CHAPTER III

CHAPTER III REHABILITATION MEASURES

1. Rehabilitation for Piers C and D

1-1 General ideas of rehabilitation for Piers C and D

According to the result of visual check by divers on the underwater portion of Piers C and D it was revealed that there existed many hollows and cracks near the boundary between the upper and middle parts of piers.

Therefore, particular emphasis is placed upon reinforcement near the boundary between the upper and middle parts in the planning for repair of piers.

(1) Piers C and D will be reinforced with reinforced concrete covering of about 50 cm thickness around the pier structure.

(2) Piers will not be influeced by any horizontal force of extra-ordinary magnitude like earthquake. Therefore, it is estimated that the sectional area of the existing pier will be fully resistible against transitional horizontal force (such as braking load).

(3) Reinforcing bar will therefore be restrained to possible minimum volume.

(4) The repair work is planned for maximum possible saving of manpower because of its operational difficulty under the water.

For placing of reinforced concrete it is planned that the under-water portion will be enclosed with pre-packed concrete while the sturcture above the water will be enclosed with ordinary concrete. Reinforcing bars will be prefabricated on the ground and be set up in place. The mold of concrete will be built with a panel of about 15 m^2.

Fig. 3-1 thru 3-4 show general design for repair of Piers C and D.

1-2 Designing of rehabilitation for Piers C and D

Design calculations as stated in details in Appendix 3-1 (1) may be summarized as follows:

(1) Stress of piers after rehabilitation

Those sections taken up for study on stress are as shown in Fig. 3-5 for both Piers C and D. Combination of loads under study constitute;

dead load + train load + impact load + longitudinal load.

Loading conditions were calculated for the single track at present and for the double track as planned for the future.

The degree of stress is measured to the maximum at the joint between pier and caisson foundation. The measured values are very small as shown in Table 3-1.

Table 3-1 Stress on Piers C and D

		Unit	Pier C		Pier D	
			Single Track	Double Track	Single Track	Double Track
Sectional force	Moment	t·m	4,802	4,802	4,802	4,802
	Vertical force	t	5,093	5,528	5,104	5,539
	Horizontal force	t	232	232	232	232
Stress of concrete		kg/cm²	8.3	8.7	8.7	9.1
Stress of reinforcing bar		"	11	16	10	15
Shearing stress of concrete		"	0.3	0.3	0.3	0.3
Allowable stress of concrete		"	80	80	80	80
Allowable stress of reinforcing bar		"	1,800	1,800	1,800	1,800
Allowable shearing stress of concrete		"	7.0	7.0	7.0	7.0

(2) Stability calculation of caisson foundation after rehabilitation

Stability of the caisson foundation after rehabilitation of Piers C and D was calculated by due reference to the results of geological and scouring surveys. The purpose of this calculation is to confirm if the caisson foundation will be supported by the stabilized ground conditions.

The result of calculation is shown in Table 3-2.

Table 3-2 Caisson Stability Calculation (Safety Factor)

	Pier C		Pier D		Allowable Safety Factor (Fa)
	Single Track	Double Track	Single Track	Double Track	
Safety factor for vertical support	7.09	6.75	7.05	6.72	2.0
Safety factor for horizontal support	53.59	54.40	53.68	54.49	2.0
Safety factor for turning	9.22	9.34	9.23	9.35	2.0

1-3 Construction plan of rehabilitation for Piers C and D

Construction plan details are stated in Appendix 3-1 (3).

The rehabilitation method puts the emphasis at the boundary between the upper and middle stages of each pier by outer enclosure of reinforced concrete of 50 cm thickness in the circumference of the old pier structure. Reinforced concrete to be used for this purpose will be pre-packed concrete in the water and regular concrete above the water. Reinforcing bars will be prefablicated on the land to form up the network. The framework will be built up by crane with panels each of about 15 m^2.

Time schedule for this rehabilitation work is shown in Table 3-3 and sequential steps are shown in Figs. 3-5 and 3-6.

1-4 Particular specifications of rehabilitation for Piers C and D

Particular specifications specify further details in each of the following items of content as arranged for this rehabilitation work in Appendix 3-1 (4):

(1) General condition

(2) Preparatory work

(3) Temporary pier instruction

(4) Chipping work of pier

(5) Removal work of precast skirt

(6) Removal work of concrete block and rubble-mounds

(7) Dredging work

(8) Piling sand bags work

(9) Regular concrete

(10) Prepacked concrete

(11) Reinforcement

1-5 Construction cost estimation of rehabilitation for Piers C and D

As per annexed in Appendix 3-1 (5).

2. Resetting of Shoes

2-1 General ideas of shoes resetting

The result of measurement reveals that movable shoes and links have been moved largely, some beyond the possible limit of displacement.

As some of those shoes far out of their normal positions may not serve well with their functional role, it has been planned that those shoes should be reset aright toward normal position.

(1) Those movable shoes at Abutments A and F, Piers B and the link should be reset into their normal positions.

(2) The shoe only at Pier E are moved less than all the rest, having potential to further displacement. Resetting is not necessary.

(3) For resetting of shoes at Abutments A and F, the work will be done in such a way that the upper half of each movable shoe will be moved to set at the center of the lower half by taking apart set bolts of the upper half of shoe from the lower chord of truss and jacking up end floor beam of truss.

(4) For resetting of shoes at Pier B and link, the girder will be jacked up by the lower chord after cutting the welded joint between the lower half of the fixed shoe at Pier C and the base plate. Then, the movable shoes at Pier B and link will be reset into their correct positions by simultaneous transfer of both anchor truss and suspend truss in a longitudinal direction toward the Haad Yai side.

Figs. 3-7 thru 3-9 show general planning for resetting of shoes.

2-2 Designing of shoes resetting

In the designing calculation (as detailed in Appendix 3-2 (1)), studies were made for reinforcement of member components, designing of necessary jigs and arrangement of necessary equipment with regard to resetting of shoes for both simple truss and anchore truss. The result of studies may be summarized as follows:

(1) Loading condition

Dead load to be taken into consideration for designing calculation was based on the calculated value of the existing bridge on a larger side by comparison between the value of the existing and improved bridges. A marginal tolerance of 20% was assumed for as the unbalanced reaction force acting upon the jack from both-side trusses.

Reaction Force at Each Shoe from Dead Load on the Existing Bridge (ton/shoe)

Span / Side / Shoe	Simple, Suspended		Anchor	
	Railway	Highway	Railway	Highway
Movable	129.9	147.2	110.1	119.1
Fixed	129.9	147.2	405.2	449.5

(2) Allowable stress

Allowable stress of member components being used for the Bridge was taken from the original standard values (as specified by British standard) and other stiffening components were based on the specifications of both SRT and JNR.

(3) Simple truss

The end beam will be jacked up for resetting of the shoe. Assuming that reaction force against jack would be about 180 tons allowing for some unbalance, the jack capable of 250 tons will be used. The end beam must be welded up with the new stiffener, in addition to the existing one, at the position where the jack will be set against the beam.

(4) Anchor truss

The jack will be set against the lower chord member to raise up and transfer longitudinally the truss for resetting of shoes. Reaction force at the jack position is estimated at about 540 tons allowing for some unbalance. The new stiffener will be fixed up, in addition to the existing stiffener, by use of high tension bolts. Two (2) jacks, each capable of 300 tons, will be used for this purpose. Since horizontal force acting upon the jack to be used for longitudinal transfer is estimated at about 60 tons per each main truss, the jack capable of 100 tons will be used. Horizontal force to act upon Piers B and C in the case of transfer aggregates to a total of about 51 tons for main trusses on both sides.

(5) Stiffening to existing member components and setting method of jig

Since the existing components are not suited as the material for welding, high tension bolts was used for stiffening to all member components and fixing of the jigs to the cross beam, and welding was adopted only in unavoidable case.

2-3 Construction plan of shoes resetting

The construction plan (as detailed in Appendix 3-2 (3)) proposed the resetting work of shoes for both simple truss and anchor truss. The method of shoe resetting was planned with special consideration to the working easiness. For the simple truss the setting bolts will be taken out of the movable shoe and only the upper shoe will be moved for centering with the lower shoe after the end beam will have been jacked up. For the anchor truss, the fixed shoe of Pier C will be cut apart from the base plate at the lower shoe and the shoe and link will be reset by longitudinal transfer of both anchor truss and suspended truss in both entirety.

Sequential steps for resetting are shown in Figs. 3-10 and 3-11 and time schedule is indicated in Figs. 3-12 thru 3-14.

2-4 Particular specifications of shoes resetting

Particular specifications specify details on the resetting work in each of the following items as arranged in Appendix 3-2 (4).

1. General Condition

2. Rehabilitation on girders and Shoes

2-1 Material

2-2 Cutting and machining

2-3 Welding

2-4 High tension bolt joint

2-5 Rivet removal

2-6 Painting

3. Rehabilitation of Base of Shoes

3-1 Mortar

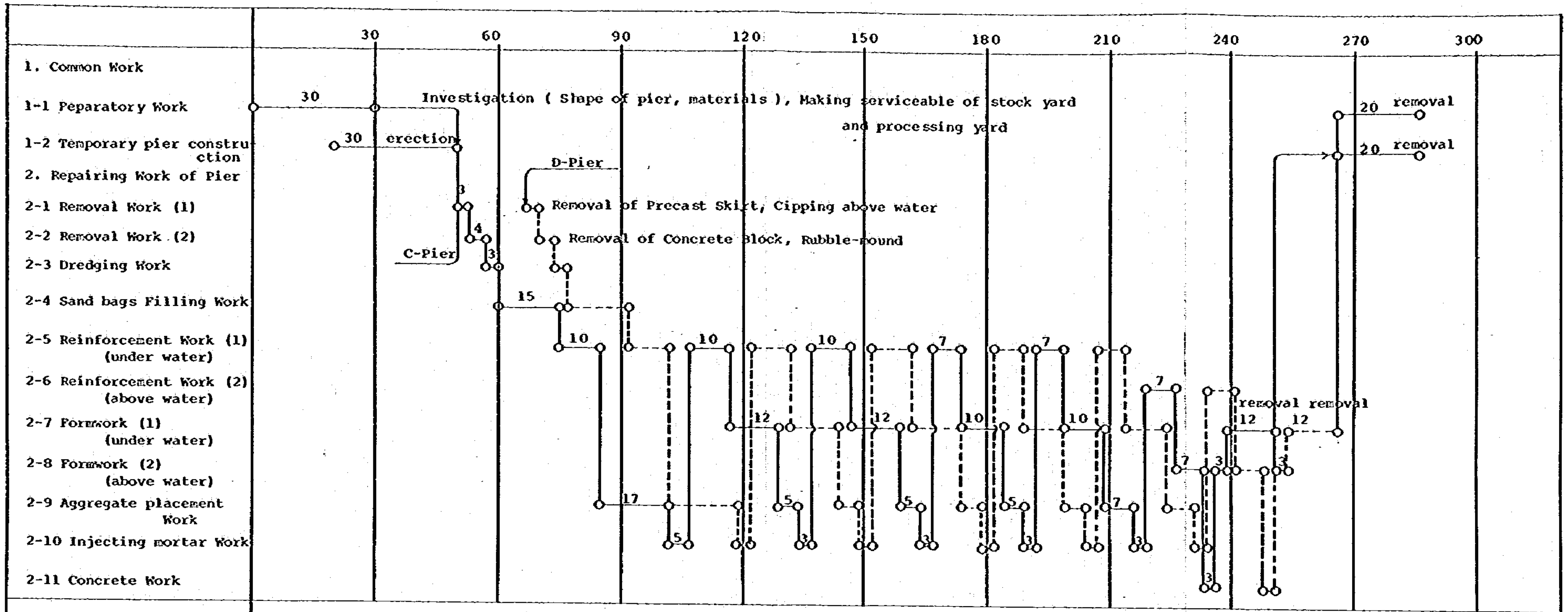
3-2 Concrete

3-3 Fixing of anchor bolts

2-5 Construction cost estimation of shoes resetting

As per annexed in Appendix 3-2 (5).

Table 3-3 NETWORKS OF RAMA VI BRIDGE REPAIR PIERS C AND D

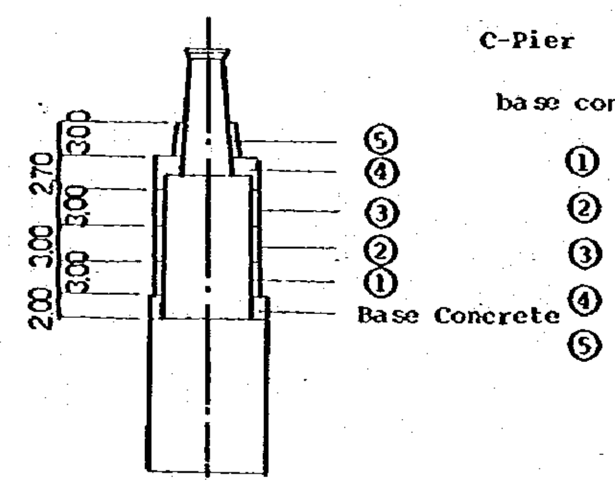


Stage of Each Lift Work

C-Pier	Base Concrete	① lift	② lift	③ lift	④ lift	⑤ lift	removal
D-Pier	Base Concrete	① lift	② lift	③ lift	④ lift	⑤ lift	removal

Outline of Shape

Outline of Quantity



C-Pier	Concrete	Forms	D-Pier	Concrete	Forms
base concrete	286 m³		base concrete	273 m³	
①	175 "	503 m²	①	154 "	525 m²
②	175 "		②	164 "	
③	175 "		③	173 "	
④	206 "		④	194 "	
⑤	106 "	111 "	⑤	95 "	111 "

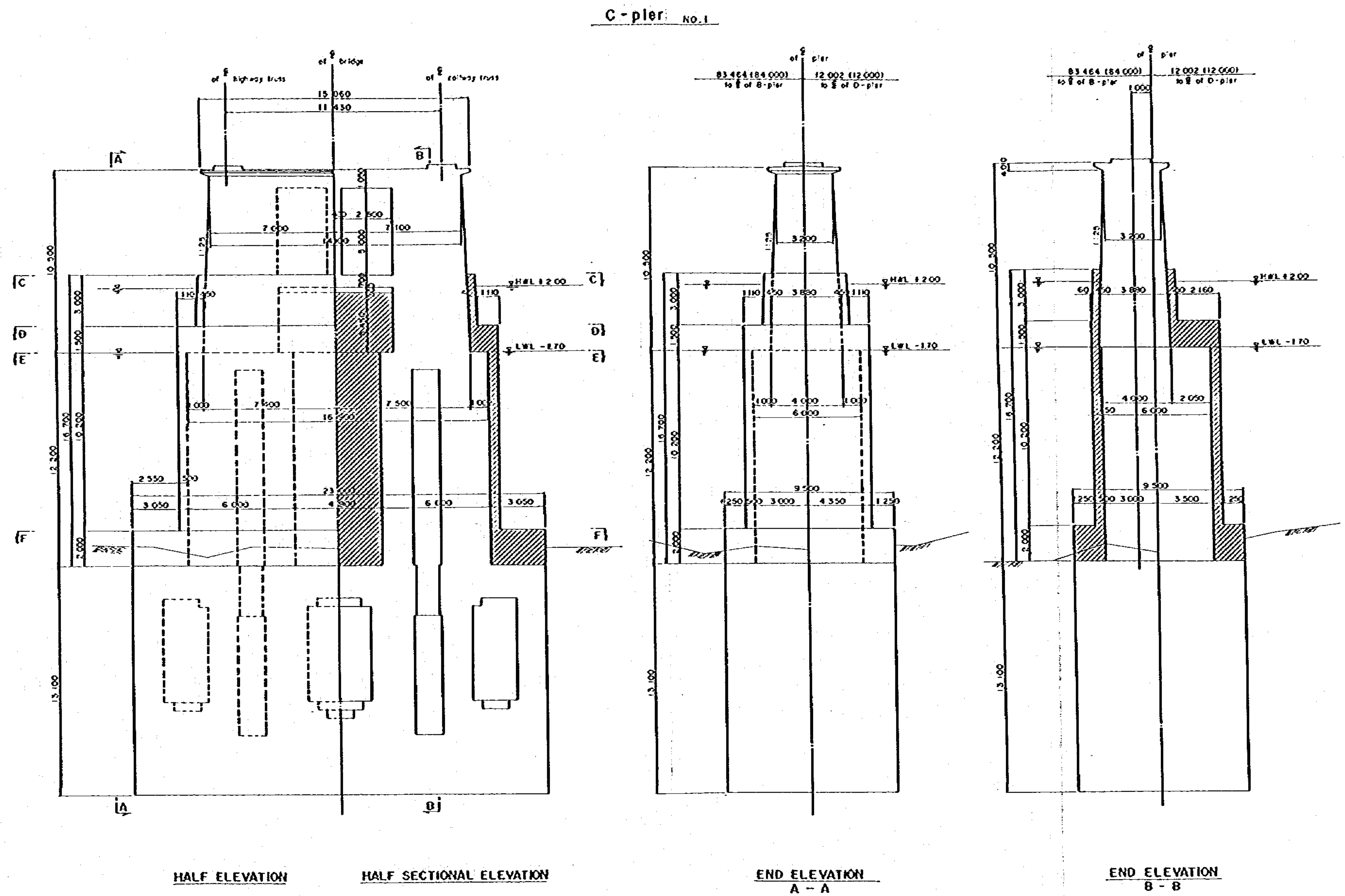
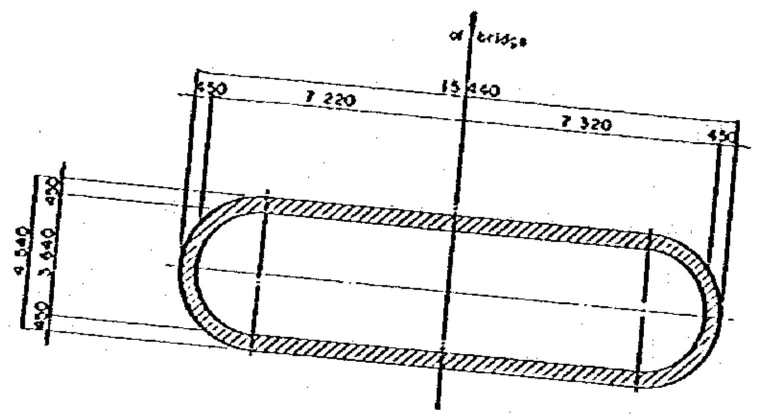
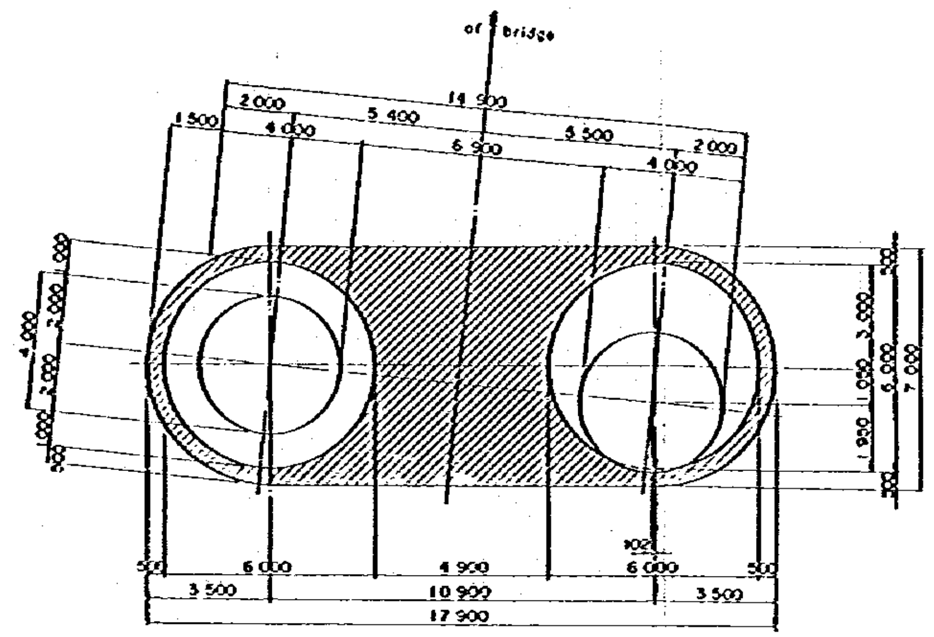


Fig. 3-1 C-Pier Rehabilitation Plan No. 1

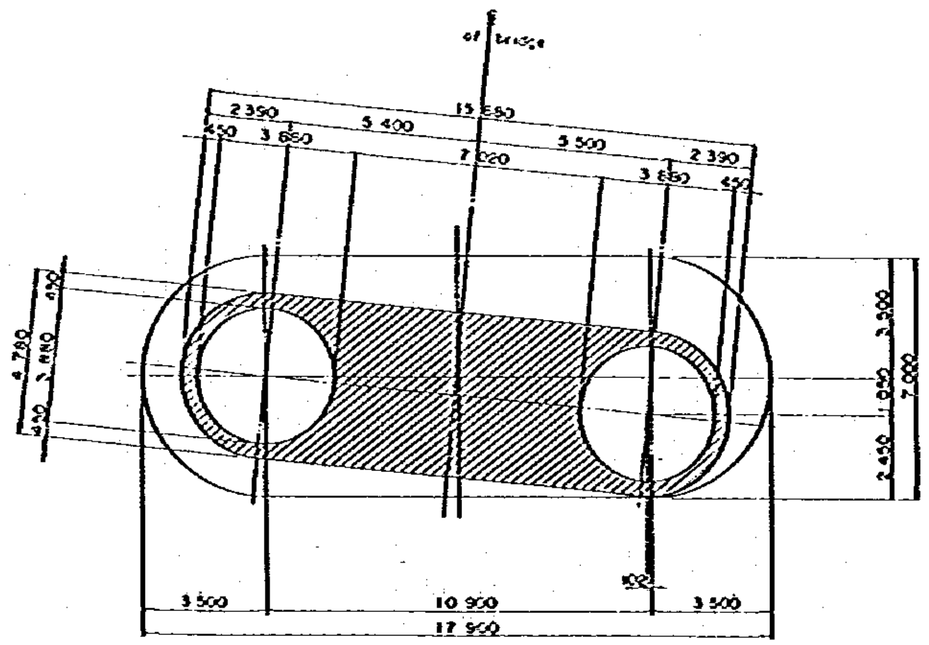
C - pier NO. 2



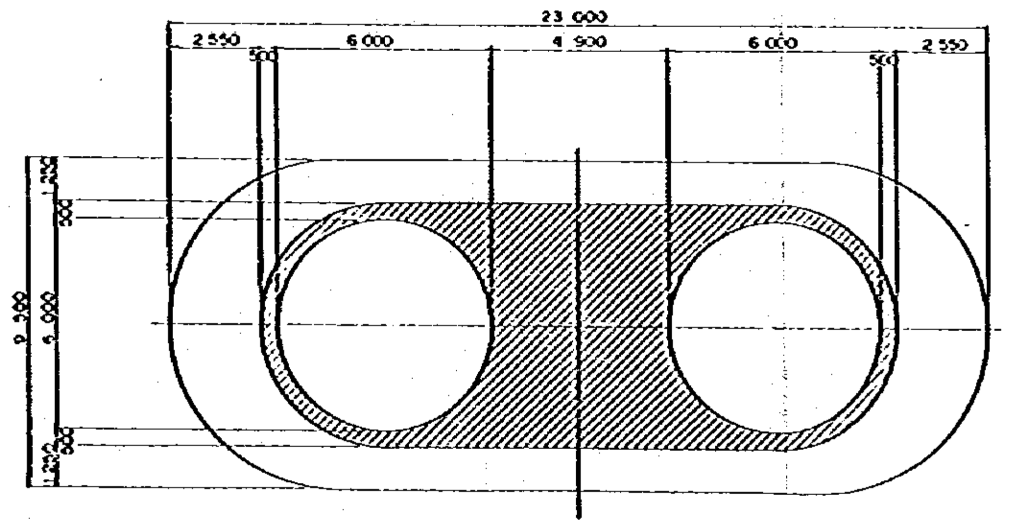
PLAN ON C - C



PLAN ON E - E



PLAN ON D - D



PLAN ON F - F

Fig. 3-2 C-Pier Rehabilitation Plan No. 2

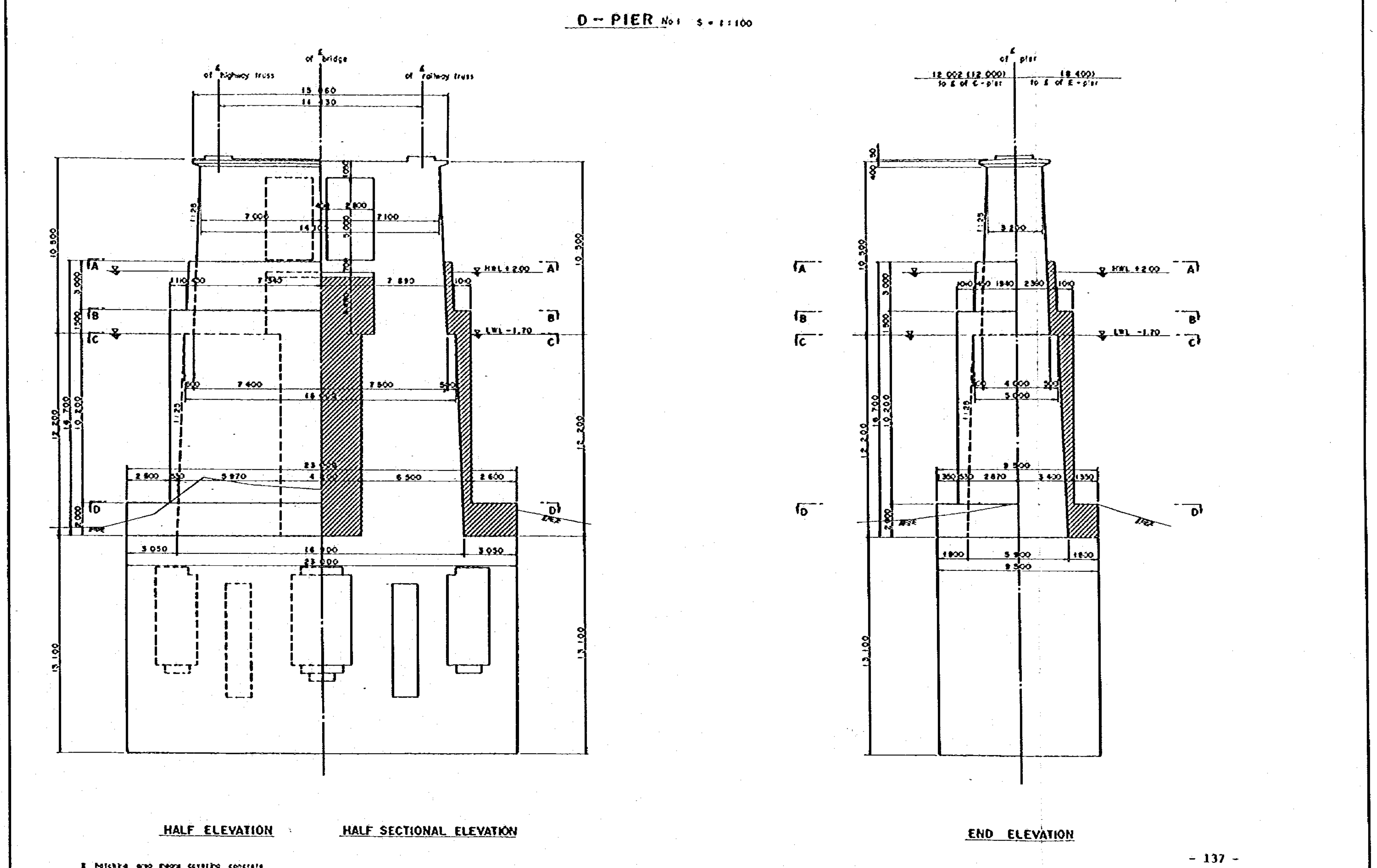
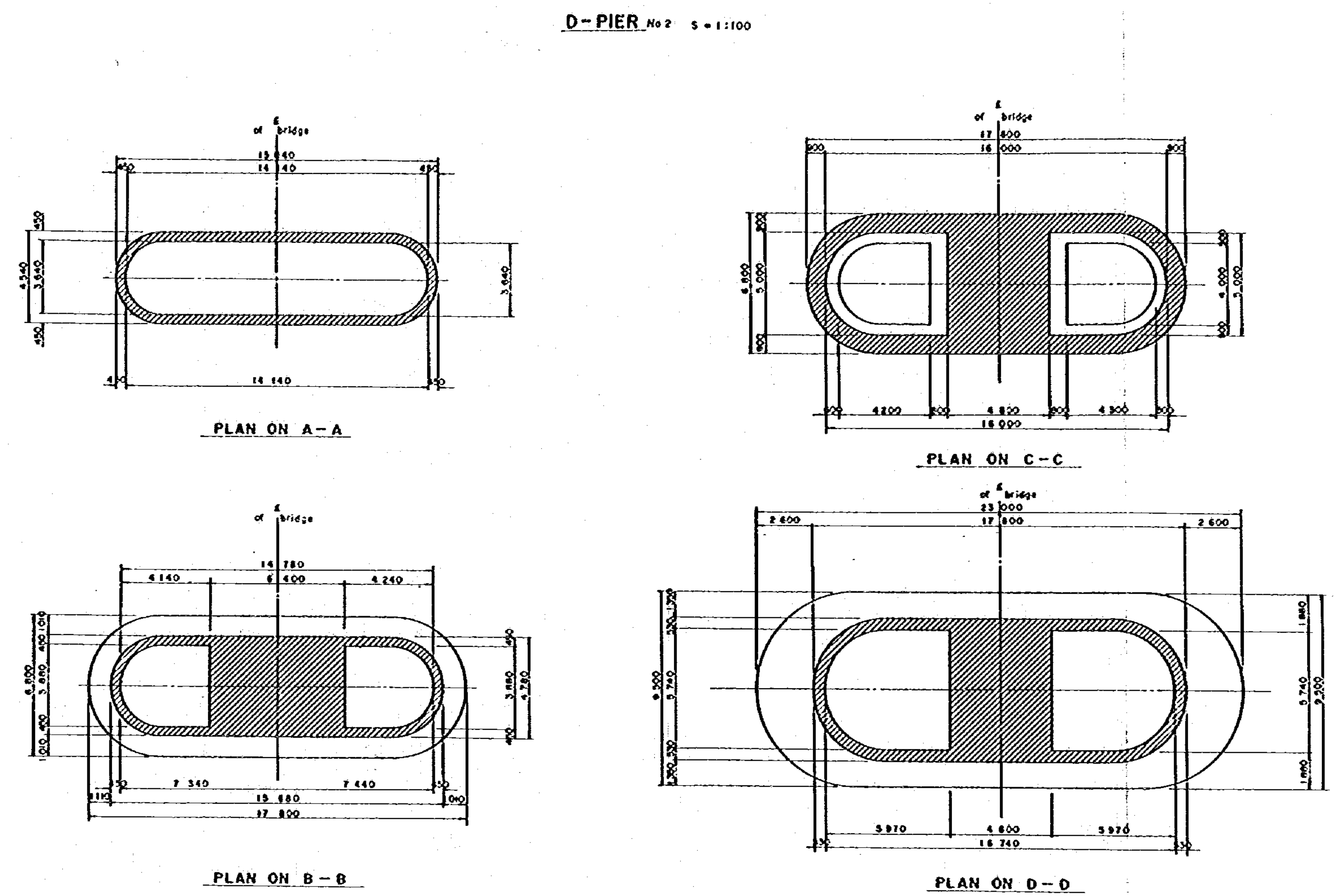


Fig. 3-3 D-Pier Rehabilitation Plan No. 1



※ hatching area means covering concrete

Fig. 3-4 D-Pier Rehabilitaiton Plan No. 2

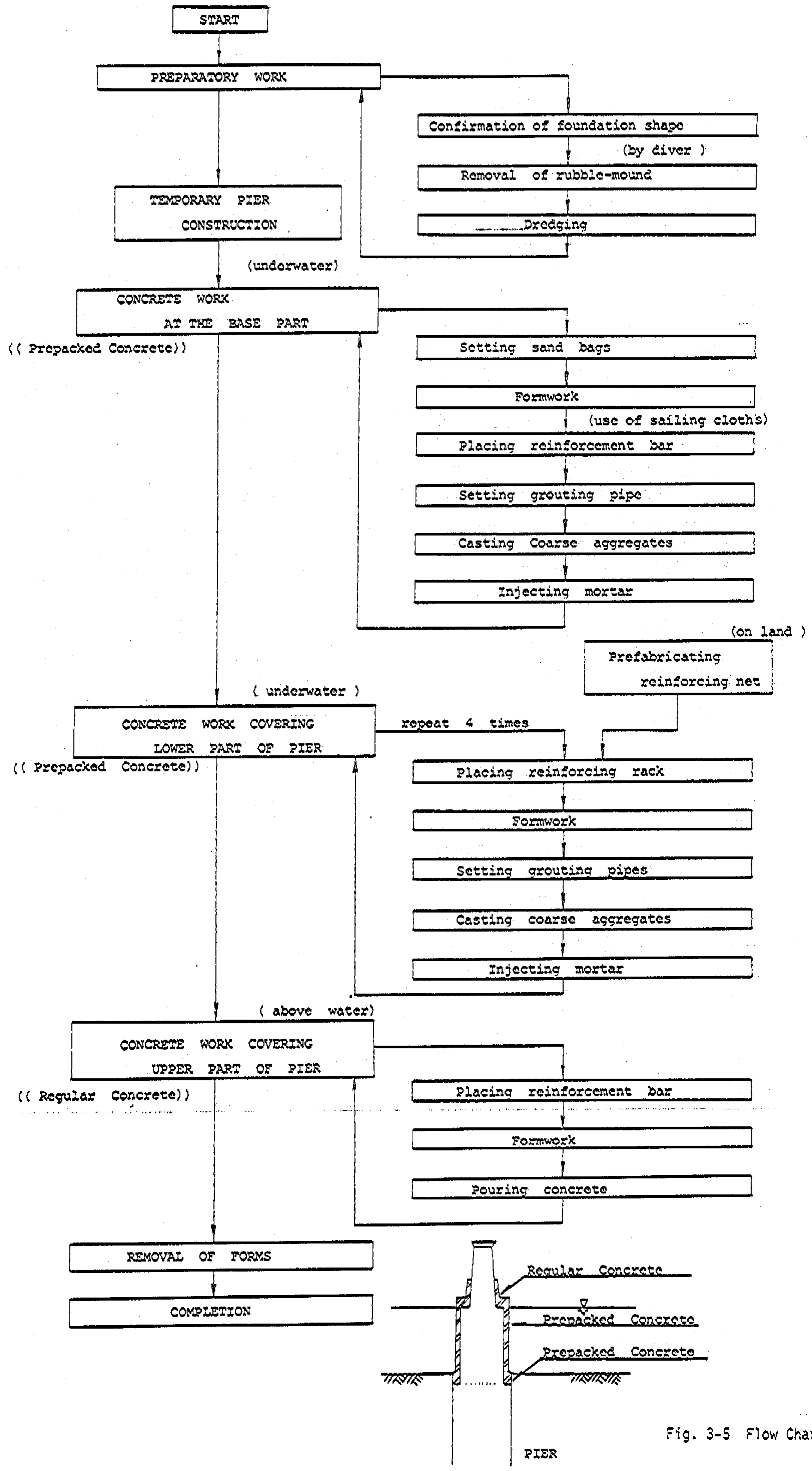
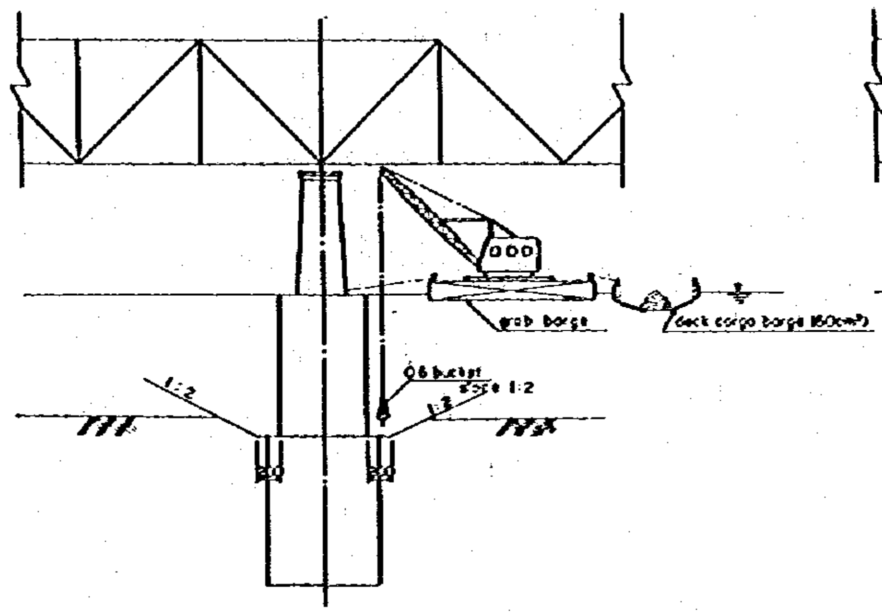
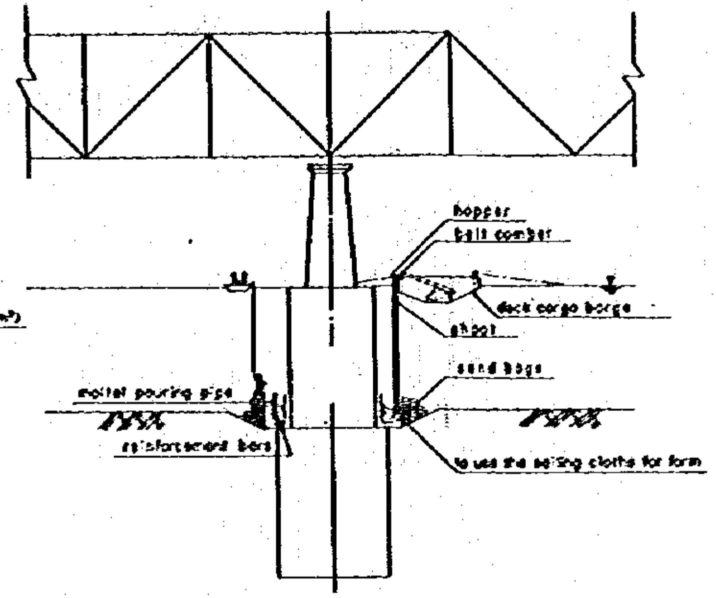


Fig. 3-5 Flow Chart of Construction



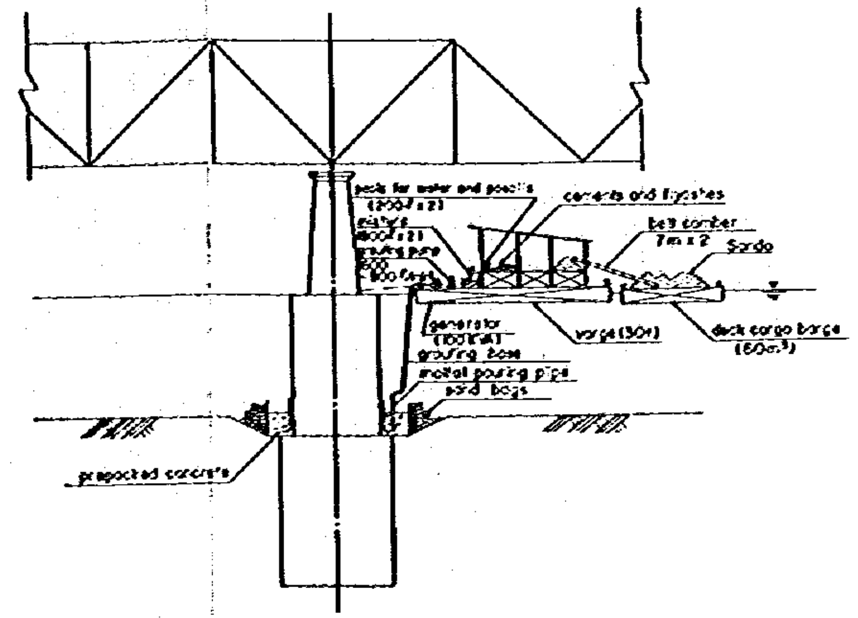
No. 1 Digging and remaking work

1. To remove riprap at the top of the caisson
2. To remove falling precast skirts
3. To dig the ground at the width of 2.00 m from the surface of the pier until the top of the caisson can be seen.



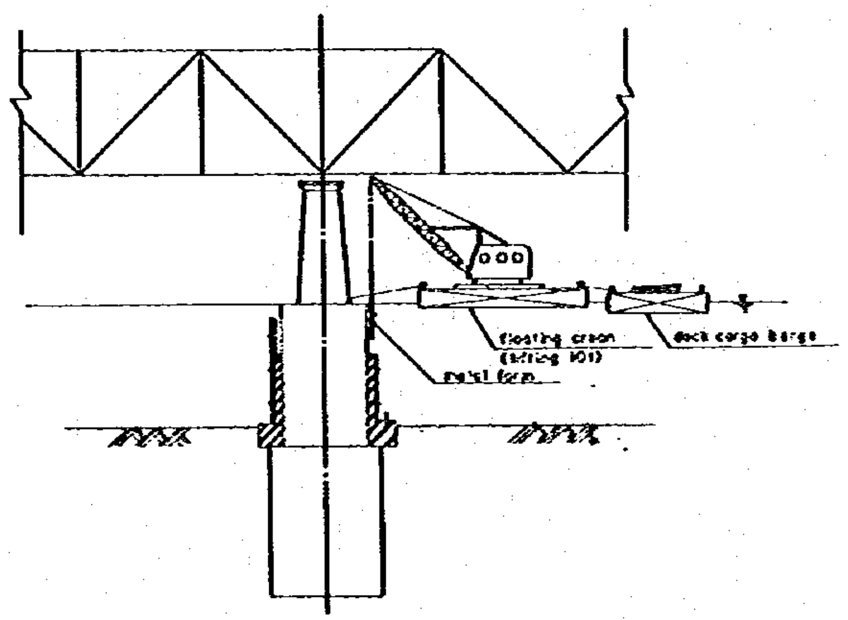
No. 2 Shooting of the aggregates

1. To use sailing cloths for foundation form and to make construction of base concrete at the width of 2.00 m from the surface of the pier, and at the height of 2.00 m from the top of the caisson.
2. Steel pipes of Φ1½" are used for pouring, and to set them with reinforcement bars (1 pipe/2 m²)
3. To fall down aggregates (30~100 mm diameter) by the way of shoot from barge.
4. Diving works are 1) to make the ground flat, 2) to pile up sand bags, 3) to set sailing cloths, 4) to set pouring pipes, 5) to make the aggregates flat, 6) to clean the old pier in the water.



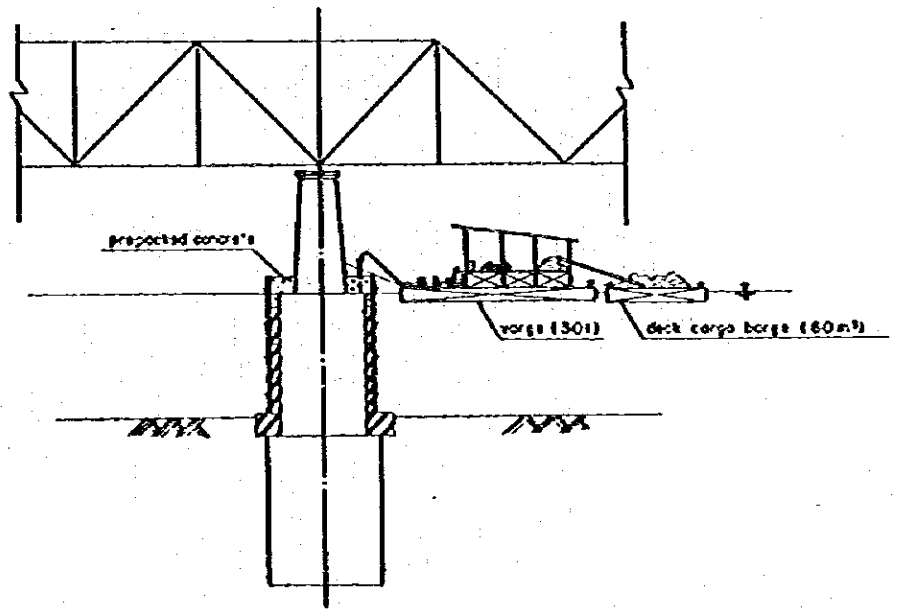
No. 3 Pouring the mortar

1. To connect a mortar plant boat with pouring pipes by grouting hose, and to grout the mortar by pump.
2. To pour the mortar every pipe in order to make the surface of the mortar flat.
3. To take off the pipes after pouring, to cure for specified days, and to take off the foundation form.



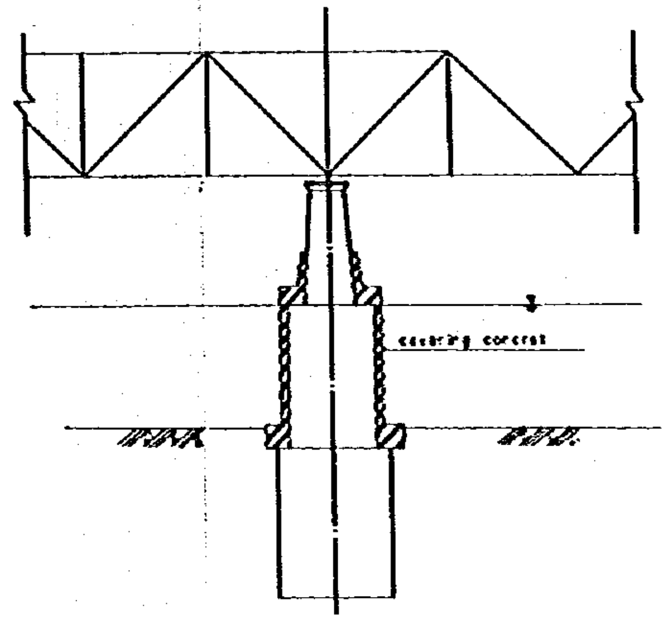
No. 4 Setting of reinforcement bars and metal form

1. To pour prepacked concrete 5 times for covering the pier.
2. To set reinforcement bars and metal form by lifting from a floating crane.



No. 5 Concreting

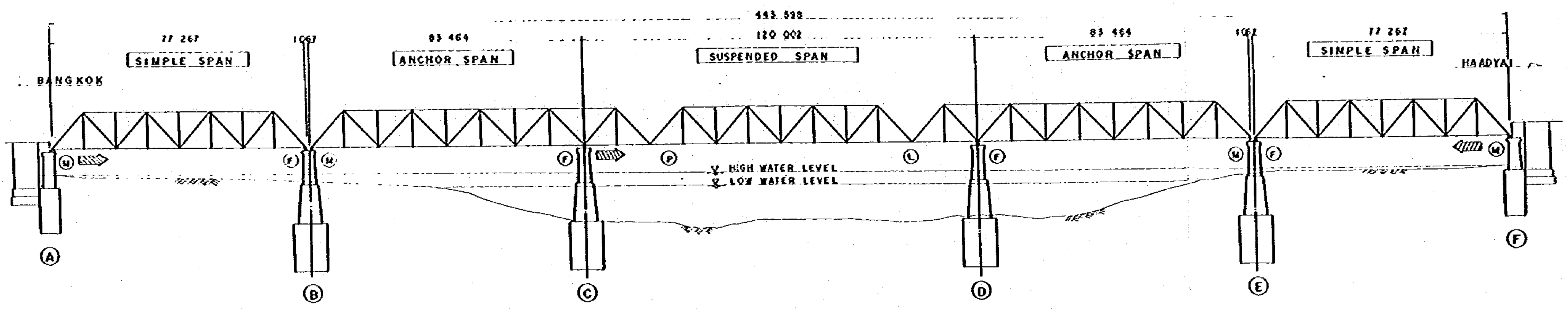
1. Covering concret are used by prepacked concrete. The procedure is the same as No. 3.
2. The part above the water is to be chipped at the surface of the pier before concreting, and to be covered by portland cement concrete.

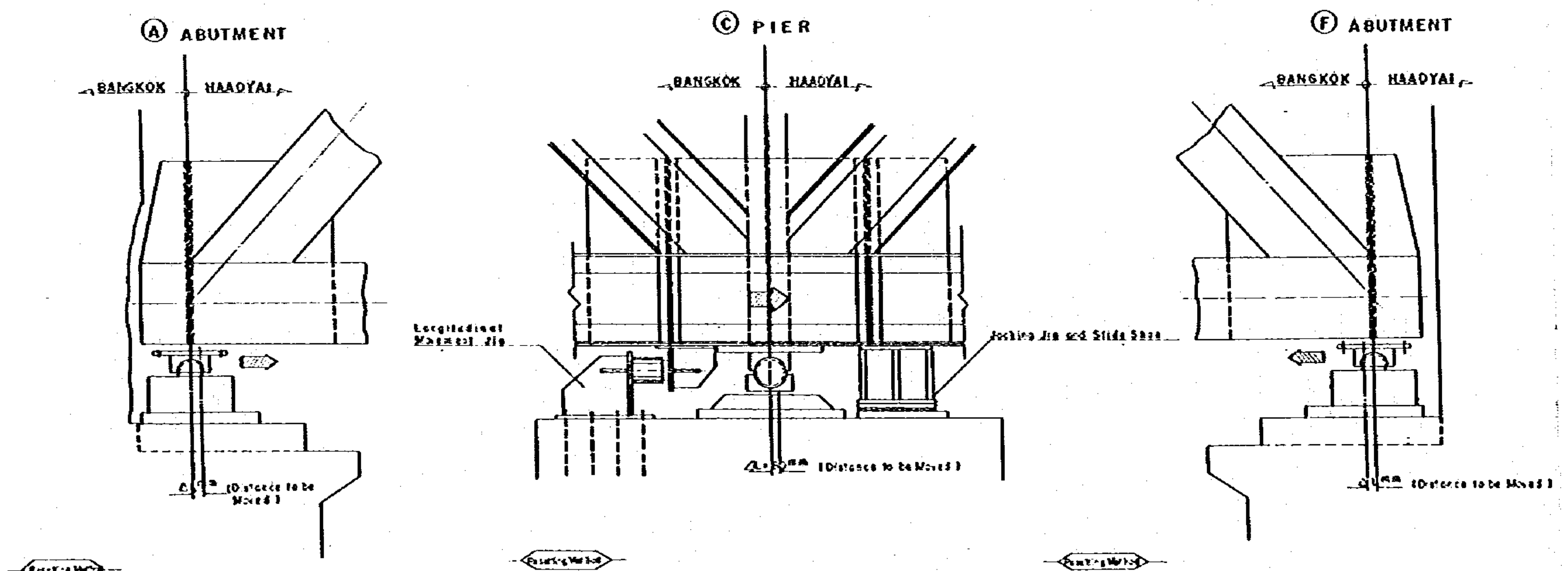


No. 6 Completion

Fig. 3-6 Construction Procedure

Fig. 3-7 RESETTING SCHEME FOR BRIDGE BEARINGS SHOES





Displacement (mm) of Movable Shoes and Link Sections

Position	Truss	Before Reset B*	Before Reset H**	After Reset B*	After Reset H**
Ⓐ	R	72		—	—
	H	76		—	—
Ⓑ	R	56			4
	H	64		4	
Ⓛ	R	61		1	
	H	66		6	
Ⓔ	R	15		15	
	H	21		21	
Ⓕ	R		76	—	—
	H		63	—	—

NOTES : * B denotes the displacement in the direction of BANGKOK.

** H denotes the displacement in the direction of HAADYAI.

R denotes the Railway Truss.

H denotes the Highway Truss.

Remove the setting bolts from the upper Shoes jack up the floor beam, and shift only the upper Shoes toward HAADYAI by ΔL mm.

Detach the lower Shoes from the baseplate at the welding spot, jack up the lower chord member, and shift the anchor span and suspended span toward HAADYAI by 60 mm.

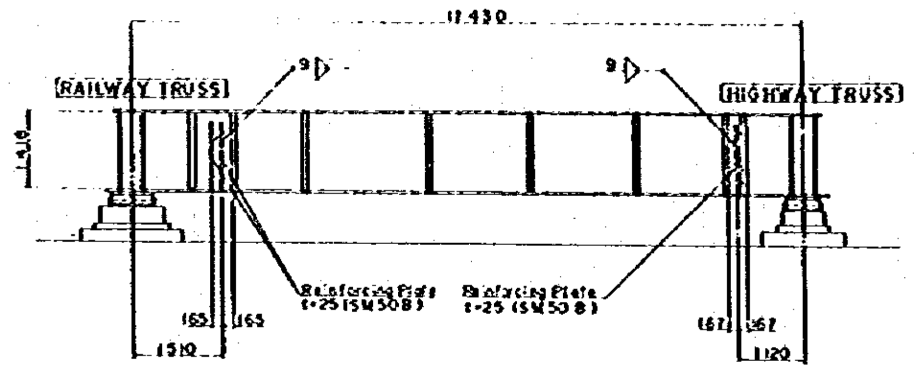
Remove the setting bolts from the upper Shoes, jack up the floor beam, and shift only the upper Shoes toward BANGKOK by ΔL mm.

RAMA VI BRIDGE REHABILITATION PROJECT
RESETTING OF SHOES
RESETTING SCHEME FOR BRIDGE SHOES

Fig. 3-8 WORKING SEQUENCE FOR SIMPLE SPANS (MOVABLE SHOES) S: 1/60

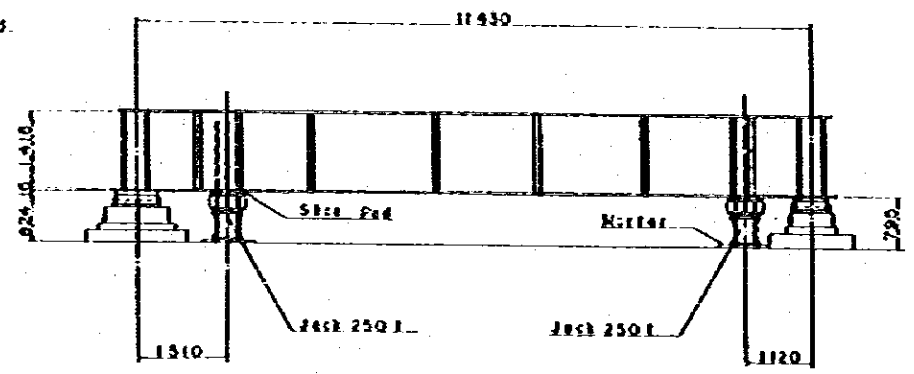
① Reinforcement of Floor Beams

1. Erect stagings.
2. Perform the field welding of vertical reinforcement ribs.



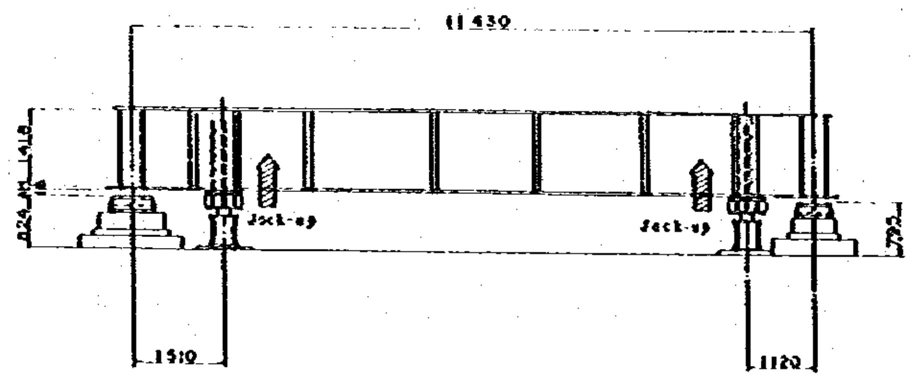
② Installation of Jacks

1. Place mortar at the positions where jacks are to be positioned.
2. Install jack boxes and pedestal with Shoe pad with recesses to protect rivet heads.
3. Remove rivets which will be in the way of the shifted upper Shoe plates and plug rivet holes.



③ Jack up Operation

1. Remove the setting bolts.
2. Jack up the beam.

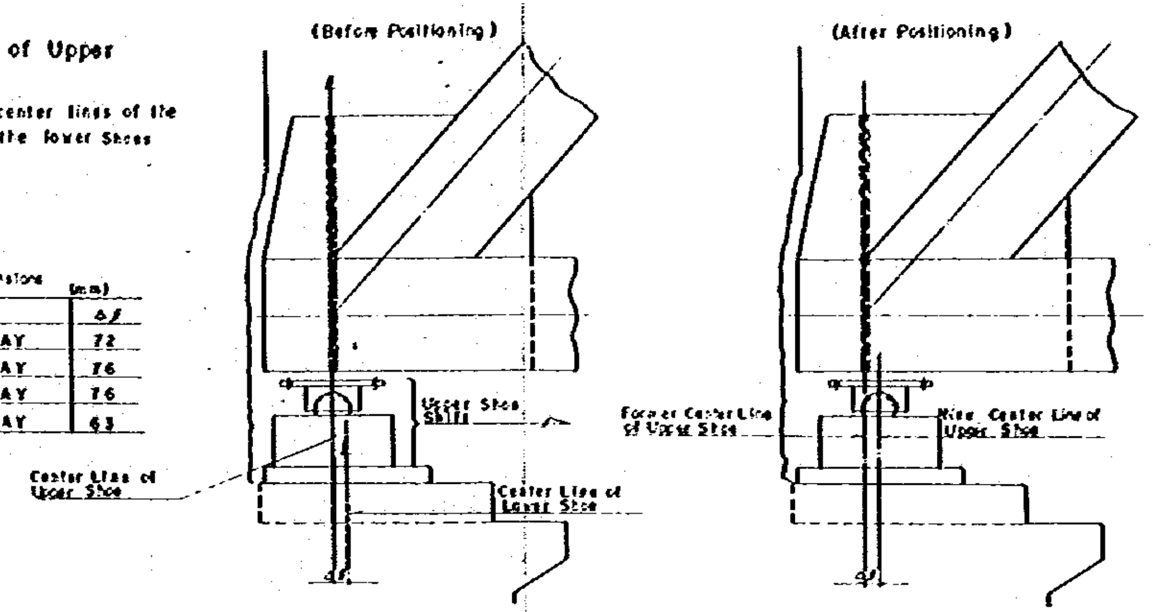


④ Positioning of Upper Shoes

1. Align the center lines of the upper and the lower Shoes

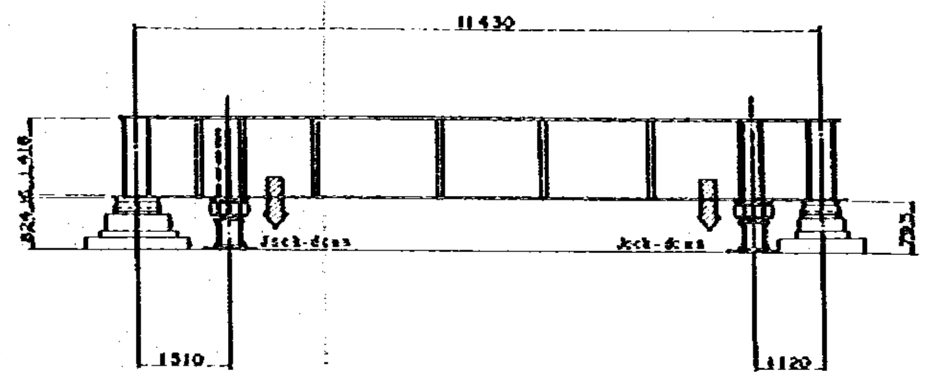
Table of Dimensions (mm)

ABUTMENT	SIDE	δ
A	HIGH WAY	72
	RAIL WAY	76
F	HIGH WAY	76
	RAIL WAY	63

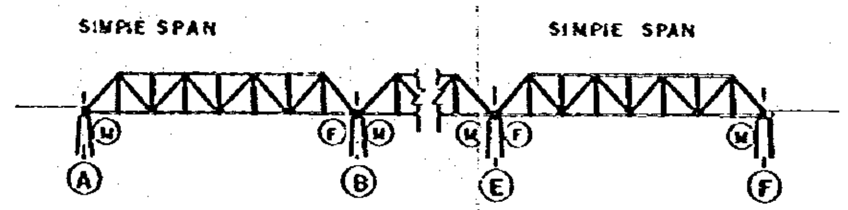


⑤ Lower Jack

1. Jack down the beam.
2. Drill bolt holes on the truss chord at spot corresponding with upper Shoe plate holes.
3. Insert the setting bolts and tighten them.
4. Plug the abandoned holes in the lower chord.



MARKING DIAGRAM

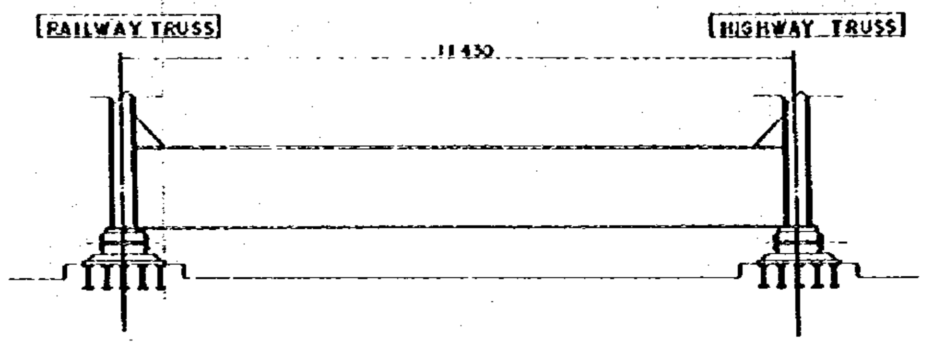


RAMA VI BRIDGE REHABILITATION PROJECT
RESETTING OF SHOES
WORKING SEQUENCE FOR SIMPLE SPANS (MOVABLE SHOES)
2

Fig. 3-9 WORKING SEQUENCE FOR ANCHOR SPANS (FIXED SHOES)

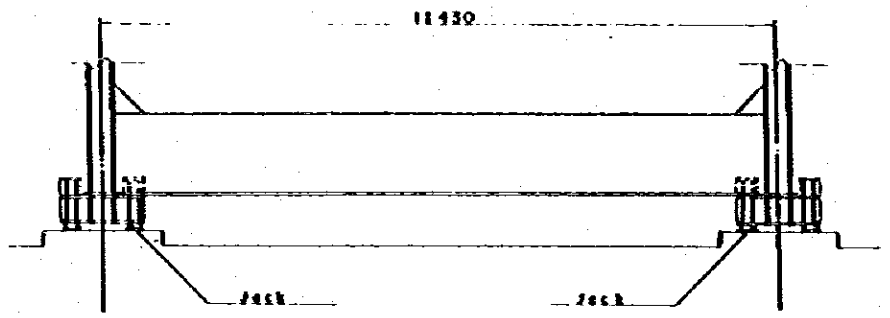
① Reinforcement of Lower Chord Members and Extension of Concrete Pedestals

1. Erect stagings.
2. Extend the concrete pedestals.
3. Install reinforcement stiffeners at the jack up location of the lower chord.
4. Install longitudinal movement jigs



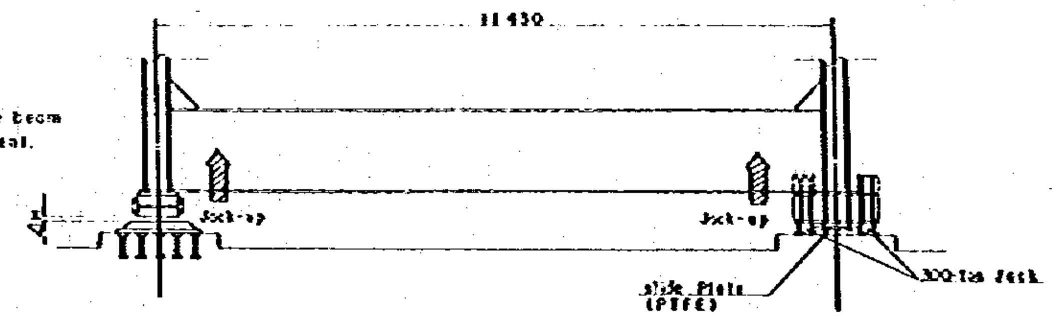
② Installation of Beam Jacking and Moving Equipment

1. Install beam jacking and moving equipment.



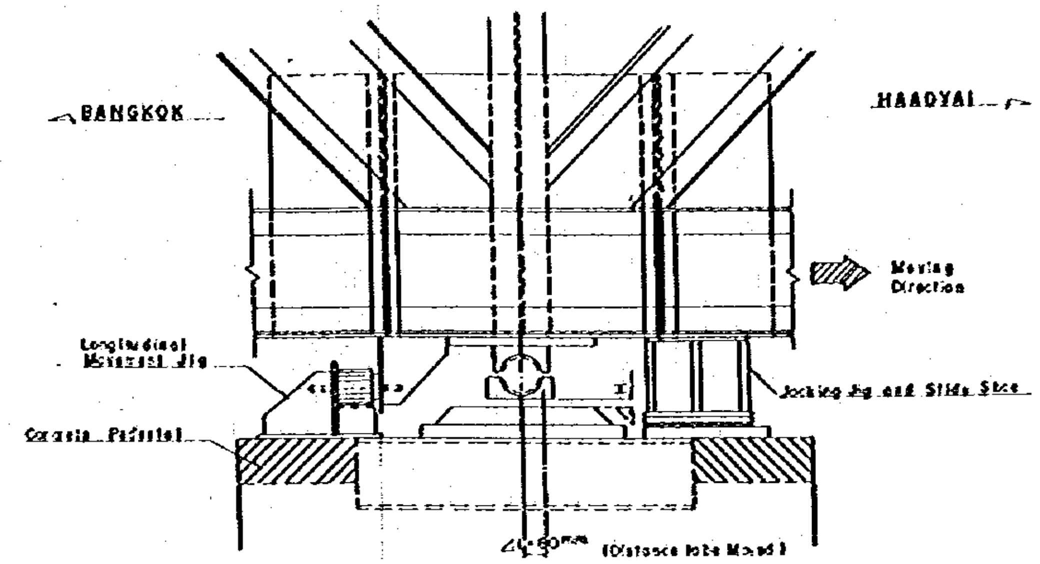
③ Jack-up Operation

1. Separate the lower Shoes from the Shoe baseplates by arc gouging.
2. Jack up the beam (δ = approx. 70mm)
3. Set the slide plate on the beam jacking and moving equipment.



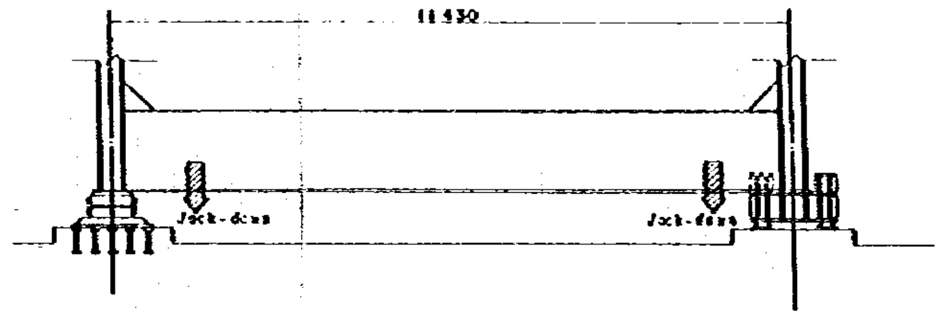
④ Movement toward HAADYAI

1. Clean the contact surfaces between the baseplate and the lower Shoe
2. Transfer the reaction to the slide Shoe by lower Jack.
3. Move the beam in the longitudinal direction.
4. Jack up the beam.
5. Remove the upper Shoes and slide plates of Jacking Jig.

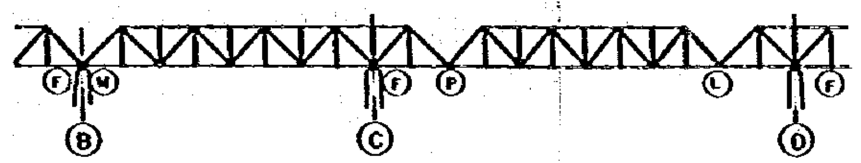


⑤ Lower Jack

1. Jack down the beam.
2. Weld the baseplates and lower Shoes together at the field.
3. Remove the jack.



MARKING DIAGRAM



RAMA VI BRIDGE REHABILITATION PROJECT

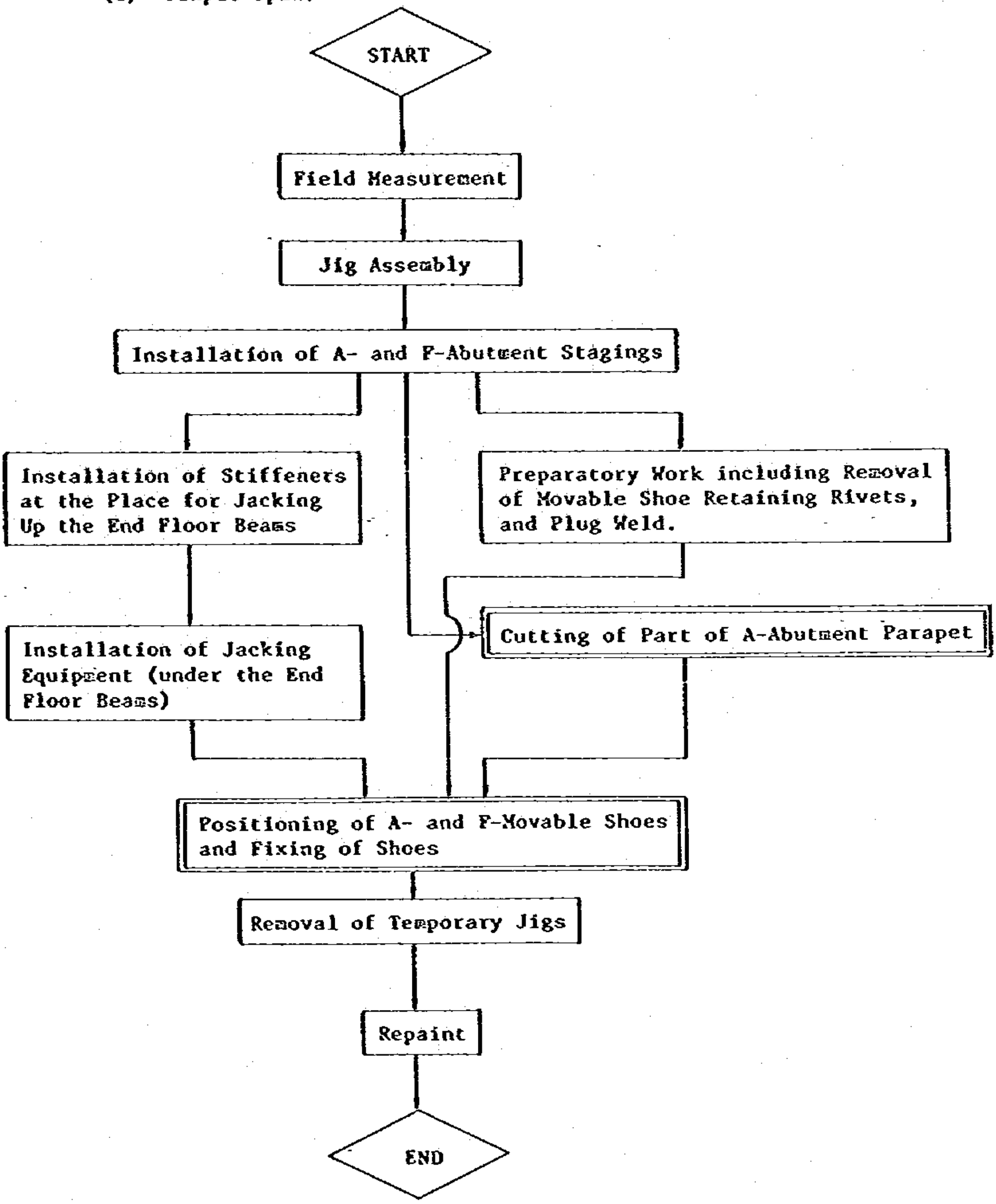
RESETTING OF SHOES

WORKING SEQUENCE FOR ANCHOR SPANS (FIXED SHOES)

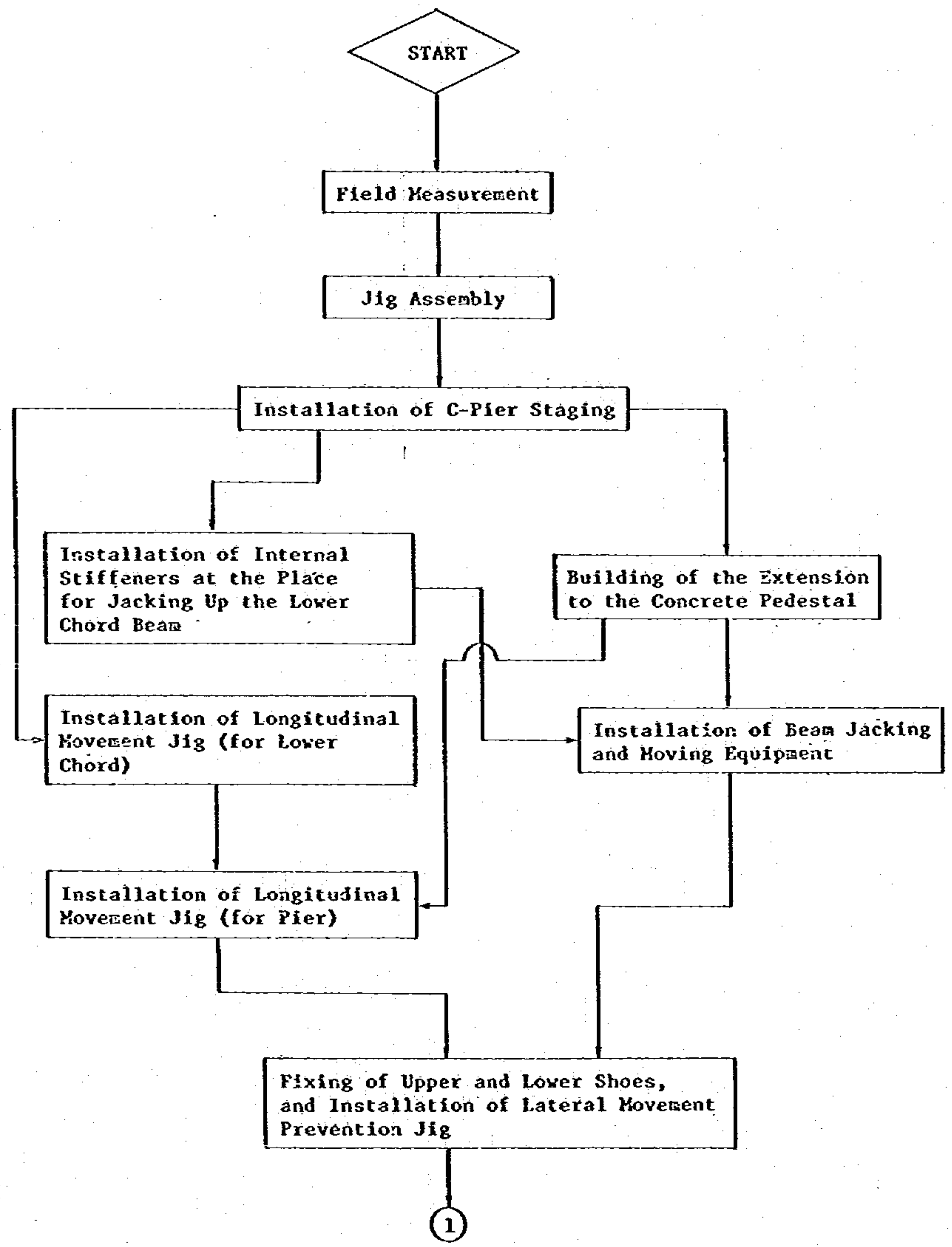
6

Fig. 3-10 Working Flowchart

(1) Simple Spans



(2) Anchor Span



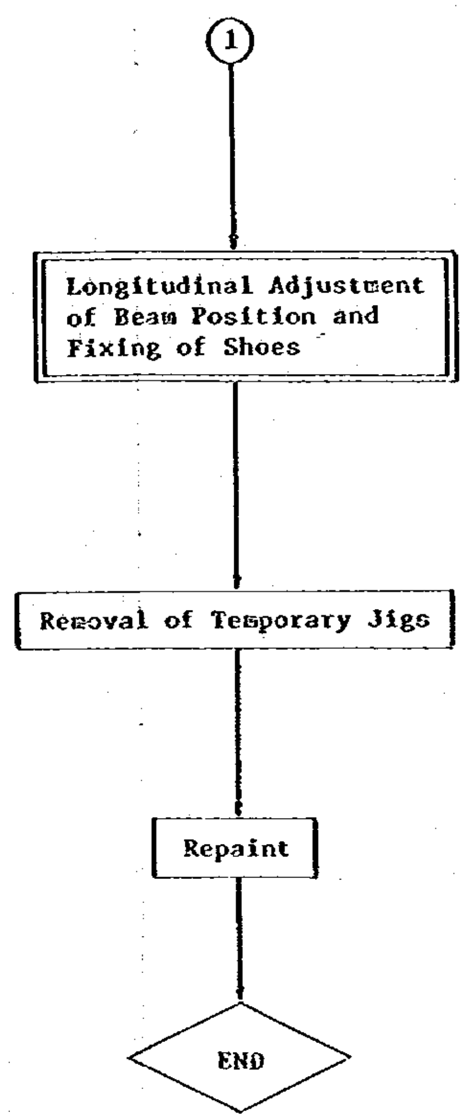


Fig. 3-11 Working Flow Chart

SCHEDULE

Fig. 3-12 OVERALL PROGRESS SCHEDULE

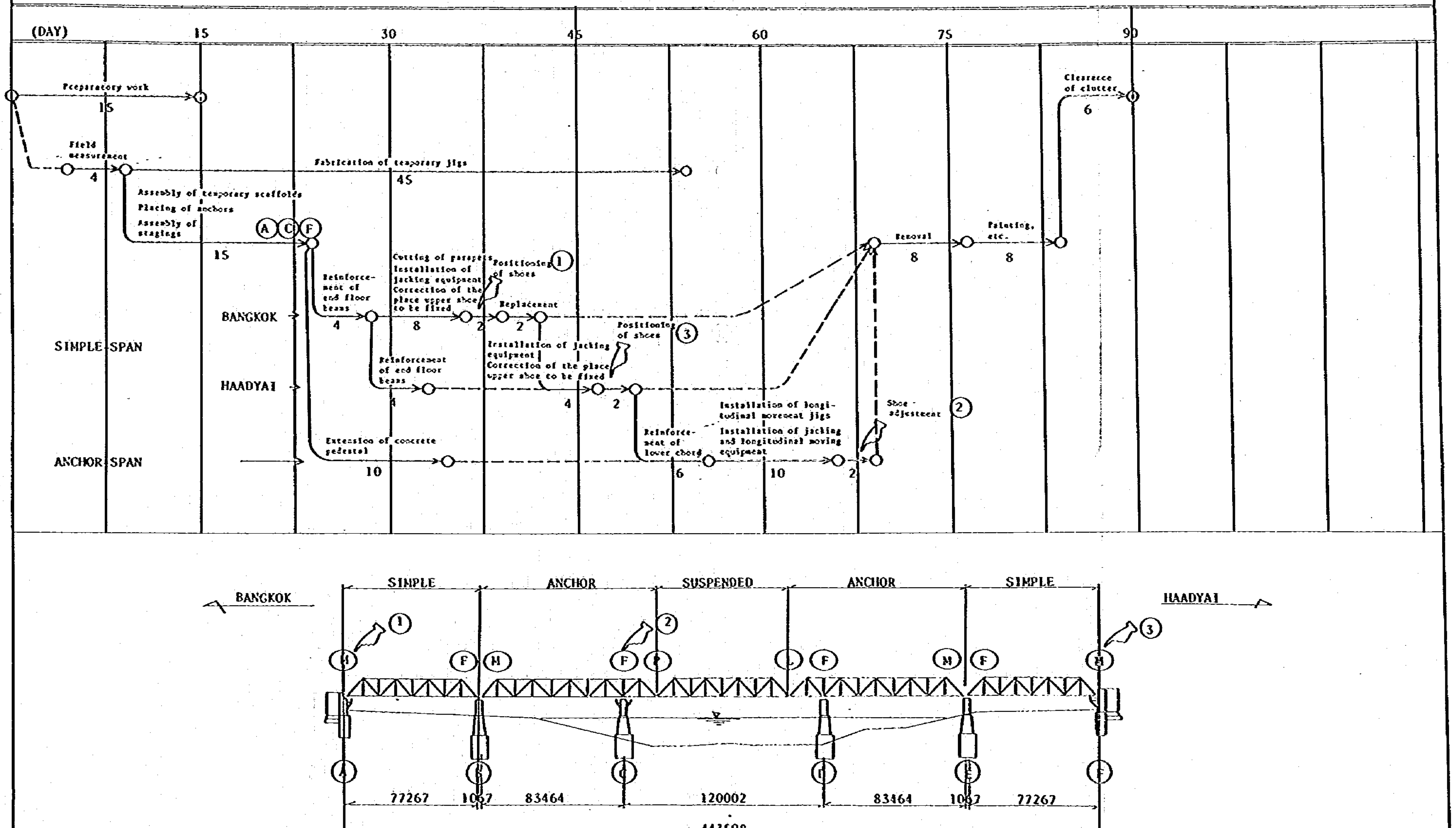


Fig. 3-13 Time Schedule of Simple Span Shoe Adjustment

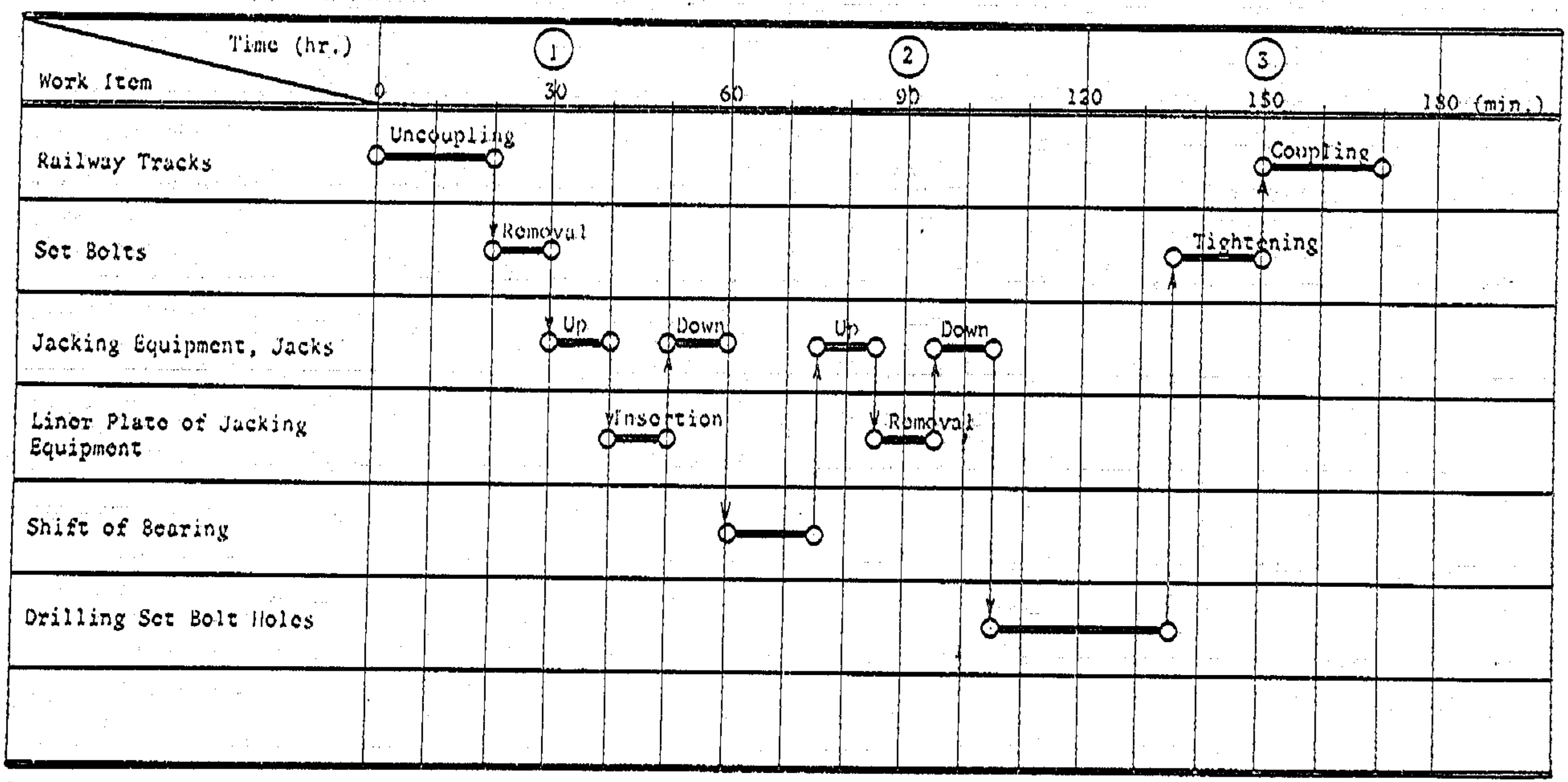


Fig. 3-14 Time Schedule of Anchor Span Shoe Adjustment