Design Comparison of Different Structural Elements By using Different International Codes

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Abstract: This paper is intended to compare the design of reinforced concrete structure with various International codes from economical point of view. Three different famous structural building codes have been adopted. These are the IS456:2000, BS8110:1985, and Euro Code2:1992. These codes have been compared in the strength design requirements of structural elements. The comparison include shear design. Throughout this study elaborated design models and criteria of the considered codes have been exhibited. Although the principles contained in these codes are basically the same, they differ in details.

Keywords— Different structural element like continuous slab, continuous beam, column and column footing.

INTRODUCTION:
Engineering is a professional art of applying science to the efficient conversion of natural resources for the benefit of man. Engineering therefore requires above all creative imagination to innovative useful application for natural phenomenon.

THE DESIGN PROCESS:
The design process of structural planning and design requires not only imagination and conceptual thinking but also sound knowledge of science of structural engineering besides the knowledge of practical aspects, such as recent design codes, bye laws, backed up by sample experience, initiation and judgment. The purpose of standards is to ensure and enhance the safety, keeping careful balance between economy and safety.
The process of design commences with planning of the structure, primarily to meet its functional requirements. Initially, the requirements proposed by the client are taken into consideration. They may be vague, ambiguous or even unacceptable from engineering point of view because he is not aware of the various implications involved in the process of planning and design, about the limitation and intricacies of structural science.

It is emphasized that any structure to be constructed must satisfy the need efficiently for which it is intended and shall be durable for its desired life span. Thus, the design of any structure is categorized into the following two main types:

1) Functional design
2) Structural design.

FUNCTIONAL DESIGN:
The structure to be constructed should be primarily serve the basic purpose for which it is to be used and must have a pleasing look.

STRUCTURAL DESIGN:
Structural design is an art and science of understanding the behavior of structural members subjected to loads and designing them with economy and elegance to give a safe, serviceable and durable.

STAGES IN STRUCTURAL DESIGN:
The process of structural design involves the following stages:
1.0 Structural planning.
2.0 Action of forces and computation of loads.
3.0 Member analysis.
4.0 Member design.
5.0 Comparison between various RCC Design code.
6.0 Detailing, drawing and preparation of schedules.

This paper is devoted to focus a spot of light on design the minimum or maximum area of steel...
A. ABBREVIATIONS AND ACRONYMS:

a) As per IS Code:

- L = Effective span
- d = Effective depth
- W = Factored dead load
- W = Factored live load
- M = Limiting bending moment
- P = Percentage of steel
- V = Shear force
- t = Nominal shear stress
- V = Design shear strength
- L = Development length
- P = Spacing of stirrups
- P = Ultimate load on column
- K = Co-efficient
- b = Short side of column section/Long side of column section
- f = Characteristic cube compressive strength of concrete
- f = Characteristic strength of steel

b) As per BS code:

- M = Bending moment
- A = Area of steel
- S = Development length
- V = Shear force
- N = Nominal shear stress
- P = Ultimate load on column
- V = Design shear stress at the column perimeter
- A = Cross sectional area of reinforcement
- A = Cross sectional area of shear reinforcement in the form of link
- F = Ultimate load
- f = Characteristic strength of reinforcement
- f = Characteristic concrete cube strength

c) As per EC code:

- M = Ultimate moment of resistance
- K = Co-efficient of main reinforcement
- V = Design shear resistance of concrete
- b = width of section
- d = effective depth of the tension reinforcement
- h = overall depth of section
- Z = lever arm
- A, a = allowance at supports used for calculating the effective span of a member

As = Area of tension reinforcement
A = Area of shear reinforcement within a distance S
M = Factored IS, BS and EC Codes moment at section
S = Spacing of stirrups
V = Nominal shear strength of section
V = Nominal shear strength provided by concrete
V = EC2 concrete shear strength

B. UNITS:

Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses).

C. EQUATIONS:

[1] As per IS code:

Basic L/d = 26 [For continuous beam]
Basic L/d = 20 [For simply supported beam]
B.M. for end span:
W/L^2/10 + W/L^2/9 [B.M. at the centre of the end span]
W/L^2/10 + W/L^2/9 [B.M. over penultimate support]
B.M. for intermediate span:
W/L^2/12 + W/L^2/12 [B.M. at the centre of the span]
W/L^2/12 + W/L^2/9 [B.M. over intermediate support]
M = 0.138fcd^2
P = 50(1-4.6*M/Afcbd^2)^1/2/(f/fck)
V = 0.6(Wc+WL)I
V = V/bd
I = 0.30(Mc/Vc)+L
P = (0.87fAed/Vc)
P = 0.40fdAc + 0.67fdAc
V = V/bd' [Nominal shear stress]
bd' dimension at the critical section of footing.
K = 0.5+b

[2] As per BS code:

M = 0.086FL
A = M/(0.87f,cz)
S ≥ (f,t)/(4rf,c)
S = f,t/2rf,c
M = 0.09FL [Near middle of end span]
M = 0.11FL [At first interior support(-Ve Moment)]
M = 0.07FL [At middle of interior spans]
M = 0.08FL [At interior supports(-Ve Moment)]
As = 0.156f,bd^2/(0.87f,cz)
V_s = 0.6F – w_u(support width/2)

V = V_s/bd < 0.8f_c\text{½}

P_u = 0.40f_{ck}A_c + 0.67f_yA_{sc}

[3] As per Euro code:

Basic L/d = 31
M_{Rd} = 0.167f_{ck}bd^2
A_s = M/0.87f_{ck}Z
Z = d[0.5+(0.25-3K_0/3.4)^{1/2}]
K_0 = M/f_{ck}bd^4
D_v = 5/8xf_{ck}A_{req}/A_{prov}
Checked Basic L/d = K[11+1.5f_{ck}^{1/2}(p_y/p)+3.2f_{ck}(p_y/p-1)^{3/2}]
A_{s,max} = 0.04A_c
A_{s,min} = 0.26f_{ck}bd/f_{ck}
V_{Rd,c} = [C_{Rd,c}K(100P_{f_{ck}})^{1/3}+Kd_{cp}]b\nu d\ V_{Ed} = \beta(V_{lo}/u_0d)
V_{Rd,max} = 0.5vf_{ck}
V = 0.6[1-(f_{ck}/250)]
C_{Rd,c} = 0.18/d,
K = 1+(200/d)^{1/4}
P_1 = (p_y p_1x) = [A_{s1,y}A_{s1,x}/bd]^{1/2}
V_{min} = 0.035K^{3/2}f_{ck}^{3/2}Kd_{cp}\times[2d/a]

LOADING:

The three codes impose partial factors of safety for loads due to design assumptions and inaccuracy of calculation, possible unusual load increases, and constructional inaccuracies.

Design load = characteristic load* partial load factor of safety

The value of this factors of safety takes into account the importance of the limit state under Consideration and reflects to some extent the accuracy with which different types of loading can be predicted, and the probability of particular load combinations occurring. Table (1) Illustrates the values of partial factors of safety for the loadings, and a basic load combination Stipulated by the three codes [1, 2, 3].

### Table (1) Basic Load Combinations and Partial Safety Factors (df) at the Ultimate Limit State:

<table>
<thead>
<tr>
<th>Code</th>
<th>Dead Load (DL)</th>
<th>Live load (LL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 456:2000</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>BS8110:1985</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td>EC2:1992</td>
<td>1.35</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**GRADE OF CONCRETE AND STEEL:**

Table (2)

<table>
<thead>
<tr>
<th>Code</th>
<th>SLAB [A_s]</th>
<th>BEAM [A_s]</th>
<th>COLUMN [A_s]</th>
<th>FOUNDATION [A_s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 456:2000 [M30 &amp; Fe415]</td>
<td>279</td>
<td>619.64</td>
<td>1240.37</td>
<td>1676.88</td>
</tr>
<tr>
<td>BS8110:1995 [M30 &amp; Fe460]</td>
<td>203.41</td>
<td>583.88</td>
<td>1653.23</td>
<td>2080</td>
</tr>
<tr>
<td>EC2:1992 [M30 &amp; Fe500]</td>
<td>269.57</td>
<td>743.17</td>
<td>1512</td>
<td>2080</td>
</tr>
</tbody>
</table>
CONCLUSION:

The main conclusions from this study can be summarized as follow:

[1]. Although the principles contained in the considered grade of concrete is same for three codes differ in grade of steel.

[2]. Calculating the area of steel with respect to actual grade of concrete and grade of steel. Result showing that-
   a. For slab Area of steel is maximum as per IS code than BS and EC.
   b. For beam Area of steel is maximum as per EC code than IS and BS.
   c. For column Area of steel is maximum as per BS code than IS and BS.
   d. For foundation Area of steel is minimum as per IS code than BS and EC.
   e. For foundation with respect to EC code minimum steel are to be provided.

[3]. Calculating the area of steel with respect to providing grade of concrete and grade of steel. Result showing that-
   a. Increasing the area of steel of the all structural element with respect to actual grade of concrete and steel.
   b. For foundation with respect to EC code minimum steel are to be provided.

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