

### 3.1 Baru Pumping Station

#### 3.1.8 Alignment Calculation of Baru River

Name of Structure		Category of calculation		Page

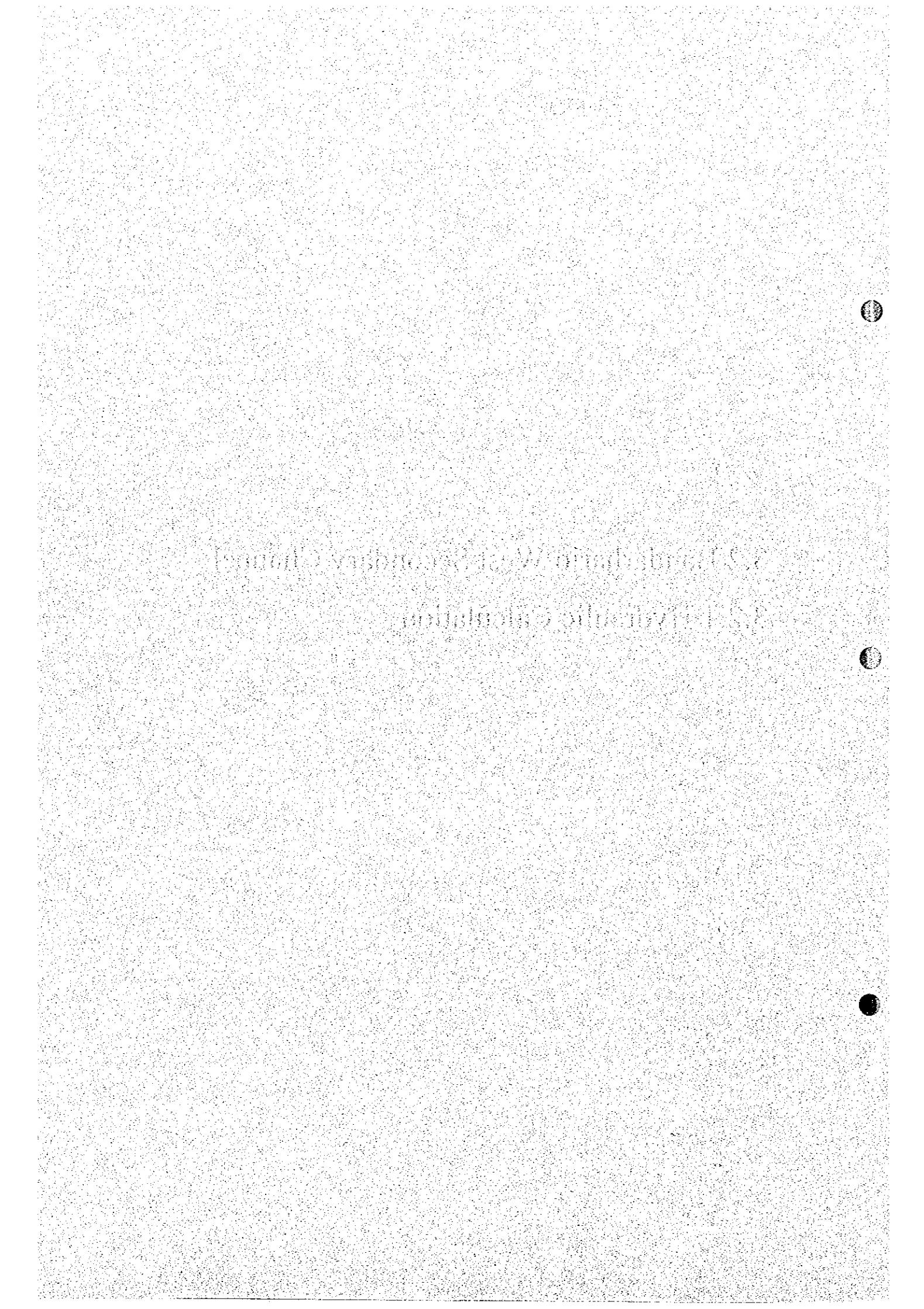
**BARU RIVER**

DRAW NO.	IP	N	E	R	DISTANCE	$\alpha$	TL	CL	Act. Dis
1	BPS	9230 961.5	435 975		55.980	109.40	177.77		55.980
	IPB1	9230 968.8	435.992.2		123.296	287.17	107.17		55.980
	IPB2	9230.791.0	436.028.6		580.612	107.43	287.48		123.296
	EPB	9230.237.2	436.203.0				107.43		179.276
									179.276
									759.888
									759.888

### **3.2 Bandarharjo West Secondary Channel**

## **3.2 Bandarharjo West Secondary Channel**

### **3.2.1 Hydraulic Calculation**



Name of Structure	Bandarharjo West Secondary Channel Open Channel	Category of calculation	design discharge	Page	1/2
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1) general

This structure is an open secondary channel to collect rain water from the west end area of Bandarharjo West. (Fig.1)

2) catchment area

The catchment area to be covered by this secondary channel is indicated in Fig.1.

The catchment area is 0.km<sup>2</sup> and the maximum channel length is km.

3) calculation of design discharge

The equation for discharge calculation is

$$Q = 0.2778 \times C_s \times C \times I \times A$$

where

Q: peak discharge (m<sup>3</sup>/s)

I : average intensity of rainfall (=166mm/hr)

A: catchment area (=0.075km<sup>2</sup>)

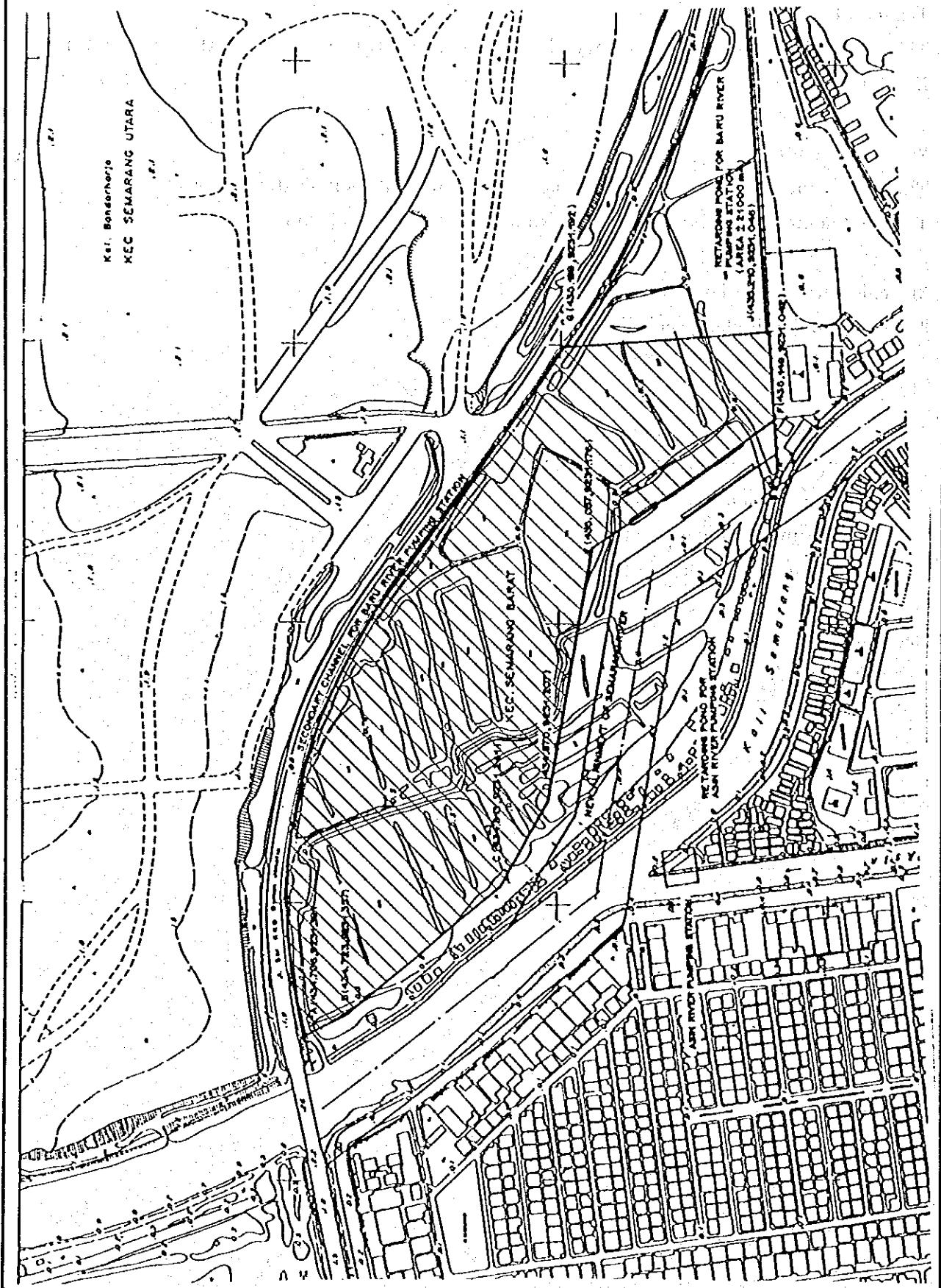
C: run-off coefficient (=0.65)

C<sub>s</sub>: storage coefficient (=0.8)

Therefore

$$Q=2.0 \text{ m}^3/\text{s}$$

Name of Structure	Bandarharjo West Secondary Channel Open Channel	Category of calculation	design discharge	Page	2/2
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### **3.3 Baru Conveyance Channel**

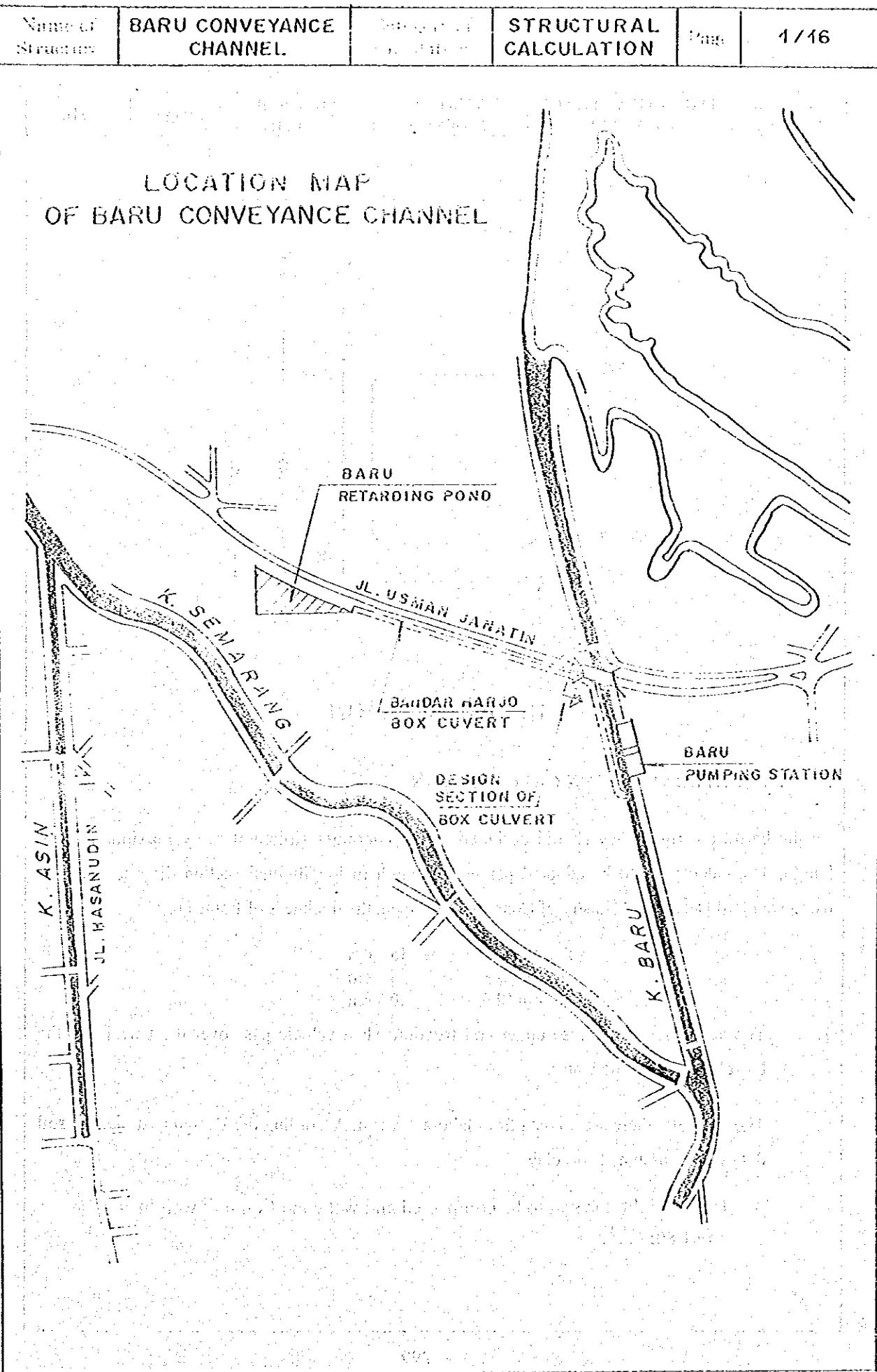
### **3.3 Baru Conveyance Channel**

#### **3.3.1 Design Discharge**

Name of Structure	Baru Conveyance Channel	Category of calculation	design discharge	Page	1/1
<b>(1) general</b>					
This box culvert is necessary to convey rainwater collected in the Baru Retarding Pond to Baru River in order to let the two retarding ponds act as one system. The design discharge is determined as the discharge to be carried when the Baru Pumping station is full operation.					
<b>(2) maximum capacity of the Baru Pumping Station</b>					
The maximum capacity of the Baru Pumping Station is $4.4\text{m}^3/\text{s}$ as designed by the catchment area ( $2.185\text{km}^2$ ) and the specific pump capacity ( $2\text{m}^3/\text{s}/\text{km}^2$ ).					
<b>(3) discharge to be carried by the conveyance channel</b>					
The catchement area of the West Bandarharjo Area, which is to be covered by the Baru Retarding Pond, is $0.58\text{km}^2$ . Therefore, design discharge for the conveyance channel is determined by the proportion of the area.					
Thus,					
$Q=4.4 \times 0.58 / 2.185 = 1.168$					
$\approx 1.2 \text{ m}^3/\text{s}$					

### 3.3 Baru Conveyance Channel

#### 3.3.2 Structural Calculation



Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	2/16

## DESIGN SECTION

### 1. STRUCTURAL DESIGN CALCULATION

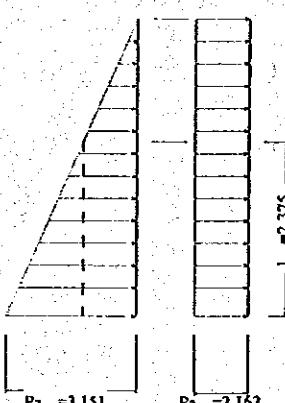
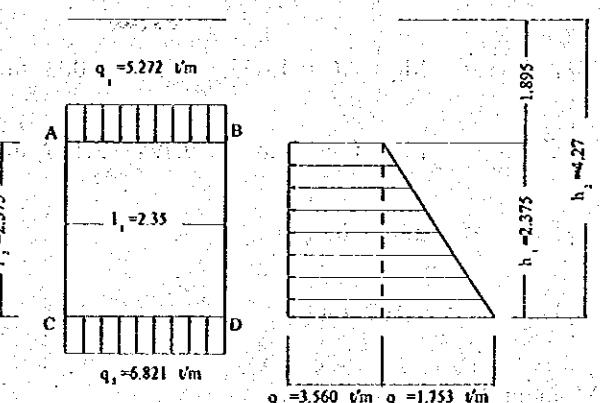
As the barrel are rigid, they should designed as the continues structural every maximum 30 m length. The calculation to be adopted per meter length to longitudinal section direction and by using standard Design of Ministry of Construction Japan, the thickness of frame are :

$$\begin{aligned}
 \text{Top Slab} &= 35 \text{ cm} \\
 \text{Side walls} &= 35 \text{ cm} \\
 \text{Bottom Slab} &= 40 \text{ cm}
 \end{aligned}$$

1. The acting forces, in case under construction when vehicle pass over the barrel and the barrel are empty / no water.
2. The soil data, there are no data from laboratory test. According the Design Criteria, the soil data will be assumed soft clay.
  - Unit Weight, the soil to be compacted and wet condition unit weight  
 $\gamma_s = 1.80 \text{ t/m}^3$ .

Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	3/16
-					
- Cohesion, to be estimated by using "N" value,					
$C = \frac{N}{8} \approx \frac{N}{11} \quad (N \text{ for soft clay, } N < 10)$					
assume $C = \frac{N}{9.50}, N = 5 \sim 10 \rightarrow N = \frac{5+10}{2} = 7.50$					
$C = \frac{7.50}{9.50} = 0.80 \text{ kg/cm}^3 = 8 \text{ t/m}^2$					
-					
- Internal Friction Angle					
$\phi = 15 + \sqrt{15N} \leq 45^\circ \quad (\text{for } N > 5)$					
$\phi = 15 + \sqrt{15 \times 7.50} = 25.60^\circ \sim 25^\circ$					
3. Loading					
a. Vertical loading					
* Weight of a saturated soil $= q_s = 1.72 \times 1.80 = 3.096 \text{ t/m}^2$					
* The vehicle pass over the barrel					
$W_e = \frac{2P(1+i)}{a \times b} \quad \text{for } B < b$					
Where, $W_e$ = Distributed load ( $\text{t/m}^2$ )					
a = width of truck (m), $a = 2.75 \text{ m}$					
a = width of distributed load to longitudinal direction (m), $a = 2h + (1.75 + 0.30)$					
B = width of structure					
P = rear wheel load of vehicle (t), $P = 10 \text{ t}$					
h = height of earth covering above top slab (m)					
i = impact coefficient, determined as follows					

Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	4/16
		$i = 0.30 \text{ for } h \leq 3,50 \text{ m}$ $i = 0.00 \text{ for } h > 3,50 \text{ m}$			
		$W_e = \frac{2 \times 10(1+0.3)}{5.49 \times 3.64} = 1.301 \text{ t/m}^2$			
		Loading over top slab = $q_t s = q_s + W_e = 3.096 + 1.301 = 4.397 \text{ t/m}^2$			
		Weight of top slab = $WT_s = 0.35 \times 2.5 = 0.875 \text{ t/m}^2$			
		Total Loading of top slab = $q_1 = q_t s + WT_s = 4.397 + 0.875 = 5.272 \text{ t/m}^2$			
		Weight of barrel per meter of length $W_{b_R}$			
		$W_{b_R} = \{(2 \times 0.35 \times 2.75) + (0.35 \times 2) + (0.40 \times 2)\} \times 2.50 + 0.10 \times 2.90 \times 2.35$ = 9.244 t			
		Total load of barrel per meter of length = $W_{tot} = W_{b_R} + q_t s \times 2.70$			
		$W_{tot} = 9.244 + 4.397 \times 2.700 = 21.116 \text{ t.}$			
		Uplift per meter of length = $q_u = (3.27 - 0.42) \times 2.70 \times 1.00 = 7.695 \text{ t.}$			
		$W_{tot} = 21.116 \text{ t} > q_u = 7.698 \text{ t} \rightarrow \text{no buoyancy (OK)}$			
		Pressure to base slab = $q_2 = \frac{W_{tot}}{2.70} - (0.4 \times 2.5) = \frac{21.116}{2.70} - 1.0 = 6.821 \text{ t/m}^2$			
b.	Horizontal loading				
		Active earth pressure by clayey soil			
		$P_a = K_a \cdot \gamma_s \cdot h - 2C\sqrt{K_a} + K_a \cdot q$			
		C value not include calculated, more save			
		$P_a = K_a \cdot \gamma_s \cdot h + K_a \cdot q$			
		Active earth pressure coefficient $K_a$			

Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	5/16
	$K_a = \frac{\cos^2(\phi - \theta)}{\cos^2 \theta \cdot \cos(\theta + \delta) \left[ 1 - \sqrt{\frac{\sin(\phi - \delta) \cdot \sin(\phi - \alpha)}{\cos(\theta + \delta) \cdot \cos(\theta - \alpha)}} \right]^2}$ for $\theta, \delta, \alpha = 0^\circ$ $K_a = \frac{\cos^2 \phi}{(1 + \sin \phi)^2} = \frac{\cos^2 25^\circ}{(1 + \sin 25^\circ)^2} = 0.41$ $P_{a1} = K_a \cdot \gamma_s \cdot h_2 = 0.41 \times 1.80 \times 4.27 = 3.151 \text{ t/m}$ $P_{a2} = K_a \cdot q_1 = 0.41 \times 5.272 = 2.162 \text{ t/m}$ $q_3 = 2.162 + \frac{1.895}{4.270} \times 3.151 = 3.560 \text{ t/m}$ $q_4 = \left(1 - \frac{1.895}{4.270}\right) \times 3.151 = 1.753 \text{ t/m}$  				

#### 4. Moment Calculation (With Hardy Cross Method)

Fixing moment

$$M_f AB = \frac{q_1 l_1^2}{12} = \frac{5.272 \times 2.35^2}{12} = 2.426 \text{ tm.(+)}$$

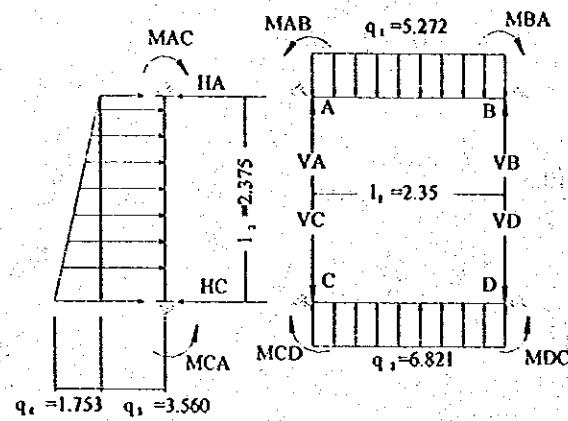
$$M_f BA = 2.426 \text{ tm.(-)}$$

Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	6/16
$M_f CD$	$= \frac{q_2 \ell_1^2}{12} = \frac{6.821 \times 2.35^2}{12} = 3.139 \text{ tm.(-)}$				
$M_f DC$	$= 3.139 \text{ tm.(+)}$				
<u>on span AC</u>					
Rectangular load, $M_R$	$= \frac{q_3 \times \ell_2^2}{12} = \frac{3.56 \times 2.375^2}{12} = 1.673 \text{ tm}$				
Triangular load					
$AC$	$= \frac{q_4 \times \ell_2^2}{30} = \frac{1.753 \times 2.375^2}{30} = 0.330 \text{ tm}$				
$CA$	$= \frac{q_4 \times \ell_2^2}{20} = \frac{1.753 \times 2.375^2}{20} = 0.494 \text{ tm}$				
$M_f AC$	$= M_R + AC = 1.673 + 0.330 = 2.003 \text{ tm (-)}$				
$M_f CA$	$= M_R + CA = 1.673 + 0.494 = 2.167 \text{ tm (+)}$				
$M_f BD$	$= 2.003 \text{ tm (+)}$				
$M_f DB$	$= 2.167 \text{ tm (-)}$				
* Moment distribution factors					
$\mu$	$= \frac{4EI}{\ell}$				
- joint A					
$\mu_{ab} : \mu_{ac}$	$= \frac{4(EI)ab}{\ell_1} : \frac{4(EI)ac}{\ell_2} = \frac{1}{2.35} : \frac{1}{2.375} = 0.426 : 0.421$				
$\mu_{ab}$	$= \frac{0.426}{0.426 + 0.421} = 0.503$				

Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	7/16																																																																																																																												
		$\mu_{ac} = \frac{0.421}{0.426 + 0.421} = 0.497$ <p style="text-align: center;"><u>joint C</u></p> $\mu_{cd} : \mu_{ca} = \frac{4(EI)cd}{\ell_1} : \frac{4(EI)ca}{\ell_2} = \frac{(hcd)^4}{\ell_1} : \frac{(hca)^4}{\ell_2}$ $= \frac{(0.4)^2}{2.35} : \frac{(0.35)^2}{2.375} = 0.109 : 0.063$ $\mu_{cd} = \frac{0.109}{0.109 + 0.063} = 0.634$ $\mu_{ca} = \frac{0.063}{0.109 + 0.063} = 0.366$ <p>* Distribution moment</p> <table border="1"> <thead> <tr> <th>Joint</th> <th>C</th> <th>A</th> <th>B</th> <th>D</th> </tr> </thead> <tbody> <tr> <td>Member</td> <td>CD</td> <td>CA</td> <td>AC</td> <td>AB</td> <td>BA</td> <td>BD</td> <td>DB</td> <td>DC</td> </tr> <tr> <td><math>\mu</math></td> <td>0.634</td> <td>0.366</td> <td>0.497</td> <td>0.503</td> <td>0.503</td> <td>0.497</td> <td>0.366</td> <td>0.634</td> </tr> <tr> <td>Mf</td> <td>-3.159</td> <td>+2.167</td> <td>-2.003</td> <td>+2.426</td> <td>-2.426</td> <td>+2.003</td> <td>-2.167</td> <td>+3.159</td> </tr> <tr> <td>M0</td> <td>-0.992</td> <td>+0.423</td> <td></td> <td></td> <td>-0.423</td> <td></td> <td>+0.992</td> <td></td> </tr> <tr> <td></td> <td>+0.629</td> <td>+0.363</td> <td>-0.210</td> <td>-0.213</td> <td>+0.213</td> <td>+0.210</td> <td>-0.363</td> <td>-0.629</td> </tr> <tr> <td></td> <td>-0.315</td> <td>-0.105</td> <td>+0.182</td> <td>+0.107</td> <td>-0.107</td> <td>-0.182</td> <td>+0.105</td> <td>+0.315</td> </tr> <tr> <td></td> <td>+0.266</td> <td>+0.154</td> <td>-0.144</td> <td>-0.145</td> <td>+0.145</td> <td>+0.144</td> <td>-0.154</td> <td>-0.266</td> </tr> <tr> <td></td> <td>-0.133</td> <td>-0.072</td> <td>+0.077</td> <td>+0.073</td> <td>-0.073</td> <td>-0.077</td> <td>+0.072</td> <td>+0.133</td> </tr> <tr> <td></td> <td>+0.130</td> <td>+0.075</td> <td>-0.075</td> <td>-0.075</td> <td>+0.075</td> <td>+0.075</td> <td>-0.075</td> <td>-0.130</td> </tr> <tr> <td></td> <td>-0.065</td> <td>0.038</td> <td>+0.038</td> <td>+0.038</td> <td>-0.038</td> <td>-0.038</td> <td>+0.038</td> <td>+0.065</td> </tr> <tr> <td></td> <td>+0.065</td> <td>+0.038</td> <td>-0.038</td> <td>-0.038</td> <td>+0.038</td> <td>+0.038</td> <td>-0.038</td> <td>-0.065</td> </tr> <tr> <td></td> <td>-2.582</td> <td>+2.582</td> <td>-2.173</td> <td>+2.173</td> <td>-2.173</td> <td>+2.173</td> <td>-2.582</td> <td>+2.582</td> </tr> <tr> <td></td> <td>()</td> <td>()</td> <td>()</td> <td>()</td> <td>()</td> <td>()</td> <td>()</td> <td>()</td> </tr> </tbody> </table>	Joint	C	A	B	D	Member	CD	CA	AC	AB	BA	BD	DB	DC	$\mu$	0.634	0.366	0.497	0.503	0.503	0.497	0.366	0.634	Mf	-3.159	+2.167	-2.003	+2.426	-2.426	+2.003	-2.167	+3.159	M0	-0.992	+0.423			-0.423		+0.992			+0.629	+0.363	-0.210	-0.213	+0.213	+0.210	-0.363	-0.629		-0.315	-0.105	+0.182	+0.107	-0.107	-0.182	+0.105	+0.315		+0.266	+0.154	-0.144	-0.145	+0.145	+0.144	-0.154	-0.266		-0.133	-0.072	+0.077	+0.073	-0.073	-0.077	+0.072	+0.133		+0.130	+0.075	-0.075	-0.075	+0.075	+0.075	-0.075	-0.130		-0.065	0.038	+0.038	+0.038	-0.038	-0.038	+0.038	+0.065		+0.065	+0.038	-0.038	-0.038	+0.038	+0.038	-0.038	-0.065		-2.582	+2.582	-2.173	+2.173	-2.173	+2.173	-2.582	+2.582		()	()	()	()	()	()	()	()					
Joint	C	A	B	D																																																																																																																													
Member	CD	CA	AC	AB	BA	BD	DB	DC																																																																																																																									
$\mu$	0.634	0.366	0.497	0.503	0.503	0.497	0.366	0.634																																																																																																																									
Mf	-3.159	+2.167	-2.003	+2.426	-2.426	+2.003	-2.167	+3.159																																																																																																																									
M0	-0.992	+0.423			-0.423		+0.992																																																																																																																										
	+0.629	+0.363	-0.210	-0.213	+0.213	+0.210	-0.363	-0.629																																																																																																																									
	-0.315	-0.105	+0.182	+0.107	-0.107	-0.182	+0.105	+0.315																																																																																																																									
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Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	8/16
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\* Shear force (SF) and Normal Force (NF)



For free body :

$$\begin{aligned}
 M_{CD} &= 2.582 \text{ tm } \curvearrowleft \\
 M_{CA} &= 2.582 \text{ tm } \curvearrowright \\
 M_{AC} &= 2.173 \text{ tm } \curvearrowleft \\
 M_{AB} &= 2.173 \text{ tm } \curvearrowright \\
 M_{BA} &= 2.173 \text{ tm } \curvearrowleft \\
 M_{BD} &= 2.173 \text{ tm } \curvearrowright \\
 M_{DB} &= 2.582 \text{ tm } \curvearrowleft \\
 M_{DC} &= 2.582 \text{ tm } \curvearrowright
 \end{aligned}$$

Free body for member A - B

$$\Sigma M_A = 0 \rightarrow V_B \times l_1 - \frac{1}{2} q_1 l_1^2 - M_{BA} + M_{AB} = 0$$

$$V_B = \frac{1}{2} \times 5.272 \times 2.35 + \frac{2.175 - 2.173}{2.35} = 6.195 \text{ t}$$

$$\Sigma M_B = 0 \rightarrow V_A \times l_1 - \frac{1}{2} q_1 l_1^2 - M_{AB} + M_{BA} = 0$$

$$V_A = \frac{1}{2} \times 5.272 \times 2.35 + \frac{2.175 - 2.173}{2.35} = 6.195 \text{ t}$$

Free body for member C - D

$$\Sigma M_C = 0 \rightarrow V_D \times l_1 - \frac{1}{2} q_2 l_1^2 - M_{DC} + M_{CD} = 0$$

$$V_D = \frac{1}{2} \times 6.821 \times 2.35 + \frac{2.582 - 2.582}{2.35} = 8.015 \text{ t}$$

Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	9/16
			$\Sigma MD = 0 \rightarrow V_C \times l_1 - \frac{1}{2}q_2 l_1^2 - M_{CD} + M_{DC} = 0$ $V_C = \frac{1}{2} \times 6.821 \times 2.35 + \frac{2.582 - 2.582}{2.35} = 8.015 \text{ t}$ <p><u>Free body for member C - A</u></p> $\Sigma MC = 0 \rightarrow H_A \times l_2 - \frac{1}{2}q_3 l_2^2 - \frac{1}{6}q_4 l_2^2 - M_{AC} + M_{CA} = 0$ $H_A = \frac{1}{2} \times 3.56 \times 2.375 + \frac{1}{6} \times 1.753 \times 2.375 + \frac{2.009 - 3.179}{2.375}$ $= 4.228 + 0.694 - 0.493 = 4.429 \text{ t}$ $\Sigma MA = 0 \rightarrow H_C \times l_2 - \frac{1}{2}q_3 l_2^2 - \frac{1}{3}q_4 l_2^2 - M_{CA} + M_{AC}$ $H_C = \frac{1}{2} \times 3.56 \times 2.375 + \frac{1}{3} \times 1.753 \times 2.375 + \frac{3.179 - 2.009}{2.375}$ $= 4.228 + 1.388 + 0.493 = 6.109 \text{ t}$		

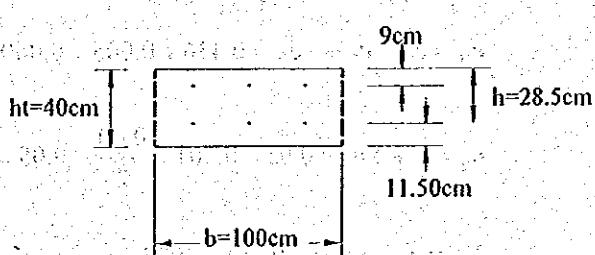
#### SUMMARY OF FORCES

	CD	CA	AC	AB	BA	BD	DB	DC
M (kg m)	2,582	2,582	2,173	2,173	2,173	2,173	2,582	2,582
NF (kg)	6,109	8,015	8,015	4,429	4,429	8,015	8,015	6,109
SF (kg)	8,015	6,109	4,429	6,195	6,195	4,429	6,109	8,015

#### 5. Reinforcing Calculation

##### (a) Member CD

$$\begin{aligned}
 M &= 2582 \text{ kgm} \\
 NF &= 6109 \text{ kg} \\
 SF &= 8015 \text{ kg} \\
 ht &= 40 \text{ cm} \\
 h &= 28.50 \text{ cm} \\
 b &= 100 \text{ cm} \\
 lt &= 2.35 \text{ m}
 \end{aligned}$$



Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	10/16
	$lk = 0.70 \times lt$ $= 0.70 \times 2.35$ $= 1.645 \text{ m}$ <p>According to design criteria as follows:</p> <p>concrete K<sub>225</sub> → <math>\bar{\sigma}_b = 75 \text{ kg/cm}^2</math>; <math>\bar{\tau}_b = 6.50 \text{ kg/cm}^2</math></p> <p>Steel U<sub>24</sub> → <math>\bar{\sigma} = 1400 \text{ kg/cm}^2</math></p> <p>Ratio of Young's modulus, assume n = 15</p> $\phi_0 = \frac{\bar{\sigma}_a}{n\bar{\sigma}_b} = \frac{1400}{15 \times 75} = 1.244$ $e_{0_1} = \frac{M}{NF} = \frac{2.582}{6.109} = 0.423 \text{ m}$ $e_{0_2} = \frac{1}{30} ht = \frac{0.40}{30} = 0.013 \text{ m}$ $e_0 = e_{0_1} + e_{0_2} = 0.423 + 0.013 = 0.436 \text{ m}$ $\frac{e_0}{ht} = \frac{0.436}{0.40} = 1.090 > 1 \rightarrow C = 7$ $e_1 = C \left( \frac{lk}{100ht} \right)^2 \times ht = 7 \left( \frac{1.645}{100 \times 0.40} \right)^2 \times 0.40 = 0.005 \text{ m}$ $e_2 = 0.15 ht = 0.15 \times 0.40 = 0.060 \text{ m}$ $e_0 = e_0 + e_1 + e_2 = 0.436 + 0.005 + 0.060 = 0.501 \text{ m}$ $e_a = e + \frac{1}{2} ht - 0.05 = 0.501 + \frac{0.40}{2} - 0.05 = 0.651 \text{ m}$ $NF \times e_a = 6091 \times 0.651 = 3977 \text{ kg m}$				

Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	11/16										
	$C_a = \frac{h}{\sqrt{\frac{n \times NF \cdot e_a}{b \times \bar{\sigma}_a}}} = \frac{28.5}{\sqrt{\frac{15 \times 3977}{1 \times 1400}}} = 4.366$ $\delta = 1 - \frac{1}{8} \times \frac{h}{e_a} = 1 - \frac{1}{8} \times \frac{0.285}{0.651} = 0.617 \sim 0.60$ $\left. \begin{array}{l} \delta = 0.60 \\ C_a = 4.366 \end{array} \right\} \quad \left. \begin{array}{l} \phi = 2.704 > \phi_0 \text{ 1.244} \rightarrow \text{ok} \\ \xi = 0.909 \\ n\omega = 0.05804 \end{array} \right\}$ $\left. \begin{array}{l} \frac{e_a}{h} = \frac{0.651}{0.285} = 2.284 \\ \xi = 0.909 \end{array} \right\} \quad i = 1.65$ $iA = \omega b h = \frac{0.05804}{15} \times 100 \times 28.5 = 11.028 \text{ cm}^2$ $A = \frac{iA}{i} = \frac{11.028}{1.65} = 6.683 \text{ cm}^2$ $A' = \delta \times iA = 0.617 \times 11.028 = 6.804 \text{ cm}^2 \sim A$ <p>to be used <math>D_{13}</math> @ <math>12.50 \text{ cm}^2</math> (<math>A = 10.64 \text{ cm}^2</math>)</p> <p>shear strength check.</p> $\tau_b = \frac{SF}{\frac{1}{8} \times b \times h} = \frac{8015}{\frac{1}{8} \times 100 \times 28.5} = 3.214 \text{ kg/cm}^2 < \bar{\tau}_b = 6.50 \text{ cm}^2$ <p>(b) Member CA</p> <table> <tr> <td><math>M = 2582 \text{ kgm}</math></td> <td><math>NF = 8015 \text{ kg}</math></td> <td><math>SF = 4429 \text{ kg}</math></td> <td><math>ht = 35 \text{ cm}</math></td> <td></td> </tr> <tr> <td><math>h = 35 - 9 = 26 \text{ cm}</math></td> <td><math>lt = 2.375 \text{ m}</math></td> <td></td> <td></td> <td><math>b = 100 \text{ cm}</math></td> </tr> </table>	$M = 2582 \text{ kgm}$	$NF = 8015 \text{ kg}$	$SF = 4429 \text{ kg}$	$ht = 35 \text{ cm}$		$h = 35 - 9 = 26 \text{ cm}$	$lt = 2.375 \text{ m}$			$b = 100 \text{ cm}$				
$M = 2582 \text{ kgm}$	$NF = 8015 \text{ kg}$	$SF = 4429 \text{ kg}$	$ht = 35 \text{ cm}$												
$h = 35 - 9 = 26 \text{ cm}$	$lt = 2.375 \text{ m}$			$b = 100 \text{ cm}$											



Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	13/16
	$\delta = 0.60$ $C_a = 3.898$	$\phi = 2.390 > \phi_0 1.244 \rightarrow \text{ok}$ $\xi = 0.901$ $n\omega = 0.07400$			
	$e_a = \frac{0.518}{h} = \frac{0.518}{0.26} = 1.992$ $\xi = 0.901$	$i = 1.82$			
	$iA = \omega b h = \frac{0.074}{15} \times 100 \times 26 = 12.827 \text{ cm}^2$				
	$A = \frac{iA}{i} = \frac{12.827}{1.82} = 7.048 \text{ cm}^2$				
	$A' = \delta \times iA = 0.561 \times 12.827 = 7.196 \text{ cm}^2 \sim A$				
	to be used $D_{13} @ 12.50 \text{ cm}^2 (A = 10.64 \text{ cm}^2)$				
	shear strength check.				
	$\tau_b = \frac{SF}{\frac{7}{8} \times b \times h} = \frac{4429}{\frac{7}{8} \times 100 \times 26} = 1.947 \text{ kg/cm}^2 < \bar{\tau}_b = 6.50 \text{ cm}^2 \rightarrow \text{ok}$				
(c)	Member AB				
M	= 2173	kNm			
NF	= 4429	kg			
SF	= 6195	kg			
ht	= 35	cm			
h	= 35 - 9 = 26	cm			
lt	= 2.350	m			
lk	= $0.70 \times lt$ = $0.70 \times 2.350$ = 1.645 m				

Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	14/16
	$e_{0_1} = \frac{M}{NF} = \frac{2173}{4429} = 0.491 \text{ m}$ $e_{0_2} = \frac{0.35}{30} ht = \frac{0.35}{30} = 0.012 \text{ m}$ $e_0 = e_{0_1} + e_{0_2} = 0.491 + 0.012 = 0.503 \text{ m}$ $\frac{e_0}{ht} = \frac{0.503}{0.35} = 1.437 > 1 \rightarrow C = 7$ $e_1 = C \left( \frac{lk}{100ht} \right)^2 \times ht = 7 \left( \frac{1.645}{100 \times 0.35} \right)^2 \times 0.35 = 0.005 \text{ m}$ $e_2 = 0.15 ht = 0.15 \times 0.35 = 0.053 \text{ m}$ $e = e_0 + e_1 + e_2 = 0.503 + 0.005 + 0.053 = 0.561 \text{ m}$ $e_a = e + \frac{1}{2} ht - 0.05 = 0.561 + \frac{0.35}{2} - 0.05 = 0.686 \text{ m}$ $NF \times e_a = 4429 \times 0.686 = 3038 \text{ kg m}$ $C_a = \frac{h}{\sqrt{\frac{n \times NF \cdot e_a}{b \times \bar{\sigma}_a}}} = \frac{26}{\sqrt{\frac{15 \times 3038}{1.0 \times 1400}}} = 4.557$ $\delta = 1 - \frac{1}{8} \times \frac{h}{e_a} = 1 - \frac{1}{8} \times \frac{0.26}{0.686} = 0.668 \sim 0.80$ $\left. \begin{array}{l} \delta = 0.80 \\ C_a = 4.557 \end{array} \right\} \quad \left. \begin{array}{l} \phi = 2.922 > \phi_0 \ 1.244 \rightarrow \text{ok} \\ \xi = 0.912 \\ n\omega = 0.05236 \end{array} \right.$ $\left. \begin{array}{l} \frac{e_a}{h} = \frac{0.686}{0.26} = 2.638 \\ \xi = 0.912 \end{array} \right\} \quad i = 1.53$				

Name of Structure	BARU CONVEYANCE CHANNEL	CATEGORY Calculation	Structural Calculation	Page	15/16
	$iA = \omega b h = \frac{0.05236}{15} \times 100 \times 26 = 9.076 \text{ cm}^2$ $A = \frac{iA}{i} = \frac{9.076}{1.53} = 5.932 \text{ cm}^2$ $A' = \delta \times iA = 0.668 \times 9.076 = 6.063 \text{ cm}^2 \sim A$ to be used D <sub>13</sub> @ 12.50 cm <sup>2</sup> (A = 10.64 cm <sup>2</sup> ) shear strength check. $\tau_b = \frac{SF}{\frac{7}{8} \times b \times h} = \frac{6195}{\frac{7}{8} \times 100 \times 26} = 2.723 \text{ kg/cm}^2 < \bar{\tau}_b = 6.50 \text{ cm}^2 \rightarrow \text{ok}$				

Name of Structure	BARU CONVEYANCE CHANNEL	Date of Drawing	STRUCTURAL CALCULATION	Pno.	16 / 16
<p style="text-align: center;"><b>REINFORCING BAR ARRANGEMENT</b></p>					

### **3.4 Bandarharjo East Secondary Channel**

## **3.4 Bandarharjo East Secondary Channel**

### **3.4.1 Hydraulic Calculation**

Name of Structure	Bandarharjo East Secondary Channel (Box Culvert)	Category of calculation	Hydraulic Calculation	Page	1/4
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**1) general**

This structure is a box culvert to reroute the flow of a secondary channel now flowing into Baru River just upstream from the North Ring Road. (Fig.1)

The channel should be rerouted upstream, so that it discharge into the Baru River upstream from the pumping station.

**2) catchment area**

According to the configuration of the existing secondary channels in the area, the catchment area to be covered by the box culvert is indicated in Fig.2. It covers a large part of the Bandarharjo East drainage area.

The catchment area is 0.856km<sup>2</sup> and the maximum channel length is 1.5km.

**3) calculation of design discharge**

The equation for discharge calculation is

$$Q = 0.2778 \times C_s \times C \times I \times A$$

where

Q: peak discharge (m<sup>3</sup>/s)

I : average intensity of rainfall (82.4) (mm/hr)

A: catchment area (0.856) (km<sup>2</sup>)

C: run-off coefficient (=0.65)

C<sub>s</sub>: storage coefficient (=0.8)

Therefore

$$Q = 10.2 \text{ m}^3/\text{s}$$

Name of Structure	BANDARHARJO EAST SECONDARY CHANNEL	Category Calculation	Hydraulic Calculation	Page
				2/4
	<p>Secondary Channel <math>L=124.452\text{ m}</math></p> <p>+0.30                    -0.11                    -0.45                    -0.90 H.V.L.  -2.40                    -2.80                    -3.10 L.V.L.</p> <p>-0.30                    -0.11                    -0.45                    -0.90 H.V.L.  -2.40                    -2.80                    -3.10 L.V.L.</p> <p><b>SECTION A-A</b></p> <p>Vertical profile: Depth = 1.95 m, Distance = 2.000 m</p>	$L = 124.452 \text{ M}$ $DH = 2.8 - 2.46 = 0.34 \text{ m}$ $I = \frac{0.34}{124.452} = 0.00273$ $V = \frac{1}{n} \times R^{\frac{2}{3}} \times I^{\frac{1}{2}} = 0.00273$ $n = 0.015$ $O = 2 \times 1.95 + 2 = 5.90 \text{ m}$ $A = 2 \times 1.95 = 3.90 \text{ m}^2$ $R = \frac{A}{O} = \frac{3.90}{5.90} = 0.661 \text{ m}$ $V = \frac{1}{0.015} \times (0.661)^{\frac{2}{3}} \times \left( \frac{0.661}{124.452} \right)^{\frac{1}{2}} = 2.644 \text{ m/s}$ $Q = A \times V = 3.90 \times 2.644 = 10.312 \text{ m}^3/\text{s} \sim 10.20 \text{ m}^3/\text{s}$		

FIG. 1 - BOX CULVERT LAY OUT

