SAFETY IN FORMWORK AND CENTERING

Loads when imposed do not disappear but are transferred till they reach a point where an equal and opposite reaction occurs. In case of design of permanent structure in Civil Engineering due care is taken to design the structure lasts for longer period. In case of Formwork / Centering / Scaffolding being temporary structure having life at one time:

a) 24 hours for walls / columns (vertical shuttering)
b) 7 to 28 days for slabs and beams and upto 6 months to one year for scaffolding. It is left to the workers or their foreman to erect the structure based on their experience rather than any structural design.

Though elaborate structural design are not required in case of centering, basic knowledge of structures is definitely required while giving proper guidance to the carpenters for erecting the formwork / centering / scaffolding.

CENTERING: Centering can be divided into parts:

- **Vertical shores consisting of:**

a) Timber Props or Bullies
b) Tubular Props in case of buildings
c) Tubular scaffolding to be used as centering for Slab beyond 6-mt height.
d) Trusses: in case of bridges or heavy structures

- All the verticals should be erected on the firm ground properly rammed. Care should be taken to see that when verticals erected on surface where PCC is not done or outside the building supporting the chajja.

- All the verticals should be plumb.

- Verticals should be braced in both direction (X & Y) to reduce the unrestrained length of the verticals thus increasing load carrying capacity to the desired value.

- In case of multi tier supporting system tubular props should be erected one above the other in one line to ensure that the load transfer is axial and no horizontal member goes into the bending.

- **Timber Props or Bullies:** In case of timber Props or Bullies, the bullies should be straight with minimum dimension of 3 inches at the top. The bullies should rest on timber base plates and should be properly nailed at the top and bottom to remain in plumb. Care should be taken to see on the casting day that the wedges are not removed by women working on site earlier evening to be used as firewood. As the prop are not nailed at the top. Props keep hanging without transferring the load to the ground which may result in failure.

- **Steel Props:** In case of steel props the props should be braced in one direction minimum when extended beyond 3.5 mt so that they remain plumb. The bracing with pipes and couplers should be done to reduce the unrestrained length to get the desired load carrying capacity. Reinforcement used with binding wire do not offer desired restraint. Props pin 14/16 mm dia should be used for the adjustment. 6/8 mm reinforcement bar (TOR) **should not be used**.

- **Tubular Scaffolding:** Tubular scaffolding as a centering for higher heights is the best solution. However care should be taken to see that – all the bracing is present at 2m/2.4m (designed level).
  In Scaffolding only verticals are to be loaded using adjustable U Heads. No horizontal member of the scaffolding should be loaded as horizontal member has only maximum 10% load carrying capacity compared to that of verticals of H frames.

- **Trestles:** In case of trestles there is always a load concentration to the tune of 20 Tons per Tressel in the plan. Hence Tressel should be erected on concrete block properly designed. Trestles as far as possible should not be erected where there is a possibility of river flowing through tressel area in monsoon season or due to release of water from the dam. In such case proper coffer dams are to be be constructed before the erection of tressels. It is suggested that instead of using Wedges for D shuttering, U jacks should be used and get the shuttering lowering slowly in systematic manner.

- **Horizontals:** In building construction timber runners are used to support beam bottom / shuttering plates. The spacing of props below the runner are decided by considering the horizontal member as simply supported / continuous beam. The table can be used as a ready reckoner:

Steel Tubular

Spans		Central Point Load		Uniformly Distributed Load	
M	**ft**	**Kg/m^2**	**Lb/ft^2**	**Kg/m^2**	**Lb/ft^2**
1.2	4	290	640	580	1280
1.5	5	227	500	453	1000
1.8	6	181	400	362	800
2.1	7	163	360	327	720
2.4	8	136	300	272	600
2.7	9	127	280	254	560

Steel Tubular Verticals

Lift Height		Axial Load	
M	**ft**	**Kg**	**Tons**
1.2	4	4268	4.2
1.5	5	3556	3.5
1.8	6	2844	2.8
2.1	7	2336	2.3
2.4	8	1828	1.8
2.7	9	1524	1.5

- **Telescopic Span:** The lattice of span is designed as tension members. Hence no intermediate support should be provided which will induce compression in bars (Lattice) and may result in failure. Hence spans should be supported only at the ends. Manufacturers design data should be considered for spacing of the spans.

- **Scaffolding:**
  a. Scaffolding should be erected on the firm ground properly rammed.
  b. All the verticals of the scaffolding should be in the plumb
  c. Scaffolding should be tied to the building properly as per site conditions.

- **Scaffolding Materials:**

  Bamboo & Rope: It is very difficult to analyse the details of bamboo scaffolding and it is left totally to the experienced scaffolders to tie and erect the scaffolding.

  Pipes and Couplers: To erect safe scaffolding with pipes and couplers, the following guidelines are followed –
  a. Pipes used 40mm NB 'C' Class
  b. Couplers having slip (friction upto 1.2 Tons)
  c. Couplers should stand Torsion upto 1.5 Tons
  d. Joint Pins with minimum 75mm bearing on either side should be used transfer the load axially, when used for extending the pipe vertically / horizontally.
  e. For all 90^{o} joints, fixed / double couples should be used.
  f. Swivel couplers should be used only for diagonal bracing.

- **Frame Scaffolding:** Frame scaffolding reduces number of loose parts and there is built in safety when loaded vertically. Enclosed herewith a table, which gives horizontal and vertical loading for tubular scaffolding. Generally the accidents occur in frame scaffolding due to excessive wind load. Hence a permeable such as Hesian cloth or net should be used for covering the scaffolding. The supporting to the building should be done on an average coving an area of 400 to 500 sq. ft. per support. Maximum allowable pull on each scaffolding should not

exceed 500 Kg. When Anchors with pipes are used the link of anchor bolts should be considered after removing the plaster is L = Concrete cover + 50 mm.

- **Specification for H frame scaffolding:**
  - Height of each Frame
  - Width of each Frame
  - Built in arrangement to have platform levels
  - Maximum 0.7 m at centres
  - (H-Frames) placed one above other having
    a. Socket joint with min, 75 mm overlap on lower frame with locking bolt
    b. Spigot joint with min. 100mm overlap on upper frame with locking bolt
    c. Spacing between frames (2m for 40 mm thick plank)
    2.45m for M.S.Steel Plank with load carrying capacity 250 kg/m^2.

- **Specification:**

Sr. no.	Description	Verticals	Horizontals	Ladder & Divider	Socket	Spigot	Pin size & length	Bracing
1.	Upto 100' ft	Min. 2.8 m	2.5 m	2 m	50 mm NB 'B' Class pipe	38 x 3 mm	12 dia x 40 mm	Pipe 2600 x 2.25 mm
2.	Upto 250' ft	Min. 3.15 m	2.8 m	2.5 m	50 mm NB 'B' Class pipe	38 x 3 mm	16 dia x 40 mm	Pipe 3300 x 2.5 mm
3.	Above 250' ft	Min. 3.65 m	2.8 m	2.5 mm	50 mm NB 'B' Class pipe	38 x 3 mm	16 dia x 40 mm	Pipe 3300 x 3.5 mm

- **Connection to Building:**

a) Stubs & Anchor Fasteners:
Maximum Area per stub = 30m^2
Length of Anchor Bolts 12.5 mm dia after removal of plasters
= concrete cover + 75 mm
No. of Anchor Fasteners per stub = 2

b) Props: Props to be tightened between floors and nailed on top and bottom plate to the upper and lower slab. Connection point should be as near to the upper & lower slab. Connection point should be as near to the base / top plate as permissible.
Maximum Area per Prop 25m^2.

c) Cantilever Brackets: Cantilever Brackets upto 1m will be connected to Scaffolding verticals where Scaffolding is erected away from the Building due to

Chhajjas or any other obstruction. These will be made of 40/B Pipe / Angle 40 x 40 x 5 mm with 2.5 couplers welded to vertical.

d) Scaffolding:

Scaffolding will be erected on the firm ground of known load bearing capacity fixed base plates will have spigot 75 mm long welded to MS Plate 150 x 150 x 6 mm.

Maximum Load Base Plate = 3 T

e) Adjustable Base: Wherever ground is not even / sloping, adjustable base are used.

Vertical: 32 mm dia bright bar 400 mm long with square / acre threads and malleable / MS nut of minimum thickness 62 mm and 32 mm deep (nut length).

f) Platforms: Platform plank of 2700 x 300 mm size should have main fram made from minimum Angle 37 x 37 x 3 mm with flat 25 x 5 mm making grinds or rectangular pipe 40 x 40 x 2.5 mm as with 20 x 20 x 2 mm pipe as grinds. Planks should have rigid arrangement of connection to the H frame horizontal.

g) Staircase: Inspection staircase will be made of staircase couplers and pipes erected on standard frames with 45^{o} slope.

Tread = 250 mm, Riser 200 to 240 mm.

Size of Timber Runner	**Spacing of Props Below Runner / Planks**							
	12”	**15”**	**18”**	**24”**	**30”**	**36”**	**48”**	
3” x 2”	2400	1920	1600	1200	960	800	660	Load carrying capacity for given spacings lbs/ft^2
3” x 3”	3600	2880	3110	1800	1440	1200	900	
4” x 3”	6400	5100	4250	3200	2550	2100	1600	
6” x 3”	14400	11520	9600	7200	5760	4800	3960	
9” x 1”	1200	960	800	600	480	400	300	
9”x 1½”	2700	2160	1800	1350	1080	900	675	
9” x 2”	2400	1920	1600	1200	960	800	660	

Assumptions: Dead Load – 2500 Kg/m^3 (150 lbs/sq.ft.)

Live Load – 250 Kg/m^2 (50 lbs/sq.ft.)

Self Weight Formwork & Centering – 50 Kg/sq.m (10 lbs/sq.ft)

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