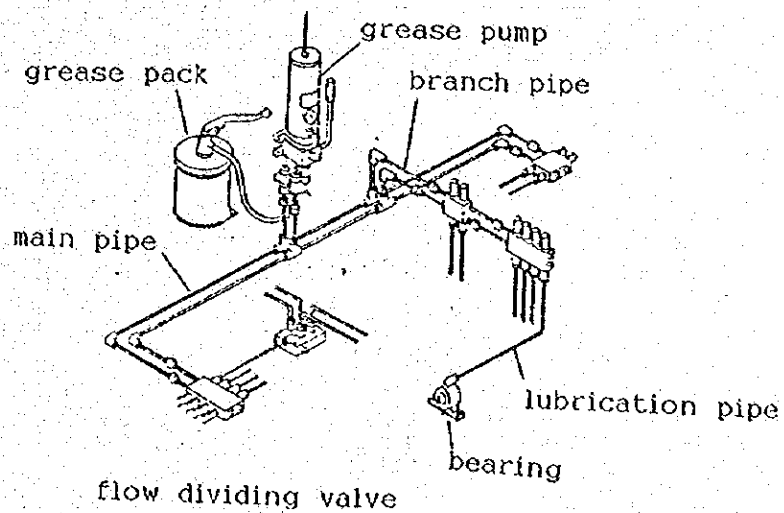
6-2-6 Lubrication system

The bearing should be lubricated for smooth rotation before running and check at regular intervals.
The lubrication system of the bearing are as follow;

1: Distribution valves must be provided to centralize the lubrication system

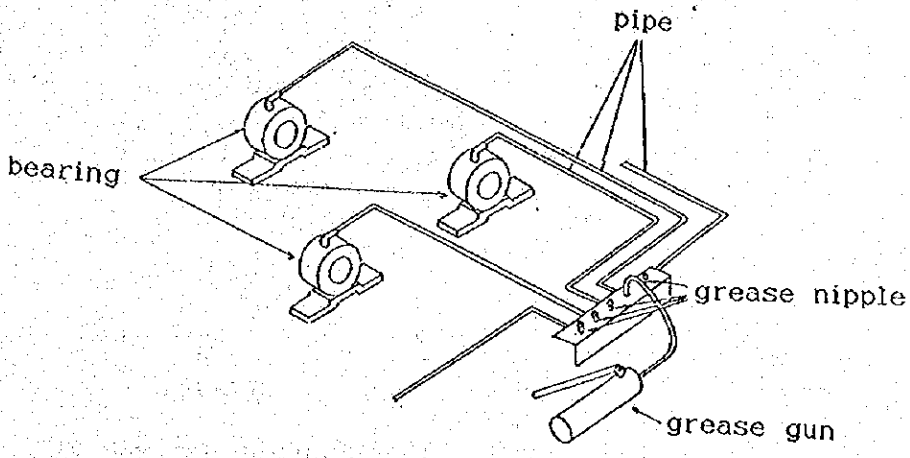
This system is done by laying pipes from a point, to the hoist of each bearing.
All bearing, wll be lubricated at once, when one grease pump is operated.
This system makes possible lubrication to each bearing which eliminates mistakes, requires short time, and easy to operate.
But with this system many bearings will not be lubricated when a breakdown at the distribution valves.
It is also difficult to know the amount of lubrication used for each different size valves, and the time reuired for lubrication is different for each bearings.
Large scale of repair works will be needed for a break down.



① Distribution valves for form centralization lubrication system

2 Manifold form of centralization lubrication system

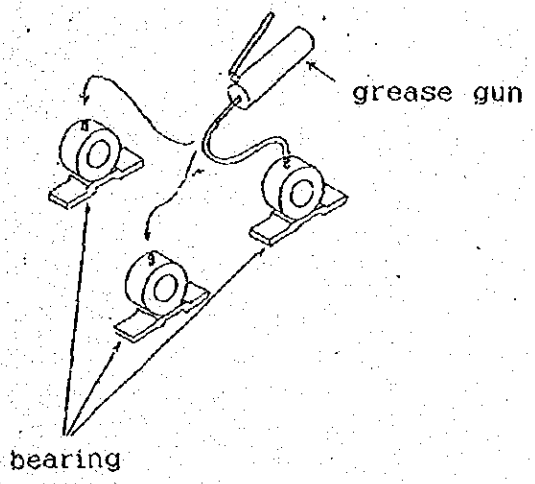
This system is done by laying pipes at several point, from each bearing of hoist.
This system of lubrication is made at one place using grease gun, on each grease nipple, and the operater can judge for necessary requirements and volumes.
For this system repair of break down is easy, because only the damage pipes will be replaced.



② Manifold form centralization lubrication system

3 Several lubrication system

This system do not requires pipes, lubrication to each bearings is made at each grease nipple using grease gun.
This system is dangerous when the operators overlook or miss a few of the greasing point and it will be difficult to locate the points that is overlook.



③ Several lubrication system

From all the above systems, the manifold form centralization lubrication system is the most suitable for the gates in Prai Barrage.

6-2-7 Hoist room

A hoist room or shelter must be provided to the hydraulic gate. This is to ersure operation can be done even during heavy rain.

6-2-8 Diameter of wirerope

The wirerope shall be suitable for its proposed use, taking into account tension, frequency and condition of use as well as the environment in which it is to be used.

1 When a wirerope is spooled onto the drum or the sheave, each wire rope is subjected to a bending moment increases, thus resulting in quick fatigue and easy breakage of each wire. The wirerope deteriorates quickly because of the deformation and internal friction caused by its irregular bending and the increasing contact pressure with the drum or the sheave. Thus, in the case of Japan, the ratio between the diameter of drum or the sheave, and that of the wirerope largely influences the life of the wirerope. The life of the wirerope also depends on its type.
A large diameter for the drum and sheave is preferable for safety inthe use of wirerope.
However, for a hydraulic gate, since its normal operating frequency is low and the wirerope winding speed and impact are relatively small, the diameter has been set at more than 19times the wirerope diameter for the drum diameter, and more than 17times for the sheave diameter.

2 Since the use hours, frequency of use, winding speed and impact of the wirerope of a hydraulic gate are relatively low.

3 For a hydraulic gate such as a self-controlled gate or a navigation lock which is frequently operated, wirerope having a good anti-fatigue property(repeated bending fatigue) is preferable.

6-2-9 Control system

1 Control place

Control should be local and remote control. Local control is oprtated near the hoist and remote control operates from the operator house. The local control should have priority and remote control should not be possible during local control.

2 Operation method

(1) Manual control
This control is operted while watching the water level of upper stream side and lower stream side, and gate position indicator, by local and remote.
(2) Automatic control
① Upper flow side water level fixed control
This control is kept to allow water to overflow over the gate at fixed level by positioning the automatic control of top gate.
② The retroactive of salt stop control
This control is to stop the rise of sea side water level at high tide, by positioning the automatic control.
③ The control to prevent flooding
At "①" and "②", if no control is provided to the rise of water level, automatic rise control of bottom gate should also be provided. This is the case where we got no choice, but to prevent flooding, i.e. by allowing the sea water to intrude into the fresh water zone.

3 Operation and measuring device

(1) The local device
Local control panel
Installed equipment are as follow;

push button swich	"raise" "stop" "lower"
gate position indicator	"top gate" "bottom gate"
water level indicator	"upper flow side"
	"lower flow side"

an intercommunication phone is conected to the remote

(2) Remote controling device
Remote control panel
Installed equipment are as follow;

push button swich	"raise" "stop" "lower"
gate position indicator	"top gate" "bottom gate"
water level indicator	"upper flow side"
	"lower flow side"

an intercommunication phone is conected to the remote
a water level recorder "upper flow side"
"lower flow side"
a device to change the fixed water level

(3) The water level detector
This detector used to record or observe water level for manual control and automatic control.

(4) Gate position indicator
This indicator is used to detect the opening position of the gate leaf either from the rotation of the gear shaft or directly from the travel movement of the gate. An indicator suitable for the controlling of the gate should be used.
It is desirable to have a display indicator at the side of the hoist and on the remote control panel for remote-controll operation. Both analog displays and digital display should be available.
An A/D converter, potentiometer, and syncro selsyn are generally used for transmitting the signals from a position detector to a position indicator.

4 Interlock device

An interlock device should be provided for the gate hoist to prevent accidents due to misoperation or overlapping operations. Various types of interlock devices are available:

(1) When both local and remote control are possible, the local control should have priority and remote control should not be possible during local control.

(2) When control is by switching gate operating power, the second operating power should not work while the first operating power is working.

(3) When the gate leaf is held by the resting device, the closing operation should not be possible.

6-2-10 Coating

Coating is required for the hydraulic gate with a view to anti-corrosion and good appearance. The paint film is the most important element in exerting the effect of the coating and for the purposes of obtaining good film properties it is absolutely necessary to select paint suitable for the atmosphere, i.e. coating specifications and conduct careful coat work.

1 Coating system

In case of Japan, the standard coating system is listed in Table.

An antifouling paint may be applied to the hydraulic gate installed in sea water which requires the prevention of marine microorganisms from attaching to the gate.

Reference: Ready mixed paint, Class 2 JIS K5516
Red-lead anticorrosive paint, Classes 1 and 2 JIS K5622
Lead suboxide anticorrosive paint, Class 2 JIS K5623
Basic lead chromate anticorrosive paint, Classes 1 and 2 JIS K5624
Lead cyanamide anticorrrosive paint, Classes 1 and 2 JIS K5625
Tar epoxy resin paint, Class 1 JIS K5664

Table Coating System

Coating system & symbol	Coating location	Process	Paint	Standard film thickness (μ)	Coating interval (20°C) Minimum & maximum
A Epoxy resin paint system	Steel mill/shop	1st primer	Zinc-rich primer (organic)	20	72H ~ 6M
	Shop	1st layer (under coat)	Epoxy resin paint	60	
		2nd layer (under coat)	Epoxy resin MIO paint (Note 4)	60	24H ~ 7D
	Field	3rd layer (intermediate coat)	Epoxy resin paint	30	24H ~ 18M
		4th layer (top coat)	Epoxy resin paint	30	24H ~ 7D
B Epoxy resin paint system (thick film)	Steel mill/shop	1st primer	Zinc-rich primer (organic)	20	72H ~ 6M
	Shop	1st layer (under coat)	Epoxy resin paint (thick film)	100	
		2nd layer (intermediate coat	Epoxy resin MIO paint (Note 4)	60	24H ~ 7D
	Field	3rd layer (top coat)	Epoxy resin paint (thick film)	100	24H ~ 18M
C Tar epoxy resin type	Steel mill/shop	1st primer	Zinc-rich primer (organic)	20	72H ~ 6M
	Shop	1st layer (under coat)	Tar epoxy resin paint, Class 1	80	
		2nd layer (intermediate coat)	Tar epoxy resin paint, Class 1	80	24H ~ 7D
		3rd layer (top coat)	Tar epoxy resin paint, Class 1	80	24H ~ 7D
D Tar epoxy resin paint system (thick film)	Steel mill/shop	1st primer	Zinc-rich primer (organic)	20	72H ~ 6M
	Shop	1st layer (under coat)	Tar epoxy resin paint (thick film)	150	
		2nd layer (top coat)	Tar epoxy resin paint (thick film)	150	24H ~ 7D
E Zinc chlorinated rubber paint	Steel mill/shop	1st primer	Zinc-rich primer (organic)	20	72H ~ 6M
	Shop	1st layer (under coat)	Zinc-rich primer (organic)	20	
		2nd layer (under coat)	Chlorinated rubber paint	40	48H ~ 6M
		3rd layer (under coat)	Chlorinated rubber paint	40	16H ~ 12M
	Field	4th layer (intermediate coat)	Chlorinated rubber paint	30	16H ~ 12M
		5th layer (top coat)	Chlorinated rubber paint	30	16H ~ 12M

Table Coating System (cont'd)

Coating system & symbol	Coating location	Process	Paint	Standard film thickness (μ)	Coating interval (20°C) Minimum & maximum
F Phthalic resin paint system	Steel mill/shop	1st primer	Wash primer	15	4H ~ 3M
	Shop	1st layer (under coat)	Red-lead or lead-type anticorrosive paint, Class 1	35	
		2nd layer (under coat)	Red-lead or lead-type anticorrosive paint, Class 2	35	24H ~ 3M
	Field	3rd layer (intermediate coat)	Ready mixed paint for upper coat, Class 2	25	24H ~ 6M
		4th layer (top coat)	Ready mixed paint for upper coat, Class 2	25	15H ~ 1M
G Lead-type anticorrosive phenolic MIO chlorinated rubber paint system	Steel mill/shop	1st primer	Wash primer	15	4H ~ 3M
	Shop	1st layer (under coat)	Red-lead or lead-type anticorrosive paint, Class 1	35	
		2nd layer (under coat)	Red-lead or lead-type anticorrosive paint, Class 2	35	24H ~ 3M
		3rd layer (intermediate coat)	Phenolic resin-type MIO paint	50	24H ~ 3M
	Field	4th layer (intermediate coat)	Chlorinated rubber paint	30	48H ~ 18M
		5th layer (top coat)	Chlorinated rubber paint	30	16H ~ 12M

Notes: 1. Surface preparation should be in accordance with SSPC-SP 6-63 Commercial Blast Cleaning or the Swedish SIS-Sa2 by using shot, grit, sand blasting, etc.
2. In the Table, H = Hour, D = Day, M = Month
3. Standard film thickness should be a mean value of each measurement but the minimum measurement should be more than 70% of the standard film thickness.
4. Maximum coating interval for coating system (A) or (B) is 18 months but when the construction work is short or all the coatings including a finish coating are conducted in the shop due to circumstances which cannot be controlled, it is permissible to use epoxy resin paint (under coat) instead of epoxy resin type MIO paint. (In this case, however, the coating interval should be from 24 hours to 7 days at 20°C.)
5. In coating systems (C) or (D), when coating at less than 15°C during the winter, an equivalent tar urethane resin paint can be used. (In this case, however, the coating interval should be from 24 hours to 7 days at 15°C.)
6. In coating system (G), phenolic resin MIO paint must be applied to the third layer.
7. When applying coating system (F) or (G) to the gate hoist, castings or forgings, the wash primer can be omitted.

2 Coating system to be applied

Coating systems to be applied are listed in the table and depend on the atmosphere. If two or more coating systems are available for the same atmosphere, a decision should be made by taking into account perfomances, workability, using conditions, etc.

Table Coating Systems to be Applied

Classification \ Atmosphere		In water	Over water	
		Sea Water and Fresh Water	Coast and Industrial Areas	Others
Guide and Anchorage		A, B, C, D	E, G	E, G
Leaf	Mostly in water	A, B, C, D	—	—
	Always wet with dew	A, B, C, D	A, B, C, D	A, B, C, D
	Mostly in atmosphere	—	E, G	E, F, G
	Auxiliary facilities	A, B, C, D	E, G	E, G
Gate hoist	Outdoors	—	F, G	F, G
	Indoors	—	F	F
Hoisting framework, etc.		—	E, F, G	F, G

A, B, C ... in the Table show coating system symbols in Table 2.79-1.

3 Coating Work

(1) Surface preparation shall not be made outdoors on a rainy day or under other such adverse weather condition. Even durng indoor work, coating cannot be conducted after blast cleaning when the temperature is below 5 ℃ or the humidity is abve 85%, and thus heating or forced drying shall be required.

(2) Wash primer shall not be applied when the humidity is more than 90%, and other paints shall not be applied when, in addition to the above humidity, the ambient temperature is below 5 ℃ and the temperature on the surfaces to be coated ismore than 50 ℃.

(3) Necessary and sufficient time shall be taken for the over coating interval by taking into account drying time, ambient temperatures, etc.

(4) Surface preparation for the steel materials is to remove mill scales, rust and other foulings by blowing abrasive materials such as sand, slag, grit , shot onto the steel materials using compressed air by means of a blast cleaning device in the steel mills or the shop. As a pretreatment, grease or machine oil on the surfaces of the steel should be removed by using an organic solvent such as thinner, etc.

(5) Particularly for tar epoxy resin type and epoxy resin type, the maximum coating interval is within 7days, and thus stuctures which require a long period before installation should basically be coated in the shop, but if this is not possible, it is required that necessary measures such as roughening the surface to be painted be taken.
For a hydraulic gate that is always submerged, the combination use of coating and electric protection is effective. Even in this case, painting is the main anticorrosive measure and electric protection is supplemental. A suitable paint should be carefully selected. There is the galvanic anode method and impressed current but the former is widely employed because of its simple work process.

[Reference]
An introduction of another coating, intruduce some maker in Japan, its development to "Ultra-heavy-duty coating", at recently.
(cf. Table 6-6)

1 Assembly

In assembling a hydraulic gate, if each part cannot be assembled as specified in the design dimensions, the operation and the water-tigthness after completion are likely to be insufficient. A trial assembly of a large sited gate guide and gate leaf should generally be made in the shop and any deformation should be corrected so that the assembly conforms to the design dimensions(drawing dimensions). Then, a dimension measurement list should be prepared and match marks should be applied. Disassembly and packing should be undertaken and the gate should be sent out. If the gate guide has already been installed, the dimension measurement list for its installation should be checked with the gate leaf and any required adjustments should be made.
Wheel pins and pin supports should be arranged in advance so as to be adjustable with an eccentric pin system or liner.
Especially in a welded structure, strain is likely to occur and thus extreme care should be taken concerning the contraction of a long span gate and the strain of the flat plane of a gate guide, by welding.

2 Handling during Transportation

A hydraulic gate is generally installed at a place where the transportation conditions are poor and the gate is likely to be deformed or damaged during the transportation due to the long distance driving on rough roads. It is preferred that members be transported as a large block as often as possible and that the part of the block that lacks rigidity be properly reinforced. The machine-finished faces should be protected with wood or some other item and proper paint or grease should be applied so that they do not become rusty during transportation.

Special attention should be paid to the case where no crane is available for the loading and unloading operations. Electric and mechanical parts should be particularly carefully handled and, if possible, should not be exposed to rain.
Rubber seals are generally transported in a wound condition which leads to deformation and therfore they should be unwound and kept open before installation.

3 Installation

(1) Installation of the Gate Guide and Anchorage

In order to smoothly operate the gate leaf, the accurate installation of the gate guide and anchorage which are subject to hydraulic pressure concentration of the leaf is of prime importance. For a fixed wheel gate, the roller seating face for each roller should be flush and the roller track should also be flush on the left and right, and each roller should contact the roller track uniformly. If the contact is uneven, the load will be concentrated on specific rollers, thus leading to thebreaking of the rollers and to irregular operation.

In order to secure an accurate installation it is desirable to use proper jigs. Liners. Wedges and adjusting bolts are also often used for adjusting.
The installation work of the guide is the most important and good watertightness and smooth hoisting operation cannot beexpected unless the guide is installed exactly.

(2) Installation of the Seal Part
The purpose of a hydraulic gate is to stop water and so a complete shutting off is preferrable but it is generally difficult to do so. However, it is necessary to minimize the leak as much as possible. A leak from the seal part is due to the irregularity of the seal contact face or to a gap between the guide members and the concrete.

A leak due to incomplete contact of the rubber seals should be stopped by adjusting the protrusive level of the rubber with rubber tightening bolts or by inserting a steel liner plate to it.

6-2-12 Inspection of construction

In the process of manufacturing a hydraulic gate, the following inspections shall be made, but some of them can be omitted depending on the type and importance of the gate:

① Material inspection
② Measurement inspection
③ Welding inspection
④ Shop trial assembly inspection
⑤ Field inspection

When manufacturing and installing a hydraulic gate, the above inspections should be made as appropriate in order to ensure that the materials are used as planned, that the dimensions are the same as those specified in the drawings and that the performances can be obtained as planned. In the material test, whether or not the specified materials are used should be checked and in the shop trial assembly inspection various important dimensions should be measured and the load of the gate hoist should be conducted if required. The field inspection is conducted to ensure that those items manufactured and installed can exert the required capabilities and can be usable, by checking the dimensions of each part and the water-tightness, as well as by conducting the operation test.

1 Maintenance, Inspection and Control

Maintenance, inspection and control for a hydraulic gate shall be conducted properly to well-maintain each function.
The hydraulic gate should be inspected regularly or as approprite in order to maintain the functions and to prevent accidents beforehand.
The historical record, specifications, design drawings, test records, and operation manuals for the hydraulic gate should be maintained. In addition, the inspection record, operating record, and repair record, etc., shoud be well-maintained.
The interval of regular inspections should be set in the control standard established separately taking into account the use conditions, functions, and importance of gate.
After flooding, it is desirable that the gate leaf, gate guide, and auxiliary facilities should be inspected temporarily and immediately.
An example of the check seat is listed in Tables 6-41 to 6-43.

2 Leak Prevention

In case of an excessive leak from the seals, immediate replacement or repair shall be made.
If the leak increases because the rubbur seal deteriorates or becomes damaged, it should be replaced with a new one.

3 Maintenance of Support

Gate supports shall always be well-maintained so as to operate smoothly.
The support for a gate leaf is a point where the hydraulic pressure working on the leaf concentrates and so all the supports should be in a completely maintained condition so that they operate smoothly under hydraulic pressure. In other words, main wheel pins of a fixed wheel gate are always required to be coverd with appropriate lubricants.
In particular, the wheel pins of a fixed wheel gate are numerous and the foothold for maintenance is generally poor thus leading to insufficient maintenance.
The hinged supports of a hydraulic gate are generally subject to large pressure and revolve at a low speed, and so extreme care should be taken so that the lubricant is always applied throughout the entire surface. With insufficient lubrication, bearings are likely to be seized, and the wheel pin tends to rotate with the wheels, thus leading to trouble in operating the gate leaf. Again, a thorough lubrication is essential for smooth operation.

4 Maintenance of Gate Hoist

A gate hoist shall always be well-maintained so as to secure perfect operation of the gate leaf.
A gate hoist should be in perfectly maintained condition so that the gate leaf is operable at any time. For this purpose, it is necessary to prepare "Hydraulic Gate Inspection Procedures" to specify how to

conduct a regular inspection before operation. Attention should be paid during the inspection to lubrication, occurrence of rust and slackness of tightening bolts at each part of the gate hoist, to temperature increases in the bearings, to checking of the electric parts and the rope wires, and to confirming the operation of the limit switches and breakes, as well as to greasing the wireropes. Cleaning up is also required for the rubber seals and rollers to get rid of tree leaves or wood chips before operation.

5 Maintenance of Auxiliary Power Equipment

Auxiliary power equipment shall always be well-maintainedso as to afford rapid and secure operation.
Engines for the auxiliary power equipment should always be under good maintenance conditions so as to start at any time, and the operator is required to master how to start them.

6 Repair and Replacement

Repair or replacement shall be made soon after the risk of malfunction of a hydraulic gate is incurred because of a decrease in material thickness, deterioration and corrosion of materials, etc. Repair or replacement of a hydraulic gate should be made based on the following:

(1) When there is a fear that the stress of each member exceeds the allowable stress for each material used, thus leading to a breakdown.
(2) When the gate is estimated to be in danger because of structure instability due to vibrations.

(3) When there is some trouble in operating the gate because of an excessive drop in performance.

Parts generally repaired or replaced are the rubber seals or wireropes.
Attention should be paid to deterioration of the hydraulic operating fluids, to the existence of foreign matter, and to the volume of oil for an oil hydraulic device, if attached. If the above is a cause for an oil pressure drop or increase, the filter should be replaced or the oil should be replenished.
A wirerope should be replaced when more than 10% of the total wires of the rope are broken or when the diameter of the wirerope decreases by more than 7% of the nominal diameter.

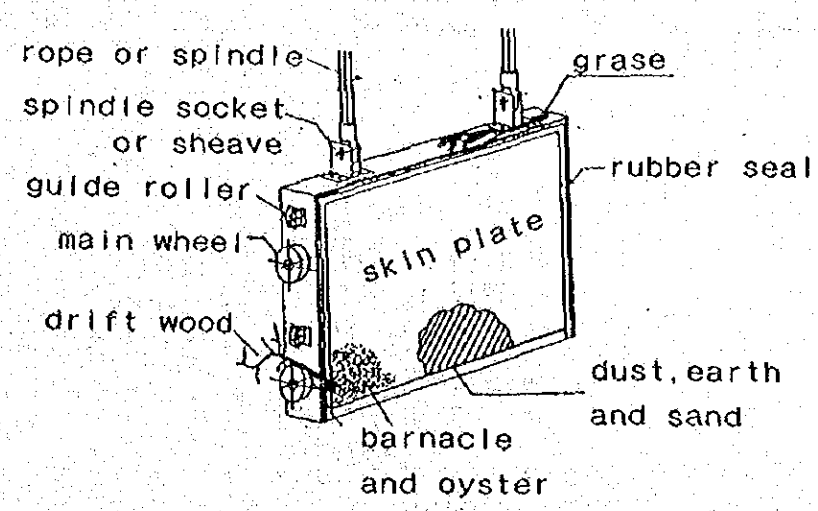
6 Recoating

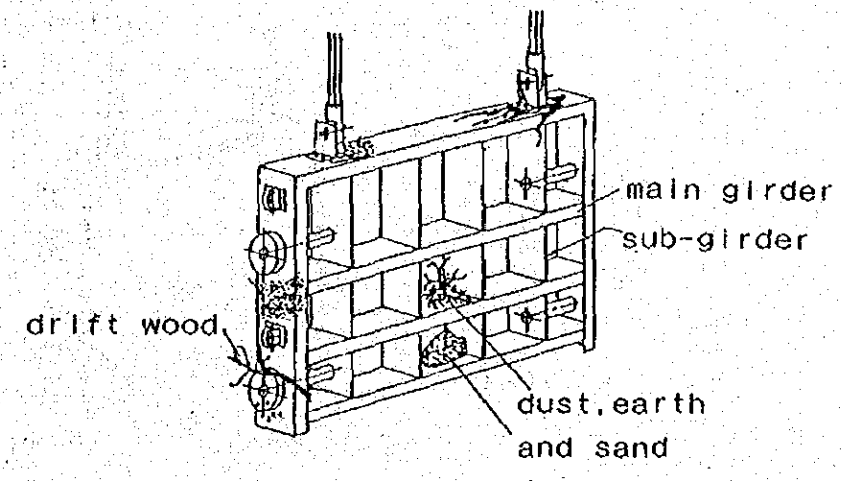
Recoating shall be made immediately when the coating of a hydraulic gate deteriorates or becomes damaged.
Recoating should be made to a hydraulic gate at certain intervals. When recoating, the paints used before should be carefully studied and checked, and the same or similar ones should be used again.

Control standard(an example)

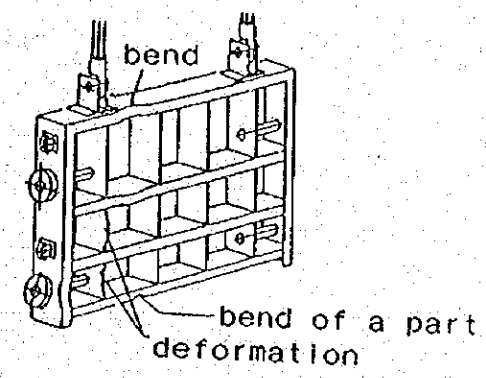
1 Leaf

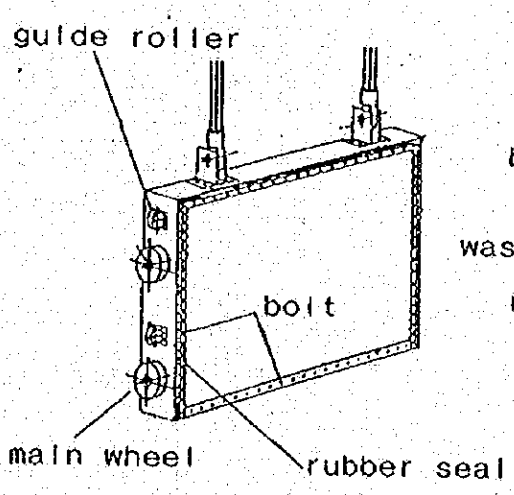
NO.	ITEM	CONTENT	INTERVAL OF CHECK	METHOD	JUDGEMENT OF QUALITY AND STANDARD	METHOD OF MAINTENANCE
1-1	general					
1-1-1		condition of cleaning	once a month	observe	1 It is good, if there is no drift wood, dust, earth and sand etc., on leaf top and inside, roller part and gate groove.	cleaning
					2 It is good, if there is no bad dirt, adhesion of grease etc.	cleaning
					3 It is good, if there is no adhesion of sea living things such as barnacle and oyster etc.	cleaning

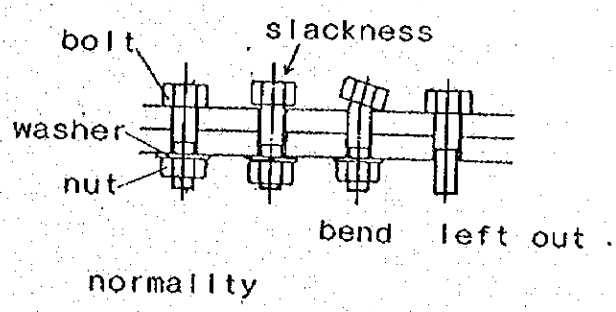




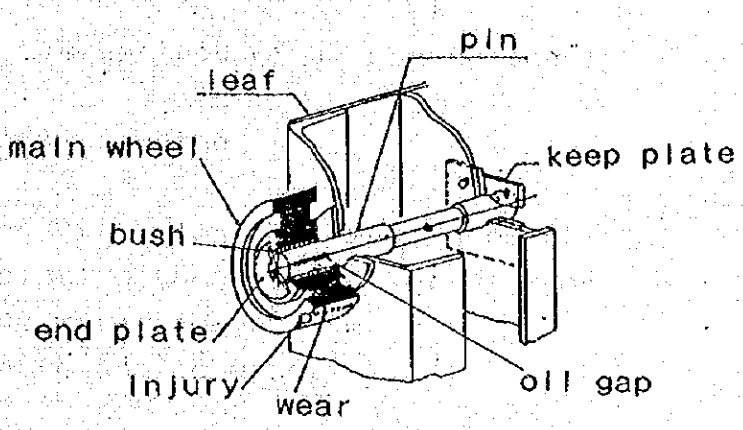
1-2	Whole of structure					
1-2-1		oscillation	every running	observe	It is good, if there is no oscillation running operation.	If out of order, investigation to the cause, when obscure, request for examination by aspecialist. for adjustment.
1-2-2		abnomal a sound	-do-	listen to sound	It is good, if there is no sound.	
1-2-3		inclination	once a month	obeave and neasure by an instrument	It is good, if there is no a hindrance in opening and shuting.	
1-2-4		bend and deformation	once a year	-do-	It is good, if there is no bending and deformation.	If found bending and deformation is found the examination must be done by specialist.
1-2-5	bolt, nut	slackness and left out	-do-	observe	It is good, if there is no slackness, by observation and after lightly hit by test hammer.	If slackness is found increase the tightness by a spanner. If some parts are massing, replace with new spares.







1-12 1-12-1 1-12-2 1-12-3	Main wheel Main wheel Wheel pin bearing	wear, injury	once a sixsh month	observe	It is good, if there is no wear and injury by observation and nothing wrong while operating vising and lowering.	If out of order investigation to the cause, when obscure, request for examination by a specialist.



6-3 The test of coating

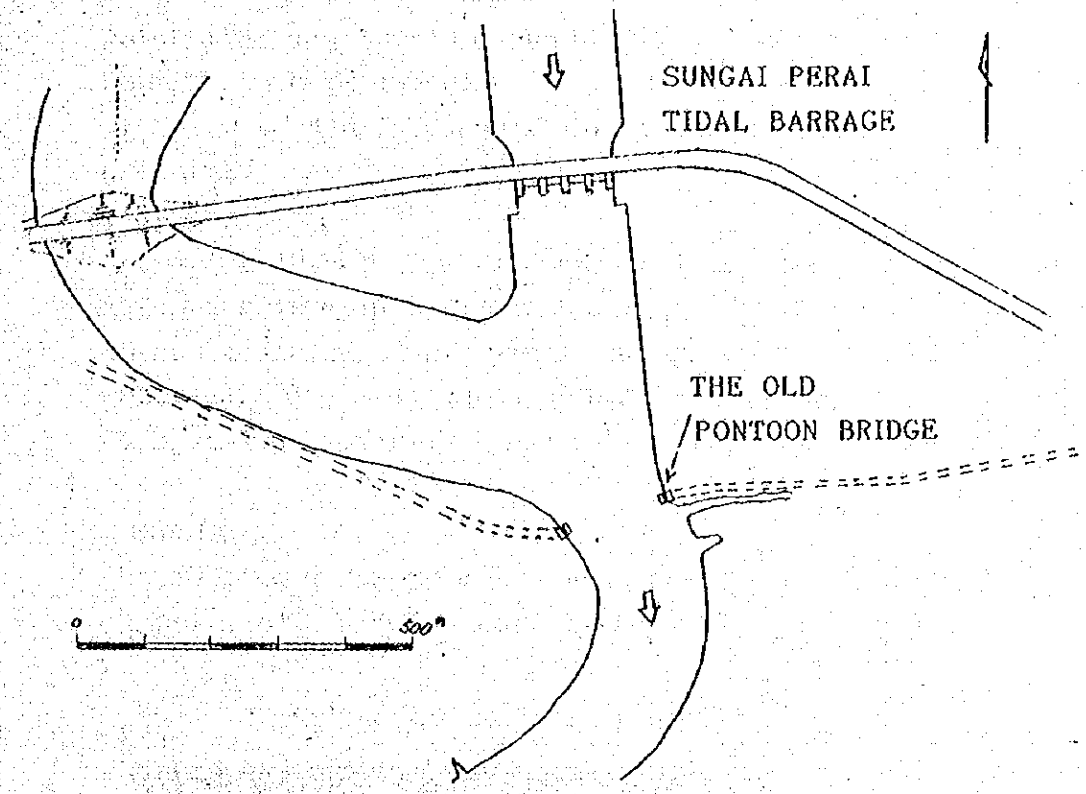
6-3-1 A purpose

A paint coating panel, suitable for tidal gates, was established, for reference coating of new gate.
The purpose is for selection of new gate coating, by one's observations.

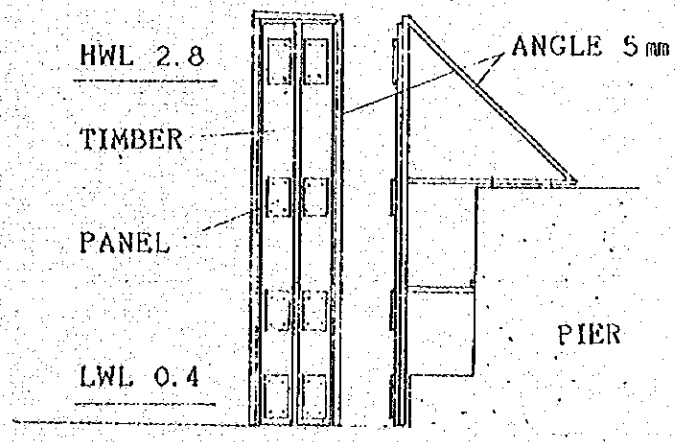
6-3-2 The test method of a coating panel

1 The establish method

(1) Date of establishment 2nd November, 1988.
(2) The location the abutment of old pontoon bridge a perai barrage 500 meter downstream.
(3) Plan of establishment.



PLAN OF LOCATION OF DECKING FOR TEST PANELS



THE DECKING FOR PANELS

2 Method for coating panel(film) degradation

Based on extensive weathering result, evaluation on film resitibility of coating on exterior steel structure is highly reliable. Previously, judgement on paint film degradation was highly subjective leading to flunctuation of results.

In view of this, "Standard On Film Degradation" is prepared.

① Gloss

Portable Glossmeter is used to check on test panel at 60°. Normality, an average readingof 2 to 3 different points obtained. Test panel should be cleaned with water and dry soft clots prior to checkng.

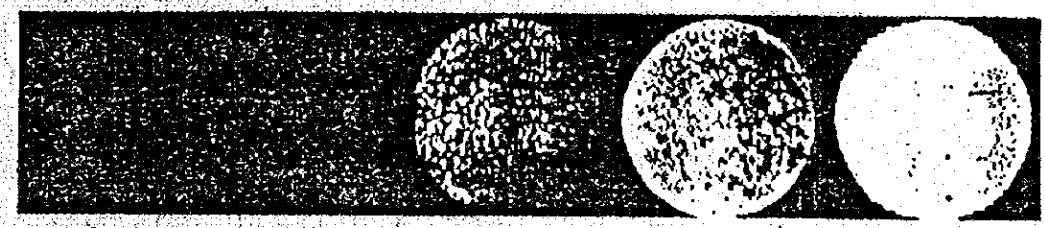
Glossmeter reading.

② Chalking

Using finger to glide through the paint film and compare with the Standard Photos below.

Standard comparison diagram

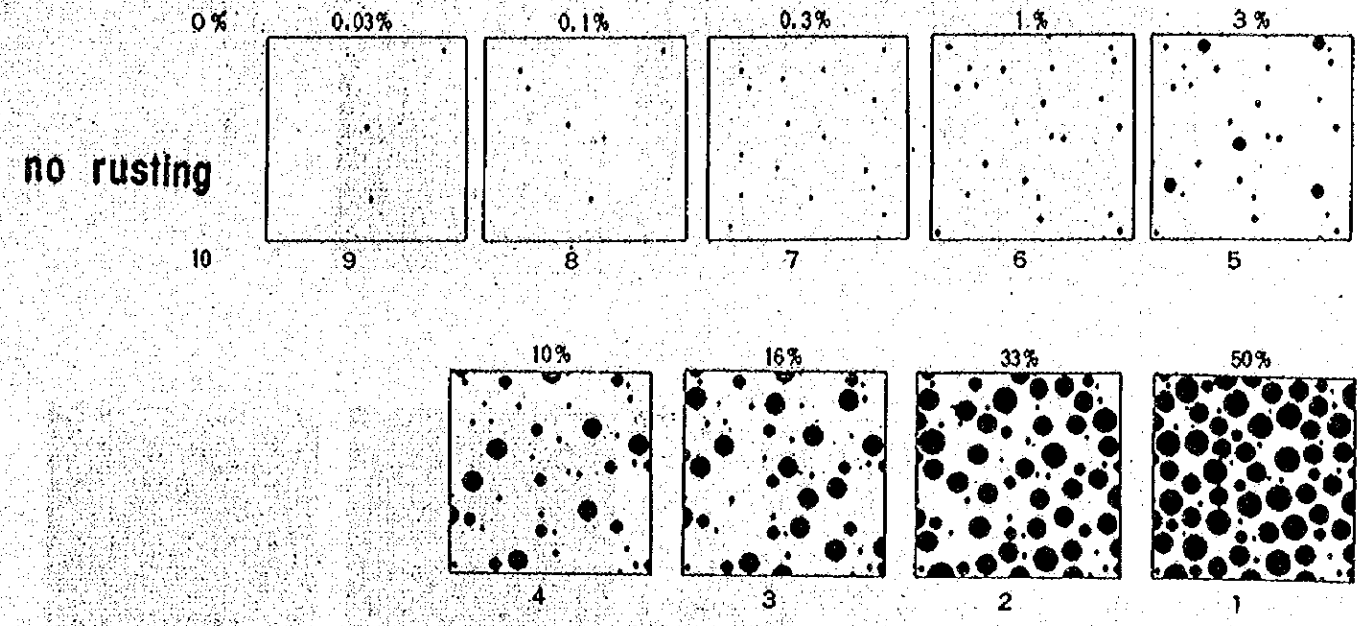
No Chalking



Points 8 6 4 2 0

③ Rusting

The following Standard is the same as ASTM D610-68.



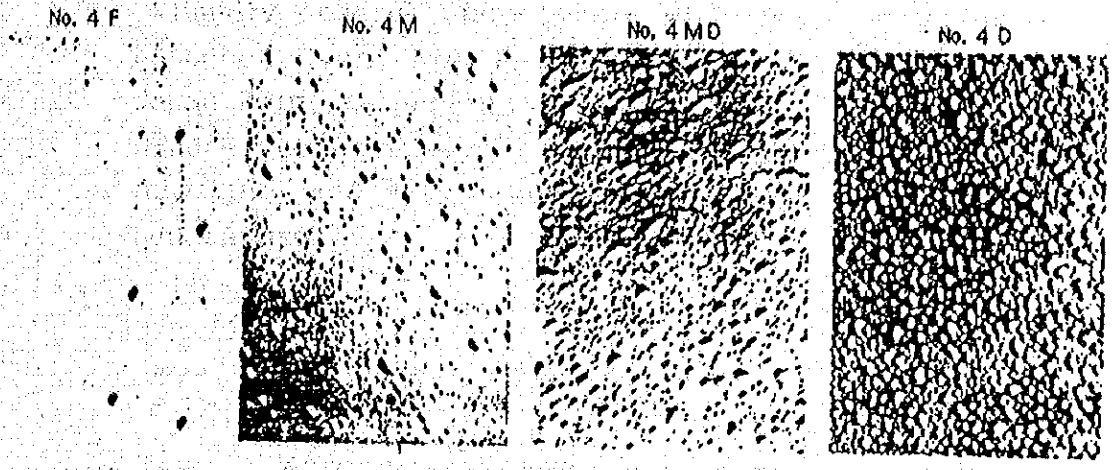
④ Blistering

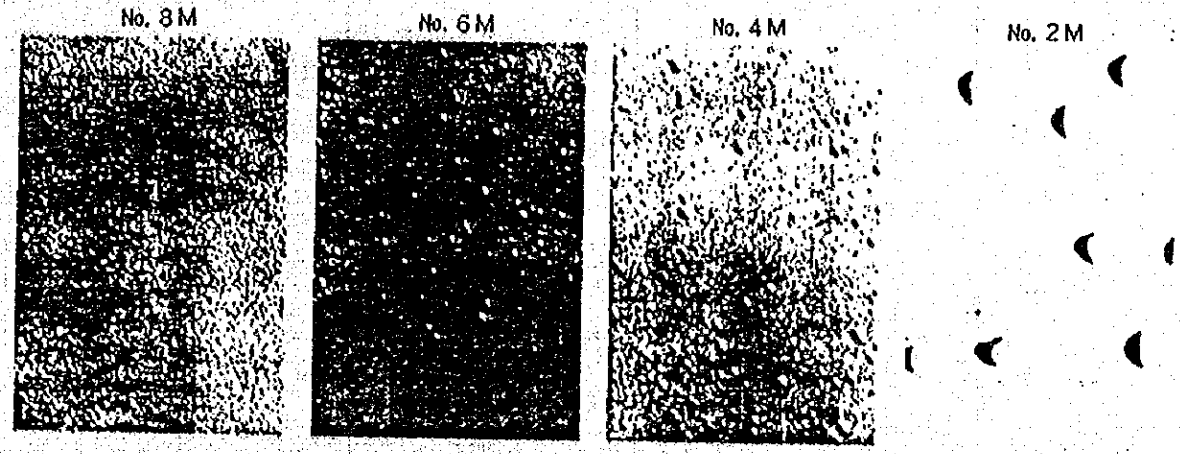
The following follows ASTM D147-56.

Blistering Size

intensity \ size	8	6	4	2
F	8	6	4	2
M	6	4	3	2
MD	4	3	2	1
D	2	2	1	0

Blistering Intensity



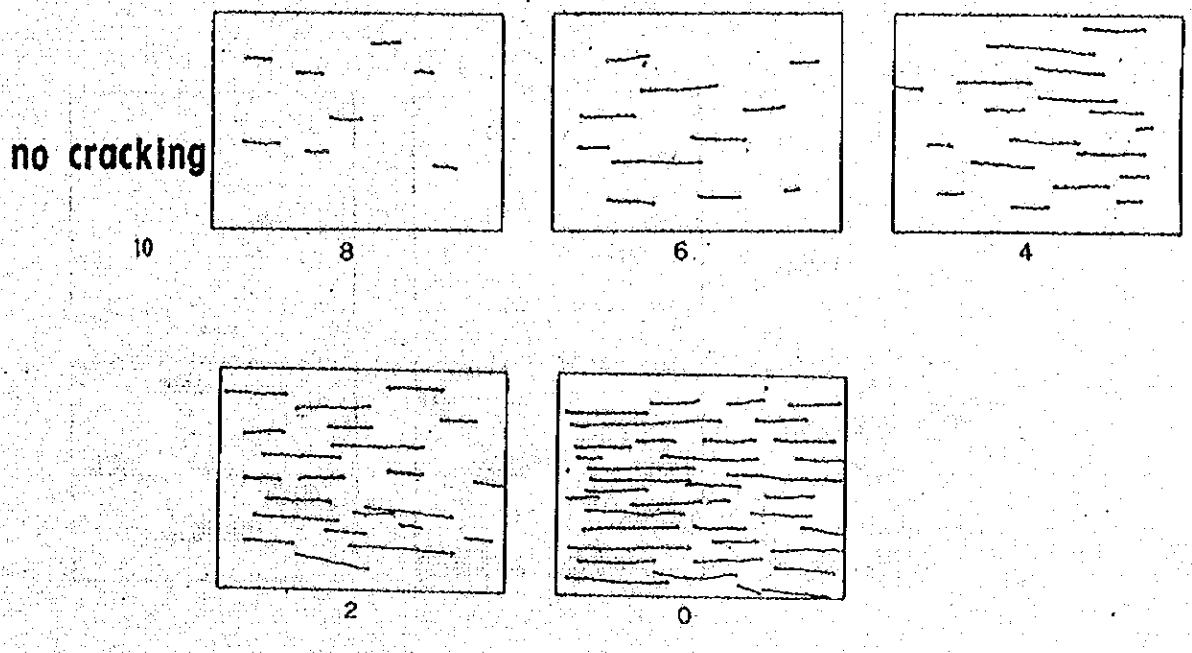


⑥ Cracking

Visually observe and compare with "Diagram" which was based on "Paint Film Evaluation Standard"(1970) from Japan Paint Inspection Association.

There are 2 types of cracking namely surface cracking (chalking) and deep cracking where primer or substrate can be seen.

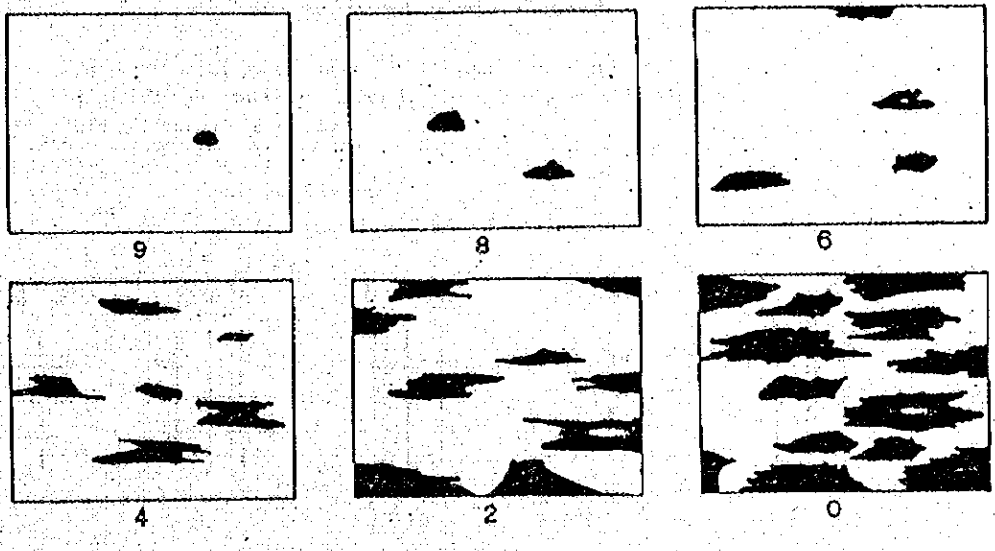
Standard comparison diagram



⑥ Peeling

Visually observe and compare with"Standard Comparison Diagram" which was based on "Paint Film Evaluation Standard"(1970) from Japan Paint Inspection Association.

Peeling Area %	0	0.5>	0.6~2	3~5	6~10	11~30	31<
Grade	10	9	8	6	4	2	0

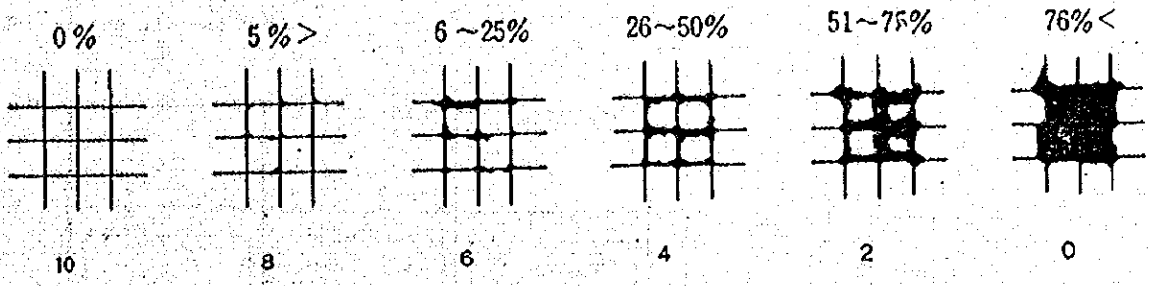


⑦ Adhesion

Coated surface should be cleaned from powdery contaminants prior to checking. A sharp cutter should be used to cut through the paint film to the bare metal substrate with a line width interval of 2 millimeter. A cellophane tape should be pull upward with a sudden jerk.

Thickness	Size Of Sq.	No. Of Sq.
60μ >	2 m/m	25
60~120μ	3 m/m	9
120μ <	5 m/m	4

For weathering period exceeding 1 year, the thickness indicated in the table is no longer applicable and the line width interval is at 5mm.



EVALUATION OF TESTING PANELS AT SITE

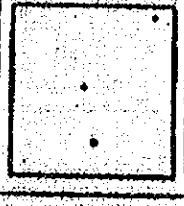
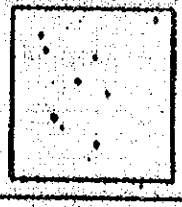
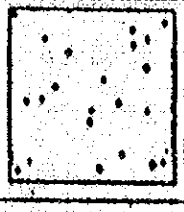
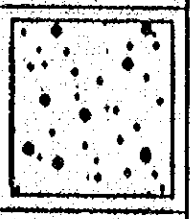
DATE OF INSPECTION : _____

NAME OF INSPECTOR(S): _____

_____

RESULT TO BE EXPRESSED AS POINTS

RUSTING

POINTS	3	2	1	0
RANGE (%)	0 - 0.03	0.03~ 0.3	0.3~ 5	5 <
DEGREE OF RUSTING				
%	0.03	0.3	1.0	10

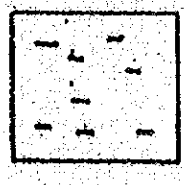
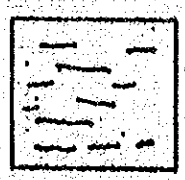
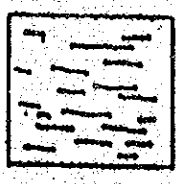
PANEL DESIGNATION							
A		B		C		D	
1	2	1	2	1	2	1	2

BLISTERING

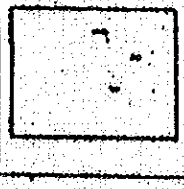
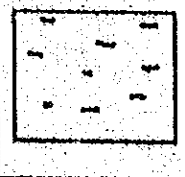
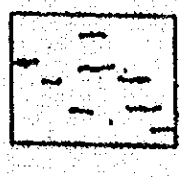
POINTS	3	2	1	0
RANGE (%)	0 - 0.03	0.03 ~ 0.3	0.3 ~ 5	5 <

The range percentage is the same as above.

CRACKING

POINTS	3	2	1	0
DEGREE OF CHALKING	NO CRACKING			

PEELING

POINTS	3	2	1	0
RANGE (%)	0	0.5	0.5 ~ 2	2 <
DEGREE OF PEELING	NO PEELING			

CHALKING

POINTS	3	2	1	0
DEGREE	NO CHALKING	SLIGHTLY CHALKING	CLOSE TO ORIGINAL COLOR & CHALKING	CHANGE OF COLOR & SEVERE CHALKING

COLOUR FADING

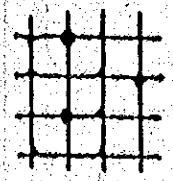
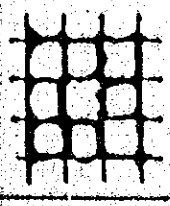
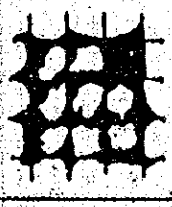
POINTS	3	2	1	0
DEGREE	NO FADING	SLIGHTLY FADING	FADING	SEVERE FADING

PANEL DESIGNATION							
A		B		C		D	
1	2	1	2	1	2	1	2

BARNACLE GROWTH

POINTS	3	2	1	0
DEGREE	NIL	SLIGHTLY	MODERATE	VERY SEVERE

ADHESION

POINTS	3	2	1	0
SQUARE CUT				More than 50% detach

REPAINTING SCHEDULE

The following table serves as guideline for judging should there be any repainting works carry out, and if so, what is the extend of the repair painting.

TABLE 1

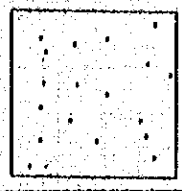
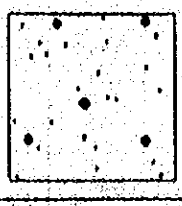
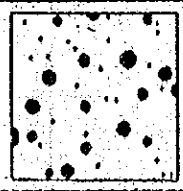
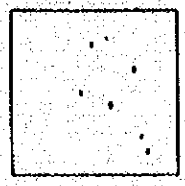
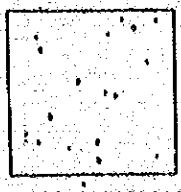
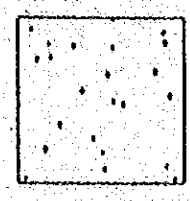
	TYPE OF REPAIR		FILM CONDITION (RUSTING INTENSITY)	SURFACE PREPARATION	REPAIR METHOD (AREA)
EXTERIOR	A	SPOT REPAIR	 (0.3%)	Defective : Grade 2 OR Grade 3	Repair painting : 3 - 4 coats on defective area only.
	B	FULL REPAIR - 1	Color Fading (Slight Film Defect)	Whole area : Grade 4	Full painting : 2 coats.
	C	FULL REPAIR - 2	 (3%)	Defective : Grade 2 OR Grade 3 Non-defective : Grade 4	Repair painting : 1 - 2 coats. Full painting : 3 - 4 coats.
	D	FULL REPAIR - 3	 (10%) Adhesion No Good	Whole area : Grade 1 OR Grade 2	Follow original painting system. Full painting : 4 - 5 coats.
INTERIOR (IMMERSION)	E	SPOT REPAIR - 1	 (0.1%)	Defective : Grade 2	Repair painting (1 coat), follow original thickness on defective area only.
	F	SPOT REPAIR - 2	 (0.5%)	Defective : Grade 1	
	G	FULL REPAIR	 (1.0%)	Whole area : Grade 1	Follow original painting system.

TABLE 2

SUBSTRATE CONDITION (BEFORE PAINTING)

GRADE	FILM CONDITON	SUBSTRATE CONDITION (AFTER CLEANING)	METHOD
1	SEVERE RUSTING	Remove all rust and loose paint film. Clean to original metal surface.	Blsating.
2	FILM DEGRADATION AND MODERATE RUSTING	Remove rust and loose paint film until bare surface.	Power tool cleaning and wire brushing.
3	SPOT RUSTING AND PAINT FILM STILL INTACT	Remove rust and loose paint film until bare surface.	Power tool cleaning and wire brushing.
4	CHALKY PAINT FILM AND DISCOLORATION	Remove dust and powdery paint film.	Wire-brushing or sanding.

6-3-3 Held a seminar

A seminar was held to painting for genaral and the test of coating.

The programe of a seminar are as follow:

1 Programe

(1) Introduction to paint technology
(2) Painting specification
(3) Product information
(4) Evaluation standard for film degradation
(5) Evaluation on testing panels at site
(6) Repainting schedule
(7) Question time/Free discussion
(8) Fixing of testing panels at site

2 Date 2nd November, 1988

3 A place I.A.D.P conference room.

4 A participants DID state and DID project stuff about 25 men.

6-3-4 Painting specification of test panel

PAINTING SPECIFICATION OF TEST PANEL

(A) EXPOSURE ZONE AND
(B) SPLASH ZONE

SURFACE PREPARATION = SA 2 1/2

↓

1st COAT — NIPPON INORGANIC ZINC COATING
Dry Film Thickness = 75 μ

↓ 5 days

* MIST COAT — COPON MASTIC RED LEAD PRIMER
Dry Film Thickness = 10 μ

↓ wet-on-wet

2nd COAT — COPON MASTIC RED LEAD PRIMER
Dry Film Thickness = 60 μ

↓ 16 hours [minimum]

3rd COAT — COPON MASTIC RED LEAD PRIMER
Dry Film Thickness = 60 μ

↓ 16 hours [minimum]

4th COAT — NIPPON POLYURETHANE FINISH
Dry Film Thickness = 25 μ

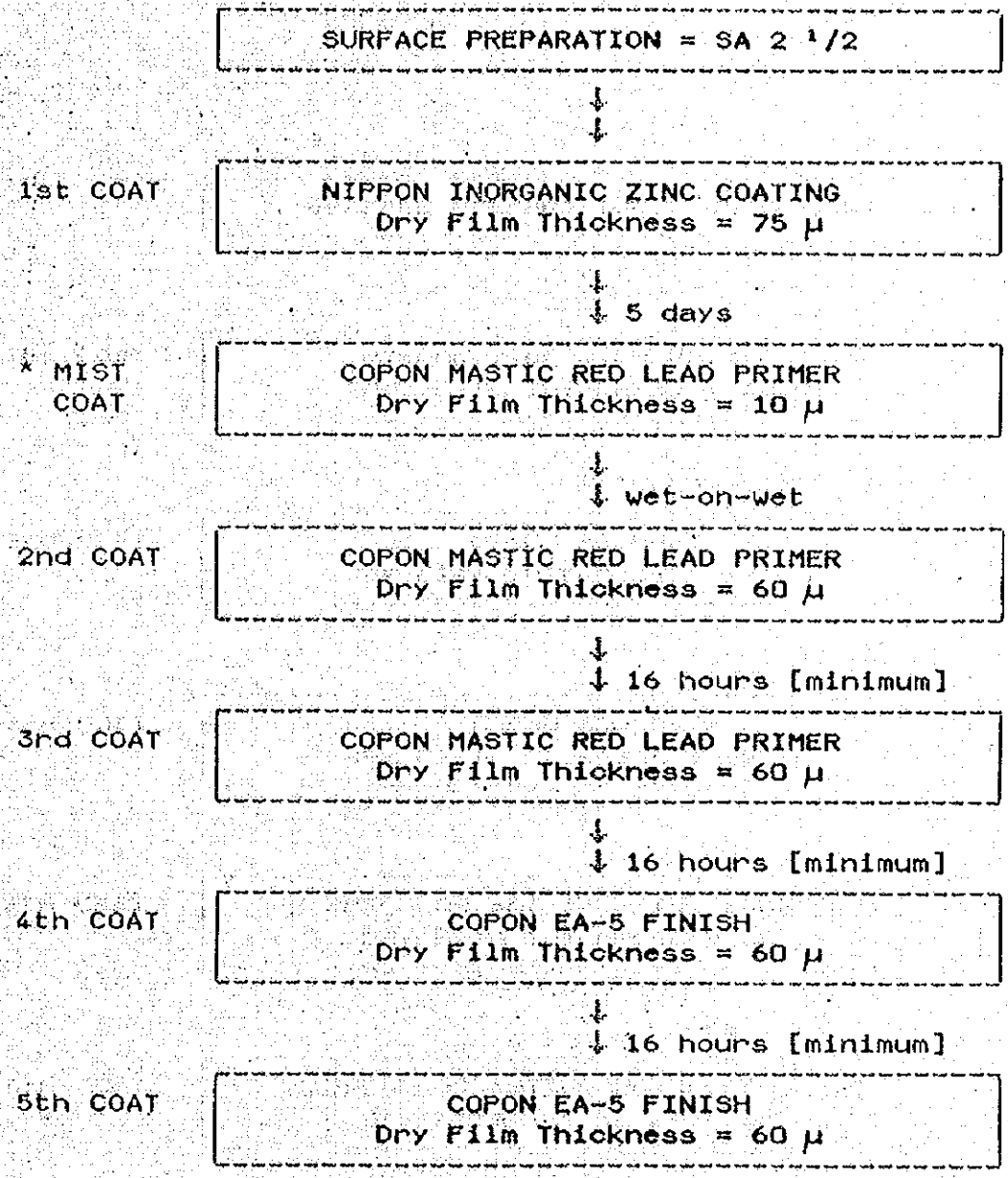
↓ 2 hours [minimum]

5th COAT — NIPPON POLYURETHANE FINISH
Dry Film Thickness = 25 μ

TOTAL DRY FILM THICKNESS = 255 microns [minimum]

* REMARK : 100% dilution with SA-18 Thinner is recommended.
(cf. Table 6-5)

(C) TIDAL ZONE

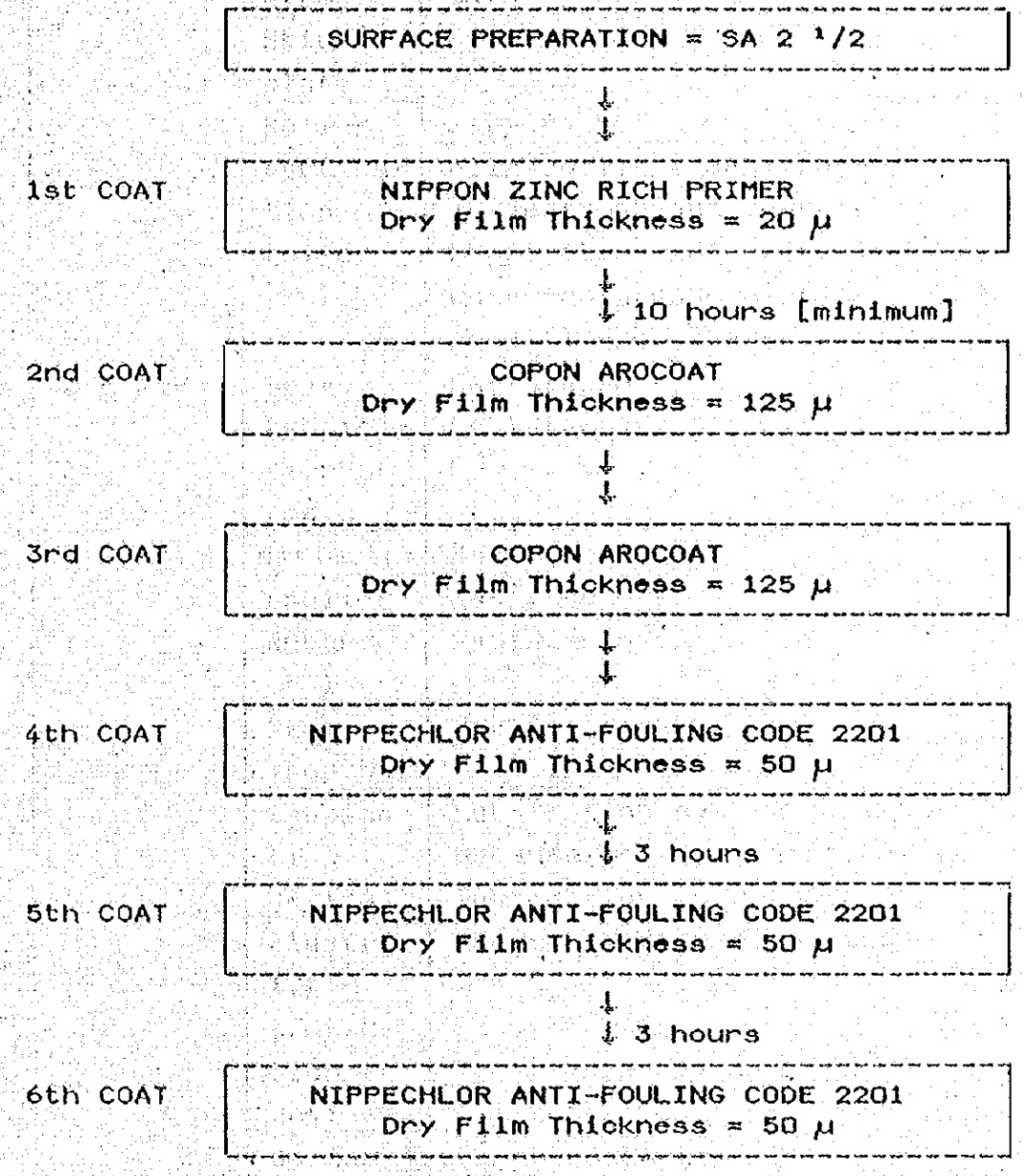


TOTAL DRY FILM THICKNESS = 325 microns [minimum]

* REMARK : 100% dilution with SA-18 Thinner is recommended.

(cf. Table 6-5)

(D) UNDER WATER ZONE



TOTAL DRY FILM THICKNESS = 420 microns [minimum]

(cf. Table 6-5)

Table 6-1 GATE NO 1 CHECK TABLE

PART NAME		COMENT
L E A F	Top leaf girder	Satisfactory.
	Bottom leaf girder	Satisfactory, corrosion is taking plase on part of the web plate of main girder.
	Skin plate	Satisfactory.
	Roller	Satisfactory.
	Lubrication of roller	main roller : Satisfactory. guide, front and lower part roller: Lubrication not properly done. Only one grease nipple in good condition on the main roller.
	Seave	Satisfactory.
	Lubrication of seave	Satisfactory.
	Deflector	Satisfactory.
	Spoiler	Satisfactory.
	Rubber seal	Satisfactory.
	Seal clamp bar	Satisfactory.
	Lubrication device	Lubrication system not satisfactory, because there is difficalty in lubrication to certain part.
	Electrolytic protection device	Anode bar reduce in size.
	Bottom leaf fixing device	no movement.

PART NAME	C O M E N T
GATE GUIDE	Minor corrosion is seen (identifield) taking place on top part of the guide.
HYDRAULIC GATE HOIST	Satisfactory.
PLATE THICKNESS	Satisfactory. (cf. Table 6-3)
COATING	Fairly satisfactory, minor corrosion is identified taking place at bottom leaf. (cf. Table 6-4, Fig. 6, 7)
WIRE ROPE (MAIN)	Satisfactory.
MOVEMENT	The movement of the gate will be fairly satisfactory during operation when both the top and bottom leaf are fixed by the leaf fixing device. But when the gates operates seperately the possibility of inclination of the gate during operation will be very high.

Table 6-2 GATE NO 2, 3, 4 CHECK TABLE

PART NAME		COMENT
LEAF	Top leaf girder	The plate thickness is badly damaged, corrosion causes the reduction in the plate over the whole gate.
	Bottom leaf girder	Similar to the above leaf but the corrosion is worst than the top leaf.
	Skin plate	Corrosion causes reduction in thickness over the whole skin plate.
	Roller	Reduction is size due to corrosion.
	Lubrication of roller	Lubrication for the rollers are difficult as there are no grease nipple attached to any of the rollers.
	Seave	Fairly satisfactory, but no movement.
	Deflecter	A part of the deflector is damaged.
	Spoiler	Corrosion is seen taking place.
	Ruber seal	Most of the ruber seal is damaged.
	Seal clamp bar	Most of the seal clamp bar is damaged.
	Electrolytic protection device.	There is reduction in the anode size.
	Bottom leaf fixiing device	This part is badly damaged.
	Bolt, Nut	All the bolt and nuts are corroded.
GATE GUIDE	Corrosion is taking place in the upper part.	
GATE HOIST	Satisfactory good.	
PLATE THICKNESS	There is reduction in plate thickness. (cf. Table 6-3)	
COATING	Corrosion is taking place over all the surface.	
WIRE ROPE MOVEMENT	Satisfactory good. No movement.	

Table 6-3 PLATE THICKNESS CHECK TABLE

GATE NO	POSITION	DESIGN VALUE ①"	MEASURED VALUE ②"	①-② ③"	③/① %	COMMENT
NO 1	No Check for good condition					
NO 2	①	0.375	0.320	0.055	17.19	no
	②	0.375	0.330	0.045	12.00	no
	③	0.375	0.370	0.005	1.33	good
	④	0.375	0.360	0.015	4.00	good
	⑤	0.375	0.370	0.005	1.33	good
	⑥	0.375	0.370	0.005	1.33	good
	⑦	0.375	0.270	0.105	28.00	no
	⑧	0.375	0.360	0.015	4.00	good
	⑨	0.375	0.350	0.025	6.66	good
	⑩	0.375	0.375	0.000	0.00	good
	⑪	0.375	0.240	0.135	36.00	no
	⑫	0.375	0.330	0.045	12.00	no
	⑬	0.375	0.280	0.095	25.33	no
	⑭	0.375	0.245	0.130	34.66	no
	⑮	0.375	0.335	0.040	10.66	no
	⑯	0.375	0.250	0.125	33.33	no
NO 3	①	0.375	0.325	0.050	13.33	no
	②	0.375	0.290	0.085	22.66	no
	③	0.375	0.210	0.165	44.00	no
	④	0.375	0.315	0.060	16.00	no
	⑤	0.375	0.230	0.145	38.66	no
	⑥	0.375	0.350	0.025	6.66	good
	⑦	0.375	0.240	0.135	36.00	no
	⑧	0.375	0.360	0.015	4.00	good
	⑨	0.375	0.270	0.105	28.00	no
	⑩	0.375	0.250	0.125	33.00	no
	⑪	0.375	0.280	0.095	25.33	no

GATE NO	POSI TION	DESIGN VALUE ①"	MEASURED VALUE ②"	①- ② ③"	③/ ① %	COMMENT
NO 4	①	0.375	0.320	0.055	14.66	no
	②	0.375	0.280	0.095	25.33	no
	③	0.375	0.365	0.010	2.66	good
	④	0.375	0.355	0.020	5.33	good
	⑤	0.375	0.340	0.035	9.33	good
	⑥	0.375	0.025	0.350	93.33	no
	⑦	0.375	0.310	0.065	17.33	no
	⑧	0.375	0.190	0.185	49.33	no
	⑨	0.375	0.235	0.100	26.66	no

(cf. Fig. 6-3 · 4 · 5 · 6)

Note: With reference to Japan, as for member of a Gate either to be submerged or to be worn, more than the values in skin plate 3 millimeter, Other main members 2 millimeter, must be added to the calculated plate thicknesses.

In case,

Steel Thickness=0.375" =9.525 ㎜

Keep for corrosion allowance 1 ㎜,

Reduction Factor=1.000/9.525=0.105

Accordingly, It seem no problem to more than the 10 percent.

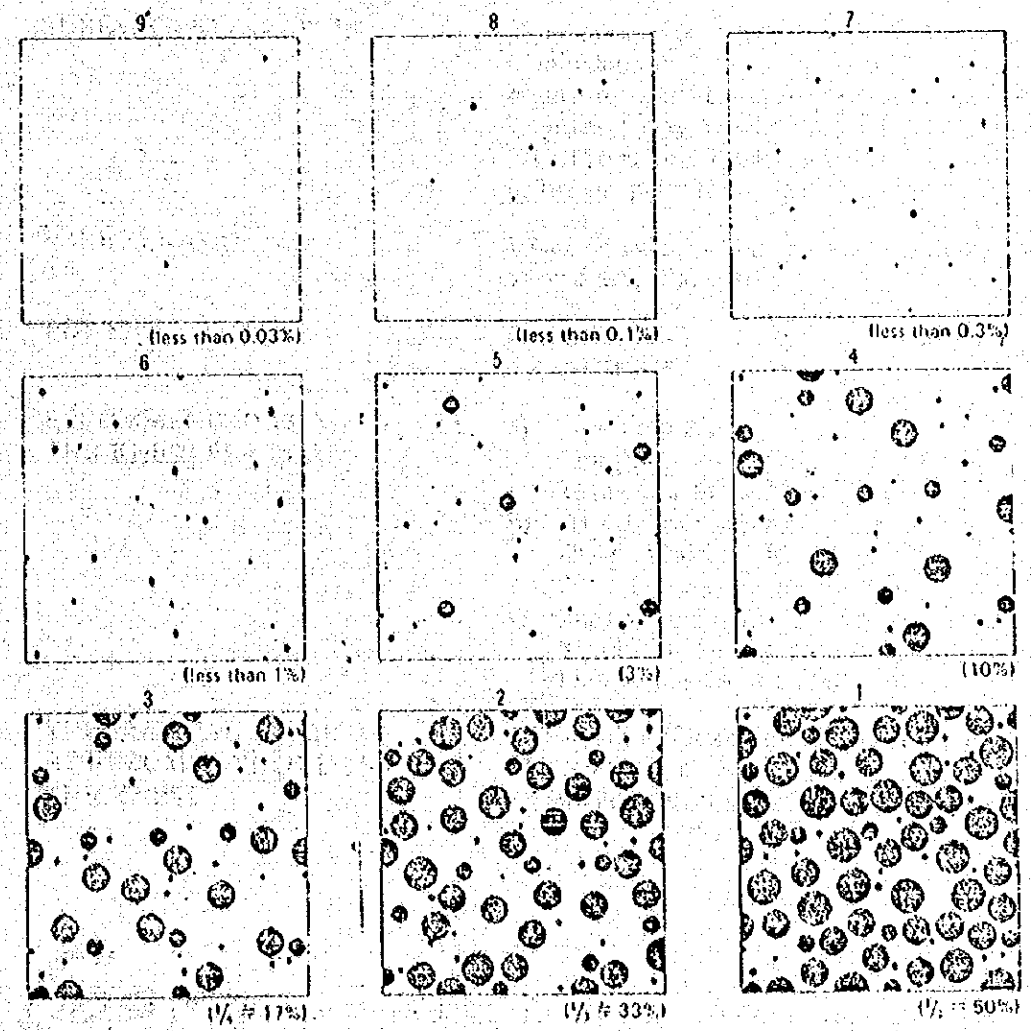
Table 6-4 Condition of Coating

The European Scale of Rusting for Anti corrosive Paints, sspc Vis 2 and ASTM, are shown below:
They are widely used to rate rust conditions.

Environmental Condition	Film Conditions (area of rust)	Recommended Surface Preparations	Modes of Repainting
Outdoor General Surface	SSPC-Vis 2, Rating 9 (0.03%)	Partial Hand Tool Cleaning	Partial Touching up
	SSPC-Vis 2, Rating 7 (0.3%)	Power or Hand Tool Cleaning	Partial Repainting (less than 30%)
	SSPC-Vis 2, Rating 5 (3%)	Blast or Power Tool Cleaning	All Over Coating
	Contamination or Fading of the Film	Fresh Water or Solvent Cleaning	All Over Coating
In Water or Chemical Solution	SSPC-Vis, 2 Rating 9 (0.03%)	Partial Power Tool Cleaning	Partial Touching up
	SSPC-Vis 2, Rating 7 (0.3%)	Partial Power Tool Cleaning	Partial Repainting (less than 30%)
	SSPC-Vis 2, Rating 5 (3%)	Blast Cleaning	All Over Coating

Note 1: *Please refer to SSPC-Vis 2 for the film condition.*
Note 2: *Details of the surface preparation are shown in Table 4.*

Conditions of Paint Film and Surface Preparations Recommended for Repainting



Rating of Painted Steel Surfaces as a Function of Area Percent Rusted
(ASTM - D610/SSPC Vis 2)

Table 6-5 Physical characteristics of paint

NIPPON INORGANIC ZINC COATING

Cat Logam Zinc Inorganik

Nippon Inorganic Zinc Coating is a two-pack coating based on ethyl silicate and zinc dust. It is suitable for use on steel as a shop primer, as a primer for high performance systems and as a single treatment coating for a variety of marine environment. It prevents corrosion and provides excellent resistance to weathering, abrasion, impact, heat and many solvents.

PHYSICAL CHARACTERISTICS OF PAINT

COLOUR	:	Grey
TEXTURE	:	Matt
SPECIFIC GRAVITY	:	2.76 ± 0.05 (for mixture of binder and zinc dust)
SOLID CONTENT	:	56% by volume (for mixture of binder and zinc dust)

RECOMMENDATION FOR USE

SURFACE PREPARATION	:	The steel surface to be painted should be abrasive blasted to minimum Sa 2½, but preferably to Sa 3. If rust bloom begins to form before the steel surface is coated, it will be necessary to reblast the steel. The surface must be dry and free from abrasive residues and other contaminants before the paint is applied.
MIXING RATIO	:	1 part by weight of binder (Pack A) to 3 parts by weight of zinc dust (Pack B)
POT LIFE	:	6 hours at 25°C 4 hours at 30°C
RECOMMENDED FILM THICKNESS PER COAT	:	a) As a shop primer: 15 microns for dry film 27 microns for wet film b) As a general purpose primer: 40 — 75 microns for dry film 75 — 135 microns for wet film c) For use uncoated: 75 microns for dry film 135 microns for wet film
THEORATICAL COVERAGE AT RECOMMENDED FILM THICKNESS	:	37.3 m²/litre (for dry film thickness of 15 microns) 14.0 m²/litre (for dry film thickness of 40 microns) 7.5 m²/litre (for dry film thickness of 75 microns)

COVERAGE WITH A LOSS FACTOR OF 20%	:	29.9 m²/litre (for dry film thickness of 15 microns) 11.2 m²/litre (for dry film thickness of 40 microns) 6.0 m²/litre (for dry film thickness of 75 microns)
NO. OF COATS RECOMMENDED	:	1 — 2 coats
APPLICATION METHODS AND EQUIPMENT	:	Preferably compressed air spray. The preferred equipment is compressed air spray system with agitated pressure pot and air pressure regulators. For touching up small areas brush can be used.
THINNER	:	ZS 100 Thinner
THINNING	:	About 10 — 20% thinner by volume for compressed air spray.
DRYING TIME	:	Dry to touch : 5 minutes at 25°C 3 minutes at 30°C Dry to handle : 3 hours at 25°C 2 hours at 30°C
CURING TIME	:	6 days at 25°C 5 days at 30°C
OVERCOATING TIME	:	Self-recoating — 3 hours at 25°C — 30°C Overcoating with organic coating — 5 days at 25°C — 30°C
ENVIRONMENTAL CONDITIONS DURING APPLICATION	:	During application of the paint, naked flames, welding operations and smoking should not be allowed and adequate ventilation should be provided.
CLEANING SOLVENT	:	ZS 100 Thinner
STANDARD PACKING	:	5 litres. The paint is supplied in two packs, Pack A (binder) and Pack B (zinc dust).

The above information is given to the best of our knowledge based on laboratory tests and practical experience. However, since we cannot anticipate or control the many conditions under which our products may be used, we do not guarantee the accuracy of our information or the suitability of our products in any given condition.

We reserve the right to alter the given data without notice.

protective coatings

COPON MASTIC RED LEAD PRIMER

Cat Asas Mastik Logam Plumbum Merah

Copon Mastic Red Lead Primer is a two-pack, high-build amine-adduct cured epoxy primer, pigmented with red lead pigment. It is an excellent primer for blast cleaned steel work and is highly recommended for use in combination with Copon EA-4 Finish in severe corrosive environment.

PHYSICAL CHARACTERISTICS OF PAINT

COLOUR	:	Reddish Brown
TEXTURE	:	Low Gloss
SPECIFIC GRAVITY	:	1.60 (for mixture of Base and Hardener)
SOLID CONTENT	:	63.0% by volume (for mixture of Base and Hardener)

RECOMMENDATION FOR USE

SURFACE PREPARATION	:	Abrasive blasting to minimum Sa 2½. It is important that the standard should be maintained until the paint is applied. If the steel changes colour or rust bloom begins to form, it will be necessary to reblast the steel. The surface must be dry and free from abrasive residues and other contaminants before the paint is applied on.
MIXING RATIO	:	4 parts by volume of Base to 1 part by volume of Hardener. Base and Hardener to be mixed thoroughly and stirred continuously for 15–20 minutes prior to application.
POT LIFE	:	6-7 hours after mixing at 25°C–30°C.
RECOMMENDED FILM THICKNESS PER COAT	:	60–80 microns for dry film 95–125 microns for wet film
THEORETICAL COVERAGE AT RECOMMENDED FILM THICKNESS	:	10.7 m²/litre (for dry film thickness of 60 microns) 8.0 m²/litre (for dry film thickness of 80 microns)
COVERAGE WITH A LOSS FACTOR OF 20%	:	8.5 m²/litre (for dry film thickness of 60 microns) 6.4 m²/litre (for dry film thickness of 80 microns) (These values are calculated based on the above theoretical coverage and a loss factor of 20%. The actual loss factor for a particular job may vary depending on the application condition, method and technique; surface condition; as well as the structure and dimension of the object to be coated.)
NO. OF COATS RECOMMENDED	:	1 coat

APPLICATION METHODS	:	Brush, roller, compressed air spray and airless spray. Preferably use airless spray if a thicker coat is required in one application. Brush, roller and compressed air spray generally lead to lower film thickness, so more applications may be required to obtain the recommended thickness per coat.
GUIDING DATA FOR AIRLESS SPRAY	:	Delivery Pressure : 140–170 kg/cm² Tip Size : 0.015"–0.017" Spray Angle : 60°–70°
THINNER	:	SA-18 Thinner
THINNING	:	Normally no thinning is required if application is by airless spray. Where thinning is necessary for workability use about 5% thinner by volume for application by brush, roller and airless spray; and 10–15% thinner by volume for compressed air spray.
DRYING TIME AT 25°C–30°C	:	Dry to touch : 1–1½ hours Dry to overcoat : Minimum 16 hours Dry to handle : 16 hours
CURING TIME AT 25°C–30°C	:	Paint film thickness of 1 x 80 microns when dry, takes 6-7 days to attain full cure. For thicker film, the curing time will be longer. In all cases, higher temperature will shorten and lower temperature will lengthen the curing time. Exposure of the coating to water, chemicals and abrasion should be avoided as far as possible before full cure of the coating.
ENVIRONMENTAL CONDITIONS DURING APPLICATION	:	1) The relative humidity during application should not exceed 85%. 2) During application of the paint, naked flames, welding operations and smoking should not be allowed and adequate ventilation should be provided.
CLEANING SOLVENT	:	SA-18 Thinner. All equipment should be cleaned out with the thinner immediately after use.
STANDARD PACKING	:	4 litres of Base and 1 litre of Hardener.

NOTE

Overcoating the previous coat of Copon Mastic Red Lead Primer should be done with 6-7 days but preferably as soon as possible after it has been allowed 16 hours' drying. This is to ensure proper inter-coat adhesion.

If the previous coat of Copon Mastic Red Lead Primer has been left exposed for more than 6-7 days it is desirable to roughen it by dry sanding with sand-paper before it is overcoated.

The above information is given to the best of our knowledge based on laboratory tests and practical experience. However, since we cannot anticipate or control the many conditions under which our products may be used, we do not guarantee the accuracy of our information or the suitability of our products in any given condition.

We reserve the right to alter the given data without notice.

protective coatings

NIPPON POLYURETHANE FINISH

Cat Kemasan Poliretana

Nippon Polyurethane Finish is a two-pack polyurethane based coating. It is a high duty finish particularly for maximum gloss and colour retention. It is highly resistant to solvents, acids, alkalis, oil, salt water and abrasion.

PHYSICAL CHARACTERISTICS OF PAINT

COLOUR	:	Solid and Metallic (Please Refer to Colour Card)
TEXTURE	:	High Gloss
SPECIFIC GRAVITY	:	0.95 — 1.15 (Depending on Colours)

RECOMMENDATION FOR USE

SURFACE PREPARATION	:	For steel surface, it must first be primed with Copon EA-9 Red Oxide Primer before overcoating with Nippon Polyurethane. For concrete surface primer is not necessary. It is important that the surface must be clean and dry before application of the paint.
MIXING RATIO	:	For white and light colours, it is 8 parts of Base to 1 part of Hardener by weight; for deep colours, it is 5 parts of Base to 1 part of Hardener by weight. Base and Hardener to be mixed thoroughly and stirred continuously for 15—20 minutes prior to application.
POT LIFE	:	5 hours after mixing at 25°C.
PRACTICAL COVERAGE	:	Approximately 5.5 — 6.5 m^2/litre (This is just an average based on application by spraying and for dry film of 30 microns thick).
RECOMMENDED NO. OF COATS	:	2 coats (In case of concrete surface an extra coat of dilute Nippon Polyurethane (100% thinning) is recommended as a sealer).
APPLICATION METHODS	:	Preferably compressed air spray. For touch-up, brush application is acceptable.
THINNER	:	Nippon Polyurethane Thinner
THINNING	:	Thinner addition by volume is 60—100% for compressed air spraying and up to 10% for brushing.

RECOMMENDED DRY FILM THICKNESS PER COAT	:	30 — 35 μ
DRYING TIME AT 25°C — 30°C	:	Dry to Touch — Approximately 1 hour Dry to Overcoat — Minimum 2 hours Dry to Handle — 16 hours
CURING TIME AT 25°C — 30°C	:	Fully cured after 5 — 6 days
CLEANING SOLVENT	:	Nippon Polyurethane Thinner
STANDARD PACKING	:	20 kg (Base and Hardener)

NOTE

Overcoating the previous coat of Nippon Polyurethane should be done within 5 days but preferably as soon as possible after it has been allowed 16 hours drying. This is to ensure proper intercoat adhesion.

The above information is given to the best of our knowledge based on laboratory tests and practical experience. However, since we cannot anticipate or control the many conditions under which our products may be used, we do not guarantee the accuracy of our information or the suitability of our products in any given conditions.

We reserve the right to alter the given data without notice.

protective coatings

COPON EA-5 FINISH

Cat Kemasan EA-5

Copon EA-5 Finish is a two-pack, amine-adduct cured high-build epoxy coating. It can be easily applied up to 150 microns in one coat. It is specially formulated for internal lining of tanks holding petroleum products.

PHYSICAL CHARACTERISTICS OF PAINT

COLOUR	:	White or Light Grey
TEXTURE	:	Semi-Gloss
SPECIFIC GRAVITY	:	1.24 (for mixture of Base and Hardener)
SOLID CONTENT	:	38% (for mixture of Base and Hardener)

RECOMMENDATION FOR USE

SURFACE PREPARATION	:	Surface to be coated must first be primed with 1 coat of Copon EA-9 Red Oxide Primer. The primer must be clean and dry before overcoated with Copon EA-5 Finish. If the primer is damaged, it must be touched-up according to the specification before application of Copon EA-5 Finish.
MIXING RATIO	:	5 parts by volume of Base to 1 part by volume of Hardener. Base and Hardener to be mixed thoroughly and aged for 20 minutes before application.
POT-LIFE	:	6 — 8 hours after mixing at 25 — 30°C.
RECOMMENDED FILM THICKNESS PER COAT	:	80 — 150 microns for Dry Film 210 — 395 microns for Wet Film
THEORETICAL COVERAGE AT RECOMMENDED FILM THICKNESS	:	4.8 m^2/litre (for Dry Film Thickness of 80 microns) 2.5 m^2/litre (for Dry Film Thickness of 150 microns)
COVERAGE WITH A LOSS FACTOR OF 20%	:	3.8 m^2/litre (for Dry Film Thickness of 80 microns) 2.0 m^2/litre (for Dry Film Thickness of 150 microns) (These values are calculated based on the above theoretical coverage and a loss factor of 20%. The actual loss factor for a particular job may vary depending on the application condition, method and technique; surface condition; as well as the structure and dimension of the object to be coated).

NO. OF COATS RECOMMENDED	:	1 — 2 coats
APPLICATION METHODS	:	Brush, roller, compressed air spray and airless spray. Preferably use airless spray if a thicker coat is required in one application. Brush, roller, compressed air spray generally lead to lower film thickness, so more applications may be required to obtain the recommended thickness per coat.
GUIDING DATA FOR AIRLESS SPRAY	:	Delivery Pressure : 140 — 170 kg/cm² Tip Size : 0.015" — 0.017" Spray Angle : 60° — 70°
THINNER	:	SA-65 Thinner
THINNING	:	Normally no thinning is required for airless spray. Where thinning is required to improve workability, use about 5% thinner by volume for application by brush, roller and airless spray; and 10 — 15% thinner by volume for application by compressed air spray.
DRYING TIME AT 25°C — 30°C	:	Dry To Touch : Approximately 3 — 4 hours Dry To Overcoat : Minimum 16 hours Dry To Handle : 16 hours
CURING TIME AT 25 — 30°C	:	Paint film thickness of 2 x 150 microns when dry takes a minimum of about 8 — 9 days to attain full cure. For thicker film, the curing time will be longer. In all cases, higher temperature will shorten and lower temperature will lengthen the curing time. Exposure of the paint film to water, chemicals and abrasion should be avoided as far as possible before it is fully cured.
ENVIRONMENTAL CONDITION DURING APPLICATION	:	1) The relative humidity during application should not be more than 80 — 85%. 2) During application, naked flames, welding operations and smoking should not be allowed and good ventilation is necessary.
CLEANING SOLVENT	:	SA-65 Thinner. All equipment should be cleaned out with the thinner immediately after use.
STANDARD PACKING	:	4.17 litres of Base with 0.83 litres of Hardener.

protective coatings

NIPPON ZINC RICH PRIMER

Cat Asas Logam Kaya Zink

Nippon Zinc Rich Primer is a two-pack epoxy shop primer for use on abrasive blasted steel prior to application of final paint system. It is recommended where high level of corrosion resistance is required.

PHYSICAL CHARACTERISTICS OF PAINT

COLOUR	:	Silver Grey
TEXTURE	:	Matt
SPECIFIC GRAVITY	:	2.02 (for mixture of Base and Hardener)
SOLID CONTENT	:	32.0% by volume (for mixture of Base and Hardener)

RECOMMENDATION FOR USE

SURFACE PREPARATION	:	Abrasive blasting to minimum Sa 2½. The standard should be maintained until the paint is applied. If the steel changes colour or rust bloom begins to form, it will be necessary to reblast the steel. The surface must be dry and free from abrasive residues and other contaminants before the paint is applied on.
MIXING RATIO	:	89 parts by weight of Base to 11 parts by weight of Hardener. Base and Hardener to be mixed preferably by power stirring and stirred continuously for at least 15 minutes before application.
POT LIFE	:	8-10 hours after mixing at 25°C-30°C.
RECOMMENDED FILM THICKNESS PER COAT	:	25-50 microns for dry film 80-160 microns for wet film
THEORETICAL COVERAGE AT RECOMMENDED FILM THICKNESS	:	12.8 m²/litre (for dry film thickness of 25 microns) 6.4 m²/litre (for dry film thickness of 50 microns)
COVERAGE WITH A LOSS FACTOR OF 20%	:	10.2 m²/litre (for dry film thickness of 25 microns) 5.1 m²/litre (for dry film thickness of 50 microns) (These values are calculated based on the above theoretical coverage and a loss factor of 20%. The actual loss factor for a particular job may vary depending on the application condition, method and technique; surface condition; as well as the structure and dimension of the object to be coated.)

NO. OF COATS RECOMMENDED	:	1 coat
APPLICATION METHODS	:	Brush, compressed air spray or airless spray.
GUIDING DATA FOR AIRLESS SPRAY	:	Delivery Pressure : 140-170 kg/cm² Nozzle Tip : 0.015"-0.017" Spray Angle : 60°-70°
THINNER	:	SA-65 Thinner
THINNING	:	If necessary, add up to 5% thinner by volume for application both by airless spray and by brush; about 10% thinner by volume for compressed air spray.
DRYING TIME AT 25°C-30°C	:	Dry to touch : Approximately 5 minutes Dry to overcoat : Minimum 10 hours Dry to handle : 1 hour
CURING TIME AT 25°C-30°C	:	Full cure takes 5-6 days. Exposure of the coating to water, chemical and abrasion should be avoided as far as possible before it is fully cured.
ENVIRONMENTAL CONDITIONS DURING APPLICATION	:	1) The relative humidity during application should not be more than 85%. 2) During application of the paint, adequate ventilation is necessary; naked flames, welding operations and smoking should not be allowed.
CLEANING SOLVENT	:	SA-65 Thinner All equipment should be cleaned out with the thinner immediately after use.
STANDARD PACKING	:	8.9 kg of Base with 1.1 kg of Hardener.

The above information is given to the best of our knowledge based on laboratory tests and practical experience. However, since we cannot anticipate or control the many conditions under which our products may be used, we do not guarantee the accuracy of our information or the suitability of our products in any given condition.

We reserve the right to alter the given data without notice.

protective coatings

COPON AROCOAT

Cat Arocoat

Copon Arocoat is a two-pack, high-build coal tar epoxy coating. It can be applied up to 150 microns or even thicker in one coat; and is intended for immersion and non-immersion services which require excellent protection against fresh and salt water, abrasion and splashes of corrosive chemicals.

Areas suitable for this application include marine structure, sheet piling, ship bottom, pipeline, ballast tank, sewage treatment plant, etc.

PHYSICAL CHARACTERISTICS OF PAINT

COLOUR	:	Black and Brown
TEXTURE	:	Semi-Gloss
SPECIFIC GRAVITY	:	1.27 (for mixture of Base and Hardener)
SOLID CONTENT	:	68.0% by volume (for mixture of Base and Hardener)

RECOMMENDATION FOR USE

SURFACE PREPARATION	:	For optimum performance, abrasive blasting to Sa 2½ is desirable. If abrasive blasting is not possible, wire-brush to St 3 is essential. For concrete, light abrasive blasting is best to remove all previous coatings and chalk. If blasting is not possible, new and uncoated concrete surface must be etched with approximately 5% phospheric acid solution. It should then be rinsed thoroughly with clean water, and allow to dry off completely before application of Copon Arocoat.
MIXING RATIO	:	85 parts by weight of Base to 15 parts by weight of Hardener. Base and Hardener to be mixed thoroughly and stirred continuously for 15-20 minutes before use.
POT LIFE	:	15-20 hours after mixing at 25°C-30°C
RECOMMENDED FILM THICKNESS PER COAT	:	80-175 microns for dry film 120-260 microns for wet film
THEORETICAL COVERAGE AT RECOMMENDED FILM THICKNESS	:	8.5 m²/litre (for dry film thickness of 80 microns) 3.9 m²/litre (for dry film thickness of 175 microns)
COVERAGE WITH A LOSS FACTOR OF 20%	:	6.8 m²/litre (for dry film thickness of 80 microns) 3.1 m²/litre (for dry film thickness of 175 microns)

(These values are calculated based on the above theoretical coverage and a loss factor of 20%. The actual loss factor for a particular job may vary depending on the application condition, method and technique; surface condition; as well as the structure and dimension of the object to be coated.)

NO. OF COATS RECOMMENDED	:	1-3 coats
APPLICATION METHODS	:	Brush, roller, compressed air spray and airless spray. Preferably use airless spray if a thicker coat is required in one application. Brush, roller, compressed air spray generally lead to lower film thickness, so more applications may be required to obtain the recommended thickness per coat. For coating over concrete, brush must be used for the first coat to ensure good penetration of the paint into the substrate.
GUIDING DATA FOR AIRLESS SPRAY	:	Delivery Pressure : 140-170 kg/cm² Tip Size : 0.015"-0.017" Spray Angle : 60°-70°
THINNER	:	SA-18 Thinner
THINNING	:	Normally not required for airless spray. Where thinning is necessary for workability, use about 5% thinner by volume for application by brush, roller and airless spray and 10-15% thinner by volume for compressed air spray.
DRYING TIME AT 25°C-30°C	:	Dry to touch : 1-1½ hours Dry to overcoat : Minimum 16 hours Dry to handle : 16 hours
CURING TIME AT 25°C-30°C	:	For a coating of 2 x 175 microns, full cure takes 7-8 days. Thicker coating will require longer curing time. In all cases, higher temperature will shorten and lower temperature will lengthen the curing time. Exposure of the paint to water, chemicals and abrasion should be avoided as far as possible before full cure is attained.
ENVIRONMENTAL CONDITIONS DURING APPLICATION	:	1) The relative humidity during application should not be more than 85%. 2) During application of the paint, naked flames, welding operations and smoking should not be allowed and good ventilation should be provided.
CLEANING SOLVENT	:	SA-18 Thinner. All equipment should be cleaned out with the thinner immediately after use.
STANDARD PACKING	:	5.4 kg of Base with 0.95 kg of Hardener.

protective coatings

NOTE

Overcoating the previous coat of Copon Arocoat should be done within 6–7 days but preferably as soon as possible after it has been allowed 16 hours drying. This is to ensure proper intercoat adhesion.

If the previous coat of Copon Arocoat has been left exposed for more than 6–7 days, it is desirable to roughen it by dry sanding with sand-paper before it is overcoated.

The above information is given to the best of our knowledge based on laboratory tests and practical experience. However, since we cannot anticipate or control the many conditions under which our products may by used, we do not guarantee the accuracy of our information or the suitability of our products in any given condition.

We reserve the right to alter the given data without notice.

NIPPECHLOR ANTI-FOULING

Code No. 2201

Type	A high toxicity anti-fouling formulated with a combination of chlorinated rubber and other resins together with cuprous oxide and organic toxins.
Uses	Protection of ship bottoms against fouling, such as shells, barnacles and algae.
Special Features	The incorporation of cuprous oxide provides protection against shells and barnacles and organic toxins against algae.
Texture	Semi-gloss.
Surface Dry	40 minutes at 20°C or 30 minutes at 30°C.
Hard Dry	3 hours at 20°C or 2 hours at 30°C.
Overcoating Interval	3 hours at 20°C or 2 hours at 30°C.
Immerse in water	Minimum 6 hours at 20°C or 4 hours at 30°C. Maximum 7 days at 20°C or 5 days at 30°C.
Non-volatile Content	60.9% by volume.
Film Thickness—Wet **Film Thickness—Dry**	85 microns. 50 microns.
Theoretical Coverage	12 sq. metres per litre.
Practical Coverage	9.6 sq. metres per litre (loss factor 20%).
Specific Gravity	1.69 kg per litre.
Thinner	2901 Nippechlor Thinner.
Flash Point	26.7°C.
Colour	Brown.
Standard Packing	5 litres and 20 litres.
Surface Preparation	The surface must be clean and dry, free from grease and oil.
Paint Preparation	Ready for use after thorough stirring.

NIPPECHLOR ANTI-FOULING

Code No. 2201

Application—Airless Spray	*Delivery Pressure:*	140—170 kg/cm2.
	Tip Size:	0.017" at 60° angle.
		0.019" at 60 or 70° angle.
	Dilution:	0—5%.
	Film Thickness—Wet:	85 microns per coat.
	Dry:	50 microns per coat.
Application—Brush or Roller	*Dilution:*	0—5%.
Precautions	It contains volatile and inflammable solvents. Ensure adequate ventilation during use, avoiding naked flame, welding operations and other fires. Avoid contact with skin and eyes. Should this happen, wash immediately with water thoroughly.	
Note	Values given are average for reference. Actual values may vary, depending on conditions.	

Table 6-6 Ultra-heavy-duty coating

We are glad to introduce ML-3000M and ML-6000M (the Ultra-heavy-duty and resistance-to-abrasion coating) which Marusei Heavy Industry Works has developed with the long-terms experience and concentrated-technology.

We generally used coaltar-enamel paint in early, tar-epoxy paint in late as anticorrosive one. Although the tar-epoxy paint has the excel-anticorrosion for sea water, because the membrane of this paint is soft, the fouling and growth of shellfish happen.

Consequently damage and scaling of the membrane occur when we remove them. And we need a great cost and labour for repairing.

To solve these problems, Marusei has developed ML-3000M(unsaturated polyester-base resin coating)and ML-6000M(glass epoxy resin coating)with superior adherence and mechanical intensity. Naturally they are maintenance-free.

These new products have been used for the circulating sea water systems of thermal and nuclear power stations, marine structures and floodgates since 1978. And Marusei has been given high estimation and appreciation from custmers for this decade.

Please inquire Marusei, if you have any trubles to the coating for sea water.

ML-3000M : Polyester-base Resin
Ultra-heavy-duty Coating

This ML-3000M, vinyl-ester resin has chemically combined with the surface of glass flakes, is the three-dimentional notting compounds. Because glass flakes are in the coating, it is difficult for water, chemical liquids and gas to penetrate the membrane of it. And this ML-3000M has more powerful anticorrosion than any other paints.

This new product offers these advantages:

— Anticorrosive quality for long terms

— Superior adhesion to surface of steel

— Superior resistance to abrasion

— Do not come off with mecanical shocks

— Flexibility to various thermal conditions

— Hardening at low temperature

— Easy repainting

ML-3000M

Physical Properties

TEST ITEM	ML-3000M	NOTE
Tensile strength	200 ~ 300kg/ cm^2	JIS K 7113
Elongation	1.0 ~ 1.5%	JIS K 6301
Thermal expansion coefficient	2.0 ~ 3.0 × 10^{-5}/℃	JIS K 6911
Hardness	5H	JIS K 5400
Anticorrosion(#40 carborundum 200kg)	6.4mg	ASTM D 968
Impact(500g ×1/2 " × 50cm height)	O.K.	Dupont Impact Test
Bending limit	35mm	JIS G 3492
Pass-humidity of water steam	under 0.05g/m^2/24H	JIS Z 0208
Adhesion to surface of steel	over 70kg/ cm^2	Tensile velocity 25mm/min

Chemical Properties

TEST ITEM	ML-3000M
Spray sea water for 10,000 hours	Good
Lay in high humidity for 10,000 hours	〃
Penetration test to 95℃-city-water for 7 days	〃
Penetration test to 60℃-city-water for a month	〃
Cool-heat repeating test 20 times	〃

SOAK IN CHEMICAL LIQUID (FOR 3 YEARS)	ML-3000M
3%-salt water	Good
10%-H_2SO_4	〃
20%-HCl	〃
5%-NaOH (for 5 months)	〃
Crude oil	〃
Gasoline	〃

Comparison List of Efficiency

ML-3000M is superior coating when it is compare with tar-epoxy resin one.

Remarks :

ML-3000M

Tar-epoxy

③ Hardness at low temperatur

1 2 3 4 5 6 7 8 9 10E

① Tensile strength

50 100 150 200 250kg/cm²

④ Pass-humidity of water steam

0.1 0.2 0.3 0.4 0.5g/m²/24H

② Anticorrosion

10 20 30 40 50mg

⑤ Adhesion to surface of steel

10 20 30 40 50 60 70 80Kg/cm²

M L - 6 0 0 0 M : Glass-epoxy Resin
Ultra-heavy-duty Coating

This ML-6000M, pure epoxy resin has strongly combined with the glass fibers, is very hard and flat surface. And it has the superior resistance to abrasion and physical intensity.

This new product offers these advantages;

- Anticorrosive quality for long terms
- Superior adhesion to surface of steel
- Superior resistance to abrasion
- Superior thickly painting

Physical Properties

TEST ITEM	ML-6000M	NOTE
Tensile strength	250 ~ 300kg/m²	JIS K 7113
Elongation	2 ~ 3%	JIS K 6301
Hardness	4H	JIS K 5400
Anticorrosion(#40 carborundum 200kg)	2.1mg	ASTM D 968
Impact(500g×1/2" × 50cm height.)	O.K.	Dupont Impact Test
Bending limit	28mm	JIS G 3492
Pass humidity of water steam	0.52g/m²/24H	JIS Z 0208

Chemical Properties

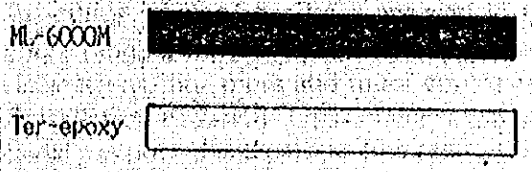
TEST ITEM	ML-6000M
Spray sea water for 35°C	Good

SOAK IN CHEMICAL LIQUID (FOR 6 MONTHS)	ML-3000M
5%-H_2SO_4	Good
5%-NaOH(for 5 months)	〃
3%-Salt Water	〃

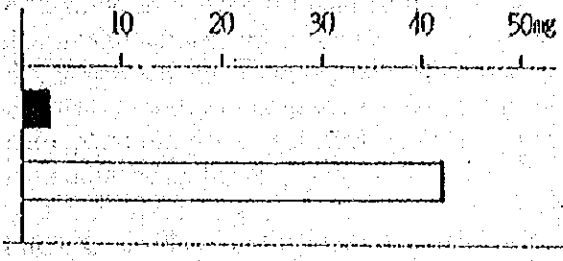
Comparison List of Efficiency

ML-6000M is superior coating when it is compare with tar-epoxy resin one.

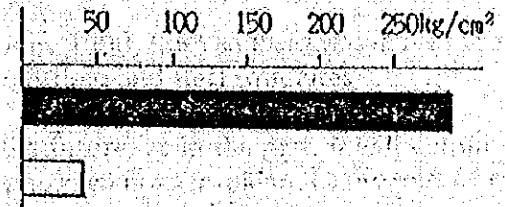
Remarks :



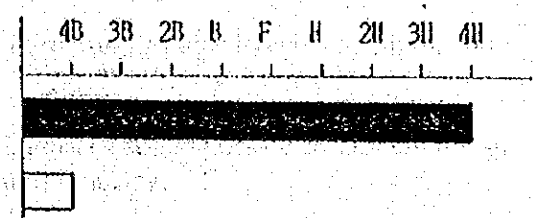
② Anti-corrosion



① Tensile strength



③ Hardness ← soft hard →



Outline of marusei

In October 1960, the Steel Construction Division was separated from Kubota, Ltd. In order to establish an independent enterprise under the name of Kubota Rikki Industry Co., Ltd., and was renamed Marusei Heavy Industry Works, Ltd. In January 1962. Since then, as an all-round manufacturer of pipe and steel constructions, Marusei has been engaged in the design, manufacture and installation of a wide variety of products ranging from steel water piping to penstocks, large diameter steel pipes for thermal and nuclear power stations, line pipes and spiral corrugated pipes, fittings and also engaged in the design, production and installation of various types of gates, water treatment, plant bridges and steel structures, products which are widely exported and enjoy a fine reputation both in domestic and overseas markets.

During 1969 to 1972, we have developed and cultivated the production techniques, and advanced into the fields of fittings and heat exchangers.

In June 1980, the Yao Plant was moved to Harima in order to produce larger steel pipes, and fabrication of pipe fittings and steel structures.

In the future, as in the past, it will continue to be Marusei's guiding policy to develop products which will play an even greater role in the progress of every field of industry.

Company Name: MARUSEI HEAVY INDUSTRY WORKS, LTD.
Head Office: 1-40, Tsurumachi 1-chome, Taisho-ku, Osaka, Japan
Phone: 06-552-3171
Telefax: 06-551-4636
President: Daizo Odawara
Established: October, 1960
Capital: ¥ 750,000,000.– (paid-up)

Branch Offices & Factories:

Tokyo Office: c/o Ehara Bldg., 6-7, Kaji-Cho 1-Chome, Chiyoda-Ku, Tokyo, Japan
Phone: 03-254-7911
Telex: 222-2497 MARUSE J
Telefax: 03-254-7916

Nagoya Office: c/o Nagoya Kyogin Bldg., 15-22, Nishiki 2-Chome, Naka-Ku, Nagoya, Japan
Phone: 052-203-0251

Kyushu Office: c/o Nagasaki-Pref. Sangyo Kaikan Bldg., 4-21, Hakata-Eklmae 4-Chome, Hakata-Ku, Fukuoka, Japan
Phone: 092-473-1921

Hokkaido Office: c/o Mihiro Bldg., Kita-Nijyo Nishi 2-Chome, Chuo-Ku, Sapporo, Hokkaido, Japan
Phone: 011-261-8841

Hiroshima Office: c/o Miyako Bldg., 1-22, Honkawa-Cho 3-Chome, Naka-Ku, Hiroshima, Japan
Phone: 0822-94-2880

Sendai Office: c/o Sendai Hokushin Bldg., 6-10, Uesugi 1-Chome, Sendai, Miyagi-Pref., Japan
Phone: 0222-61-1430

Tsurumachi Plant: 1-40, Tsurumachi 1-Chome, Taisho-Ku, Osaka, Japan
Phone: 06-552-3121

Harima Plant: 6, Nijima, Harima-Cho, Kako-Gun, Hyogo-Pref., Japan
Phone: 0794-35-5301

Izuo Plant: 24-12, Izuo 2-Chome, Taisho-Ku, Osaka, Japan
Phone: 06-554-6921

Stock Holder:

Marusei Bussan Co., Ltd.	555,000 shares
Kubota, Ltd.	280,000 shares
Nippon Steel Corporation	200,000 shares
Kawasaki Steel Corporation	200,000 shares
Nippon Life Insurance Co.	75,000 shares
Sumitomo Life Insurance Co.	75,000 shares
Takenaka Komuten Co., Ltd.	50,000 shares
Dalichi Life Insurance Co.	30,000 shares
Others	35,000 shares

Correspondent Bank:

The Sumitomo Bank, Ltd., Head Office
The Sanwa Bank, Ltd., Namba Branch
The Dai-Ichi Kangyo Bank, Ltd., Namba Branch
The Mitsubishi Trust & Banking Corp., Osaka Branch
The Sumitomo Trust & Banking Co., Ltd., Namba Branch

Space of Works:

Name of Plant	Site (m^2)	Building (m^2)
Tsurumachi Plant	38,400	21,800
Harima Plant	105,000	35,700
Izuo Plant	3,200	2,200
Total:	146,600 m^2	59,700 m^2

A. Steel Construction Division (Tsurumachi Plant)

1. Steel Structures
   Engineering, Manufacturing and Installation of;
   Bridge, Steel Structure, Gate for Dam and Irrigation, Tank, Steam and Hot water Boiler, Condenser tube
2. Water Treatment Equipment
   Engineering, Manufacturing and Installation of;
   Screen ;with mechanical rake, Grit collector, Primary and final sludge collector, Travelling screen for cooling water inlet for thermal and nuclear power station, numerous other equipment for municipal, industrial water supply, Sewage and industrial waste treatment plant
3. Industrial Machinery
   Engineering, Manufacturing and Installation of;
   Conveyor, Crane, Batching plant, Pneumatic conveyor for industrial and chemical industries
4. Architectural Office
   Consulting, Engineering, Designing and General contractor (Licensed first class architect)

B. Welded Steel Pipe Division (Harima Plant)

Engineering, Manufacturing and Installation of;
Welded steel pipes for municipal, industrial and agricultural water supply, High tension steel pipes for thermal and nuclear power station, Penstock for hydroelectric power station, Columns and piles for construction, Steel pipes for gas, chemical and steel mill
Butt-welding fittings, Welded flanges and corrugated spiral pipes

PRODUCTION CAPACITY (monthly)

DIVISION	ITEM	CAPACITY
Pipe	Welded Steel Pipe	2,000 tons
	Spiral Corrugated Pipe	700 tons
	Steel piling, Steel colume & other Pipes	200 tons
	Welding fittings & Welding flange	500 tons
Steel Structure Items and Industrial machinery	Steel Structure, Bridge Construction	1,500 tons
	Water Gate, Mechanical Screen, Industrial-use Machine, Water Treatment Equipment	1,500 tons
Heat Exchanger	Spiral Tube & Heat Exchanger, etc.	300 tons
TOTAL:		6,700 tons

EMPLOYEES

Organization	Technical Staff (Engineer, Skilled)	Clerical	Female	Total
Head Office	31	53	19	103
Tokyo Office	14	22	6	42
Tsurumachi Plant	336	29	10	375
Harima Plant	295	23	8	326
Other Offices	5	9	5	19
Total:	681	136	48	865

as of Oct., 1984

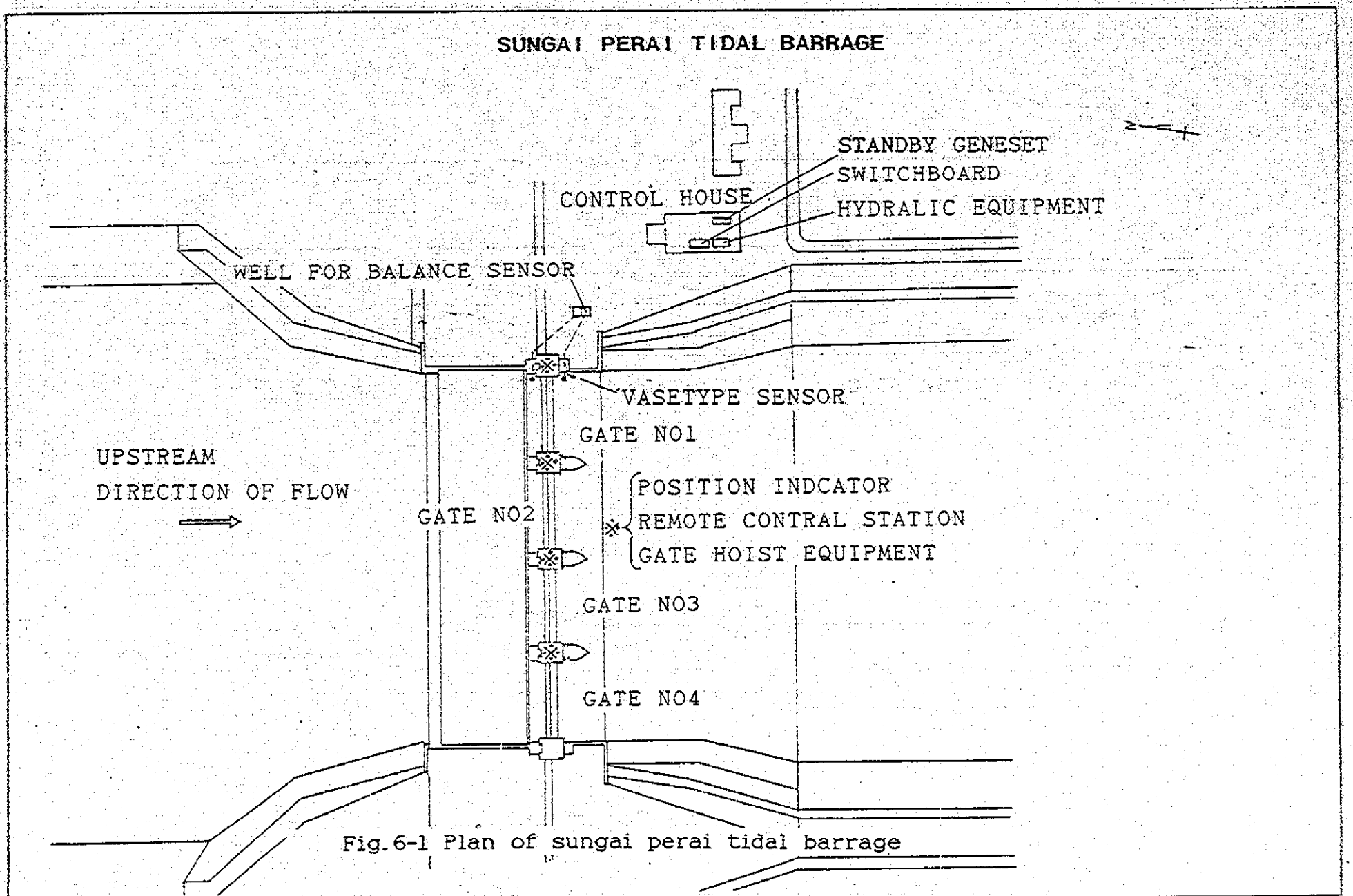


Fig.6-1 Plan of sungai perai tidal barrage

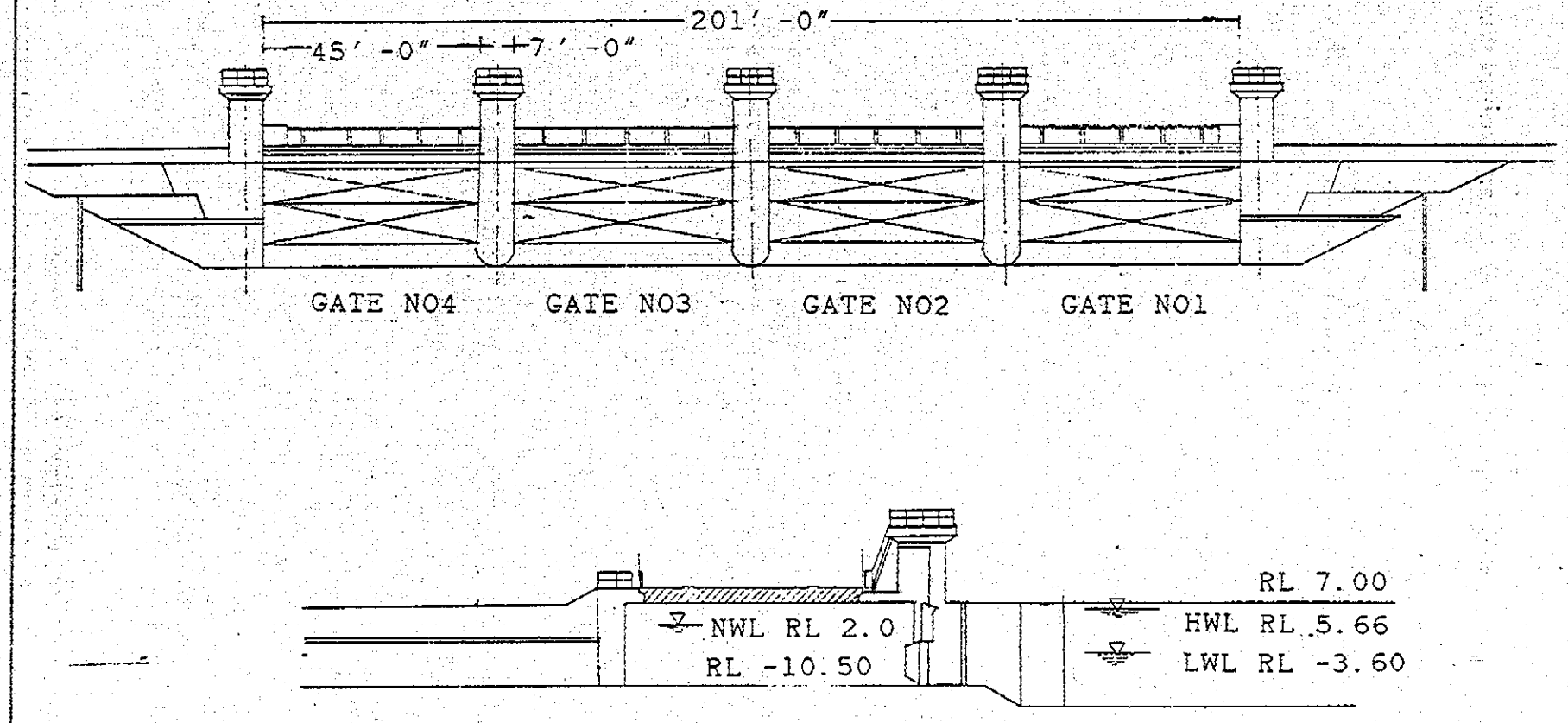
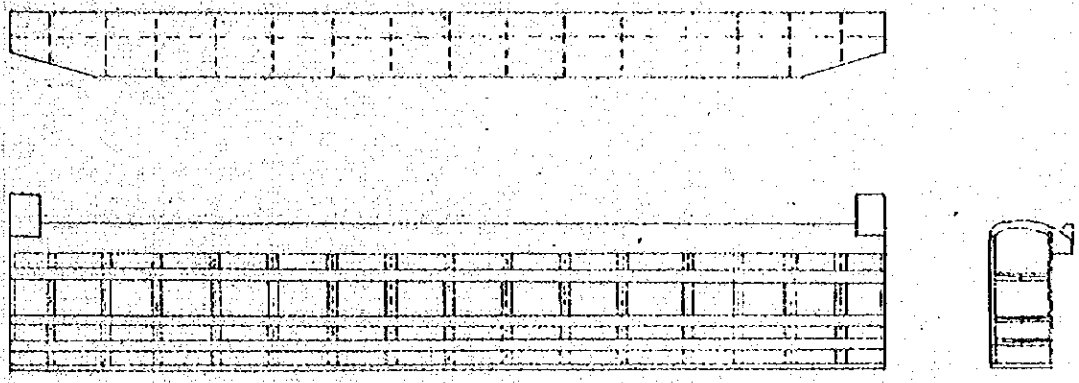


Fig.6-2 Cross section of sungai perai tidal barrage

No measurement made as there is no corrosion identified.

TOP LEAF



BOTTOM LEAF

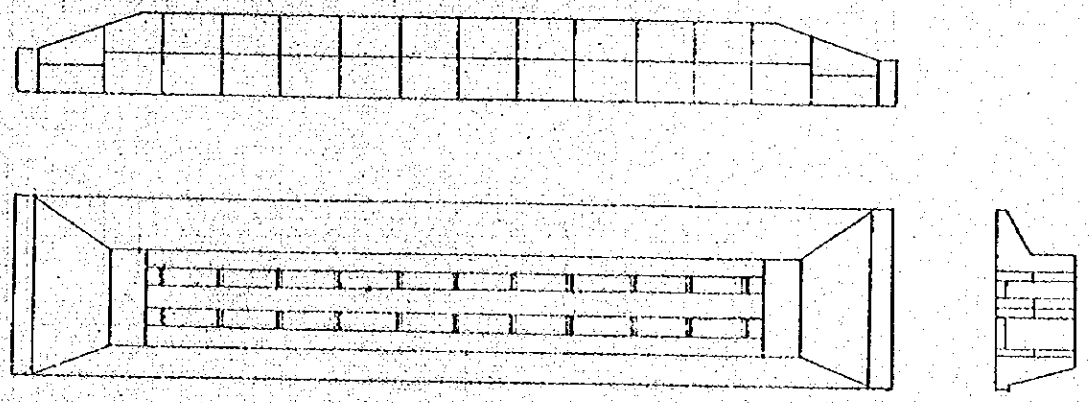


Fig. 6-3 Gate nol plate thickness checking position

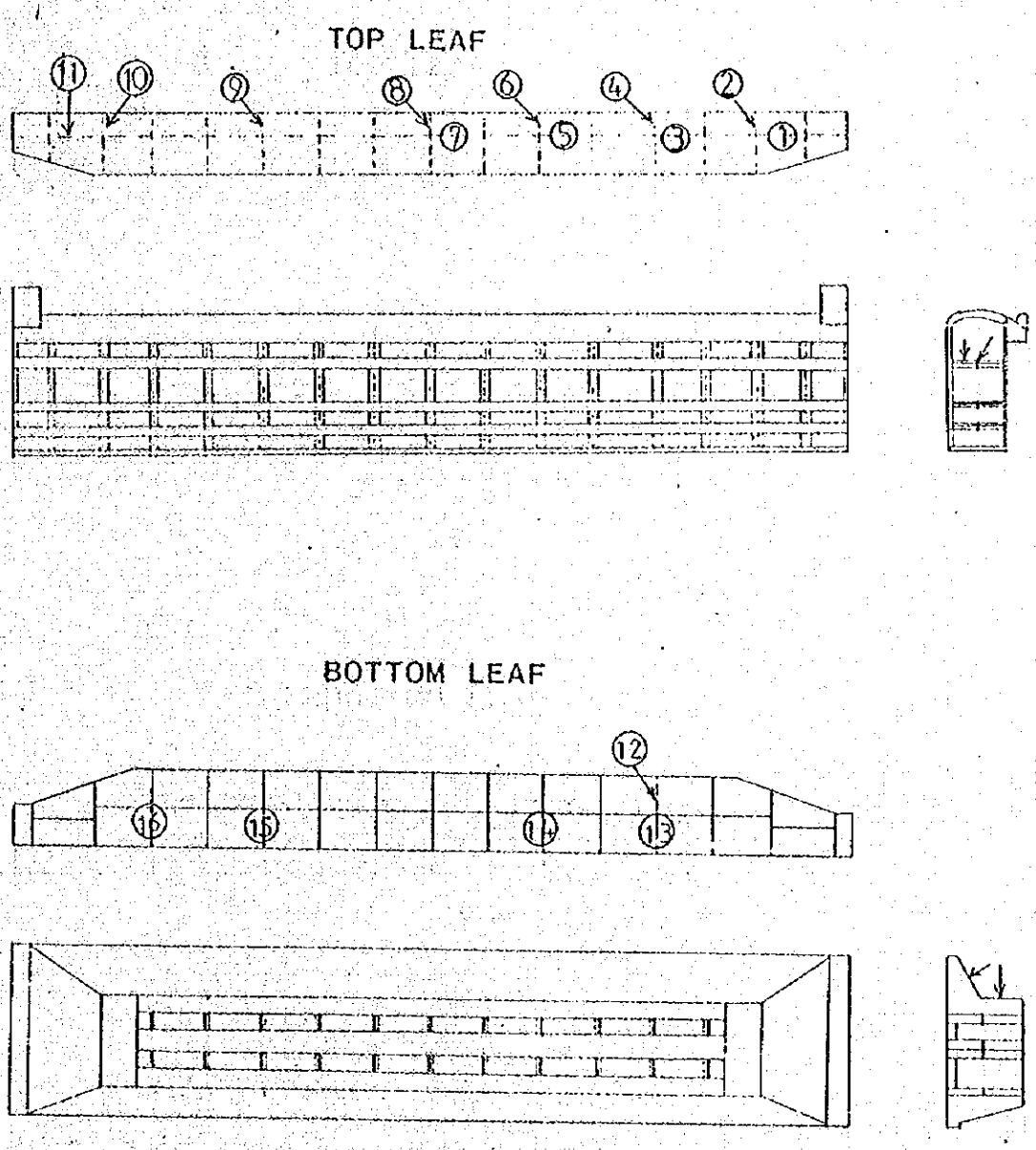
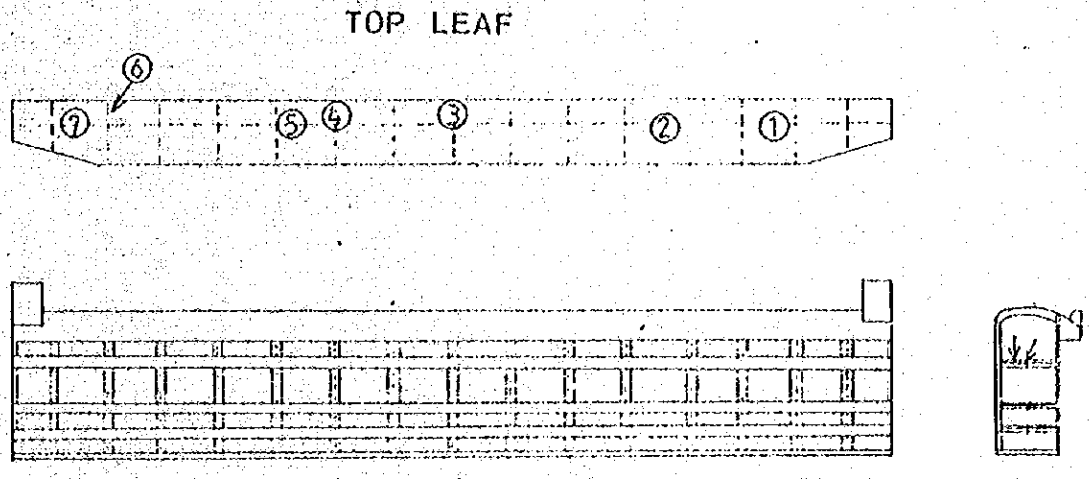


Fig.6-4 Gate no2 plate thickness checking position



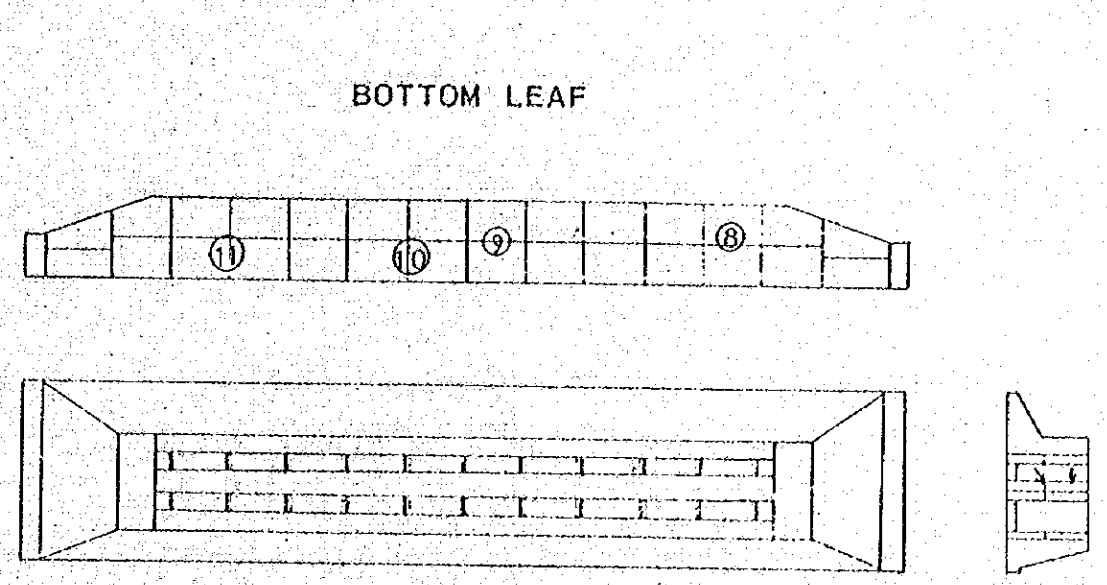
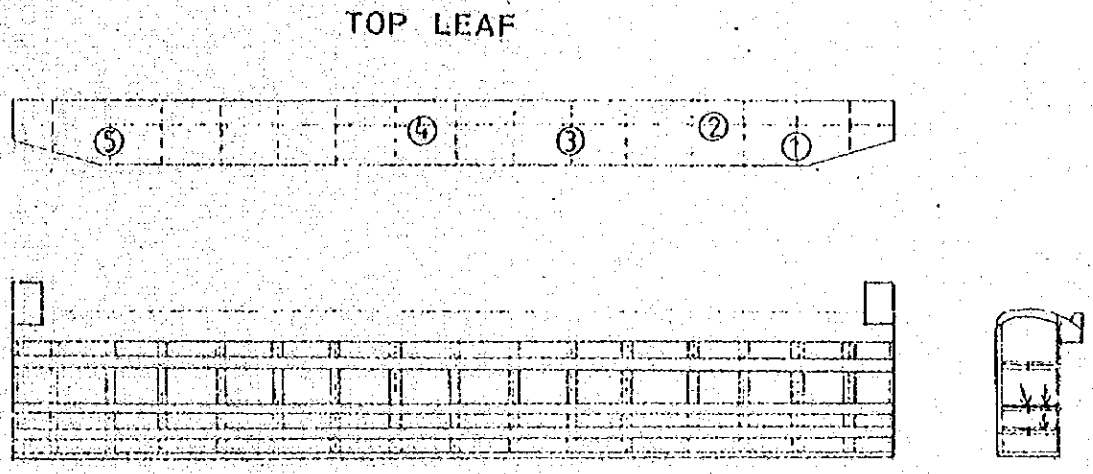


Fig. 6-5 Gate no3 plate thickness checking position



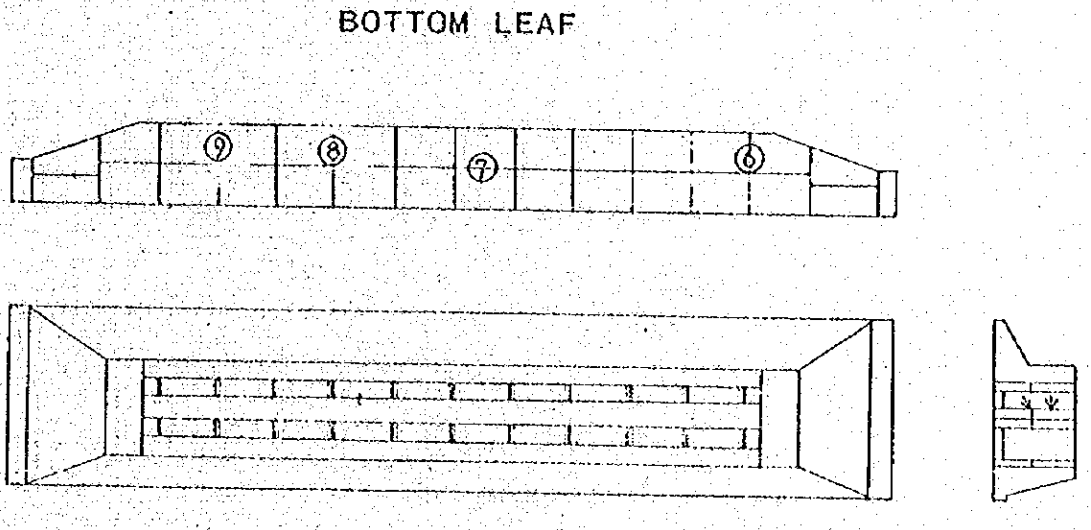
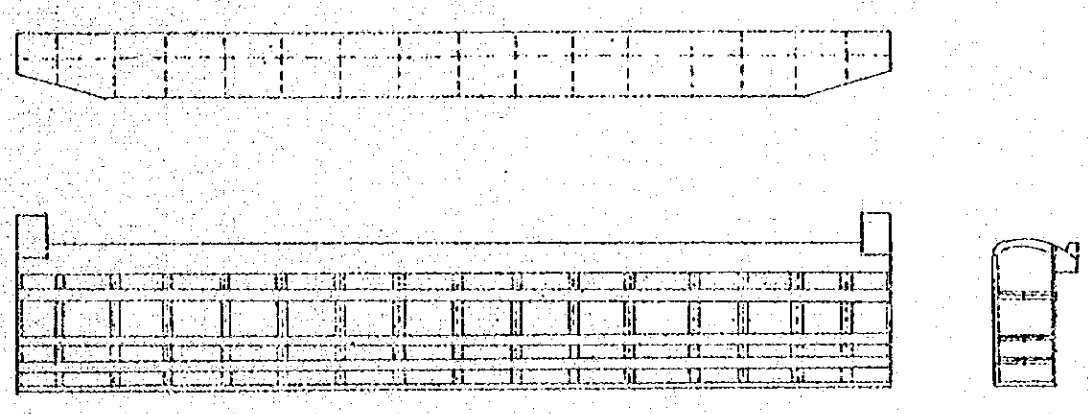


Fig. 6-6 Gate no4 plate thickness checking position

No corrosion

TOP LEAF



Minor corrosion(top, bottom girder)

BOTTOM LEAF

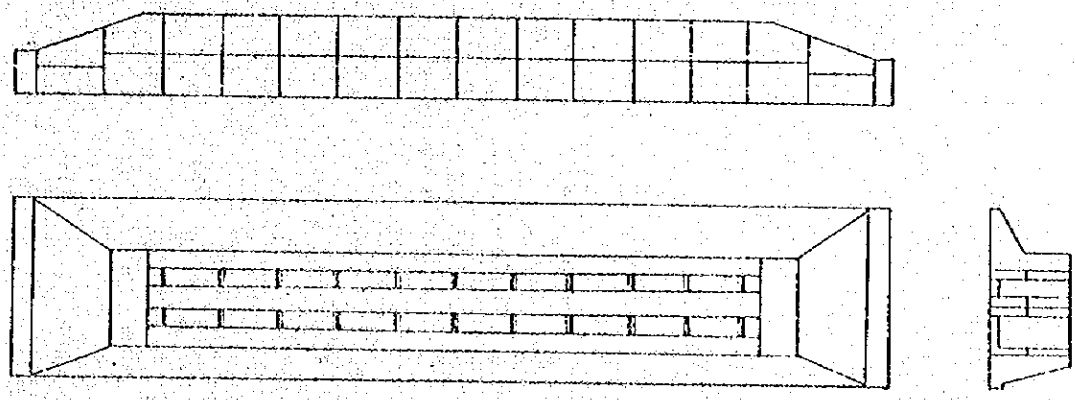
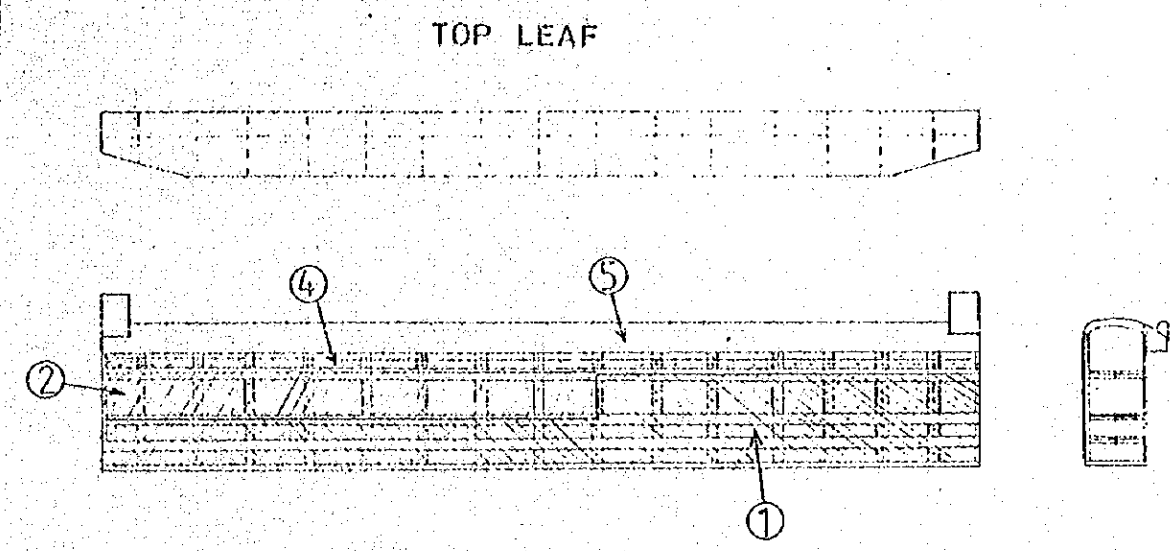
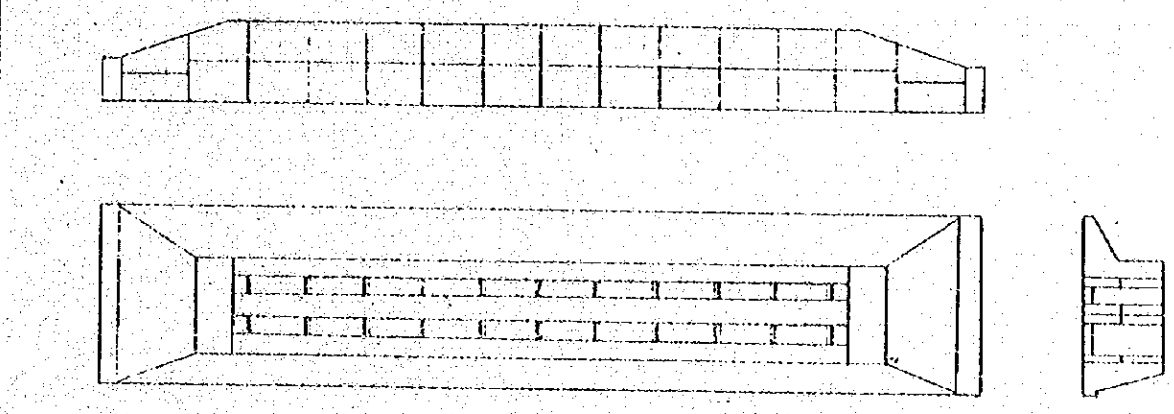


Fig.6-7 Gate nol condition of coating

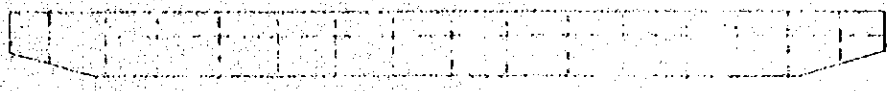




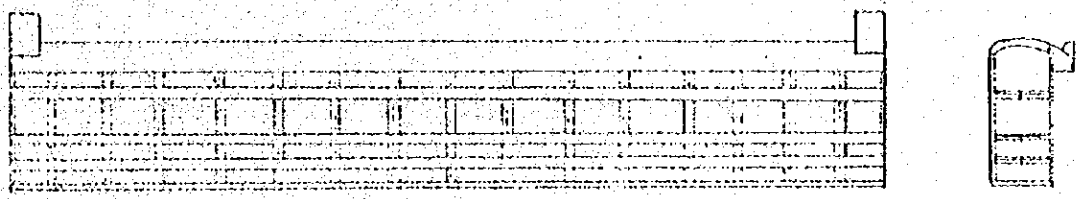
Over All ①

Fig. 6-8 Gate no2 condition of coating

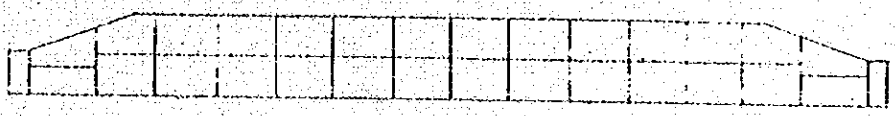
TOP LEAF

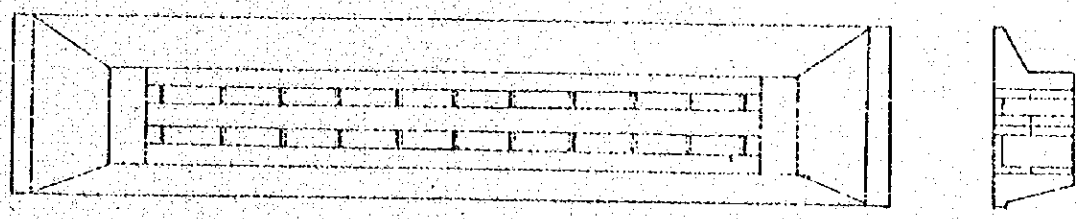


Over All ①



BOTTOM LEAF





Over All ①

Fig. 6-9 Gate no3.4 condition of coating

VII. STUDY ON THE DOWNSTREAM AREA ALONG THE SG.PERAI

7-1 Sg.Perai riverbank survey from barrage to the Perai bridge

The D.I.D. state of Penang have surveyed the area along the right bank but only within the area of factory zone. The embankment around this stretch has been designed.

Three pumps will be installed along this stretch to eliminate the water during flooding and high tide. Certain areas along the stretch, consists of piers and residential area. The D.I.D. state of Penang will not pay any compensation on the land usage, as the land is within the river reserved.

The D.I.D. state of Penang has almost completed the construction on the left bank with earth bund. But D.I.D. did not construct the embankment in a certain stretches, because there are many houses within the area where the embankment is planned to be constructed. In this case construction will be impossible unless and until the house owners are prepared to move out.

A stretch of about 500 meter from the factory zone on the right bank is along the main road having a reduce level of about 1.8 meter. The line stretches further downstream from there to Perai bridge which is covered with swamp and reclaimed land. All areas above mentioned are very low and feared to be inundated during high tide, when all the gates at barrage are closed. In line with the above problems another survey works was done continuing the stretch downstream from the factory zone to the Perai bridge of about 3,000 meter for this study. The purpose of the survey is to examine the necessity of the construction of embankment along the 3,000 meter stretch. (Fig.7-1)

7-2 Result of survey works

The section between c/s 0 and c/s 500 is along the main road. There are many warehouses within the area between c/s 500 and c/s 1,000. The river side along this stretch is used as jetty. The section from c/s 1,000 to the finished point of survey is swamp land within the range of 20~200 meter. This area has been reclaimed and construction of industries are under planning.

There are two drains which join to Sg.Perai. The drain which joins Sg. Perai at c/s 1,070 has a gate at the point 450 meter upstream of confluence. The drain which joins it at c/s 1,500 has no gate. (Fig.7-2)

7-3 Decision of top elevation of embankment

According to the conclusion of simulation using the highest tidal level of 1.48 meter, the highest water level downstream of the barrage become 1.55 meter when all the gate are closed. But the record of the highst water level observed on 17 May 1984 was 1.68 meter. Moreover, D.I.D. state of Penang adopts the 1.68 meter of highest water level of tide for the design of facilities concerning

to the river. Judging from above mentions, 1.68 meter of highest water level was adopted in this study, considering some safety.

On the other hand, according to the D.I.D. manual the height of freeboard is 0.60 meter. Its height will be enough even when the data contain a certain error which come from survey and analysis. Therefore, the top elevation of embankment was decided to be R.L. 2.3 meter.

7-4 Necessity and the type of embankment and discussions

According to the results of survey, the circumference of Sg.Perai is lower than the decided top elevation of embankment throughout whole line. So embankment should be constructed whole along the Sg.Perai. As there is little area of river side, the space for the construction of embankment would be requested.

Two types of embankment are considered, judging from the field investigation. The section from c/s 0 to c/s 1,000 has only a narrow area for the construction of embankment. Moreover the area from c/s 500 to c/s 1,000 has already been used for jetty. So that the concrete gravity type of embankment which can save the space should be constructed. (Fig.7-3)

Whereas in the area from c/s 1,000 to finished point of survey, it is sufficient enough to construct the earth bund which is the same type already constructed at left bank because there is relatively wider space. (Fig.7-4)

In case the embankment would be constructed along the river, the elimination of internal water would not be possible, so that drains must be constructed along the inside of whole embankment.

7-5 Necessity of gates

There are two drains which join Sg.Perai within the range where the survey has been executed at this time. The elevations around these drains are higher than the highest water level of 1.68 meter, but this area may be inundated when the abnormal water level would occur, owing to the loss of freeboard. Furthermore quite a large amount of outflow which come from industrial waste water should be taken into account, in case the industrial area might be extended into this area.

Therefore, it is important to investigate about the developping plan in this area in advance, and to prepare the gates and pumps which would be the same type as that under planning at upstream of industrial zone for the elimination of internal water.

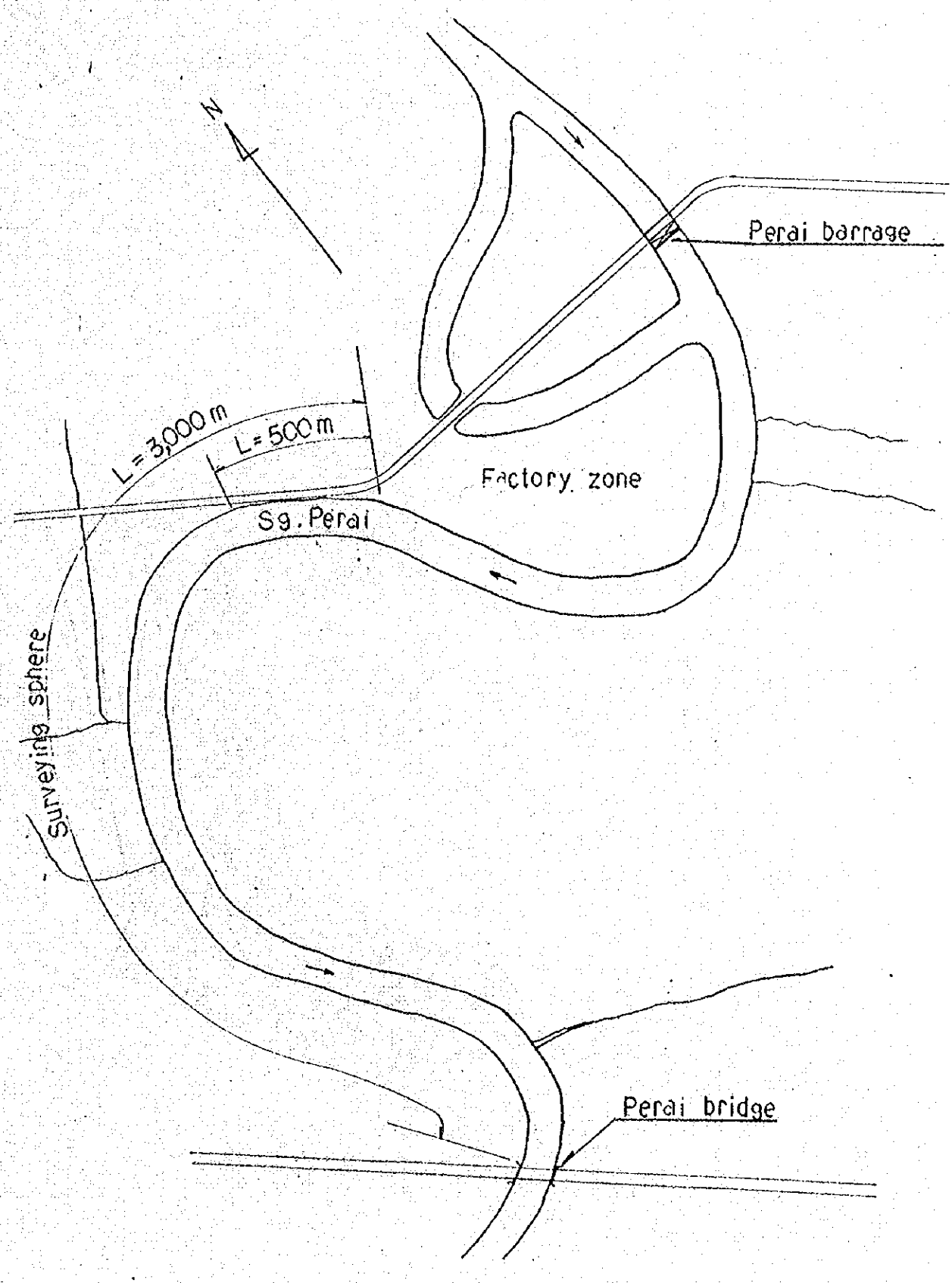


Fig. 7-1 Range of surveying

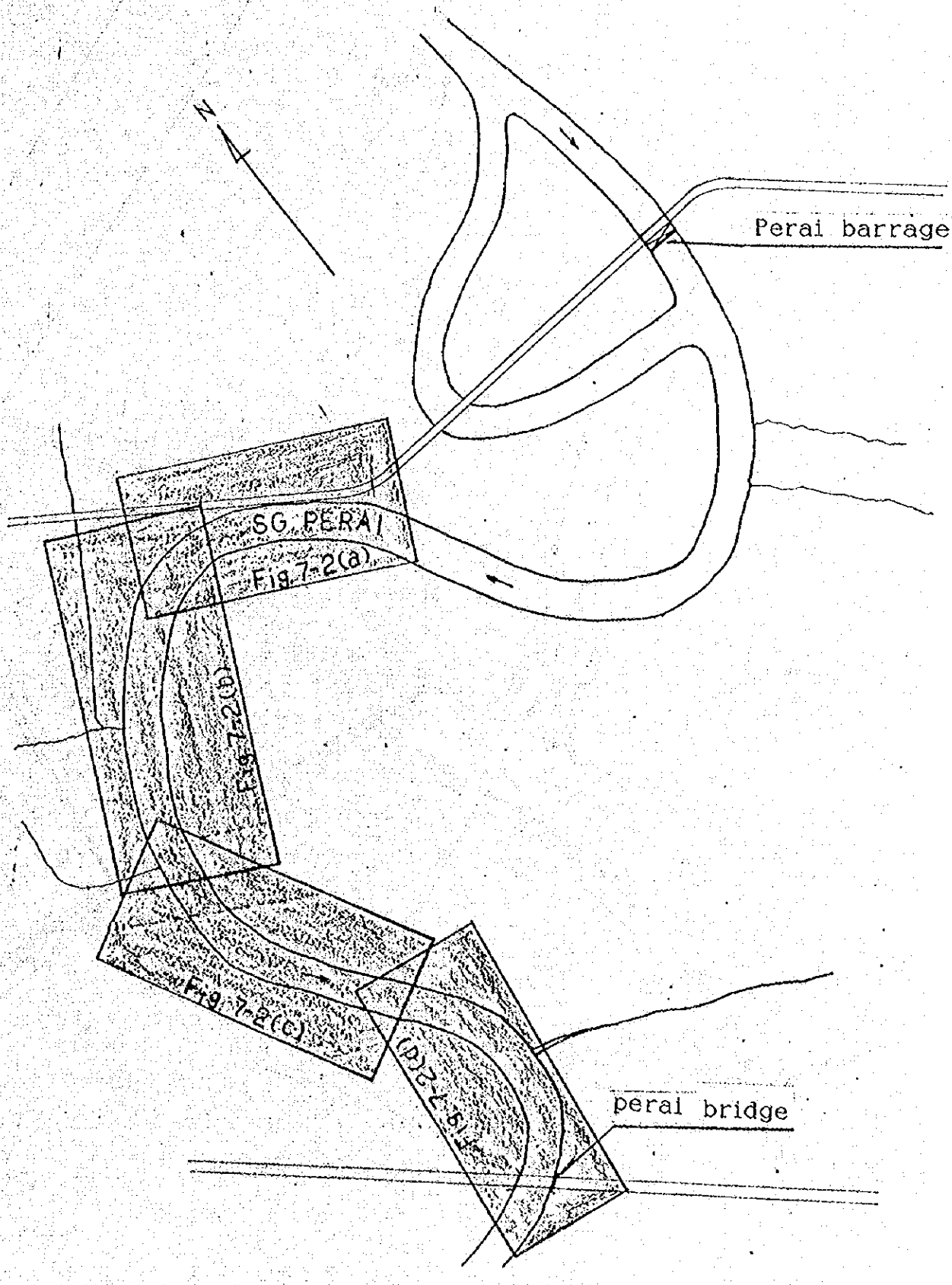


Fig. 7-2 Composition of esch plare figuer of surveying

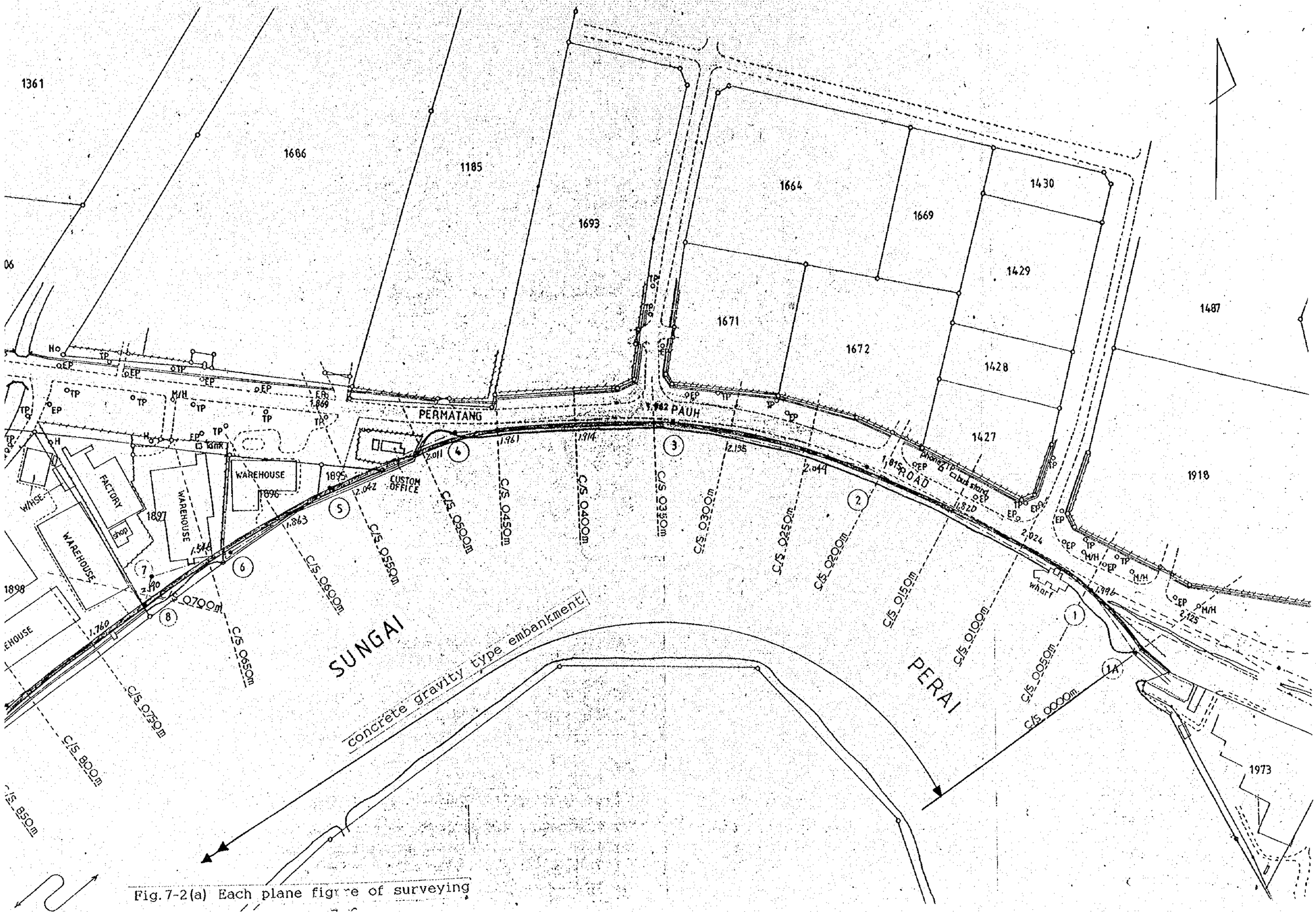


Fig. 7-2(a) Each plane figure of surveying

Fig. 7-2(b) Each plane figure of surveying

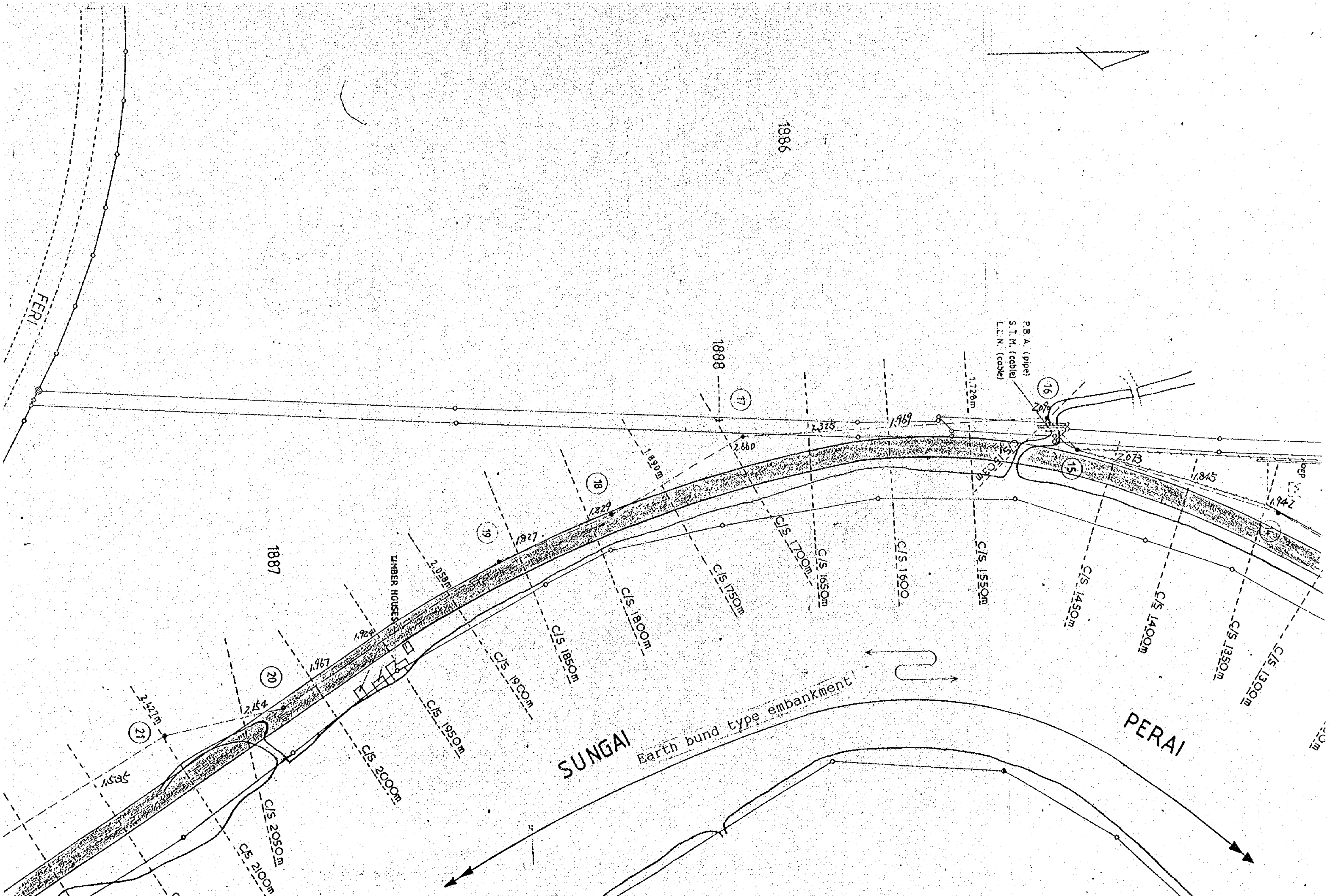


Fig. 7-2(c) Each plane figure of surveying

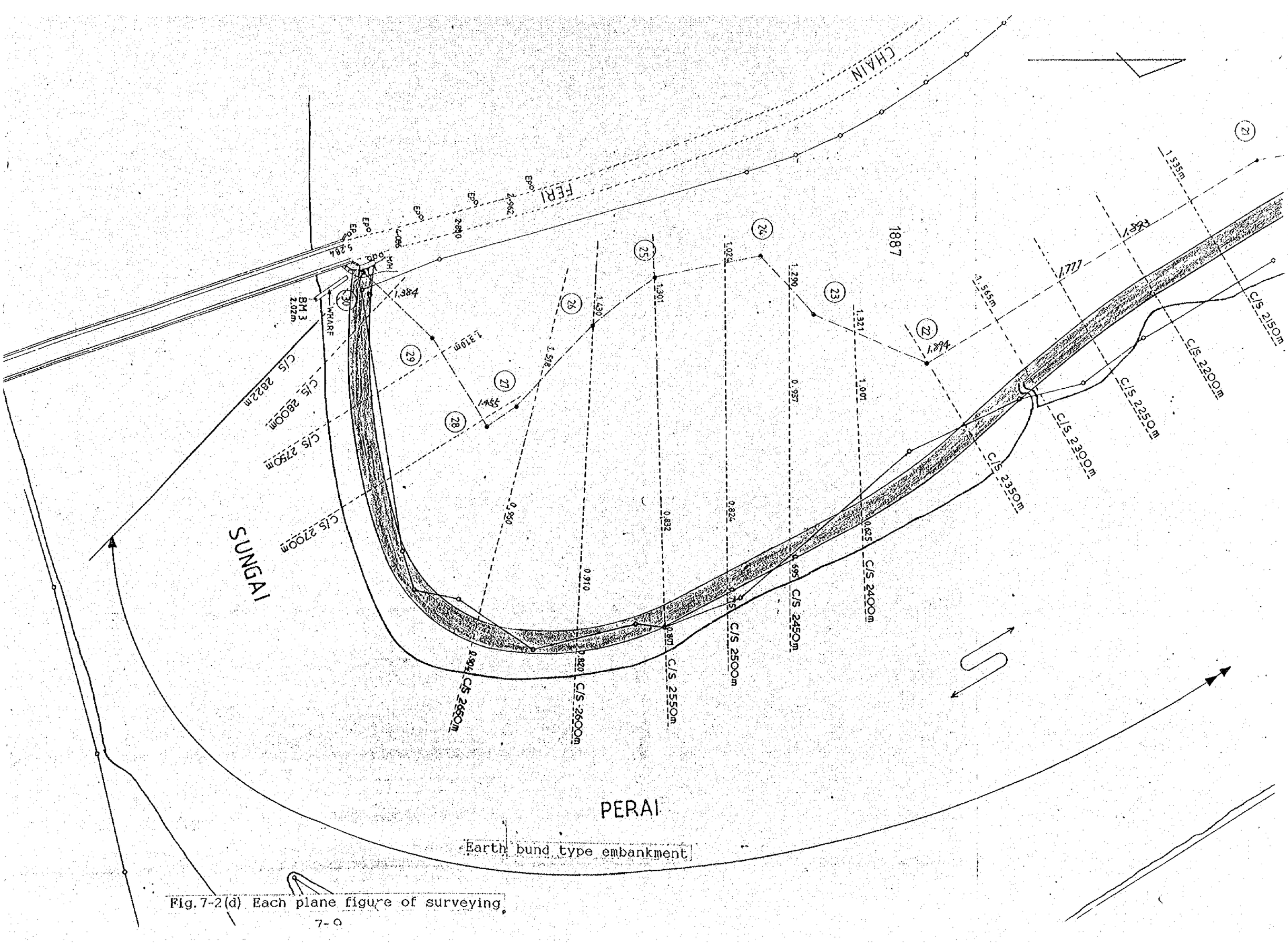


Fig. 7-2(d) Each plane figure of surveying

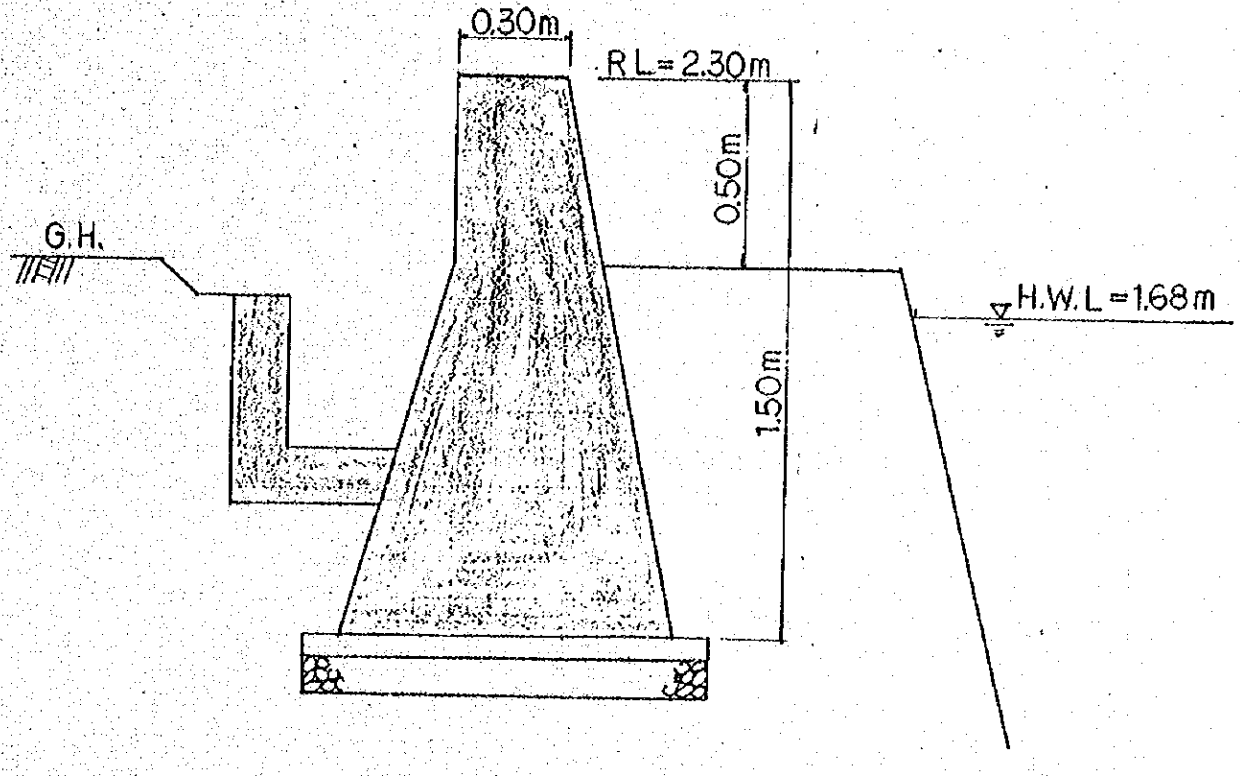


Fig. 7-3 Schematis figuer of concrete gravity type embankment

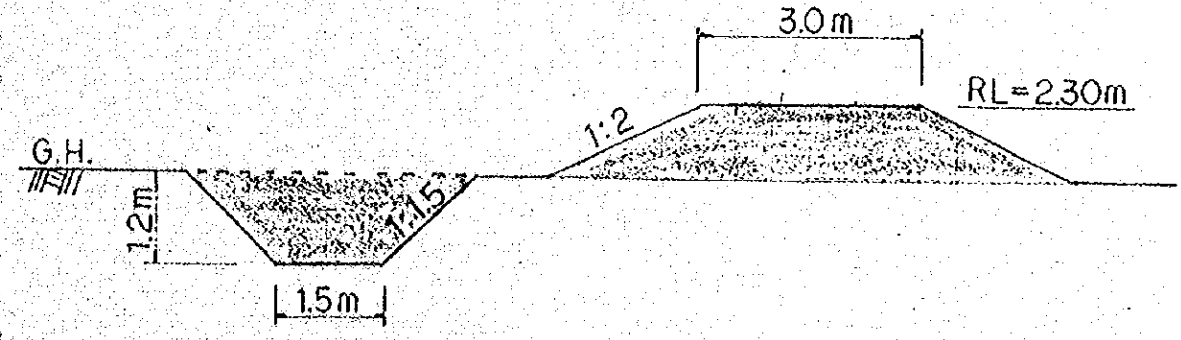


Fig. 7-4 Schematis figuer of Earth bund type embankment

VIII. Gate operation

The gate operation procedure of case-3 in chapter V is recomended. The followings should be considerd on operation:

(1)water level indicator
The indicator of water level should be installed in opration room to cheak the both water levels, up and downstram of the Barrage, at the same time.

(2) prediction of tide
Flowing up of tida must be predicted, for example using tide table, to prevent ingression saline water. Since it take a long time to close the gates, the operation of gate closing should start before flowing up of tide satrts.
Therefore, the gate closing water level should be established. The gate should be started to close, when the estuary water level become over that as shown in Fig.8-1

(4) datum error
Usualy, there is error in data, for example datum error of surveying, calculation error occured by unknown factor and difference between estuary tidal fluctuation and tide tabl of Penan. Since it is serious in inoundation problem, it is necessary to consided its influnce.

(5) attempt operation
The attempt opration should be carried out step by step and be started from the day when tide is lower than R.L. 1.0 m (tide table 2.4 m) and becomes gradually higher. The observation of water level at estuary, up and downstream of the Barrage and upstream area should be carrid out.

(6) advanse release
In spite of lower level the water level becomes over N.I.W.L. after closing gate. It means that advance releae is necessary for a large inflow, especially in rainy season.

In total inflow of 10 cu.m/sec, wate level rises about 0.25 m in 9 hours in simulation.

(7) reform of the gate operation procedure
The procedure of this report is one example guidance of gate operaion. Therefore, this procedure must be improved to get the better operation procedure based on th experience of practical operation.

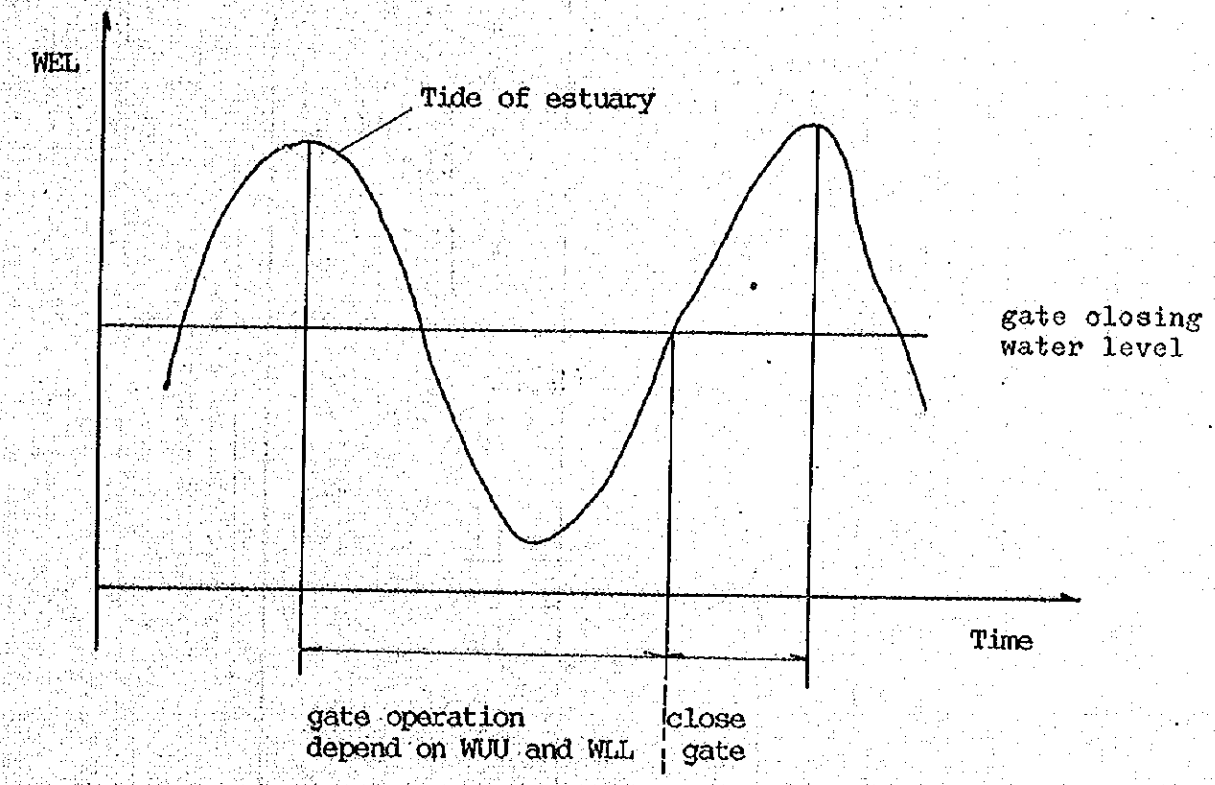


Fig.8-1 (1) outline of gate operation procedure

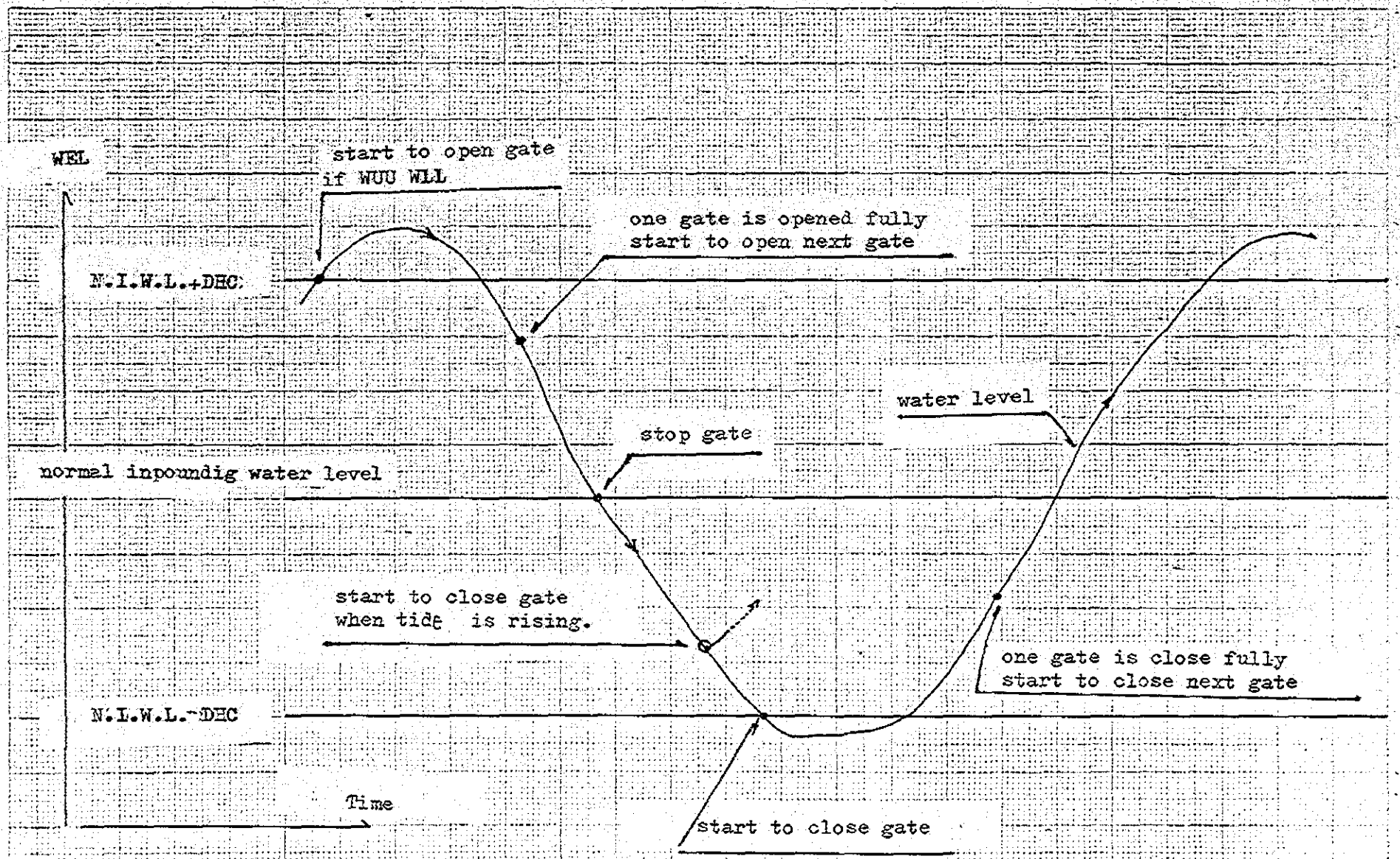


Fig.8-1 (2) outline of gate operation procedure

IX. Conclusion and Recomendation

IX. Conclusion and Recomendation

The peak water level on downstream of the Barrage becomes higher than that on the estuary when gates are operated, and high tide in spring tide is higher than the ground level of lowlying area near the Barrage. Therefore, the embankment should be constracted for safty and freely gateoperation.

The flood discharge in F/S is estimated to be analyzed on the assumption that the area is developed. Its peak is 580 cu.m/sec for 10 year return period. It is rather larger. The peak discharge of flood for 10 yeas return period is estimated to be approximately 100~300 cu.m/sce in existing condition.

The gate closing operation should be started early to prevent the ingresion of saline water taking into consideration rising tide at the estuary and the delay of operation.

The gates should be renewed, since the gate leaf are damaged by corrosion and the structure of gate requires delicate operation. At new gate construction, the structure should be considered that gate doesn't inclie.