No. 1

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF SURFACE TRANSPORT
GOVERNMENT OF INDIA

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR CONSTRUCTION OF
THE NIZAMUDDIN BRIDGE
IN
INDIA

JANUARY 1995

NIPPON KOEI CO., LTD.
in association with
KATAHIRA & ENGINEERS INTERNATIONAL

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PREFACE

In response to a request from the Government of India, the government of Japan decided to conduct a basic design study on the Project for the Construction of the Nizamuddin Bridge and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to India a study team headed by Mr. Sigeru Okamoto, Deputy Director, Study Review and Coordination Division, Grant Aid Study and Design Department, JICA and constituted by members of Nippon Koei Co., Ltd. in associated with Katahira & Engineers International, from 19th July to 1st September 1994.

The team held discussions with the officials concerned of the Government of India, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to India in order to discuss a draft report, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of India for their close cooperation extended to the teams.

January 1995

Kimio Fujita
President
Japan International Cooperation Agency

January 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

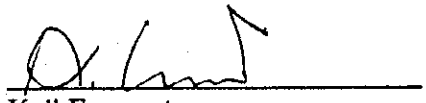
We are pleased to submit to you the basic design study report on the Project for Construction of the Nizamuddin Bridge in India.

This study was conducted by Nippon Koei Co., Ltd. in associated with Katahira & Engineers International, under a contract to JICA, during the period 13th July 1994 to 14th February 1995. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of India and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

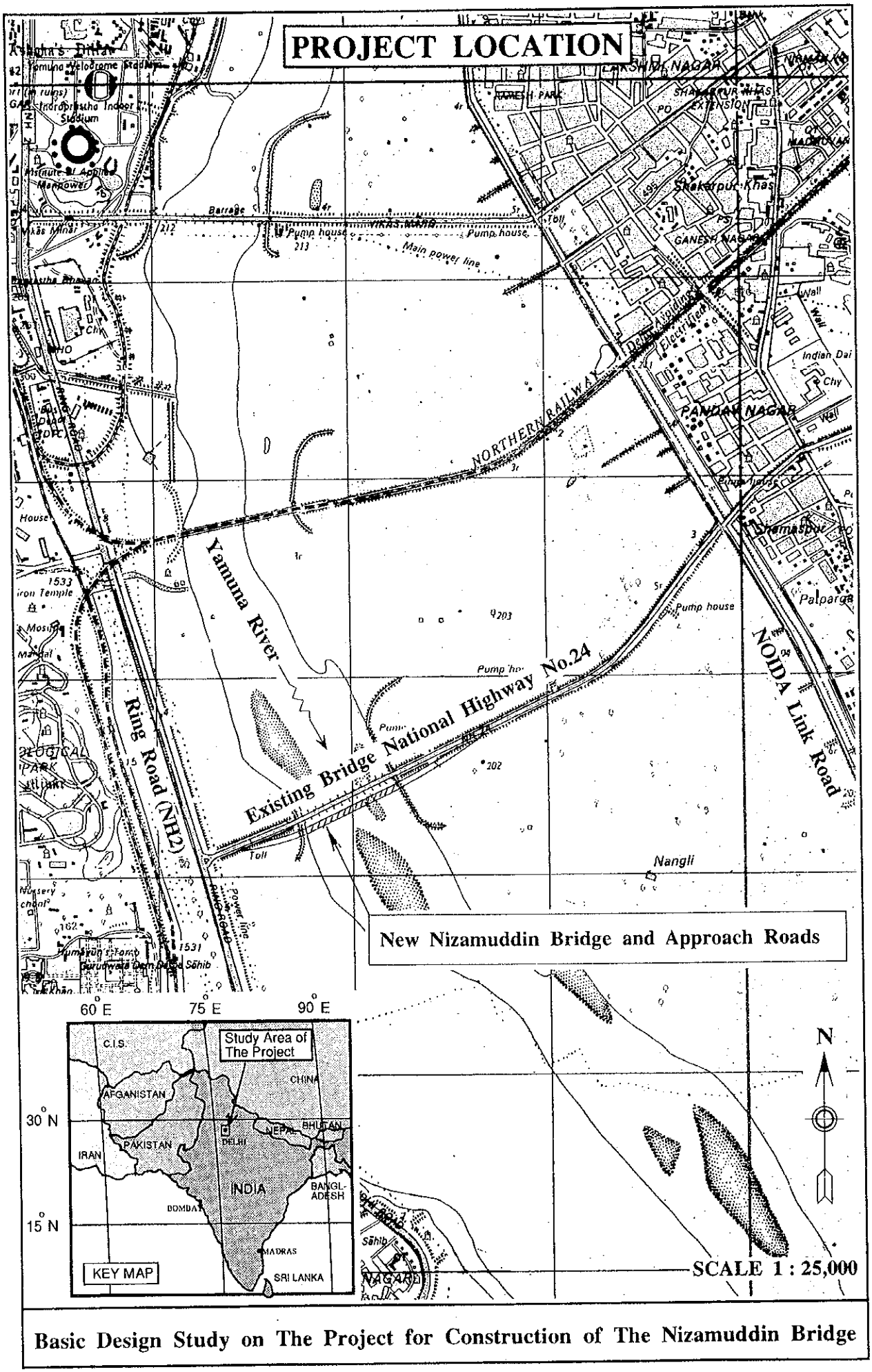
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and Ministry of Construction. We would also like to express our gratitude to the officials concerned of Ministry of Finance, Ministry of Surface Transport, Government of Delhi, the JICA India Office, the Embassy of Japan in India for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

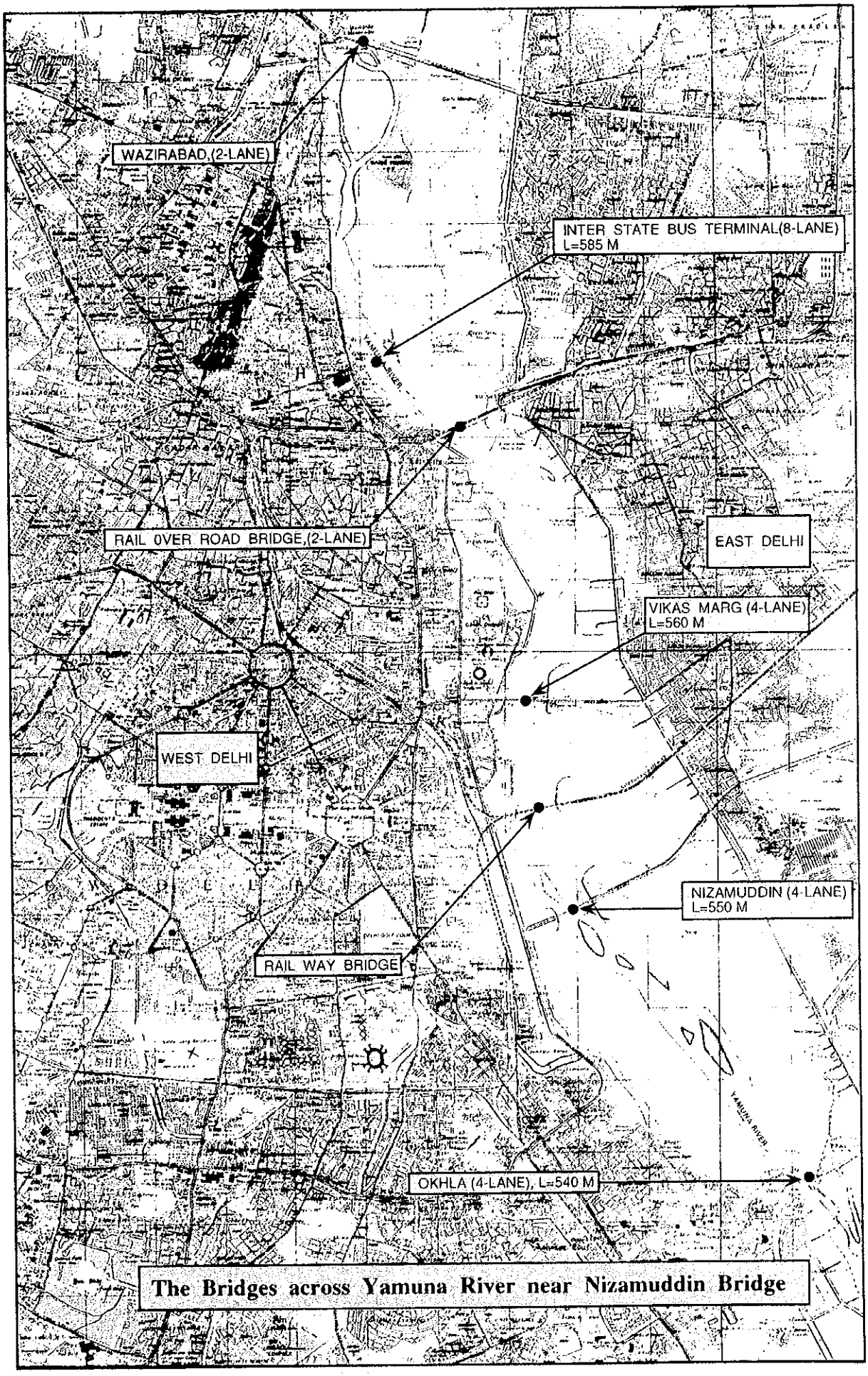


Koji Enomoto
Chief Consultant
Basic Design Study Team on
The Project for Construction of the
Nizamuddin Bridge
Nippon Koei Co., Ltd.



New Nizamuddin Bridge and Approach Roads

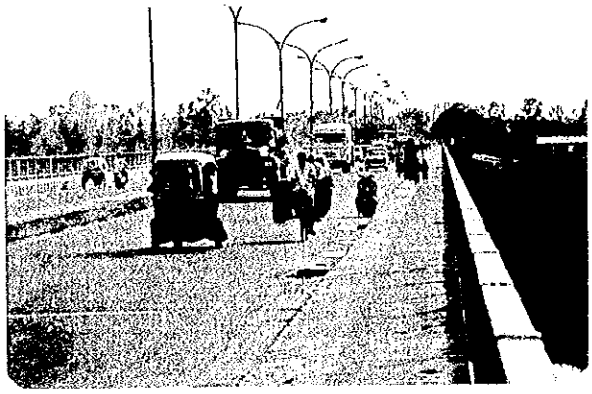
Basic Design Study on The Project for Construction of The Nizamuddin Bridge


WAZIRABAD (2-LANE)
INTER STATE BUS TERMINAL(8-LANE)
L=585 M
RAIL OVER ROAD BRIDGE,(2-LANE)
EAST DELHI
VIKAS MARG (4-LANE)
L=560 M
WEST DELHI
NIZAMUDDIN (4-LANE)
L=550 M
RAIL WAY BRIDGE
OKHLA (4-LANE), L=540 M
The Bridges across Yamuna River near Nizamuddin Bridge

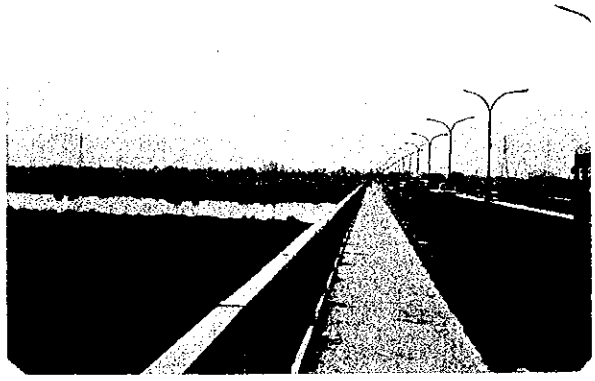
(F)

PERSPECTIVE VIEW OF THE NIZAMUDDIN BRIDGE

PHOTOGRAPHS

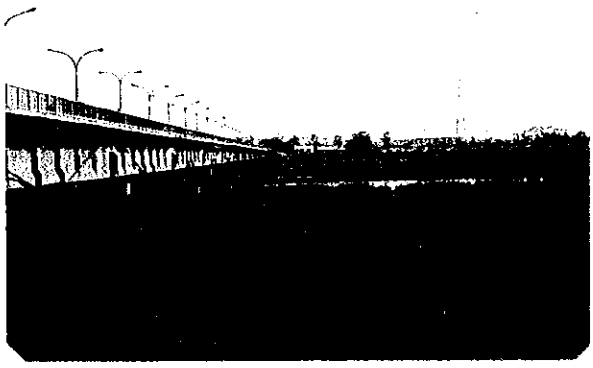


Traffic on the existing bridge



Surface of the bridge deck and sidewalk of the existing bridge

Trucks running on the existing bridge



Side view (from the downstream) of the existing bridge

Traffic mixed with bicycles running toward the existing bridge near the existing intersection

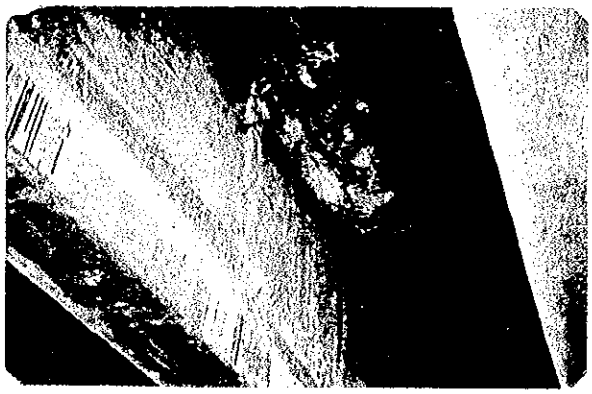
The piers of the existing bridge

BASIC DESIGN STUDY
ON
THE PROJECT FOR CONSTRUCTION OF THE NIZAMUDDIN BRIDGE

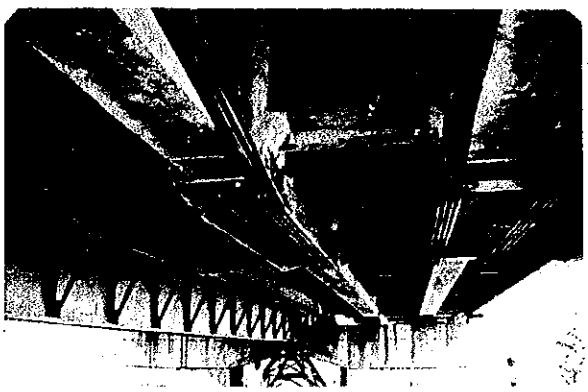
The anchorage part of the external cable reinforcing the existing main girder

The deviators distributing the verfical component of the prestressing force to the existing girder

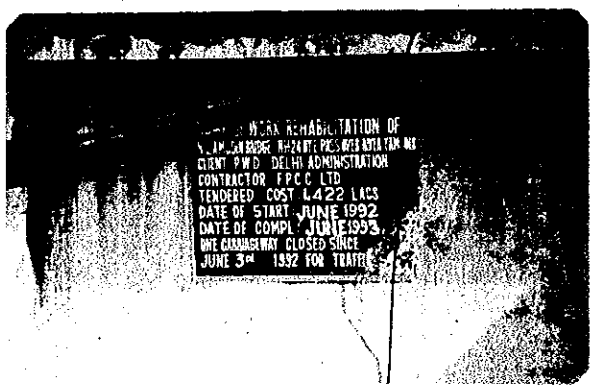
The anchoring in the deck slab of the external cable



The anchoring in the deck slab of the external cable



Provision of the external cables and the deviators for the main girders



The project plate of the rehabilitation work

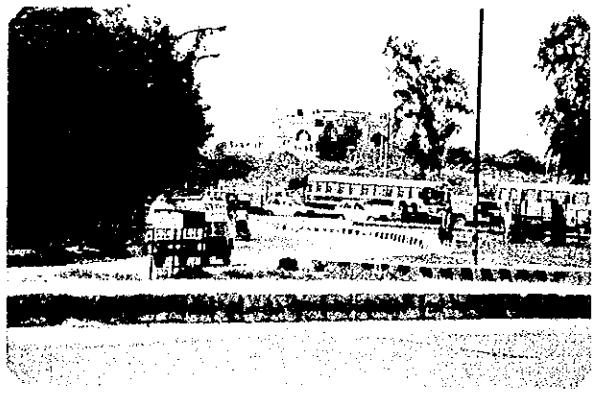
The water main on the upstream side along the existing approach road

Joint of the water main which is vulnerable to the vibrations

Cultivator's houses near the existing intersection on the National Highway (NH - 2) side

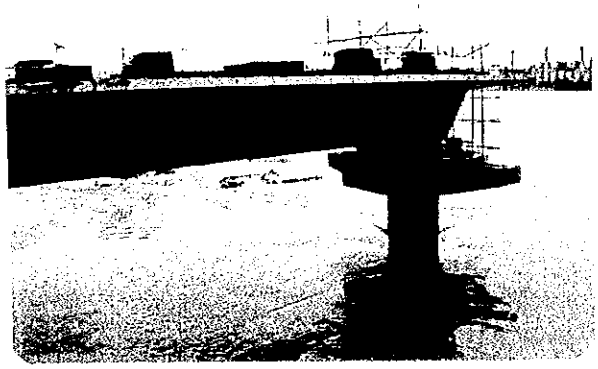
Encroachments near the existing intersection on the NH - 2

Power transmission line along the National Highway (NH - 2)

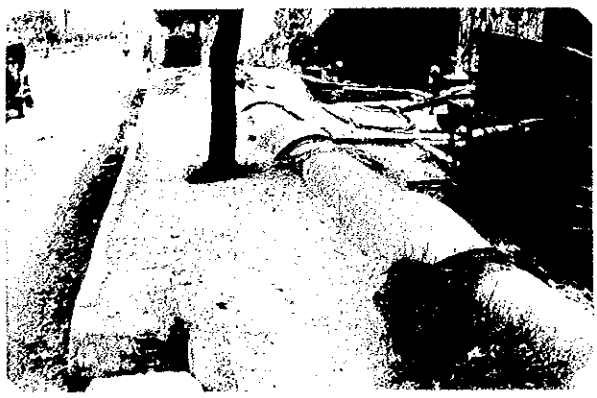


Mausleum in the Nizamuddin area

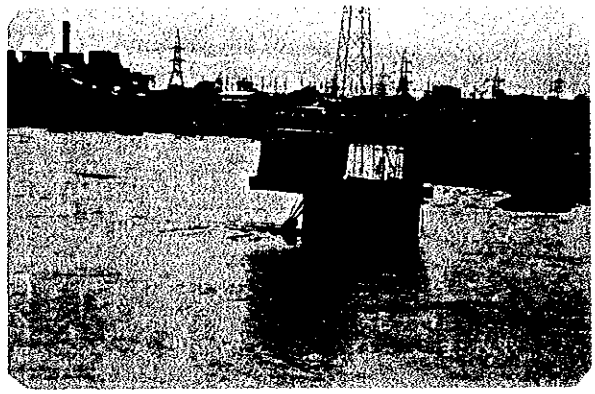
Elecficity wire and poles to be relocated due to the new approach road



PC - box birder on the piers of the new ITO Bridge

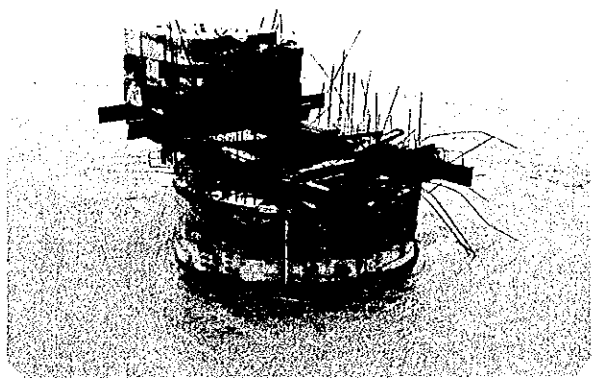


Water main to be relocated due to the new approach road



The open caisson foundation of the new ITO Bridge ammending to upright position using concrete block

S'taff surveying traffic volume beside the existing approach road



Another open caisson foundation of the new ITO Bridge

SUMMARY

India has achieved multifaceted socio-economic progress during the last 47 years of its Independence. The Eight Five Year Plan (1992 - 97) was endorsed by the National Development Council (NDC) in May, 1992. The Plan proposes a growth rate of 5.6 percent per annum on an average during the Plan period. In the Eight Five Year Plan (1992 - 97), Transport Sector has been indicated as the priority sector for continuous economic development. And importance of harmonious relationships for transportation development among technical innovation, energy and environment has been realized.

As for Transport Sector, upto March 1992, a huge amount of work in the transport sector has been undertaken and completed by the Government of India (GOI) such as a following: 4,624 Km of road links including diversions, 19,889 Km of improved low-grade roads, 24,161 Km of single lane roads that were widened/strengthened to doubled lanes, and 10,542 Km of weakened two-lane pavements which have been strengthened. In addition, 494 of major bridges and 2,701 of minor bridges were also completed. In spite of the achievements previously described, there are still a number of deficiencies that exist in terms of: inadequate capacity; insufficient pavement; poor riding quality; weak and distressed bridges/culverts; congested city sections; railway level crossings and lack of wayside amenities. Old bridges, specially, face collapse due to their deteriorated condition.

The metropolitan city of Delhi has developed with the Yamuna River being a natural divider. The river that flows from north to south, divides the city into two halves, namely, the East Delhi and the West Delhi. The traffic interaction between the two parts of this capital city of India, which are linked each other through the six bridges crossing the Yamuna River, increased tremendously and particularly during the last two decades. The total peak hour traffic of the six bridges are about 27,000 PCU/hour which largely exceeds the hourly design traffic capacity, according to the traffic survey result conducted during the basic design study. Moreover, it is expected that the population of the Delhi city will increase from 9.3 million people in 1991 to 12.0 million people in 2001, which may cause a further increase in traffic volume crossing the Yamuna River in the future.

The areas on the east bank of the river that are accessible by the Nizamuddin Bridge have been witnessing very rapid pace of development particularly with regard to residential uses. Also, intense interaction between Delhi and New Okhla Industrial

Development Authority (NOIDA), an existing Industrial Model Town within Uttar Pradesh, has very significantly added to the traffic load on the Nizamuddin Bridge.

The existing Nizamuddin Bridge on the National Highway No. 24, constructed in 1968, was seriously damaged and made collapse of footpath due to the increase of traffic volume and loads which made excessive vibration of the water mains, located in the middle part of the existing bridge, the rehabilitation works were carried out in 1992 to enhance service life of the bridge structures. The Ministry of Surface Transport (MOST), Government of India, has reviewed the requirements of the National Highway No. 24 and has concluded that construction of a second four-lane bridge parallel to the existing Nizamuddin Bridge is most urgently needed, especially in the event of the existing rehabilitated bridge becoming unserviceable.

In such situation, the Government of India (GOI) made a request in February 1994 for construction of the Nizamuddin Bridge in Delhi on the National Highway No. 24 Bypass for availing Japanese grant aid assistance to the Government of Japan (GOJ). In response to a request from the Government of India, the government of Japan decided to conduct a basic design study and entrusted the study of the Japan International Cooperation Agency (JICA). JICA sent to India a study team from 19th July to 1st September, 1994.

The Team exchanged views with the representatives of the Government of India on the basic design of the Project requested by the Government of India. The Team conducted a bridge site investigation and data collection to determine the bridge location an configurations, and clarified the undertakings to be covered by the Government of India and that the Executing Agency from the Government of India (GOI) is the Ministry of Surface Transport (MOST) through Public Works Department of the Delhi Government.

In order to analyze the present situation and the characteristics of the traffic crossing over the Yamuna River, the classified surveys for 24 hours were carried out on the existing six bridges, namely, Wazirabad, ISBT, Old Yamuna, ITO, Nizamuddin and Okhla. The total traffic volume was about 460,000 vehicles per day. The ITO Bridge handles the highest volume with 131,000 vehicles per day and the volume of Nizamuddin Bridge was 71,000 vehicles per day. The traffic of two wheelers such as scooters, bicycles and motorcycles were 70% in the total traffic volume. This is caused by that many commuters and students are using these kind of light vehicles. The peak traffic hours can be observed in the morning (8:00 a.m. - 9:00 a.m.) and afternoon (6:00 p.m. - 8:00 p.m.) commuting time.

As a result of the study, the new bridge location was determined on the downstream side of the existing bridge from the reasons: minimal influence to the encroachments beside the existing approach road; avoiding the vibration disturbance to the existing vulnerable water-main facilities; avoiding traffic congestion at the new connecting points and the existing intersection, specially on the ring road side and avoiding the hydraulic problems to the existing piers which might be affected by the new piers.

Schematic conditions of the new Nizamuddin Bridge are as follows:

Bridge Name	The New Nizamuddin Bridge			
Bridge Structures	Bridge Length	550 m	Bridge Width	22.5 m (21.9 m)
	Superstructure	PC-I-Beam (1 continuous with 4 connected spans + 3 continuous with 3 connected spans)		
	Substructrue	2-Abutment: RC-Rigid Frame 11-Piers: RC-Wall		
	Foundation	Open Caisson for Pier, Cost-in-Place Pile for Abutment		
Approach Roads	Left Bank	400 m	Right Bank	350 m

Note: The figure bracketed represents the effective bridge width.
PC: Prestressed Concrete
RC: Reinforced Concrete

Prestressed concrete continuos I-beams, which will be post-tensioning type and pre-fabricated as simple span beams afterward the concrete deck slabs will be connected each other to reduce the number of expansion joints, is recommended. Construction of this continuos type of bridge has not been previously introduced to India, and therefore the transfer of technology can be achieved. In addition, better riding condition of vehicles will be achieved compared to other types such as simple span I or T-beams, box girders with central hinges, etc.

Following the sub-clause No. 4.1 of the "Guidelines on Supplemental Measures for Design, Detailing and Durability of Important Bridge Structures" published in 1989 by the Indian Roads Congress, foundations of piers that will be located in deep water channel are open caisson type with oval section. On the other hand, cast-in-place RC piles are to be adopted for abutments since the location of abutments are quite some distance from the river channel.

The overall project implementation will be tentatively scheduled for 37 months, i.e. Detaield Design: 4-month, Tendering: 3-month and Construction: 30-month, after conclusion of exchange of notes (E/N) between GOJ and Government of India. After

Consultant contract, detailed design and tender document preparation, the prequalification evaluation and tender process will be carried out. And then the bridge construction will be commenced.

After completion of the construction of the new bridge, all traffic through the existing bridge will be shifted to the constructed bridge. The requirements for maintenance activities relating to the constructed bridge will be: damage by vehicle collision to such bridge accessories as handrails, curb-stones and end-posts; corrosion of the bearing shoes in case of insufficient maintenance of the bridges; spalling of the concrete bearing bed due to thermal and possibly earthquake forces; local scouring around piers and abutments due to river flooding, and damage to the pavement of the approach road due to deterioration as traffic increases.

Thus, the construction of the bridge will not only create an economic effect, but will also have on influence on the technical improvement of bridge construction in India as follows:

a) The new bridge can maintain transport and traffic safety of the arterial road, National Highway No. 24 - Bypass, in the areas divided by the Yamuna River, in case of traffic jams caused by bridge collapse.

b) Since the Nizamuddin Bridge is located within the metropolis of Delhi, it is often used by commuters (approximately 30,000 people) living on eastern bank of Yamuna River and working in the capital city. Moreover, it is used by those (approximately 20,000 people) living in the main capital and working in the industrial belt of NOIDA and Gaziabad. The Project is expected to be beneficial to around one million people. Also the plan to construct a new bridge near the Okhla (Water Gate) Bridge, which is located downstream of the Nizamuddin Bridge, has recently been suspended because of technical and financial problems. Under this situation, the construction of the new Nizamuddin Bridge is significantly more important.

c) Because of the wide cross-sectional arrangement, the Project when completed, would facilitate the flow of traffic. This would result in considerable savings in travel time of two minutes per/vehicle, that is, a saving cost of approx. 330,000 Rs./day, and fuel consumption of approx. 60,000 Rs/day, as well as reducing air pollution and traffic accidents.

d) Since the construction of the new bridge will involve large-scale concrete works which require a lot of man-power, the Project will contribute to the expansion of employment opportunities.

e) The construction method, involving the latest bridge technologies, can contribute to technology transfer to India.

Consequently, the Project's position in the national development plan and the feasibility and rational of the Project were examined as follows:

a) The new bridge will improve transport and traffic safety of the arterial road which links both areas in Delhi divided by the Yamuna River.

b) The new cross-section, which divides heavy vehicles and light vehicles/bicycles by a crash barrier, can resolve the present traffic troubles caused by the mixing of vehicles and bicycles.

c) The new bridge structures can greatly contribute to reducing maintenance costs.

As previously described, the Project would be greatly effective and contribute to improving living standards (Basic Human Needs) of the people living in Delhi. Therefore, the implementation of this Project through the cooperation of Japan's Grant Aid Program would be feasible and effective. After completion of the Project, the well -organized Ministry of Surface Transport (MOST) and the Delhi Government will manage and maintain the new bridge structures. Therefore, its early realization is most desirable and the Project is highly recommendable. The following conditions are also recommended to implement the Project smoothly and effectively:

a) Careful treatment of encroachments to be relocated.

b) Close relations among the related authorities and organizations.

c) Safety for the vehicles and pedestrians during the construction.

d) Traffic shift from the existing bridge to the new bridge after completion of the Project.

e) Smooth and effective traffic control at the connecting points of the approach roads after completion of the Project.

f) Smooth and prompt actions following the procedures of the Japan's Grant Aid system.

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CHAPTER 1 BACKGROUND OF THE PROJECT

1.1 Background of the Project

India has achieved multifaceted socio-economic progress during the last 47 years of its Independence. The Eight Five Year Plan (1992 - 97) was endorsed by the National Development Council (NDC) in May, 1992. The Plan proposes a growth rate of 5.6 percent per annum on an average during the Plan period. In the Eight Five Year Plan (1992 - 97), transport Sector has been indicated as the priority sector for continuous economic development in India. And importance for harmonious relationships for transportation development among technical innovation, energy and environment has been realized.

A key target of the Eighth Five Year Plan was that for rapid economic development of the priority sectors which were identified to be power, transport and communications. In an important area of the country's infrastructure, National Highways (NH) require adequate attention, especially in view of the large scale of deficiencies in the existing transport system. In this regard, the following priorities for programs of the Transport Sector were suggested:

a) Construction of new bridges and reconstruction of weak bridges.
b) Widening the road to suit the traffic needs such as upgrading single lane to two lanes and two lanes to four lanes.
c) Strengthening of weak pavements to handle the required level of traffic loads.

From Independence in 1947 up to March, 1992, a huge amount of work in the transport sector has been undertaken and completed by GOI such as a following: 4,624 Km of road links including diversions, 19,889 Km of improved low-grade roads, 24,161 Km of single lane roads that were widened/strengthen to double lanes, and 10,542 Km of weakened two-lane pavements which have been strengthened. In addition, 494 of major bridges and 2,701 of minor bridges were also completed. The present national highway system includes a total length 34,058 Km.

In spite of the achievements previously described, there are still a number of deficiencies that exist in terms of: inadequate capacity; insufficient pavement; poor riding quality; weak and distressed bridges/culverts; congested city sections; railway level crossings and lack of wayside amenities.

Thus, road transport has emerged as the most dominant mode out of all the modes of transport in India. Of the total road network, National Highways are carrying over 40 percent traffic whereas they constitute only 2 percent of the total road system. As such there is an urgent need for an increase in the length of the National Highway system as well as in the capacities of many of its sections.

The metropolitan city of Delhi has developed with the Yamuna River being a natural divider. The river that flows from north to south, divides the city into two halves, namely; the East Delhi and the West Delhi. The traffic interaction between the two parts of this capital city of India increased tremendously and particularly during the last two decades.

The areas on the east bank of the river that are accessible by the Nizamuddin Bridge have been witnessing a very rapid pace of development, particularly with regard to residential uses. Also, intense interaction between Delhi and NOIDA, an existing Industrial Model Town within Uttar Pradesh, has significantly added to the traffic load on the Nizamuddin Bridge. As the existing Nizamuddin Bridge, constructed in 1968, was seriously damaged and made collapse of footpath due to the increase of traffic volume and loads which made excessive vibration of the water mains, located in the middle part of the existing bridge, the rehabilitation works were carried out in 1992 to enhance service life of the bridge structures.

The Ministry of Surface Transport (MOST), Government of India, has reviewed the requirements of the National Highway No. 24 and has concluded that construction of a second four-lane bridge parallel to the existing Nizamuddin Bridge is most urgently needed, especially in the event of the existing rehabilitated bridge becoming unserviceable.

In such situation, the Government of India (GOI) made a request in February 1994 for construction of the Nizamuddin Bridge in Delhi on the National Highway No. 24 Bypass for availing Japanese grant aid assistance to the Government of Japan (GOJ). In response to a request from the Government of India, the government of Japan decided to conduct a basic design study and entrusted the study of the Japan International Cooperation Agency (JICA). JICA sent to India a study team from 19th July to 1st September, 1994.

1.2 Outline of the Request and Main Component

The contents of the request by the Government of India are to construct a new 550 meter long, four-lane bridge across the Yamuna River and approach roads at each end.

1.3 Project of Other Doners

The World Bank is providing loan assistance of following US$13.3 crore (10 million) for improvement of national highways in five states namely Gujarat, Haryana, Punjab, Tamil Nadu and West Bengal. The Asian Development Bank is providing loans worth US$19.8 crore for development of national highways in the states of Andhra Pradesh, Haryana, Uttar Pradesh and for state roads in the states of Andhra Pradesh, Karnataka and Tamil Nadu under Package-I. In addition a second loan agreement worth US$25 crore has been signed with the Asian Development Bank for improvement of national highways in Karnataka, Kerala, Rajasthan and of state roads in Andhra Pradesh, Orissa, Uttar Pradesh and West Bengal under Package-II.

Agreements have also been signed with World Bank for a second loan/credit for US$30.6 crore for development of national highways in the six states namely Haryana, Madhya Pradesh, Maharashtra, Orissa, Punjab and West Bengal under Package-II. The project also includes reconstruction of flood damaged bridges in the state roads of Orissa.

Four-laning of 51.33 Km of the Mathura-Agra Section of 51.33 km length of National Highway No. 2 in Uttar Pradesh is being assisted by an Overseas Economic Cooperation Fund (Japan) loan worth ¥485.5 crore. The Agreement for the loan was signed on 10 January 1992.

Under the JICA's grant aid program, the Project for Improvement of Educational Media Production Facilities of the Indira Gandhi National Open University in Delhi was commenced in February 1994 is still going on.

As for Expressway Construction, the Development of Long Term Plan for Expressway (DLTPE) has been programmed with financial assistance of Asian Development Bank (ADB). For the long term plan, seven routes of Expressway Construction with aggregated length of 1,350 km by 2000-year as listed below and 10,020 km by 2015-year have been planned.

TABLE 1.3.1 EXPRESSWAY CONSTRUCTION PLAN

No.	Route	Length (km)
1	Ahmedabad - Vadodara	120
2	Karnal - Ambala	80
3	Kampur - Varanasi	313
4	Delhi - Karnal	119
5	Ghaziabad - Kanpur	414
6	Thane - Nasik	145
7	Vadodara - Surat	159
	Total	1,350 km

CHAPTER 2 OUTLINE OF THE PROJECT

2.1 Objectives of the Project

The metropolitan city of Delhi has developed with the Yamuna River, which divides the city into two halves, namely, the East Delhi and the West Delhi. The areas on the east bank of the river that are accessible by the Nizamuddin Bridge have been witnessing of rapid development particularly with regard to residential uses. The increase of traffic volume and load along the Nizamuddin Bridge affected further structural deterioration and vibration on the water mains. In 1989, some parts of the sidewalk collapsed and necessitated the rehabilitation works including additional laying of a concrete deck-slab and reinforcing the main girders with external cable prestressing tendons in 1992. The increase in traffic may affect the existing Nizamuddin Bridge recently rehabilitated, which might become unserviceable. The construction of the new bridge, therefore, will contribute to not only the economic effect but the technical improvement concerning the bridge construction in India as belows:

a) The new bridge construction can relieve problematic loading on the existing bridge that has been recently repaired.

b) After completion of the new bridge, it is often used by commutes living on eastern bank of the Yamuna River to go to the working places in the central part of the city and also used by those living in the industrial belt of New Okhla Industrial Development Authority (NOIDA).

c) The Project when completed would allow smooth flow of traffic and reduce congestion. This would result in saving travel time and fuel consumption, as well as reduction of air pollution.

2.2 Study and Examination on the Request

In February 1994, the Government of India (GOI) made a request for grant aid assistance to the Government of Japan (GOJ), for the Project for Construction of the Nizamuddin Bridge. The Ministry of Foreign Affairs deemed the Project's objective to be generally appropriate for Japanese grand aid and decided to hold a study to examine the viability of the Project in this system. The Japan International Cooperation Agency (JICA), the governmental organization in charge of international cooperation to developing countries, decided to hold a Basic Design Study and to send the study team, headed by Mr. Shigeru OKAMOTO, Deputy

Director, Study Review and Coordination Division, Grant Aid Study and Design Department JICA.

The study team conducted the field survey in the study area during the period 19th July 1994 to 30th August 1994, and confirmed the contents of the Project through the discussions with the representatives of the Government of India. The confirmed items and actions of the field surveys conducted by the study team are as follows:

a) Confirmation of the background of the Project

b) Justification of the Project as Japan's Grand Aid Program

c) Relations between the Sector and the Project

d) Current Situation of the Sector and External Assistance by International Organization

e) Confirmation of the Executing Agency of India

f) Field reconnaissance of the Project site

g) Field inspection of the existing Nizamuddin Bridge

h) Surveys of natural conditions at the Project site

i) Survey and collection of technical and economic data on bridge construction, and construction materials

j) Traffic Survey

k) Collection of data for cost estimate

After returned to Japan, the study team examined the justification and the necessity of the Project based on the results of the field surveys, and prepared the Draft Report in accordance with the comparison studies on configuration and construction method.

In order to explain and consult the Indian side on the component of the Draft Report, the study team stayed in India from 9th to 18th November 1994. Both parties, Ministry of Surface Transport (MOST), the Government of India and the Basic Design Study Team,

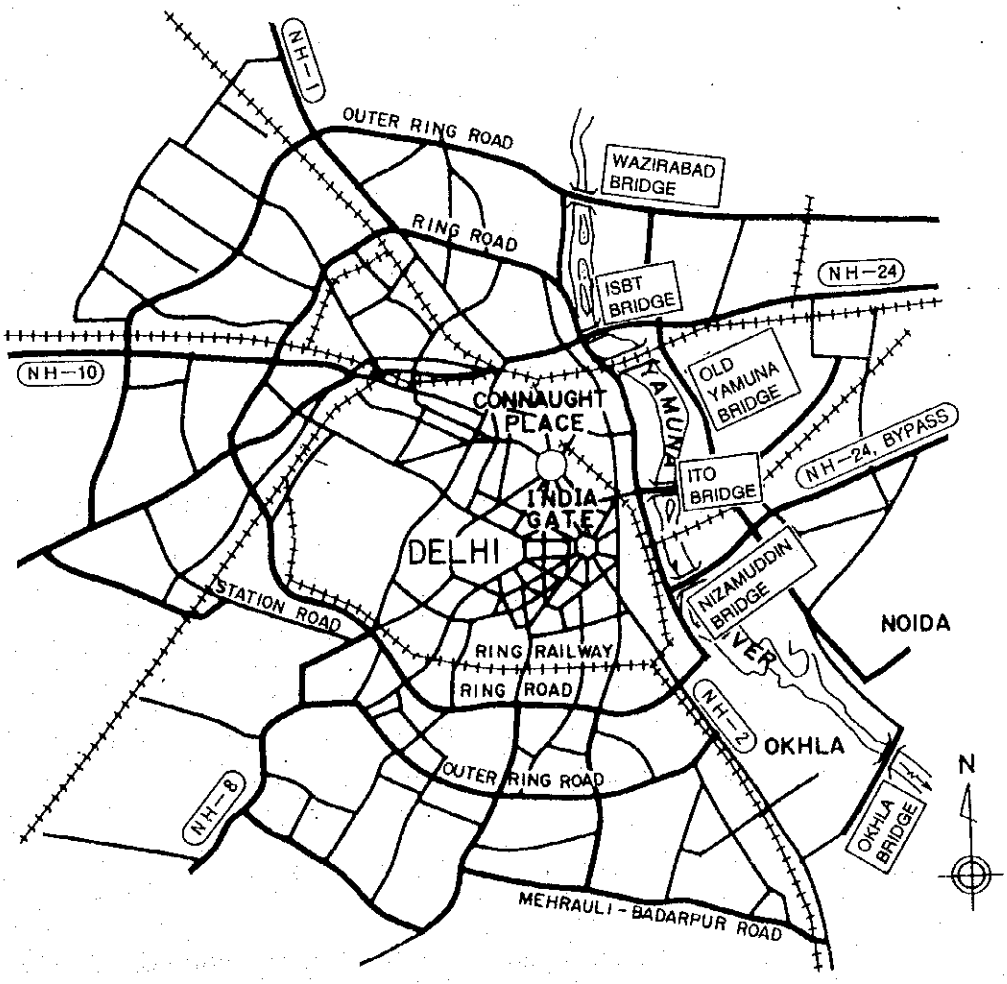
confirmed the main conditions described in the Draft Report through a series of discussion, and agreed on the scope of the Project.

2.3 Outline of the Study Area

2.3.1 Traffic Conditions

In order to analyze the present situations and the characteristics of the traffic crossing over the Yamuna River, classified traffic counting surveys were carried out on the six bridges on 2nd (Wednesday) to 3rd (Thursday) August 1994. The counting surveys were conducted by vehicle type and by direction for 24 hours from 7:00 a.m. to 7:00 a.m. of next morning. The results of surveys are presented in Appendix-10.

FIG. 2.3.1 TRANSPORTATION NETWORK OF DELHI



(1) 24-Hour Traffic Volume

The total traffic volume crossing over the Yamuna River was about 460,000 vehicles per day. Of the total traffic, the I.T.O. Bridge handles the highest volume with 131,000 vehicles/day followed by the Old Yamuna Bridge with 101,000 vehicles, I.S.B.T. Bridge with 81,000 vehicles, Nizamuddin Bridge with 71,000 vehicles, Wazirabad Bridge with 47,000 vehicles and Okhla Bridge with 29,000 vehicles. Traffic volume expressed in terms of PCU (Passenger Car Unit) indicates the I.T.O. Bridge handles the highest volume with 117,000 PCUs followed by the I.S.B.T. Bridge with 83,000 PCUs, Nizamuddin Bridge with 74,000 PCUs, Old Yamuna Bridge with 67,000 PCUs, Wazirabad Bridge with 53,000 PCUs and Okhla Bridge with 31,000 PCUs.

The results above indicate that the traffic volume on the I.T.O. Bridge is the highest in terms of both number of vehicles and PCU. This is because of the grade separation at the intersection of I.T.O. Bridge and the ring road on the Delhi side and because of the important location directly accessible to the central area of Delhi.

The Old Yamuna Bridge which comes in 2nd highest vehicle traffic will comes in 4th highest in terms of PCU because of relatively high composition ratio of two wheelers.

(2) Vehicle Type

The traffic of two wheelers such as scooters, bicycles and motorcycles are dominant in total river crossing traffic (70%) and hence, the mixed traffic are observed. This is because that many commuters and students are using these kinds of light vehicles. The percentage shares of trucks on the Wazirabad and Okhla Bridges are relatively higher than other Bridges, passenger cars on the Nizamiddin Bridge is the highest and bicycles on the Old Yamuna Bridge is the highest in the six Bridges.

(3) Hourly Traffic by Direction (in PCU)

The peak traffic hours can be observed in the morning and afternoon commuting time. The peak traffic from outside of Delhi to inside is higher than the opposite direction. The peak traffic coming inside Delhi is

observed at 8:00 a.m. - 9:00 p.m. and the peak traffic going out of Delhi is in 6:00 p.m. t- 8:00 p.m. The total peak hour traffic of the six Bridges are about 27,000 PCU/hour which largely exceeds the hourly design traffic capacity. Therefore, the traffic crossing the river is almost the maximum volume which is handled by the present capacity.

According to the Census in 1991, present population in Delhi was estimated more than 9.3 million and expected to increase to more than 12 million. About 40% of this population are estimated to live on the east side of the Yamuna River and hence, traffic which will cross the River will continue to increase in the future together with an increase of car ownership.

2.3.2 Natural Conditions

(1) Geological Structure

The geological regions of India may be grouped into three regions: the Himalayas and their associated group of mountains, the Indo-Ganga plain and the Peninsular Shield. The Himalayan mountain belt to north and the Naga-Lusha mountain in east are in regions of mountain building movement. On the other hand, the Indo-Ganga plains are a great alluvial tract that separates the Himalayas in the north from the Peninsula in south. The peninsula is a region of relative stability and rare seismic disturbance. The Project area has alluvial soils ranging between hard clayey-clay, sandy-loam and sandy soils. The soils close to the Yamuna River are sandy in nature.

(2) Climate

The climate of India may be broadly described as of a tropical monsoon type. There are four seasons: (i) winter (January-February), (ii) hot weather summer (March-May); (iii) rainy south-western monsoon period (June-September) and (iv) post-monsoon period, also known as north-east monsoon period in the southern Peninsula (October-December). India's climate is affected by two seasonal winds the north-east monsoon and the south-west monsoon. The north-east monsoon commonly known as the winter monsoon blows from land to sea whereas south-west monsoon known as the summer monsoon blows from sea to land after crossing the

Indian Ocean, the Arabian Sea and the Bay of Bengal. The south-west monsoon brings most of the rainfall to India.

TABLE 2.3.1 TEMPERATURE AND RAINFALL IN DELHI

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
21.4	23.7	29.4	35.9	40.4	39.1	35.2	33.9	34.2	33.6	28.4	23.2
6.3	9.6	13.9	19.8	26.0	28.1	26.7	25.8	24.2	17.9	11.0	7.2
25.1	21.1	12.9	8.4	13.2	77.0	178.6	183.6	122.9	10.2	2.5	10.9

Upper : Average maximum temperature (°C)
Middle : Average minimum temperature (°C)
Lower : Rainfall (m/m)

(3) Rivers

Rivers in India may be classified as: (i) Himalayan rivers; (ii) Peninsular rivers; (iii) coastal rivers and (iv) rivers of the inland drainage basin. The Himalayan rivers are perennial as they are generally snow-fed and have the reasonable flows throughout the year. During the monsoon the Himalayas receive very heavy rainfall and the rivers discharge the maximum quantity of water causing frequent floods. The Peninsular rivers are generally rain-fed and, therefore, fluctuate in volume with a large number of the streams being non-perennial. The coastal streams, especially on the west coast are short in length and have limited catchment areas. Most of them are flashy and non-perennial. The streams of the inland drainage basin of western Rajasthan are few and far between, having an ephemeral character.

(4) Floods

In the rainy season, when the flood-gates of Tajewara Dam, located at about 300 km upstream of Delhi, are opened followed by the opening of that of Wazirabad and I.T.O. bridge under the control by the Flood Control Office of Delhi Government. At the Nizamuddin bridge site on 22 July 1994, the flood water rose to the level of 203.50 meter. In the past flood water level has reached to 204.00 meters several times each year, while the historically highest record was 205.68 meter in 1988. In the main (low water) channel, the current velocity was 5.2 m/sec and the maximum water

discharge was 14,860 cu m/sec in 1988. The local scouring behavior around the bridge piers, therefore, is likely to be serious problem. If the new piers are constructed on the adjacent upstream side of the existing piers, hydraulic problem may be further intricacy to the existing bridge piers which have a foundation depth of only 30 meters.

TABLE 2.3.2 FLOOD LEVELS AT NIZAMUDDIN BRIDGE

Year	Highest Flood Level of River Yamuna (m)	Level of Yamuna during Low Flow (m)	Difference of Highest & Lowest Level of Water (m)
1988	205.68	202.4	3.28
1989	204.37	202.4	1.97
1990	203.72	202.4	1.32
1991	204.10	202.4	1.70
1992	204.10	202.4	1.70
1993	204.18	202.4	1.78

Average difference between the highest and lowest level of water is 1.96 meters

(5) Seismic

The Himalayan-Nagalushai Region, Indo-Gango Plain, Western India, Kutch and Kathiawar Regions are geologically unstable parts with some devastating earthquakes occurring there. Historically, significantly damaged earthquakes are the 1897 Meghalaya/Assam with a Magunitude 8.7, the 1905 Kangra M8.6, the 1934 Bihar M8.7, the 1988 Bihar M8.4, and the 1950 Arunachal/Upper Assam M8.7. On October 7th, 1993, the worst disaster earthquakes with a M6.4 on the Indian subcontinent in 58 years hit the towns on the Deccan Plateau, Latur, Killari, Umaga and Hyderabad, claiming beyond 30,000 lives. During the field survey of the Basic Design Study in India, two earthquakes relatively lesser intensity were reported in the newspaper, i.e. a moderate intensity earthquake rocked many parts of North India on July 28 and parts of the north-east area on 8 August.

2.3.3 The Public Utilities and Right of Way

(1) Power Transmission Line:

Power lines transmitting high voltage exist along the Ring Road (NH2) on the right bank side of the Yamuna River. The existing approach road passes under this power line at the point where the clearance between the road surface and power line is maintained sufficiently.

(2) Water Mains:

On the Ring Road side, the water mains are located on both the upstream and downstream sides of the existing approach road, and after reaching to the Ring Road, they are going in both northward and southward along the Ring Road. On the existing bridge, the water mains (2 each ϕ900 m/m) which are supported by the steel trestles built between the two-bridge piers. On the NOIDA Link Road side, the water mains are divided into two lines and supported by rows of the concrete columns similar to a viaduct structure. The water mains which are located on the upstream side along the approach road appear to be vulnerable to the vibrations that are induced by the passing vehicles.

(3) Electrical Lines and Poles

On the downstream side of the approach road on the NOIDA side, electrical lines and poles, may be ordinary distribution system, exist along the slope of the approach embankment.

(4) Encroachments

There are encroachments on both sides of the existing approach road near the intersection connecting with the Ring Road. On the upstream side, there are the houses in which the cultivators live, while on the downstream side there must be squatters staying on the slope of the embankment. On the upstream side of the NOIDA side, there are also some houses of cultivators.

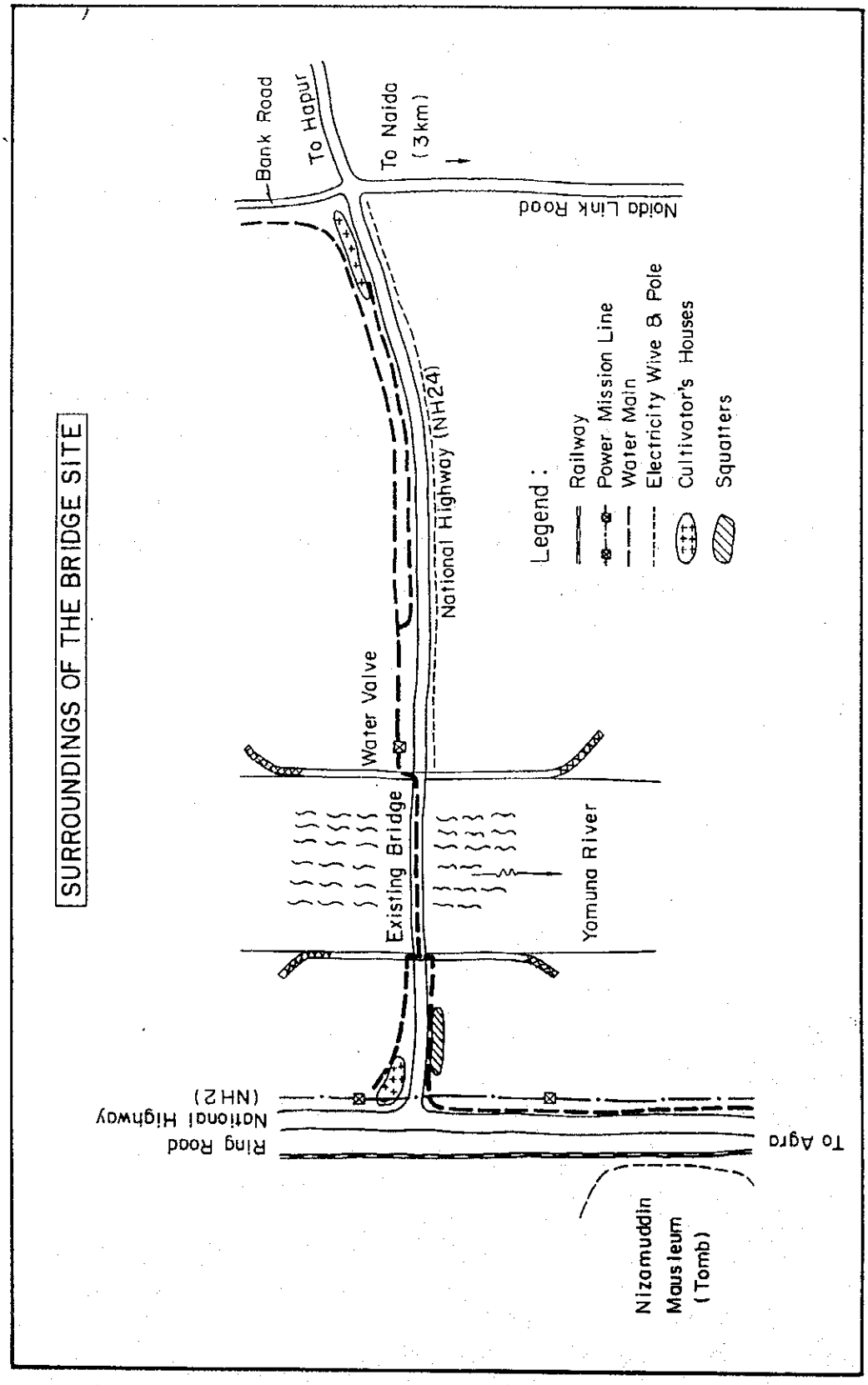
(5) Possible Disturbance to Other Facilities

Significant facilities and buildings near the bridge site which might be disturbed by the new bridge construction, there are the railway along the Ring Road on the western side and the Nizamuddin Mausleum (Tomb) beside the railway. However, since the new approach road is connected with the existing approach road before reaching the existing interchanges, no disturbance to these facilities will be caused by the new bridge construction because these facilities are located beyond the Ring Road and far from the bridge site.

(6) Right of Way

According to the standards of the Ministry of Surface Transport, the right-of-way width is to be 90 m to accommodate road facilities. In case that the additional lands are required by the new plan, the right-of-way to accommodate the new road facilities can be acquired through the Delhi Development Authority (D.D.A.) following the internal procedures between the Government offices.

FIG. 2.3.2 SURROUNDINGS OF THE BRIDGE SITE



2.3.4 Bridges Crossing the Yamuna River in Delhi

The bridges crossing over the Yamuna River in Delhi are the Wazirabad, Inter State Bus Terminal (ISBT), Old Yamuna (Rail over Road), Vikas Marg (ITO), Railway Bridge, Nizamuddin and Okhla, and two pontoon type bridges which are only available during the dry reason. As these bridges link the business center of the capital with the residential and industrial areas on the eastern side of the river, they have been playing an important role in the economic development of capital. The Old Yamuna Bridge is double deck steel truss type with the upper deck used for a railway and the lower deck used for a roadway. The roadway deck portion is terribly congested with the mixed up traffic with small and low-speed vehicles like bicycle, motor-bike and auto-rikshaw.

The existing I.T.O Bridge, located directly on the upstream side of the existing Nizamuddin Bridge, is progressively deteriorated due to the significant increase of traffic volume and appeared to be insufficient to the future traffic. Recently, therefore, a new four-lane bridge is under construction in parallel with the existing one on the downstream side.

The existing Nizamuddin bridge built in 1968 directly links the city centre with the residential colonies of Delhi and large industrial development areas on the outskirts of Delhi. In addition, the National Highway traffic towards the eastern parts of the country.

TABLE 2.3.3 BRIDGES ACROSS THE YAMUNA RIVER AT DELHI

Seq. No.	Name of Bridge	Bridge Length/ Span Length	Bridge Type	Nos. of Lane	Traffic Volume (Mil. Vehicles)
1.	Wazirabad	–	–	2 *	4.7
2.	ISBT	13@45 = 585 m	PC-Box	8	8.1
3.	Old Yamuna	–	Double Deck Steel Truss	4	10.1
4.	ITO	560 m	PC-Girder	4 *	13.1
5.	Railway	–	Steel Truss	–	-
6.	Nizamuddin	13@42.3 = 550 m	PC-Girder	4	7.1
7.	Okhla	27@20 = 540 m	PC-Girder	4 *	2.9

Sequence is numbered from upstream toward downstream.
PC means Prestressed Concrete
* : with water-gate

2.3.5 The Existing Nizamuddin Bridge

The 550 m long four-lane Nizamuddin Bridge on the NH-24 Bypass, connecting the Ring Road at Delhi to the trans-Yamuna area, was constructed during 1964-1968. Two 900 mm diameter water mains are supported by the superstructure. 3-meter-wide sidewalks supported on cantilevered brackets have been provided at each side. The existing bridge type is the T-shape prestressed concrete girde with the span length of 42.3 meters.

The increase of traffic volume and loads affected further structural deterioration and vibrations on the water mains. On 9 February 1989 about 12 meters of the sidewalk collapsed and necessitated the rehabilitation works including additional laying of a concrete deck-slab and reinforcing the main girders with external cable prestressing tendons in June, 1992. At present status, the existing superstructure of the Nizamuddin Bridge may be tentatively assessed through ocular inspection based on the assessment manner of Special Publication 37, IRC, the results of which are given as belows:

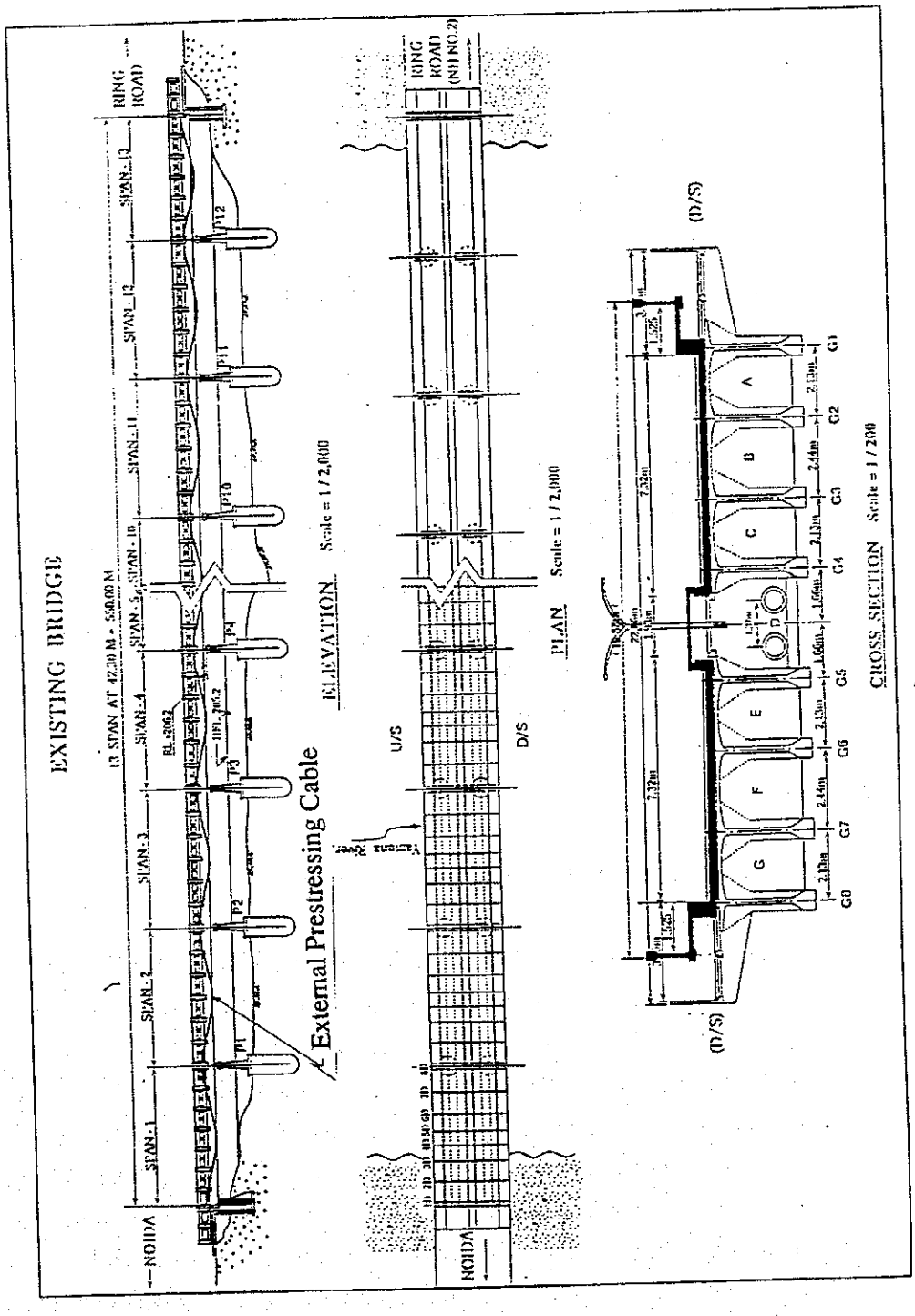
Table 2.3.4 Assessment of the Existing Superstructures

Structure Component	Full Marks	Reduction Factor	Marks Assessed
(1) Surface Pavement	5	0.8	4
(2) Concrete Deck Slab	25	0.6	15
(3) Longitudinal Girders	50	0.6	30
(4) Cross Girders	15	0.6	9
(5) Expansion Joints	5	0.8	4
Total	100		62

Full marks mean the proportional weight of the individual structural component to the entire superstructure and reduction factors are on the basis of the results of ocular inspection and considerations of the degrees of rehabilitation works. In case that the total assessed mark is less than 50, closing the bridge to the traffic will be required.

A drawing showing the elevation, plan and cross-section views of the existing Nizamuddin Bridge is shown as Fig. 2.3.3.

FIG. 2.3.3 EXISTING NIZAMUDDIN BRIDGE



2.3.6 Related Bridge Projects

(1) The New ITO Bridge

The huge increase of traffic volume over recent years necessitated the new ITO bridge. This bridge, designed to take a load of 30,000 PCUs, is under construction on the downstream side and in parallel with the existing one. The new bridge was design having a carriageway with two water mains (ϕ1500 mm) on each side and the total bridge length is 550 m with the prestressed concrete mono-box type. The new bridge totaling 550 meters in length will be open to the public traffic by December, 1995.

(2) Future Plan of Grade-Separation Intersection (Bridge)

To improve the flow of traffic in Delhi, a signal-free intersection system is being required for connecting the Ring Road to the bridges across the Yamuna River. According to the Feasibility Study conducted in March, 1993, a grade-separation intersection was recommended at the connecting point between the Ring Road and the approach road for the Nizamuddin bridge. The alignment of the additional lane is beside the existing approach road and bridge on the downstream side.

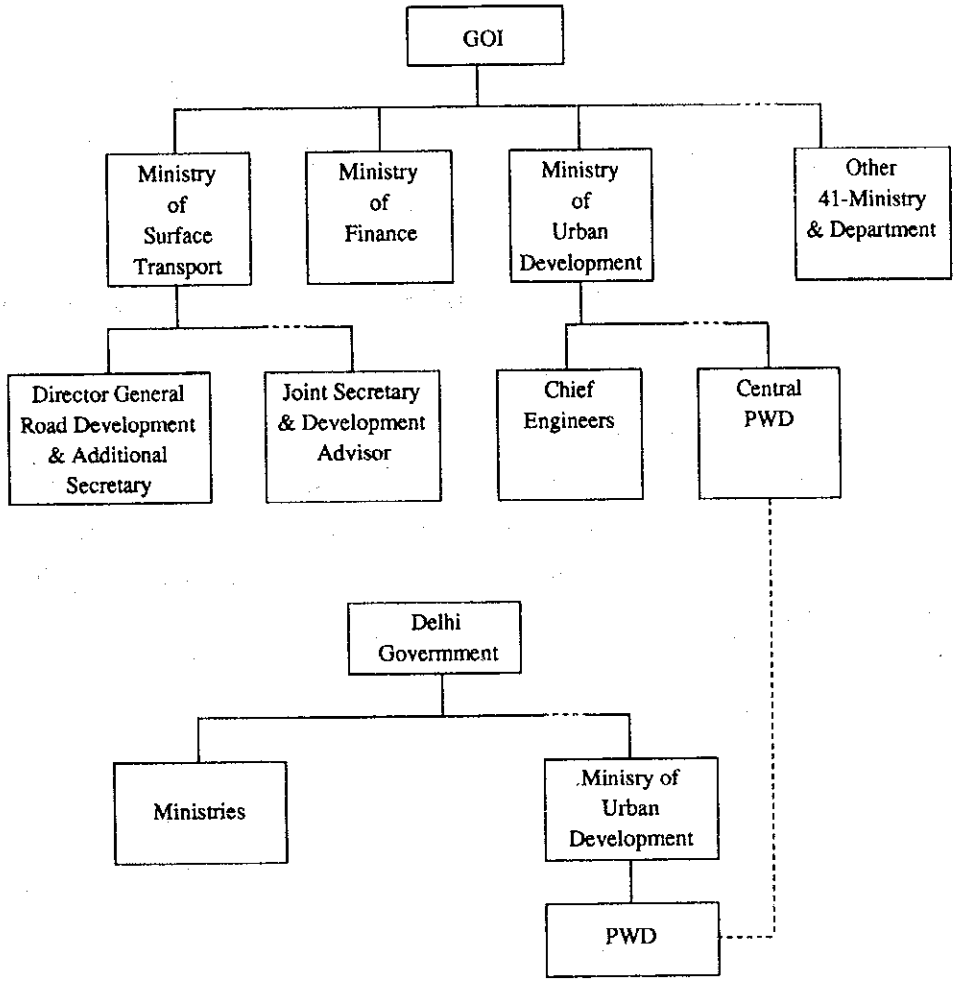
2.4 Project Description

2.4.1 Executing Agency and Operational Structure

The Executing Agency of the Project will be GOI's Ministry of Surface Transport (MOST) through the Public Works Department of the Delhi Government. MOST will be the representative party of GOI for the contract between Japanese Consultant to be recommended by JICA and for the Japanese Contractor to be selected through tendering for the Project. Among the ministries and departments under the Government of India, Ministry of Surface Transport, Ministry of Finance and Ministry of Urban Development will all considerably involved in this particular bridge project while the Delhi Government will be in charge of an implementing or a supervising agency. The PWD of the Delhi Government is in charge of planning, design, construction and maintenance of the road and bridge constructions in the areas within

jurisdiction of the Delhi government. An organization chart concerning this is shown as Fig. 2.4.1.

FIG. 2.4.1 ORGANIZATION CHART OF GOI



2.4.2 Bridge Location

To determine the most suitable location where the new bridge and its approach roads should be constructed, the surroundings of the project area should be carefully examined and a comparative study the conditions related to selecting the new bridge location, should be made. Such conditions includes the encroachments along the existing approach roads, high voltage power transmission-line, water mains, land acquisition matters, hydrological and hydraulic problems concerning the bridge structures and traffic flow system and intersections.

The new bridge location can be determined on the downstream side of the existing bridge from the following reasons:

a) Minimal influence to the encroachments;

b) Avoiding the vibration disturbance to the existing vulnerable water main facilities;

c) Avoiding traffic congestion at the new connecting points and/or the existing intersection, specially the Ring Road side, and

d) Avoiding the hydrological and hydraulic problems to the existing bridge piers.

The following comparison table shows evaluation for selecting the new bridge location based on the key considerations previously described. The same location on the existing bridge is not recommendable because of traffic control problem and a costly temporary detour bridge to be required during the new bridge construction.

TABLE 2.4.1 COMPARATIVE STUDY ON
SELECTING THE LOCATION OF THE NEW BRIDGE

CONDITIONS	(1) UPSTREAM	(2) DOWNSTREAM	(3) ON EXISTING
1. Encroachments	- Disturb the Cultivator's houses	- Minor disturbance to the squatters	The same location on the existing bridge is not recommendable because of traffic control problem and costly temporally detour bridge required during the new bridge construction.
	×	△	
2. Power Transmission Line	- Proper clearance near the tower	- Proper clearance near the tower	
	○	○	
3. Water Main	- Serious disturbance to the existing facilities	- Minor protection required	
	×	○	
4. Right-of-Way	- Necessitates wider acquisition due to Water Main	- Minor widening of R.O.W	
	△	○	
5. Flood Water	- Hydrological problem affect to the existing piers	- Possible to avoid hydrological problem to the existing piers	
	×	○	
6. Future Plan of Intersection	- Inconvenient to accommodate to the future plan	- Convenient to accommodate to the future plan	
	△	○	
7. Significant Facilities	- Not affected	- Not affected	
	○	○	

Note: ○: No serious problems △: Problems to be solved by measures ×: Complicated problems involved

2.4.3 Approach Roads

In studying the alignment and the connecting points of the new approach roads, the following three alternatives can be considered under the condition that the new bridge is to be located on the downstream side of the existing one.

TABLE 2.4.2 ALTERNATIVES OF APPROACH ROAD.

Schematic Alternatives	Connecting Locations
Alternative (A) Ring Road (NH2) Exst. Br. (NH24) New Br. Yamuna Riv. NOIDA	(Ring Road Side) - At the middle point of the existing approach road (NOIDA Link Road Side) - At the point near the existing bridge on the approach road
Alternative (B) Ring Road (NH2) Exst. Br. (NH24) New Br. Yamuna Riv. NOIDA	(Ring Road Side) - At the meeting point with Ring Road, close to the existing intersection (NOIDA Link Road Side) - Same as Alternative-(A)
Alternative (C) Ring Road (NH2) Exst. Br. (NH24) New Br. Yamuna Riv. NOIDA	(Ring Road Side) - At the meeting point with Ring Road, separated from the existing intersection by not less than 300 m (NOIDA Link Road Side) - Same as Alternative-(A)

Alternative-(A) was recommended because it is superior to the other alternatives in terms of technical and economical viewpoints, such as less interference to traffic flow, alignment with rather larger radii and shorter distance of the approach roads.

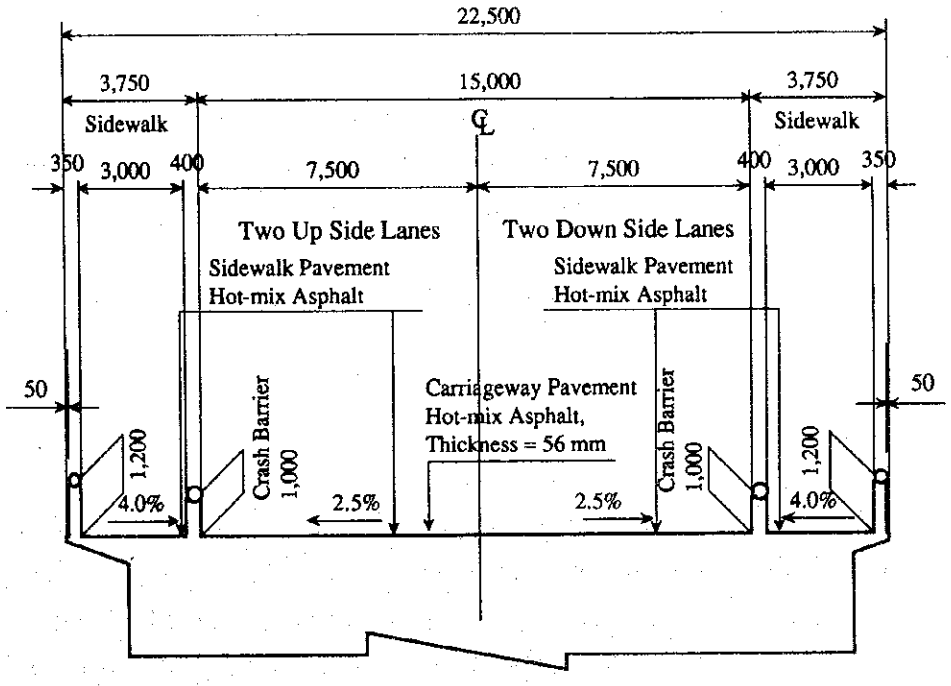
2.4.4 Bridge Configuration

(1) Bridge Width

The cross-section of the proposed bridge should be determined based on the Indian Standard Specifications and Code of Practice for Road Bridges and Geometric Design Standards for Urban Road in Plains, or otherwise Japanese Geometric Design Standard.

The carriageway requires a 15.0 m width for four lanes. Three lanes of this flexible carriage lanes can cover the traffic volume of 5,403 PCU which was observed at the peak hour of vehicles coming into Delhi during traffic survey conducted on August 2 and 3 1994. On each side, a 3 meter sidewalk for bicycles and pedestrians is provided. Fig. 4.4.1 shows a Cross-Section of the proposed bridge.

FIG. 2.4.2 THE PROPOSED BRIDGE CROSS-SECTION



Note: All distances are in millimeter.

(2) Bridge Length

Normally, major factors affecting the bridge length are the existing bridge length, river width, flood runoff, damages by flooding and river orientation. The bridge length of the new Nizamuddin Bridge can be determined from the following conditions at the bridge site:

a) The existing Nizamuddin Bridge length is 550 m, with the abutments being protected by river dikes, and as yet no damage such as breaching of the dike has occurred during past flooding.

b) The length of the existing bridges across the Yamuna River, located up and downstream of the Nizamudding Bridge, very between 500 m and 600 m.

c) The waterway surface opening for alluvial channel can be suggested based on the Lacy's formula, that is, in case the water discharge is 14,860 cu.m/sec, the required waterway opening should be not less than 500 m.

d) In addition, the river morphology near the bridge site has not been changed for last several decades according to the comparison of meandering river course on available maps.

Accordingly, the new bridge length is to be 550m, just same as the existing one.

(3) Span Length

Major factors affecting the span length are the size of driftage and since the Nizamuddin Bridge is located among the bridges across the Yamura River, the minimum span length of the new bridge should be equal to or not less than the existing span lengths of these bridges. On the new Nizamuddidng Bridge, the span length should be 42.3 m, the same as the existing one.

(4) Deck Level

Major factors determining the deck level of the bridge are the design high water level, last highest water level, damages by flooding and size of driftage. According to the monitoring survey carried out by the Basic Design Study Team and the records from the Flood Control Authority of Delhi Government, the last maximum high water level was 205.68 m in 1988 at the Nizamudding Bridge but no dikes were breached at that time.

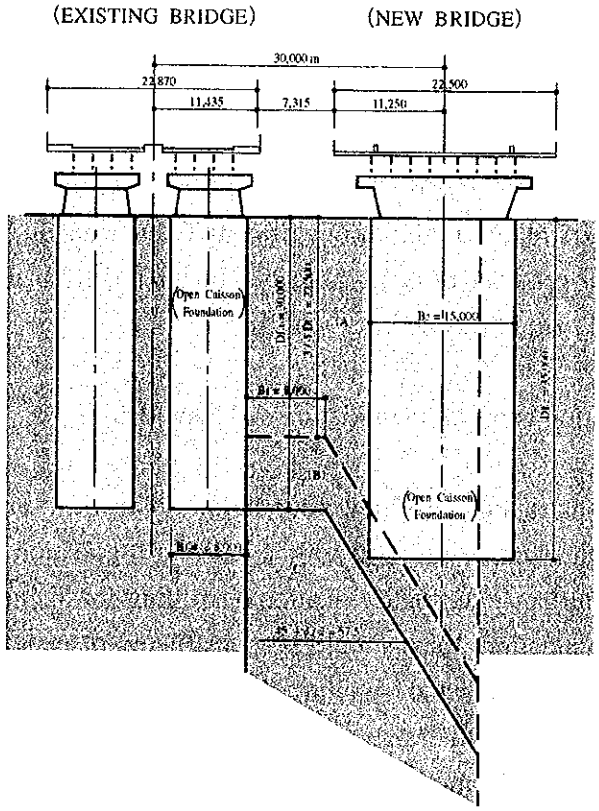
Based on this highest record, the deck level should be estimated after including of 1.5 m vertical clearance above the flood water level and structural depths of the superstructure. It is important to confirm, however, that the soffit of the new girders is to be higher than the existing ones. And for maintaining drainage function on the bridge surface, vertical gradient of 0.5% is to be considered from the middle of bridge toward both bridge end.

(5) Separation between the Existing and New Bridge

The construction of a new foundation adjacent to an existing one, may affect the surrounding soils of the existing foundation to loosen caused by the disturbance during excavation or drilling for the new foundation. The new foundation, thus, should be constructed or penetrated carefully into the area out of that special attention and countermeasures shall be considered in both design and construction stage as illustrated below. As a results, the distance to be separated between the existing and the new bridge should be 30 meters, center to center as shown below.

FIG. 2.4.3 SEPARATION BETWEEN THE EXISTING AND NEW BRIDGE

SEPARATION BETWEEN THE EXISTING
AND NEW BRIDGE



(A) Movement on the structures and foundations shall be carefully observed during construction.

(B) The area between the considerations of (A) and (B).

(C) Special attention and countermeasures shall be considered in both design and construction stage.

2.4.5 Bridge Type

(1) Considerations

As for finalizing the structural types of the proposed bridge, the following characteristics and situation were considered:

a) Since the location of the proposed bridge is close to the existing bridge (about 30 m upstream), adverse impacts to the Yamuna River on hydraulic view point should be minimized in the most possible manner.

b) The Government of India has sufficient river engineering data as well as the experiences on the constructing bridges over the Yamuna River in the vicinity of the Project site, and therefore standardized design requirements such as vertical clearance of the bridge are already existing.

c) According to the sub-clause No. 4.1 of the "Guidelines on Supplemental Measures for Design, Detailing and Durability of Important Bridge Structures" published in 1989 by the Indian Roads Congress, only possible type of foundation should be caisson in case that the foundation is located in deep water channel.

d) As with c) of the above, the same sub-clause stipulates that the number of intermediate foundations shall be reduced as far as practical. Therefore, the span length should be that of the existing bridge or more.

e) Many kinds of construction materials and equipment are produced in the country and possible to use for the Project.

f) Transfer of technology from Japan to India is one of the most significant matter for implementing the Project.

(2) Proposed Types of Bridge Components

Based on the above as well as from the construction liability and economic viewpoints, the following was proposed for the bridge components:

a) Superstructure

Prestressed concrete I-beams which will be the pre-fabricated as simple span beams and connected to continuos beams after erection.

Construction of this type of continuous beams has not been previously introduced to the country, and therefore the transfer of technology can be achieved. In addition, as the number of expansion joints reduces, a better riding condition of vehicles will be achieved compared to other types such as simple span I or T-beams, box girders with central hinges, etc.

b) Abutment

A reinforced concrete rigid frame is proposed.

The use of rigid frame having a similar shape to a box culvert may be advantageous against the soil pressure behind the abutment.

c) Piers

A reinforced concrete wall type pier having oval section.

The wall type can minimize the hydraulic problems to the piers in the river flow. The concrete wall with the cap which will support the concrete girders are recommendable from the structural stability aspect..

d) Foundation

For abutments : Cast-in-place reinforced concrete piles.

For Piers : Reinforced concrete open caisson.

Following the sub-clause No. 4.1 of the "Guidelines on Supplemental Measures for Design, Detailing and Durability of Important Bridge Structures" published in 1989 by the Indian Roads Congress, foundations of piers that will be located in deep water channels are to be open caisson type with oval section. On the other hand, cast-in-place RC piles are to be adopted for the abutments since the locations of abutments are quite some distance from the river's channel.

CHAPTER 3 BASIC DESIGN

3.1 Basic Design Principles

The principles to prepare the basic design of the proposed bridge as well as its approach roads are as follows:

a) Since the construction of the bridge is to maintain the functions of the existing bridge of which reconstruction is urgently needed, the configurations such as bridge length, bridge width and deck level should be as same as the existing ones. Therefore, after completion of the new bridge, the existing bridge should be closed to traffic.

b) To minimize the construction costs and to shorten the construction period, the new approach roads to be designed before and after the bridge should be connected with the existing ones with their minimum required distance.

c) As for the approach road design, the possibility of future improvements of intersections by the Indian Government should be considered. Therefore the approach road will be aligned close to the proposed bridge so as not to disturb the future improvement work.

d) The bridge to be constructed should be located on the downstream side of the existing bridge in order to avoid hydraulic problems such as local scoring around the piers.

e) Various kinds of materials are available in India. Therefore, domestically available materials should be used for the major elements of the bridge structure.

f) The design methods should be based on the Japanese Standards and the Indian Roads Congress's Standard Specifications and Code of Practice for Road Bridges.

g) Since the Government of India is well aware of the requirements regarding the river engineering and foundation aspects of the Yamuna River in the Delhi area, the design criteria related to this will be based on the Indian specifications, standards and guidelines.

h) Because the existing bridge is located on the upstream side and thus may adversely affect the smooth river flow to some extent, the proposed bridge has to

be so designed that the areas of the piers and foundations exposed to the current are smaller than those of the existing bridge.

3.2 Design Criteria and Standards

3.2.1 Loading for Bridge

(1) Dead Load

The following unit weights will be considered for the calculation of the dead load based on the Japanese Standards (Standard Specifications by Japan Road Association):

TABLE 3.2.1 UNIT WEIGHT BY MATERIALS

Unit: Kgf/cu.m

Material	Unit Weight	Material	Unit Weight
Steel, Cast Steel, Forged Steel, etc.	7,850	Plain Concrete	2,350
Cast Iron	7,250	Cement Mortar	2,150
Aluminum	2,800	Hot-mixed Asphalt	2,300
Reinforced Concrete	2,500	Bituminous Material	1,100
Prestressed Concrete	2,500		

In addition, weight of the telephone, electricity-cable wire and lighting facilities are to be considered.

(2) Live Load

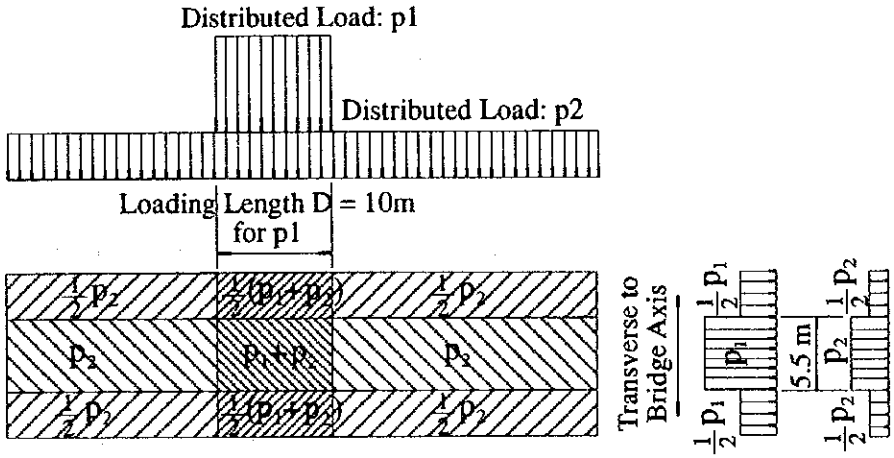
The result of comparison study on the live loads of JRA and Class-A-2-lane/70R track/wheeled vehicles, whichever is greater will be considered in the design.

TABLE 3.2.2 B-LOADING OF JRA SPECIFICATION

Main Loading (Unit of Load: kgf/sq.m)					
Distributed Load p1			Distributed Load p2		
Loading Length: D (m)	For Bending Moment	For Shear Force	L≤80m	80<L≤130m	L>130m
10	1,000	1,200	350	430 - L	300

L: Span Length (m)

FIG. 3.2.1 LOADING APPLICATION



(3) Impact

The impact effect will be calculated according to the live loads that are multiplied by the following impact fraction.

For Prestressed Concrete Bridge: i = 10 / (25 + L), where L= span length (m)

(4) Wind Load

The design wind forces will be based on Clause 212 of Section II, Loads and Stresses of IRC Standard Specifications.

(5) River Current Forces

The maximum current velocity of the Yamuna River recorded in the past is 5.2 m/s.

The intensity of the current force will be based on Clause 213 of Section II Loads and Stresses of the IRC Specifications of Road Bridges.

(6) Longitudinal Forces

According to Clause 214 of Section II Loads and Stresses of the IRC Specifications for Road Bridges, longitudinal forces are to be calculated taking into consideration of Class-A/70R track/wheeled vehicles.

(7) Buoyancy

The effect of buoyancy will be considered for the substructure and foundation designs.

(8) Earth Pressure

The earth pressure will be calculated based on Coulomb's formula.

(9) Seismic Force

The seismic force will be calculated according to Clause 222 of Section II Loads and Stresses of the IRC Specifications for Road Bridges. The calculation method is by means of the following horizontally equivalent force method:

$$F_{eq} = \alpha\beta\lambda G$$

Where, F_{eq}: Seismic Force

α : Horizontal seismic coefficient = 0.05 (Zone IV)

β : A coefficient depending on the soil foundation = 1.2 (for medium soils of N-value of SPT between 10 and 30)

λ : A coefficient depending on the importance of the bridge = 1.5

G : Dead weight (tf)

(10) Temperature Effect

According to Clause 218 of Section II Loads and Stresses of the IRC Specifications for Road Bridges, the variation degree of temperature for concrete structures is ± 25°C.

3.2.2 Material Requirements

The following materials will be considered for the basic design:

(1) 28-day Cylinder Strength of Concrete

- PC main girders : 350 kgf/cm^2
- Diaphragms : 300 kgf/cm^2
- Slabs : 300 kgf/cm^2
- Piers and abutments : 240 kgf/cm^2
- Open caissons : 240 kgf/cm^2
- Bottom slabs of caissons : 225 kgf/cm^2 (Tremie Concrete)
- Cast-in-place RC piles : 300 kgf/cm^2

(2) Strength of Steel Materials

- Reinforcing bars : 49 - 63 kgf/mm2
- PC Tendons (Main) : 195.6 tf (12T12.4)
- PC Tendons (Transverse) : 58.4 tf (1T21.8)

- PC Tendons (Connection) : 76.2 tf (12ø7)

3.2.3 Geometric Design Standard for Bridge and Approach Roads

All the requirements for geometric design should be based on the Geometric Design Standards for Urban Roads in Plains (IRC: 86-1983) by IRC.

3.3 Basic Design

3.3.1 Basic Plan

The configuration of the facilities of the Project was determined as follows:

(1) The Delhi side approach road starts at the STA No. 1 + 80 m and ends at the STA No. 5 + 48 m of the A1 abutment in the length of 368 m.

(2) The proposed 550 meters bridge, starting at the STA No. 5 + 48 m of the A1 abutment and ending the STA No. 10 + 98 m of the A2 abutment in the length of 550 m. The bridge consists of 3-span and 4-span continuous PC I-beams supported by solid piers on open caissons.

(3) The NOIDA side approach road starts at the STA No. 10 + 98 m of the A2 abutment and ends at the STA No. 15 + 10 m.

(4) At the conjunctions between abutments and approach roads, link slabs are designed. The approach slabs will have a width of 15 m (same as carriageway) and a length of 8 m.

3.3.2 Profile Design

Since the proposed bridge is located in the very congested traffic area and relatively gentle grade is required. As such a carriageway, grade of 0.5 % is adopted both the Delhi side and NOIDA side toward the both connecting points to the existing approach roads.

3.3.3 Cross Sectional Design

The width composition was determined as already discussed in Section 4.4.

3.3.4 Design of Superstructure

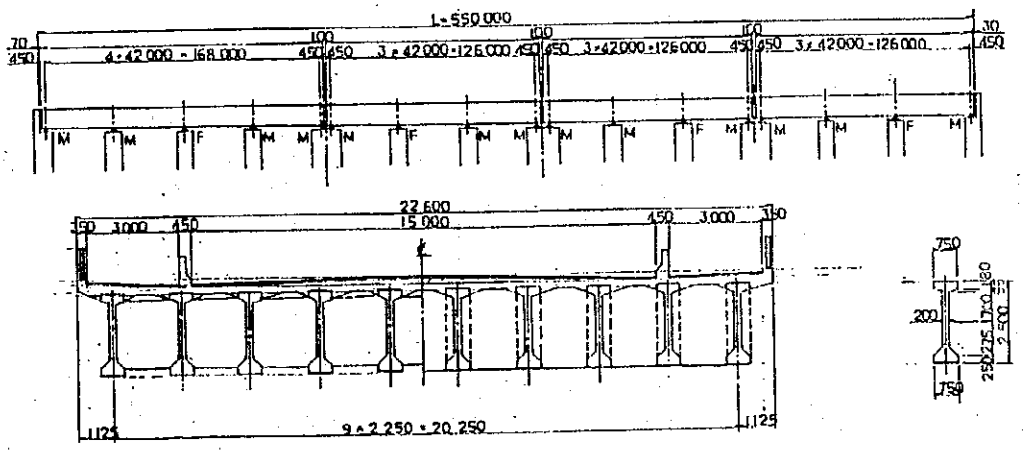
As a result of the preliminary engineering design, the following was determined for the superstructure elements:

(1) Type of Superstructure

Composite type of PC continuous I-beam (so-called connection beam) was designed. The beams will first be prefabricated as simple beams, after being erected, will then be connected to continuous beams using prestressing tendons.

The proposed bridge consists of one each of 4-span continuous structure and three each 3-span continuous structures as shown below:

FIG. 3.3.1 DETAILS OF 3-SPAN AND 4-SPAN CONTINUOUS STRUCTURES



(2) Girder Depth

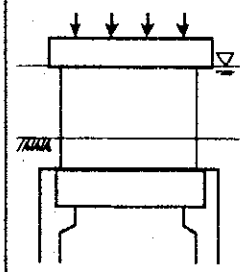
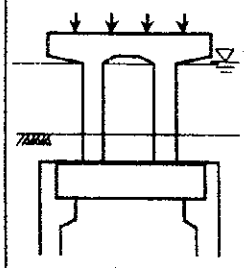
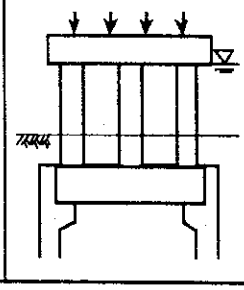
The girder depth will be 2.5 meters (Ratio of Span / Girder Depth = 16.8)

3.3.5 Design of Substructure

The type of substructure is generallydetermined by the magnitude and direction of the reactions from the superstructure, river conditions and earthquake

resistance. In comparing the substructure types, factors such as structural features, ease of construction, river-flow disturbance and construction cost were considered. Three suitable substructure types, wall type, rigid frame type and multi-column type, are compared in the following table.

TABLE 3.3.1 COMPARISON OF SUBSTRUCTURES

Type	Sketch	Structural Feature	Ease of Construction	River-Flow-Disturbance	Construction Cost
Wall Type		Enough earthquake resistance ○	No need for complicate form work and scaffolding △	Suittable ○	1.00
Right Frame Type		Relatively complex structure △	High quality contrl required △	Problems with driftage ×	1.00
MulltiColumn type		Influence of temperature stress △	- Scaffolding required - High quality control required △	Problems with driftage ×	1.20

○ Good △ Fair × Bad

Based on the above, the wall type is recommended for the pier because it is superior to other types from the economical and technical viewpoint, while the abutments on both the Ring Road side and Noida side should be rigid frame type because of open space being available for installation of water mains.

3.3.6 Design of Foundations

The foundation type can be determined mainly from the soil conditions, soil bearing capacity and analyzed soil constants. In addition, the factors of ease of construction, material procurement, foundation depth and minimum cost should be carefully considered. In this viewpoint, suitable foundation types for the Project are cast-in-situ-piles and open caisson foundations.

Structural characteristics and the peculiarity of cast-in-situ-piles are such that structural rigidness and moment of inertia with wider spacing between piles can hold higher stability and a reliable confirmation of bearing capacity can be expected through loading tests. However, open caisson foundation have a large bearing capacity because of large foundation size and structural stability especially against lateral forces like an earthquake vibration and water-flow pressure can be expected.

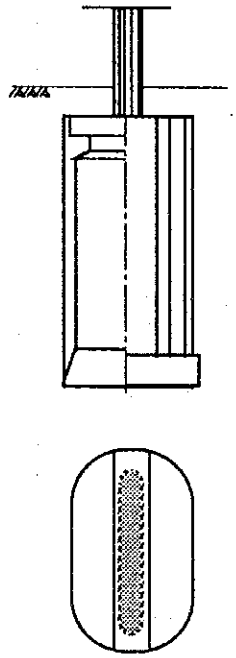
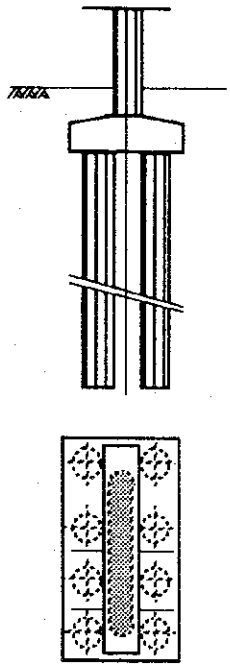
On cast-in-situ-piles, work action above water level is possible using a stand pipe and since the bore holes can be made by using drilling machine, the construction time is reasonable.

On open caisson foundations, the construction time for sinking work of the caisson body may be lengthy due to incline and shift of caisson body. This situation necessitates, therefore, the use of additional equipment for relieving skin friction and forcing the caisson body using jacks in order to finish the work within a reasonable construction time. Using jacks will effectively give solution to avoid the disturbance to loosen soils around the existing foundation by a new foundation and to control inclining or shifting the caisson body during sinking works.

For this Project, open caisson foundations are adopted for the reasons of their ability of maintaining structural stability under conditions of hydraulic effect such a local scouring around the piers during flooding period and no significant difference on construction costs between two types of foundation can be seen.

The following table shows a comparison of the different types of foundation being considered.

TABLE 3.3.2 COMPARISON OF FOUNDATION TYPE

Foundation Type	(A) Open Caisson	(B) Cast-in-Situ-Pile
Schematic Illustration of Foundation		
Structural Characteristic	Sufficient bearing capacity	Moment of inertia can hold higher stability
Ease of Construction	Sinking work requires additional equipment	Careful removal of slime at borehole bottom
Construction Time	Unstable due to incline or shift	Stable because of machine drilling
Construction Cost	almost equal to (B) in cost	almost equal to (A) in cost

However, for the foundations of both abutments of the bridge, which are situated on river dikes, cast-in-situ-piles can be adopted because the foundations of the abutments are out of the river's flood zone and its construction timing is scheduled to be done in the flooding period. Therefore, cast-in-situ-piles can allow the foundation work to be completed within the scheduled duration, they are recommended for both abutments .

3.4 Basic Design Drawings

The following basic design drawings are included herein:

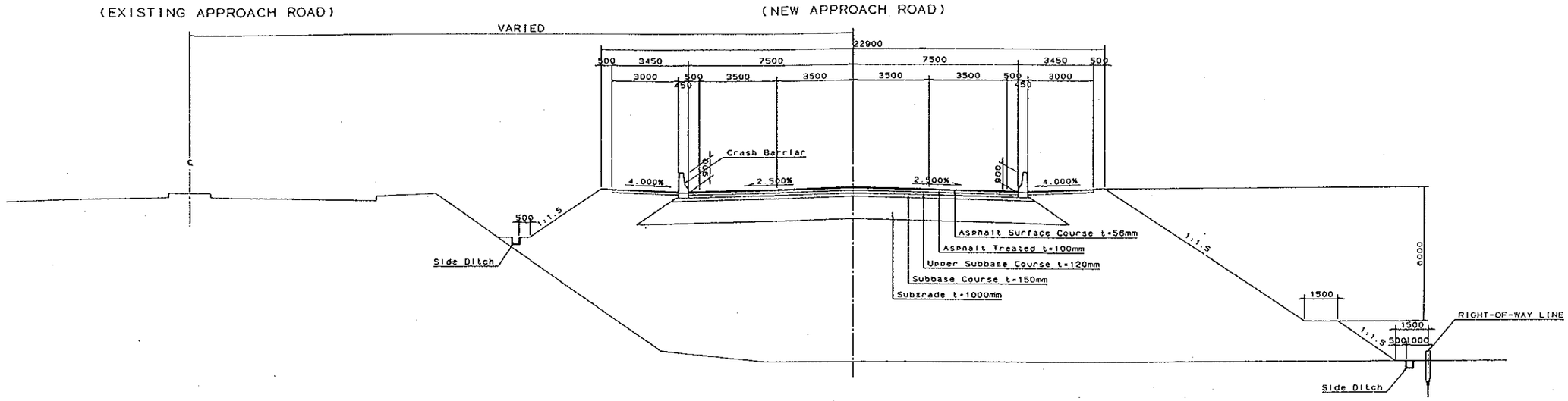
- Fig. 3.4.1 Typical Cross-Section of Embankment and Superstructure
- Fig. 3.4.2 General Layout and Profile
- Fig. 3.4.3 General Layout of Bridge

Fig. 3.4.1 Typical Cross - Section of Embankment and Superstructure

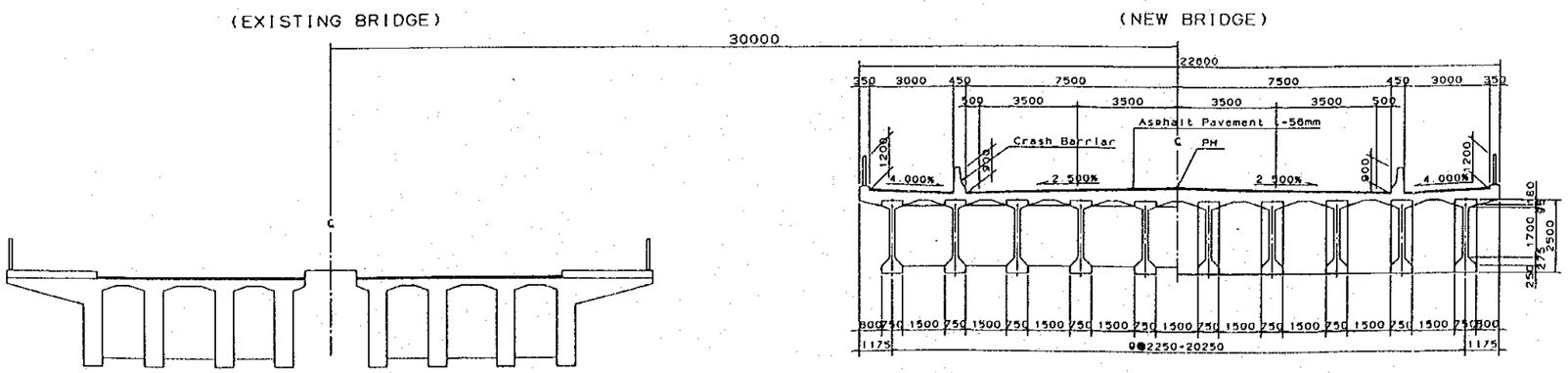
TYPICAL CROSS-SECTION

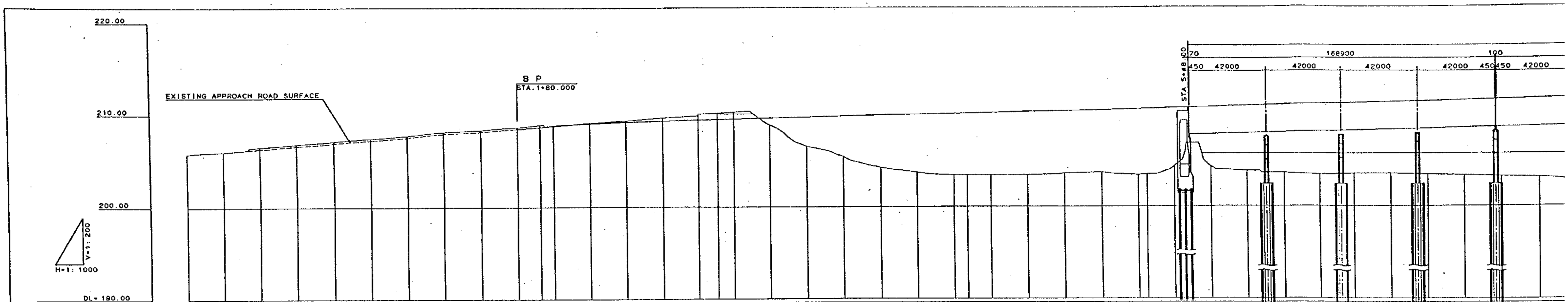
S=1:100

EMBANKMENT CROSS-SECTION



BRIDGE CROSS-SECTION



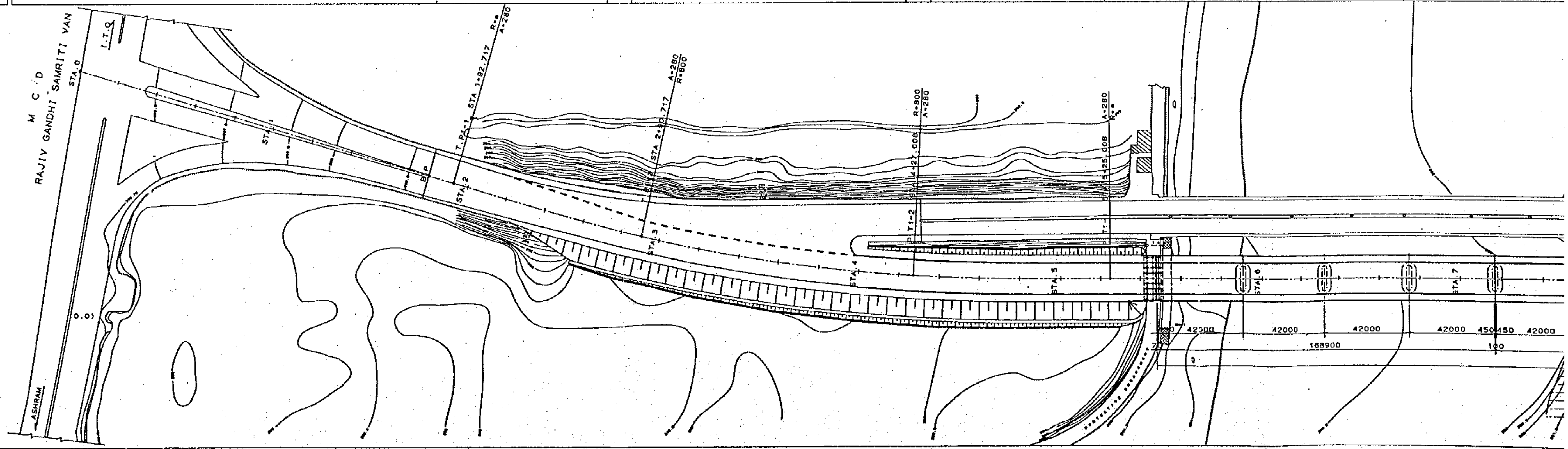


GRADIENT: 208.420 — i=1.575% L=40.000 — 209.050 — i=0.500% L=390.000

STATION	ACCUMULATED DISTANCE	DISTANCE	GROUND ELEVATION	PROPOSED BRIDGE HEIGHT
STA. 0	0.000	0.000	205.78	
+20	20.000	20.000	206.00	
+40	40.000	20.000	206.50	
+60	60.000	20.000	206.80	
+80	80.000	20.000	207.10	
STA. 1	100.000	20.000	207.40	
+20	120.000	20.000	207.70	
+40	140.000	20.000	208.10	
+60	160.000	20.000	208.30	
+80	180.000	20.000	208.60	208.420
T.P1-1	192.717	12.717		208.620
STA. 2	200.000	7.283	208.80	208.732
+20	220.000	20.000	209.10	208.983
+40	240.000	20.000	209.30	209.147
+60	260.000	20.000	209.60	209.250
+80	280.000	20.000	209.60	209.350
T.P1-2	280.717	10.717		209.404
STA. 3	300.000	9.283	210.20	209.450
+20	320.000	20.000	208.80	209.550
+40	340.000	20.000	206.50	209.650
+60	360.000	20.000	205.40	209.750
+80	380.000	20.000	204.20	209.850
STA. 4	400.000	20.000	203.70	209.950
+20	420.000	20.000	203.40	210.050
P.T1-2	427.008	7.008		210.085
+40	440.000	12.992	203.40	210.150
+60	460.000	20.000	203.40	210.250
+80	480.000	20.000	203.60	210.350
STA. 5	500.000	20.000	203.70	210.450
+20	520.000	20.000	203.40	210.550
P.T1-1	525.008	5.008		210.575
+40	540.000	14.992	204.30	210.850
+60	560.000	20.000	204.30	210.750
+80	580.000	20.000	203.80	210.850
STA. 6	600.000	20.000	203.60	210.950
+20	620.000	20.000	203.40	211.050
+40	640.000	20.000	203.50	211.150
+60	660.000	20.000	203.50	211.250
+80	680.000	20.000	203.40	211.350
STA. 7	700.000	20.000	203.30	211.450
+20	720.000	20.000	203.20	211.548
+40	740.000	20.000	203.10	211.628

CURVE ELEMENT: R=∞ L=192.717; VCL=50 R=4700; A=280 L=98.000; R=800 L=138.291; A=280 L=98.000

SUPERELEVATION: 1/214; 1/191; 1/214; 1/191

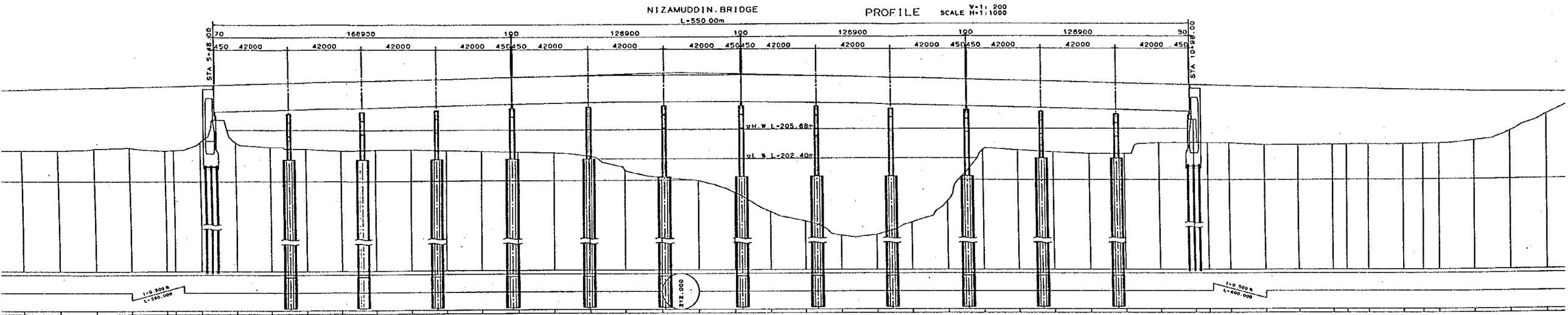


NIZAMUDDIN. BRIDGE

L=550.00m

PROFILE

SCALE V=1: 200 H=1: 1000



PLAN

SCALE 1:1000

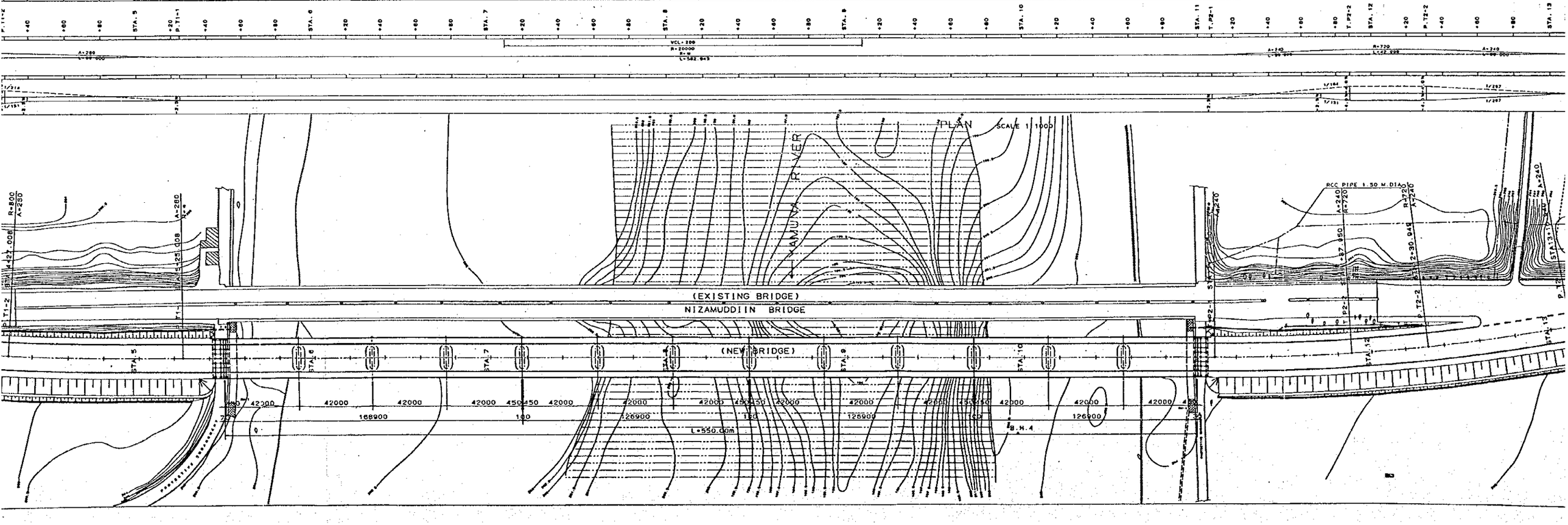
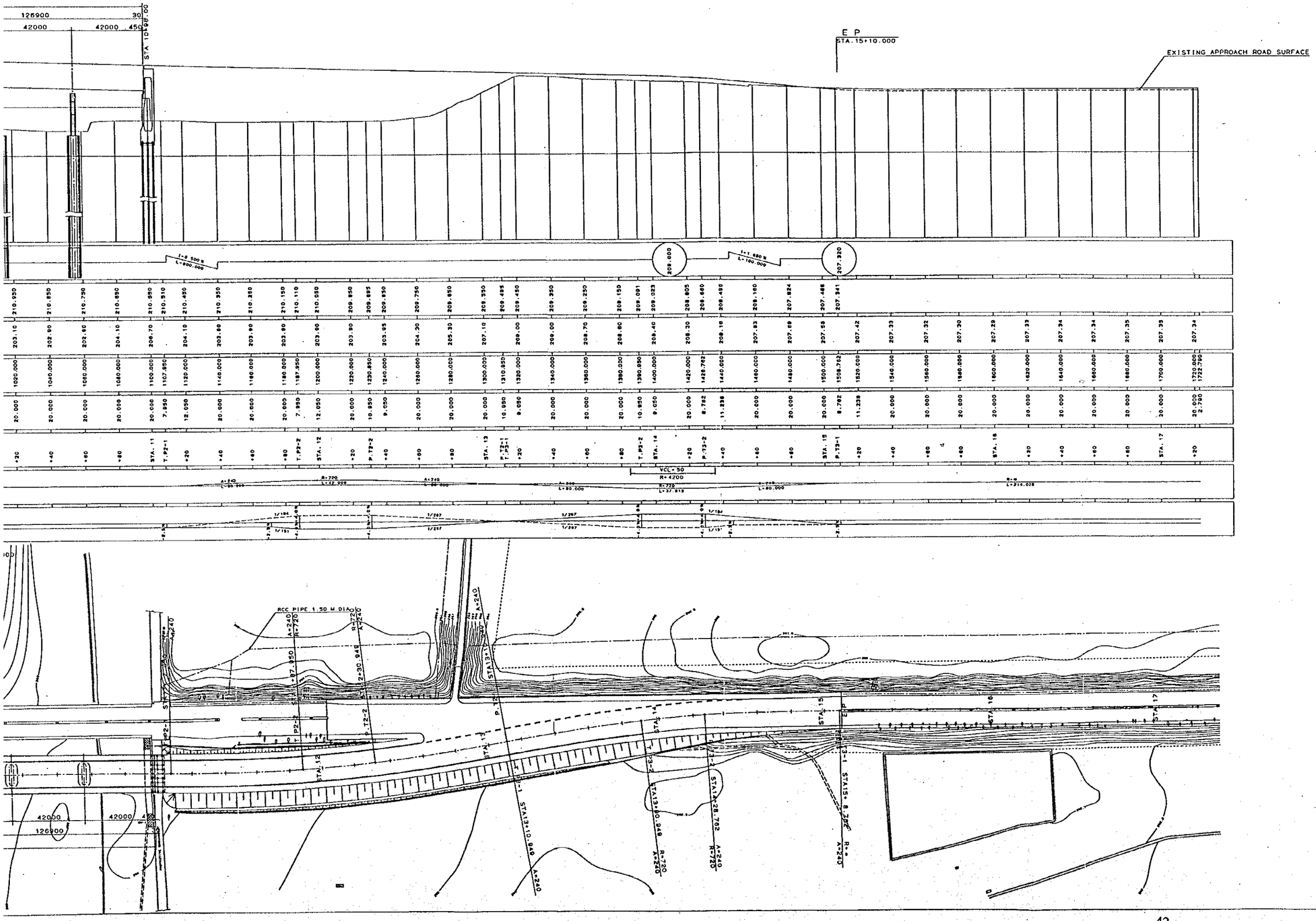
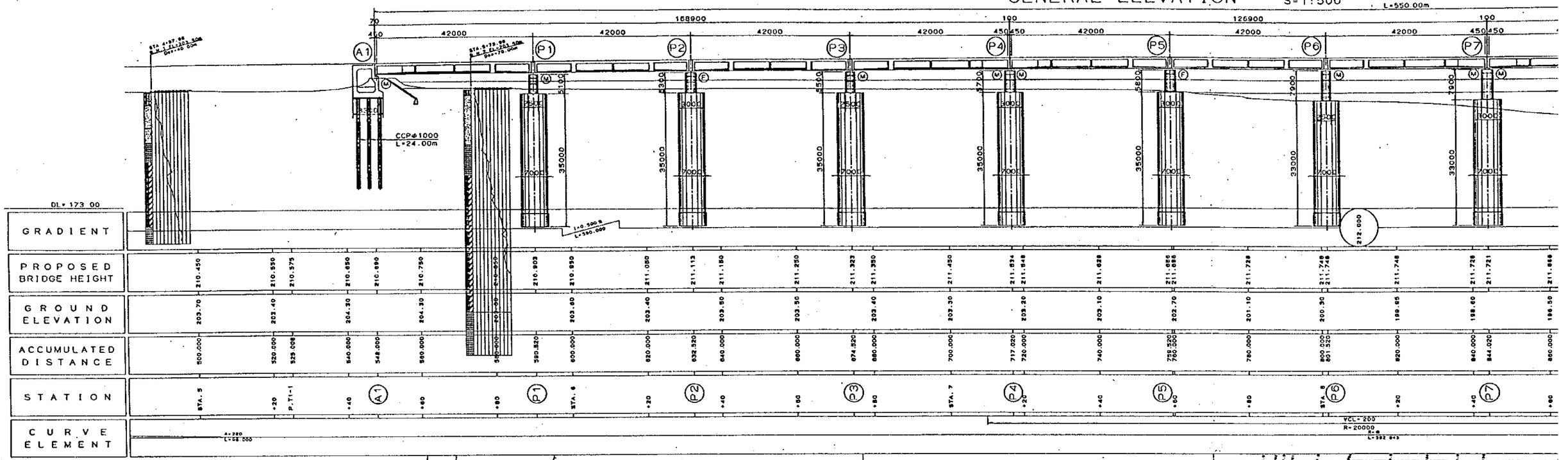


Fig. 3.4.2 General Layout and Profile



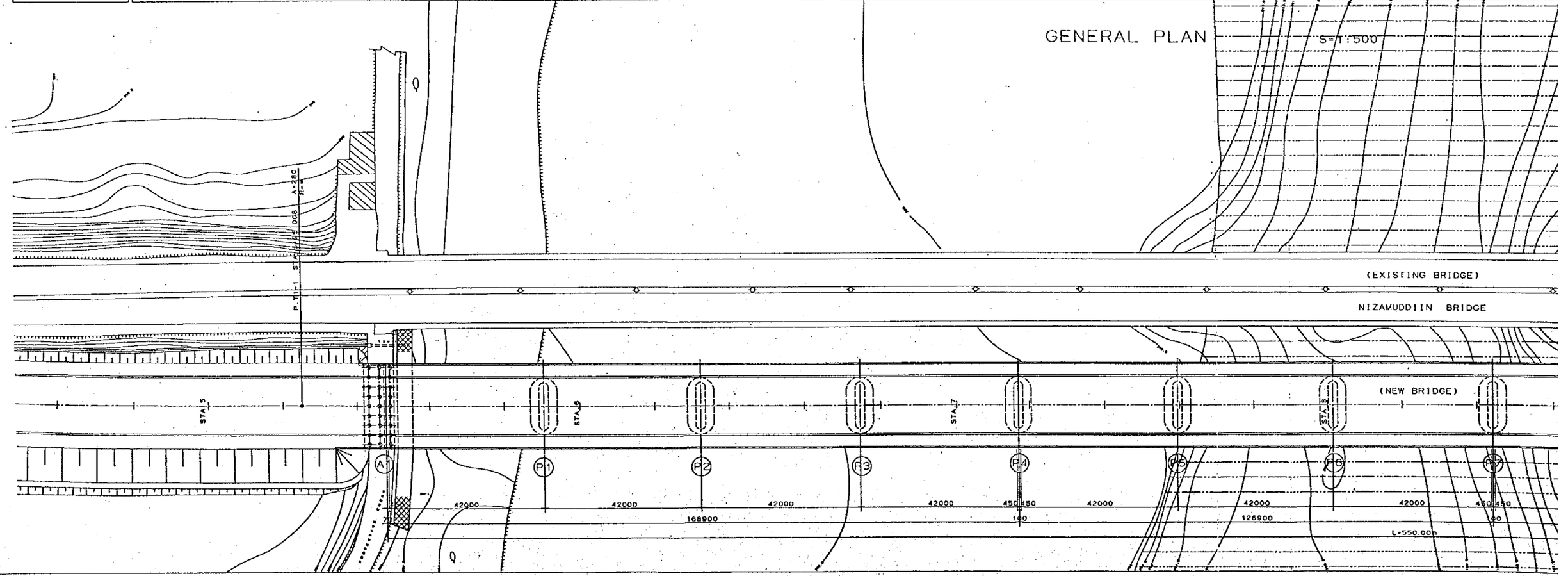
GENERAL ELEVATION S=1:500

NIZAMUDDIN. BRIDGE
L=550.00m

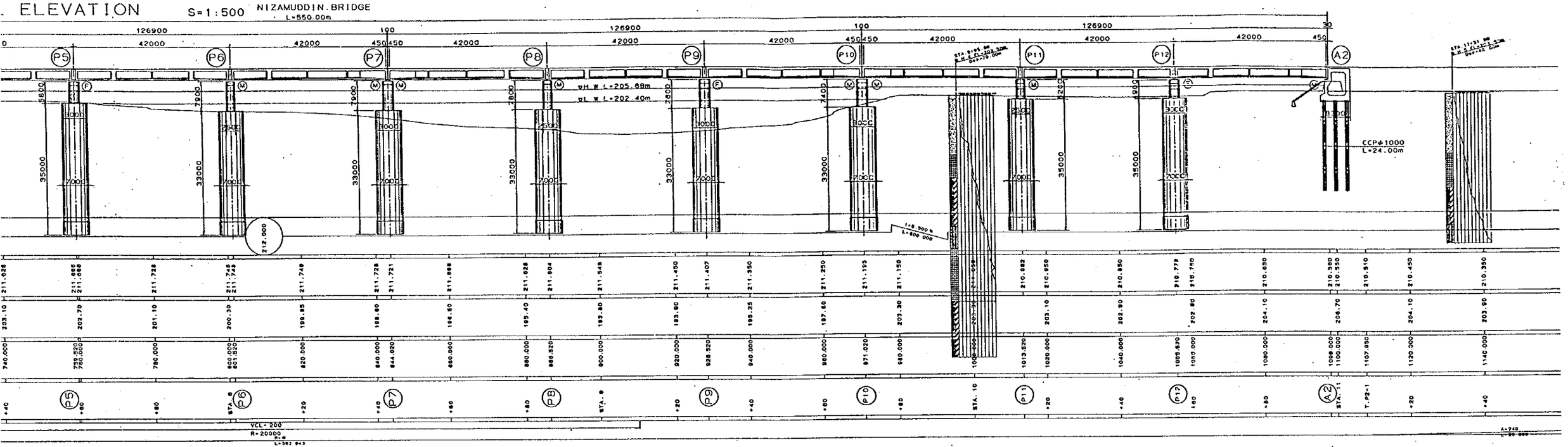


GENERAL PLAN

S=1:500



ELEVATION S=1:500 NIZAMUDDIN BRIDGE
L=550.00m



ERAL PLAN S=1:500

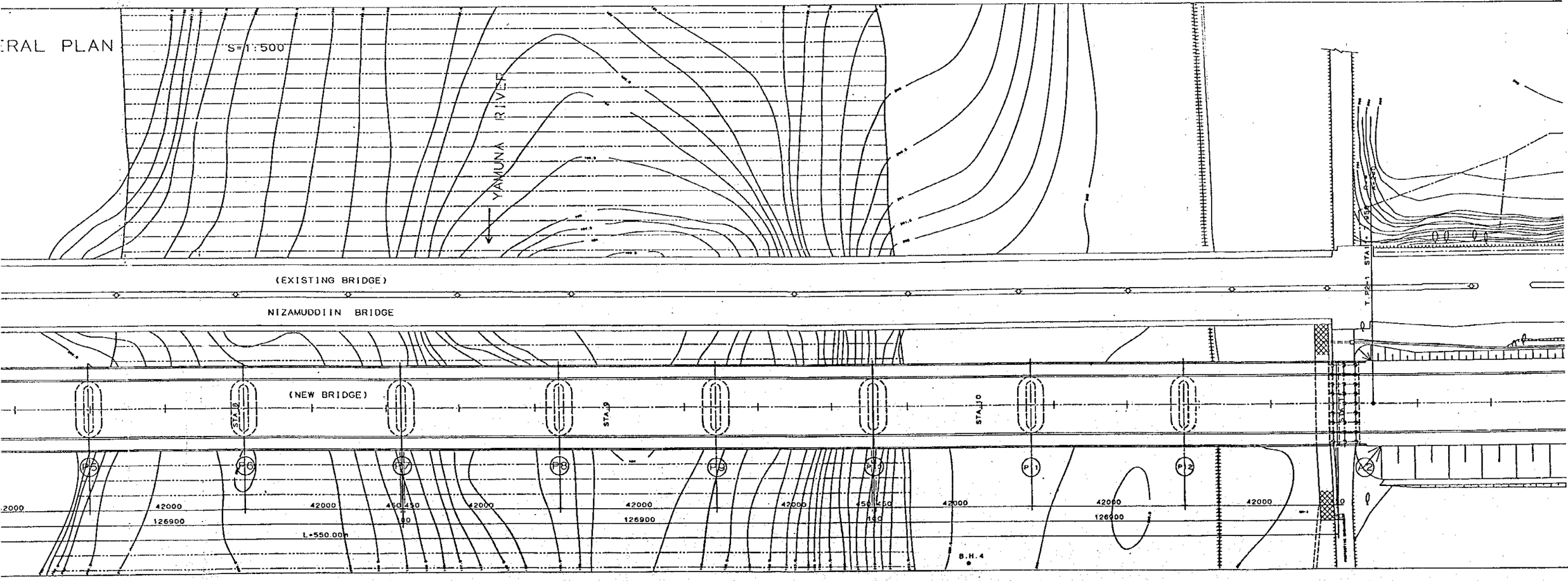
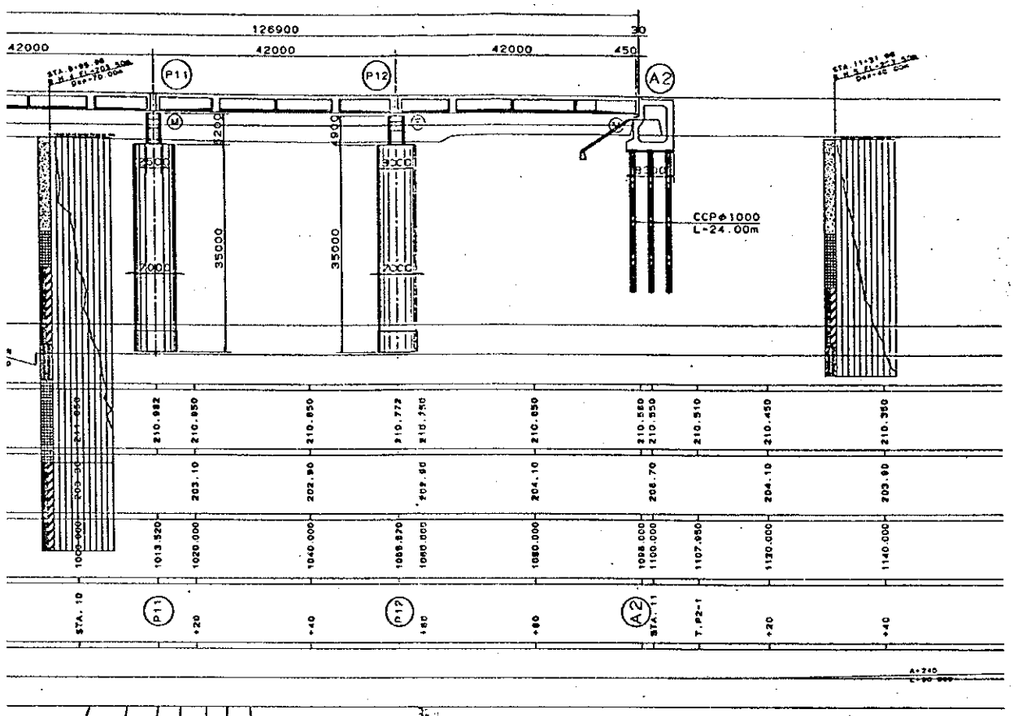
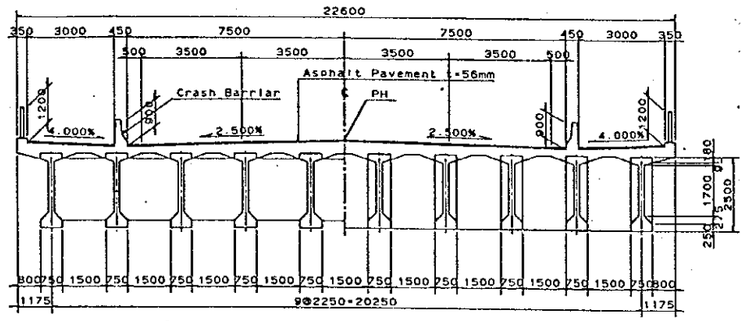


Fig. 3.4.3 General Layout of Bridge



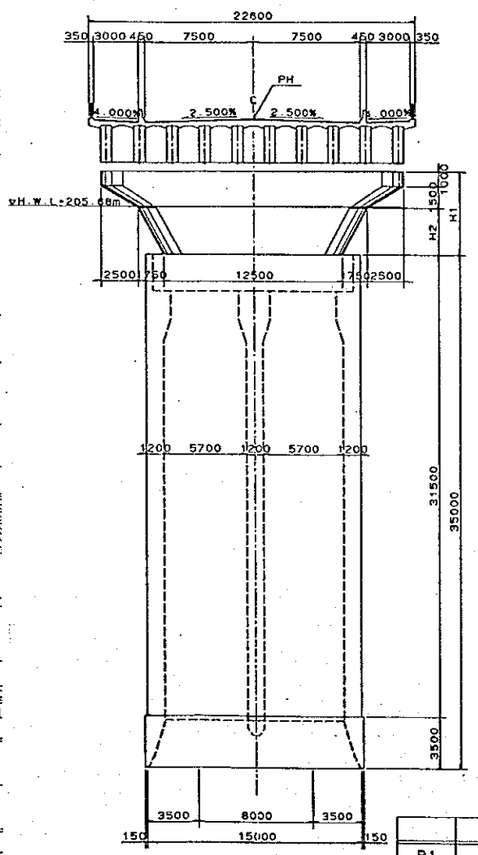
CROSS SECTION S=1:100



DESIGN CONDITION

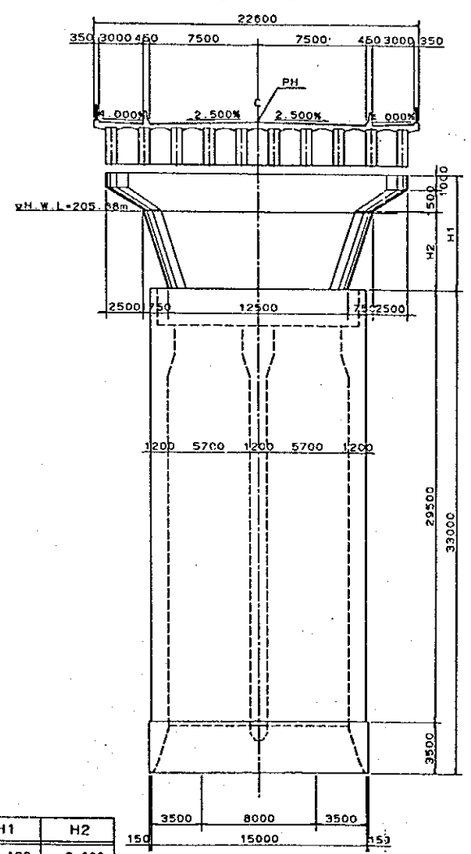
TOTAL BRIDGE LENGTH	L=550.00m
SPAN	S=42.00m
WIDTH	W=2×7.50m+15.00m
LIVE LOAD	B-TYPE LIVE LOAD (TL-25)
IMPACT COEFFICIENT	I=10/(25+L)
SEISMIC COEFFICIENT	Kh=0.20
ANGLE OF SKEW	90° 00' 00"
RADIUS OF CURVATURE	R=∞
LONGITUDINAL SLOPE	I=0.500%~-0.500%

P1 ~ P5 , P11 ~ P12



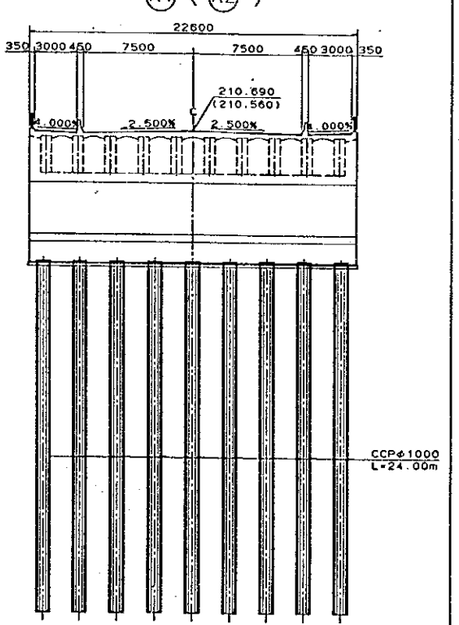
	H1	H2
P1	5.100	2.600
P2	5.300	2.800
P3	5.500	3.000
P4	5.700	3.200
P5	5.800	3.300
P11	5.200	2.700
P12	4.900	2.400

P6 ~ P10



	H1	H2
P6	7.900	5.400
P7	7.900	5.400
P8	7.800	5.300
P9	7.600	5.100
P10	7.400	4.900

A1 (A2)



3.5 Implementation Plan

3.5.1 Implementation Plan

a) Estimate of Construction Period

The project site of the new bridge is located in the Delhi city. The materials and equipment for special construction methods for girder erection and foundations will be imported from Japan and be unloaded at Bombay Port. They will be transported to Delhi through Ahmadabad and Jaipur after Bombay Port. The soil material for the approach embankment can be hauled from borrow pit approx. 20 km south from the project site, while the aggregate for concrete structures can be hauled from the quarry site approx. 100 km south. Superstructure (PC-Beam) will be produced at the temporary construction yard beside the left river bank of the Yamuna River and be erected using erection-girder with launching nose. The open caisson foundations to be constructed in the river should be built avoiding the flood season (June - October). Aiming at the accomplishment of the foundations and substructures during the dry season, the special method forcing sinking the caisson and three crews will be needed for this works. The entire construction period will be 30 months including such construction works as preparatory work, temporary construction yard, bridge structures, approach roads, miscellaneous work and demobilization.

b) Construction Methods

Initially, the area for the temporary construction yard on the left river bank of downstream of the existing bridge, should be cleared and grubbed. PC-Beam can be produced after preparing the construction yard. The open caisson foundations should be built from the central part of the river toward the both river banks. After accomplishing a half of the foundations and substructures, the erection of the superstructure (PC-Beams) can be started, which will be conducted only from the left river bank side using erection-girder. The bridge accessories such a hand-rail and crash barrier, pavement on the concrete deck slab, and approach roads will be accomplished afterward.

3.5.2 Construction Conditions

To implement the Project, the following factors concerning river flooding, construction space and procurement of materials must be considered:

a) According to available records of the Flood Control Authority, the flooding period is from June to October. The relationship between construction time and methods during the flooding period will be critical to the implementation schedule of the Project.

b) The construction work items during the flooding period are limited to those which can be executed above flood water level of the river.

c) The special equipment for erecting the bridge girders must be provided so as to maintain the progress even during the flooding period.

d) Before commencement of the Project, some public utilities such as water mains and electrical lines and poles must be relocated. Also the newly required land for the Project must be acquired.

e) In general, necessary equipment and materials for the construction can be procured in India except for the types of construction having special methods.

f) To complete the foundation within the scheduled construction time, special operating groups and equipment must be provided and assigned from Japan.

g) Care will be required for handling the encroachments which are stuck on the slope of the existing approach embankment on the Ring Road (NH-2) side.

3.5.3 Job Description of Consultant Personnels

The Consulting Services for Detailed Design, Tendering and Construction Supervision will be carried out by the Consultant personnels under the Agreement between the Consultant and the Executing Agency of India. The Consulting Services will be phased into Detailed Design/Tendering and Construction Supervision Stage.

a) Detailed Design/Tendering Stage

Position	Job Description
- Project Manager	Fully responsible for Detailed Design/Tendering
- Bridge Engineer (Superstructure)	Responsible for the design of superstructure of the bridge
- Bridge Engineer (Substructure/ Foundation)	Responsible for the design of substructure and foundation of the bridge
- Highway Engineer	Responsible for the design of approach roads and pavement
- Construction Planner/ Cost Estimator	Responsible for construction plan and detailed-cost estimation
- Document Writer	Responsible for the preparation of Specification and Tender Documents

b) Construction Supervision Stage

Position	Job Description
- Project Manager	Fully responsible for the entire construction supervision
- Resident Engineer	Establish the managing system of the Project and cooperate with the Executing Agency of India
- Soil/Materials Engineer	Responsible for the quality control of the materials for the bridge structures and approach road
- Bridge Expert (Superstructure)	Responsible for the construction supervision of the bridge superstructures
- Bridge Expert (Substructure/ Foundation)	Responsible for the construction supervision of the bridge substructures and foundations
- Highway Expert	Responsible for the construction supervision of the construction of the approach roads and alignment control of the bridge

3.5.4 Availability of Labors, Materials, Equipment and Transport

(1) Labors

In general, ordinary labors and skilled labors can be available in India. It is, however, recommended that skilled labors and supervisory staff should

be assigned from Japan for the special operations such like caisson foundation with special equipment and the erection of the girders on the piers during the flooding period.

(2) Materials

Basic materials needed for the Project are available in India or near the Project site. Coarse aggregate and fine sand for concrete and asphalt mixture can be obtained at quarry sites located within about 100 km south from Delhi. The embankment material for the new approach roads can be obtained from the borrow pits which are located within about 20 km from the Project site. The prestressing tendons and their anchors, however, will have to be imported from outside of India because of their tight specifications.

(3) Equipment

Construction equipment required for the foundations, such as a crawler cane, three-leg derrick crane and special jacks for pressing the foundation, and equipment for operating prestressed concrete girders are not available in India. They will therefore have to be transported from Japan.

(4) Transport

The major route for the inportation of construction materials and equipment will be from Japan to Bombay port and inland transport from Bombay to Delhi.

3.5.5 Implementation Schedule

From Exchange of Note to completion of the Project, the implementation schedule can be separated into three stages: consultant contract and detailed design, tendering and construction contract, and construction (refer to Implementation Schedule).

(1) Consultant Contract and Detailed Design

First, GOI will sign a contract with the selected consultant, after the consultant's contract has been signed, detailed engineering, pre-qualification documents, cost estimate and related reports will be prepared.

(2) Tendering and Construction Contract

Pre-qualification of contractors who wish to apply for tendering is to be carried out under the JICA guidelines. Pre-qualification should be executed by the consultant on behalf of the executing agency of GOI. Tender opening, tender evaluation and the decision on the contractor are carried out by the Consultant and staff of GOI in the presence of the bidders and JICA staff, and then the construction contract award is made.

(3) Construction

During construction stage, preparatory work, materials and equipment transportation, foundation work, substructure work, superstructure work, construction of approach roads, etc. will be performed. In the flooding period (June to October), the works in the river will be limited.

TABLE 3.5.1 IMPLEMENTATION SCHEDULE FOR DETAILED DEISGN & TENDERING

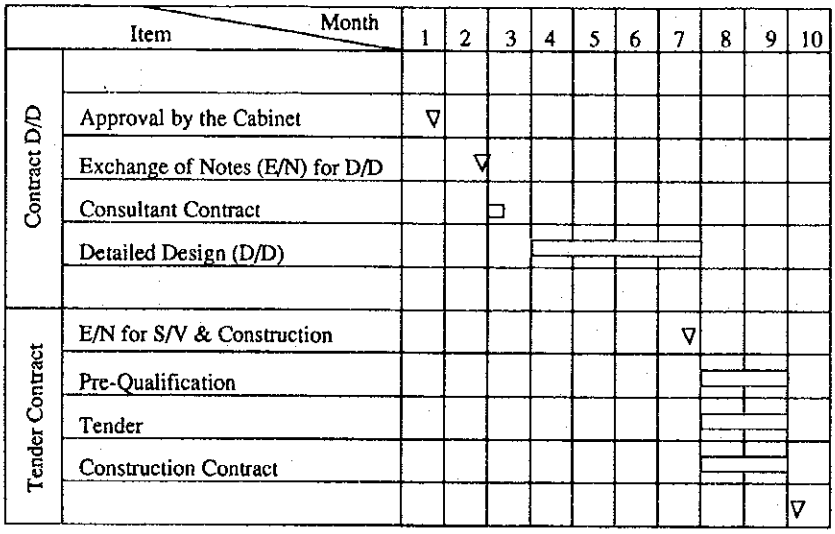
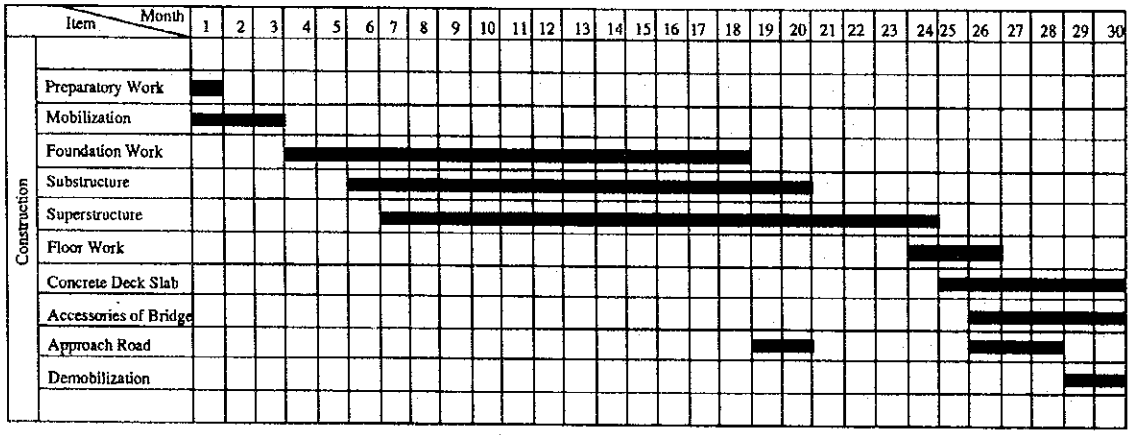


TABLE 3.5.2 IMPLEMENTATION SCHEDULE FOR CONSTRUCTION



3.5.6 Maintenance Program

(1) Maintenance for New Bridge

The bridge to be constructed under the Project is designed so that all traffic through the existing Nizamuddin Bridge will be shifted to the new bridge after the completion. Therefore, the existing structures will be inspection bridge for the water mains in the future. The key maintenance points for the new bridge are:

a) Damage by vehicle collision to such bridge accessories as handrails, curb-stones and end-posts.

b) Corrosion of the bearing shoes in case of insufficient maintenance of the bridge.

c) Spalling of the concrete bearing bed due to thermal and possibly earthquake forces.

d) Local scouring around the piers and abutments due to river flooding.

e) Damage to the pavement of the approach roads due to deterioration as traffic increases.

f) Damage to riverbank protection during flooding.

(2) Methods for Inspection and Maintenance

a) Inspection

The types of inspections of the bridge are classified as a normal inspection carried out by the inspectors having technical knowledge of the bridge, a periodic inspection by staff trained in bridge inspection, and a special inspection following the passage of an abnormal load, after an earthquake shock and river flooding.

Periodic inspections are recommended in principle and special inspections should be obligatory after earthquakes and river floods. The inspected items should be based on a check-list including the previous requirements for maintenance. Inspection data should be

analyzed and abnormal results should be pointed out for further inspection. A maintenance and rehabilitation program can be established, based on these analyzed results.

b) Maintenance Organization

MOST should be the organization responsible for the maintenance program, while the Delhi Government can manage the bridge. Therefore, staffing consisting of bridge engineers and inspectors, can be chosen from the above two organizations.

c) Budget

The budget for bridge maintenance will be covered by the Delhi Government with assistance by the Ministry of Surface Transport.

3.5.7 Necessary Measures by GOI

The necessary measures that have to be performed by GOI, are land acquisition, leasing land for temporary facilities and works, cleaning/grubbing of the Project site, relocation of the encroachments, the water main and electricity cable and poles. The cost estimate regarding these works have been on the basis of the basic design results, construction plan and schedule. Necessary measures should be started as soon as possible after the Exchange of Notes (E/N) for construction between the both Governments, taking into account the limited construction period of the new bridge.

Relocation of the encroachments on the slope of the existing embankment of the approach road on the Ring Road side must be carefully treated. The water main along the embankment that is downstream of the approach road must be relocated before starting the temporary or scheduled work in that area. It is important to recognize that delay of these actions will considerably affect construction implementation scheduled.

Other necessary actions to be arranged by the Executing Agency of GOI are to apply the necessary EFC (Expenditure Finance Committee) and CCEA (Cabinet Committee on Economic Affairs) clearance, and to propose budgetary arrangement for counterpart fund.

CHAPTER 4 PROJECT EVALUATION AND CONCLUSION

The construction of the bridge will not only create an economic effect, but will also have on influence on the technical improvement of bridge construction in India as follows:

a) The new bridge can maintain transport and traffic safety of the arterial road, National Highway No. 24 - Bypass, in the areas divided by the Yamuna River, in case of traffic jams caused by bridge collapse.

b) Since the Nizamuddin Bridge is located within the metropolis of Delhi, it is often used by commuters (approximately 30,000 people) living on eastern bank of Yamuna River and working in the capital city. Moreover, it is used by those (approximately 20,000 people) living in the main capital and working in the industrial belt of NOIDA and Gaziabad. The Project is expected to be beneficial to around one million people. Also the plan to construct a new bridge near the Okhla (Water Gate) Bridge, which is located downstream of the Nizamuddin Bridge, has recently been suspended because of technical and financial problems. Under this situation, the construction of the new Nizamuddin Bridge is significantly more important.

c) Because of the wide cross-sectional arrangement, the Project when completed, would facilitate the flow of traffic. This would result in considerable savings in travel time of two minutes per/vehicle, that is, a saving cost of approx. 330,000 Rs./day, and fuel consumption of approx. 60,000 Rs/day, as well as reducing air pollution and traffic accidents.

d) Since the construction of the new bridge will involve large-scale concrete works which require a lot of man-power, the Project will contribute to the expansion of employment opportunities.

e) The construction method, involving the latest bridge technologies, can contribute to technology transfer to India.

Consequently, the Project's position in the national development plan and the feasibility and rational of the Project were examined as follows:

a) The new bridge will improve transport and traffic safety of the arterial road which links both areas in Delhi divided by the Yamuna River.

b) The new cross-section, which divides heavy vehicles and light vehicles/bicycles by a crash barrier, can resolve the present traffic troubles caused by the mixing of vehicles and bicycles.

c) The new bridge structures can greatly contribute to reducing maintenance costs.

As previously described, the Project would be greatly effective and contribute to improving living standards (Basic Human Needs) of the people living in Delhi. Therefore, the implementation of this Project through the cooperation of Japan's Grant Aid Program would be feasible and effective. After completion of the Project, the well -organized Ministry of Surface Transport (MOST) and the Delhi Government will manage and maintain the new bridge structures. Therefore, its early realization is most desirable and the Project is highly recommendable. The following conditions are also recommended to implement the Project smoothly and effectively:

a) Careful treatment of encroachments to be relocated.

b) Close relations among the related authorities and organizations.

c) Safety for the vehicles and pedestrians during the construction.

d) Traffic shift from the existing bridge to the new bridge after completion of the Project.

e) Smooth and effective traffic control at the connecting points of the approach roads after completion of the Project.

f) Smooth and prompt actions following the procedures of the Japan's Grant Aid system.