Basic Infrastructure Study of Foundation & Column of Under Pass Crossing Structure at Phase-I Jaipur

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Abstract: ***Practical knowledge means the visualization of the knowledge, which we read in our books. For this, we perform experiments and get observations. Practical knowledge is very important in every field. One must be familiar with the problems related to that field so that he may solve them and become a successful person. After achieving the proper goal in life, an engineer has to enter in professional life. According to this life, he has to serve industry, may be public or private sector or self-own. For the efficient work in the field, he must be well aware of the practical knowledge as well as theoretical knowledge. To be a good engineer, one must be aware of the industrial environment and must know about management, working in the industry, labor problems etc. So he can tackle them successfully. Due to all the above reasons and to bridge the gap between theory and practical, our engineering curriculum provides a practical training. During this period, a student works in the industry and gets all types of experience and knowledge about the working and maintenance of various types of machinery and construction. The present study is based on the training under gone at filed about creation and execution of foundation and column of under pass crossing at phase-I Jaipur.***

Keywords: Pile foundation, Design criteria, Mix Design, Quality control, Laboratory experiments

1. Introduction

Every building consists of two basic components: the super structure and the substructure or foundations. The substructure or foundation is the lower portion of the building, usually located below ground level, which transmits the load of the super-structure to the sub-soil. The basic function of a foundation is to transmit the dead loads, super-imposed load (or live load) and wind loads from a building to the soil on which the building rests, in such a way that the settlements are within permissible limits, without causing cracks in the super-structure, and the soil should not fail.
If this settlement is slight and uniform throughout, no damage will be caused to the building. But if the settlement is excessive or unequal, serious damage may result in the form of cracked walls, distorted doors and window openings, cracked lintels, walls thrown out of plumb etc.

2. Function of Foundation

2.1 Foundation serves the following purposes

- Reduction of load intensity: - Foundation allocates the loads of the super-structure, to a larger area so that the intensity of the load at its base does not exceed the safe bearing capacity of the sub-soil. In the case of deep foundation, it transmits the super imposed loads to the sub-soil both through side friction as through end bearing.
- Even distribution of load:- Foundation distribute the non-uniform load of the super-structure evenly to be sub-soil.
- Provision of level surface: - Foundation provide leveled and head surface over which the super-structure can be built.
- Lateral stability: - It anchors the super-structure to the ground, thus informing lateral firmness to the super-structure. The stability of the building against sliding and overturning, due to horizontal forces is increased due to foundations.
- Safety against undermining: - It offers the structural safety in contradiction of undermining or scouring due to burrowing animals and flood water.
- Protection against soil movement:-special foundation measures prevent or minimize the distress in the super-structure, due to expansion of the sub soil because of moisture movement in some problematic soil.

2.2 Type of Foundation

Foundations may be broadly classified under two heads;-

2.2.1 Shallow foundations

- Spread footing
- Strap footing
- Combined footing
- Mat or raft foundation

2.2.2 Deep foundations:

- Column foundations
- Pile foundations
- Well foundations

2.3 Foundation used at the site

2.3.1 Pile foundation: Pile foundations are used to carry and transfer the load of the structure to the bearing ground located at some depth below ground surface. The main mechanisms of the foundation involve the pile cap and the piles. Piles transfer the load to deeper soil or rock of high bearing capacity. Piles can also be used in other applications such as pile-supported embankments, sound wall barriers, retaining walls, bulkheads, mooring structures, anchorage structures and cofferdams.

2.3.2 Function of piles

The functions of pile foundations are:

- To transmit a foundation load to a solid ground
- To resist vertical, lateral and uplift load

- A structure can be started on piles if the soil immediately underneath its base does not have adequate bearing capacity. If the results of site investigation show that the shallow soil is unbalanced and weak or if the magnitude of the estimated settlement is not acceptable a pile foundation may become considered.
- In the cases of heavy constructions, it is likely that the bearing capacity of the shallow soil will not be satisfactory, and the construction should be built on pile foundations.
- Piles can also be used in normal ground conditions to resist horizontal loads. Piles are a convenient method of foundation for works over water, such as jetties or bridge columns.

2.4 Classification of piles

Classification of pile on the basis of load transmission mechanism and functional behavior

- End bearing piles (point bearing piles)
- Friction piles (cohesion piles)
- Combination of friction and cohesion piles

3. Excavation for Foundation

3.1 Excavation- Foundation trenches shall be dug out to the exact width of the foundation concrete and the sides shall be vertical. If the soil is not stable and does not permit vertical sides, the sides should be sloped back or protected with timber shoring.

3.2 Finish and Trench- The foundation trench bottom trenches shall be perfectly leveled in both directions and the sides of the trench shall be dressed perfectly vertical from bottom up to least thickness of lose concrete may be laid to the exact width as per design. The foundation bed shall be tightly watered and well rammed. Soft or defective spots shall be dug out excess digging if any shall be filled with concrete.

3.4 Water in Foundation- Water if any accumulates in trench should be baled or pumped out.

3.5 Trench Filling- After the concrete has been laid and masonry has been constructed, the remaining portion of the trench shall be filled up with earth in layers of 51 cm and watered and well rammed.

3.6 Measurement- the measurement of the excavation shall be taken in cu m as for rectangular trench, bottom width of concrete multiplied by the vertical depth of the foundation from ground level and multiple by the length of the trench. At my project side it was part of river there that's why work of pumping out water caused by spring, tidal or river seepage, broken water mains or drains with use of power consuming water pump,

3.7 After this, a layer of plain cement concrete is spread on surface upon which footing is placed. The foundation shall be daily consolidation after watering till concrete is converted into a solid homogenous mass. In PCC (plain cement concrete) M-15 grade concrete by mechanical concrete mixer with 20mm nominal size aggregate used coarse aggregate to use should be hard, strong and durable free from clayey coatings and other deleterious materials.,

3.8 Curing of cement concrete should be done for a period of at least 10 days but new work over it can be started after 2 days of concreting only.

4. Pile Cap Design & Construction

4.1 Design

A geological survey must be passed out first to found the stability of the proposed site for the support cap. The cap thickness will be calculated by the load that it has to support and the number of piles used to allocate the load into the underlying soil. Other attentions, such as any limited loading that any part of the mat must support are taken into consideration. Some soil is so fluids in nature that screw shaped piles are used, these resist the propensity for the pile to sink under the added weight of the cap and the load placed upon it. Standard engineering practice is followed with regard to the square area of the cap, thickness, and its design loading. From a set of appropriate intentions the sizes will be determined and the quantity of concrete required calculated.

4.2 Construction

The mat is made of concrete of designated mix design. This mixture has to be supported by a framework to avoid sagging and breakage whilst setting. This process is known as shuttering and reinforcing. Once this steel mat is laid, timber is attached around the perimeter to contain the wet concrete mixture. Once poured the concrete is enthused to remove any air pockets that might deteriorate the structure when set. The concrete under goes a chemical change as it hardens and this produces a lot of heat.

4.3 Design of Pile Cap

Load on one pile= Axial column load /3=331.4 KN
Maximum bending moment in beam B_1= 331.4*1.73/3=382.66 KN
Maximum bending moment in beam B_2 =331.4*2.00/2=331.4 KN

Table 1: Design Output of a Pile Cap

b	mm	850	850
D	mm	900	900
Cover	mm	120	120
d	mm	780	780
M_u	N-mm	573990000	497100000
F_{ck}	N/mm^2	25	25
F_y	N/mm^2	415	415
Area of steel required	mm^2	2155.5	1851.9
Dia. Of bar chosen	mm^2	20	20
No. of bars required	Nos.	7	6
No. of bars provided	Nos.	10	8

4.4 Design of Pile

Load coming from the column (from one pier to pile cap), from design of column calculation, =846433.4 N
Providing a triangular pile cap
Pile diameter= 0.55 m
c/c distance of piles = 2.00 m

Projection of pile cap = 0.15 m
Assuming thickness of pile cap = 0.9 m
Self-weight of pile cap = 126600.75 N
Total load coming on pile cap = 846433.4+126600.75=973034.15 N
Load on each pile = 973034.15/3=325 KN
h= 1.732m

Table 2: Moment due to water, M_{wa}

Component	Pier= (hfl- bl) * width	Pile cap
Projected area(mm^2)	3.317 (5.24*0.633)	2.61 (2.9*0.9)
Pressure (N/mm^2)	2133.00 ($10*23.7*3^2$)	2133.00 ($10*23.7*3^2$)
force (N)	7075.16	5567.13
lever Arm (m)	1.746	0.45
Moment (N-m)	12353.23	2505.21
		14858.44

Table-3 Moment due to wind, M_w

SN	Component	Projected area(mm^2)	Pressure (N/mm^2)	force (N)	lever Arm (m)	Moment (N-m)
1.	Duct	19.775	1325.4	26209.8	7.35	192642.0
2.	Pier cap (rectangular)	0.35	1325.4	463.9	6.525	3026.9
3.	Pier cap (triangular)	0.45	1325.4	596.4	6.27	3739.4
4.	Pile cap	2.0	1325.4	2650.8	3.4	9012.0
						208421

M_{wa}=2*R*h/3+2*R*2*h/3 etc. =4Rh/3
R = 14858.44*3/(4*1.732)/1000=6.4 KN
Design load on pile = 325+6.4=331.4 KN
Thrust due to wind = R_w= 208421*3/(4*1.732)/1000=90.25 KN
Ratio= 90.25/331.4*100= 27.23 %

As the ratio is less than 33%, there is no need to provide extra provision for the wind effect.

5. Structural Design and Reinforcement of Column

As we know that concrete is weak in tension so we provide reinforcement to cater this problem. At my site bars of different diameter like 10, 12, 16, 20 mm was used for this purpose. Except these for bending purpose we used 18 gauge annealed wire. The laying and tying process is different for different structural member.
It is essential to restrict the spacing of both longitudinal and transverse reinforcement to ensure that the column does not fall prematurely due to buckling of bars and also to avoid local failures. Each of the longitudinal bars should be supported laterally in orthogonal directions, so that they are not displaced during concreting and do not buckle under applied loads later.

5.1 Longitudinal bars

- At the starting point of columns we provide these bars with anchorage length equal to development length with a bent at the bottom for better bond.
- Now these bars are tied with the help of transverse bars or we can say by the help of horizontal stirrups.
- Corner bar can be deemed to be restrained fully by the ties passing around them. a bar is also generally deemed to be restrained only if the bar is not more than 75 mm away from another fully restrained bar.
- If column dimension is <400mm only corner bars can be used. for column dimensions greater than 400mm more bars are desirable
- The spacing between bars should be adequate to ensure proper compaction of concrete but should not be greater than 300mm for effective load distribution among bars.
- The minimum cover to these bars is 40 mm.

5.2 Transverse reinforcement

Transverse reinforcement plays a significant role in preventing buckling failure of columns and prorogation of cracks hence should be adequately provided to restrain the longitudinal bars from buckling and confining the concrete.

- These bars are used to tie the longitudinal bars.
- Spacing should be minimum of following:
  < 16x dia. Of longitudinal bar
  < 48x dia. Of transverse bar
  < 300mm or smaller dimension of column
- The unsupported length of transverse ties should not exceed 48 times the dia of the transverse bar nor 300mm
- Where longitudinal bars are at spacing more than75mm, more than one tie in each plane will be necessary to provide adequate restraint to the longitudinal bars.
- In case of closed stirrups, the ends should be bent at about 135 degree; even though the code permits a 90 degree bend. A 90 degree bend may not ensure satisfactory behavior at ultimate load, since concrete cover may spill off in compression region due to high tensile force in stirrups, which tries to straighten the bend.
- Here spacing near the column- beam junction was decreased to 100mm due to earthquake consideration. This spacing is provided up till one third of the span.

5.3 Design of Column at Site

LWL=391.76 m
HFL= 397.00 m
BL = 391.76 m
Top of Deck Level Proposed Structure=399.74 m
F_{ck} =25 N/mm^2
Depth of water =HFL-LWL=5.24 m
K_1 =1
K_2 =1 (from IS 875)
K_3=1
V_b=47.00m/s
V_w, velocity of wind (47*1*1*1) = 47.00 m/s
Depth of beam= (D) =1300 mm.
Depth of pier cap= (D_p) =700 mm.
Top dimension of pier cap b_1=1.9 m
D_1 =1.4 m

Thickness of neoperion pad =50 mm
Top of the pile cap (from av. BL) =0 mm
Density of water, p =1000 kg/m^3

Velocity of water, v = 3.0 m/s
Shaper of pier, K=23.70
Span of beam, L =14.125 m
Height of column, $L^{`}$, =4.824m =5 m
Unsupported length of column, L_{us}=10.0m
Width of column, b =0.40 m
Depth of column, d=0.90 m
Pressure due to wind = $0.6*V_w^2$, P_w=1325.40 N/m^2
Force due to wind= $L*D*P_W=F_w$=28921 N
Pressure due to water =$P_{wa}=10*K*V^2$=2133 N/m^2
Force due to water=$F_{wa}=0.5*b*h*P_{wa}$=2240 N
$100*b^2/d$=17.78 m

CHECK (slenderness ratio) SAFE
As $L_{us}<100b^2/d$=>safe
Load from super structure W_s= 54867.85 N/m
P_1=775008.38 N
Moment due to wind =M_w=179201 N-m
Moment due to moving water 1/3 $*h*F_{wa}=M_{mwa}$=3920 N-m
Self-weight of pier
cap=P_2=(((1.9*1.4)+(0.4*0.9))*0.7*25000)/2=26425.00 N
Self-weight of column, P_3, 45000.00 N
Total load on column, $P=P_1+P_2+P_3$= 846433.4 N

Check for short & slender column

Multiplication factor for effective length according to the end condition=2.00
Effective length =10.0 m
Ratio L/b=10/0.4=25

Design the column as long column

Reduction factor for long column =C_r=1.25- L_{eff}/(48*b)= 0.729

Table 4: Reinforcement in the beams:-

Load combinations	D.L.+ Side water thrust	D.L.+ Side water thrust+ wind
b (in mm)	400	400
d (in mm)	900	900
$d^{`}$ (in mm)	50	50
$d^{`}$/D	0.06	0.06
F_{ck} (in N/sq. mm)	25	25
F_y (in N/sq. mm)	415	415
P (in N)	846433.4	846433.4
P_u (in N)	1269650.1	1015720.1
M (in N-mm)	3920000	182941000
M_u (in N-mm)	5880000	219529200
P_u / (F_{ck} *b*d)	0.14	0.11
M_u /(F_{ck} *b*d^2)	0.001	0.027
P / F_{ck}	0	0
p- %	0.8	0.8
p-provided-%	0.8	0.8
Dia. Of bar chosen (mm)	20	20
Area of steel required(mm^2)	2880	
No. of bars required	9.16	
No. of bars provided	10	
Lateral Ties		
Dia. Of bar selected (mm)	12	
Spacing provided (mm c/c)	175	

6. Beam Reinforcement

As the overlying loads were very high so the size and the reinforcement were quite high. First we saw the lining of beams being done. Then they start laying the main bars of beams. This is followed by placing of shear stirrups at proper spacing. Then they placed the top main bars and extra bars. The beam is often lifted by the help of a temporary staging so that all these operations are easily done. It is forced to its original position after the assembly is completed. If two beams are crossing then primary beam is inserted first followed by the secondary beams. Care should be taken to properly tie all the stirrups and beams reinforcement.

- The beam reinforcement can be provided in several layers, if number of bars required is more. However if the reinforcement is provided in more than one layer, it is extremely important to place the bars exactly one over another.
- However horizontal spacing should be large enough for course aggregate to pass through, this should be at least +5 mm more than maximum nominal size of aggregate.
- Side reinforcement- if depth of beam is greater than 750 mm, side reinforcement should be provided. The total area of such reinforcement should not be less than 0.1% of the web area and shall be equally distributed.
- Max spacing of shear reinforcement in no case should exceed 300 mm or 0.75d (here d is effective depth).
- If width of beam is greater than 500 mm and if beam is deeper than 1 m, it is desirable to provide four legged stirrups, instead of usual two legged stirrups. This ensures uniform distribution of compression stress and reduces the possibility of web splitting.

6.1 Beam column joint

It is essential to detail reinforcement at beam column joint so as to avoid congestion and to ensure proper concreting.

- It is preferable not to specify bent up bars for beam or slab reinforcement at such locations because of fabrication difficulties.
- The column dimensions usually match the web thickness in order to simplify shuttering.
- Beam reinforcement may have to crank in slightly to accommodate the
- column reinforcement

6.2 Design Criteria of Beam at Site:-

F_{ck} =25 N/mm^2
E_c =5700 $(F_{ck})^{1/2}$=25000 N/mm^2
F_y =415N/mm^2
D'= 50mm.
Unit weight of concrete =25 KN/mm^3
Density of waste water =10.5 KN/mm^3
Thickness of sewer pipe =0.050 m.
c/c of piers (supports) (L) =14.125 m.
c/c of beams (X)= 1.6 m.
Diameter of sewer =900 mm.
Width of beam =(B)=300 mm.
Depth of beam= (D)=1300 mm.
Clear width= X*1000-B= 1300 mm.

Thickness of precast slab= Dds=100 mm.
Depth of bottom supporting slab of duct Deff= D-D'= $D_{eff.}$=1250 mm.
Live load= 4500 N/mm^2
Self-weight of beams=300x1300x25x0.001x2+100x150x25x0.001x2= 20250N/m.
Dead load of precast slab=(1.6x1000)x100x25x0.001=4000 N/mm.
Dead load of bottom supporting slab=(1.6x1000-300)x150x25x0.001=4875N/mm.
Weight of waste water= $(3.143x(900/1000)^2x10.5x1000)/4$ =6682.80 N/mm.
Dead load from sewer pipe=$3.143x((900/1000)+2x0.05)^2$-$((900/1000)^2/4)$x25x1000 =3732.31 N/mm.
Weight of pipe railing=200N/mm.
Load of concrete launching in bottom half of duct= 6577.73 N/mm.
Live load (4500x (1900/1000)) = 8550 N/mm.

Total Load= 5467.85 N/Mm.

Load on one beam= (w)=54867.85/2= 27433.92N/mm.
Ultimate load from beam=P_u=1.5x27433.92=41150.88 N/mm.
Effective span=14.125m.
Total load= W=w x L=581256.18N
Maximum positive moment at mid span=1026280.44 N-m.
(Moment multiplication factor=0.125)
Maximum negative moment at support=513140.22 N-m.
(Moment multiplication factor= 0.062)
Maximum shear force at support= 290628 N

Table 5: Reinforcement in the beams

	At support	At mid span
Design bending moment(N-mm.)	513140220	1026280440
Design shear force (N)	290628	22590
$bxdxF_{ck}/0.87F_y^2$	25685136.22	51370272.45
A_{st} required (mm^2)	1200	2566
Dia. Of bars chosen (mm.)	20	20
No. of bars	5	10

Design for shear:-
Design shear strength = T_c= 0.55N/mm^2
T_c x b x d =206250 N
Nominal shear stress =T_v =0.77 N/mm^2
Provide shear reinforcement (V_{us})=V_u-T_c x b x d=84378 N
Diameter of two legged stirrup= 10 mm.
Spacing of stirrups =150 mm. c/c
(Provide spacing at support & at mid span)

Check for bond near simple support:-
Check-L_d <=1.3M1/V+ L_o
X_u= $0.87xF_yxA_{st}/(0.36xF_{ck}xb)$= 336mm.
M1=$0.87xF_yx A_{st} x(d-X_u)$= 829379706.6 N-mm.
V= S.F. =W_u x L/2=290628.09 N
L_d=$0.87xF_yx$**A**/ (4x T_{bd})
T_{bd}= 2.24 N/mm.^{2}
L_d = 806 mm.
L_o=L_s/2-X'=660 mm.
The code recommends that the bars should be extended from the face of the support by L_d/3= 269 mm.

No hook is required
Now, 1.3xM1/V + L_o= 4370 mm.

Side Face Reinforcement:
0.1% of b x d =390 mm^2
Choosing diameter of bar =10 mm.
Total no. of bars required for both sides =4.97
Provided on each side =3
Spacing $_{provided}$ =288 mm c/c

Check for Deflection:
I_{xx} =$bD^3/12$ =$5.49x10^{10}$ mm^4
Maximum Deflection =$5P_0L^4/384E_cI_{xx}$ =13.6 mm.
Permissible Deflection =L/250 =57 mm. (SAFE)

Design of Slab:
Slab is supported on the inverted beams & restrained at the ends
U.D.L. per meter =w= 9000 N/mm^2
Point load per meter =W=10415.12 N/m
(6682.80+3732.31)
Moment at the center (M)=5286.16 N-m.
M=$wL^2/(8+WxL/4)$
M_u =$7.93x10^6$ N-mm.

Table 6: Reinforcement in the slab

ITEM	AT SUPPORT
Design Bending Moment(N-mm.)	7929244
Design Shear Force (N)	11057.5
$bxdxF_{ck}/(F_y)$	11750
$M_uxbxF_{ck}/(0.87F_y^2)$	1719886
A_{st} required (mm^2)	180.1
Min. A_{st} required (mm^2)	344
Dia. Of Bar Choosen(mm.)	10
Spacing c/c (mm.)	200

6.3 Some important measures at site:

- Beam reinforcement may be lowered only after providing cover block
- Column reinforcement should be in plumb.
- In case of slab reinforcement the depth of chairs should be decided properly in the absence of which the slab reinforcement may sink or protrude from the concreting.
- Slab reinforcement is laid in exactly same manner as the beams but here the accuracy in levels kept higher than that in raft beams.
- One chair is provided for every one square meter of area.

7. Concrete Mix Design

7.1 Factors to be considered for mix design

- The grade designation giving the characteristic strength requirement of concrete.
- The type of cement influences the rate of development of compressive strength of concrete.
- Maximum nominal size of aggregates to be used in concrete may be as large as possible within the limits prescribed by IS 456:2000.

- The cement content is to be limited from shrinkage, cracking and creep.
- The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

Table 7: Mix Proportion of M-25

Details Of Concrete Mix For 1 Cum			
GRADE	1:04:08	1:02:04	M-25/380 (Structure)
W/C	0.90	0.63	0.45
Cement	170.00	320.00	380.00
20 MM	842.00	782.00	695.00
10 MM	561.00	521.00	463.00
SAND	737.00	684.00	675.00
WATER	153.00	202.00	171.00
Admixture	1:04:08	2.24	3.80
TOTAL WT.	2463.00	2511.24	2387.80

8. Quality Control Concrete

Quality Control Concrete is generally produced in batches at the side with the locally available materials of variable characteristics. It is, therefore, likely to vary from one batch to another. The scale of this difference depends upon several factors, such as variation in the quality of component materials, variation in mix proportions due to batching process, difference in the quality of batching and socializing apparatus available, the quality of overall workmanship and supervision at the site. More ever, concrete undergoes a number of operations, such as transportation, placing, compaction and curing. During this operations considerable variations occur partly due to quality of plant available and partly due to differences in the efficiency of techniques used. Thus there are no sole qualities to define the quality of concrete in its entirety. Under such situation concrete is generally referred to being as good, fair or poor quality. It is, consequently, essential to define the quality in terms of desired performance characteristics, economics, aesthetics, safety and other factors. Due to large number of variables influencing the performance of concrete, quality control is an involved task.

Therefore, the goal of quality control is to decrease the above variations and produce uniform material providing the characteristics desirable for the job envisaged. Thus quality control is a corporate, dynamic programmer to assure that all aspects of materials, equipment and workmanship are all well looked after.

8.1 Quality Control at Site

A Material Testing lab has been established at the site which helps in strictly controlling the quality of building materials to be used. The lab has the facility for conducting many tests and the registers regarding the tests are maintained.

Material Testing is an essential part in the execution of the construction work because the quality of material used should match with those specified in the IS code.

8.2 Shuttering sand Form Work

It is a sort of temporary construction in wood or steel, erected to give the concrete its desired shape. Shuttering is used as a mould for the construction, in which concrete is placed and in which it hardens and matures. It should be strong enough to carry the weight of wet concrete, impact due to consolidation and the load of workman, without deflection. The process of removing the formwork is known as Stripping. The shuttering used at site was of combined wood and steel type. The shuttering were designed and manufactured by the company itself so as to suit the design of construction. The prop used were made up of steel and of adjustable type.

8.3 Purpose of Formwork

- Supporting structure for reinforcement
- Staging for conveying of manpower and material.

8.4 L&T Formwork System

- L&T FORMWORK systems are easy to understand from Traditional Workmen flexible and simple to assemble requiring very little working skill.
- Uniformly good quality of finish is achieved due to the manufacture of the various components under strict quality control and their dimensional stability. The recommended sheathing is plywood which delivers high quality surface finish eliminating the need for plastering.
- Components are few, versatile and interchangeable for all major applications. The system gives high labor and material productivity and hence investment need be made on the minimum quantity of formwork items.

8.5 Wall Formwork System

The plywood covering is supported by H-Beams which are in turn reinforced by the steel whalers. The wall formwork facilitates fixing platforms for access, checking of reinforcement; concreting etc. The panels also have facility for fixing for arrangement system which ensures verticality. The pressure due to concrete is sustained by high strength tie system.

The walers are available in sizes of 0.8m, 1.2m, 1.6m, 1.8m, 2m &2.4m the inside corners are formed by “universal inside corners” by universal outside fixing or angle plates. The high strength tie system can be through tie system or lost anchor system dependent on the structure. The formwork panel along with the working platform and alignment systems can be lifted as a single unit using a crane thus the labor involved in each operation of erection and de-shuttering is reduced to a minimum.

9. Column Formwork System

The column formwork facilitates fixing working platforms for access, checking of reinforcement, concreting etc. The formwork panel along with the working platform and alignment system can be lifted as a single unit using a crane thus the labor involved in each operation of erection and de-shuttering is reduced to a minimum.

9.1 Components

- Ledgers (horizontal member)
- Standards (vertical member)
- Base jack
- Steel props
- Drop head
- Primary beam
- Secondary beam
- Semi- dandified ply
- Wooden battens

9.2 Beam Formwork

The L&T Beam Forming Support system is suitable for RC-Beam odd depth between 30 cm to 110 cm.

9.3 Beam Bottom

The plywood sheathing is supported by a secondary H-20 Beams at the designed spacing to form the beam.

9.4 Beam Sides

The plywood sheathing is supported by H-beams at the designed spacing running along the length of the RC beam to form the sides. The BFS ext. provides the necessary adjustment in depth.

The beam forming supports with extension are available in three sizes viz. BFS with extn.600, 900 & 1200 mm long.

The system is very well adapted for use along with the L&T flex & heavy duty tower system.

10. Equipment at Site

10.1 Concrete Pumping Equipment:

For high volume works, concrete is now a days pumped using a wide variety of concrete pumps. These can handle all kinds of mixes and can pump up to 100 m3/hr, and the distances can be anywhere from 50m to 600m horizontally, and 20m to 125m vertically. These pumps may be mounted on trucks or trailers.

These pumps are of three types:-

- Piston type
- Pneumatic type
- Squeeze type, named after the method being used to force the concrete through the delivery line.

The delivery line is properly rested on chairs, avoiding sharp bends to maintain a smooth flow.

It has to be ensured that no concrete should be left in the pipe after the completion of work. This is usually done by forcing a solid foam ball through the entire delivery line, which wipes off any remaining concrete.

10.2 Bar Bending Equipment

It is used for bending of reinforcement bars in any desired shape. Due to this the speed & quality of work increases and man power requirement reduces.

10.3 Bar Cutting Equipment

It is used for cutting reinforcement bars of desired length.

10.4 Concrete Vibrators:

In order to eliminate the air bubbles from the concrete it is to be properly compacted. This can be done either manually or mechanically. At our site mechanical vibrators in the form of needle vibrators were used. These are internal vibrators consisting of an electrically operated metal rod, like vibrating head which is immersed in the full depth of the concrete layer. It is kept in one position by removing and placing again.

These vibrators can be used even for the sections which are as thin as 3 inches, and its needle like shape facilitates easy penetration through any type of reinforcement.

10.5 Curing of concrete

Curing is one of the most prime important stage in concrete construction in view of the strength and durability aspects.

After concrete is placed, a satisfactory moisture contents and temperature (between 50º F and 75º F) must be preserved, process called curing. Adequate curing is energetic to quality concrete. Curing has a strong influence on the properties of hardened concrete such as durability, strength, water tightness, abrasion resistance, volume stability and resistance to freezing and thawing and deicer salts. Unprotected slab surfaces are especially sensitive to curing. Surface strength development can be reduced suggestively when curing is defective.

Curing the concrete aids the chemical response called hydration. Most freshly mixed concrete contains significantly more water than is required for complete hydration of the cement; however, any considerable loss of water by evaporation or by otherwise will delay or prevent the hydration. If temperature is favorable, hydration is comparatively rapid the first few days after concrete.

References

[1] Testing Method: Sieve Analysis (Dry Sieving) - IS: 2386 (Part 1)-1963
[2] Testing Method: Strength of Cement Concrete- IS: 4031-1968
[3] Testing Method: Grain Size Analysis (Wet Sieving Method)- IS : 2386 (Part 1)-1963

[4] Testing Method: Aggregate Impact Value- IS: 2386 (Part 4)-1963
[5] Testing Method: Aggregates for concrete -S.G. (Pycnometer Method) - IS: 2386 (Part 3)-1963
[6] Testing Method: Ten % fine value- IS: 2386 (Part 4)-1963
[7] Testing Method: Bulk density of Sand- IS: 2386 -1963
[8] Testing Method: Silt content- CPWD Specification
[9] Testing Method: Cement Initial and Final Setting Time- IS: 4031-1968
[10] Testing Method: Determination of Soundness test- IS: 4031-1968
[11] Testing Method: Fineness (By dry sieving) - IS: 4031-1968
[12] Testing Method: Strength of Cement- IS: 4031-1968
[13] Testing Method: Slump test- IS: 1199
[14] Testing Method: Tensile Strength of Steel- CPWD Specification.