Analysis And Design Of Flat Slab And Grid Slab And Their Cost Comparison

Amit A. Sathawane*, R.S. Deotale**

*(P.G. Student (M.Tech- Structure),Department of Civil Engineering, YCCE, Nagpur-441110, Maharashtra, India
** (Assistant Professor,Department of Civil Engineering, YCCE, Nagpur-441110, Maharashtra, India

ABSTRACT
The FLAT slab system of construction is one in which the beam is used in the conventional methods of construction done away with the directly rests on column and the load from the slabs is directly transferred to the columns and then to the foundation. Drops or columns are generally provided with column heads or capitals. Grid floor systems consisting of beams spaced at regular intervals in perpendicular directions, monolithic with slab. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement.

The aim of the project is to determine the most economical slab between flat slab with drop, Flat slab without drop and grid slab. The proposed construction site is Nexus point apposite to Vidhan Bhavan and beside NMC office, Nagpur. The total length of slab is 31.38 m and width is 27.22 m. total area of slab is 854.16 sqm. It is designed by using M_{35} Grade concrete and Fe_{415} steel. Analysis of the flat slab and grid slab has been done both manually by IS 456-2000 and by using software also. Flat slab and Grid slab has been analyzed by STAAD PRO. Rates have been taken according to N.M.C. C.S.R

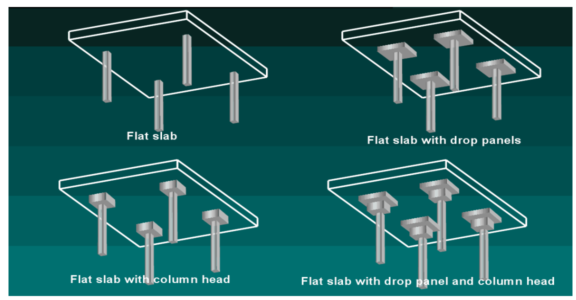
It is observed that the FLAT slab with drop is more economical than Flat slab without drop and Grid slabs.

Keywords **– Flat slab with drop, Flat slab without drop, grid slab, drop, column capital**

I. INTRODUCTION

1.1 FLAT SLAB

A reinforced concrete flat slab, also called as beamless slab, is a slab supported directly by columns without beams. A part of the slab bounded on each of the four sides by centre line of column is called panel. The flat slab is often thickened closed to supporting columns to provide adequate strength in shear and to reduce the amount of negative reinforcement in the support regions. The thickened portion i.e. the projection below the slab is called drop or drop panel. In some cases, the section of column at top, as it



meets the floor slab or a drop panel, is enlarged so as to increase primarily the perimeter of the critical section, for shear and hence, increasing the capacity of the slab for resisting two-way shear and to reduce negative bending moment at the support. Such enlarged or flared portion of and a capital. Slabs of constant thickness which do not have drop panels or column capitals are referred to as flat plates. The strength of the flat plate structure is often limited due to punching shear action around columns, and consequently they are used for light loads and relatively small spans.

METHODS

DESIGN OF FLAT SLAB

Methods of Design:

Two approximate method methods are adopted by the codes for the design of flat slab or flat plate .These method can be used provided the limitations specified therein are satisfied. The two design methods are:
(a) The direct design method
(b) The equivalent frame method

1.2 GRID SLAB

Grid floor systems consisting of beams spaced at regular intervals in perpendicular directions, monolithic with slab.

Item	X	Y
c to c span	10.6	8.86
Clear span(L_n)	10.6-1.772= 8.828	7.088
Width of span(L_2)	8.86	10.6
Width of column strip (BS)	4.43	4.43
Width of mid strip	4.43	6.17
L_2/L_1	0.836	1.20

They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement.The rectangular or square void formed in the ceiling is advantageously utilized for concealed architectural lighting. The sizes of the beams running in perpendicular directions are generally kept the same. Instead of rectangular beam grid, a diagonal.

ANALYSIS OF GRID SLAB

1) Approximate Methods
2) Analysis of grid Floor by Plate Theory

2. Design of flat slab with drop interior panel of size 10.6 × 8.86 m

Size of columns = L_1/16 or H/8=500mm

Estimate size of column capital= D = L_2 /5=1772

Length of drop=1/3 span = 3.5 x 3.0 m

slab thickness= L_n = L_1-b=300 mm.

thickness of drop H=1.25 to 1.5 h=450mm

Size of external column =500 mm square

Size of edge beam= 300 × 600 mm

fck= 35 ; f_y = 415 ;

Load Calculations:

(a) Dead Load: bDγ = 1×0.3×25 = 7.5 KN/m

(b) Floor Finish = 1 kN/m

(c) Live Load = 4 kN/m

Total Design Load = 18.75 KN/m

Dimensions:

Table 1

Analyze the Interior X frame:

$M_0=wL_2L_n^2 / 8$ = 1618.34 kNm

DISTRIBUTION FACTORS:

longitudinal distribution Inter span

Support (-ve) = 0.65, Span (+ve) = 0.35

End spans: Interior –ve = 0.75-0.1R= 0.69

Span +ve =.63-0.28R = 0.45; Exterior –ve = 0.65R= 0.42

Transverse distribution

Interior –ve : 75% to column strip;25% to mid

Span +ve : 60% to column strip;40%to mid-strip

Exterior –ve : 100% to column strip

Type of moments	**Longitudinal Direction**		**Factors**	**Transverse Direction**	
	Factor	**Moment**		**CS**	**MS**
Negative	0.65	1051.92	0.75 0.25	788.9	262.98
Positive	0.35	566.41	0.6 0.4	339.85	226.5
End span analysis (IS 456)					
Interior (-ve)	0.685	1108.77	0.75 0.25	831.58	277.19
Span(+ve)	0.448	725.62	0.6 0.4	435.37	290.24
Exterior	0.422	682.34	1	682.3	

Table 2

Check for shear:

Effective depth of slab = 270 mm,

Effective depth of slab = 270 mm,

Weight of drop projection below slab = 25 × (0.3 – 0.24)×1.5 = 2.25 kN/m^2

Design shear at critical section around capital

V_{ud} =16.125(10.6 ×8.8 6 - (π ×(2.26 ^{2}/4))+2.25 (3.6 × 3 - π ×(2.26 ^{2}/4))

= 1450.0 + 15.0 = 1936.5 KN.

Design shear strength of concrete:

τc = k. τ_c where, τ_c = 0.25√f_{ck}
$\tau_{c=}$ 0.25√35 = 1.48 N/ m^2

k =(0.5+β) τ_c but ≤ 1.0

k= 1.0 ; τ_{uc} = 1.48 N/mm^2 Shear resistance of concrete v_{uc} = τ_{uc} × p × d = 1.48 × (π ×2260) × 0.260 =4723.42 KN > v_{ud} (= 1936) check for shear around the drop: The critical section is at a distance d/2 = 270/2 = 135 mm from the periphery of the drop

Design shear at critical section:

v_{ud} = 18.125 {(10.6 × 8.8 6) - (3.6+0.20) × (3.6 + 0.270) } = 1480.4 KN.

Shear resistance of concrete,

v_{uc} = 1.48 × 2(3800+3800) × (270/1000)

= 6185 KN > v_{ud}

LOCATION	MOMENTS (per m width)			AREA OF STEEL (mm^2)			DIAMETER OF BARS			Spacing (mm c/c)		
	Longitudinal direction	Transverse direction		Longitudinal	Transverse		Longitudinal	Transverse		Longitudinal	Transverse	
		Column	Middle		Column	Middle		Column	Middle		Column	Middle
Interior support												
-ve support	237.453	178.09	59.363	2775.30	2004.19	626.50	20	20	16	110	175	175
+ve support	127.85	76.72	51.143	1398.10	816.643	537.59	20	16	12	220	150	125
End span ACI METHOD												
Interior (-ve)	255.71	191.79	63.929	3026.87	2176.40	676.21	20	20	16	100	140	165
Span + ve	182.656	109.59	73.062	2061.24	1186.63	776.33	20	16	16	150	260	145
Exterior (-ve)	109.594	82.195	27.398	1186.63	877.40	284.75	20	16	12	260	355	395
End span IS 456												
Interior (-ve)	250.28	187.72	62.572	2951.28	2124.86	661.40	20	20	16	105	145	170
Span + ve	163.797	98.278	65.518	1827.81	1057.79	693.56	20	16	16	170	295	160
Exterior -ve	154.028	154.03		1709.10	1709.10		20	20	12	180	180	

negative kNm		

3. COMPARISION

Comparison of Maximum Moments obtained Manually and by Software for Flab Slab:

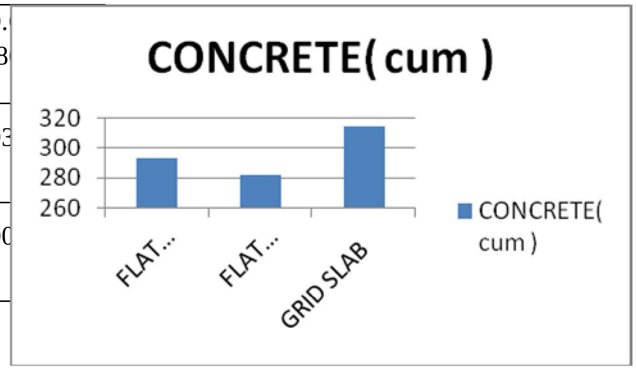
Maximum Moments	Manually	Software
Column strip positive kNm	76.72	73
Column strip negative kNm	178.1	177
Middle strip positive kNm	51.14	54.06
Middle strip	59.36	61.66

Comparison of Maximum Moments obtained Manually and by Software of Grid Slab:

	MANUALLY	SOFTWARE
MAXIMUM MOMENT kNm	1020	1163
MAXIMUM SHEAR FORCE kN	625	618

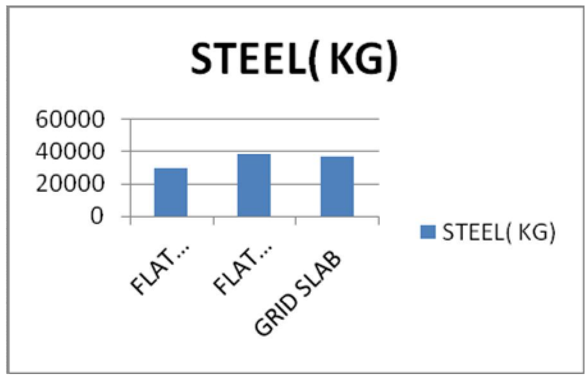
Flat Slab With Drop:

SPAN (m)	7 ×6	8 × 7	9 × 8	10 × 9	10. 8.8
CONCRETE (m^3)	88.2	137.52	190.696	270.1	293
AMOUNT (Rs)	853360	1348540	2052690	2972681	300

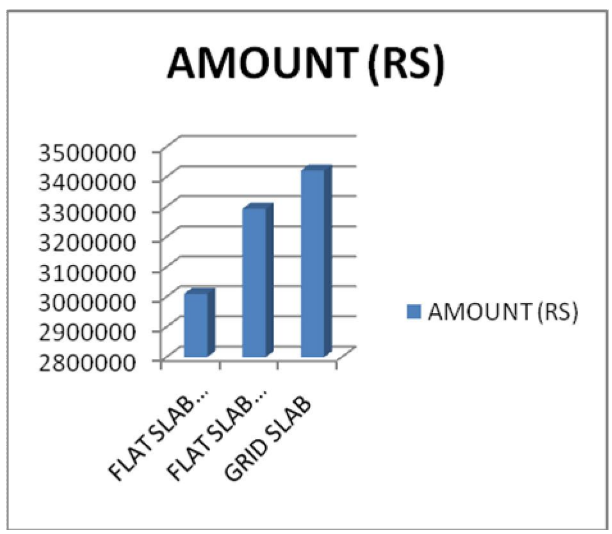


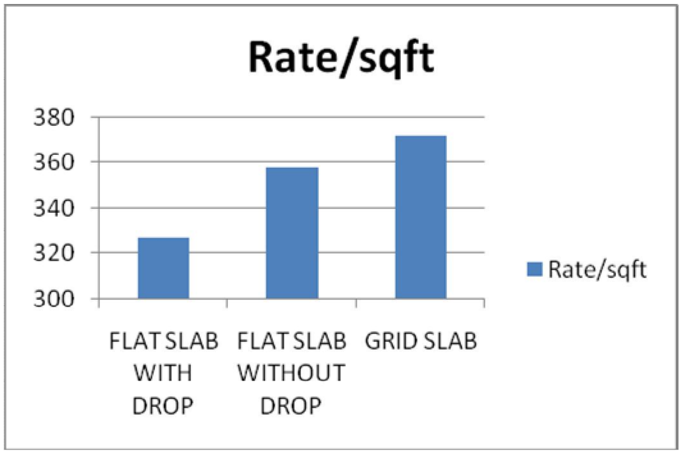
	FLAT SLAB WITH DROP	FLAT SLAB WITHOUT DROP	GRID SLAB
CONCRETE (m^3)	293.01	281.87	314.63
STEEL (KG)	29800	38125	36500
TOTAL AMOUNT (Rs)	3009660	3292650	3420780
RATE PER Sqm	3524	3855	4005
RATE PER Sqft	327	358	372

Rate Comparison:



4. GRAPHS:





5. CONCLUSION :

1) Drops are important criteria in increasing the shear strength of the slab.

2) Enhance resistance to punching failure at the junction of concrete slab & column.

3) By incorporating heads in slab, we are increasing rigidity of slab.

4) THE NEGATIVE MOMENT'S SECTION SHALL BE DESIGNED TO RESIST THE LARGER OF THE TWO INTERIOR NEGATIVE DESIGN MOMENTS FOR THE SPAN FRAMING INTO COMMON SUPPORTS.

5) Concrete required in Grid slab is more as compared to Flat slab with Drop and Flat slab without Drop.

6) Steel required in Flat slab without Drop is more as compared to Flat slab with Drop and Grid slab.

7) FLAT SLAB WITH DROP IS MORE ECONOMICAL THAN FLAT SLAB WITHOUT DROP AND GRID SLAB.

8) RATE PER SQUARE METER OF FLAT SLAB WITH DROP (3524) WAS FOUND TO BE MORE ECONOMICAL THAN FLAT SLAB WITHOUT DROP (3855) AND GRID SLAB (4005).

9) RATE PER SQUARE FEET OF FLAT SLAB WITH DROP (327) WAS FOUND TO BE MORE ECONOMICAL THAN FLAT SLAB WITHOUT DROP (358) AND GRID SLAB (372).

REFERENCES

I. PAPERS:

[1] VEMURI VENKATA RANGARAO, NARAPARAJU, VENKATA RAMANARAO FLAT STRIP SLAB SYSTEM, INTERNATIONAL CLASSES: E04B1/16; (03-04-2010)

[2] GOWDA N BHARATH; GOWDA S. B. RAVISHANKAR; A.V CHANDRASHEKAR; REVIEW AND DESIGN OF FLAT PLATE/SLABS CONSTRUCTION IN INDIA .

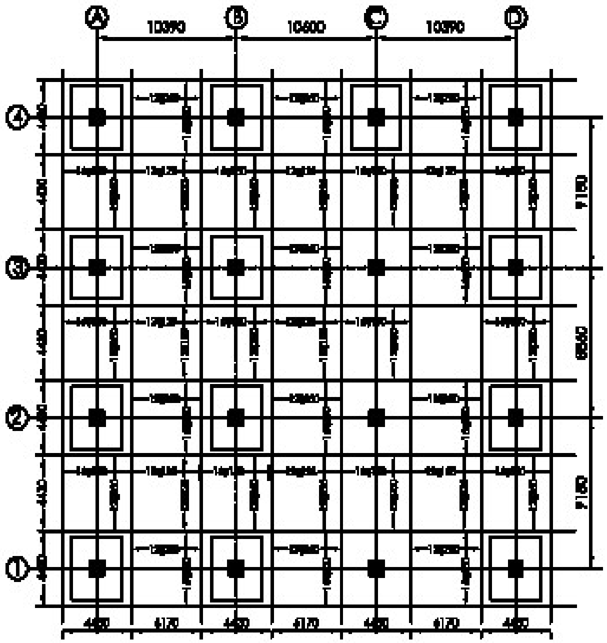
[3] AHMED IBRAHIM' ', HANI SALIM AND HAMDY SHEHAB EL-DIN; MOMENT COEFFICIENTS FOR DESIGN OF FLAT SLABS WITH AND WITHOUT OPENINGS. (11-06-2011)

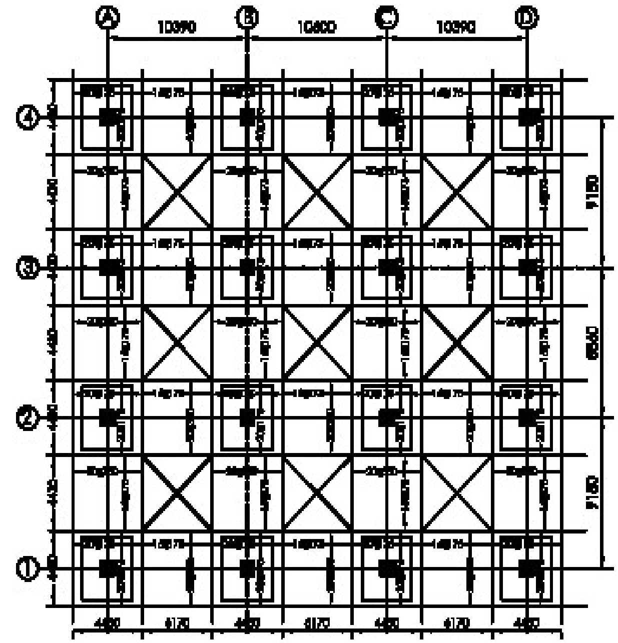
[4] DARIO CORONELLI; 'GRID MODEL FOR FOR FLAT SLAB STRUCTURES

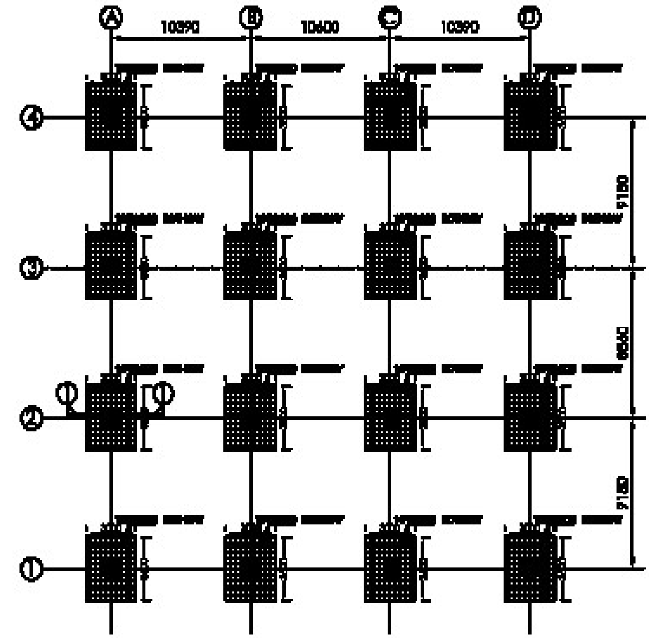
[5] LAWSON,PATRICKD; STRUCTURAL GRID FOR SLAB FACING MATERIALS; (03-28-1972)

II. BOOKS:

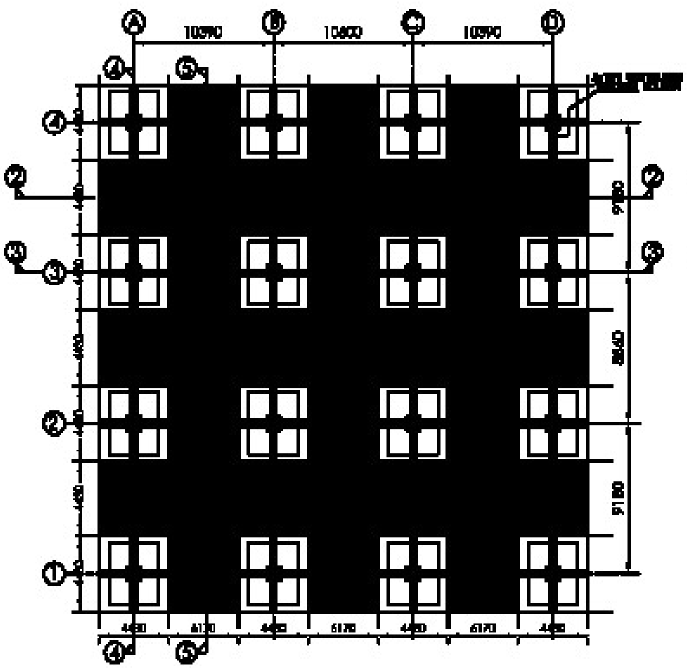
P. C. Varghese- Advanced Reinforced Concrete Design
Ramachandra , vijay Gehlot –Limit state of Design concrete structure
S. N. Sinha - Reinforced Concrete Design
IS: 456 – 2000 – Plain and Reinforced Concrete – Code of Practice
S.Ramamrutham - Design of Reinforced concrete structure
Dr.V.L. Shah , Late Dr. S.r. kurve - Limit state theory & Design of Reinforced concrete



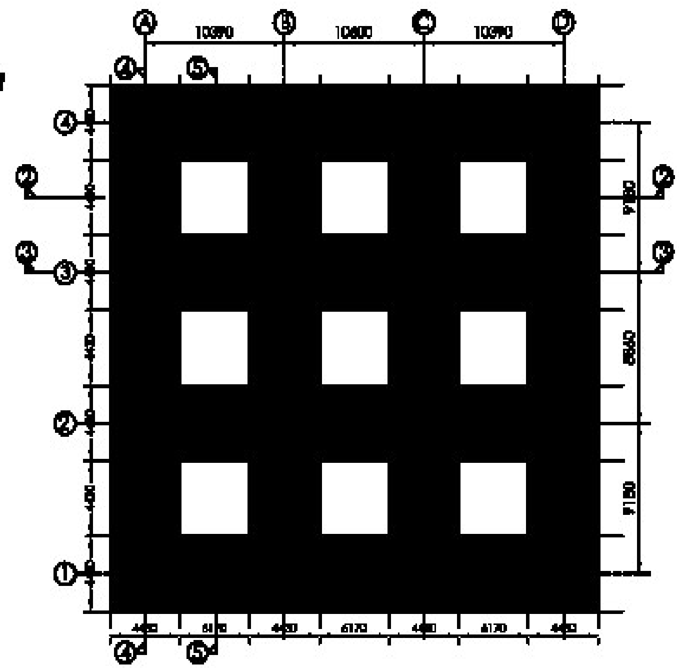




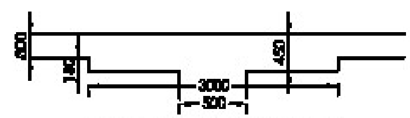
PLAN SHOWING BOTTOM R/F OF CAPITAL



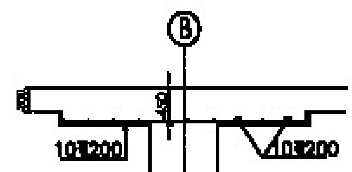
PART PLAN SHOWING BOTTOM R/F OF FLAT SLAB



PART PLAN SHOWING TOP R/F OF FLAT SLAB

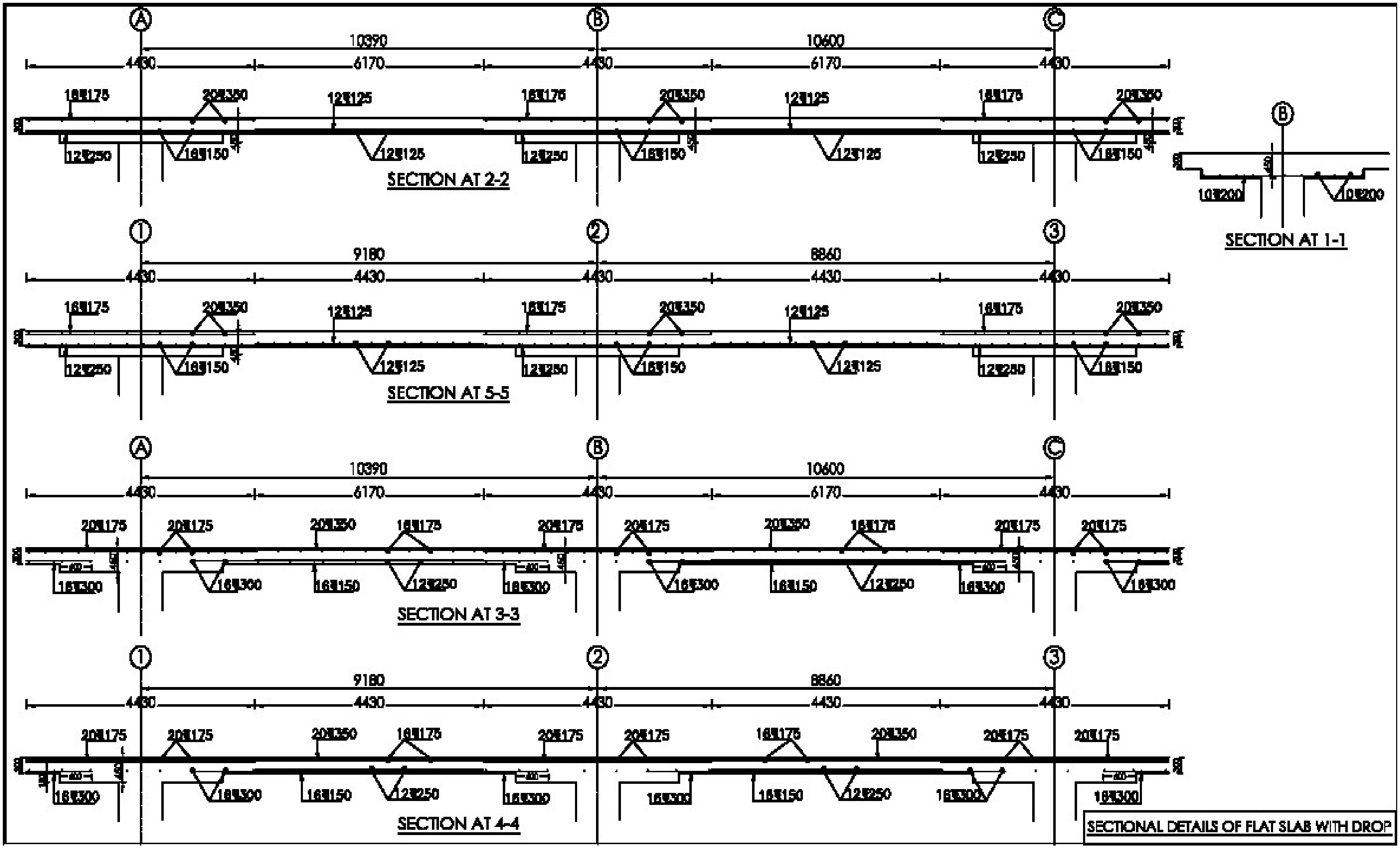


TYPICAL SECT. OF CAPITAL/DROP

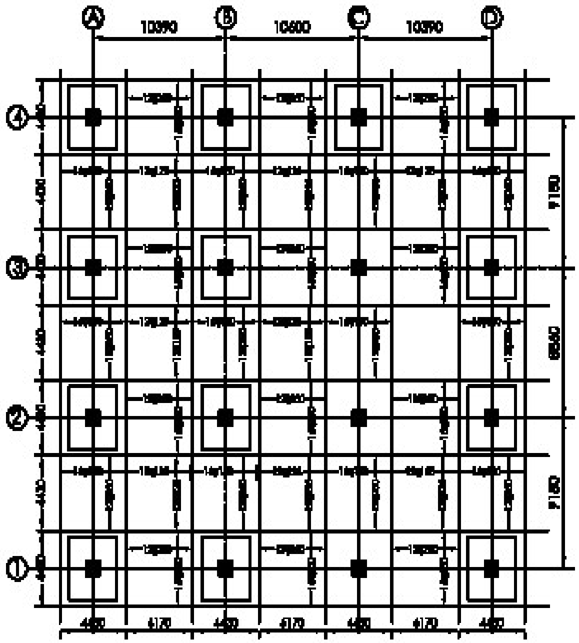


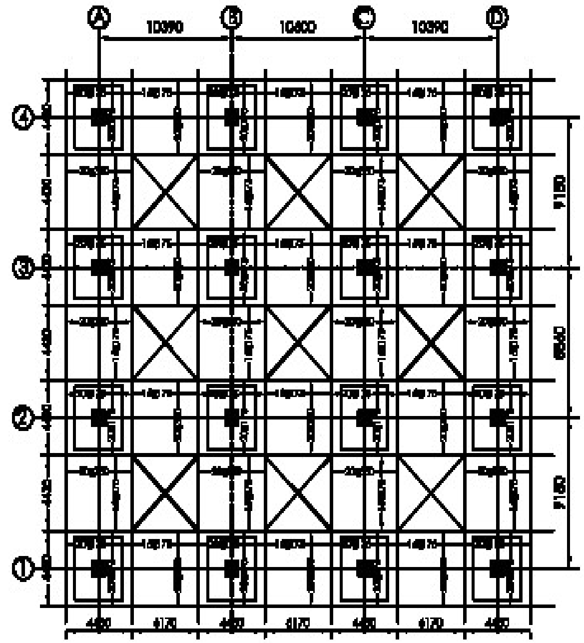
SECTION AT 1-1

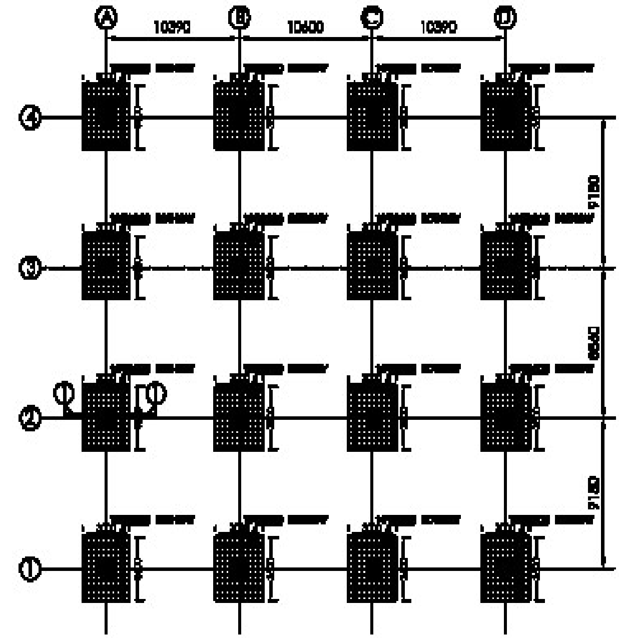
REINFORCEMENT DETAILS OF FLAT SLAB WITH DROP



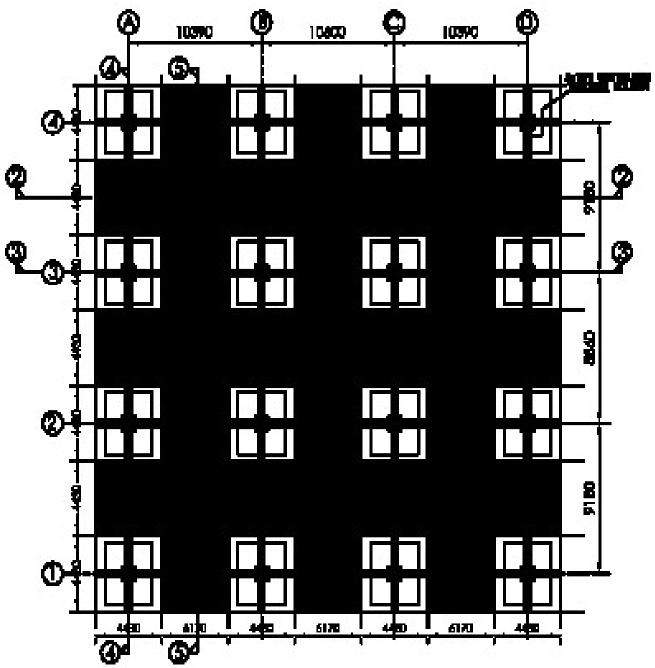
SECTIONAL DETAILS OF FLAT SLAB WITH DROP



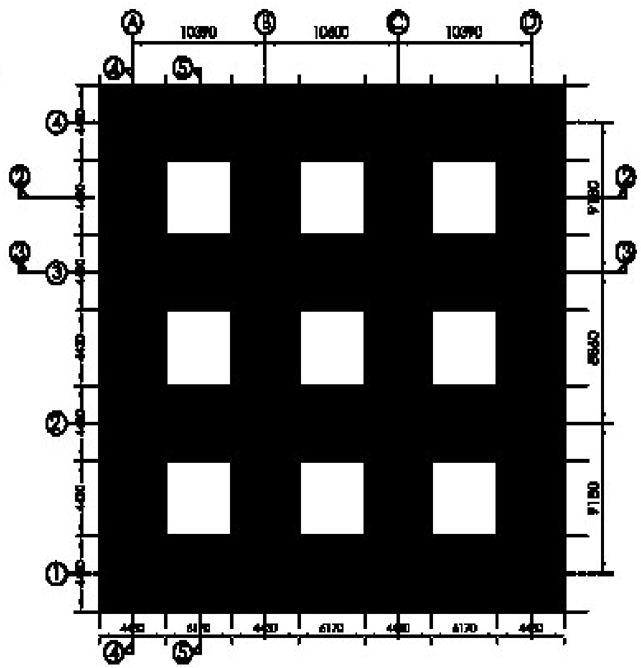




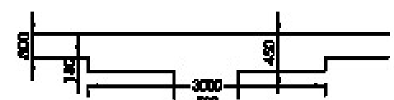
PLAN SHOWING BOTTOM R/F OF CAPITAL



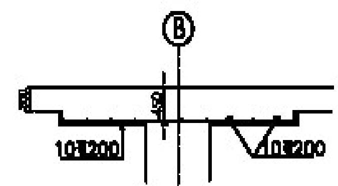
PART PLAN SHOWING BOTTOM R/F OF FLAT SLAB



PART PLAN SHOWING TOP R/F OF FLAT SLAB

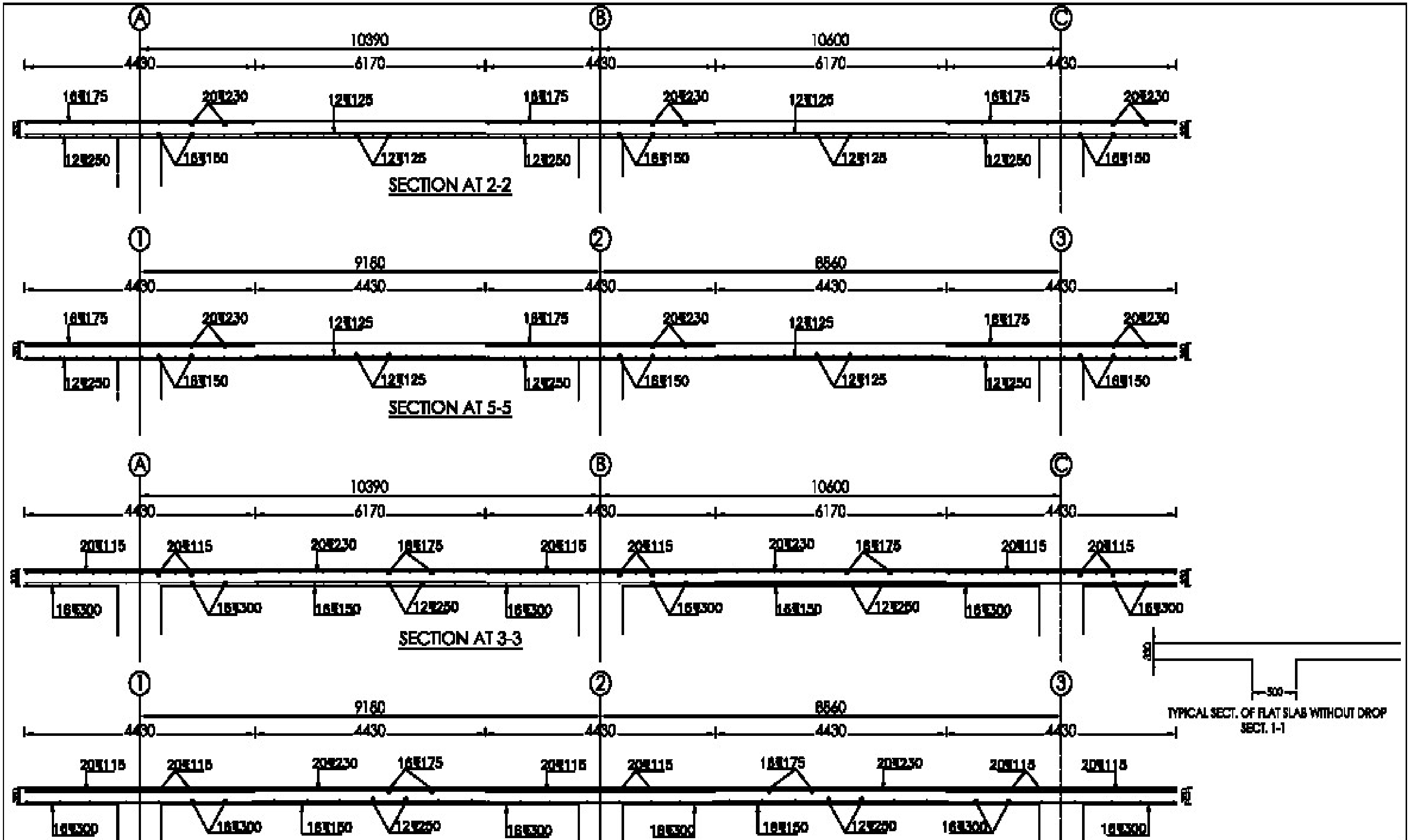


TYPICAL SECT. OF CAPITAL/DROP

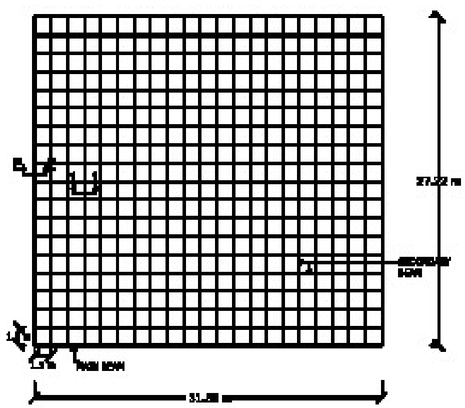


SECTION AT 1-1

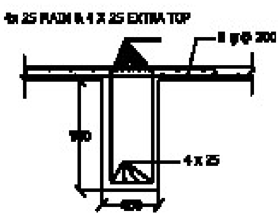
REINFORCEMENT DETAILS OF FLAT SLAB WITH DROP



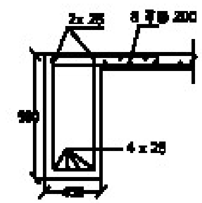
SECTIONAL DETAILS OF FLAT SLAB WITHOUT DROP



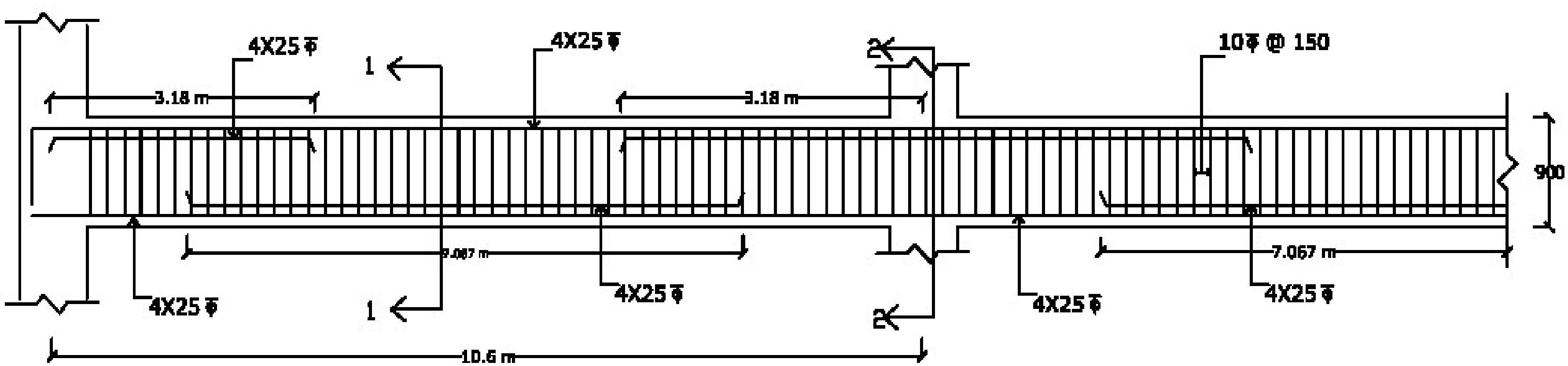
PLAN



c/s of Main beam(2-2) at mid span



c/s of Main beam(1-1) at mid span



DETAILING OF MAIN BEAM