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Department: Civil Engineering

Subject: PRCD II

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Q1

(a) ~~Ben~~ Briefly describe principle & advantages of pre-stressing.

Principle of Prestressing

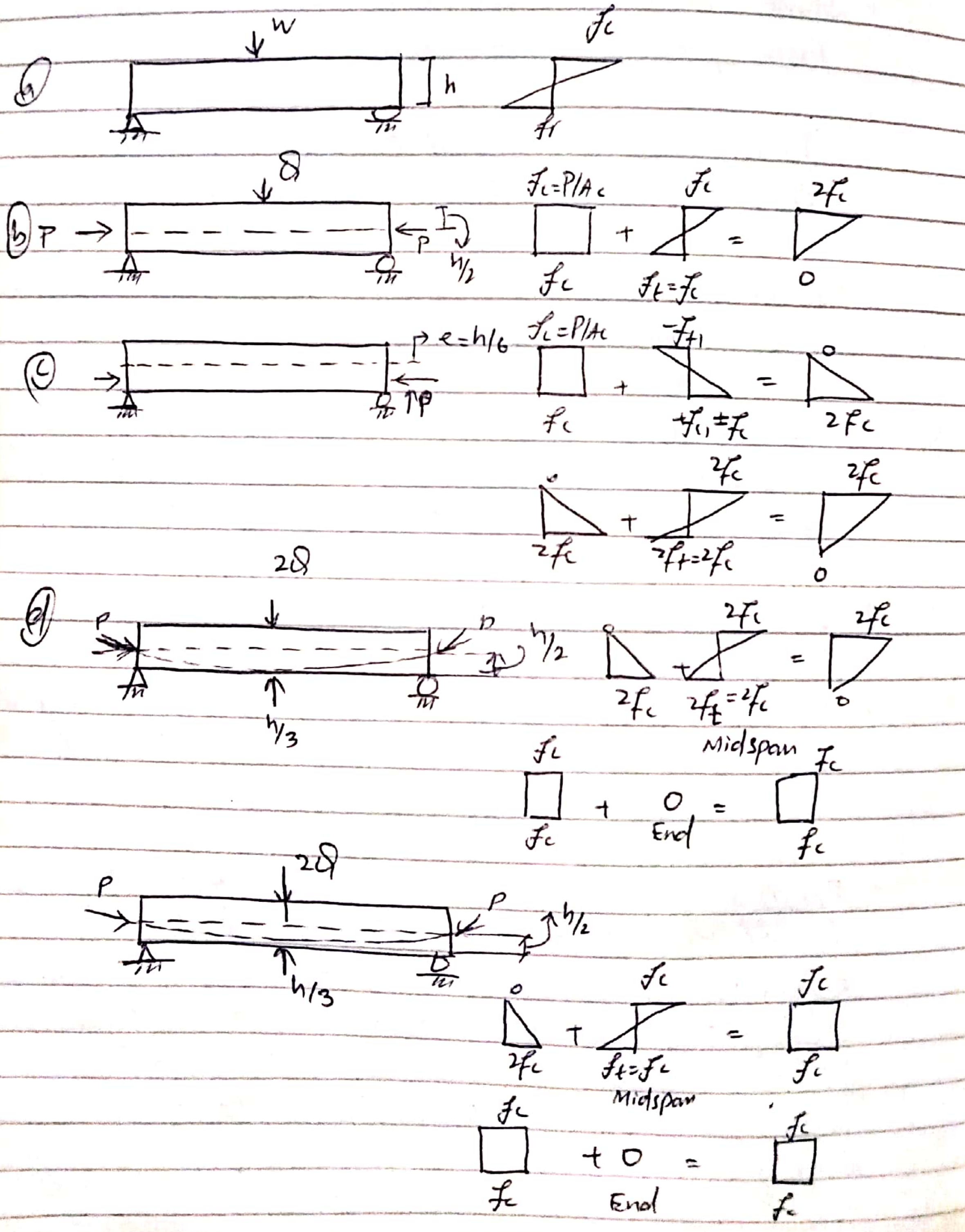
- Some important conclusion can be drawn from previous simple example
  - Prestressing can control or even eliminate concrete tensile stress for specified loads
  - Eccentric prestress is usually much more efficient than concentric prestress.
  - variable eccentricity is usually preferable to constant eccentricity, from the viewpoints of both stress control and deflection control.

Advantages of Pre-stressing

- Prestressing results in the overall improvement in performance of structural concrete used for ordinary loads and spans.
- Prestressing extends the range of application far beyond the limits for ordinary reinforced concrete, leading not only to much longer spans, with economical member cross sections than previously thought possible, but permitting innovative new structural forms to be employed.

- objectionable deflection and cracking, which would otherwise be associated with the use of non prestressed reinforced concrete members at high stress, are easily controlled by prestressing.

Principle of prestressing



(b) Briefly discuss methods of pre-stressing

Method of Prestressing

- Although many methods have been used to produce the desired state of precompression in concrete members, all pre-stressed conc members can be placed in one of two categories

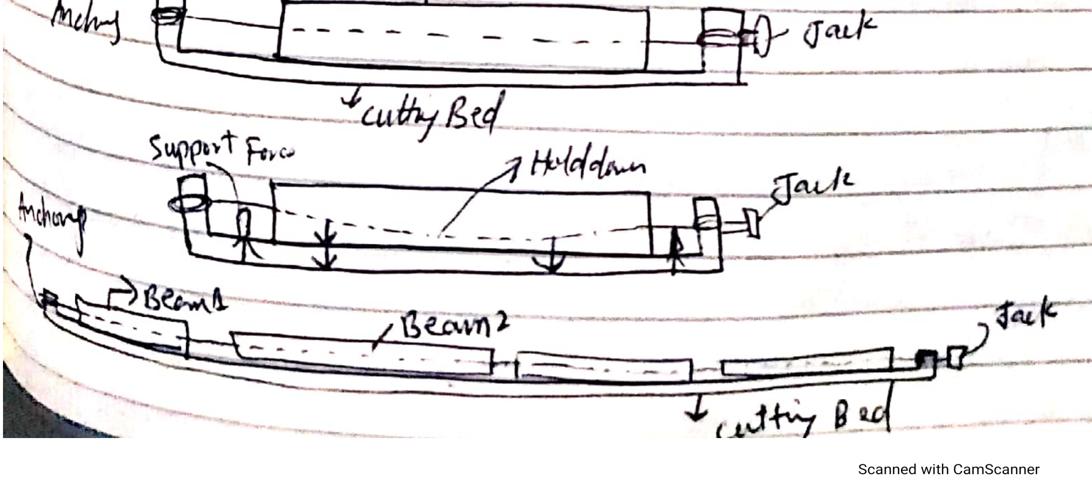
(1) Pre-Tensioned

- The strands are tensioned over the full length of the casting bed at once time, after which a number of individual members are cast along the stressed tendon.

- When the Jacking Force is ~~real~~ released, the prestress force is transferred to each member by bond, and the strands are cut free b/w members

- In present practice anchorage & jacking abutments may be as much as 800ft apart

- Cable depressors are often used with long-line prestressing just as with individual members.



(2) Post-Tensioning

- Usually hollow Conduits containing the unstressed tendons are placed in the beam Forms to the desired profile, before pouring the Concrete

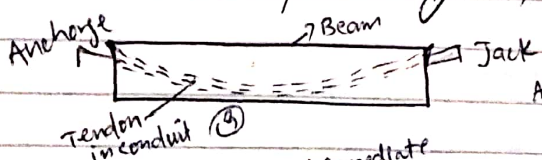
- The conduit is wired to auxilliary beam reinforcement (unstressed stirrups) to prevent accidental displacement, and the Concrete is poured.

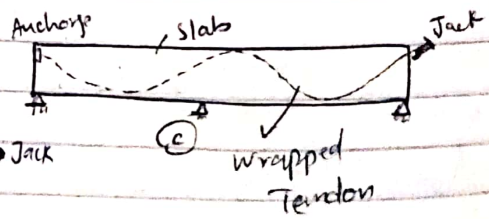
- when it has gained sufficient strength, the Concrete beam itself is used to provide the reaction for the stressing Jack.

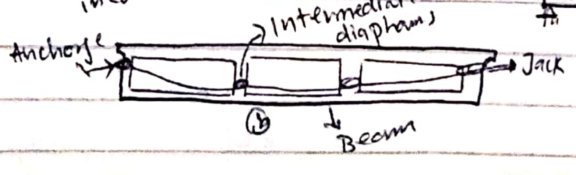
- with the tendon anchored by special Fittings at the Far end of the member, it is stretched and then anchored at the jacking end by Similar Fittings, and the Jack removed.

- The tension is gauged by measuring both the Jacking pressure and the elongation of the steel.

- The Tendons are normally tensioned one at a time, although each tendon may Consist of many strands or wires







(c) Difference b/w Bridge and culvert with example.

Bridge	Culverts
(1) A bridge is a passage of transportation over a large body of water or physical obstruction.	A culvert is generally a tunnels like structure that allows water to pass under a roadway or rail way
(2) Bridges are constructed at height more than 20ft	culvert are built at less than 20 ft high over the obstruction.
(3) A bridge spans from 6m to more than 120 m	The length of culvert is typically not more than 6m
(4) piers and abutments are the supporting structure of a bridge	culverts are usually embeded in the soil which bears the major portion of culvert load.
(5) A bridge contains no Floor	A culvert is an enveloping structure that consist of two sides a roof, and a Floor.

Example (Bridge)

- → Beam Bridges
- → Truss Bridges
- → Cantilever Bridges
- → Suspension Bridge
- → Cable-Stayed Bridge.

Example (Culvert)

- → Pipe (single or multiple)
- → Pipe Arch (single / multiple)
- → Concrete Box (single/multi)
- → Metal Arch Box

(d) Types of load considered in bridge design

Loads to be considered in bridge design can be divided into two broad category

(1) permanent loads

- Self weight of girders and deck, wearing surface, curbs and parapets and railings, utilities and luminaries and pressures from earth retainments.

- Two important dead load are
  - → DC: Dead load of structural component and non-structural attachments
  - → DW: Dead load of wearing surface.

- Material properties for pavement
  - $\gamma_{bitumen} = 140 lb/cft$
  - $\gamma_{concrete} = 150 lb/cft$

- Load factors for pavement dead loads
  - The max load factor for DC = 1.25
  - The max load factor for DW = 1.5

(2) Transient loads

- Gravity (live) loads due to vehicular, railway and pedestrian traffic

- The automobile is one of the most common vehicular live load on most bridges, it is the truck that causes the critical load effects

- lateral loads due to water, wind, earthquake and ship collision etc.

- Following effects caused by live load are also very important & must be considered in the design of a bridge

  -> Impact (dynamic effects)
  -> Centrifugal Forces (if present) and
  -> The effect of other truck simultaneously present

(c) Difference b/w SMRF & OMRF

→ Ordinary Moment Resisting Frame (OMRF) is a moment-resisting frame not meeting special detailing requirements for ductile behavior.

→ Special Moment Resisting Frame (SMRF) is a moment-resisting frame specially detailed to provide ductile behavior and comply with the requirement given in IS-4326 or IS-13920 or SP6.

→ Ordinary Moment Resisting Frames are the frames that are unable to fulfill the special detailing requirement for ductile behavior.

→ Special Moment Resisting Frames are the frames that are able to fulfill the special detailing requirements for ductile behavior

Q2

Given Data

Span length = 35' c/c
Road width = 44' curb to curb
Bituminous overlay = 3"
$f_c' = 4000psi$
$f_y = 60\ ksi$

Sol

step #01

Sizes

- span length of bridge (s) = 35' c/c
- clear roadway width (w) = 44' (curb/curb)
- For a curb width of 15 inches total width of bridge $(w_1) = 44 + (2 \times 15/12) = 46.5\ ft$
- Mini thickness of bridge slab is given by Formula

$$h_{min} = 1.2(s+10)/30$$
$$= 1.2(35+10)/30$$
$$= 1.8ft$$
$$= 21.6'' \simeq 22''$$

Step #2

loads

Slab loads $(w_{DC}) = h\,\gamma_{conc}$

$$= (22/12) \times 0.15$$
$$= 0.275\ KSf$$

wearing surface load $(w_{DW}) = h\,\gamma_{wearing\ surface}$

$$= (3/12) \times 0.14$$

$$= 0.035\ KSf$$

step# 03

Analysis

slab moments $(M_{DC}) = W_{DC} S^2/8$

$= 0.275 \times (35^2)/8$

$= 42\ ft-kip/ft$

wearing Surface moment $(M_{DW}) = W_{DW} S^2/8$

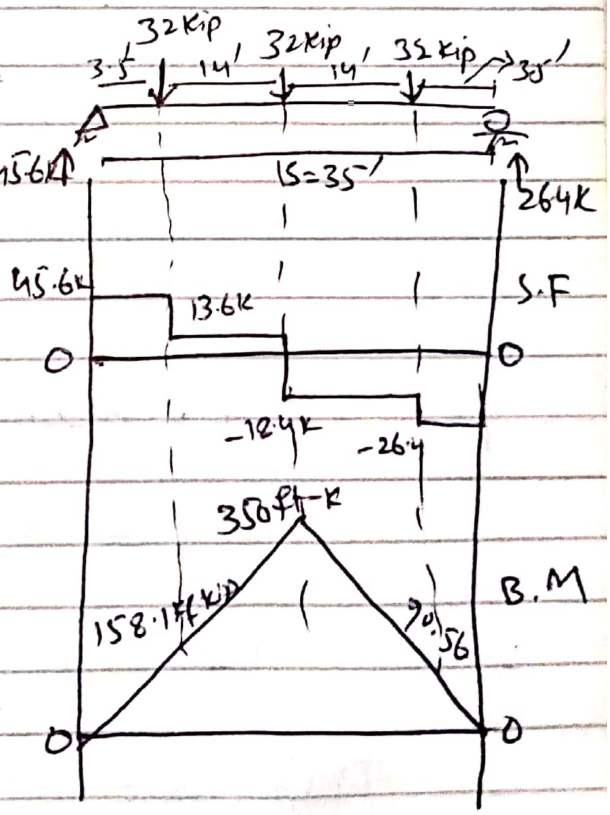
$= 0.035 \times 35^2/8$

$= 5.3\ ft-kip/ft$

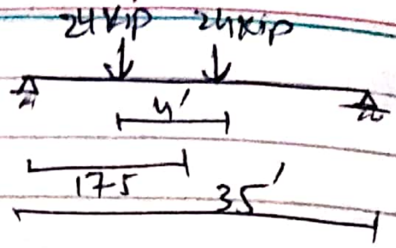
Live load moments

Truck load moment

$M_{Truck} = 350\ ft-kip$

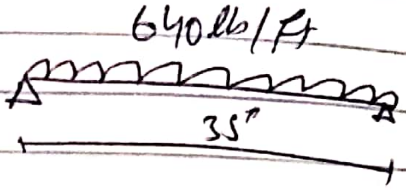


- Tandem moment



$M_{Tandem} = 372\ ft\text{-}kip$

- Lane moment



$M_{lane} = 0.64 \times 35^2/8$

$M_{lane} = 98\ ft\text{-}kip$

Live Load moments

- $M_{Tandem} > M_{Truck}$ therefore we will use M_{Tandem}
- M_{LL+IM} (including Impact) $= 1.33 M_{tandem} + M_{lane}$

$= 1.33 \times 372 + 98$

$= 593\ ft\text{-}kip$

- To convert M_{LL+IM} to moment/ft Divide M_{LL+IM} by "E" design lane width.

- Design lane width 'E"
  - For Single lane loaded
    - $E(inch) = 10.0 + 5.0\sqrt{L_1 W_1}$

L_1 = Modified span length = Mini ($S = 35'$) & 60 ft = 35 ft

W_t = Modified edge to edge width = Mini of (W_1 = 46.5ft) or 30ft = 30ft

- There Fore $E = 10.00 + 5\sqrt{(35 \times 30.0)}$
  $= 172$ in
  $= 14.3$ ft

Design lane width "E"

For multilane loaded

- E (inches) $= 84 + 1.44\sqrt{(L_1 W_1)} \leq W_1/N_L$
  $L_1 = 35$ ft

W_1 = Mini of (W_1 = 46.5ft) or 60ft = 46.5ft
N_L = No. of design lanes
$= \text{InT}(W/12)$
$= \text{InT}(44/12)$

$= 3$

- $E = 84 + 1.44\sqrt{35 \times 46.5)} \leq 46.5/3$
  $= 142''$ or $11.84\text{ft} \leq 15.5$

There Fore $E = 11.84$ ft (least of all)

- Moment (Per Foot)
  - M_{LL+IM} Per Foot $= 593/11.84$
    $= 50$ ft-kip/ft

NOW

- $M_u = 1.05[1.25 M_{DC} + 1.5 M_{DW} + 1.75 M_{LL+IM}]$ (Per Foot)
- $M_u = 1.05(1.25 \times 42.7 + 1.5 \times 5.33 + 1.75 \times 50)$
- $M_u = 155.3$ ft-Kip/ft

$M_u = 1863.6$ in-Kip/ft

Step # 04

Design

(a)

- Moment (M_u) = 155.3 ft-Kip/ft
  = 1863.6 in-Kip/ft

- Effective depth of bridge slab (d) = h - Cover - ½ × Dia of bar used

- Using #8 bar, effective depth is bottom cover For slab is taken equal to 1"

- $d = 22 - 1 - \frac{1}{2} \times 1$
  $d = 20.5''$

- $A_{s\,min} = 0.0018 \times 12 \times 22$
  $A_{s\,min} = 0.47\ in^2$

- $A_s = M_u / (\phi f_y (d - a/2))$

After trial $A_s = 1.80\ in^2$ (#8 @ 4" c/c)

(b) Distribution reinforcement (bottom transvase reinforcement)

- The amount of bottom transverse reinf. may be taken as percentage of the main reinforcement required for +ve moment as follow but not less than shrinkage reinforcement

- $A_{Transverse} = (100/\sqrt{S}$ or $50\%)$ of A_s which is less

$100/\sqrt{L} = 100/\sqrt{35}$

$= 16.9\% < 50\%$

- Therefore $A_{Transv} = 0.169 \times 1.80$

$= 0.304\ in^2$

- $A_{s\,Trans}$ (shrinkage) $= 0.0018 A_s$

$= 0.0018 \times 12 \times 22$

$= 0.47\ in^2$ (#5 @ 8" c/c)

Check
(b) Distribution reinforcement (bottom transverse reinforcement)

- Max spacing for temp. steel reinforcement in one way slab according to min steel

$= 5h_f$

$5 \times 22 = 110"$

$= 18"$

Therefore #5 @ 8" c/c is (OK)

(e) Shrinkage & Temp reinforcement in top face of slab (long & Transverse both) For grade 60 steel.

$A_{st} = 0.0018 A_g = 0.0018 \times 12 \times 22$

$= 0.47\ in^2$ (#5@8" c/c)

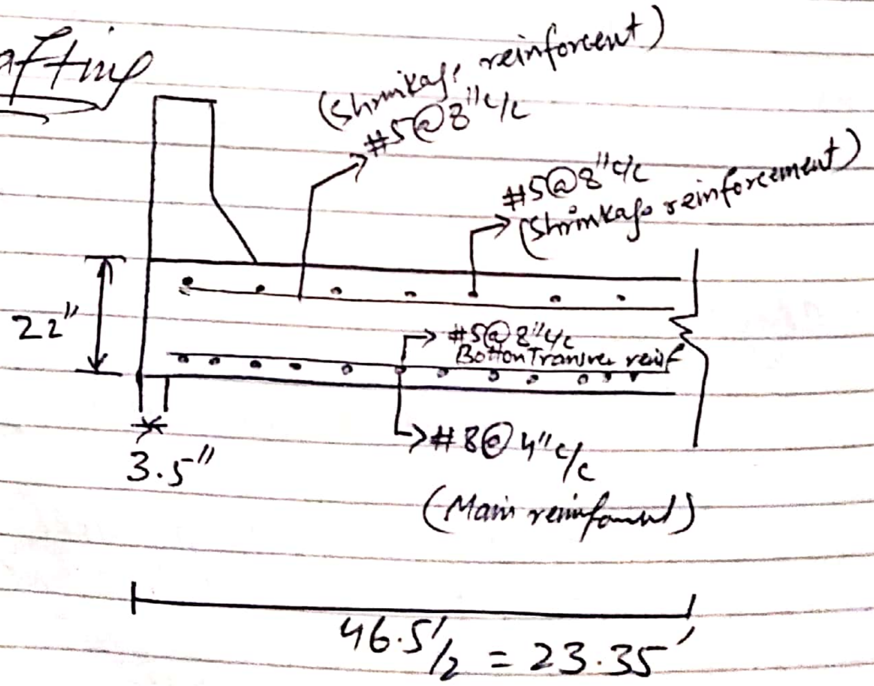
- Finally use #5@8" c/c

Final Recommendation

- Main steel (bottom) = #8 @ 4" c/c
- Transverse bottom reinforcement = #5@8" c/c throughout
- Top steel (long & Transverse) = #5@8" c/c

Step#05

Drafting



Q 3

solution

step #01 selection of Ca & Cv

Base shear "V" = $\frac{C_v I}{R T} \times W$ —(1)

For Sp soil and zone B

$C_a = 0.36$
$C_v = 0.54$
$I = 1$
$R = 8.5$

Now $T = C_t \times h_n^{3/4}$

$= 0.03 \times (60)^{3/4}$
$= 0.646$ sec

$W = W_1 + W_2 + W_3 + W_4 + W_5$
$= 800 + 800 + 800 + 800 + 700$
$= 3900$ Kips

put value in eq (1)

$V = \frac{0.54 \times 1}{8.5 \times 0.646} \times 3900$

V = 383 Kips

the Total design shear wall shall not less than the Following

(17)

$V = 0.11 C_a I W$

$= 0.11 \times 0.36 \times 1 \times 3900$

$= 154.44$

$\therefore$ $V = 383$ Kips

$$F_x = \frac{(V - F_t)\, w_x h_x}{\Sigma w_i h_i} \quad — ②$$

$\Sigma w_i h_i = 800 \times 12 + 800 \times 24 + 800 \times 36 + 800 + 48 + 700 \times 60$

$= 138000$ Kips

There Fore the case under consideration Force For story 1 is, putting values in eq ②

$$F_1 = \frac{(383 - 0) \times 800 \times 12}{138000}$$

$F_1 = 27$ Kips

Level	h_x	w_x	$w_x h_x$	$\frac{w_x h_x}{\Sigma w_i h_i}$	F_x
5	60	700	42000	0.304	116
4	48	800	38400	0.278	107
3	36	800	28800	0.209	80
2	24	800	19200	0.139	53
1	12	800	9600	0.070	27

Check $\Sigma F_x = V = 383$ Kips (OK)