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A comparative analysis of civil engineering codes of practice, cp110 and bs8110 on distribution of load on a beam supporting a two-way spanning slab

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Abstract

This paper presents a comparative analysis of provisions of British Standard Institution (BSI), Civil Engineering codes of practice, CP 110 (1972) and BS 8110 (1985) on distribution of load on a beam supporting a two-way spanning slab. A plan of typical two-span, two-way beam and slab layout was adopted and analyzed differently using the provisions of the two codes of practice. It was clearly observed that using BS 8110 both the support and span moments for beams supporting discontinuous edges are lower, while they are higher for beams supporting continuous edges. The shear forces at supports obtained are lower on both cases with BS 8110. There is therefore a net advantage in economy of steel in the use of BS 8110 over that of CP 110.

1. Introduction

The civil engineering code of practice for the structural use of concrete, provided by the British Standard Institution (BSI) is widely used in many countries for the design of buildings. This code of practice has continued to undergo changes and transformation over periods of time as the institution continues to review and proffer better ways of handling various design of structural elements. The point of interest in this work is in the application of distribution of load on a beam supporting two-way spanning slab.

CP 110 (1972) provided in Figure 6, the triangular – equilateral method of arriving at equivalent uniformly distributed load on the beams. The provisions of table 62 of Reinforced Concrete Designers Handbook by Reynolds, C.E. and Steedman, J.C. which most Engineers still use today is based on this old code. Some other engineers do one form of approximation or the other to arrive at equivalent total uniformly distributed load on the beams, without applying the provision of a more recent code of practice BS 8110 (1985).

BS 8110 introduced the use of shear force coefficient on table 3.16, the shear force equations, equation 19 and 20 and the subsequent load distribution pattern on a beam supporting two-way spanning slab offered in figure 3.10. The cumulative effect of the earlier mentioned approximations has without doubt continued to affect the loading of various structural elements of the building.

This work intends to do a comparative analysis on the provisions of these two BSI codes of practice on beams supporting a two-way spanning slab and to highlight the differences in the design moments and shear forces obtainable from them, with particular reference to panels that have both continuous and discontinuous edges.

2. Method of analysis

The method of analysis includes adopting a plan of typical two-span, two-way beam and slab layout for the study (Fig.1).

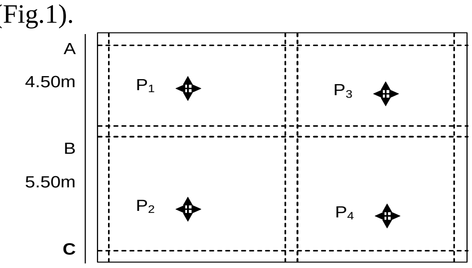


Fig. 1. Typical Two-span, Two-way Beam and Slab Layout.

Some other basic assumptions are:
1. Slab design load η = 12KN/m^2
2. Beam own load = 5KN/m
3. Wall and roof load = 20KN/m
4. All beams are of uniform stiffness
5. ly and lx represents the longer span and shorter span respectively

The determining factor for any panel to be regarded as a two-way spanning slab is that the ration ly/lx is less than 2.00 (BS 8110). The values of this ratio (K) for each of the panel in our chosen plan are as shown below:

Slab	*P1*	*P2*	*P3*	*P4*
K(ly/lx)	1.33	1.09	1.07	1.15

By the above definition the four panels represented in the plan are two-way spanning slabs. The loads on the beams are therefore obtained by the provisions of the BSI codes.

CP110 (Fig. 6) specified that the panel load should be uniformly distributed to the beams accordingly by triangular – equilateral method of proportioning as shown in Figure 2.

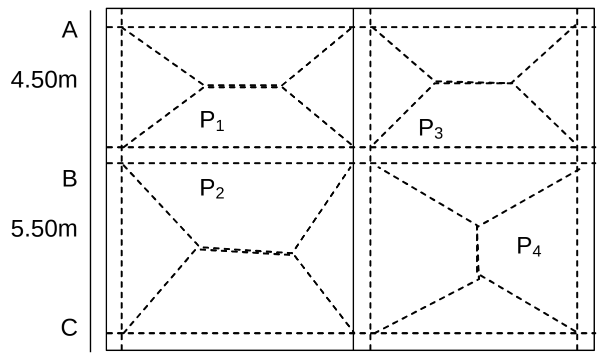


Fig. 2. Distribution of load on a beam supporting a two-way spanning slab (CP 110).

Based on the above loading arrangement, an equivalent uniformly distributed loading for maximum span moment was developed for simplified usage. The uniformly distributed load on the longer span (W_y) is given by

$W_y = ½ \, n \, lx \, (1-{}^{1}/_{3K}{}^{2})$ … (Renold & Steedman pg. 246)

While the uniformly distributed load on the shorter span (W_x) is given by

$W_x = {}^{1}/_{3} \, n \, lx$ …… (Renold & Steedman pg. 246)

In the case of BS 8110 (Fig 3.10), the specification is that the panel load should be uniformly distributed centrally over 75% of the length of the beam as shown in Figure 3.

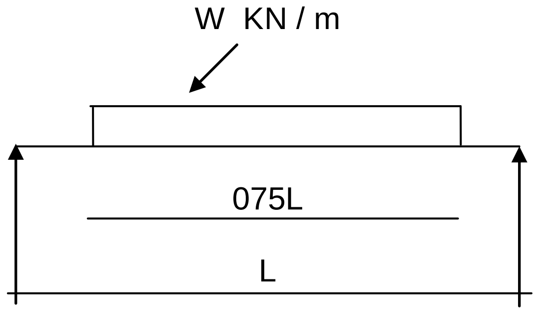


Fig. 3. Distribution of load on a beam supporting a two-way spanning slab. (BS 8110, Fig. 3.10).

The values of these loads (w) are obtained from equation 19 and 20.

$W_y = \beta_{VY} \, nlx$ ….. eqn. 19 (BS8110)

$W_x = \beta_{VX} \, \eta lx$ ….. eqn. 20 (BS8110)

Where shear force coefficients β_{vy} and β_{vx} are obtained from table 3.16 (BS8110).

The implication of the above is that the beam carries two types of uniformly distributed loads (Fig. 4).

i. Uniformly distributed load (W_1) throughout its length as a result of beam self weight, wall and roof load.
ii. Centrally placed uniformly distributed load (W_2) over the 75% of its length as a result of the panel load.

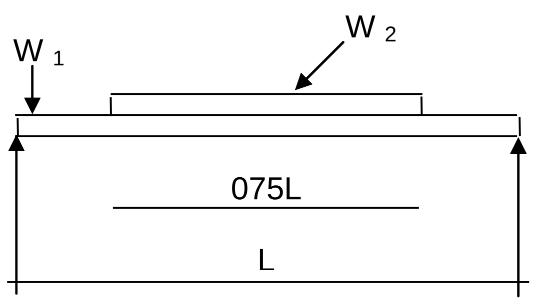
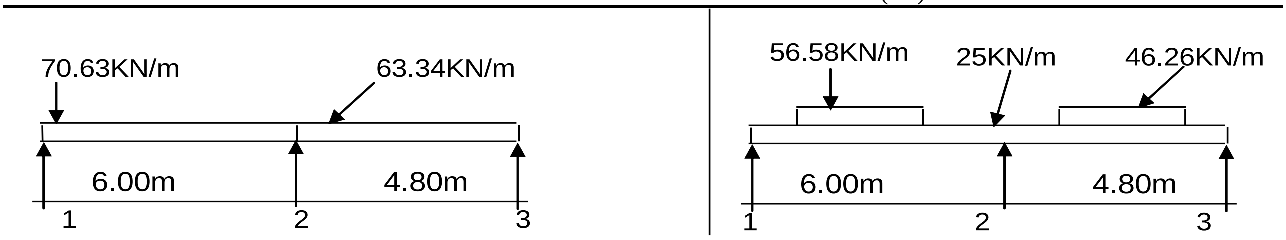


Fig. 4. Typical loading pattern on a beam supporting two-way spanning slab.

After assessing the loads, the beams were analyzed using moment distribution and super imposition methods to arrive at the support moments and mid span moments. The shear forces were also ideally calculated. A sample of typical loading pattern for beam B 1-3 is here presented below.

Loading

BS1	*CP 110*		*BS1*	*B58110*	
Span	1 – 2	2 – 3	Span	1 – 2	2 -3
Self weight	5.00	5.00	Self weight	5.00	5.00
Roof & Wall	20.00	20.00	Roof & Wall	20.00	20.00
$P_1 = ½ \times 12 \times 4.5 (1 – {}^1/3 \times 1.33^2)$	21.87	-	Total Udl. (W1)	25.00	25.00
$P_2 = ½ \times 12 \times 5.5 (1 – {}^1/3 \times 1.09^2)$	23.76	-	$P_1 = 0.51 \times 12 \times 4.50$	27.54	-
$P_3 = ½ \times 12 \times 4.5 (1 – {}^1/3 \times 1.07^2)$	-	19.14	$P_2 = 0.44 \times 12 \times 5.50$	29.04	-
$P_4 = {}^1/_3 \times 12 \times 4.8$	-	19.20	$P_3 = 0.43 \times 12 \times 4.50$	-	23.22
			$P_4 = 0.40 \times 12 \times 4.80$	-	23.04
Total Udl	70.63KN/M	63.34KN/M	Total Slab load (w2)	56.58KN/M	46.26KN/M



3. Summary of result

		Moments (kNm)			*Shear forces (kN)*			
		Support 2	Mid Span 1-2	Mid Span 2-3	V_{12}	V_{21}	V_{23}	V_{32}
Beam	CP 110	258.26	188.71	53.29	168.85	254.93	205.82	98.22
B 1-3	BS 8110	278.66	211.89	56.87	155.87	248.75	201.32	85.22

		Moments (kNm)			*Shear forces (kN)*			
		Support B	Mid Span A-B	Mid Span B-C	V_{AB}	V_{BA}	V_{BC}	V_{CB}
Beam	CP 110	212.03	48.40	153.16	90.13	184.37	227.04	149.94
2A-C	BS 8110	225.52	53.05	168.29	79.04	179.26	218.26	136.26

		Moments (kNm)			*Shear forces (kN)*			
		Support 2	Mid Span 1-2	Mid Span 2-3	V_{12}	V_{21}	V_{23}	V_{32}
Beam	CP 110	174.05	123.90	40.10	111.60	169.62	146.20	69.68
A1-3	BS 8110	153.89	111.89	35.89	90.05	141.35	119.28	55.16

		Moments (kNm)			*Shear forces (kN)*			
		Support B	Mid Span A-B	Mid Span B-C	V_{AB}	V_{BA}	V_{BC}	V_{CB}
Beam	CP 110	146.73	35.48	104.36	64.14	129.36	155.93	102.57
1A-C	BS 8110	127.73	32.74	91.51	51.56	108.32	127.36	80.92

4. Discussion

It is clearly seen from the loading analysis that CP 110 uses the same equivalent loading arrangement for all types of beams regardless of degree of restraint along the four edges of the panels supported by the beams. In sharp contrast, BS 8110 recognizes the varying degree of restraints and continuity, and provided in table 3.16 the shear force coefficients for uniformly loaded rectangular panels supported on four sides, with provisions for torsion at corners for different edge conditions. The coefficients vary for different edge conditions and ly/lx ratio and are utilized in equations 18 and 20 of the code to obtain the uniformly distributed load on the beams as shown in Figure 3.10 of BS 8110.

From the result of the comparative analysis of the two loading patterns shown in the table, it is clear that using BS8110, both the span and support moments for beams supporting discontinuous edges are lower, while they are higher for beams supporting continuous edges. Also the shear forces at supports are generally lower using BS 8110 loading pattern.

The implication of the above observations is that, the advantage in economy of steel achieved by BS 8110 in beams supporting discontinuous edges is counterbalanced by its disadvantage in beams supporting continuous edges, but there is an additional advantage in the economy of steel achieved by BS 8110 due to the generally lower shear force values. Hence, there is obvious net economy in the use of BS 8110 over CP 110.

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