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Comparison and Analysis in using British Standard Code of Practice [BS8110] and Euro code [Ec2] in the Design of Structural Elements: A Case Study of Floor Slab in a General Office Building Complex

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ABSTRACT

Design codes and standards are used in designing structures in different parts of the world. Each country has a standard code of practice for designing structures for human's use and services. The codes under consideration in this study are BS8110 and Euro code [Ec2] as they applied to the design of different structural Elements. This study specifically compares the design applications of these two codes and draws a conclusion from them.

Keywords: Comparison, Analysis, B.S. [8110] Euro-code [Ec2], Slab Design

INTRODUCTION

Standards are usually employed by civil and structural Engineers during the design of every structure; these standards are available in most countries where civil and structural Engineering professions are being practiced. These standard are Usually employed in order to meet the strength, economy, service-ability, e.t.c by any structure that is design work are usually published in the form of code of practice, such as Nigerian Standard code of practice (NSCP), Reinforced concrete Designer's Handwork, British standard code of practice (CP) of various Editions; and Euro codes of also various Editions.

MATERIALS AND METHOD

In carrying out this study, a typical floor slab in a general office Building complex is chosen; with the application of British standard [BS8110] code and Euro-code [Ec2].the design is then carried out under the various processes in the two methods and finally a comparison is then drawn from the two methods of design.

Design of Structures

Design of structures is a step by step procedure through which an economical section or part of a structure is chosen and design to safety withstand the effects of the applied loads to that particular section of the structure. In design, each element is considered separately, and the element being designed is considered balanced to withstand the applied loads i.e. the structures should be in Equilibrium statically.

Slab Design: A slab is a solid plate like surface structure which is used to support vertical loads. Slabs in buildings are used to separate vertical height of buildings. In bridges, it forms the surface called the bridge decks on which the vehicles are supported while crossing the bridges.

Comparison between BS8110 and Euro-code [2]

A comparison between BS8110 and Euro-code are clearly stated below in their applications during the design of structures: Ultimate Moment of Resistance for Beams and Slabs Computations.

-B.S8110:- MU= $0.15fcubd^2$

Euro-code: - MU= $0.167fckbd^2$

Area of Tension Reinforcement for Beams and Slabs Computations

BS8110:- $A3 = \frac{M}{0.87fyzod}$

Euro-code: - $AsI = \frac{M}{0.87fyzod}$

III. Lever arm(z)

BS8110:- ~~z~~ $=d\ [0.5+\sqrt{\frac{0.25-k}{0.9}}$

Euro-code:- ~~z~~ $= d\ [0.5+\sqrt{\frac{(0.25-3k)}{3.4}}$

Relationship between BS8110 and Euro-code2

BS8110	Euro-code
Fcu= 20N/MM^2	fck=16N/MM^2
Using concrete cube	using cylinder
Fy= 250N/MM^2	Fy=250N/MM^2
Mild steel	Mild steel
Fy= 410N/MM^2	fy =460N/MM^2
High steel	high steel
Design load(n)=	design load(n)=
1.4xdead load+	1.35xDead load+
1.6x imposed load	1.5xImposed load
Or	or
N=1.4gk+1.6qk	n=1.35gk+1.59k

Determination of k under BS8110 with other known values

$$K = \frac{m}{bd^2}$$

Determination of k under Euro-code [EC] with other known values

$$K = \frac{M}{Bd^2 fck}$$

Typical Analysis and Design Using BS8110 and Euro-code [EC2] For a floor slab in a general office Building complex

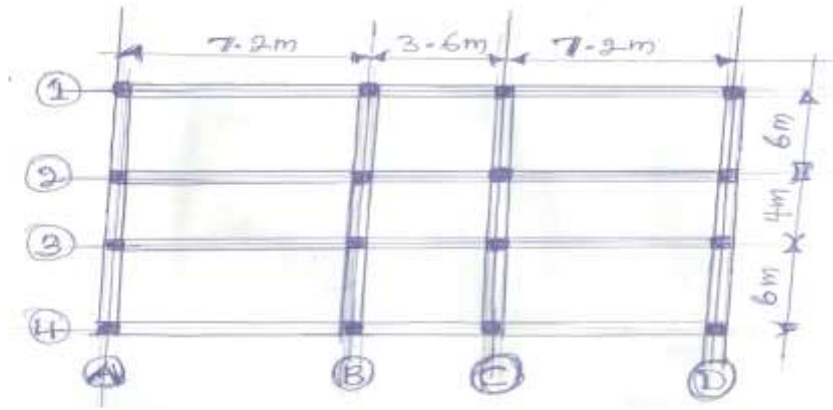


Figure 1: Typical Floor Plan of Slab in a Five Storey Building Office Complex

General Description

I. The Structure above is a five Storey Building with Structural Framed Concepts having Foundations, Concrete slabs, Reinforced Concrete Beams, Columns and the Block Walls used as a Fill Material

II. The Columns are used to take of the Vertical and Lateral loads due to wind effects.

III. The intended use of the structure is for general purpose.

IV. Foundation:- the allowable bearing pressure on ordinary clay=200KN/M^2

V. Basic Wind Speed =32m/Sec.

VI. Required thickness of the slab as a guide:-i.e. the longest span of the continuous slab given as: $\frac{6000}{30}$ = mm.

Therefore, the preliminary design for slab thickness = 200mm

Loadings on the Slab

I. Self weight of 200mm slab = 0.2x24 KN/m^3 =4.8KM/M^2

II. Finishes using 50mm concrete screed =0.05x24KN/M^3=1.2KN/M^2

III. 150mm blocks as partitions 0.15x15KN/M^3=2.3KN/M^2

IV. Characteristic dead load = (4.8+1.2+2.3)=8.3KN/M^2

V. Characteristics imposed load=2.5KM

DESIGN WITH BS8110

I. Minimum Design load=8.3+2.5
=10.8KN/M^2

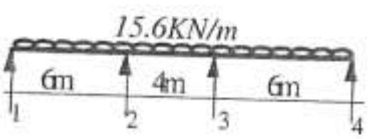
II. Maximum Design load= (1.4x8.3) + (1.6x2.5)=15.6KN/M^2

Consider the slab in unit Meter width

Load = 15.6KN/M

Loading Types

Type I maximum load on all spans spans



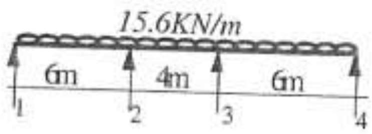
DESIGN WITH EURO-CODE2

Minimum Design load = 8.3 + 2.5
=10.8KN/M^2

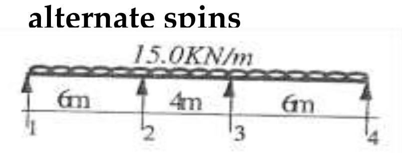
Maximum Design load actions i.e. permanent (dead) and variable (imposed) load = (1.35 x 8.3) + (1.5x2.5) = 15.0KN/M^2

Loading Types

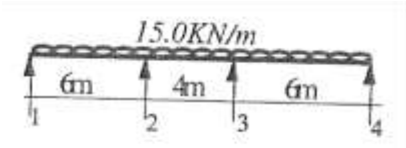
Type I maximum load on all



Type II maximum loads on alternate spins alternate spins



Design with BS8110



Step1

Using the ratio coefficient method continuous span 6:4:6

Divide through by the value in the first span from the left hand side i.e.

$\frac{6}{6} : \frac{4}{6} : \frac{6}{6}$

1: 0.67:1

1:0. 7 : 1

M_{12}0.084X 15.6X6^2=47.2KNm

M_{23}=0.021X15.6X6^2=11.8KNm

M_{34}=0.084X15.6X6^2=47.2KNm

M_2=0.82X15.6X6^2=46.05KNm

M_2=0.0082x15.6x6^2=46.05kNm

To check for reinforcement

Stab thickness for preliminary analysis = 200mm

Effective depth =

Total depth – reinforcement cover – ½ Diameter of Reinforcement

Effective depth – 200 – 20 – ½(12) = 174mm

To find the lever arm factor z/d

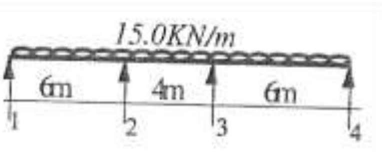
$z/d = 0.5+\sqrt{0.25-3k/3.4)}$

Where $k_0 = \frac{M}{(f_{ck}bd^2)}$

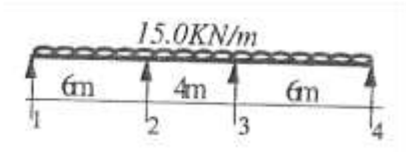
Or in the alternative

Table of lever arm and neutral axis depth factors can be used see the table below

Type II maximum loads on



Design with Euro-code2



Step1

Using the ratio coefficient method continuous spans6:4:6

Divide through by the left hand side i.e.

6: u 6

6 6 6

1: 0.67:1

1:0. 7: 1

M_{12}0.084X 15.0X6^2=45.36KNm

M_{23}=0.021X15.0X6^2=11.34KNm

M_{34}=0.084X15.0X6^2=45.2KNm

M_2=0.82X15.0X6^2=44.28KNm

M_3=0.082X15.0X6^2=44.28KNm

To check for reinforcements

Slab thickness for preliminary analysis =200mm

Effective depth – reinforcement cover –

½ Diameter of Reinforcement

200-20-1/2(12)

=174mm

Where F_{ck}= characteristics compressive cylinder strength of concrete

M=Design ultimate moment

B=Width of section

D=Effective depth of the tension reinforcement

Z=lever arm

$K=M/bd^2f_{cu}$	Z/d	x/d
0.05	0.94	0.13
0.06	0.93	0.16
0.07	0.91	0.19
0.08	0.90	0.22
0.09	0.89	0.25
0.100	0.87	0.29
0.104	0.87	0.30
0.110	0.86	0.32
0.119	0.84	0.35
0.130	0.82	0.39
0.132	0.82	0.40
0.140	0.81	0.43
0.144	0.80	0.45
0.150	0.79	0.047
0.156	0.775	0.050

Area of steel in continuous slab using the formula For span M_{12}

$$K=\frac{47.2 X 10^6}{20 X 1000 X (172)^2}$$

K=0.08

Substitute, k=0.08 into the main equation

$$Z/d = 0.5+\sqrt{(0.25-0.08/0.9)}$$

=0.9

Z/d=0.9

Therefore: z=0.9d

$$As=\frac{M_{12}}{0.87fy \times z} = \frac{47.2 \times 10^6}{0.87 \times 410 \times 0.9 \times 172}$$

$=854.8mm^2$

Using the lever arm table

$$K=\frac{M^{12}}{bd^2fcu} = 0.08 \qquad z/d=0.9$$

Therefore:

$$As = \frac{M_{12}}{0.87fy \times z} = \frac{47.2 \times 10^6}{0.87 \times 410 \times 0.9 \times 172}$$

$=854.8mm^2$

Area of steel in continuous slab using the formula

$$k_o = \frac{M}{(f_{ck} bd^2)}$$

$f_{ck} \cong 0.67f_{cu}$

Using 25N/ mm^2 for compressive cube strength

$f_{ck} \cong 0.67 \times 25 \cong 16N/mm^2$

$$k_o = \frac{45.4 \times 10^6}{16 \times 1000 \times (172)^2}$$

=0.096

Z=d[0.5+[0.25-(3x0.096)/3.4]}

Z=d {0.5+0.407}

=0.91d

$$As = \frac{M_{12}}{0.87f_{yk} \times z} = \frac{45.4 \times 10^6}{0.87 \times 410 \times 0.9 \times 172}$$

$=813mm^2$

Where f_{yk} = characteristic strength of reinforcement

Looking through the steel table

Area of steel: - use Y12 @125c/c Bottom

The spacing and the size of the Reinforcement can be found through the first principal
Or through the standard table.
Area of steel, use Y12 @ 125c/c ($905mm^2$) bottom

From Basic Principle

Number of 12mm diameter iron rod required within 1 metre length is

$$\frac{\text{Area of reinforcement (obtain)}}{\text{Area of iron rod}}$$

i.e. $= \frac{854.8}{\pi r^2}$

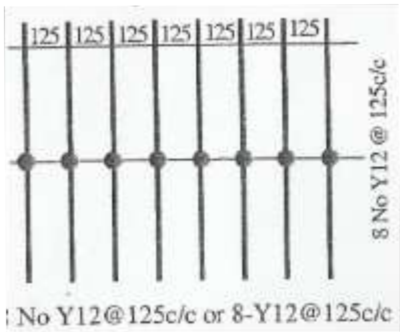
i.e. for 12mm ∅ rod $= \frac{854.8}{\pi \times (6)^2}$

$= 7.56 \cong 8$

i.e one need 8 No of 12mm ∅ iron rod in 1 linear metre

Spacing required is a matter of Proportion i.e. $\frac{\text{unit metre}}{\text{No of iron rods}}$

I.e. $\frac{1000}{8} = 125$mm center apart



8 No Y12@ 125c/c or 8-Y12@125c/c

Area of steel for span 2-3

M_{23}=11.8 KNm(Hogging moment)

As $= \frac{11.8 \times 10^6}{}$

Area of steel for span 2-3

M_{23}= 11.34kNm (Hogging moment)

As = 11.34×10^6

$0.87 \times 410 \times 0.91 \times 172 = 203mm^2$

Ditto as Left Hand Side

Area of steel for span 3-4

M_{34} = 45.4 kNm

0.87 x410 x 0.9 x 12
=213.7mm^2
Use minimum reinforcement allowed Top & bottom
The negative value indicates that the Reinforcement is really necessary at the top of the span rather than at the bottom of the span.
Area of steel for span 3-4
M_{34} =47.2 KNm

Ast = 47.2x10 ^{6}
0.87x410x 0.9x 172
=854.8mm^2
Areal of steel for support 2
Ast =*-46.1x10^6
0.87x410x9x172
=835mm^2
Use Y12 @ 125 c/c
*The negative value indicated that the reinforcement must be placed at the top of support 2
Areal of steel for support 3
Ast =*-46.1x10^6
0.87x410x9x172
=835mm^2
Use Y12 @ 125 c/c Top

CHECK FOR DEFLECTION
BS 8110 provided a standard table for Basic span/effective depth ratios for rectangular or flanged beams. The Table can equally be used for slab because slabs are normally designed as beams per unit metre width.

Support conditions	Rectangular Beams	Flinged beams with bw/b<0.3
Cantilever	7	5.6
Simply supported	20	16.0
continuous	26	20.8

Asts = 47.2x10 ^{6}
0.87x410x 0.91x 172
= 813.2mm^2
Use Y12 @ 125 c/c Bottom
Areal of steel for support 2
Ast =*-44.3x10^6
0.87x410x 0.91x172
=793MM^2
Use Y12 @ 125 c/c Top
*The negative value indicated that the reinforcement must be placed at the top of support 2
Areal of steel for support 3
M^3 = 44.3KNm
Ast = 793mm^2
Use Y12 @ 125 c/c Top

CHECK FOR DEFLECTION
There is a standard table of Ec2 which gave the Basic ratio of span/ effective depth for reinforced concrete members without axial compression.

The values obtained from the design and analysis above shows the following:

i) Appropriate bending memento values:- The values computed from both methods design are slightly different.

BS8IIO	**EURO-CODE2**
i). 854.8MM^2	813MM^2
ii). 213.7MM^2	203MM^2
iii). 835MM^2	793MM^2

ii) The areas of steel BS computed under the BS8110 method is higher than that computed under Euro-code 2 i.e

CONCLUSION

To ensure a good construction practices, the various codes of practice provides a guide to the structural use of concrete, which should be use always by practicing civil and structural engineers. The available codes has also taken into account the climatic conditions and the Evolution of civil and structural engineering practice in different countries. For good Engineering practice, professionals should be very familiar with the contents of these codes. Registered Engineers should always ensure that all works comply with the codes available for carrying out the design of every structural Element

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