REPUBLIC OF PALAU

KOROR - BABELTHUAP BRIDGE

REPAIRMENT PLAN

(DRAFT PLAN)

FEBRUARY, 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

I RECOMMENDATION OF REHABILITATION

1 Options for Corrective Action

The bridge is expected to have no structural problems for the present in case of being left. An examination was made of the following items as a reference for future maintenance. (Only a theoretical estimate of the plan to repair and prevent further sagging of the bridge was possible as original design blueprints were not available.)

① Prevention of further sagging of the main beam
Make the flow of traffic on the bridge smoother

② Repair the worn main concrete beam and take preventative action against further damage

③ Repair other defects

1) Prevention of further sagging of the main beam
Make the flow of traffic on the bridge smoother

To prevent further sagging of the main beam, two plans are proposed and compared in Table 1.

Plan A : Unchanged structural form (with hinge)

The tendons anchored to the inside of the concrete girder box are to be installed on the upper flange inside the main box beam to prevent deflection caused by increased loading. Also the concrete wearing surface on the bridge would be resurfaced.

Plan B : Changed structural form

A rigid frame bridge would result from closing the central hinge. The tendons anchored to the inside of the concrete girder box would be installed on the floor inside the main box beam. Other structural changes would be necessary to facilitate this.

(1) Plan A Rehabilitation

i) Flow of execution

The flow of the execution of Plan A is shown in Chart 1.

An illustrated description of execution is shown in Diagram 1.

ii) Refurbishment of superstructure

The superstructure would be repaired to improve the carriage-way of the bridge. Taking into account both the elastic and plastic deformations likely to occur, due to increased loading and the estimated future deflection of the central hinge (estimated at 10 cm), an extra 20 cm of concrete surface would be applied to the carriage-way as shown in Diagram 11.

iii) Evaluation of the tendons anchored to the inside of the concrete girder box

Modulus of elasticity after overlay is 5.7 cm. With additional ($\phi = 1.0$) deflection due to creep and an estimated future deflection of 10 cm (estimated from Diagram 6), the improvement of the bridge by overlay alone would be expected to hinder traffic again sometime in the future. Therefore, the tendons anchored to the inside of the concrete girder box would reduce the modulus of elasticity and possible future deflection, thus insuring continued trafficability.

24 tendons anchored to the inside of the concrete girder box are needed with

12 tendons anchored to the inside of the concrete girder box on either side of the central midspan segment if SEEE TIEBLE F 360 T are used, as shown in Diagrams 3～ 5. (Pre-stressed to 2,400 t.)

iv) Keeping the bridge open to traffic

The amount of deflection at midspan is as follows :

Elasticity deformation due to overlay and weight of concrete	10.7 cm
Elasticity deformation due to pre-stress of the tendons anchored to the inside of the concrete girder box	−15.9 cm

Deflection after improvement 10.7− 15.9 = 5.2 cm (upper deflections)

Deflection is −10.4 cm after creep is completed considering plastic deflection (ϕ = 1.0), but this will be offset by the expected sagging (≈ 10 cm) and become level enough to keep the bridge open to traffic.

(2) Plan B Rehabilitation

i) Flow of execution

The flow of execution of Plan B is shown in Chart 2.

An illustrated description of execution is shown in Diagrams 6, 7.

ii) Evaluation of the tendons anchored to the inside of the concrete girder box

When the central midspan segment is closed, (ie. central hinge is removed) the superstructure becomes a rigid frame bridge.

High stress is created at the base (in the floor) of the box style main beam due to the over-lay and loading. To absorb the stress, the tendons anchored to the inside of the concrete girder box are attatched to the floor inside the box beam to keep the stress within permitted limits.

As shown in Diagrams 8~10, 12 tendons anchored to the inside of the concrete girder box are needed. (Pre-stressed to approx 2,400 t.)

Use SEEE TIEBLE F 360 T.

iii) Carriage way improvement

Plan A is executed ie. extra concrete is applied to the wearing surface of the carriage way. Deflection of the central segment is as follows :

Elasticity deformation due to overlay and weight of concrete	3.3 cm
Elasticity deformation due to pre-stress of the tendons anchored to the inside of the concrete girder box	−4.3 cm
Deflection after improvement 3.3 − 4.3 =	−1.0 cm

This plan will enable the bridge to be kept open by improving the carriage way surface (as shown in Diagram 11) and by producing a smaller deflection as creep will be reduced.

2) Repair the worn main concrete beam and take preventative action against further damage

Cracks in the main beam, if no repairs are made, are expected to lead to the corrosion of reinforcing rods and deterioration of the concrete superstructure, thus reducing the durability of the bridge.

Repairs should be made as soon as possible by injecting epoxy resin into the cracks etc.. (This is standard treatment)

As this bridge spans the sea, it is susceptable to damage by salt. For this reason, it is desirable that the whole main beam be coated to ensure that the structure can withstand weathering and also, to improve the over all aesthetics of the bridge.

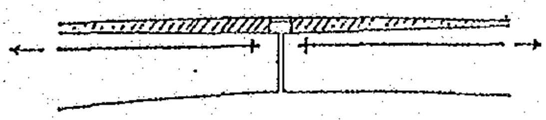
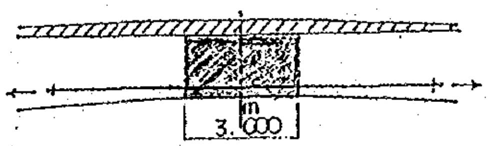
3) Repair other defects

Other defects uncovered during the survey and which need repairment work are :

- Cracks on the front of the abuttments
- PVC tie-down pipe needs repair
- Defective handrails
- The carriage way surface has worn so much that the reinforcing mesh has been exposed.

TABLE 1

Comparison of the Two Rehabilitation Project Plans

Item	Plan A (With hinge) (Improvement of the present bridge)	Plan B (Remodeling the bridge into a rigid frame bridge)
Measures	• To overlay the bridge with concrete to keep the bridge open to traffic Profile improvement • To place the tendons anchored to the inside of the concrete girder box inside the main beam to control deflections against the increase of loading To introduce pre-stress	• To unite the midspan central segments To remodel the bridge into a rigid frame bridge • To overlay the bridge with concrete to keep the bridge open to traffic Profile improvement
Drawings		
Structual Features	• There is no structual change. • At the moment the bridge is still sagging, so careful attention must be paid to the choice of the tendons anchored to the inside of the concrete girder box and the estimated amount of sagging caused by the increased overlay weight and the estimated amount of future sagging.	• There is structual change. • As loading and overlaying produce tensile stress at midspan's lower part, the tendons anchored to the inside of the concrete girder box need to be placed inside the box and prestressed. • If the amount of creep deformation is not as estimated, the difference will have negligible influence. • There is little temperature influence because there is not a big change in temperature.
Traffic Restriction	• One side of the road would be restricted during overlaying There would be little traffic restriction during other work.	• A temporary span will prevent overall traffic restriction while midspan central segments are cut.
Maintenance	• Maintenance will be needed if the central hinge shoe is damaged by friction	• Little need for maintenance
Term	13 months	13 months
Costs	US$ 4,183,000	US$ 4,098,000
Total Assessment	○	◎

Note : 1 US$ = 145 yen

Chart 1

Plan A Flow of Execution

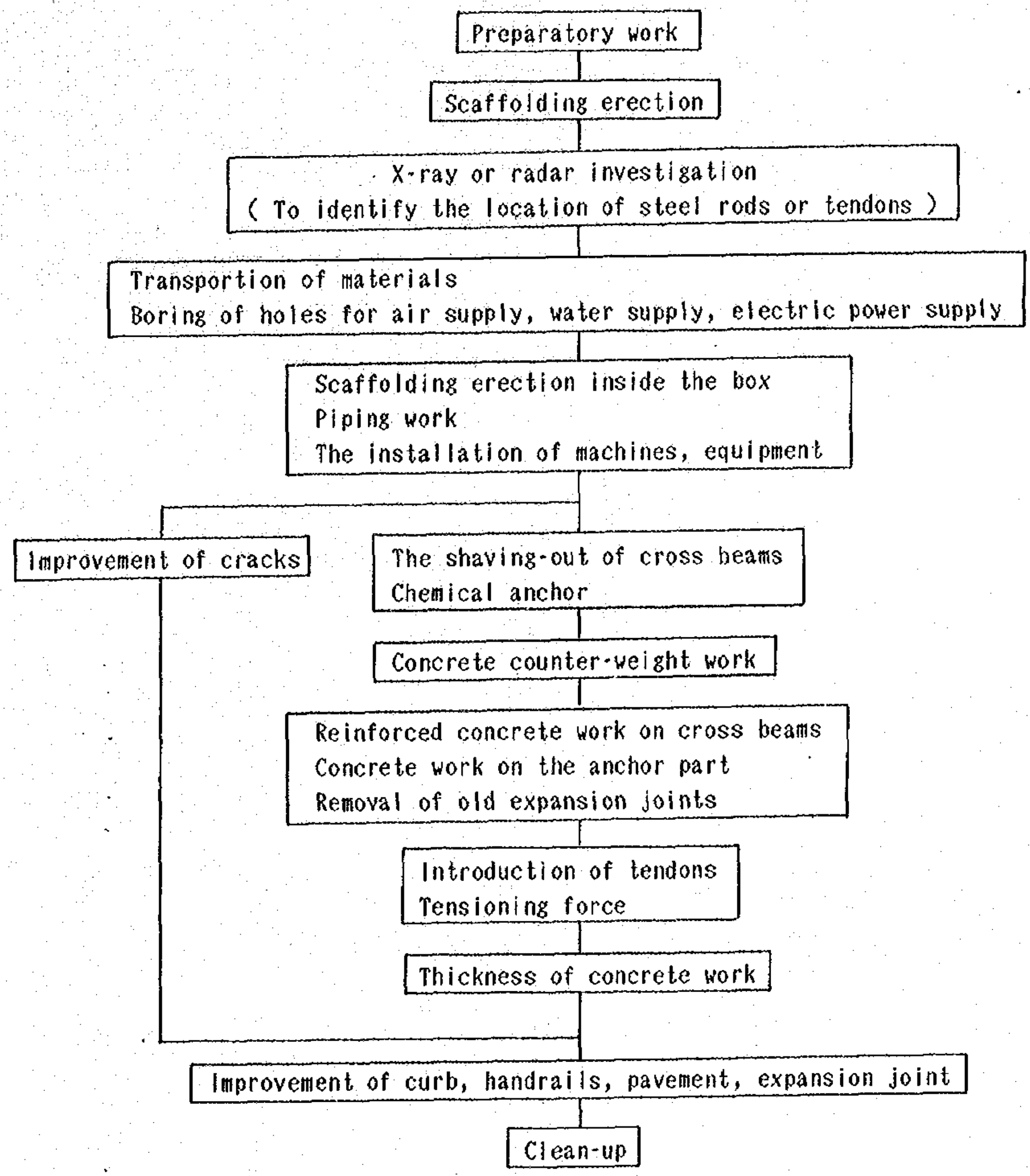
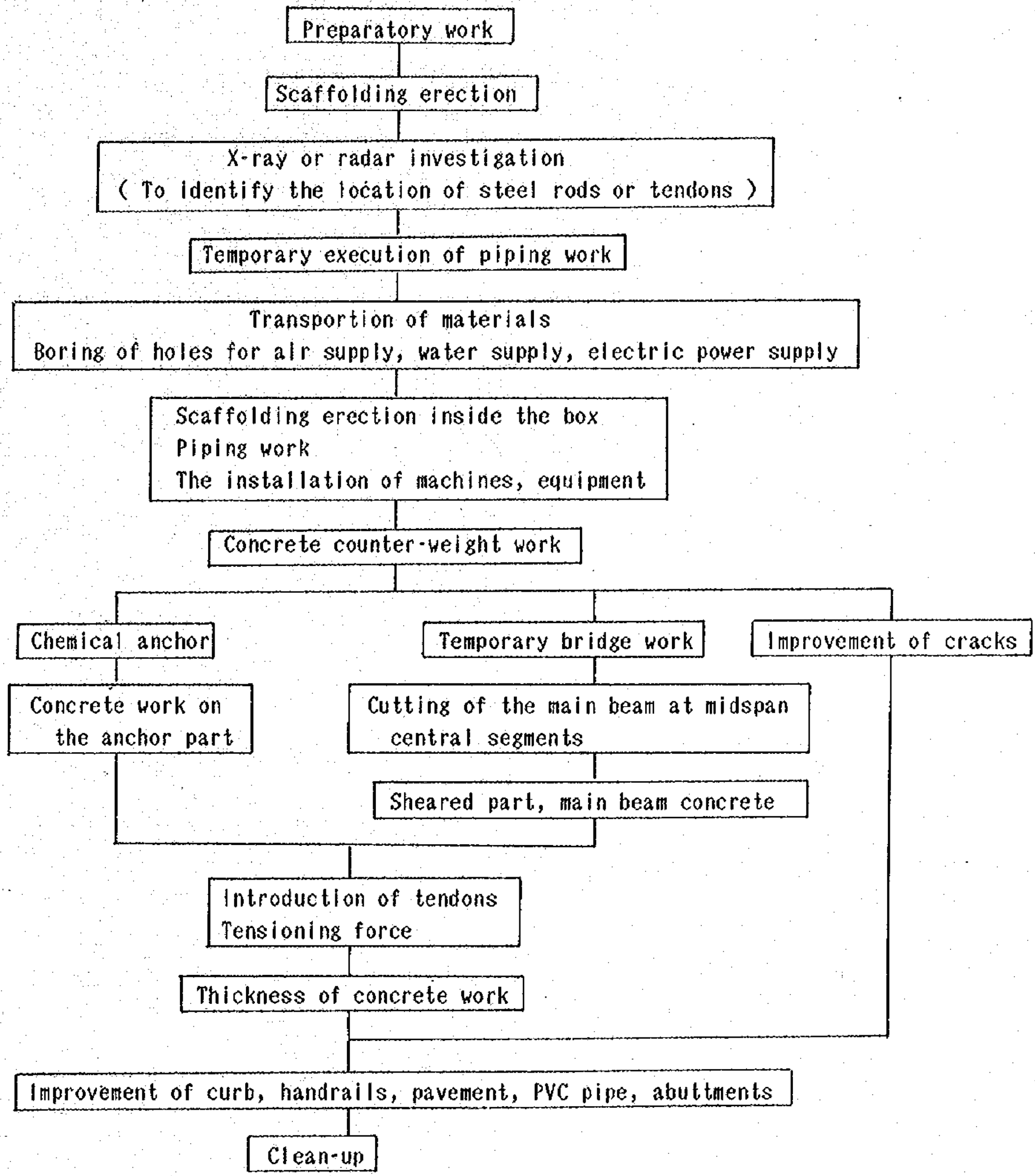
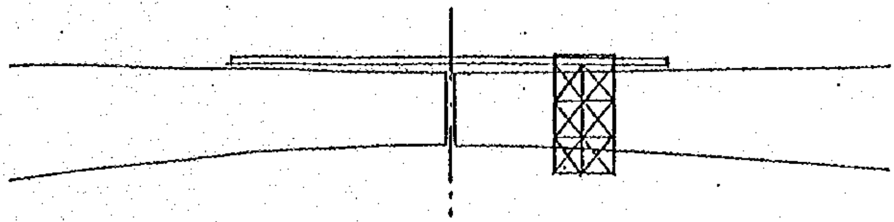


Chart 2

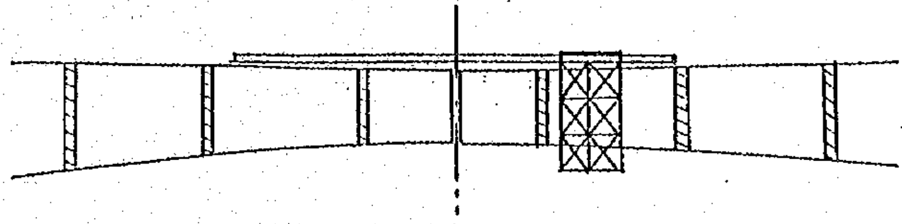
Plan B Flow of Execution



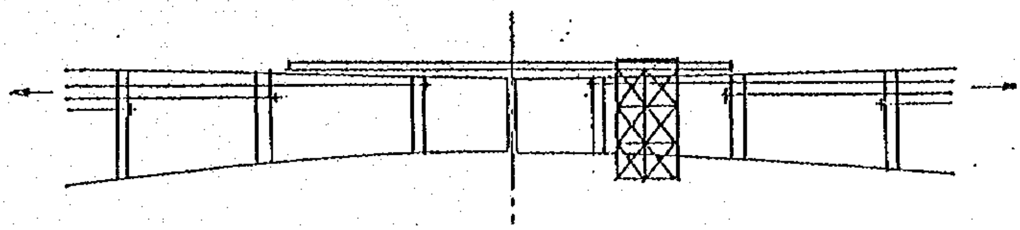
Scaffolding erection (Transfer platform)



Concrete work on the anchor part



Introduction of tendons, tensioning force



Thickness of concrete work

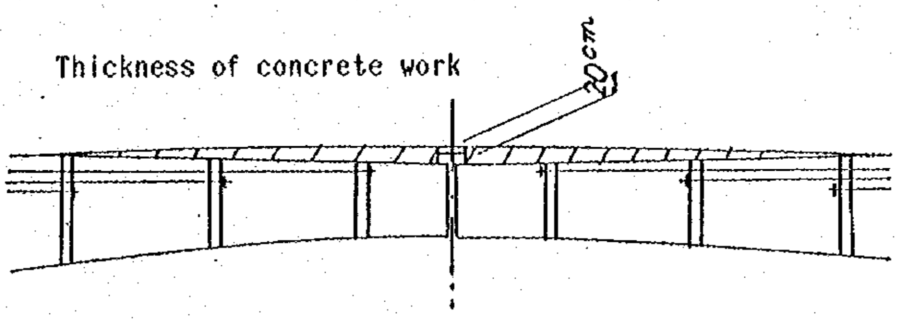
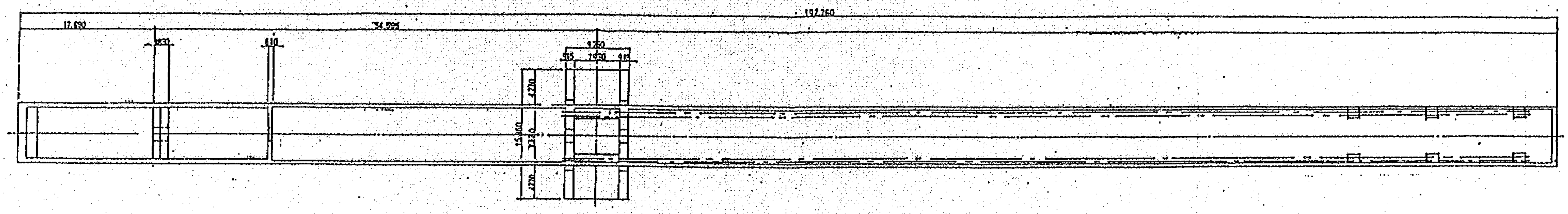


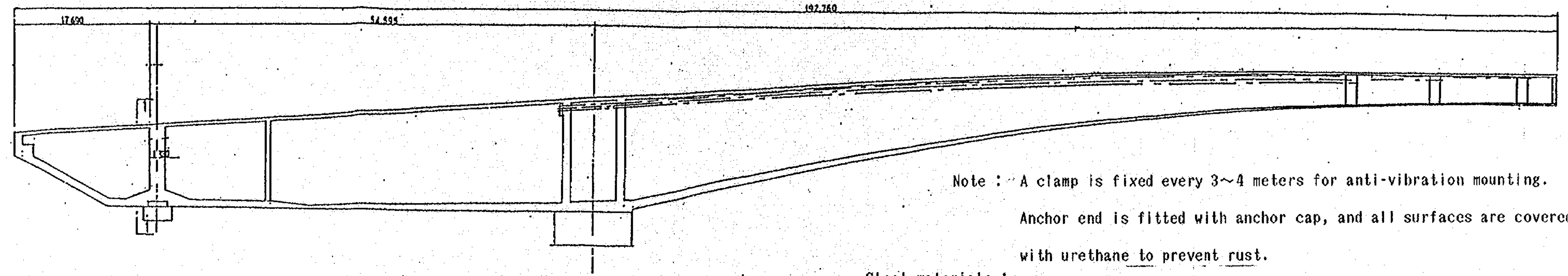
Diagram 1

Plan A Steel Rod Location Drawings

PLAN S=1:250



ELEVATION S=1:250



Note : A clamp is fixed every 3～4 meters for anti-vibration mounting.

Anchor end is fitted with anchor cap, and all surfaces are covered with urethane to prevent rust.

Steel materials :

SEEE TIEBLE F 360 T 24 tendons anchored to the inside of the concrete girder box

(12 tendons anchored to the inside of the concrete girder box on both sides of the midspan)

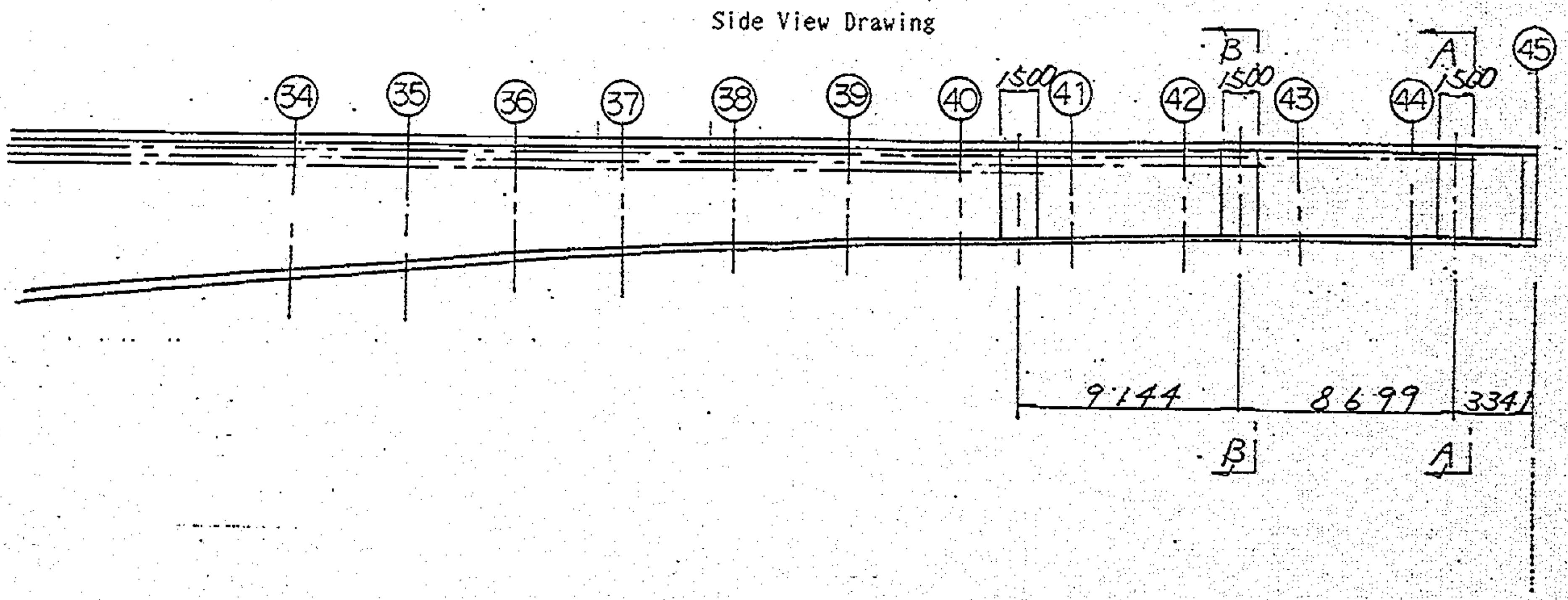
ℓ = 122m 8
ℓ = 114m 8
ℓ = 106m 8

8 tendons anchored to the inside of the concrete girder box

Diagram 2

Plan A Detailed Plot Diagram of Steel Rod Locations (at midspan central segments)

Side View Drawing



Ichnography

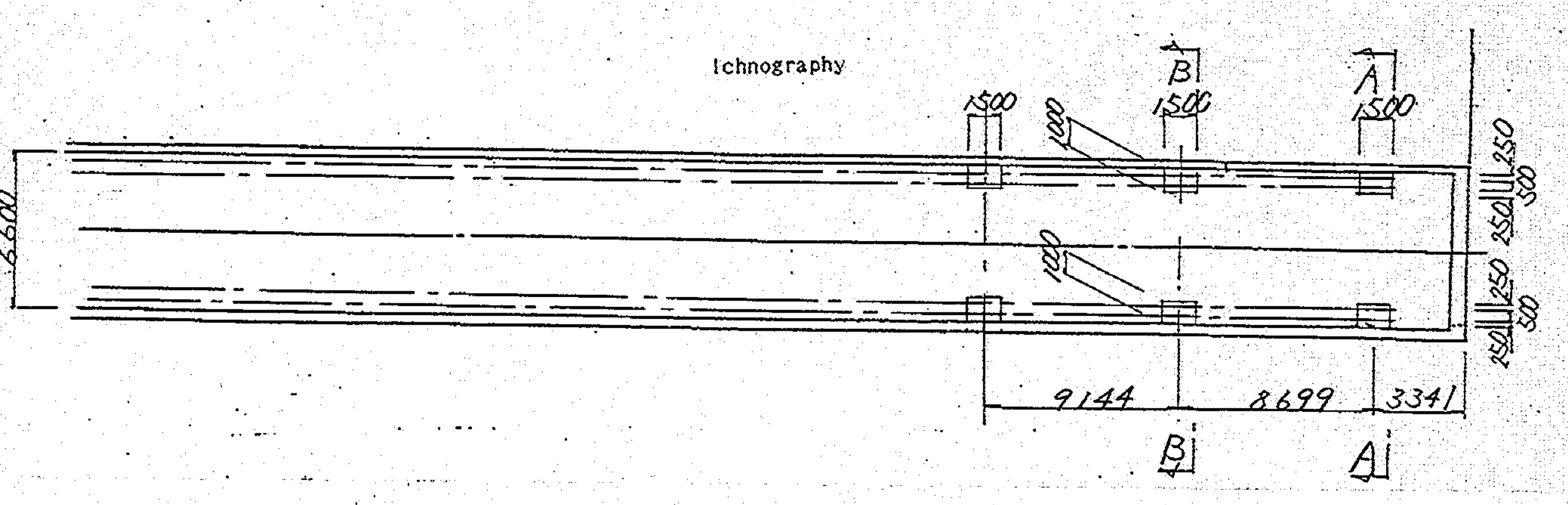


Diagram 3

Plan A Crosssection of Steel Rod Placement

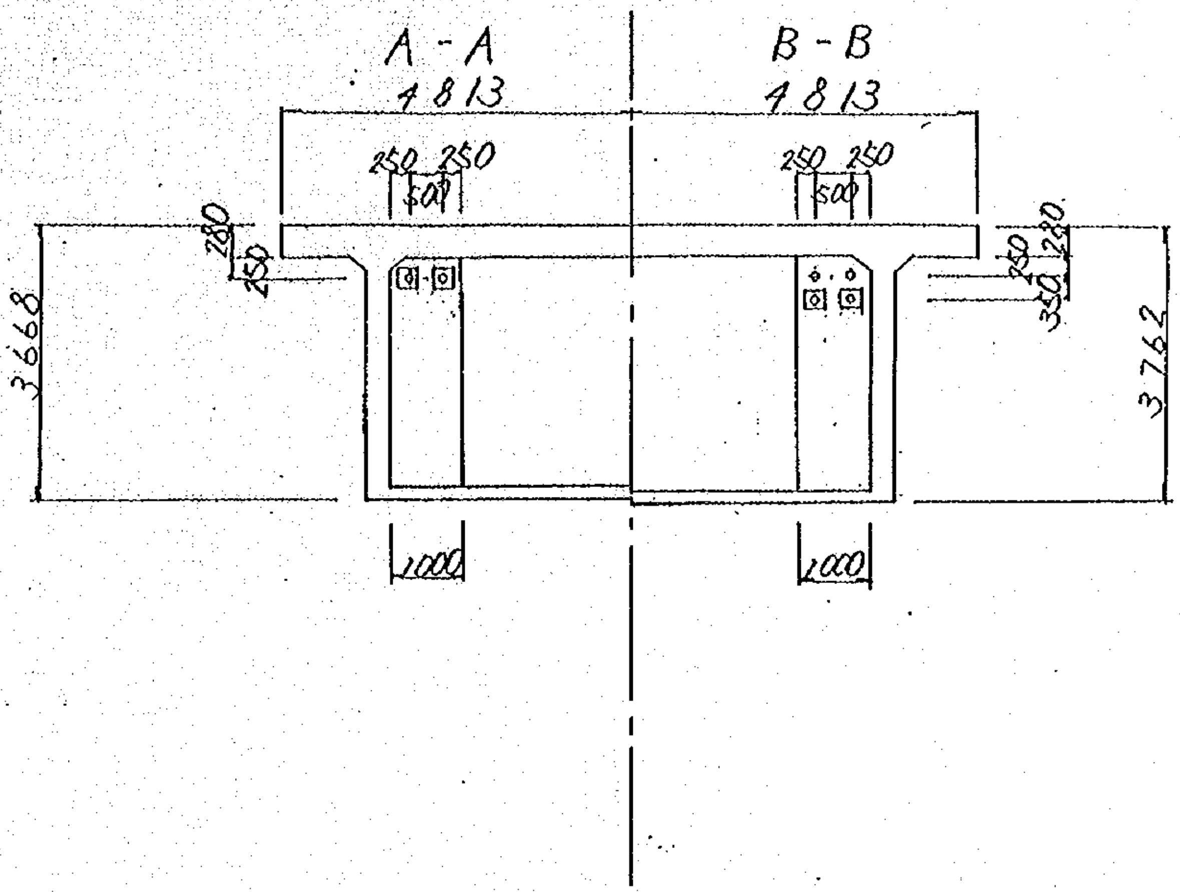
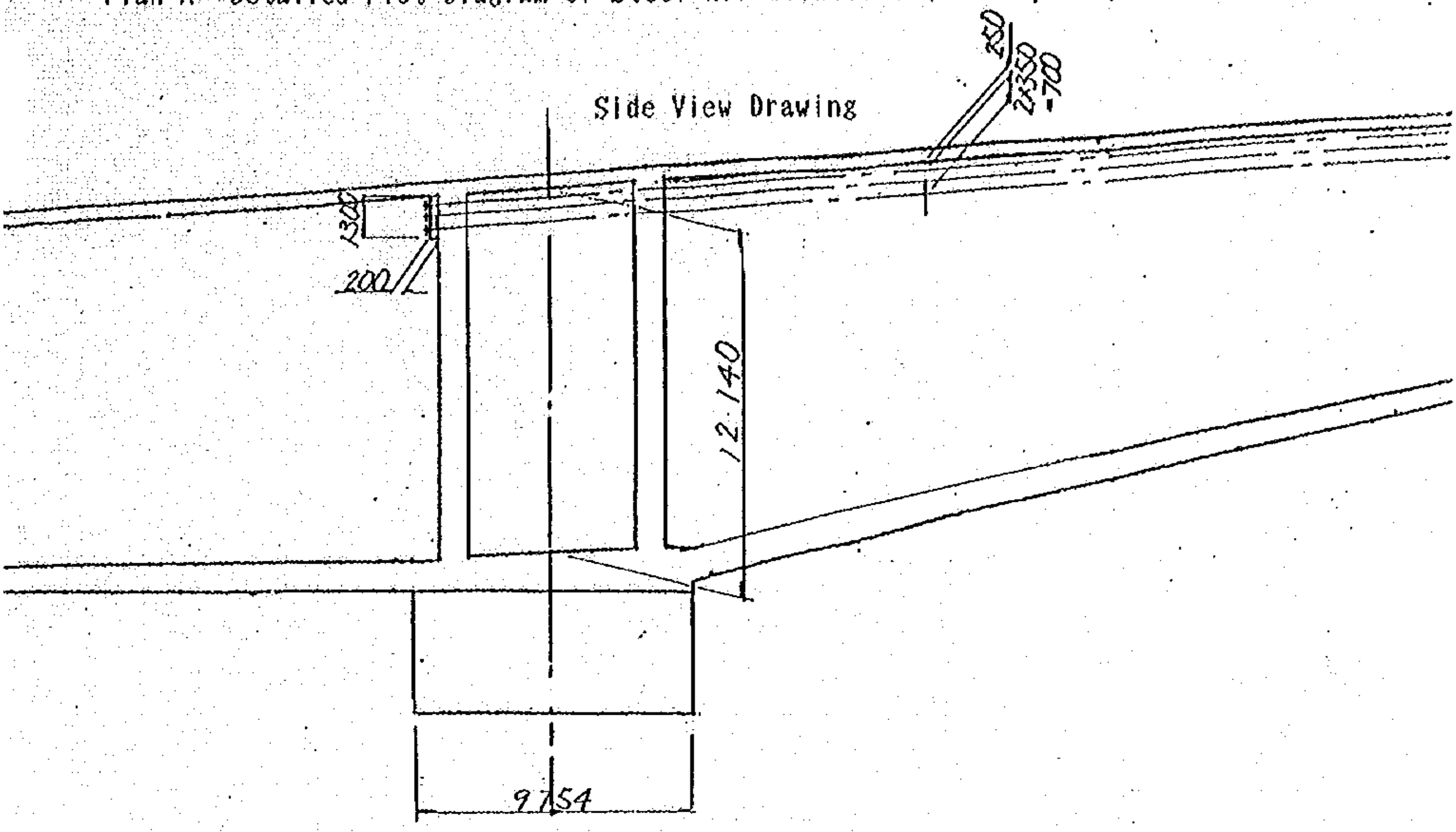


Diagram 4

Plan A Detailed Plot Diagram of Steel Rod Locations (main pier)

Side View Drawing



Ichnography

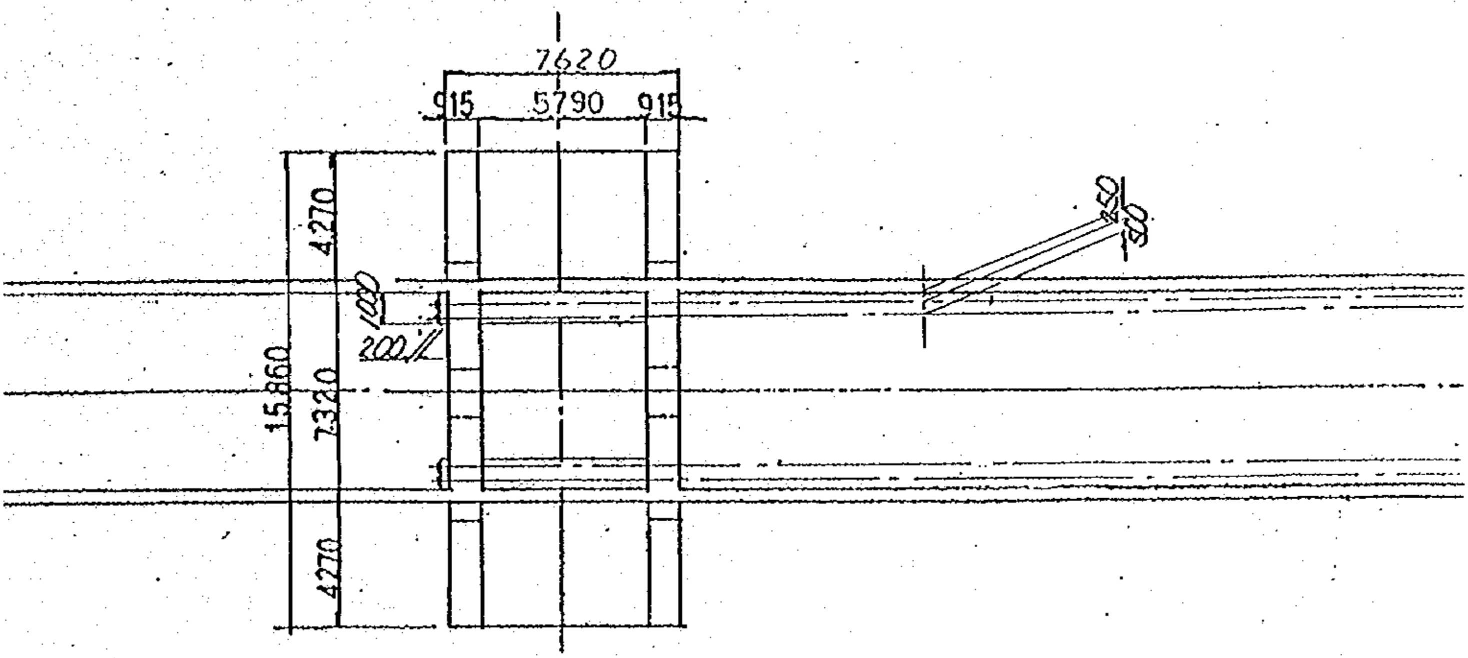
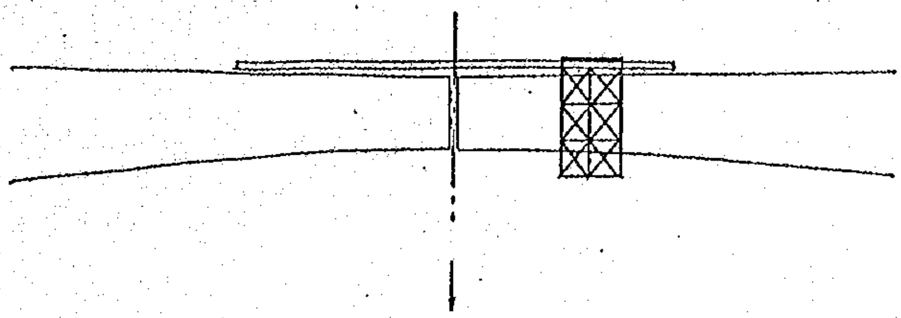


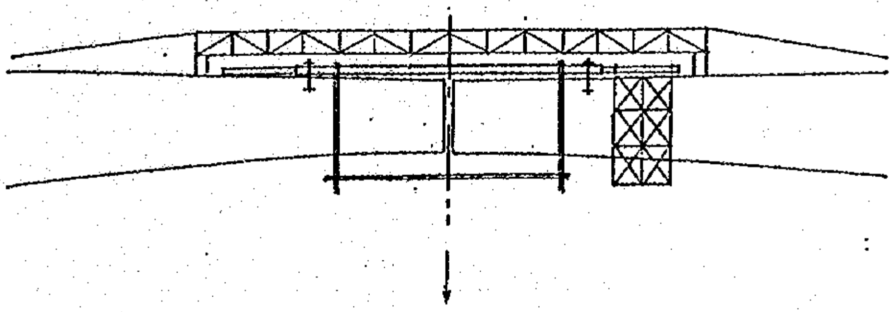
Diagram 5

Plan B Execution Order Drawings

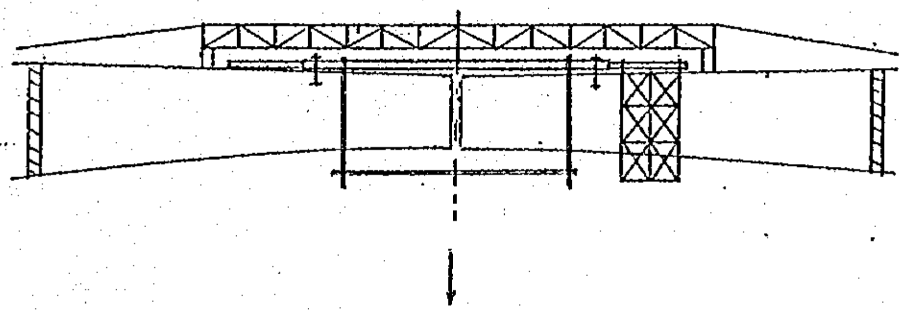
Scaffolding erection (transfer platform)



Temporary bridge, suspended support structure



Concrete work on the anchor part



Cutting of the main beam at midspan central segments

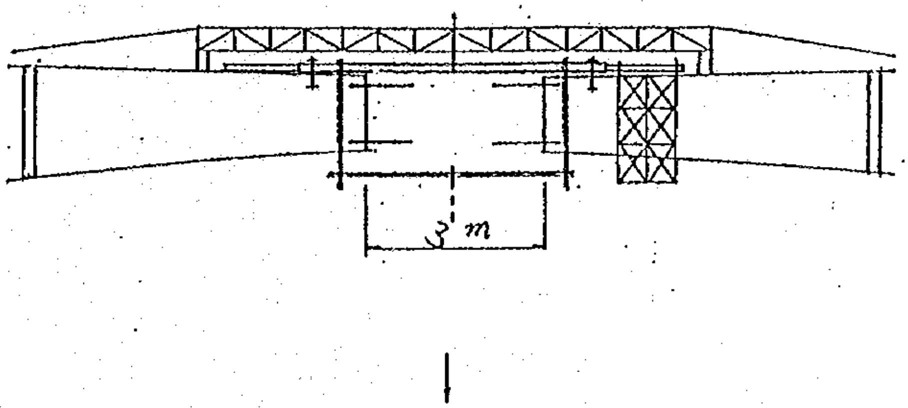
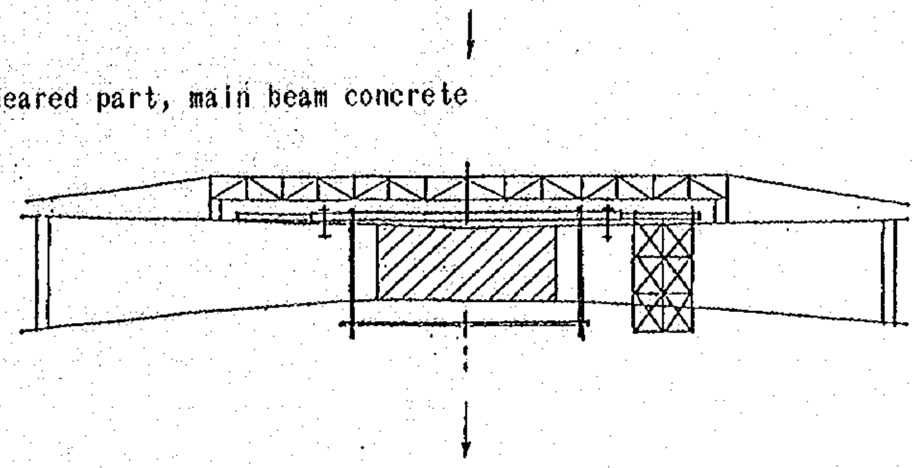
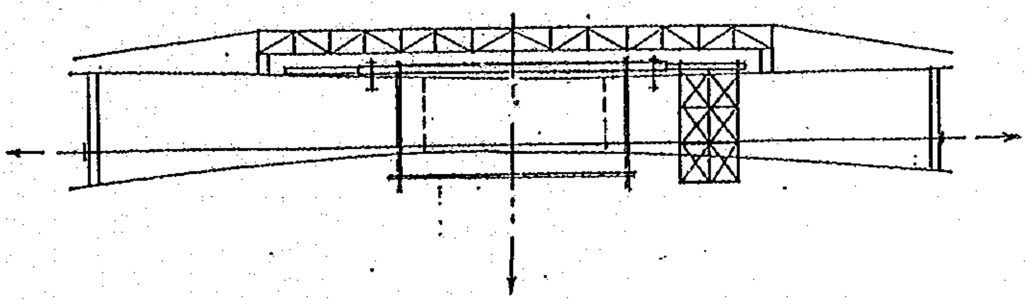


Diagram 6

Sheared part, main beam concrete



Introduction of tendons, tensioning force



Thickness of concrete work

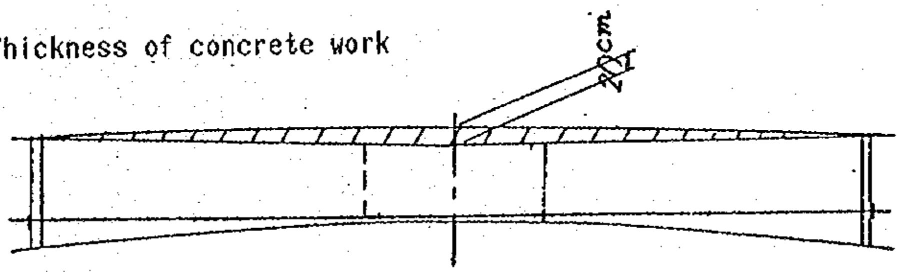
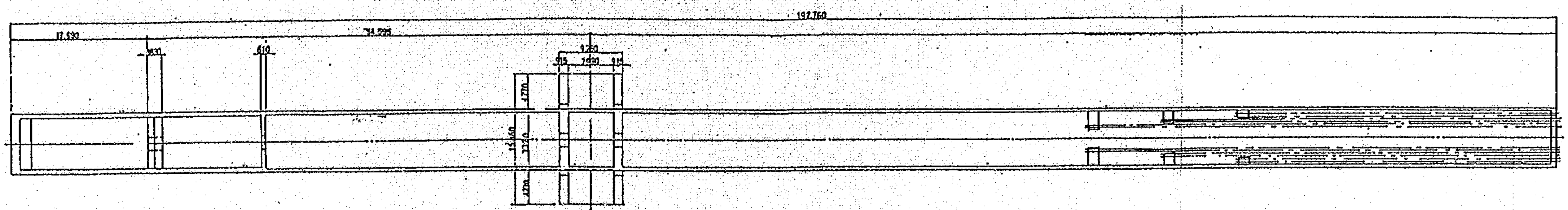


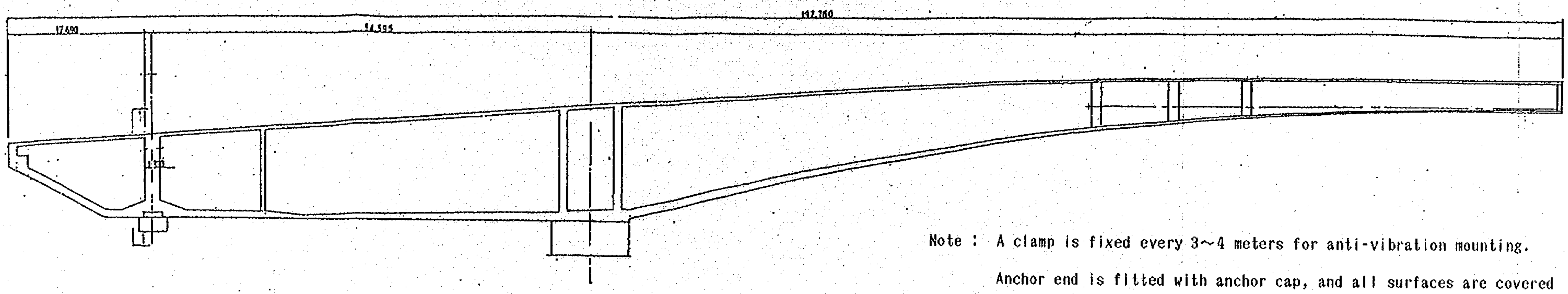
Diagram 7

Plan B Steel Rod Location Drawings

PLAN



ELEVATION



Note : A clamp is fixed every 3~4 meters for anti-vibration mounting.
Anchor end is fitted with anchor cap, and all surfaces are covered with urethane to prevent rust.

Steel materials :

SEEE TIEBLE F 360 T 12 tendons anchored to the inside of the concrete girder box

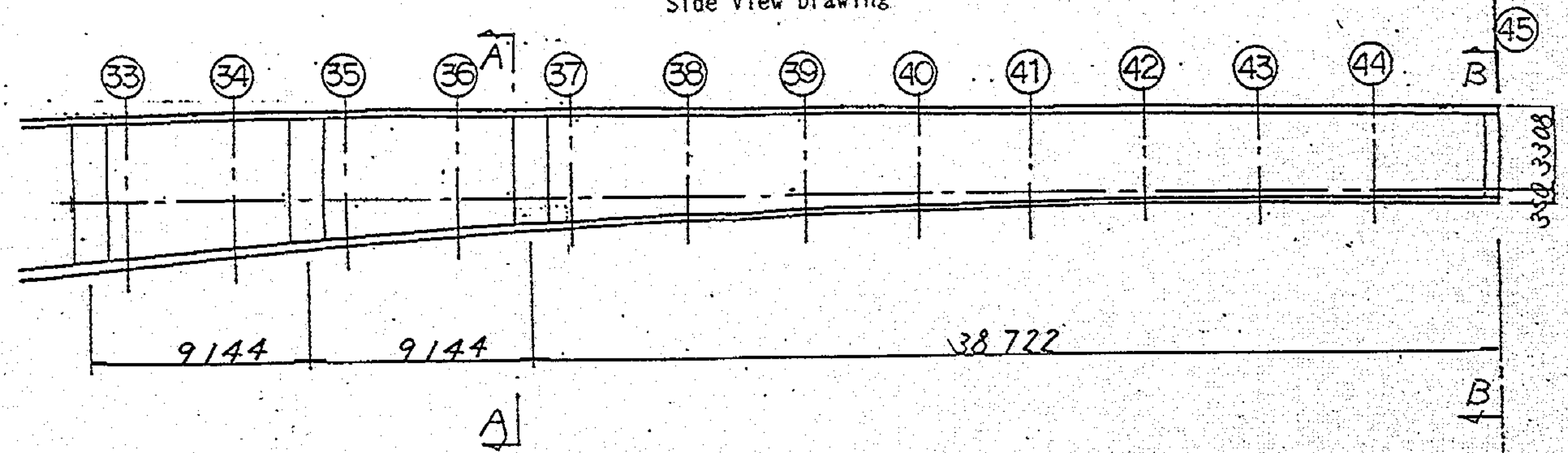
ℓ = 130m 4
ℓ = 110m 4
ℓ = 90m 4

4 tendons anchored to the inside of the concrete girder box

Diagram 8

Plan B Detailed Plot Diagram of Steel Rod Locations

Side View Drawing



Ichnography

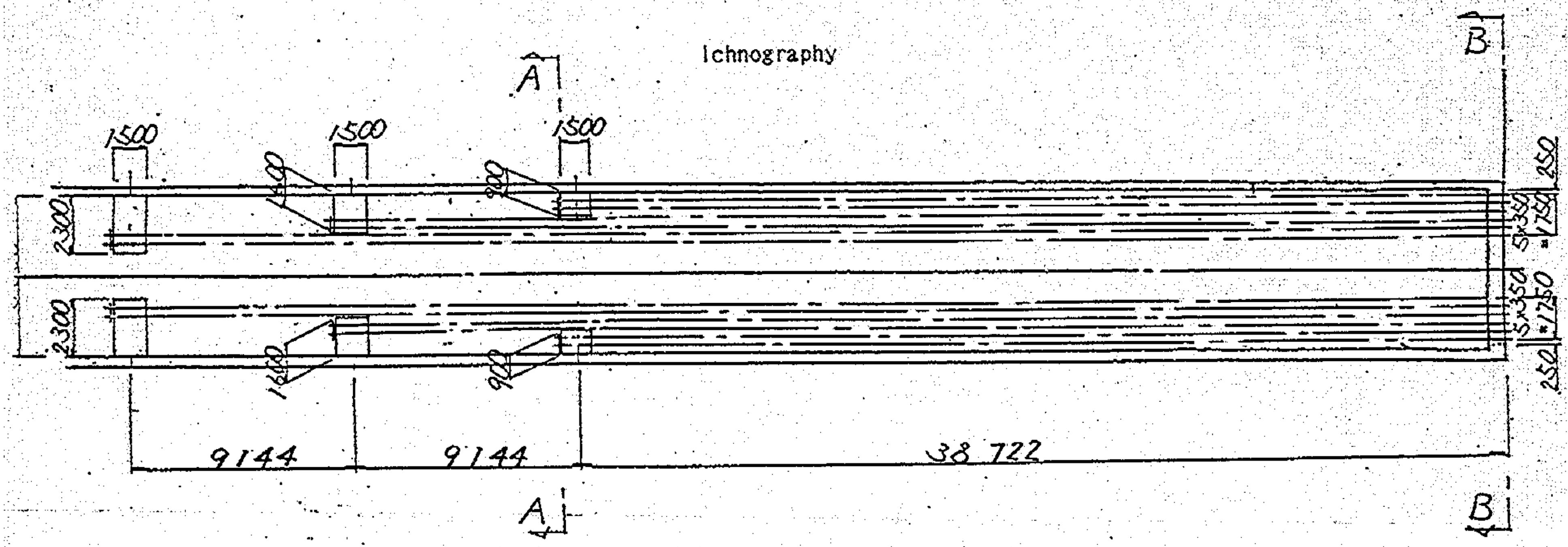


Diagram 9

Plan B Crosssection of Steel Rod Placement

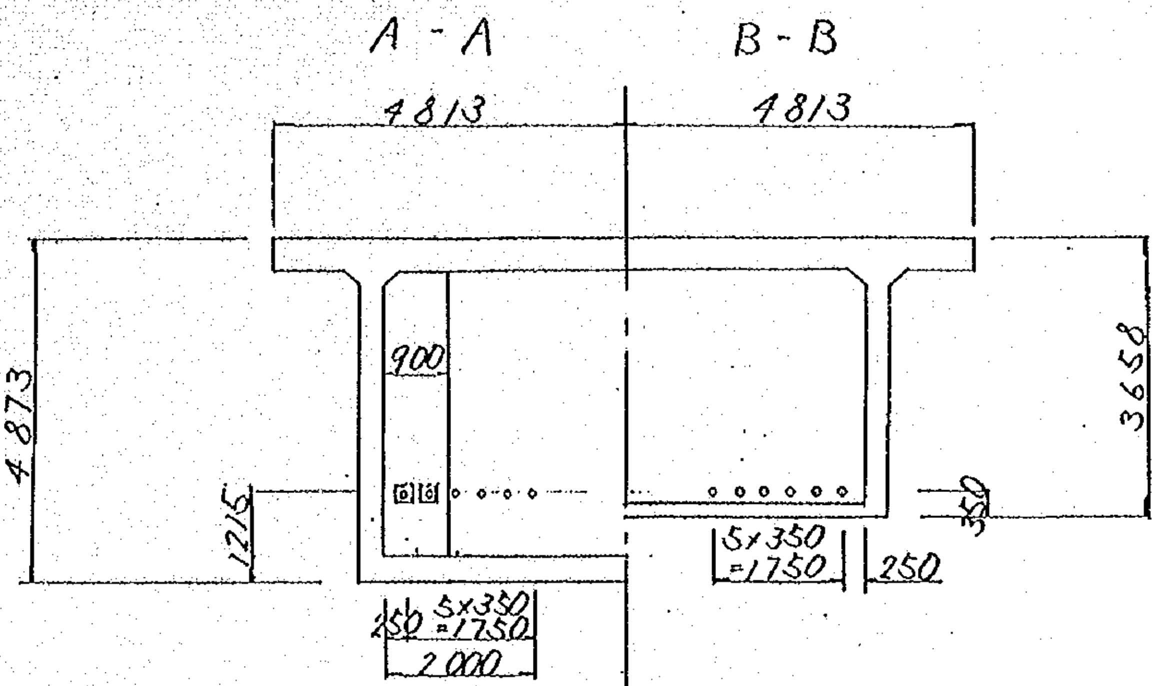


Diagram 10

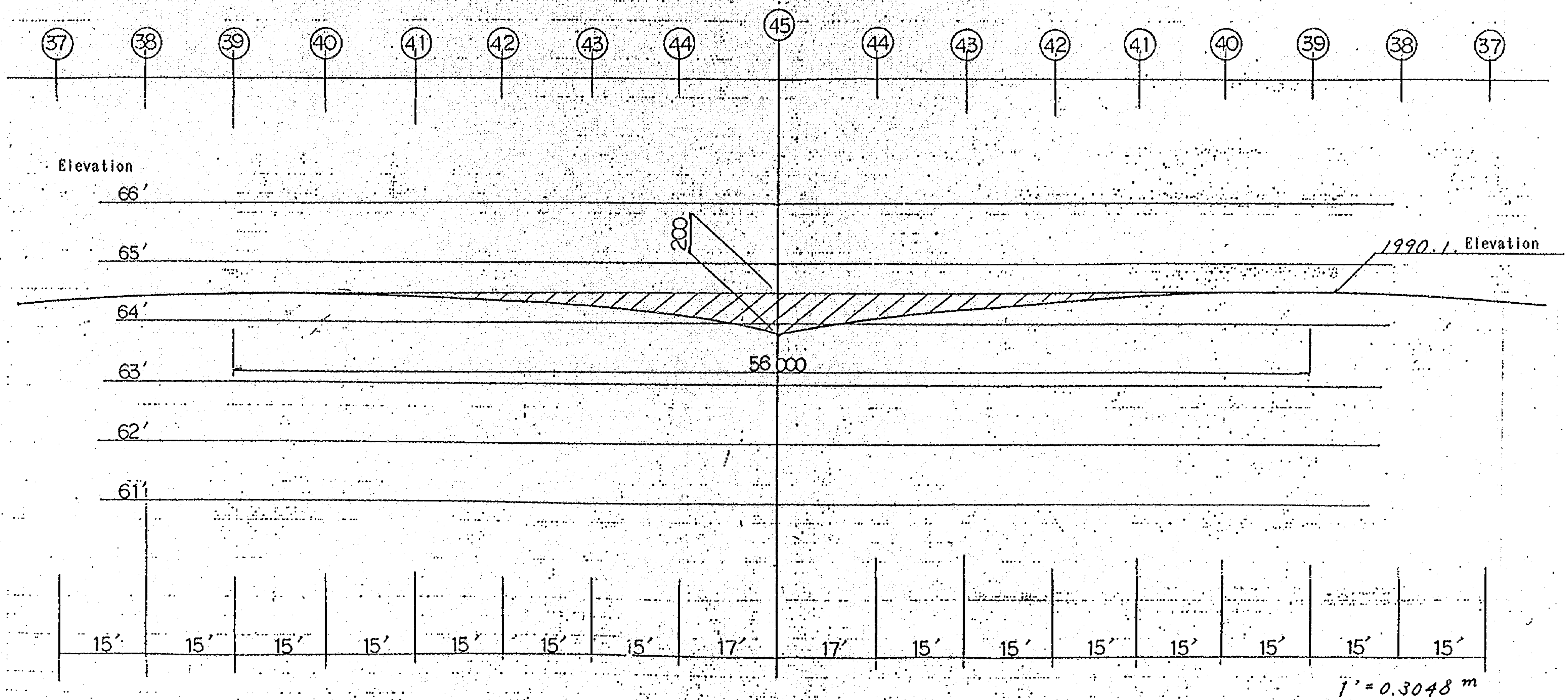


Diagram 11 Thickness and range of concrete wearing surface

2 Execution Plan

(1) Execution schedule and development of initial cost estimates

Outline of cost estimates for each plan (A, the midspan plan, B, the beam joining plan) is as follows :

Working Expenses

(Unit = U.S.$ in thousands)

Costs	A : Midspan Plan	B : Beam joining Plan
1) Construction	1,980	1,854
2) Common temporary works	202	202
3) Transportation, packing	323	323
4) Consultant dispatching	188	239
5) Site expenses	597	597
6) Head office expenses	217	209
I Construction Fee (1)～(6)	3,507	3,424
II Reserve Fund	115	113
III Design Expenses	561	561
Working Expenses (I + II + III)	4,183	4,098

Note : 1 U.S.$ = 145 yen

(2) Technology transfer

Technology transfer will be achieved through co-operative work with the local staff during the site survey, planning stage and construction stage.

The Japanese staff will act as supervisors to the local staff in the areas of data collection, preparation of report, explanation, site survey, maintenance and control, inspection, and assessment of durability, to maximise the transfer of technology.

Construction Execution Schedule (Midspan Plan : A) — 1

	Execution Project						
	Execution Design		Tendering · Contracts				
	Contract with consultant and recognition of the consultant	Execution of detailed design and documents for tendering	Notification of construction tendering	Distribution of documents for dendering	Tendering	Report on tendering investigation	Negotiation and recognition of construction contracts
1	○	|					
2		|					
3		|					
4							
5							
6			○				
7				|	|		
8					|		
9					|	|	
10							○
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							

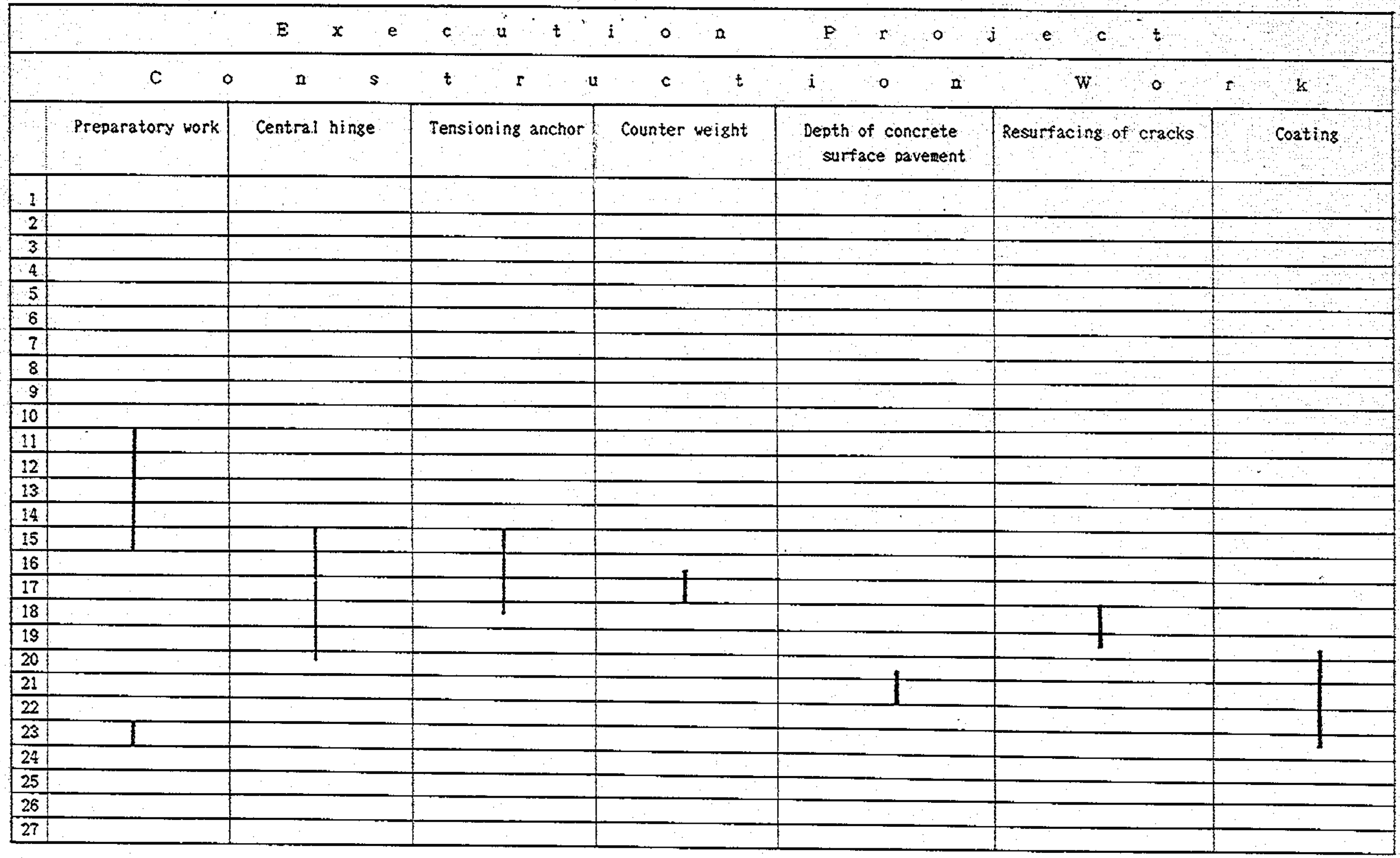
Construction Execution Schedule (Midspan Plan : A) - 2

	Execution Project					
	Construction Work					
	Preparatory work	Tensioning anchor	Expansion equipment	Resurfacing of concrete wearing surface	Resurfacing of cracks	Coating
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						

Construction Execution Schedule (Rigid Frame Bridge Plan : B) — 1

	Execution Project						
	Execution Design		Tendering · Contracts				
	Contract with consultant and recognition of the consultant	Execution of detailed design and documents for tendering	Notification of construction tendering	Distribution of documents for dendering	Tendering	Report on tendering investigation	Negotiation and recognition of construction contracts
1	○						
2							
3							
4							
5							
6			○				
7							
8							
9							
10							○
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							

Construction Execution Schedule (Rigid Frame Bridge Plan : B) - 2



II FUTURE INVESTIGATION, CONSTRUCTION ITEMS

A minute examination before construction as well as measurements and an investigation during construction are needed. The basic design items as well as investigation and examination items during construction are as follows :

1. Site Survey
   - Main beam elevation
   - Condition of ballast and unit volume weight
   - Condition of toremy concrete (In the sea)
   - Soil survey (Boring)

2. Design and Evaluation of the Project
   1) Evaluation by refering to the original design
      ① establishing factors affecting construction
      ② analytical study of structure
   2) Inspection during construction
      ① inspection of tendons anchored to the inside of the concrete girder box, anchoring, etc.
      ② analytical study of structure
   3) Detailed evaluation after modification
   4) Construction work plan
   5) Survey plan

3. Evaluation and Measurement During Construction

1) X-ray and radar examination (Confirming location of steel rods and tendons)

2) Measurement of stress during construction

① stress measurement of the tendons anchored to the inside of the concrete girder box

② stress measurement of the anchor partmeasurement

3) Deformation measurement