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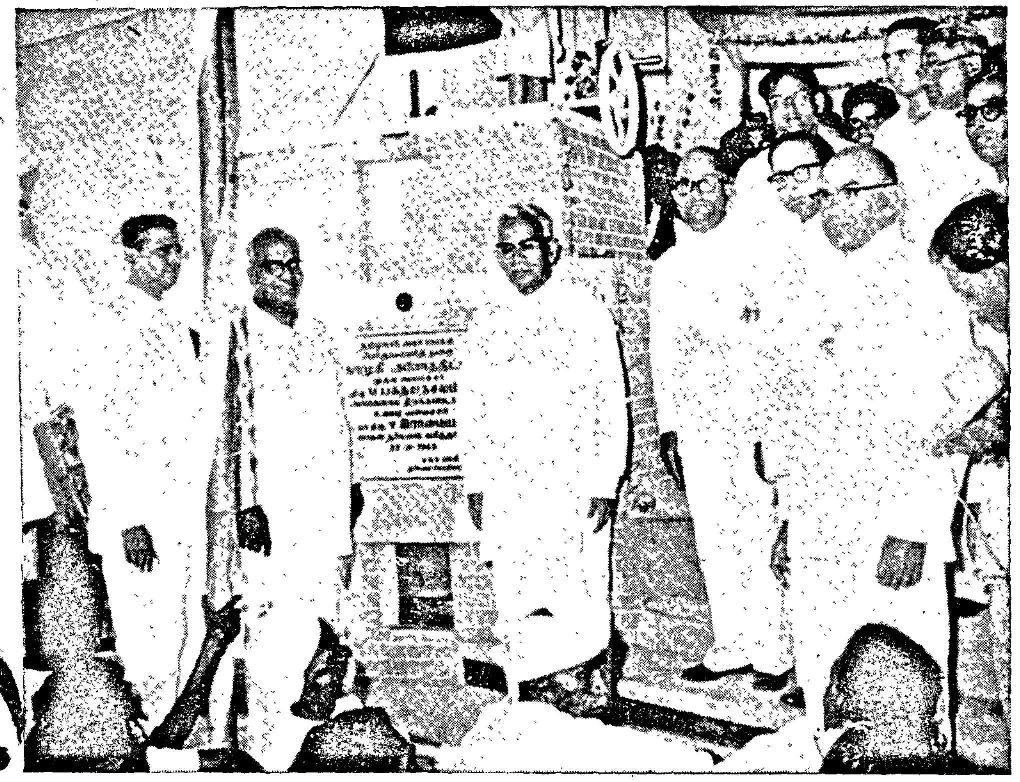
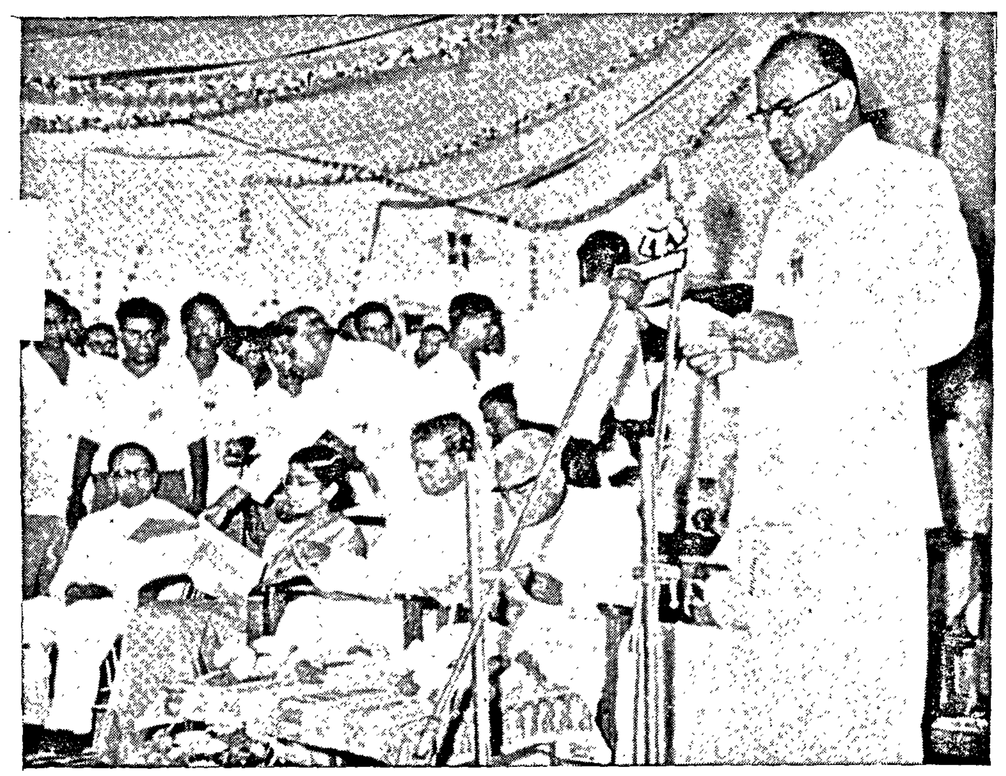
PARAMBIKULAM DAM.



The Hon'ble Chief Minister with others at the inauguration tablet of the Gomukhinadhi Project.



The Chief Engineer (Irrigation) reading the report on the occasion of the Inaugural function of the Gomukhinadhi Project

THE NEW IRRIGATION ERA

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SHORT IMPACT TYPE OF STILLING BASIN

BY

SRI. R. RAMASWAMY, B.E. (HONS.).*
SRI S. SHANMUGAM, B.E., M.SC.†
SRI A. NATHANIEL RAJ, B.E.‡

Synopsis.

The subject of energy dissipation in rear of spillways and sluices in dams is introduced. A few thumb rules which could be evolved as a result of studies conducted over a number of years at the Irrigation Research Station, Poondi are furnished. Non-dimensional plots validating the thumb rules are also furnished.

Introduction.

It is not many years since engineers became confident of dealing with the high velocity flow at toe of dams to make them harmless to the river bed downstream. The most usual form of dealing with the high velocity jet is to convert it into a tranquil stream by means of a hydraulic jump. Normally the tail water level in rear of dams will be much less than what will be required for formation of a good hydraulic jump. It was the usual practice in western countries to depress the apron level so as to obtain the correct sequent depth. The basins were kept of length equal to that of the jump which was 4.5 to 7 times the jump depth D_2—D_1).

Several dams were constructed in this State during the three five-year plans which were medium in heights. With a view to economise, the stilling basins were arbitrarily shortened and made of a shallower depth also. It was found possible to do so with one disadvantage, namely, that there was a hump on the water surface profile.

2. *Development of basin with blocks.*

There came a stage when the idea of using the blocks within the basin was put to test. In practice it was found that these blocks brought about reduction of the height of hump by about 20 per cent. Two rows of blocks were also much favoured the rear row of blocks being placed opposite the clear space between those of the front row.

While such studies were done the Tee blocks were evolved for the case of Lower Bhavani Project. The struts of the Tee blocks were considered desirable for the following purposes:—

(*a*) Physical support to the rectangular blocks,

(*b*) Increasing frictional drag,

(*c*) Resisting cross flow within the basin when isolated spans would be operated.

But later on it was observed that as the blocks and struts were only half the depth of basin the cross flows for isolated operation of spans could not be prevented. It was considered that the rectangular block can be designed as reinforced concrete ones requiring no further support in rear. It was also concluded as the blocks were blunt the friction forces due to the strut were not likely to give substantial increase in resisting forces. As such in later designs only rectangular blocks were adopted.

3. *Thumb rules evolved.*

As a result of number of studies having been conducted a few thumb rules could be evolved for this type of basins with or without rectangular blocks. Of these the most important one is for the depth of the basin (d) for the case of spillways given by $d = \frac{P}{15} + \frac{H}{5}$ where, P is the height of spillway crest above

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stilling basin floor elevation and H is the head of overflow. The non-dimensional plot connecting the depth of basin and Froude number of flow along with designs finalised at this Station will indicate the validity of the thumb rules. (Vide Fig. A.) It was also concluded that basins without blocks had to be of length of about 5.5 to 6 times the depth and basins with blocks needed to be of length of about 3 to 3.5 times the depth. If one row of blocks was adopted the best position was seen to be about 1|3rd length of basin from toe of spillway. It was also concluded that bottom and top corners of the end wall of stilling basin should be square.

All the above general remarks apply equally well to those in rear of river sluices and canal sluices. The thumb rule for the depth of basin is as follows:—

$$d = \frac{H}{15} + \frac{(V\sqrt{h/De})^{\frac{2}{3}}}{10}$$

Where H=fall upto basin floor from M.W.L.
h= fall upto sluice floor from M.W.L.
V= vertical dimension of sluice

$$De = \text{Dispersion} = \frac{\text{Width of stilling basin}}{\text{Width of sluice}}$$

d= depth of basin

The non-dimensional plot for thumb rule for sluices along with the results furnished for some of structures here are given in fig. B.

For sluices at a level higher than the river bed straight glacis of slope 2 hor. to 1 vert. have been found feasible with a R.C. Hood at the exit end of sluice (which is finalised after model experiments) resulting in considerable economy over the conventional parabolic glacis.

4. *Conclusion.*

Eventhough many successful designs have been evolved for spillways and sluices of almost all the dams of this State the theory for designing such basins is yet to be propounded. In conclusion it will be quite pertinent to present a comparison of stilling basins recommended from the Irrigation Research Station, Poondi and those adopted in other places for appreciation of the tremendous economy achieved.

STATEMENT.

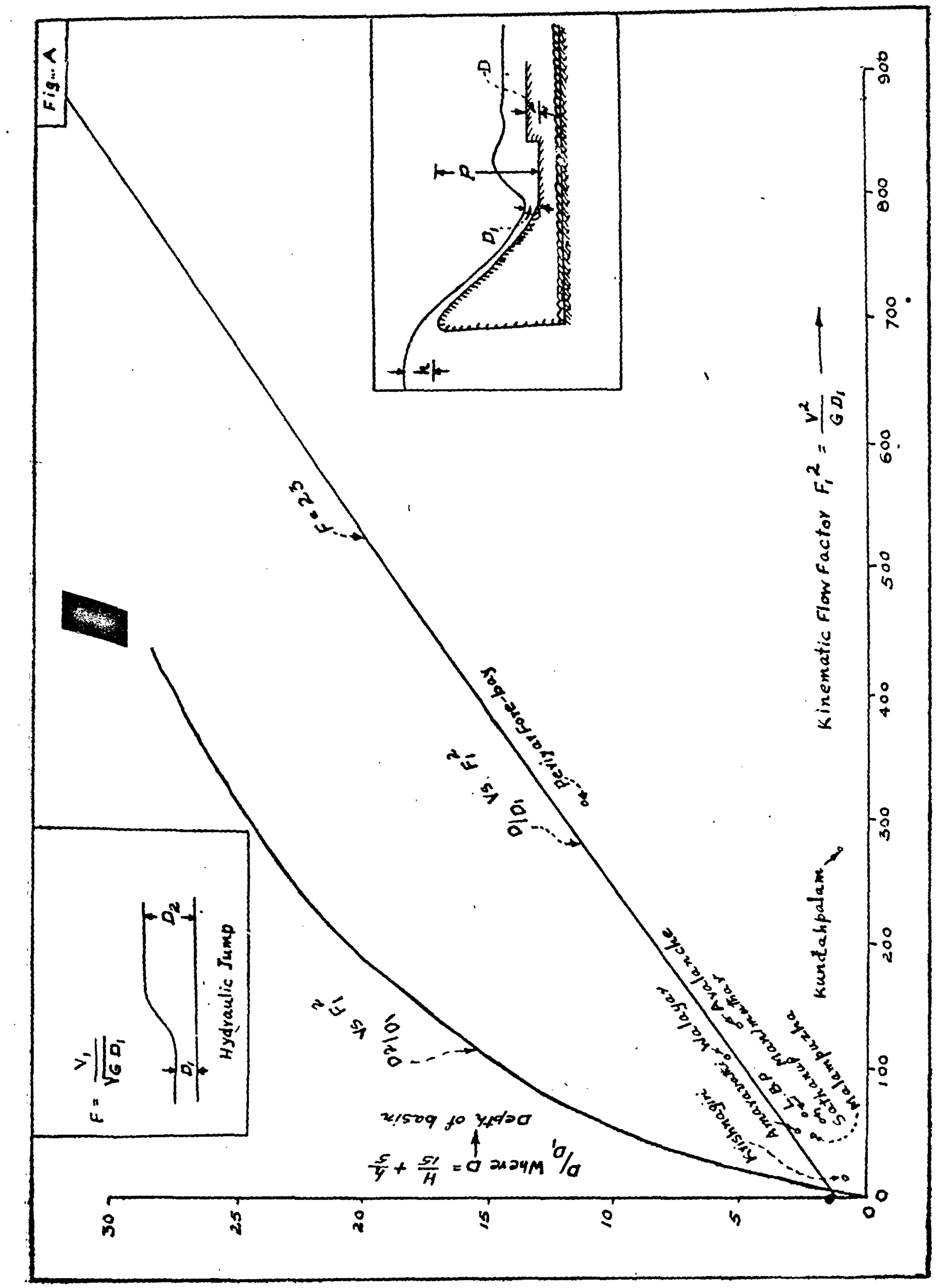
DAMS IN THIS STATE.

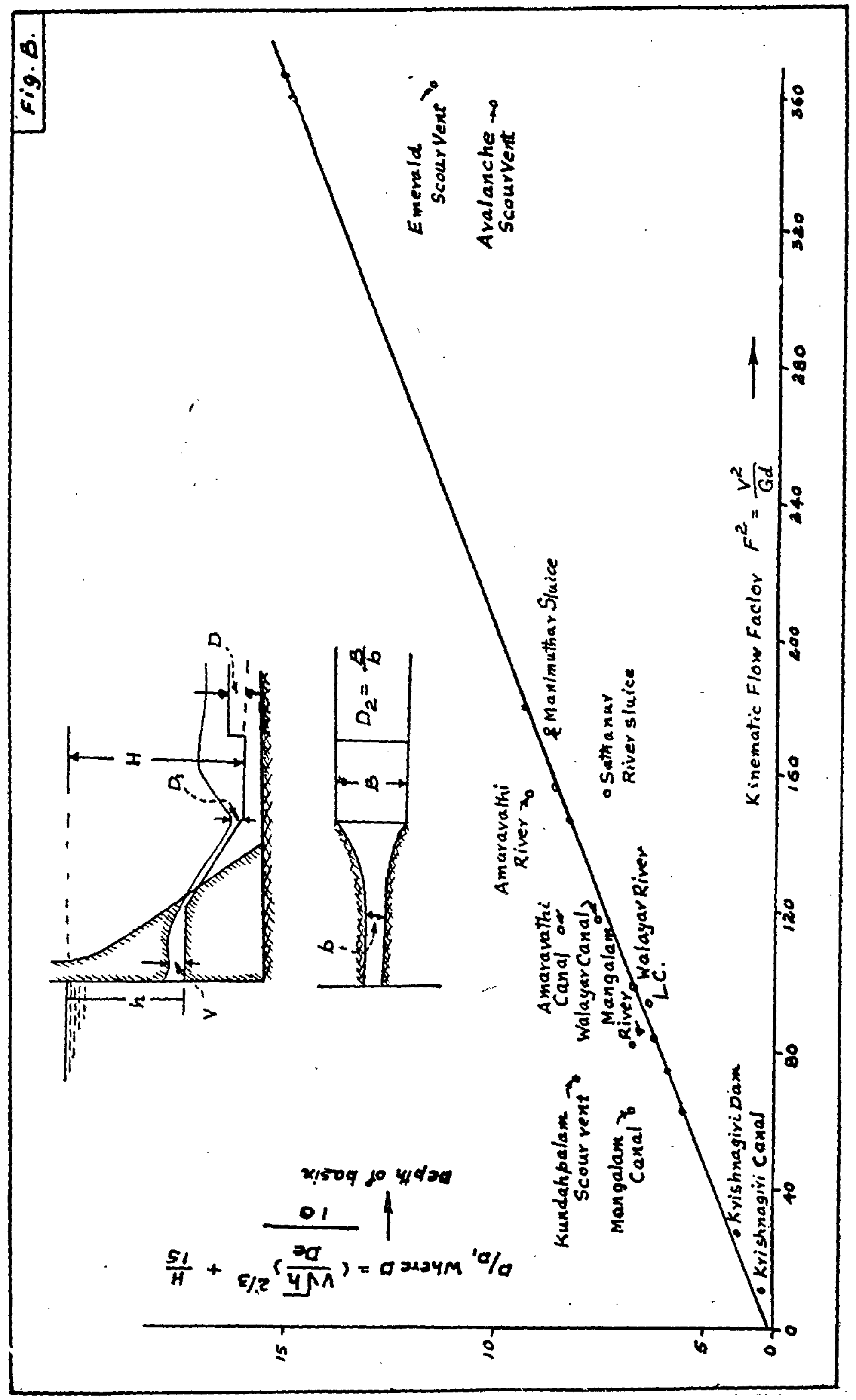
Name.	*Head.*	*Discharge per foot run.*	*Basin.* *Depth.*	*Basin.* *Length.*
(1)	(2)	(3)	(4)	(5)
1 Sathanur ..	131	319	7·00	33·0
2 Walayar ..	82	100	7·00	18·0
3 Manimuthar	131	218	5·0	48·0
4 Lower Bhava-ni.	138	225	10·0	30·0
5 Periyar ..	99	190	7·0	18·0
6 Tungabadra	118	430	10·0	30·4

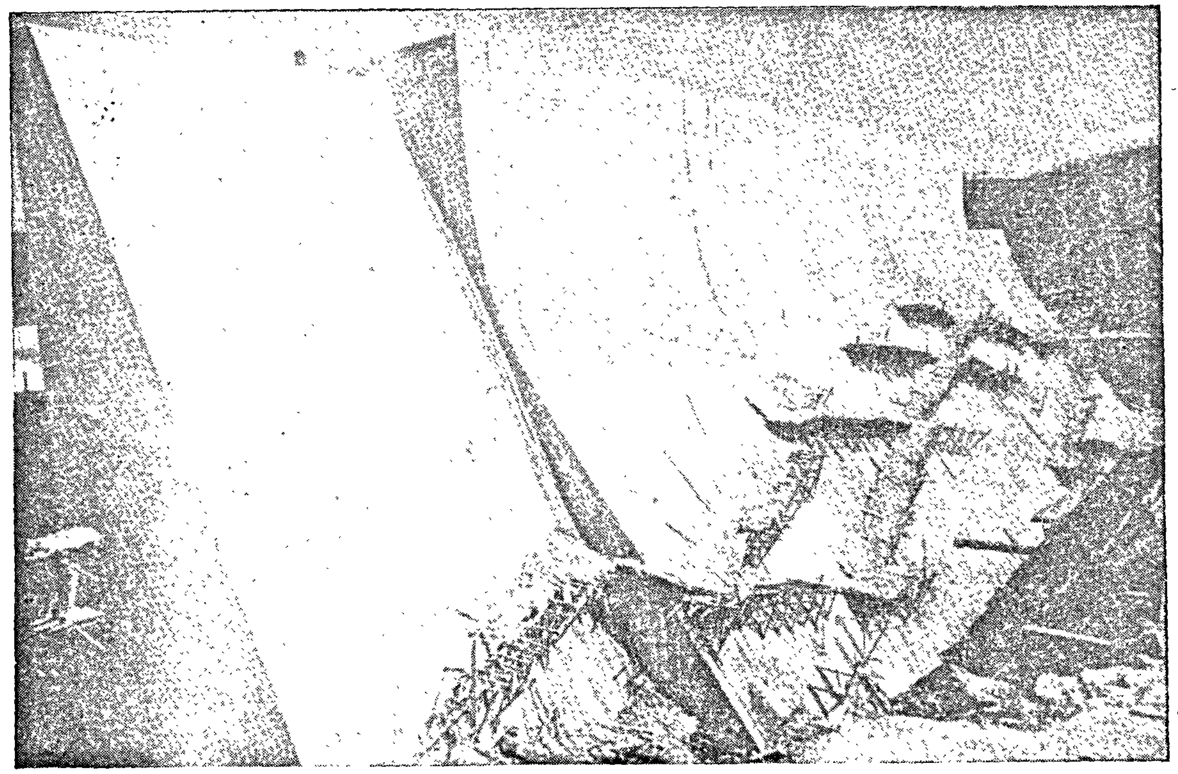
DAMS IN OTHER COUNTRIES.

Name.	*Head.*	*Discharge per foot run.*	*Basin.* *Depth.*	*Basin.* *Length.*
(1)	(2)	(3)	(4)	(5)
Caballo	96	306	6·5	78·0
Bull lake	80	100	4·0	75·0
Pine view	85	225	5·0	96·0
Ageney valley.	106	200	10·0	110·0
Cle Elm	143	200	10·0	108·0
Cedar Bluff.	157	437	9·0	141·0

It is hoped that field officers will co-operate in collecting prototype data regarding the function of this type of basin and furnish them to Irrigation Research Division, Poondi so that they may analyse and this dynamic type of energy dissipation arrangement may be put on a firmer footing.







Rear view of the Sholiar Dam.

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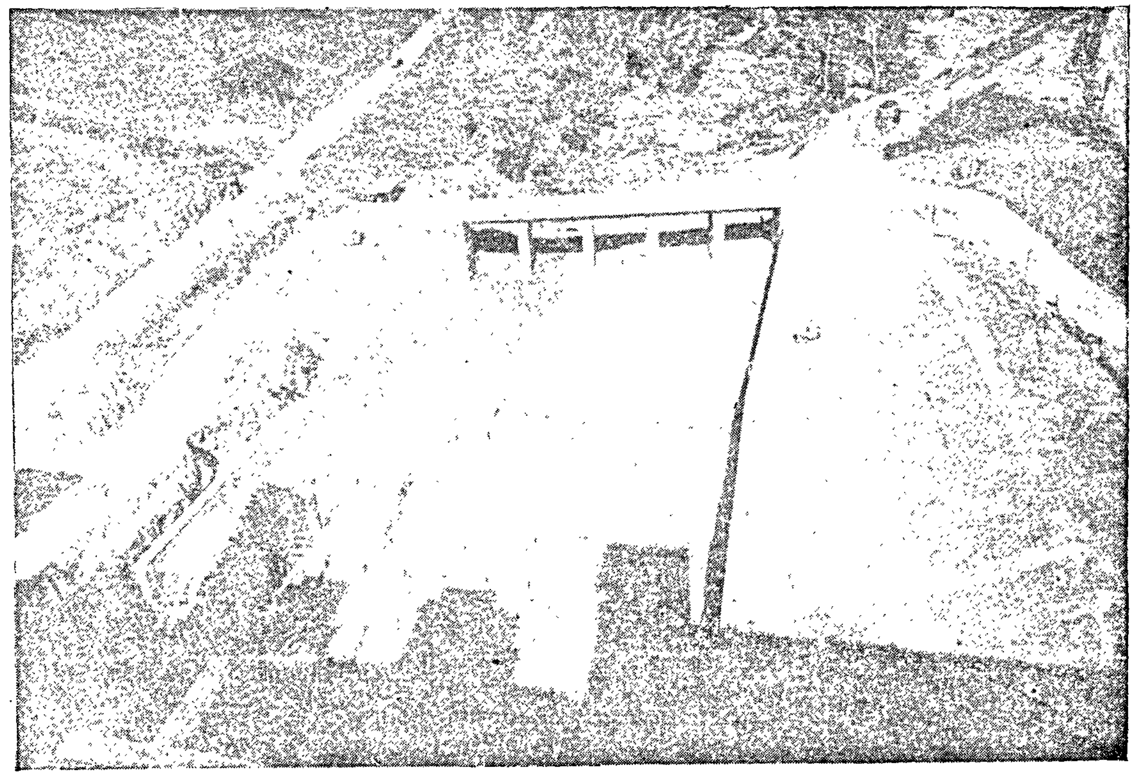
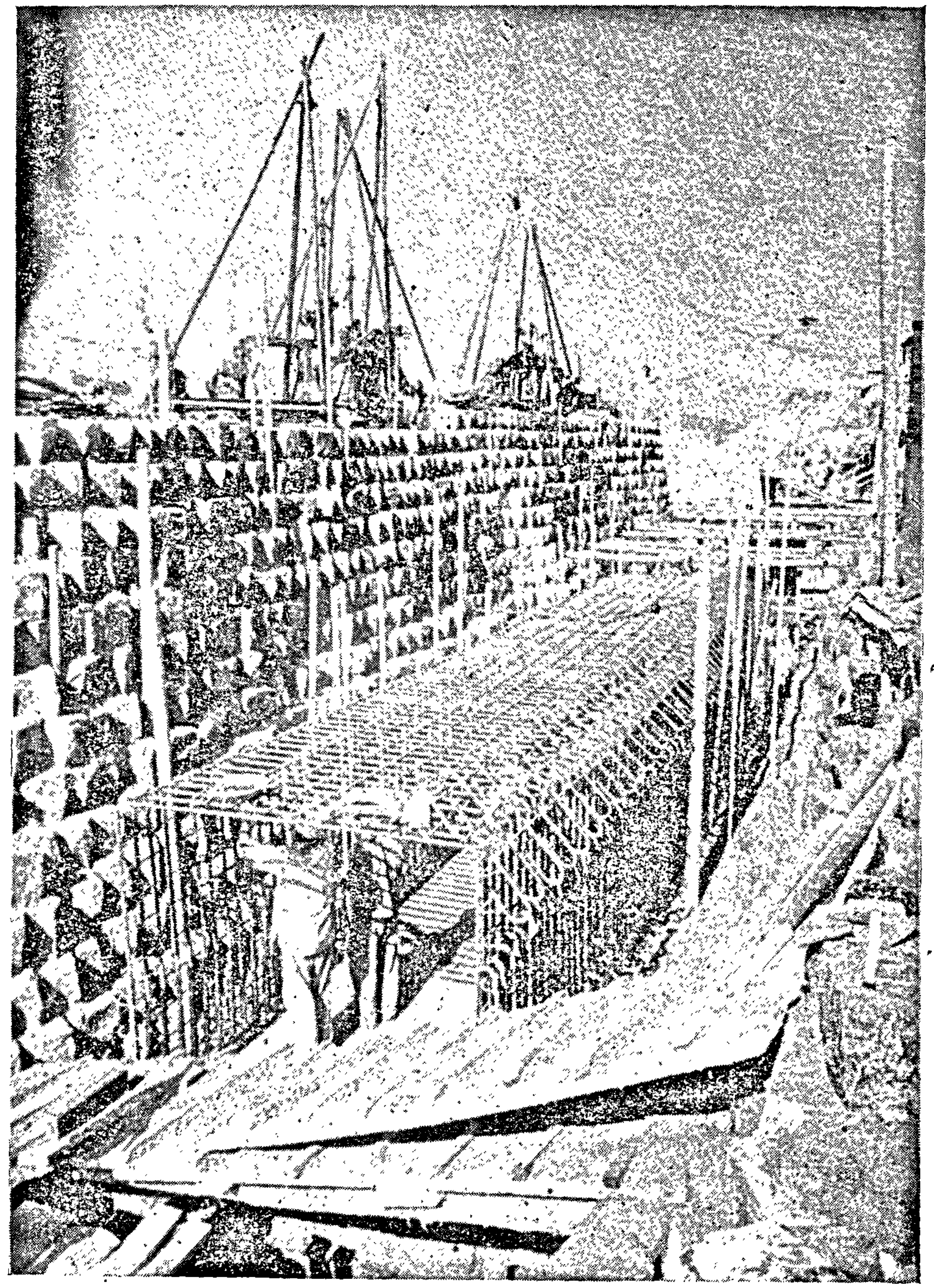


Down stream bridge below Parambikulam Dam.



Reinforcement for the inspection gallery in the Shollar Dam.

NOTE ON DESIGN ASPECT OF REINFORCEMENT AROUND GALLERY (continuation)

BY

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APPENDIX.

PROBLEM.—

To design reinforcement around longitudinal gallery, floor level located at EL 15·00 and the centre line of gallery is at a distance of 20·5 ft. from the axis of the non-spillway section, as shown in the sketch. Top of dam EL. 305·00, maximum water level EL 295·00, and silt level 130·00,

Base width = 217·84 ft.

$\frac{1}{3}$ base width= 72·6137 ft.

$\frac{2}{3}$ base width= 145·2273 ft.

$\frac{1}{2}$ base width= 108·9205 ft.

ASSUMPTION—

Unit weight of masonry = 0·145 kips/Cft.

Unit weight of water = 0·0625 ,,

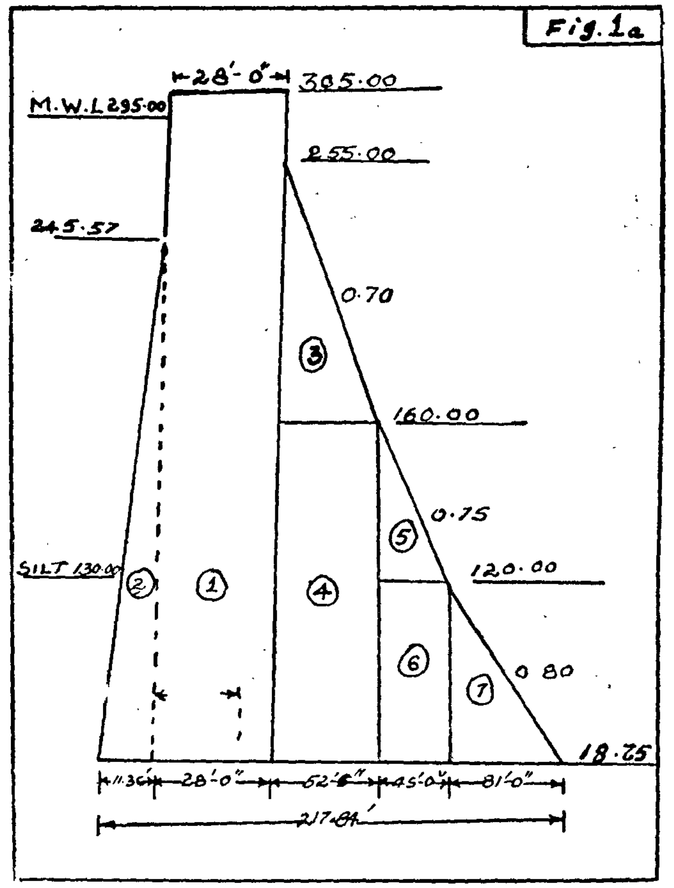
Unit weight of silt = 0·056 ,,

Angle 'ϕ' for silt = 30°

H = Horizontal force in kips.

V = Vertical force in kips.

M = Moment in ft. kips.



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MOMENTS TAKEN ABOUT CENTRE OF BASE.

Number and description of forces.	*H. in kips.*	*V. in kips.* +	*V. in kips.* −	*Lever arm in feet.*	*M. in ft. kips.* +	*M. in ft. kips.* −
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Weight of masonry—						
1. $23 \times 286{\cdot}25 \times 0{\cdot}145$	..	1162	..	83·5795	97160	..
2. $\frac{1}{2} \times 11{\cdot}341 \times 226{\cdot}82 \times 0{\cdot}145$	..	186·4	..	101·3598	18890	..
3. $\frac{1}{2} \times 52{\cdot}5 \times 75 \times 0{\cdot}145$	..	285·6	.	52·0795	14870	..
4. $52{\cdot}5 \times 161{\cdot}25 \times 0{\cdot}145$	..	1228	..	43·3295	53210	..
5. $\frac{1}{2} \times 45 \times 60 \times 0{\cdot}145$	..	195·8	..	2·0795	407·1	..
6. $45 \times 101{\cdot}25 \times 0{\cdot}145$	.	660·6		—5·4205	.	3581
7. $\frac{1}{2} \times 81 \times 101{\cdot}25 \times 0{\cdot}145$	..	894·6	..	—54·9205	.	32660
Reservoir Empty		4313·0			184537·1	36241
	$\Sigma V =$ + 4313·0			+ 34·38	$\Sigma M =$ + 149296·1	
8. *Weight of water—*						
$11{\cdot}341 \times 49{\cdot}43 \times 0{\cdot}0625$	..	35·03	..	103·25	3616	..
$\frac{1}{2} \times 11{\cdot}341 \times 226{\cdot}82 \times 0{\cdot}0625$	..	80·53	..	105·1042	8445	..
9. *Weight of silt—*						
$\frac{1}{2} \times 111{\cdot}25 \times 5{\cdot}563 \times 0{\cdot}056$	..	17·33	..	107·0662	1856	..
10. *Water pressure—*						
$\frac{1}{2} \times 276{\cdot}25^2 \times 0{\cdot}0625$	2385	..	..	92·083	..	219700
11. *Silt pressure—*						
$\frac{1}{2} \times \frac{1}{3} \times 111{\cdot}25^2 \times 0{\cdot}056$	115·5	..	..	37·083	..	4283
Reservoir full without uplift	2500·5	4445.89		—13·90	162213·1	223983
	$\Sigma V =$ + 4445·89				$\Sigma M =$ —61769·9.	

CALCULATION OF STRESSES.

1, *Reservoir empty—*

eccentricity $e = 34{\cdot}38'$, $b = 217{\cdot}841'$

$$\text{Heel stress} = \frac{4313 \times 1000}{217{\cdot}841}\left(1 + \frac{6 \times 34.38}{217{\cdot}841}\right) = +\,38560 \text{ lbs/Sq. ft.}$$

$$\text{Toe stress} = \frac{4313 \times 1000}{217{\cdot}841}\left(1 - \frac{6 \times 34{\cdot}38}{217{\cdot}841}\right) = +\,1047 \text{ lbs/Sq. ft.}$$

2. *Reservoir full without uplift—*

eccentricity $e = 13{\cdot}90'$, $b = 217{\cdot}841'$

$$\text{Heel stress} = \frac{4445{\cdot}89 \times 1000}{217{\cdot}841}\left(1 - \frac{6 \times 13{\cdot}90}{217{\cdot}841}\right) = +\,12600 \text{ lbs/Sq. ft.}$$

$$\text{Toe stress} = \frac{4445{\cdot}89 \times 1000}{217{\cdot}841}\left(1 + \frac{6 \times 13{\cdot}90}{217{\cdot}841}\right) = +\,2830 \text{ lbs/Sq. ft.}$$

Number and Design condition.	$\propto ZU$ [Upstream stress in lbs/Sq. ft.]	$\propto ZD$ [Down stream stress in lbs/Sq. ft.]
1. Reservoir empty	38560	1047
2. Reservoir full without uplift ..	12600	28230

PRINCIPAL STRESS EQUATIONS

(*Vide paragraph* 3·11.)

1. *Reservoir empty—*

1. Normal stress on vertical plans.

$$\propto Z = a + by \qquad \text{when } a = \propto ZD$$

$$b = \frac{\propto Zu - \propto ZD}{T}$$

when T = base width

$$\propto Z = 1047 + \left(\frac{38560 - 1047}{217{\cdot}841}\right) y = \underline{1047 + 172{\cdot}2\,y}$$

2. *Shear stress—*

$Tzy = a_1 + b_1 y + c_1 y^2$ where

$a_1 = TzyD = TzD \tan \phi_D$ where $\tan \phi_D$ = Down stream slope.

$a_1 = 1047 \times 0{\cdot}8 = \underline{837{\cdot}6}$

$$b_1 = \frac{1}{T}\left[\frac{6\,\Sigma V}{T} + 2\,Tzyu + 4\,Tzy\,D\right]$$

$$\Sigma V = 0$$

$Tzyu = (P + Sp - \propto Zu) \tan \phi\, u.$

$(P + Sp) = 0$ as reservoir is empty.

$= -\,38560 \times 0{\cdot}05 = -\,1928$

$$b_1 = \frac{1}{217{\cdot}841}\left[-\,2 \times 1928 + 4 \times 837{\cdot}6\right] = \underline{\underline{2{\cdot}321}}$$

$$c_1 = \frac{1}{T^2}\left[\frac{6\,\Sigma V}{T} + 3\,Tzyu + 3\,TzyD\right]$$

$$= \frac{1}{217{\cdot}841}\left[3 \times -\,1928 + 3 \times 837{\cdot}6\right] = -\,0{\cdot}06893$$

So, $\underline{Tzy = 837{\cdot}6 + 2{\cdot}321\,y - 0{\cdot}06893\,y^2}$

check Put $y = 217{\cdot}841$

then $Tzyu = 837{\cdot}6 + 505{\cdot}6 - 3271 = -\,1927{\cdot}8$ against $-\,1928.$

3. *Normal stress on vertical plane—*

$\propto y = a_2 + b_2 y + c_2 y^2 + d_2 y^3$, where

$a_2 = a_1 \tan \phi\, D + P_1 = 837{\cdot}6 \times 0{\cdot}8 + 0 = \underline{670{\cdot}08}$

$$b_2 = b_1 \tan \phi\, D + \frac{\delta a_1}{\delta z}$$

$$\frac{\delta a_1}{\delta z} = \frac{\delta}{\delta z}\left[\propto ZD - p_1\right] \tan \phi\, D.$$

$$= \frac{\delta}{\delta z} \propto ZD \tan \phi\, D.$$

$$\propto ZD = \frac{\Sigma W}{T} - \frac{6\,\Sigma M}{T^2}$$

$$\frac{\delta}{\delta z} \propto zD = \frac{\delta T}{\delta Z}\left[\frac{-\,\Sigma W}{T^2} + \frac{12\,\Sigma M}{T^3}\right] + \frac{1}{T}\,\frac{\delta}{\delta z}\,\Sigma W - \frac{6}{T^2}\cdot\frac{\delta}{\delta z}\,\Sigma M.$$

$$(1)\quad \frac{\delta \Sigma W}{\delta Z} = \frac{\delta W}{\delta Z} + \frac{\delta WW}{\delta Z} + \frac{\delta Ws}{\delta Z}$$

$$= WcT + P \tan \phi u + Sp \tan \phi u = WcT + O + O$$

$$= WcT = 145 \times 217{\cdot}841$$

$$(2)\quad \frac{\delta M}{\delta Z} = \frac{\Sigma W}{2}\left[\tan \phi_D - \tan \phi_u\right] = 0{\cdot}375\, \Sigma W$$

$$= 0{\cdot}375 \times 4313 \times 1000 = 16{,}17{,}000$$

$$(3)\quad \frac{\delta T}{\delta Z} = \tan \phi\, u + \tan \phi\, D = 0{\cdot}05 + 0{\cdot}8 = 0{\cdot}85$$

$$\frac{\delta}{\delta Z} \propto ZD = 0.85\left[\frac{-43{,}13{,}000}{217{\cdot}841^2} + \frac{12 \times 14{,}82{,}96{,}100}{217{\cdot}841^3}\right]$$

$$+ 145 - \frac{6 \times 16{,}17{,}000}{217{\cdot}841^2}$$

$$= 9{\cdot}605$$

$$\therefore \frac{\delta a_1}{\delta Z} = \frac{\delta}{\delta Z} \propto ZD \quad \tan \phi\, D$$

$$= 9{\cdot}605 \times 0{\cdot}8 = +7{\cdot}684$$

$$b_2 = b_1 \tan \phi\, D + \frac{\delta a_1}{\delta Z} = 7{\cdot}684 + 2{\cdot}321 \times 0{\cdot}8$$

$$= 7{\cdot}684 + 1{\cdot}8568 = +9{\cdot}5408$$

$$\propto Zu = \frac{-\Sigma W}{T} + \frac{6 \Sigma M}{T^2}$$

$$\frac{\delta}{\delta z}(\propto ZU) = \frac{\delta T}{\delta z}\left(-\frac{\Sigma W}{T^2} - \frac{12 \Sigma M}{T^3}\right) + \frac{1}{T}\frac{\delta \Sigma W}{\delta z} + \frac{6}{T^2}\frac{\delta \Sigma M}{\delta z}$$

$$= 0{\cdot}85\,(-90{\cdot}90 - 172{\cdot}2) + 145 + 204{\cdot}5$$

$$= +125{\cdot}865$$

$$-\frac{\delta}{\delta z} T\, zyu = \tan \phi\, u \left(\frac{-\delta \propto Zu}{\delta Z}\right) = -125 - 865 \times 0{\cdot}05$$

$$= 6{\cdot}29325$$

$$\frac{\delta b_1}{\delta z} = \frac{-6}{T^2}\frac{\delta \Sigma v}{\delta z} - \frac{2}{T}\frac{\delta}{\delta z} Tzyu - \frac{4}{T}\frac{\delta}{\delta z} TzyD + \frac{12}{T^3}\Sigma V \frac{\delta T}{\delta z}$$

$$+ \frac{2}{T^2} Tzyu \frac{\delta T}{\delta Z} + \frac{4}{T^2} TzyD \frac{\delta T}{\delta Z}$$

$$= 0 - \frac{2 \times 6{\cdot}29325}{217{\cdot}841} - \frac{4 \times 7{\cdot}684}{217{\cdot}841} + 0 + \frac{2 \times 0{\cdot}85 \times -1928}{217{\cdot}841^2}$$

$$+ \frac{4 \times 0{\cdot}85 \times 837{\cdot}6}{217{\cdot}841^2}$$

$$= -0{\cdot}09237$$

$$\frac{\delta c_1}{\delta Z} = \frac{3}{T^2}\left[\frac{\delta Tzyu}{\delta z} + \frac{\delta TzyD}{\delta z}\right] - \frac{6}{T^3}(Tzyu + TzyD)\frac{\delta T}{\delta Z}$$

$$= \frac{3}{217{\cdot}841^2}\left[-6{\cdot}29325 + 7{\cdot}684\right] - \frac{6}{217{\cdot}841^3}\left[-1928 + 837{\cdot}6\right]^{0{\cdot}85}$$

$$= +0{\cdot}00062584$$

$$C_2 = \tfrac{1}{2}\frac{\delta b_1}{\delta z} + C_1 \tan \phi\, D = \frac{-0{\cdot}09237}{12} + 0{\cdot}8 \times -0{\cdot}06893$$

$$= -0{\cdot}101329$$

$$d = \tfrac{1}{3}\frac{\delta c_1}{\delta z} = \frac{0{\cdot}00062584}{3} = 0{\cdot}000208613$$

so the equation is,

$$\propto y = 670{\cdot}08 + 9{\cdot}5408\, y - 0{\cdot}101329\, y^2 + 0{\cdot}000208613\, y^3$$

Check: Put $y = 217{\cdot}841$

$$\underline{\propto yu = 670{\cdot}08 + 2078 - 4806 + 2156 = +98{\cdot}08}$$

Also $\propto yu = P + sp - Tzyu \tan \phi u$

$$= 0 + 0 - (-1928 \times 0{\cdot}05) = +96{\cdot}4$$

2. RESERVOIR FULL WITHOUT UPLIFT.

(1) *Normal stress on vertical plane*—

$$\propto z = 28230 + \left[\frac{12600 - 28230}{217{\cdot}841}\right] y$$

$$\underline{\propto z = 28230 - 71{\cdot}74\, y}$$

(2) *Shear stress*

$$Tzy = aS + b_1 y + C_1 y^2$$

$$Tzyu = (P + Sp - \propto zu) \tan \phi\, u$$

$$= \left(62{\cdot}5 \times 276{\cdot}25 + \frac{56 \times 111{\cdot}25}{3} - 12600\right) 0{\cdot}05$$

$$= +337{\cdot}35$$

$$TzyD = (\propto zD - p^1) \tan \phi\, D = 28230 \times 0{\cdot}8 = 22584$$

$$a_1 = TzyD = 22584$$

$$b_1 = -\frac{1}{T}\left(\frac{6 \Sigma V}{T} + 2\, Tzyu + 4\, TzyD\right)$$

$$= \frac{-1}{217{\cdot}841}\left(\frac{-6 \times 2500500}{217{\cdot}841} + 2 \times 337{\cdot}35 + 4 \times 22584\right)$$

$$= -101{\cdot}6$$

$$c_1 = \frac{1}{T^2}\left(\frac{6 \Sigma V}{T} + 3\, Tzyu + 3\, TzyD\right)$$

$$= \frac{1}{217{\cdot}841^2}\left(\frac{-6 \times 2500500}{217{\cdot}841} + 3 \times 337{\cdot}35 + 3 \times 22584\right)$$

$$= -0{\cdot}002649$$

So $Tzy = 22584 - 101{\cdot}6y - 0{\cdot}002649\, y_2$

Check: Put $y = 217{\cdot}841$

then, $22584 - 22120 - 125{\cdot}7 = 338{\cdot}3$ against $357{\cdot}35$

(3) *Normal stress on vertical plane.*—

$$\propto y = a_2 + b_2 y + c_2 y^2 + d_2 y^3$$

$$a_2 = a_1 \tan\phi D + p^1 = 22584 \times 0{\cdot}8 + 0 = +\ \underline{\underline{18067{\cdot}2}}$$

$$b_2 = b_1 \tan\phi D + \frac{\delta a_1}{\delta z}$$

$$\frac{\delta a_1}{\delta z} = \frac{\delta}{\delta z}\left(\propto ZD - P_1\right) \tan\phi D \text{ (but } P_1 = 0)$$

$$= \frac{\delta}{\delta z}(\propto ZD) \tan\phi D$$

$$\propto ZD = \frac{\Sigma W}{T} - \frac{6\Sigma M}{T^2}$$

$$\frac{\delta}{\delta z} \propto ZD = \frac{\delta T}{\delta z}\left(-\frac{\Sigma W}{T^2} + \frac{12\Sigma M}{T^2} + \frac{1}{T}\frac{\delta\Sigma W}{\delta z} - \frac{6}{T^2}\frac{\delta\Sigma M}{\delta z}\right)$$

(1) $$\frac{\delta\Sigma W}{\delta z} = \frac{\delta W}{\delta Z} + \frac{\delta Ww}{\delta z} + \frac{\delta WS}{\delta z}$$

$$= Wc\,T + p\tan\phi u + Sp.\tan\phi u$$

$$= 145 \times 217{\cdot}841 + \left(62{\cdot}5 \times 276{\cdot}25 + \frac{56 \times 111{\cdot}25}{3}\right) \times 0{\cdot}05$$

$$= 32557{\cdot}35$$

(2) $$\frac{\delta\Sigma M}{\delta z} = \frac{\delta M}{\delta z} + \frac{\delta MW}{\delta z} + \frac{\delta Mp}{\delta z} + \frac{\delta MSP}{\delta z} + \frac{\delta MWS}{\delta z}$$

$$\frac{\delta M}{\delta z} - \frac{\delta W}{\delta z}(\tan\phi D - \tan\phi u) = 0{\cdot}0375 \times \Sigma W$$

$$= 0{\cdot}375 \times 4445890 = +\ 1667000$$

$$\frac{\delta MW}{\delta z} = 0{\cdot}025\ W(2\,TZ - 0{\cdot}05\ z^2)$$

$$= 0{\cdot}025 \times 62{\cdot}5\ (2 \times 217{\cdot}841 \times 276{\cdot}25 - 0{\cdot}05 \times 276{\cdot}25^2)$$

$$= +\ 182100$$

$$\frac{\delta MWS}{\delta z} = 0{\cdot}025 \times 56\ (2 \times 217{\cdot}841 \times 111{\cdot}25 - 0{\cdot}05 \times 111{\cdot}25^2)$$

$$= +\ 66970$$

$$\frac{\delta MP}{\delta z} + \frac{\delta MSP}{\delta z} = -\ 2500500$$

$$\frac{\delta\Sigma M}{\delta z} = 1667000 + 182100 + 66910 - 2500500$$

$$= -584430$$

So, $$\frac{\delta}{\delta z} \propto zD = 0{\cdot}85\left[-\frac{4445890}{217{\cdot}841^2} - \frac{12 \times 61769900}{217{\cdot}841^3}\right] + \frac{32557{\cdot}35}{217{\cdot}841}$$

$$+ \frac{6 \times 584430}{217{\cdot}841^2}$$

$$= +\ 82{\cdot}8$$

$$\frac{\delta a_1}{\delta z} = 82{\cdot}8 \times 0{\cdot}8 = +\ \underline{\underline{66{\cdot}24}}$$

$$\frac{\delta \propto zu}{\delta z} = \frac{\delta T}{\delta z}\left[-\frac{\Sigma W}{T^2} - \frac{12\Sigma W}{T^3}\right] + \frac{1}{T}\frac{\delta\Sigma W}{\delta z} + \frac{6}{T^2}\frac{\delta\Sigma M}{\delta z}$$

$$= 0{\cdot}85\left[-\frac{4445890}{217{\cdot}841^2} + \frac{12 \times 61769900}{217{\cdot}841^3}\right] + \frac{32557{\cdot}35}{217{\cdot}841}$$

$$- \frac{6 \times 584430}{217{\cdot}841^2}$$

$$= +\ \underline{56{\cdot}91}$$

$$\frac{\delta\,Tzyu}{\delta z} = \left[\frac{\delta P}{\delta z} + \frac{\delta SP}{\delta z} - \frac{\delta \propto zu}{\delta z}\right]\tan\phi u$$

$$= 0{\cdot}05\left(62{\cdot}5 + \frac{56}{3} - 56{\cdot}91\right) = \underline{1{\cdot}213}$$

$$\frac{\delta b1}{\delta z} = \frac{-6}{T^2}\frac{\delta\Sigma V}{\delta z} - \frac{2}{T}\frac{\delta\,Tzy\,u}{\delta z} - \frac{4}{T}\frac{\delta\,Tzy\,D}{\delta z} + \frac{12}{T^3}\Sigma V\frac{\delta T}{\delta z}$$

$$+ \frac{2}{T^2}Tzy\,u\frac{\delta T}{\delta z} + \frac{4}{T^2} + Tzy\,D\frac{\delta T}{\delta z}$$

$$= \frac{6 \times 19347}{217{\cdot}841^2} - \frac{2 \times 1{\cdot}213}{217{\cdot}841} - \frac{4 \times 66{\cdot}24}{217{\cdot}841} - \frac{12 \times 0{\cdot}85 \times 2500500}{217{\cdot}841^3}$$

$$\frac{2 \times 0{\cdot}85 \times 337{\cdot}35}{217{\cdot}841^2} + \frac{4 \times 0{\cdot}85 \times 22584}{217{\cdot}841^2}$$

$$= +\ \underline{\underline{0{\cdot}38095}}$$

$$\frac{\delta C_1}{\delta z} = \frac{6}{T^3}\frac{\delta\Sigma V}{\delta z} - \frac{18}{T^4}\Sigma V\frac{\delta T}{\delta z} + \frac{3}{T^2}\left(\frac{\delta\,Tzy\,u}{\delta z} + \frac{\delta\,Tzy\,D}{\delta z}\right)$$

$$- \frac{6}{T^3}\left(Tzy\,u + Tzy\,D\right)\frac{\delta T}{\delta z}$$

$$= \frac{6 \times 19347}{217{\cdot}841^3} + \frac{18 \times 0{\cdot}85 \times 2500500}{217{\cdot}841^4} + \frac{3}{217{\cdot}841^2}\left[1{\cdot}213 + 66{\cdot}24\right]$$

$$- \frac{6}{217{\cdot}841^3}\left(337{\cdot}35 \times 22584\right) \times 0{\cdot}85$$

$$= -\ \underline{0{\cdot}001295}$$

$$a_2 = a_1 \tan\phi D = 18067{\cdot}2$$

$$b_2 = b1 \tan\phi D + \frac{\delta a_1}{\delta z} = -\ 101{\cdot}6 \times 0{\cdot}8 + 66{\cdot}24 = -\ 15{\cdot}04$$

$$c_2 = \tfrac{1}{2}\ \frac{\delta b_1}{\delta z} + c_1 \tan\phi D = \frac{0{\cdot}38095}{2} - 0{\cdot}002649 \times 0.8 = +\ 0{\cdot}1873608$$

$$d_2 = \tfrac{1}{3}\ \frac{\delta c_1}{\delta z} = \frac{-\ 0{\cdot}001295}{3} = 0{\cdot}00043167$$

so the equation is,

$$\propto y = 18067{\cdot}2 - 15{\cdot}04\ y + 0{\cdot}1883608\ y^2 - 0{\cdot}00043167\ y^3$$

check: put $y = 217{\cdot}841$

then, $\propto yu = 18067{\cdot}2\ 3275 + 8939 - 4462 = +\ 19269{\cdot}2$

Also, $\propto yu = P + SP - Tzyu \tan\phi u$

$$= 62{\cdot}5 \times 276{\cdot}25 - \frac{56 \times 111{\cdot}25}{3} - 337{\cdot}35$$

$$= \underline{\underline{19330{\cdot}93}}$$

EQUATIONS.

Reservoir empty.—

$\propto z = 1047 + 172{\cdot}2y$

$Tzy = 837{\cdot}6 + 2{\cdot}321\ y - 0{\cdot}06893\ y^2$

$\propto y = 670{\cdot}08 + 9{\cdot}5408\ y - 0{\cdot}101329\ y^2 + 0{\cdot}000208613\ y^3$

put y = 186′ (centre line of gallery) Then

$\propto z = 33057$, $Tzy = -1114{\cdot}7$, $\propto y = 283{\cdot}08$

Reservoir full without uplift. Equation.—

$\propto z = 28230 - 71{\cdot}74\ y$

$Tzy = 22584 - 101{\cdot}6\ y - 0{\cdot}002649\ y^2$

$\propto y = 18067{\cdot}2 - 15{\cdot}04\ y + 0{\cdot}1883608\ y^2 - 0{\cdot}00043167\ y^3$

put y = 186′, then

$\propto z = 14880$, $Tzy = 3602{\cdot}36$, $\propto y = 19011{\cdot}2$

When y = 186′

Condition.	$\propto z$	$\propto y$	*Tzy.*
1. Reservoir empty	33057	283·08	—1114·7
2. Reservoir full without uplift	14880	19011·2	3602·36

CALCULATION OF PRINCIPAL STRESSES.

No.	*Condition.*	$\propto z$	$\propto y$	Tzy	$\frac{\propto z + \propto y}{2}$	$\frac{\propto z - \propto y}{2}$	$\frac{(\propto z - \propto y)^2}{2}$
1	Reservoir empty ..	33057	283·08	—1114·7	16670·04	16386·96	268600000
2	Reservoir full without uplift.	14880	19011·2	3602·36	16945·6	—2065·6	42700001

No.	*Condition.*	Txy².	$\int\frac{(\propto z - \propto y)^2}{2} + Tzy^2$	$\propto p$	$\propto p_2$	ϕP_1 (Angle) ″
1	Reservoir empty ..	1243000	16430	33100·04	240·04	+1°-54′-17″
2	Reservoir full without uplift.	12970000	4153	12792.6	21098·6	+30°-9′-30″

Calculation of reinforcement.—(Vide Paras 3·7, 3·8 and 3·9)

$\propto P_1 = 33100{\cdot}04$ & $\propto p_2 = 240{\cdot}04$ (Reservoir empty condition)

stress at C D=$3\propto P_1 - \propto p_2 = 3 \times 33100{\cdot}04 - 240{\cdot}04 = 99060{\cdot}08$ lbs/sq. ft.

Allowable compression=67200 lbs.

So excess compression=99060·08—67200=31860·08

So total compression=31860·08 x 1/2×0·4 x 4·5 (Radius of the enveloping circle=4·5″)

=28674·072 lb.

Allowing 16000 lbs./Sq″ stress in steel, compression reinforcement required $= \frac{28674{\cdot}072}{16000} = \underline{1.793\ Sq''}$

Stress at E-f=$3\propto P_2 - \propto P_2 = 3 \times 240{\cdot}04 - 33100{\cdot}04 = 32379{\cdot}92$ (Tension)

Total tension=32379·92 x1/2 x9/4=36420 lbs. (9″ Dia. of circle)

So tensile reinforcement required= $\frac{36420}{16000} = \underline{2{\cdot}277}$ sq. in.

Fig. 1

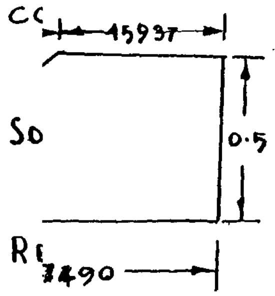
WITHOUT

ˌSERVOIR FULL UPLIFT CONDITIONS.

NO	DISTANCE OUT IN FEET	S DUE TO				Tnt	MAJOR PRINCIPAL STRESS.	MINOR PRINCIPAL STRESS.
		$\propto_y$		$\propto_{2y}$				
		COEFFICIENTS	STRESSES	COEFFICIENT	STRESSES		$\propto P_1$	$\propto P_2$
1.	0′	3·2	0	0	0	0	137490	0
2.	0·5′	1·821984		0·84	3026	11954·2	45937	22337·2
3.	1′	1·440640		0·91	3277	14512·4		

CALCULATION

EXCESS CC



So

R

:OMPRESSION]

Fig. 1

II PHOTO ELASTIC METHOD [VIDE PARA 4.0]

TO DETERMINE STRESSES ALONG J LINE FOR THE FOLLOWING STRESSES OCCURING UNDER RESERVOIR FULL WITHOUT UPLIFT CONDITIONS.

$\alpha_2 = 14880$ $\alpha_y = 19011.2$ $T_{2y} = 3602.36$

No	Distance out in Feet	Stresses due to						α_n	Stresses due to						α_t	Stresses due to						T_{nt}	Major Principal Stress.	Minor Principal Stress.
		α_2		α_y		T_{2y}			α_2		α_y		T_{2y}			α_2		α_y		α_{2y}				
		Coefficient	Stresses	Coefficient	Stresses	Coefficient	Stresses		Coefficient	Stresses	Coefficient	Stresses	Coefficient	Stresses		Coefficient	Stresses	Coefficient	Stresses	Coefficient	Stresses		αP_1	αP_2
1.	0'	3.2	47620	3.4	64650	7.00	25220	137490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	137490	0
2.	0.5'	1.82	27090	-0.05	-9506	1.95	7023	331624	0.26	3870	1.35	25660	1.55	5582	35112	0.05	744.2	0.42	7984	0.84	3026	11954.2	45937	22337.2
3.	1'	1.44	21430	-0.22	-4182	1.29	4646	21894	0.24	3572	1.13	21480	1.46	5259	30311	0.04	595.4	0.56	10640	0.91	3277	14512.4		

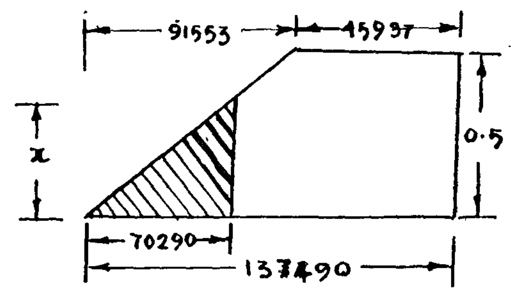
CALCULATION OF COMPRESSIVE RAINFORCEMENT:

EXCESS COMPRESSION ALLOWING 67200 Lbs/Sq.ft. STRESS: 137490 − 67200 = 70290

$$x = \frac{70290 \times 0.5}{91553}$$

SO TOTAL EXCESS COMPRESSION $= \frac{70290}{2} \times \frac{70290 \times 0.5}{91553} = 13490$ LBS.

REQUIRED COMPRESSIVE RAINFORCEMENT $= \frac{13490}{16000} = 0.8431\ \square''$



[AREA OF EXCESSIVE COMPRESSION]

Fig. 2.

TO DETERMINE THE TENSILE STRESS ALONG 'M' LINE FOR THE FOLLOWING STRESSES OCCURING UNDER RESERVOIR EMPTY CONDITIONS.

$\alpha_2 = 33057$ $\alpha_y = 283.08$ $T_{2y} = 1114.7$ Psf.

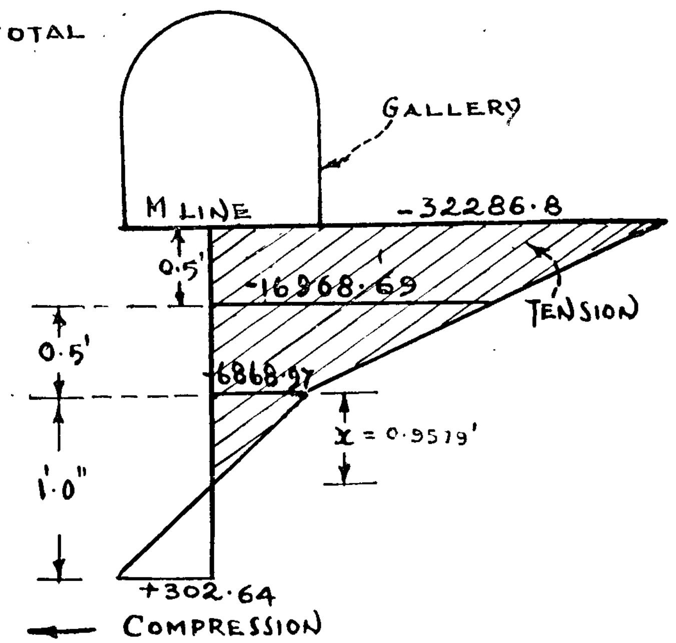
No.	Distance Out In	Stress due to α_2		Stress due to α_y		Stress due to T_{2y}		α_n	Stress due to α_2		Stress due to α_y		Stress due to T_{2y}		α_t	Stress due to α_2		Stress due to α_y		Stress due to T_{2y}		T_{nt}	Major Principal Stresses $\phi\ P_1$	Minor Principal Stresses $\phi\ P_2$
		Coefficient	Stresses	Coefficient	Stresses	Coefficient	Stresses		Coefficient	Stresses	Coefficient	Stresses	Coefficient	Stresses		Coefficient	Stresses	Coefficient	Stresses	Coefficient	Stresses			
1.	0	-1.0	-33057	2.72	770.2	0	0	-32286.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-32286.8	0
2.	0.5'	-0.53	-17520	2.09	591.7	0	0	-16928.3	-0.03	-991.7	0.20	56.62	0	0	-935.08	0	0	0	0	-0.72	802.4	802.4	-16968.69	-894.62
3.	1.0'	-0.22	-7273	1.86	526.6	0	0	-6746.4	0	0	0.27	76.45	0	0	76.45	0	0	0	0	-0.83	925.1	925.1	-6869.97	199.03
4.	2.0'	0	0	1.57	444.5	0	0	444.5	0.21	6942	0.25	70.78	0	0	7012.78	0	0	0	0	-0.88	980.9	980.9	302.64	7154.64

CONSIDERING THE MAJOR PRINCIPAL STRESSES ALONG 'M' LINE FOR UPTO 2'-0" FROM THE GALLERY, THE TOTAL AMOUNT OF TENSION IS CALCULATED AS FOLLOWS:-

$$x = \frac{6868.97}{6868.97 + 302.64} = 0.9579'$$

$$\text{TOTAL TENSION} = \left(\frac{32286.8 + 16968.67 \times 0.5}{2}\right) + \left(\frac{16968.67 + 6868.97 \times 0.5}{2}\right) + \left(\frac{6868.97 \times 0.9579}{2}\right) = 21564 \text{ Lbs.}$$

$\therefore$ REQUIRED STEEL RAINFORCEMENT FOR TENSION $= \frac{21564}{16000} = \underline{1.348}$ Sq. INCHES.



ABSTRACT OF REINFORCEMENT.

Condition.	*Tensile reinforcement in square inch.*	*Compressive reinforcement in square inch.*
RESERVOIR EMPTY—		
1 Equivalent Circle Method	2·277	1·793
2 Photo-Elastic Method ..	1·348	..
RESERVOIR FULL WITHOUT UPLIFT—		
1 Equivalent Circle Method	..	..
2 Photo-Elastic Method ..	..	0·8431

$$\text{Average tensile reinforcement} = \frac{2{\cdot}277 + 1{\cdot}348}{2}$$

$= 1{\cdot}813$ square inch.

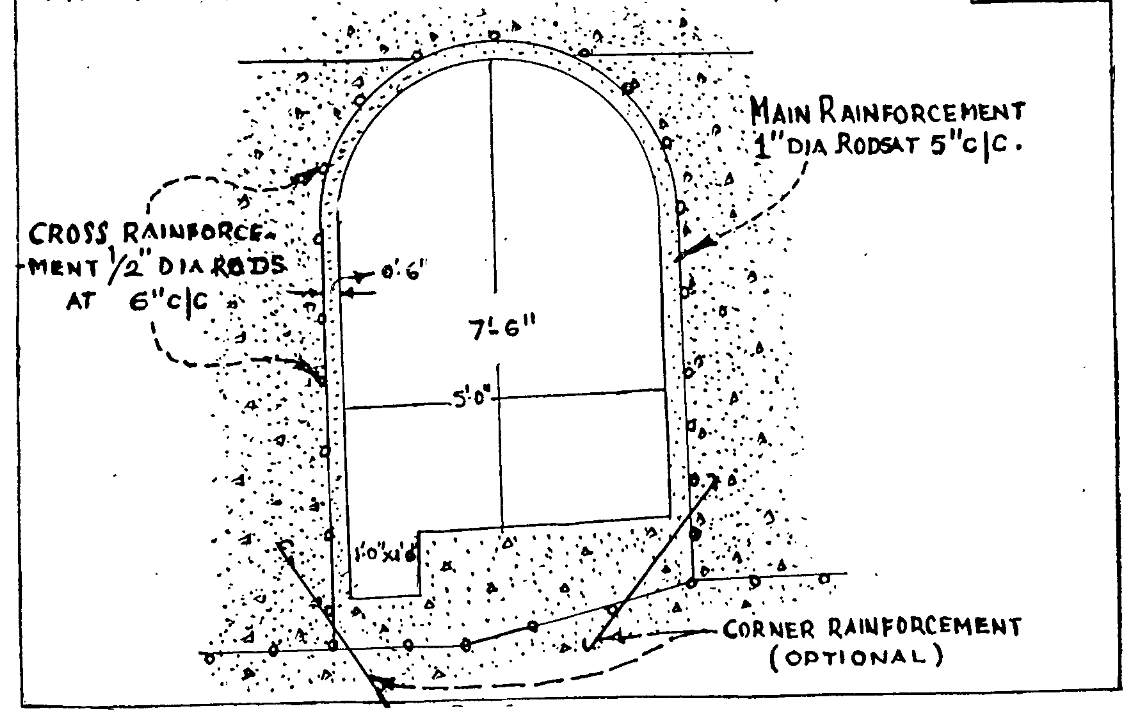
(*Vide* paragraph 5·0)

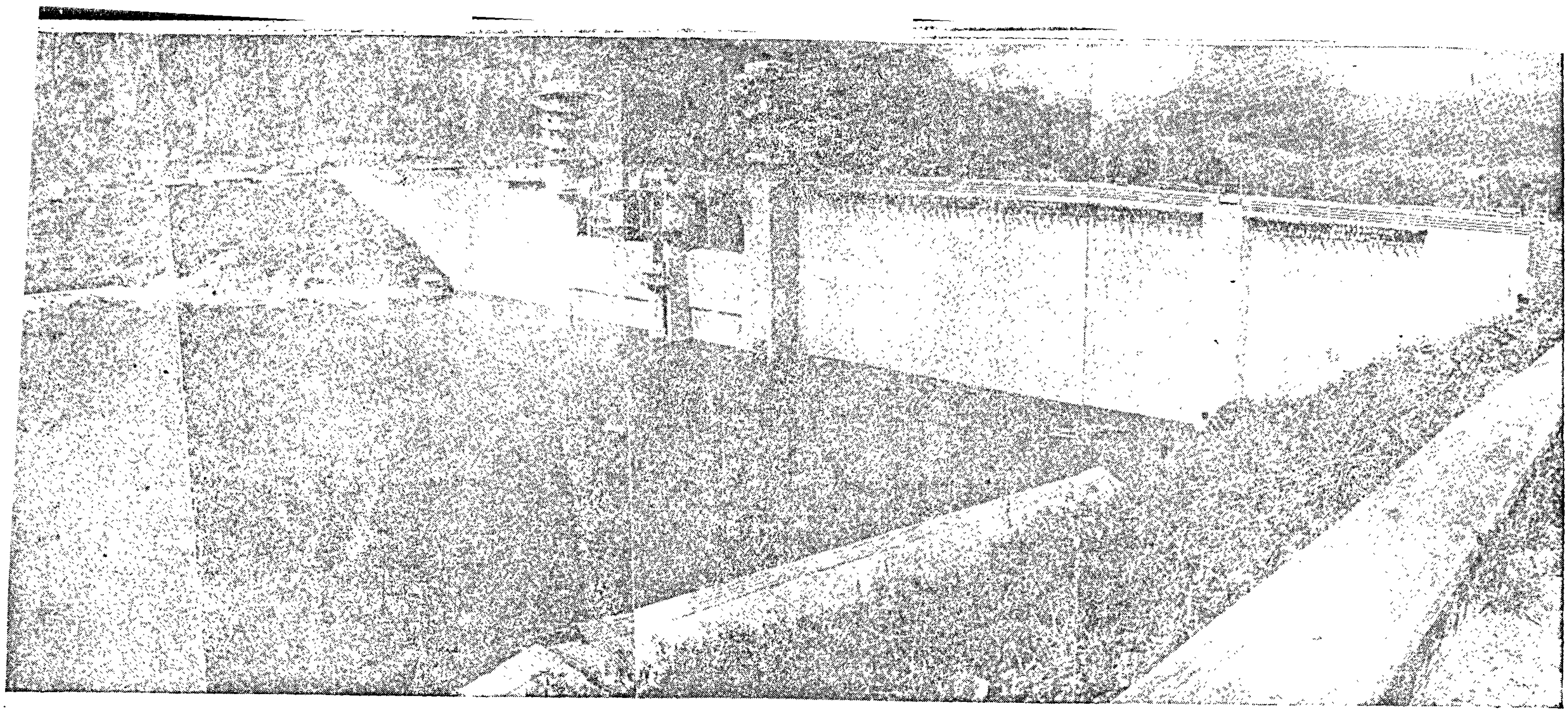
The same reinforcement may be adopted right through, as the maximum compressive reinforcement is also less than 1·813 square inch (viz., 1·793).

i.e., Adopt 1 " ϕ bars @ 5 "c/c as main reinforcement (At = 1·885 square inch.)

Cross reinforcement$= \frac{1{\cdot}885}{5} = 0{\cdot}377$; square inch (*vide* paragraph 5·1). Hence adopt $\frac{1}{2}''$ ϕ rods at 6" c/c (At = 0·393 square inch.)

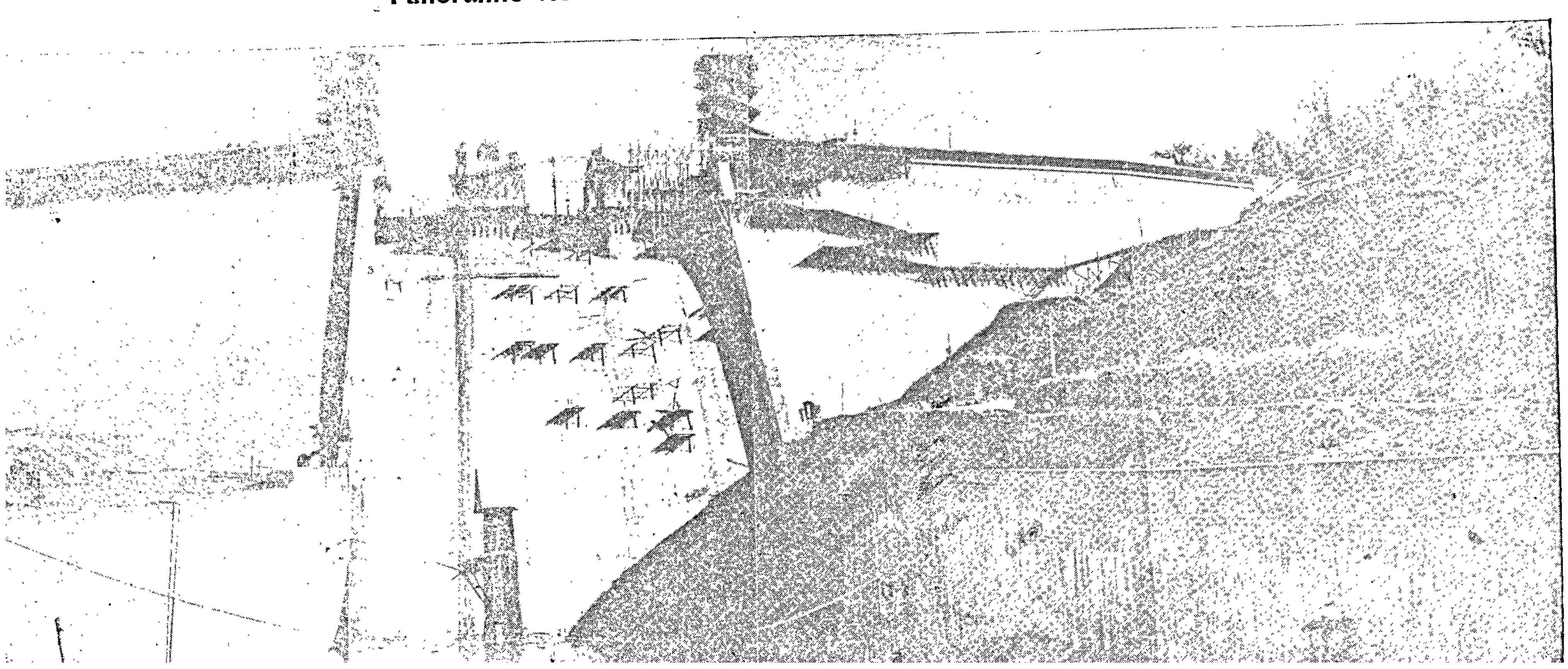
TYPICAL REINFORCEMENT AROUND GALLERY *Fig. 3.*





Panoramic view of the Parambikulam Dam (Front view).

Panoramic view of the Parambikulam Dam (Rear view).



DESIGN CONCEPTS OF COUNTERWEIGHT BEAM FOR CREST GATES

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1.0. *Introduction*

Counterweight beam are generally employed for raising or lowering of spillway gates—vertical lift gates. These are essentially meant for reducing the hoist capacity considerably. These shall be box loaded with convenient ballast of built up steel plates or R.C. beam, which shall be guided throughout its travel in channel grooves. In our State we usually provide R.C. beams only. The gates are normally operated by mechanical means using electrical energy as otherwise it would involve enormous man-hours, causing undesirable delays thereby increasing the probability of damages during floods. The weight of the balance beam is so chosen that hoist capacity is required only to overcome the frictional forces. This article gives a brief note on the forces to be considered in the design of counterbalance beams for wheeled gates.

2.0. *Disadvantages*

Except for a small increase in the height of piers, there is practically no disadvantage in providing a counterweight for vertical lift gates. There is considerable reduction in the capacity of the hoist machinery to be installed which would mean greater economy.

3.0. *Forces on vertical lift gates*

As the weight of the counterbalance beam is influenced by the weight of the gate, it is necessary to find out the forces acting on the gate.

The principal forces affecting the movement of the gate are—

(*a*) Weight of the gate.

(*b*) Horizontal water pressure normal to the gate.

(*c*) Friction forces arising as a result of (*b*) and resisting motion.

(*d*) Unbalanced vertical water pressure.

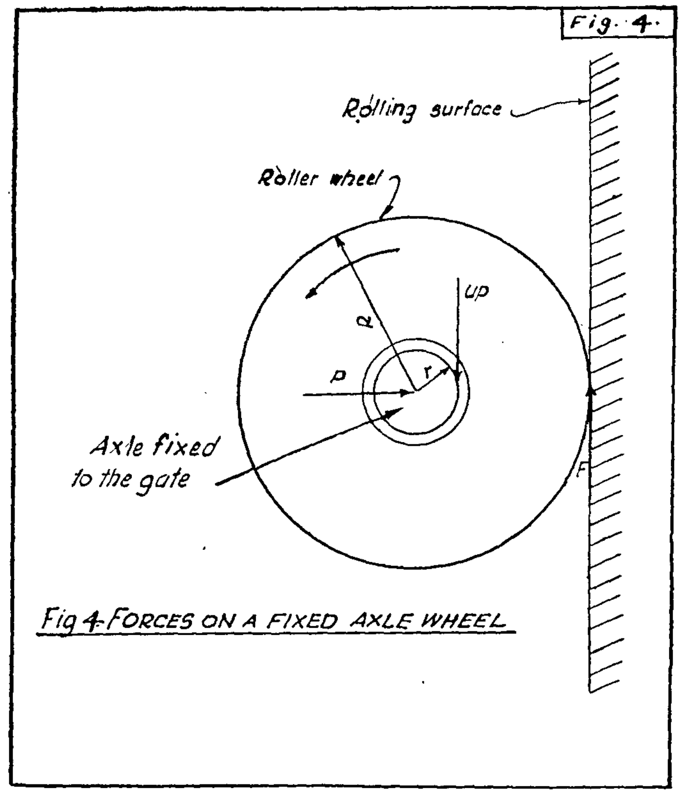

Fig 4-FORCES ON A FIXED AXLE WHEEL

(From Hydro-Electric Engineering Practice —Guthrie Brown. Page 639.)

3.1. Weight of the gate—this includes the weight of chains, rollers, rubber seals, etc., which are attached to the gate.

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3.2. Horizontal water pressure normal to the gate.

Friction forces opposing the movement of the gate.

The water thrust acting on the skin plate is transmitted through axle bearings to wheels that operate on guides. (*Vide* Fig. 5.)

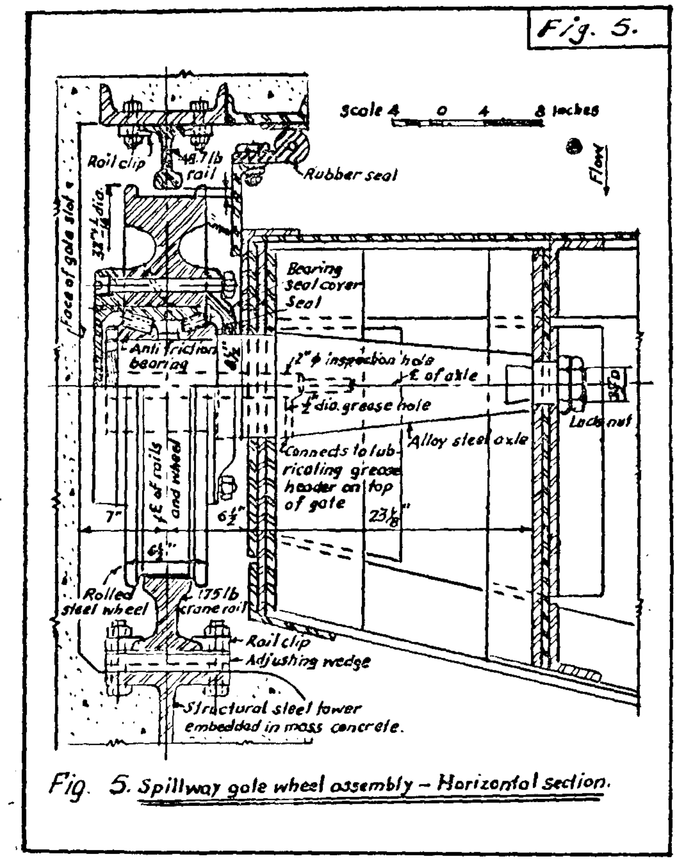


Fig. 5. Spillway gate wheel assembly – Horizontal section.

It may be noted that friction at rest is greater than friction at motion (or) starting friction rather than moving friction determines the operating force.

The starting co-efficient of axle friction, fa with plain axle bearings has a safe value of about 0.3. If the axle has ball bearings, fa will not exceed about 0.01. The starting co-efficient of rolling friction should be taken as 0.003. For very high head gates a moving train of rollers composed of horizontal rollers held in position by shafts bolted into continuous vertical bars on each side, is attached neither to the gate nor the guide, but rolls vertically between the two as the gate is moved. As the rollers transmit the entire load from a bearing strip on the gate to a roller path on the guide, there is no axle friction and only rolling friction is developed.

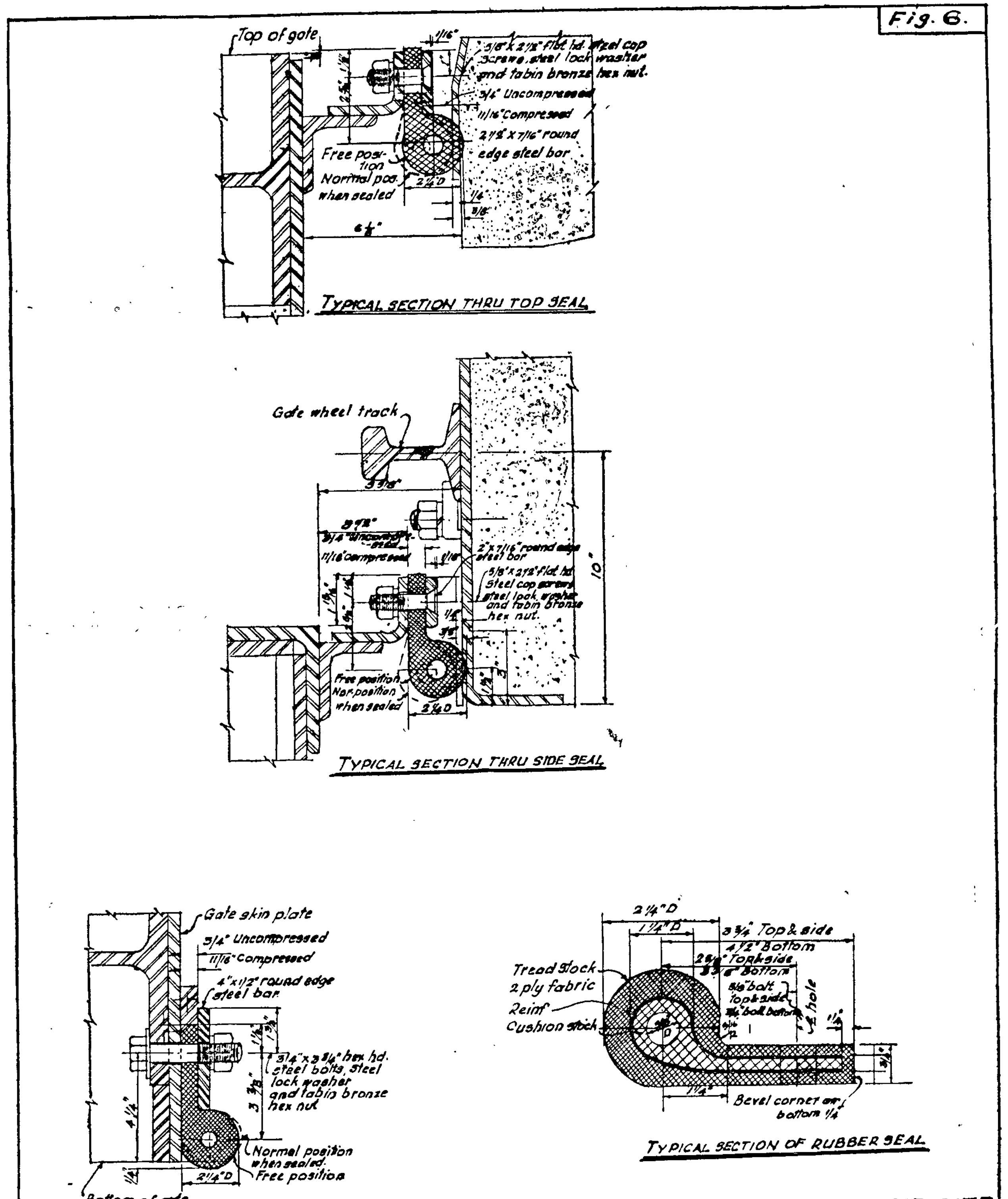
In our State only wheel gates are used for spillway crest gates and it has been customary to adopt only one per cent of horizontal thrust as bearing friction against the adequate 1.3 per cent required. It would have been considerate if the bearing friction is allowed just 50 per cent or so over-load capacity; but this has not been the practice in our State.

3.3. *Sealing friction*

Sealing friction, developed on account of the seals provided at the sides of the gate is also a part of the resisting motion.

Seal friction is dependent on the pressure exerted upon the seal contact and the co-efficient of friction between sealing surfaces. In flexible seals, the force exerted at the seal contact is usually derived from the head water pressure, although mechanical springs have been used to increase the contact pressure. In rubber seals, closure is generally effected close to the head water side of the contact area, and head water pressure should be considered as acting over the entire seal area. The less flexible wooden seal surfaces may have their line of closure at any point in the contact area, and therefore, it is safer to assume for the estimation of seal friction that the head water pressure acts over the entire contact areas. The co-efficient of friction between rubber and smooth metal surfaces is low as long as the contact is lubricated by a thin film of water. In gate seals water is not retained between the contact surfaces and the co-efficient of friction is relatively high. Co-efficients of friction for

Fig. 6.



SEALING DEVICE ON HEAD GATE OF CHICKAMAUGA HYDRO PLANT (TVA)

materials commonly used for seals are given below.

Recommended allowances for K-Co-efficient of static friction for smooth finished dry surfaces—

Steel on steel 0.6.

Steel on cast-iron 0.6.

Steel on bronze 0.45.

Bronze on bronze 0.45.

Wood on metal 1.00.

Wood on wood 1.10.

Rubber on metal 1.10.

However, it is customary in our State to allow 1-ton for sealing friction and it is presumed that this force will never be exceeded under any circumstances.

A typical section of seals is shown in fig. 6.

Fig. 7.

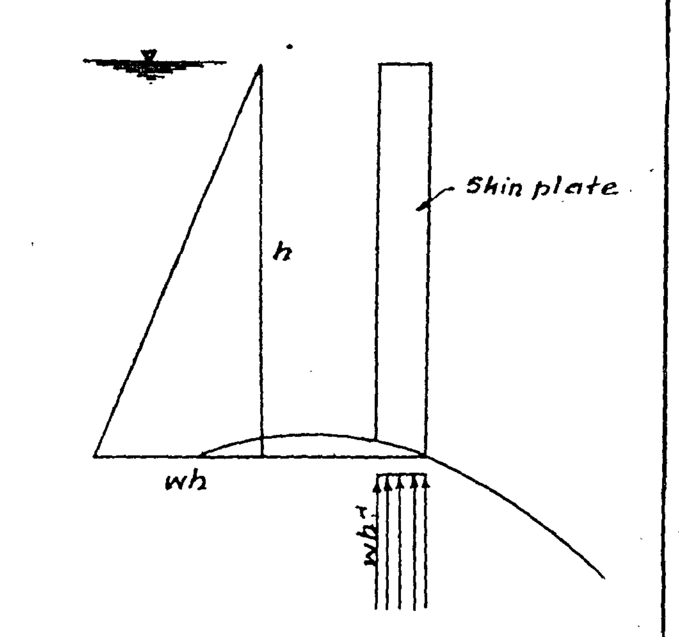


Fig 7.
UPLIFT DIAGRAM

3.4. The unbalanced vertical water pressure in other words called uplift in the present case occurs when the gate is about to close or when the gate is just to open. Assuming effective seal is ensured at the farther end, i.e., down stream side of skin plate, the uplift is considered as acting over the entire contact area with intensity of full head water pressure, i.e., 62.5 (*Vide* Fig. 7.)

4.0. *Nature of forces*

The frictional forces oppose the movement of the gate whereas the uplift pressure, if any, support the movement of the gate when it is raised and oppose when the gate is closed.

5.0. *Design*

Hoist capacity-forces required to operate gates—

The force required to operate roller bearing wheeled gates is given by the following equations. These equations apply directly, however, only where the wheels bear on vertical guides and the pull, F, is also vertical where the guide is at an angle to the direction of pull, the force necessary to lift the gate is equal to F plus P tan X where X is the angle between the pull and the direction of travel.

$$F = \frac{P}{R}(fr + fa\ r) + W$$

Where, F = the force required to raise the gate in lb.
P = the water pressure against the gate in lb
R = radius of wheels in ft.
r = radius of axles in ft.
fr = the co-efficient of rolling friction.
fa = the co-efficient of axle friction.
W = the submerged weight of gate.

$$F_1 = \frac{P}{R}(fr + fa\ r) - W.$$

Where, F_1 = the force required to lower the gate in lbs.

The total force to be over-come by the lifting mechanism is the difference between the force F or F_1 and any counter balance weight. Here it is mainly concerned to find out the optimum counter-balance weight so that hoist capacity is minimum. When the difference between F or F_1 and any counter balance weight is determined, the horse power of the motor can be obtained for a chosen speed of lifting; adequate allowance should be made for the efficiency of the gearing and the maximum friction likely to occur in all moving parts.

So, in determining the size of hoist, the values obtained from the above is multiplied by a factor of safety of 2.

6.0. By giving different values for counter-weights, the forces are computed suitably for arriving at the minimum hoist capacity. While sealing force is the main criterion for fixing the weight of counter-weight there will be two desirable values for counter-weight with minimum positive hoist capacity. Hence, the counter weight beam has to be designed for the lesser weight, which will be used for lowering the gate and the additional weights which can be accomplished in the form of rider weights will be used for raising the gate.

There will be longitudinal lug at the top of the beam throughout its length and corresponding grooves left in the riders so that the rider weights will fit against the beam thus preventing them from falling down. The rider weights are usually of smaller sections so that they can be easily handled by manual labour itself. Sometimes pulley hoists are employed for placing the rider weights over the counter weight beam.

7.0. *Suspension fixtures for counter-weight.*

These consist of two M.S. flats 6 inches by 1 inch at either end of suitable length embeded along the depth of counter weights one being for temporary suspension from the deck bridge and the other for chain suspension (vide Fig. enclosed). These two flats are kept mutually perpendicular. Generally the extreme flats kept at right angles to the axis of counter weight are used for permanent suspension arrangements.

It is necessary to check the adequacy of suspension arrangements. The bond stress allowed is 100 psi and the tensile stress allowed for M.S. flats is 8 T|Sq. in.

8.0. *Conclusion.*

In view of the operation easiness of the hoist machinery and reduction in the running cost, counter balance beams may invariably be provided wherever it is felt needed. A sample calculation of a 36 feet gate for 25 feet head water is appended herewith.

Bibliography.

1. Hydro-electric hand book by William Creager and Joel D. Justin.

2. Hand book of applied Hydraulics by Calvin Victor Davis.

3. Hydro-electric Engineering Practice by Guthrie Brown.

APPENDIX

CALCULATIONS FOR CHOOSING PROPER COUNTER-WEIGHT AND FINDING THE HOIST CAPACITY.

1 *Gate fully closed—*

The gate has to be raised against its own weight W; against a bearing friction due to water pressure taken as 1 per cent of the water pressure, against a sealing friction F acting along the vertical sides due to the rubber seals. There is an uplift force on the bottom of the gate acting upwards equal to the uplift pressure on the bearing area which is a ½" skin plate—36' 0" long.

Weight of gate W = 28 tons
(including chains, rollers, rubber seals, etc.)
sealing friction F = 1 ton (+)
Assumed bearing friction due to water pressure as:

$$1\ \%\ \text{of}\ P = 1/100\ \frac{\times 62{\cdot}5 \times 25{\cdot}252^2 \times 36}{2 \times 2240} = +\ 3{\cdot}203$$
tons.

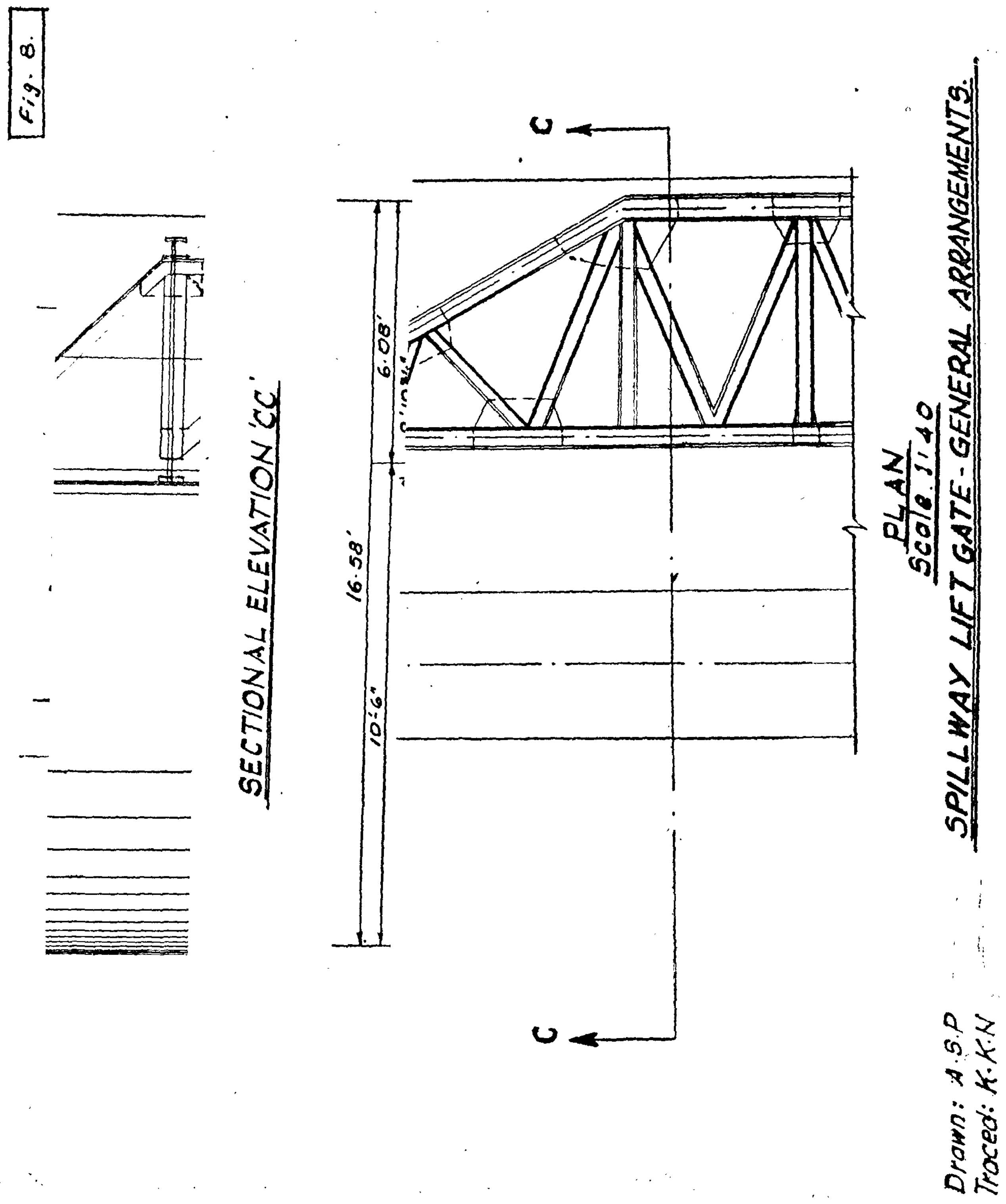
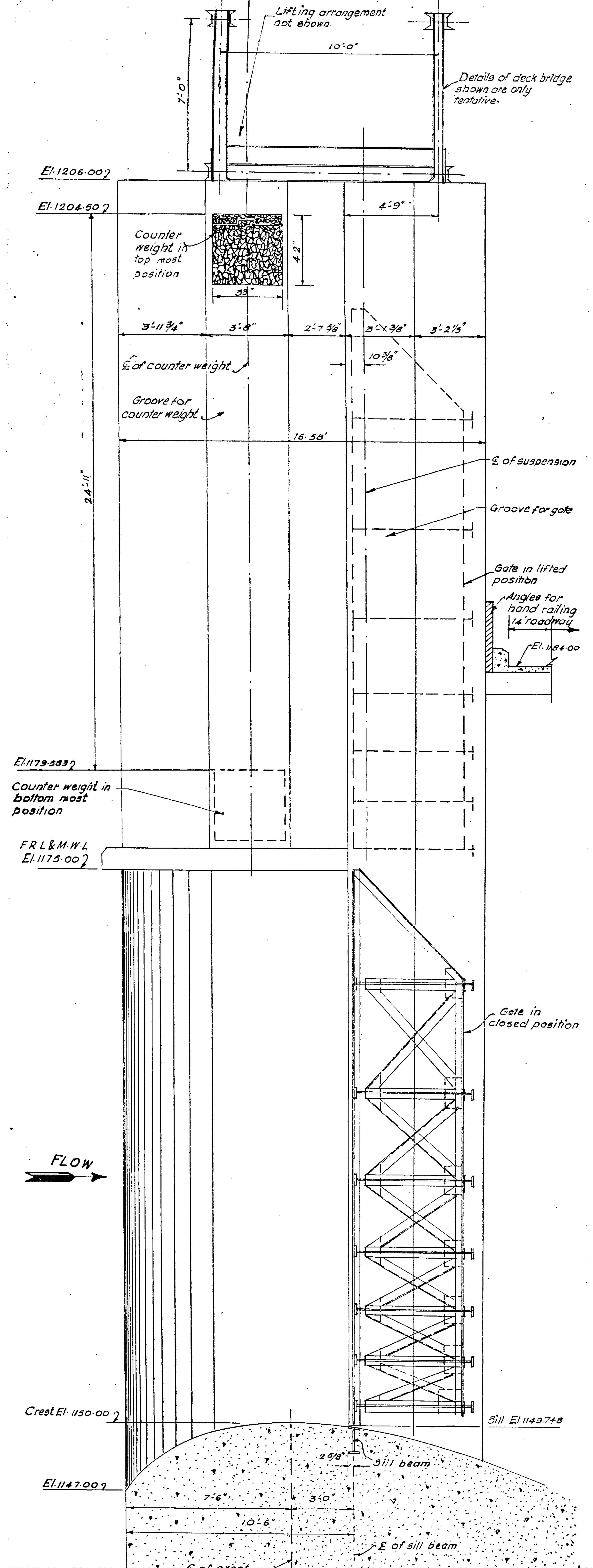
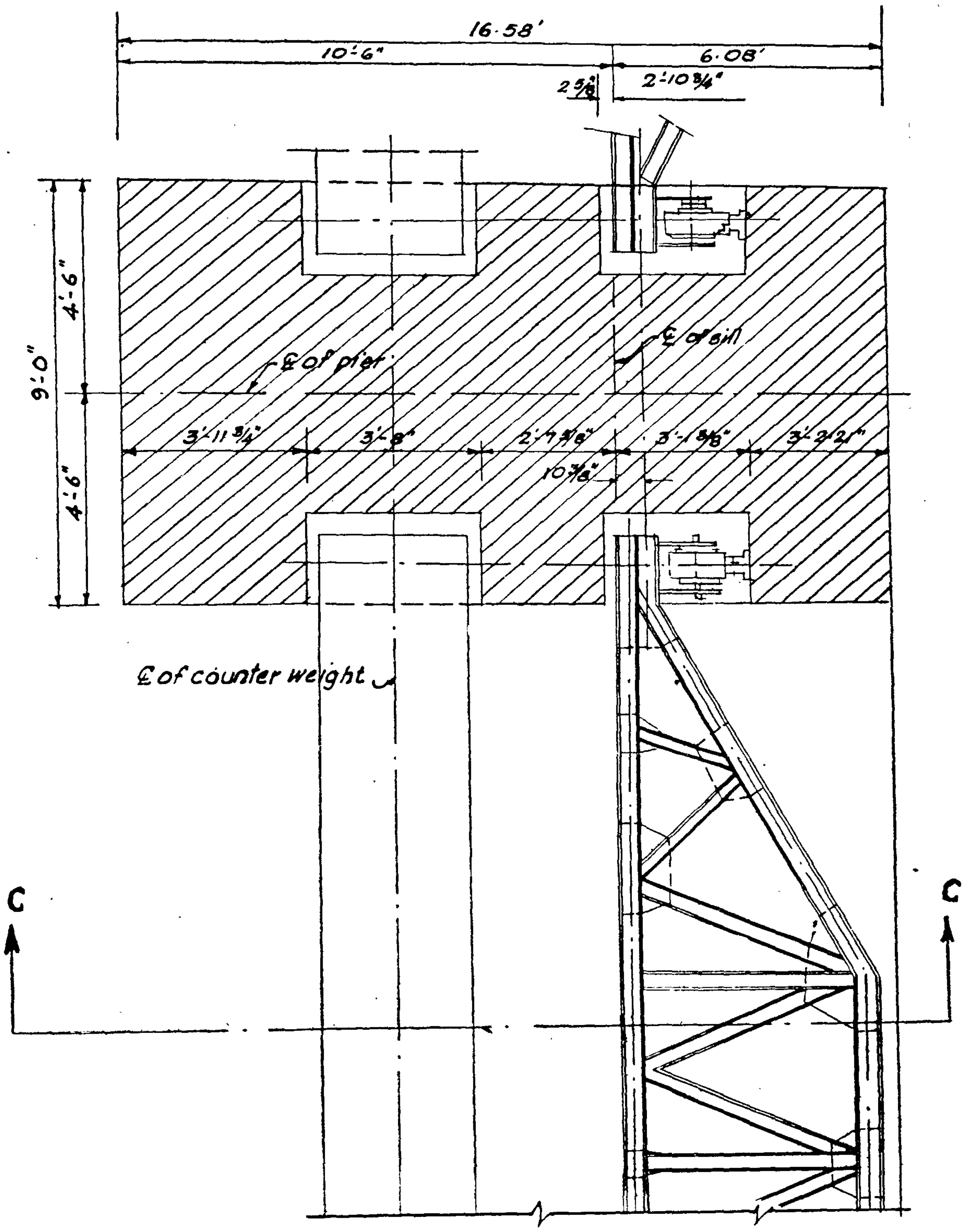


Fig. 8.


Lifting arrangement not shown.
10'-0"
7'-0"
Details of deck bridge shown are only tentative.
El. 1206.00
El. 1204.50
Counter weight in top most position
42"
33"
4'-9"
3'-11 3/4"
3'-8"
2'-7 5/8"
3'-1 3/8"
3'-2 1/3"
10 3/8"
℄ of counter weight
Groove for counter weight
16.58'
℄ of suspension
Groove for gate
Gate in lifted position
Angles for hand railing
14' roadway
El. 1184.00
24'-11"
El. 1179.583
Counter weight in bottom most position
F R L & M.W.L
El. 1175.00
FLOW
Gate in closed position
Crest El. 1150.00
Sill El. 1149.748
2 5/8"
Sill beam
El. 1147.00
7'-6"
3'-0"
10'-6"
℄ of sill beam

SECTIONAL ELEVATION 'CC'

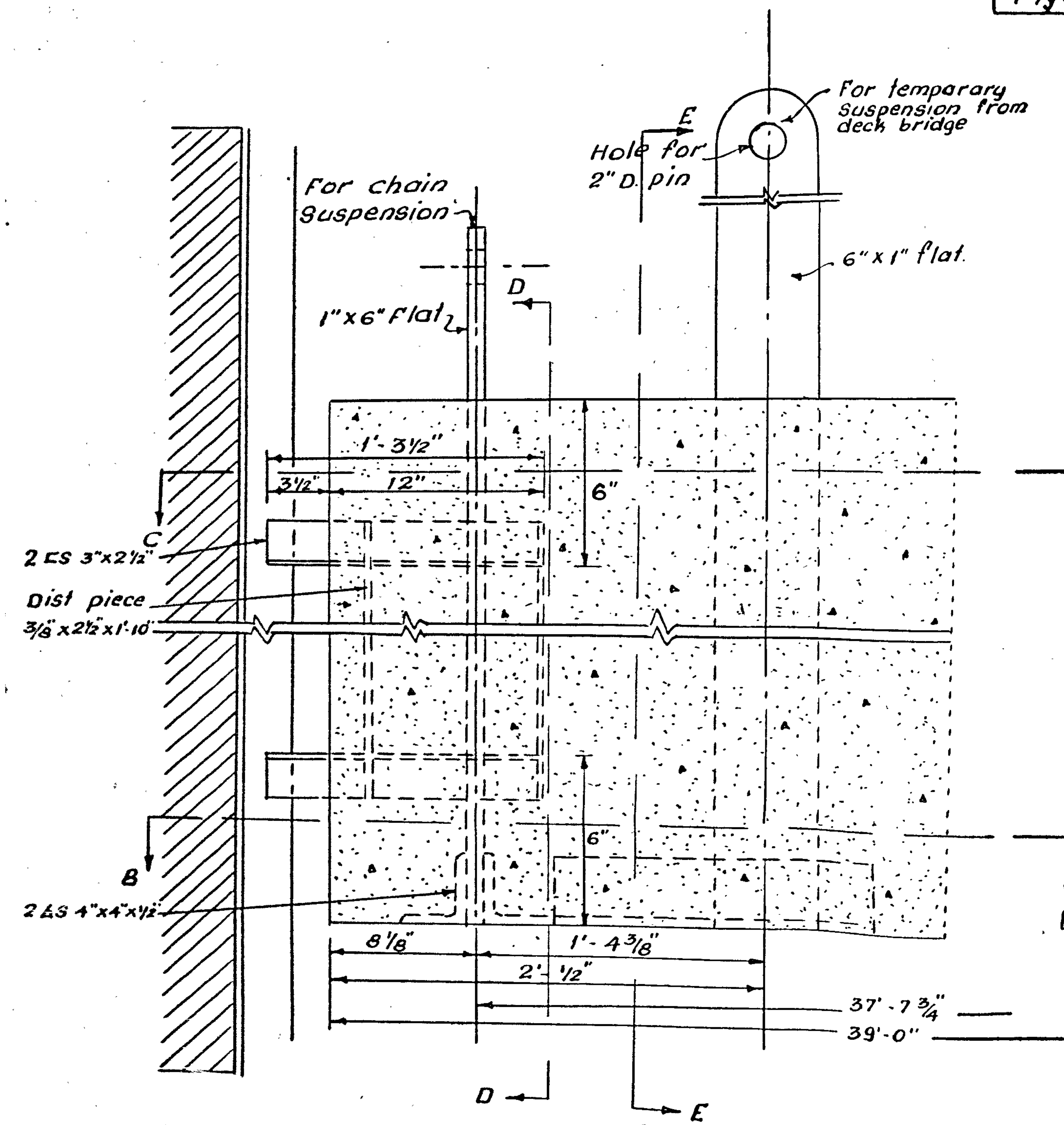


PLAN
Scale 1:40

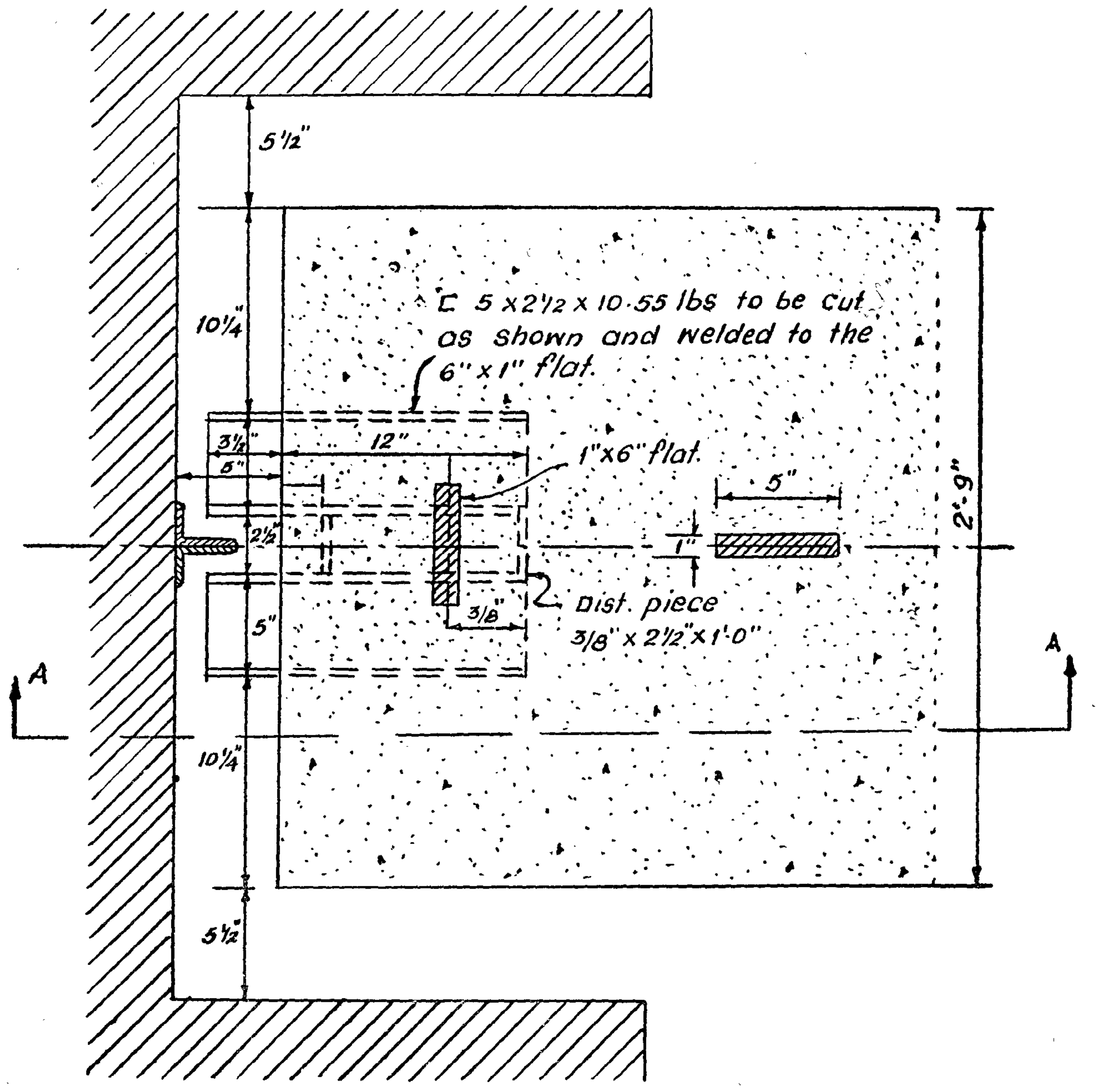
SPILLWAY LIFT GATE - GENERAL ARRANGEMENTS.

Drawn: A·S·P
Traced: K·K·N

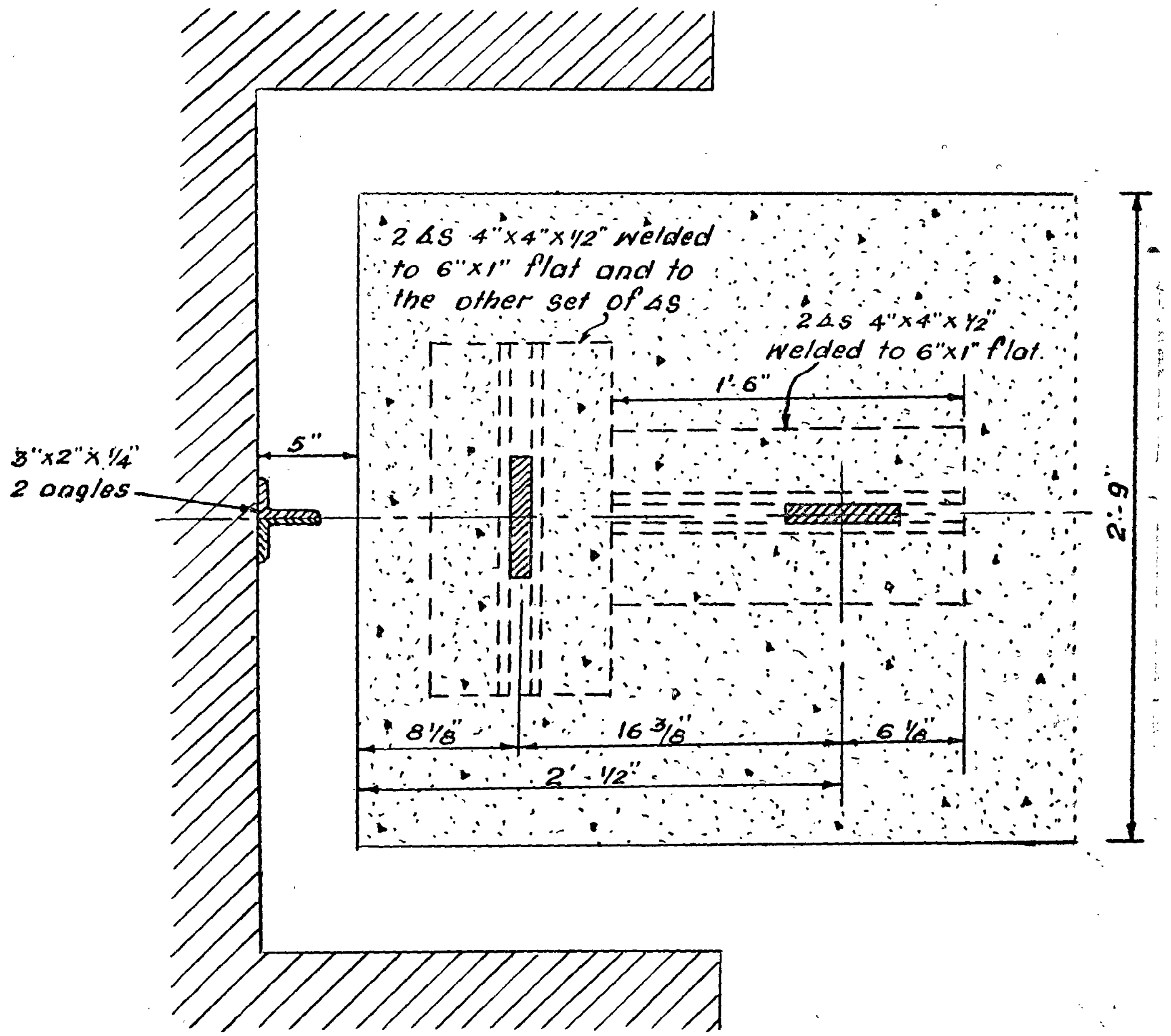
Fig. 9.



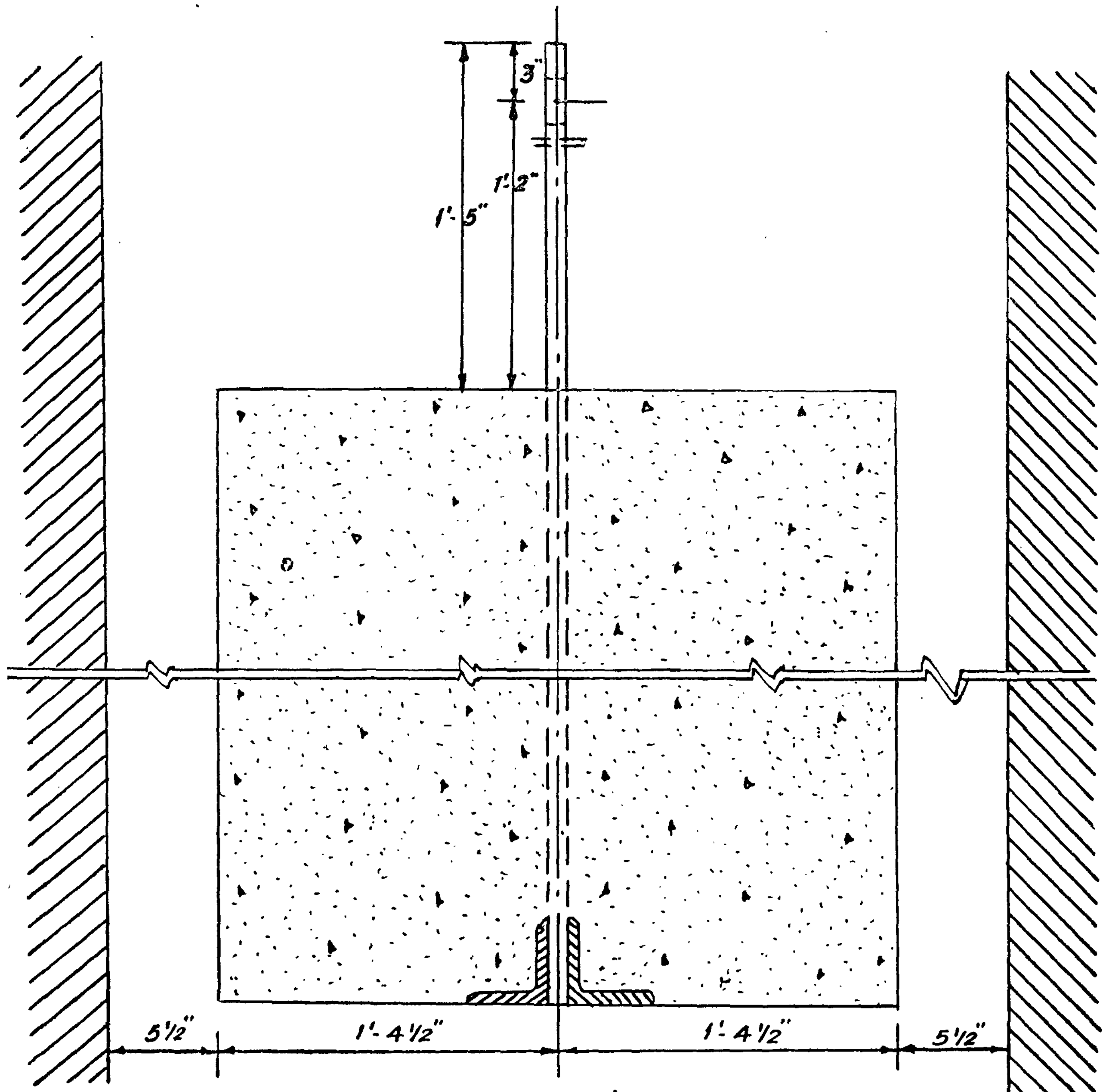
SECTION 'AA'



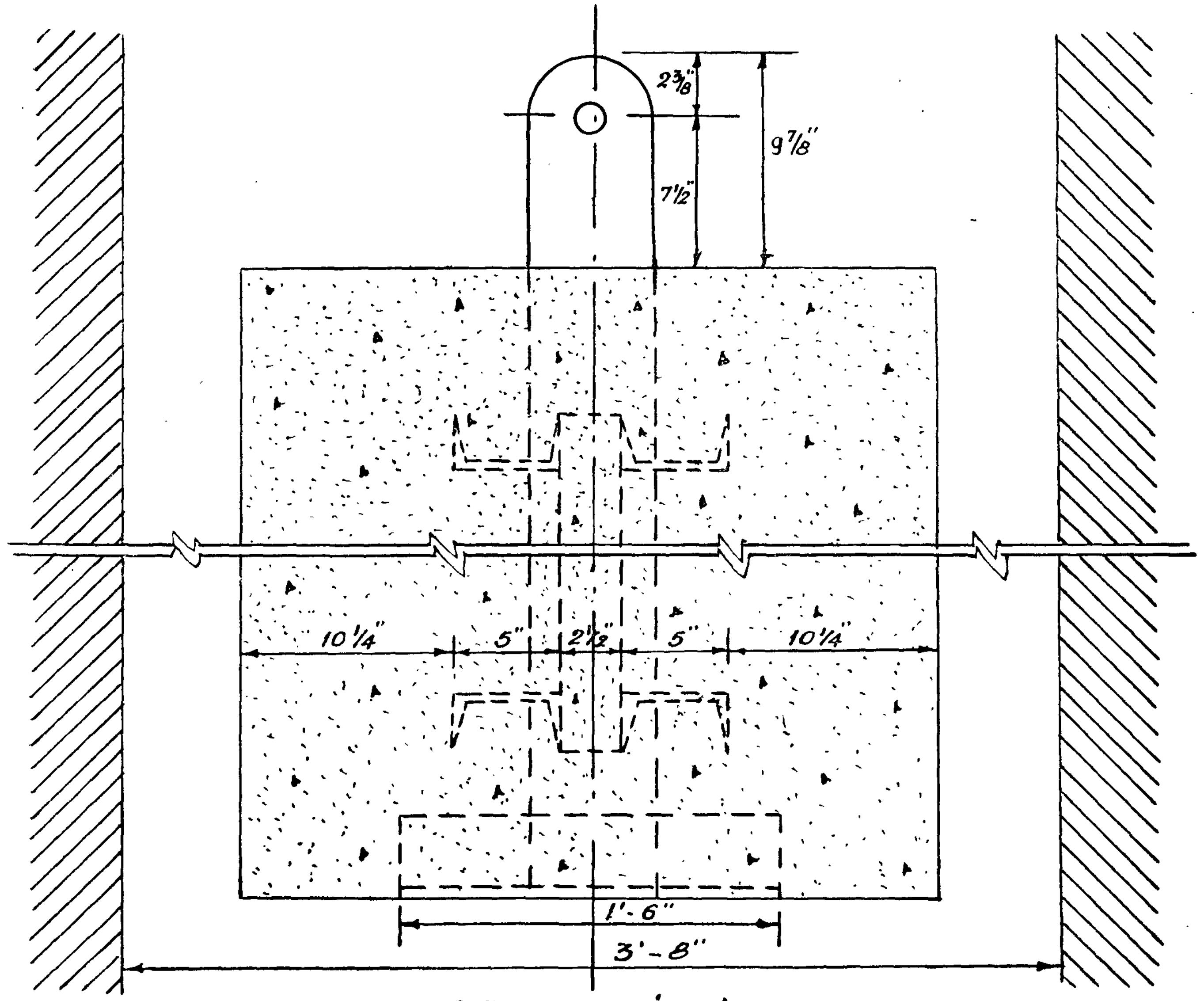
SECTION 'CC'



SECTION 'BB'



SECTION 'EE'



SECTION 'DD'

DRAWN: A.S.P.

TRACED: G. Narayanan

Suspension Fixtures
for
COUNTERWEIGHT

Scale 1:8

Uplift pressure = $\frac{1}{2} \times \frac{1/12 \times 62{\cdot}5 \times 25{\cdot}25 \times 36}{2{\cdot}240}$

= 1·057 ton (—)

Net downward force = 31·146 tons.

∴ Downward force on gate side = 31·146 tons or 31·15 tons.

Hoist capacity with factor of safety 2 with a counter weight of.—

(1) 19 tons (31·15–19) × 2 = 24·30 tons.
(2) 21 ,, (31·15–21) × 2 = 20·3 ,,
(3) 22 ,, (31.15–22) × 2 = 18·3 ,,
(4) 23 ,, (31·15–23) × 2 = 16·3 ,,
(5) 24 ,, (31·15–24) × 2 = 14·3 ,,
(6) 25 ,, (31·15–25) × 2 = 12·3 ,,
(7) 27 ,, (31·15–27) × 2 = 8·3 ,,

2. *Gate opening 5′0″ above sill.—*

Weight of gate = 28 tons.
Sealing friction = 1 ton.
Bearing friction = 1 per cent of P=

$1/100 \times \frac{62{\cdot}5 \times 20{\cdot}25 \times 36}{2 \times 2{,}240}$ = 2·061 tons.

Uplift pressure = Nil.
Net downward force = 31·061 tons.

Hoist capacity with a factor of safety 2 with a counter-weight of.—

(1) 19 tons (31·06 — 19) × 2 = 24·12 tons.
(2) 21 ,, (31·06 — 21) × 2 = 20·12 ,,
(3) 22 ,, (31·06 — 22) × 2 = 18·12 ,,
(4) 23 ,, (31·06 — 23) × 2 = 16·12 ,,
(5) 24 ,, (31·06 — 24) × 2 = 14·12 ,,
(6) 25 ,, (31·06 — 25) × 2 = 12·12 ,,
(7) 27 ,, (31·06 — 27) × 2 = 8·12 ,,

3. *Gate opening 10′ above sill.—*

Weight of gate = 28 tons
sealing friction=F=1 ton
Bearing friction=1 per cent of P=

$\frac{1/100 \times 62{\cdot}5 \times 15{\cdot}25' \times 36}{2 \times 2240}$ = 1·168 tons.

Uplift pressure = Nil
Net downward force = 30·168 = 30·17 tons.

Hoist capacity with a factor of safety 2 with a counter-weight of—.

(1) 19 tons (30·17–19) × 2 = 22·34 tons.
(2) 21 ,, (30·17–21) × 2 = 18·34 ,,
(3) 22 ,, (30·17–22) × 2 = 16·34 ,,
(4) 23 tons. (30·17–23) × 2 = 14·34 tons.
(5) 24 ,, (30·17–24) × 2 = 12·34 ,,
(6) 25 ,, (30·17–25) × 2 = 10·34 ,,
(7) 27 ,, (30·17–27) × 2 = 6·34 ,,

4. *Gate opening 15′ 0″ Above sill.—*

Weight of gate = W = 28 tons.
Sealing friction = F = 1 ton.
Bearing friction = 1 per cent of P=

$\frac{1/100 \times 62{\cdot}5 \times 10{\cdot}25^2 \times 36}{2 \times 2240}$ = 0.5277 tons.

Uplift pressure = Nil.
Net downward force = 29·5277
or
29·53 tons.

Hoist capacity with a factor of safety of 2 and for counter-weight:—

(1) 19 tons. (29·53—19) × 2 = 21·06 tons.
(2) 21 ,, (29·53—21) × 2 = 17·06 ,,
(3) 22 ,, (29·53—22) × 2 = 15·06 ,,
(4) 23 ,, (29·53—23) × 2 = 13·06 ,,
(5) 24 ,, (29·53—24) × 2 = 11·06 ,,
(6) 25 ,, (29·53—25) × 2 = 9·06 ,,
(7) 27 ,, (29·53—27) × 2 = 5·06 ,,

5. *Gate opening 20′ above sill.—*

Weight of gate = W = 28 tons
Sealing friction = F = 1 ton.
Bearing friction = 1 per cent of P =

$\frac{1/100 \times 62{\cdot}5 \times 5{\cdot}25 \times 36}{2 \times 2240}$ = 0·1385 tons.

Uplift pressure Nil
Net downward force = 29·139
or
29·14 tons.

Hoist capacity with a factor of safety of 2 and for counter-weight of.—

(1) 19 tons. (29·14—19) × 2 = 20·28 tons-
(2) 21 ,, (29·14—21) × 2 = 16·28 ,,
(3) 22 ,, (29·14—22) × 2 = 14·28 ,,
(4) 23 ,, (29·14—23) × 2 = 12·28 ,,
(5) 24 ,, (29·14—24) × 2 = 10·28 ,,
(6) 25 ,, (29·14—25) × 2 = 8·28 ,,
(7) 27 ,, (29·14—27) × 2 = 4·28 ,,
24 tons = (29·139 – 24) × 2 = 10·28.

6. *Gate just before fully raised position.—*

Weight of gate = W = 28 tons.
Sealing friction = F = +1 ton.
Bearing friction = Nil
Uplift pressure
Total 29 tons
Net downward force = 29 tons.

Hoist capacity with a factor of safety of 2 and for counter-weight of.—

(1) 19 tons. (29—19) × 2 = 20 tons.
(2) 21 ,, (29—21) × 2 = 16 ,,
(3) 22 ,, (29—22) × 2 = 14 ,,
(4) 23 ,, (29—23) × 2 = 12 ,,
(5) 24 ,, (29—24) × 2 = 10 ,,
(6) 25 ,, (29—25) × 2 = 8 ,,
(7) 27 ,, (29—27) × 2 = 4 ,,

Gate fully opened and shutter being lowered.—

The sealing friction, the bearing friction and uplift pressure if any act against the weight of gate. Now the work is done on the counterweight. The shutter acts as counter-weight.

Weight of gate = W = 28 tons.
Sealing friction = F = —1 ton.
Bearing friction = Nil
Uplift pressure = Nil

Net downward force = 27 tons.

Hoist capacity with a factor of safety of 2 and for counter weight—

(1) 19 tons (27—19) × 2 = 16 tons.
(2) 21 ,, (27—21) × 2 = 12 ,,
(3) 22 ,, (27—22) × 2 = 10 ,,
(4) 23 ,, (27—23) × 2 = 8 ,,
(5) 24 ,, (27—24) × 2 = 6 ,,
(6) 25 ,, (27—25) × 2 = 4 ,,
(7) 27 ,, (27—27) × 2 = 0 ton.

Gate opening kept at 20′

Weight of gate = W = 28 tons
Sealing friction = F = —1 ton.
Bearing friction = 1 per cent of P= —(0·139) ton.
Uplift pressure = Nil

Net downward force= 26·861 tons.

Hoist capacity with F.S. 2 and for counter-weight of.—

(1) 19 tons (26·86—19) × 2 = 15·72 tons.
(2) 21 ,, (26·86—21) × 2 = 11·72 ,,
(3) 22 ,, (26·86—22) × 2 = 9·72 ,,
(4) 23 ,, (26·86—23) × 2 = 7·72 ,,
(5) 24 ,, (26·86—24) × 2 = 5·72 ,,
(6) 25 ,, (26·86—25) × 2 = 3·72 ,,
(7) 27 ,, (26·86—27) × 2 = — 0·28 ton.

Gate opening kept at 15′.—

Weight of gate=W = 28 tons.
Sealing friction = F = 1 ton.
Bearing friction = 1 per cent of P= —(0·5277). ton.
Uplift pressure = Nil.

Net downward force = 26.4723
or
26·47 tons.

Hoist capacity with a factor of safety 2 and for counter-weight of—

(1) 19 tons (26·47 — 19) × 2 = 14·94 tons.
(2) 21 ,, (26·47 — 21) × 2 = 10·94 ,,
(3) 22 ,, (26·47 — 22) × 2 = 8·94 ,,
(4) 23 ,, (26·47 — 23) × 2 = 6·94 ,,
(5) 24 ,, (26·47 — 24) × 2 = 4·94 ,,
(6) 25 ,, (26·47 — 25) × 2 = 2·94 ,,
(7) 27 ,, (26·47 — 27) × 2 = —1·06 ,,

Gate opening kept at 10′—

Weight of gate=W=28 tons.
Sealing friction=F= —1·0 ton.
Bearing friction=1 per cent of P= —(1·168) tons.
Uplift pressure = Nil.

Net downward force = 25·832
or
25·83 tons.

Hoist capacity with a factor of safety of 2 and for counter-weight of—

(1) 19 tons (25·83 — 19) × 2 = 13·66 tons.
(2) 21 ,, (25·83 — 21) × 2 = 9·66 ,,
(3) 22 ,, (25·83 — 22) × 2 = 7·66 ,,
(4) 23 ,, (25·83 — 23) × 2 = 5·66 ,,
(5) 24 ,, (25·83 — 24) × 2 = 3·66 ,,
(6) 25 ,, (25·63 — 25) × 2 = 1·66 ,,
(7) 27 ,, (25·83 — 27) × 2 = —2·34 ,,

Gate opening kept at 5′.—

Weight of gate=W=28 tons.
Sealing friction=F= −1 ton.
Bearing friction=1 per cent of P= −(2·061) tons.
Uplift pressure = Nil.

Net downward force =24·939
or
24·94 tons.

Hoist Capacity with a factor of safety of 2 and for counter-weight of—

(1) 19 tons (24·94 − 19) × 2 = 11·88 tons.
(2) 21 ,, (24·94 − 21) × 2 = 7·88 ,,
(3) 22 ,, (24·94 − 22) × 2 = 5·88 ,,
(4) 23 ,, (24·94 − 23) × 2 = 3·88 ,,
(5) 24 ,, (24·94 − 24) × 2 = 1·88 ,,
(6) 25 ,, (24·94 − 25) × 2 = −0·12 ton.
(7) 27 ,, (24·94 − 27) × 2 = −4·12 tons.

Gate about to be closed.—

Weight of gate=W= +28 tons.
Sealing friction=F= −1 ton.
Bearing friction=1 per cent of P= −(3·203) tons.
Uplift force = −1·057 tons.

Net downward force=22·74 tons.

Hoist capacity with a factor of safety of 2 for counter-weight of.—

(1) 19 tons (22·74 − 19) × 2 = 7·48 tons.
(2) 21 ,, (22·74 − 21) × 2 = 3·48 ,,
(3) 22 ,, (22·74 − 22) × 2 = 1·48 ,,
(4) 23 ,, (22·74 − 23) × 2 = − 0·52 ton.
(5) 24 ,, (22·74 − 24) × 2 = − 2·52 tons.
(6) 25 ,, (22·74 − 25) × 2 = − 4·52 ,,
(7) 27 ,, (22·74 − 27) × 2 = − 8·52 ,,

I. *Counter weight of* 19 *tons.*—

Gate opening. (1)	*Hoist capacity for (with F.S. 2).* *Gate to be raised.* (2) TONS.	*Gate to be lowered.* (3) TONS.	*S.F.*
Closed	24·30	7·48	..
5′—0″ opening	24.12	11·83	
10′—0″ ,,	22·34	13·66	
15′—0″ ,,	21·06	14·94	
20′—0″ ,,	20·28	15·72	
25′—0″ Fully open	20·00	16·00	

Gate opening. (1)	*Hoist capacity for (with F.S. 2)* *Gate to be raised.* (2)	*Gate to be lowered.* (3)	
II. *Counter-weight of* 21 *tons with F.S.* 2.—	TONS.	TONS.	*S.F.*
Closed	20·3	3·48	1·74
5′—0″ opening	20·12	7·88	
10′—0″ ,,	18·34	9·66	
15′—0″ ,,	17·06	10·94	
20′—0″ ,,	16·28	11·72	
25′—0″ or fully open	16·00	12·00	
III. *Counter-weight of* 22 *tons. F.S.* 2.—	TONS.	TONS.	*S.F.*
Closed	18·3	1·48	0·74
5′—0″ opening	18·12	5·88	
10′—0″ ,,	16·34	7·66	
15′—0″ ,,	15·06	8·94	
20′—0″ ,,	14·28	9·72	
25′—0″ or fully open	14·00	10·00	
IV. *Counter-weight of* 23 *tons.*—	TONS.	TONS.	
Closed	16·3	—0·52	
5′—0″ opening	16·12	3·88	
10′—0″ ,,	14·34	5·66	
15′—0″ ,,	13·06	6·94	
20′—0″ ,,	12·28	7·72	
25′—0″ or fully open	12·00	8·00	
V. *Counter-weight of* 24 *tons—indicates gate side is lighter.*—	TONS.	TONS.	
Closed	14·3	—2·52	
5′—0″ opening	14·12	1·88	
10′—0″ ,,	12·34	3·66	
15′—0″ ,,	11·06	4·94	
20′—0″ ,,	10·28	5·72	
S.F. 25′—0″ or fully open	10·00	6·00	

NOTE.—S. F.=Sealing Force.

VI. *Counter-weight of* 25 *tons.*—	TONS.	TONS.
Closed	12·03	—4·52
5′—0″ opening	12·12	—0·12
10′—0″ ,,	10·34	1·66

Gate opening.	*Hoist capacity for (with F.S. 2).* *Gate to be raised* (1) TONS.	*Gate to be lowered* (2) TONS
VI *Counter weight of* 25 *tons*—cont.		
15′—0″ ,,	9·06	2·94
20′—0″ ,,	8·28	3·72
25′—0″ or fully open	4	8
VII. *Counter weight of* 27 *tons.*—	TONS.	TONS.
Closed	8·3	—8·52
5′—0″ opening	8·12	—4·12
10′—0″	6·34	—2·34
15′—0″	5·06	—1·06
20′—0″	4·28	—0·28
25′—0″ or fully open	4·00	—

While the gate is being raised it is evident that the least hoist capacity can be obtained with the 27 tons counterweight. But when the gate is to be lowered the maximum weight of counterweight can be only 22 tons as then only there will be a sealing force of 0·74 ton when the gate is about to close. It is not advisable to have a rider of more than 2 tons as it is a problem to have the riders and reserve them when and as required.

The hoist capacity provided for this gate will be 24 tons with a F.S. of 2. This is required as the hoist may have to hold counterweight when the gate gets stuck up. Hence the counterweight should be less than 24 tons.

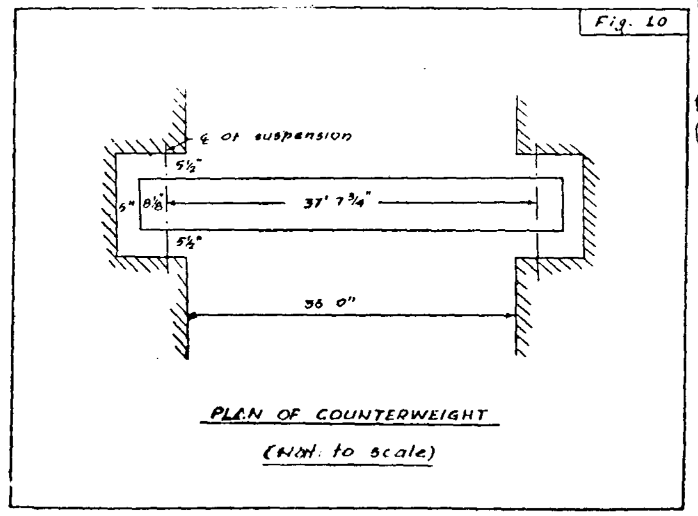


Fig. 10

PLAN OF COUNTERWEIGHT

(Not to scale)

Length of counterweight (centre to centre of suspension) =37′—7¼″

The sealing force being the criterion in fixing the weight of counterweight in this case, the weight of counterweight is fixed as (21+2)=23 tons. The 23 tons counterweight will be used for raising the gate and when the gate is to be lowered the 2-ton rider weights will be removed so that only 21-ton counterweight will operate.

DESIGNS OF C.W.T. 23 TONS WEIGHT.

The weight of the gate as has actually been manufactured =28 tons. Two tons of the counterweight should be in the form of removable blocks (riders). A counterweight of (21+2)=23 tons will be used.

The depth of the counterweight beam should be so designed that the weight of counter weight inclusive of portion at the top for engaging the riders should be (23—2 tons) =21 tons. Weight of lug$=9/12\times 3/12\times 39\frac{\times 150}{2240}=0{\cdot}4897$ ton. Weight of the rectangular portion of the counterweight is to be (21—0·4897) = 20·5103 tons. 2′9″ width has been adopted.

$$\therefore \text{Depth required for the counter weight}=\frac{20{\cdot}51\times 2240}{39\times 150\times 2\frac{3}{4}}$$

$= 2{\cdot}856'$
(say) $2'-10{\cdot}3''=34\frac{1}{2}''$

Actual weight of this section

$$=0{\cdot}4897+\frac{33\times 34{\cdot}5\times 39\times 150}{12\times 12\times 2240}$$
$$=0{\cdot}4897+20{\cdot}65$$
$$=21{\cdot}14 \text{ tons.}$$

For design of reinforcements the rider weight of 2 tons is also included.

Total weight = 21·14 + 2 = 23·14 tons.

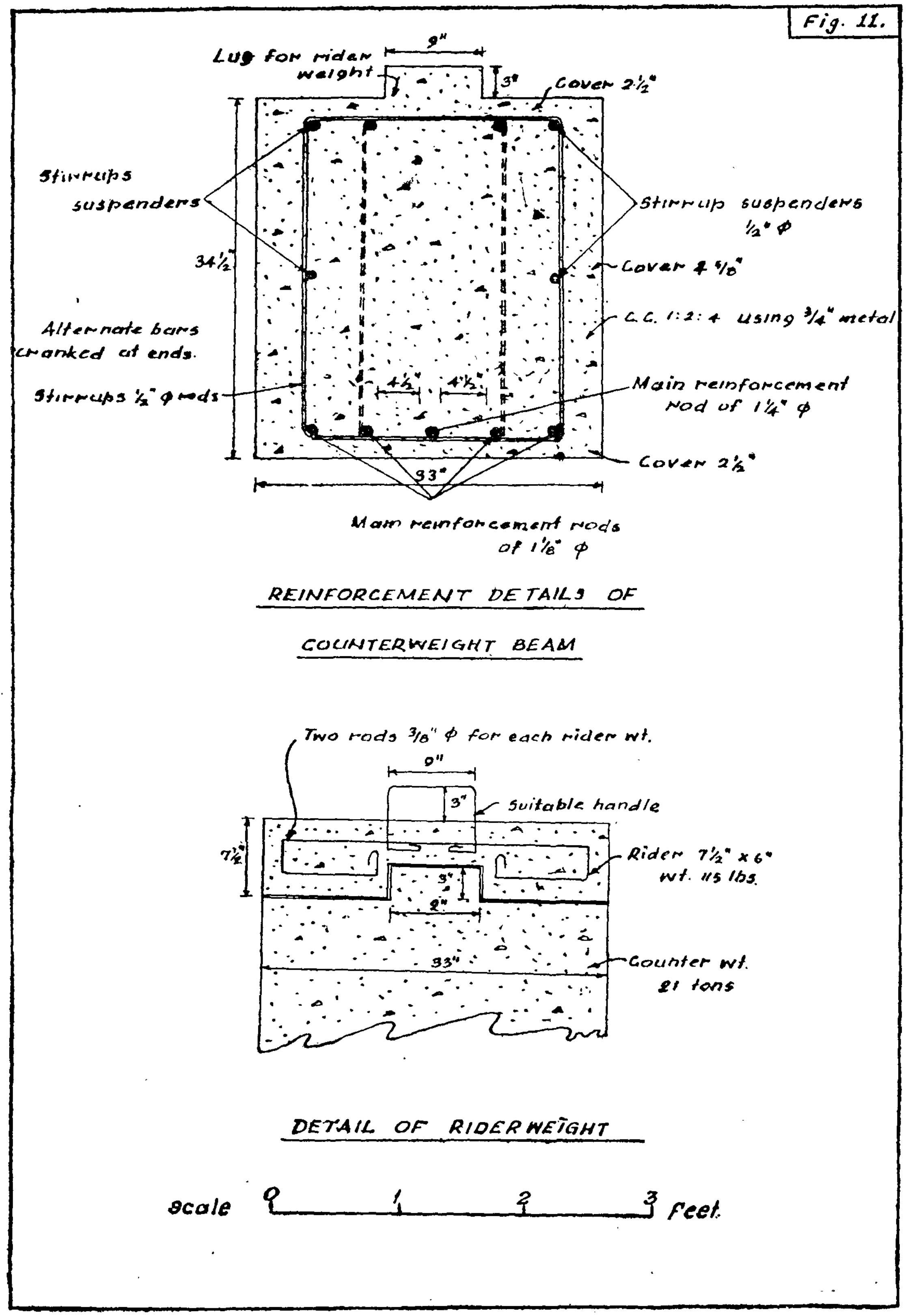
The counterweight will be termed as a (21 + 2) = 23 ton counterweight eventhough the actual weight is (21·14) + 2 = 23·14 tons.

Using C.C. 1: 2:4 and ¾″metal $\begin{cases} c = 750 \text{ lbs./sq. in.} \\ t = 18{,}000 \text{ lbs./sq. in.} \\ m = 15. \quad Rm = 126 \\ \quad bd^2 \end{cases}$

$$\therefore \text{B.M} = \frac{WL}{8}$$
$$=\frac{23{\cdot}14\times 2{,}240\times(37'-7\frac{3}{4}'')\times 12}{8}\text{ inch lb.}$$
$$= 29{,}27{,}000 \text{ inch lbs.}$$
$$\therefore 126{,}bd^2 = 29{,}27{,}000$$

$$d=\sqrt{\frac{29{,}27{,}000}{126\times 33}}=26{\cdot}54''$$

Available effective depth = $34{\cdot}5''-2\frac{1}{2}''$ (cover) $-\frac{1}{2}=31\frac{1}{2}''$.



REINFORCEMENT DETAILS OF COUNTERWEIGHT BEAM

DETAIL OF RIDER WEIGHT

Depth required as per weight calculations = 34½". Hence 34" depth has been adopted with effective depth 31½".

Lever arm = 0·87 d = 0·87 × 31·5 = 27·4".

Area of steel required for 26·44 effective depth = 0·008 × b × d

= 0·008 × 33 × 26·54

= 7·006 sq. in.

Corresponding to the effective depth of 31½" area of steel reinforcement required = $\frac{7{\cdot}006 \times (26{\cdot}54)^2}{(31{\cdot}5)^2}$ = 4·974 sq. in.

Adopt 5 rods of 1-1/8" dia. giving 5 × 0·9936 = 4·968 sq. in. Hence, use 4 rods of 1-1/8" dia. and a central rod of 1¼" dia. giving 4 × 0·9936 + 1 × 1·2272 = 3·9744 + 1·2272.

= 5·2016 sq. in.

Check for Shear.—

Maximum shear $\frac{W}{2}$ tons = $\frac{23{\cdot}14 \times 2240}{2}$ = 23·14 × 1120 = S

Shear stress = $\frac{S}{ab} = \frac{23{\cdot}14 \times 1120}{0{\cdot}87 \times 31{\cdot}5 \times 33}$ = 28·65 lbs/sq.in.

Allowable shear stress = 0·1 c. = 75 lbs./sq. in. Hence no shear reinforcements is found to be necessary. However nominal stirrups of ½" dia. area (0·196) s.q.m. is provided at 24" C/C and ½" dia. rods will be used stirrup suspenders at top and middle.

Design of Rider Weight:—

Weight of rider weight = 2 tons.

Weight/ft. run of rider = $\frac{2 \times 2240}{39} = \frac{4480}{39}$ = 114·8 lbs.

say 115 lbs.

Take each rider block to be of length = 6"

Weight of per ft. run of rider should be = $\frac{(33d - 27)}{144} \times \frac{1}{2} \times 150$ and equal to 115 lbs.

$\therefore \frac{(33d-27)}{144} \times \frac{1}{2} \times 150$ = 115 lbs.

d = $\frac{247{\cdot}8}{33}$ = 7·509" say 7·5"

Adopt the depth of rider weight as 7·5" while casting the rider, weight ½" clearance may be left between the lug and inside faces of the rider weight for easy lifting.

Checking the Adequacy of Suspension Arrangements for Counterweight of Spillway Gate.

(1) Weight of counter weight with riders = 23·14 tons.

Reaction of each suspension = 11·57 tons

Check of bond strength of M. S. Flat 6" × 1" used for suspension in the concrete portion.

M. S. Flat 6" × 1" has to withstand bond stress produced.

Depth of counter weight including lug = 34½" + 3" = 37½"

Taking permissible bond stress as 100 lbs./Sq. in.

area of embedment of M. S. flat for bond = 2 (6 + 1) × 37½

= 14 × 37½

= 525 Sq. in.

Bond strength for this area = $\frac{525 \times 100}{2240}$ = 23·44 tons

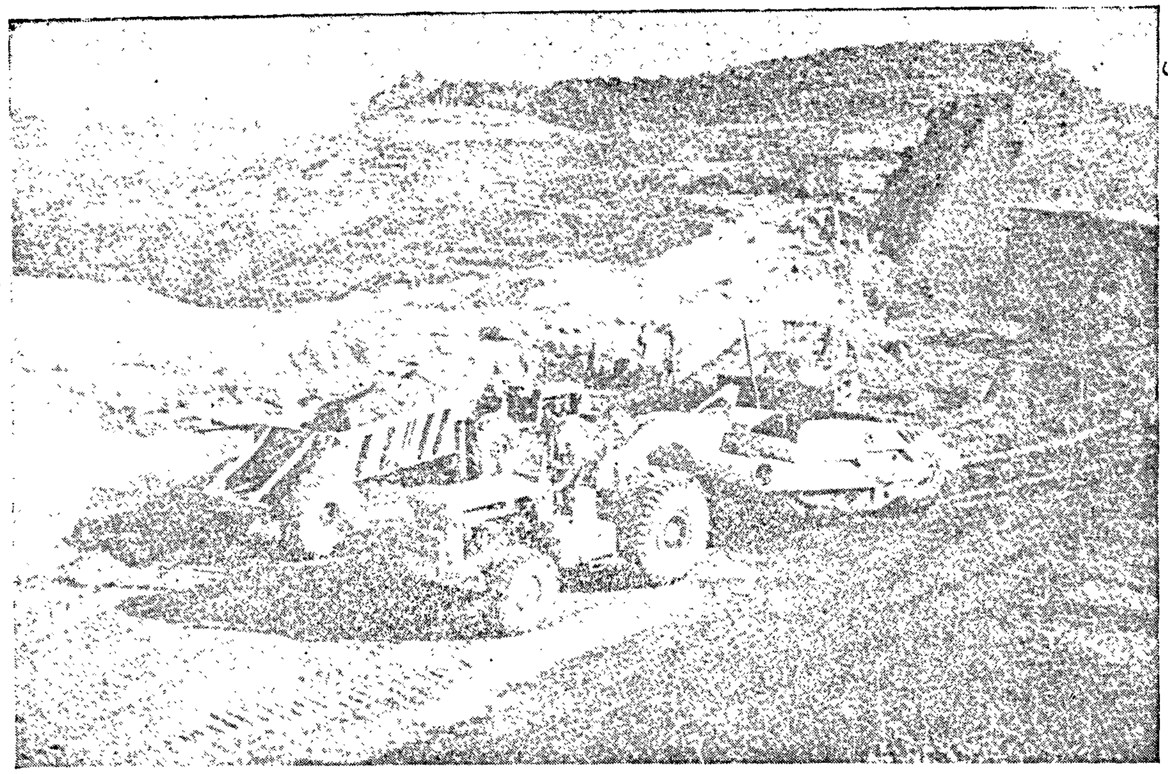
against the reaction of 11·57 tons and hence safe.

Embedment length provided is quite sufficient for suspending the counterweight.

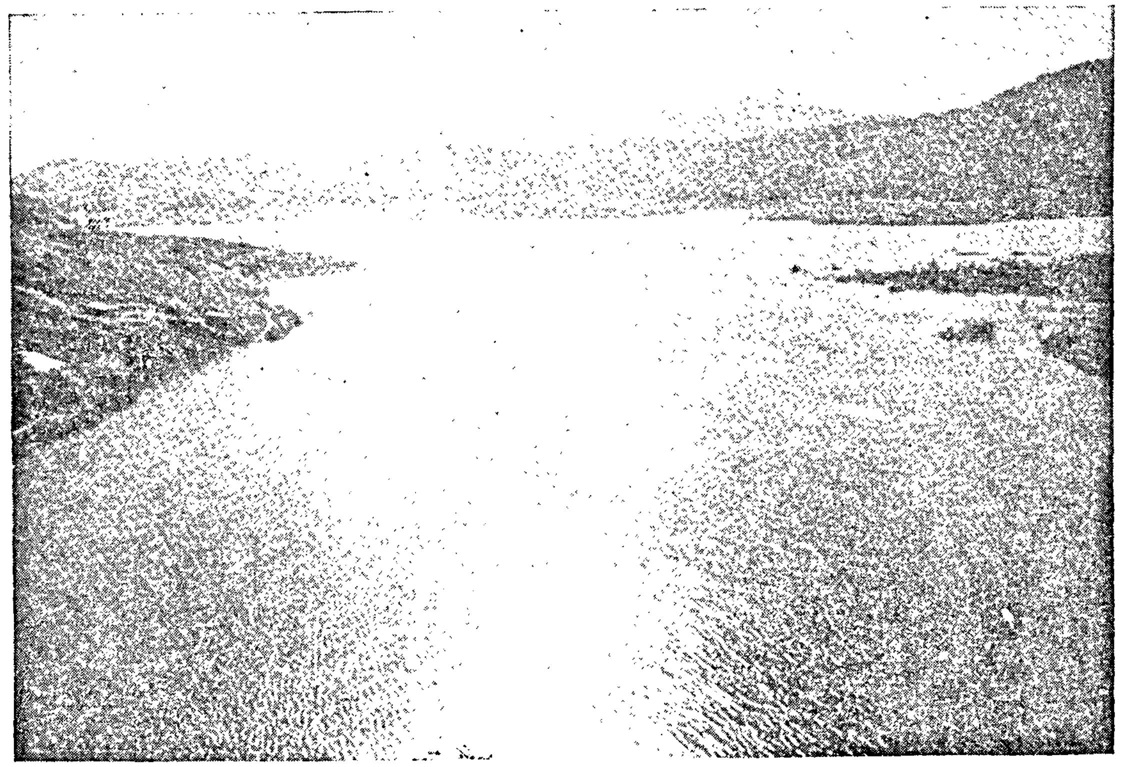
Tensile stress in the flat iron suspended

= $\frac{11{\cdot}57}{6 \times 1}$ = 1·93 tons < 8 tons

and hence safe.



Earth movers in action at the Sholiyar Dam site.



Waters of Parambikulam river that were hitherto running to waste are now impounded by the Dam.

USE RATE FOR EARTH MOVING MACHINERY

(Continuation).

BY

* Sri K. RAMACHANDRAN, B.E. (HONS.), A.M.I.E. (INDIA).

4. *Interest on capitals.*

It is customary in foreign countries to figure interest on the capital cost and taxes as a part of ownership cost. This element is not included in the ownership cost on our projects formerly because inter-divisional relations on a project do not require the raising of such debits. But this introduced an unfair ground for comparison of unit rates done by several agencies. Normally the Accountant-General raises the debit as an indirect charge based on capital expenditure to-date on the work. In fact when an equipment is given on hire to a contractor, the element of interest on capital is included. The construction plant and machinery committee opines that the interest is a realistic charge on the project as a whole and that the correct place to figure, it is in the unit rates. One important point of difference between this charge and others is that it is proportionate to the capital invested, as progressively depreciated and unlike the charges for depreciation, is applied independently of the actual utilisation of the equipment in terms of hours worked or outturn achieved. If the equipment is uniformly utilised during the working year, the incidence of interest charge can be spread out uniformly per work-hour of each item of equipment in which case this charge will resemble the levy of depreciation charge on hourly basis. Such levy of interest charge, included as a component item of ownership charge, is adopted in estimating the units charge for items of work. In working the actual cost rates for items of civil work, it is necessary to include a proportionate charge for interest on capital invested in the purchase of relevant items of special tools and plant, based on the outturn achieved during the working year. The rate of such charge per unit of work increases as the degree of utilisation falls and outturn decreases. This is not adequately realised. This charge can be very high on highly mechanised projects where there is inadequate utilisation of the equipment. Rough calculations show that it varies from about 5 per cent to as high as 20 per cent on our projects. Incidentally the percentage ratio of the interest charges on the outstanding capital expenditure on equipment to the total value of work done during the year by the machines is an excellent index for appraisal of the overall efficiency of the working of mechanical equipment. A quick method of working out the ratings is available as App. 3.8 of the report of construction plant and machinery committee.

5. *Major overhauls and repairs.*

Much controversy exists in the definition of the term " Major Repairs " as distinguished from " Capital expenditure " or " Running repairs ". Definitions are given by the United States Bureau of Reclamation, U.S.A. in their publication " Schedule of equipment ownership expense " of 3rd January 1949 and are quoted below.

Major repairs and overhauls.

Replacement of major machine parts because of excessive wear through a long period of use or which fail through breakage normally after long use and are so costly that they are normally considered as being properly chargeable to an overall or life-time average cost rather than to operating of or daily cost and which will prolong the life of the equipment do not justify an increase in the ownership expense rates.

Minor or field repairs are regarded as job or operating costs that require special study for each individual job and as such are

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entered as cost of the work on cost plus operations. Minor or field repair include the replacing of only minor parts, for example, spark plugs, fan belts, broken bolts, shackles, an occasional broken track tread or pin (does not include replacement of complete track) and other small parts comparable in cost. Also, minor repairs may include only the cost of labour and is sometimes confused with or to some extent, included in the cost of servicing. Loss of operating time for minor repairs normally would vary from a few minutes to a maximum of 8 hours. Sometimes minor repairs accumulate to such an extent that the correcting of several or all such defects in a single repair operation results in a too high cost and a too long shut down to allow of it being chargeable directly to operation. In such a case, the charge should be to major repairs and assumed by the lesser.

Major and minor repairs are frequently difficulty to distinguish. Occasionally a major part may become unusable through rough or careless operating or overloading of the machine or accident for which the lessee is responsible. In such cases, the lessee should be charged the cost of repairs. In other cases, similar failure may be the result of long use or because of damage suffered unnoticed on other work, or damage suffered for which the lesser is responsible or for other reasons not chargeable to the current work. In these circumstances, the lesser should absorb the cost of repairs. Replacement cost of wire-ropes, tyres and conveyer belts are considered as capital costs and are to be borne by the lesser. Responsibility in such instances should be determined at the time by agreement between lessor and lessee.

Proper control on the hourly cost of major repairs is important to the project executives to keep down the earthwork rates. An exact and workable formula to class the expenditure under this head is essential. Any rules evolved by a project organization should be simple enough to be interpreted uniformly by the lowest staff who classify the expenditure. Thus in actual practice "major repairs" is defined in various ways such as (1) the cost incurred by the base shop, (2) any repairs requiring more than 24 hours or (3) jobs costing more than 1 per cent of the value of the equipment, etc.

5.2. *Flat rate charge.*

The expenditure for major repairs to an equipment is heavy and comes at relatively long intervals of time. Unless these costs are evened out, the unit rates fluctuate violently with the result that proper cost control becomes impossible. To meet this situation a flat rate levy per plant hour should be made and the amount thus collected should be pooled to meet periodical major repair charges. The rate should be such as will balance the expenditure over the life of the equipment. An approximate rule to check whether the flat rate of levy is adequate is to see that there is sufficient amount in the major repair Reserve Fund at any time to carry out a complete major overhaul of the equipment.

Expenditure on such items cannot follow any uniform pattern but some method has to be devised for debiting it to the unit cost. The only datum available is purchase price of the machine on which depreciation is based. The recommended procedure for arriving at the cost of overhaul and major repairs of the machine is to express the total cost of overhauls and replacements during the life of the machine, as a percentage of the purchase price. Various percentages have been recommended in this regard. The recoveries effected on hourly basis for this purpose will be kept as a "Reserve Fund" for the particular machinery and all charges as and when incurred debited to this fund. The balance at credit of this fund will also be transferred along with the machine when transfers take place.

5.3. *Field maintenance and repairs.*

This covers the cost of normal day-to-day maintenance of the machinery on the field, servicing charges, etc., including petty repairs and can include cost of replacements also

which does not exceed 1 per cent of the initial cost of machine. Items in excess of 1 per cent should be accounted for under major repairs and overhauls. A provision of 25 per cent of the cost of the machine is considered sufficient.

(*b*) *Fuel, lubricants, etc.*—This cost includes expenditure on fuels, lubricants, and like consumables required for working the machinery per hour. The normal standard of consumption can be estimated from the rated B.H.P. of the engine, consumption of fuel per H.P. hour and the average load factor at which a machine will work. The lubricants required by a machine normally fall into five different groups.

(*a*) Engine, crank case oils,

(*b*) Air filter oils,

(*c*) Transmission oils,

(*d*) Greases, and

(*e*) oils for hydraulic operation system. Every machine has its own recommended types of oils and greases.

(*c*) *Operating crew.*—This is to cover the cost of operating crew like drivers and cleaners who are employed in actually operating the machine on the works. The expenses incurred on leave reserve personnel and incidentals like wages paid during non-working season and also provision for payment of retrenchment compensation should all be covered under this head. The actual cost of such labour prevailing in the locality plus 25 per cent to cover the incidentals mentioned above may be taken as the overall operating charges and this should be taken into account in arriving at the hourly cost of operating crew.

The charges under this head are borne by the suspense estimate sanctioned for each machine every year and the cost adjusted.

Use rate.—The hourly cost of working of machinery is made up of all the component charges stated in paragraphs supra. They are detailed below:—

I. Capital accounts—
(*a*) Depreciation.
(*b*) Interest charges.

II. Reserve Fund—Major overhauls and repairs.

III. Running account—
(*a*) Field maintenance and repairs.
(*b*) Fuel, lubricants, etc.
(*c*) Operating crew.

6. *Life of machinery as is adopted in Madras.*

The life of several machines was fixed by the Chief Engineer for Irrigation and all the officers were requested to adopt the life furnished therein to ensure uniformity in practice. The life of earthmoving machines are furnished below:—

1	D.W. 10 scrapers	12,000	hours
2	D.W. 15 scrapers	15,000	,,
3	D.W. 20 scrapers	15,000	,,
4	Crawler tractor drawn scraper	12,000	,,
5	Excavators 3/8 to 3/4 cubic yds.	10,000	,,
6	Crawler tractor D 6 ..	12,000	,,
7	Do. D 7 ..	12,000	,,
8	Do. D 8 ..	12,000	,,
9	Do. T·D. 18 ..	12,000	,,
10	Do. T.D. 24 ..	12,000	,,
11	D.D. cletrac	10,000	,,
12	Wheeled track 40 H.P. ..	10,000	,,
13	Motor graders	12,000	,,
14	Dumpers Muirhill Aveling Barford-Motorail.	12,000	,,
15	Euclid dumpers	12,000	,,
16	Road Rollers Diesel	12,000	,,
17	Do. Steam	20,000	,,
18	Sheep foot Roller	20,000	,,
19	Disc Harrow	20,000	,,

	B. Tramway meterials—		
20	Tram lines	20,000	hours.
21	Diesel locos	12,000	„
22	Steam locos	20,000	„
23	Tipping wagons	20,000	„
24	Tramline accessories	10,000	„
C.	*Transport Vehicle*—		
25	Transport lorries Diesel	100,000	miles.
26	Transport lorries petrol	80,000	„
27	Station Wagon	80,000	„
28	Jeep	80,000	„
29	Trailors	20,000	„
D.	*Workshop accessories*	10,000	hours.

Tyres and tubes.

Though the suppliers include the price of tyres initially fitted on an equipment in their quotations for the equipment, tyres have to be treated quite separately for the inclusion of pro-rate cost in the use rate. The cost of the tyres is a substantial part of the total price and their lives are not the same as those of the machines. The recommendations of the construction Plant and machinery committee in respect of the overage life of tyres of various types of equipment are appended below:—

Life of Tyres.

LIFE EXPECTANCY HOURS.

Equipment.	*Average material.*	*Abrasive material.*
(1)	(2)	(3)
Scrapers ..	3000	2500
Dumpers-bottom ..	3500	3000
Dumpers-rear ..	3000	2500
Tractors	2500	2000
Rubber belt for loaders	3000	2500
Drawn scrapers ..	4000	3500

The rates furnished above have to be modified to suit the present rates.

7. *Typical calculation sheet of use rate for*—

I. *A. Pay scraper*—

The overall cost of the machinery Rs. 1,76,000

cost of tyres assumed as 1/6 of the overall cost of the machinery

1/6 × 1,76,000 = Rs. 29,333

Cost of machinery less tyres = Rs. 1,46,667

Life of the machinery = 12,000 hours

I. *Depreciation*—

(*a*) Cost of machine less tyres = Rs. 1,46,667
Life of machine = 12,000 hours

$$\text{Depreciation per hour} = \frac{1{,}46{,}667}{12{,}000} = \text{Rs. } 12{\cdot}22$$

(*b*) Cost of tyres = Rs. 29, 333
Life of tyres = 3,000 hours.

$$\text{Depreciation per hour} = \frac{29{,}333}{3{,}000} = \text{Rs. } 9{\cdot}78$$

Total depreciation per hour = Rs. 22·00

(*c*) Interest charges at 5 per cent of the capital cost, i.e., 5 per cent of Rs. 1,76,000 = Rs. 8,800

Working hours per year = 200 × 10 = 2,000 hours

$$\text{Interest charges per hour} = \frac{8{,}800}{2{,}000} = \text{Rs. } 4{\cdot}40$$

Total under capital accounts
= Total depreciation + Interest charges
= 22·00 + 4·40 = Rs. 26·40

II. *Major repairs and overhaul of*
Machine at 75 per cent of depreciation

$$= \frac{75}{100} \times 12{\cdot}22 = \text{Rs. } 9{\cdot}17$$

III. *Operating cost*—

(*a*) Field maintenance and repairs.—

(1) of machine at 25 per cent of depreciation,

$$\text{i.e., } \frac{25}{100} \times 12{\cdot}22 = \text{Rs. } 3{\cdot}06$$

(2) of tyres at 60 per cent of depreciation

$$\text{i.e., } \frac{60}{100} \times 9{\cdot}78 = \text{Rs. } 5{\cdot}87$$

Total=Rs. 8·93

(*b*) *Fuels and lubricants.*—

5 Glns. H.S.D. oil at Rs. 2 per gallon =	Rs.	10·002
lubricants, grease, etc. =	Rs.	3·00
Total	Rs.	13·00

(*c*) *Crew charges.*—

2 drivers one at Rs. 137 per month and the other at Rs. 102 per month and 2 cleaners one at Rs. 59 and other at Rs. 64 per month = Rs. 2·17

Travelling allowance, leave reserve, retrenchment compensation, etc. = Rs. 0·68

Totalling,	I	capital accounts	Rs.	26·40
	II	major overhauls (Reserve Fund)	Rs.	9·17
	III	Operating cost.	Rs.	24·78
		Total	Rs.	60·35

This will be the use rate per hour. Similarly the use rate per hour for D6, D7, D8, T.D. 24 or anything can be worked out. Similar rates are worked out for lorries per mile of run.

8. *Accounting procedure.*

The use rate will have to be worked out for each type of machine and the rates got approved by competent authority. The cost of labour, fuel and lubricants and the quantities of fuel and lubricants are likely to vary year to year and hence the use rate determined for a particular year in this regard will have to be reviewed during the beginning of the following year and necessary corrections made, so that the use rate is modified to be in line with the actual working cost.

The use rate per hour thus worked out is applicable to all works, wherever these machines are used, whether in the owning division or in any other division or even the machines can be hired out to any contractors and private individuals. Wherever the machinery is working the concerned work on which the machinery is employed should bear the use rate. If the machines are working in the owning division, or in the hiring division, the method is the same. Thus, it may be seen that wherever the machinery has worked on a specific type of work, the use rate per hour will be the same.

The purchase of a new machine is made after getting proper administrative and technical sanctions. The amount paid to the firm for supply of the machine, with all taxes, insurance, railway freight and other incidental charges goes as the capital cost of the equipment. This includes cost of erection and trial runs also. The credits for depreciation and interest charges will be compiled thereafter.

Annual estimates for major repairs for each machine should be made based on actual requirements for the year. This is the best and correct method. The construction plant and machinery committee do not advocate a separate estimate for each machine *on each occasion* as it arises because this would lead to too much estimating and account work and an accurate individual estimate will not be possible until the machine is stripped. Moreover the chances are that such estimates will remain open over long periods when some spare parts are not available. The debits to these estimates will come from job cards or from bills paid straightway to repairers and dealers. The expenditure will be offset against the reserve fund. The credits for major repairs will be collected at a flat rate per plant hour, i.e., item II of use rate worked out above and accounted for under the Reserve Fund which should be carried forward from year to year. The balance at credit of this fund will be transferred along with the machine, when transfer takes place.

A suspense estimate for the maintenance of the machinery should be prepared and got sanctioned for every year of operation and this estimate should get credited.

If the machine is hired out to a different division, then the hire charge to be recovered shall be based on this hourly use rate and adjustments are made accordingly. If the hiring division incurs the expenditure on fuels, lubricants and crew charges or even any of the repair charges that may be found necessary during working of the machine, then such costs will have to be first met by the hiring division and then debited by the hiring division to the owning division duly supported by voucher for necessary adjustments.

Thus it may be seen from the above that whether the machine works in the owning division or in the hiring division, the rate adopted is the same.

If due to the closure of the division or work, the machinery has to be transferred to some other work, project or division, the transfer value is correctly worked out. The residual Reserve Fund and residual spare parts, etc., must also be transferred with the operating crew, etc. The unused log books and other day to day records must also be transferred. The most important thing to be

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transferred is the history book of the machine, which should contain all the technical and cost data of the machine to indicate the complete history of the machine for technical and fiscal evaluation at any time. It should give manufacturer's data about the technical details of the machine, its cost records, history of repairs and alterations, the abstract of utilisation of hours, the depreciated value, use rate per hour, etc.

When machines are sent to a hiring division, it was found that certain amount of idle period crept in and it is a known fact that the equipment depreciates even while idle. So far no depreciation was allowed for the idle period in the working of the unit rate. The rates and costs committee recommended that a quarter of the full rate of depreciation be charged for idle hours. During monsoons when there is a shut down on most of the works it can be expected that the equipment would be overhauled for the proper use in the following season. This period which may last for 2 to 3 months should not be considered as idle item for purpose of charging depreciation for idle hours. Any shut down during the working season, howsoever long should be treated as an idle period.

9. *Conclusion.*

The above method of accounting has been adopted in Madras State. The paucity of further major resources to develop has actually been turned to good account in this State by exploiting the wasted minor resources to achieve maximum results at minimum cost. To a State like Madras which has few major water resources to develop though it has done a better job than other states in using available water, minor irrigation works are even more important because they are almost the only means left for raising food production. In the State of Madras such works are undertaken under Special Minor Irrigation Programmes and desilting-*cum*-reclamation of tanks. In an area totalling 50,974 square miles there are about 36,000 tanks irrigating about a total area of 2·6 million acres representing a total investment of about 250 crores of rupees at present cost. Most of the tanks are in a sad state of disrepair, some of them having just emerged from a long period of neglect under the Zamindars. Under the desilting-*cum*-reclamation scheme, a novel one sponsored by the Madras Government, it is proposed to deepen the existing tanks by desilting and use the earth so removed, partly to raise the level of the foreshore lands. The result is that the tank gains in its storage capacity while its waterspread is reduced and new land on the foreshore is available for cultivation. The desilting and reclamation is done by the use of heavy earthmoving machinery and so the adjustment of cost for each individual works is made easier by adopting the use rates. Instead of waiting till the end of the year to adopt a pro-rata distribution, the use rate is adopted for each hour of the machines working in each tank, thus getting a correct picture on expenditure on each tank.

Secondly after the completion of the major projects, the available and serviceable machines have been pooled up under a common pool, from which machines are drawn for such of the Special Minor Irrigation Programme and Desilting-*cum*-Reclamation works. Such pooling up in one division and hiring to other divisions necessitated the adjustment of cost on several works then and there, so that each division may budget their expenditures correctly and this method has been found to give satisfactory results. Accounting also has become easier in all divisions.

TRAINING IN MINOR IRRIGATION AND WATER USE

BY

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AND

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1. *Synopsis.*

A scheme for training Extension Officers (Agriculture) and Panchayat Union Engineers and Overseers in Minor Irrigation and Water Use is in operation in Madras State at the Agricultural College and Research Institute, Coimbatore, from May 1963. An attempt is made in this article to indicate the nature of the irrigation problems to be tackled by these officers, and how the training will be beneficial to them and the country in conserving irrigation water and augmenting food production. Details of the training scheme are also given.

2. *Introduction.*

India is predominantly an agricultural country, with about 70 per cent of the people dependent on land for their livelihood. Agricultural production accounts for nearly half the national income of the country. A strong agricultural base is an essential prerequisite, not only from the point of view of achieving self-sufficiency in food, in the face of an alarming increase in population growth, but also for producing necessary raw materials for the successful industrialisation of the country. The importance of irrigation in India, in this context, cannot be overemphasised.

3. *Importance of Minor Irrigation.*

The area under cultivation in India is 329 million acres, of which 70 million acres are provided with irrigation facilities. About 44 per cent of this area comes under major and medium irrigation projects and 56 per cent under minor irrigation works, such as tanks, small anicuts and channels, wells, tube wells, etc. Individually they are small works, but collectively, they irrigate more area than all the major projects put together. Many of the minor irrigation works, especially wells, are constructed, operated and maintained by the farmers themselves. Minor schemes can be executed swiftly and yield quick results, and they stimulate people's participation. Also, there are vast areas of arid and semi-arid land, where successful agriculture, resulting in satisfactory crop yields, is impossible without proper irrigation facilities. In Madras State especially, the major rivers have almost been exploited for irrigation, and further development of irrigation is to be achieved mainly in minor schemes. Increasing attention is therefore, being bestowed in successive five-year plans, towards acceleration of the minor irrigation programme. The importance of minor irrigation had been stressed years back by the Indian Irrigation Commission (1903) and subsequently by the Royal Commission on Agriculture (1928), under the Grow More Food Campaign (1943), and again by the Grow More Food Enquiry Committee (1952), the Foodgrains Enquiry Committee (1957) and the Agricultural Production Team of the Ford Foundation.

4. *Problems in Minor Irrigation.*

The design criteria and construction techniques in respect of minor irrigation works are usually less rigorous than those for major projects, as greater risks can be taken and costs can be economised. Again, the efficient tapping of underground water by constructing deep tube wells, and deepening or boring in existing open wells, and installing suitable lifting devices is an important part of the

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minor irrigation programme. Most of these works are owned, operated and maintained by the farmers in their own holdings. The farmers require technical guidance and assistance in constructing and operating such works. The Public Works Department of the State Government will be busy with the construction and maintenance of major projects and also the construction of State-owned minor irrigation works for tapping surface water. The whole country is now covered by the Community Development Blocks, and the farmers have the opportunity of coming into contact with the block officials often. Hence the block staff have to provide the necessary assistance to the farmers in improving their own minor irrigation resources, and they must be technically competent to do so. For this purpose, they have to be equipped with the knowledge on the subject. The responsibility for the maintenance of minor irrigation works owned by the State Government has also been transferred to the Block agency and therefore the Block staff should also be conversant with the techniques and standards of construction of those works.

5. *Water use.*

The water delivered from the irrigation system built at a high cost should be used efficiently and economically, so as to cover the largest area and reap the highest yield of crops possible. For this, the water delivered at the Government outlets should be conveyed to the fields, minimising transit losses, and the right quantity of water applied to the fields at the correct time and interval. The responsibility of the Public Works Department now ceases when once the required quantity of water is released at the canal outlet, and adequate attention has so far not been paid to water management beyond the outlet. It has been estimated that more than half the quantity of water supplied is wasted in the field channels and the fields, by seepage, and irregular and excessive irrigation. Field channels have to be aligned, constructed and maintained satisfactorily by the ryots, and in areas where seepage in channels is high, the water courses may also be lined with cheap indigenous lining materials. Good yields of crops can be obtained with economical application of irrigation water, provided the farmers are taught and induced to adopt the improved agricultural practices and irrigation methods, and they are conversant with the nature of soils, water requirements of crops, bad effects of over-irrigation, etc. Here again, it is the Block staff, especially those members concerning agriculture and irrigation, who have to impart the necessary knowledge and render assistance to the farmers.

6. *Training in Minor Irrigation and Water Use.*

The Extension Officer (Agriculture) and the Union Engineer and the Minor Irrigation Overseer of the Block or Panchayat Union are the officers directly connected with agricultural production and therefore it is desirable that they are trained in different aspects of minor irrigation and water use, so that the knowledge gained by them is disseminated among the farmers, and improved agricultural and irrigation techniques are adopted by them. One of the schemes sponsored by the Government of India after the declaration of the national emergency in 1962 was the scheme for training in minor irrigation and water use. The scheme was sanctioned by the Government of Madras in G.O. Ms. No. 213 (Food and Agriculture), dated 22nd January 1963 and was implemented from May 1963. The scheme provides for training of Extension Officers (Agriculture) and Union Engineers and Overseers in Minor Irrigation and Water Use for a period of three months, in batches consisting of 20 Extension Officers and 10 Union Engineers and Overseers. There will be three training courses in a year with a gap of one month between any two sources. The venue of the training in the Agricultural College and Research Institute, Coimbatore, where facilities for the training are readily available. The cost of running the scheme is borne by the Government of India.

7. *Details of the training scheme.*

Instruction is imparted to the trainees in Agronomy and in Engineering, and special

emphasis is laid on practical work in the fields. A Lecturer in Agriculture, who has undergone the Orientation training in Minor Irrigation and Water Use, conducted by the Government of India, handles the agronomy classes, and an Assistant Engineer of the Public Works Department, having experience in irrigation work, and obtained on deputation, is handling the engineering classes. They are assisted by an Upper Subordinate in Agriculture and a Junior Engineer, especially in conducting the practical classes. The trainees are also taken on study tours to places of agricultural and irrigation interest, in and outside the State so that they can have a fuller realisation of the scope and application of the knowledge imparted to them. Several officers of the Agricultural and Engineering Departments and Professors of the Agricultural College and Research Institute are invited to deliver special lectures to the trainees during the training course. The library facilities available in the institute are also made good use of, by the trainees. The syllabus for the training is given below:

(1) Minor irrigation schemes—scope, objectives and salient technical features of different types of schemes.

(2) Open wells, their design, construction, boring and deepening.

(3) Water lift appliances—different types of manpowered, animal powered and mechanical powered appliances in vogue; their design, construction; comparative performance and water output, scope for further improvements in their design.

(4) Design criteria and standards for construction and restoration of tanks, storage works and diversion schemes.

(5) Surveys, levelling and investigations for minor irrigation works and preparation of fields.

(6) Operation and maintenance of irrigation works, regulation of supplies and restoring of channels, concepts of duty, depth, water allowance, outlet factors, etc., crop planning for maximum production with available supplies in the irrigation system.

(7) Plant-soil-water relations; the physical and chemical properties of soil, the suitability of soils for irrigated farming, the need for and advantages of scientific crop patterns, suitable crop rotations; the water requirements of different crops under varying conditions of soils and climate, crop evaluation in the field.

(8) Irrigation methods and field proportion selection of irrigation methods for cultivation of different crops under varying conditions of terrain and soils, levelling and preparation of fields with improved implements and in a Scientific manner, fixation of field size and slopes according to soil intake rate and discharge of the water course.

(9) Irrigation farm structures including water distribution, regulation and measurement—alignment, construction and lining of field channels; cheap designs for and construction of field channels, crossings and falls. The Parshall flumes, wooden regulating boxes, canvas dams and syphon tubes, gated pipes and other devices for measuring water-supply to fields.

(10) Soil and water conservation practices—contour bunding, terracing, gully plugging, etc.

(11) Drainage for waterlogging; quality of ground water, salinity and alkalinity problems and their cure, the taking of soil samples for salinity and alkalinity examinations; the taking of water samples, their collection and despatch; recognition in the field of saline soil and alkaline soil and deficiency symptoms to accompany the leaf samples.

8. *Conclusion.*

The training in Minor Irrigation and Water Use will be of great benefit to the Extension Officers (Agriculture) and Union Engineers and Overseers in discharging their responsibilities towards the further development and efficient use of our minor irrigation potential. The training programme is likely to be continued in the fourth plan also, so that almost all these officers can be trained. A similar scheme to train the Subordinate Officers of the Irrigation Department in agriculture is also under consideration of the Government.

BOOK REVIEW :

IRRIGATION AND CLIMATE

BY

HENRY OLIVIER

[*Published by Edward Arnold (Publishers), Limited, London.* Price 100s nett; pp. 250.]

As the announcement on the jacket of the book states, this book by Henry Olivier, provides for engineers and agriculturists who are preparing water balance sheets and planning new water resources development projects, particularly in under-developed countries, relatively simple methods for estimating the quantities and times of crop water requirements for different localities. The book also presents a summary of accumulated experience on the subject culled from the literatures of the allied fields of agriculture, soil science and meteorology.

The book is of special interest to the Irrigation Engineers of Madras State in view of the fact that the development of most of the Water Resources of the State on conventional lines has already been completed and the future of irrigation development in the State depends almost entirely upon schemes for economising the use of water and thereby bringing additional areas under the plough.

The total water resources of the United States, their present utilisation and the estimated future uses as presented by the author make interesting reading. In 1955, the position was as follows:—

I Population	165.25 Million.	
II Water use: (*a*) Irrigation.	90·7 Million	Ac. ft.
(*b*) Domestic and Municipal.	12·1 Million	Ac. ft.
(*c*) Electric power ..	67·0 Million	Ac. ft.
(*d*) General Industry ..	45·5 Million	Ac. ft.
Total	215·3	
III Per cent of total resourses	16·3	

For the development in future, his estimate is as follows:—

Years.	*Population in millions.*	*Total water use.*	*Percentage of total resources.*
1965	180	248·5	18·8
1975	200	298·0	22·6
1995	250	576·0	43·7
2015	300	854·0	64·8
2035	350	1012·0	76·8
2055	400	1126·0	85·4
2070	450	1215·0	92·2

The figures show that roughly in a century from now the United States would be almost completely exhausting its total water resources. This should set us thinking seriously as our population is growing at a much faster rate than that of the United States and we would be exhausting our total resources much earlier.

The author builds up an enormous terminology for the study of crop water requirement, evaporation, climatic conditions, etc. He furnishes as many as 10 different formulæ adopted by various authorities in different countries for working out the Free Water Surface Evaporation.

The crop water requirements as studied in various parts of the world are summarised. They are given in eight series pertaining to (*a*) North Africa, (*b*) East Africa, (*c*) South Africa, (*d*) Australia, (*e*) India and Pakistan, (*f*) Miscellaneous, (*g*) Europe and (*h*) United States of America.

Under India and Pakistan, seasonal basis field water requirement characteristic curves are prepared for Darbhanga in Sind (Pakistan) and Meerut in United Provinces (India).

The author prefers the expression of the duty of water in term of depth of water applied over the area irrigated against our method of expressing it in term of area of crop which would be matured by the steady flow of one cusec over the entire growing period of the crop. The former method has the advantage of being readily comparable with rainfall as well as with evaporation measurement. The studies for India and Pakistan deal with cotton, wheat, barley and sugarcane crops only. The basic water requirement curve for sugarcane gives a field duty of 33·6 inches, that for cotton gives 23 inches, for wheat 10.3 inches. Requirements of rice are not studied in India. But it is studied in Lower Egypt where it works out to 25 inches for plant transpiration and 39 inches for evaporation giving a total of 64 inches. Here it is interesting to compare this figure with our usual "50 duty" which works out to 85 inches with a base of 180 days.

The book concludes by giving the practical application of the formulæ discussed and the future lines of research. This is a useful book for the irrigation engineers who are in charge of research in the usually neglected side of irrigation, namely, water distribution and its control.

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ABBREVIATIONS FOR METRIC ENGINEERING UNITS

The Standards of Weights and Measurements Act, 1956, has placed India on the map of the metric world. The Act lays down a period of 10 years for the complete change-over to the metric system. During the transition period, the various branches of engineering are slowly changing over to the metric system; but it appears that enough attention is not being paid to the correct, uniform and internationally accepted usage of abbreviations. It is not very uncommon to see abbreviation of kilometre as 'km' instead of "k" and of gram as 'gm' instead of 'g'. This paper describes the abbreviations for metric engineering units based on international recommendations by the International Organisation for Standardisation (ISO), the International Electrotechnical Commission (IEC), and the General Conference of Weights and Measures.

TABLE 1.

ABBREVIATIONS FOR PREFIXES OF SUB-MULTIPLES AND MULTIPLES OF METRIC UNITS.

Prefix.	*Numerical value.*	*Abbreviation.*
Pico.	10^{-12}	p
nano	10^{-9}	n
micro	10^{-6}	μ
milli	10^{-3}	m
centi	10^{-2}	c
deci	10^{-1}	d
deca	10	da
hecto	10^2	h
kilo	10^3	k
mega	10^6	M
giga	10^9	G
tera	10^{12}	T

TABLE 2.

ABBREVIATIONS FOR METRIC ENGINEERING UNITS.

1. *Length*—	
10^{-6} m or micron	μm or μ
millimetre	mm
centimetre	cm
metre	m
kilometre	km
nautical mile (international) ..	n mile
2. *Area*—	
square millimetre	mm²
square centimetre	cm²
square metre	m²
area	a
hectare	ha
square kilometre	km²
3. *Volume*—	
cubic millimetre	mm³
cubic centimetre	cm³
cubic metre	m³
4. *Capacity*—	
millilitre	ml
litre	l
kilolitre	kl
5. *Time*—	
second	s
minute	min
hour	h
day	d
year	a
6. *Angle*—	
(*a*) Plane angle—	
radian	rad
degree	°
minute	′
second	″
grade	g
(*b*) Solid angle—	
steradian	rs
7. *Velocity*—	
(*a*) Angular velocity	
radian per second	rad/s
degree per second	°/s
revolution per minute	rpm or rev/min
revolution per second	rps or rev/s
(*b*) Linear velocity	
metre per second	m/s
kilometre per hour	km/h
nautical mile (international) per hour or international knot	kn
8. *Acceleration*—	
(*a*) Angular acceleration	
radian per second per second ..	rad/s²
degree per second per second ..	°/s²
revolution per second per second ..	rev/s²
(*b*) Linear acceleration	
gal — 1 Gal = 1 cm/s² ..	cm/s²
metre per second per second ..	m/s²
(*c*) Acceleration due to gravity ..	g
(*d*) Standard gravity = 980.665 cm/s²	gn
9. *Mass*—	
microgram	μg
milligram	mg
gram	g
kilogram	kg
quintal	q
metric tonne	t
metric carat	c
10. *Density*—	
(*a*) Linear density (Mass)/(Length)	
kilogram per metre	kg/m
(*b*) Density (Mass)/(Volume)	
gram per cubic centimetre ..	g/cm³
gram per millilitre	g/ml
kilogram per cubic metre ..	kg/m³
11. *Specific volume*—	
cubic metre per kilogram ..	m³/kg
12. *Momentum*—	
kilogram metre per second	kg m/s
13. *Moment of momentum*.—	
kilogram metre squared per second.	kg m²/s
14. *Moment of inertia*—	
(*a*) Dynamic—	
kilogram metre squared	kg m²
(*b*) Geometric	
centimetre⁴	cm⁴
metre⁴	m⁴
15. *Section modulus*—	
centimetre cubed	cm³
metre cubed	m³
16. *Force*—	
dyne	dyn
newton	N
Sethene	sn
kilogram force	kgf
17. *Bending moment*—	
kilogram force metre	kgf m
kilogram force centimetre	kgf cm
18. *Stress and pressure*—	
newton per square metre	N/m²
bar (1 bar=10⁵ dyn/cm²)	bar
kilogram force per square metre ..	kgf/m²
kilogram force per square centimetre.	kgf/cm²
kilogram force per square millimetre.	kgf/mm²
metric tonne force per square metre.	tf/m²
19. *Dynamic viscosity*—	
poise (poise=dyn s/cm²)	P
20. *Kinematic viscosity*—	
stokes (stokes=cm²/s)	S
21. *Surface tension*—	
dyne per centimetre	dyn/cm
22. *Work and energy* —	
erg	erg
joule	J
kilogram force metre	kgf m
kilowatt hour	kwh

Note.—In practical engineering, the word 'force' is usually dropped and bending moment is designated as kilogram metre, etc.

Note.—In practical engineering, the word 'force' is usually dropped and pressure is designated as kg/cm², etc.

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23. *Power*—	
watt	W
kilowatt	KW
Kilogram force metre per second ..	kgf m/s
24. *Temperature*—	
(*a*) Scale—	
degree kelvin	°K
degree celsius	°C
(*b*) Interval—	
degree kelvin	deg K
degree celsius	deg C
25. *Quantity of heat*.—	
calorie	cal
kilocalorie	kcal
26. *Heat flow rate*—	
calorie per second	cal/s
kilocalorie per hour	kcal/h
27. *Density of heat flow rate*—	
Calorie per square centimetre second	cal/cm²s
kilocalorie per square metre hour ..	k cal/m²h
28. *Thermal conductivity*—	
calorie per second centimetre degree C	cal/s cm deg C
kilocalorie per hour metre degree C	kcal/hm deg C
29. *Thermal conductance*—	
calorie per square centimetre second degree C.	cal/cm² s deg C.
kilocalorie per square metre hour degree C.	kcal/m² h deg C.
30. *Calorific value*—	
joule per gram	J/g
calorie per gram	cal/g
31. *Specific heat*—	
joule per gram degree C	J/g deg C
calorie per gram degree C	cal/g deg C
32. *Fuel consumption* $\frac{(Volume)}{(Length)}$—	
litre per kilometre	l/km
33. *Fuel consumption* $\frac{(Length)}{(Volume)}$—	
kilometre per litre	km/l
34. *Frequency*.—	
hertz	Hz
35. *Magnetic flux*—	
webber	Wb
36. *Magnetic inductance*—	
tesla	T
37. *Luminous flux*—	
lumen	lm
38. *Illumination*—	
lux	lx
phot	phot
39. *Brightness*—	
lambert	L
stilb	sb
40. *Intensity of a luminous source*—	
candela	cd
41. *Luminous efficiency*—	
lumen per watt	lm/W
42. *Sound power level*—	
decibel	dB
43. *Sound pressure level*—	
decibel	dB

TABLE 3.

SYMBOLS AND ABBREVIATIONS FOR PRACTICAL ELECTRICAL QUANTITIES AND UNITS.

Quantity.	*Symbol.*	*Practical unit.*	*Abbreviation of practical unit.*
(1)	(2)	(3)	(4)
Electro-motive Force	E	volt	V
Resistance	R	ohm	Ω
Current	I	ampere	A
Quantity	Q	coulomb	C
Capacitance	C	farad	F
Inductance	L	henry	H
Energy	W	joule	J
Power	P	watt	W

NOTE.—(i) Abbreviations should be written without full-stop; e.g., for centimetre, write 'cm' and not 'cm.'.

(ii) Do not add 's' after abbreviation to signify plural number; e.g. for 10 kilograms, write '10 kg' and not '10 kgs'.

(iii) Do not begin an abbreviation with a capital letter unless the abbreviation or the prefix is a capital letter: e.g., for kilogram, write 'kg' and not 'Kg' and for megawatt, write 'MW' and not 'mW'.

NEWS FROM ABROAD

President Truman praises Civil Engineers.

" Civil engineers plan, design, construct and operate most of the facilities used in our everyday life, especially in our urban communities. Civil Engineers are mixed up in almost everything.

" All my life I have had to rely a great deal on engineers and they were mainly civil engineers. I have grown to have a most wholesome respect for the Civil Engineering profession, and it seems to me to be one which should hold a lot of attraction to young men picking their future course in life. I recommend it highly.

" And while you are doing it (addressing himself to Civil engineering students present) get into politics, too.

" I have found that experienced engineers have acquired an unusual know how in matters of business and finance. It seems to me the combination of engineering and its related business aspects on all projects, especially large ones, offers most challenging and interesting opportunities.

" Engineering has not been recognized as a profession as long as some of the others, but it is my opinion that without question it should be ranked with the highest. It seems to me the man who invented the wheel should have been called a professional. At any rate engineering has been recognized as a profession for well over 100 years, which should give it sufficient venerability even if such were needed.

" Yours is a profession calling for the application of the highest grade of moral as well as technical qualifications. The necessity of meeting the strict technical, practical and moral requirements of good engineering justifies your being recognized as a real professional. Yours is a walk in life that must recognize the term 'conflict of interest' most seriously.

" Engineering, and it seems to me particularly civil engineering, does a lot to equip one to take an important place in all walks of life. I find engineers as heads of many of our great industrial and commercial enterprises, and even of our banks. The field of management must be a field having great attraction to those of you who might prefer such positions to that of strict adherence to the actual practice of engineering.

" Your profession not only has an honourable past but a most challenging future ".

—EXTRACT OF PRESIDENT HARRY S. TRUMAN'S SPEECH AT THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

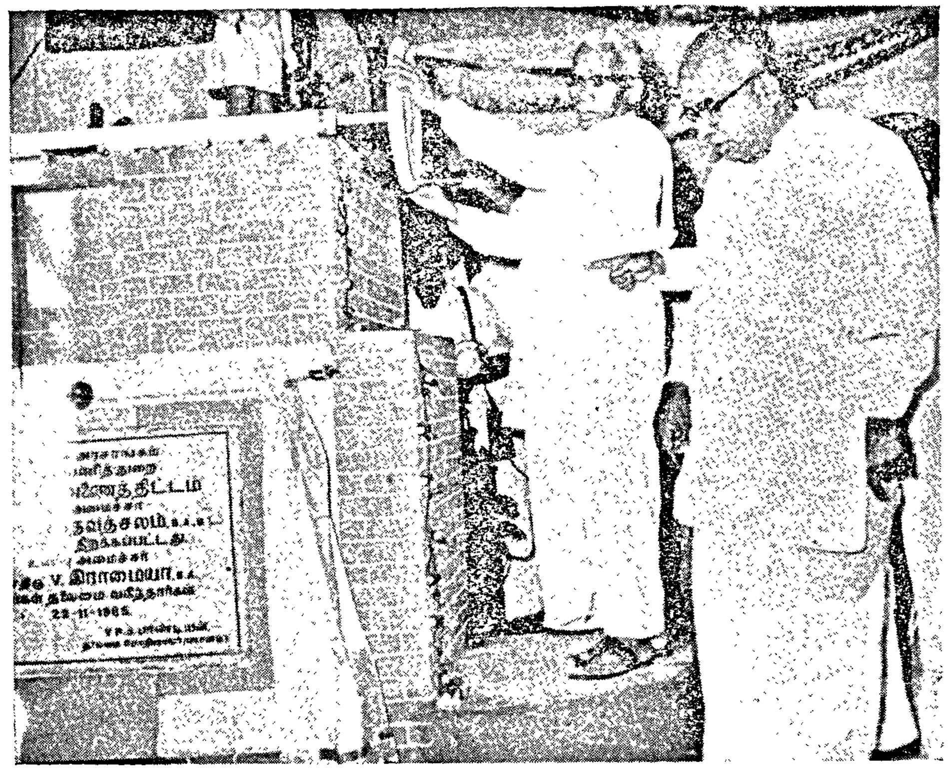
Echo of Malpasset Dam Collapse

In 1959, Malpasset Dam in France collapsed. It was a thin earth dam, 197 feet high. This collapse resulted in the complete destruction of several villages besides killing 421 persons.

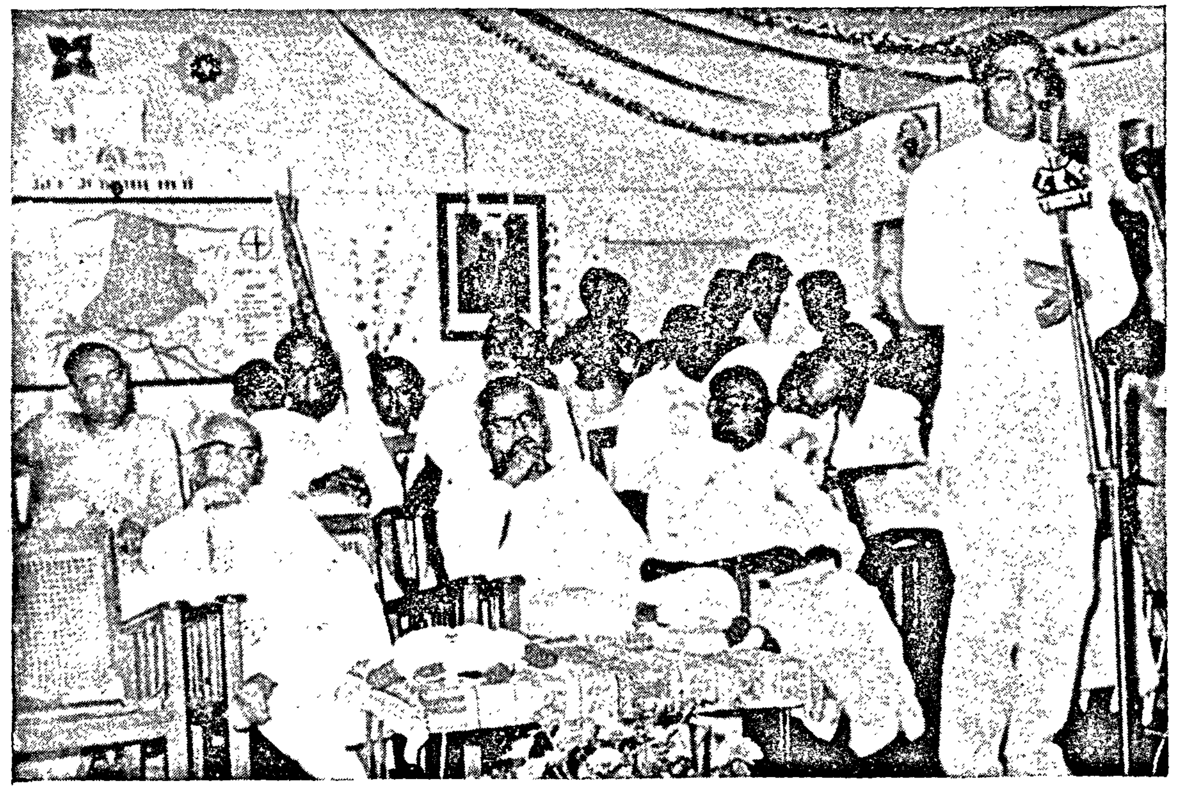
In this connection the French Government Engineer, Jacques Dargeon was prosecuted for involuntary homicide through negligence. He was acquitted. But an appeal preferred by the Government is not yet decided.

In the meanwhile the relatives of the victims of the dam collapse have sued the other persons connected with the construction and maintenance of the Dam. Bellier, a partner of the firm which designed and supervised the construction of the dam is accused of not having taken an active part in the dam project. Martin and Kaufman, Managers of the firm which was engaged for taking aerial and other photographs to check the geological and other foundation deformations are accused of failure to perform their duties properly. Nourrit, who was the Government Engineer incharge of the Dam when it actually collapsed, is accused of not having taken proper action on the report of the photographic company which gave the details of the deformations in the dam and its foundations.

The damages claimed by the French Railways, private companies and relatives of the victims aggregate to 40.34 millions. It is expected that it would take more than a year for these cases to be finally settled, though seven years have already passed since the dam collapsed.



The Hon'ble Chief Minister turning the lever to unveil the tablet signalling the inauguration of Gomukhinadhi Project.



The Hon'ble Information Minister who declared open a Children's Park at the Gomukhinadhi Project addressing the gathering.

The Hon'ble Chief Minister unlocking the Canal Head Sluice at the time of inaugural function of Gomukhinadhi Project.

The Hon'ble Food Minister who presided, addressing the gathering on the occasion of the inaugural function of the Gomukhinadhi Project

NEWS ROUND UP

S.M.I.P. Schemes.

1. The estimate for excavating a right side channel taking off from Holdsworth Anicut in Thirumayam taluk of Tiruchirappalli district was approved in G.O. Ms. No. 2265, Food and Agriculture, dated 20th July 1963, at a cost of Rs. 4,74,000. The scheme was inaugurated by Hon'ble Minister for Food on 20th July 1965. The right side channel will feed sixteen tanks enroute. By the execution of the above scheme an extent of 2,775 acres will be brought under cultivation yielding an additional food production of 710 tons.

2. The proposal for formation of a new tank across Godubaipallam in Ajjanahalli village in Dharmapuri taluk and district was approved by Government for Rs. 1,94,000 in G.O. Ms. No. 2970, Food and Agriculture, dated 28th October 1964. The scheme was inaugurated by Hon'ble Minister for Home, on 21st July 1965. The Collector of Dharmapuri district presided over the function.

The flow in the stream Godubaipallam will be abstracted by forming earthen bund for 835 feet long; a surplus weir for a length of 216 feet and a calingulah for 124 feet long will be constructed to discharge the maximum flood. A head sluice will be constructed for providing supply to the lands.

The tank after formation will benefit 120 acres and they will yield an additional food production to the tune of 53 tons of rice.

3. The scheme "Formation of a tank across Maddallapallam in Sidhumanahalli village of Dharmapuri taluk and district approved for Rs. 5,93,000 by Government in G.O. Ms. No. 3259, Food and Agriculture, dated 26th November 1964, was inaugurated by the Hon'ble Minister for Home on 21st July 1965 under the presidentship of the Collector of Dharmapuri.

The tank will have 1,320 feet long earthen bund, 200 feet long calingulah and one head sluice.

An area of 670 acres will be brought under wet cultivation. An additional food yield to the tune of 328 tons of rice will be expected when the scheme is brought into beneficial use.

4. The work of "Forming a new tank near Sundarapandian village", Srivilliputhur taluk, Ramanathapuram district, approved by Government in G.O. Ms. No. 2472, Food and Agriculture, dated 28th August 1964, at a cost of Rs. 1,84,350 was inaugurated by Hon'ble Minister for Home on 30th August 1965. Sri R. Krishnaswami Naidu, M.L.A., President, Tamilnad Congress Committee, presided over the inaugural function. The length of the tank bund will be 6,900 feet and will impound 21.85 M.Cft. of water in the proposed tank. Two sluices are proposed to irrigate a new ayacut of 266 acres under the tank. The anticipated additional food production from the scheme will be 133 tons of rice.

5. *Alanduraipattu Anicut Scheme.*—The estimate for the work of constructing an anicut across Alanduraipattu or Peria Odai in Vridhachalam taluk of South Arcot district was approved in G.O. Ms. No. 2788, Food and Agriculture, dated 12th August 1965, for Rs. 3,60,000. The scheme was inaugurated on 19th September 1965 by the Hon'ble Minister for Home under the presidentship of the Hon'ble Minister for Broadcasting. The scheme contemplates construction of an anicut across Alanduraipattu drain or Peria Odai for a length of 100 feet, a head sluice on the right flank of the anicut and excavation of a leading channel from the anicut to the Tholudur head high level channel below drop No. 18. The length of the leading channel is 3 miles 3 furlongs 110 feet. By the execution of the scheme an extent of 1,462 acres of existing ayacut will get stabilised supply and a new ayacut of 360 acres will also be brought

under plough, yielding an additional food production of 360 tons.

6. *Gomuki Reservoir scheme.*—The scheme contemplates construction of a reservoir of 560 M.Cft. across Gomuki river in Kachirapalayam village limits of Kallakurichi taluk in South Arcot district and excavation of a channel from the reservoir running for a length of 5 miles 5 furlongs to irrigate an extent of 5,000 acres. The total length of the dam is 7,117 feet of which the earth dam portion will be 6,900 feet and the balance 217 feet will be of masonry dam. The scheme was sanctioned for Rs. 87.00 lakhs in G.O. Ms. No. 3309, Public Works, dated 10th December 1962 and technically sanctioned for Rs. 95.70 lakhs. A revised estimate for Rs. 121.60 lakhs has been sent to Government for approval. The scheme was taken up for execution in 1963. The channel was formerly opened for irrigation on 2nd November 1965 by the Hon'ble Chief Minister, Sri M. Bhaktavatsalam under the Chairmanship of Sri V. Ramiah, Minister for Food. The extent thrown open for irrigation during this year (1965-66) is 440 acres. The project is nearing completion. The anticipated additional food production will be about 2,500 tons.

7. The work of " forming a new tank near Thenkarai village Srivilliputhur taluk, Ramanathapuram district approved by Government in G.O. Ms. No. 3865, Food and Agriculture, dated 2nd December 1965 at a cost of Rs. 2,85,000 was inaugurated by the Hon'ble Minister for Home on 23rd February 1966. Sri R. Krishnaswami Naidu, M.L.A., President, Tamilnad Congress Committee presided over the inaugural function. The length of the tank bund will be 10,500 feet and will impound 46.88 M.Cft. of water in the proposed tank. Three sluice will be constructed to irrigate a new ayacut of 277 acres under the tank. The anticipated additional food production from the scheme will be 138.5 tons.

OUR OWN FORUM

It is proposed to open a special feature " OUR OWN FORUM " from the next issue of the journal in order to provide a forum to our departmental engineers to express their opinions on the various technical problems and other administrative and accounting problems allied to technical subjects which they may come across in the course of their duties or elsewhere.

The contributions to the forum are to be in the form of short and crisp letters addressed to the Editor ' New Irrigation Era ', Madras and sent to the Executive Engineer, P.W.D., Gauging Division, Madras-5.

In this forum the readers of the New Irrigation Era may also express (1) their opinion on the usefulness of the articles published in the journal, (2) their observations and comments in support of or contrary to the information or opinions expressed in the various articles, (3) their suggestions to improve the usefulness of the journal, or (4) any other topic which may be of general interest to the Engineers of the P.W.D.

The readers are requested to co-operate to make this feature interesting and useful.

EDITOR
NEW IRRIGATION ERA.

புதுயுகப் பாசனம்

விண்ணப்பம்

தமிழ் மொழியே தமிழ் நாட்டின் ஆட்சி மொழியாக வேண்டும் என்று தமிழ்நாட்டு அரசாங்கம் முடிவு செய்திருப்பது வாசகர்களுக்குத் தெரிந்திருக்கும். இந்த நோக்கத்துடன் நமது பாசனத் துறையிலும் கடிதப் போக்குவரத்தைப் படிப்படியாகத் தமிழிலேயே மாற்றிக் கொண்டு வருகிறோம். ஆனால், தற்பொழுது தொழில் நுட்பச் சொற்கள் வராத கடிதங்கள் மட்டுமே தமிழில் எழுதி வருகிறோம். மற்றவையெல்லாம் ஆங்கிலத்திலேயே எழுதப்பட்டு வருகின்றன. இன்னும் சிறிது காலத்திற்குள்ளாக அனைத்தும் தமிழிலேயே நடத்தப்பட வேண்டும் என்பதே அரசாங்கத்தின் நோக்கமாகும்.

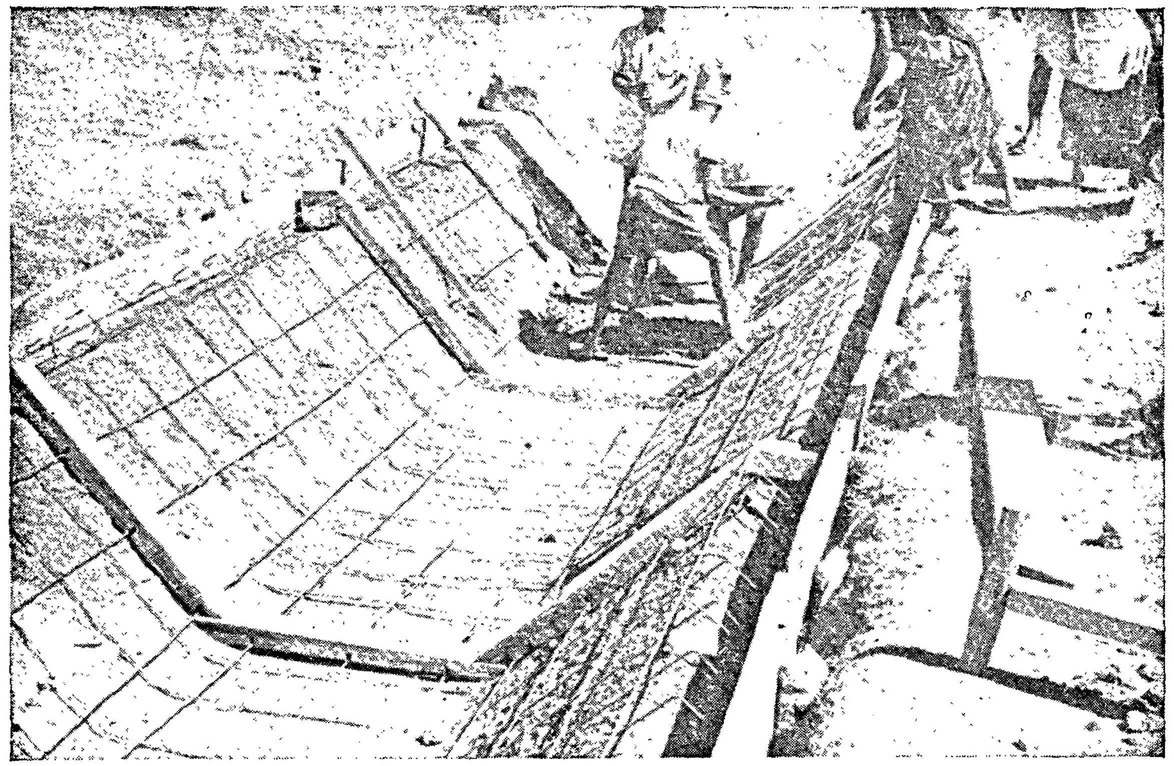
இந்நோக்கம் சீரிய முறையில் வெற்றிபெறத் துணை செய்கின்ற வகையில், பொதுப் பணித்துறையில் பணிபுரிகின்ற தமிழார்வம் கொண்ட தொழில் நுட்ப வல்லுநர்கள், பொறியாளர்கள் ஆகியோர் தொழிற் சம்பந்தமான கட்டுரைகளையும், செய்திகளையும் தமிழில் எழுதி அனுப்பினால் அவை நமது புதுயுகப் பாசன வெளியீட்டில் பிரசுரிக்கப்பெறும் என்னும் நற்செய்தியினை அறிவிக்கின்றோம்.

எனவே, பொதுப்பணித்துறையில் பணிபுரியும் பொறியாளர்களும், மற்றும் ஏனையோரும் தொழில் நுட்பக் கட்டுரைகளைத் தமிழில் எழுதியனுப்ப வேண்டும் என்று கேட்டுக் கொள்ளுகிறோம். தற்பொழுது பொதுப்பணித்துறையில் சிறியனவும் பெரியனவுமான பல பாசனத் திட்டங்கள் நிறைவேற்றப்பட்டு வருகின்றன. இத்திட்டங்களைச் செயற்படுத்தும்போது எத்தனையோ இடர்பாடுகளும், பிரச்சினைகளும் எழுகின்றன. அவற்றையெல்லாம் நமது பாசனத்துறைப் பொறியாளர்கள் நன்முறையில் தீர்த்து வெற்றி காணுகின்றனர். இத்தகைய வெற்றியிலே கிடைத்த அனுபவம் எல்லாப் பொறியாளர்கட்கும் பயன்படவேண்டும் என்ற நோக்கத்துடன் இக்கட்டுரைகள் அமைந்திருக்க வேண்டும். இதைத் தவிர கடந்த ஐந்தாண்டு திட்டங்களில் அநேகப் பாசனத் திட்டங்கள் நிறைவேற்றப்பட்டுள்ளன. அவற்றைப் பற்றிய கட்டுரைகளும், அவற்றைப் பராமரிப்பதில் எழுகின்ற பிரச்சினைகளை விளக்கும் கட்டுரைகளும் வரவேற்கப்படும். மற்றும் பாசனத் துறைக்குத் தொடர்புள்ள ஏனைய பொருள்களைப் பற்றிய கட்டுரைகள், பாசனத்துறைப் பொறியாளர்களுக்குப் பயன்படும் வகையில் அமைந்திருந்தால் அவைகளும் ஏற்றுக் கொள்ளப்படும்.

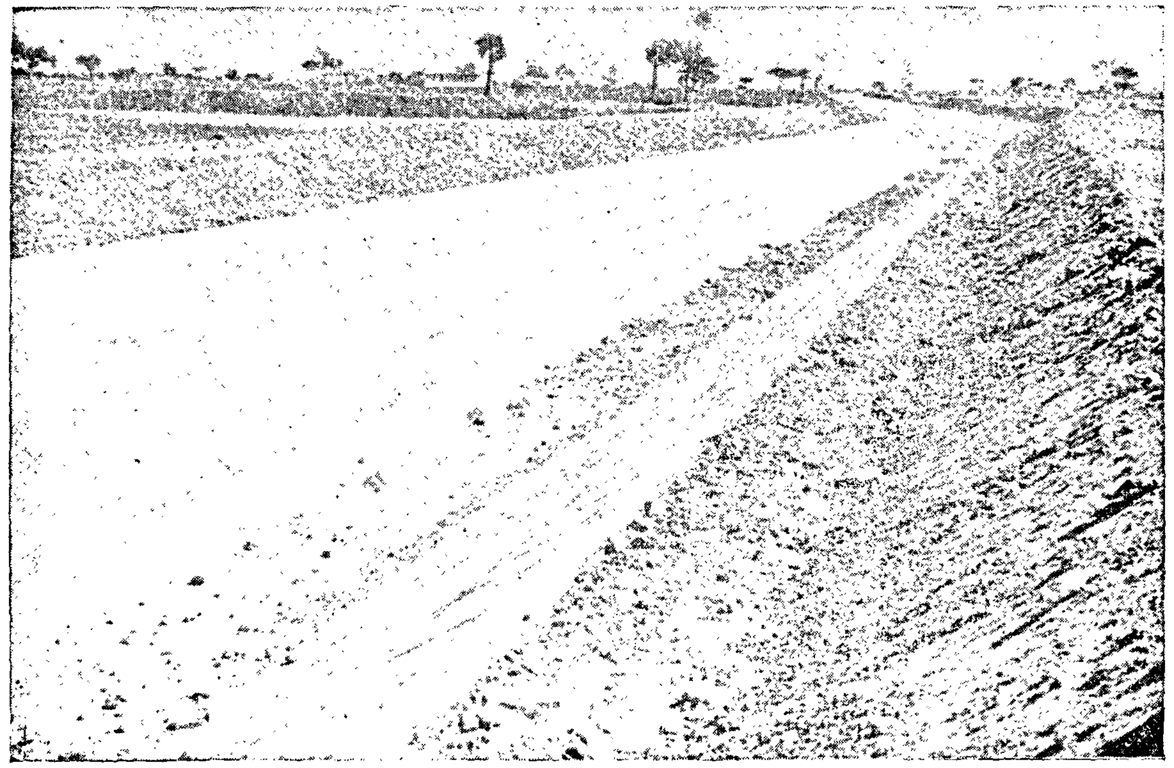
பொதுப் பணித்துறையிலுள்ள எல்லாப் பொறியாளர்களும், ஏனையோரும் மேற் குறிப்பிட்ட பொருளடங்கிய கட்டுரைகளை எழுதியனுப்பி, இத்துறையில், தமிழின் வளர்ச்சிக்குத் தங்களது பரிபூரண ஒத்துழைப்பையும், நல்லாதரவையும் அளிப்பார்கள் என நம்புகிறோம்.

ஆசிரியர்

'புதுயுகப் பாசனம்'



Reinforcement placed in position for the lining of canals in Parambikulam-Aliyar Project.



Lined canal in Parambikulam-Aliyar Project (Pongalur Division area.)

INVITATION TO READERS

Kind attention of the Engineers of the Madras Public Works Department and readers of the journal elsewhere is drawn to the meagre response to repeated requests for contribution of articles to the journal.

May we once again emphasise the two-fold objective of the journal, viz., to promote the interest of engineers and aiding their specialised work by placing before them the many problems of technical importance and ways and means of solving them, and secondly, opportunities being scarce for engineers to express their own experience in solving practical problems of design and execution, we wish to add that this journal has been the only medium of expression for those in the field. It is earnestly desired that the Engineering fraternity will come forward in large numbers to utilise this medium to its best advantage by offering their valuable contribution.

The scope of the articles to the journal need not be rigorously confined to the subjects on irrigation alone. Articles which have a direct bearing on subjects given below are also welcome:—

(1) Technical aspects of foundation soils and foundation Engineering.

(2) Auxiliary works in the field of irrigation and other water-retaining structures and works.

(3) Practical solution to hydraulic problems in canals and distribution systems with reference to their maintenance.

(4) Problems of soil erosion and conservation and reclamation of land.

(5) Practical silt problems in rivers and reservoirs.

(6) Problems of sanitation and public health and possibilities of utilisation of sewage.

(7) Inland waterways and navigation, fishing schemes and protection of land against sea erosion, etc.

(8) Problems of drainage in deltaic tracts and entrance of rivers into the sea

(9) Run-off studies in catchments and evaporation studies in reservoirs.

(10) All allied subjects.

The Executive Engineers of the Madras Public Works Department are specially requested to encourage their Subordinate Officers to come forward with articles and enable the journal to flourish and serve the common cause of the Engineers of the State.

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