6. DESIGN OF THE FIELD STRUCTURES

1) Box Culvert

The box culvert is provided to carry drainage water from field drain FD-3 under the main farm road MFR.

Design considerations

Width = 3 times drain width = 0.9 m

Height = 2 times the maximum flow

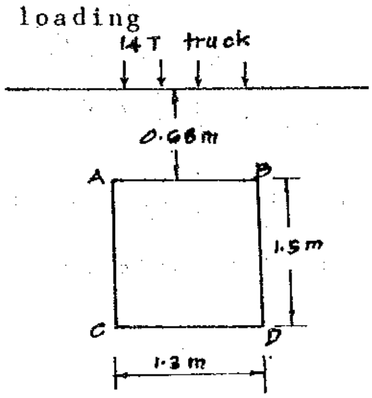
depth = 1.1 m

Thickness of wall = 0.2 m

A- The Span AB

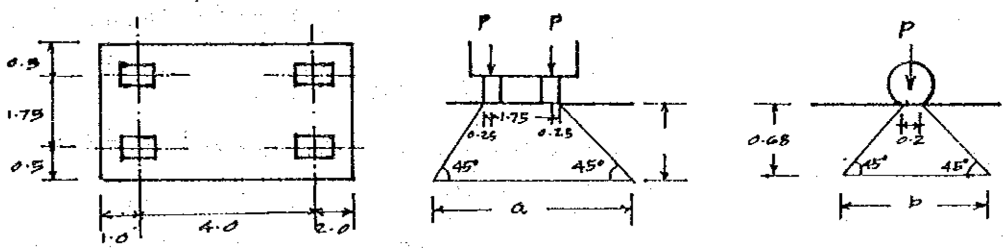
- 1) To determine the loading

a) Live Load



Consider a 14 T truck passing the farm road.

The loading distribution on AB is as shown



a = 1.75+2(0.25+0.68)

= 3.61

b = 0.2+2(0.68) = 1.56

$$i = \frac{20}{50+B}$$

$$= \frac{20}{50+1.10}$$

$$= 0.391$$

We = the equivalent load distribution per unit area

$$We = \frac{2P(1+i)}{a.b}$$

$$= \frac{2x5.6(1+0.391)}{3.61x1.56}$$

$$= 2.77\ T/m^2$$

$$= 27.15\ KN/m^2$$

Live load = 27.15 KN/m^2

b) To determine dead load

i) Self weight = 23.6x0.2

= 4.73 KN/m^2

ii) Top soil = 18x0.68

= 12.24 KN/m^2

∴ Ultimate load W = 1.4 D.L + 1.6 L.L

= 1.4(12.24+4.73)+1.6x27.15

= 67.20 KN/m^2

= 67.20x1.1 KN/M

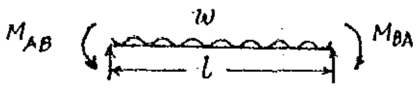
= 73.92 KN/m

2) a) For simply supported beam, AB

$$M = \frac{wl^2}{8}$$

$$= 73.92 \times \frac{1.32}{8} = 15.6 \text{ KN m/m}$$

b) For Fixed end moment



$$M_{AB} = M_{BA} = \frac{wl^2}{12}$$

$$= 73.92 \times \frac{1.3^2}{12}$$

$$= 10.4 \text{ KN m/m}$$

3) To check the section

$$M_r = 0.15 f_{cu} bd^2$$

where M_r = ultimate moment,

f_{cu} = concrete cube strength = 25 N/mm^2

b = width of section = 1000 mm

d = effictive depth of tension reinforcement = 175 mm.

$$\therefore Mu = 0.15 \times 25 \times 1000 \times 175^2$$

= 114.8 KN m/m (greater than the actual moment.

4) To provide the reinforcement

a) The span
using CP 110, Part 2

$$\frac{M}{bd^2} = \frac{15.6 \times 10^6}{10^3 \times 175^2}$$

$$= 0.5$$

From chart,

$$\frac{100\ A_s}{bd} = 1.05$$

$$A_s = \frac{1.05 x 1000 x 175}{100}$$

$$= 1837\ mm^2$$

provide 16 mm @ 125 c/c

b) The support

$$\frac{M}{bd^2} = \frac{10.4 x 10^6}{10^3 x 175^2}$$

$$= 0.33$$

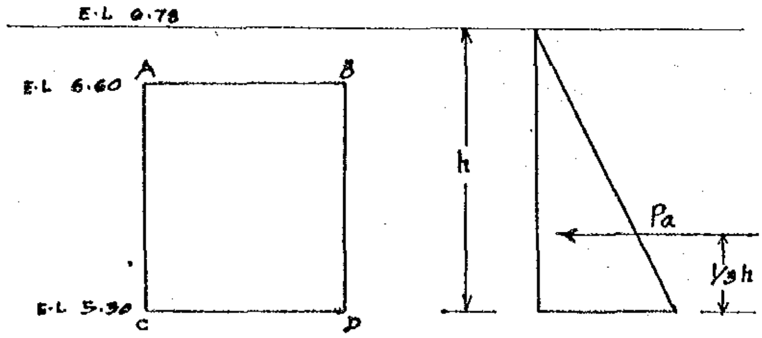
$$\frac{100\ A_s}{bd} = 0.57$$

$$A_s = \frac{0.57 x 10^3 x 175}{100}$$

$$= 9.98\ mm^2$$

provide 13 mm ∅ @ 250 c/c

B – The wall, AC



assumption

clay soil, $\phi = 0$

$k_a = 1$

$\gamma_b = 1.8 T/m^3 = 17.64 \ KN/m^2$

$h = 6.78 - 5.3 = 1.48 \ m$

The active soil pressure, Pa acting on the wall of the culvert at the one third the height of the soil equivalent from the base.

Pressure Pa $= \gamma_b \ h \ ka + \gamma_w h$

Thus the force Fa acting on the wall can be determined by.

Force = Pressure x Area

$$= \gamma_b h k a x \frac{h}{2} + \gamma_w \frac{h^2}{2}$$

Moment at C $= Fa \times \frac{h}{3}$

$$= \frac{h}{3}\left(\tfrac{1}{2}\gamma_b h^2 ka + \tfrac{1}{2}\gamma_w h^2\right)$$

$$= \frac{1.48}{3}\left(\frac{1}{2} \times 17.64 \times 1.48^2 \times 1 + \frac{1}{2} \times 9.8 \times 1.48^2\right)$$

$= 14.83$ KN m/m

1) To provide the reinforcement

a) Wall

$$\frac{M}{bd^2} = \frac{14.83 \times 10^6}{10^3 \times 175^2}$$

$$= 0.48$$

$$\frac{100A_s}{bd} = 1.0$$

$$A_s = \frac{1.0 \times 10^2 \times 175}{100}$$

$$= 1750$$

provide Ø16 mm @ 125 c/c

b) The hunch

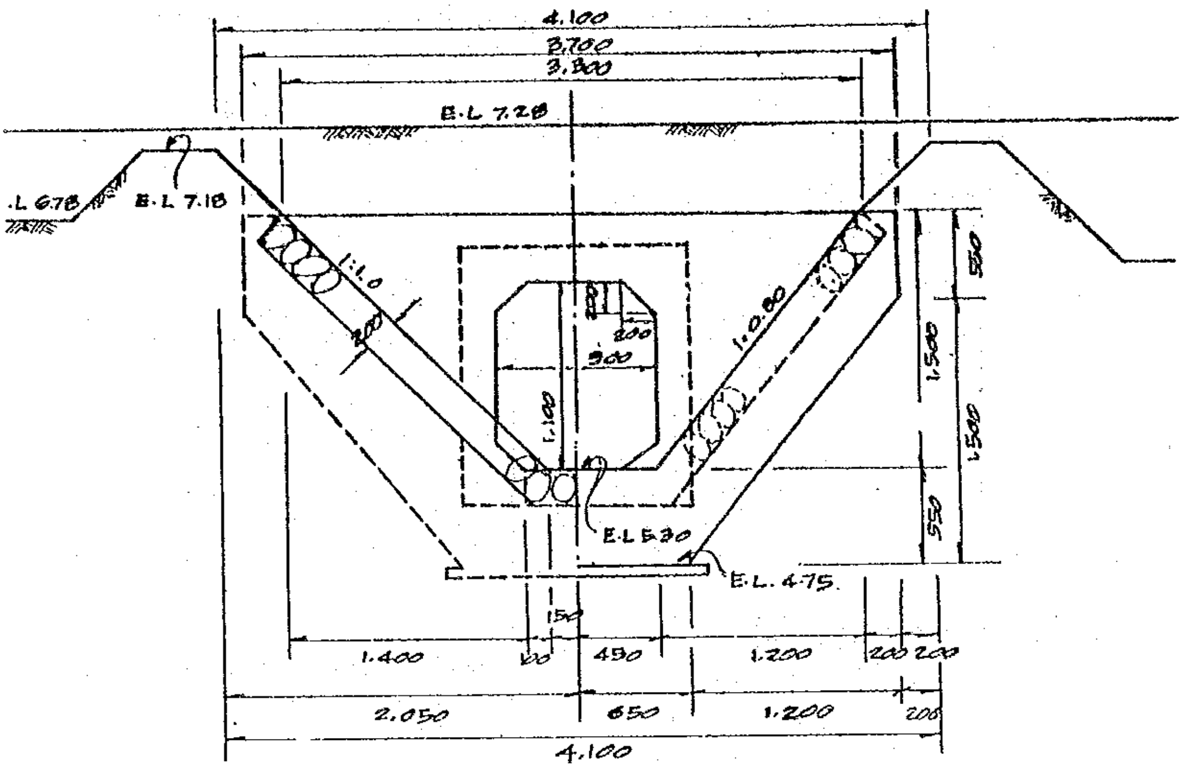
provide Ø10 @ 250 c/c

The cross section of the culvert is as shown below.

Fig. 50. cross section of Box Culvert

SCALE 1:40

FIG. 50



SECTION .F - F'

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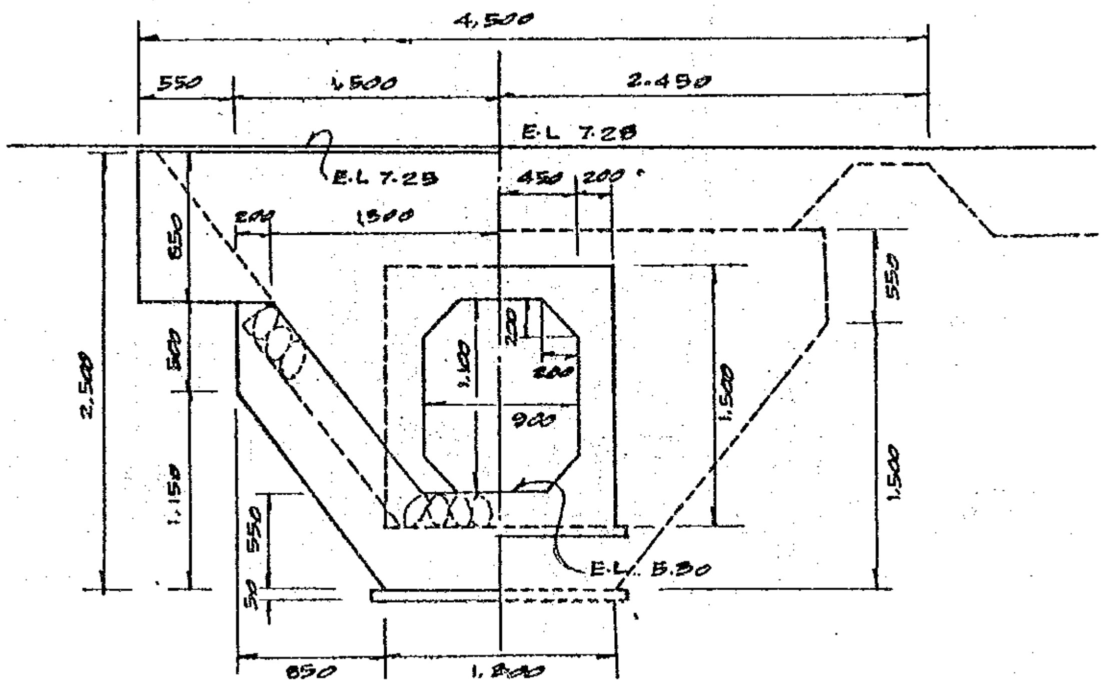


2) Control box

The control box is provided at the end of the pipe line as its function is to control the water supply to the following field block, that is F.b-4.5, 6.7 and 8, and to control the water level by the spill-way.

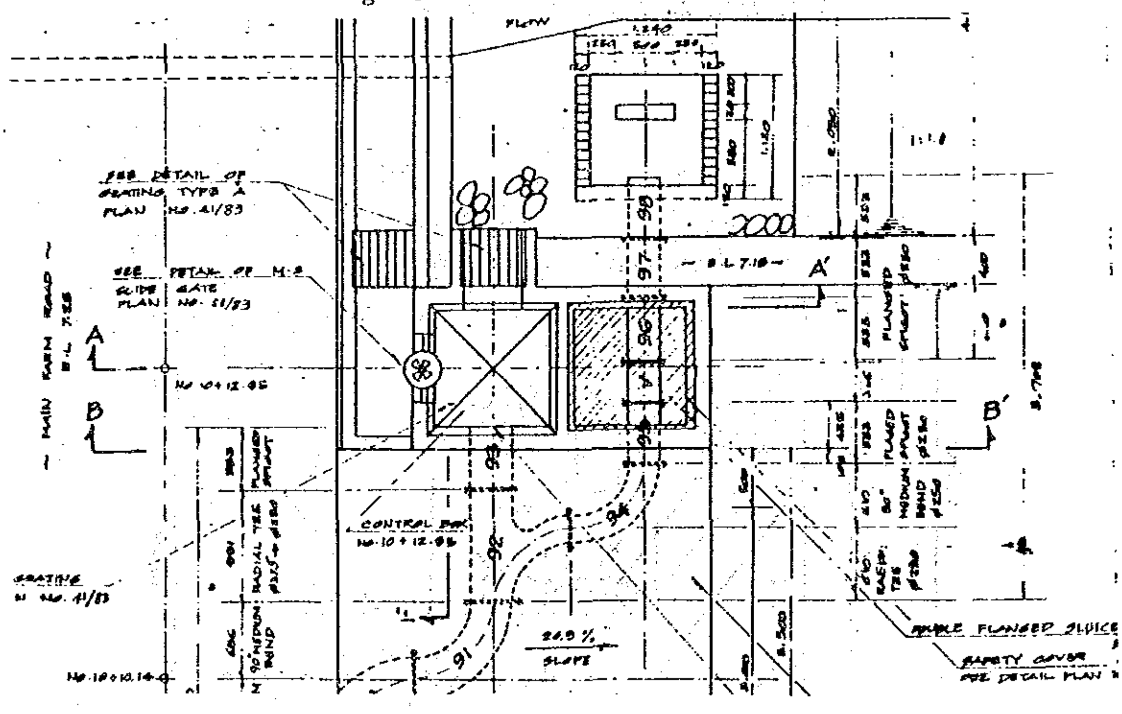
In addition, the blow of value is also provided into this control box as mention before.

The irrigation water is controlled by following operation.

Items	Operation
1. irrigation water is supplied to the F.B 1, 2 and 3	M.S gate is closed in order to keep the proposed height.
2. irrigation water is supplied to the F.B 4, 5, 6, 7 and 8.	M.S gate is opened and give the free flow to the irrigation canal.
3. cleaning of the pipe line	open the blow off value and flash out the sedimented obstacles.

The control box is shown as in Fig-. 51

Fig.-51 Control box



3) Drainage control

The purpose of the drainage control is said that the ground water table should be controlled by operating the drainage control gate and give the optimum water table for plants in accordance with the rice cultivation stages.

Actually, the control gate will be operated as follows.

Items	Operation
1. Before presaturation and right presaturation time	gate is closed in order to increase the water table.
2. Growing stage	to control the water table depends on the circumstances.
3. Harvesting time	gate is opened in order to decrease the water table and increase the bearing capacity.

six numbers of drainage control are provided in this project and F.D. 4, 5 and 6 are located at the end of the drainage canal. These structures are designed by the same way as the D.F. 1 and 2.

The rest that are the F.D. 1, 2 and 4-1 have a control drop so that the calculation method is indicated as follows.

3)-1 Drainage control F.D. 4-1

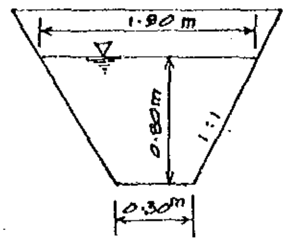
1) Determination of the drainage dischrge (Qmax)

Qmax is decided as follows:

(1) maximum designed flow of Q.C. 1 is to be Ql.

(2) Q.C. 1 has a function to store the drained water by H.W gate whose height is given as 0.8 m

(3) Just after opened the gate, amount of flow (Q2) will be calculated as follows by Manning formula.



$$A = \frac{1.90+0.30}{2} \times 0.80 = 0.88\ m^2$$

$$Q2 = A \times \frac{1}{n} \times R^{2/3} \times I^{\frac{1}{2}}$$

where: $n = 0.03$

$R + A/P = 0.343$

$I = 1/1000$

$\therefore Q2 = 0.49\ m^3/sec$

in this case $Q2 > Q1$, thus Qmax is determined by $0.49\ m^3/sec/$

2) Determination of type of drop

Water drop type is judge by following check list.

Tab. 40. Classification of Drops

TYPES OF DROP	CONDITION	
	EFFECTIVE FALL	Q. (m^3/sec)
(1) STEP TYPE	≒ 1 m	3.00 – 0:50
(2) HYDRAULIC JUMP TYPE	1.5 – 2.0 m	3.00 – 0.50
(3) IMPACT BOX TYPE	>1.0 – 2.0 m	<0.50

In this case; $H = E.L\ 6.14\ m - E.L\ 5.29\ m = 0.90\ m\ (\fallingdotseq 1\ m)$

$Q = 0.43\ m^3/sec\quad (\fallingdotseq 0.50\ m^3/sec)$

Then, the recommended type is determined by the step type drop as the result.

3) Design of approach channle.

1. Length of approach channel (l_1)

It is calculated by the following formula,

$$l_1 = 1.2 + \frac{3}{2}\sqrt{Q}$$

where; Q : Maximum drainage discharge $= 0.43\ m^3/sec$

$$\therefore l_1 = 1.2 + \frac{3}{2} \times \sqrt{0.43} = 2.18\ m$$

$$\doteqdot 2.50\ m$$

2. Depth of cut-off wall at the starting point (i_1)

i_1 is calculated by the following formula.

$$i_1 = 0.6\sqrt{h_1}$$

where, h_1 : upstream water depth $\doteqdot 0.80m$

$$\therefore i_1 = 0.6 \times \sqrt{0.80} = 0.536\ m$$

$$\doteqdot 0.55\ m$$

3. Free board of approach channel (Fb_1)

Fb_1 is calculated by the following formula but minimum Fb_1 should be 0.30 m.

$$Fb_1 = \frac{1}{3} h_1 = \frac{1}{3} \times 0.80 = 0.266\ m < 0.30\ m$$

then $Fb_1 = 0.30$ m.

4) Design of out-fall

1. Critical depth at out-fall point (hc)

hc is calculated by the following formula

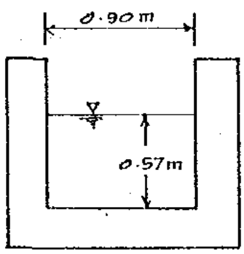
$$hc = \frac{2}{3}x(h+\frac{\alpha V^2}{2g})$$

where, $\alpha = 1.1$

V = Velocity of upstream flow

in this case, width of canal (B) is 0.90 m

$n = 0.015$ (concrete), $I = \frac{1}{1000}$



Let's suppose V = 0.84 m

then, $A = \frac{Q}{V} = 0.43/0.84 = 0.512\ m^2$

$h = \frac{A}{B} = 0.512/0.90 = 0.57\ m$

$R = \frac{A}{P} = 0.251$

Check accounts

$$V = \frac{1}{n}x\ R^{2/3}xI^{\frac{1}{2}}$$

$$= \frac{1}{0.015}\ x0.251^{2/3}x\ (\frac{1}{1000})^{\frac{1}{2}}$$

= 0.84 m/sec ..... O.K

$$\therefore hc = \frac{2}{3}x(0.57+\frac{1.1x0.84^2}{2x9.8})$$

= 0.41 m

2. Width of Out-fall (b)

b is decided by the following formula

$$b = \frac{Q}{q} = \frac{Q}{2.98\ hc^{3/2}}$$

where; q = unit width flow

$= 2.98\ hc^{3/2}$

$= 0.78$

$$\therefore b = \frac{0.43}{2.98 \times 0.41^{3/2}} = 0.55\ m$$

$\doteqdot 0.60\ m$

5) Design of stilling basin

1. Length of stilling basin (L)

L is decided by the following formulas.

$$L = \frac{(L1+L2)}{2} \times \alpha L$$

$$L1 = 2 \times Vc\ \left(\frac{2(H+h')}{g}\right)^{\frac{1}{2}}$$

$$L2 = 3(E.F)^{\frac{1}{2}}$$

where; αL : 1.2 - 1.5 (in this case αL = 1.2)

$h' = \frac{1}{2} hc \ (= \frac{0.41}{2} = 0.205\ m)$

H = DROP HEIGHT (=0.90 m)

$Vc = \frac{Q}{hc.b} \ (= \frac{0.43}{0.41 \times 0.60}) = 1.75\ m/sec)$

$E = h + \frac{\alpha V^2}{2g} \ (0.57 + \frac{1.1 \times 0.84}{2 \times 9.8} = 0.617\ m)$

(: Specific energy of upper stream)

F : HEIGHT OF FALL

= (HEIGHT OF UPPER STREAM H_1)

– (HEIGHT OF DOWN STREAM H_2)

(DEPTH)

H_1 : E.L 6.14+0.57 = E.L 6.71 m

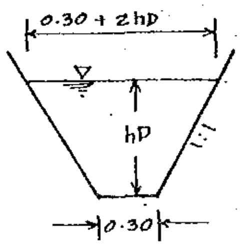
H_2 is calculated as follows.

(1) (Amount of downstream flow QD)

=(Amount of Q.C. 1)+(Amount of Q.C.2)

$= 0.43\ m^3/sec + 0.17\ m^3/sec = 0.60\ m^3/sec$

(2) Cross section of downstream



$$\therefore AD = \frac{(2hD+0.30)+0.30}{2} \times hD$$

$$= hD^2 + 0.30\ hD$$

$$PD = 0.30 + 2.\sqrt{2}.hD$$

$$RD = AD/PD$$

(3) $I = \frac{1}{1000}$, n = 0. 03 (given condition)

(4) Let's suppose VD = 0.55 m/sec

$$AD = 0.60\ m^3/sec \div 0.55\ m/sec = 1.09\ m^2$$

$$= hD^2 + 0.30\ hD$$

$$\therefore hD = 0.91\ m$$

$$\therefore RD = \frac{AD}{0.30+2.\sqrt{2}.hD} = \frac{1.09}{0.30+2.\sqrt{2}.091}$$

$$= 0.382$$

(5) Check accounts (Manning formula)

$$V_R = \frac{1}{n} x (R)^{2/3} x (I)^{\frac{1}{2}}$$

$$= \frac{1}{0.03} x 0.382^{2/3} x (\frac{1}{1000})^{\frac{1}{2}}$$

$$= 0.55\ m^3/sec \quad ..... \quad O.K$$

∴ (6) H_2 = E.L 5.24+0.91 = E.L 6.15

$$\therefore F = H_1 + H_2$$

$$= 6.71 - 6.15 = 0.56\ m$$

Then, $L_1 = 2xVc\ (\frac{2(H+h')}{g})^{\frac{1}{2}}$

$$= 2x1.75x(\frac{2x(0.90+0.205)}{9.8})^{\frac{1}{2}}$$

$$= 1.66\ m$$

$$L_2 = 3(ExF)^{\frac{1}{2}}$$

$$= 3x(0.617x0.56)^{\frac{1}{2}}$$

$$= 1.76\ m$$

Finally $L = \frac{(L_1+L_2)}{2} x 1.2$

$$= (\frac{1.66+1.76}{2}) x 1.2 = 2.05$$

$$\doteqdot 2.10\ m$$

2. Depth of water cushion (D)

D is decided by the following formula.

$$D = \frac{1}{2}(E \cdot F)^{\frac{1}{2}}$$

$$= \frac{1}{2} x (0.617x0.56)^{\frac{1}{2}} = 0.294$$

$$= 0.30\ m$$

3. Thickness of Base (t_2)

t_2 is decided by the following formula, if calculated t_2 is less than 15 cm, t_2 should be 15 cm.

$$t_2 = \alpha t(0.1+0.1\sqrt{q.F})$$

where; αt = 0.6 (in the case concrete)

$$\therefore t_2 = 0.6(0.1+0.1x\sqrt{0.78x0.56})$$
$$= 0.10 < 0.15 \text{ m}$$

then t_2 = 0.15 m

4. Free board (Fb_2)

Fb_2 is decided by the following formula.

$$Fb_2 = 0.10+0.30x\sqrt{Q}$$
$$= 0.10+0.30x\sqrt{0.43} = 0.296 \text{ m}$$
$$\doteqdot 0.30 \text{ m}$$

6) Design of approach channel to downstream.

1. Length of approach channel (l_2)

l_2 should be same as L then L_2 = L = 2.10 m

$\doteqdot$ 2.00 m

2. Depth of cut-off wall at the end point (i 2)

$$i_2 = 0.6x\sqrt{h_2}$$

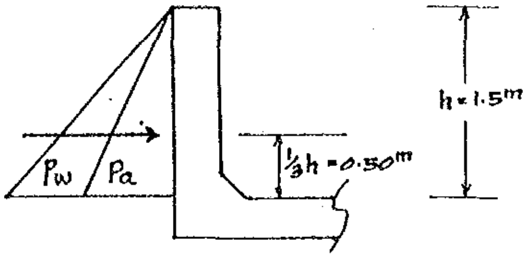
where' h_2 : depth of downstream

$$i_2 = 0.6x\sqrt{0.91} = 0.57$$

$\doteqdot$ 0.55 (make it all of uniform height as the other cut-off)

7) Reinforcement of stilling basin wall.

1. External pressure (P)



Condition

$\gamma w = 1.0 \ t/m^3$

$\gamma m = \gamma s - \gamma w$

$= 2.0-1.0=1.0 \ t/m^3$

$\phi = 30^o$

Ka = 0.33

P = (Water pressure) + (earth pressure)

= Pw+Pa

$= \frac{1}{2} x \ \gamma w x h^2 + \frac{1}{2} x \ \gamma m x h^2 x Ka$

$= \frac{1}{2} x 1.0 x 1.5^2 + \frac{1}{2} x 1.0 x 1.5^2 x 0.33$

= 1.50 t

$M = \frac{1}{3} x h x P = \frac{1}{3} x 1.5 x 1.5 = 0.75$ t-m

2. Let's suppose As = 7.85 m^2/m (BRC B10)

effective height : 10 cm

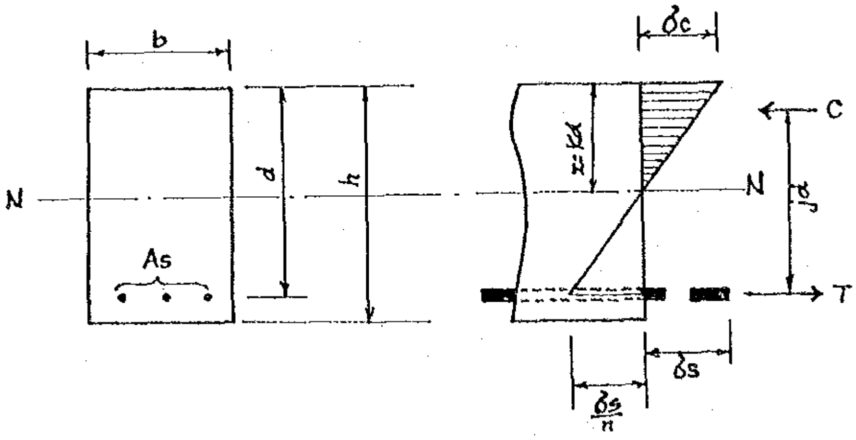
$P = \frac{As}{b.d}$

where; P = steel ratio

b : unit width

d : effective height

$\therefore P = \frac{2.85}{100x10} = 0.00785$



where; b : width

d : effective height

h : total height

As : reinforcement area

N : neutral axis

x : distance to N

n : Es/Ec

Es : Young's modules of steel

Ec : " " " concrete

C : Total compressive stress

T : " tension "

δc : compressive strength of concrete

δs : tension " " steel

In this case

A) C should be T

Then $\frac{1}{2}\delta ckdb = As\delta s$

$As = pbd$, and $\delta s = n\delta c\,(1-k)/k$

$\therefore K^2 + 2kpn - 2pn = 0$

$\therefore K = \sqrt{2np + (np)^2} - np$

B) distance from N to C is 2/3 k.d

then $j.d = d-\frac{1}{3}k.d = (1-\frac{1}{3}k)d$

$\therefore j = 1\frac{1}{3}k$

C) Bending moment by external force should balance to resistance moment by internal force.

then $Mc = \frac{1}{2}\,\delta ca.K.j.b.d^2 \ldots \quad (1)$

where Mc : resistance moment by concrete

δca : allowable compressive stress of concrete

if $Kc = 2/k.j$

then $Mc = \frac{1}{kc} x b.d^2 x\,\delta ca$

also $Ms = \delta sa.As.j.d = \delta sa.p.j.b.d^2 \ldots\ldots (2)$

where Ms : resistance moment by steel

δsa : allowable tension stress by steel

if $Ks = \frac{1}{p.j}$

then $Ms = \frac{bd^2}{ks}\,\delta sa$

Tab. (1)

$p=\frac{A_s}{bd}$	$k=\frac{x}{d}$	$j=\frac{z}{d}$	$K_c=\frac{bd^2}{M}\sigma_{ca}$	$K_s=\frac{bd^2}{M}\sigma_{sa}$
0.0010	0.169	0.947	13.28	1,058
12	173	942	12.27	885
14	185	938	11.53	759
16	196	935	10.91	668
18	207	931	10.38	597
0.0020	0.217	0.928	9.93	539
22	226	925	9.57	491
24	235	922	9.23	452
26	243	919	8.96	418
28	251	916	8.70	390
0.0030	0.258	0.914	8.48	365
32	266	911	8.25	343
34	272	909	8.09	324
36	279	907	7.90	306
38	285	905	7.78	291
0.0040	0.292	0.903	7.59	277
42	298	901	7.45	264
44	303	899	7.34	253
46	309	897	7.22	242
48	314	895	7.12	233
0.0050	0.319	0.894	7.01	224
52	325	892	6.90	216
54	330	890	6.81	208
56	334	889	6.74	201
58	339	887	6.65	194
0.0060	0.344	0.885	6.57	188
62	348	884	6.50	182
64	353	882	6.42	177
66	357	881	6.36	172
68	361	880	6.30	167
0.0070	0.365	0.878	6.24	163
72	369	877	6.18	158
74	373	876	6.12	154
76	377	874	6.07	151
78	381	873	6.01	147
0.0080	0.384	0.872	5.97	144
82	388	871	5.92	140
84	392	869	5.87	137
86	395	868	5.83	134
88	398	867	5.80	131

$p=\frac{A_s}{bd}$	$k=\frac{x}{d}$	$j=\frac{z}{d}$	$K_c=\frac{bd^2}{M}\sigma_{ca}$	$K_s=\frac{bd^2}{M}\sigma_{sa}$
0.0090	0.402	0.866	5.75	128
92	405	865	5.71	126
94	408	864	5.67	123
96	412	863	5.63	120
98	415	862	5.59	118
0.0100	0.418	0.861	5.56	116
110	433	856	5.40	108
120	446	851	5.27	97.9
130	459	847	5.14	90.8
140	471	843	5.04	84.7
0.0150	0.483	0.839	4.94	79.5
160	493	836	4.85	74.8
170	503	832	4.78	70.7
180	511	829	4.70	67.0
190	522	826	4.64	63.7
0.0200	0.531	0.823	4.59	60.8
210	539	820	4.53	58.1
220	547	818	4.47	55.6
230	554	815	4.43	53.3
240	562	813	4.38	51.2
0.0250	0.569	0.810	4.34	48.4
260	575	808	4.30	47.6
270	582	805	4.26	46.0
280	588	804	4.23	44.4
290	594	802	4.20	43.0
0.0300	0.600	0.800	4.17	41.7
310	606	798	4.14	40.4
320	611	796	4.11	39.3
330	616	795	4.08	38.1
340	621	793	4.06	37.1
0.0350	0.626	0.791	4.04	36.1
360	631	790	4.01	35.2
370	636	788	3.99	34.3
380	640	787	3.97	33.4
390	644	786	3.96	32.7
0.0400	0.649	0.784	3.93	31.9

using table (1), in case P=0.00785, j = 0.873 and k = 0.381

Therefore, from formula (1)

$$Mc = \tfrac{1}{2}.\ \delta ca.\ k.j.b.d.$$

$$\therefore \delta c = \frac{2M}{k.j.b.d^2}$$

$$= \frac{2x0.75x1000x100}{0.381x0.873x100x10^2} = 45.1\ kg/cm^2 < 70kg/cm^2 ..o.k$$

from formula (2)

$$Ms = \delta s.As.j.d.$$

$$\therefore \delta s = \frac{M}{As.j.d.}$$

$$= \frac{0.75x1000x100}{7.85x0.873x10} = 1.094\ kg/cm^2 < 1.400\ kg/cm^2 ..\ o.k$$

3)-2 Drainage control F.D. 1 and 2

The drainage control of F.D. 1 and 2 are also carried out by using the same method so that the calculation procedure is obridged hereby.

4) Water taps

The water taps are provided to in-take the irrigation water from the pipe line to each field lot.

The important thing is that the assumed irrigation water to supply into each field block should be taken constantly even pressure is low like the end of the pipe line.

Therefore the proposed water pressure to meet this matter is taken from the lowest portion, that is:-

lowest portion	No. 10 + 4.67
pressure head	W.L 7.240 m
proposed ground level	E.L 6.52
proposed water level in the field lot No. 381 A	W.L 6.62 m
proposed farm road level	E.L 6.89 m

$\therefore$ water head = 7.240 - 6.62

= 0.63 m

Generally, the water head should be given approximately 0.30 to 0.50 m at least.

Take into consideration about the water discharge to each field block, there are five to six lots within a one field block so that the recommended water discharge to each field lot is to be around 0.10 m^3/sec in order to supply the irrigation water at the same time.

4)-1 Determination of the size of G.I pipe.

The water discharge is determined by the following equation.

$$Q = c.A.\sqrt{2.g.H}$$

where, c : coefficient of the velocity 0.65

A : flow area of the valve

H : water head

$$\therefore\ 0.010 = 0.65 \times A \times \sqrt{2 \times 9.8 \times 0.65}$$

$$A = 0.0044\ m^2$$

$$D = 0.066 \doteq 0.065$$

$$V = 2.27\ m/sec$$

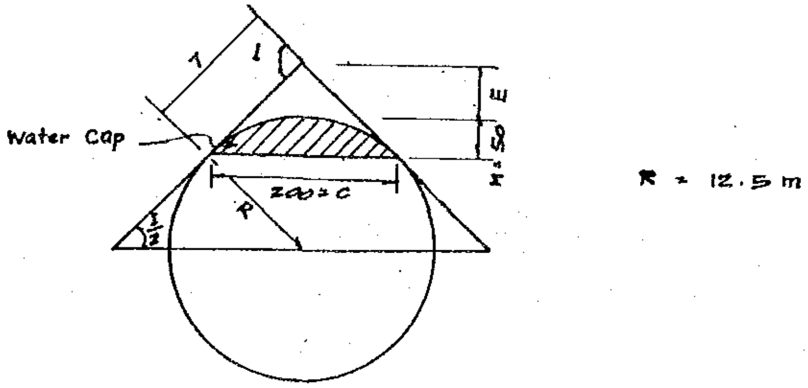
Therefore, the G.I pipe with the diameter of 65 mm is provided to this water tap.

4)-2 Water Cap

The velocity in the G.I pipe is to be 2.27 m/sec so that if there is no cap it is sure the water is going to shoot into the sky.

Therefore, the water cap is provided to still the water velocity and supply to the field lot properly.

Fig.- 52 water cap



Long chord	$C = 2.R.\sin\frac{I}{2} = 2.T.\cos\frac{I}{2} = 0.200$
External secant	$E = T.\text{Tan}\frac{I}{4} = R.\tan\frac{I}{2}.\tan\frac{I}{4}$
Tangent length	$T = R.\tan\frac{I}{2}$

$$C = 2(R.\tan\frac{I}{2}).\cos\frac{I}{2} = 0.20$$

$$\therefore R = \frac{0.20}{2.\tan\frac{I}{2}.\text{Cos}\frac{I}{2}} \quad \text{-------} \quad (1)$$

$$E + M = 0.10.\tan\frac{I}{2} = R.\sec\frac{I}{2}$$

$$M = 0.1.\tan\frac{I}{2} - E$$

$$= 0.1.\tan\frac{I}{2} - R.\tan\frac{I}{2}.\tan\frac{I}{4} = 0.05$$

$$\therefore R = \frac{0.1.\tan\frac{I}{2} - 0.050}{\tan\frac{I}{2}.\tan\frac{I}{4}} \quad \text{-------} \quad (2)$$

If the R is assumed by 0.125 m the intersection angle is to be:-

$$\therefore R = \frac{0.20}{2.\tan\frac{I}{2}.\cos\frac{I}{2}} = 0.125$$

$$\therefore \tan\frac{I}{2}.\text{Cos}\frac{I}{2} = 0.80$$

$$\therefore I = 107$$

$$\therefore E = R.\tan\frac{I}{2}.\tan\frac{I}{4}$$

$$= 0.125.\tan\frac{107^o}{2}.\tan\frac{107^o}{4} = 0.085$$

$$\therefore E + M = 0.1.\tan\frac{I}{2}$$

$$= 0.1.\tan\frac{107^o}{2} = 0.135$$

$$\therefore M = 0.135 - 0.085 = 0.05 \quad \ldots\ldots \quad \text{o.k}$$

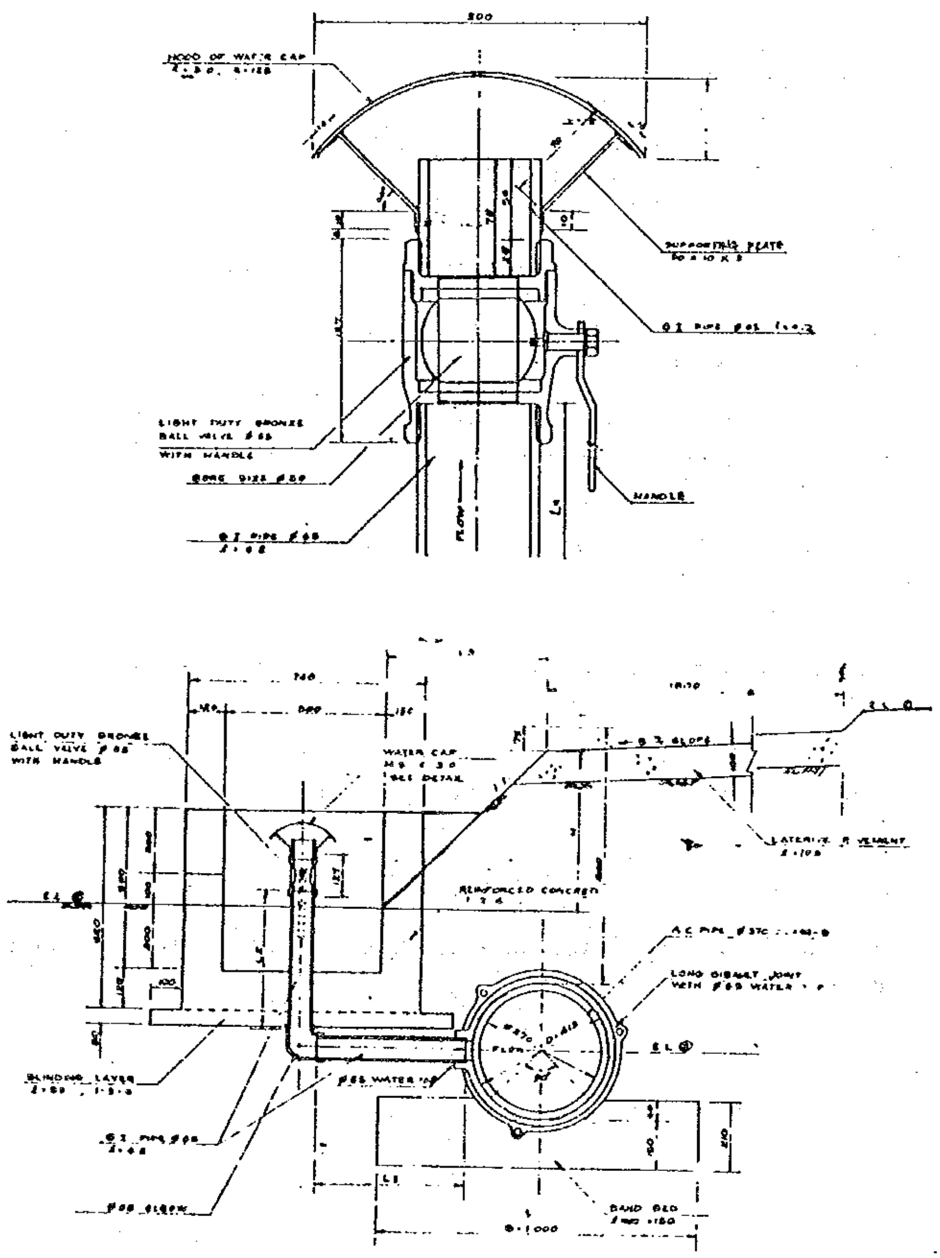
Consequently, the water cap is designed by the 0.125 m radius and the details of the water cap is shown as in Fig.-

4)-3 Concrete box

The irrigation water is supplied through the notch which is provided to the concrete box.

The water discharge through the notch is calculated as follows.

Fig.-53 Details of water tap



$$Q = m.A.\sqrt{2.g.h} \quad \ldots \quad \text{complete over flow}$$

Q : water discharge $0.010\ m^3/sec$

where,

m : coefficient of discharge 0.35

A : area of notch

h : up-stream water height 0.10 m

$$\therefore\ Q = 0.35 x A x \sqrt{2x9.8x0.10} = 0.010$$

$$\therefore\ A = 0.02\ m^2$$

Therefore the width is determined by 0.20 m

5) Field off-take

The field blocks of the F.B-4, 5, 6, 7 and 8 are supplied by the irrigation water directly from the quaternary canal as Q.C. 1, 3 and 4.

In principle, the determination method is the same way as the concrete box of the water tap, however the guide walls are provided at each field off-take except the one which are belongs to the F.B-4.

The water flow is expected as the complete over flow so that the width of the field off-take is determined by 0.20 m as well.

The field off-take is shown as in Fig.-

6) Field out-let

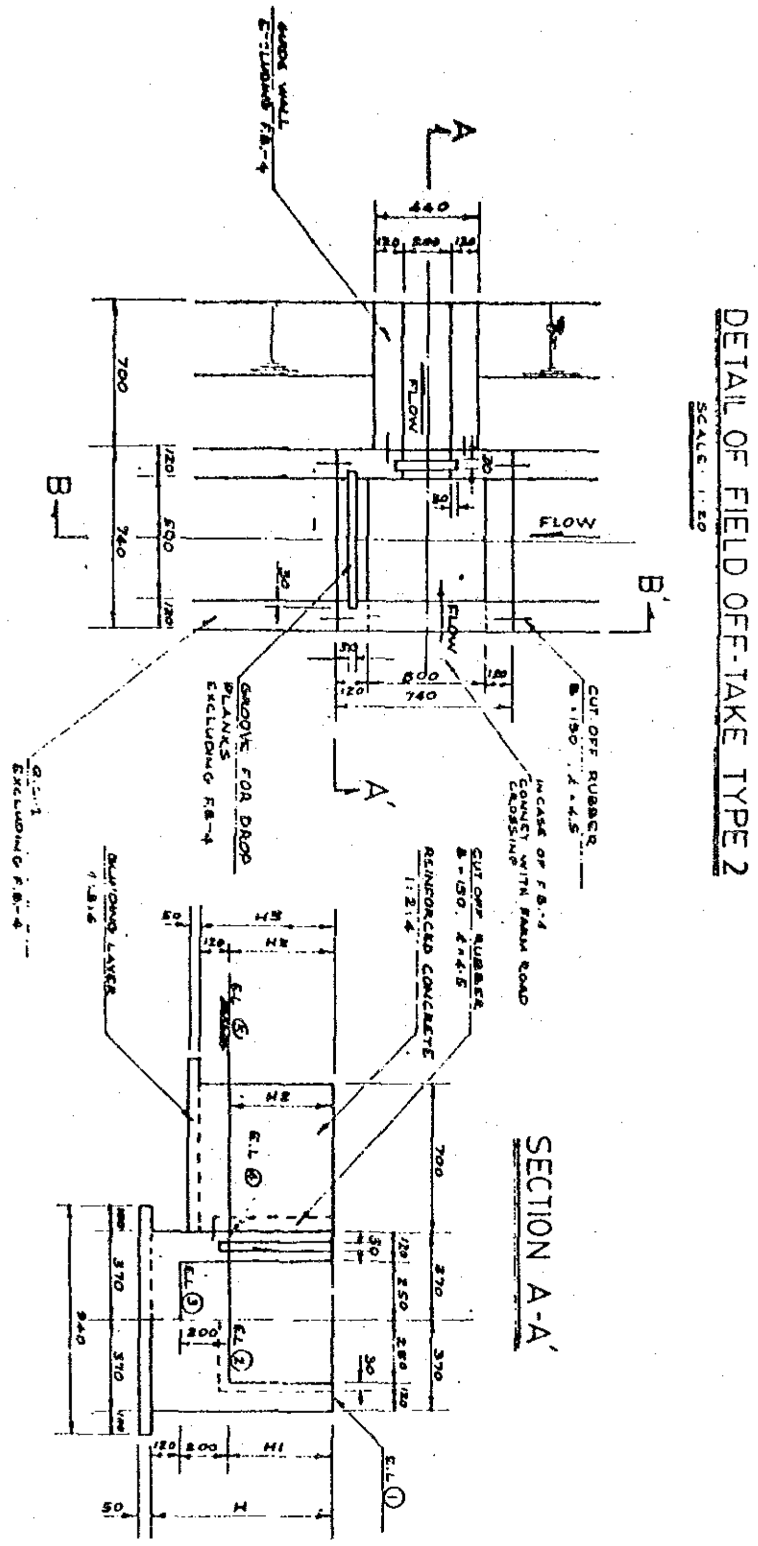
The average field lot area in this benefitted area is determined by 0.215 ha.

Now the converted rate to the on farm facilities is considered about 10 percent, so that the actual paddy field area is to be:-

0.215x0.9 = 0.1935 ha

The depth of flooding water is supposed to be 0.30 m and it must be drained out within a day.

Fig.- 54 Field off-take



drainage volume $= 0.1935 \times 10^4 \times 0.30$

$\doteq 581 \ m^3$

∴ drainage discharge is to be:-

$$\frac{581}{86,400} = 0.0067 \ m^3/sec$$

The water flow from the field out-let is expected by the complete over flow such that the width of the notch is calculated as follows.

$$Q = m.b.h.\sqrt{2.g.h}$$

$$0.0067 = 0.35 x b x 0.15 x \sqrt{2 x g x 0.15}$$

$$\therefore b = 0.07 \ m$$

Where the water depth is considered as 0.30 m at the first time and at that time the drainage discharge is also very large, however by decreasing the water depth at the up-stream then it's drainage discharge is going to small.

Therefore, in this design the up-stream depth is given the average water height of the flooding water, that is 0.15 m.

Though the width of the notch is determined as 0.07 m, take into consideration of the differences of the lot size the width of the notch is determined by 0.300 m as the standard width together with the Ø300 P.V.C. pipe.

Regarding this field out let, a very important thing to consider is that the crest level should be provided lower than the paddy field elevation.

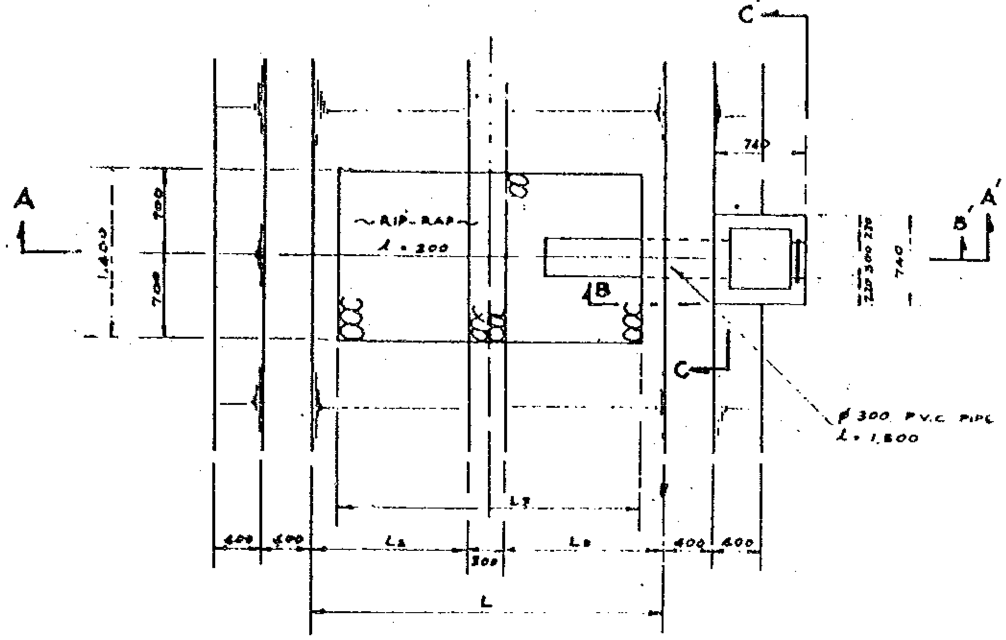
If the crest level is provided at the same level as the paddy field elevation, sometimes it may prevent the drainage discharge because the soil surrounding the field out-let will be taken away and the ground elevation will go down.

Consequently, the field out-let is shown as in Fig.- 55

Fig.-55 Field out let

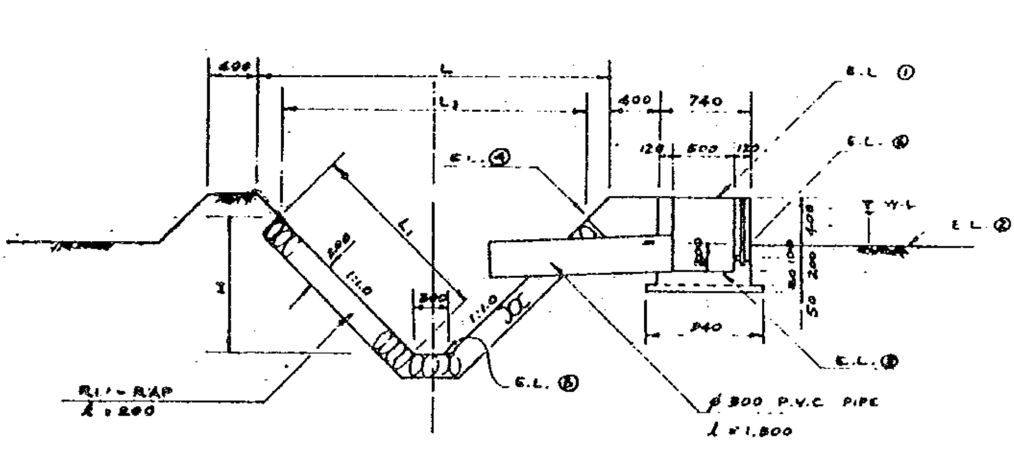
PLAN OF FIELD OUTLET BOX
TYPE A

SCALE 1:40



SECTION A-A'

SCALE 1:40



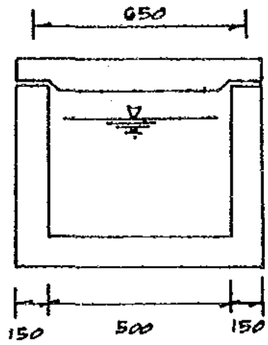
7) Farm road crossing grating

The farm road crossings are provided for the field block No. 4 and the distribution box No. 1 and No. 2.

At that time, the irrigation canal should be covered by some materials to prevent the soil from falling down into the canal and the samll children as well.

7)-1 Concrete cover.

The thickness of the concrete cover is calculated as follows.



(conditions)

1. span $l = 650$ mm
2. width $b = 500$ mm
3. $\sigma ca = 70\ kg/cm^2$
4. $\sigma sa = 1.400\ kg/cm^2$

$$\therefore i = \frac{20}{50+0.65} = 0.395$$

$$P = 5.6x1.395 = 7.812 \text{ ton}$$

$$M\,Max = \frac{p.l}{4}$$

$$= 7.812x0.65x0.25x1000x100$$

$$= 126,945 \text{ kg-cm.}$$

effective thickness is to be:-

$$d = C_1\sqrt{\frac{M}{b}}$$

where, d : effective thickness

C_1 : 0.279

C_2 : 0.00299

$$\therefore d = 0.279x\sqrt{\frac{126,945}{50}} = 14 \text{ cm}$$

area of the reinforcement is to be:-

$$\therefore As = C_2\sqrt{M.b}$$

$$= 0.00299x\sqrt{126,945x50} = 7.53\ cm^2$$

$$so,\ P = \frac{As}{b.d} = \frac{7.53}{50x14} = 0.011$$

$$k = 0.433,\ j = 0.856$$

therefore, the compressive stress intensity of the concrete is:-

$$f_c = \frac{2.M}{k.j.b.d^2}$$

$$= \frac{2x126,945}{0.433x0.856x50x14^2} = 69.9\ kg/cm^2 \leq 70\ kg/cm^2$$

and the tensile stress intensity of the reinforcement is:-

$$f_s = \frac{M}{As.j.d.}$$

$$= \frac{126,945}{7.53x0.856x14} = 1,407\ kg/cm^2 > 1,400 \quad ..\ No.$$

Though the tensile stress of the reinforcement is not insufficient, however the thickness of the cover is already very thick.

Because, add the minimum cover to the reinforcement of 5 cm thickness, the total thickness is to be 19 cm.

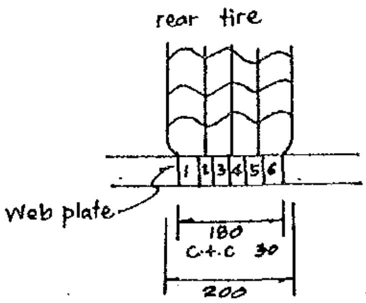
In this case the up-and-down will happen on the road and it is not to be a good design.

7)-2 Grating

Therefore, the grating which is made by Mild Steal are considered for the cover.

(conditions)

1. span $l = 650$ mm
2. width $b = 500$ mm
3. shear stress intensity of the web plate $\tau = 1{,}000$ kg/cm^2
4. interval of the web plate In = 30 mm



The dynamic load of one of the rear tire of the 14 ton track can be devided into 7 by the web plate.

So, the dynamic load for the one web plate is:-

$$Pw = 7.812 \times \frac{1}{7} = 1.116 \text{ ton}$$

$$P = 1.116 \times 1.396 \times 1000$$

$$= 1.558 \text{ kg.}$$

so, the maximum shear stress is to be:-

$$S_{max} = R_A = \frac{P.b}{l}$$

$$= \frac{1.558 \times \frac{50}{2}}{50} = 779 \text{ kg} < 1{,}000$$

therefore $\tau = \frac{S_{max}}{A_{wn}}$ where, A_{wn} : area of web plate

$$1000 = \frac{779}{A_{wn}}$$

$$\therefore A_{wn} = 0.779 \text{ cm}^2$$

the thickness of the web plate is decided as follows:-

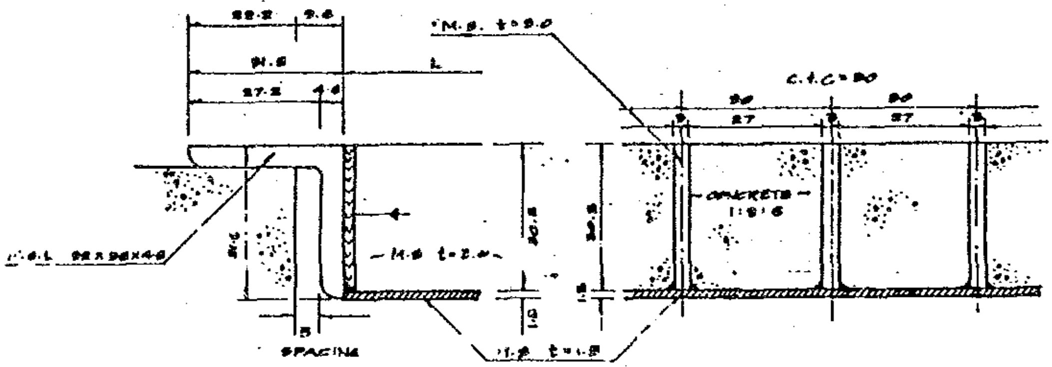
$$t = \frac{6}{170} = \frac{500}{170} = 2.9 \doteqdot 3 \text{ mm}$$

∴ the height of the web plate is to be:-

$$h = \frac{0.779 \text{x} 100}{3} = 26 \text{ mm} \doteqdot 30.3 \text{ mm.}$$

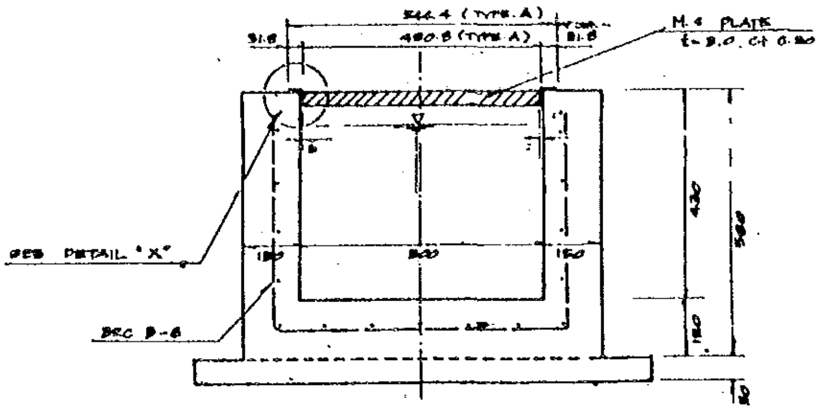
so, the size of the web plate is shown as in Fig.- 56)

Fig.-56) Size of the Grating.



The cross-section of the farm road crossing is shown as in Fig.- 57

Fig.- 57 Cross-section of the farm road crossing



and the calculation table for the stress intensity is shown as in tab.- 40A

Tab.- 40A Table for the stress intensity

σ_{ca} (kg/cm²)	σ_{sa} = 1200 kg/cm²		σ_{sa} = 1300 kg/cm²		σ_{sa} = 1400 kg/cm²	
	C_1	C_2	C_1	C_2	C_1	C_2
30	0.518	0.00177	0.532	0.00158		
35	0.457	0.00203	0.469	0.00181		
40	0.411	0.00228	0.421	0.00205	0.430	0.00185
45	0.375	0.00253	0.383	0.00227	0.391	0.00204
50	0.345	0.00277	0.354	0.00248	0.360	0.00224
55	0.321	0.00300	0.328	0.00269	0.334	0.00244
60	0.301	0.00323	0.307	0.00290	0.313	0.00263
65	0.284	0.00345	0.289	0.00310	0.295	0.00281
70	0.269	0.00367	0.274	0.00330	0.279	0.00299
75			0.261	0.00350	0.265	0.00315
80			0.249	0.00368	0.253	0.00334
85			0.239	0.00386	0.242	0.00351
90			0.229	0.00404	0.233	0.00368

p	*k*	*j*	*p*	*k*	*j*	*p*	*k*	*j*
0.0030	0.258	0.914	0.0070	0.365	0.878	0.0110	0.433	0.856
0.0032	0.263	0.912	0.0072	0.369	0.877	0.0112	0.435	0.855
0.0034	0.271	0.910	0.0074	0.373	0.876	0.0114	0.433	0.854
0.0036	0.277	0.908	0.0076	0.377	0.875	0.0116	0.441	0.853
0.0038	0.284	0.905	0.0078	0.381	0.873	0.0118	0.443	0.852
0.0040	0.292	0.903	0.0080	0.384	0.872	0.0120	0.446	0.851
0.0042	0.298	0.901	0.0082	0.388	0.871	0.0122	0.448	0.851
0.0044	0.303	0.899	0.0084	0.392	0.869	0.0124	0.451	0.850
0.0046	0.309	0.897	0.0086	0.395	0.868	0.0126	0.454	0.849
0.0048	0.315	0.895	0.0088	0.398	0.867	0.0128	0.457	0.848
0.0050	0.320	0.893	0.0090	0.402	0.866	0.0130	0.459	0.847
0.0052	0.325	0.892	0.0092	0.405	0.865	0.0132	0.461	0.846
0.0054	0.330	0.890	0.0094	0.408	0.864	0.0134	0.464	0.845
0.0056	0.334	0.889	0.0096	0.411	0.863	0.0136	0.466	0.845
0.0058	0.339	0.887	0.0098	0.415	0.862	0.0138	0.468	0.844
0.0060	0.344	0.885	0.0100	0.418	0.861	0.0140	0.471	0.843
0.0062	0.348	0.884	0.0102	0.421	0.860	0.0142	0.473	0.813
0.0064	0.353	0.882	0.0104	0.424	0.859	0.0144	0.475	0.842
0.0066	0.357	0.881	0.0106	0.427	0.858	0.0146	0.477	0.811
0.0068	0.361	0.880	0.0108	0.430	0.857	0.0148	0.479	0.840

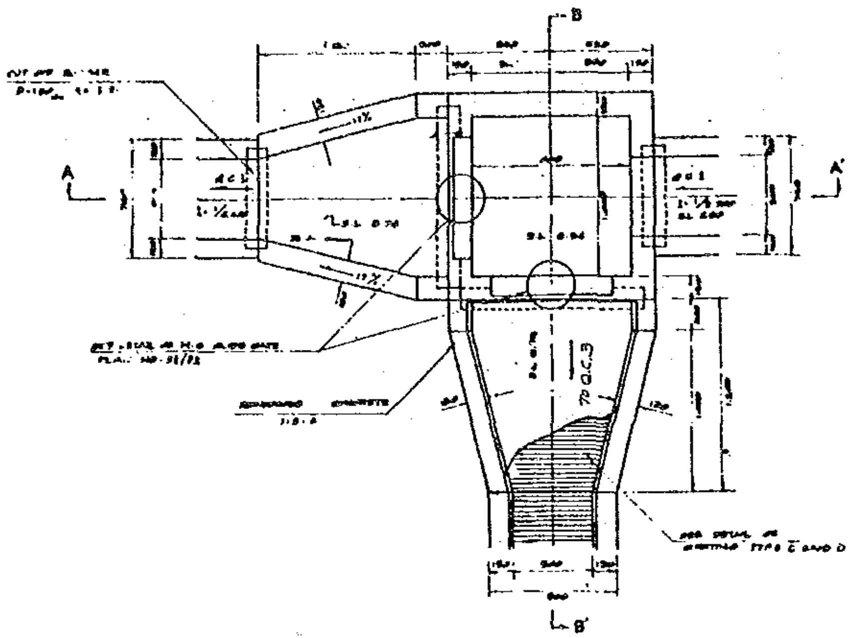
8) Division box

There are two division boxes which are provided to distribute the irrigation water from the main canal, that is Q.C.1, to Q.C. 3 and Q.C. 4.

The M.S gates are also provided to control the irrigation water in this division boxes.

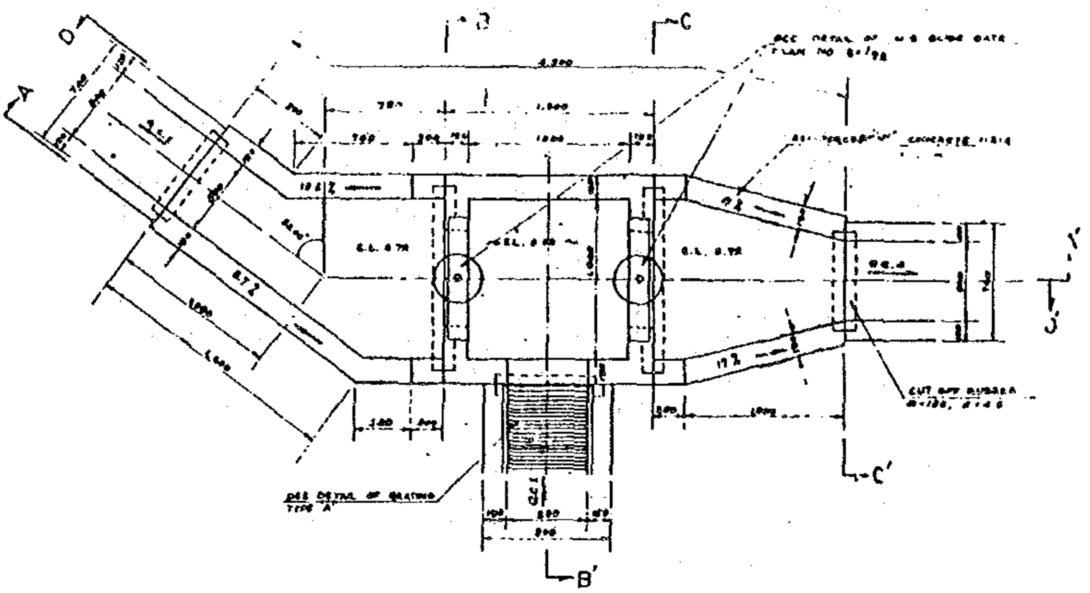
The operation of this gate should follow the rotational irrigation system and should be maintained properly.

Fig.- 58 Division box No. 1 and No. 2



Division Box No. 1

Division Box No. 2



9) Multi purpose centre.

It is recommended that the multi purpose centre should be set up for the purpose of the paddy processing and for storing chemicala/fertilizers and as a meeting place for the cooperative members.

As the convnetional farming, the farmers is not cooperated together therefore it might be said that there is no farmers cooperatives here and all of the farming works are on their own initiative.

These matters cause to the cultivation schedule and it is very hard to control not only the water supply but also transplanting and harvesting time.

On the other hand, to follow the rotational irrigation system and improved cultivation techniques on the land consolidated area, it is required to set up the farmers cooperatives unless otherwise it will failed due to the lack of systematic rule.

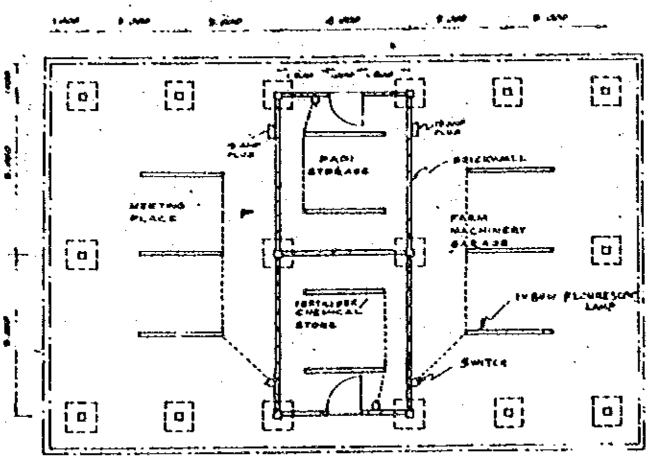
The cooperative members can use the multi purpose center at anytime and they could discuss matters concerning about the farming schedule with the KADA extension workers in accordance with the proposed cultivation schedule.

The chemicals and fertilizers which are subsidized by the government can be stored at one place and in accordance with the improved cultivation schedule it can be supplied by the gotong royong to each field block.

Thus, the activities surrounding in this area is expected to change much better centering around the multi purpose center.

The size of the multi purpose center is shown as in Fig.- 59

Fig.-59 Multi purpose center

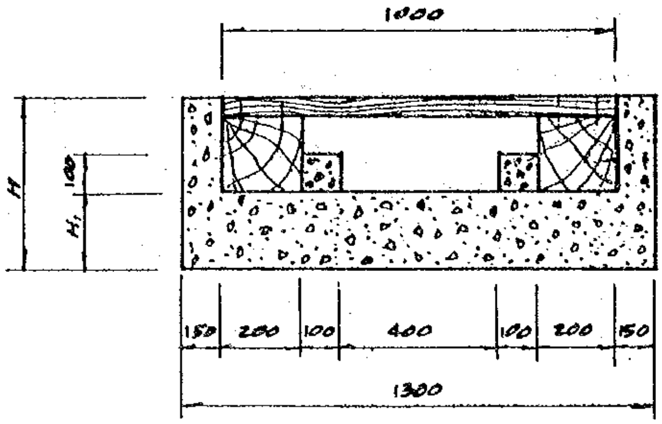


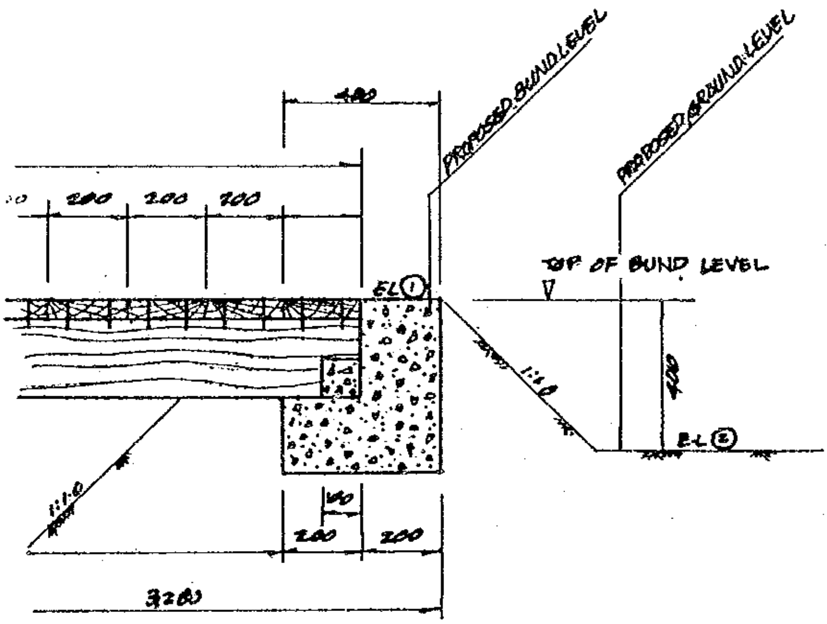
10) Wooden bridge

The wooden bridge which is mainly used for the pedestrian is provided at the point of No. 11 + 10.0 in field block No. 6 with a size of 2.88 m x 1,0 m.

There is a conventional kampong road at that point, however because of the new drain as the on farm facilities will cut off the road in order to connec t to the other side, this wooden bridge is provided.

Fig.- 60 wooden bridge





§ 7. SOIL IMPROVEMENT WORKS

This is the most important aspect in a land consolidatin project.

One is apt to take part in the engineering works but not agronomic works, however it must be emphasised that soil improvement works should be carried out simultaneously otherwise the whole project will fail even though the construction works is carried out successfully.

There are some good results and recommendations which are observed at The National Water Management Training Centre at Kota Bharu as indicated below.

1) Ground condition

The demonstration farm has been constructed with a style of land consolidation, however the levelling works has not be carried out very well, therefore the differences in the level of each field lot was 0.25 to 0.30 m and 20 percent of the transplanting cannot be carried out properly because of the deep water condition as a result of the unlevelled ground. Moreover, the sub soil was also mixed together with the top soil such that the fertility of the soil was very low and it affected yield production directly, that is only 1.5 ton per hectare was obtained with differences in the heading period of 10 to 30 days.

2) Counter measure

2)-1 Land levelling

The land levelling has to be carried out several times in order to realise the best field condition. In fact, it took at least three times to achieve a ground level of from 0.30 m to 0.04 m in difference.

The levelling works was done under flooded condition and it was found that it was very difficult to do levelling by using a small tractor.

Thus it can be said that the early phase of construction works is the prime period for soil improvement works to be carried out otherwise it might be very difficult to carry out the levelling works for the farmers if it is delayed after the construction time.

2)-2 Application of fertilizer and chemicals

To improve the fertility of the soil N.P.K at 80.60.30 kg/Ha was supplied as the standard application together with the Calcium Silicate of 1.7 tons per hectare.

In addition, rice straws were plowed into the ground every season and it's volume was about 5 tons per hectare.

3) Results

These countermeasures as mentioned above were carried out and the soil condition was improved as compared to the condition immediately after consolidation. Actually, it took about three years to achieve a homogeneous fertile soil condition and this period is not much different between Malaysia and Japan.

Without doubt, this is the result of the countermeasures undertaken and it goes without saying that it will take much longer time if no soil improvement works is carried out.

Considering the difficulty of obtaining Calcium Silicate in Malaysia, Ground Magnesium Limestone is therefore recommened for application in place of the calcium silicate.

However, in this case, the quality of the silicate is rather insufficient such that it is recommended also to use rice husks or other silicate materials together with the G.M.L. In addition, it is also recommended that C.I.R.D at 200 kg/Ha must be applied together with the G.M.L in order to improve soil fertility. In this design, therefore, the following works are recommended to be carried out:-

1. Application of G.M.L.

proposed volume	5 ton/ha
price	$ 4/40 kg.
object area	10.1 ha

$$\therefore \frac{10.1x5x1000x4}{40} = \$5,050/-$$

2. Application of C.I.R.P ($34-35\%\ P_2O_5$)

proposed volume	200 kg/ha
price	$ 285/ton
objected area	10.1 ha

$$\frac{0.2}{0.345}x10.1x285 = 1,669/-$$

2. Rice husk

proposed volume	5 ton/ha
price	free of charge (L.P.N)
object area	10.1 ha
∴ Total volume	5 x 10.1 = 50.5 ton

One truck (2 ton) can carry the colume of 5.1 m^3 of the rice husk and its weight is estimated to be 571.2 kg.

So, the total number of transportation is

$$\frac{5,000 \times 10.1}{571.2} = 89 \text{ trucks.}$$

The results which was obtained at N.W.M.T.C at Kota Bharu is shown as in Tab.- 41.

Table-41. Fertility Improvement Practice And Effects on Land Consolidation Rice Field

Agronomy)

Cropping Season	M.S. 1979/80	O.S.1980	M.S.1980/81	O.S.1981	M.S. 1981/82	O.S.1982	M.S.1982/83
Rice Cultivation:							
No. of cropping	Fallow	1st.	2nd.	3rd.	4th.	5th.	6th.
Name of variety		SM II	PM I	MR 7	MR 7	MR 7	MR 7
Application of fertilizer (Kg/ha, N.P.K.)		80-6--30	80-60-30	80-60-30	80-60-30	80-60-30	80-60-30
Fertility Improvement Practices:							
Field levelling works			1st. Oct.1980	2nd.Apr.1981	3rd.Nov.1981	x	x
Calcium silicate[2] (kg/ha)		1700	1700	1700	1700	x	x
Rice straw (of previous crop)(kg/ha)			(5000)[3] total straw	(4000) total straw	(6000) total straw	(5000)[4] without leaf straw (total straw= 7,500)	(5000) without leaf straw (total straw= 8.600)
Effect of improvement							
Field level (cm)		27	16	6	4	4	4
Rice yield (kg/ha)		2,860	1,490	2,853	2,033	2,210	5,140
Rice growth (observation)		very un-even	very un-even	un-even	un-even	slightly un-even	even
Heading period (days)		N.A.	30	(20)	12	8	6
Reference data;							
Pest damage		heavy by bird	heavy by rice bug	heavy by Bird & hoppers	heavy by Rice Black Bug	heavy by Bird & hoppers.	non
Rice Yield of surrounding farmer's field		x	1.03	x	1.64	x	
Heading period of non-land consolidation field		Fallow	Fallow	N.A.	11	6	6

Note: (1 Study plot : Plot No. 10
(2 SiO_2 31%, CaO 46%, MgO 5%
(3 (approximate) = 64% total yield.
(4 burned rice straw leaf (70% of straw weight - 60% - 76%)
(5 non preparation rice wieght

Type of field
A = top soil only
B = 50% below mixed with subs(
C = 50% over mixed with subso

Tab.- 42 Results of the soil improvement

Fertility Improvement Program for P/F No. 3 (Agronomy)

	Type of field	cropping season					
		1st.	2nd.	3rd.	4th.	5th.	6th.
1. Rice field levelling							
(1) Target (t.-cm.)		16	8	6	6	6	6
(2) Levelling Work (before transplant)		1st.	2nd.	3rd.			
2. G.M.L. application (Kg/ha)	A	(2000)			x	x	x
	B	4000	(2000)	(2000)	x	x	x
	C	5000	(2000)	(2000)	x	x	x
3. Rice husk (kg/ha)	A	x	x	x	x	x	x
	B	5000 (45m^3)	x	x	x	x	x
	C	5000 (45m^3)	x	x	x	x	x
4. Rice straw (ton/ha)(straw of previous crop)	A	x	total (3-5)	total (4-5)	5 (8)	5 (8)	5
	B	x	total (2-3)	total (3-4)	total (4-5)	5	5
	C	x	total (1-2)	total (2-3)	total (3-4)	total (4-5)	5
5. N.P.K.	A. B. C	80-60-30	80-60-30	80-60-30	80-60-30	80-60-30	80-60-30
Yield target (kg/ha)	A	3000	2500	3000	3000	3500	4000
	B	2000	1500	2000	25000	3000	3500
	C	1500	1500	2000	2500	3000	3500
Rice growth (observe)	A	un-even	un-even	slightly un-even	even	even	even
	B	very un-even	very un-even	un-even	un-even	slightly un-even	even
	C	very un-even	very un-even	very un-even	very un-even	un-even	un-even

8. ROTATIONAL IRRIGATION SYSTEM.

Each field lot will possess the irrigation and drainage canal as the independent system, however if the operation of water control is aone without any systematic method, the shortage of the irrigation water will happen thus efficient water management cannot be achieved.

Therefore, the rotational irrigation system is recommended whereby the irrigation water will be supplied from upper stream field block to down stream block one after another.

1) *Formula for the rotational irrigation in presaturation period.*

1)-1 Calculation method for the rotational irrigation.

Calculation method is carried out as follows.

1. Field blocks are saturated gradually from the up-stream blocks to down-stream blocks.
2. A saturated block is supplied with supplemented water succeedingly.
3. Presaturation period calculated for one block is to be corrected to a whole round-up number so as to facilitate easy water management.
4. Evaporation losses from unsaturated soil are calculated only for presaturation period of one field block.
5. Infiltration losses during presaturation period of whole area are neglected, because the losses are already assumed in the water requirement of puddling.

1)-2 Calculation formula

The calculation of the presaturation period is carried out as follows:-

$$Q = Q1+Q2$$

$$Q1 = \frac{(S+H+E.T)A}{864.T}$$

$$Q2 = \frac{Es.T.L.B}{T}$$

In this case T is fixed from above formula

$$T = \frac{(S+H).A}{864.Q-(L.Es.B+E.A)}$$

where,

Q :	Total water requirement for presaturation period	m^3/sec.
Q1:	water requirement for presaturation	m^3/sec.
Q2:	water requirement for supplement	m^3/sec.
T :	presaturation period	day
A :	presaturation area	ha
B :	supplement area	ha
S :	puddling water	15 cm.
H :	standing water layer	10 cm.
L :	field loss	20%
Es:	evaporation from saturated soil	4mm/day
E :	evaporation from unsaturated soil	4mm/day

1)-3 Calculation

Tab.- 42. Calculation table for presaturation period

Field Block	A(ha)	B(ha)	(S+H)A	E.A	L.Es.B	denominator	T (day)
			25.A	0.4.A	0.48.B		
F.B 1	0.67	-	16.75	0.27	-	41.37	0.40
2	1.19	0.67	29.75	0.48	0.32	40.84	0.73
3	1.21	1.86	30.25	0.48	0.89	40.27	0.75
4	1.43	3.07	35.75	0.57	1.47	39.60	0.90
5	1.49	4.50	37.25	0.60	2.16	38.88	0.96
6	1.83	5.99	45.75	0.73	2.87	38.04	1.20
7	1.13	7.82	28.25	0.45	3.75	37.44	0.75
8	1.12	8.95	28.00	0.45	4.30	36.89	0.76
Total	10.07 ave.1.26						6.45

where $Q = 0.050-0.0018 = 0.0482\ m^3/sec$

After round up the presaturation period the corrected calculation is shown as in Fig.- 43

Tab.-43 Corrected calculation table for presaturation period

Field Block	A(ha)	T(day)	Q1'(m^3)	B(ha)	Q2'(m^3)	Q1'+Q2'(m^3)	$T=\frac{Q1'+Q2'}{Q}$
1	0.67	1	1,702	-	-	1,702	0.41
2	1.19	1	3,023	0.67	34	3,057	0.73
3	1.21	1	3,073	1.86	93	3,166	0.76
4	1.43	1	3,632	3.07	154	3,786	0.91
5	1.49	1	3,785	4.50	225	4,010	0.96
6	1.83	2	4,721	5.99	599	5,320	1.28
7	1.13	1	2,870	7.82	391	3,621	0.87
8	1.12	1	2,845	8.95	448	3,293	0.79
Total	10.07	9	25,651		1.944	27,595	

where,

Q1' : total water requirement for presaturation
(S+H+E.T).A.100 m^3

Q2' : total water requirement for supplement
Es.T.L.B.100 m^3

Q : total supply water per day
$0.0482 \times 86,400 \doteqdot 4,164\ m^3$

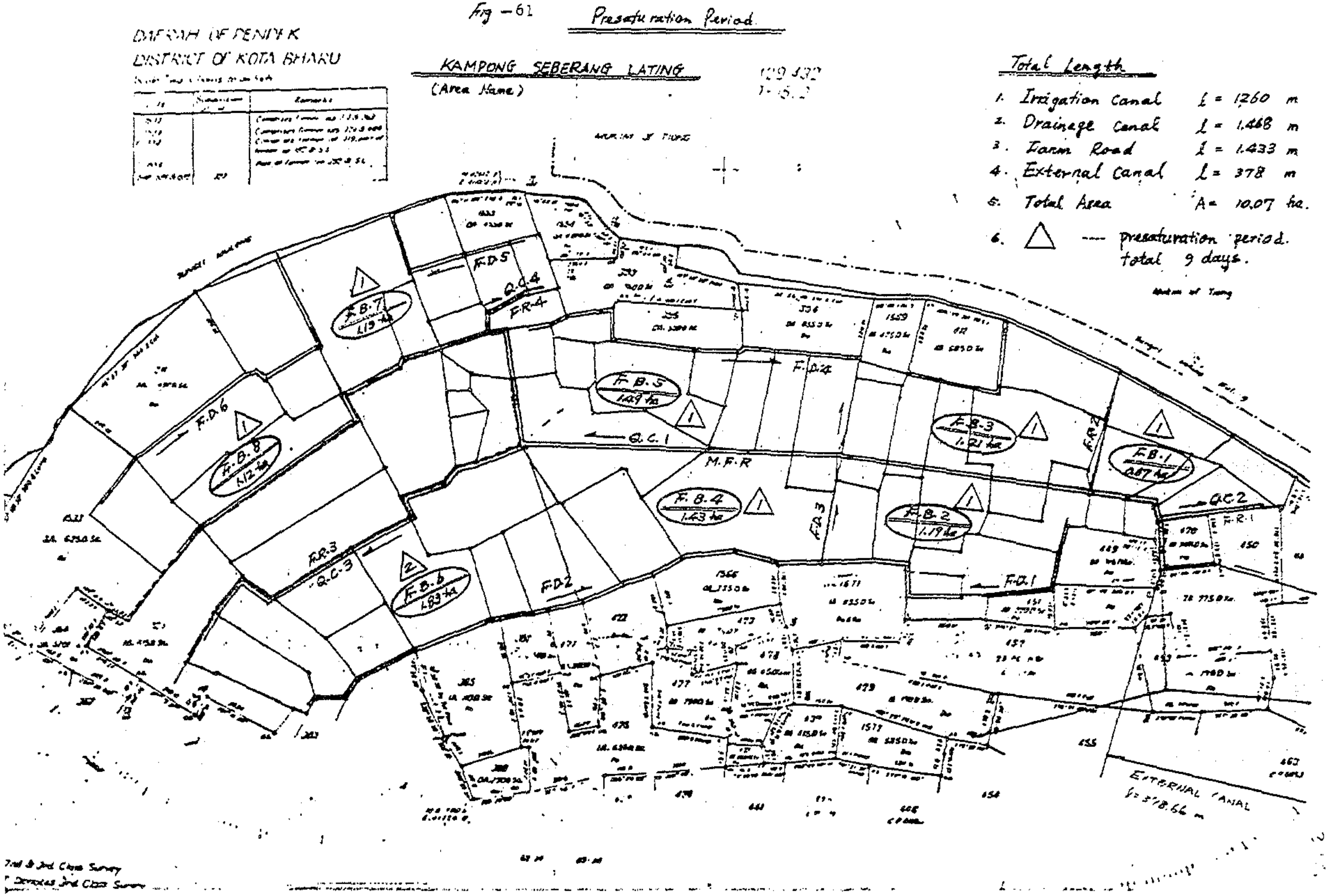


Fig — 61 Presaturation Period
DAERAH OF PENDEK
DISTRICT OF KOTA BHARU
KAMPONG SEBERANG LATING
(Area Name)
Total Length
1. Irrigation Canal ℓ = 1260 m
2. Drainage Canal ℓ = 1.468 m
3. Farm Road ℓ = 1.433 m
4. External Canal ℓ = 378 m
5. Total Area A = 10.07 ha.
6. △ — presaturation period. total 9 days.
F.B.1 0.87 ha
F.B.2 1.19 ha
F.B.3 1.21 ha
F.B.4 1.43 ha
F.B.5 1.49 ha
F.B.6 1.83 ha
F.B.7 1.19 ha
F.B.8 1.12 ha
M.F.R
Q.C.1
Q.C.2
Q.C.3
Q.C.4
F.D.1
F.D.2
F.D.3
F.D.4
F.D.5
F.D.6
F.R.1
F.R.2
F.R.3
F.R.4
EXTERNAL CANAL
ℓ = 378.66 m

Thus, the water discharge for each block is to be:-

Field block	A(ha)	T(day)	Q1(1/sec)	B(ha)	Q2(1/sec)	Q1+Q2(1/sec)
1	0.67	1	19.7	-	-	19.7
2	1.19	1	35.0	0.67	0.4	35.4
3	1.21	1	35.6	1.86	1.1	36.7
4	1.43	1	42.0	3.07	1.8	43.8
5	1.49	1	43.8	4.50	2.6	46.4
6	1.83	2	27.3	5.99	3.5	30.8
7	1.13	1	33.2	7.82	4.5	37.7
8	1.12	1	32.9	8.95	5.2	38.1
Total	10.07	9				

Consequently, the presaturation period is determined as 9 days and it's required volume is amounted to 27,595 m3.

9. Earth Work

Total area for land consolidation is actually the padi area plus the batas area. The area for the facilities such as irrigation and drainage and other structures are excluded.

1) Standard machinery

The medium type swampy bulldozer can be used. (13 ton)

2) Operation hours of the medium type swampy bulldozer

Time (T)=Standard time (to) + Supplementary time It1+t2+t3+t4)

where; t1 : supplementary time by top soil removing

t2 : " by site conditions

t3 : " by site gradient

t4 : " by drainage conditions

t_o = 33.0 hr/ha

t1 = taxβ

where; ta : supplementary time by the rate of the rate of top soil performance area and its method.

β : supplementary coefficient by the thickness of top soil removing

2)-1 Supplementary time by the rate of top soil performanced area and it's method.

1) in case of the rate is 100 percent.

method	ta/ha
by order	29.8 hr/ha
cut and fill	45.6 hr/ha

2) in case if the rate is in between 0 percent and 100 percent and/or mixed method.

ta = 29.8x(rate by order method)+45.6x (rate by cut and fill)

where;

rate of top soil performance = object area of top soil removing/ Land consolidation area.

2)-2 Supplementary time by the thickness of top soil removing.

(t)	t<10cm	10≤t≤13cm	13≤t≤15cm	t>15cm
β	1.05	1.0	1.10	1.20

where the thickness shows the average one in the whole top soil removing area.

2)-3 Supplementary time by the site conditions

t2 = ta+tb

where, ta : supplementary time by site conditions

tb : " by average lot area under existing condition.

1) Supplementary time by site conditions.

This time should be determined by considering the site conditions such as obstacles, shape of the existing field lot and whether the land reformation project have been done before or not. Then the index of the site can be decided by the following formula.

Tab.- 44 Site index for the bulldozer operation

Rate of standard lot		Land reformation		Obstacles		Shape of the lot	
class	Index ($\alpha 1$)	class	Index ($\alpha 2$)	class	Index ($\alpha 3$)	class	Index ($\alpha 4$)
(1) $r \geq 80\%$	1.0	done	1.0	nothing	1.0	very good	1.0
(2) $60 < r < 80\%$	2.0	non	3.0	normal	2.0	normal	2.0
(3) $r \leq 60\%$	3.0			many	3.0	complicated	3.0
$r = \frac{\text{total area which can cover by the standard lot}}{\text{Land Consolidation area}}$				obstacles: electric pole, graveyard, road, river, housing area etc.			

site index $=(\alpha 1+\alpha 2+\alpha 3+\alpha 4)/4$

$\therefore$ ta = 2.9x+0.4

2) supplementary time by average lot area under existing condition.

$$\text{average lot area} = \frac{\text{total area}}{\text{number of lots}}$$

$\therefore$ tb=-0.7.x+4.1

2)-4 Supplementary time by the site gradient

The gradient shows that the existing slope run along the proposed short side of the lot.

t3=-9.8 log x+23.2

where, x shows the denominator of the slope. It cannot be adopted if the slope is over 1:200.

2)-5 Supplementary time by the drainage conditions

Tab.- 45 Drainage index for the bulldozer operation.

class	Content	weighted Index
A	always flooding	0
B	topsoil is saturated	1
C	between B and D	2
D	good drainage	3

$\therefore$ t4 = -10.55x+35

2)-6 Calculation of the operation hours.

Then, the operation hours of the medium type swampy bulldozer is calculated as follows.

1) t_o = 33.0 hr/ha

2) t1 = taxβ

top soil performance rate-100%

method -by order

topsoil thickness -15 cm

∴ t1 = 29.8x1.10 = 32.8 hr/ha

3) t2 = ta+tb

$(\alpha 1+\alpha 2+\alpha 3+\alpha 4)/4$=(3.0+3.0+3.0+3.) /4=3.0

∴ ta = 2.9x3.0+0.4

= 9.1 hr/ha

average lot area = 11.1991/44 = 0.25

∴ tb = 0.7x0.25+4.1

= 3.9 hr/ha

∴ t2 = 9.1+3.9 = 13.0 hr/ha

4) t3

existing slope 1/500 (N.E)

∴ t3 = -9.8xlog 500+23.2

= -3.2 hr/ha

5) t4 .. Index = 3.0

$$t4 = -10.55 \times 3.0 + 35$$

$$= 3.4 \text{ hr/ha}$$

$$\therefore T = 33.0+32.8+13.0-3.2+3.4$$

$$= 79.0 \text{ hr/ha}$$

Actually, the 11 ton class bulldozer can be used in this construction so that the time which is calculated by the above method should be converted to 11 ton bulldozer as follows.

Tab.--46 Conversion table from medium type swampy bulldozer to 11 ton normal bulldozer

machine	coefficiency of conversion	machine	coefficiency of conversion
bulldozer 6 ton	0.61	swampy bull. 7 ton	0.68
" 8	0.67	9	0.83
" 11	0.73	13	1.00
" 15	0.97	16	1.22
" 21	1.36	super swampy bull. 10	0.95
" 32	2.08	13	1.00
		16	1.41

∴ TC = 79.0/0/73 = 108.2 hr/ha

total hours

11.1991x0.9x108.2 = 1.091 hr.

operation hour per day   11 ton bulldozer - 7.1 ton

∴ construction period

1091/7.1/30 = 5.1 month/unit

3) Capability of the works by 11 ton Bulldozer

$$Q = \frac{60xqxfxE}{cm}$$

where,

Q : capability of the works per hour (m^3/hr)

q : excavation volume per one cycletime (1.307m^3)

f : coefficiency of the soil

E : efficiency of the works.

Cm: cycletime (min)

$Cm = 0.034x50^m x0.25$

$= 1.95$ min.

f : 0.9 clay
0.95 topsoil

Efficiency of the works is determined as follows.

soil	ordinary	cut topsoil	fill topsoil	Land grading
clay	0.6	0.7	0.65	0.5
Q	Q1	Q2	Q3	Q4

Thus, the capability of the works under each condition is determined as follows.

$$\therefore Q1=(60\times1.307\times0.9\times0.6)/1.95$$
$$=21.7\ m^3/hr.$$

$$Q2=(60\times1.307\times0.95\times0.7)/1.95$$
$$=26.7\ m^3/hr.$$

$$Q3=(60\times1.307\times0.95\times0.65)/1.95$$
$$=24.8\ m^3/hr.$$

$$Q4=(60\times1.307\times0.9\times0.5)/1.95$$
$$=18.1\ m^3/hr.$$

Incidentally, the cost of each earth work can be decided as follows.

Item	Ordinary	TOP SOIL		Grading
		Cut	Fill	
Price	\$4/00	-	-	-
volume (m^3/hr)	21.7	26.7	24.8	18.1
ratio	1.0	0.81	0.88	1.20
@(M\$/yd^3)	\$4/00	\$3/20	\$3/50	\$4/80

4) Levelling works.

In general, the levelling works are carried out as follows.

Top soil removing → Land grading → Top soil refill

→ Land levelling → Final levelling.

4)-1 Top soil removing

The soil study is carried out in this area and the thickness of the top soil is identified approximately 0.20 m. and the rest is to be sub soil.

Thus, the top soil removing should be carried out in order to keep the soil homogenized unless otherwise the sub soil is mixed together with the top soil whereby its will affect the yield directly.

In this design, the thickness of the top soil removing is recommended as 0.15 m, because the cost of the top soil removing involved huge amount of money if all the thickness is performed.

And, the method of the top soil removing can be done in accordance with the rotational order.

The expected volume of the top soil removing is calculated as follows.

1. top soil under the facilities

Normally, the top soil can be lost easily due to the heavy rain that might flush away the top soil from the stock area and wind or transportation.

Therefore, the top soil is taken, by 0.2 m thickness which is obtained from the soil study and also it is to be a good foundation for the facilities.

2. top soil from each field lot.

The thickness of the top soil which is required to be remove is recommended as 0.15 m thickness.

Thus the volume of the top soil is to be:-

1. under the facilities .. 2,510 m^3

2. from the field lot .. 100,792x0.15= 15,120 m^3

The soil conversion factor of the top soil is supposed to be 0.95, so that the surplus volume of the top soil is to be:-

$2,510 \times 0.95 - (15,120 - (15,120 \times 0.95)) \fallingdotseq$

1,630 m^3

This surplus top soil can be stocked for the supplimental material.

Tab.- 47. Top soil removing.

Item	Volume (m^3)	Remarks
Cut	17,630	2,510+15,120= 17,630
Refill	15,120))16,750	
Surplus	1,630)	

4)-2 Land Grading

This work is to be a key point of the levelling works. The accuracy of the land levelling is about $\pm$ 5 cm and to keep this range the grading works should be carried out more carefully.

At that time, though the elevation on each field lot is expected to be kept level however, the drainage side is recommended to be slightly below the irrigation canal side.

Take into consideration about the grass land which has not been cultivated for so long, such that the ground is supposed to be harder due to the bulldozer which has passed many times previously.

Thereofre, it is recommended that the drive harrow should be used to crash the hard soil about 20 cm depth in order to facilitate better cultivation condition at the same time.

The volume of the land grading is calculated as in tab.-

That is, $V = 11,920\ m^3$

4)-3 Land levelling

Prior to refill the top soil, the land levelling is carried out in order to give the good foundation for the top soil layer. If the land grading is not performed properly the thickness at the certain part is to be either deep or shallow and not even.

Afterwards, the top soil is refilled The volume of the land levelling is calculated as in tab.- . That is $V = 7.560m^3$.

4)-4 Final levelling

This is a final works of the land levelling works. There are two types of the method to do this final levelling, that is:-

1. Final levelling in dry condition.
2. Final levelling in wet condition.

The dry condition is to be a normal way, however the farmers are going to cultivate straight away after construction, thus the wet condition method is taken, the work is carried out under the flooding condition in order to keep the final level even for the land preparation work.

5) Determination of the each field lot elevation.

The proposed elevation on each field lot should be considered such that to give the optimum elevation i.e over cut and fill.

This decision making is not so easy, it must be carried out by trial and error in accordance with the assumed elevation and it's total earth work balance.

The factors which is considered for this matter are as follows:-

1. Weighted elevation under existing ground.
2. Farm road height.
3. Earth work balance of the field facilities.
4. Gradient of the irrigation and drainage canal.
5. Difference of the height between neighbour lot.
6. Some exceptional factors on the ground.
7. Comparison of the construction cost.

All these factors should be satisfied especially the earth work balance which is the most important factor.

The final arrangement of the elevation on each field lot is shown as in Tab.- 48.

On the other hand, the quantities on earth work can be arranged as in Tab.- 49.

Tab.- 48. Identification of field lot elevation

Field Block	Lot No.	weighted E.L. (m)	Farm Road E.L	Max./Min. E.L. (m)	Irrigation Canal W.L.	Final E.L.(m)	Area (m^2)	Cut/Bank Volume (m^3)
1.	328 A	5.810	6.50	6.13	7.352	6.00	1,805	- 343
	328 B	5.705	6.50	↕	7.381	6.00	1,805	- 532
	415 A	5.646	6.50		↓ pipe line	6.00	1,356	- 480
	417	5.269	6.50			6.00	957	- 700
	397	5.319	6.50	5.93	7.334	6.00	783	- 533
Sub-total ave.		5.61					6,706	-2,588
2.	418	5.664	6.50	6.13	7.390	6.00	1,537	- 516
	412	6.226	6.50	↕	↓ pipe line	6.13	2,514	241
	1,570	6.058	6.50	5.93		6.13	2,340	- 168
	447	6.387	6.89	6.52		6.39	3,000	- 9
	419	6.382	6.89	↕		6.39	1,094	- 9
	409	6.483	6.89	6.32	7.18	6.48	1,458	4
Sub-total ave.		6.21					11,943	- 702 + 245
3.	403	6.017	6.50	6.13	7.340	6.00	1,800	31
	416 ii	6.214	6.50	↕	↓ pipe line	6.20	4,424	62
	416 i	6.446	6.50	5.93		6.20	1,479	364
	317	6,568	6.89	6.52		6.39	1,203	214
	381 B	6,614	6.89	↕		6.52	1,594	150
	381 A	6.879	6.89	6.32	7.8	6.52	1,594	572
Sub-total ave.		6.39					12,094	+1,393

Field Block	Lot No.	weighted E.L. (m)	Farm Road E.L	Max./Min. E.L. (m)	Irrigation Canal W.L.	Final E.L.(m)	Area (m^2)	Cut/Bank Volume (m^3)
4.	410	6.578	7.28	6.91	7.18	6.78	1,458	- 295
	414	6.642	7.28	↕	↓	6.78	2,032	- 280
	1568 i	6.621	7.28		I = 1/2,700	6.78	2,125	- 338
	1568 ii	6.726	7.28			6.78	2,640	- 143
	1568 iii	6.826	7.28			6.82	3,080	- 18
	405	6.997	7.28	6.71	7.10	6.91	2,934	255
Sub-total ave.		6.76					14,269	-1,056 + 273
5.	450	6.529	7.28	6.91	7.18	6.78	1,162	- 292
	415 B	6.898	7.28	↕	↓	6.91	1,356	- 16
	400 ii	7.174	7.28		I = 1/2,700	6.91	1,728	456
	400 i	7.151	7.28			6.91	1,953	471
	320 ii	6.877	7.28			6.91	1,850	- 61
	320 i	6.848	7.28			6.91	1,904	- 118
	398	7.318	7.28			6.91	3,389	-1,383
	323	7.141	7.28	6.71	7.10	6.91	1,575	364
Sub-total ave.		7.05					14,917	- 487 +2,674
6.	1534 i	7.072	7.28	6.91	7.10	6.80	2,880	783
	1534 ii	7.031	7.28	↕	↓	6.80	2,804	648
	1592 A	7.062	7.28		I = 1/4,400	6.80	2,752	721
	1592 B	7.100	7.28			6.80	2,023	607
	1591	7.079	7.28			6.80	2,187	610
	378	6.786	7.28			6.80	3,407	- 48
	382	7.167	7.28	6.71	7.04	6.80	2,295	842
Sub-total ave.		7.03					18,348	+4,211 - 48

Field Block	Lot No.	weighted E.L. (m)	Farm Road E.L	Max./Min. E.L. (m)	Irrigation Canal W.L.	Final E.L.(m)	Area (m^2)	Cut/Bank Volume (m^3)
7.	316	6.448	7.15	6.78	7.08	6.76	1,075	- 335
	415 C	6.246	7.15		I=1/2,400	6.76	678	- 348.
	449	6.129	7.15			6.76	584	- 369
	395	5.892	7.15	6.58	7.07	6.76	693	- 602
	315	6.721	7.15	6.78	7.08	6.76	1,258	- 49
	314 B	6.379	I=1/2,400		I=1/2,400	6.76	3,510	-1,337
	314 A	6.627	7.13	6.56	7.06	6.76	3,510	- 467
Sub-total ave.		6.45					11,308	-3,507
8.	312 ii	7.002	7.13	6.83	7.06	6.83	2,650	456
	312 i	7.127	I=1/2,400			6.83	2,105	625
	1590 B	7.280			I=1/2,400	6.83	1,767	795
	1590 A	7.266	7.10			6.83	1,767	770
	1533	7.355	7.10	6.60	7.01	6.83	2,918	1,532
Sub-total ave.		7.20					11,207	+4,178
total							100,792	-8,388 +12,974

∴ Balance:

$$12,974 - \frac{8.388}{0.9} = 3.654$$

$$\doteqdot 3.654 \quad \text{surplus}$$

Tab.- 49 Quantities on earth work

Items	Quantities (m^3)	f	Handling Volume (m^3)	machine/hand
cut	1,550	-	-	B.H
cut	30	-	-	B.D
Bank	3,587.3	0.9	3,990	B.D
Bank	458.2	0.9	510	Hand
Batas	616.8	0.9	690	B.D
Import soil	430	-	-	
Sand bend	70	-	-	
Leterite	430	-	-	
Top soil cut	2,510	-	-	

So, the insufficient soil volume is to be:-

$$5,190 - 1,580 = 3,610 \ m^3$$

Therefore, the surplus soil will be supplied from the levelling works in the beneffitted area and the volume which is obtained is to be 3,650 m^3.

Consequently, thesurplus soil volume is given as follows.

$$3,650 - 3,610 = 40 \ m^3$$

Take into consideration of the soil conversion factor wich is not identified in this area, so 0.9 is assumed as the falue for clay soil.

In addition, the accuracy of the land levelling is allowed as $\pm$ 5 cm, therefore this surplus volume can be changed all the time thus making it very difficult to balance or adjust the earthwork value.

In this project, the surplus earthwork volume is to be used for the facilities.

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