Indian code (IS456:2000) and European code (Eurocode 2 EN 1992-1-1).

***IndexTerms* - IS456:2000, Eurocode 2 EN 1992-1-1, Beam.**

I. Introduction

The comparison between the two codes is done with the aim of identifying significant differences both at the level of values of calculation and at the level of maximum and minimum values of design and constructive dispositions. The Eurocode 2 is derived from the British Standard BS8110. The Eurocode code 2 proves to be more complex than the Indian Standard IS 456:2000. This manual will serve as tool form Design Engineers , students, and also learning enthusiasts who want to know more about the Eurocode 2 and IS 456:2000. This comparison was carry out by means of tables, in order to make the comparison more visual and easy to understand. The comparison of the various design aids for the different members of the structure was made to specify the design requirements and constraints that must be satisfied. The structural members to be compared are beams, slabs, columns and footings.

II. INDIAN STANDARD IS 456

This Indian Standard (Fourth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council. IS 456-2000 Plain and Reinforced Concrete - Code of Practice is an Indian Standard code of practice for general structural use of plain and reinforced concrete. This standard deals with the general structure use of plain and reinforced concrete. This code uses the limit state design approach as well working stress design approach. It is written for use in India. It gives extensive information on the various aspects of concrete.

III. EUROCODES

The EN Eurocodes are expected to contribute to the establishment and functioning of the internal market for construction products and engineering services by eliminating the disparities that hinder their free circulation within the Community. Further, they are meant to lead to more uniform levels of safety in construction in Europe. The EN Eurocodes are the reference design codes. After publication of the National Standard transposing the Eurocodes and the National Annexes, all conflicting standards shall be withdrawn. It is mandatory that the Member States accept designs to the EN Eurocodes.

In the Eurocode series of European standards (EN) related to construction, Eurocode 2: Design of concrete structures (abbreviated EN 1992 or, informally, EC 2) specifies technical rules for the design of concrete, reinforced concrete and prestressed concrete structures, using the limit state design philosophy. It was approved by the European Committee for Standardization (CEN) on 16 April 2004 to enable designers across Europe to practice in any country that adopts the code. Eurocode 2 applies to the design of buildings and civil works in plain, reinforced and prestressed concrete. It complies with the principles and requirements for the safety and serviceability of the structures.

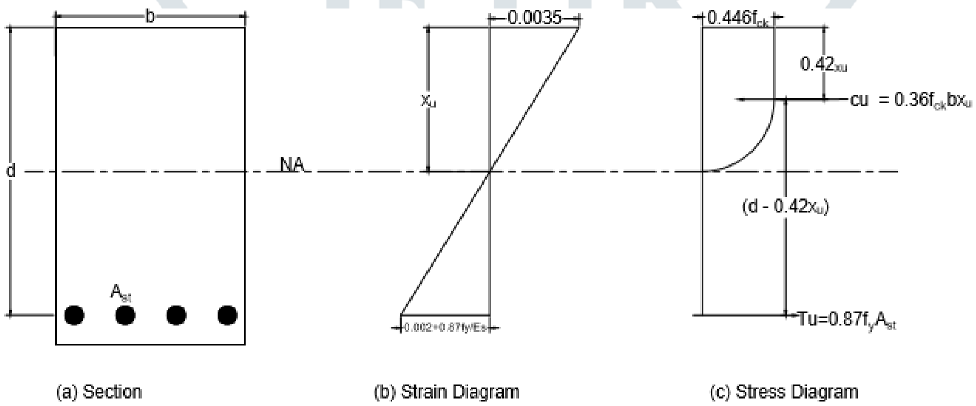
2.0 Work carried out so far

Structural loads or actions are forces, deformations, or accelerations applied to a structure or its components. Loads cause stresses, deformations, and displacements in structures. Assessment of their effects is carried out by the methods of structural analysis. Excess load or overloading may cause structural failure, and hence such possibility should be either considered in the design or strictly controlled. The table below illustrated the various load combination according to IS 456:2000 and Eurocode 2.

Table 1. Values of Partial safety factors for Loads						
Load Combinations	**IS 456:2000**			**Eurocode 2**		
	DL	IL	WL	DL	IL	WL
DL + IL	1.5	1.5	--	1.35	1.5	--
DL + WL	1.5 or 0.9	--	1.5	1.0	--	1.5
DL + IL + WL	1.2	1.2	1.2	1.35	1.35	1.35
Notes: DL = Dead load, IL = Imposed load or Live load, WL = wind load						

2.1 STRESS - STRAIN BLOCK DIAGRAM FOR SINGLY REINFORCED SECTION

The theory of bending for reinforced concrete assumes that the concrete will crack in the regions of tensile strain and that, after cracking, all the tension is carried by the reinforcement. It is also assumed that the plane sections of a structural member remain plane after straining, so that across the section there must be a linear distribution of strains. The figure shows the cross-section of a member subjected to bending and the resultant strain and stress diagram. The rectangular-parabolic stress block represents the distribution at failure when the compressive strains are within the plastic range and it is associated with the design for the ultimate limit state.



STRESS - BLOCK (IS **STRAIN DIAGRAM 456:2000)**

2.2 Depth of neutral axis

Depth of neutral axis is obtained by considering equilibrium of internal forces. Total compression, C_u = Total tension, T_u .

$$\therefore\ 0.36f_{ck}bx_u = 0.87f_yA_{st}$$

$$\therefore x_u = \frac{0.87f_y}{0.36f_{ck}} \times \frac{A_{st}}{b} \qquad \text{..... (1)}$$

$$\therefore k_u = \frac{x_u}{d} = \frac{0.87f_y}{0.36f_{ck}} \times p_t \qquad \text{.....(1.1)}$$

$$\therefore A_{st} = \frac{0.36f_{ck}bx_u}{0.87f_{ck}} \quad or \quad p_t = \frac{0.36f_{ck}k_u}{0.87f_y} \qquad \text{.....(1.2)}$$

Where, $p_t = \frac{A_{st}}{bd}$ = steel factor

2.3 Ultimate Moment of Resistance

The moment of resistance $M_{ur,}$ is obtained by taking moment of total compression, C_u, about resultant tension T_u and vice-versa.

$$M_{ur} = T_u \times Z_u \qquad \text{.....(1.3)}$$

$$M_{ur} = M_u = 0.87f_yA_{st}(d - 0.42x_u) \qquad \text{.....(1.4)}$$

Substituting the value of x_u from equation (1) we get,

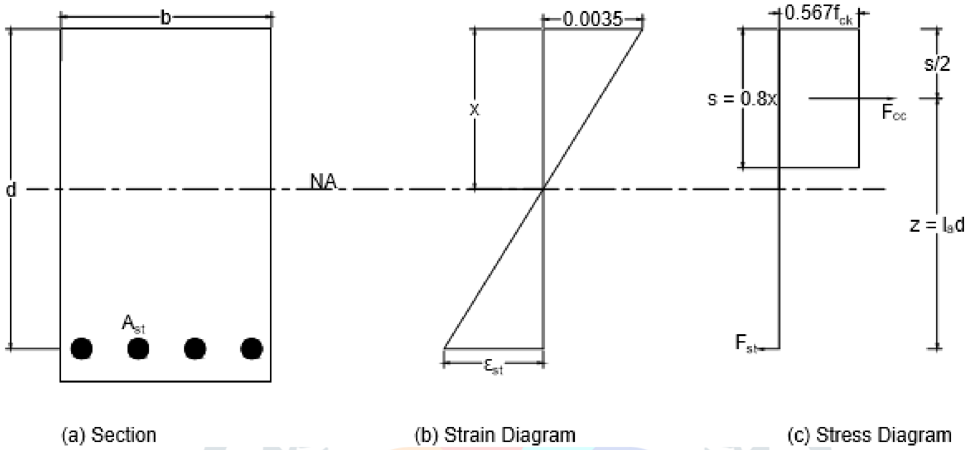
$$M_{ur} = M_u = 0.87 f_y A_{st}\left(1 - \frac{f_y}{f_{ck}} \times \frac{A_{st}}{bd}\right) \quad .....(1.5)$$

The solution of the above equation gives A_{st} as:

$$A_{st} = \frac{0.5 f_{ck}}{f_y}\left[1 - \sqrt{1 - \frac{4.6 M_u}{f_{ck} b d^2}}\right] \quad ....(1.6)$$

3.0 STRESS - STRAIN BLOCK DIAGRAM FOR EUROCODE 2

The Eurocode 2 utilizes the equivalent rectangular Stress block. It is as simplified alternative to the rectangular-parabolic distribution. This simplified stress distribution will facilitate the analysis and provide more manageable design equations, in particular when dealing with non rectangular sections.



Bending of the section will induce a resultant tensile force F_{st} in the reinforcing steel and a resultant compressive force in the concrete F_{cc} which acts through the centroid of the effective area of the concrete in compression as shown in the. For equilibrium, the ultimate design moment, M, must be balanced by the moment of resistance of the section so that

$$M = F_{cc} \times z = F_{st} \times z \quad .....(2)$$

F_{cc} = stress × area of action

$$F_{cc} = 0.567 f_{ck} \times bs \text{ and } \; z - s/2 \quad .....(2.1)$$

So that substituting in equation (2)

$$M = 0.567 f_{ck} bs \times z$$

and replacing from equation (2.1)

$$M = 1.134 f_{ck} b(d - z)z \quad ......(2.3)$$

Rearranging and substituting $K = \frac{M}{bd^2 f_{ck}}$:

$$(z/d)^2 - (z/d) + \frac{K}{1.134} = 0$$

Solving this quadratic equation:

$$z = d\left[0.5 + \sqrt{0.25 - K/1.134}\right] \quad .....(2.4)$$

In equation (2)

$$F_{st} = \left({f_{yk}}/{\gamma_s}\right) A_s \qquad \text{with } \gamma_s = 1.15$$

$$F_{st} = 0.87 f_{yk} A_s$$

$$\text{Hence } A_s = \frac{M}{0.87 f_{yk} \times z} \quad ....(2.5)$$

The lower limits of $z_{bal} = 0.86d$ and $z_{bal} = 0.82d$ are when the depth of the neutral axis equals 0.35d and 0.45d respectively, which are the maximum values allowed by the code for singly reinforced section in order to provide a ductile section that will have a gradual tension type failure. The limit of 0.82d corresponds to concrete grades not greater than or equal to C35/45 and the limit of 0.86d applies to the concrete grades greater than C35/45.

With z = 0.82d, from equation (2.3)

$$M_{bal} = 1.134 f_{ck} b(d - 0.82d) \times 0.82d$$

Or

$$M_{bal} = 0.167 f_{ck} bd^2 \qquad \text{….. (2.6)}$$

4.0 BEAM ACCORDING TO IS 456

Clause 23- Effective Depth

Effective depth of a beam is the distance between the centroid of the area of tension reinforcement and the maximum compression fibre, excluding the thickness of finishing material not placed monolithically with the member and the thickness of any concrete provided to allow for wear. This will not apply to deep beams.

Initially the effective span is computed depending on the supporting conditions.

(a) For simply supported slab or beam which is not built integrally with its supports, and for continuous slab or beam having breath of support less than ½ of clear span.

Effective length = L = (c/c distance between the supports or clear span + effective depth) whoever is less.

(b) For continuous sab or beam having breadth of support greater than 1/12 of clear span or 600mm whichever is less, the effective span shall be taken as under:

(i)For end span with one end fixed and the other continuous or for intermediate spans, Effective span = L = clear span between supports.

(ii)For end span with one end simply supported and the other continuous, Effective span = L = (clear span + ½ effective depth of slab / beam or clear span + half the width of discontinuous support) whichever is less.

(c) For Cantilevers

(i)Effective span = L = Length of a cantilever to the face of the support + half the effective depth.

(ii)Cantilever at the end of continuous beam : Effective span = L = Length of cantilever to the centre of support.

(d)Continuous frame: Effective span = L = distance between the centre of supports .

In practice the centre to centre distance between the supports is taken as an effective span for simplicity and on the safer side.

Clause 23.1.2- Effective with of flange

The effective width of flange should not be greater than the breath of the web plus half the sum of the clear distances to the adjacent beams on the other side.

Clause 23.2 – Control of deflection

The limitations of the deflection are stipulated in this article, it is stated that it shall not adversely affect the appearance or efficiency of the structure or finishes or partitions.

Clause 26.5.1- Minimum and maximum longitudinal reinforcement

This clause deals with areas of minimum and maximum longitudinal reinforcement in a beam.

Clause 26.3 – Spacing of Reinforcement

for the purpose of this clause, the diameter of a round bar shall be its nominal diameter, and in the case of bars which are not round or in case of deformed bars or in crimped bars, the diameter shall be taken as the diameter of a circle giving an equivalent effective area.

Clause 26.5.1.3 Side face reinforcement

The IS 456 provides the surface reinforcement when the depth of the beam exceeds 750mm, and it shall be provided along the two faces.

Clause 26.5.1.6 Shear reinforcement

The minimum shear reinforcement is provided in the form of stirrups, where the maximum shear stress calculated is less than the half permissible value. For the design of shear reinforcement the clause 40 will as well come into picture.

Clause 265.1.5 Spacing of shear reinforcement

This clause mention the maximum shear reinforcement measured along the axis of the member.

Clause 26.5.1.7 Torsion reinforcement

This clause mentions the limitations for a member designed for torsion. The clause 40 gives conditions specifying when a member should be designed for torsion.

4.1 BEAMS ACCORDING TO EUROCODE2

The chapter 9 of the Eurocode 2 gives the detailing and of members and particular rules for the design of beams.

Clause 9.2.1.1 – Minimum and maximum reinforcement areas

Sections containing reinforcement less than the minimum reinforcement should be considered as unreinforced. The cross-sectional area of tension or compression reinforcement should not exceed the maximum reinforcement area outside lap locations.

Clause 9.2.1.2 – Other detailing arrangements

In monolithic constructions, even when simple supports have been assumed in design, the sections at support should be designed for a bending moment arising from partial fixity of at least β_1 of the maximum bending in the span.

Clause 5.3.2.1- Effective width of flange

In T beams the effective flange width, over which uniform conditions of stress can be assumed, depends on the web and flange dimensions, the type of loading, span, the support conditions and the transverse reinforcement.

Clause 7.4 – Deflection control

The deformation of a member on a structure shall not be such that it adversely affects its proper functioning or appearance.

Clause 9.2.2 Shear reinforcement

The shear reinforcement may consist of a combination of links enclosing the longitudinal tension reinforcement and the compression zone, and bent-up bars. (1) The shear reinforcement should form an angle α of between 45^0 and 90^0 to the longitudinal axis of the structural element. (2) The shear reinforcement consists of a combination of.

-links enclosing the longitudinal tension reinforcement and the compression zone bent-up bars - cage, ladders, etc. which are cast in without enclosing the longitudinal reinforcement but are properly anchored in the compression and tension zones.

Clause 9.2.3 Torsion reinforcement

The torsion links should be closed and anchored by mean of laps or hooked ends, and should form an angle of 90^0 with the axis of the structural element.

Clause 9.2.4 Surface reinforcement

It may be necessary to provide reinforcement either to control cracking to ensure adequate resistance to spalling of the cover.

CONCLUSION

- In this study we made basic comparison of IS 456-2000 and Eurocode 2.0 for R.C.C. beam. Here we made some conclusion.
- For the design of most reinforced concrete structures it is usual to commence the design for the conditions at the ultimate limit state, which is then follow by checks to ensure that the structure is adequate for the serviceability limit state without excessive deflection or cracking of the concrete.
- After making the design calculation for beam, based on this study, it was concluded that the IS 456 and Eurocode 2 are mainly equivalent and the differences between the codes are about minimal, although the Eurocode 2 is slightly more conservative than the IS 456:2000.

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