Prestressed Concrete

Notes by-

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(a)

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formwork.

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(1) Properties of wet Concrete :— C + S + C.A + water → Concrete

workability — It is a prime property of fresh concrete which affects the strength of concrete. hardened — short term requirement — workability.

→ Factors affecting workability
> Measurement of workability
> Segregation & Bleeding.

water content, mix proportions — aggregate/cement ratio affect workability — higher the ratio, leaner the mix ... poor workability

ii) Aggregate size.
large size — surface area — less water required for wetting the surface.
more workability — within certain limit.

iii) Aggregate shape:— angular – flaky – elongated — harsh concrete
rounded Aggregates — more workability

v) Aggregate Texture — rough surface —
smooth surface — gives better workability.

vi) Aggregate grading — well-graded aggregate — less voids –

vii) Admixture → air entraining agent → increase workability

viii) Temperature → high — low workability — evaporation – hydration rate high.

• Measurement of Workability :— It is complex phenomena & difficult to define it.
Measurement of workability is equally difficult.
various tests – no correlation – emperical

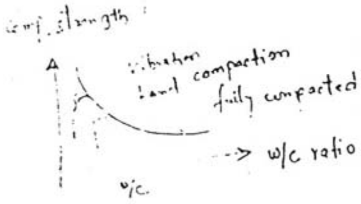
0-25, 25-50, 50-100, 100-175 — (1) slump test ✓
0.78, 0.85, 0.92, 0.95 — (2) compaction factor ✓
(3) flow test — 0-150 ✓ IS code refers
(4) Vee Bee Consistometer test ✓

properties

① Strength of concrete
- → comp
- → tensile
- → bond
- → fatigue
- → impact

② modulus of Elasticity
③ creep of concrete
④ shrinkage of concrete
⑤ Electrical properties of concrete

Factors Affecting Strength:
ⓐ w/c ratio



w/c ... cement remain unhydrated.

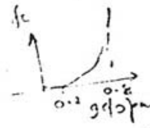
5% voids — 30% reduction

$S = \frac{k_1}{k_2^{w/c}}$

where S = comp st after 28 days
k_1 & k_2 are empirical constant.
This rule doesn't include many qualifications necessary for its validity.

In hardened concrete 1% voids are present

ⓑ gel/space ratio



ⓒ Porosity — strength is controlled by volume of voids.

ⓓ properties of coarse aggregate —
smooth gravel — early cracking
angular gravel — late cracking

ⓔ Aggregate / cement ratio — richness of mix.
2.5 to 10
rich mix lean mix

ⓕ Age of concrete

Test on Hardened Concrete :-

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Formwork Design

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MPSC - Engg Services Examination.

Introduction :-

The formwork is a temporary ancillary construction used as a mould for the structure in which concrete is placed, hardens and matures.

Permissible stress in timber

Property	Type of timber: Fir	Deodar	Kail	Chir
Density → N/m^3	4500	5450	5150	5750
E → N/mm^2	9400	9500	6800	9800
Permissible stress in bending & tension → N/mm^2				
Inside	7.8	10.2	6.6	8.4
Outside	6.6	8.8	5.6	7.0
Wet	5.6	7.0	5.0	6.0
Permissible stress in shear.				
Horizontal →	0.6	0.7	0.6	0.4
Along grain →	0.8	1.0	0.8	0.9
Permissible comp. stress (Parallel)				
Inside →	6	7.8	5.2	6.4
Outside →	5.2	7.0	4.6	5.6
Wet →	4.2	5.6	3.8	4.5

Permissible comp. stress (perpendicular)

N/mm²

Inside	1.6	2.6	1.7	2.2
outside	1.2	2.1	1.3	1.7
wet	1.0	1.7	1.0	1.4

(Prop Design)

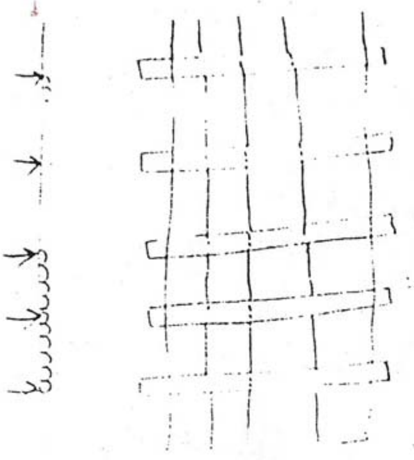
Safe stress $= f\left(1 - \frac{h}{50d}\right)$

h — ht of prop

d — least dimension.

f — safe comp. stress as short strut

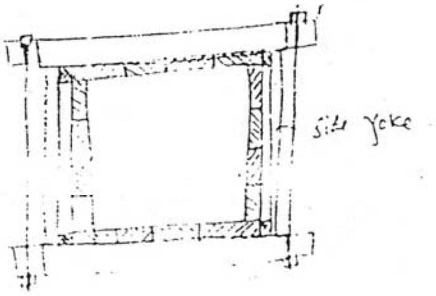
(i) spacing of yokes

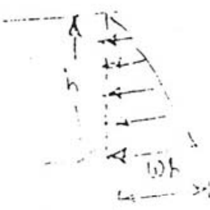


1 Hrs. duration

h = depth of concrete poured within 3/4 to 1 Hrs.

W total load on each yoke uniformly distributed over the length 'b'





l = span of side yoke.

w = equivalent fluid weight of concrete = kN/m³

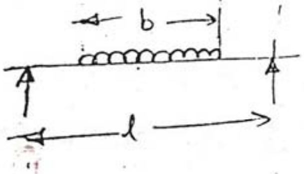
Total load on each yoke

b = width of column.

W =

Bending Moment in sheathing,

B.M. $\frac{ws^2}{10} = \frac{wh \times b \cdot s^2}{10}$ — continuous member.



If f is the permissible stress in sheathing, 'd' is the thickness of sheathing,

$$f \times \frac{bd^2}{6} = \frac{wh \cdot b \cdot s^2}{10}$$

from this equation, spacing of side yoke is decided. This spacing should be checked for shear & deflection in the sheathing. — Eq. (1)

w = equivalent fluid weight of concrete.

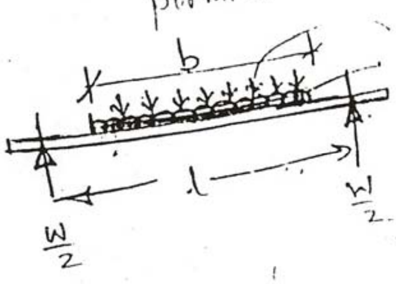
for ht upto 1.5 m → w = 23000 N/m³ of concrete

when ht of concrete in one pour is 6 m, the equivalent fluid wt may be 12,000 N/m³. — for intermediate ht. of pour, by interpolation it may be calculated.

The maximum permissible deflection of sheathing & joists etc. should

The above equation is based on permissible in sheathing.

Let us also find the value of 's' based on permissible stress in yoke.



Total load over the yoke is

$W = wh \times b \times s$

over the length 'b'.

Max B.M

$= \frac{W}{2} \times \frac{l}{2} - \frac{W}{2} \times \frac{b}{4}$

$= \frac{W}{4}(l - b/2)$

B.M in yoke $= \frac{W}{4}(l - b/2)$

if f' is the permissible bending stress in yoke

$f' \cdot z = \frac{W}{4}(l - b/2)$ —— (2)

$f' \times z = \frac{wh\, b.\, s}{4}(l - b/2)$ —— (2)

Lesser the value of spacing given by (1) / (2) eq is adopted.

Example: (1)

Design the formwork for a column 400 x 400 mm having a height of 3.5 m. It is proposed to pour the entire concrete in one stage.

(a) The unit fluid weight is $= 23000 - \left(\frac{23000 - 12000}{6 - 1.5}\right) \times (3.5 - 1.5)$

$w = 18111\ N/m^3$

(b) Bending stress in sheathing:

Let the spacing of yokes is 's' mm c/c

also distance between the bolt centres 'l' = 650 mm

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using d = 25 mm thick sheathing, we have, [Eq (1)]

h = 3.5 m
b = 400 mm
s = ?

$$f \times \frac{bd^2}{6} = \omega h \cdot b \cdot \frac{s^2}{10}$$

~~8.4 × 400 × 25² / 6 = 18111 × 10 × 400 × s² / 10 × 3500~~

$$8.4 \times 400 \times \frac{(25)^2}{6} = \frac{18111 \times 3.5}{10^6} \times 400 \times \frac{s^2}{10}$$

(kN/m³ in)

S = 371.53 mm,
Say, keep the spacing @ 370 mm c/c.

...sible ... ng stress ... od)
Deodar — Chir
10.2 → (8.4) N/mm² (inside)
8.8 → 7.0 N/mm² (outside)
7.0 → 6.0 N/mm² (wet)
1.0 → 0.9 N/mm² ← shear stress
9500 − 9800 N/mm² ← Elasticity

Check for shear & Deflection in sheathing:

Permissible shear stress = 0.9 N/mm²

$$\text{Shear force} = V = \frac{wh \cdot b}{2} \times \frac{370}{1000}$$

$$= 18111 \times 3.5 \times 0.4 \times \frac{370}{1000}$$

$$= \frac{9382}{2}\ N = 4691\ N.$$

$$\text{Maxi shear stress} = 1.5 \times \frac{V}{bd} = 1.5 \times \frac{4691}{400 \times 25}$$

$$= 0.7\ N/mm^2 \not> 0.9\ N/mm^2$$

— SAFE

~~Unsafe. revise thickness of sheathing or spacing of yoke.~~
~~thickness is revised say 40 mm.~~
~~Maxi shear stress = 1.5 × 9382 / 400 × 40 = 0.87 < 0.9 N/mm² O.K.~~

$\delta = \frac{3}{384} \frac{(w_h b) s^4}{EI}$

$EI = 9800 \times \frac{400 (25)^3}{12} = 0.51 \times 10^{10}$ ~~2.09~~

$w_h b = 18111 \times 3.5 \times 0.4 \times \frac{1}{1000} = 25.35$ N/mm

Substituting these values;

$\delta = \frac{3}{384} \times \frac{25.35 \times (370)^4}{0.51 \times 10^{10}}$ ~~2.09~~

$= 0.728$ mm < 2.5 mm. —— o.k.

Design of Yokes:-

Total load on yoke

$W = w_h b \cdot s$

$= 18111 \times 3.5 \times 0.4 \times 0.37$

$= 9382$ kN.

l = span of yoke in mm = 650 mm.

$B.M = \frac{W}{4}(l - b/2)$

$= \frac{9382}{4}(650 - 400/2) = 1055475$ N.mm.

Permissible bending stress in yoke (chir) = 8.4 N/mm²

$8.4 \times Z = 1055475$

$Z = 1.256 \times 10^5$ mm³.

use 90×100, $Z = 90 \times \frac{100^2}{6} = 1.5 \times 10^5$ mm³. —— o.k

Check for deflection

$$\delta = \frac{5}{384} \times \frac{W l^3}{EI}$$

$$= \frac{5}{384} \times \frac{9382 \times (650)^3 \times 12}{9800 \times 90 \times (100)^3}$$

$$= 0.406 \text{ mm} < 2.5 \text{ mm} \text{ — O.K.}$$

Design of bolts: Bolts are subjected to both direct pull as well as bending since the load is being transfered through wedges.

$$W = 9382$$

load in each bolt $= 9382/2 = 4691$ ~~kN~~.

Assuming that the distance of load transmitted through wedges is 40mm.

B.M. in bolt $= 4691 \times 40 = \underline{187640}$ N.mm.

Using 30 mm ⌀.

~~Area~~

Tensile stress $= \dfrac{4691}{\pi/4\,(30)^2} = 6.64$ N/mm²

bending stress $= \dfrac{187640 \times \frac{30}{2}}{\pi/64\,(30)^4} = 70.78$

total stress $= 70.78 + 6.64$

$= \underline{77.42}$ N/mm² < 165 N/mm²

M.S. O.K.