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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,contineuous 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 requirement for elements of concrete structure. Three different International Structural building codes are adopted in this study. These are: [1] IS 456:2000; [2] BS 8110:1985 and [3] EC2:1992 for the design of concrete structures.

A. ABBREVIATIONS AND ACRONYMS:

a) As per IS Code:

L = Effective span
d = Effective depth
W_d = Factored dead load
W_l =Factored live load
$M_{u,lim}$ = Limiting bending moment
P_t = Percentage of steel
V_u = Shear force
t_v = Nominal shear stress
t_c = Design shear strength
L_d = Development length
P = Spacing of stirrups
P_u = Ultimate load on column
K_s = Co-efficient
b_c = Short side of column section/Long side of column section
f_{ck} = Characteristic cube compressive strength of concrete
f_y = Characteristic strength of steel

b) As per BS code:

M = Bending moment
A_s = Area of steel
S = Development length
V_s = Shear force
V = Nominal shear stress
P_u = Ultimate load on column
V_{Ed} = Design shear stress at the column perimeter
A_s = Cross sectional area of reinforcement
A_{SV} = Cross-sectional area of shear reinforcement in the form of link
F = Ultimate load
f_y = Characteristic strength of reinforcement
f_{cu} = Characteristic concrete cube strength8+/

c) As per EC code:

M_{Rd} = Ultimate moment of resistance
K_0 = Co-efficient of main reinforcement
$V_{Rd,c}$ = 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_1, a_2 = allowance at supports used for calculating the effective span of a member
g_k, G_k= characteristic permanent action
q_k, Q_k = characteristic variable action
fck = characteristic compressive cylinder strength of concrete at 28 days
fyk = characteristic yield strength of reinforcement
As = Area of tension reinforcement
A_V = Area of shear reinforcement within a distance S
M_u Factored IS,BS and EC Codes moment at section
S: Spacing of stirrups
V = Nominal shear strength of section
V_c = Nominal shear strength provided by concrete
V_{Rd1} = 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:
$W_dL^2/12 + W_lL^2/10$ [B.M. at the centre of the end span]
$W_dL^2/10 + W_lL^2/9$ B.M.[over penultimate support]
B.M. for intermediate span:
$W_dL^2/16 + W_lL^2/12$[B.M. at the centre of the span]
$W_dL^2/12 + W_lL^2/9$ [B.M. over interior support]
$M_{u,lim}=0.138f_{ck}bd^2$
$P_t = 50[1-\{1-(4.6*M_u)/f_{ck}bd^2\}½]/(f_y/f_{ck})$
$V_u = 0.6(W_d+W_l)L$
$t_v = V_u/bd$
$L_d < 0.1.30(M_1/V_u)+L_0$
$p = (0.87f_yA_wd/V_{us})$
P_u = o.40$f_{ck}A_c + 0.67f_yA_{sc}$
$t_v = V_u/b'd'$ [Nominal shear stress]
b'd' dimension at the critical section of footing.
$k_s = 0.5+b_c$

[2] As per BS code:

$M = 0.086FL$
$A_s = M/ (0.87f_yz)$
$S \geq (f_t\Phi)/(4rf_b)$
$S_{max} = f_t\Phi/2rf_b$
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)]
$As = 0.156f_{cu}bd^2/(0.87f_yz$

$V_s = 0.6F - w_u$(support weidth/2)

Code	Actual grade of concrete	Considering grade of concrete	Actual grade of steel	Considering grade of steel
IS 456:2000	M_{30}	M_{30}	Fe415	Fe415
BS8110: 1995	M_{30}	M_{30}	Fe460	Fe415
EC2:1992	M_{30}	M_{30}	Fe500	Fe415

$V = V_s/bd < 0.8f_{cu}½$
$P_u = 0.40f_{ck}A_c + 0.67f_yA_{sc}$

[3] As per Euro code:

Basic L/d = 31
$M_{Rd} = 0.167f_{ck}bd^2$
$A_s = M/0.87f_{yk}Z$
$Z = d[0.5+(0.25-3K_0/3.4)^{1/2}]$
$K_0 = M/f_{ck}bd^2$
$D_s = 5/8\times f_{ck}\times A_{req}/A_{prov}$
Checked Basic L/d = $K[11+1.5f_{ck}^{1/2}(p_0/p)+3.2f_{ck}(p_0/p-1)^{3/2}]$
$A_{s,max} = 0.04A_c$
$A_{s,min} = 0.26f_{ctm}b_td/f_{yk}$
$V_{Rd,c} = [C_{Rd,c}K(100P_1f_{ck})^{1/3}+Kd_{cp}]b_wd$ $V_{Ed} = ß(V_{1d}/u_0d)$
$V_Rd,max = 0.5vf_{cd}$
$V = 0.6[1-(f_{ck}/250)]$
$C_{Rd,c} = 0.18/d_c$
$K = 1+(200/d)^{½}$
$P_1 = (p_{1y}\ p_{1x}) = [A_{s1,y}/bd\ .\ A_{S1,x}/bd]^{½}$
$V_{min} = 0.035K^{3/2}f^{½}$
$V_{Rd,c} = [C_{Rd,c}K^{3/2}+K_1d_{cp}]\times[2d/a]$

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.

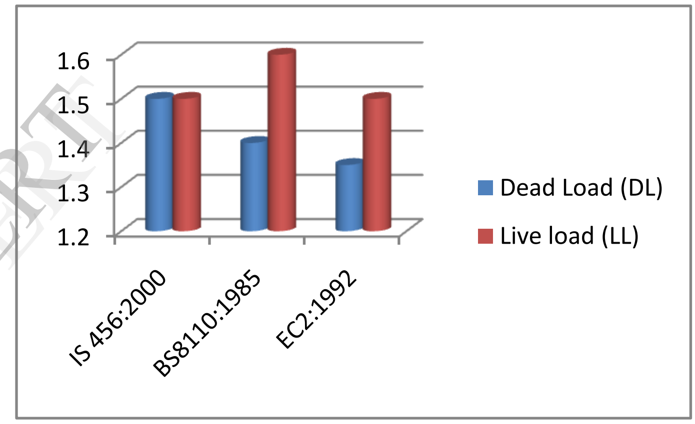
Design load = characteristic load* partial load factor of safety

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 :

Code	Dead Load (DL)	Live load (LL)
IS 456:2000	1.5	1.5
BS8110:1985	1.4	1.6
EC2:1992	1.35	1.5

Table (1)

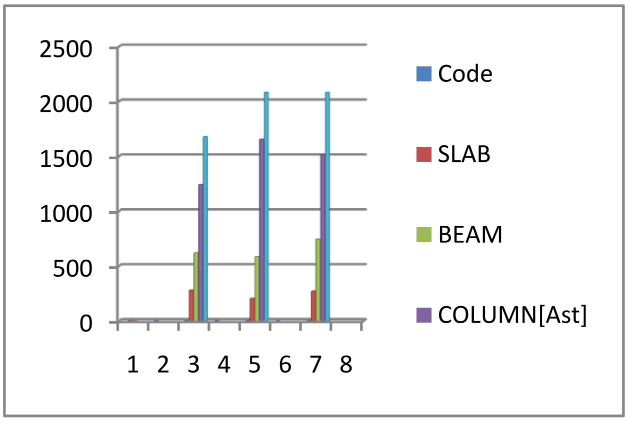


GRADE OF CONCRETE AND STEEL:
Table (2)

RESULT:
A.CALCULATING AREA OF STEEL WITH RESPECT TO ACTUAL GRADE OF CONCRETE AND STEEL:

Code	SLAB $[A_{st}]$	BEAM $[A_{st}]$	COLUMN$[A_{st}]$	FOUNDATION$[A_{st}]$
IS 456:2000 $[M_{30}$ &Fe415]	279	619.64	1240.37	1676.88
BS8110: 1995$[M_{30}$& Fe460]	203.41	583.88	1653.23	2080
EC2:1992 $[M_{30}$&Fe500]	269.57	743.17	1512	2080

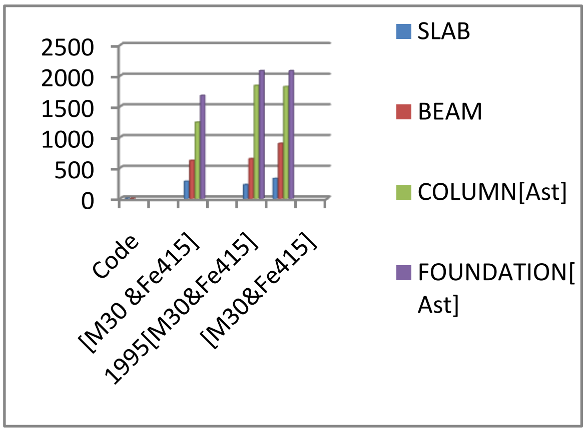
Table (3)



B.CALCULATINGAREAOFSTEELWITH RESPECT TO CONSIDERIND GRADE OF CONCRETE AND STEEL:

Code	SLAB [A_{st}]	BEAM [A_{st}]	COLUMN[A_{st}]	FOUNDATION[A_{st}]
IS 456:2000 [M_{30} &Fe415]	279	619.64	1240.37	1676.88
BS8110: 1995[M_{30}& Fe415]	225.47	647.12	1840.21	2080
EC2:1992 [M_{30}&Fe415]	324.78	895.39	1821.67	2080

Table (4)



CONCLUSION:

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

[1]. Although the principles contained in the considered the 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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