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SUBJECT – WATER RESOURCE ENGG.

BRANCH – CIVIL ENGG.

1(a)

12

For cotton,

$$\Delta = \frac{8.64\,B}{D} = \frac{8.64 \times 240}{1430} = 1.45 \text{ m}$$

$\therefore$ Volume of water = 1.45 × Area for cotton

$= 1.45 \times 3000 \times 10^4 \text{ m}^3$

$= 43.5 \text{ Mm}^3$

Similarly,

For sugarcane,

$$\Delta = \frac{8.64 \times 365}{860} = 3.667 \text{ m}$$

$\therefore$ Volume of water $= 3.667 \times 2000 \times 10^4 \text{ m}^3$

$= 73.34 \text{ Mm}^3$

For wheat

$$\Delta = \frac{8.64 \times 120}{2150} = 0.482 \text{ m}$$

Volume of water $= 0.482 \times 4000 \times 10^4 = 19.28 \text{ Mm}^3$

For Rice,

$$\Delta = \frac{8.64 \times 120}{860} = 1.206 \text{ m}$$

Volume of water $= 1.206 \times 2000 = 24.11 \text{ Mm}^3$

∴ Total Annual water requirement for all the crops

$= 43.5 + 73.34 + 19.28 + 24.11$

$= \boxed{160.23\ Mm^3}$ Ans

1 (b).

Preservation of stones –

i) Application of Coal tar

It is applied to protect the stone from wheather agencies. But it changes the appearance of stone to black and also absorb heat from the sun. So, this method is generally not adopted.

ii) Application of Linceed oil.

It is applied normally or boiled. It does not change the natural shade of the stone, however, if boiled linceed oil is applied then it make the colour dark.

iii) Application of paint.

It changes the natural colour of the stone but are very effective to preserve the stone. The effective bonding of paint with stone is necessary.

iv) Application of paraffin.

It also changes the colour of stone and protect the stone from moisture and humidity and make it durable.

v) Application of alum with soap.

vi) Application of baryta →

It is the application of barium hydroxide over the surface of stone. It is most suitable if the stone is subjected to a attack of calcium sulphate. It react with calcium sulphate and $Ca(OH)_2$ is formed which further react with CO_2 in atmosphere and $CaCO_3$ is formed thus protect the stone.

1(c) Varnishes are the transparent, hard protective covering applied on the finished wood. These are resineous substance with either alcohol or spirit. It makes the wood surface glossy. It improve the durability of the timber. It also protect the timber from decay and attack from the fungi or whit ants.

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Ingradients –

i) Resins : eg: Copal, Balsam, Dammers

ii) Dryer :- to dry the varnish quickly eg: spirit, ~~to~~

iii) Thinner :- to thin the solvent according to the requirement. It depends on the type of resin and timber. eg:- turpentine.

Types of Varnishes.

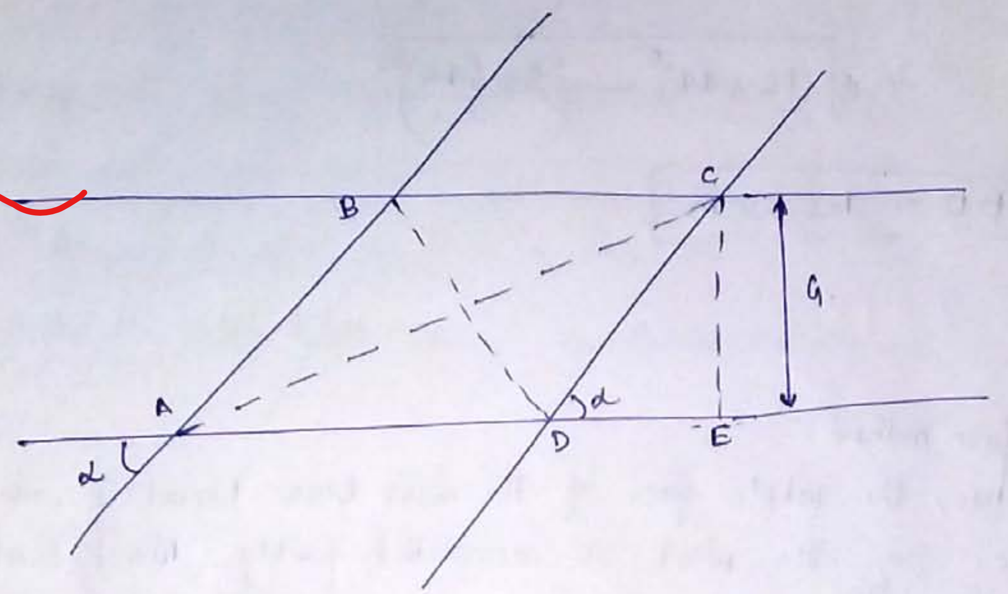
i) Oil varnish – dries slowly but hard protective layer is formed. eg: copal with linseed oil.

ii) spirit Varnish – It dries quickly.

iii) Turpentine Varnish

iv) Water Varnish.

1(d)



$G = 1.676$

$N = 10$

$\therefore \alpha = \cot^{-1}(N) = \cot^{-1}(10) = 5^\circ 42' 38''$

$\therefore CD = CE \operatorname{cosec}\alpha = G \operatorname{cosec}\alpha$

$= 1.676 \times \operatorname{cosec}(5^\circ 42' 38'')$

$= 16.844\,m$

$\therefore$ **AB = BC = CD = DA = 16.844 m**

$$AC = \sqrt{(AD + DE)^2 + CE^2} \qquad DE = \frac{CE}{\tan\alpha} = \frac{G}{\tan\alpha}$$

$$= \sqrt{\left(16.844 + \frac{1.676}{\tan(5^\circ 42' 38'')}\right)^2 + 1.676^2}$$

AC = 33.646 m

$$BD = 2\sqrt{(AB)^2 - \left(\frac{AC}{2}\right)^2}$$

$$= 2\sqrt{(16.844)^2 - \left(\frac{33.646}{2}\right)^2}$$

$$\boxed{BD = 1.682\ m}$$

1 (c)

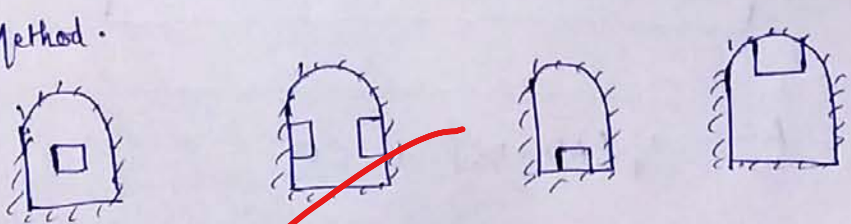
(i) Full face method.

In this, the whole face of the main bore tunnel is attacked at the same time. So, the work is completed quickly. Tunnel track can be laid simultaneously. Also, tunnelling & mucking process can be carried out simultaneously. It is suitable for hard rock. However it require heavy machinery to carry the muck and unsuitable for unstable rocks. It is used for the tunnel section having diameter not more than 3m.

(ii) Heading and Bench Method

The top portion of tunnel is driven in advance of bottom portion called bench. It is used when tunnel section is larger. It is possible to make simultaneous drilling and mucking process. It require less explosive than full face method.

(iii) Drift Method.



The tunneling is carried out by drilling the drift portion first. It may be classified as top drift, bottom drift, centred drift depending on the relative position with respect to main bore. First the small section is driven and further widened. It is used as a correction measure for water table. Also, timber installation of support become easy. The drift is used as a ventilation. But it is costly. and main bore can not driven until the drift portion is completed.

3(a) (i)

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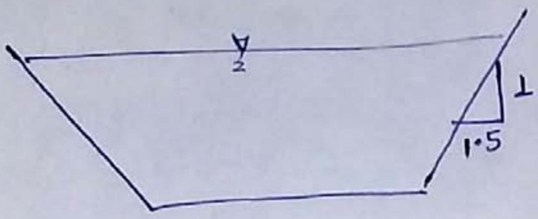
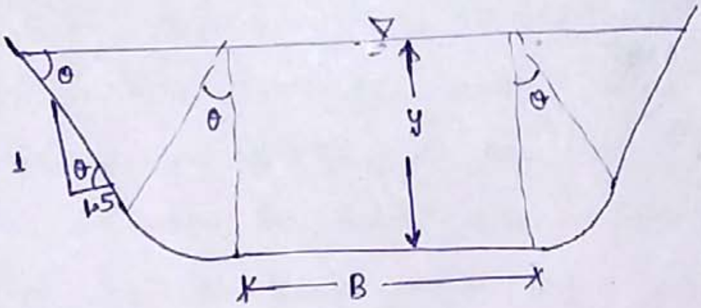


$Q = 29\ m^3/s$

$V \ngtr 1\ m/s$.

$n = 0.015$



$\cot\theta = 1.5$ $\theta = 33.69° = 0.588$ radians

$A = By + y^2(\theta + \cot\theta)$

$A = By + y^2(0.588 + 1.5) = By + y^2 \times 2.088$ — (1)

~~Assuming~~

$P = B + 2y(\theta + \cot\theta)$

$\Rightarrow P = B + 4.176\,y$.

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Using ①

$$P = \frac{A}{y} - 2.088y + 4.176y$$

$$P = \frac{A}{y} + 2.088y$$

For minimum wetted Perimeter.

$$\frac{dP}{dy} = 0$$

$$\Rightarrow -\frac{A}{y^2} + 2.088 = 0$$

$$\Rightarrow A = 2.088y^2 \quad \text{— (ii)}$$

$$\therefore P = \frac{2.088y^2}{y} + 2.088y = 4.176y \quad \text{— (iii)}$$

Assuming $V_{max} = 1\ m/s$

$$\therefore A = \frac{Q}{V} = \frac{29}{1} = 29\ m^2$$

$\therefore$ from (ii) $\quad A = 2.088 \times y^2$

$$\Rightarrow 29 = 2.088y^2$$

$$\Rightarrow y = 3.727\ m$$

$\therefore$ from (iii)

$$P_{min} = 4.176y = 4.176 \times 3.727 = 15.563\ m$$

$$\therefore \boxed{P_{min} = 15.563\ m}$$

Now $\quad V = \frac{1}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$

$$\Rightarrow 1 = \frac{1}{0.015} \times \left(\frac{29}{15.563}\right)^{2/3} \times S^{1/2}$$

$$\therefore \boxed{S = \frac{1}{10191}}$$

3(a)(ii)

Effects of waterlogging –

i) flooding of root zone of plants and make it ill aerated.

ii) reduction in crop yield

iii) inference in cultivation operation

iv) efflorescence or deposition of salt over the root thus reduce the osmosity of plant root.

v) breeding of insects and mosquitos thus epidemics problem.

vi) Nuisance odder and development of microorganism in water.

vii) Pollution in groundwater table and subsurface waters.

Remedial Measures –

i) Lining of canal and watercourse.

ii) Reducing the intensity of irrigation.

iii) Using crop rotation so, that water rich plants can be grown in rotation.

iv) Optimum use of water in irrigation and reducing the excess flow of water in canal.

v) Providing an efficient drainage system eg: Intercepting drainage.

vi) Reclaimation of alkaline and saline soil using leaching and gypsum.

3(b) (i)

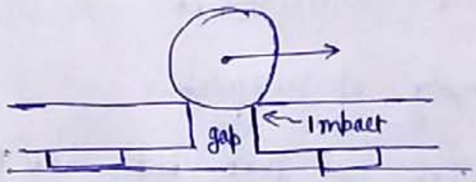
Theories for Creep –

i) Wave Theory. –

When the whell roll on the ~~roll~~ rail then a wave is formed in rail which progressively move with the wheel direction of movement thus creep is developed in the rail.

ii) Percussion Theory –

It states that when the wheel move along the rail then at the location on of expansion gap due to loss connection or inadequate gap the impact is generated on the rail thus push the rail forward and creep is developed.



iii) Drag Theory –

It states that the creep in the rail is developed due to sudden acceleration or sudden stopping of wheel. Due to sudden acceleration it generate a drag force in backward or forward direction, thus, the rail displaced slightly forward and creep is formed.

3 3(b)(ii)

Gate Capacity for single gate $= \frac{1}{\text{Weighted avg. of service time}}$

$= \frac{1}{0.2 \times 10 + 0.3 \times 3 + 0.5 \times 60}$ Aircraft/min

$= \frac{10}{329}$ Aircraft/min

$= \frac{10}{329} \times 60$ Aircraft/hr.

$= 1.824$ Aircraft/hr.

∴ Gate Capacity for all 30 gates $= 30 \times 1.824$ Aircraft/hr.

$=$ **55 Aircraft/hr** Ans

3(c)(i) 7

Classification of Lime -

1) Poor lime →
- $CaO + MgO$ is more than 70%
- MgO is less than 5%
- Clay impurities (Silica + Alumina) > 30%
- make ~~thick~~ thin paste
- Slack slowly and hydrates slowly.
- Used in inferior type work.

2) Hydrated lime →
- $CaO + MgO$ is 70-80%
- MgO is less than 5%
- clay impurities is more than 30%
- obtained by moderate burning of limestones

It is of three types

Feebly Hydraulic Lime	Moderately Hydraulic Lime	Eminently Hydraulic lime
⇓	⇓	⇓
• clay = 5-10%	• clay = 10-20%	• clay = 10-30%
• slack in 5-15 minutes	• slack in 1-2 hr	• slacks slowly
• Used in damp places	• used in superior type work	• Used in oil retaining structures

3) Fat lime → • CaO + MgO is is less than 85%
- MgO less than 4%
- clay is less than 5%
- It is almost a pure calcium oxide.
- It slacks vigorously in water and formed $Ca(OH)_2$.
- It sets slowly, so, not used in thick wall.
- It does not set under water.
- Its plasticity is not affected by the water.
- It is used in mortar, white wash, as a base in distemper etc.

3 (c) (ii)

8

Qualities of timber —

i) freshly cut timber should have shinny surface
ii) structure should be uniform.
iii) Sweet smell (indicate no decay)
iv) clear ringging sound when struck (no decay)
v) elasticity.
vi) Fire resistant

vii) Resistance to insect and fungi and chemical

viii) Capable of retaining shape after seasoning process

ix) hard enough to resist the penetration.

x) tough enough to resist the impact due to vibration.

xi) Should have enough strength along and across the grain.

xii) should recieve the oil and paint easily and smoothly.

xiii) Medullary rays should be hard and compact.

xiv) Annual rings should be regular and closely located.

Factors affecting strength of Timber.

i) fungi attack causing decay of timber. eg: dry rot, wet rot, blue stain

ii) Chemical attack

iii) Formation of shakes eg: ring shakes, cup shakes, star shakes etc

iv) Defects due to natural forces eg:- blow, twisting fibre, cup etc

v) Seasoning of timber eg: boiling the timber.

vi) Age of the timber

vii) Formation of knots in timber.

viii) Durability of timber

ix) Moisture absorption capacity of timber.

x) Arrangement of timber sheets in forming a plywood.

xi) Preservative over the timber (indirectly make it resistance to decay and hence retain the strength of timber)

5(a) Considering the economic factors of labour safety -

i) Direct Cost → It is the cost of medical or compensation or legal cost paid directly by the organisation through the insurance scheme. It includes the cost of safety equipments.

ii) Indirect Cost → It is the cost which is imposed on the organisation indirectly. It includes.

i) Cost of safety material
ii) Cost of safety related conferences, seminars etc.
iii) Cost of wage payement to the employee for attaining the safety training
iv) Cost of PPEs.
v) Cost of salary payement of safety officers
vi) Cost of survey of safety related issues.
vii) Cost in avoiding small mistakes that can be hazardous.
viii) Cost in adopting standard operating Procedures (SOPs)

5(b).

Common mistakes while executing a construction projects -

i) Mistake in proper planning.
ii) Mistake in adequate supervision.
iii) Mistake in handaling hazardous material.
iv) Mistake in proper communication between the worker.
v) Mistake in selecting the time limits and adequate targets.
vi) Mistake in careful and attentive use of safety equipments.
vii) Mistake in selecting incompetent contractor or worker

viii) Mistake in following the standard operating Procedures (SOPs)

ix) Mistake in selecting adequately skilled workers.

x) Mistake in checking hazardous issues before and after the start of work eg:- checking slippery surface, electrical wires, water logging, fire hydrants, pumps and turbines, leakage, etc.

xi) Mistake in proper coordination of information between employees.

xii) Unforeseen mistakes caused by weather

5(c)(i)

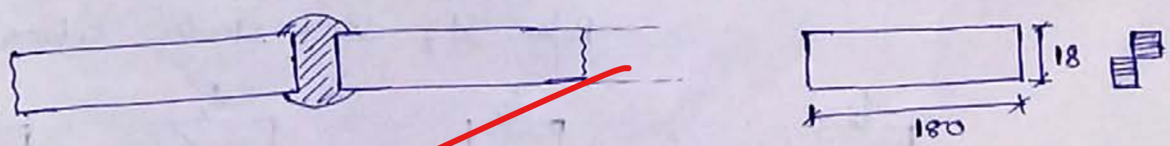
5

Force Majeure → It is a clause mentioned in the contract to remove the liability of contractor to pay compensation in case of a natural or unforeseen catastrophe. eg:- earthquake, war, flooding etc. This clause favours the employer as a safety against these catastrophe.

Escalation → It is the increase of cost of material or labour over a defined period of time. It is due to the inflation and deflation in market. This increase in cost is totally dependent of market forces and availability of resources.

5(C) (ii)

3



Thickness of weld $= t_e = 18\,mm$

$\therefore$ Bending moment capacity $= f_y \times \frac{d}{2} \times b \times \frac{d}{2} = 250 \times 180 \times \frac{18^2}{4}$

$= 3.645\ kN\text{-}m$

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Shear strength of joint $= (180 \times 18) \times \frac{f_y}{\sqrt{3} \times \gamma_{mo}}$

$$= 180 \times 18 \times \frac{250}{\sqrt{3} \times 1.1}$$

$$= 425.14 \text{ kN} > 200 \text{ kN}$$

So, safe against shear force.

5(d)

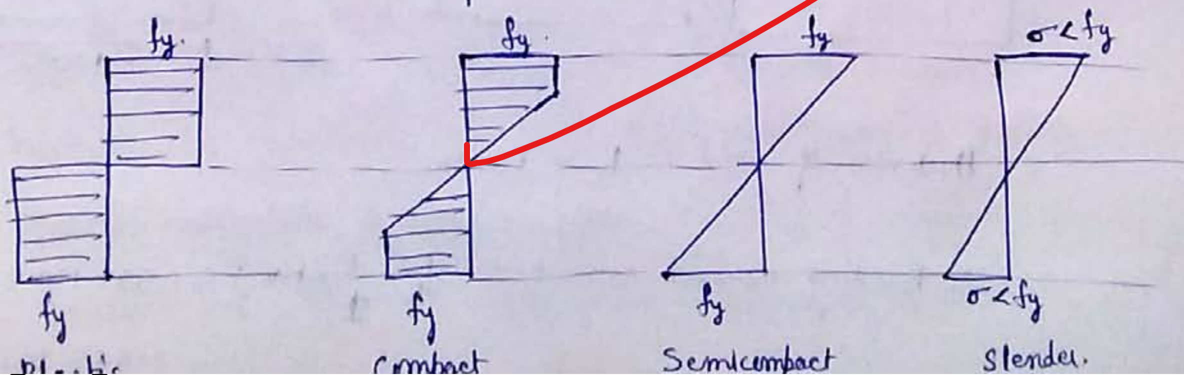
Classification of steel cross section.

i) Plastic section → The section in which all the fibres are yielded and so, can develop plastic moment capacity and have sufficient capacity to rotate about plastic hinge. is called plastic section.

ii) Compact section → The section ~~in~~ which can develop plastic moment capacity but can not require rotation capacity to fail by formation of plastic hinge by plastic mechanism is called compact section.

iii) Semicompact section → The section which has its extreme fibre reaches its yield stress but can not form plastic moment due to buckling of compression fibre., is called semicompact.

iv) Slender Section → The section which can not has its extreme fibre reaches to ~~extre~~ yield stress and thus buckle before it, called slender column.



5(e) (i)

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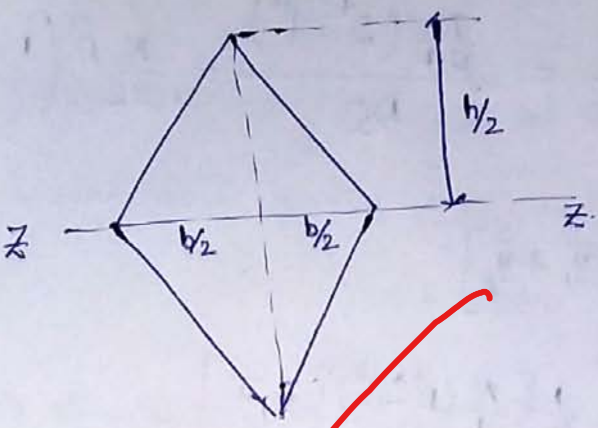


$$I_{zz} = 2\left[\frac{1}{12} b \cdot \left(\frac{h}{2}\right)^3\right] = \frac{bh^3}{48}$$

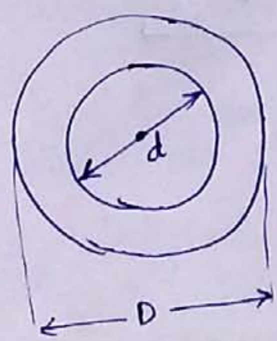
$$Z_{zz} = \frac{bh^3/48}{h/2} = \frac{bh^2}{24}$$

$$Z_p = 2\left[\frac{1}{2} \times b \times \frac{h}{2} \times \frac{1}{3}\frac{h}{2}\right] = \frac{bh^2}{6\times 2} = \frac{bh^2}{12}$$

$\therefore$ shape factor $S = \frac{Z_p}{Z_e} = \frac{bh^2/12}{bh^2/24} = 2$

$$\boxed{S_{\diamond} = 2}$$

(ii)



$$I_{zz} = \frac{\pi}{64}\left(D^4 - d^4\right)$$

$$Z_{zz} = \frac{I_{zz}}{D/2} = \frac{\frac{\pi}{64}\left(D^4 - d^4\right)}{D/2} = \frac{\pi}{32} D^3\left(1 - \left(\frac{d}{D}\right)^4\right)$$

$$Z_p = \frac{A}{2}\left[\bar{y}_1 + \bar{y}_2\right]$$

$$= 2 \times \left[\frac{1}{2}\left\{\frac{\pi}{4}\left(D^2 - d^2\right)\right\} \times \bar{y}\right]$$

$$= 2\left[\frac{1}{2}\left\{\frac{\pi}{4} D^2 \times \frac{2D}{3\pi} - \frac{\pi}{4} d^2 \cdot \frac{2d}{3\pi}\right\}\right]$$

$$= \frac{\pi}{4} \cdot \frac{2D^3}{3\pi} - \frac{\pi}{4} \cdot \frac{2d^3}{3\pi}$$

$$= \frac{D^3}{6} - \frac{d^3}{6}$$

$$= \frac{D^3}{6}\left[1 - \left(\frac{d}{D}\right)^3\right]$$

$$\therefore S = \frac{Z_p}{Z_e} = \frac{\frac{D^3}{6}\left[1 - \left(\frac{d}{D}\right)^3\right]}{\frac{\pi}{32} D^3\left[1 - \left(\frac{d}{D}\right)^4\right]} = \frac{16}{3\pi}\left[\frac{1 - k^3}{1 - k^4}\right]$$

$$\boxed{S_{⓪} = \frac{16}{3\pi}\left[\frac{1 - k^3}{1 - k^4}\right]} \quad \text{where } k = \frac{d}{D}$$

6(a) (i)

7

Principles of ISO 9000 →

i) Customer focus → It includes the present and future needs of customer and techniques to meet them.

ii) Leadership → It is to create and maintain an environment to involve the contribution of all people.

iii) Involvement of people → It improve the product design and production by using new and creative ideas.

iv) Process approach → It is to optimum used of resources including labours and the production is efficient

v) Systematic Approach to management → It is to inter relate the different processes to make the product efficient.

Advantages -

i) Increase access to global market

ii) Aquiring new customer.

iii) have a edge over competition.

iv) saving of time, material and effort.

v) aquiring trust of the customer.

vi) Improving overall productivity.

vii) Increase in profit margin.

6 (a) (ii) 10

1 m^3 of finish lime require 1.52 m^3 dry ingredients.

$\therefore$ 15 m^3 of finished lime require $\frac{1.52}{1} \times 15 m^3$ dry ingredient

$= 22.8 m^3$

$\therefore$ Quantity of white lime $= \frac{1}{1+3+6} \times 22.8 = 2.28 m^3$

Quantity of fine agg $= \frac{3}{1+3+6} \times 22.8 = 6.84 m^3$

Quantity of stone Ballast $= \frac{6}{1+3+6} \times 22.8 = 13.68 m^3$

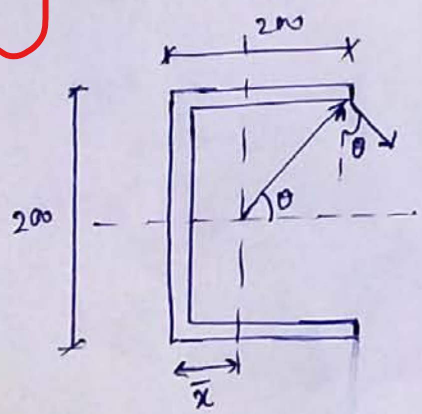
$\therefore$ Total Cost $= 2.28 m^3 \times Rs\ 1000/m^3 + 6.84 m^3 \times Rs\ 1250/m^3 + 13.68 m^3 \times Rs\ 2210/m^3$

$=$ **Rs. 40926.**

6 (b) 16

Size of weld $s = 6$ mm

thickness of weld $t = 0.7s = 0.7 \times 6 = 4.2$ mm



$$\bar{x} = \frac{2 \times (200 \times 4.2) \times 100 + 0}{2 \times (200 \times 4.2) + 200 \times 4.2}$$

$$= 66.67 \text{ mm}$$

$$\therefore \theta = \tan^{-1}\left(\frac{100}{200 - 66.67}\right) = 36.87^\circ$$

$$I_{xx} = \frac{4.2 \times 200^3}{12} + 2\left[\frac{200 \times 4.2^3}{12} + 200 \times 4.2 \times 100^2\right]$$

$$= 19602470 \text{ mm}^4$$

$$I_{yy} = \frac{200 \times 4.2^3}{12} + 200 \times 4.2 \times (66.67)^2$$

$$+ 2\left[\frac{4.2 \times 200^3}{12} + 200 \times 4.2 \times 33.33^2\right]$$

$$= 11201235 \text{ mm}^4$$

$$\therefore I_p = I_{xx} + I_{yy} = 30803705 \text{ mm}^4$$

$$\therefore f_t = \frac{T \cdot r}{I_p} = \frac{P \times (75 + 133.33) \times \sqrt{100^2 + 133.33^2}}{30803705}$$

$$= \frac{P}{887.175} \times 10^3 \text{ N/mm}^2$$

$$= 1.127\, P \text{ N/mm}^2$$

$$f_d = \frac{P \times 10^3}{3 \times (200 \times 4.2)} = 0.3968\, P \text{ N/mm}^2$$

$$\therefore f_R = \sqrt{f_d^2 + f_t^2 + 2 f_d f_t \cos\theta}$$

$$= \sqrt{(0.3968P)^2 + (1.127P)^2 + 2 \times 0.3968P \times 1.127P \cos(36.87)}$$

$$= 1.4639\, P \text{ N/mm}^2$$

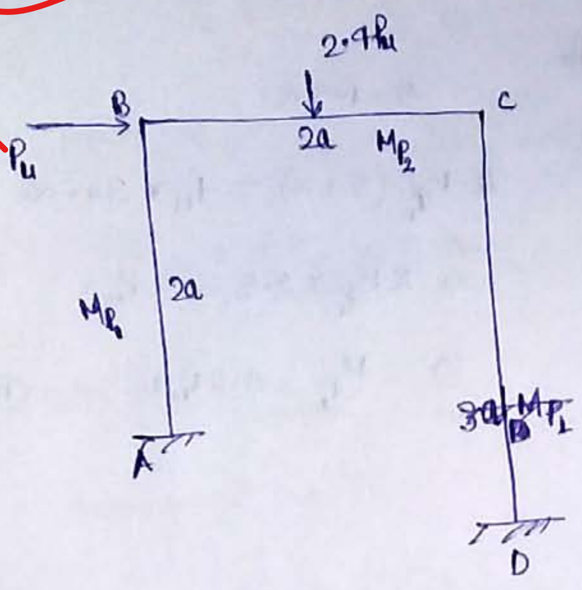
$$\Rightarrow \frac{f_u}{\sqrt{3}\, \gamma_{m1}} = 1.4639\, P$$

$$\Rightarrow \frac{410}{\sqrt{3} \times 1.25} = 1.4639\, P$$

$$\Rightarrow P = 129.36 \text{ KN}$$

$$\therefore \text{Total load} = 2P = 2 \times 129.36 = 258.72 \text{ KN}$$

6(c)



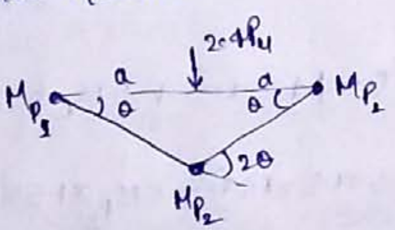
$M_{p_1} < M_{p_2}$

No. of possible hinges = 5.

No of redundant = 3.

∴ No. of mechanism = 3 − 1 = 2

Beam Mechanism.



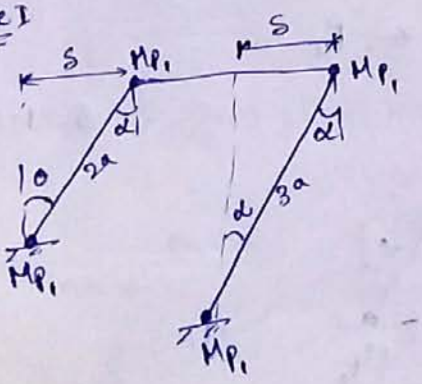
$$M_{p_1} \times \theta + M_{p_2}(2\theta) + M_{p_1}\theta = 2.4 P_u \times a\theta$$

$$\Rightarrow 2M_{p_1} + 2M_{p_2} = 2.4 P_u a$$

$$\Rightarrow M_{p_1} + M_{p_2} = 1.2 P_u a \quad \text{— (I)}$$

Sway mechanism–

Case I



$$\delta = 2a\theta = 3a\alpha$$

$$\Rightarrow \theta = 1.5\alpha$$

$$M_{p_1}\theta + M_{p_1}\theta + M_{p_1}\alpha + M_{p_1}\alpha = P_u \times 2a\theta$$

$$\Rightarrow 2M_{p_1}(\theta + \alpha) = 2P_u a\theta$$

$$\Rightarrow 2M_{p_1} \times 2.5 = 2P_u a \times 1.5$$

$$\Rightarrow M_{p_1} = 0.6 P_u a \quad \text{— (II)}$$

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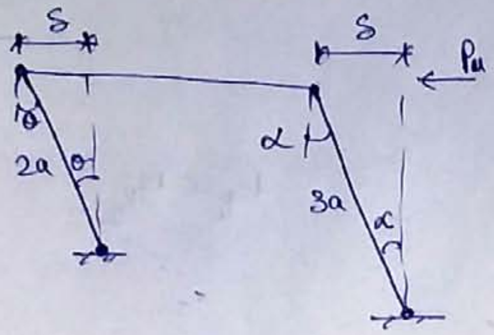
Case II



$\theta = 1.5\alpha$.

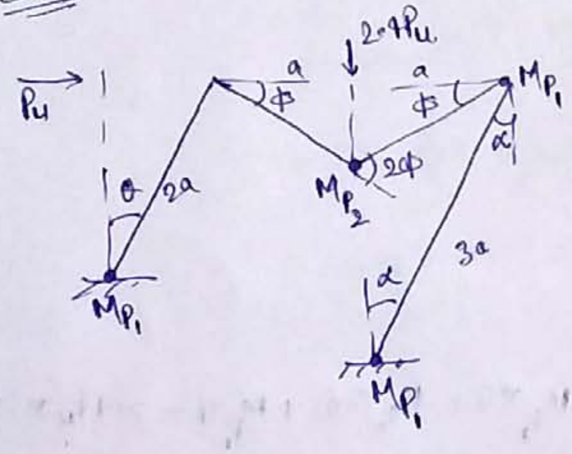
$2M_{p_1}(\theta+\alpha) = P_u \times 3a \cdot \alpha$

$\Rightarrow 2M_{p_1} \times 2.5 = 3P_u a$

$\Rightarrow M_{p_1} = 0.6 P_u a$ — (III)

Combined Mechanism.

Case I



$\phi = \theta = 1.5\alpha$

$\theta = 1.5\alpha$

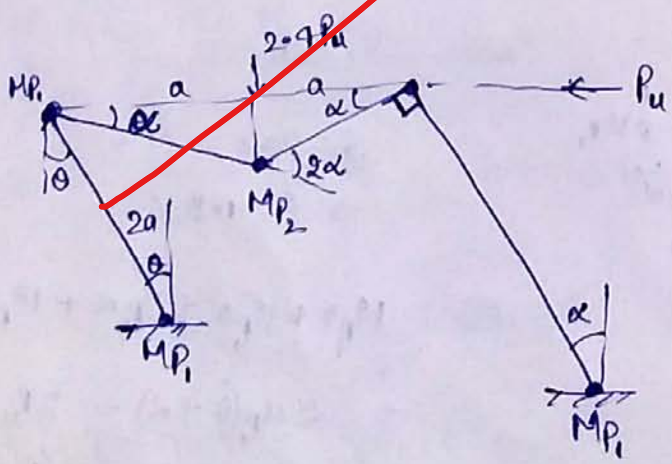
$M_{p_1}\theta + M_{p_2}(2\phi) + M_{p_1}(\phi+\alpha) + M_{p_1}\alpha =$
$2.4P_u a\phi + P_u \cdot 2a\theta$

$\Rightarrow M_{p_1}(\theta+\phi+\alpha+\alpha) + 2M_{p_2}\phi = 2.4P_u a\phi + P_u \cdot 2a\theta$

$\Rightarrow M_{p_1} \times (1.5+1.5+1+1) + 2M_{p_2} \times 1.5 = 2.4P_u a \times 1.5 + P_u \cdot 2a \cdot (1.5)$

$\Rightarrow 5M_{p_1} + 3M_{p_2} = 6.6 P_u a$ — (IV)

Case II



$\theta = 1.5\alpha$

$M_{p_1}\theta + M_{p_1}(\theta+\alpha) + M_{p_2}(2\alpha) + M_{p_1}\alpha = 2.4P_u \cdot a\alpha + P_u.(3a).\alpha$

$\Rightarrow 1.5M_{p_1} + 2.5M_{p_1} + 2M_{p_2} + M_{p_1} = 5.4 P_u a$

$\Rightarrow 5M_{p_1} + 2M_{p_2} = 5.4 P_u a$ — (v)

According to question,

solving (iv) and (v)

$M_{p_1} = \frac{3}{5} P_u a = 0.6 P_u a$

$M_{p_2} = \frac{6}{5} P_u a = 1.2 P_u a$

7(a)

20

$P_u = 1700$ kN.

$f_{ck} = 15$ MPa.

$\therefore$ Bearing strength of Concrete $= 0.45 f_{ck} = 0.45 \times 15 = 6.75$ N/mm²

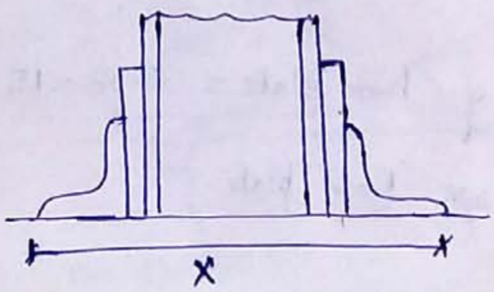
bolt diameter = 24 mm.

$\therefore$ hole diameter $d_o = 24 + 2 = 26$ mm.

pitch distance $= p = 2.5 d_o = 2.5 \times 26 = 65$ mm

edge distance $= e = 1.5 d_o = 1.5 \times 26 = 13$ mm ≈ 15 mm.

Area of base plate required $= \frac{1700 \times 10^3}{6.75}$ mm² $= 251852$ mm²



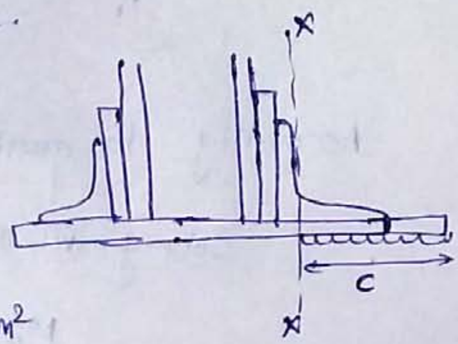
Minimum Length of base plate = 350 + 16 × 2 + 2 × 115

$= 612\ mm$

Width of base plate = $\frac{251852}{612} = 411\ mm$

∴ Provide 650 × 450 mm base plate.

∴ Overhang = $\frac{650-612}{2} = 19\,mm$



Soil pressure = $\frac{1700 \times 1000}{650 \times 450} = 5.81\ N/mm^2$

∴ Moment at critical section x – x

$M = \frac{wc^2}{2}$ where $c = 19 + (115 - 15)$

$= 119\ mm$

$= \frac{5.81 \times 119^2}{2}$ N-mm

$= 41137.7$ N-mm/mm

$M_d = \frac{1.2\, f_y \cdot Z_e}{\gamma_{m0}} = 1.2 \times \frac{250}{1.1} \times \left(\frac{1000}{1000} \times \frac{t^2}{6}\right)$ N-mm/mm

$= 45454\, t^2$ N-mm/mm

∴ $M = M_d$

⇒ $41137.7 = 45.454\, t^2$

⇒ $t = 30.08\ mm$

∴ thickness of base plate = $30.08 - 15 = 15.08\ mm$.

Provide 16 mm base plate.

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Strength of bolt :-

$$V_{dsb} = 0.78 \cdot \frac{\pi}{4} \times 24^2 \times \frac{400}{\sqrt{3} \times 1.25} = 65.19 \text{ kN}$$

$$V_{dpb} = 2.5\, k_b\, d\, t_{min} \cdot \frac{f_{up}}{1.25} = 2.5 \times 0.5 \times 26 \times 11.6 \times \frac{410}{1.25} = 123.656 \text{ kN}$$

∴ Strength of bolt = 65.19 kN.

Assuming 50% of load is taken by bolts

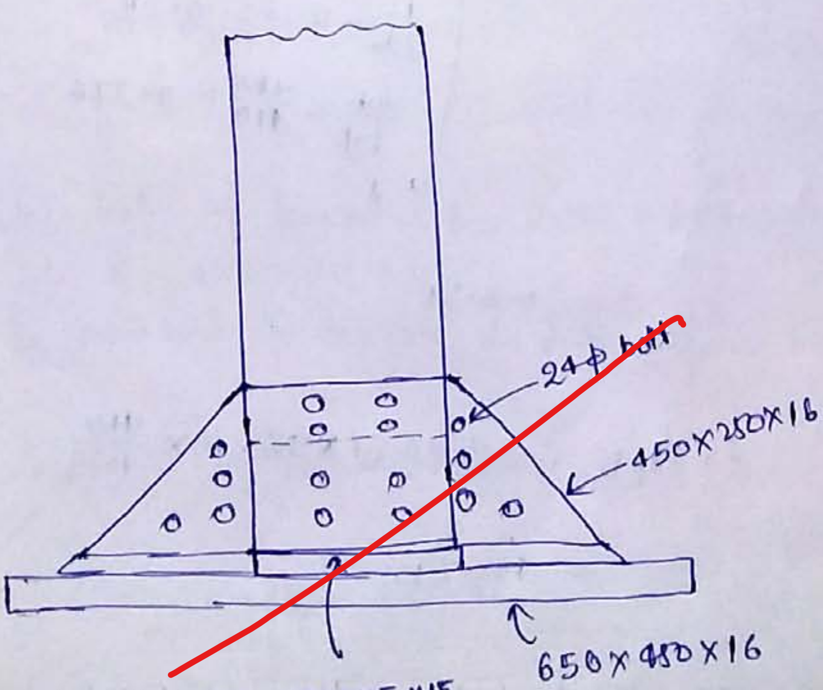
$$\therefore \text{No. of bolts} = \frac{0.5 \times 1700}{65.19} = 13.04 \approx 14 \text{ bolts}$$

Provide 14 bolts on each flange both side

Length of gusset = Length of base plate = 450mm.

Height of gusset base = 150 + 15 + 65 + 15 = 245 mm ≈ 250mm

Provide 250mm × 450mm × 16mm gusset Plate on both sides.



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7(b).

20

Factored load $P_u = 225$ kN.

bolt diameter $d = 24$ mm.

hole diameter $d_0 = 24 + 2 = 26$ mm.

pitch distance $p = 2.5 d_0 = 2.5 \times 24 = 60$ mm.

end distance $e = 1.5 d_0 = 1.5 \times 26 = 39$ mm ≈ 40 mm.

Provide pitch $p = 65$ mm and end distance $= 40$ mm.

strength of bolt —

Shear strength of bolt $V_{dsb} = 0.78 \frac{\pi}{4} d^2 \cdot \frac{f_{ub}}{\sqrt{3} \times 1.25}$

$= 0.78 \times \frac{\pi}{4} \times 24^2 \times \frac{400}{\sqrt{3} \times 1.25}$

$= 65.19$ kN

Bearing strength of bolt $V_{dpb} = 2.5\, k_b\, d\, t_{min} \frac{f_{up}}{1.25}$

$$k_b = \min \begin{cases} \frac{e}{3d_0} = \frac{40}{3 \times 26} = 0.51 \\ \frac{p}{3d_0} - 0.25 = 0.52 \\ \frac{f_{ub}}{f_{up}} = \frac{400}{410} = 0.976 \\ 1 \end{cases}$$

$= 0.51$

$\therefore V_{dpb} = 2.5 \times 0.51 \times 26 \times 10 \times \frac{410}{1.25}$ (Assuming 10mm column flange)

$= 108.7$ kN.

$\therefore$ Strength of bolt $= V_{db} = 65.19$ kN

Tensile strength of bolt = $T_{db} = 0.9 \times \left(0.78 \times \frac{\pi}{4} \times 24^2\right) \times \frac{400}{1.25} < \frac{\pi}{4} \times 24^2 \times \frac{240}{1.1}$

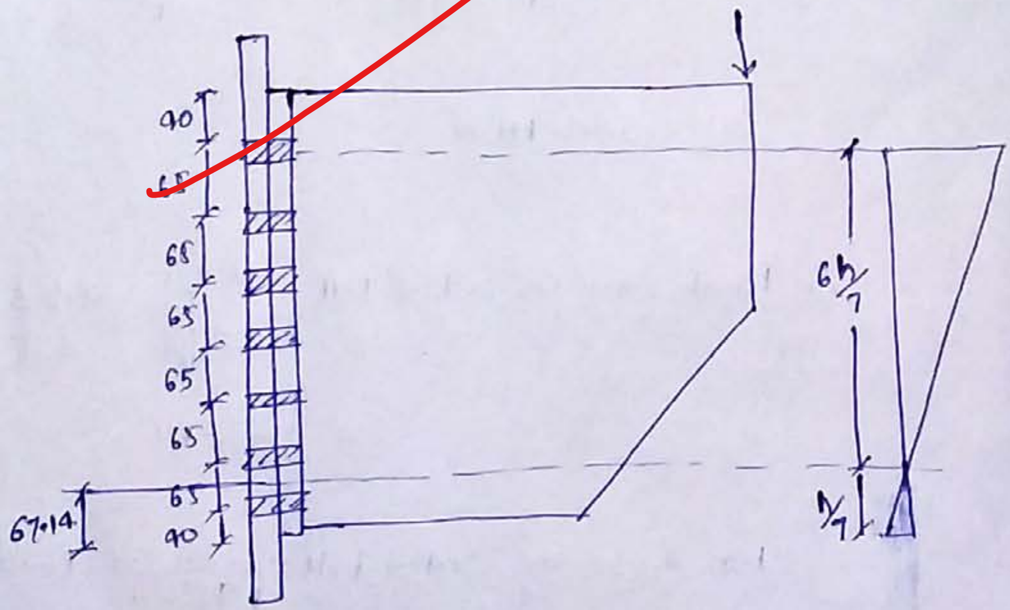
$= 101.62\ kN < 98.7\ kN$ Not ok

$T_{db} = 98.7\ kN$

Moment $M = 225\ kN \times 0.3 = 67.5\ kN\text{-}m$.

Providing 2 vertical line of bolts -

$$n = \sqrt{\frac{6M}{mpV_{db}}} = \sqrt{\frac{6 \times 67.5 \times 10^6}{2 \times 65 \times 65.19 \times 10^3}} = 6.9 \approx 7$$



Total depth of bracket = $h' = 65 \times 6 + 2 \times 40 = 470$ mm

$\therefore\ h = 470 - 40 = 430$.

NA is assumed to lie at $\frac{h}{7}$ distance from bottom.

$\therefore \frac{h}{7} = \frac{436}{7} = 61.42$ mm.

$\therefore \Sigma y_i = [(65+40-61.42) + (2\times65+40-61.42) + (3\times65+40-61.42)$
$+ (4\times65+40-61.42) + (5\times65+40-61.42) + (6\times65+40-61.42)] \times 2$

$= [43.58 + 108.58 + 173.58 + 238.58 + 303.58 + 368.58] \times 2$

$= 1236.48 \times 2$

$\Sigma y_i^2 = [43.58^2 + 108.58^2 + 173.58^2 + 238.58^2 + 303.58^2 + 368.58^2] \times 2$

$= 328751.3 \times 2$

$$\therefore \quad M' = \frac{M}{1 + \frac{2h}{21}\frac{\Sigma y_i}{\Sigma y_i^2}} = \frac{67.5}{1 + \frac{2\times430}{21} \times \frac{1236.48\times2}{328751.3\times2}}$$

$= 58.5$ kN-m.

$\therefore$ Tensile force on critical bolt $= \frac{M\, y_n}{\Sigma y_i^2} = \frac{58.5\times10^3\times368.58}{328751.3\times2}$ KN

$= 32.79$ kN

Shear force on critical bolt $= \frac{225}{7\times2} = 16.07$ kN

Check

$$\left(\frac{V_s}{V_{db}}\right)^2 + \left(\frac{T}{T_{db}}\right)^2 \leq 1$$

$$\Rightarrow \left(\frac{16.07}{65.19}\right)^2 + \left(\frac{32.79}{98.7}\right)^2 \leq 1$$

$\Rightarrow 0.17 \leq 1.$ ok

So, design is safe

7 (c) (i)

Turnkey Contract →

In this, the owner of project hires a contractor and provide him access to the site and help in aquiring the licence related to work. The contractor is only given drawing and specifications. The contractor further hires subcontractors and designate the different works to them. So, there is no interference of owner in the project and overall responsibility of executing the project is on contractor. It is suitable in those department where there is a project involving different branches. like, electrical, mechanical, civil etc. It is generally adopted by Nuclear Power plant, and Petrochemical Industries

Non Turnkey Contract →

In this the contractor perform the work only according to the drawing and specifications provided to him. Almost all the civil engineering projects are involved in non-turnkey contract

7 (c) (ii) Lumpsum - Contract.

In this, the one party of the contract is consent to give a sum of amount to the other party to execute the project. It is adopted for small project because, there is a chance of loss in these type of contract. The owner only provide the drawing and specification and with a fixed sum of money, they provide all the risk and responsibility (related to material, equipments) to the contractor.

7(c)(III) Unit price Contract →

In this, the contractor is paid their money on a unit item basis. The contractor first perform the work in the field with all their labour, equipments etc and then the unit work items are measured in the field and the accumulated price is paid to the contractor. It is the price of the work actually performed and measured in the field. It makes the owner confident and relax that there is no wastage or irregular use of money and the price is as per the unit work performed in field. The contractor also feel themselves more responsible and complete daily task or work very efficiently and regularly. Also, there will be optimum use of resources and time.

7(c)(IV) Item rate Contract :-

It is also called unit price contract or scheduled Contract. The Contractor has to quote the prices of individual items of work on the basis of bill of quantities. The payement is as per the work actually performed in the field. It is adopted by all civil engineering projects.

Merits -

1) Detailed analysis of rate is possible and the payment is on item rate basis so, it is more scientific method.
11) changes in drawing and specification can be done at any time according to the requirements.
111) no urgency to available the drawing.
IV) official may compare the rate quoted by the contractor with the scheduled rate to find the imbalance in tender.

Demerits –

i) Contractor may increase the rate of item whose price is likely to increase and may decrease the rate of item whose price is likely to decrease.

ii) Additional staff are required to measure the work.

iii) Total cost of work is known only after the work is completed. This may create problem of finance.

iv) Intelligent scrutiny is required.

v) Contractor may use inferior quality materials.

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