CONSTRUCTION OF BALANCE CANTILEVER APPROACH SURAMADU BRIDGE

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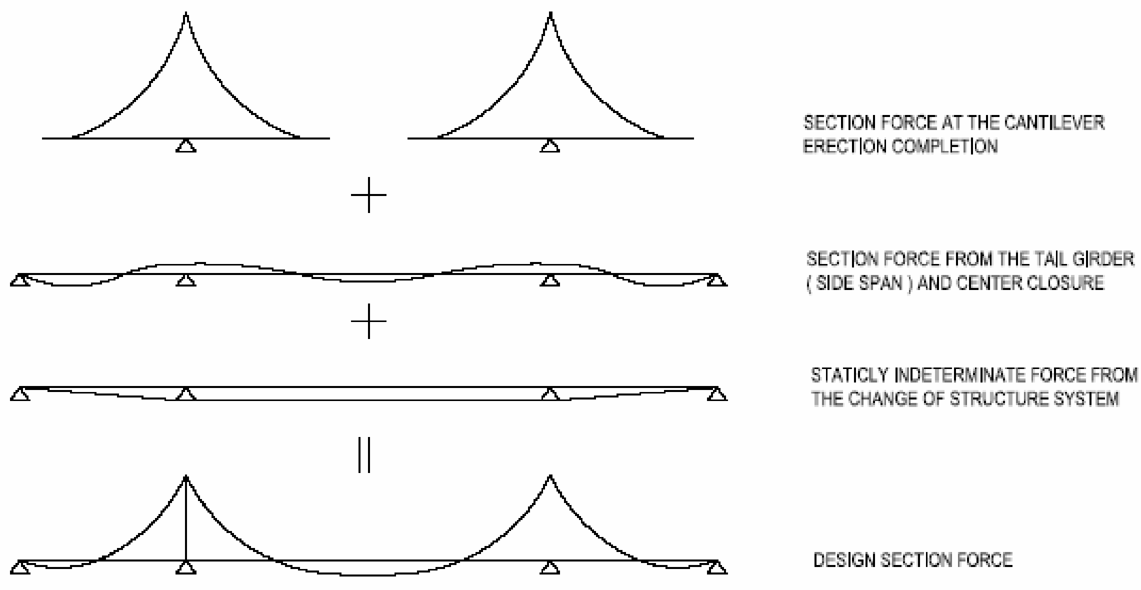
1. DESIGN

1.1. Concept of Design of Cantilever Erection Method

In the cantilever-method bridge, segments (pre-cast segment or cast in situ) are connected so that the structure as the whole girder would be completed and during the erection stage, statically-indeterminate force from the creep and dry-shrinkage will occur inside the structure. Therefore, accumulative section forces during the each construction stage and statically-indeterminate should be the design section force.

The necessity of the analysis in accordance with the construction step and the necessity of the analysis of affection by the change of structural system in the design are the difference from the other erection methods.

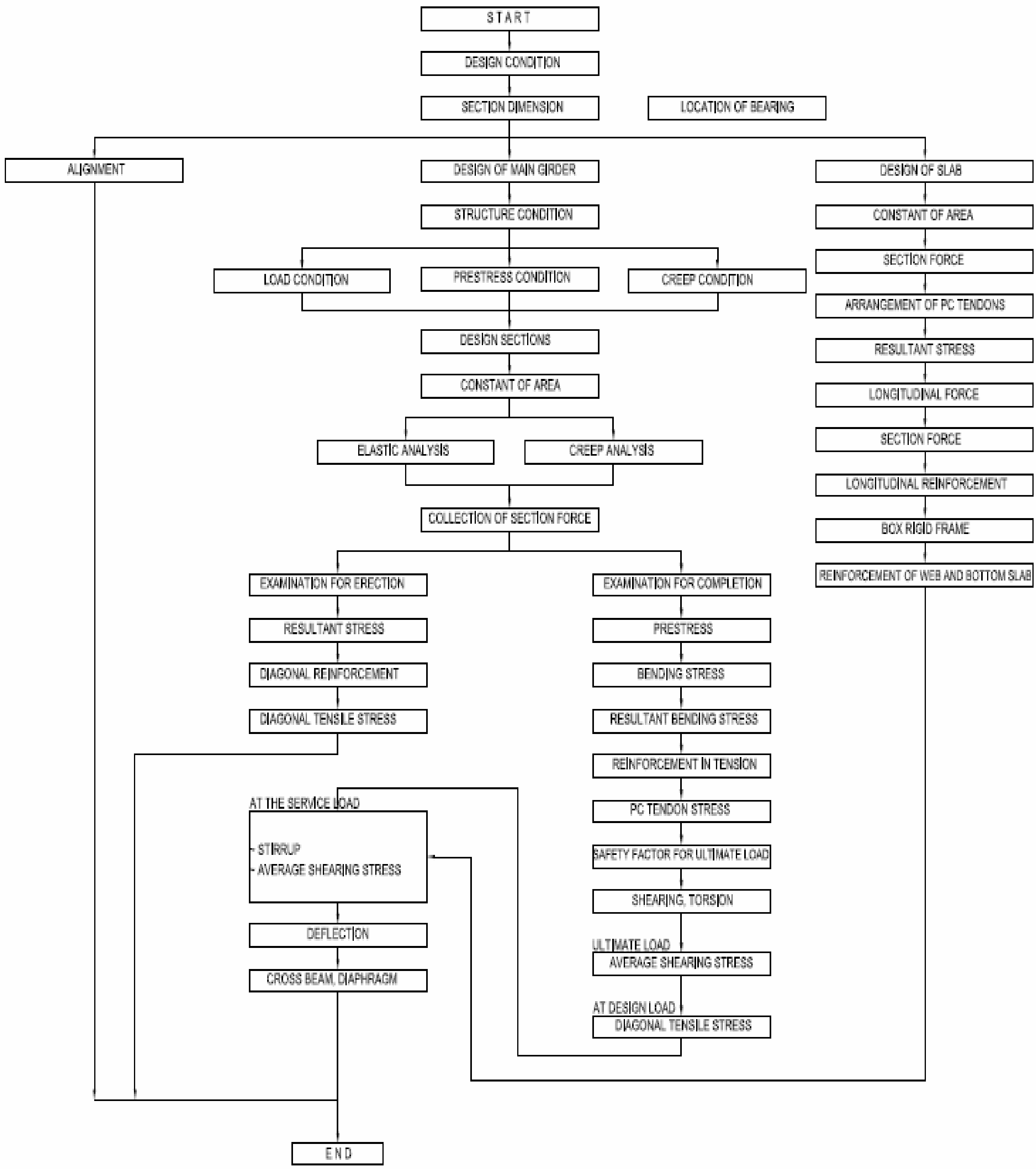


DESIGN SECTION FORCE IN THE CANTILEVER - ERECTION METHOD

1.2. Design Flow

Cantilever erection method is that 2-5m blocks would be connected at the both sides of a pier to the completion of the girder. In the design stage, it is necessary to trace the work sequence accurately, therefore, the type of the structure, case of examination and sections of examination would be more than the design of the other erection methods and be more complicated and need great deal of work.

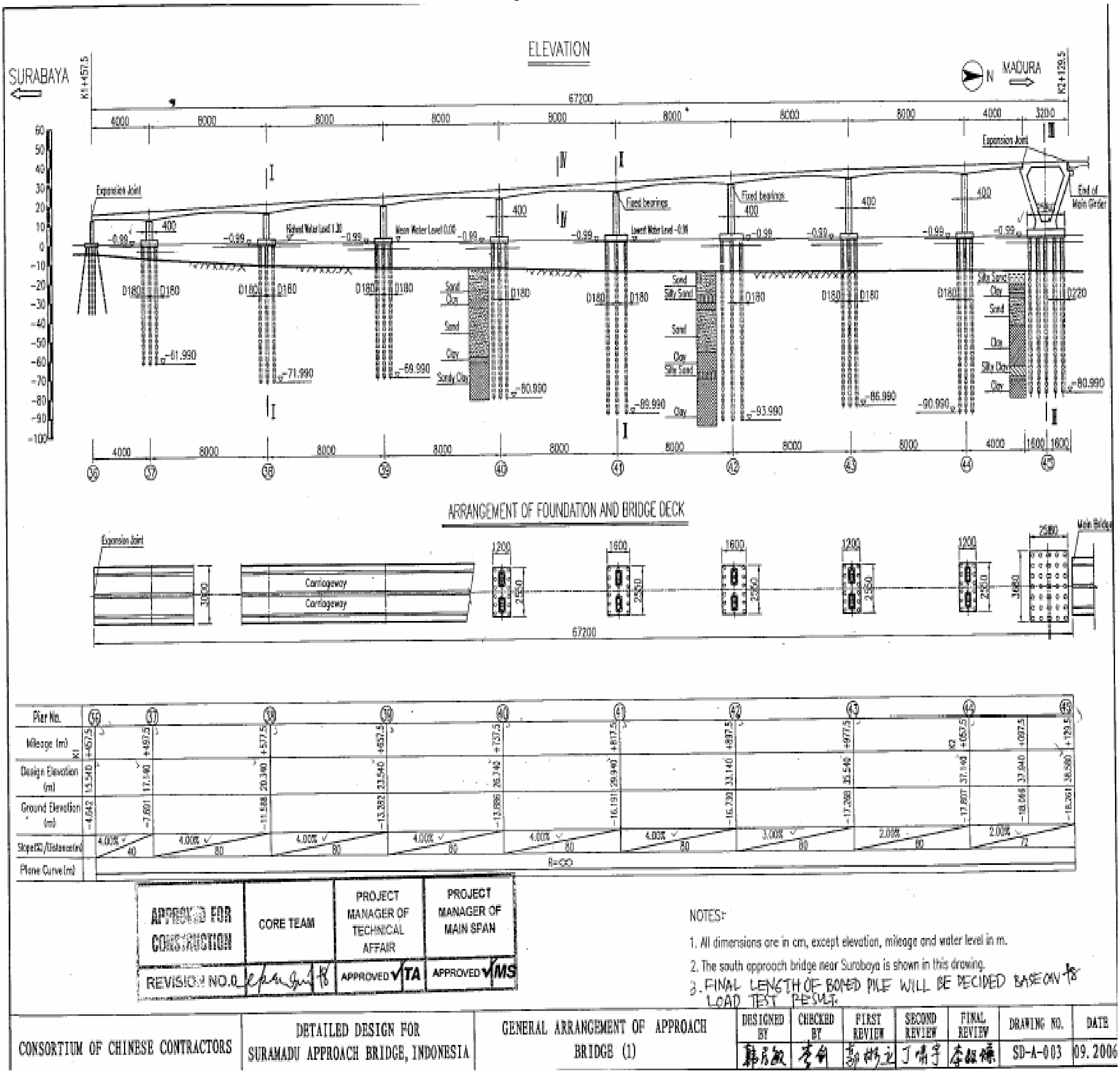
Fig. 1.2. Shows the design flow of cantilever-erection method.



1.3 Span

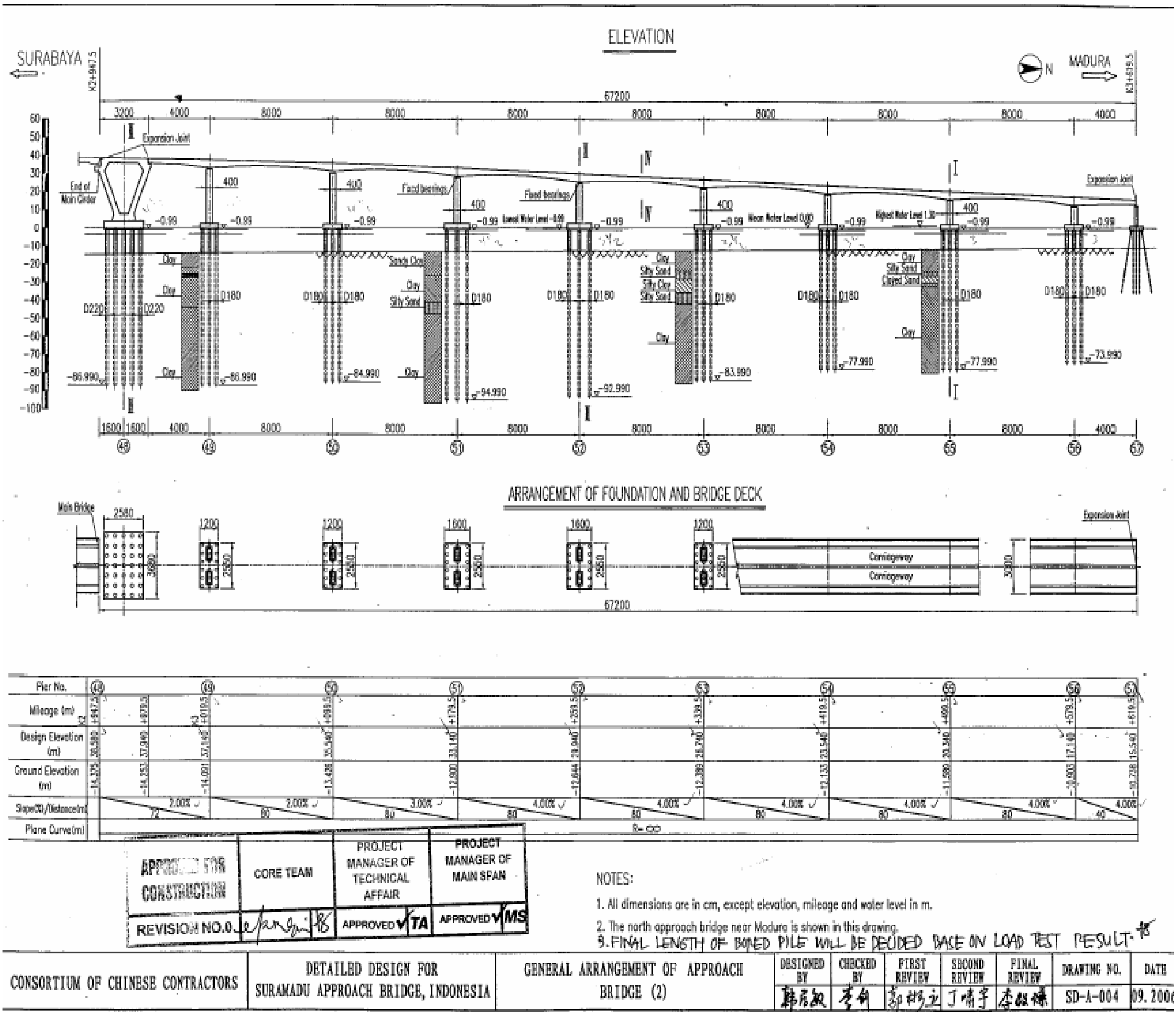
The span of Suramadu Approach Bridge is shown in the following drawings for Surabaya and Madura side.

Surabaya Side



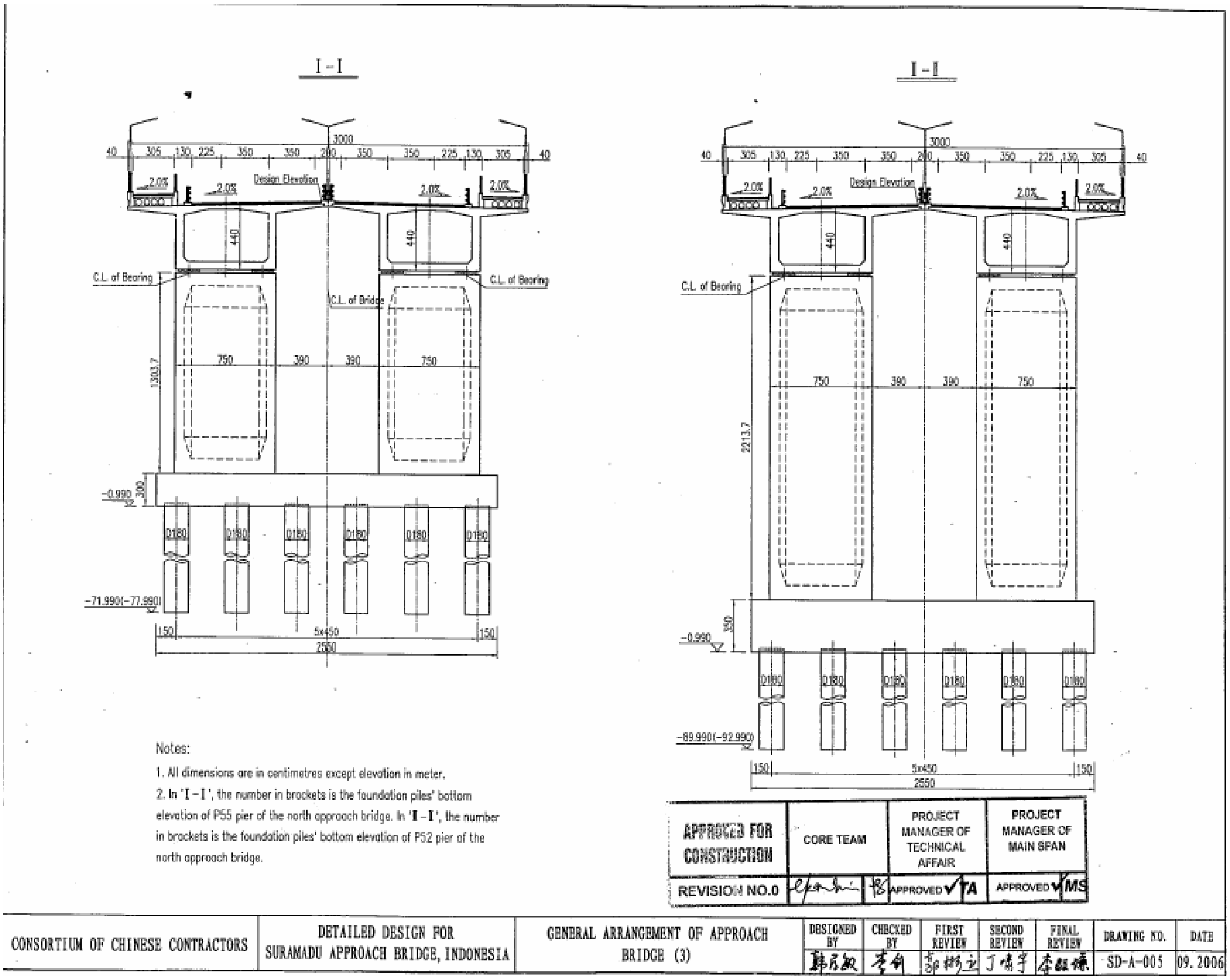
Drawing SD-A-003

Madura Side



Drawing SD-A-004

Cross section is also shown.

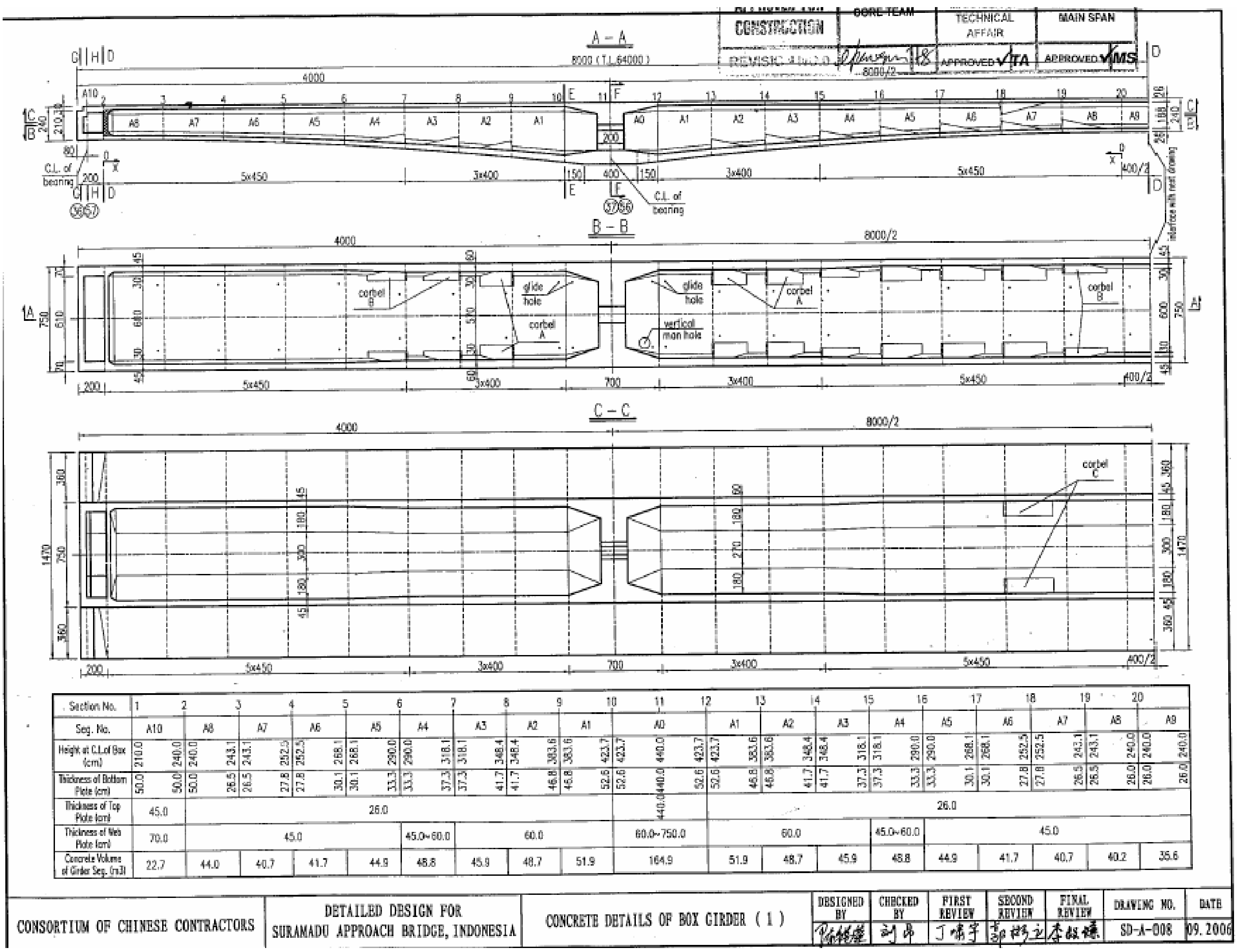


Drawing SD-A-005

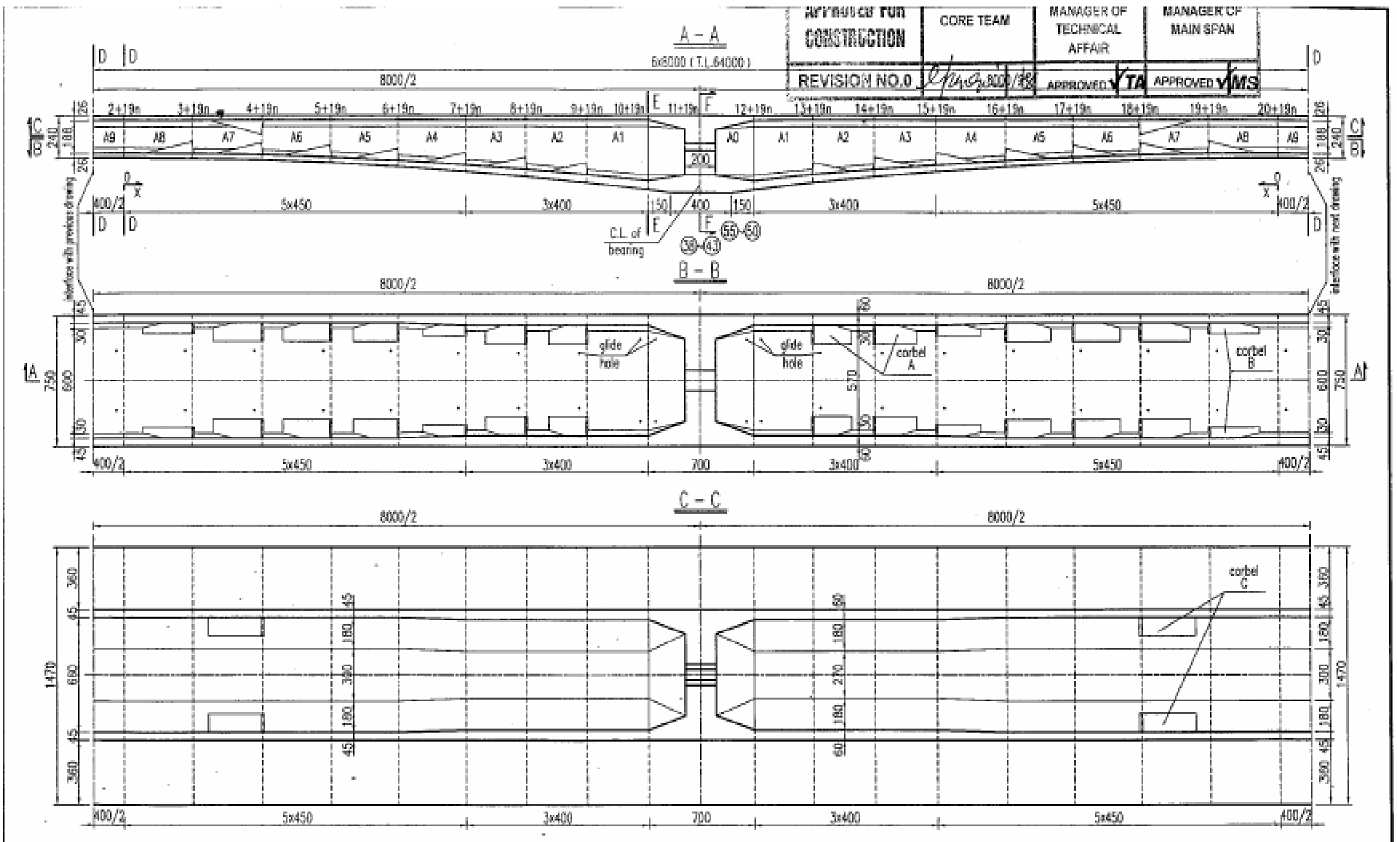
1.4 Design of Segment

The design of segments is shown in the drawing SD-A-008 for the first span in Surabaya side (P36-P37) and SD-A-009 is for the second span and consecutive span (P37~).

Dimension of segment would be decided by the capacity of traveller, location of PC tendons, and span length.



Drawing SD-A-008



Section No.(n=1~6): 2+19n, 3+19n, 4+19n, 5+19n, 6+19n, 7+19n, 8+19n, 9+19n, 10+19n, 11+19n, 12+19n, 13+19n, 14+19n, 15+19n, 16+19n, 17+19n, 18+19n, 19+19n, 20+19n

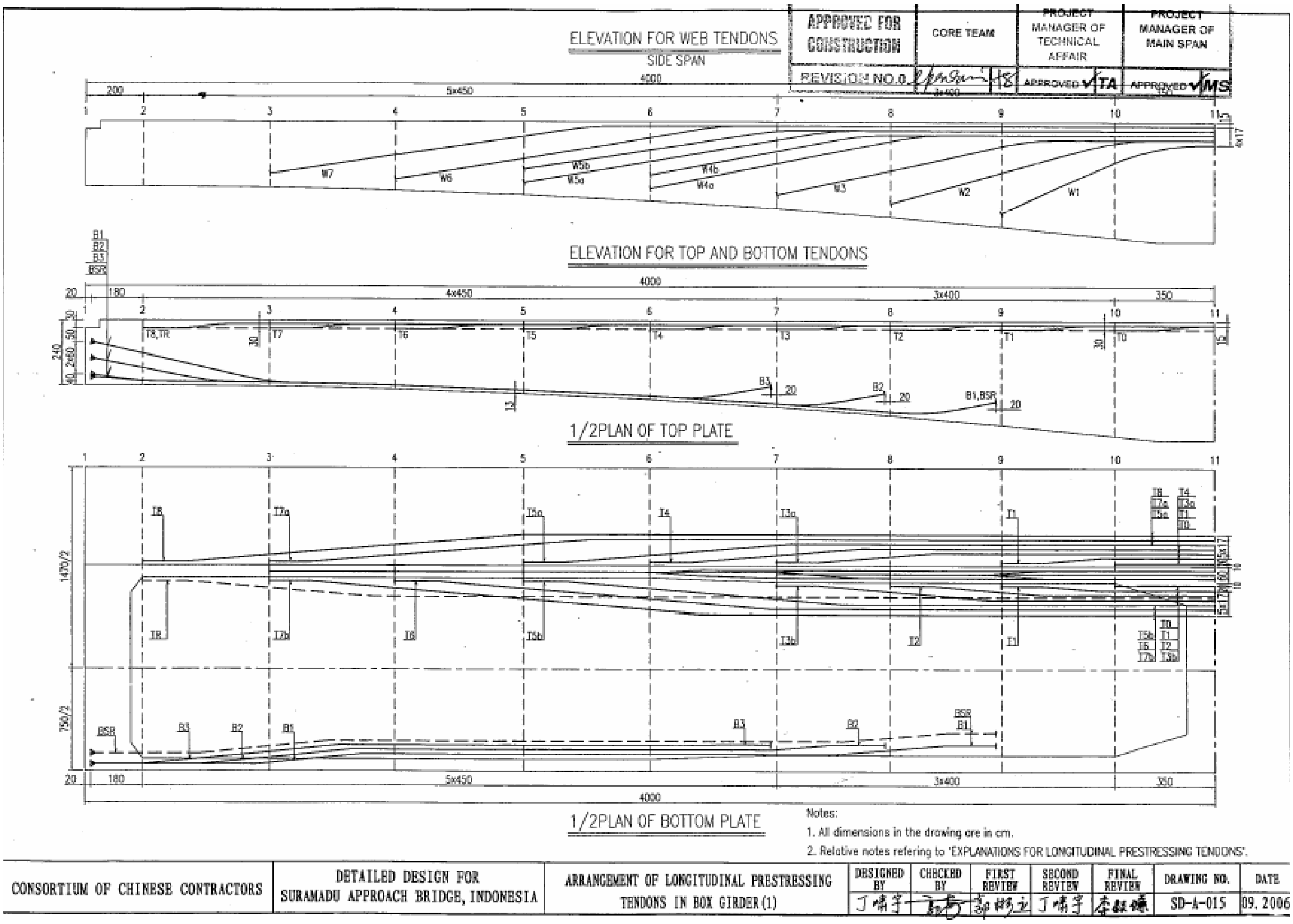
Seg. No.	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9
Height of C.L.of Box (cm)	240.0 240.0	240.0 243.1	243.1 252.5	252.5 268.1	268.1 290.0	290.0 318.1	318.1 348.4	348.4 383.6	383.6 423.7	423.7 440.0 423.7	423.7 383.6	383.6 348.4	348.4 318.1	318.1 290.0	290.0 268.1	268.1 252.5	252.5 243.1	243.1 240.0	240.0 240.0
Thickness of Bottom Plate (cm)	26.0 26.0	26.0 26.5	26.5 27.8	27.8 30.1	30.1 33.3	33.3 37.3	37.3 41.7	41.7 46.8	46.8 52.6	52.6 440.0440.0 52.6	52.6 46.8	46.8 41.7	41.7 37.3	37.3 33.3	33.3 30.1	30.1 27.8	27.8 26.5	26.5 26.0	26.0 26.0
Thickness of Top Plate (cm)		26.0								440.0	26.0								
Thickness of Web Plate (cm)		45.0				45.0~60.0	60.0			60.0~750.0	60.0			45.0~60.0	45.0				
Concrete Volume of Girder Seg. (m3)	35.6	40.2	40.7	41.7	44.9	48.8	45.9	48.7	51.9	164.9	51.9	48.7	45.9	48.8	44.9	41.7	40.7	40.2	35.6

CONSORTIUM OF CHINESE CONTRACTORS	DETAILED DESIGN FOR SURAMADU APPROACH BRIDGE, INDONESIA	CONCRETE DETAILS OF BOX GIRDER (2)	DESIGNED BY	CHECKED BY	FIRST REVIEW	SECOND REVIEW	FINAL REVIEW	DRAWING NO.	DATE
			[signature]	[signature]	[signature]	[signature]	[signature]	SD-A-009	09. 2006

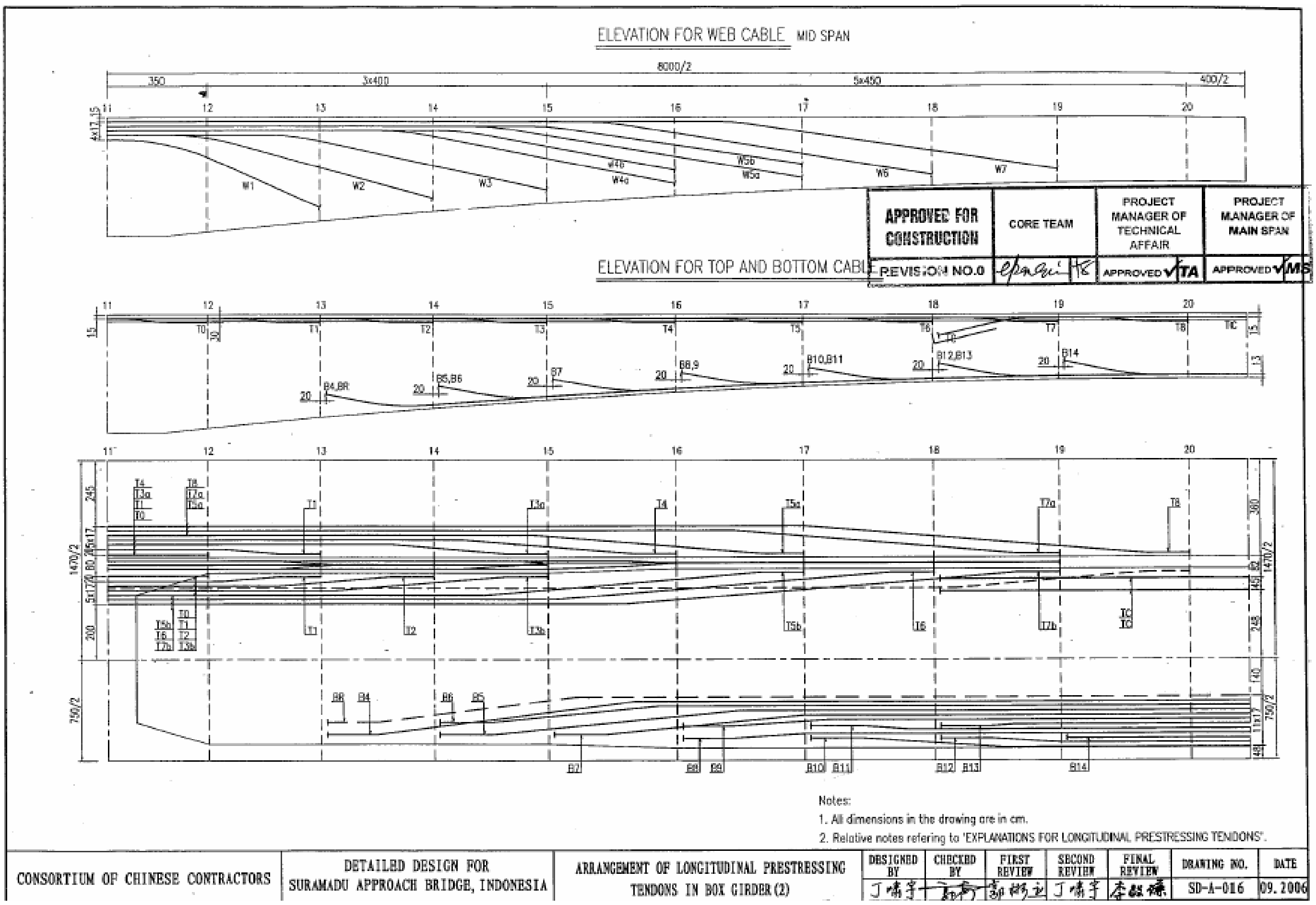
Drawing SD-A-009

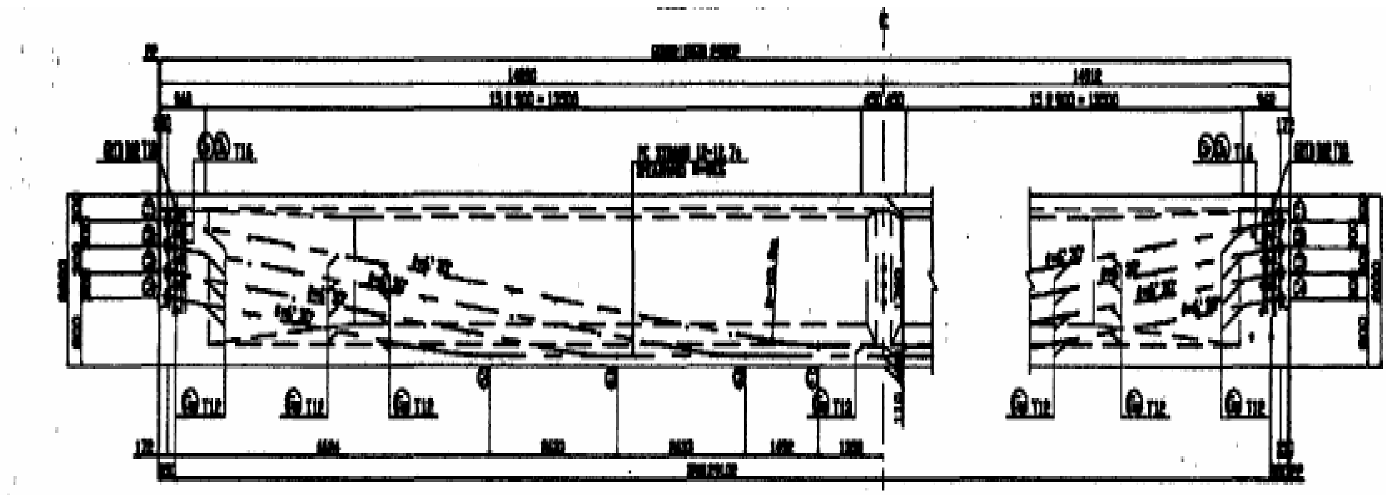
1.5 . Arrangement of PC Tendons

Comparison is made in the arrangement of PC tendons between Cantilever Bridge and T-shape girder.



Drawing SD-A-015





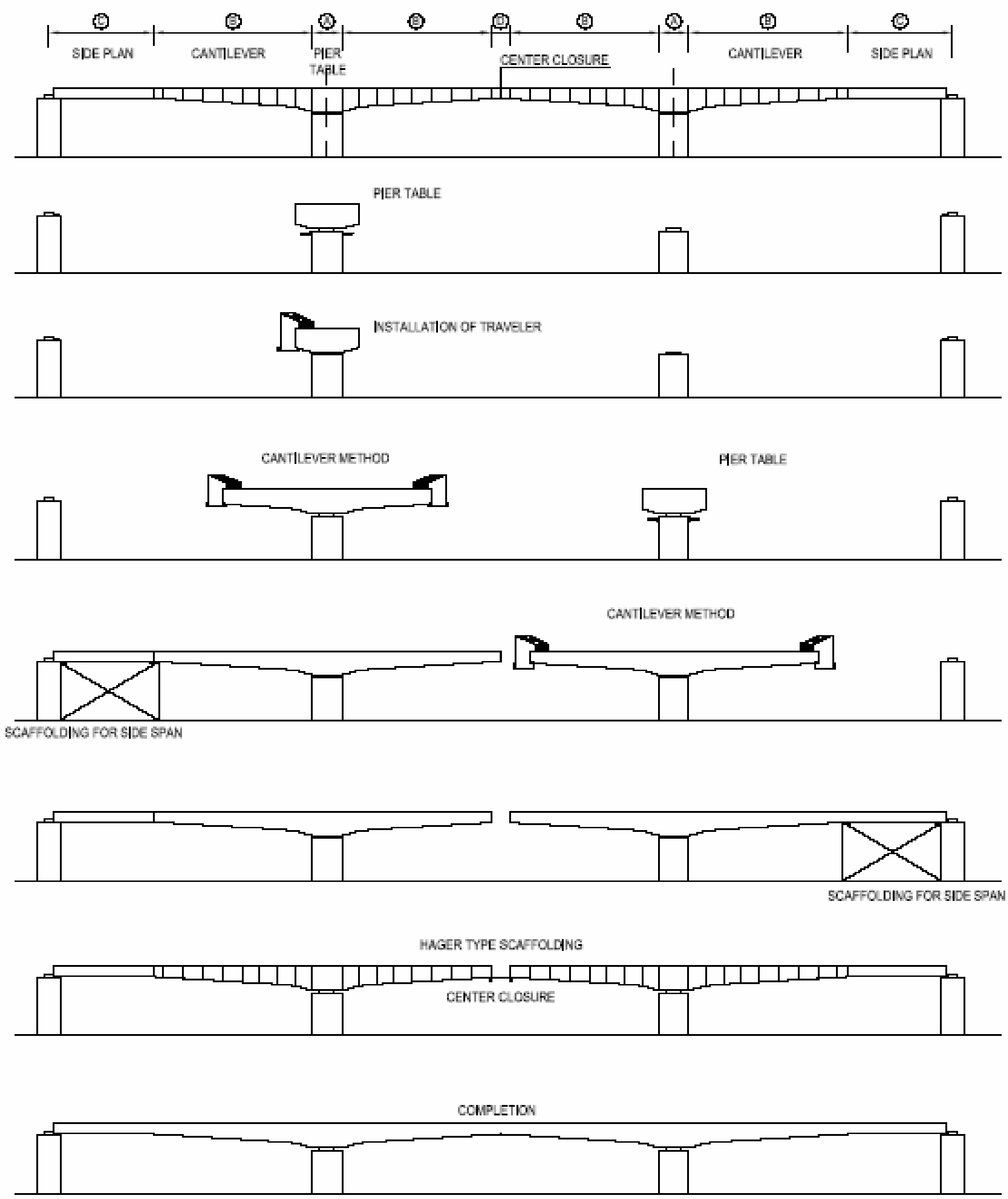
Example of the tendon arrangement of the typical T-girder

2. EXECUTION

Work sequence in the model of the cantilever-method bridge is shown in the following drawing figure 2.1. The work sequence is based on the concept design of cantilever-method.

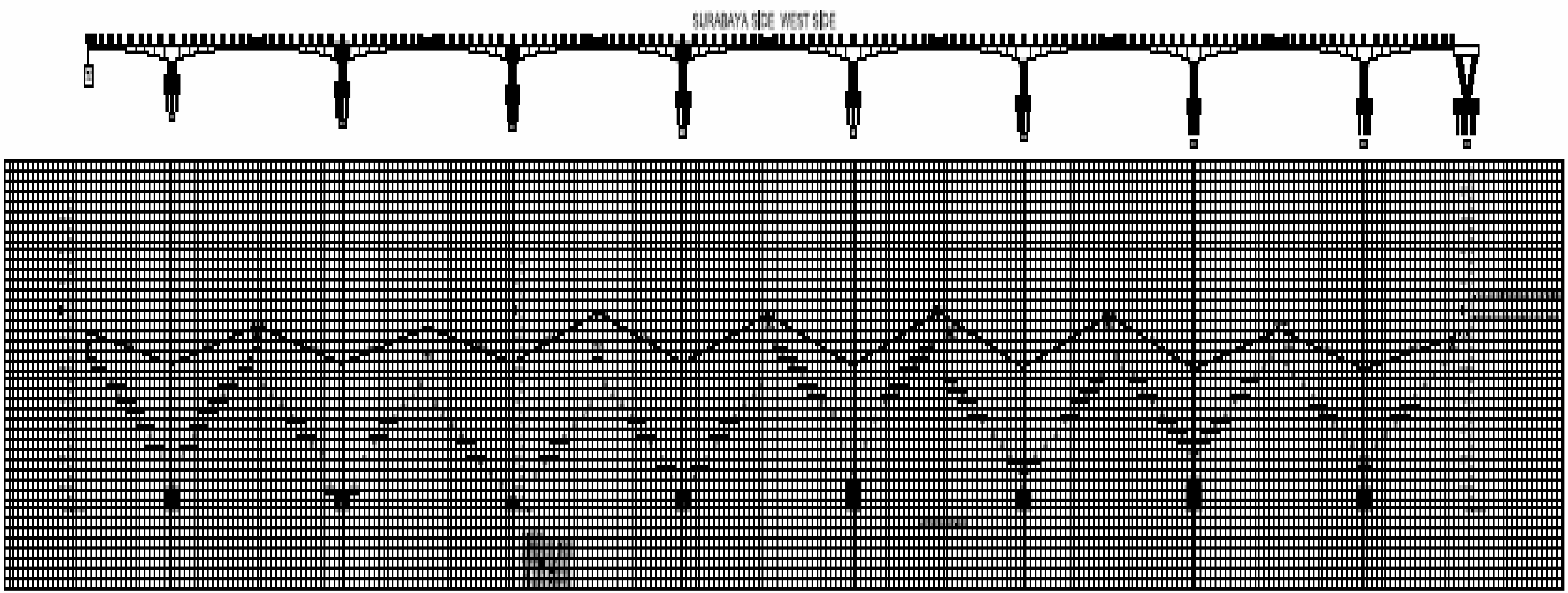
Cast-in situ method and Pre-cast segment method are used in the cantilever bridge. Cast-in situ method has the advantage that the accuracy of the girder could be kept since during the construction, the deflection and/or the pre-camber control could be easily done.

Fig. 2.1. Cantilever-method concept



2.1 Schedule

Practical schedule for Suramadu Approach Bridge is shown in the next page:
(Example)

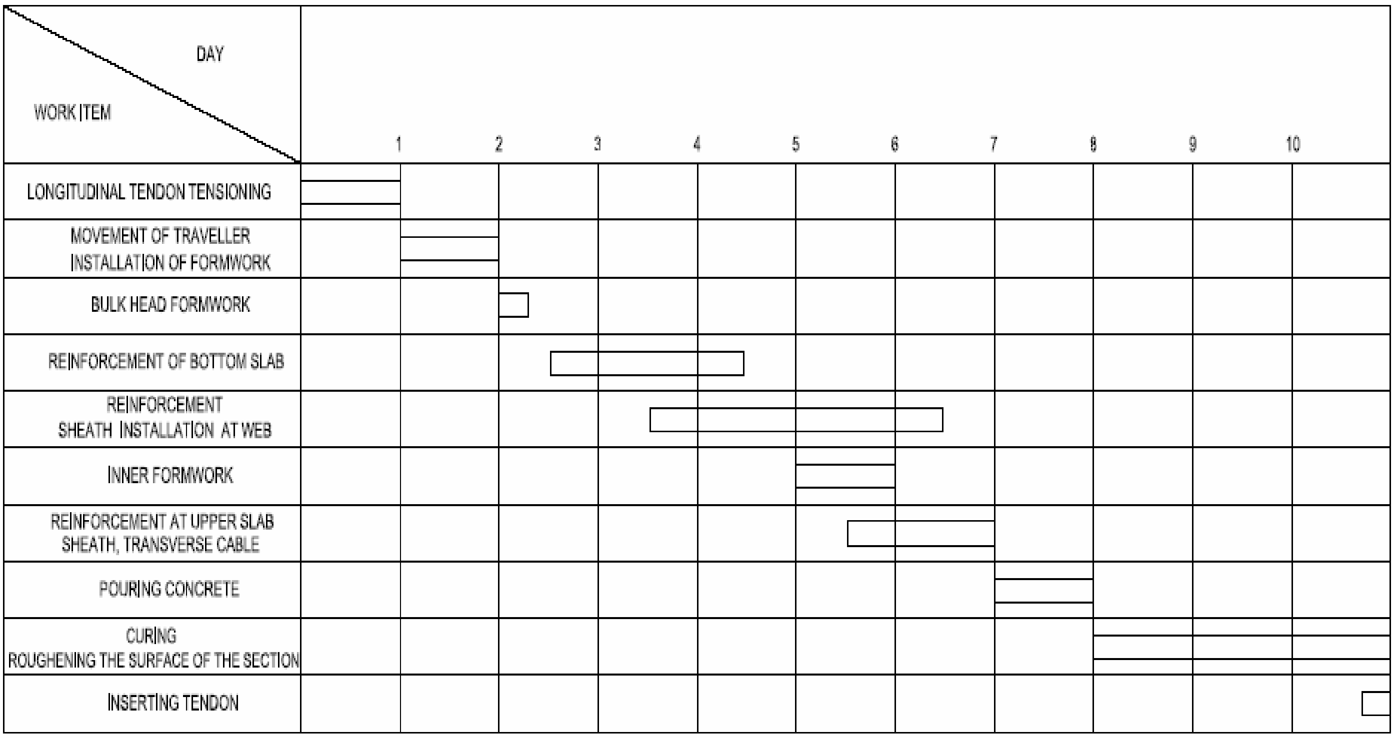


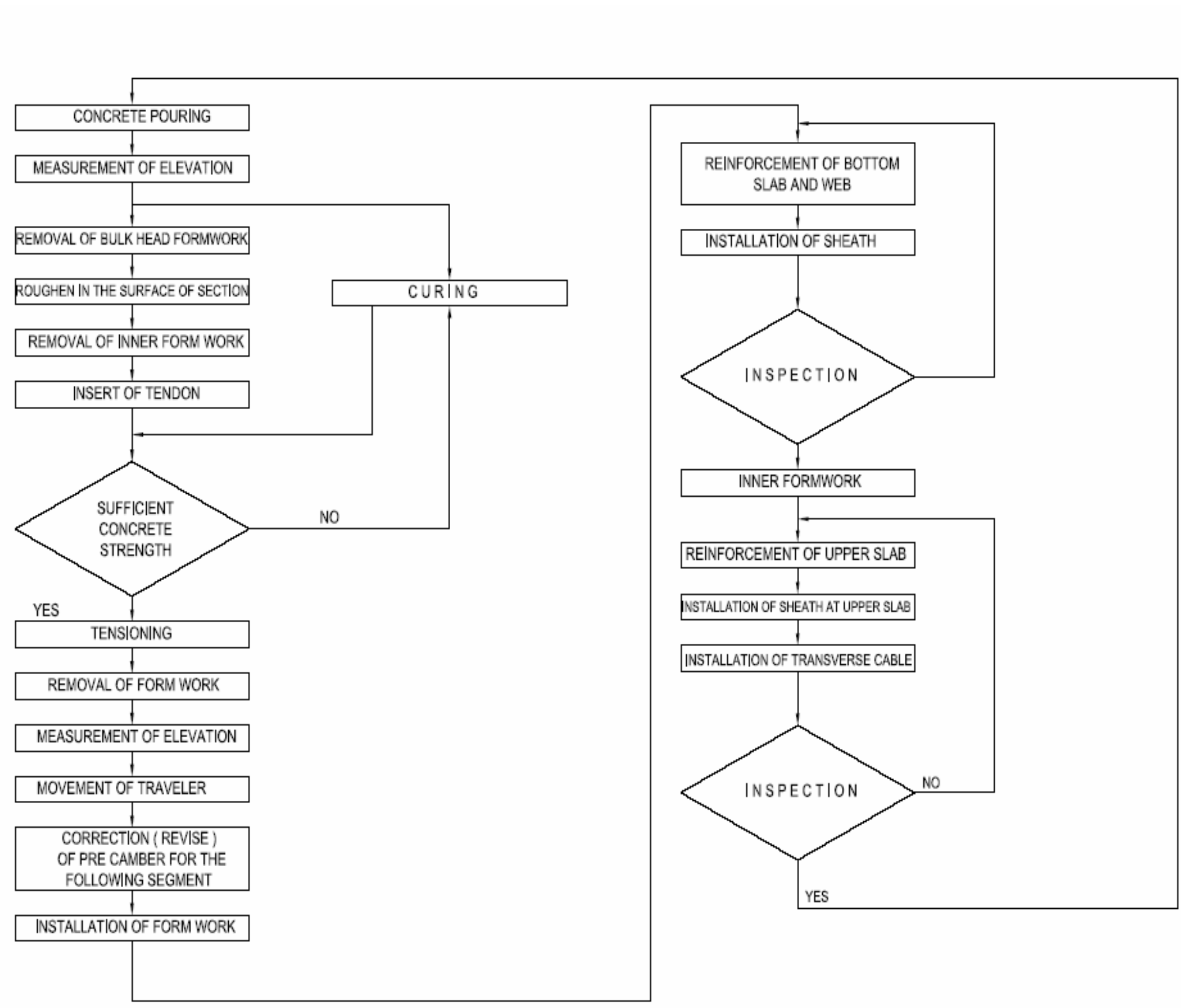
2.2 Pier Table

Photo of scaffolding is shown here.

2.3 Cycle Time for Cantilever Section

Standart cycle time for the cantilever section is shown in the following table and the flowchart of one cycle is also shown in the next.





Flow chart of one cycle for one segment

2.5 Traveller

In this Suramadu Bridge Project, CCC is the main Contractor and CIC is the nominated sub-Contractor to CCC. CCC uses his own traveller. CIC also has his own traveller system which was introduced in the previous seminar.

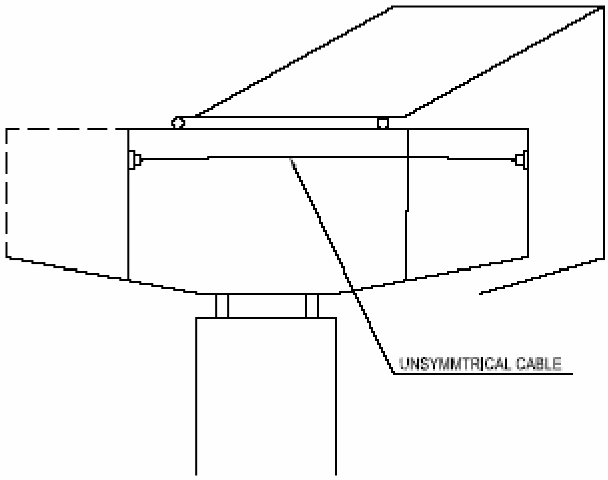
Because the length of the pier table is only 7 m, CCC' two travellers were not be able to be assembled simultaneously. Therefore, erection girder is utilized for the first two segments for both sides of a pier. CIC's traveller was designed so as to that the two sets of the traveller could be assembled simultaneously within 7 m for the both sides of a pier.

CCC's Traveller

CCC's erection girder for segment A1

Japanese traveller length is usually from the main jack to anchor jack is ± 5m, therefore, the design of unsymmetrical cable (tendon) arrangement could be utilized when the pier table has insufficient length for two travellers.

Fig. 2.5.1 shows the unsymmetrical arrangement of tendon.



UNSYMMETRICAL ARRANGEMENT OF THE CABLE

2.6 Pre-camber

Precamber is one of the most important elements in cantilever-method bridge. During cantilever stage, the vertical movement of the girder can be observed. Therefore, during the construction, pre-camber shall be considered at the installation of the slab formwork in order that the actual elevation could meet the designed elevation at the completion of the girder and/or the end of creep. For this reason, the deflection at each construction stage shall be calculated in the design stage.

The considerable types of deflection are as follows:

1. By the concrete dead load (↓)
2. By the weight of traveller (↓)
3. By the pre-stress (↑)
4. By the traveler's own deflection (↓)
5. By creep and shrinkage (↕)
6. By the superimposed load (↓)
7. By removal of traveller (parapet, pavement) (↑)

(items 1–7: Japan)

And as additional deflection are calculated in China as follows:

1. ½ @ live load (↕)
2. Elongation of Anchor bar of traveller (↓)
   (If the tensioning is not given to the Anchor bar)

The photos show the measurement point for checking the elevation of the girder. At the moment in Suramadu Bridge ± 20 mm of the tolerance is specified for the elevation during the construction. Therefore, some correction or revisions shall be needed of the value of pre-camber for the following segment according to the result of survey of the elevation. This difference between the actual elevation and designed is because of the assumption of E, I of the concrete girder itself at the design stage.

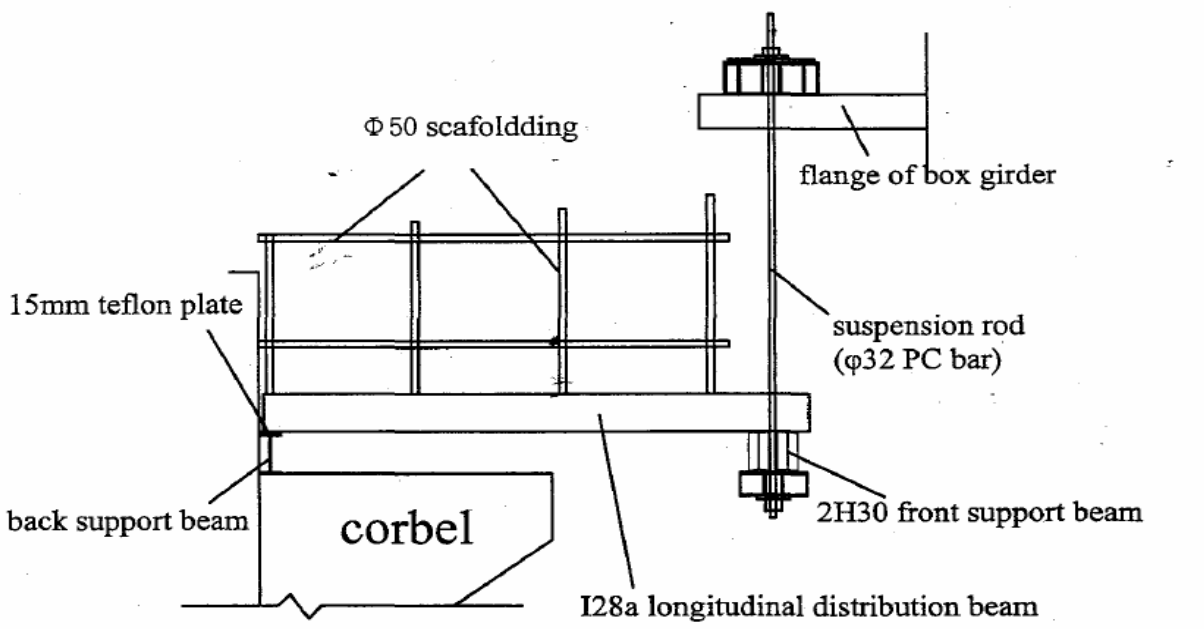
In Suramadu Bridge, at least 4 times of elevation checking for one segment is executed.

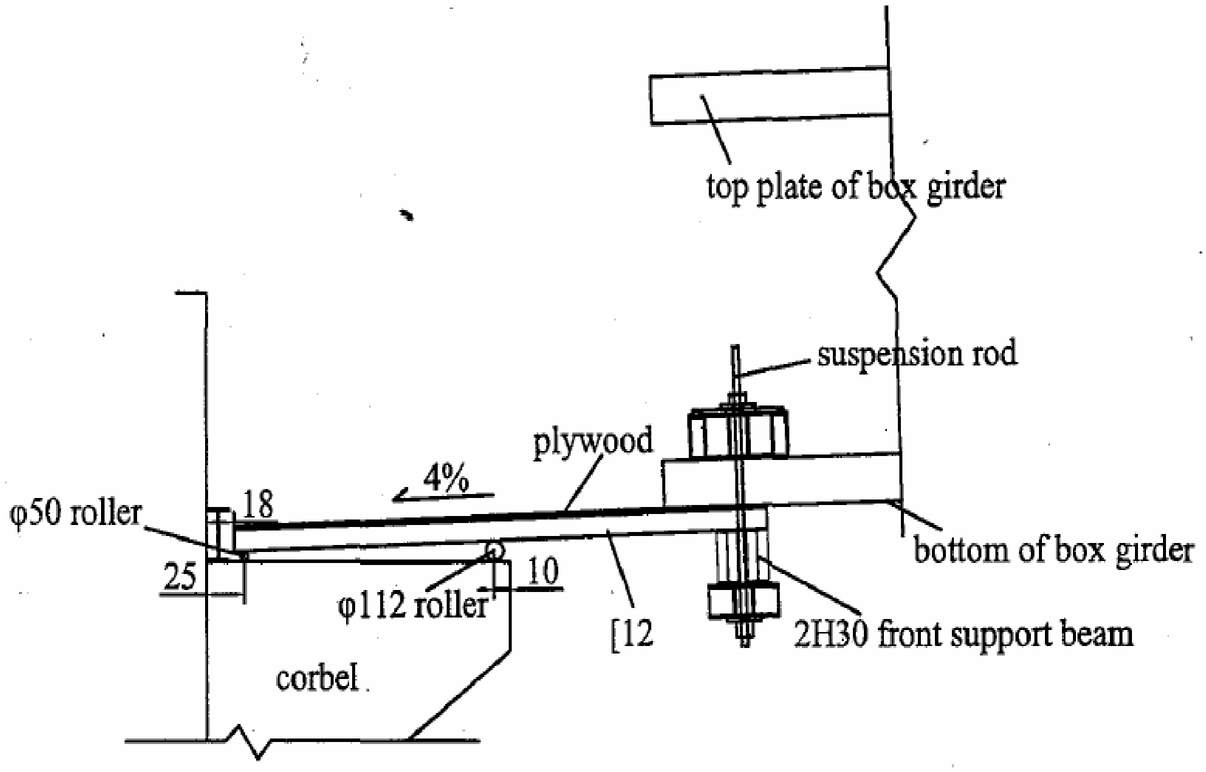
1. At the installation of slab formwork.
2. After the pouring concrete.
3. After the tensioning.
4. After the forward movement of the traveller.

Measurement point

2.7 . Scaffolding for The Side Span (Tail Girder)

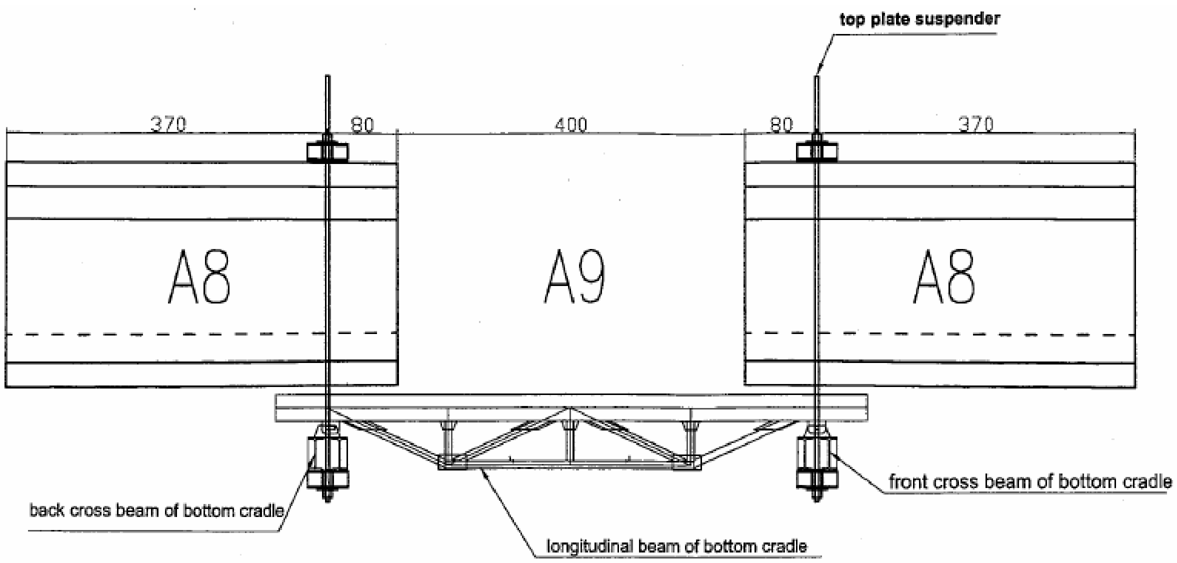
Following drawing shows the hanger-type scaffolding used in the Suramadu Bridge by CCC. The corbel at P57 supports the one end of the scaffolding. The other end is supported by the hanger from the cantilever segment.

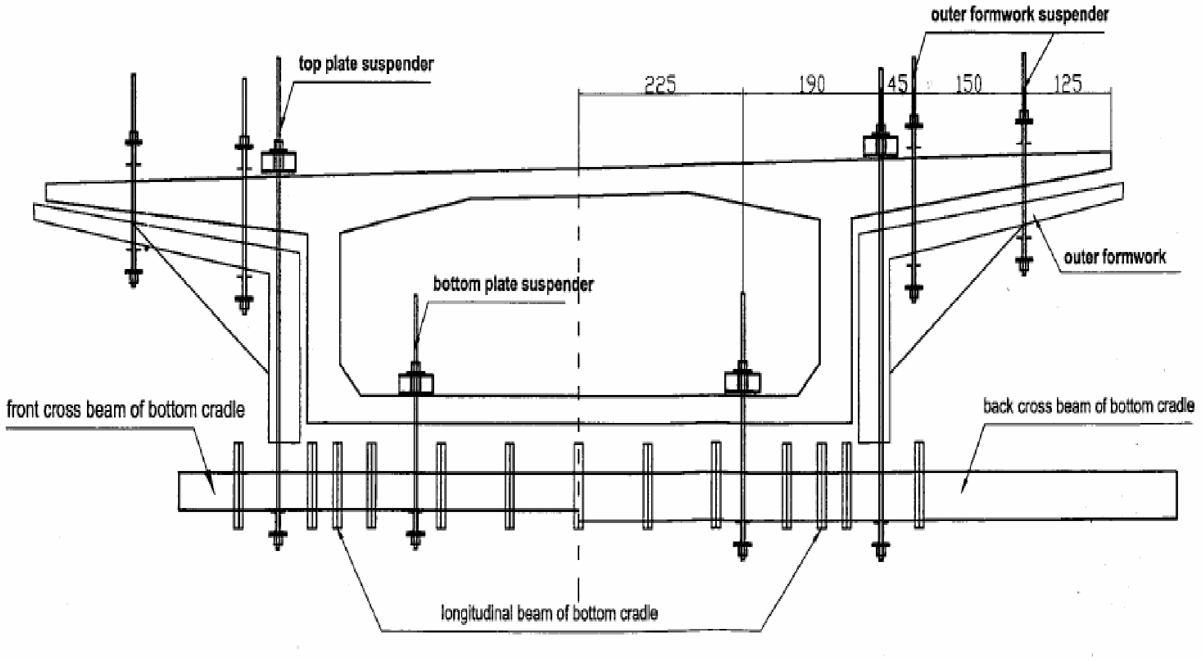




2.8 . Scaffolding for The Center Closure

The following drawing shows the scaffolding for the center closure. This is also hanger-type scaffolding which is used by CCC. In the other projects, traveller is also utilized as the scaffolding for the center closure.





3. CONCLUSION (ADVANTAGES OF CANTILEVER METHOD)

1. This type of bridge could be erected without any scaffoldings from the ground.
2. Accordingly erection need not to be affected by the land condition (River, Sea, Valley, and Ravine) and/or road, railway surrounding the erection spot.
3. Could be erected SAFELY and be erected by a small number of workers, because of the repetition works.
4. Arrangement of the PC tendons and the bending moment distribution are similar. Therefore, the rational design could be done.
5. Reference of this type of bridge in Japan is more than 2,200.
6. Can be applied for the span length of 40 m-300 m.
7. Can be applied for the certain curve alignment.