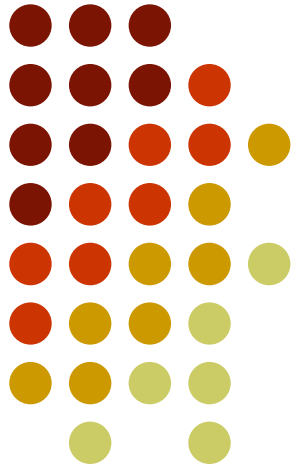
Plain & Reinforced Concrete-1

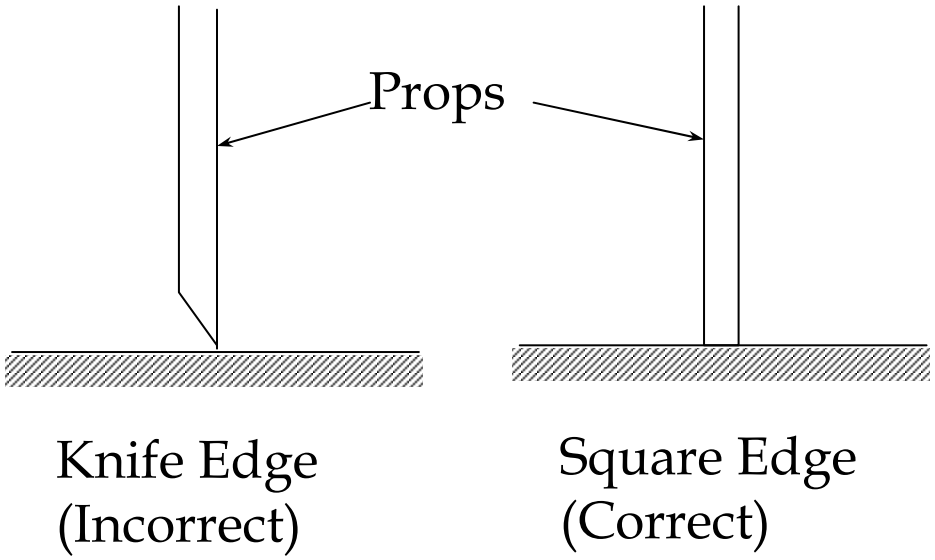
CE-314

DESIGN OF FORMWORK



PROPPING AND CENTERING

- Prop is a strut which is light enough to be man-handled.
- When adjustable it is known as an adjustable prop.
- The term centering is used to transfer the load vertically to the base.
- The props used for centering may be of steel pipes, timber posts or pillars made up of brick masonry in mud plaster.
- Wooden props should rest without knife edge (see Fig. 5.12) on wooden sole plates laid either on ground or on brick masonry pillars in mud plaster.
- The wooden plate should have an area of at least 0.1 m^2 and it should be at least 40 mm in thickness.
- Double wedges are essentially provided between the sole plates and the props to permit accurate adjustment of the shuttering.



- Adjustable steel prop is made up of two tubular sections such that one slides by rotation into the other.
- One end of each tubular section has a 150 mm square base or head.
- The rotation of inner tube is carried out by a collar and nut operated by a hinged lever. Steel props are available in length range of 1 to 5 m.

- The props / standards should be braced against buckling by providing horizontal and diagonal bracing in two perpendicular planes.
- The vertical interval of this bracing is kept approximately equal to 1.6 m.
- Pipes with 8 gage wall thickness (4 mm) and 50 mm outer diameter may resist the following safe loads:

  Tubes braced vertically at 1.8 m: 2780 kgs

  Tubes braced vertically at 2.1 m: 2200 kgs

For 45 mm outside diameter and 2.5 mm wall thickness, effective length factor equal to 1.0 and using factor of safety of 1.6 to convert factored capacities to service load carrying capacity along with further FOS of 1.5 for eccentric loading, the load capacity is given below:

Unbraced Length (m)	Slenderness Ratio	Load Capacity (kgs)
1.2	80	2100
1.5	100	1770
1.8	120	1400

Similarly, for 50 mm outside diameter and 3 mm wall thickness, effective length factor equal to 1.0 and using factor of safety of 1.6 to convert factored capacities to service load carrying capacity along with further FOS of 1.5 for eccentric loading, the load capacity is given below:

Unbraced Length (m)	Slenderness Ratio	Load Capacity (kgs)
1.5	80	3210
1.8	96	2760
2.0	107	2450
2.2	117	2180

- Double couplers are the fixing components used to join steel tubular scaffolding at any angle in space (Fig. 5.13).
- These transfer load from one pipe to the other by friction between the grip of the coupler and the outside surface of the pipe.
- The capacity of each coupler should be estimated and more than one couplers must be used if the applied loads are larger.
- The friction capacity of 45 mm diameter pipe coupler is about 475 kgs and that of 50 mm diameter pipe is about 600 kgs.

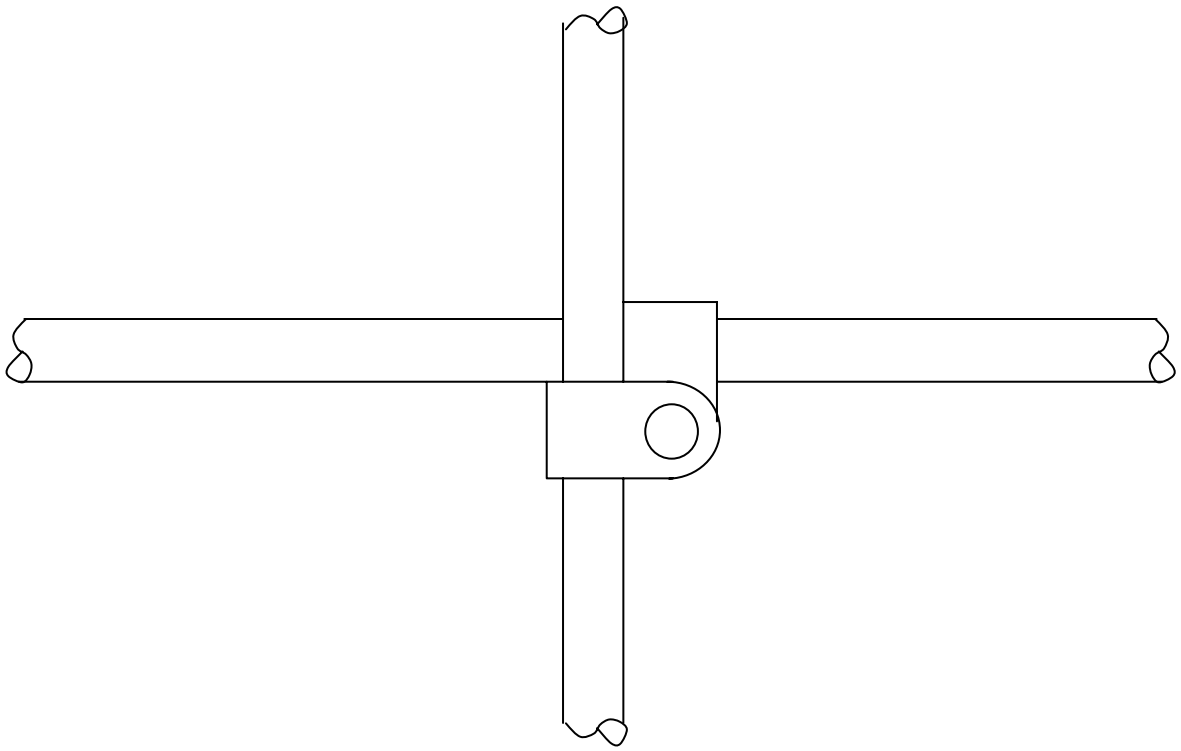
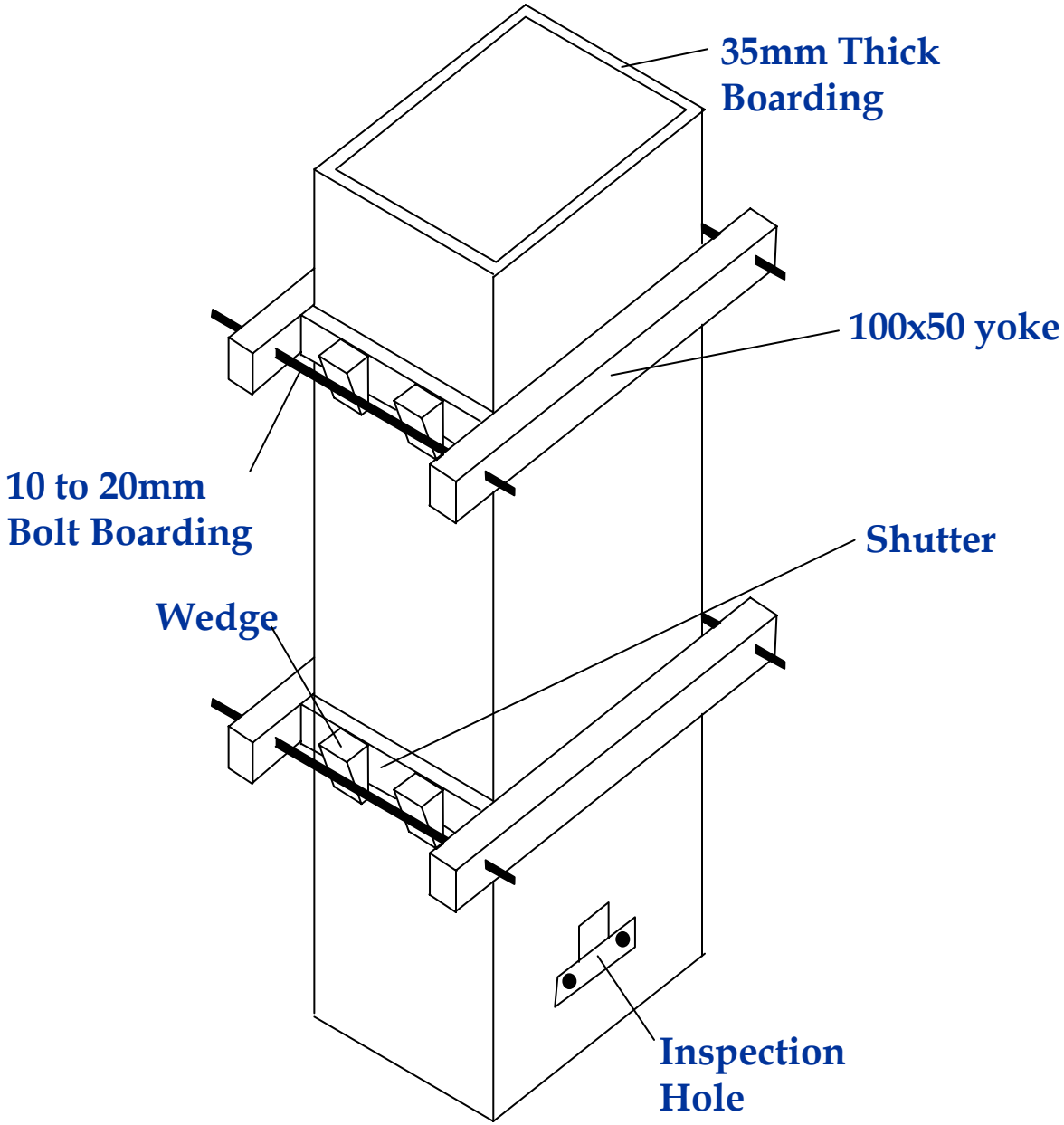


Fig. 5.13. Sketch of a Double Coupler.

WOODEN COLUMN FORMWORK

- A typical wooden column formwork consists of 35 mm thick boarding (Fig. 15.14).
- This column lining is supported at interval with rings formed by yolks and ties.
- Two opposite sides of the lining are held together by yokes and the other two sides are kept in position by hardwood wedges and shutters between the ties / bolts and the form.


35mm Thick
Boarding
100x50 yoke
10 to 20mm
Bolt Boarding
Shutter
Wedge
Inspection
Hole

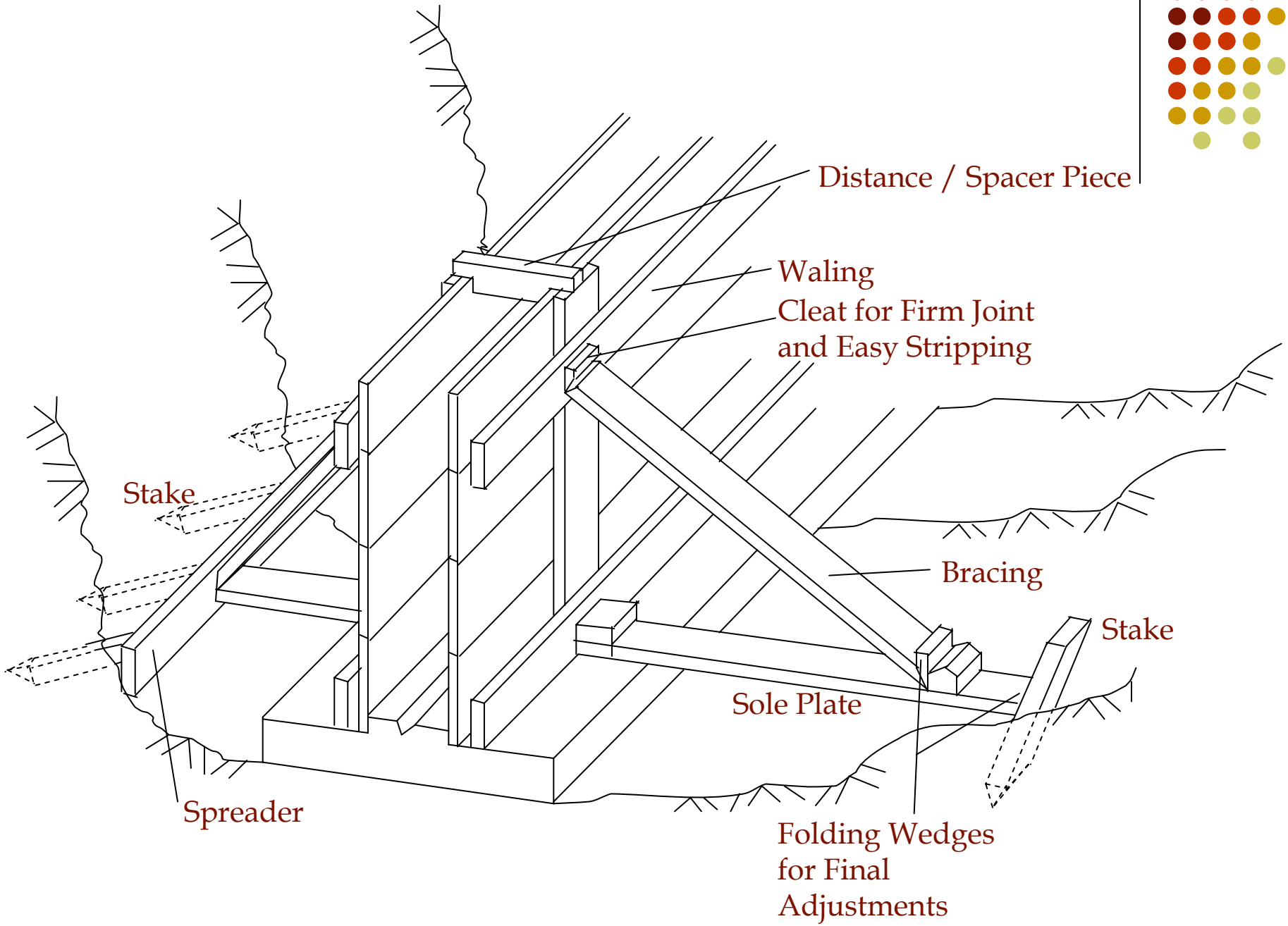
- The sheathing consists of panels in the vertical direction and holes are provided at interval to place and inspect the concrete. Sometimes, one side of the form is made up of removable panels of 1m height to place concrete from the sides.
- However, it is not easy to place concrete from the side if the reinforcement is congested.
- Provision is made in the form at the head to link up with the formwork for the horizontal beams.

- **Access door** is a removable panel in the formwork for a high lift to give access for inspection or for placing and compacting concrete.
- **Check out** is a piece of wood or other material fixed to the face of the form to get a recess in the concrete.
- **Column box** means the assembled forms for a column.
- **Yoke** is a tie or clamping device around column forms or over the top of wall or footing forms to keep them from spreading because of the lateral pressure of fresh concrete.

WOODEN WALL FORMWORK

- A typical wooden wall formwork is shown in Fig. 15.15.
- The formwork may be supported on ground having level approximately equal to the foundation (on right side of the figure) or on sides of an approximately vertical cut (on left side of the figure).
- Various terms used in the wall formwork are defined next.

  Brace is a member used to strengthen another member by reducing its effective length and hence the chances of its buckling.


Distance / Spacer Piece
Waling
Cleat for Firm Joint
and Easy Stripping
Stake
Bracing
Stake
Sole Plate
Spreader
Folding Wedges
for Final
Adjustments

- The term **cleat** is used for a small wooden board used to connect formwork members or used to act as a brace.
- **Cross-joint** is defined as the joint at the end of individual pieces between battens or other supporting members.
- **Distance piece** is a short piece of timber or other material used to hold parallel forms for walls or beams at the correct spacing.
- It also provides rigidity to the cantilever edges of the form lining.
- The device used to secure formwork to previously placed concrete of adequate strength is called **form anchor**; which is normally embedded in the concrete during placement.

- **Form lining** is the provision of treatment / sheathing used to line the concrete face of formwork in order to impart a smooth surface and to prevent escape of moisture from the concrete.
- **Grout seal** is a method used for sealing joints in forms to prevent grout loss. This usually consists of a strip of compressive material inserted in the joints.
- **Kicker** is a small concrete platform cast above floor level to position wall or column forms for the next lift and to assist the prevention of grout loss.

- **Mud sill** is a sill which is in direct contact with the ground.
- A section of form sheathing, constructed from boards, plywood, metal sheets, etc., that can be erected and stripped as a unit is referred to as a **panel**.
- **Plate, sheeting, sheathing** is a flat, horizontal member at the top or bottom or both of studs or posts.
- **Snap tie** is a special type of concrete wall-form tie, the end of which can be twisted or snapped off after the forms have been removed.
- **Sole plate** means a horizontal plate resting on ground to distribute the load from shores or inclined braces.

- **Stake** is a wooden piece pointed at one end that is driven into the ground to provide restraint to other members. It restrains the movement of spreader against the vertical cut in soil.
- **Spreader** is a piece of wood used to distribute the load coming from the formwork to the vertical or inclined face of soil.
- **Stud / strut** is a **v**ertical member of appropriate size (50×100 to 100×250 mm) and spacing (400 to 750 mm) to support sheathing of concrete forms.
- **Tieback / tie rod** is a rod fastened to a rigid foundation, a rock or soil anchor to prevent lateral movement of formwork, sheet pile walls, retaining walls, bulkheads, etc.

- **Wale, waling, waler or ranger** is a long horizontal formwork member (usually double) used to hold studs in place.
- **Wall form** means a form constructed to give the necessary shape, support and finish to a concrete wall.
- **Wedge / folding wedges** are piece / pieces of wood or metal tapering to a thin edge, used to adjust elevation or tighten formwork.

  Folding wedges consist of a pair of wedges to maintain a flat top surface while adjusting the elevation.

LOADS ON FLAT SLAB FORMS

- Dead load of the concrete and the reinforcing steel resting on the forms is usually taken as 2400 kgs/m^3.
- For self weight of decking, temporary live load of workmen and equipment with impact is taken equal to 370 kgs/m^2. The span of the decking is generally smaller and this load is also concentrated over such smaller areas.
- Stacking of building materials on freshly placed concrete is not allowed.
- Construction load on the centering may be taken equal to 240 to 360 kgs/m^2.
- Allowable flexural stress may be taken equal to 7 MPa for soft timber and 9 MPa for plywood.

HYDROSTATIC PRESSURE ON VERTICAL FORMS

- Freshly poured concrete exerts an equal pressure in all directions just like water.
- The intensity of this pressure at any point is equal to the depth of concrete poured multiplied with its density.
- As soon as the concrete starts setting, the lateral pressure on the side walls starts reducing.
- The factors given on the next slide influence the maximum lateral pressure acting on the vertical forms.

- ***Depth of pour, H (mm).***
- ***Rate of placing, R (m/h)***. Greater is the rate of vertical placing of the concrete, greater is the lateral pressure.
- ***Least dimension, d (mm)***. The maximum pressure is exerted by wall thickness or least column dimension greater than 500 mm.

  If the thickness reduces beyond this limit, the pressure reduces due to the bridging action of coarse aggregate and restraining effect of the reinforcement.

- The ***impact load*** due to the falling of concrete during placing is usually considered equal to 10 kN/m^2 for the full height of pour.

  This includes the average effect of concrete vibrations.
- ***Density of the concrete,*** γ_c *(kgs/m*^{3}*)*.
- ***Workability*** of the mix in terms of slump in mm.
- ***Concrete temperature, t*** ℃.

The maximum hydrostatic pressure produced by the wet concrete is the minimum of the following three:

1. For full pressure of wet concrete with allowance for vibration, the pressure is given by:

$$P_{\max} = \left(\frac{\gamma_c H}{100} + 10 \right) \quad kN/m^2$$

2. For the arching action depending upon the rate of pouring and the least dimension of the formwork (*d*), the pressure is given by:

$$P_{\max} = \left(3R + \frac{d}{10} + 25 \right) \quad kN/m^2$$

Maximum value of *d* = 500 mm

This equation includes the allowance for vibrations.

3. The pressure determined for the stiffening of the concrete is given by:

$$P_{\max} = \left(\frac{\gamma_c R k}{100} + 15 \right) \quad kN/m^2$$

Where *k* is a correction factor for the concrete temperature and workability and its value is given in Table 15.1.

Table 15.1. Values of *k*-Factor for Determination of Concrete Pressures.

Mean Slump (mm)	**Concrete Temperatures °C**					
	5	10	15	20	25	30
25	1.45	1.10	0.80	0.60	0.45	0.35
50	1.90	1.45	1.10	0.80	0.60	0.45
75	2.35	1.80	1.35	1.00	0.75	0.55
100	2.75	2.10	1.60	1.15	0.90	0.65

Example 15.1:

Given the pour height H = 4m, rate of fill R = 4 m/h, d = 400 mm, t = 15 °C and slump = 100 mm, calculate the maximum hydrostatic pressure on walls of the formwork.

Solution:

The maximum hydrostatic pressure produced by the wet concrete is the minimum of the following three:

From Table 15.1, k = 1.60

$$P_{\max} = \left(\frac{\gamma_c H}{100} + 10\right) \quad kN/m^2$$

$$= \frac{2400 \times 4}{100} + 10 = 106.0 \quad kN/m^2$$

$$P_{\max} = \left(3R + \frac{d}{10} + 25\right) \quad kN/m^2$$

$$= 3 \times 4 + \frac{400}{10} + 25 = 77.0 \quad kN/m^2$$

$$P_{\max} = \left(\frac{\gamma_c Rk}{100} + 15\right) \quad kN/m^2$$

$$= \frac{2400 \times 4 \times 1.60}{100} + 15 = 138.6 \quad kN/m^2$$

$\therefore$ $P_{\max}$ = 77 kN/m^2

Continued on Part-III