(9) No.18 Jahazoona Dak Bridge

As shown in Fig. 4.12, the topography of the proposed bridge construction site have one river terrace and two flat plains along the Sakhakot river.

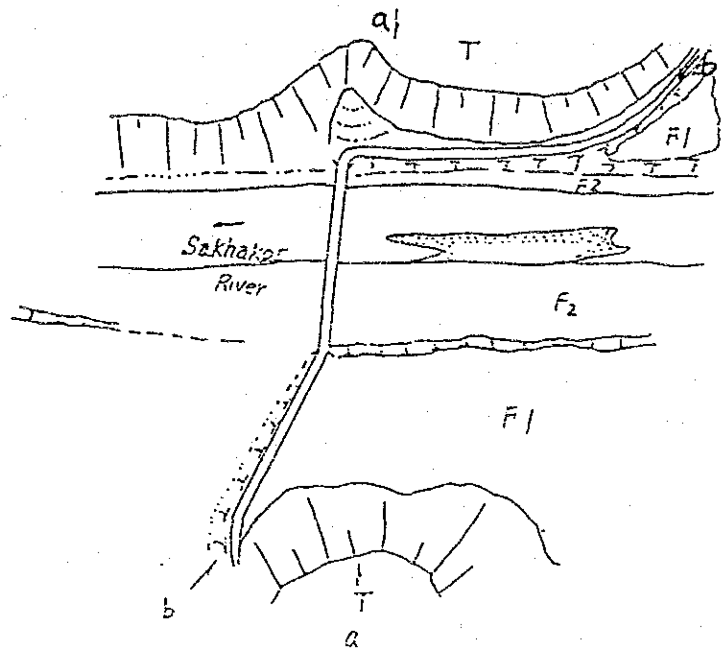


Fig. 4.12 General Geographical Features of the No.18 Jahazoona Dak Bridge

Elevation of the terrace is 460 meters, and 15 m from the river-bed. Slope of the terrace cliff is steep with about 45 degrees and the terrace has a wide spread. Dargai and Sakhakot hamlets and crop lands are found on this terrace.

Flat plain of the area is shown in Fig. 4.12. This lies below the terrace and comprises two distinguishable flat surfaces. The upper flat plain (F1) has an elevation of 450 meters, and distributed along the left bank of the Sakhakot river.

The lower flat plain, (F1) extends over the bed of the present Sakhakot river with an elevation of 446 m, and 40 meters above the Sakhakot river bed. This plain is largely distributed over the left bank of the Sakhakot river and a narrow strip on the right bank. On the right bank of the river, sandstone deposit is found. Jahazoona Dark to Gawar Killey road passes over both sides of this plain. As the road approaches the river, it takes a declination towards the lower portion of the upper flat plain, and crosses the river over the existing bridge. As the existing bridge is located in a low altitude, usage of this bridge during high flood season is hampered. The new bridge site is planned on the upper flat plain to avoid these inconveniences.

(10) No.19 Totakan Bridge

Characteristics of this area can be explained by the following two factors. (1) As shown in Fig. 4.13 river flat plain and river terrace can be found along the Swat river. The river flows in the west direction and is 70 m wide. (2) As shown in Fig. 4.14, surface of the terrace cliff on either side of the river has a different formation.

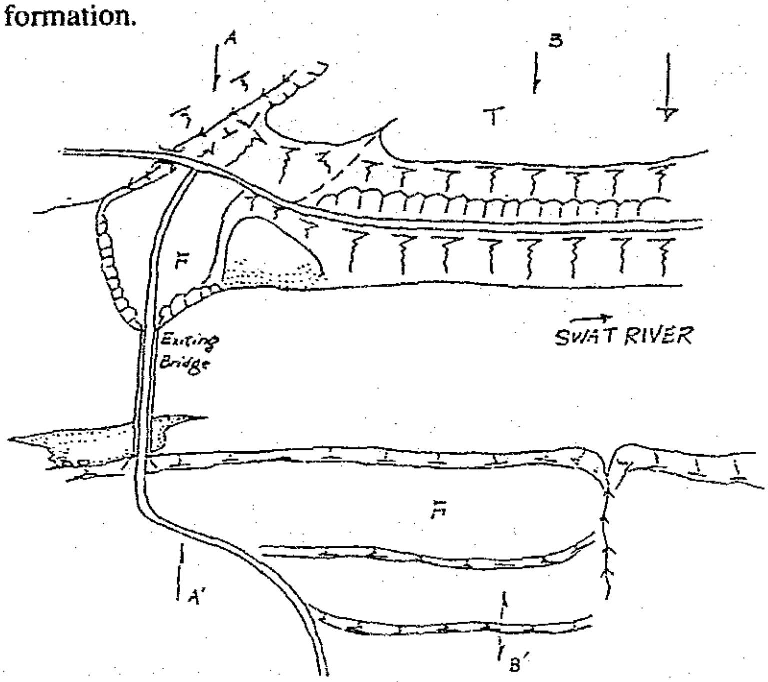


Fig. 4.13 General Geographical Features of the No.19 Totakan Bridge

Elevation of the terrace surface (T) is 790 m and 20 m above the river bed. Terrace is distributed on either side of the Swat river. Elevation of the flat plain (F) is 680 m, and 8 m above the river. This is located on the left side of the Swat river, and houses are built on this plain. An abut of the existing Totakan bridge is under construction. The flat plain and other side of the Swat river is widely used as crop lands. Terrace cliff on the left of the Swat river has about 45 degrees of steep slope. Totakan-Kamala road is located on the steep slope on the left bank of the river. Schist is cropped out on the slope of this road. As shown on Fig. 4.14, the terrace cliff on the right bank of the Swat river is used as crop lands. These crop lands extends from 660 m to 680 m in elevation at 1 m steps.

The existing bridge is shown in Fig. 4.13, The bridge was constructed at the narrowest portion of the Swat river. The new bridge is planned 100 m down stream from the existing bridge. This bridge will be constructed to make full use of the new road now under construction.

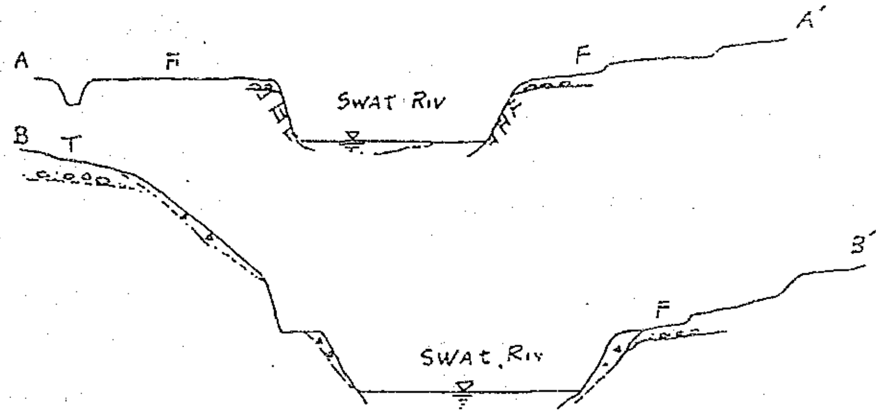


Fig. 4.14

(11) No.20 Sakhakot Bridge

As shown in Fig. 4.15, characteristic of the topography of the proposed bridge construction site is the river terrace that spreads along the Sakhakot river.

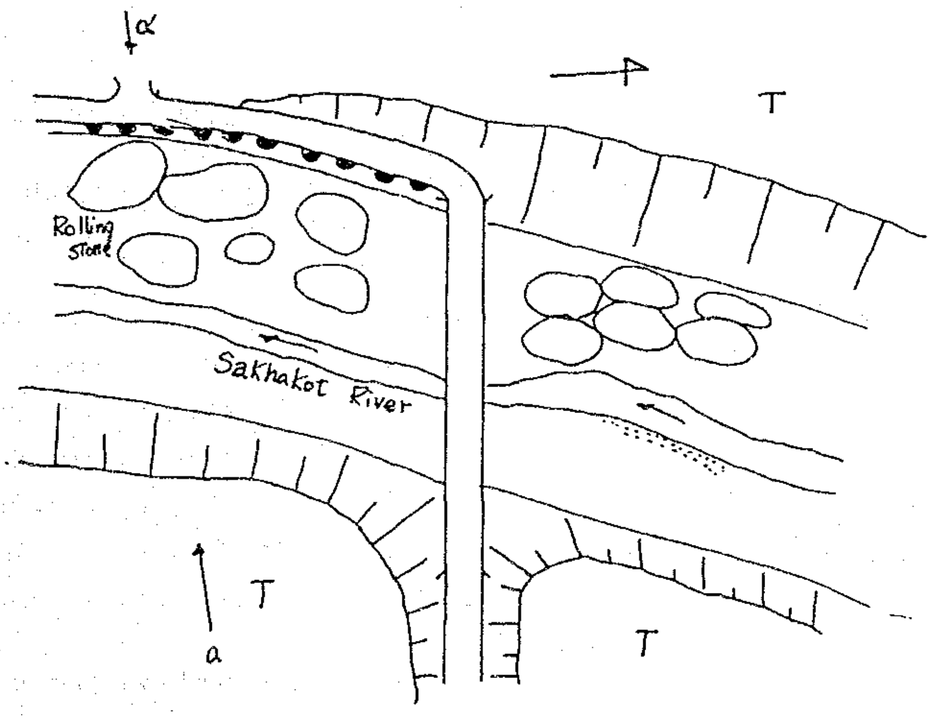


Fig. 4.15 General Geographical Features of the No.20 Sakhabot Bridge

Elevation of the terrace (T) is 488 meters, and 15 m above the river bed. Wide distribution of the Sakhakot river is shown in Fig. 4.16, which forms a U shape. Massive rolling stone with diameter of about 2-3 meters are located in the river. Presence of these stones could retard the flow of the river. The Sakhakot road that starts from Sakhakot bazaar runs through the terrace and meets the Sakhakot river bank at the existing bridge site. Elevation of the existing bridge site is 480 meters. After crossing the bridge, the road inclines and reaches the terrace. The low elevation of the existing bridge make it vulnerable to high floods. A new road will be built over the terrace by changing the course of the existing roads.

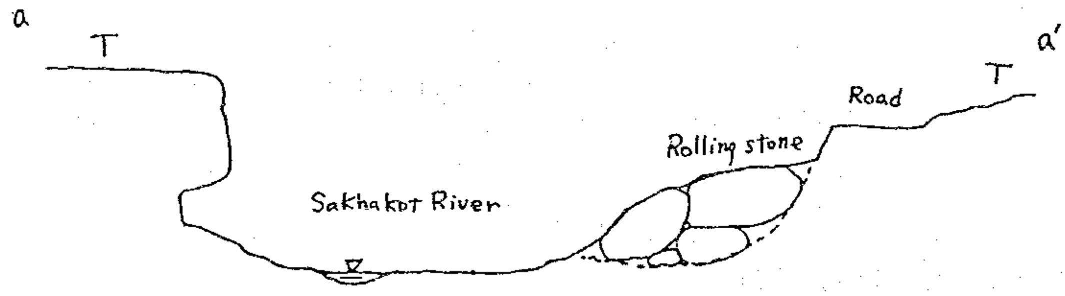


Fig. 4.16

4.2.3 Geological conditions of Bridge Foundation

(1) No.1 Narlai Bridge

A limestone layer is distributed 10-20 m from the surface, and river sediment is located above the limestone layer. Therefore, the river foundation has to be set up on the river sediment layer or on the limestone.

River sediment is formed by a mixture of sandy silt and boulders. On the ground surface, diameter of boulders is about 1-1.5 meters but due to limitation in the boring machine, diameter of the observed boulders was 6-12 cm. The S.P.T test were hindered by the rebound action of boulders where the direct penetration is warranted. Also, a boulder layer with satsifactory width was not found. Therefore, the boring results can not be taken as satisfactory results when deciding the position of the foundation. If the foundation is planned on the sediment layer, changes in the depth of the foundation and other unseen problems could occur.

In contrast to this, it was found from the boring results that the limestone is grayish white, hard and has a massive core. This indicates that the limestone is better for constructing the foundation.

It was estimated that the limestone compressibility is over 400 kg/cm^2 and the shear strength is over 10 kg/cm^2.

(2) No.5 Pashorai Bridge

In this region the geology can be described by terrace sediment, river sediment, with gneiss as the base rock.

The results of boring investigation done at the river bed and the abutment location of the new bridge shows that the geology of this area can be divided into two categories. The first layer is the boulder layer of river sediment. This layer is distributed 5.2 - 6 m from the ground surface and is formed by a mixture of clay-clayey sand and boulders. Boulders are comprised of granite with diameter of 9 - 55 cm. The S.P.T. test results during the drilling were hindered by the rebound action of boulders.

Below the first layer, a gneiss layer was found at the depth of G.L-5.2 - -6.0m. This gneiss is a partly weathered layer comprising altered mafic minerals.

Therefore the second layer is suitable for the bridge foundation as the first layer is thin and the strength of the second layer is sufficient for the foundation of bridge. In such a case, that direct foundation on the gneiss layer is recommendable. Also the strength of gneiss is expected to have a cohesion of 30 - 40 t/m^2, inter-friction angle of 35 degree and compressibility of 100 - 140 kg/cm^2.

(3) No.7 Panipa Bridge

In this area there are river sediment, talus sediment with granite as the base rock. The talus sediment is distributed only along slopes.

In this geological layout, the tower and anchor foundation of the new bridge is planned to be set on the granite distributed area, and construction road is to be located on the talus sediment distributed area.

Granite rocks in this area are very hard and sometimes have gabbro intrusions with garnets. The bridge planning area is located at the granite outcrops. These granite rocks corresponds to the CM class in the classification of rocks. Therefore, the strength of the granite rocks is expected to hav a cohesion of 50 - 60 t/m^2, inter-friction angle of 35 - 37 degree and compressibility of about 400 kg/cm^2.

There are two problems in this bridge construction. One is the looseness of granite rocks. On the right bank of the Indus River, the granite rocks have many open cracks. These cracks shows that its strike is north 50 degree east and dip is 40 degree toward east concordant with ground surface slope. These cracks are called Seating Joints, and were formed by the long natural relaxation of rocks during the erosion of Indus River. Accident could occur during the construction stage or the opening stage of this bridge unless proper countermeasures are taken against these looseness of granite rocks.

Another problem is the instability of the talus sediment distributed on the slope of the left bank of the Indus River because the thickness of this sediment is thin. Therefore, flexible gabion wall, which would withstand the earth pressure of slopes and prevents any damage to road in a slope failure must be provided along the construction road. If the talus sediment should cause a failure, the setting of reinforcement bar vertical to the ground as temporary countermeasures is recommendable.

(4) No.11 Choni Bridge

In this region the geology can be described by terrace sediment, river sediment, and fan sediment with slate as the base rock. But slate was not observed by drilling at the bridge site.

The result of the drilling shows that the boulder layer of river sediment and fan sediment are distributed 20 m from the ground surface. This layer is formed by clayey sand bearing boulders. Boulders are comprised of granite with a max. diameter of 50 cm. The S.P.T. test results during the drilling were hindered by the rebound action of boulders.

As the thickness of the boulder layer is about 20 m, it is recommended to construct a pile foundation for the tower into the boulder layer, which could stand against scoring by the water flow, and a direct type foundation for the suspension anchorage.

(5) No.12 Khal Bridge

The geology of the area can be divided into four categories; Detritus (D_t), River sediment (R_S), Terrace deposit (Tdgl) and Granite (Gr). Detritus is composed of silt and clay with cobble stone and distributed along the NCC road and the dumping site. Terrace sediment consists of sand and boulders with large boulders of granite. This is distributed at the left side of the Panjkora river. Therefore, the foundation in the river has to be setup on the river sediment layer or on the granite layer.

From the boring results, it was found that the river sediment is formed by silty sand with granite boulders with diameters of about 3-11 cm. The S.P.T test results were hindered by the rebound action of boulders. Also, a boulder layer of satisfactory width was not found. Therefore, the boring results can not be used as a reliable data when deciding the position of the foundation. If the foundation is planned on the sediment layer, changes in the depth of the foundation and other unseen problems could occur.

In contrast to this, granite was found at about 20-30 m depths from the surface, and the upper surface of the granite layer showed very gentle slope. Also, it was found that the granite is white, compact and very hard. Therefore, this place is suitable for constructing foundation for the proposed bridge.

It was estimated that the limestone compressibility is over 400 kg/cm^2, the internal friction angle over 35 degrees, cohesion over 40 degrees and V_p over 2.5 km/sec.

(6) No.14 Bukari Khawar Bridge

In this region, the geology can be also described by the errace sediment, river sediment, with granite as the base rock similar to the Haya Serai Bridge.

However, borings performed at the river bed and abutment of the new bridge could not reach the surface of the granite layer. The result of the boring investigation shows that the boulder layer of river sediment is distributed about 21 m from the ground surface and the boulder layer is formed by a mixture of clayey sand and boulders. Boulders are comprised of granite with a max. diameter of 100 cm. The S.P.T. test during the drilling were hindered by the rebound action of boulders. The N value recorded only once showed 30. Therefore, the boulder layer is considered suitable for the bridge foundation as the boulder layer is thick and direct foundation on the boulder layer is recommendable.

(7) No.16 Kaidonl Bridge

In this region, the geology can be described by the terrace sediment, river sediment, detritus with granite as the base rock.

The result of the boring investigation performed at the river bed and abutment of the bridge shows that the geology of this area can be divided into three categories. The first layer is the top soil comprised of clayey sand-sandy clay. This layer is distributed about one meter from the ground surface.

The second is the boulder layer of river sediment. This layer is distributed at about 11 - 15 m below the first layer and is formed by a mixture of clay - clayey coarse sand and boulders. Boulders are comprised of granite with a max. diameter of 80 cm. The S.P.T. test during the drilling were hindered by the rebound action of boulders.

Below the second layer, the third layer, a granite layer was found at the depth of G.L. -12 to -16.0 m. This granite is very hard with white gray color.

From these geological conditions, the second layer is considered to be the most suitable for the bridge foundation as the boulder layer is sufficiently thick to be stable and therefore, the direct foundation on the boulder layer is recommendable.

(8) No.17 Peer Baba bridge

In this region, the geology can be described by the alluvium sediment with the Devonian and Silurian granite and meta-rocks as the base rocks.

The results of four boring test performed at the river bed and abutment of the new bridge shows that the geology of this area can be divided into three categories. The first is the upper boulder layer. This layer is distributed at about 5.-6 m from the ground surface and is formed by a mixture of coarse sand and boulders. Boulders are comprised of granite. The S.P.T. test during the drilling were hindered by the rebound action of boulders.

The second is the clayey layer having a thickness of 10 m below the first layer. The S.P.T. test shows that this layer is so loose and has a N value of 4 ~ 20.

Below the second layer, the third layer, a boulder layer was observed at a depth of G.L. -15 - -16.0 m. The S.P.T. test of the lower boulder layer during the drilling were hindered by the rebound action of boulders.

From these geological conditions, the third layer is considered to be the most suitable for the bridge foundation as the upper boulder layer is thin and the clayey layer has not enough strength and therefore the pile foundation on the lower boulder layer is recommendable.

(9) No.18 Jahazoona Dak Bridge

Geology of this area can be divided into the following 6 categories :

(1) River sediment 1 (Rdl), (2) River sediment 2 (Rd2), (3) Detritus 1 (Dt1), (2) Detritus 2 (Dt2), (5) Sandstone (Ss), (6) Mudstone (Md).

Detritus 1 and 2 are composed of sand and boulders. Detritus 1 is a composition of materials distributed on slope, and consists of loam and sand with cobble.

Detritus 2 is formed by loam and sand with cobble and distributed in flat areas. River sediments and Detritus sometimes are found in reddish color, hard and conglomerate rolling stones with a diameter of about 1-2 meters.

This distribution is not continuous. The formation can be due to the temporary cementation of calculus liquid.

Below the river sediment, mudstone layer and sandstone layer is distributed. Sandstone layer has a grayish blue color and composed by fine sand and coarse sandstone.

Mudstone layer has a dark grayish color and massive.

River sediment and detritus are not well cemented and the N value on the S.P.T. test was below 30. Therefore, these layers are not considered suitable for construction of the proposed bridge foundation.

In contrast to this, the N value of the sandstone and the mudstone layer in the S.P.T. test was in the range of 30 to 50. Also, these are soft rocks. Continuous distribution in the lateral direction, therefore can be considered as suitable for foundation construction. According to the rock classification, the **qu** of mudstone and sandstone was about 5-10 kg/cm^2. With these observation the following important points can be enumerated;

1. The foundation of the bridge should not be placed on the reddish color conglomerate rolling stone.

2. Mudstone and sandstone have a slaking characteristic. Therefore, these could be subjected to easy weathering. To avoid this, excavation has to be fast and soil layers after work have to be protected from exposure.

(10) No.19 Totakan Bridge

Geology of this area can be divided into the following 7 categories:

(1) Detritus (Dt), (2) Terrace sediment (Ts), (3) Old river sediment 1 (Ors1), (4) Old river sediment 2 (Ors2), (5) Weathered schist (Wsch), (6) Pelitic schist (Pel), (7) Psammitic schist (Psa).

Detritus is distributed along the left side of the Swat river, and composed of silt and loam with cobble. Thickness is about 1 meter. This layer can be considered as the soil that have been deposited during the construction of Totakan-Chakdara road.

On the left of the Swat river weathered schist, Pelitic schist and Psammitic schist are distributed below the Detritus layer.

Weathered schist have been formed by the rocks disturbed during the construction of the Totakan-Chakdara road or due to natural weathering. This has been classified as C_L in the rock classification.

Pelitic and Psammitic are stable and compact in this area. These are classified as C_L-C_M in the rock classification.

To the right side of the river terrace sediment, old river sediment 1, old river sediment 2, weathered schist, Pelitic schist and Psammitic schist are distributed from the surface in the consecutive order. Terrace sediment depth is about 5 meters and the N value of the S.P.T. test is greater than 25.

Old river sediment is distributed in the terrace sediment layer. This old sediment layer is comparatively deep and this can be divided into two groups; layer containing boulders with a diameter of 0.5-3 cm. (Ors1), and the layer containing boulders with a diameter of 1-12 cm (Ors2), which are comparatively larger.

Schist was identified at 1 meter below the surface in the drilling at No.19 Br-3 bore hole. From this result, it was assumed that the schist distribution of the area is convex shape.

On these findings and assumptions, it was deduced that weathered schist, Pelitic schist and Psammitic schist layers are suitable for the bridge foundation. It was estimated that one axial compressional strength, **qu** of this schist is about 300 kg/cm^2, shear strength 30 kg/cm^2, and Vp 2.5-2.8 km/sec. Considering the state of the equipments used in the project, the friction strength between rock and cement milk of the ground anchors planned to be constructed on the left slope of the Swat river should not be less than 5 kg/cm^2.

(11) No.20 Sakhakot Bridge

Geology of this area can be divided into the following 5 categories:

(1) Detritus (Dt), (2) Silt with boulders, (3) Sandy silt (Si), (4) Conglomerate (Cgl), (5) Mudstone (Md).

Detritus is sediments of topsoil and river sediment of the Sakhakot river. This is composed of hard, reddish conglomerate rolling stones. In the lower part of Detritus, terrace sediment is distributed. Terrace sediment is a composition of silt with boulders, sandy silt and conglomerate, but continuity of this layer is very poor.

Silt layer with boulders is composed of hard silt, clay and sand.

Boulder layer is composed of 3-10 cm boulders. Drilling results showed that this boulder layer is cemented and composed of conglomerate.

Below the terrace sediment layer, mudstone layer is distributed. To the left of the river, this layer is above the river bed, while it is below the river bed to the right of the river.

S.P.T. on silt with boulders layer can not be taken as accurate as the test was obstructed by the rebound.

Mudstone layer had a N value greater than 50 in the S.P.T. test. From the above observations it can be deduced that Detritus, Silt with boulders and Sandy silt, are not cemented, therefore not suitable for constructing bridge foundation. Drilling results showed that conglomerate is hardened, but the same materials found on the surface not cemented. Also, this layer is not continuous and lack of homogeneous strength. Therefore, conglomerate is not suitable for foundation.

On the other hand, mudstone layer N value was greater than 50 on S.P.T. test, and found to be homogeneous and soft rock. Lateral distribution was found and is therefore considered suitable for foundation construction. **qu** value of this layer was estimated as 5-10 kg/cm^2. Foundation of the existing bridge are also laid on this layer. The following two factors have to be considered in constructing the foundation on the mud layer.

1. The foundation of the bridge should not be placed on the reddish color conglomerate rolling stone.

2. Mudstone has a slaking characteristic. Therefore, this layer could be subjected to easy and fast weathering. Therefore, excavation has to be fast and soil layers after work have to be protected from exposure.

4.2.4 River Condition and Climate

(1) Subject Rivers

Rivers related to the 11 bridges of the Project consist of the following in discharge scale order.

1) Indus River:	No. 7	Panipa Bridge
2) Chitral River:	No.11	Choni Bridge
3) Swat River:	No.16 No.19	Kaidon Bridge, Totakan Bridge
4) Panjkora River:	No.12	Khal Bridge
5) Siran River:	No. 1	Narlai Bridge
6) Sakhakot Khawar:	No.18 No.20	Jahazoona Dak Bridge, Sakhakot Bridge
7) Malakpur Khawar	No.17	Peer Baba Bridge
8) Nandia Khawar:	No. 5	Pashorai Bridge
9) Nulla Bukari:	No.14	Bukari Khawar Bridge

Rivers of the above 1 to 5 have relatively large discharge volumes while the rest 6 to 9 flow occasionally in rainy season.

Characteristic of major rivers of the above 1 to 5 along with their climatic conditions are as follows:

(2) Indus River at No.7 Panipa Bridge

The Indus River, a world famous river, has its origin in Karakoram Range of the Himalayan Mountains. Water velocity is at 3 m/sec or more at the proposed bridge site. In summer, discharge volume is swollen (5,000 t/sec or more) by rain fall and snow thawing.

River course at the proposed Panipa Bridge, where hard rock exposes on both side banks, is quite stable and no serious river bank erosion might occur in near future.

The river width at the proposed bridge site is approximately 150 m. Due to extremely high velocity of water current and large discharge of the river, it seems quite impossible to construct piers in the river.

Climate is chilly and arid, and annual precipitation is approximately 500 mm or less. Maximum temperature is at most 20°C in summer, and snow fall begins in November.

(3) Chitral River at No.11 Choni Bridge

River basin of the Chitral River originates in the border between NWFP and Afghanistan and Gilgit, and its catchment area is approximately 7,000 km^2. The river flows through Chitral District, passing westwards into Afghanistan to join with the Kabul River, which turns eastwards and flows into Peshawar, NWFP.

Most of the Chitral River basin occupies Hindukush Range of the Himalayan Mountains, where precipitation is extremely low, approximately 500 mm per annum or less. Climate is chilly, freezing cold in winter.

Water current velocity of the river is relatively slow, approximately 1.7m/sec, at the proposed bridge site since the riverbed slope is relatively gentle. Maximum water discharge takes place in summer, approximately 1,200 t/sec, as a result of swell by snow thawing and rain fall.

(4) Swat River at No.16 Kaidon Bridge and No.19 Totakan Bridge

River basin of the Swat River originates in the border of NWFP and Gilgit. the river flows through Swat District, then passing Malakand Agency, and join with the Kabul River at Mohmand. Catchment area of the river is approximately 6,000 km^2 and an approximate discharge 2,760 t/sec at No. 19 Totakan Bridge site. The catchment area and discharge of No.16 Kaidon Bridge site is almost a half of those at the downstream side No. 19 bridge site and water are transparent.

The river course is relatively stable and any immediate erosion of riverbanks is not anticipated in both cases of No.16 and 19 bridges.

Velocity of river current water is high at approximately 2 m/sec, and therefore difficult construction of piers in the river is predicted.

(5) Panjkora River at No.12 Khal Bridge

River basin of the Panjkora River originates at about 40 km north from Kalkot. The river meets two major tributaries: one having origin near Lowari Pass and another having origin at Binshal. The river flows southwards through Gandigar, Wari and so on, and turns toward south-west then expanding its river width and flowing toward the proposed Khal Bridge site.

The Panjkora River, varying its river widths 70 m to 150 m, has a rapid flow velocity at approximately 2.38 m/sec that has been measured at the proposed bridge site in relatively low water period August 1992.

River basin covers most of entire land of Dir District and its catchment area is relatively large, approximately 3,500 km^2.

Annual precipitation is less than 625 mm. Annual mean temperature in the area is approximately 20°C.

(6) Siran River at No. 1 Narlai Bridge

The Siran River varies its width from 80 m to 130 m approximately. Water velocity is relatively high at approximately 1.54 m/sec that has been measured in relatively low water period, August 1992. The river has vast catchment area, approximately 1,450 km^2. Most of the area has annual precipitation 875 mm or less, but over 1,000 mm in the vicinity of the proposed bridge site.

Approximate discharge is about 1,100 t/sec.

Annual mean temperature at the proposed bridge site is approximately 22°C.

CHAPTER 5

CONFIGURATION OF THE PROJECT

CHAPTER 5 CONFIGURATION OF THE PROJECT

5.1 Target of the Project

The Project aims at improving the welfare and assisting the development of 8 districts in NWFP such as Abbottabad, Mansehra, Kohistan, Swat, Buner, Chitral, Dir and Malakand by way of construction bridges at the places:

- where the existing pedestrian bridge is seriously dilapidated and can no longer carry vehicles,
- where decks of the existing bridge is likely to be submerged during floods, and
- where no bridge exists and only heavy vehicles are possible to cross the river bed only when the water level is low.

5.2 Justification of the Requested Project

5.2.1 Significance of the Project

The characteristics of the Project are to meet one of the major targets of the 7 th 5-year National Development Program which emphasizes "Improvement of Public Services in Transport and Medical Sectors" especially in NWFP. As NWFP is geographically divided by numerous valleys and rivers, construction of permanent bridges are essential for exporting agricultural and forestry products and importing basic goods for villagers. The highly prioritized 11 bridges, out of the requested 20 bridges, are located on vehicular roads. However, these bridge sites are now at such places where no bridge exists, or existing pedestrian bridges are seriously dilapidated, or existing bridge decks are likely to be submerged by floods. In this regard, construction of bridges in these areas has been longed by the inhabitants.

Completion of these bridges can facilitate improvement of livelihood qualities and strengthening of economic activities as a result of achievement of effective road networks by means of linking feeder roads with national highway or major provincial roads.

Population benefiting from the Project (construction of 11 bridges) are estimated at approx. 490,000 (at present: 1990) and approx. 740,000 (in future: 2010) as shown in Table 5-1.

Table 5-1 Recipient Population and Future Traffic Volume by the Project

Bridge Name	District	Population benefiting from Project		Vehicular Traffic Volume (/day)	
		Present (1990)	Future (2010)	Present (1990)	Future (2010)
No.1 Narlai	Abbottabad	200,000	300,000	0	400
No.5 Pashorai	Mansehra	50,000	75,000	0	370
No.7 Panipa	Kohistan	30,000	45,000	200	450
No. 11 Choni	Chitral	15,000	23,000	1,200	2,250
No.12 Khal	Dir	40,000	60,000	100	400
No.14 Bukari Khawar	Dir	50,000	75,000	650	950
No.16 Kaidon	Swat	6,000	9,000	90	300
No.17 Peer Baba	Buner	15,000	23,000	250	500
No.18 Jahazoona Dak	Malakand	22,000	33,000	200	400
No.19 Totakan	Malakand	35,000	53,000	50	200
No.20 Sakhakot	Malakand	30,000	45,000	150	500
Total		493,000	741,000	2,890	6,720

5.2.2 Similar Development Projects

Communication & Work (C&W) Department of the Government of NWFP is attaining the following 23 road/bridge construction projects:

Table 5-2 Road and Bridge Project Underway

		Road Section/Bridge Location	Outline of Works
Chitral	1.	Ashrait Nullah	Bridge construction
	2.	Mastuj	Bridge construction
	3.	Brep ~ Braghul Pass	Gravel road construction
Dir	4.	Dir ~ Sheringal	Gravel road (35 km) construction
	5.	Lal Qila ~ Gal	Asphalt pavement works
	6.	Daramdala ~ Badar Kani	Gravel road construction
	7.	Warai ~ Niagdara	Asphalt pavement works (22 km)
	8.	Asband ~ Swat	Asphalt pavement works (10 km)
	9.	Shawa Khawar No.1 Bridge	Bridge construction
	10.	Shawa Khawar No.2 Bridge	Bridge construction
	11.	Chakdarra ~ Kamala	Asphalt pavement works (26.8 km)
	12.	Mayar ~ Miskini	Asphalt pavement works (13 km)
	13.	Darora ~ Almas Namlai	Asphalt pavement works (30 km)
Swat	14.	Totkai Yakhtangi ~ Dheri Alooch	Asphalt pavement works (25 km)
	15.	Damorai	Bridge construction
	16.	Manglore ~ Kass Shingrai	Asphalt pavement works (12 km)
	17.	Khawaza Khela	Bridge construction
	18.	Behrain ~ Kalam	Asphalt pavement works (32 km)
	19.	Karora ~ Chakisar	Asphalt pavement works
Buner	20.	Baggar ~ Gokand	Asphalt pavement works
	21.	Badal ~ Battara	Gravel road construction
Malakand	22.	Thana ~ Chirat Palai	Widening & asphalt pavement (10 km)
	23.	Kot Totai ~ Loe Agra	Widening & asphalt pavement (24 km)

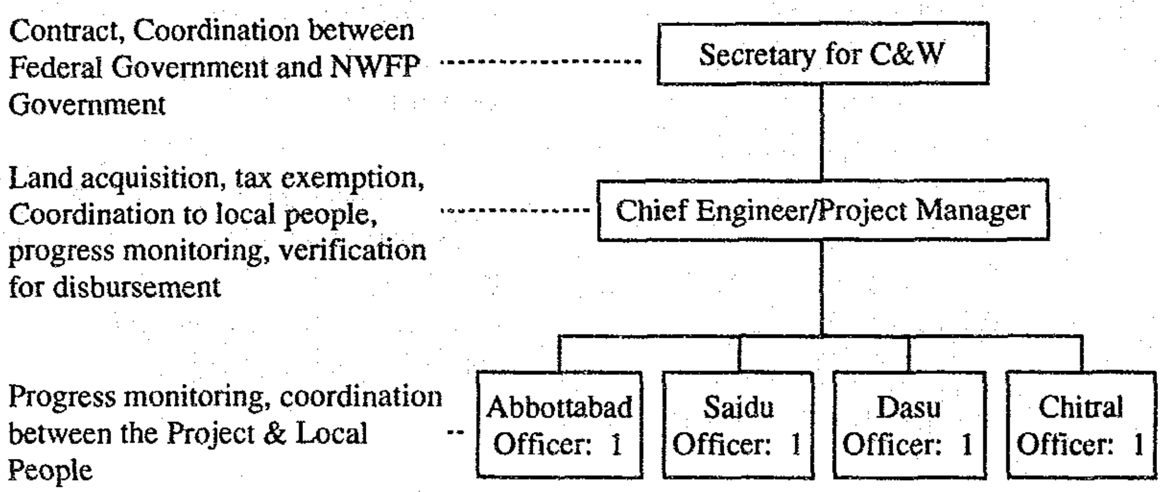
Normal practice by the C&W Department of the Government of NWFP is firstly to construct gravel roads, and then building bridges and being followed by pavement works. As for asphalt pavement works, funds of the ADB and OECF are sometimes utilized in addition to the NWFP's own funds.

5.2.3 Executing Organization

Executing organization from the Government of the Islamic Republic of Pakistan is the C&W Department of the Government of NWFP. Overall organization chart of the C&W Department is shown in Fig. 2.1

The major works to be conducted by the C&W are :

- Land acquisition, proceedings for tax exemption for the execution of the Project
- Assignment of Project Manager, Site Officers for the Project.



It was informed that the C&W Department would assign the Chief Engineer of the C&W to the Project Manager and assign Assistant Engineers to the site officers.

5.2.4 Necessity of Technical Assistance from Japan

The Government of NWFP is considering the construction of 200 bridge. As constructing the 11 bridges by the Japan's Grant Aid Program would cover only a part of the NWFP Government's targets, it is very important to train bridge experts from the C&W staff in order to construct the rest numerous bridges by the C&W own forces in future. To attain this, it would be recommendable that JICA invite trainees form the C&W staff under JICA Training Program.

The major purposes of JICA training for the C&W staff are:

- Transfer of bridge construction technology, and
- Transfer of knowledge on bridge maintenance.

5.2.5 Concept of Japan's Grant Aid toward the Project

The highly prioritized 11 bridges out of the requested 20 bridges show the efficiency, realities and the Pakistan side capability to implement the Project and these 11 bridges are judged favorable as a project by the Japan's Grant Aid Program.

In this regard, basic design has been carried out for the 11 bridges on the basis of Japan's Grant Aid Program.

5.3 Outline of the Project Sites

5.3.1 Location of the Respective Bridge Sites

(1) No.1 Narlai Bridge

Existing pedestrian suspension bridge is located in a gorge. If the new bridge location is determined in the vicinity of the existing bridge, structural type of the new bridge would be of steel suspension type. In this case, improvement of approach road on the right bank side is deemed to be difficult due to its topographic constraints. Therefore, location of the new bridge was determined about 1,000 m upstream from the existing bridge. In this case, the topographic condition allows to adopt conventional and economical structures for the new bridge, such as prestressed concrete type girders.

(2) No.5 Pashorai Bridge

Differences of elevation between the both banks are quite large in the vicinity of the existing bridge. In addition, there are many houses around the existing bridge, the acquisition and compensation for which are deemed to be very difficult. In this regard, the locations in the vicinity of the new bridge are not favorable.

Accordingly, the new bridge location was decided at about 1.5 km downstream from the existing pedestrian suspension bridge. This new bridge location is in the curvature of the existing national highway KKH. Difference of elevation between the both banks of the Nandia Khawar River is relatively smaller than the other places, and therefore conjunction of approach road of the new bridge and KKH can be constructed easily.

(3) No.7 Panipa Bridge

Conceivable locations of a new bridge are found only in the vicinity of the existing bridge. If location of a new bridge is about 200 m upstream or more from the existing bridge, where two rivers, the Indus and Kandia rivers comes into confluence, the project would have to include the construction of two bridge crossings over these rivers and therefore these upstream locations are deemed not to be economical for the new bridge.

As for the downstream side more than 200 m from the existing bridge, construction of approach road on the right bank side was judged difficult due to its topographic and geological constraints.

Subsequently, the location of the new bridge was decided just down stream of the existing bridge, where traffic blocks on the existing Kandia Valley Road during construction works is not anticipated while the upstream location seems to disturb the traffic on the same.

(4) No.11 Choni Bridge

On the downstream side of the existing bridge, there exist a beautiful mosque, many shops and residences. Leveling works of these existing structures seems to be impossible because of social issues. Therefore, the upstream side of the existing bridge was considered as conceivable locations of the new bridge.

As for the upstream side about 400 m from the existing bridge, the Mohlen Gole Nullah flows into the Chitral River in almost right angle. As the Nullah carries big boulders once flood takes place, the likelihood of the left side bank erosion is anticipated.

In this regard, the location of the new bridge is decided at about 50 m upstream of the existing bridge, where erosion on the left bank side is not anticipated and leveling works of the existing structures are not required.

(5) No.12 Khal Bridge

Khal Village has been expanding on the right bank of Panjkora river, reached from the NCC road by a superannuated suspension bridge. It is seen that both on the left and right banks of the packed bridge's surrounding, crowded settlements are being formed. As for the left bank, parallel with Panjkora river along NCC road, stretching 200 m upstream and 150 m downstream are buildings without gap in between them. On the right bank, near the stuffed bridge, there is a settlement being developed. Khal village, when viewed from the existing bridge, is developed evenly downstream and upstream. However, after crossing the river, the road is slightly facing downstream reaching the foot of the mountain and then it extends downstream.

The location of the new bridge was studied based on the points mentioned below.

1. The connection of the new bridge and the present trunk road is that it will become the connection of the left bank's NCC road and the road that extends downstream on the right bank, therefore it will be natural for the new bridge location to be the downstream side.

2. The local officials had expressed the following request.

   a. If possible, it must be as near to the present settlement.

   b. If possible, the existing buildings be preserved.

3. Since the buildings along the NCC road are developed further upstream, it is better for the bridge site to be downstream.

4. The river width is decreasing from upstream to downstream.

Based on the above conditions, the bridge construction site is decided to be toward downstream away from the existing bridge, about 200 m downstream, where there is a suitable gap of buildings.

Further downstream, the river width becomes narrow, and the river is more stable. The river condition makes it technically easier to construct. However, since it is far from the existing settlements, it did not satisfy the requests made by the local officials, and the distance of the right bank road with the long access road will become longer. With these and the environmental conditions, it becomes a disadvantage. From a comprehensive decision, the construction location is decided to a point near the existing bridge.

(6) No.14 Bukari Khawar Bridge

At present, heavy vehicles are crossing the riverbeds of two channels. If the bridge locations is selected at this route, lengths of approach roads would be longer. The selected location of the new bridge is near the end point of horizontal curve of the existing road on the left bank side, and the continuation stretch of the existing road on the right bank side. By this, favorable and shortest alignment can be obtained.

(7) No.16 Kaidon Bridge

Both upstream and downstream sides of the existing wooden bridge have potential sites for the new bridge location. Upstream side route about 30 m away from the existing bridge was decided as the new bridge location taking into consideration the preferable alignment and less adverse impacts against the existing traffic.

(8) No.17 Peer Baba Bridge

Should the approach roads on the left and right banks, be connected in a straight line and crosses the Malakpur Khawar River in a very sharp skew angle, the bridge length would become longer about 75 m which will be relatively costly. As a result, horizontal curves would be employed on the both sides of the river by adopting right angle curve as much as possible resulting in reduction of bridge length to 50 m and hence the consruction cost.

(9) No.18 Jahazoona Dak Bridge

The topographic feature of the Jahazoona Dak bridge is, the road on the left bank runs gently down towards the river, and after crossing the river, the road turns upstream at a steep angle on the right bank and then climbs the small hilly areas. The normal water level is low, but since the existing bridge is barely above the water surface, it is submerged for about 2 meters during high water level. The location of the bridge is investigated by considering the road alignment in order to maintain the road's height.

The selected route is almost directly the extension of the right bank's road alignment to the left bank. The result of this selection is that the height of the road will be more than 5 m higher than the existing bridge. Also, since the road's steep angle alignment could be made into an easier alignment, it is very much desired.

(10) No.19 Totakan Bridge

The Swat River is narrowest in width at the site of the existing bridge, where rocks are visible on both the left and right banks. It expands its width, affected by the river tributary, and the flow is unstable at the upstream of the bridge site. It keeps almost the same width and a stable river condition at downstream. Therefore, the location of the new bridge is in principle to be downstream of the existing bridge.

The topography is steep near the river on the left bank, and a trunk road runs along the river about 10 meters above the river surface. The existing road, a rural road, that bifurcates from a trunk road passes the existing bridge as soon as it runs through Totakan Settlement. The new bridge site is selected at the downstream where it is far from the community and the new access road is connected to the trunk road by T-junction.

The rural road runs to and away from the river almost at a right angle. For connecting the rural road, the new bridge should be located near the old bridge.

In the geographical survey from the existing bridge to downstream, a suitable site for the foundation of structures was found at about 650 meters down stream. The new bridge location was selected here because the river is also narrow.

The center line of the new bridge on the right bank meets the rural road at 200 meters away from the bridge site. Therefore, the bridge contributes to an improvement of the road alignment.

(11) No.20 Sakhakot Bridge

The existing Sakhakot bridge, links the road coming down slope from both the left and right banks. Because submerging of the bridge in the rainy season is reported, a site investigation is made for elevating the road by constructing the new bridge as well as selecting the best location.

The existing road runs at downstream of the Sakhakot River. Therefore, the location of new bridge is, of cause, at the downstream. The Sakhakot River meanders greatly at 70 meters downstream of the existing bridge and river condition is not stable. Especially, there are private houses on the left bank about 80 meters downstream of the existing bridge. Examining conditions mentioned above, the new route is selected at 30 meters downstream of the existing bridge. The selected route takes a line of the short-cut of the existing road, and elevated by 5 meters at the site.

5.3.2 Bridge Lengths and Deck Levels

(1) Determination of Bridge Lengths

The following 3 items are predominant factors to decide the bridge lengths:

(i) Topographic conditions (river width, depth of valley etc.),

(ii) Elevation of existing roads to be connected, and

(iii) High Water Level of river and vertical clearance below the girder bottom.

The following table shows the most predominant factor for determining the length of each bridge.

Table 5-3 Most Dominant Factor for Bridge Length

		River Width	Elevation of Exst. Road	Vertical Clearance	Bridge Length (m)
No.1	Narlai Bridge	◎			100 + 25
No.5	Pashorai Bridge		◎		75
No.7	Panipa Bridge	◎			180
No.11	Choni Bridge	◎			90
No.12	Khal Bridge	◎			88
No.14	Bukari Khawar Bridge	◎			2 x 25
No.16	Kaidon Bridge	◎			44
No.17	Peer Baba Bridge	◎			50
No.18	Jahazoona Dak Bridge			◎	75
No.19	Totakan Bridge	◎			90
No.20	Sakhakot Bridge	◎			75

As a result, lengths of most bridges (9 bridges) except 2 bridges are determined on the basis of river widths. On the other hand, the elevation of KKH on the right side bank at No.5 Pashorai Bridge site is higher about 5 m than that of cultivated land on the left side bank. If bridge length is determined by river width, abutment height of the right side bank will be about 15 m or more, which is not recommendable in the view points of less construction cost and structural liability. Therefore, bridge length is increased from 50 m to 75 m to reduce construction cost. As for No.18 Jahazoona Dak Bridge, vertical clearance of more than 2 m is considered. In this case, abutment height will be more than the economic height if the bridge length is determined by the river width. Therefore the bridge length is increased from 50 m to 75 m as with No.5 bridge.

(2) Determination of Deck Levels

Deck levels of the respective bridges are determined on the basis of the following:

(i) Deck Level ≥ HWL + Vertical Clearance (2 m) + Girder Depth, and

(ii) To connect smoothly with the existing roads.

Accordingly, road formation levels (deck level + pavement thickness) are determined in the following table.

Table 5-4 Road Formation Levels

	Left Bank Side (m)	Right Bank Side (m)
No.1 Narlai Bridge	615.65	620.35
No.5 Pashorai Bridge	876.50	881.00
No.7 Panipa Bridge	988.00	982.00
No.11 Choni Bridge	1,448.00	1,447.00
No.12 Khal Bridge	981.35	928.70
No.14 Bukari Khawar Bridge	1,142.00	1,143.60
No.16 Kaidon Bridge	1,530.00	1,530.00
No.17 Peer Baba Bridge	815.00	815.00
No.18 Jahazoona Dak Bridge	453.20	453.45
No.19 Totakan Bridge	662.40	663.40
No.20 Sakhakot Bridge	484.10	482.20

5.3.3 Cross Section

All the bridges, except No.11 Choni Bridge where traffic volume is bigger than others and 2-lane bridge is scheduled, have 1 lane. Bridge cross section of the Project consists of the following two:

Type A : 1 lane bridge, as agreed unanimously in the Minutes of Discussions dated July 19, 1992. Carriageway width = 3.6 m.

This cross section will be adopted in case of No.1 Narlai, No.5 Pashorai, No.7 Panipa, No.12 Khal, No.14 Bukari Khawar, No.16 Kaidon, No.17 Peer Baba, No.18 Jahazoona Dak, No.19 Totakan and No.20 Sakhakot bridges.

Type B : 2 lane bridge. Carriageway width = 6.6 m.
This cross section will be adopted in case of No.11 Choni Bridge.

Components of these cross sections are shown in Fig. 6.1 and 6.2 (Chapter VI).

5.3.4 Principles of Bridge Type Selection

As for selection of structural types of each bridge, the following 4 items were considered:

(i) Favorable types from an economic (less construction cost) view point.

(ii) Types which will not require field works during the periods of floods and snow-fall.

(iv) As the Project is wide-spread and sites are located sporadically in NWFP, not-so-many structural types should be considered to simplify or standardize the site works for reliable quality control.

Accordingly, the following 3 types and 2 types were selected for the superstructures and foundations respectively:

(1) Superstructures

- 25 m span PC concrete girder bridges would be considered where the execution of the substructure works could be carried out safely and when no problem exists in completing the works within the scheduled time (within 12 months).

- Steel plate girder bridges would be considered where the pier construction in the river bed is difficult from the point of construction scheduling but the width of the river is about 40 ~ 50 m (= bridge span) medium size bridge. Also for bridge with 40 ~ 50 m span but when the problem of scheduling could be solved by decreasing the number of piers, then, steel plate girder bridges would be adopted.

- Suspension type bridges would be considered where the river width (= bridge span) is large and the construction of piers in the river bed would be difficult viewed from the points of technical and construction scheduling.

(2) Foundations

- Spread foundation (so-called direct foundation) will be used where rock layers or gravel layers exist in a relatively shallow depth (within 5 m below the river bed).
- Cast-in-place RC piles will be used where bearing strata exist in deep position. Diameter of a pile will be 60 cm, which is broadly utilized in Pakistan.

5.3.5 Scope of the Project under the Japan's Grant Aid

The scope of the Project is to construct the following facilities:

<u>No.1 Narlai Bridge</u>

A new bridge and its approach roads (approx. 300 m on the left bank side, approx. 80 m on the right bank side)

<u>No.5 Pashorai Bridge</u>

A new bridge and its approach roads (approx. 100 m on the left bank side, approx. 200 m on the right bank side)

<u>No.7 Panipa Bridge</u>

A new bridge and its approach roads (approx. 260 m on the left bank side, approx. 20 m on the right bank side)

<u>No.11 Choni Bridge</u>

A new bridge and its approach roads (approx. 390 m on the left bank side, approx. 20 m on the right bank side)

No.12 Khal Bridge

A new bridge and its approach roads (approx. 25 m on the left bank side, approx. 90 m on the right bank side)

No.14 Bukari Khawar Bridge

Two bridges crossing over two channels, causeway (approx. 200 m) passing through the sand-bar island, and approach roads (approx. 30 m on both of the left and right banks)

No.16 Kaidon Bridge

A new bridge and its approach roads (approx. 20 m on the left bank side, approx. 30 m on the right bank side)

No.17 Peer Baba Bridge

A new bridge and its approach roads (approx. 40 m on both of the left and right bank sides)

No.18 Jahazoona Dak Bridge

A new bridge and its approach roads (approx. 25 m on the left bank side, approx. 90 m on the right bank side)

No.19 Totakan Bridge

A new bridge and its approach roads (approx. 90 m on the right bank side only)

No.20 Sakhakot Bridge

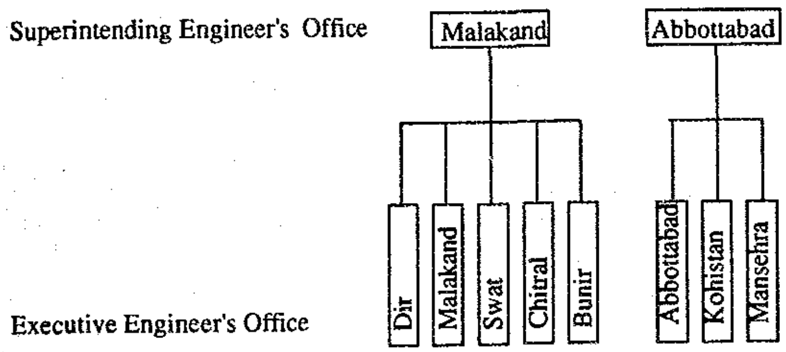
A new bridge and its approach roads (approx. 80 m on the left bank side, approx. 10 m on the right bank side)

5.3.6 Maintenance after Completion

After completion of the 11 bridges by the Project, the following works are envisaged as maintenance work in the future:

- Painting of steel members (approx. 7 ~ 10 year interval)
- Overlay of asphaltic concrete pavement (approx. 7 ~ 10 year interval)
- Adhoc repair of guard rail and cement concrete pavement (in case of damages by accident)
- Repair of riverbank protection (in case of damages by flood)

This basic design on structural elements has been carried out so as to minimize the maintenance works in the future. However, repair works as mentioned above will not be avoidable. In this regard, the C&W Department of the Government of NWFP will carry out the maintenance works by way of the following organization.



CHAPTER 6

BASIC DESIGN

CHAPTER 6 BASIC DESIGN

6.1 Basic Design Principles

This basic design on 11 bridges has been conducted taking into consideration the following:

(1) Construction works for bridge piers can be carried out only when the water level is low. Therefore, construction time schedule and volumes of superstructure, substructure and foundation should be taken into account to determine the sizes of structural elements.

(2) Special consideration should be placed on lowering the total construction costs and also minimizing the future maintenance works. Appropriate construction method should be selected for the construction of superstructure, substructure, foundation, approach road and other associated facilities from the view points of minimizing construction time, costs and future maintenance works.

(3) Very strong winds may occur in some bridge sites, where wind loads should be considered as one of the predominant factors for design. Strong gust takes place twice a day (morning and evening) at No.7 Panipa and No.11 Choni bridges, where the new bridge is located in a gorge. In such places, areas of exposure of structural members should be minimized to stabilize the bridge structures against wind.

(4) In most bridge sites, reliable strata such as hard rock and gravel layers exist in relatively shallow depths from existing ground levels. In these cases, rooting depth of spread foundation (footings) should be determined taking into consideration the scouring phenomena in addition to the bearing capacities.

(5) Selection of bridge types, construction methods and false work materials should be determined taking into consideration the possibility of using domestic materials as much as possible to aim at emphasizing the economic activities in Pakistan.

As a result of the above, basic design has been carried out on the basis of the following principles:

(1) To decrease the number of bridge piers in river courses in order to reduce the volume of works in water. In cases where pier construction is indispensable,

RC crib structures (so-called temporary caisson) should be considered instead of using the open excavation method which might cause difficulties to dewater for footing works.

(2) Simple type structures like PC composite I beam should be adopted as many sites as possible in order to minimize the construction costs of the project and future maintenance costs. In case of short span (about 25 m) bridge, PC composite I beam is the cheapest structure. Therefore, PC composite I beam should be used for short span bridges. As for the longer spans (about 45 m), composite steel plate girder is advantageous from the economic viewpoint. In cases where a single plate girder span without any supporting pier can not cross over the river, steel suspension bridge should be used.

(3) Steel pipe type railings should be used for the bridges which are located in a gust-prone valley so as to decrease the exposure area against wind resulting in reduction of wind influences. In addition, storm cables should be used at No.7 Panipa Bridge, which is located in a gust-prone gorge and has a long span of 180 m, not only to increase the structural stability but also to reduce the weight of stiffening truss members.

(4) Footing of spread foundation should be embedded into the gravel layer in appropriate rooting depth taking into consideration the scour depths.

6.2 Design Criteria and Standards

In accordance with the agreement through discussions between the C&W Department and the Study Team, the following design criteria and standards are adopted.

(1) Composition of Bridge Width

Type A (1 lane bridge)

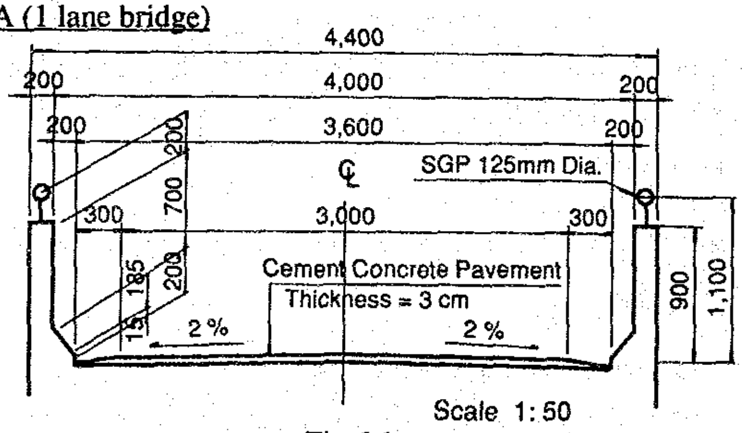


Fig 6.1

Type B (2 lane bridge)

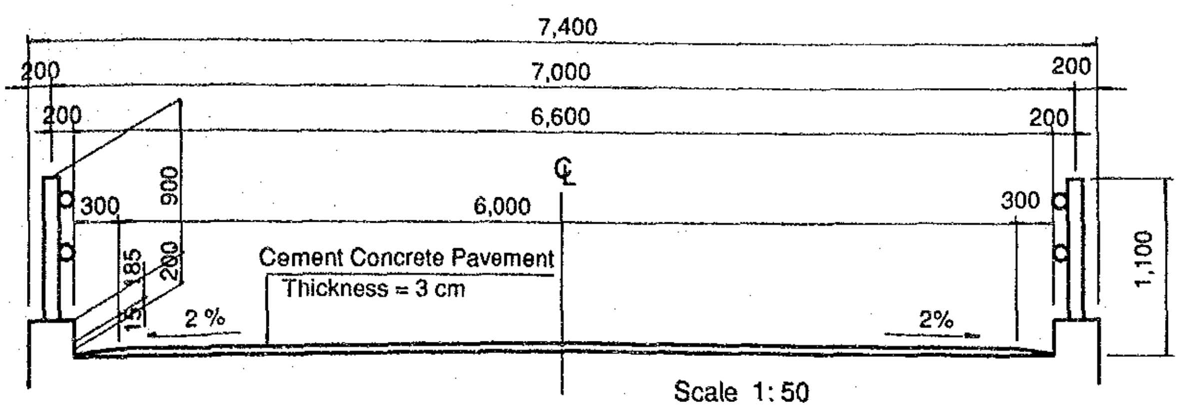


Fig 6.2

(2) Design Live Load

The Truck Load TL-14 of the Japan Road Association will be applied to all the bridges as agreed in the minutes of meeting dated 19 July 1992.

However, reinforced concrete deck slabs should be designed to have a minimum thickness to carry TL-20 of the same specification.

(3) Other Loads

- Design dead load

The design dead load will comply to the highway bridge specification of the Japan Road Association and should be as follows.

Table 6-1 Unit weight of Materials

Material	Unit weight
Steel, Cast steel, Forged steel	7,850 kgf/m^3
Cast iron	7,250 kgf/m^3
Aluminum	2,800 kgf/m^3
Reinforced concrete	2,500 kgf/m^3
Pre-stressed concrete	2,500 kgf/m^3
Non-reinforced concrete	2,350 kgf/m^3
Cement motor	2,150 kgf/m^3
Pavement asphalt	2,300 kgf/m^3
Lumber	800 kgf/m^3

- Base wind velocity for wind load: $V_{10} = 40$ m/sec

- Thermal range: 50°C (0°C ~ 50°C) ... Except No.11 Chitral : 40°C (-5°C ~ 35°C)

- Earthquake: Horizontally equivalent force $K_H = 0.1$

- Earth pressure: Based on Coulomb's formula

(4) Vertical Clearance of Approach Road

H = 4.5 m + 0.3 m = 4.8 m
(Max. Vehicle existing) (Pavement overlay)

(5) Design Criteria for Approach Road

(i) Width: 6.6 m (Shoulder 1.5 m + Carriageway 3.6 m + shoulder 1.5 m)

(ii) Slope of embankment

Embankment height ≤ 4 m
- Common soil = 1 : 1.5
- Gravel + Sand = 1 : 1.0

(iii) Slope protection: - Mortar riprap should be used up to HWL + 0.5 m. In this case, mortar rubble foundation should have a height of 1.5 m and width 1.0 m.
- Sodding should be used above HWL + 0.5 m.

(iv) Guard Block

Mortar rubble guard block, which consists of domestic materials, will be used in order to avoid the difficulties of maintenance works in future. The sizes of guard block are:

0.6 m x 0.6 m x 0.9 m
(Width) (Height) (Length)

Depth of 15 cm out of a height 60 cm should be embeded into the shoulders. Interval of installing guard blocks should be 1.2 m (C.T.C).

6.3 Description of Basic Design

6.3.1 Superstructure Design

Basic design has been conducted for the following four types:

(i)	PC Beam (Span length = 25 m)	:	No.1 Narlai Bridge No.5 Pashorai Bridge No.14 Bukari Khawar Bridge No.17 Peer Baba Bridge No.18 Jahazoona Dak Bridge No.20 Sakhakot Bridge
(ii)	Steel Plate Girder (Span length = 44 m)	:	No.12 Khal Bridge No.16 Kaidon Bridge
(iii)	Stiffening Truss Type Suspension Bridge (Span length = 90 m x 2 lanes)	:	No.11 Choni Bridge
(iv)	Stiffening Truss Type Suspension Bridge (Span length = 90 m x 1 lane)	:	No.19 Totakan Bridge
(v)	Stiffening Truss Type Suspension Bridge (Span length = 180 m x 1 lane)	:	No.7 Panipa Bridge

(1) 25 m Span PC Beam

Composite type PC I-beam was selected on the basis of the following:

- As the clear width (so-called effective width) is relatively narrow (3.6 m), required number of beam is only 2 for one span.
- Railing will be of wall type, and should be firmly connected to the slab deck which rigidity be high.

The proposed cross section of the PC composite I-beam is shown below:

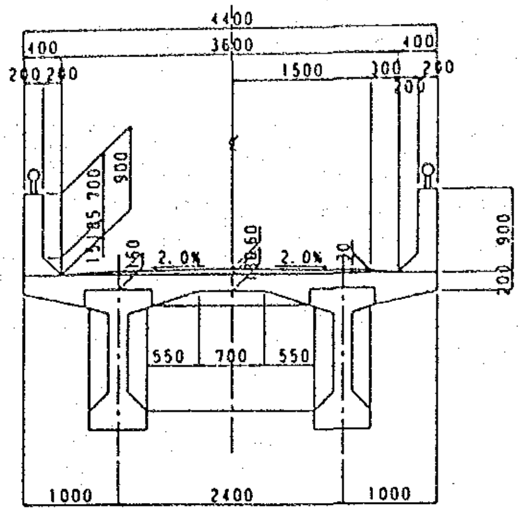


Fig. 6.3 Cross Section of PC Composite I-Beam

(2) 44 m Span Steel Plate Girder

As with PC composite I-beam, composite type steel plate girders having a similar girder arrangement was selected. The proposed cross section is shown as follows.

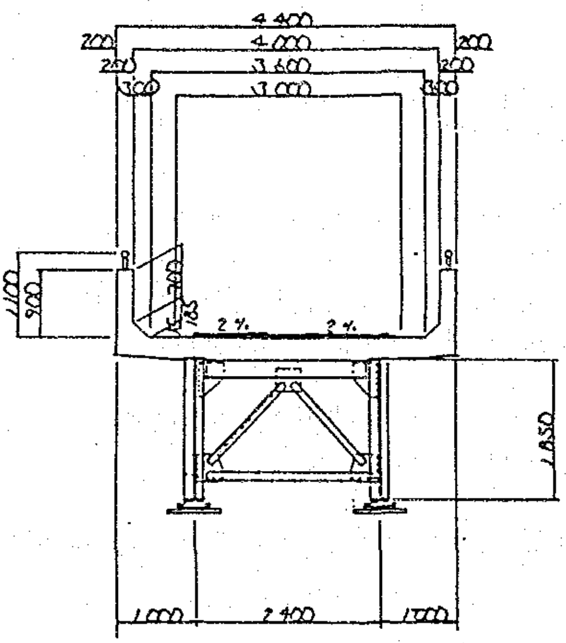


Fig. 6.4 Cross Section of Steel Composite Plate Girder

(3) Steel Stiffening Truss Type Suspension Bridge

(i) Sag Ratio

Sag ratio 1/10 was selected for the main cable profile according to the normal practices in Japan.

(ii) Stiffening Truss

Stiffening truss girders were designed to support the RC slab deck via stringers. Girder depth and transverse spacing of girders are as indicated in Table 6-2

Table 6-2 Required Girder Depth & Girder Spacing

	Girder Depth	Girder Spacing
1-lane, Span 90 m	1.8 m	5.0 m
2-lane, Span 90 m	2.2 m	8.0 m
1-lane, Span 180 m	2.2 m	5.0 m

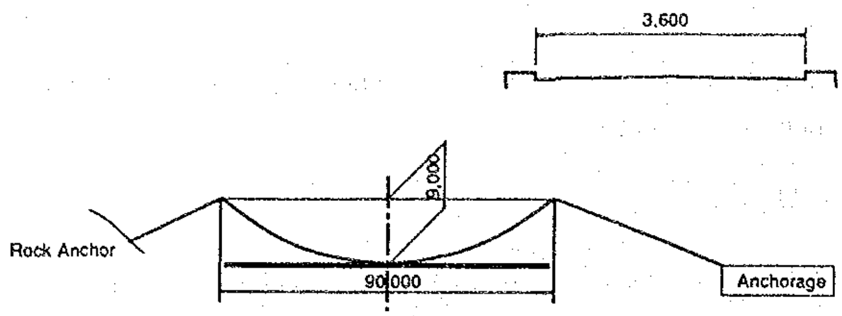


Fig. 6.5 (a) 90 m Span 1-Lane Suspension

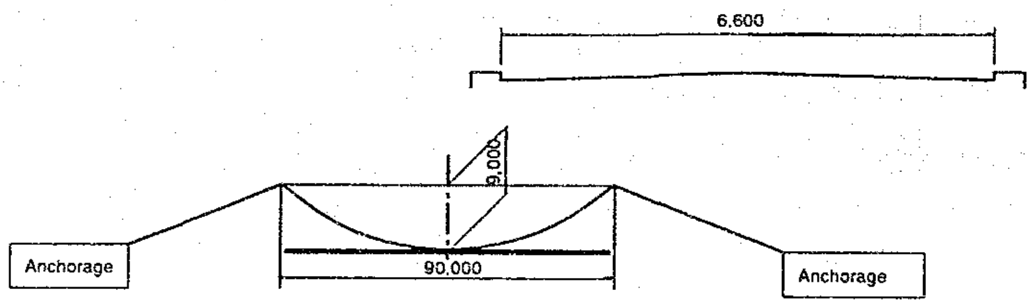


Fig. 6.5 (b) 90 m Span 2-Lane Suspension

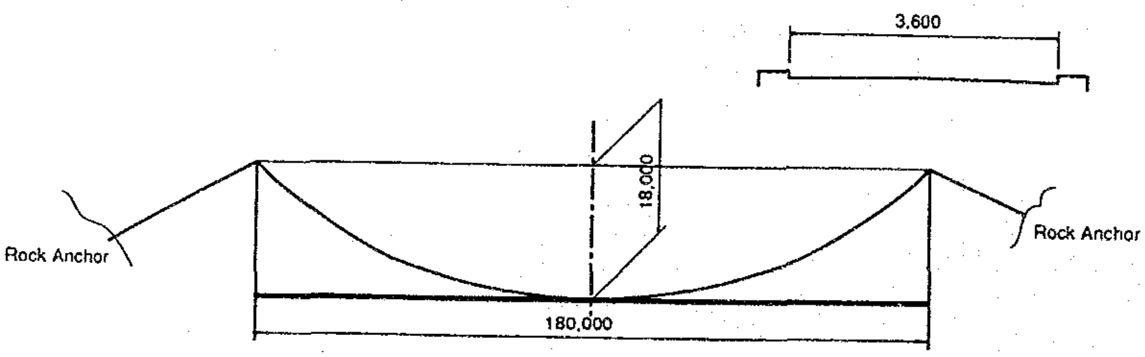


Fig. 6.5 (c) 180 m Span 1-Lane Suspension

6.3.2 Substructure Design

Types of Substructures for 11 bridges are broadly divided into 5 types as shown below:

- Abutment
  - (1) RC inverted T-shaped abutment ... For PC composite I-beam, Steel composite plate girder
  - (2) RC Tower Abutment ... For suspension bridge
- Pier
  - (3) RC Inverted T-shaped Pier ... For PC composite I-beam, steel composite plate girder
- Cable Anchor for Suspension
  - (4) Gravity Type RC Anchorage ... In case of soil
  - (5) Rock Anchor ... In case of rock

(1) Abutment Structures

From the economic viewpoint, RC inverted T-shaped abutment was selected. Depth of footing was appropriately determined. Maximum height was determined at 10 m.

Tower abutment of suspension bridge was determined as RC inverted T-shaped abutment supporting RC tower structures upward.

(2) Pier Structures

Piers supporting the PC composite I-beam or steel composite plate girders were determined as RC inverted T-shaped piers having a cylindrical column to enable a smooth river flow against any flow direction.

Depth of footing was appropriately by one determined based on the estimated scour depth.

(3) Cable Anchors for Suspension Bridge

According to the results obtained from subsoil exploration by the Study Team, usage of RC gravity type anchorage or rock anchor was determined as follows:

Table 6-3 Anchor Types Adopted

	Left Bank Side	Right Bank Side
No.7 Panipa Bridge	Rock Anchor	Rock Anchor
No.11 Choni Bridge	Gravity Anchorage	Gravity Anchorage
No.19 Totakan Bridge	Rock Anchor	Gravity Anchorage

6.4 Basic Design Drawings

Drawings have been prepared, for cost estimation purposes, taking into consideration the volumes and time-table by work items.

(1) No.1 Narlai Bridge

General layout plan of Br. No. 1 Narlai Bridge is shown in Figure 6.6.

The longitudinal formation of the road surface is determined by allowing space for the high water level of the river and also the clearance height of 2 m.

The bridge is made up of two parts; one crossing the main flow of the river and the other the flash water passage, all utilizing 25 m long PC girders.

Main river crossing : 4 spans x 25 m = 100 m
Sub river crossing : 1 span x 25 m = 25 m

Three piers of the main river crossing bridge is constructed in ordinary water level and shall be deep enough against scouring.

Foundation shall be 60 cm diameter cast-in-situ concrete piles which are commonly used in Pakistan. The pile length shall be 10 m reaching the limestone layer.

The access road on the left bank is extended straight from the bridge center line. The road height where possible is to be a low embankment method, so that it will be on the present ground contours. Behind the left abutment, there is a dry river where a box culvert is used. The embankment part of the access road where it will directly face the high water level, stone masonry is used for scouring prevention. The location, where the access road meets with the existing road, is linked by a T-junction, and is connected in a hitch in order to preserve the corner's alignment.

Since the access road on the right bank is linked to the latter part of the right bank bridge pier with a T-junction, it is attached in a hitch to preserve the corner alignment. However, the existing road here is submerged during the high water level. Therefore, the whole of the submerged part is embanked by about 1.5 m. The slope of the embankment in direct contact with the flow of the high water level is protected by stone masonry.

The prescribed width of the access road is to be of macadam paving.

(2) No.5 Pashorai Bridge

General layout plan of No.5 Pashorai Bridge is shown in Figures 6.7 (a) and (b).

Deck levels of the bridge is determined so that it would connect smoothly with the existing riverbank elevation on the left bank side and the existing KKH elevation on the right bank side. As the KKH runs in a high elevation and there are high rise slopes on the right bank side, a steep grade (10 %) of approach road is employed while that of the bridge is 6 %.

Clear width of bridge is determined at 3.6 m as a 1-lane bridge.

As with No.1 Narlai Bridge, PC beams are employed for superstructure: 3 span x 25 m = 75 m.

RC inverted T-shaped structures are designed both for abutments and piers.

Mortar rubble stone masonry is made to withstand the approach road embankment and to eliminate high cut works.

Pavement structure is designed as macadam pavement.

(3) No.7 Panipa Bridge

General Layout Plan in shown in Fig. 6.8.

The existing Kandia Valley Road on the right bank side of the Indus River runs 17 m high above HWL and that on the left bank side (which connects with KKH) is 6 m higher than the right bank side road. Therefore the longitudinal grade of 3.3 % downward from the left bank side to the right bank side is employed. Vertical clearance below the girder bottom to HWL is sufficiently maintained.

Clear width of the bridge is determined at 3.6 m.

Bridge type is of suspension bridge with steel stiffening truss girders having a long span of 180 m between the two main towers.

Many pedestrian suspension bridges with wooden deck have been built in Pakistan designed by local consultants. However, according to the information from local engineers, the design method of suspension bridge is not fully formulated and a lot of their designs are merely copies of the existing one. Since there is little experience for suspension bridge with steel stiffening truss girders which is planned for this Project, the bridge is mainly designed based on the Japanese design standard and therefore technology transfer will be available through this project.

Spread foundation (so-called direct foundation) is employed for tower abutments according to the subsoil condition at the site where hard rock exposes on both banks. Rock anchor system is employed to fix the main cables into rock. Storm cables are used to stabilize the stiffening truss girders against wind forces.

As for approach road on the left bank side, a curve is employed near the abutment. Embankment height of this place becomes very high and therefore retaining wall of mortar rubble masonry is provided to withstand the embankment.

On the right bank side, a small curve is employed at the abutment structure. In addition, auxiliary space is considered.

Pavement structure is designed as macadam pavement.

(4) No.11 Choni Bridge

General layout plan is shown in Fig. 6.9 (a), (b).

New fork type (T) intersection is scheduled on NCC Road. Approach road starts at the new interchange, passing farm land, crosses the Chitral River at right angle and ends at Chitral Town road. Total distance of approach road and bridge is approx. 500 m.

Deck level is determined to maintain sufficient vertical clearance above the H.W.L. Elevation of the left bank is about 4 m higher than that of right bank. Therefore, the longitudinal grade 2 % is employed.

Clear width of the bridge is 6.6 m (2 lanes).

Bridge type is of suspension bridge having steel stiffening truss girders. According to the subsoil exploration, sandy layer with gravels exists. As the external vertical force to be transmitted by the tower is large, cast-in-place RC pile is scheduled for the foundation to support such a heavy structure.

RC gravity type anchorages are employed for anchoring the main cables.

Approach road on the left bank side is about 300 m long, having a S-curve near the tower abutment. Embankment height is approx. 1 m in average.

Slope protection of approach road is made of sodding.

Pavement structure is macadam pavement.

(5) No.12 Khal Bridge

General layout plan of Br. No. 12, Khal bridge is shown in Fig. 6.10.

The height of the road is decided by the longitudinal alignment where the left bank road height and the right bank settlement's road height is connected by 2% gradient. The gradient is enough to clear the high water level (HWL) of Panjkora river.

The main bridge is a 2 span steel plate girder bridge (L = 44 m x 2). The Japanese design standard is mainly used in the design.

The abutment and bridge piers are of the invert T-type reinforced concrete structures. Even though the construction in the river of the 1 bridge pier is made during the normal water level, there is still a fear of scouring after completion. Therefore, both embedded depth and foot protection must be done. The other 2 abutment are constructed on the ground. However, to prepare for submersion and scouring during high water level, embedded depth and foot protection is used to cope with possible accident.

The foundation structure is decided by reflecting the geological survey result. The geological feature is that there are rocks on the left bank and layers of the river sediments on the right bank. Therefore, the left bank abutment is to be spread foundation. The remainder of 1 bridge pier and 1 abutment are pile foundation by cast-in-situ reinforced concrete pile of 60 cm diameter. The embedded depth of the pile is decided based on the geological survey result.

The left bank access road of 25 m long is linked with the NCC road in a T-junction. It is designed so that the corner alignment be preserved to ensure smooth traffic flow. The road height is maintained by embankment behind the abutment, however, since the front is in contact with the river flow, protection is needed. The stone masonry, which has achievement in Pakistan, is used.

The right bank access road is linked with the Khal settlement road by a 250 m low embankment from the end of the bridge. The attachment is a T-junction sufficient corner is taken, especially at the narrowest angle side to ensure a smooth of traffic flow . The slope of the embankment is protected by stone masonry.

The width of the access road is to be macadam pavement.

(6) No.14 Bukari Khawar Bridge

General Layout plan of No.14 Bukari, Khawar Bridge is shown in Fig. 6.11.

Route alignment is determined to smoothly connect the new bridges with Samar Bagh ~ Shahi Road (especially, smooth connection in longitudinal alignment). As a result, extension of the existing road on the right bank side toward the river is favorable for both horizontal and vertical alignments.

Two bridges are scheduled to cross over the two channels. Vertical clearances of the bridges are considered at 2 m above HWL or more. A concrete paved causeway is employed to pass through a sandbar island between the channels. This causeway is designed to allow the flow-over of river water in case of high floods, and therefore a minimum embankment height is considered.

Clear width of the bridge is 3.6 m

As with the superstructure of No.1 Narlai and No.5 Pashorai bridges, 25 m span PC composite I-beam is employed, of which 1 span can pass over each channel. Abutment structure is RC inverted shaped abutments supported by spread foundation.

Macadam asphalt pavement is scheduled for the approach road while cement concrete pavement is employed for the causeway taking into consideration the flow-over effects during floods.

Slope protection of causeway is mortar riprap.

(7) No.16 Kaidon Bridge

General Layout plan of No.16 Kaidon Bridge is shown in Fig. 6.12.

Route alignment of the new bridge is about 20 m upstream of the existing timber bridge, km 0 of Kaidon - Goornai Road which is a tributary road of Bahrain - Kalam Road.

As the elevations of the existing roads are relatively high, no issue about the requirement of vertical clearance below girder is anticipated. Therefore, deck level of the bridge is determined to directly connect the existing road surfaces on both left and right bank side.

Clear width of the bridge is 3.6 m

As with the superstructure of No.12 Khal Bridge, steel composite type plate girder is employed. One span of 44 m can cross over the river width. Abutment structure is RC inverted T-shaped abutments supported by spread foundation embedded into the gravel layer.

Curvatures of the approach roads are small and embankment heights are relatively high, hence mortar rubble masonry is employed not only to withstand the embankment body but also to eliminate wide-spread toe of embankment.

Pavement structure is macadam asphalt pavement.

(8) No.17 Peer Baba Bridge

General Layout plan of No.17 Peer Baba Bridge is shown in Fig. 6.13.

The new bridge will cross over the Malakpur Khawar on Peer Baba - Malakpur Road. An ideal route alignment is to just connect the ending points of Peer Baba - Malakpur Road on the both left and right bank sides. In this case, the bridge should be constructed in sharp skew angle which will result in the bridge length to become longer, which will be costly and disadvantageous from the least cost aspect. Accordingly, curves are employed at both sides to reduce the bridge length.

Deck level is determined to allow a 2 m vertical clearance below the girder bottom to HWL.

Clear width of the bridge is 3.6 m.

As with the superstructure of No.1 Narlai Bridge, No.5 Pashorai Bridge and No.14 Bukari Khawar Bridge, 2 spans of 25 m long PC composite I-beam are employed.

Substructure consists of 2 nos. of RC inverted T-shaped abutments and 1 no. of RC inverted T-shaped pier. Subsoil condition of the site is clayey soil, and therefore cast-in-place RC piles having 15 m length (so as to reach gravel layer) are scheduled.

As for the approach road embankment, mortar riprap and sodding are employed for the slopes up to HWL + 0.5 m and slopes above HWL + 0.5 m, respectively. Three barrel pipe culvert (3@600) is scheduled to flow the existing irrigation channel water on the left bank side.

Pavement structure is macadam asphalt pavement.

(9) No.18 Jahazoona Dak Bridge

General layout plan of Br. No. 18 Jahazoona bridge is shown in Fig. 6.14.

The road on both sides of the bridge is connected by the existing road that down-grade towards the bridge and the straight and level area of the part where it turns into a steep angle curve. As a result, a substantial improvement of the road alignment will maintain clearance height during the high water level of Sakhakot river.

The effective width of the bridge is, 3.6 m (roadway is 3.6 m)

The main bridge, which is a 3 span simple PC girder bridge (L = 25 m x 3), is designed mainly by Japanese standards in addition to the reference on the examples found in Pakistan.

The substructures are all of the invert T-type reinforced concrete. Construction for 2 abutments and 1 pier are ground work, whereas the remaining 1 bridge pier at the right bank is river work during the dry season. Scouring is considered when foot protection for substructure is decided, which is to be deeper down the river bed compared with the depth during high water level. Furthermore, scouring prevention around the footing is done by the cobblestone foot protection.

The geological features near the bridge is that there are shallow rocks on both the left and right banks which can be used as the structure's bearing layer. The foundation is spread type.

The access road of the left bank is built on the embankment (maximum height is 4 m). The embankment slope is protected by sodding but around the abutment in contact with the river flow is protected by stone masonry.

The existing road will be used as the access road of the right bank, but embankment is used for the section that undergoes alignment improvement. The embankment slope is protected by sodding, but around the abutment in contact with the river flow is protected by stone masonry.

The width of the access road will be of macadam pavement.

(10) No.19 Totakan Bridge

General layout plan of Br. No. 19 Totakan Bridge is shown in Fig. 6.15.

The bridge is built on the access road that separates from the trunk road at a right angle. It goes upwards following the topography of right bank, then connects with the existing rural road. It is about 10 meters from the rural road on the left bank to the central span of the bridge. Considering the topography at the bridge site, RC slab bridge with a 10 meter span is constructed between them. The same thing is done on the right bank.

The width of bridge is planned at 3.6 meters in effective width.

The main bridge is a single steel truss girder suspension bridge with a central span of 90 meters. Many suspension bridges have been built in Pakistan by the design of local Consultants. However, according to the local engineers, the design method of suspension bridge is not fully formed because a lot of their designs are just a simple copy of the existing one. Since there is little experience for the steel truss girder suspension bridge that is proposed this time, the bridge is mainly designed by the Japanese design standard and technology transfer would be available through this project.

Because the main pier stands directly on the rock, the tower is built by reinforced concrete upon the concrete spread footing. The sag ratio of the main cable is 1/10, and the height of the tower, from footing, is 18 meters. The main cable is fixed by rock anchor on the left bank, because rock is able to bear the load. On the right bank, a gravity anchorage is constructed to fix the main cable.

The RC hollow slab bridge is selected for the side span considering the topography. The side span on both left and right bank is 10 meters. The gravity abutment is constructed for the RC floor slab bridges.

Since the RC hollow slab bridge on the left bank is a part of the T (fork) junction and connects the trunk road by itself directly, the access road is not necessary. On the right bank, there is 200 meters from the RC floor slab bridge to the existing rural road. The access road is built on a low embankment nearly as high as the ground because of the gentle slope on the right bank.

The access road is simply paved for the determined width by macadam.

(11) No.20 Sakhakot Bridge

General layout plan of Br. No. 20 Sakhakot Bridge is shown in Fig. 6.16.

The access road near the bridge, connects the existing road which is approaching the bridge with a down slope and a large curve. It makes quite an improvement to the road alignment on the left bank. The cross point on the right bank is T type junction.

The width of the bridge is determined at 3.6 meters.

The main bridge is a 3 spans simple PC girder bridge (L = 25 m x 3).

The design is prepared according to the common design practiced in japan with reference to examples practiced in Pakistan.

Invert T-Type reinforced concrete is used for all of the substructures.

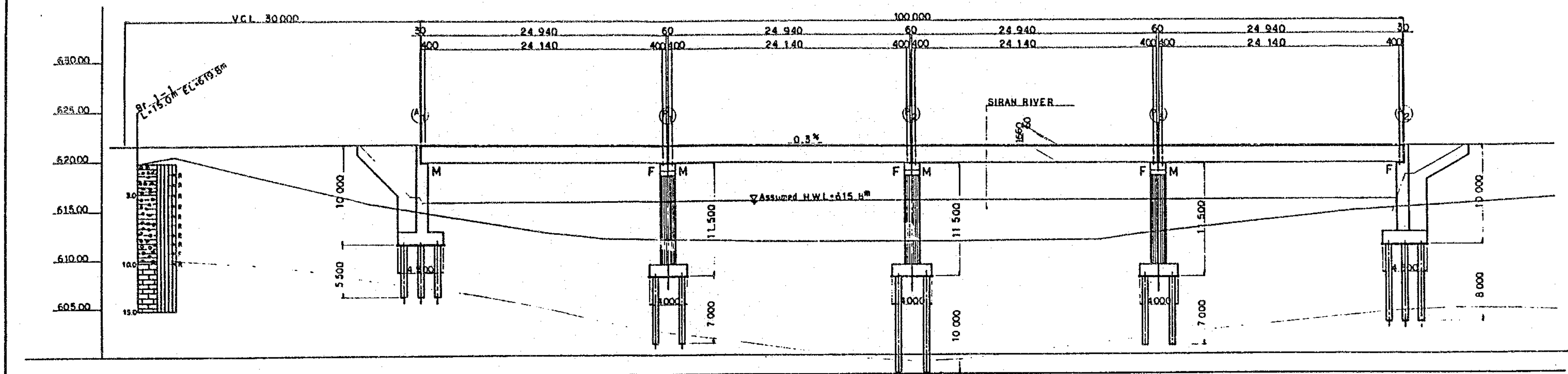
On both the left and right bank of the bridge site, there exists a shallow rock with a good condition and the supporting layer of structures is available. The foundation is designed as spread type.

The access road on the left bank is built in a cut. The slope of the cut is protected by sodding.

The access road on the right bank is planned to use the existing road.

The access road is to be macadam pavement.

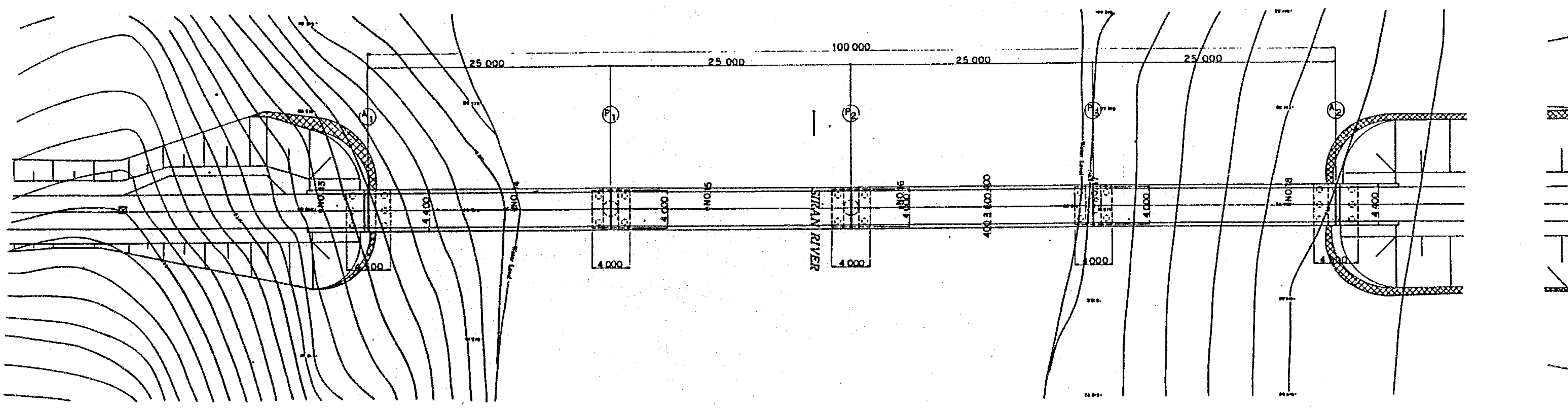
ELEVATION SCALE = 1:200



VERTICAL AHGNMENT	i=7.361 L=57.600 621.82								
FORMATION HEIGHT	622.08	621.57	621.56	621.52	621.51	621.51	621.50	621.48	621.45
GROUND HEIGHT	620.39	615.65		612.67		612.39	612.00		611.70
DISTANCE	177.6	260.0	265.0	277.0	280.0	280.6	283.4	290.0	300.0
CROSS SECTION NO.	NO.8 +17.6	NO.13	A1 (NO.13) +5.0		NO.14			P1 (NO.14) +10.0	NO.15
HORIZUNTAL AHGNMENT									

VERTICAL AHGNMENT	i=0.300% L=300.000							
FORMATION HEIGHT	621.41	621.39	621.35	621.34	621.33	621.27	621.26	621.21
GROUND HEIGHT		611.70	611.80	612.39	612.61	614.79		615.92
DISTANCE	315.0	320.0	334.0	338.2	340.0	360.0	365.0	380.0
CROSS SECTION NO.	P2 (NO.15) +15.0	NO.16			P3 (NO.17)	NO.18	A2 (NO.18) +5.0	NO.19
HORIZUNTAL AHGNMENT								

PLAN SCALE = 1:200



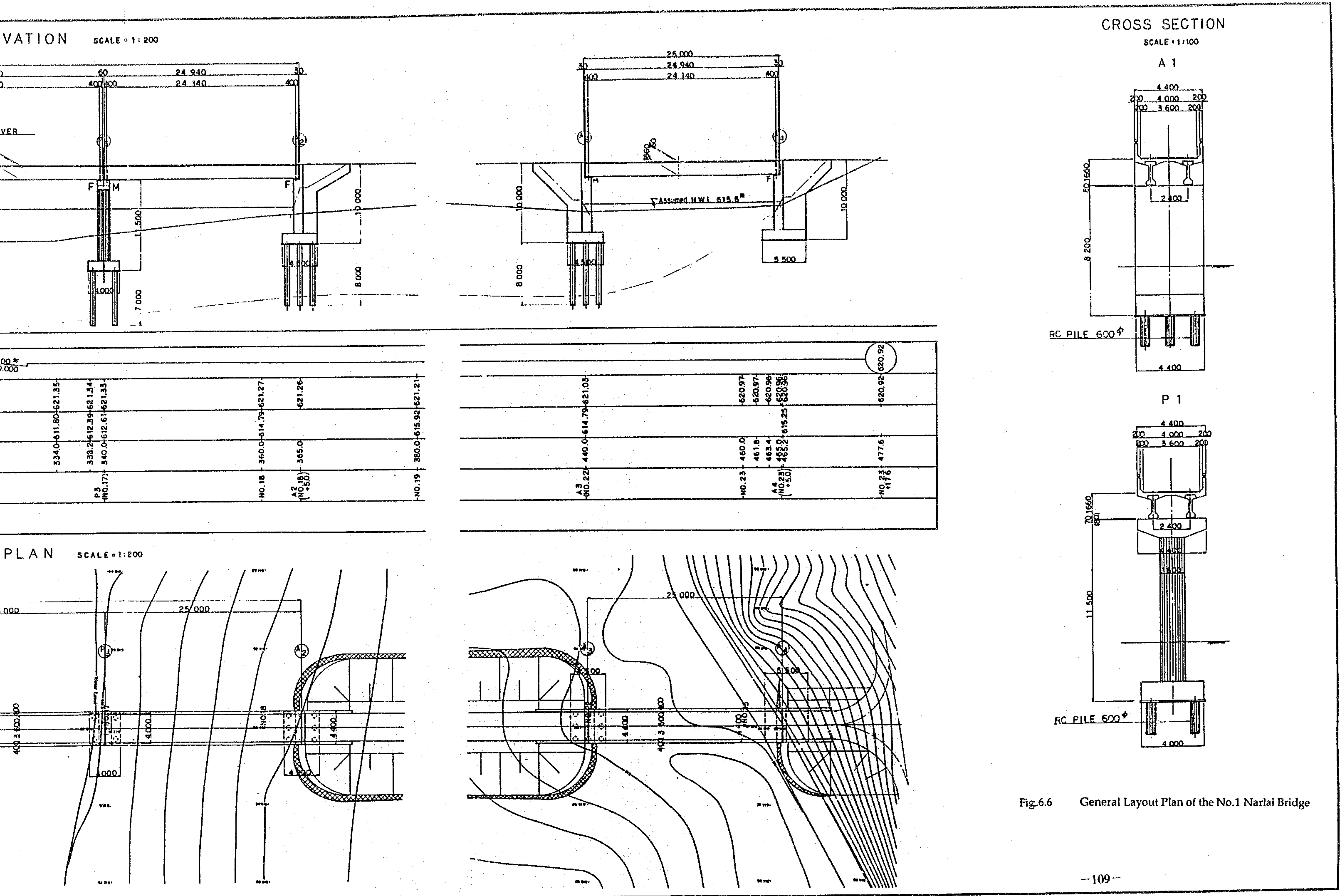
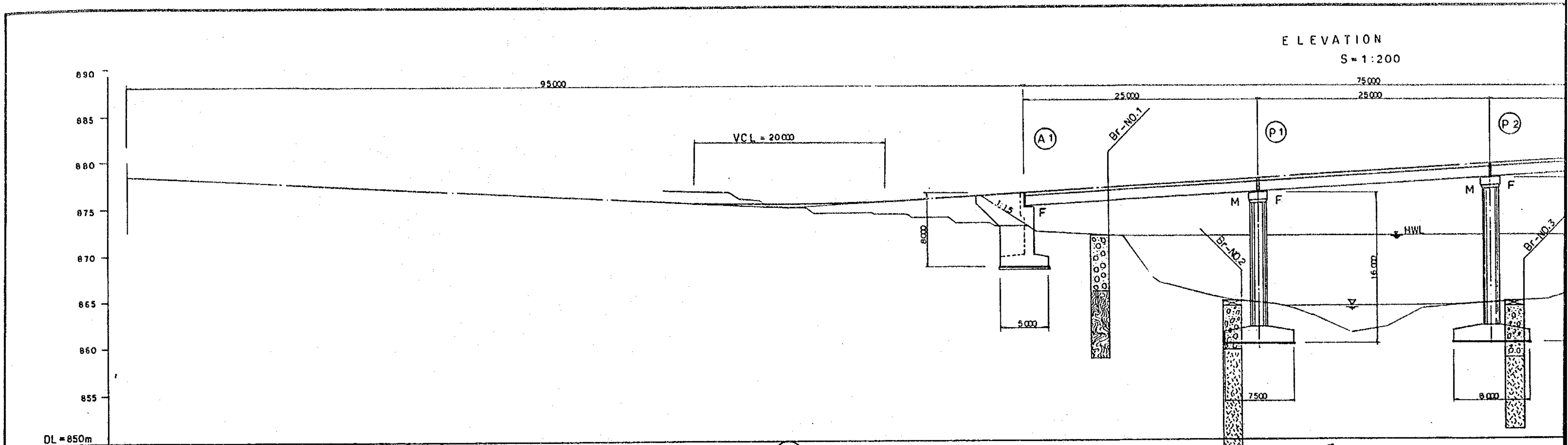
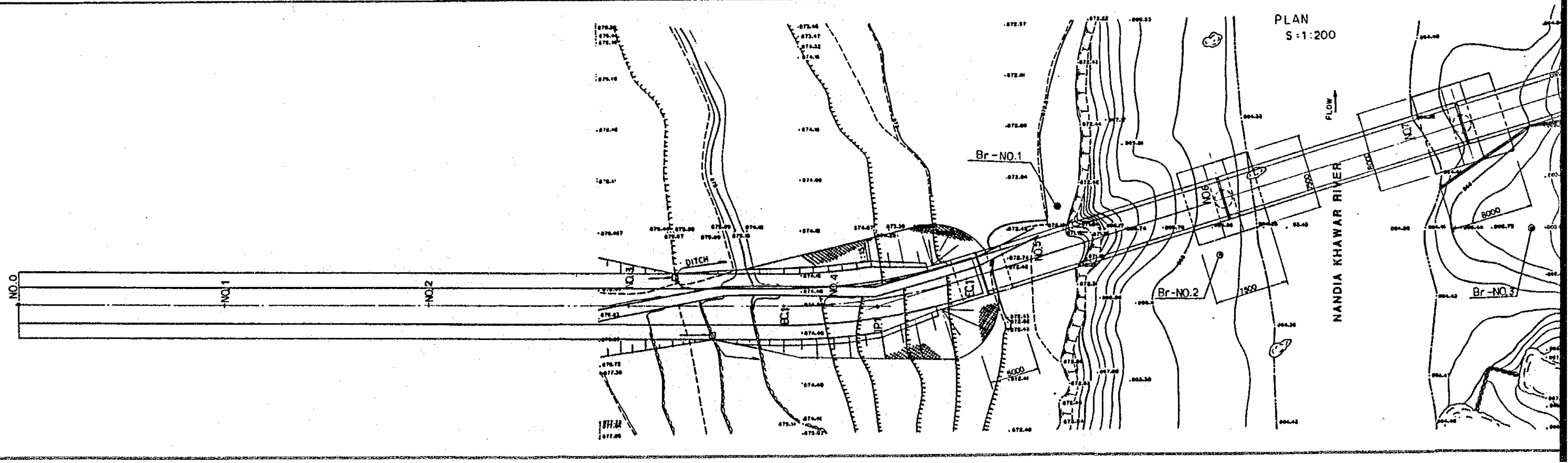


Fig.6.6 General Layout Plan of the No.1 Narlai Bridge



VERTICAL ALIGNMENT	878.5	5% L = 70m			875.0				6% L = 110m		
FORMATION HEIGHT	878.50	877.5	876.50	875.50	875.275	875.60	876.50	876.80	878.0	879.20	879.50
GROUND HEIGHT				876.8	875.0	874.3	873.0	872.2	864.7	864.2	864.6
DISTANCE	0.0	20.0	20.0	20.0	10.0	10.0	15.0	5.0	20.0	20.0	5.0
CROSS SECTION NO.	NO.0	NO.1	NO.2	NO.3		NO.4		NO.5	NO.6	NO.7	
HORIZONTAL ALIGNMENT	R = 60 I = 17°26'19" TL = 9.202, CL = 18.262										



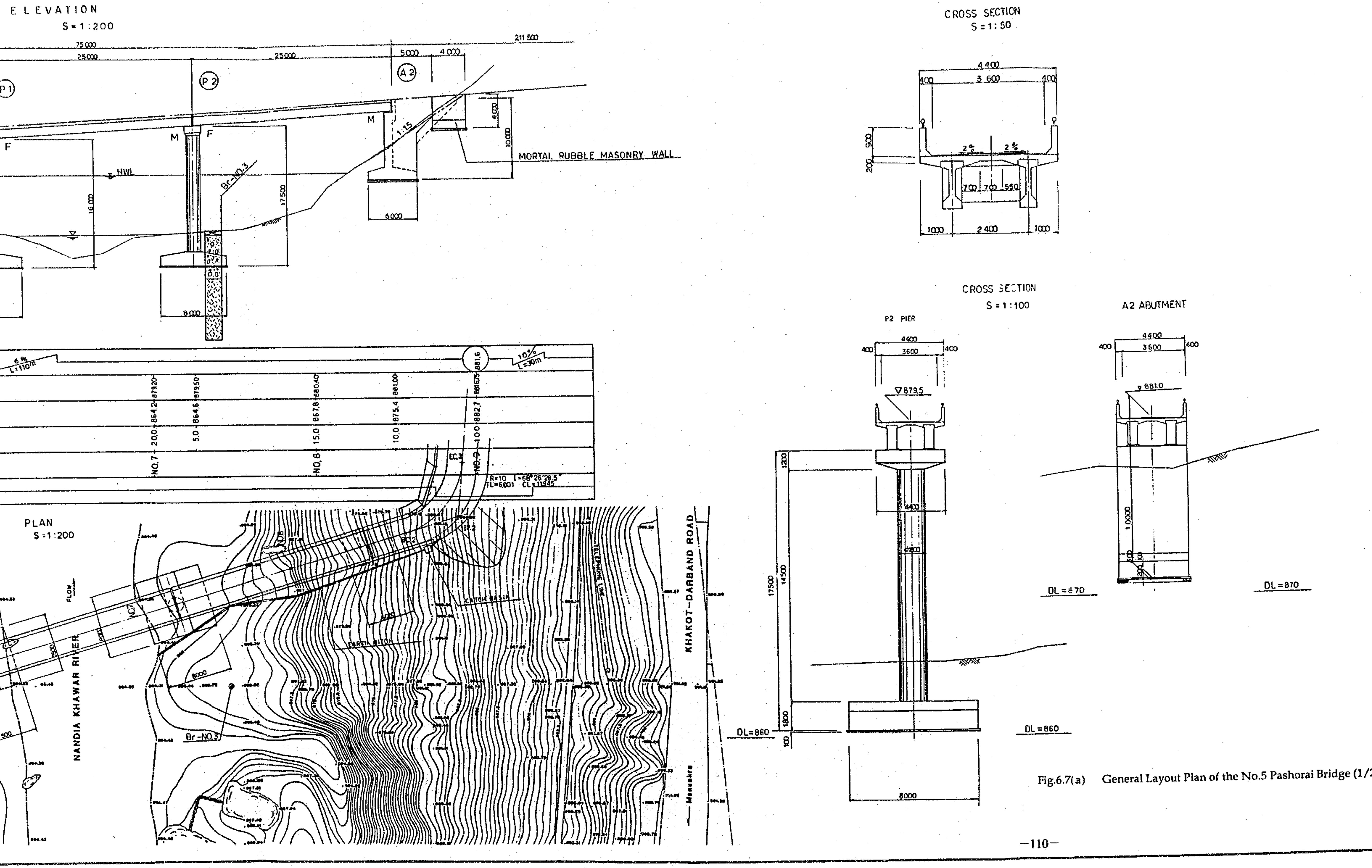
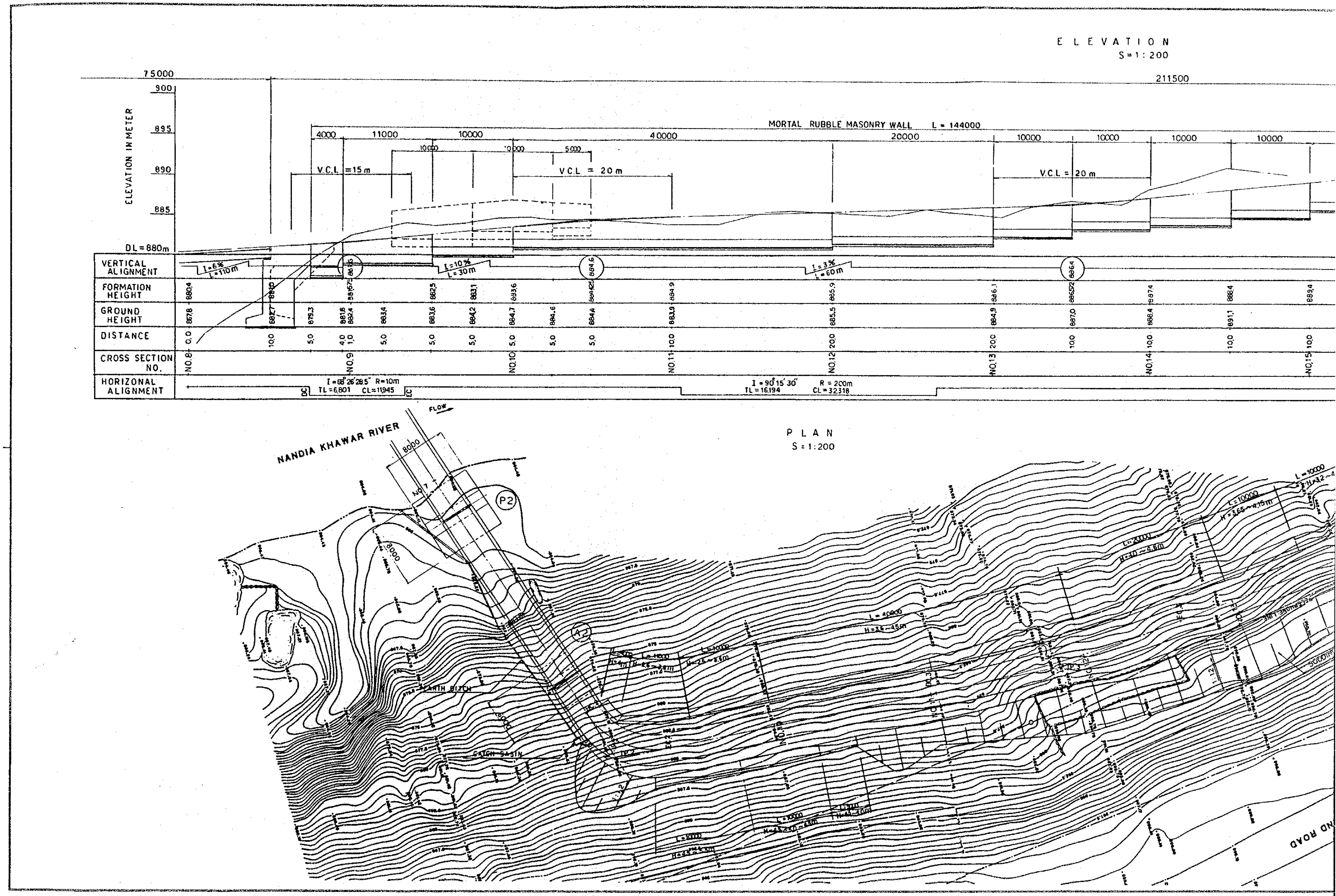


Fig.6.7(a) General Layout Plan of the No.5 Pashorai Bridge (1/2)



ELEVATION
S=1:200
75000
211500
ELEVATION IN METER
900
895
890
885
DL=880m
MORTAL RUBBLE MASONRY WALL L = 144000
V.C.L =15 m
V.C.L = 20 m
V.C.L = 20 m
VERTICAL ALIGNMENT
FORMATION HEIGHT
GROUND HEIGHT
DISTANCE
CROSS SECTION NO.
HORIZONAL ALIGNMENT
NO.8
NO.9
NO.10
NO.11
NO.12
NO.13
NO.14
NO.15
R=10m
R = 200m
FLOW
NANDIA KHAWAR RIVER
PLAN
S=1:200
EARTH DITCH
CATCH BASIN

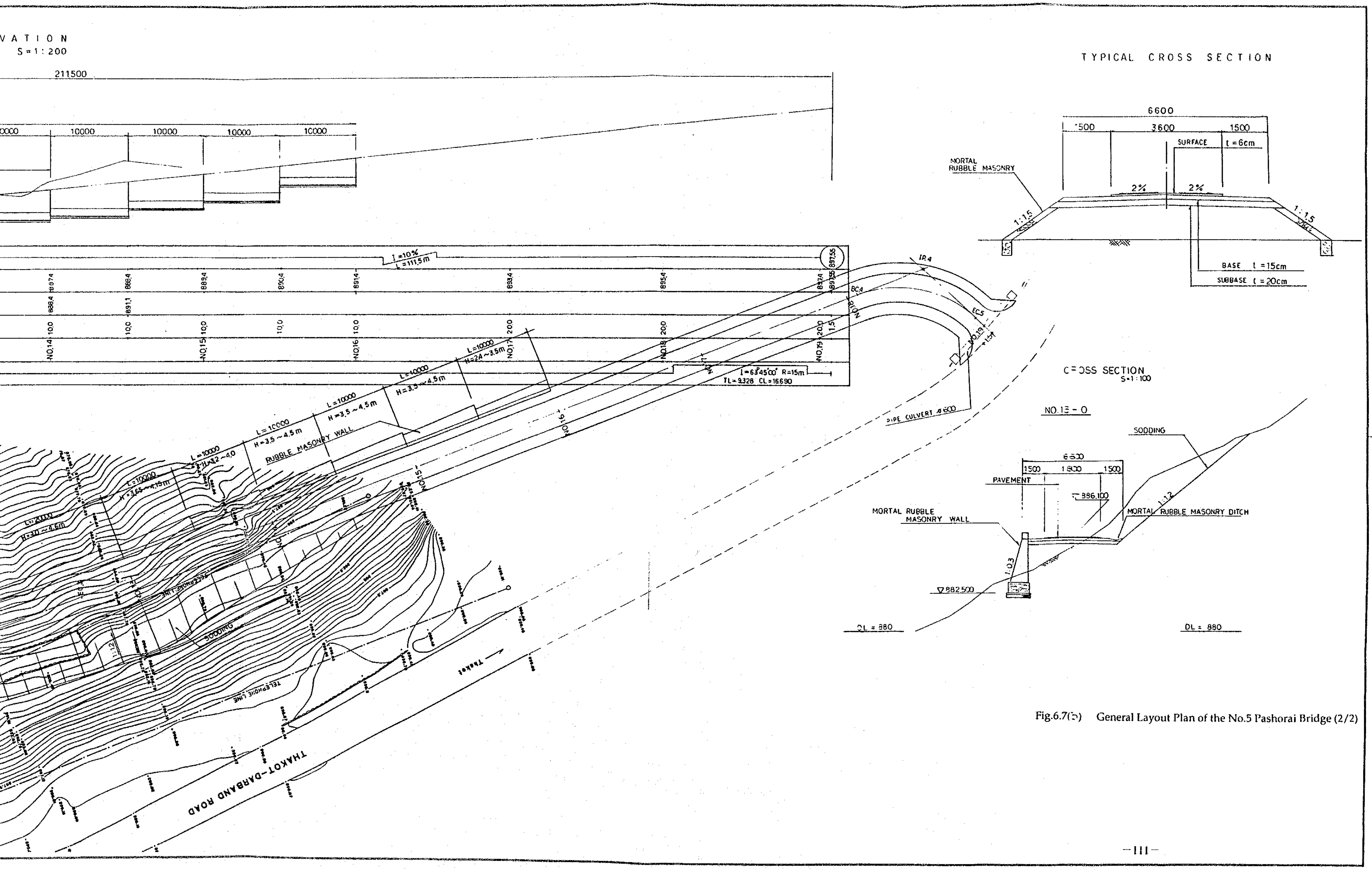
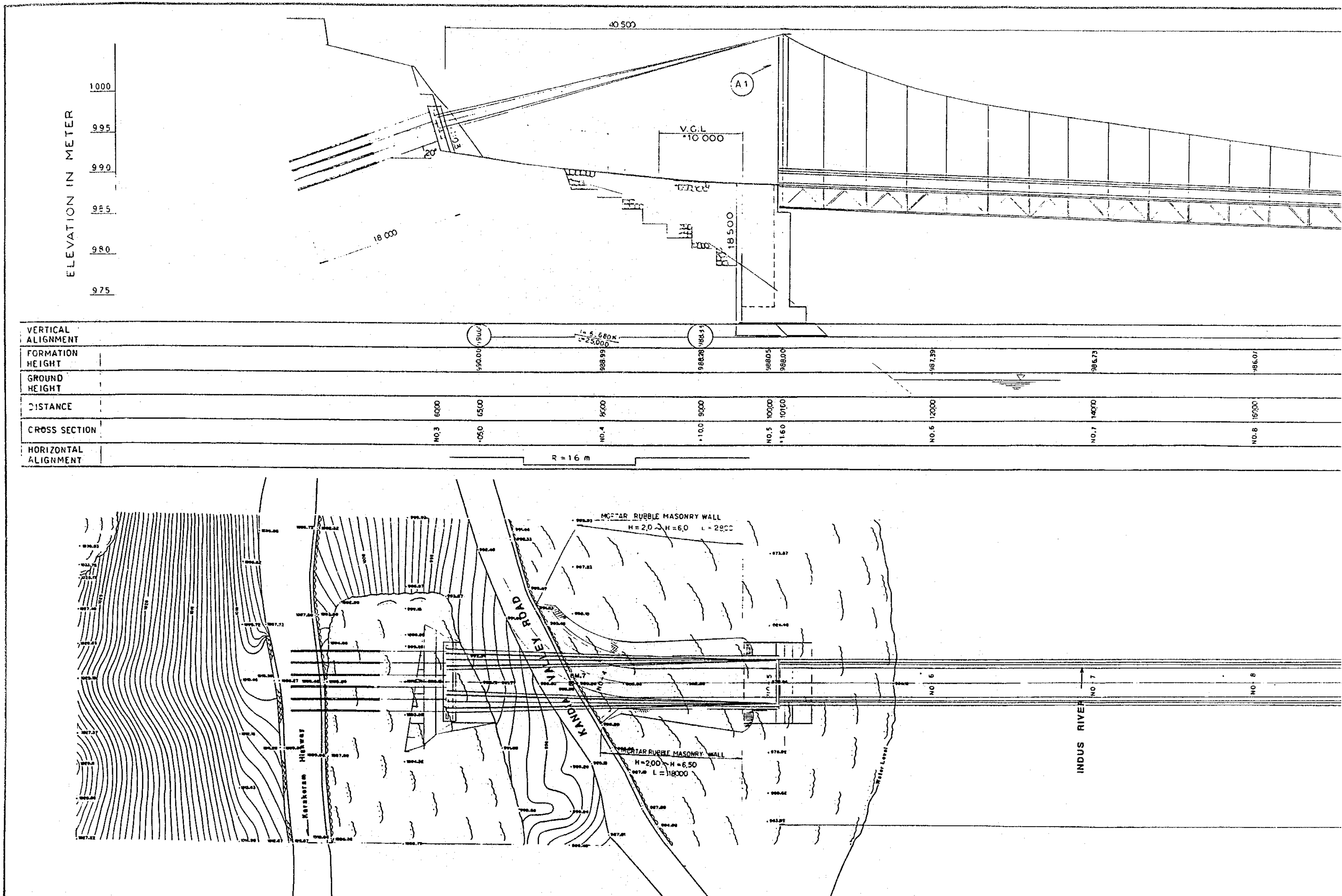
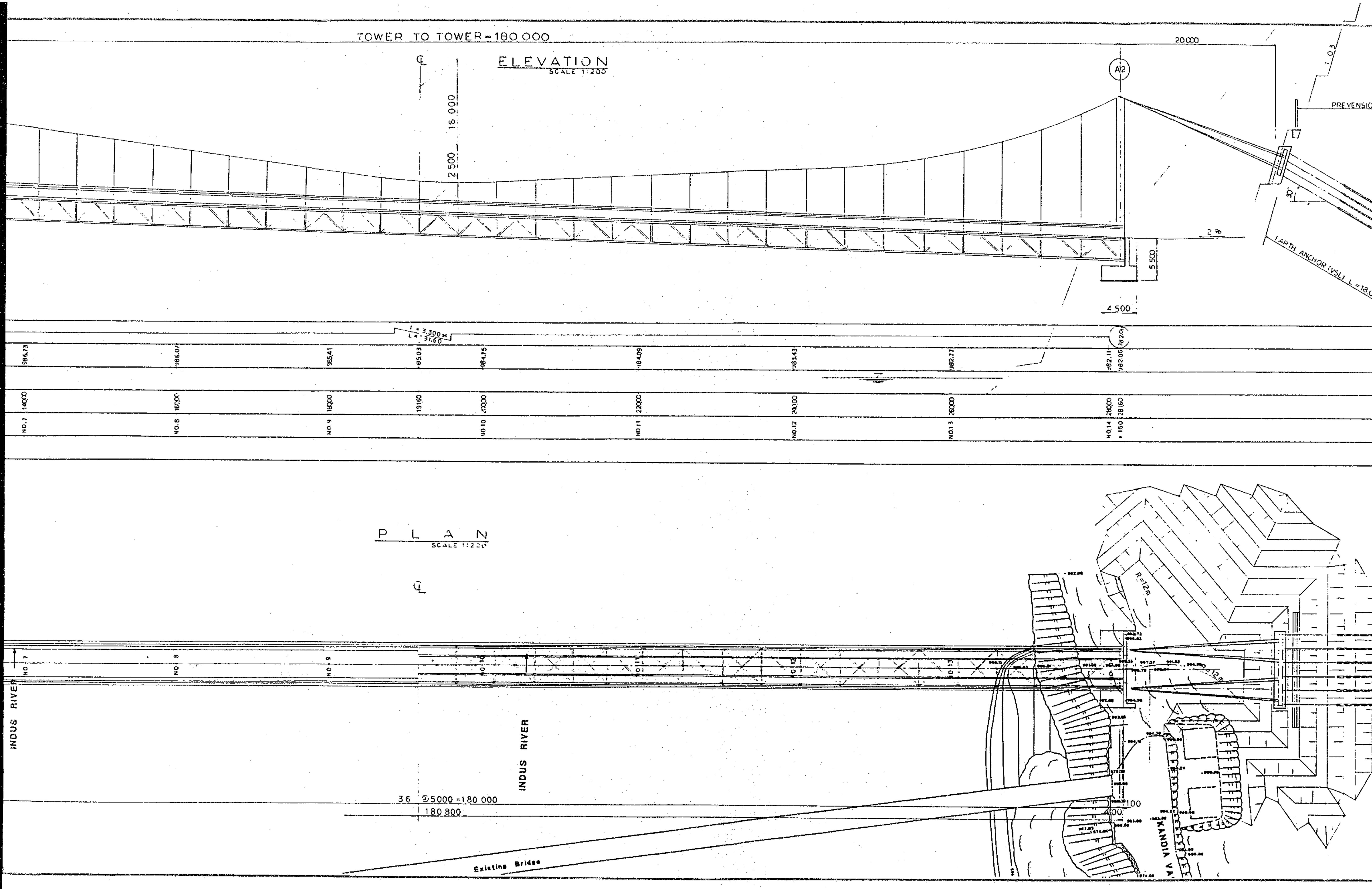


Fig.6.7(b) General Layout Plan of the No.5 Pashorai Bridge (2/2)



ELEVATION IN METER
1000
995
990
985
980
975
40 500
A1
V.C.L
10 000
18 000
18 500
20°
VERTICAL ALIGNMENT
FORMATION HEIGHT
GROUND HEIGHT
DISTANCE
CROSS SECTION
HORIZONTAL ALIGNMENT
990.00
988.99
988.28
988.05
988.00
987.39
986.73
986.07
60.00
65.00
80.00
90.00
100.00
101.60
120.00
140.00
160.00
NO.3
+05.0
NO.4
+10.0
NO.5
+1.60
NO.6
NO.7
NO.8
R = 16 m
MORTAR RUBBLE MASONRY WALL
H = 2,0
H = 6,0
L = 2800
MORTAR RUBBLE MASONRY WALL
H = 2.00
H = 6.50
L = 18000
KANDIA VALLEY ROAD
Karakoram Highway
INDUS RIVER
Water Level


TOWER TO TOWER = 180 000
ELEVATION
SCALE 1:200
18 000
2 500
A2
20 000
1:0.3
PREVENSIO
30°
2 %
EARTH ANCHOR (VSL) L = 18.0
5 500
4 500
986.73
986.07
985.41
985.03
984.75
984.09
983.43
982.77
982.11
982.05
14000
16000
18000
19160
20000
22000
24000
26000
28000
28160
NO.7
NO.8
NO.9
NO.10
NO.11
NO.12
NO.13
NO.14
PLAN
SCALE 1:200
R=12m
INDUS RIVER
INDUS RIVER
36 @5000 = 180 000
180 800
Existing Bridge
KANDIA VA

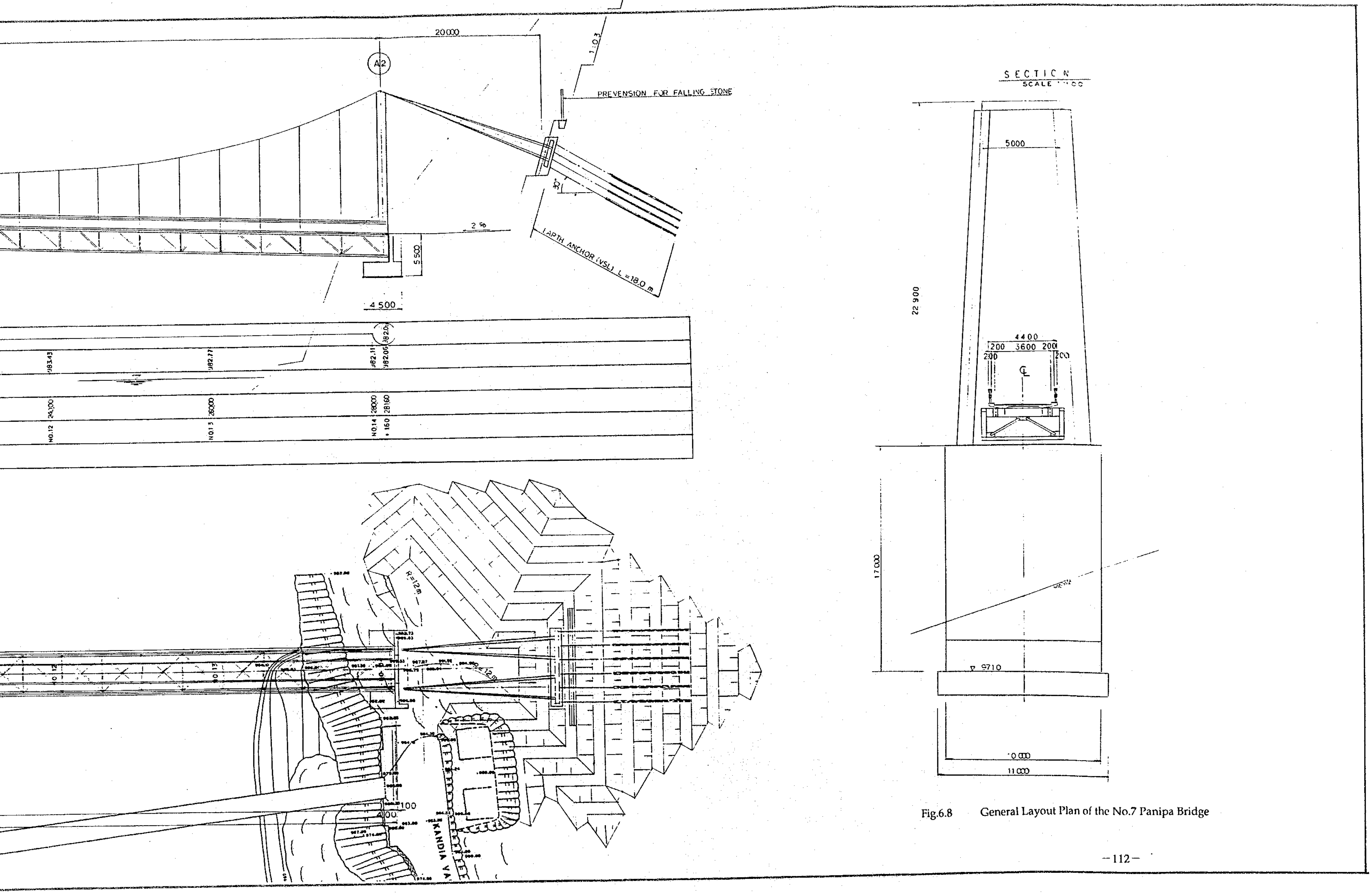
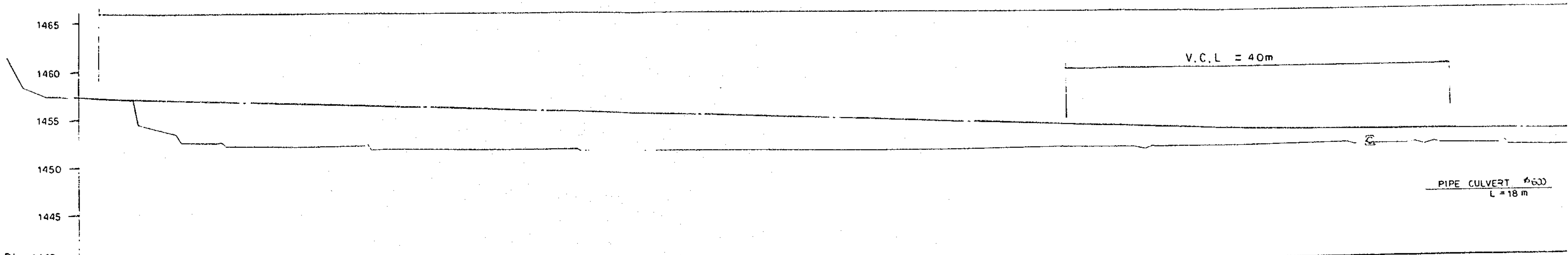
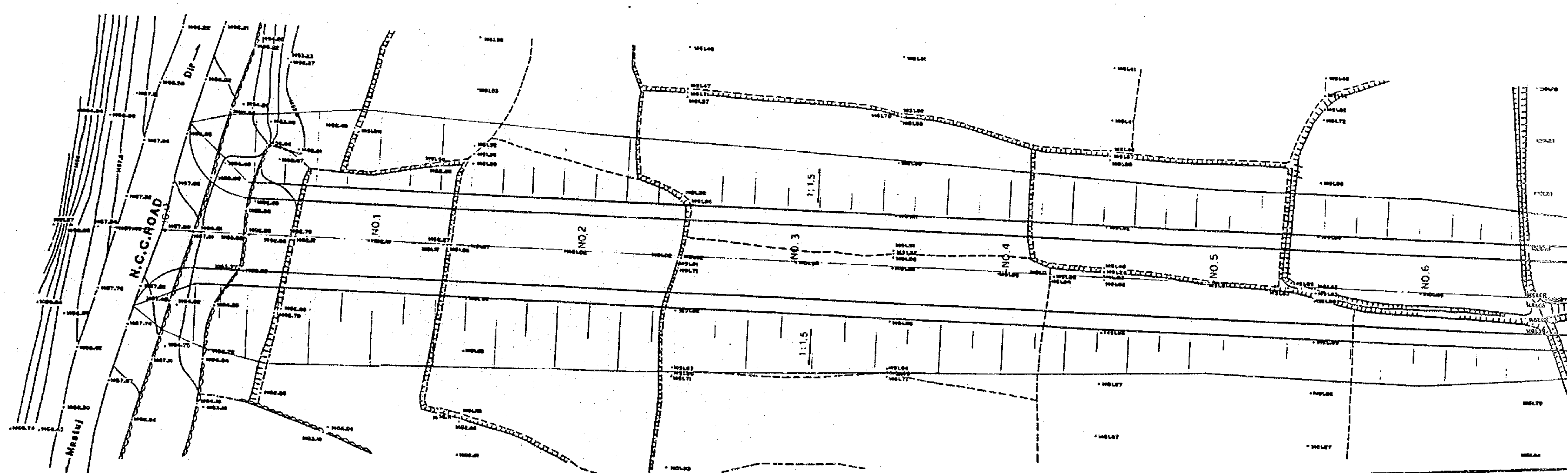


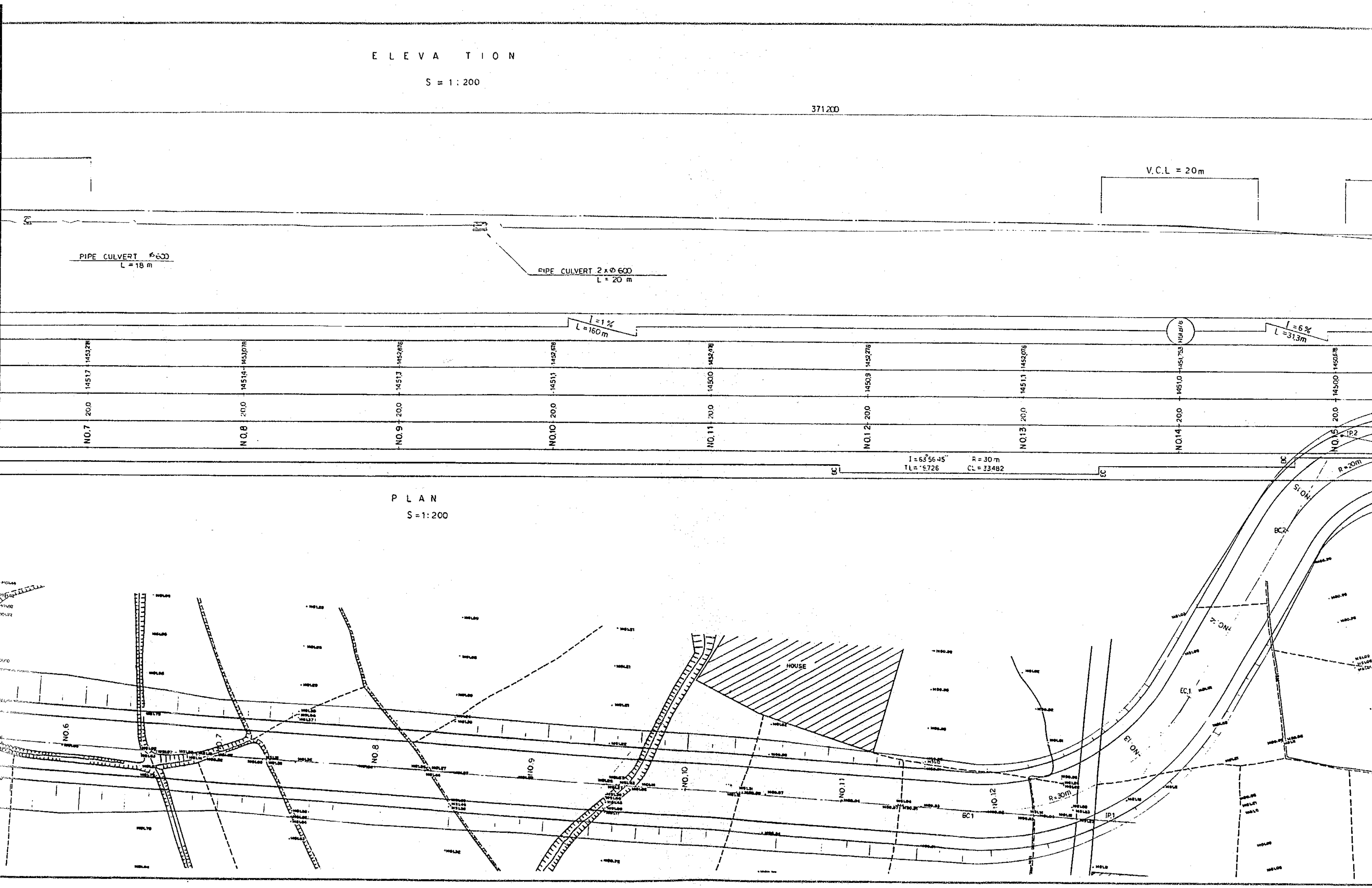
Fig.6.8 General Layout Plan of the No.7 Panipa Bridge



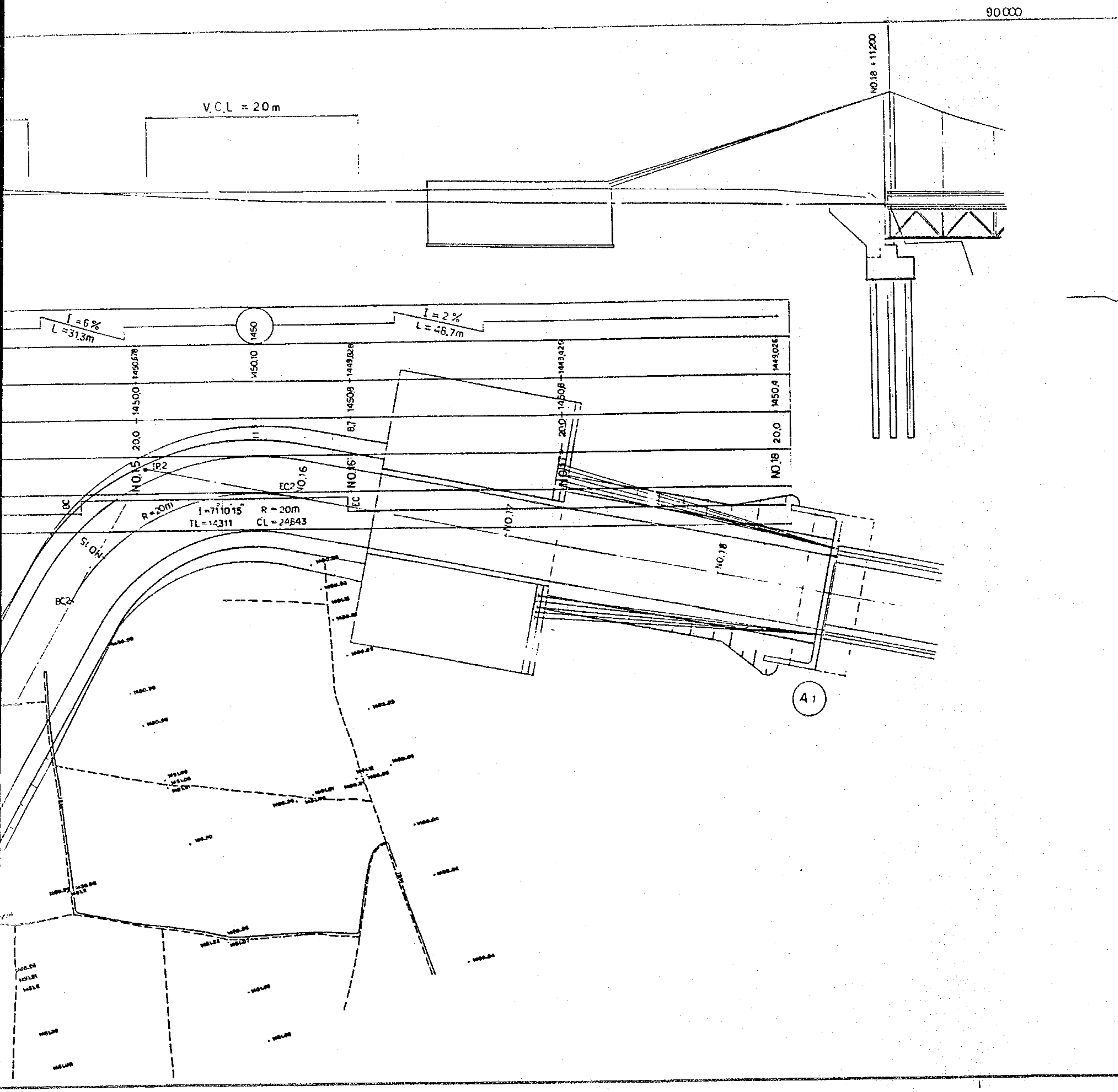
DL =1440m

	NO.0	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
VERTICAL ALIGNMENT	1457.27			= 3.16% L = 120m			1453.478	
FORMAITION HEIGHT	1457.27	1456.638	1456.006	1455.374	1454.742	1454.11	1453.586	1453.278
GROUND HEIGHT	1457.3	1452.1	1451.9	1451.7	1451.5	1451.8	1451.8	1451.7
DISTANCE	0.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
CROSS SECTION NO.	NO.0	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7
HORIZONTAL ALIGNMENT								





ELEVATION
S = 1 : 200
371.200
V.C.L = 20m
PIPE CULVERT φ600
L = 18 m
PIPE CULVERT 2 x φ 600
L = 20 m
I = 1 %
L = 160 m
I = 6 %
L = 31.3m
1453.278
1453.078
1452.678
1452.678
1452.478
1452.278
1452.078
1450.678
1451.7
1451.4
1451.3
1451.1
1450.0
1450.9
1451.1
1451.0
1450.0
20.0
NO.7
NO.8
NO.9
NO.10
NO.11
NO.12
NO.13
NO.14
NO.15
I = 63°56'45"
TL = 19.726
R = 30 m
CL = 33.482
PLAN
S = 1 : 200
HOUSE
BC1
IP.1
R = 30m
EC1
BC2
IP.2
R = 20m



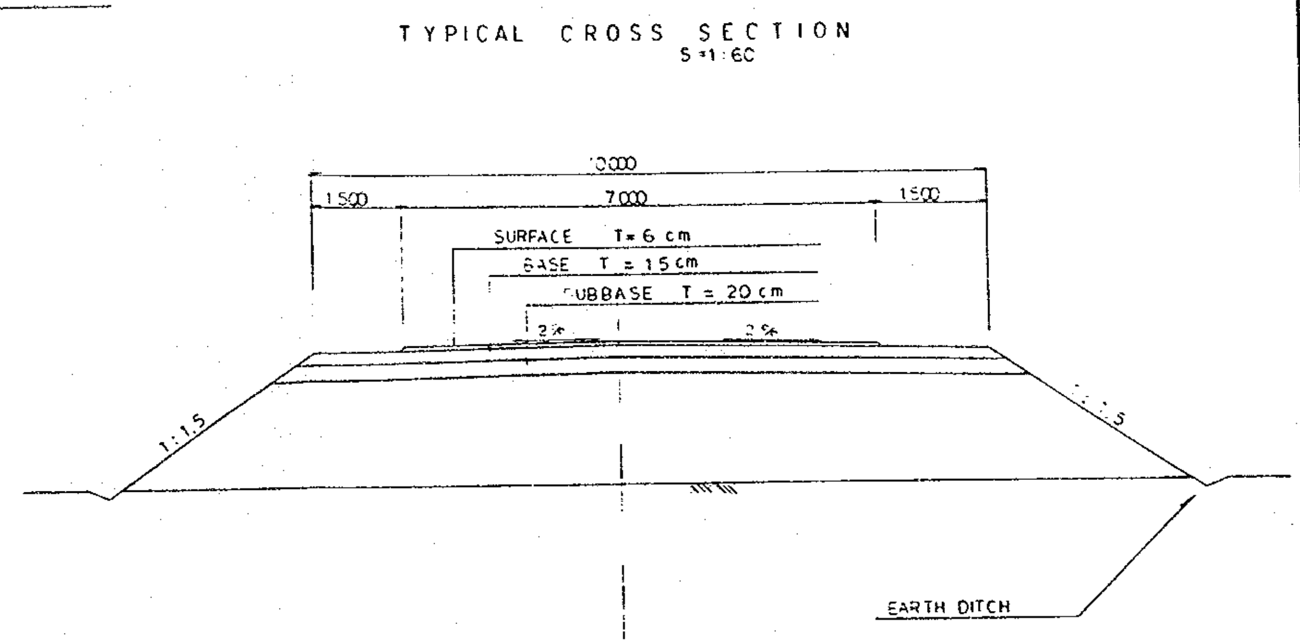
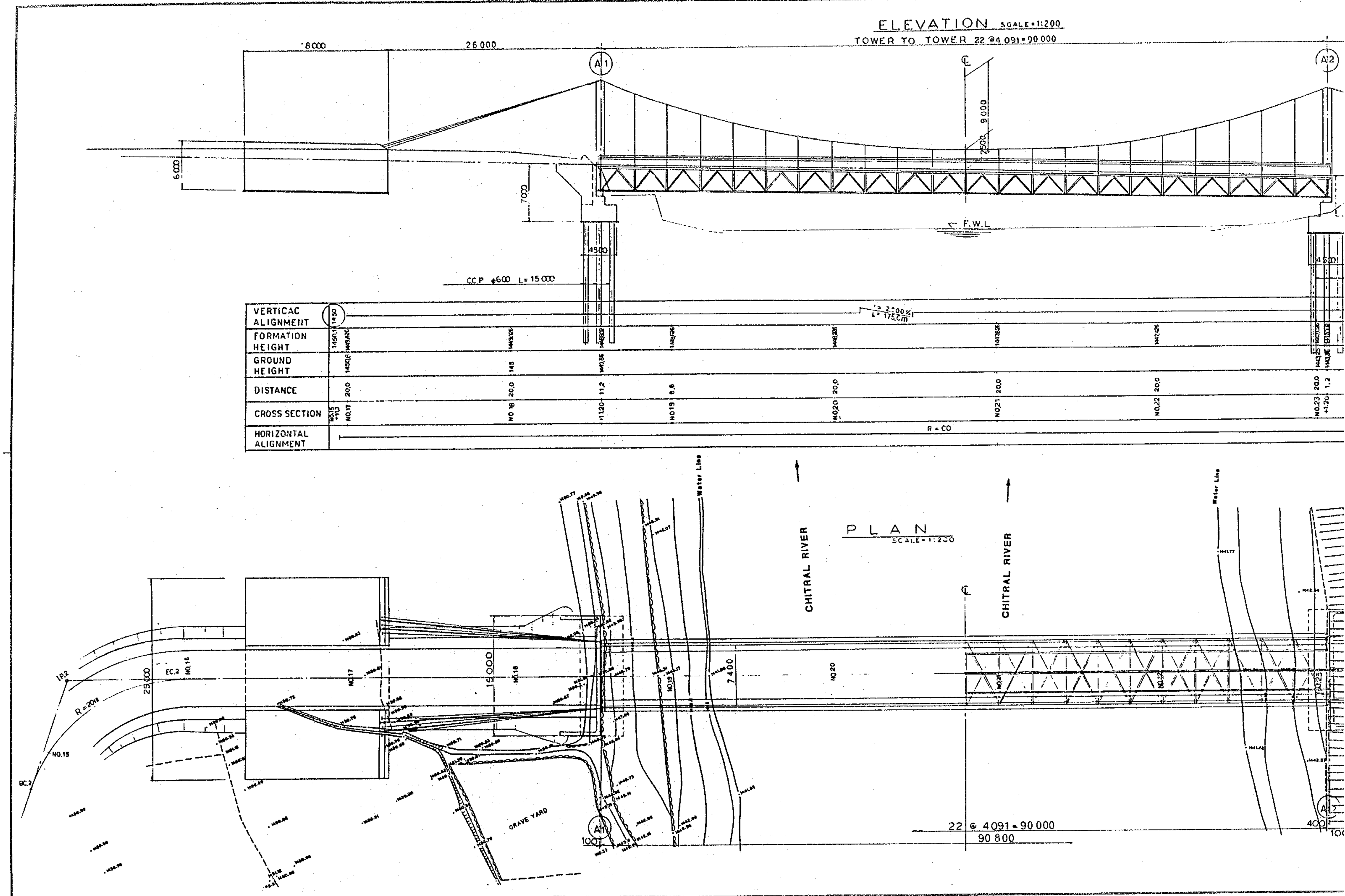
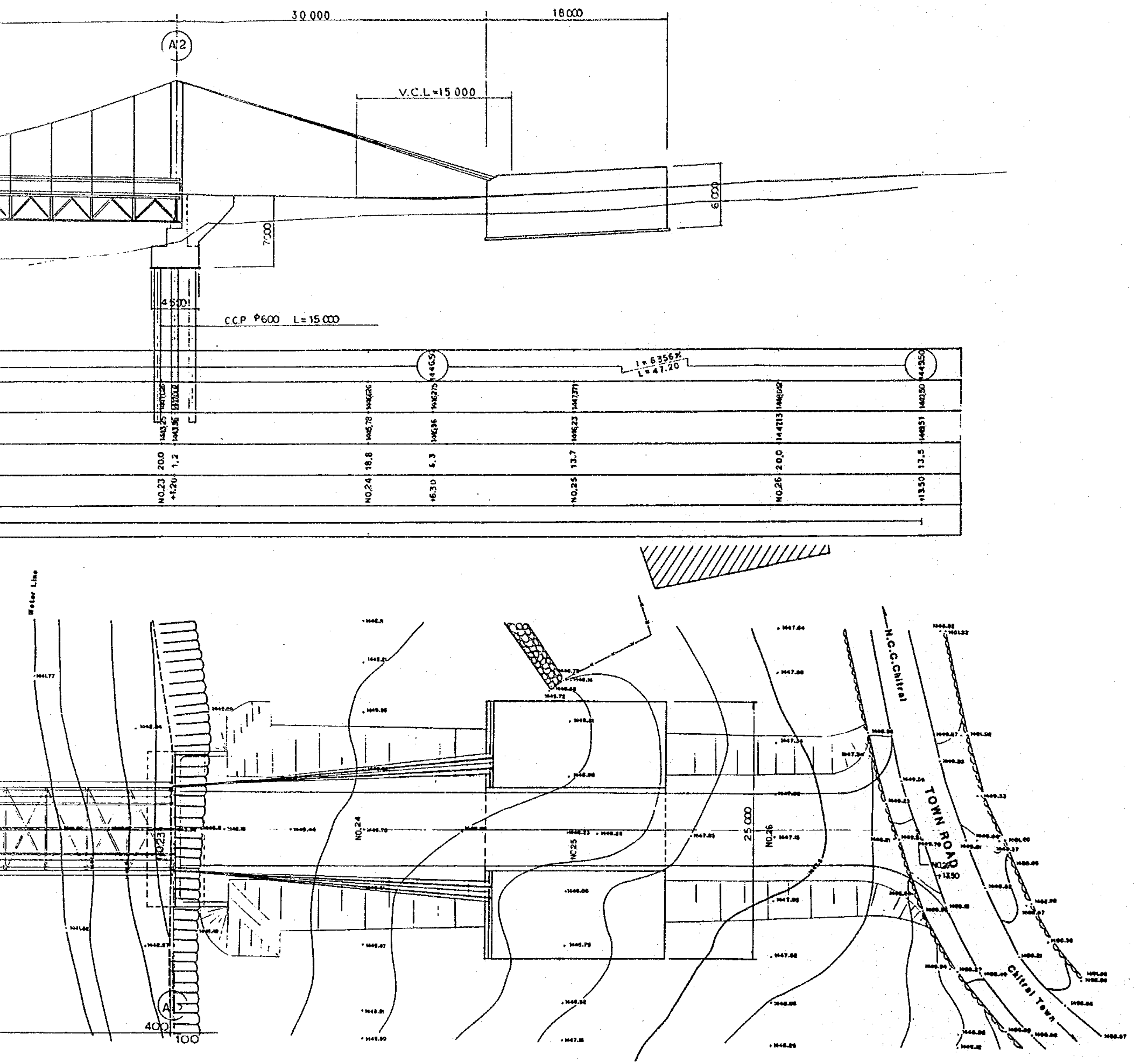


Fig.6.9(a) General Layout Plan of the No.11 Choni Bridge (1/2)



ELEVATION SCALE=1:200
TOWER TO TOWER 22 @4.091=90.000
8000
26000
9000
2500
6000
7000
4500
F.W.L
CCP φ600 L=15000
VERTICAC ALIGNMENT
FORMATION HEIGHT
GROUND HEIGHT
DISTANCE
CROSS SECTION
HORIZONTAL ALIGNMENT
R = CO
PLAN
SCALE=1:200
CHITRAL RIVER
CHITRAL RIVER
Water Line
Water Line
GRAVE YARD
25000
15000
7400
EC.2
BC.2
IP.2
R=2018
NO.15
NO.16
NO.17
NO.18
NO.19
NO.20
NO.21
NO.22
NO.23
22 @ 4091=90000
90800



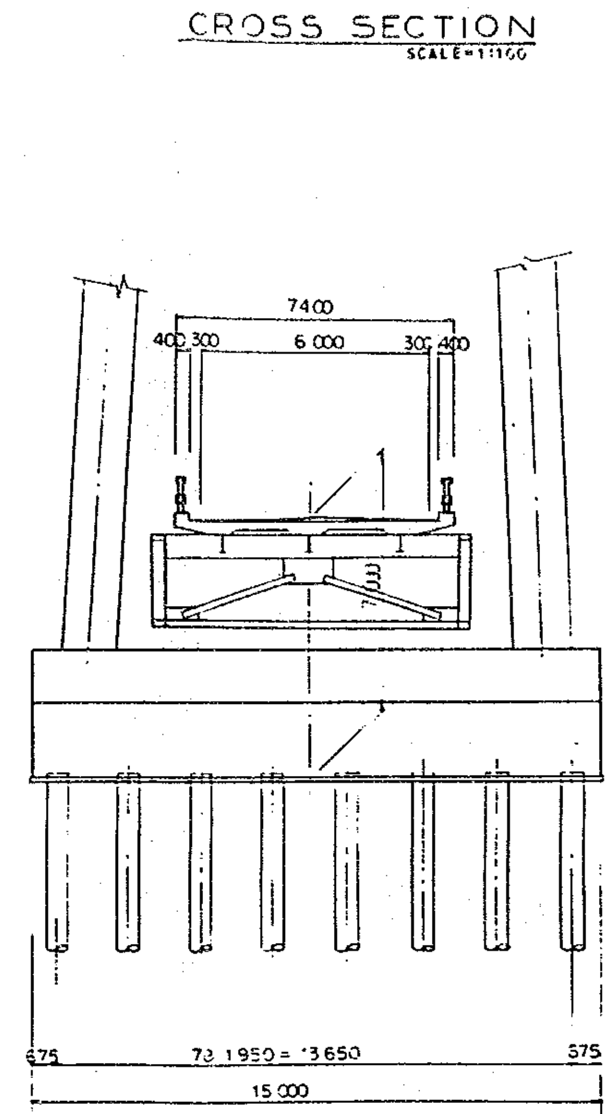
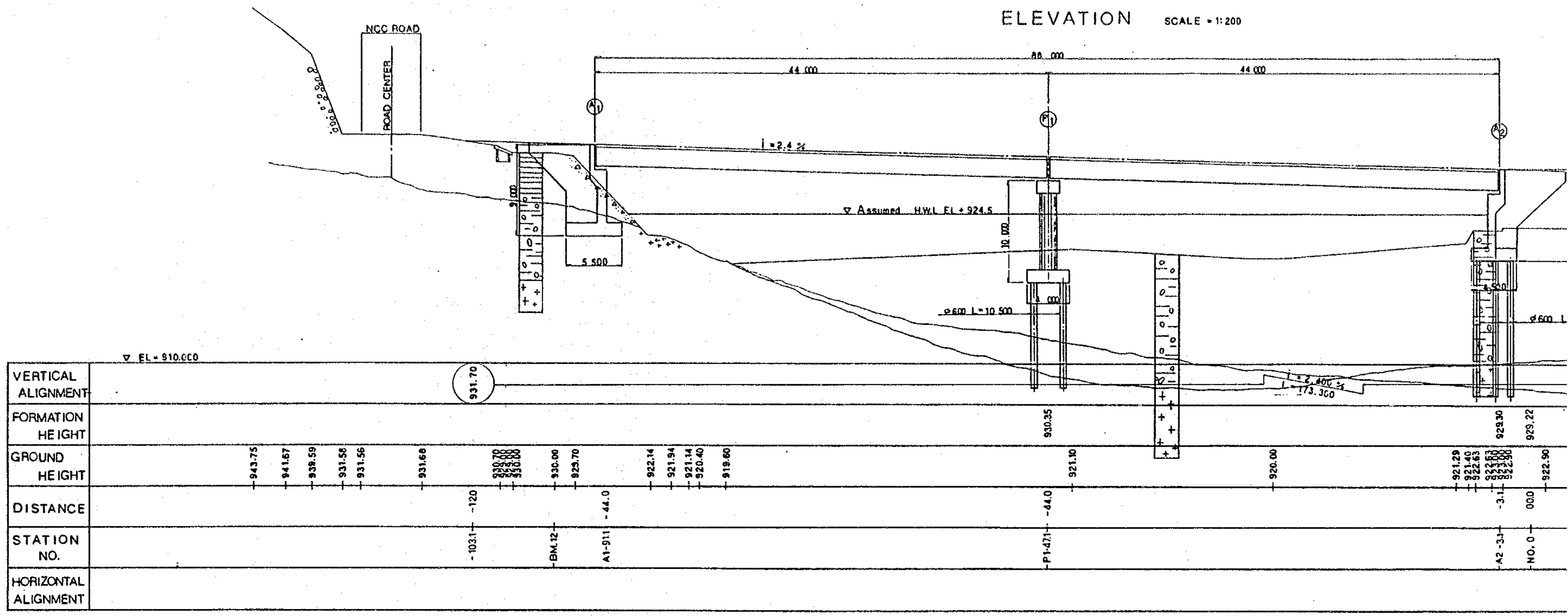
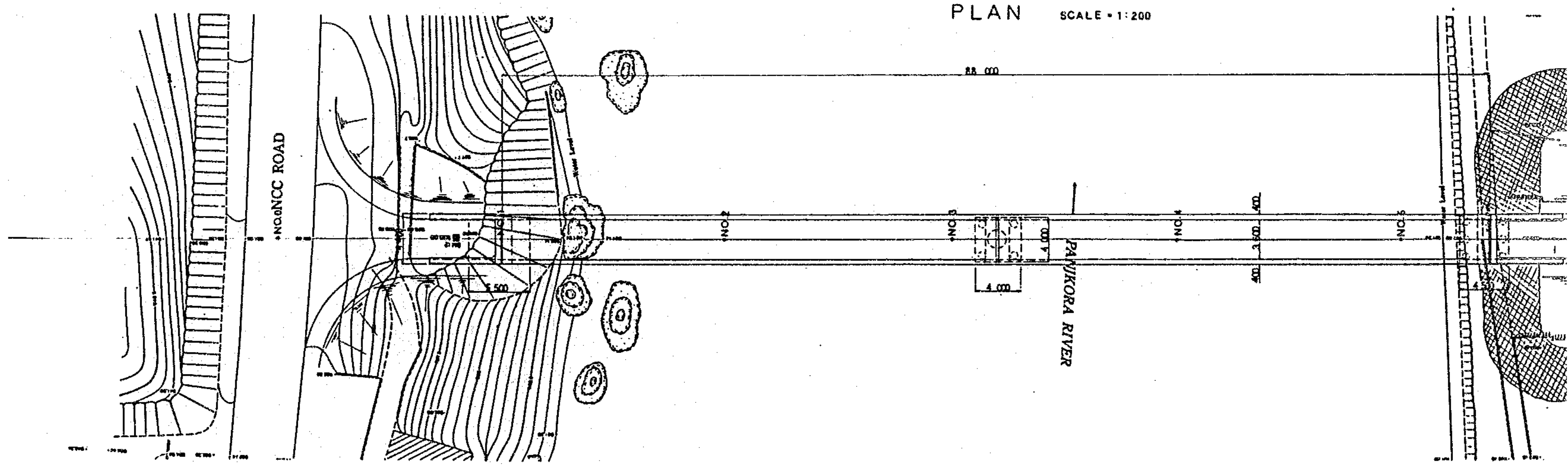


Fig.6.9(b) General Layout Plan of the No.11 Choni Bridge (2/2)

ELEVATION SCALE = 1:200



PLAN SCALE = 1:200



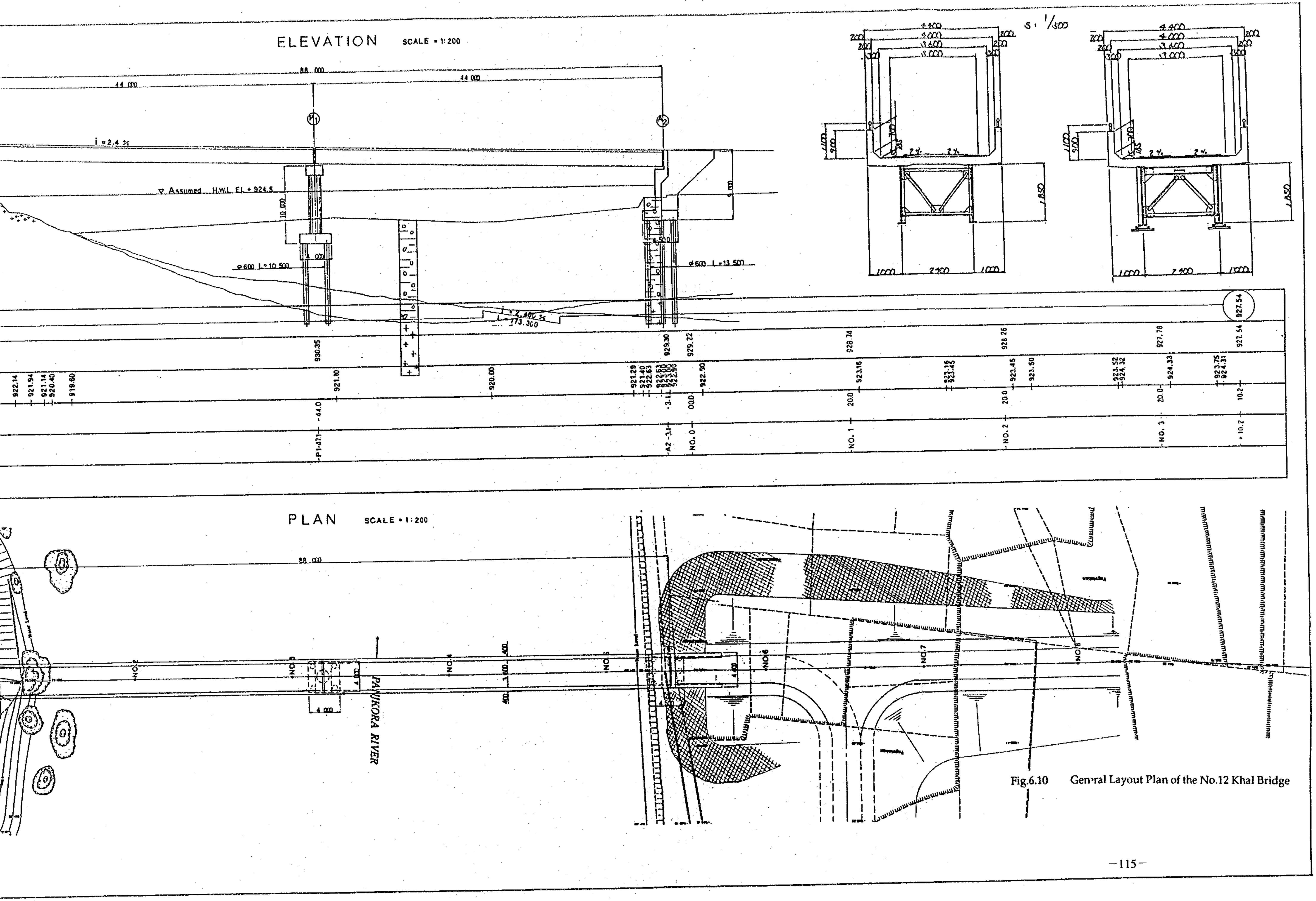
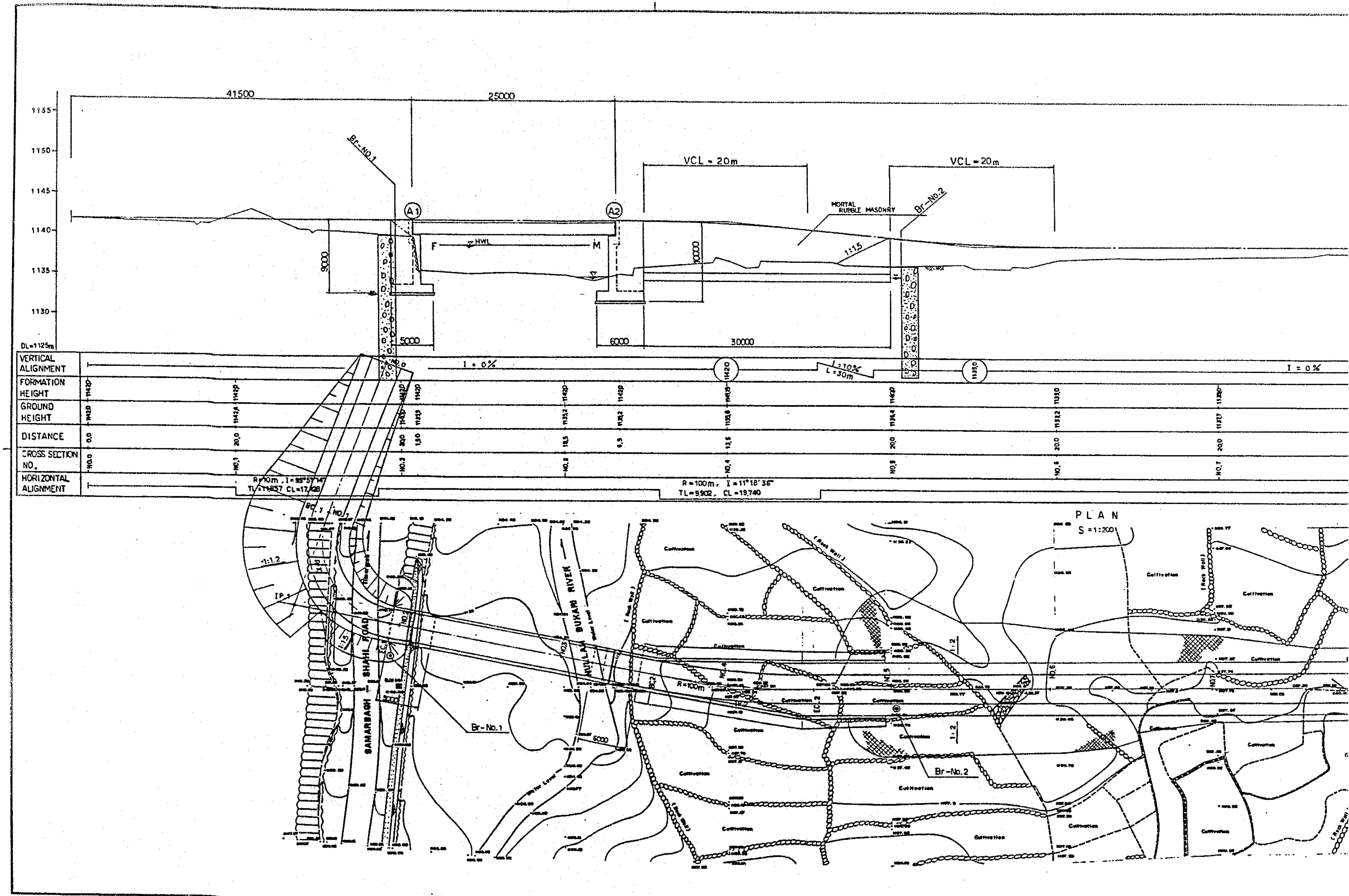


Fig.6.10 General Layout Plan of the No.12 Khal Bridge



41500
25000
1155
1150
1145
1140
1135
1130
DL=1125m
Br-NO.1
A1
A2
HWL
VCL = 20m
VCL = 20m
MORTAL RUBBLE MASONRY
Br-No.2
1:1.5
9000
10000
5000
6000
30000
VERTICAL ALIGNMENT
I = 0%
I = 10%
L = 30m
I = 0%
FORMATION HEIGHT
GROUND HEIGHT
DISTANCE
CROSS SECTION NO.
HORIZONTAL ALIGNMENT
R = 100m, I = 11°18'36"
TL = 9.902, CL = 19.740
PLAN
S = 1:200
SAHARBAGH - SHAHI ROAD
BUKANI RIVER
Br-No.1
Br-No.2
R = 100m
Cultivation
Rock Wall
Water Level
1:2
1:1.2
1:1.5
IP.1
6000