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Analysis & Design of Prestressed Concrete Flat Slab Using Various Codes

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ABSTRACT
The flat slab construction approach eliminates the need for beams, which are often used in traditional building procedures. Rather the slab is supported by the columns, which enables the weight to be carried directly to the columns and subsequently to the foundation, To accommodate substantial weights, the slab's thickness at the point of contact with the columns is increased; this modification is known as drops. The lack of beams results in a flat ceiling, enhancing the architectural aesthetics and reducing fire risks compared to traditional beam-supported structures. A flat celing enables better light distribution, is easier to construct, & necessitates less expensive formwork. Different countries have developed various design methods for flat slabs based on local conditions and material availability, providing guidelines in their codes. This project aims to demonstrate the flat slab design methodologies as outlined in the
ACI-318, BS-1997, Eurocode2, & IS:456 design codes.

Keywords: Column heads, Loads.

INTRODUCTION
Claud Turner was one of the early proponents of flat slab system is also known as "Mushroom system." C.A.P. Turner constructed flat slabs in U.S.A. in 1906 mainly using conceptual ideas, which was start of this type of construction.

FIG.No.1: TYPICAL FLAT SLAB CONSTRUCTION

Components of flat slabs:
1. Drops: Moments in the flat slabs are large near to the column Hence the slab is thicned near the columns by providing the drop.
2. Column heads: The column head is expanded to reduce punching shear on the slab. The extension is called the column head.
3. Panel: The part of the slab bounded on each of its sides by the centre line of a column / centre line of a adjacent spans.
4. Column Strip: A column strip is design strip in Flat slab that runs either side of a column's centre line. The width of a column strip is (25%) of the span length or width, Whichchrever is minimum.
5. Middle Strip: A desigm strip bounded on eacg of its opposite directions by the colums strip.

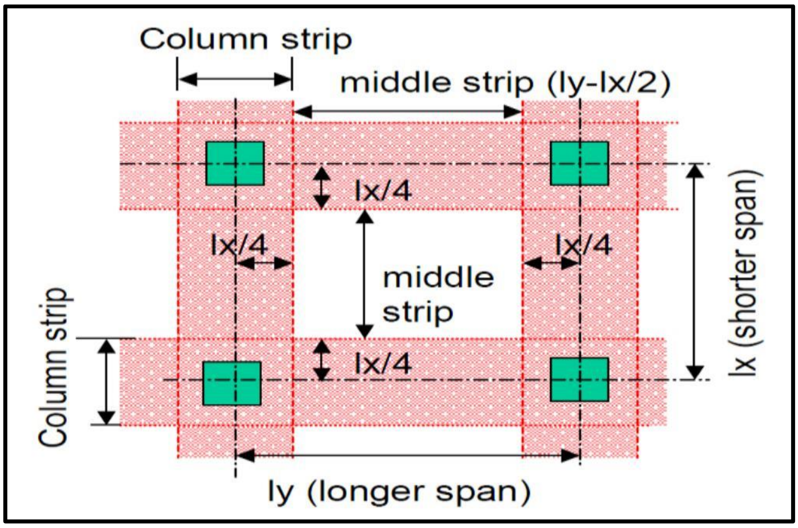

FIG.No.2: COMPONENTS OF FLAT SLAB.

TYPES OF FLAT SLAB
a. Flat slab with drop & column head.
b. Flat slab with drop & without column head.
c. Flat slab without drop & with column head.
d. Flat slab without drop & column head.

INTRODUCTION TO PRESRESSED CONCRETE
Prestressed concrete is a specialized type of concrete that incorporates internal compressive stresses to counterbalance the tensile stresses that arise when the structure is subjected to service loads. This method significantly improves the structural capabilities of concrete, enhancing its strength, durability, and overall performance. Consequently, it is commonly employed in the construction of high-rise buildings, long-span structures, and bridges.
The core principle of prestressing involves applying compressive forces to the concrete before it faces any external loads. Since concrete has a high capacity for compression but a limited ability to withstand tension, the application of pre-compression helps to reduce or prevent tensile cracking. Prestressing is typically executed through two main techniques: pre-tensioning and post-tensioning. In the pre-tensioning technique, steel tendons are stretched prior to the casting of the concrete, whereas in the post-tensioning method, the tendons are tensioned after the concrete has set.

BENEFITS OF PRESTRSSED CONCRETE

Greater Load Carrying Capacity: Prestressing makes concrete components more capable of supporting loads, enabling longer spans and less structural depth.

Crack Control: By lowering or eliminating tensile stresses, the prestressing procedure helps shield surfaces from cracking when subjected to service loads.

Material Efficiency: Compared to traditional reinforced concrete, less steel and concrete are needed to get the same results.

Durability: Less deflection and cracking improve durability, particularly in harsh settings like industrial or maritime constructions.

Longer Spans: This minimizes the need for intermediate supports and is perfect for bridges, floors, and roofs with wide spans.

6. Better Serviceability: Structures operate better and are more comfortable when deflection and vibration are better controlled.

LIMITATIONS OF PRESTRESSED CONCRETE

1. A thicker slab is required.
2. Attention to deflection control is necessary.
3. Losses in Prestress: Over time, prestress losses occur due to creep, shrinkage, and relaxation of
4. steel, which must be accounted for in design.

DESIGN PHILOSOPHY

There are two methods are as follows:

1. Direct Design Method (DDM)
2. Equivalent Frame Method (EFM)
3. Finite Element Method (FEM)

The I.S. code suggests the first two approaches (approximate methods) for calculating the bending moments in the slab panel; either approach is acceptable (as long as the necessary conditions are met). These approaches are only applicable to two-way rectangular slabs, not one-way slabs, and in the case of the direct design method, the recommendations only apply to the gravity loading condition (not the lateral load condition).

FINITE ELEMENT METHOD

The FEM can easily examine buildings with irregular designs that the EFM cannot. FEM is an effective technique used in the

Analysis of flat slabs. Finite element programs often use elastic moment distributions and materials that follow Hooke's law. While this works for steel plates, reinforced concrete is an elasto-plastic material with non-linear cracking behavior. This leads to an overestimation of support moments and an underestimation of slab deflections. One major critique of FEM analysis is its reliance on elastic solutions, which lead to large peaked support moments over the column. Due to cracking, these support moments may not be realized under service loads, resulting in higher service span moments. When utilizing the finite element approach, consider the following:

a. Selecting an appropriate finite element.
b. The level of degree of disceretisation.

c. Computational economy.

The same problem can therefore be represented by a variety of finite element models. At the lowest possible computing cost, a model that can account for all significant structural impacts is referred to as the finest model.

Dynamic Evaluation

1. The coefficient technique.
2. The response to Spectrum technique.
3. The time history technique.

Design Example of Indian Standard 456-2000 (IS)

- With Staggered Column

Design the prestressed concrete flat slab with staggered column shown in figure using equivalent frame method. It is subjected to live load of 3 kN/m^2 and floor finish of 1 kN/m^2. Use 12 wires of 5 mm diameter stressed at 1000 N/mm^2. Floor to floor height of column 3.5m.

Given:

L.L = 3 kN/m^2 clear cover = 30 mm

fck =30 N/mm^2

Column diameter = 350 mm Floor to floor height of column = 3.5 m

Excel sheet with staggered column:-					
FRAME 1					
(1) Exterior Span A-B:-					
Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	40.533281	KN/m			
M1	72.522182	KN.m	span A-B	X Direction	6.6
M2	173.42729	KN.m		Y direction	5.615
Reaction at Left Support				M1	72.52218
R1=VL=((W*L)/2)-((M2-M1)/L)	118.47118	KN		M2	173.4273
Reaction at Right Support					
VR= (W*L)-R1	149.04848	KN			
The critical Section for 'negative' design moment are at the column faces; the moment at the left end (Mul) and right end (Mur) are, Accordingly given by:					
At interior support critical section for flexure occurs at a distance= 350/2				0.175	m
At exterior support critical section for flexure occurs at a distance= 350/2				0.175	m

Negative design moment at					
Left support=	MuL =	52.4104	KN.m		
Right support=	MuR=	147.964	KN.m		
The maximum positive moment					
Location at X= (Vr/W)	3.6771876	m			
Positive moment at X distance=	100.61233	KN.m			
Moment in longitudinal direction					
Total negative moment at Left support		52.4104	KN.m		
Total negative moment at Right support		147.964	KN.m		
Total positive moment at mid span		100.612	KN.m		

Distribution of longitudinal Panel moment into strip moment					
(A) Distibute moment in column strip					
Left negative moment=	52.410392	KN.m			
Right negative moment=	110.97335	KN.m			
Positive moment=	60.367396	KN.m			
Prestressing force	1111	KN			
Eccentricity	100	mm			
(B) Distribute moment in middle strip					
Left negative moment=	0	KN.m			
Right negative moment=	36.991118	KN.m			
Positive moment=	40.24493	KN.m			
Prestressing force	893	KN			
Eccentricity	82	mm			
(2) Interior span B-C					
Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	42.44625	KN/m			
L2	2.94	m	Span B-C	X Direction	6.6
Ln= 7.5-0.350	6.25	m		Y direction	5.88
M1	160.43007	KN.m		M2	160.4301
M2	164.44992	KN.m		M3	164.4499
Reaction at Left Support					
R1=VL=((W*L)/2) -((M2-M1)/L)	139.46356	KN			
Reaction at Right Support					

VR= (W*L)-R1	140.68169	KN			
The critical Section for 'negative'					
design moment are at the column					
faces; the moment at the left end					
(Mul) and right end (Mur) are,					
Accordingly given by:					
At interior support critical section for flexure occurs at a distance= 350/2				0.175	m
At exterior support critical section for flexure occurs at a distance= 350/2				0.175	m
Negative design moment at					
Left support=	MuL =	136.674	KN.m		
Right support=	MuR=	140.481	KN.m		
The maximum positive moment					

Location at X= (Vr/W)	3.3143492	m			
Positive moment at X distance=	68.684202	KN.m			
Moment in longitudinal direction					
Total negative moment at Left support		136.674	KN.m		
Total negative moment at Right support		140.481	KN.m		
Total positive moment at mid span		68.6842	KN.m		
Distribution of longitudinal Panel moment into strip moment					
(A) Distibute moment in column strip					
Left negative moment=	102.50543	KN.m			
Right negative moment=	105.36044	KN.m			
Positive moment=	41.210521	KN.m			
Prestressing force	1111	KN			
Eccentricity	95	mm			
(B) Distribute moment in middle strip					
Left negative moment=	34.168478	KN.m			
Right negative moment=	35.120146	KN.m			
Positive moment=	27.473681	KN.m			
Prestressing force	893	KN			
Eccentricity	82	mm			
(3) Exterior span C-D					

Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	42.337969	KN/m			
L2	2.9325	m	Span C-D	X Direction	6.6
Ln= 7.5-0.350	6.25	m		Y direction	5.865
M1	179.71164	KN.m		M3	179.7116
M2	74.616056	KN.m		M4	74.61606
Reaction at Left Support					
R1=VL=((W*L)/2) -((M2-M1)/L)	155.63887	KN			
Reaction at Right Support					
VR= (W*L)-R1	123.79172	KN			
The critical Section for 'negative'					
design moment are at the column					
faces; the moment at the left end					
(Mul) and right end (Mur) are,					

Accordingly given by:			
At interior support critical section for flexure occurs at a distance= 350/2			
At exterior support critical section for flexure occurs at a distance= 350/2			
Negative design moment at			
Left support=	MuL =	153.123	KN.m
Right support=	MuR=	53.6008	KN.m
The maximum positive moment			
Location at X= (Vr/W)	2.9238938	m	
Positive moment at X distance=	106.36087	KN.m	
Moment in longitudinal direction			
Total negative moment at Left support	153.123	KN.m	
Total negative moment at Right support	53.6008	KN.m	
Total positive moment at mid span	106.361	KN.m	
Distribution of longitudinal Panel moment into strip moment			
(A) Distibute moment in column strip			
Left negative moment=	114.84235	KN.m	
Right negative moment=	53.600804	KN.m	
Positive moment=	63.816523	KN.m	

Prestressing force	1111	KN	
Eccentricity	103	mm	
(B) Distribute moment in middle strip			
Left negative moment=	38.280784	KN.m	
Right negative moment=	0	KN.m	
Positive moment=	42.544348	KN.m	
Prestressing force	893	KN	
Eccentricity	103	mm	

Design Example of British Standard 8110-1997(BS)

Design the flat slab with staggered column shown in figure using equivalent frame method. It is subjected to live load of 3 kN/m^2 and floor finish of 1 kN/m^2. Use 12 wires of 5 mm diameter stressed at 1000 N/mm^2. Floor to floor height of column 3.5m.

Excel sheet with staggered column:-					
FRAME 1					
(1) Exterior Span A-B :-					
Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	39.515563	KN/m			
M1	70.701278	KN.m	span A-B	X Direction	6.6
M2	169.07284	KN.m		Y direction	5.615
Reaction at Left Support				M1	70.7013
R1=VL=((W*L)/2)-((M2-M1)/L)	115.49657	KN		M2	169.073
Reaction at Right Support					
VR= (W*L)-R1	145.30614	KN			
The critical Section for 'negative'					
design moment are at the column					
faces; the moment at the left end					
(Mul) and right end (Mur) are,					
Accordingly given by:					
At interior support critical section for flexure occurs at a distance= 350/2				0.175	m
At exterior support critical section for flexure occurs at a distance= 350/2				0.175	m
Negative design moment at					
Left support=	MuL =	51.0945	KN.m		

Right support=	MuR=	144.249	KN.m		
The maximum positive moment					
Location at X= (Vr/W)	3.6771876	m			
Positive moment at X distance=	98.086129	KN.m			
Moment in longitudinal direction					
Total negative moment at exterior support		51.0945	KN.m		
Total negative moment at interior support		144.249	KN.m		
Total positive moment at mid span		98.0861	KN.m		

Excel sheet with staggered column:-					
FRAME 1					
(1) Exterior Span A-B :-					
Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	39.515563	KN/m			
M1	70.701278	KN.m	span A-B	X Direction	6.6
M2	169.07284	KN.m		Y direction	5.615
Reaction at Left Support				M1	70.7013
R1=VL=((W*L)/2)-((M2-M1)/L)	115.49657	KN		M2	169.073
Reaction at Right Support					
VR= (W*L)-R1	145.30614	KN			
The critical Section for 'negative'					
design moment are at the column					
faces; the moment at the left end					
(Mul) and right end (Mur) are,					
Accordingly given by:					
At interior support critical section for flexure occurs at a distance= 350/2				0.175	m
At exterior support critical section for flexure occurs at a distance= 350/2				0.175	m
Negative design moment at					
Left support=	MuL =	51.0945	KN.m		

Right support=	MuR=	144.249	KN.m		
The maximum positive moment					
Location at X= (Vr/W)	3.6771876	m			
Positive moment at X distance=	98.086129	KN.m			
Moment in longitudinal direction					
Total negative moment at exterior support		51.0945	KN.m		
Total negative moment at interior support		144.249	KN.m		
Total positive moment at mid span		98.0861	KN.m		
Distribution of longitudinal Panel moment into strip moment					
(A) Distibute moment in column strip					
Exterior negative moment=	38.320845	KN.m			
Interior negative moment=	108.18701	KN.m			
Positive moment=	53.947371	KN.m			
Prestressing force	1087	KN			
Eccentricity	100	mm			
(B) Distribute moment in middle strip					
Exterior negative moment=	12.773615	KN.m			
Interior negative moment=	36.062337	KN.m			
Positive moment=	44.138758	KN.m			
Prestressing force	965	KN			
Eccentricity	84	mm			
(2) Interior span B-C					
Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	41.3805	KN/m			
			Span B-C	X Direction	6.6
Ln= 7.5-0.350	6.25	m		Y direction	5.88
M1	156.40196	KN.m		M2	156.402
M2	160.32088	KN.m		M3	160.321
Reaction at Left Support					
R1=VL=((W*L)/2)-((M2-M1)/L)	135.96187	KN			
Reaction at Right Support					
VR= (W*L)-R1	137.14943	KN			

The critical Section for 'negative'					
design moment are at the column					
faces; the moment at the left end					
(Mul) and right end (Mur) are,					
Accordingly given by:					
At interior support critical section for flexure occurs at a distance= 350/2				0.175	m
At exterior support critical section for flexure occurs at a distance= 350/2				0.175	m
Negative design moment at					
Left support=	MuL =	133.242	KN.m		
Right support=	MuR=	136.953	KN.m		
The maximum positive moment					
Location at X= (Vr/W)	3.3143492	m			
Positive moment at X distance=	66.959664	KN.m			
Moment in longitudinal direction					
Total negative moment at exterior support		133.242	KN.m		
Total negative moment at interior support		136.953	KN.m		
Total positive moment at mid span		66.9597	KN.m		
Distribution of longitudinal Panel moment into strip moment					
(A) Distibute moment in column strip					
Exterior negative moment=	99.931703	KN.m			
Interior negative moment=	102.71503	KN.m			
Positive moment=	36.827815	KN.m			
Prestressing force	1087	KN			
Eccentricity	94	mm			
(B) Distribute moment in middle strip					
Exterior negative moment=	33.310568	KN.m			
Interior negative moment=	34.238342	KN.m			
Positive moment=	30.131849	KN.m			
Prestressing force	965	KN			
Eccentricity	73	mm			
(3) Exterior span C-D					
Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	41.274938	KN/m			

			Span C-D	X Direc-tion	6.6
Ln= 7.5-0.350	6.25	m		Y direc-tion	5.865
M1	175.1994	KN.m		M3	175.199
M2	72.742579	KN.m		M4	72.7426
Reaction at Left Support					
R1=VL=((W*L)/2)-((M2-M1)/L)	151.73105	KN			
Reaction at Right Support					
VR= (W*L)-R1	120.68353	KN			
The critical Section for 'negative'					
design moment are at the column					
faces; the moment at the left end					
(Mul) and right end (Mur) are,					
Accordingly given by:					
At interior support critical section for flexure occurs at a distance= 350/2				0.175	m
At exterior support critical section for flexure occurs at a distance= 350/2				0.175	m
Negative design moment at					
Left support=	MuL =	149.278	KN.m		
Right support=	MuR=	52.255	KN.m		
The maximum positive moment					
Location at X= (Vr/W)	2.9238938	m			
Positive moment at X distance=	103.69034	KN.m			
Moment in longitudinal direction					
Total negative moment at exterior support		149.278	KN.m		
Total negative moment at interior support		52.255	KN.m		
Total positive moment at mid span		103.69	KN.m		
Distribution of longitudinal Panel moment into strip moment					
(A) Distibute moment in column strip					
Exterior negative moment=	111.95886	KN.m			
Interior negative moment=	39.191237	KN.m			
Positive moment=	57.029686	KN.m			
Prestressing force	1087	KN			

Eccentricity	103	mm			
(B) Distribute moment in middle strip					
Exterior negative moment=	37.319621	KN.m			
Interior negative moment=	13.063746	KN.m			
Positive moment=	46.660652	KN.m			
Prestressing force	965	KN			
Eccentricity	103	mm			

(3) Exterior span C-D					
Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	41.274938	KN/m			
			Span C-D	X Direction	6.6
Ln= 7.5-0.350	6.25	m		Y direction	5.865
M1	175.1994	KN.m		M3	175.199
M2	72.742579	KN.m		M4	72.7426
Reaction at Left Support					
R1=VL=((W*L)/2)-((M2-M1)/L)	151.73105	KN			
Reaction at Right Support					
VR= (W*L)-R1	120.68353	KN			
The critical Section for 'negative'					
design moment are at the column					
faces; the moment at the left end					
(Mul) and right end (Mur) are,					
Accordingly given by:					
At interior support critical section for flexure occurs at a distance= 350/2				0.175	m

Excel sheet with staggered column:-					
FRAME 1					
(1) Exterior Span A-B :-					
Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	39.515563	KN/m			

M1	70.701278	KN.m	span A-B	X Direc-tion	6.6
M2	169.07284	KN.m		Y direc-tion	5.615
Reaction at Left Support				M1	70.7013
R1=VL=((W*L)/2)-((M2-M1)/L)	115.49657	KN		M2	169.073
Reaction at Right Support					
VR= (W*L)-R1	145.30614	KN			
The critical Section for 'negative'					
design moment are at the column					
faces; the moment at the left end					
(Mul) and right end (Mur) are,					
Accordingly given by:					
At interior support critical section for flexure occurs at a distance= 350/2				0.175	m
At exterior support critical section for flexure occurs at a distance= 350/2				0.175	m
Negative design moment at					
Left support=	MuL =	51.0945	KN.m		
Right support=	MuR=	144.249	KN.m		
The maximum positive moment					
Location at X= (Vr/W)	3.6771876	m			
Positive moment at X distance=	98.086129	KN.m			
Moment in longitudinal direction					
Total negative moment at exterior support		51.0945	KN.m		
Total negative moment at interior support		144.249	KN.m		
Total positive moment at mid span		98.0861	KN.m		
Distribution of longitudinal Panel moment into strip moment					
(A) Distibute moment in column strip					
Exterior negative moment=	38.320845	KN.m			
Interior negative moment=	108.18701	KN.m			
Positive moment=	53.947371	KN.m			
Prestressing force	1087	KN			
Eccentricity	100	mm			
(B) Distribute moment in middle strip					
Exterior negative moment=	12.773615	KN.m			

Interior negative moment=	36.062337	KN.m			
Positive moment=	44.138758	KN.m			
Prestressing force	965	KN			
Eccentricity	84	mm			
(2) Interior span B-C					
Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	41.3805	KN/m			
			Span B-C	X Direc-tion	6.6
Ln= 7.5-0.350	6.25	m		Y direc-tion	5.88
M1	156.40196	KN.m		M2	156.402
M2	160.32088	KN.m		M3	160.321
Reaction at Left Support					
R1=VL=((W*L)/2)-((M2-M1)/L)	135.96187	KN			
Reaction at Right Support					
VR= (W*L)-R1	137.14943	KN			
The critical Section for 'negative'					
design moment are at the column					
faces; the moment at the left end					
(Mul) and right end (Mur) are,					
Accordingly given by:					
At interior support critical section for flexure occurs at a distance= 350/2				0.175	m
At exterior support critical section for flexure occurs at a distance= 350/2				0.175	m
Negative design moment at					
Left support=	MuL =	133.242	KN.m		
Right support=	MuR=	136.953	KN.m		
The maximum positive moment					
Location at X= (Vr/W)	3.3143492	m			
Positive moment at X distance=	66.959664	KN.m			
Moment in longitudinal direction					
Total negative moment at exterior support		133.242	KN.m		

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Total negative moment at interior support		136.953	KN.m		
Total positive moment at mid span		66.9597	KN.m		
Distribution of longitudinal Panel moment into strip moment					
(A) Distibute moment in column strip					
Exterior negative moment=	99.931703	KN.m			
Interior negative moment=	102.71503	KN.m			
Positive moment=	36.827815	KN.m			
Prestressing force	1087	KN			
Eccentricity	94	mm			
(B) Distribute moment in middle strip					
Exterior negative moment=	33.310568	KN.m			
Interior negative moment=	34.238342	KN.m			
Positive moment=	30.131849	KN.m			
Prestressing force	965	KN			
Eccentricity	73	mm			
(3) Exterior span C-D					
Critical Section is at a distance = (d/2)	93.5	m			
Rate of loading per meter= w*L2	41.274938	KN/m			
			Span C-D	X Direction	6.6
Ln= 7.5-0.350	6.25	m		Y direction	5.865
M1	175.1994	KN.m		M3	175.199
M2	72.742579	KN.m		M4	72.7426
Reaction at Left Support					
R1=VL=((W*L)/2)-((M2-M1)/L)	151.73105	KN			
Reaction at Right Support					
VR= (W*L)-R1	120.68353	KN			
The critical Section for 'negative'					
design moment are at the column					
faces; the moment at the left end					
(Mul) and right end (Mur) are,					
Accordingly given by:					
At interior support critical section for flexure occurs at a distance= 350/2				0.175	m
At exterior support critical section for flexure occurs at a distance= 350/2				0.175	m

Negative design moment at					
Left support=	MuL =	149.278	KN.m		
Right support=	MuR=	52.255	KN.m		
The maximum positive moment					
Location at X= (Vr/W)	2.9238938	m			
Positive moment at X distance=	103.69034	KN.m			
Moment in longitudinal direction					
Total negative moment at exterior support		149.278	KN.m		
Total negative moment at interior support		52.255	KN.m		
Total positive moment at mid span		103.69	KN.m		
Distribution of longitudinal Panel moment into strip moment					
(A) Distibute moment in column strip					
Exterior negative moment=	111.95886	KN.m			
Interior negative moment=	39.191237	KN.m			
Positive moment=	57.029686	KN.m			
Prestressing force	1087	KN			
Eccentricity	103	mm			
(B) Distribute moment in middle strip					
Exterior negative moment=	37.319621	KN.m			
Interior negative moment=	13.063746	KN.m			
Positive moment=	46.660652	KN.m			
Prestressing force	965	KN			
Eccentricity	103	mm			

CONCLUSION

The following findings were reached from the work done in this dissertation on 'analysis and design of prestressed concrete flat slab by employing IS code and BS code requirements'.

1. The IS and BS codes specify the same width for the center strip and column strip.
2. At two intermediate staggered columns, the hogging bending moment determined by IS code provision is 5% and 15% more than that determined by BS code at the same place.
3. A comparison is made between the moments derived from BS code and the moments derived from IS code regulations. Below is a discussion of their variants.

The staggered column moment variation: -

A) Column strip moments

1. Compared to IS code provision, the external negative moments of flat slabs over the longer and shorter span generated by BS code provision are lower by 25% to 30%.

2. Compared to IS code provisions, the interior negative moments of flat slabs along the larger and - shorter spans achieved by BS code provisions are lower by 1% to 5%.
3. Compared to IS code provisions, the middle positive moments of flat slabs along the larger and shorter spans generated by BS code provisions are lower, ranging from 10% to 13%.

B) Middle strip moments

1. According to IS code, the flat slab's exterior negative moments over its longer and shorter spans are zero, but BS code yields insignificant moments.
2. Compared to IS code provisions, the internal negative moments of flat slabs over the larger and shorter spans generated by BS code provisions are lower by 1% to 5%.
3. Compared to IS code provisions, the middle positive moments of flat slabs along the longer and shorter spans achieved by BS code provisions are greater by 5% to 10%.

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