No.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
REHABILITATION OF GATES
OF TAUNSA BARRAGE
IN
ISLAMIC REPUBLIC OF PAKISTAN

DECEMBER 2004

JAPAN INTERNATIONAL COOPERATION AGENCY
SANYU CONSULTANTS INC.
YACHIYO ENGINEERING CO.,LTD

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04-238

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Preface

In response to a request from the Government of Islamic Republic of Pakistan, the Government of Japan decided to conduct a basic design study on the Project for Rehabilitation of Gates of Taunsa Barrage and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Pakistan a study team from May 28th to July 19th, 2004.

The team held discussion with the officials concerned of the Government of Pakistan, 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 Pakistan in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project 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 Islamic Republic of Pakistan for their close cooperation extended to the teams.

December 2004

Kojima Seiji
Vice President
Japan International Cooperation Agency

December 2004

Letter of Transmittal

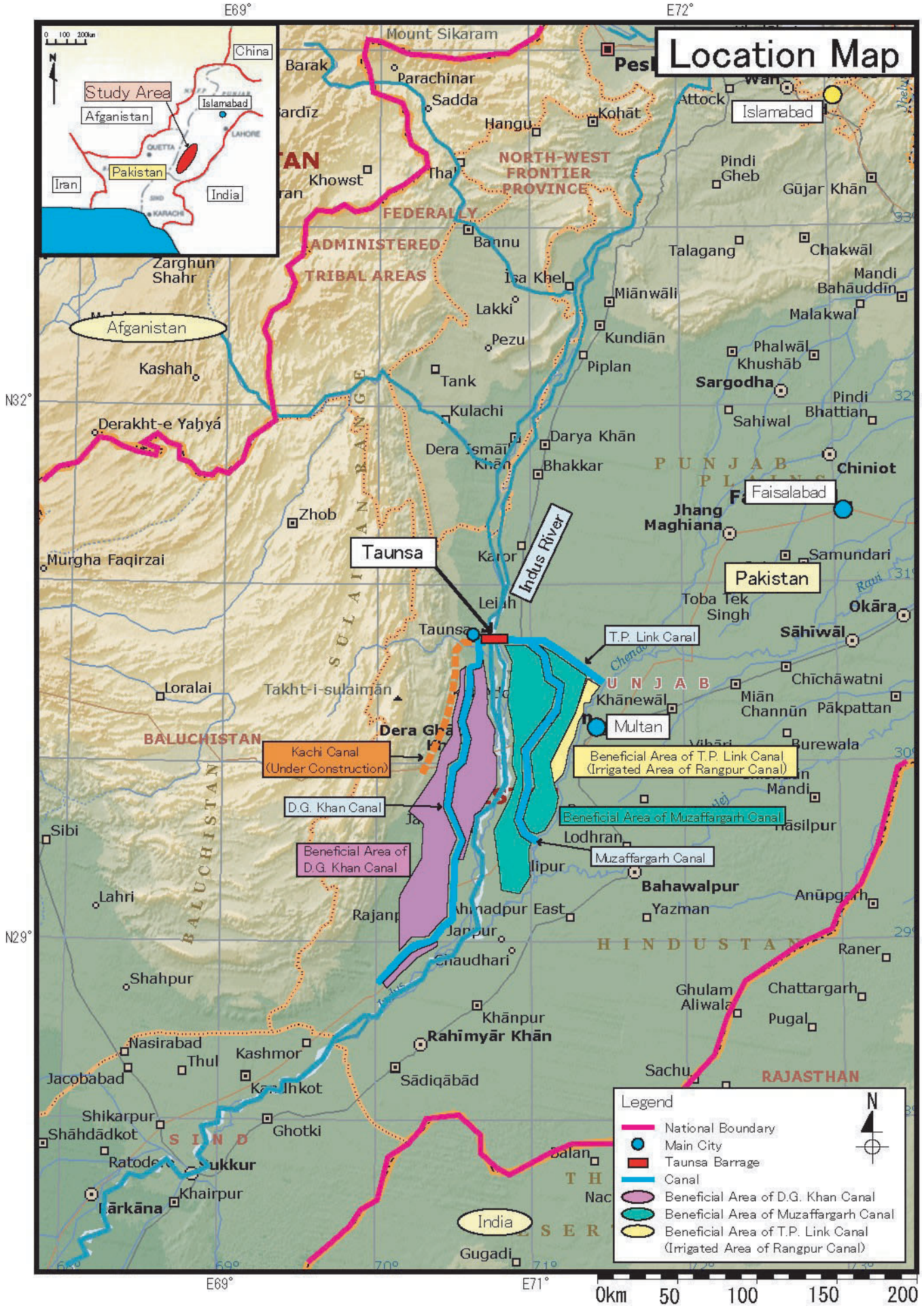
We are pleased to submit to you the basic design study report on the Project for Rehabilitation of Gates of Taunsa Barrage in Islamic Republic of Pakistan.

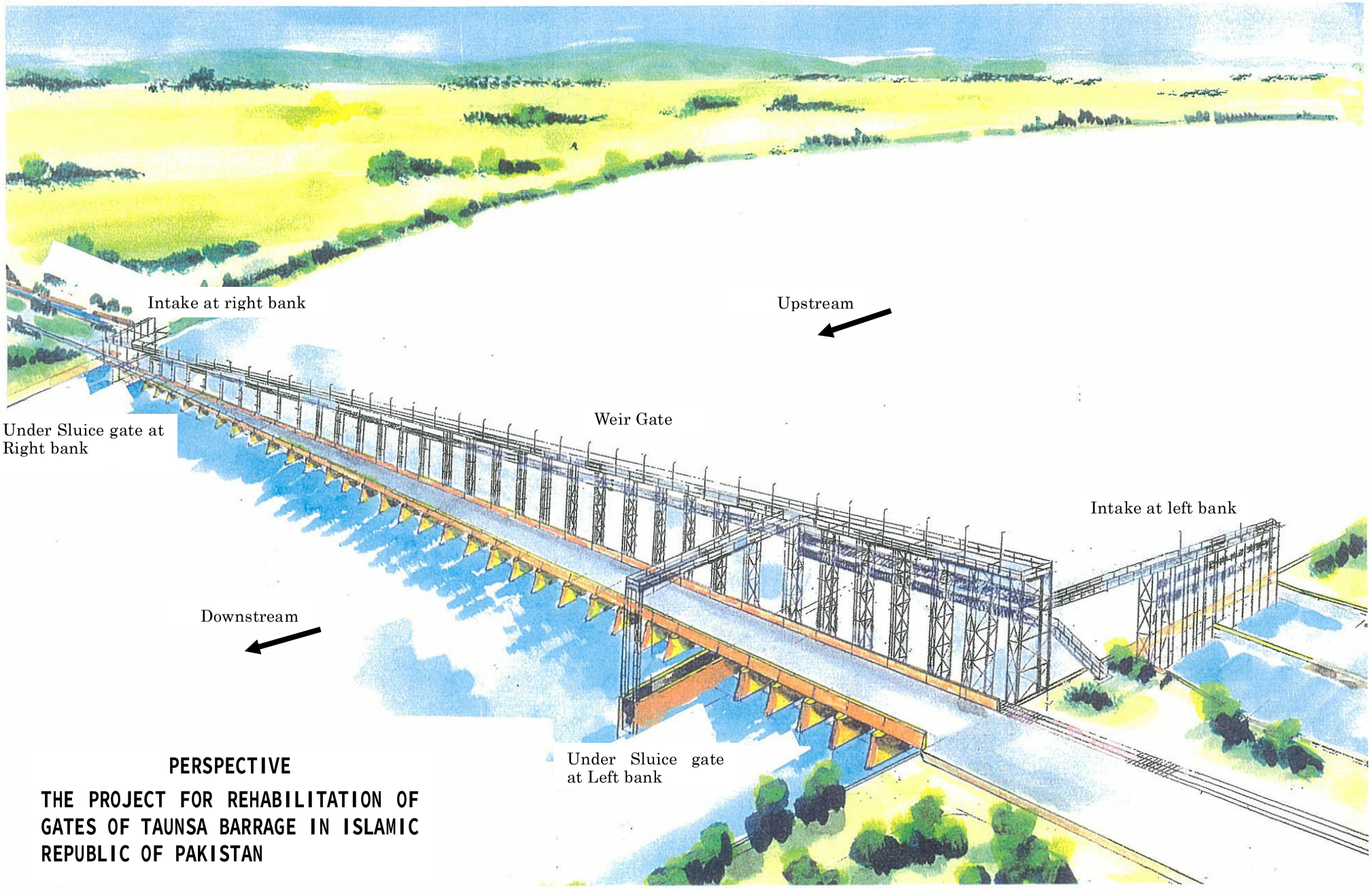
This study was conducted by the joint venture between Sanyu Consultants Inc. and Yachiyo Engineering Co.,Ltd, under a contract to JICA, during the period from May to December 2004. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Pakistan and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

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

Very truly yours,

Tatsuhiko Mori
Project manager,
Basic Design Study Team on the Project for Rehabilitation of Gates of Taunsa Barrage
Sanyu Consultants Inc.


Location Map
Study Area
Afganistan
Pakistan
Iran
China
India
Islamabad
Taunsa
Indus River
T.P. Link Canal
Kachi Canal
(Under Construction)
D.G. Khan Canal
Beneficial Area of
D.G. Khan Canal
Beneficial Area of T.P. Link Canal
(Irrigated Area of Rangpur Canal)
Beneficial Area of Muzaffargarh Canal
Muzaffargarh Canal
Multan
Bahawalpur
Rahimyār Khān
Sādiqābād
Khānpur
Sargodha
Faisalabad
Chiniot
Jhang
Maghiana
Mianwali
Bannu
Dera Ismāīl Khān
Darya Khān
Bhakkar
Kundiān
Piplan
Tank
Kulachi
Lakki
Pezu
Kohāt
Attock
Pindi Gheb
Gūjar Khān
Talagang
Chakwāl
Mandi Bahāuddīn
Malakwal
Phalwāl
Khushāb
Sahiwal
Pindi Bhattian
Samundari
Okāra
Sāhīwāl
Toba Tek Singh
Chīchāwatni
Miān Channūn
Pākpattan
Khānewāl
Burewala
Vihāri
Mandi
Hāsilpur
Lodhran
Yazman
Anūpgarh
Raner
Chattargarh
Pugal
Ghulam Aliwala
Sachu
Shahpur
Chaudhari
Jampur
Rajanpur
Khairpur
Ghotki
Shikarpur
Shāhdādkot
Jacobabad
Kashmor
Thul
Nasirabad
Sukkur
Lārkāna
Gugadi
Lahri
Sibi
Loralai
Takht-i-sulaimān
Zhob
Murgha Faqirzai
Derakht-e Yaḥyá
Kashah
Afganistan
Zarghun Shahr
Mount Sikaram
Barak
Parachinar
Sadda
Hangu
Khowst
NORTH-WEST FRONTIER PROVINCE
FEDERALLY ADMINISTERED TRIBAL AREAS
BALUCHISTAN
SULAIMAN RANGE
PUNJAB PLAINS
HINDUSTAN
RAJASTHAN
SIND
Legend
National Boundary
Main City
Taunsa Barrage
Canal
Beneficial Area of D.G. Khan Canal
Beneficial Area of Muzaffargarh Canal
Beneficial Area of T.P. Link Canal
(Irrigated Area of Rangpur Canal)
N
E69°
E72°
E71°
N32°
N29°
0km 50 100 150 200



PERSPECTIVE

THE PROJECT FOR REHABILITATION OF GATES OF TAUNSA BARRAGE IN ISLAMIC REPUBLIC OF PAKISTAN

Summary

Economy of Islamic Republic of Pakistan (Population 149,030 thousand, GNP 470 USD per Capita, in 2003) has been largely dependent on the agricultural sector with such dominant indexes of about 1/4 of GDP, about 1/2 of working population, etc. However, the agriculture sector is now in a very difficult and sensitive situation being subjected to problematic weather conditions affecting the area. The GDP of the country in 2000/01 came down due to severe drought that occurred in the country. Situation changed in 2003/2004 because the country's GDP was 6.4 percent higher than the government objective figures of 5.3 percent due mainly to the favorable conditions of the manufacturing sector, as well as the recovery of the agricultural sector.

However, economy of the country is still on the decline due to problems of debt repayment, and other medium and long-term problems such as delay of adequate privatization, stagnation of agricultural productivity, sluggish growth of export industry, etc. Major problems in the fields of irrigation and drainage are summarized in the issues of: a) shortage of water resources in accordance with population increase, b) lowering of irrigation efficiencies caused by the deterioration of provided irrigation systems, c) facility damages due to water-logging and salt, water contamination, lowering of ground-water table, flood, and; d) shortages of operation and maintenance (O&M) costs due to low recovery of water-charges, etc.

Of the agricultural infrastructures in the country, Irrigation systems play major role in the development of the agricultural economy. However, the irrigation systems in the country have been constructed more than 50 to 100 years ago. Due to its age, the irrigation systems now require large-scale rehabilitation and improvement. The Punjab Government conducted a survey in 1997/98 and results of survey revealed that six (6) out of 14 major barrages should urgently be rehabilitated. Especially, the Taunsa Barrage, that has been constructed more than 46 years ago, is considered to be severely deteriorated and was considered as top priority for rehabilitation among other barrages.

Also, based on the "Feasibility Study on Taunsa Barrage Irrigation Systems Rehabilitation", undertaken by the JICA Study Team in the same period of 1997/98 stated that the Taunsa Barrage should be urgently rehabilitated as its facilities are very deteriorated.

Details of the problems of the Taunsa Barrage are summarized below confirming the need for the urgent rehabilitation works of the related facilities;

1) Remarkable lessening function of gates operation due to deterioration of gate facilities, resulting in inadequate gate operation at flooding period and for diversion of irrigation water. Decrease in the function of gates can bring about ineffective gate operation for flood discharge, and the possibility of the Barrage to collapse in the future.

2) Occurrence of remarkable water leakage from gate structure due to lessening function of water-tightness of the gates.

3) Progress of the damages of apron and riprap structures due to lowering of the river-bed immediately downstream of the Barrage.

4) Shortages of irrigation water for DG Khan area due to development of sediment materials in the DG Khan Irrigation Canal at the right bank of the river, which is possibly caused by the shifting of water-route of the Indus River

The Pakistan Government has considered as most urgent 1), 2) and 4) out of the above mentioned problems and considered these as priority for improvement and requested to the Japanese Government the following works/equipment to be undertaken under the Japan Grant-Aid Program in July 2002, aiming at functional recovery of the Taunsa Barrage and improvement of future operation and maintenance activities.

a) Rehabilitation of 24 weir gates and replacement of 7 under sluice gates
b) Rehabilitation of 60 gate opening and closing devices (hoists) and electrification of 31 gates
c) Rehabilitation of 60 gate continual decks of superstructures
d) Procurement of 6 bulkhead gates*[1] using for coffering dam
e) Provision of one set of bulkhead gate stockyard and jetty for the gates
f) Procurement of construction equipment (one set of 80 ton and 30 ton cranes, 2 tugboats, 3 working boats, etc.) and spare-parts.

In response to the request made by the Pakistan Government, the Government of Japan dispatched the Preliminary Survey Team to Pakistan through the Japan International Cooperation Agency (JICA) during the periods of August to September 2003 and January 2004, to evaluate the urgency and adequacy of the request, and as a result decided to undertake the Basic Design of the Project under the Grant-Aid Program. JICA, furthermore, dispatched the Basic Design Study Team to Pakistan from May to July 2004, and conducted a series of discussion with the Pakistan Government agencies concerned and confirmation of the request contents. The Team conducted the survey on the current conditions of the Taunsa Barrage and irrigation areas covered by the Barrage, and also operation and maintenance organization, etc. As the results, gate facilities of the Taunsa Barrage were identified to be in serious conditions with lessening function due to the deteriorations of the facilities, hard to operate gates adequately under flooding period and also hard to supply stable irrigation water to the areas. Under the situations, it was proven that an urgent rehabilitation of the related Taunsa Barrage facilities is needed. Following these survey results, JICA dispatched the Draft Basic Design Explanation Team to Pakistan in September 2004 to discuss and confirm the basic design contents of the Project.

The Punjab Provincial Government, therefore, has the plan to provide and rehabilitate related facilities of the Taunsa Barrage, that includes the following: a) rehabilitation of gate leafs, b) rehabilitation of apron and riprap structures of the Barrage, c) rehabilitation of under sluice structure at the right bank, d) construction of new subsidiary weir at the immediate downstream of the Barrage, e) construction and

*[1] Floating type gates for the use of temporary coffering dam with water-tightness structures, and towed into the position by boats, and plunged/emerged by the operation of pumping and drainage devices.

rehabilitation of spur dikes at the upstream portion of the Barrage, etc. in the "Punjab Barrages Rehabilitation and Modernization Project".

As to the remaining rehabilitation works excluded from the Japan Grant-Aid program, the Government of Punjab now discussing with the World Bank and requesting financial assistance for the required loan to be needed.

In the Basic Design of the Project, the following basic rehabilitation plan has been formulated after due considerations of restoring of original form, functional recovery, improvement of operation and maintenance systems of the Taunsa Barrage, etc.

a) On the basis of study results made by the JICA Preliminary Survey Team and data of gate rehabilitation records conducted by the Punjab Provincial Government during past 5 years, regarding 22 weir gates, which were evaluated with high priority from view points of rehabilitation urgency, i) improvement of wheel portions, ii) partial improvement of vertical end girders and sill beams, and iii) heightening of gate height of one feet (0.31 m) would be undertaken.

   Furthermore, regarding 7 under sluice gates provided at the left bank, i) replacement of whole gate leafs, ii) improvement of sill beams, and iii) raising of gate height of one feet (0.31m) would be implemented. The purposes of raising intake water level of one feet height are to secure stable water supply to the DG Khan Irrigation Canals to restore original conditions, because the current DG Khan canal capacity was decreased by about 78 percent of the designed capacity due to severe deposit of diverted sediment materials in the canals. The raising gate crest of one foot was planned for 29 gates inclusive of weir gates and under sluice gates under the Grant-Aid Program. The implementation however of the other gates to cope with the raising water level would be undertaken by the Pakistan Government.

b) Regarding the improvement of gate hoists and rehabilitation of continual decks of superstructures, gate hoists for 7 under sluice gates and 22 weir gates would be improved with electrification to cope with a prompt response to meet river flooding speed.

c) In order to expect future improvement of an effective operation and maintenance works of the Barrage, 65 continual decks of superstructures will be improved from wooden-made decks to metal decks by grating structure, and 29 opening and closing devices were planned to be shifted to these decks considering their operability and easy operation and maintenance works.

d) Necessary bulkhead gate numbers were planned to be 5 gates, based upon the study results of the most optimal and economical number of gates considering the relationships between introduced numbers of gates and required construction periods, and also required numbers to carry out an adequate operation and as well as maintenance works of the Taunsa Barrage after implementation of the Project.

e) Provision of one set of bulkhead gate stockyard and jetty for the gates

f) Procurement of necessary construction equipment (1 unit of 50 ton crane, 2 units of tugboats, and 3 units of working boats) and their spare-parts.

Present maintenance and repair periods for gate leafs and Barrages are limited to only 20 days in January (considered as "Annual Closure Period"), witch would take place under no river flow conditions in the Indus River around the vicinity of the Barrage owing to coffering by the Chashma Barrage at the upstream. Under these conditions, it would be difficult to undertake a full-scale rehabilitation works of the Barrage within the limited period of time, so that the bulkhead gate systems to close the Barrages at an immediate upstream were proposed in the Project, in order to realize the implementation of necessary maintenance and rehabilitation works. These bulkhead gates would be used not only for the gate rehabilitation works in this Project, but also for similar rehabilitation works at other barrages in the Punjab Province. The scale and contents of the proposed facilities and equipment proposed by the Basic Design Study Team are summarized below.

Scale and Contents of Proposed Facilities and Equipment

Items	Project Scale and Contents
1. Replacement of Left Bank Under Sluice Gate	Type : Single gate type (steel plate guider structure) Scale : Clear span 60 ft x gate leaf height 23 ft x 7 gates (not including 4 under sluice gates at right bank) Replaced Parts : Gate leaf and water-tightness structure, and sill beams (for 7 gates) Improved Parts : Side flame and roller parts
2. Improvement of Related Facilities of Weir Gate	Type : Single gate type (steel plate guider structure) Scale : Clear span 60 ft x gate leaf height 20 ft x 22 gates (total gate numbers: 53 gates) Replaced Parts : Gate leaf and water-tightness structure, and sill beams (for 22 gates) Improved Parts : Raising sill structure, gate leaf vertical end girder, wheel portions, and water-tightness (22 gates)
3. Replacement and Improvement of Gate Hoists	Type : One motor, two drums, electric wire rope winch type Operation Method : Operated from motor side only (Local Control) Number : Under sluice gate : 7 units (7 gates), and weir gate: 22 units (22 gates) Head : Under sluice gate: 32 ft (9.75 m) and weir gate : 29 ft (8.84 m)
4. Electrification of Gate Hoists	Motor Type : Totally enclosed fan-cooled outdoor motor Motor : Under sluice gate : 2.2 kw 6 P continuous rating, Weir gate : 1.5 kw 6 P continuous rating Power Source : 3 phase AC 50 Hz 400 V Number : 29 units (under sluice gate: 7 units, and weir gate: 22 units)
5. Rehabilitation of Continual Decks of Superstructures	Type : Grating type Scale : Total length 4,342 ft x width 10 ft, total number : 65 gates
6. Procurement of Bulkhead Gates for Temporary Coffering Dam	Type : Steel floating gate Scale : Clear span 60 ft x gate leaf height 25.26 ft x 5 gates Diversion to Others : Possible to divert to other barrages
7. Provision of Bulkhead Gated Stockyard and Its Jetty	Scale : 14,400 m^2 (length 150 m x width 90 m) Incline Facility : Rail length 427 ft slope 1/10, winch motor output 5.5 kw x speed 1.0 m/sec Jetty : Dry masonry revetment
8. Procurement of required Construction Equipment	Truck crane : 50 ton class truck crane Tugboats : Horse power 150 ps x 2 boats Working Boats : Length 8.5 m x width 2.3 m x height 0.8 m x 73 ps x 3 boats
9. Procurement of required Spare-parts for Construction Equipment	Spar-parts required for 3 years of construction periods

The proposed Project implementation period is 50.0 month, with 5.5 month for detailed design and 44.5 months for manufacturing /procurement and rehabilitation. The preliminary project costs were estimated at 5,469 million Japanese Yen (Japanese Yen portion of 5,281 million Yen and Pakistan portion of 188 million Yen).

With the implementation of the Project, the following project benefits could be expected.

a) Direct Benefits

Reservation of Stable Irrigation Water

The rehabilitation works for the Taunsa Barrage that will be implemented under the Japan Grant-Aid Program for 29 gates, and the gate leaf raising works with one feet height that will be implemented by the Pakistan Government for the remaining gates is expected to bring back the original amounts of diverted irrigation water in the Taunsa Irrigation System. This will therefore make possible the supply of stable irrigation water to the areas.

- DG Khan Irrigation Canal diverted from the Taunsa Barrage at the right bank of the Indus River is taking irrigation water of reduced amounts of 9,047 ft^3/sec (256 m^3/sec) due to the sediment materials in the Canal. However theses amounts will be increased to 11,564 ft^3/sec (327 m^3/sec) *[2] after the implementation of the project.

- Canal capacity of Muzaffargah Irrigation Canal diverted from the Taunsa Barrage at the left bank is expected increase to 8,300 ft^3/sec (235 m^3/sec)*[2]. The present capacity is only 7,476 ft^3/sec (2,125 m^3/sec).

Improvement of Gate Operation Speed by Gate Electrification and Reduction of Flood Damages

Required gate operation speed to meet flowing down of flood discharges safely would be secured by the electrification of the gate hoisting devices. Gate operation speed at the conditions of present and after project implementation could be assessed as shown below, based on the past maximum flood discharges that occurred in September 14, 1992.

- Required gate operation speed could be calculated at 0.16 m/minute for the initial stage of flooding and 0.27 m/minute for the final stage of flooding.

- Present gate operation speed made by manual operation is 0.05 m/minute for gate rising case, and 0.10 m/minute for gate lowering case, and these speeds could not respond to the flood occurring speed.

- Gate operation speed after the project implementation would be 0.30 m/minute for both gate rising and lowering cases, and these speeds can respond to the flood occurring speed.

*[2] The canal capacity of 11,564 ft^3/sec and 8,300 ft^3/sec indicate the water right at the sites.

Safety Improvement with Well-Maintenance of Barrage

After the implementation of the Taunsa Barrage the safety of the facilities is assured as the introduction of bulkheads will enable that periodical operation and maintenance works will be done at the most efficient and appropriate period of time. The present gate maintenance and rehabilitation works is being done within the limited period of 20 days in January, (during the "Annual Closer Period"). Under these conditions, it would be difficult to do full-scale rehabilitation works of the Barrage within the very limited period of time.

b) Indirect Benefits

Usages of Bulkhead Gates at Other Rehabilitation Works of Barrages

Bulkhead gates introduced in the Project can also be used for the rehabilitation works of other barrages such as Jinnah and Trimmu Barrages contributing to the reduction of required working period and costs.

Holding of Social Lifeline Functions

The Taunsa Barrage is presently equipped with other important function beside the irrigation purpose, that is, functions of road bridge, railway bridge, oil and gas-pipelines, electricity and communication lines, etc. The presence of security measures/facilities of the Taunsa Barrage will bring about a sense of peace and security to the people working/involved in the O&M of the facility. These may bring about more time for social life activities and functions due to the assurance that the facility is safe.

Future management and operation and maintenance (O&M) works of the project facilities are planned to be undertaken continuously by the Taunsa Barrage Division (TBD) under Irrigation and Power Department, the Government of Punjab, which has a enough experiences and actual performances on the management and O&M works of the Taunsa Barrage for the past 50 years. In the Project new facilities and equipment will be provided namely 5 bulkhead gates, incline facilities for usages of bulkhead gates, tugboats, cranes, etc. The required staff to maintain these facilities and equipment could taken/tapped from the present number of the TBD staff with minor changes in the working positions of staff and/or introduction of on-the-job-training (OJT) systems.

Required O&M costs after project implementation will slightly increased as compared to the present because of the introduction of bulkhead gates and other equipment. The incremental rates are estimated at 2 percent of the mean annual O&M costs of the TBD Office for past 10 years.

From the environmental view point, it was assessed that the implementation of the project will not have any negative impacts around the vicinity of the project area. The Environmental Conservation Division in the Punjab Provincial Government approved the implementation of the project in September 6, 2004 based on the provisions of the environmental impact assessment (EIA) and other necessary environmental procedures adopted in Pakistan.

Based on the series of presentations mentioned above, the project is found to be viable and recommended for possible Japan Grant-Aid Program project. Finally, it is also recommended that "Punjab Barrages Rehabilitation and Modernization Project" proposed by the Government of Pakistan with possible financial assistance from the World Bank be also implemented to effectively support and complement this Project proposed under Japan Grant Aid Programme. The implementation of the two projects (under Japan Grant Aid Programme and Under the World Bank Loan programme) will bring about smooth and effective operations as well as security of Taunsa Barrage Irrigation Facility. This will also bring about improvement of the social and economic condition and well being of the farmers and other residents of the Project area and its surrounding areas.

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[Appendices]

Lists of Figures and Tables

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Abbreviations

Abbreviations

ADB	Asian Development Bank
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BHG	Bulkhead Gate
CTBT	Comprehensive Test Ban Treaty
DAU	Data Acquisition Unit
D.G.Khan	Dera Ghazi Khan
D/S	Downstream
ECNEC	Executive Committee of National Economic Council
EIA	Environment Impact Assessment
EPA	Environment Protection Agency
F-PRSP	Full-Poverty Reduction Strategy Paper
GDP	Gross Domestic Product
GOP	Government of the Punjab
GPS	Gate Positioning Sensor
IEE	Initial Environment Examination
IPD	Irrigation and Power Department
I-PRSP	Interim-Poverty Reduction Strategy Paper
IRSA	Indus River System Authority
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
MOAF	Ministry of Agriculture, Forestry and Fisheries of Japan
NPV	Net Present Value
NWFP	North West Frontier Province
TBD	Taunsa Barrage Division
T.P.Limk Canal	Taunsa-Panjinad Link Canal
U/S	Upstream
WAA	Water Apportionment Accord
WAPDA	Water and Power Development Authority
WB	World Bank

Glossary

Annual Closure	The period for around 20 days in January every year in which water diversion to canals from barrage is suspended.
Kharif	Summer cropping season from April 15th to October 15th
Rabi	Winter cropping season from October 16th to April 14th

Currency

Rs	Pakistan Rupee(s)
Yen or J¥	Japanese Yen
USD or US$	US Dollar

Exchange Rate（August 2004）

Rs	= ¥ 1.90
US$	= ¥109.51

Units

mm	millimeter	cusec	cubic feet per second
cm	centimeter	MCM	million cubic meter
m	meter	MAF	million acre feet
km	kilometer	kg	kilogram
ft	feet	t (ton)	ton
sq.m (m^2)	square meter	A	ampere
sq.km (km^2)	square kilometer	V	voltage
acre	acre	KW	Kilowatt
ha	hectare	MW	Megawatt
m/s (m/s)	meter per second	KVA	Kilovolt ampere
m^3/s (m^3/sec)	cubic meter per second	N	Newton
cu.m (m^3)	cubic meter	KN	Kilo-Newton
min	minute	M/M	Man-month
hr	hour	RD	Reduced distance
ft^3/sec (CS)	cubic feet per second	RL	Relative level

Chapter 1 Background of the Project

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1-1 Background and Outline of the Project

Economy of Islamic Republic of Pakistan (Population 149,030 thousand, GNP 470 USD per Capita, in 2003) has been largely dependent on the agricultural sector with such dominant indexes of about 1/4 of GDP, about 1/2 of working population, etc. However, the agriculture sector is now in a very difficult and sensitive situation being subjected to problematic weather conditions affecting the area. The GDP of the country in 2000/01 came down due to severe drought that occurred in the country. Situation changed in 2003/2004 because the country's GDP was 6.4 percent higher than the government objective figures of 5.3 percent due mainly to the favorable conditions of the manufacturing sector, as well as the recovery of the agricultural sector.

However, economy of the country is still on the decline due to problems of debt repayment, and other medium and long-term problems such as delay of adequate privatization, stagnation of agricultural productivity, sluggish growth of export industry, etc. Major problems in the fields of irrigation and drainage are summarized in the issues of: a) shortage of water resources in accordance with population increase, b) lowering of irrigation efficiencies caused by the deterioration of provided irrigation systems, c) facility damages due to water-logging and salt, water contamination, lowering of ground-water table, flood, and; d) shortages of operation and maintenance (O&M) costs due to low recovery of water-charges, etc.

Of the agricultural infrastructures in the country, Irrigation systems play major role in the development of the agricultural economy. However, the irrigation systems in the country have been constructed more than 50 to 100 years ago. Due to its age, the irrigation systems now require large-scale rehabilitation and improvement. The Punjab Government conducted a survey in 1997/98 and results of survey revealed that six (6) out of 14 major barrages should urgently be rehabilitated. Especially, the Taunsa Barrage, that has been constructed more than 46 years ago, is considered to be severely deteriorated and was considered as top priority for rehabilitation among other barrages.

Also, based on the "Feasibility Study on Taunsa Barrage Irrigation Systems Rehabilitation", undertaken by the JICA Study Team in the same period of 1997/98 stated that the Taunsa Barrage should be urgently rehabilitated as its facilities are very deteriorated. As a result, the Pakistan Government requested to the Japanese Government the implementation of the Taunsa Barrage rehabilitation project under the Grant-Aid Program in July 2002, aiming at functional recovery of the Taunsa Barrage and improvement of future operation and maintenance activates.

In response to the request made by the Pakistan Government, the Government of Japan dispatched the Preliminary Survey Team to Pakistan through the Japan International Cooperation Agency (JICA) during the period of August to September 2003, to evaluate the urgency and adequacy of the request, and as a result decided to undertake the Basic Design of the Project under the Grant-Aid Program. JICA, furthermore, dispatched the Basic Design Team to Pakistan from May to July 2004. The Project was

named " The Basic Design Study on the Project for Rehabilitation of Gates of Taunsa Barrages".

The Government of Punjab has submitted "the PC-1 PROFOMA" to the Government of Pakistan for approval. "Taunsa Barrages Irrigation System Rehabilitation Project" was finally approved for implementation on April 23, 2003.

1-2 Main Components Requested

The main components requested by the government of Pakistan are as follows;

Table 1-2.1 Main Components Requested

No	Type of Work	Application by the Government of Pakistan	Proposal in the Preliminary Survey （Alternative 1）
1	Replacement of the under sluice gate at left bank	7gates	7gates
2	Rehabilitation of the weir gate facilities	24gates	24gates
3	Replacement of old-type gate hoist to new type and rehabilitation	60gates under sluice gate：7gates, weir gate ：53gates	31gates under sluice gate：7gates, weir gate ：24gates
4	Electrification of gate hoist	31gates under sluice gate：7gates, weir gate ：24gates	31gates under sluice gate：7gates, weir gate ：24gates
5	Rehabilitation of deck on superstructure	60gates under sluice gate：7gates, weir gate ：53gates	65gates under sluice gate：11gates, weir gate ：53gates, navigation lock ：1gate
6	Provision of bulkhead gate for temporary cofferdam works	6gates	6gates
7	Construction of stockyard for bulkhead gate and slope protection works for loading way	1set	1set
8	Procurement of construction machinery	1set	1set
9	Procurement of Spare parts for item 8	1set	1set

Note: Alternative 1 : proposed by the Preparatory Study Team (preliminary Survey) as the most suitable plan

Chapter 2 Contents of the Project

Chapter 2. Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Purpose

Details of current problems of the Taunsa Barrage could be summarized as follows, and urgent rehabilitation works of the related facilities are essential and prerequisite in order to secure stable irrigation water supply, adequate operation of irrigation systems, etc.

1) Remarkable lessening function of gate operation due to deterioration of gate facilities, resulting in inadequate gate operation at flooding period and for diversion of irrigation water. Increase of inoperative gates would bring about an ineffective gate operation for flood discharge, and there would be fear that Barrage itself would be collapsed in future.
2) Occurring remarkable water leakage from gate structure due to lessening function of water-tightness of the gates.
3) Progress of the damages of apron and riprap structures due to lowering the river-bed immediate downstream of the Barrage.
4) Shortages of irrigation water for DG Khan areas due to development of sediment materials in the DG Khan Irrigation Canal on right bank of the river, which would be caused by shifting water-route of the Indus river

The Punjab Provincial Government, therefore, has the plan of newly provision and rehabilitation works for the related Taunsa Barrage facilities, that is;

a) Rehabilitation of gate leaves,
b) Rehabilitation of apron and riprap structures of the Barrage,
c) Rehabilitation of under sluice structure at the right bank,
d) Newly construction of subsidiary weir immediate downstream of the Barrage,
e) Newly construction and rehabilitation of spur dikes at the upstream portion of the Barrage, etc.

The Pakistan Government put a prioritization for improvement of the Taunsa Barrage as mentioned below, considering the most urgent solution against the problems of 1), 2) and 4) out of the above mentioned problems, and requested to the Japanese Government as the Grant Aid-program.

a) Rehabilitation of 24 weir gates and replacement of 7 under sluice gates
b) Rehabilitation of 60 gate opening and closing devices (hoists) and electrification of 31 gates
c) Rehabilitation of 60 gate continual decks of superstructures
d) Procurement of 6 bulkhead gates[1] using for coffering dam

[1] Floating type gates for the use of temporary coffering dam with water-tightness structures, and towed into the position by boats, and plunged/emerged by the operation of pumping and drainage devices.

e) Provision of one set of bulkhead gate stockyard and jetty for the gates

f) Procurement of construction equipment (one set of 80 ton and 30 ton cranes, 2 tugboats, 3 working boats, etc.) and spar-parts.

Regarding the remaining rehabilitation works excluded from the Japan Grant-Aid program, the Punjab Provincial Government is under discussion with the World Bank for their financial assistances to be needed.

With the implementation of the Grant Aid Project, the function of the Taunsa barrage will be improved and the following effectiveness will be expected.

① The flood will be discharged safely to the downstream area.

② Stability of weir and safety against piping under weir will be secured by appropriately maintaining water level of barrage upstream appropriately.

③ Water intake (diversion) will be stabilized by appropriately maintaining upstream water level.

Furthermore, it is expected that these improvement mentioned above will contribute to the stabilization of the regional agricultural production as the overall goal.

2-1-2 Outline of the Project

The existing Taunsa barrage is equipped with vertical lift Stoney (free roller) type gate with truss steel structure composed of 7 units left Under Sluice Gate (two leaves gate), 53 units Weir Gate, 4 units right Under Sluice Gate (two leaves gate) and others. The gate facilities constructed about 45 years ago are now deteriorated. To restore the functions of the deteriorated gate facilities, rehabilitation works and replacement are proposed to be undertaken, as follows;

- Replacement of 7 units of under sluice gate
- Rehabilitation of 22 units of weir gates
- Replacement and electrification of 29 units gate hoists
- Rehabilitation of 65 bays deck structure

At present, maintenance or repair works of the gates and barrage structure are insufficiently being undertaken for a limited period of annual closure usually in January for 20days. During this period, intake of irrigation water is suspended to undertake rehabilitation work. But, it is too short to conduct the rehabilitation works radically. Therefore, to improve maintenance work and to be able to undertake adequate maintenance work at any given period of time the following gate facilities for cofferdam will be introduced to the Taunsa barrage.

- Provision of 5 units Bulk Head Gate
- Provision of Bulk Head Gate Stockyard with equipment, boats and a crane

In addition, the Bulk Head Gate will be so designed so as to be able to apply the facility to other barrages in Punjab province, where rehabilitation is planned to be also undertaken in succession to the

Taunsa barrage.

This Grant Aid Project will mainly consider improvement of gate facilities of the Taunsa barrage that are mostly problem-ridden. On the other hand, the Government of Punjab has commenced the feasibility study (hereinafter referred to as "Punjab F/S") regarding the civil and hydraulic structures of Taunsa barrage under "Punjab Barrages Rehabilitation and Modernization Project". The result of the feasibility study stressed the need for the implementation of the reinforcement work without delay for civil and hydraulic structures to ensure safety and stability of the barrage.

The Government of Punjab has also requested financial assistance from the World Bank. The World Bank assistance will cover the works what is excluded from the scope of Japan's Grant Aid Project, i.e. ① structural improvement of barrage, ② rehabilitation and modernization (electrification) of gate facilities that are excluded from Japan's Grant Aid Project, and ③ technical support.
Thus, both projects will complement one another to recover function of the barrage which affects socio economy and environment greatly.

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

Basic policies that will be applied to the basic design of the Grant Aid Project will be as follows;

① The scope of grant aid will be studied based on the "Alternative Plan 1" proposed in the preliminary survey (refer to the Section 1-2),

② In the rehabilitation project by the grant aid, priority will be given to the subjects that need urgent improvement and advanced technologies,

③ The Government of Pakistan will rehabilitate remaining facilitates of the Taunsa barrage excluded from the scope of Japanese grant aid project successively in the Taunsa Barrage Rehabilitation and Modernization Project planned by Pakistan side,

④ The optimum rehabilitation plan for gates will be designed based on the design standard of Japan and taking into consideration current capability of engineers of the executing agency of Pakistan.

⑤ Office of Taunsa Barrage Division of the Irrigation and Power Department of Punjab Province shall operate and maintain facilities and equipment that will be rehabilitated under the Japanese grant aid,

⑥ As the project requires high urgency, rehabilitation works shall be commenced as early as possible.

⑦ As to gate roller type, Stoney type roller gate will be employed as with the present one.

⑧ Gate height will be heightened for one foot in order to raise up water level of the Taunsa Barrage to restore the original design intake discharge for irrigation canals.

⑨ The gates subject to be studied for rehabilitation plan will be seven (7) under sluice gates at left bank and the weir gates except No. 59, 60 and 61 at right bank. No. 59, 60 and 61 gates of weir gate and four (4) gates of under sluice gate at right bank shall be improved by Pakistan side in relation to the Kacchi Canal Project. The other existing head regulating gates will not be subjected to rehabilitation works since these are still in good condition and are still functioning well,

⑩ With regards to temporary cofferdam method at upstream necessary for gate rehabilitation, the Balk Head Gate will be selected taking into consideration adjustability, water tightness and economical efficiency,

⑪ The Bulkhead gates will be planned to be reused in other barrages in Punjab other than Taunsa Barrage,

⑫ The Bulkhead gate stockyard will be constructed at the left bank at about 450m upstream of the Taunsa Barrage,

⑬ The gate hoist and superstructure will be improved and modernized,

⑭ Annual closure period will be planned for 30 days for the project during the month of January,

⑮ Since the project being implemented by the Government of Pakistan and the Japan Grant Aid project complement one another, there is a need for coordination between the two with regards to facility design, procedure and construction schedule,

⑯ The grant aid project shall be planned so as not to affect surrounding environment and operation of

irrigation water intake at the barrage,

⑰ Through reviewing survey results on O & M of the hydraulic facilities of Taunsa Barrage, appropriate plans for improvement will be also proposed in relation with facilities to be rehabilitated by grant aid, if necessary,

⑱ Technical suggestions will be proposed if necessary through review of the Punjab F/S results conducted by Pakistan side.

2-2-1-2 Natural Conditions

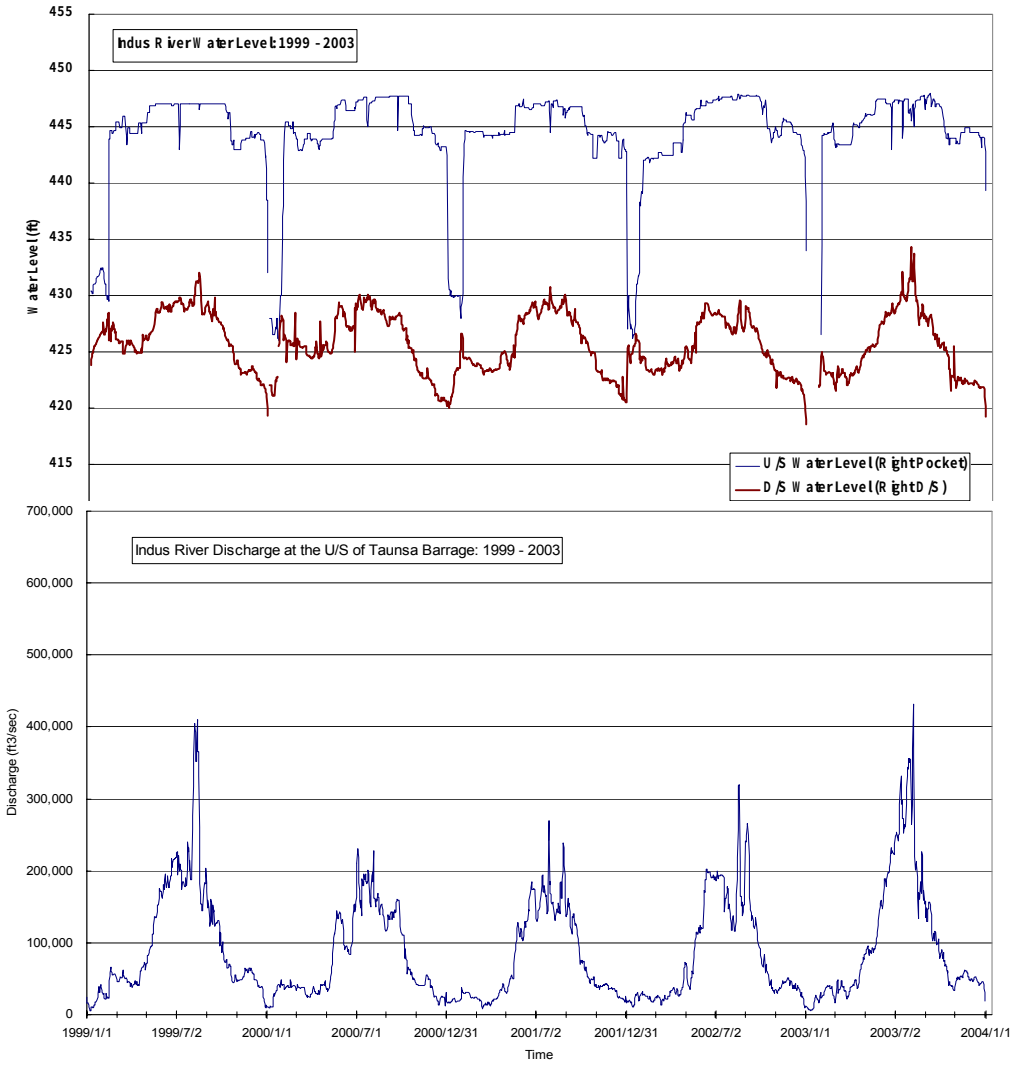


Figure 2-2-1.1 Water Level between Up and Downstream, and Discharge at Upstream of Taunsa Barrage

Design policies considering natural conditions are as follows;

- Annual total rainfall over 10 years at Taunsa Barrage is not much ranging only from 35mm to 488mm, involving only slight damage to steel structures. Therefore the facilities that will be designed will consider one that is appropriate to the characteristics of the rainfall,
- Facilities will be designed accordingly taken into account characteristics of temperature at Multan

city nearby Taunsa Barrage, where 42.3 ℃ is considered highest average on June and 4.5 ℃ is considered as lowest in January,

- Countermeasure for acid rain and saline water, which affect seriously steel structures, will not be considered since these are not identified around Taunsa Barrage,
- Facilities will be designed in accordance with characteristics of water level and discharge over five (5) years as shown in Figure 2-2-1.1. These graphs show water level between up and downstream and discharge at upstream.

2-2-1-3 Soil Mechanical and Geological Conditions

Geology around Taunsa Barrage site is formed with alluvial deposits inclusive of fine and coarse sand, and holds a lot of lime. Part of the areas (in the vicinity of the proposed site of Kachhi Irrigation Canal) located in the western part of the site, has a relatively soft clayey soils, which is easily cracked when dried in dry season.

(1) Geological Features of Foundation Ground

The geological foundation and soil mechanic conditions around the Taunsa Barrage, has been described in detail in the JICA Report, " Feasibility Study on Taunsa Barrage Irrigation System Rehabilitation" prepared in August 1998. The summary of the report is presented below, as follows.

① Bed slope of the Indus River around the Taunsa Barrage site ranges from 1/5,000 to 1/10,000 at present. The width of the Indus River in the vicinity of the site before the Barrage construction would be about 13 km for high-flood channel, and it could be supposed that the river course and formulated sand bar would be meandered and shifted repeatedly by each big flood occurred within this river width. When considered current River characteristics of the mean annual maximum flood of 13,000 m^3/sec (460,000 ft^3/sec), average bed slope of 1/5,000, low-flood channel width of 2 to 3 km, etc., it could be assumed that sand deposit with fine sand could easily observed.

② According to the results of boring investigation, foundation of barrage site is formed by alluvial deposits with almost uniform fine sand in the depth of about 40 m. Particle size distribution of the foundation materials is; 3-16% for 0.9-0.3 mm, 84-92% for 0.15-0.3 mm, and 1-10 % for below 0.15 mm. Similar distributions of particle side could be observed at other investigated sites. Permeability is estimated at (1-2) x 10^{-2} cm/sec based on the above particle size distribution.

③ N-values of foundation differ from site to site, but in general, the larger values are observed in accordance with the deeper depth. The N-values in the ranges of ground surface (elevation of 134-140 m, equivalent to 440-459 ft) to 5m in depth is partially less than 15, and larger N-values of 15-30 are observed at deeper layer of 5-10 m. At the depth of more than 15 m, bigger N-values more than 50 are observed.

④ Long-term allowable bearing capacity of the foundation will be set as shown below.

·River bet at the elevation of around 130 m (425t ft) : 15 ft/m^2

·Foundation at the elevation of 125 m (410 ft) : 30 ft/m^2

·Bearing stratum at the elevation of 120 m (395 ft) : 50 ft/m^2

(2) Soil Mechanic Conditions

Soil mechanic conditions (sandy soil at Indus alluvial deposits : R.L. 395 ft-410 ft (EL. 120 m-125 m) for designing Taunsa Barrage facilities is described below, based on the geological features of the foundation conditions.

① Unit Weight of Soil

Unit weight of soil for sandy layer is around 1.8 t/m^3 at natural conditions, so that unit weights of soil at different conditions are assumed as;

·Dry condition soil : 1.6 t/m^3

·Wet condition soil : 1.8 t/m^3

·Submerged soil : 2.0 t/m^3

② Internal Friction Angle of Soil

Considering the N-values of 15-30 for sandy layer , internal friction angle of soil is assumed as follows on the basis of equation of $\phi = \sqrt{15 \cdot N} + 15$.

·Mean N-value : N = 15

·Internal friction angle : $\phi = \sqrt{15 \times 15} + 15 = 30°$

③ Cohesion of Soil

Cohesion of soil for sandy layer is negligible; therefore no cohesion of soil is taken into account in the design.

·Cohesion of soil : C = 0 kgf/cm^2

2-2-1-4 Rehabilitation of Under Sluice Gate and Weir Gate

(1) Number of Gate Leaf of Under Sluice Gates

① Design Conditions for Under Sluice Gates

The design conditions for under sluice gates are described below.

1) Type of Gate

The type of the existing under sluice gates is “a steel truss roller gate”. When the total rehabilitation of the gates is planned, however, “steel plate girder roller gates” will be adopted due to the following reasons (refer to Table 2-2-1.1).

- When the Taunsa Barrage was originally constructed some 50 years ago, rivet joints were mainly used because of unreliability regarding the quality and manufacturing technology of steel. The steel truss roller type was adopted for long-span gates because the structure was easy to assemble using rivet joints.

- However, compared to a plate girder structure, the truss structure has a disadvantage as it has a tendency towards a heavier gate leaf weight and difficulty of repainting as part of maintenance work because of the large number of members.

- In recent years, the improved steel and steel plate manufacturing technologies possessed by mill makers means that it is easier to manufacture wide steel plates. Together with improved welding technologies, it has become easier and less costly to produce a plate girder structure which is easy to repaint. Steel girder roller gates are, therefore, commonly adopted as the type for under sluice gates nowadays.

- Compared to a steel girder structure, a truss structure is very complicated, requiring higher precision for manufacture, transportation and installation, resulting to higher cost.

2) Number of Gates

Seven (7) under sluice gates will be installed at the left bank.

3) Clear Span

Because of the use of the existing barrage piers, the clear span will be the same as the existing clear span of 60 feet (= 18.288 m).

4) Gate Sill Elevation

The gate sill elevation is RL. 425.00 feet

5) Elevation of Gate Crest and Gate Height

The normal maximum water level planned under the "Punjab Barrages Rehabilitation and Modernisation Project" by Punjab Province is 447 feet. Taking into consideration design freeboard of 1 foot for the gate, the elevation of the gate crest and gate height will be as described below.

- Elevation of the gate crest = normal maximum water level (RL. 447.00 feet)
  + design freeboard (1.00 feet) = RL. 448.00 feet

- Gate height = elevation of the gate crest (RL. 448.00 feet) – sill elevation (RL. 425.00 feet)
  = 23.00 feet (= 7.01 m)

6) Design Water Level and Design Water Head

- Design water level (upstream side) = elevation of the gate crest RL. 448.00 feet

- Design water level (downstream side) = sill elevation RL. 425.00 feet
- Design water head (upstream side) = design water level (RL. 448.00 feet)
  - sill elevation (RL. 425.00 feet)
  = 23.00 feet (= 7.01 m)
- Design water head (downstream side) = design water level (RL. 425.00 feet)
  - sill elevation (RL. 425.00 feet)
  = 0.00 feet (= 0.00 m)

7) Operating Water Level and Operating Water Head

- Operating water level (upstream side) = elevation of the gate crest RL. 448.00 feet
- Operating water level (downstream side) = sill elevation RL. 425.00 feet
- Operating water head (upstream side) = operating water level (RL. 448.00 feet)
  - sill elevation (RL. 425.00 feet)
  = 23.00 feet (= 7.01 m)
- Operating water head (downstream side) = operating water level (RL. 425.00 feet)
  - sill elevation (RL. 425.00 feet)
  = 0.00 feet (= 0.00 m)

8) Design Sedimentation Depth

The sedimentation depth in front of the gate, considering existing conditions, will be as follows.

- Design sedimentation depth = sedimentation elevation (RL. 431.00 feet)
  - sill elevation (RL. 425.00 feet)
  = 6.00 feet (= 1.83 m)

9) Watertight Method

- Watertight method: watertight on three sides by the front using rubber

10) Hoist

In the case of the existing under sluice gates, the “one motor, two drum, wire rope winch system” will be employed due to the continual deck shape of the superstructure of the present barrage. This “one motor, two drum, wire rope winch system” will also be used as the hoisting system for the under sluice gates to be rehabilitated because of its simple and economical mechanism.

11) Operating Method

Electrified gates will be controlled on the motor side (local control panel) in consideration of safe gate operation. However, manual operation may also be conducted as a backup mode of operation in case of

failure of electric operation due to breakdown of the motor or any other reason.

12) Operating Speed

The operating speed of the existing gates (0.05 m/min) is not fast enough to efficiently operate the gates at the time of flooding. An operating speed of 1 foot/min (= 0.30 m/min) will, therefore, be adopted in accordance with the relevant design standard used by the "Punjab Barrages Rehabilitation and Modernisation Project" by Punjab Province.

13) Lifting Height

The lifting height for the gates will be as follows.

- Lifting height of the gate = elevation at the lower end when lift up (RL. 457.00 feet)
  – sill elevation (RL. 425.00 feet)
  = 32.00 feet (= 9.75 m)

14) Allowable Stress and Allowable Deflection

The Technical Standards for Steel Water Gates Gate and Penstocks established by Hydraulic Gate and Penstock Association of Japan will be used to determine these values.

The above standard provides that the allowable deflection is less than 1/800 of the gate span in case of gate with 20m to 30m of span, however, 1/600 of span is applied to the gates of Taunsa Barrage as the allowable deflection taking into consideration the present gate span of 18m, that would gives the gates almost equivalent deflection and stress as well as water-tightness based on the following calculation.

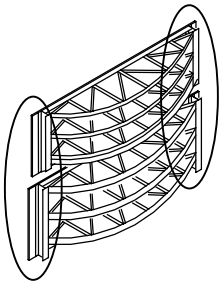
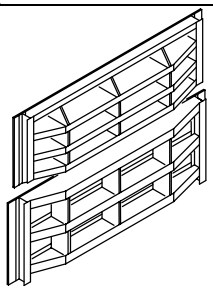
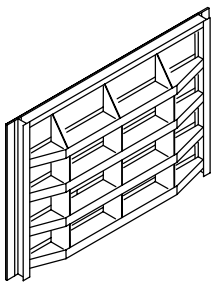
(25m/18m) x (1/800) = 1/600

② Rehabilitation Methods for Under Sluice Gates

The following three rehabilitation methods have been compared to determine the best method in consideration of the study findings such as the situation of leakage and frequency of use, both of which were confirmed during the latest survey.

① Partial rehabilitation of double gates type
② Total rehabilitation of double gates type (replacement)
③ Remodelling to single gate type

Table 2-2-1.1 Under Sluice Gates Rehabilitation Methods

Descriptions	① Partial Rehabilitation of Double Gates Type (Steel Truss Structure)	② Total Rehabilitation of Double Gates Type (Steel Plate Guider Structure)	③ Remodelling to Single Gate Type (Steel Plate Guider Structure)
General Drawing			
Gate Leaf	Rehabilitation of vertical side girders of upper and lower gate, straightening plate, gate support & watertight sections at the base and between the gates	Complete replacement of double gates of plate girder structure	Complete replacement of single gate of plate girder structure
Guide Frame	Rehabilitation of truck plate only while using the existing guide frame	Rehabilitation of truck plate only while using the existing guide frame	Rehabilitation of truck plate only while using the existing guide frame
Hoist	Complete rehabilitation, including motorization (two motors to operate upper and lower gates)	Complete rehabilitation, including motorization (two motors to operate upper and lower gates)	Complete rehabilitation, including motorization (one motor)
Watertight Function	Water tightness between upper and lower gates is required	Water tightness between upper and lower gates is required	Unnecessary due to no separation
Sand Removing Function	Sand removing from the base is possible	Sand removing from the base is possible	Sand removing from the base is possible
Operability	Operability is not as good as operation of lower gate requires simultaneous operation of upper gate	Operability is not as good as operation of lower gate requires simultaneous operation of upper gate	Operability is excellent as only a single gate is involved
Economy	approx. 105%	approx. 125%	100%
Evaluation Result	Δ	Δ	⊙

Alternative ③ (complete remodelling to single gate) is selected as the rehabilitation method for the under sluice gates because of the following reasons.

- The purpose of using double gates for the under sluice gates is to control water level of the barrage and the discharge to the downstream easier. At the Taunsa Barrage, the under sluice gates are fully closed at a runoff of 450,000 feet^3/sec based on the operation performance of some 50 years to control such a water level and volume of discharge through the operation of 53 weir gates.
- Accordingly, there is no special need for the under sluice gates to use double gates to control water level and discharge to the downstream.
- In order for the under sluice gates to fully perform their sand removing function, gate operation of underflow discharge involving the simultaneous removing of sand deposited in the sediment pockets is

required along with normal water discharge.

- When the double gates type is employed for under sluice gates which are frequently operated, the operation of the two gates must be synchronised. The single gate type offers better operability in this regard and, therefore, such a structure will be used for under sluice gates frequently used.

- In the case of discharge from inter-space of double gates, many foreign matters enter the lower roller guard. As these foreign matters are deposited on the roller support section, operation of the roller is adversely affected. To prevent this, it will be necessary to newly install deflector of 14 feet in height to the lower gate (the cost of this new deflector is estimated to be about 20% of the total rehabilitation cost of a gate leaf).

- Alternative ③ (complete remodelling to single gate) is the least expensive of the three alternatives when the installation cost of the new deflector plate to a double gates type is taken into consideration.

(2) Rehabilitation Method for Weir Gates and Number of Gates to be Rehabilitated

① Design Conditions for Weir Gates

1) Type of Gates

Based on the survey result, rehabilitation will be made only for vertical side girder, parts of the weir gate leaf which are seriously damaged. Accordingly, existing gate body is utilized and the type of weir gates is the same as existing gate "a steel truss roller gate".

2) Number of Gates

Total of 22 units of weir gates are selected to be rehabilitated in consideration of existing maintenance records of repair contents and frequency as discussed later.

3) Clear Span

Because of the use of the existing barrage piers, the clear span will be the same as the existing clear span of 60 feet (= 18.288 m).

4) Gate Sill Elevation

The gate sill elevation is RL. 428.00 feet.

5) Elevation of Gate Crest and Gate Height

The normal maximum water level planned under the "Punjab Barrages Rehabilitation and Modernisation Project" by Punjab Province is R.L.447 feet. Taking into consideration design freeboard of 1 foot for the gate height, the elevation of the gate crest will be as described below.

- Elevation of the gate crest = normal maximum water level (RL. 447.00 feet) +
  design freeboard (1.00 feet) = RL. 448.00 feet

- Gate height = elevation of the gate crest (RL. 448.00 feet) – sill (RL. 428.00 feet)
  = 20.00 feet (= 6.10 m)

6) Design Water Level and Design Water Head

- Design water level (upstream side) = elevation of the gate crest RL. 448.00 feet
- Design water level (downstream side) = sill elevation RL. 428.00 feet
- Design water head (upstream side) = design water level (RL. 448.00 feet)
  - sill height (RL. 428.00 feet)
  = 20.00 feet (= 6.10 m)
- Design water head (downstream side) = design water level (RL. 428.00 feet)
  - sill elevation (RL. 428.00 feet)
  = 0.00 feet (= 0.00 m)

7) Operating Water Level and Operating Water Head

- Operating water level (upstream side) = elevation of the gate crest RL. 448.00 feet
- Operating water level (downstream side) = sill elevation RL. 428.00 feet
- Operating water head (upstream side) = operating water level (RL. 448.00 feet)
  - sill elevation (RL. 428.00 feet)
  = 20.00 feet (= 6.10 m)
- Operating water head (downstream side) = operating water level (RL. 425.00 feet)
  - sill elevation (RL. 425.00 feet)
  = 0.00 feet (= 0.00 m)

8) Design Sedimentation Depth

The sedimentation depth in front of the gate, considering existing condition, will be as follows.

- Design sedimentation depth = Sedimentation elevation (RL. 431.00 feet)
  - sill elevation (RL. 428.00 feet)
  = 3.00 feet (= 0.91 m)

9) Watertight Method

- Watertight method: watertight on three sides in the front using rubber

10) Hoist

In the case of the existing weir gates, the “one motor, two drum, wire rope winch system” was employed due to the continual deck shape of the superstructure of the present barrage. This “one motor, two drum, wire rope winch system” will also be used as the hoist for the weir gates to be rehabilitated because of its simple and economical mechanism.

11) Operating Method

Electrified gates will be controlled on the motor side (local control panel) in consideration of safe gate operation. However, manual operation may also be conducted as a backup mode of operation in case of failure of electric operation due to breakdown of the motor or any other reason.

12) Operating Speed

The operating speed of the existing gates (0.05 m/min) is not fast enough to efficiently operate the gates at the time of flooding. An operating speed of 1 foot/min (= 0.30 m/min) will, therefore, be adopted in accordance with the relevant design standard used by the "Punjab Barrages Rehabilitation and Modernisation Project" by Punjab Province.

13) Lifting Height

The lifting height for the gates in question will be as follows.

- Lifting height of the gate = elevation at the lower end when lift up (RL. 457.00 feet)
  – sill elevation (RL. 428.00 feet)
  = 29.00 feet (= 8.839 m)

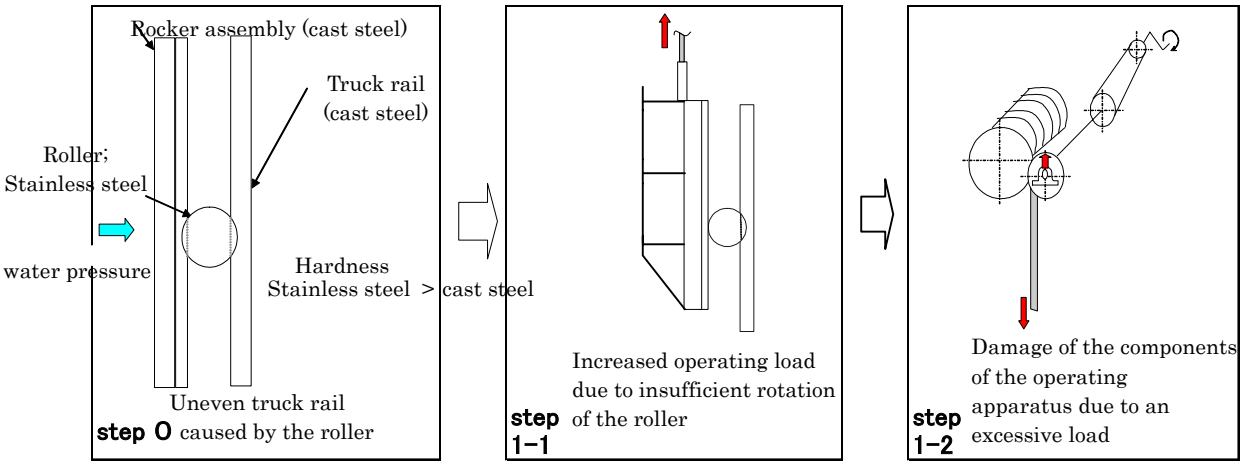
14) Allowable Stress and Allowable Deflection

The Technical Standards for Steel Water Gates Gate and Penstocks established by Hydraulic Gate and Penstock Association of Japan will be used to determine these values.

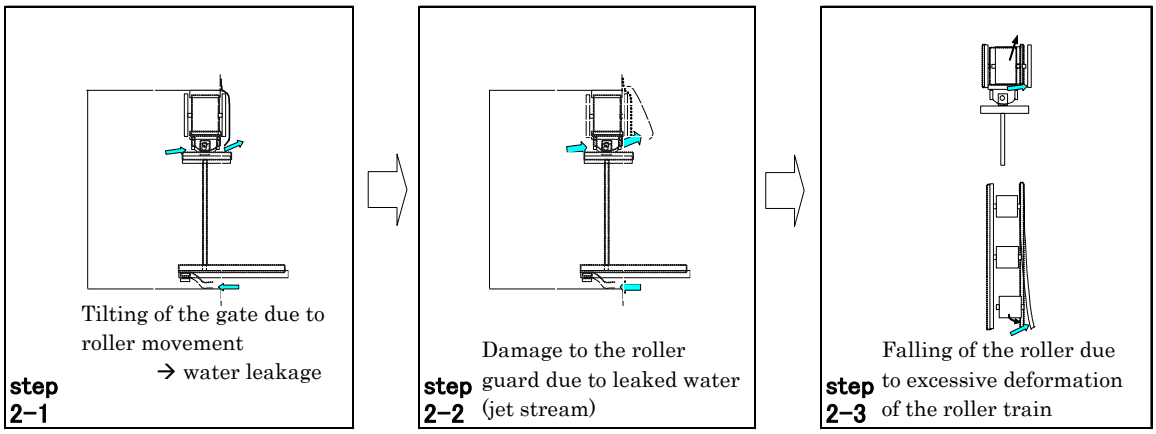
The above standard provides that the allowable deflection is less than 1/800 of the gate span in case of gate with 20m to 30m of span, however, 1/600 of span is applied to the gates of Taunsa Barrage as the allowable deflection taking into consideration the present gate span of 18m, that would gives the gates almost equivalent deflection and stress as well as water-tightness based on the following calculation.

$$(25m/18m) \times (1/800) = 1/600$$

< Hoist>



< Roller Train >



< Sealing Plate >

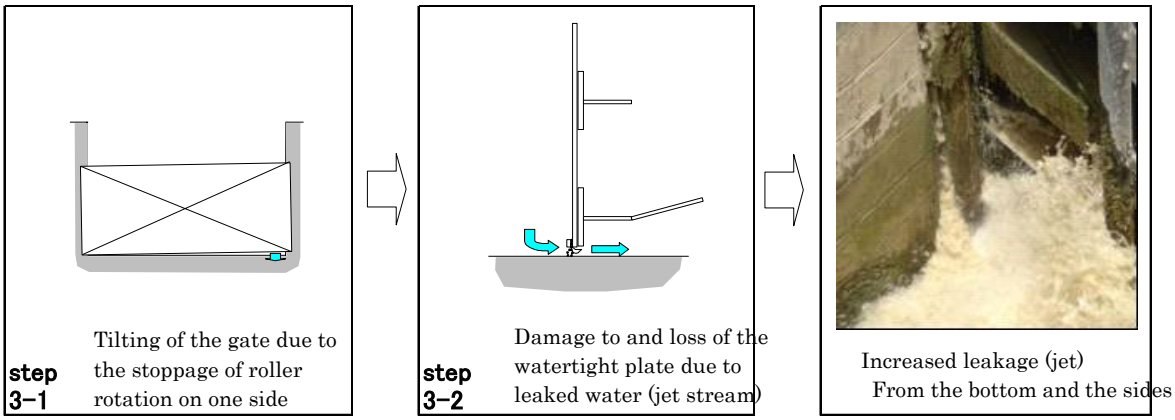


Figure 2-2-1.2 Mechanisms Causing Problems with Under Sluice Gates and Weir Gates

② Rehabilitation Method

1) Analysis of Present Problems

At present, the under sluice gates and weir gates are experiencing the following problems.

- Leakage from the bottom and sides of the gates
- Increased operating load of the gates
- Falling of the roller
- Damage to components of the hoist (pillow block and others)

The mechanisms causing these problems are shown in Figure 2-2-1.2. The fundamental causes are believed to lie with the rocker assembly (oscillating truck plate), roller train and truck rail.

2) Planning of Remedial Measures

Studying the mechanisms causing the problems, the planned rehabilitation of the weir gates can be successfully achieved by eradicating the causes of the problems.

Table 2-2-1.2 Causes of Problems and Remedial Measures

Problem	Cause	Remedial Measure	Remarks
Guide frame becoming uneven	The roller material is equivalent to or harder than the rail material.	Use of a harder material for the rail than the material for the roller	
Leakage from the bottom	The sill beams at the bottom is becoming uneven.	① Renewal of the metal sill beams ② Changing the watertight plate at the bottom to watertight rubber to improve the capacity to deal with unevenness	
Leakage from the sides	① Deformation of the gate leaf due to unevenness of the roller ② Problem with the mechanism and structure of the rocker assembly	① Improvement with the use of an appropriate guide frame and roller ② Modification of the structure and mechanism of rocker assembly and replacement with the new one modified	The main cause of ② is believed to be that a load higher than the design one is acting on the gate leaves because of the inadequate rotation of the rocker assembly.

In addition to the above table, further detail of rehabilitation will be studied based on the concepts that existing vertical side girders and beams at the gate lips, which are deformed and cracked in some gates by the influence of the problems, will be replaced with the new ones.

3) Detailed Structure

Table 2-2-1.3 compares the present situation, the proposal under the JICA F/S and the latest proposal regarding the structure of the roller unit (roller train, rocker assembly and guide frame). It is proposed to change the rocker assembly mounting method from mounting to the gate leaf to mounting to the guide frame, which will be less influence to the gate leaf if the rocker assembly or roller train get some problems,

based on the results of the fact-finding survey on the Taunsa Barrage and other barrages.

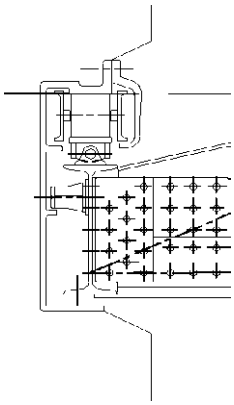
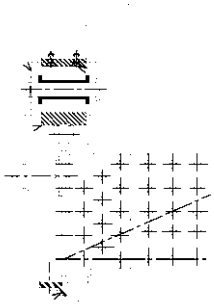
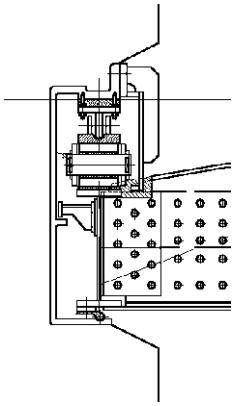
The major difference between the three studies conducted is that the locker assembly is mounted at the guide frame side instead of the gate leaf side.

Either structure poses no problem as long as the mechanism is functioning as designed. However, when the oscillating mechanism of the locker assembly fails to fully function because of corrosion, the intrusion of foreign matter or any other matter (situation not considered in the original design) will act on the side girder in the case of the structure where the locker assembly is mounted to the gate leaf. In contrast, such situation will not act on the gate leaf in case the structure where the locker assembly is mounted to the guide frame side.

In the examination of the current irregularities of the side girder discovered the deformation described above was discovered. As a result, it was proposed to replace the existing structure with a new structure (This proposal was recommended at the time of the F/S).

Moreover, with the present structure and proposal at the time of the F/S, if unevenness emerges with the track rail, the only way to repair it is to grind the track rail on-site, eventually necessitating major rail replacement work. However, with the latest proposal, the same situation can be dealt with by simply replacing the locker assembly.

Table 2-2-1.3 Comparison of Roller Unit Structure

Description	Present Situation	JICA F/S	Latest Proposal
Sketch of Roller Part			
Roller Train	Roller: stainless steel Derailing is prevented by the truck rail stop and roller guard	Roller: cast steel Derailing is prevented by the truck rail shape	Roller: cast steel Derailing is prevented by the track rail stop and roller guard
Rocker Assembly	Mounted to the gate leaf	Mounted to the gate leaf	Mounted to the groove
Roller Guard	Cast steel	None	Bolt-mounted to the guide frame welded steel plate
Gate Guide	Integral cast steel Roller rail: cast steel	Roller rail: stainless steel	Roller rail: stainless steel
Remarks	The roller material is changed to cast steel one by one		An example can be seen at the Sukkur Barrage.
Evaluation	△	○	◎

The parts that will be subjected for rehabilitation are shown in Figure 2-2-1.3.

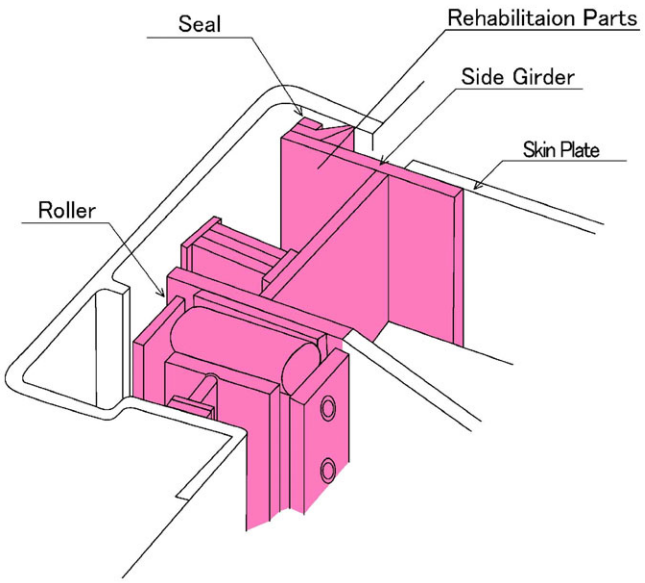
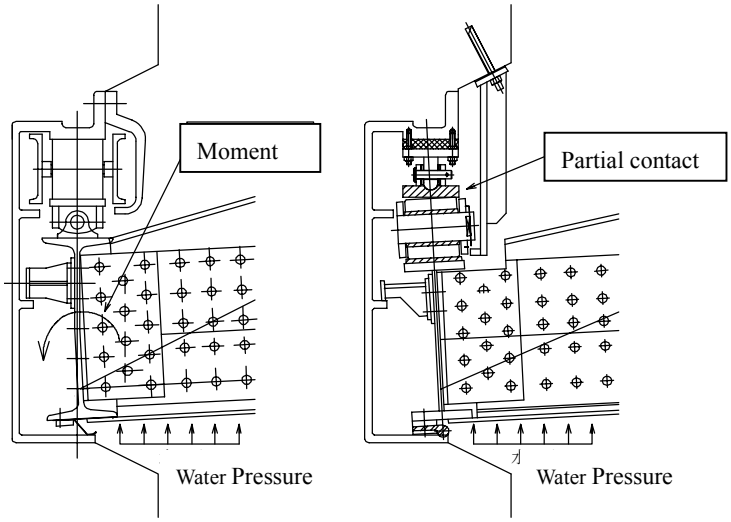


Figure 2-2-1.3 Subject Parts for Rehabilitation



Existing **Latest Proposal**

Figure 2-2-1.4 Comparison of Roller Structures

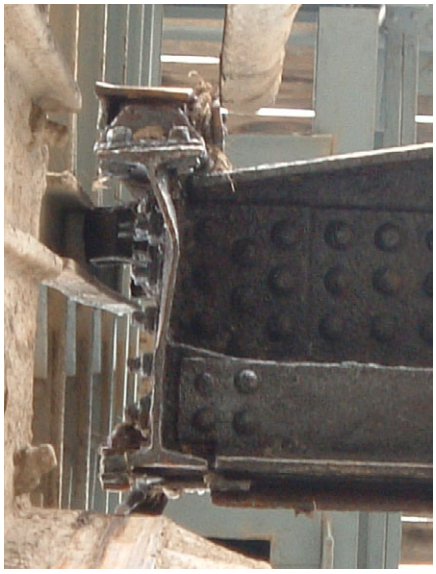


Figure 2-2-1.5 State of Side Girder Deformation

③ Number of Gates to be Rehabilitated

The JICA F/S and the Preliminary Study have already confirmed the deteriorating condition of the gates (visual external inspection and plate thickness test, etc.) and problems with the hoists (visual external inspection and operating capacity test).

Besides the results of these preceding studies, the gates requiring urgent rehabilitation have been re-examined by the rehabilitation records in the last five years.

This is because of the judgement that any findings of a single survey can be significantly affected by the contents of the maintenance work conducted during the previous year as those gates with problems are usually repaired every year during the annual closure. Figure 2-2-1.6 compares the gates that are judged to be problematic during the F/S in 1998, the Preliminary Study in 2003 and the present Study. Because of frequent repairs, the gates with problems vary depending on the study timing. For example, Gate No. 34 which was ranked priority in terms of rehabilitation at the time of the F/S, does not anymore require rehabilitation at the time of the Preliminary Study.

Figure 2-2-1.7 shows the classification results of the repair records in the last five years based on the following three levels.

Level 1: rehabilitation of the roller train
Level 2: rehabilitation of the roller train and truck rail
Level 3: rehabilitation of the roller train, truck rail and components of the hoist

It was agreed that the criteria for rehabilitation gates will be based on any of the following:

① Gate which has been classified at Level 2 at least twice
② Gate which has been classified as Level 3 even once

As a result, 22 weir gates listed below were proposed to be rehabilitated (excluding three gates on the right bank side of which the conversion to under sluice gates is planned).

10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
23, 24, 25, 26, 27, 31, 33, 35, 38, 55, 58

④ Heightening Methods of Weir Gate

There are two methods of heightening weir gate.

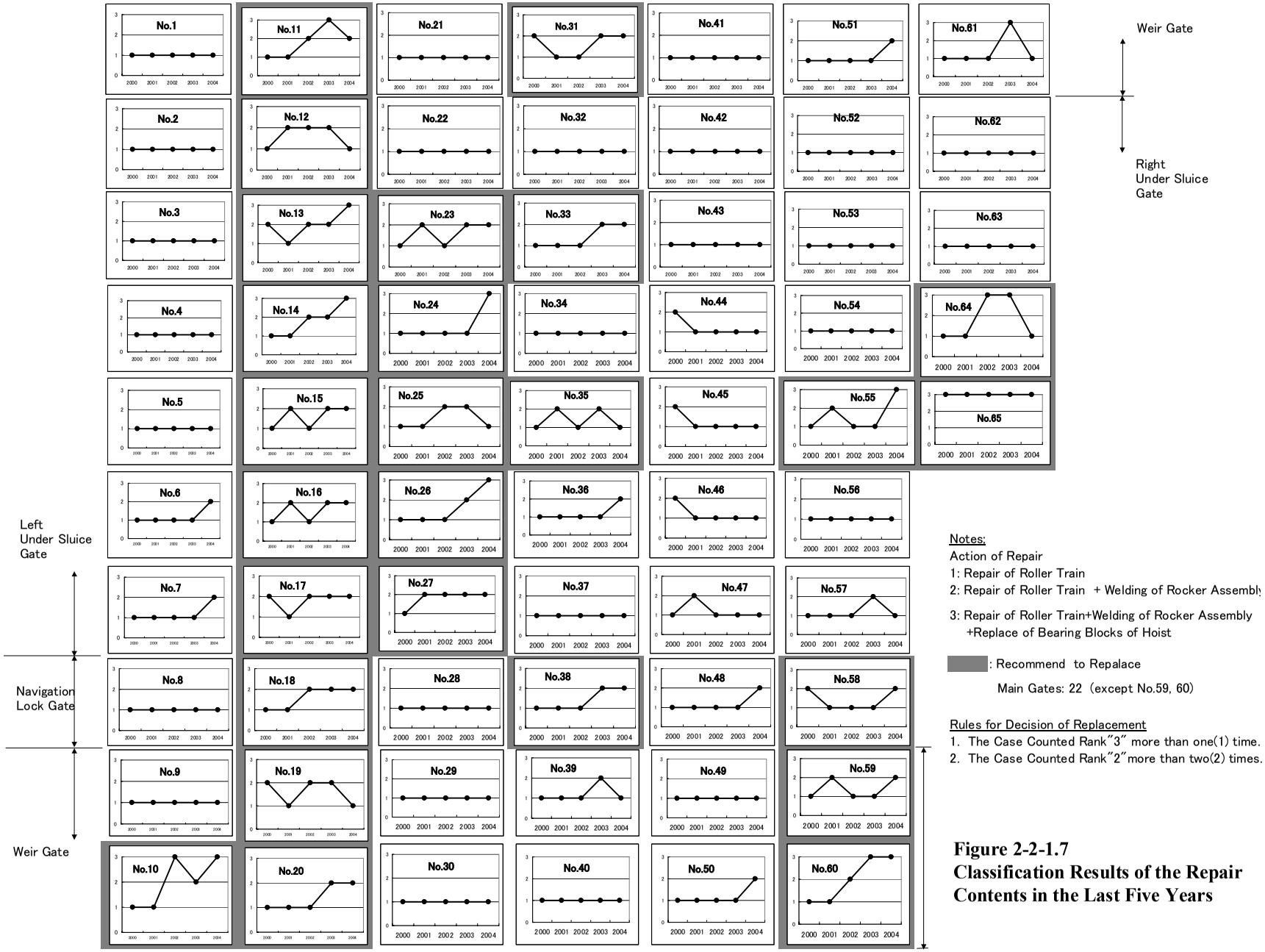
- Heightening at the Bottom
- Heightening at the Top

Comparison of heightening methods of weir gates is shown in table 2-2-1.4.Heightening at the bottom is selected as the heightening method for the weir gates because of lesser impact on the existing gate.

Gate No.	−1998		1998			1999		2000		2001		2002		2003		2004		Gate No.
	Trouble	Mentenance	Trouble	ranking	Mentenance	Trouble	Mentenance	Trouble	Mentenance	Trouble	Mentenance	Trouble	Mentenance	Trouble	Mentenance	Trouble	Mentenance	
1																		1
2																		2
3																		3
4																		4
5																		5
6																		6
7																		7
8																		8
9																		9
10			■	24												■		10
11			■	7										■		■		11
12			■	12										■		■		12
13				32												■		13
14			■	5										■		■		14
15			■	5										■		■		15
16			■	4										■		■		16
17			■	7										■		■		17
18			■	2										■		■		18
19			■	7										■		■		19
20			■	3										■		■		20
21				45														21
22				41														22
23			■	23												■		23
24				29										★		■		24
25				25												■		25
26				35												■		26
27				25												■		27
28				25														28
29				35														29
30			■	11														30
31				49												■		31
32			■	14														32
33			■	14												■		33
34			■	1														34
35				35										■		■		35
36			■	13										■				36
37				41										★				37
38				51										★		■		38
39				50										★				39
40			■	14														40
41				33														41
42				40														42
43				29														43
44			■	14										■				44
45				38														45
46				38														46
47			■	10										■				47
48				25														48
49				44														49
50				52														50
51				41														51
52			■	14										■				52
53			■	14										■				53
54			■	14										■				54
55				45										■		■		55
56			■	14										■				56
57				33										★				57
58				45										★		■		58
59				45														59
60			■	14														60
61				29														61
62																		62
63																		63
64																		64
65																		65

Note: An asterisk (*) indicates that the gates not subject to rehabilitation at the time of the F/S but were subsequently judged to require rehabilitation by the Preliminary Study. The gates with ▨ were dropped from the scope of rehabilitation after the Preliminary Study even though their rehabilitation were considered necessary at the time of the F/S.

Figure 2-2-1.6 Comparison of Subject Gates for Rehabilitation



Notes:

Action of Repair

1: Repair of Roller Train

2: Repair of Roller Train + Welding of Rocker Assembly

3: Repair of Roller Train+Welding of Rocker Assembly +Replace of Bearing Blocks of Hoist

: Recommend to Repalace

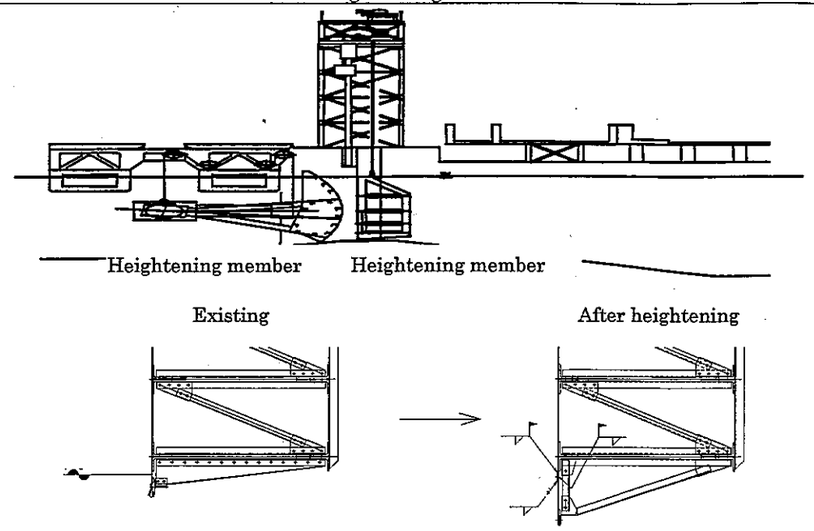
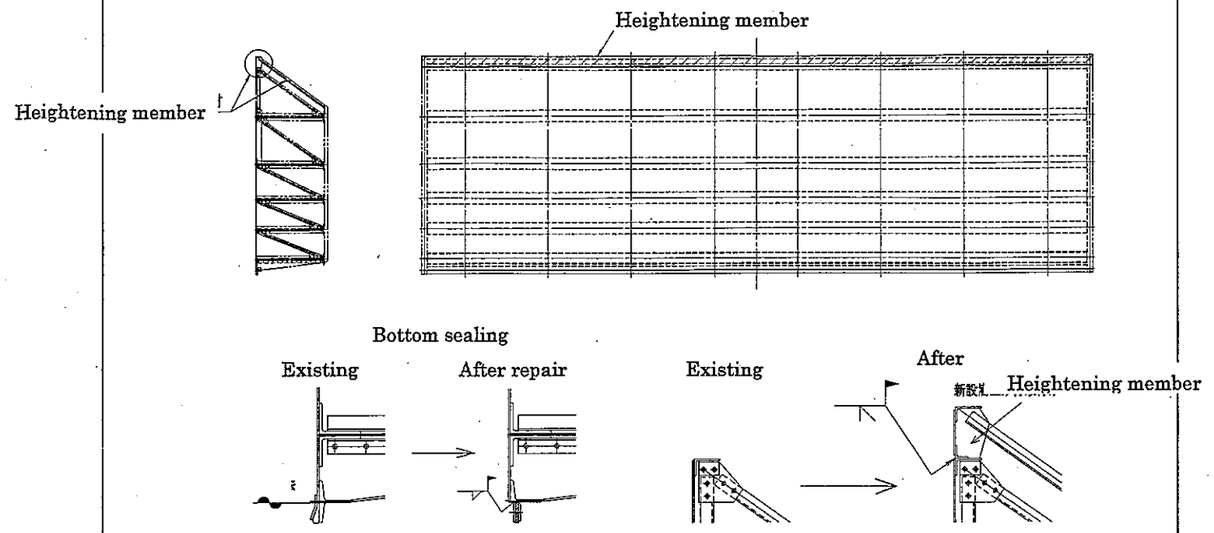
Main Gates: 22 (except No.59, 60)

Rules for Decision of Replacement

1. The Case Counted Rank"3" more than one(1) time.
2. The Case Counted Rank"2"more than two(2) times.

Figure 2-2-1.7
Classification Results of the Repair Contents in the Last Five Years

Table 2-2-1.4 Comparison of Heightening Methods of Weir Gate

		Plan A. Heightening at the Bottom	Plan B. Heightening at the Top
Schematic Diagram			
Concept		Addition of a heightening member at the gate bottom to raise by 1 ft in order to lessen the impact on the existing main girder.	Addition of a heightening member at the gap top to raise by 1 ft in consideration of easy tie-in with the existing gate structure.
Scope of Reinforcement	Skin PL	No special reinforcement is required.	No special reinforcement is required.
	Main Girder	Heightening at the bottom increases the load distributed to the lowest stage but no special reinforcement is required as the stress by increased load is within the permissible stress even if decreasing thickness of allowance.	Heightening at the top increases the water load on each step but no special reinforcement is required as the stress by increased load is within the permissible stress even if decreasing thickness of allowance.
	Heightening Member	A heightening member consisting of a skin PL, sub vertical girder, beam and diagonal member are welded at the gate bottom after removal of the existing skin PL, watertight rubber seat and sub vertical girder in consideration of structural tie-in ; In this planned heightening at the bottom, rehabilitation of the watertight rubber seat at the bottom is structurally conducted at the same time.	Welding of the new heightening member consisting of the skin plate and frame member to the uppermost part of the gate: a diagonal member is introduced at the back of the heightening member to support the water load on the heightening member.
Workability		• The work sequence starts with the installation of the bottom heightening member while suspending the gate. In this plan, rehabilitation of the rubber seal seat at the bottom is simultaneous as it is part of the same work. • After completion of the work at the bottom, the gate is raised for rehabilitation of the end girder of the gate while making the temporary frame support the dead weight of the gate. • It is necessary to cut and remove the existing members, such as the skin plate, to ensure proper tie-in with the bottom member. • With the existing skin plate, there is concern regarding the weldability of T-1 steel (high tension steel of 50 years ago) which requires careful management of the heating. • The total work duration is the same as that of Plan B as the heightening at the bottom and rehabilitation of the rubber seal seat at the bottom can be simultaneously conducted.	• The work sequence is to start with improvement of the rubber seal at the bottom, followed by heightening of the gate to make the temporary frame support the gate's dead weight while reinforcing the end girder and the heightening member of the gate. • It is necessary to remove the existing sealing rubber seal seat at the bottom because of the damage to it. • As the heightening member is installed above the upper girder, welding between the new member and the existing skin plate is unnecessary, removing the uncertainty regarding weldability. • As the heightening member and sealing rubber seal seat at the bottom have different structures, they cannot be worked on at the same time, making the total work duration the same as that of Plan A.
On-Site Installation Period		Required days for remodelling of gate: pre-heightening process + 5 days/gate (54 days/gate)	Required days for remodelling of gate: pre-heightening process + 5 days/gate (54 days/gate)
Economy	Weight	Heightening member: 2.0 tons Total: 2.0 tons	Heightening member: 2.0 tons Sealing rubber seal seat at the bottom: 0.5 tons Total: 2.5 tons
	Comparison of Estimated Costs	Fabrication and transportation : ¥3.6 million Removal : ¥0.8 million Installation : ¥1.3 million Total : ¥5.8 million	Fabrication and transportation : ¥4.6 million Removal : ¥0.4 million Installation : ¥1.4 million Total : ¥6.4 million
		Although the total work volume is slightly more than Plan B because of removal of the existing members and welding of the skin plate, the structurally integrated heightening member and watertight rubber seat at the bottom makes the fabrication and installation costs cheaper than Plan B, achieving better overall economy.	The cost of removing the watertight rubber seat at the bottom is cheaper than Plan A because of the less work volume. However, as the said seal and heightening member are structurally separated, the fabrication cost is higher, pushing the total cost above that of Plan A.
Evaluation		This plan is adopted because (i) the existing members have sufficient strength, (ii) the work duration is the same as that of Plan B and (iii) it is more economical than Plan B.	There is no problem regarding the strength of the existing members for adoption of this plan but the higher cost and same work length as Plan A mean that there is no strong advantage of opting for this plan.

Notes 1) While an allowance is not considered for existing members, the design for the planned rehabilitation (remodelling) includes an allowance of 0.5 mm in thickness at the water contact face of the sluice gate.

2) The evaluation of economy is based on the direct cost.

(3) Gate Hoist and Its Electrification

① Operational Conditions of the Existing Gate

Operational conditions of the existing weir gates (53 units) and under sluice gates (11units) by manual are as follows;

- In the original plan, 0.05 m/min.（= 10 ft/hr）of raising speed by four (4) persons and 0.10 m/min.（= 20 ft/hr）of lowering speed are planned respectively.
- However, 0.05 m/min.（= 10 ft/hr）of raising speed by four (4) to eight (8) persons and 0.10 m/min.（= 20 ft/hr）of lowering speed were confirmed in B/D survey.

② Simulation of Gate Operation

1) Objective Flood

The top three (3) floods occurrences for which time-basis records are shown in the table below;

Table 2-2-1.5 Objective Floods for Simulation of Gate Operation

Rank	Date of Occurrence	Peak Flood Discharge Q (ft^3/sec)	Max. Change Speed in Flood Discharge ⊿Q (ft^3/sec/hr)	Water Level at Upstream U/S WL. (ft)	Water Level at Downstream D/S WL. (ft)	Difference in Water Level between Up and Downstream ⊿H (ft)
1 st	1992/9/14	655,079	34,749 -50,228	446.00 445.00	434.50 434.50	11.50 10.50
2 nd	1995/7/29	617,096	15,937 -34,526	446.00 446.50	432.20 434.20	13.80 12.30
3 rd	1988/7/21	563,416	23,718 -31,512	446.00 446.50	435.35 435.20	10.65 11.30

The flood that occurred on the 14th of September 1992 is selected for the objective flood for simulation of gate operation since it is ranked first in peak flood discharge and maximum changing speed in flood discharge (peak flood discharge 655,079 ft^3/sec= equivalent to 65.5% of design flood discharge).

2) Gate Operation Rules

Weir gate and under sluice gate will be operated according to the currently used operation rules for Taunsa Barrage.

a) Only one (1) gate shall be activated when it is manually operated.
b) Difference in opening between neighboring gates of weir gate and under sluice gate shall be less than two (2) ft.
c) Only weir gate shall be operated when flood discharge is under 450,000 ft^3/sec. Under this condition, the under sluice gate shall be fully closed.
d) Under sluice gate shall be opened at the maximum opening when flood discharge is above 450,000 ft^3/sec in order to control water level at upstream of Barrage by operating weir gate.
e) Gate operation shall be done in step-operation to control gate opening at two (2) ft per step.

3) Simulation for Manual Gate Operation

The result of simulation for manual gate operation on flood that occurred on the 14th of September 1992 is shown below (peak flood discharge：655,079 ft^3/sec = equivalent to 65.5% of design flood discharge)(refer to Table 2-2-1.6).

a) Four (4) gates must be operated simultaneously since required maximum raising speed of gate become 32.00 ft/hr（0.16 m/min.）at 1:00 AM in 14th September 1992.
b) Three (3) gates must be operated simultaneously since required maximum raising speed of gate become 54.00 ft/hr（0.27 m/min.）at 10:00 AM in 15th September 1992.
c) The time zone in which manual operation (simultaneous operation of one gate with 0.05m/min.=10 ft/hr of raising speed and 0.10 m/min.=20 ft/hr of lowering speed) cannot be done will be 15 hours in total, eight (8) hours in raising and seven (7) hours in lowering, (equivalent to 8.9% of seven (7) days of flooding period)

③ Electrification of Gate Hoist

The results of simulation for manual gate operation show that eight (8) hours delay in raising operation during seven (7) days of flooding period will occur and water level at upstream will rise as a result, and long operation of 111 hours by manual operation (equivalent to 66.1% of seven (7) days flooding period) will be required. Therefore, current operation system (10 to 12 persons x 3 shifts) needs to be strengthened to four (4) times or raising speed must be improved.

Other barrages already rehabilitated in Punjab Province have been powered by electricity. Therefore gates operated by electricity become indispensable for efficient operation, accurate water control and discharge management.

In addition, objective for electrified gate hoist is planned only for leaves to be rehabilitated. The reason for this is that gate leaf might be broken and some serious problems might occur if electrification of gate hoist only leaving leaf structure is not improved.

Though various parts of the gate hoist are generally well managed at present, it is proposed to replace drum and drum gear along with change of power source because of necessity of replacement due to its strength in structure (described later about examination of strength).

Since it was clarified through the latest field survey that there are many problems with middle gear system in the present structure of gate hoist, it is proposed to change part of the middle gear of the chain structure to the system where the whole gate hoist will be placed at the upper deck.

Table 2-2-1.6 Simulation for Gate Operation（Flood on 14th September 1992）

Date and Time	Discharge Q (ft^3/sec)	Difference in Discharge (ft^3/sec)	Water Level at Upstream U/S WL. (ft)	Water Level at Downstream D/S WL. (ft)	Weir Gate Group A			Weir gate Group B			Under Sluice Gate Group A			Under Sluice Gate Group B			Total Discharge Q (ft^3/sec)	Total Opening ∑a (ft)	Opening Speed V_g (ft/hr)
					Opening a_1 (ft)	No. of gates N (Unit)	Discharge Q_1 (ft^3/sec)	Opening a_2 (ft)	No. of gates N (Unit)	Discharge Q_2 (ft^3/sec)	Opening a_3 (ft)	No. of Gates N (Unit)	Discharge Q_3 (ft^3/sec)	Opening a_4 (ft)	No. of gate N (Unit)	Discharge Q_4 (ft^3/sec)			
9/10 00:00	256,167	0	446.50	431.00	4.00	50	235,855	6.00	3	20,409	0.00	11	0	2.00	0	0	256,264	0	0.00
9/11 18:00	334,951	78,784	444.00	431.90	6.00	50	311,537	8.00	3	23,678	0.00	11	0	2.00	0	0	335,214	106	2.52
9/11 22:00	**376,345**	**41,394**	**444.00**	**432.10**	**6.00**	**25**	**156,062**	**8.00**	**28**	**221,452**	**0.00**	**11**	**0**	**2.00**	**0**	**0**	**377,514**	**50**	**12.50**
9/12 00:00	376,345	0	444.00	432.10	6.00	25	156,062	8.00	28	221,452	0.00	11	0	2.00	0	0	377,514	0	0.00
9/12 01:00	**404,649**	**28,304**	**444.00**	**432.20**	**6.00**	**9**	**56,262**	**8.00**	**44**	**348,539**	**0.00**	**11**	**0**	**2.00**	**0**	**0**	**404,800**	**32**	**32.00**
9/12 06:00	404,649	0	444.00	432.20	6.00	9	56,262	8.00	44	348,539	0.00	11	0	2.00	0	0	404,649	0	0.00
9/13 03:00	525,642	120,993	445.00	433.85	8.00	37	307,470	10.00	16	157,900	4.00	8	39,808	6.00	3	21,619	526,797	100	4.76
9/13 04:00	**542,364**	**16,722**	**445.00**	**433.90**	**8.00**	**37**	**307,793**	**10.00**	**16**	**158,083**	**4.00**	**1**	**4,980**	**6.00**	**10**	**72,119**	**542,975**	**14**	**14.00**
9/13 05:00	542,364	0	445.00	433.90	8.00	37	307,793	10.00	16	158,083	4.00	1	4,980	6.00	10	72,119	542,975	0	0.00
9/13 09:00	544,472	2,108	445.00	434.05	8.00	37	308,033	10.00	16	158,220	6.00	6	43,296	8.00	5	46,327	555,875	12	3.00
9/13 10:00	**569,178**	**14,706**	**445.00**	**434.10**	**8.00**	**37**	**308,331**	**10.00**	**16**	**158,389**	**8.00**	**10**	**92,726**	**10.00**	**1**	**11,128**	**570,574**	**14**	**14.00**
9/13 12:00	569,178	0	445.00	434.10	8.00	37	308,331	10.00	16	158,389	8.00	10	92,726	10.00	1	11,128	570,574	0	0.00
9/13 20:00	599,587	30,409	445.50	434.25	8.00	37	314,761	10.00	16	162,043	8.00	0	0	10.00	11	124,650	599,587	20	2.50
9/13 21:00	**634,336**	**34,749**	**446.00**	**434.50**	**8.00**	**37**	**321,147**	**10.00**	**16**	**165,664**	**12.00**	**9**	**119,552**	**13.00**	**2**	**28,157**	**634,520**	**24**	**24.00**
9/13 22:00	640,330	5,994	446.00	434.55	8.00	37	321,269	10.00	16	165,733	12.00	2	26,577	13.00	9	126,756	640,334	7	7.00
9/15 07:00	606,117	-34,213	445.00	435.00	8.00	43	359,239	10.00	10	99,271	13.00	11	149,040	15.00	0	0	607,549	-12	-0.36
9/15 08:00	**585,278**	**-20,839**	**445.00**	**434.80**	**6.00**	**3**	**19,656**	**8.00**	**50**	**417,116**	**13.00**	**11**	**148,823**	**15.00**	**0**	**0**	**585,595**	**-26**	**-26.00**
9/15 09:00	**555,457**	**-29,821**	**445.00**	**434.70**	**6.00**	**19**	**124,264**	**8.00**	**34**	**283,075**	**13.00**	**11**	**148,526**	**15.00**	**0**	**0**	**555,865**	**-32**	**-32.00**
9/15 10:00	**505,229**	**-50,228**	**445.00**	**434.50**	**6.00**	**46**	**299,992**	**8.00**	**7**	**58,098**	**13.00**	**11**	**148,060**	**15.00**	**0**	**0**	**506,151**	**-54**	**-54.00**
9/15 11:00	505,229	0	445.00	434.50	6.00	46	299,992	8.00	7	58,098	13.00	11	148,060	15.00	0	0	506,151	0	0.00
9/15 12:00	**479,502**	**-25,727**	**445.00**	**434.40**	**4.00**	**6**	**27,188**	**6.00**	**47**	**306,097**	**13.00**	**11**	**147,838**	**15.00**	**0**	**0**	**481,122**	**-26**	**-26.00**
9/15 15:00	479,502	0	445.00	434.40	4.00	6	27,188	6.00	47	306,097	13.00	11	147,838	15.00	0	0	481,122	0	0.00
9/15 18:00	466,639	-12,863	445.00	434.50	4.00	13	58,871	6.00	40	260,337	13.00	11	147,731	15.00	0	0	466,939	-14	-4.67
9/15 21:00	**379,289**	**-87,289**	**445.00**	**434.00**	**4.00**	**13**	**58,656**	**6.00**	**40**	**259,298**	**4.00**	**7**	**34,643**	**6.00**	**4**	**28,657**	**381,253**	**-91**	**-30.33**
9/16 00:00	366,650	-12,700	445.00	433.90	4.00	13	58,628	6.00	40	259,165	2.00	2	5,114	4.00	9	44,523	367,430	-12	-4.00
9/17 00:00	251,949	-114,701	445.00	430.30	4.00	45	202,223	6.00	8	51,632	0.00	11	0	2.00	0	0	253,855	-104	-4.33

(4) Electrification and Operating Method

① Subjects of Electrification

The gates proposed to be electrified are the gates are to be rehabilitated as described earlier.

② Operating Method

When the hoist is electrified, the gate can be operated from the motor (local) side or by remote control. The results of the fact-finding survey on other electrified barrages indicate the limited use of a remote control mechanism as gates are usually operated from the motor side.

- Used only during the flood season (Chashma Barrage)
- Not used (Marala Barrage)

The planned rehabilitation does not feature additional monitoring devices. As such, the use of remote control can be very dangerous as the gates will be operated without visual confirmation. Together with the actual situation of remote control operation, it has been decided to plan gate operation from the motor (local) side only.

(5) Rehabilitation of Superstructure Deck

With the electrification of the hoist, the upper deck will be rehabilitated for the purpose of improving its maintainability. As the latest field survey has found that dispersion of the control floor poses a problem in terms of operability as well as structure, the drum and drum gears will be placed at the uppermost deck to make the hoist located on a single floor in order to improve the structure, operability, maintainability and safety.

Following such improvement, reinforcement of the superstructure will be necessary. Meanwhile, this improvement will enable the omission of a platform for gear maintenance as will be described later.

(6) Painting of Superstructure Deck

As painting of the upper deck is part of the normal inspection and repair work, the exclusion of this painting work from the planned rehabilitation work is proposed.

(7) Rehabilitation of Hoisting Drum and Gears

As indicated by the past study results, the maintenance conditions of each component of the hoist are generally good. However, the planned change to power source will necessitate a change of the drum and drum gears to increase their structural strength and, therefore, these will be replaced as part of the planned rehabilitation work.

Table 2-2-1.7 shows the examination results of the drum gear strength after electrification. Neither the bending strength of the gears nor the bearing strength of the tooth surface satisfies their respective current reference value.

Table 2-2-1.7 Calculation Results of Gear Strength

Items	Safety Factor for Bending Strength		Safety Factor for Bearing Strength	
	Calculated Value	Allowable Value	Calculated Value	Allowable Value
At Rated Operation	1.2	5.0	0.05	1.0

(8) Platform for Gear Maintenance

As already described earlier, the present proposal calls for the installation of hoist at the upper deck. Accordingly, the originally planned platform for gear maintenance will no longer be required. Therefore, the omission of this platform from the rehabilitation plan is possible.

2-2-1-5 Bulkhead Gates

(1) Possibility of Using Bulkhead Gates for Other Barrages

An enquiry was made with the Pakistan side regarding the converted use of bulkhead gates for other barrages. The recommended suitable places were the Jinnah Barrage and the Trimu Barrage.

These recommended sites were then analysed from the two points described below. It was concluded that converted use at these two barrages would be most effective. The use of two bulkhead gates at each barrage, including the Taunsa Barrage, will be possible. All five gates may be used as single barrage in case of barrage rehabilitation.

① Checking of Possibility of Converted Use of Bulkhead Gates

Barrages in Punjab Province are classified into three phases based on their respective year of construction. Phase I barrages were rehabilitated around 1970 under a World Bank project. At the time of the implementation of the World Bank assisted project, the barrages constructed in Phase III were not due for rehabilitation and, therefore, have never been rehabilitated. All of the barrages constructed in Phase II are gateless head works. In contrast, those constructed in Phase III have gates with a span of 18 m.

Based on Table 2-2-1.8, possible sites for the converted use of the bulkhead gates after use at the Taunsa Barrage are restricted to the Jinnah and the Trimu Barrage if they would be used only for rehabilitation work.

Table 2-2-1.8 Barrages in Punjab

	Name	Construct	Repair	Type	1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 1)	Condition 2)
I	Khanki	1892				★
	Sidhnai	1897	1965			○
	Rasul	1901	1974			○
	Malara	1912	1968			○
	Baloki	1913		H/W		-
	Qadirabad	1967?	1967		?	○
	Chashima	1971				○
II	Slemanki	1927		H/W		-
	Isram	1928		H/W		-
	Punjunad	1929		H/W?		-?
III	Trimmu	1939				★
	Jinnah	1946				☆
	Taunsa	1958				☆

Notes

1) The number of years since construction or rehabilitation is colour coded in the following manner

- 0 – 20 years
- 20 – 40 years
- 40 – 60 years
- 60 – 80 years
- 80 – 100years
- over 100years
- Rehabilitation conducted

2) O Within 40years of construction or rehabilitation

☆ Within 40-60 years of construction or rehabilitation

★ More than 60 years since construction rehabilitation

② Checking of Structural Dimensions of Jinnah Barrage and Trimu Barrage

The structural dimensions of the barrage and gates of these two barrages to be considered as preferential sites for the converted use of the bulkhead gates were checked and are shown in Table 2-2-1.9.

Table 2-2-1.9 Structural Dimensions of Two Barrages

	Jinnah	Trimu	Taunsa
Span (L)	18 m (60 feet)	18 m (60 feet)	18 m (60 feet)
Height (H) (Sediment Discharge Gate)	5.5 m (18 feet)	5.5 m (18 feet)	6.7 m (22 feet)
Height (H) (Floodgate)	4.6 m (15 feet)	4.7 m (15.5 feet)	6.0 m (20 feet)

At the Trimu Barrage, work to replace the lower part of the gate is in progress because of the evident corrosion of the gate leaf members. Given this situation, it is anticipated that the gate rehabilitation work will take place fairly soon in the coming years.

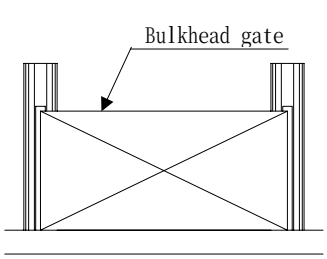
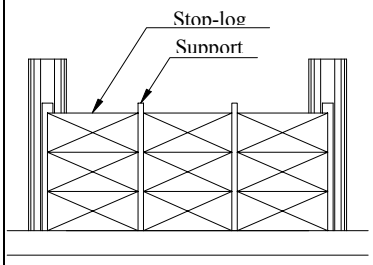
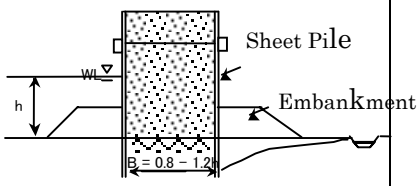
(2) Validity of Temporary Cofferdam Method for Barrage Rehabilitation

Due to the following objectives, introduction of new bulkhead gates is proposed for the rehabilitation of Barrage and future O & M;

- Temporary cofferdam works at upstream of the Barrage for gate rehabilitation by grant aid project
- Temporary cofferdam works upstream of the Barrage for the rehabilitation of gate, and civil works on barrage body and apron to be done by Pakistan side.
- Temporary cofferdam works at upstream of the Barrage for annual O & M repairing works such as repainting of gates after completion of rehabilitation works of Barrage.

Generally there are three (3) methods in temporary cofferdam that have actually been employed so far, 1) bulkhead gate method, 2) stop-log gate method, and 3) cofferdam by steel sheet plate. When determining optimum method, efficiency in function, water seal, installation and removal, economy and availability for repeated-use etc must be examined comprehensively.

Table 2-2-1.10 Comparison Table of Temporary Cofferdam Methods to be Selected

Methods	Bulkhead Gate Methods		Stop-Log Gate Method		Cofferdam by Steel Sheet Pile Method	
Structure						
Outline of Structure	1) Leaf type is sealed box structure. 2) Pouring & drainage devices will be equipped to install or float leaves. 3) It is necessary for leaves to fix in preparation to reversed water pressure.		1) Leaf type is plate girder structure. 2) Mid-piers are necessary, which will be fixed by anchor on piers' bottom and supporting apron. 3) To be sealed with pier and part of steel at bottom.		1) Double cofferdam structure with steel sheet pile. 2) Banking is necessary to install steel sheet pile since concrete apron or rubble foundation established on foundation ground.	
Function	1) Availability in response to difference in gate span to some extent.	◎	1) Two (2) piers will be necessary due to long gate span with 18.8m.	○	1) Steel sheet pile of IV type x 9.0 m length will be necessary due to 8.5m height of temporary cofferdam. 2) It is difficult to IV typed steel sheet pile in Pakistan.	△
Water Seal	1) Small water leak is predicted due to water seal with water pressure. 2) In rehabilitation, small water leak can be drained by drainage pump. 3) Some water leak is allowed considering future O&M(repainting etc)	○	1) Considerable water leak is predicted due to long water seal with mid-piers, bottom and part of mid-connecting. 2) Large scale drainage will be necessary for considerable leak of water in rehabilitation works. 3) Difficulty is predicted in O&M (repainting etc) due to considerable leak of water.	△	1) Adequate depth for sheet pile cannot be secured because of existence of concrete apron or rubble foundation on foundation ground. 2) Considerable seepage from foundation ground is predicted due to inadequate depth of steel sheet pile. 3) In rehabilitation, dewatering works by deep well etc is necessary due to difficulty for drainage of considerable seepage by drainage pump.	△

Methods	Bulkhead Gate Methods		Stop-Log Gate Method		Cofferdam by Steel Sheet Pile Method	
Installation and Removal or Construction	1) Leaf will be floated on canal surface with incline and towed to the site by tugboat. 2) Leaves will be installed by pouring water into them. 3) When removing to store in stockyard, adverse procedure of 2) will be taken. 4) Special technology is necessary when installing and removing. 5) It will take about two(2) days to install and remove one (1) leaf.	◎	1) Installation and removal of middle piers will be done in diving operation since water depth will be predicted to be about 7.0m. 2) Difficulty is predicted for diving operation due to low degree of water clearness. 3) Since installation and removal of stop-log will be done by crane placed on attached road bridge, closure of attached road bridge will be necessary for this period. 4) It will take about five (5) days for installation and removal of one (1) leaf.	×	1) Large quantity of soil will be necessary (about 2,500 $m^{3)}$ to install steel sheet piles into banking, and it will take about five (5) days to install and remove banking from work barge. 2) It will take about 20 days to install and remove steel sheet piles and soil from work barge per one (1) leaf.	×
Availability for Application to the Existing Piers of Barrage	1) It is necessary to heighten water seal efficiency by installing steel plates on the existing apron and to lay underground steel as guide frame at a side of piers. 2) More than three (3) m is necessary between downstream of Bulkhead gate and upstream of the gate to secure space for rehabilitation works. For the purpose, it is necessary to pay attention to leaf's shape of Bulkhead gate.	○	1) Slot for stop-log is necessary on the piers to support leaves. 2) Necessary space for rehabilitation works is not secured because there is only 2.1 m to set a slot for stop-log on the existing piers.	×	1) No impact is predicted on the existing piers since temporary cofferdam will be established at a distant from the existing piers. 2) Necessary space for rehabilitation works will be secured freely.	◎
Repeat-use	1) Possible	◎	1) Possible	◎	1) Impossible	×
Diverted use for Other Barrages	1) Repeat-use is possible for a barrage with less than 22ft height of leaves since gate span and thickness of pier for large scale barrage are unified in Pakistan. 2) Newly installation of steel plate for Bulkhead gate and steel for guide frame is also necessary.	◎	1) Repeat-use is possible for a barrage with less than 22ft height of leaves since gate span and thickness of pier for large scale barrage are unified in Pakistan. 2) Newly installation of steel plate for Bulkhead gate and steel for guide frame is also necessary.	△	1) Repeat-use in other barrages is impossible.	×
Economical Efficiency	1) Duration in year：50 years 2) Usable 91 times with repainting every 7 years. 3) Economical efficiency (per one temporary cofferdam with one gate)：3,503 thousand Yen	△	1) Duration in year：50 years 2) Includes cost to water leakage. 3) Usable 91 times with repainting every 7 years. 4) Economical efficiency (per one temporary cofferdam with one gate)：3,651 thousand Yen	◎	1) Installation and removal will be done seven (7) times for 50 years. 2) It includes cost to drain seepage water from foundation ground. 3) Economical efficiency (per one temporary cofferdam with one gate)：11,360 thousand Yen	×

Methods	Bulkhead Gate Methods		Stop-Log Gate Method		Cofferdam by Steel Sheet Pile Method	
Comprehensive Evaluation	1) Efficiencies in function and operation are most advantageous compared with other methods. 2) Advantage in water seal efficiency and easiness for installing on the existing piers. 3) Possible for repeat-use and reuse in other barrages. 4) Most economical among the three (3) methods and expectable certain construction works.	◎	1) Advantage in efficiency in function. 2) Possible for repeat-use and reuse in other barrages. 3) Less efficiency in water seal and easiness for installing on the existing piers. 4) Low efficiency in certain works because difficulty in installation and removal is predicted due to low degree of water clearness. 5) Economical efficiency is lower compared with Bulkhead gate method.	×	1) Advantage in easy installation on the existing piers. 2) Less efficiency in function and water seal as well as low efficiency in construction works. 3) Impossible for repeat-use and reuse in other barrages. 4) Lesser economical efficiency among the three (3) methods.	×

Based on the comparison made in the above table,「Bulkhead gate method」is finally recommended to be employed for temporary cofferdam method for rehabilitation works of the Barrage. It is also recommended the following reasons;

1) When considering construction period for rehabilitation, which is limited in low water season (eight (8) months from middle of October to middle of May),「Bulkhead gate method」or「stop-log gate method」are advantageous.
2) Installation of middle piers in「stop-log gate method」is predicted to be difficult due to low degree of water clearness at the point of the Barrage in the Indus River.
3) Since pier type of the Barrage is different (with and without guide wall),「Bulkhead gate method」is advantageous, which is able to respond to difference in gate span.
4) Complete dried condition is required for the replacement work of paved steel plates and welding. Therefore「Bulkhead gate method」, which has better efficiency in water seal, is advantageous.
5)「Bulkhead gate method」is also advantageous because the facilities in this method can be installed on the existing piers by installing steel plates for water seal on the existing piers and apron.
6)「Bulkhead gate method」is advantageous because of availability for repeat-use in this Barrage and reuse in other barrages due to its easy installation and removal.
7) When comparing cost for installation and removal of gates,「Bulkhead gate method」is most economical among the tree (3) methods.

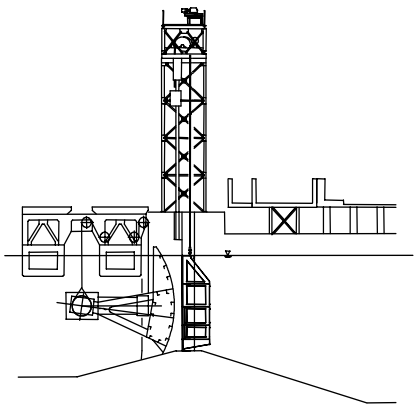
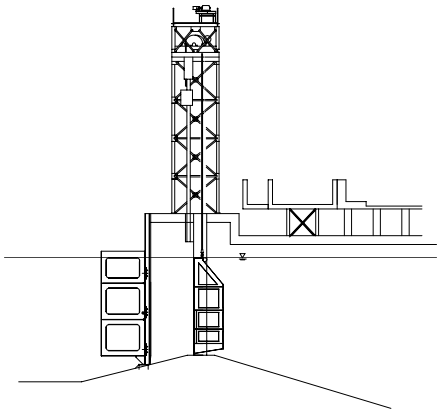
(3) Types of Bulkhead Gates

Bulkhead gates are used in Pakistan at the Sukkur and Kotri Barrage. Among these, the Bulkhead gates at the Sukkur Barrage are the pontoon type that has separate structure from the temporary closing gates. Table 2-2-1.11 compares the pontoon and Bulkhead type which are used for the Kotri Barrage and which are popular in Japan.

Although the pontoon type of Bulkhead gate is advantageous in terms of economy, application of the

pontoon type to the Taunsa Barrage is difficult from the structural point of view. The Bulkhead type is superior to the pontoon type when the operability, water tightness and converted use for another barrage are taken into consideration. Given the particularly large number of barrages for management in Punjab Province, the prospective converted use for other barrages must be taken into consideration as rehabilitation work is already planned for the Trimu and Jinnah Barrage which will certainly be followed by other barrages in the future. For these reasons, the Bulkhead type will be adopted for the present Project.

Table 2-2-1.11 Comparison of Bulkhead Gate Types

Descriptions	Pontoon Type	Bulkhead Type
General Drawings		
Watertight Performance	As side water tightness is structurally required, water tightness must be done at the sides of the barrage piers. As the watertight performance is easily affected by the completed conditions of these piers, the water tightness at the sides is inferior.	As the water tightness is structurally done at the top of the barrage piers, the impact of the completion conditions of the piers is less prominent compared to the pontoon type, providing a better watertight performance.
Application to Taunsa Barrage	Because the upstream piers are shorter at the Taunsa Barrage, the Bulkhead gate must be fairly near the main gate to secure the side water tightness, making the clearance to the main gate very small. The application of the radial type to the Taunsa Barrage is impossible as its arched gate would make the gate nearer the downstream main gate, leaving a space of only some 500 mm for work.	As water tightness is established at the top of the barrier piers, sufficient clearance to the main gate can be secured, causing no obstacle to rehabilitation work.
Converted Use for Other Barrage	Difficult to divide the gate.	Possible to divide the gate.
Economy	90% The pontoon can be shared; good economy if the number of gates is large.	100% Slightly disadvantageous from an economic point of view.
Judgement	Functionally, it is difficult to apply the pontoon type to the Taunsa Barrage and this type, therefore, is not employed.	Functionally, its use for the Taunsa Barrage has no problems and, therefore, this type is employed.

(4) Gate Numbers of Bulkhead Gates

Study on the required number of the Bulkhead gates was made considering ① the most optimum scale in terms of project economy based on the gate numbers and rehabilitation periods and ② adequate operation and maintenance works for the rehabilitated gates after the implementation of the project. Finally, it was concluded that the most optimum numbers of gate is 5.

① Study from Viewpoint of Project Economy

Project economy was evaluated in comparison with net production values (NPV), based on the following conditions.

- Out of 65 gates, 29 gates of the Taunsa Barrage would be rehabilitated under the Japan Grant Aid Program. The remaining 36 gates would be rehabilitated under the Punjab Barrage Rehabilitation and Modernization Project under World Bank assistance.
- Bulkhead gates to be procured under the Japan Grant Aid Program are planned to be utilized for both projects mentioned above.
- Required project implementation periods are examined with alternation of Bulkhead gate numbers from 4 to 7 gates as shown in the following Table 2-2-1.12. In this study, manufacturing periods of bulkhead gates, which seems to be constant in spite of gate number alternations, are not taken into account in the rehabilitation periods.

Table 2-2-1.12 Comparison Study on Bulkhead Gate Numbers and Required Rehabilitation Periods

Numbers of Bulkhead Gates	4	5	6	7
Required periods for installation of 29 gates under grant aid program（year）	2.5	2.0	2.0	1.5
Required periods for installation of 36 gates by World Bank (year)	3.5	2.5	2.5	2.0
Total periods for 65gates（year）	6.0	4.5	4.5	3.5

- The costs for the Contractor's construction management and Consultant's supervision activities would be needed.
- Required maintenance costs for the existing gates installed in the Taunsa Barrage would be reduced in accordance with the implementation of rehabilitation works mentioned above, and these reduced amounts are counted as the project benefit concerned.
- In evaluating the net production values (NPV), 12 % of interest rate is applied.

From the above study, it was revealed that the most economical case is in 5 bulkhead gates with the lowest NPV. Difference of the NPV between the 5gates plan and 4 gates plan is only 1 %. However, rehabilitation period of the Project is reduced at 1.5 year as compared with the 4 gates plan. Under the conditions, 5 gates plan was recommended as the most optimum scale in the Project. Implementation schedule for 5 gates plan is given in Figure 2-2-1.9. Detailed calculations of the study are referred to in the attached data (A6-2), and it is summarized as shown below.

Table 2-2-1.13 Comparison of NPV

BHG (Nos)	N.P.V. (M.Rs)	Ratio
4	276	1.01
5	275	1.00
6	307	1.12
7	313	1.14

Intarest = 12%

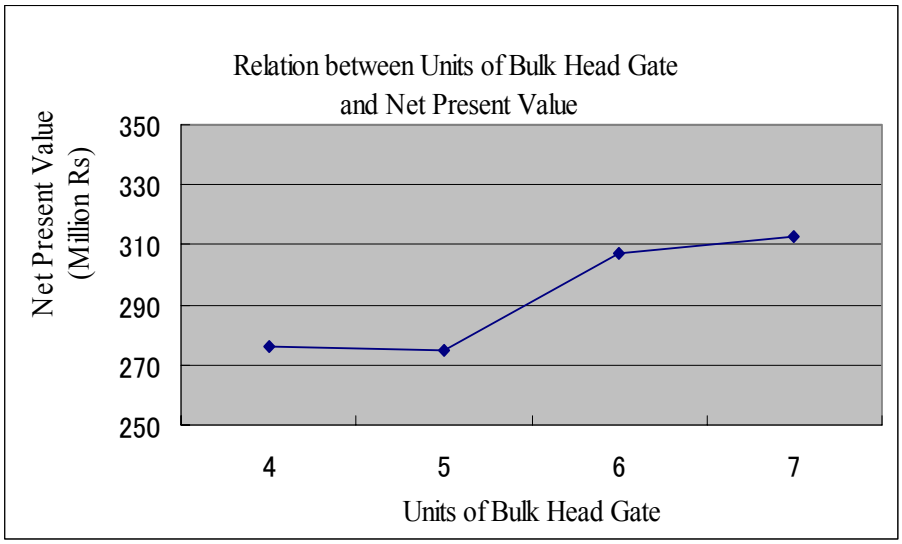


Figure 2-2-1.8 Relation between Bulkhead Gate Numbers and NPV

② Study from Viewpoint of Operation and Maintenance after Project Implementation

Effective periodical gate operation and maintenance and improvement works, such as gate repainting, gate improvement, regulatory structure improvement, etc. could be expected after project implementation by using the introduce bulkhead gates. In studying the adequate number of bulkhead gates from the operation and maintenance viewpoints, data from other related barrages were used.

In case of the Kotri barrage constructed in Sind Province, 3 sets of bulkhead gates have been installed. Barrage and related facilities have been properly maintained and in good conditions utilizing the bulkhead gates. Utilization records of bulkhead gates in the Kotri Barrage are given below.

Maintenance Period：	1.5 month／gate
No. of Bulkhead gates：	3 gates
Total no. of gates：	45 gates

According to the data, the installed gates have been maintained and improved once every 2years on the average (45 x 1.5 / 3 / 12 = 1.9 year).

If the operation and maintenance works of the Taunsa Barrage would be undertaken in the same frequency as the Kotri Barrage, the required number of bulkhead gates for the Taunsa Barrage is estimated at 5 gates as shown below.

65gates / 45gates x 3 gates ＝ 4.3 gates,
Say 5 gates

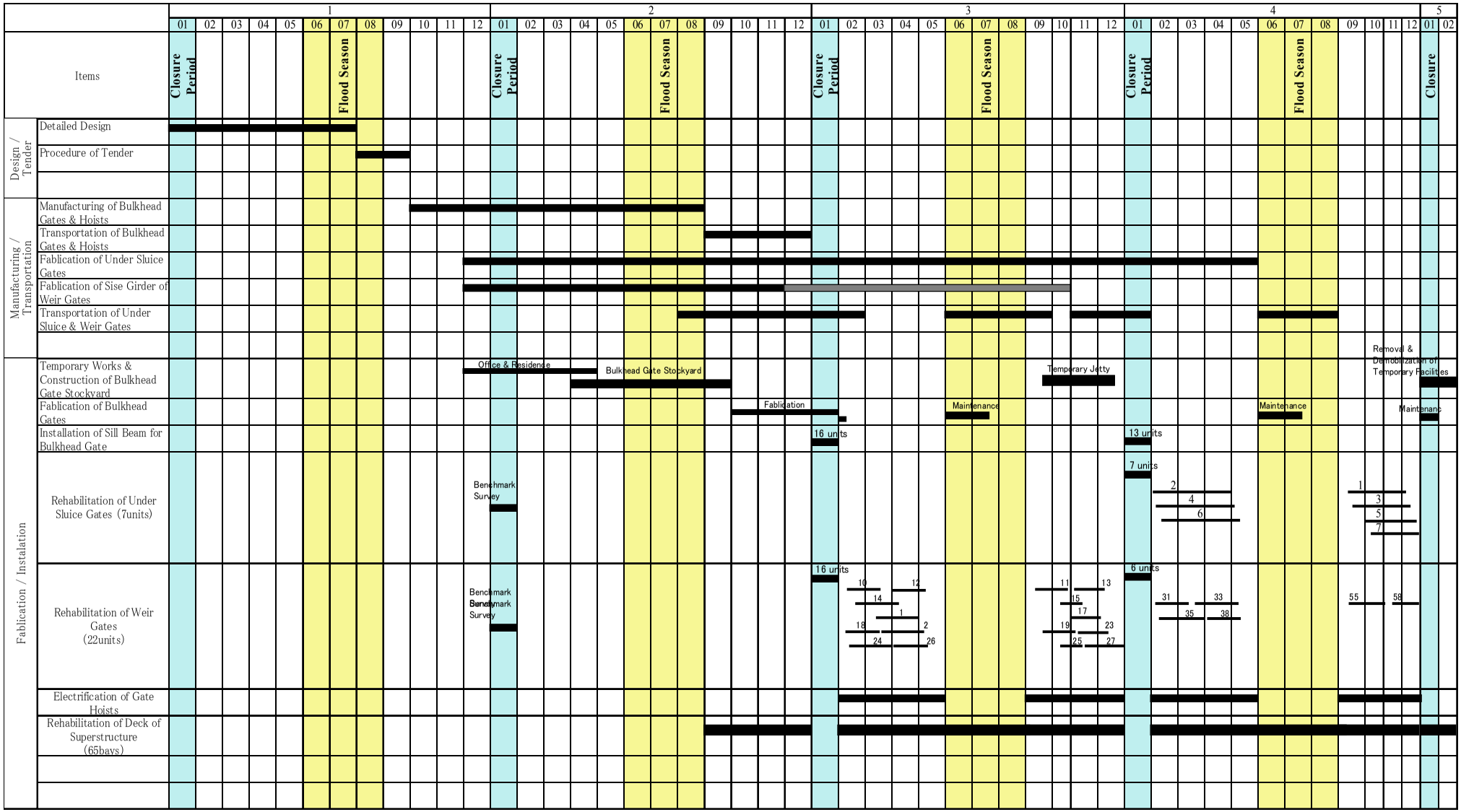


Figure 2-2-1.9 Gate Rehabilitation Work Schedule with 5 units of Bulkhead Gates

(5) Height of Bulkhead Gate

① Study on Combination of Bulkhead Gates for Under Sluice and Weir Gate

Based on the study result discussed in the former Section, provision of five (5) number of bulkhead gates is the optimum for the project.

Since the required height of bulkhead gate is different between that for the Under Sluice Gate (height:25ft) and that for the Weir Gate (height:22ft) due to the different gate height, it is necessary to study the composition of number of the bulkhead gate for the under sluice and weir gate. Basically, two (2) bulkhead gates for the under sluice gate will at leased be required to arrange the construction schedule of the project within the least period of four (4) years. Therefore, the following four (4) alternative cases are studied.

Table 2-2-1.14 Combination of the Bulkhead Gates using for Under Sluice and Weir Gates

Items	Case 1 (5 units for Under Sluice)	Case 2 (4 units for Under Sluice)	Case 3 (3 units for Under Sluice)	Case 4 (2 units for Under Sluice)
Nos. of Bulkhead Gate for Under Sluice (Height: 25ft)	5 units	4 units	3 units	2 units
Nos. of Bulkhead Gate for Weir Gate (Height: 22ft)	0 unit	1 unit	2 units	3 units

② Basic Conditions for Study

Basic Conditions for study of the Bulkhead gate height are as follows.

1) Total weight of the Bulkhead Gate for Under Sluice Gate (Height: 25ft) is estimated at 130 ton /unit and the production cost in case of fabrication of only one bulkhead gate is also estimated approximately 100 million yen/unit.

2) Cost reduction coefficients for simultaneous fabrication of plural number of gate are provided as follows in conformity with the standard for cost estimation of the mechanical plant construction stipulated by the Ministry of Land, Infrastructure and Transport.

Table 2-2-1.15 Cost Reduction Coefficient with Production Number of Gate

Production Number (unit)	2 units	3 units	4 units	5 units
Reduction Coefficient (per unit)	0.95	0.93	0.92	0.91

Namely, unit cost of bulkhead gate is given as “100 million yen x 0.91 = 91 million yen” in case of fabrication of unified five (5) units of the bulkhead gate.

3) Total weight of the Bulkhead Gate for Weir Gate (Height: 22ft) is estimated at 123 ton /unit which corresponds 95 % of the one for Under Sluice Gate. Then, the production cost of the Bulkhead Gate for Weir Gate will be estimated in proportion to the weight of that for Under Sluice Gate. Therefore, the production cost of the Bulkhead Gate for the Weir Gate in case of fabrication of

only one unit is estimated approximately 95 million yen/unit.

③ Comparison of the Production Cost among 4 Cases

Table 2-2-1.16 Production Cost of Bulkhead Gate of Each Alternatives

Items	Case 1 (5 units for Under Sluice)		Case 2 (4 units for Under Sluice)		Case 3 (3 units for Under Sluice)		Case 4 (2 units for Under Sluice)	
Unit Number of Bulkhead Gate	For Under Sluice	For Weir Gate	For Under Sluice	For Weir Gate	For Under Sluice	For Weir Gate	For Under Sluice	For Weir Gate
	5 units	-	4 units	1 unit	3 units	2 units	2 units	3 units
Weight Ratio of Bulkhead Gate for Weir Gate (Height:22 ft) against that for Under Sluice Gate	0.95		0.95		0.95		0.95	
Reduction Coefficient according to Production Unit Number	For Under Sluice	For Weir Gate	For Under Sluice	For Weir Gate	For Under Sluice	For Weir Gate	For Under Sluice	For Weir Gate
	0.91	1.00	0.92	1.00	0.93	0.95	0.95	0.93
Accumulated Coefficient for 5 units of Bulkhead Gate converted to the one for Under Sluice Gate (Height:25ft)	1.00 x 0.91 x 5units + 0.95 x 1.00 x 0unit = 4.55		1.00 x 0.92 x 4units + 0.95 x 1.00 x 1unit = 4.63		1.00 x 0.93 x 3units + 0.95 x 0.95 x 2units = 4.60		1.00 x 0.95 x 2units + 0.95 x 0.93 x 3units = 4.55	
Unit Production Cost of Bulkhead Gate for Under Sluice Gate （million yen /unit）	100		100		100		100	
Total Production Cost for 5 units of Bulkhead Gate (Ratio)	455（1.00）		463（1.02）		460（1.01）		455（1.00）	
Difference of Production Cost （million yen）	0		8		5		0	
Evaluation	◎		△		○		◎	

④ Conclusion

Based on the above result and the following reasons, Case 1 gives the optimum alternative. Therefore, five (5) units of the Bulkhead Gates with the height of 25 ft will be fabricated for the project.

1) Two cases of Case 1 and Case 4 give the most cheapest production cost of the Bulkhead Gate.
2) Case 1 is more suitable between two cases (Case 1 and Case 4) in order to satisfy the requirement of the construction plan that will need 4 units of the Bulkhead Gate for the Under Sluice Gate (Height: 25ft).
3) No constraint will arise in arrangement of maintenance order between the Sluice Gate and Weir Gate when gate maintenance works such as repainting after project will be scheduled in the Case 1 due to all higher bulkhead gates.
4) In the Case 1, there is high compatibility of the parts of the Bulkhead Gate when repair is needed because of all the same shaped gate blocks and parts that have interchangeability.

(6) Ancillary Equipment for Bulkhead Gate

The following equipment will be required when the bulkhead gate is made usable.

- Crane to assemble the bulkhead gate
- Bulkhead gate lifting equipment
- Bulkhead gate towing equipment

① Crane for Assembly

The crane must be capable of hoisting the weight of the largest block of the bulkhead gate within the operating radius which takes the layout of the storage area into consideration. Assuming that the weight of the largest block is 15 tons and the operating radius is 8 m, the required crane must be a 45 ton truck crane.

② Lifting Equipment

When the bulkhead is used, it must be lowered to the water front along the rails laid on the slipway by placing it on a cart. For this purpose, winch type lifting (and lowering) equipment will be installed. Assuming the speed of the cart is 1.0 m/min, a 5.5 kW winch will be required.

③ Towing Equipment

To install the bulkhead gate, it must be towed by tow (2) tug boats from the storage to the installation site. Assuming a river water velocity of 1 m/sec, the required motor output to allow the tug boat to navigate at a speed of 4 knots (2 m/s) against the current is 150 PS. At the time of towing, two tug boats positioned at the front and back of the bulkhead gate will be used. A total of three working boats will be provided, two of which will be used to transport the bulkhead operating equipment while the other will be used for communication purpose with the land.

2-2-1-6 Bulkhead Gate Stockyard

(1) Layout for Bulkhead Gate Stockyard

Regarding the stockyard of bulkhead gates, two places of stockyard storing 3 gates at both right and left banks have been proposed in “Feasibility Study on Taunsa Barrage Irrigation System Rehabilitation” prepared by JICA Study Team in August 1998. However, a lump stock plan with 5 gates at the left bank is proposed for JICA Grant Aid Program instead the above plan considering their storages and O&M.

① Location of Bulkhead Gate Stockyard

The following were considered in the determination of the adequate location of bulkhead gate stockyard.

- Location with low sedimentation on inclination
- Convenient location from view point of storage, management, O&M, etc.
- Location of easy security for towing bulkhead gates

② **Scale of Stockyard for Bulkhead Gate**

The following were considered in the selection of appropriate scale of stockyard;

- Length of stockyard
  Inclination length, passage width, embankment road width, etc
- Width of stockyard
  Embankment road width, passage width, gate loading space, gate stock width, working space, etc.
- Ground elevation of stockyard
  Since the stockyard will be provided at river-side land, ground elevation of the yard will be planned to be RL 454.00 ft as the same as that of proposed bank.

(2) Equipment Plan

① **Inclination**

The following were taken into account in consideration an adequate scale of inclination;

- Top elevation of inclination
  Design maximum water level, required draft, truck height, allowance, etc.
- Crest elevation of inclination
  Flood water level, freeboard of embankment, etc.
- Slope of inclination
  Slope of inclination will be studied for the following three cases of alternatives of 1/15, 1/10, and 1/5 in the aspects of equipment scale, installation schedule, costs, etc.
- Length of inclination
  Elevation difference, slope, etc.

② **Lifting-up Winches for Bulkhead Gate**

The following were taken into account in consideration an adequate scale of winches;

- Gate lifting-up speed
- Gate lifting-up power
- Electric motor capacity

Electrical power sources for winch will be studied using the following alternative plans from viewpoint of reliability, costs, etc. , that is, 1) Plan-1:commercial electric power + motor, 2) Plan-2: generator + motor, and 3) Plan-3: generator

(3) Bank Revetment for Loading Slope

The following were taken into consideration in designing bank revetment works of the Indus River.

- Scale of loading revetment

- Structures of loading revetment

(4) Civil Works

In designing the major civil works for the bulkhead gate stockyard, the following were taken into account.

- Land preparation works
- Earth works
- Foundation works
- Pavement works
- Revetment works

2-2-1-7 Electrical Facilities

The electrical systems must be able to fully resist the tropical climate given the harsh weather conditions and operating temperature range of 0°C to 55°C is taken into consideration for the design of the systems. The systems shall be simple and well-balanced in terms of structure and function to ensure good operationality, safety and maintainability. For gate operation, prevention of manmade flooding in the downstream due to operational error shall be considered. Both electrical operation and manual operation will be conducted from the equipment (local) side to ensure safety during gate opening or closing operation.

The number of gates to be simultaneously opened at the time of flooding will be 10 in consideration of the following facts.

① Based on the result of simulation of gate operation in the flood, gates more than two units are required to operate simultaneously at the Taunsa Barrage.
② Six (6) units of gate were simultaneously operated at Chashma barrage and eight (8) units at Marala barrage based on past record.
③ The planned number of simultaneous operation gates is set at ten (10) at the maximum for Taunsa barrage.

Although the number of gates subject to rehabilitation under the Project is 29, the power supply system will be designed for all 64 gates in order to introduce unified power supply system considering that the remaining gates will be rehabilitated under the Punjab Barrage Rehabilitation and Modernization Project.

(1) Applicable Codes/Standards and Units

Such international standards as IEC and ISO and the Japanese standards listed below will be applied for the design of the main functions of the equipment to maintain compatibility with the existing equipment of other barrages. As there are no local standards governing electrical work, Japanese standards will be

used for such work. The International System of Units (SI) will be used for the units.

a)	International Electrotechnical Commission (IEC)	: applied to electrical products in general
b)	International Standards Organization (ISO)	: applied to industrial products in general
c)	Japanese Industrial Standard (JIS):	: applied to industrial products in general
d)	Standard for the Japan Electrical Committee (JEC):	: applied to electrical products in general
e)	Standards of Japan Electrical Manufacturers Association (JEM)	: applied to electrical products in general
f)	Japanese Electric Association (JEAC)	: applied to electrical products in general
g)	Japanese Cable Makers Standard (JCS)	: applied to electrical wires and cables
h)	Technical Standards for Electrical	: applied to the design of electrical equipment and Facilities in Japan work in general

(2) Equipment Size

① Power Receiving Equipment

Under the Project, arrangements will be made to receive power through a single line extended from the 11 kV local distribution network. The local distribution network has so far reached the premises of the administration office of the Taunsa Barrage. Outdoor power receiving equipment will be installed at the side of the control office. The transformer will be the stationary type and will be installed within the fence for the purpose of safety control. Low voltage distribution panel and reserve generator will be provided with roof for protection from direct sunlight and rain and also in view of better operability.

② Gate Operating Apparatus

The Taunsa Barrage consists of a total of 64 gates. While the rehabilitation of 29 gates is planned under the Project, the Pakistani side plans to conduct the rehabilitation and electrification of the remaining 35 gates with World Bank assistance. However, as the gate locations subject for rehabilitation under the Project is not continuous, it is still necessary to design a unified standard for electrification, as power cable to supply power will be laid for all 64 gates.

The gate opening per one time operation will be restricted to prevent manmade flooding in the downstream due to operational error.

③ Lifting Equipment

Although the Taunsa Barrage has some lighting equipment, 20% of this equipment is not functioning at present. Improvement of the existing lighting equipment will be conducted by the Pakistani side.

④ **Communication Equipment**

At present, the gates are manually operated by a group of gate operators (approximately 10 persons per shift). The operators' group uses radio equipment to communicate with the staff office or the control office and operates under specific instructions regarding which gates to be operated and the degree of opening. Following the electrification of these gates, a multiple number of gates will be simultaneously operated and the number of existing radio equipment will be inadequate to deal with this situation.

⑤ **Emergency Generator**

The 11 kV local distribution network experiences frequent power cuts, particularly at the time of rain, hence the power supplied by this network is unstable, making the installation of a reserve generator necessary. This emergency generator shall be outdoor type and manually operated using a battery.

⑥ **Equipment for Bulkhead Gate Removal and Storage**

After use, a bulkhead gate will be moved into the ground for storage. This landing operation from Indus River will use a winch, making the procurement of motor and control panel necessary. Power supply to the motor and control panel will be made from the exclusive reserve generator. As the equipment will not be frequently used, it will be stored in the workshop in view of better maintenance.

⑦ **Relocation of Telemeter Panels and Gate Position Sensors**

At present, nine (9) telemeter panels (DAU : Data Acquisition Unit) to transmit data on the gate aperture, etc. have been installed by the WAPDA at the pier section on the operating deck. These will be relocated to an appropriate location near the centre of the gate to allow remodelling of the gate operating apparatus and reinforcement of the piers.

Meanwhile, the existing gate position sensors (GPS, two pair per gate) are installed on the transmission shaft linked to the drum. As this shaft will be relocated to the upper deck, relocation of the gate position sensors will be necessary.

2-2-1-8 Conditions of Construction and Equipment

(1) Contractor

In Pakistan, there are many big and small-scale contractors. Some major contractors have large-scale construction experiences and their technical level is relatively high. Small contractors are mostly located in the provincial areas.

Contractors in the towns near the project site are small-and-medium-scale. No contractor in the towns has large-scale bridge and dam construction experiences. There are 12 contractors that are approved by IPD as class A (class A contractors have the right to bid all kinds of construction works), which are concentrated in Islamabad and Lahore.

Contractors with large-scale construction work such as bridge, barrage and dam construction are confined to the major cities of Karachi, Islamabad and Lahore.

Domestic contractors in Pakistan have executed repair works of barrage (e.g. repair work of gate, improvement of river bed protection work) single-handedly or under a joint venture with foreign companies. Therefore, it is possible to execute construction work by Pakistani companies under supervision of selected Japanese contractor.

(2) Labor Force

Employment of unskilled labors around Taunsa Barrage (e.g. Cot Adu, D.G.Khan, Muzaffar Garh, Multan) will be possible but it would be difficult to employ skilled labors near the site.

As the project is mainly for rehabilitation work, securing workforce is planned as follows.

- Skilled labor such as welders, mechanics and electricians will be sourced out from Lahore city and Islamabad city.
- Lack of workers during peak period of construction will be also come from both cities above mentioned.
- Welders and erection workers who are engaged in gate rehabilitation work are required to be technically eligible for qualification of JIS or AWS. In view of this, it is planned that to be able to get qualified skilled workers, contractors coordinate with firms that has experiences in manufacturing and installation of gate or plant. By so doing, the contractor will be able to get the required skilled workers..

(3) Construction Equipment

Most of common construction equipment can be procured in Pakistan. Local contractors own these common construction equipment. In addition, there are company leasing equipment that the contractor can tap when necessary.

However, as procurement of construction equipment is difficult around Taunsa Barrage, they are planned to be procured in the cities of Lahore and Islamabad.

2-2-1-9 Procurement and Fabrication of Gate Facilities

Bulkhead gates, which are cofferdam gates, will be procured as the equipment and supply project separate from the rehabilitation works. Under sluice gates and weir gates are planned to be part of the main rehabilitation works. However, Bulkhead gates are connected with the main works, the tender shall be applied about manufacture and procurement after detailed design instead of the tender including design, manufacture and procurement.

Some of factories that were surveyed have sufficient ability to manufacture hydraulic steel gates. Though the past records of manufacturing hydraulic gate are a few, major factories have a lot of experience in manufacturing steel structures such as products used in the plant.

Therefore, end beam of weir gate, under sluice gate and so on, are possible to be manufactured in the factory of Pakistani companies. However, the bulkhead gate will be possible to be manufactured in the factory of Pakistan with the technical support of the Japanese Heavy Industry Company (Gate

Manufacturer) who has experiences of manufacture of the bulkhead gate.

The estimated weight of steel product required in this project is shown in the Table 2-2-1-18. SUS (stainless used steel) material is planned to be procured in Japan since it is not produced in Pakistan. While it is possible to procure SS (carbon steel for general structure) material in Pakistan, along with the increased demand for steel materials in China and growth of export to Afghanistan in recent days, steel prices is raising rapidly and therefore there is short supply of steel materials in Pakistan. Local prices of steel in Pakistan and third country are not much different from that in Japan.

Taking into consideration the above situation, SS material is also planned to be procured in Japan since required amount for steel material in this project is more than 2,000 tons.

Table 2-2-1. 17 Candidates of Procurement on Gate Facilities

Item of Procurement		Manufacturing Country		
		Japan	Pakistan	Third country
Bulkhead Gate	Gate Leaf	○	△	○
	Guide Frame	○	○	○
Under Sluice Gate	Gate Leaf	○	○	○
	Roller Train	○	○	○
	Track Plate on Guide Frame	○	○	○
	Sill Beam	○	○	○
Weir Gate	Leaf End	○	○	○
	Roller Train	○	○	○
	Track Plate on Guide Frame	○	○	○
	Sill Beam	○	○	○
Gate Hoist		○	×	×
Deck on Superstructure	Deck Plate	○	○	○
Equipments in Bulkhead Gate Stockyard	Cart, Platform	○	○	○
	Lifting Device (Winch)	○	×	×

Table 2-2-1. 18 Estimated Weight of Steel Product (unit : ton)

Item	Number	Major Component		Auxiliary Component	Parts / Equipment	Total Weight
		Carbon Steel (SS)	Stainless Steel (SUS)			
Bulkhead Gate (Body)	5 gates	650.0	2.9	—	10.3	663.2
Bulkhead Gate (Guide Frame)	29 gates	138.0	87.5	—	9.5	235.0
Under Sluice Gate (Leaf/Guide Frame)	7 gates	331.0	15.1	13.3	1.9	361.3
Weir Gate (Leaf (End Beam) / Guide Frame)	22 gates	137.0	48.7	—	6.4	192.1
Gate Hoist	29 gates	430.0	0.0	25.3	80.9	536.4
Deck on Superstructure	65 gates	13.6	0.0	—	130.2	143.8
Equipments in Bulkhead Gate Stockyard	1 lot	114.8	4.0	—	2.1	120.9
Total		1,814.6	158.2	38.6	241.3	2,252.7

(1) Bulkhead Gate

Bulkhead Gates are manufactured and procured by experienced Japanese heavy industrial companies (gate manufacturing company) in Japan. Some of them have factories in China and Taiwan and so on, so the possibility is high to manufacture them in the third world country.

Cost estimation on the procurement of the Bulkhead Gates is shown in the Table 2-2-1.19. When the gates are manufactured in Pakistan or third world country, work expense will be lesser than when they are manufactured in Japan. Manufacturing at the factories in Pakistan is considered preferentially in this project. However it is planned to procure gates dispersedly including third country to assure quality and process because 5 gates are manufactured in a short time.

Table 2-2-1. 19 Comparison of Amount of Procurement for Bulkhead Gates

Manufacturing factory		Japan	Pakistan	Third country
Equipment Availability of Large Scale Milling Machine		Most of the factories have equipment.	Available in only limited company. Company without machine shall be outsourcing, which will affect delivery time.	Company without machine shall be outsourcing.
Experience and Skill in manufacturing Bulkhead Gates		About 5 companies have experience. It is possible to fabricate by the company who has experience on shell type gate.	No experiences It is possible as a cooperation factory of the Contractor who has experience and technology to support.	No experiences However, it is possible to manufacture by affiliated company with Japanese gate manufacturer.
Number of gates possible to deliver within scheduled time		All of 5 planed gates will be possibly delivered in time	Approximate 3 number of gates out of 5 planed gates will be necessary to be manufactured in other countries	All of 5 planed gates will be possibly delivered in time with proper procurement management plan
Manufacturing Cost (thousand yen / ton)		1,665	995	1,056
Evaluation	Manufacturing Facilities	◎	△	○
	Skill	◎	△	○
	Delivery time	◎	△	○
	Cost	△	◎	○
	Comprehensive Evaluation	△ Cost is remarkably high. No problem in delivery time.	○ (subject to cooperate with Japanese manufacturer) Expecting cheapest cost. By procuring some gates from third country where cost could not be high, it will be possible to procure bulkhead gates economically within planed delivery time.	○ Cost is a little higher than that in Pakistan. Proper procurement management plan for delivery time will be required。

Note; A large scale milling machine is required for manufacturing the joint portion of the Bulkhead Gate because milling will be made after fabricating to large pieces.
Manufacturing Cost in Pakistan is the one when the Japanese manufacturer utilizes the factory in Pakistan to fabricate the Bulkhead Gate. Such cost includes all necessary expense to fabricate it in Pakistan.

(2) Under Sluice Gate / Weir Gate

While the existing gates have a steel truss structure, the new Under Sluice gates replaced will be a plate girder structure. Fabrication and procurement of the gates with such structure will be possible to be manufactured at the factories in Japan, Pakistan and the third world country that have experiences of fabrication of plate girder type gates. Cost estimation of procurement of Under Sluice Gate and Weir Gate are shown in table 2-2-1.20. When the gates are manufactured in Pakistan or third world country, work expense may be lower than when they are manufactured in Japan. Manufacturing at the factories in Pakistan is considered preferentially in this project.

Table 2-2-1. 20 Comparison of Amount of Procurement for Gates

Manufacturing factory		In Japan	In Pakistan	In Third world country
Equipment Possession of Large Scale Milling Machine		Sufficient facilities available in most of Gate Maker factories	Available in limited steel manufacturing factories	Available in limited steel manufacturing factories
Experience and Skill in Manufacturing the Truss Type Structure and Plate Guider Type Structure		Many Gate Makers have experience in manufacturing.	Limited steel manufacturing factories have experience. It will be possible for steel manufacturing factories to manufacture those gates as subcontractor under supervision of Japanese experienced Gate Makers	Limited steel manufacturing factories have experience. It will be possible for steel manufacturing factories who have affiliation to Japanese experienced Gate Makers or for steel manufacturing factories as subcontractor under supervision of Japanese experienced Gate Makers to manufacture those gates.
Delivery time： Number of gates to be delivered within planned schedule		All of 7 planned Under Sluice gates and 22 planned Weir gates will be possibly delivered in time	All of 7 planned Under Sluice gates will be possibly delivered in time. 8 numbers of gates out of 22 planned Weir gates will necessarily be manufactured in other countries	All of 7 planned Under Sluice gates and 22 planned Weir gates will be possibly delivered in time with proper procurement management plan.
Combined Under Sluice Gate and Weir Gate Manufacturing Cost (Thousand Yen/ton)		1,694	1,157	1,281
Evaluation	Manufacturing facilities	◎	△	○
	Skill	◎	○	○
	Delivery time	◎	△	○
	Cost	△	◎	○
	Comprehensive Evaluation	△ Cost is remarkably high. No problem in delivery time.	○ Expecting the cheapest cost. By procuring some gates from Third country where cost could be not high, it will be possible to procure those gates economically within the planned delivery time.	○ Cost is a little higher than in Pakistan. All of 7 planned Under Sluice gates and 22 planned Weir gates will be possibly delivered in time with proper procurement management plan.

However, some numbers of Weir Gate would be manufactured in third world country out of 22 gates when the Under Sluice gates and a few bulkhead gates will be planned to manufacture at the factory in Pakistan due to limited number of manufacturing facilities. Therefore, it is planned to procure gates dispersedly

including third country to assure quality and process because of necessity of delivery of gates in a short period.

(3) Gate Hoist

Gate hoist must conform to strict standards on the strength and quality.

Particularly, when electrifying gate operation, torque will become bigger than current manual operation. Therefore, higher technical specifications regarding strength of parts and accuracy on manufacturing and assembling are required on this device.

Pakistani factory has no experience in manufacturing electrified gate hoist though they have experiences with manual type. On manufacturing electrified devices, some works such as precise workmanship, for example, butt seam welding of dram shell, gear engagement, centering of coupling and so on are required. Therefore, it may be difficult for the factories in Pakistan to execute the work complying with high accuracy technical standards, such as welding, machining, assembling and adjustment.

Accordingly, gate hoist is planned to be procured in Japan.

(4) Electrical Facilities

There are two major companies dealing with incoming and substation facilities in Pakistan. These two (2) companies collectively occupy 80% share of the domestic market in Pakistan. Each company has about 40% of market share and the rest by other smaller companies. Therefore, these 2 major companies have sufficient work experience in Pakistan.

Furthermore, considering O&M conditions in the future, it is desirable for this project to introduce domestically produced equipment. Accordingly incoming and substation facilities are planned to be procured in Pakistan.

However, local control panel for gate hoist is planned to be procured in Japan considering that both two (2) major electric companies do not have the work experience in manufacturing this kind of panel. This panel should be designed tolerable for the use in tropical area.

(5) Deck on Superstructure

It is planned that reinforcing components for superstructure and the components necessary for repair work of deck on superstructure will be manufactured in the factories in Pakistan.

2-2-1-10 Procurement of Other Material and Equipment

(1) Tug boat, Boat and Truck crane for the Installation of Bulkhead Gate

The tugboat, the boat and the truck crane to be procured in this project will be used in construction work, however, the delivery period is limited.

Equipment to be Procured	Purpose of Procurement	Time Limit of Procurement
Truck Crane: 50 ton class	Assembly of Bulkhead Gate	Before Oct, 2006
Tug Boat: 150ps, Boat : Live Load 1.2t	Towing of Bulkhead Gate	Before Jan, 2007

In Pakistan, there is only one dockyard in Karachi for building steel ships, which is run by government and most of its products are mainly delivered to the state industries. There are some private companies building glass fiber ships in Pakistan, and that deals with imported products from foreign countries.

Therefore, considering the limited period of delivery of ship, the above-mentioned boats are planned to be procured in Japan.

(2) General Materials for Construction

It is possible for the contractor to procures the following construction materials, e.g. cement, reinforcing bar, lumber, general building materials, lightweight steel product, electric wires, piping materials and so on.

Most of them are planned to be transported from Lahore city to the project site. Coarse and fine aggregates for concrete works are planned to be procured in D.G. Khan.

(3) Construction Machines

Most of general construction equipment such as backhoe, bulldozer, truck, crane can be procured (80 ton class crane is also available) in Pakistan. Local contractors have their own construction equipment. In addition, there are companies that can lease these required / needed equipment.

However, procurement of construction equipment around Taunsa Barrage is difficult. Therefore, it is proposed that the construction equipment be procured in Lahore city and transported to the project site.

Pontoon of unit float type will be used for repair work of under sluice gates, which is possible to assemble and disassemble over a short period of time. It is proposed to procure this in Japan because it is hard to procure in Pakistan and neighboring countries.

(4) Materials for the Temporary Works

Many of local construction companies use timbers as support materials and use boards for formworks as well as steel scaffold. So, these temporary materials can be procured in Pakistan. Cofferdam in the river is planned to be made with sandbags. Although usual sandbags are available in the market of Pakistan, the large size bags that will be used in this project are planned to be procured in Japan.

In the procurement of steel sheet pile, there is neither market of the lease companies in Pakistan nor neighboring Middle East countries. Procuring the leased materials from Japan is moderate in price than purchasing in the neighboring countries of Pakistan. Therefore, it is proposed that the contractors procure the leased steel sheet pile from Japan.

2-2-1-11 Construction Plan and Method

(1) Basic Construction Plan

Major components of this project consist of replacement of gate such as the under sluice gate, the end beam of weir gate, the guide frame of sill beam and side beam, and the bulkhead gate will be set up at upstream of the main gate as cofferdam.

The installation of bulkhead gate will be stopped from the middle of May to the middle of September due to high velocity of river flow. On the other hand, the bulkhead gates have to be returned to stockyard at the end of December due to annual closure period, in which rivers flow dramatically drop. Consequently, taking these conditions into account, as it takes 3.5 months (February - Middle of May, Middle of September – December) for the replacement period of one gate, basic construction plan shall be designed to complete in the period.

The guide frame for bulkhead gate must be installed under dry condition during the annual closure period. However as the period is limited to 30 days, number of work shifts must be increased in order to complete the installation work within one month.

Existing equipment to be removed and installation equipment shall be carried by truck crane placed on the attached road bridge. Construction schedule is formulated on the ground that daytime transportation will be closed during construction period, except one hour. Taking into consideration Class AA (70 tons army tank) loading, in case that weight of construction equipment exceeds 70 tons, pontoon shall be required.

IPD requested the Japan's Grant Aids for filling work of 100,000 m^3 for bulkhead gate stockyard. However, based on the principle of Japan's Grant Aids, the filling works, which does not require high technology, shall be carried out by recipient country. The filling work should be completed before October 2005, which is the beginning of the Project.

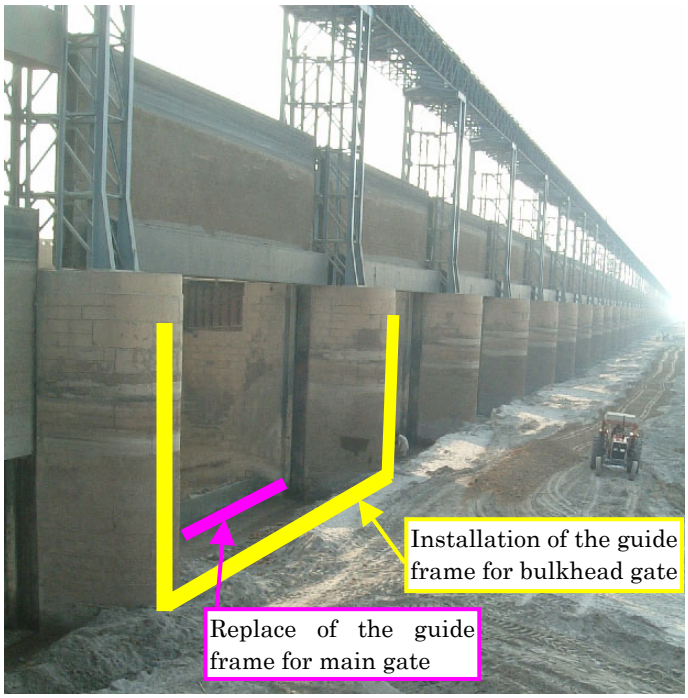
(2) Construction of Stockyard for Bulkhead Gate and Incline work

The incline work in the river requires cofferdam. The cofferdam is planned to combine embankment and sheet piling and is designed to reduce the volume of filling soil as much as possible. Since concrete volume of 1,600 m^3 is necessary, it is planned to mix concrete at the site as there is no existing concrete plant within the vicinity of Taunsa Barrage. Countermeasures against hot weather concrete placement should be taken due to over 35 ℃ as a maximum temperature in the expected period of concrete works.

In addition, the construction of stockyard for bulkhead gate and incline work shall be completed before the end of September 2006, which is the commencement of bulkhead gate assembly.

(3) Installation Work of Guide Frame for Bulkhead Gate

The guide frame for bulkhead gate must be installed under dry condition during the annual closure period (around 30 days from 1st January), because water amount decreases and downstream discharge can be stopped from Chashma Barrage located in the upper area of Taunsa barrage during this period. The Guide frame for bulkhead gate is supplied as equipment project separately. It is planned to install the first gate frame in January 2007. Installation period is restricted within one month, therefore 16 gates will be installed in January 2007 and 13 gates in January 2008. Total construction number of gate to be rehabilitated will decrease if the exchange works of sill beam will be made combined with the main gate rehabilitation works at the same time. Therefore, exchange of sill beam of the Under Sluice and Weir gates shall be done during the annual closure period simultaneous with the installation of the gate frame



Indus River is dry condition for only annual closure period in a year.

Amount of Guide Frame for Bulkhead Gate, Weir and Under Sluice Gates

	January 2007	January 2008
Bulkhead Gate	16 gates (18 piers)	13 gates (18 piers)
Bulkhead Gate	16 gates	13 gates
Weir Gate	13 gates	6 gates
Under Sluice Gate	-	7 gates

The guide frame and concrete materials shall be carried by 25 tons truck crane from the attached road bridge due to insufficient time to construct the temporary access road in the river during annual closure period.

(4) Rehabilitation of Under Sluice and Weir Gates

Rehabilitation period of main gate and guide frame is limited to 3.5 months each from middle of September to December and from February to middle of May exclusive of annual closure period and flooding period from middle of May to middle of September.

Besides, it is expected that the downstream water level of Taunsa Barrage during the construction of the subsidiary weir, which is planned to be constructed at the downstream of Taunsa Barrage under the project of Punjab Barrages Rehabilitation and Modernization from October 2005 for two years, is rather higher than that after completion of the subsidiary weir as discussed in Section 2-2-1-12. In order to

realize the proper condition for rehabilitation and to reduce the scale of the downstream cofferdam for rehabilitation of gates, precedence will be given to rehabilitation of the Weir Gates due to higher elevation of sill crest than that of the Under Sluice Gates. Accordingly, rehabilitation of the Weir Gates will mainly be planned to implement in the year 2007 and that of the Under Sluice Gates will be in the year 2008 after completion of the subsidiary weir.

There are two methods regarding to replacement of under sluice gate, such as pontoon method and truck crane method. The pontoon method is the construction method by pontoon equipped with crane from upstream of barrage and the truck crane method is by truck crane from the attached road bridge at downstream.

Table 2-2-1. 21 Comparison of Construction Method for Replacement of Under Sluice Gate

Method	Pontoon (80TTC)	Pontoon (50TTC)	Truck Crane Method
Execution	Pontoon equipped with 80 tons crane	Pontoon equipped with 50 tons crane.	Truck equipped with 25tons crane and winch for pulling.
Number of Gate Segment	9 segments （Maximum weight：8.0t）	15 segments （Maximum weight：4.5t）	25 segments （Maximum weight：3.5t）
Required period	76 days/one gate 4 gates/3.5 months	103 days/one gate 1 gate/3.5 months Construction period has to be extended	131 days/one gate Running over 3.5 months
	○	×	×
Quality	No problem	Negative impact such as twist and shrinkage by welding due to large number of segments	Negative impact such as twist and shrinkage by welding due to large number of segments
	○	×	×
Evaluation	Good	Not suitable	Not suitable

Furthermore, other two cases of crane capacity mounting on pontoon are considered. The first case is that the 50 tons truck crane procured for the project for assembling and disassembling of bulkhead gate will be utilized for under sluice gate works. Another case is that 80 tons truck crane will be leased to reduce the number of gate partition. Consequently based on the three cases study mentioned above, the pontoon equipped with 80 tons truck crane is planned to be adopted. In addition, 25 tons truck crane is adopted for hanging guide frame from attached road bridge.

(5) Rehabilitation of Gate Hoist

The gate hoist will be rehabilitated together with the gates. Considering that the replacement work of gate hoist and the rehabilitation work of gate will be carried out at ups and downs simultaneously, safety catcher will be installed for safety measures. 25 tons truck crane will be used for hanging guide frame of gate from the attached road bridge. In addition, electric incoming and distribution line should be completed before the commencement of gate rehabilitation because gates will be operated immediately after rehabilitation. Final inspection and operation training will be executed at the time of completion of

gate hoist installation and gate rehabilitation.

(6) Rehabilitation of Upper Deck (Superstructure Deck)

Rehabilitation work of upper deck will be carried out simultaneously with rehabilitation work of the gate hoist because partial reinforcement works of beam members of upper deck structure is required along with replacement of gate hoist. Rehabilitation work of upper deck at the bay without gate rehabilitation will also be carried out in flood season mainly in accordance with the progress of other gate rehabilitation. 25 tons truck crane on the attached road bridge will be used for removal and newly installation of upper deck, hanging of reinforcing steel materials.

(7) Relocation of Telemeter Panel (DAU) (Pakistan side responsibility)

Gate position sensor (GPS), data acquisition unit (DAU) and other cables for data acquisition of gate opening controlled under WAPDA might be obstacle for electrification of gate hoist and strengthening of superstructure if left as is. Consequently these facilities of nine (9) units are planned to be placed at the upper deck at the upstream of the barrage. Details are shown in Table 2-2-1.22.

Accordingly, relocation of telemeter panel and so forth will be relocated and its cost will be borne by Pakistan side.

Table 2-2-1.22 List of Telemeter to be Relocated

Panel No.	Location	
DAU 1	Gate No 5 of M.Garh canal (for both canals T.P.Link & M.Garh)	
DAU 2	Gate No.2-3 center (pier)	
DAU 3	Gate No.9-10 center	
DAU 4	Gate No.17-18 center	
DAU 5	Gate No.25-26 center	
DAU 6	Gate No.33-34 center	To be relocated
DAU 7	Gate No.41-42 center	
DAU 8	Gate No.49-50 center	
DAU 9	Gate No 57-58 center	
DAU 10	Gate No.63-64 center	
DAU 11	Gate No.4 of D.G.Khan Canal	

2-2-1-12 Temporary Works

(1) Temporary Diversion Channel

The construction works on this grant aid project, such as 1) rehabilitation of weir gates, 2) replacement of under sluice gates, 3) rehabilitation and electrification of gate hoist, 4) rehabilitation of deck on superstructure, 5) installation of bulkhead gates, will be done in the Indus River. Therefore, temporary diversion channel should be secured to flow the river discharge safely during implementation of works. The Taunsa Barrage has 53 weir gates (60ft=18.3m span each) and 11 under sluice gates (60ft=18.3m span

each). In order to flow the river discharge certainly, those gates will be utilized as temporary diversion channel, provided that the temporary diversion channel should be more than one (1) gate away from the actual gate to be rehabilitated.

① Construction Period and Design Discharge to be Diverted

The design discharge to be discharged by temporary diversion channel is estimated as the second to the third – ranking of actual flood discharge during construction period which are recorded at the barrage point in the last 10 years. If it is taken the probability analysis way to set the design discharge, the design discharge is estimated as five years return period (refer to the criteria of design standard for Head-works, MOAF Japan,).

The following three cases are considered for construction period under water of the River.

Case①; 9 months (from September,1 to May,31 of next year)
Case②; 8 months (from September,16 to May,15 of next year)
Case③; 7 months (from October,1 to Apri,30 of next year)

Table 2-2-1.23 The Actual River Discharge in Each Case (recorded in 1994-2003)

Case Construction period Actual river discharge Ranking	Case① 9 months (ft^3/sec)	Case② 8 months (ft^3/sec)	Case③ 7 months (ft^3/sec)
The first	360,680	173,935	173,935
The second	352,908	168,264	153,746
The third	333,731	167,700	146,777

The construction period in the Indus River and the design discharge to be diverted are set up as follows taking into consideration the flood discharge during the period and height of the temporary cofferdam required at downstream of the barrage.

- The construction period; 8 months (Case②, from September,16 to May, 15 of next year)
- The design discharge ; Q=170,000 ft^3/sec = 4,800 m^3/sec

Remarks:

1) In case of Case ①, since it is supposed to be 350,000 ft^3/sec of design discharge and 432.7 ft of downstream water level, the height of temporary cofferdam at the downstream side of the barrage should be high, about 8.0 ft. The period of nine (9) months is enough for implementation of rehabilitation activities.
2) In case of Case ②, since it is supposed to be 170,000 ft^3/sec of design discharge and 429.6 ft of downstream water level, the height of temporary cofferdam should be relatively low, about 4.0 ft. The period of eight (8) months is enough for implementation of rehabilitation activities.
3) In case of Case ③, since it is supposed to be 150,000 ft^3/sec of design discharge and 429.2 ft of

downstream water level, the height of temporary cofferdam should be low, about 3.0 ft. However, the period of seven (7) months is too short for implementation of rehabilitation activities.

② The Number of Gate to be Utilized as Temporary Diversion Channel

The discharge per one gate and the required number of the gates to be operated to maintain upstream water level of barrage at R.L.446.00 ft are as follows:

- Water level at upstream: R.L. 446.00 ft = WL. 135.94 m
- Water level at downstream: R.L. 429.60 ft = WL. 130.94 m
- Elevation at gate sill: R.L. 428.00 ft = WL. 130.45 m
- Gate span: 60 ft = 18.29 m
- Water depth at upstream: H = 446.00 – 428.00 =18.00 ft = 5.49 m
- Water depth at downstream: H = 429.60 – 428.00 = 1.60 ft = 0.49 m<2/3・H = 3.66m (complete overflow)
- Unit discharge per gate: $q = 3.09 * 60.00 * 18.00^{3/2} = 14{,}200\ ft^3/sec/gate$
- The number of gate required: N = 170,000 / 14,200 = 12 gates

The design discharge during the construction period is diverted certainly when 12 units of gates are fully opened. There is, however, a regulation concerning gate operation of the Taunsa Barrage which is called as "The 2 ft rule". The rule provides that the difference of gate opening range for two neighboring gates should be for 2 ft or less. Therefore, the detailed plan of gate operation for rehabilitation works should be prepared in conformity with this regulation.

(2) Temporary Coffer Dam at Downstream Side

① Water Level at Downstream of the Barrage for Gate Rehabilitation

The crest height of the subsidiary weir, which will be constructed at the downstream of the Taunsa Barrage, is planned at R.L.424ft and the design discharge of flood expected during the construction is 170,000 ft^3/sec (= 4,700 m^3/sec). Under these conditions, the river water level at downstream of the Barrage estimated are as follows:

- Before construction of the subsidiary weir: D/S WL. 427.50 ft = D/S WL. 130.30 m
- Under construction of the subsidiary weir: D/S WL. 433.90 ft = D/S WL. 132.25 m
- After construction of the subsidiary weir: D/S WL. 429.60 ft = D/S WL. 130.94 m

As mentioned above, the river water level at downstream of the Taunsa Barrage under construction of the subsidiary weir is supposed to be 433.90 ft. Therefore, the months where small scale floods occur (April, May, and September) should be excepted from the rehabilitation work period.

Accordingly, the river water level at the downstream of the Taunsa Barrage under rehabilitation is regarded at D/S WL429.60 ft after the construction of the subsidiary weir.

② Height and Structure of the Cofferdam at Downstream

1) The crest elevation of the cofferdam

The crest elevation of the cofferdam is to be R.L. 432.00ft (= EL. 131.67m) added some free board to the river water level at downstream of D/S. WL. 429.60ft (= D/S WL. 130.94m).

・ The water level at downstream of the Barrage		D/S WL. 429.60ft = D/S WL. 130.94m
・ The crest elevation of the cofferdam		R.L. 432.00ft = EL. 131.67m
・ The elevation of existing inclined apron	Weir	R.L. 425.00ft = EL. 129.50m
	U. sluice	R.L. 422.00ft = EL. 128.60m
・ The height of the cofferdam	Weir	7.00 ft = 2.13 m
	U. sluice	10.00 ft = 3.05 m

2) The structure of the cofferdam

Since the cofferdam will be constructed on the existing inclined apron due to the height of the cofferdam which is relatively low, (2.13m to 3.05m), large size sandbag should be utilized so as to make construction of the cofferdam easy and well sealed (waterproof).

(3) Temporary Construction Road and Temporary Bridge

① Temporary Construction Road

・ It is not necessary to construct temporary road due to availability of trunk road which is running through the project site from the Indus highway. Construction equipment can pass through the highway as the height of power line crossing the road is beyond 4.5mand based on international standard.

・ The corner, which is to be connected to the stockyard for bulkhead gate at left bank of upstream, is passable to trailers by utilizing the parking space.

・ The allowable designed truck load for the existing bridge of the Taunsa Barrage is 12 tons per axle. The feasibility study conducted by the Government of Punjab reports that the existing bridge is safe for construction transportation even by “Class AA (the design load for bridge considered 70 tons as heavy tank)”.

・ The feasibility study conducted by the Government of Punjab also reports that the existing bridges, which are located at RD 7,500, at the intake of Muzaffargah canal and T.P. Link Canal , are safety based on “Class AA (the design load for bridge considered 70 tons as heavy tank)”.

② Temporary Bridge

・ It is unnecessary to construct the temporary bridge for the gates rehabilitation works because these works can be undertaken at the gates site from the existing bridge or by using the pontoon approaching from the upstream side.

(4) Temporary Jetty

・ The temporary jetty for shipment of construction material should be provided because the construction

works are supposed to be done by utilizing the pontoon accessing from upstream of the Taunsa Barrage.

- The location of the temporary jetty should be decided through the comparative study between locations at upstream of both right and left banks if the temporary stockyard for construction material and goods is planned at right bank of the Barrage.

(5) Electric Power Supply Facilities for Construction

① Undertaking of Construction and Installation

- Pakistan side responsibility is provision of outside wiring of electric facilities, while Japan side responsibility are the receiving lines, receiving panel, and transformer as well as power for construction.

- Regarding responsibility of temporary power supply for construction, it will be done as the same as that of power for permanent electric facilities.

- The point which allots a portion of these kind works to each side should be 11 kV high voltage power line in the site of Taunsa Barrage O&M office.

② Comparison between Commercial Power Supply and Generator as the Power for Construction

Several alternatives are proposed to ensure the huge capacity of power supply for under sluice gate rehabilitation work as follows:

- Case①; All the power supply for construction is to depend on commercial power supply as temporary.

- Case②; The electric power supply facility to be provided under the Project will supply the power for construction. The shortage of power depends on the commercial power as temporary.

- Case③; Taking account the frequent occurrence of power failure and the site condition, there are two ways of supplying power system for the project. The power generator is proposed to be used for rehabilitation works of under sluice gate because of the short period of construction with large capacity of power requirement, while weir gate rehabilitation works is to depend on commercial power supply as temporary because of dispersed spots with small consumption of power..

- Case④; Taking account of the occurrence of power failure, the site condition, and responsibility of Pakistan side, all the temporary power supply is to be received from temporary generator.

The cases mentioned above should be studied taking every factor into consideration.

(6) General Temporary Facilities

- For the site office (approximately 3 container house) and accommodation of the contractor, and rest room of labor are planned as general temporary facility.

- The yard for general temporary facilities should be approximately 1,200m^2 (=20m x 60m).
- With regard to the electricity, it is planned to receive the power from existing 11KV high voltage power line that is running near the Taunsa Barrage. There occurs about 10 times of power failure a month. It is needed to prepare stand-by power generator for major facilities.
- Regarding water supply, there is no domestic water supply facility but underground water is utilized in the project area. The Indus River cultivates the underground water in the area. It is, therefore, planned to utilize the underground water through the well.
- With respect to communication, international line as well as domestic one can be secured. Furthermore, the network of mobile phone is available in the area of Taunsa.

(7) Temporary Yard for Gate Rehabilitation/Construction Work

① Temporary Yard for Construction Materials and Goods

- The temporary stockyard (1,500m^2) to keep construction materials and goods is planned to be located at right bank at downstream of the Taunsa Barrage.
- Ownership of the land mentioned above belongs to the Government. Therefore, it will be used without compensation during construction and rehabilitation works.

② Temporary Yard for General Facilities

- The temporary yard (2,700m^2) for general facilities such as the site office of contractors is planned to be located at left bank of T.P. Link Canal which is placed at left bank at upstream of the Taunsa Barrage.
- The land mentioned above belongs to the Government. Therefore, it will be used without compensation during construction and rehabilitation works.

2-2-1-13 Operation and Maintenance of Facilities

Operation and maintenance policy is shown as follows.

1) The Taunsa Barrage Division, Irrigation and Power Department, Punjab Province will be responsible for operation and maintenance of Taunsa barrage rehabilitated as with present condition.
2) The maintenance method of the facilities will basically follow the existing arrangement at the Taunsa barrage.
3) Technical transfer of operation and maintenance of the Bulkhead gate, which will be newly introduced, is planned through “On the Job Training (OJT)” to Pakistan side.

2-2-1-14 Ability on Operation and Maintenance of Executing Agency

(1) Ability on Operation and Maintenance (O/M) of Executing Agency

At present, the Taunsa barrage is operated and maintained by the Taunsa Barrage Division（TBD）with a total staff of 380. They have sufficient O/M experience about 50 years, and there is no identified constraint in their capacity to undertake O/M of the barrage with the existing staff.

(2) Number of Gate Operator and Electrician

Since the project executed under Grant Aid is mainly concerned with the rehabilitation of mechanical facilities, no additional organization is required for O/M. However, the number of gate operator will be reduced because gates will then be operated by the electricity instead of existing manual operation.

At present, the Taunsa barrage gate is operated by 35 members (Regulation Beldar) with three shifts of groups of 10 to 12 members and which is increased from time to time during the flood season.

29 units of gate will be electrified under the Grant Aid Project while the remaining gates will be electrified under the " Punjab Barrages Rehabilitation and Modernization Project". Accordingly, it is expected that the gates will be maintained and operated by 15 members (three shifts of 5 persons), which is almost half of existing number based on the survey results of the other barrages.

Besides, the number of an electrical engineer and technician will not be increased because it would be possible to have shifts or hold the post with other section.

2-2-1-15 Environmental and Social Considerations

This grant aid project consists mainly of the rehabilitation of the gates, and no environmental and social impacts are expected. At the same time, "Punjab Barrages Rehabilitation and Modernization Project" by the Punjab Province includes the large scale of civil works, and bad environmental effects are concerned. However, the procedure of environmental impact assessment by the IPD has been preceded combining both the above projects and the Environment Protection Agency (EPA) approved for construction phase of Taunsa Barrage rehabilitation on September 6, 2004.

Considering the above condition, environmental and social consideration will be progressed based on the following policy:

- Based on the "Pakistan Environment Protection Law 1997", the IPD should follow the procedure and policy of environment impact assessment (EIA) in the implementation of the project.
- Social consideration will be secured such as information of road closure of Taunsa Barrage to the neighboring people completely that the bridge is going to close about 8.00-12.00 in the morning and 13.00-17.00 in the afternoon during the construction except the flood season together with information of the detour road, using mass media or a signboard.

2-2-2 Basic Plan

2-2-2-1 Rehabilitation of Under Sluice Gates and Weir Gates

(1) Outline

As the locker assembly mechanism is the main cause of the current problems, this mechanism will be completely rehabilitated in all the Under Sluice gates and Weir gates.

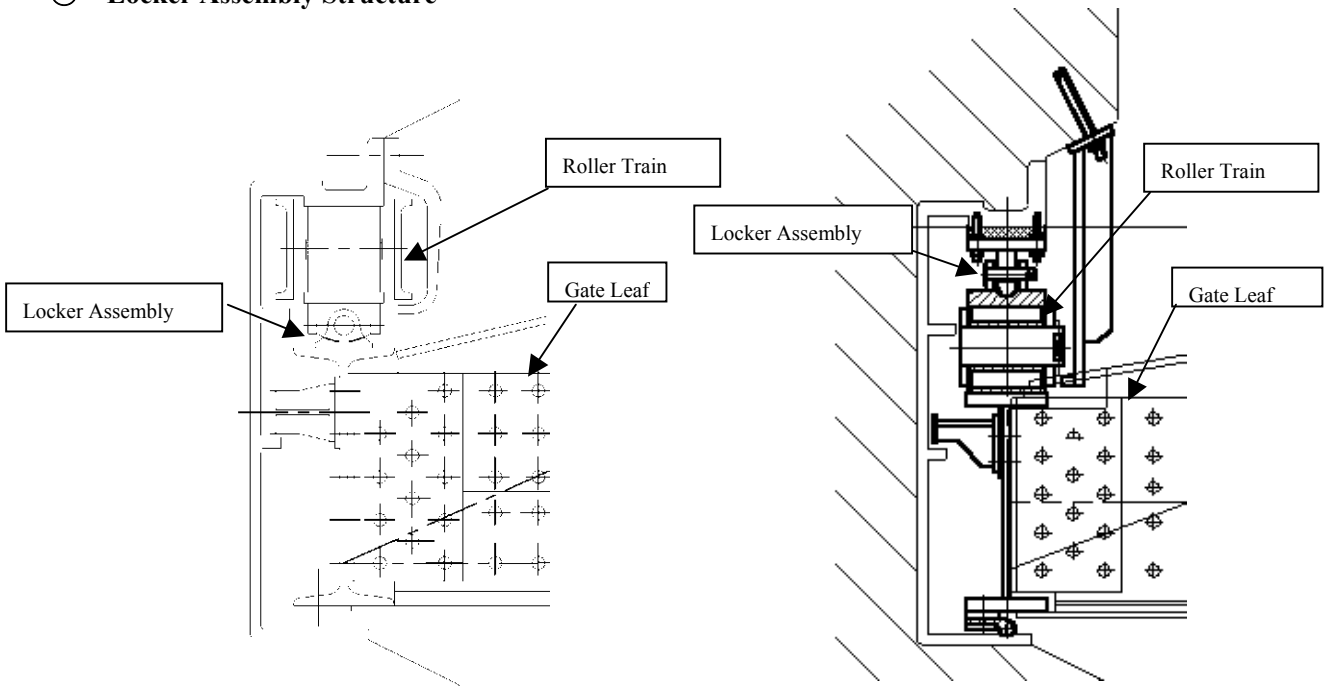
(2) Under Sluice Gates

① Type of Gate Leaf

The existing double gate leaf of under sluice gates will be modified to single gate leaf gates because of the following reasons.

- Water leak between the gate leaf will damage the watertight structure between the upper and lower gate leaves. This damage to the watertight structure will increase the amount of leakage while the vibration of the gate will adversely affect the gate leaf, wire rope and hoist, etc.
- Discharge through the gate leaf in the case of double gate leaf is unnecessary for under sluice operation at the Taunsa Barrage.
- Double gate leaf will require synchronised operation of the upper gate leaf and lower gate leaf for gate opening or closing operation, making such operation complicated.

② Locker Assembly Structure



[Existing Structure] [Proposed]

Figure 2- 2-2.1 Remodelling of Locker Assembly

In view of the current problems, the following modifications will be made to the locker assembly structure.

- The fixing point of the locker assembly will be changed from the gate leaf to the gate guide.
- The locker assembly brackets which are currently mounted horizontally at several points will be changed to vertical continual brackets.

③ Materials to be used

The materials to be used for each member will be selected based on relevant provisions of the Technical Standards for Gates and Penstocks.

Table 2-2-2.1 shows the materials to be used for each member. The selection of the materials for the roller, which is closely related to the current problems, is described below. The current problems with the roller originated from the fact that the roller hardness is higher than the groove hardness. By selecting the combination described below in accordance with the said Technical Standards, the roller hardness will be lower than the groove hardness.

Table 2-2-2.1 List of Materials to be used (Under Sluice Gates)

Parts		Spec (JIS)	Symbol	Notes
Gate leaf	Skin Plate	Rolled steels for welded structure JIS G 3106	SM490	ASTM A633 Gr.C
	Girder	Rolled steels for welded structure JIS G 3106	SM490	ASTM A633 Gr.C
	Roller	Rolled steels for welded structure JIS G 3106	SM400	ASTM A283 Gr.D
	Inter Mediate Girder	Rolled steels for welded structure JIS G 3106	SM400	ASTM A283 Gr.D
	Roller	High tensile strength carbon steel castings and low alloy steel castings for structural purposes JIS G 5111	SCMn3B	ASTM A148M-93b 105-85
	Roller Pin	Stainless steel bars JIS G 4303	SUS304	ASTM A240M-01 Type304
	Truck Plate	Stainless steel bars JIS G 4303	SUS304N2	ASTM A276-98a XM-21
Groove	Rocker Assembly	Stainless steel bars JIS G 4303	SUS304N2 SUS304	ASTM A240M-01 Type304 ASTM A276-98a XM-21
	Sill Plate	Stainless steel bars JIS G 4303	SUS304	ASTM A240M-01 Type304
	Sill beam	Rolled Steel for General Structure JIS G 3101	SS400	ASTM A36
Hoist	Drum gear	Chromium Molybdenum Steels JIS G 4105	SCM440	AISI ISS209
	Pinion gear	Chromium Molybdenum Steels JIS G 4105	SCM440	AISI ISS209
	Drum	Rolled steels for welded structure JIS G 3106	SM490C	ASTM 633 Gr.C
	Pin	Carbon Steels for Machine Structural Use JIS G 4051	S45C	AISI ISS209
	Bed flame	Rolled steels for welded structure JIS G 3106	SM400	ASTM A283 Gr.D

④ Design Stress

Table 2-2-2.2 lists the design stress and the allowable stress for the main members of the under sluice gate.

Table 2-2-2.2 List of Stresses for Main Members of Under Sluice Gate

Inspection Item		Dimensions	Type of Stress	Generated Stress (N/mm^2)	Allowable Stress (N/mm^2)	Material
Main Girder	③ Girder	③ BH2200 x 300 x 19/22	Bearing	143	158	SM490
			Shearing	29	91	SM490
	Maximum Deflection (③ Girder)		Deflection	1/825	1/600	SM490
Skin Plate (section of maximum stress: ③ section)		③ Section: PL10	Bending	125	158	SM490
Main Roller		① ϕ150 x 130B	Roller Contact	717	754	SCMn3B
Guide Frame			Contact	910	1,029	SUS304N2

The generated stress corresponds to about 80% of the allowable stress. The gate leaf deflection is the most severe among design conditions with a generated deflection of 1/829 against an allowable deflection of 1/600.

Table 2-2-2.3 shows the under sluice gate specifications.

Table 2-2-2.3 Under Sluice Gate Specifications

Type		Steel plate girder roller gate	
Quantity		7	
Clear Span x Gate leaf Height		(B) 60.00 ft x (H) 23.00 ft [(B) 18.29 m x (H) 7.01 m]	
Design Water Depth		Upstream Side	23.00 ft (7.01 m)
		Downstream Side	0.00 ft (0.00 m)
Operating Water Depth	Opening Operation	Upstream Side	23.00 ft (7.01 m)
		Downstream Side	0.00 ft (0.00 m)
	Closing Operation	Upstream Side	23.00 ft (7.01 m)
		Downstream Side	0.00 ft (0.00 m)
Design Sedimentation Height		6.00 ft (1.83 m)	
Sill Height		RL. 425.00 ft (EL. 129.54 m)	
Water Tightness Method		Rubber sealing on three front sides	
hoist		One motor, two drums, wire rope winch type	
Operating Method		Operated from the motor side	
Operating Speed		1.0 ft/min (0.3 m/min)	
Lifting Height		31.00 ft (9.45 m)	

(3) Weir Gates

① Outline

The rehabilitation of the weir gates consists of the following two types of work.

- Improvement of the current problems (roller)
- Heightening of the gate leaf height by one foot

With regards to the planned improvement of the current problems, the present structure will be kept for the main sections of the leaf based on the study results. However, the severely damaged end girders will be remodelled in consideration of their vital relation to the roller.

② Structure of Roller

As in the case of the under sluice gates, the roller will have a structure where the locker assembly is mounted to the groove side.

③ Materials to be used

As in the case of the under sluice gates, different materials will be combined so that the roller hardness is lower than the groove hardness.

The materials to be used for the main structural members are shown in Table 2-2-2.4.

Table 2-2-2.4 List of Materials to be used (Weir Gates)

Parts		Spec (JIS)	Symbol	Notes
Gate leaf	Skin plate	Rolled steels for welded structure JIS G 3106	SM400	ASTM A633 Gr.C
	Side beam	Rolled steels for welded structure JIS G 3106	SM400	ASTM A283 Gr.D
	Roller	High tensile strength carbon steel castings and low alloy steel castings for structural purposes JIS G 5111	SCMn3B	ASTM A148M-93b 105-85
	Roller Pin	Stainless steel bars JIS G 4303	SUS304	ASTM A240M-01 Type304
	Track Plate	Stainless steel bars JIS G 4303	SUS304N 2	ASTM A276-98a XM-21
Groove	Rocker Assembly	Stainless steel bars JIS G 4303	SUS304N 2 SUS304	ASTM A240M-01 Type304 ASTM A276-98a XM-21
	Sill Plate	Stainless steel bars JIS G 4303	SUS304	ASTM A240M-01 Type304
	Sill beam	Rolled Steel for General Structure JIS G 3101	SS400	ASTM A36
Hoist	Drum gear	Chromium Molybdenum Steels JIS G 4105	SCM440	AISI ISS209
	Pinion gear	Chromium Molybdenum Steels JIS G 4105	SCM440	AISI ISS209
	Drum	Rolled steels for welded structure JIS G 3106	SM490C	ASTM 633 Gr.C
	Pin	Carbon Steels for Machine Structural Use JIS G 4051	S45C	AISI ISS209
	Bed flame	Rolled steels for welded structure JIS G 3106	SM400	ASTM A283 Gr.D

④ Design Stress

Table 2-2-2.5 lists the design stresses and allowable stresses for the main members of weir gate.

Table 2-2-2.5 List of Stresses for Main Members of Weir Gate

Inspection Item	Dimensions	Type of Stress	Generated Stress (N/mm^2)	Allowable Stress (N/mm^2)	Material
End Girder	BH400 x 150 x 12/22	Bending	30	118	SM400
		Shearing	21	68	
Main Roller	(13) ϕ150 x 130B	Roller Contact	746	754	SCMn3B
Guide Frame		Contact	946	1,029	SUS304N2

As the dimensions of the girders and other components of the weir gate end structure are determined in conformity with that of the existing gate leaf, there is much more leeway in terms of the unit stress than in the case of under sluice gate.

Table 2-2-2.6 shows the weir gate specifications.

Table 2-2-2.6 Weir Gate Specifications

Type		Steel Truss Roller Gate	
Quantity		7	
Clear Span x Gate leaf Height		(B) 60.00 ft x (H) 20.00 ft [(B) 18.29 m x (H) 6.10 m]	
Design Water Depth		Upstream Side	20.00 ft (6.10 m)
		Downstream Side	0.00 ft (0.00 m)
Operating Water Depth	Opening Operation	Upstream Side	20.00 ft (6.10 m)
		Downstream Side	0.00 ft (0.00 m)
	Closing Operation	Upstream Side	20.00 ft (6.10 m)
		Downstream Side	0.00 ft (0.00 m)
Design Sedimentation Height		3.00 ft (0.91 m)	
Sill Height		RL. 428.00 ft (EL. 130.45 m)	
Water Tightness Method		Rubber sealing on three front sides	
Hoist		One motor, two drums, wire rope winch type	
Operating Method		Operated from the motor side	
Operating Speed		1.0 ft/min (0.3 m/min)	
Lifting Height		29.00 ft (8.84 m)	

2-2-2-2 Gate Hoist

(1) Outline

The following two modifications will be made to the hoist.

- Electrification (including renewal of the drum and drum gear, etc.)
- Change of the location (change to a single floor configuration)

(2) Electrification

The hoist of both the under sluice gates and weir gates will be electrified.

(3) Change to Single Floor Configuration

An analysis of problems of the existing hoist indicates that many problems occur with the structural members and components, etc. when the power and drum unit are located on different floors (in this present system located at the upper and lower floors respectively). To rectify the identified problems and to

improve the operational control of this apparatus, it is planned to locate the power and drum unit on the same floor under the Project.

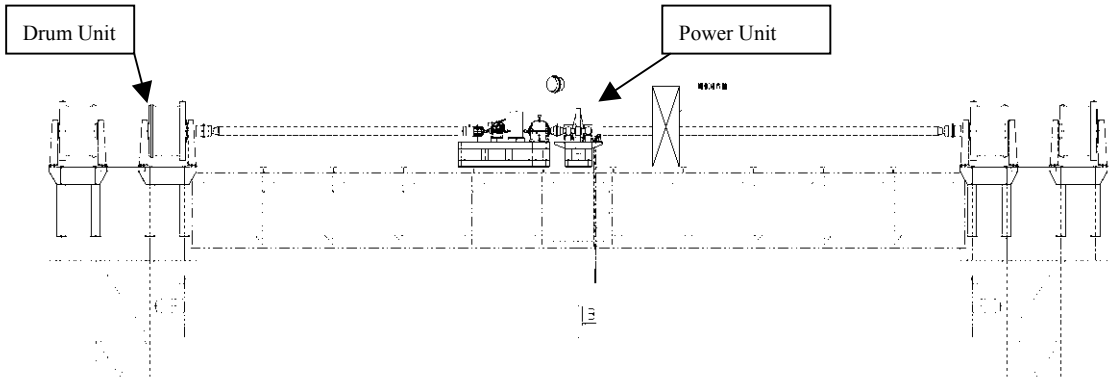


Figure 2-2-2.2 Configuration of Hoist

2-2-2-3 Electrification of Gate Hoist

(1) Required Motor Output for Hoist

The results of examination of the required motor output for hoist are described below.

① Operating Load

Table 2-2-2.7 shows the operating load, taking the dead weight of the gate leaf and the roller friction, etc. into consideration for calculation purposes.

Table 2-2-2.7 Operating Load of Under Sluice Gate

Item	Opening	Closing	Downward Force When Opening
Dead Weight of Gate Leaf	520 ↓	520↓	520 ↓
Friction Resistance of Roller	62 ↓	62 ↑	62 ↑
Friction Resistance Between Sealing Rubber and Metal	27 ↓	27 ↓	27 ↓
Friction Resistance Between Sediment and Metal	49 ↓	0 ↑	49 ↓
Down Pull Force	0 ↓	0 ↑	0 ↓
Counterweight	395↑	395 ↑	0 ↑
Total	263 ↓	36 ↓	658↓

The operating load is set at 265 kN based on an operating load of 263 kN at the time of opening operation.

② Required Motor Output (Pm)

$$Pm = \frac{W \cdot V}{60 \cdot \eta}$$

Where,

W : operating load = 265kN

V : operating speed = 0.30 m/min

η : general efficiency at start-up = 0.645

$$Pm = \frac{265 \times 0.30}{60 \times 0.645} = 2.02 \text{ kW}$$

The rated output of 2.2 kW which is the nearest rated output above 2.02 kW will be adopted.

③ Specifications of Motor to be Used

Type	:	totally enclosed fan-cooled outdoor motor
Output	:	continuous rating of 2.2 kW
Poles	:	6P; 50 Hz
Rated Speed	:	940 rpm

Similar calculation for the weir gates produced an operating load of 165 kN and a motor output of 1.5 kW.

Table 2-2-2.8 shows the hoist specifications.

Table 2-2-2.8 Hoist Specifications

	Under Sluice Gate	Weir Gate
Type	One motor, two drum, electric wire rope winch type	One motor, two drum, electric wire rope winch type
Number of Installations	7 units (for 7 gates)	22 units (for 22 gates)
Operating Load	265 kN	165 kN
Operating Speed	1.0 ft/min (0.30 m/min)	1.0 ft/min (0.30 m/min)
Lifting Height	32.00 ft (9.75 m)	29.00 ft (8.84 m)
Motor	2.2 kW 6P continuous rating	1.5 kW 6P continuous rating
Wire Rope	ϕ60 IWRC 6 x WS (36) Type B	ϕ56 IWRC 6 x WS (36) Special type
Operating Method	Operated from the local panel	Operated from the local panel
Power Source	3 phase AC, 50 Hz, 400 V	3 phase AC, 50 Hz, 400 V

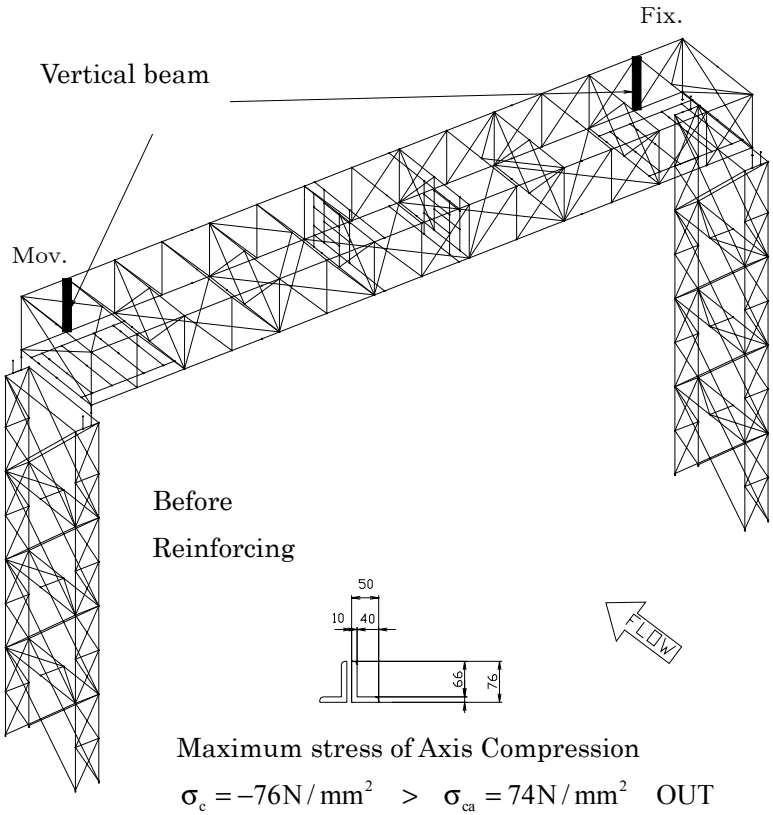
2-2-2-4 Rehabilitation of Upper Deck (Superstructure)

The following modifications will be undertaken to the upper deck (superstructure).

- Change of the deck plates (from wooden plates to grating)
- Reinforcement of the structural members following electrification of the hoist

The deck plates will be changed from the current wooden plates to grating. In consideration of the load of the hoist which will be remodelled, the crowd load and wind load, the suitability of the steel frame structure of the existing superstructure was examined. It was concluded that the structure for the under sluice gates will require reinforcement at both ends where the drum unit will be installed.

As the size of the members forming the steel frame structure of the superstructure for the weir gates is much smaller than that of the under sluice gates, reinforcement will be required at both ends where the drum unit will be installed and also at the central section where the power unit will be installed. This reinforcement will be conducted by welding flat steel (PL 50 x 6) to the existing unequal angle steel (L 76 x 50 x 10). The reinforcing sections for the structural members are shown in Figure 2-2-2.3.

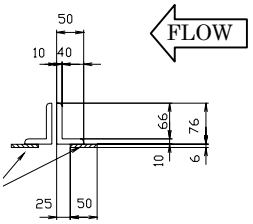


Before
Reinforcing

Maximum stress of Axis Compression

$\sigma_c = -76\text{N/mm}^2 \quad > \quad \sigma_{ca} = 74\text{N/mm}^2$ OUT

After
Reinforcing



Section of Reinforcement Material

2-PL50x6 (SM400)

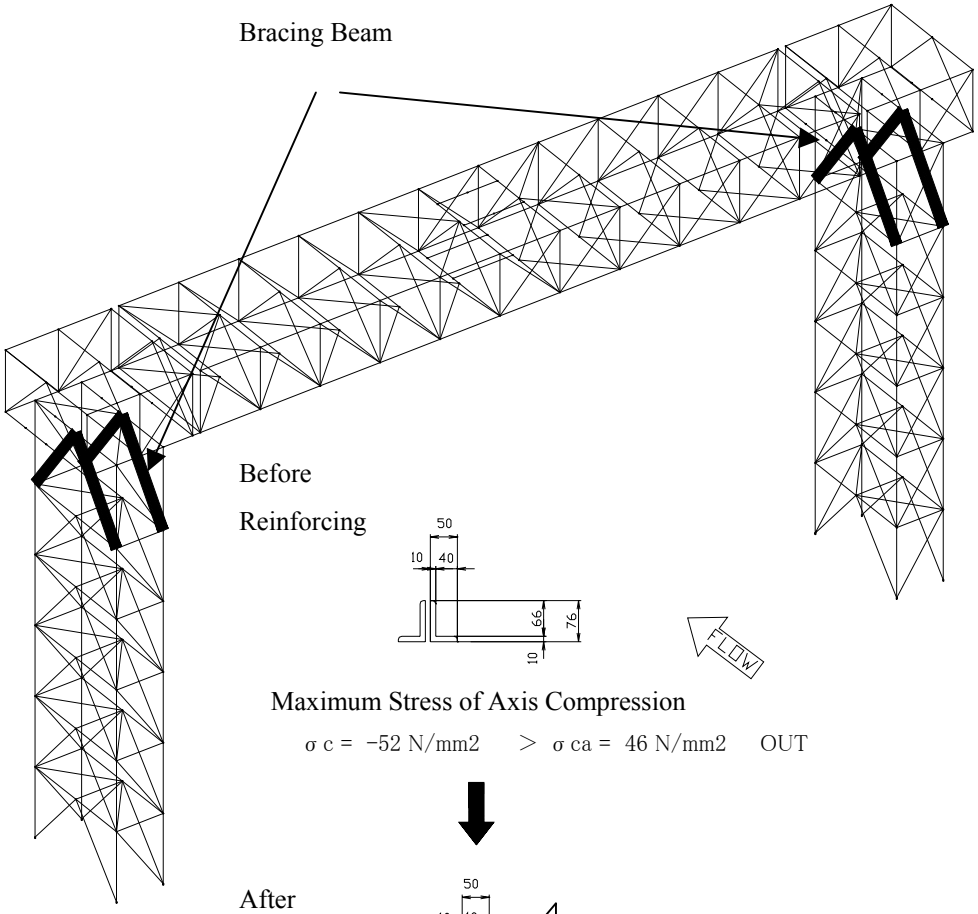
Reinforcement Material

2 - PL 50 x 6 (SM400)

Maximum Stress of Axis Compression

$\sigma_c = -60\text{N/mm}^2 \quad < \quad \sigma_{ca} = 86\text{N/mm}^2$ OK

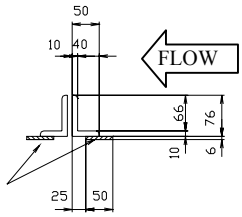
Under Sluice Gate



Maximum Stress of Axis Compression

σ c = −52 N/mm2 ＞ σ ca = 46 N/mm2 OUT

After
Reinforcing



Reinforcement Material

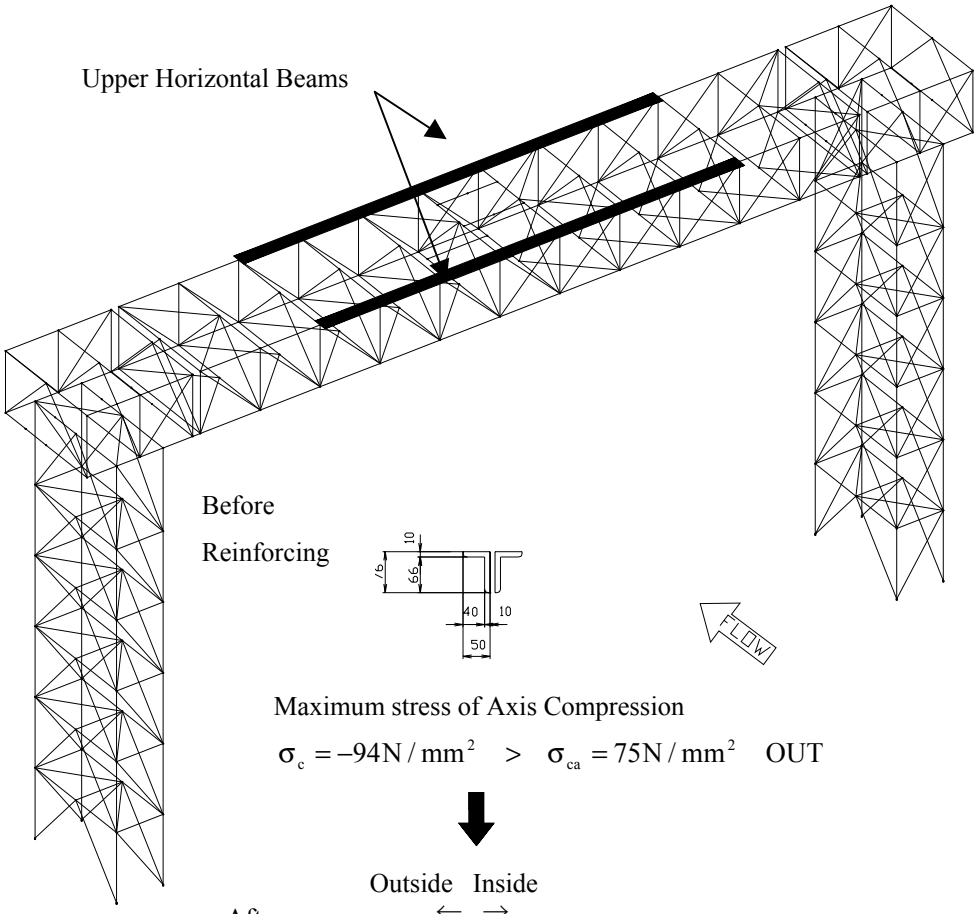
Section of Reinforcement Material

2-PL50x6 (SM400)

Maximum Stress of Axis Compression

$\sigma_c = -37 N/mm^2 \quad < \quad \sigma_{ca} = 61 N/mm^2$ OK

Weir Gate



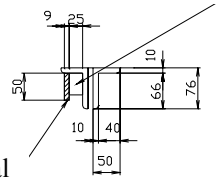
Maximum stress of Axis Compression

$\sigma_c = -94\text{N/mm}^2 \quad > \quad \sigma_{ca} = 75\text{N/mm}^2$ OUT

Outside Inside

$\leftarrow \quad \rightarrow$

After
Reinforcing



Rib(Pitch 1m)

Section of Reinforcement Material

2-PL50x9 (SM400)

Reinforcement Material

Maximum Stress of Axis Compression

$\sigma_c = -79\text{N/mm}^2 \quad < \quad \sigma_{ca} = 84\text{N/mm}^2$ OK

Weir Gate

Figure 2-2-2.3 Reinforcing Sections for Superstructure

2-2-2-5 Bulkhead Gates

The bulkhead gate system has been selected based on the results of a comparative analysis involving other systems, including the temporary coffering system. Table 2-2-2.9 shows the bulkhead gate specifications.

Table 2-2-2.9 Bulkhead Gate Specifications

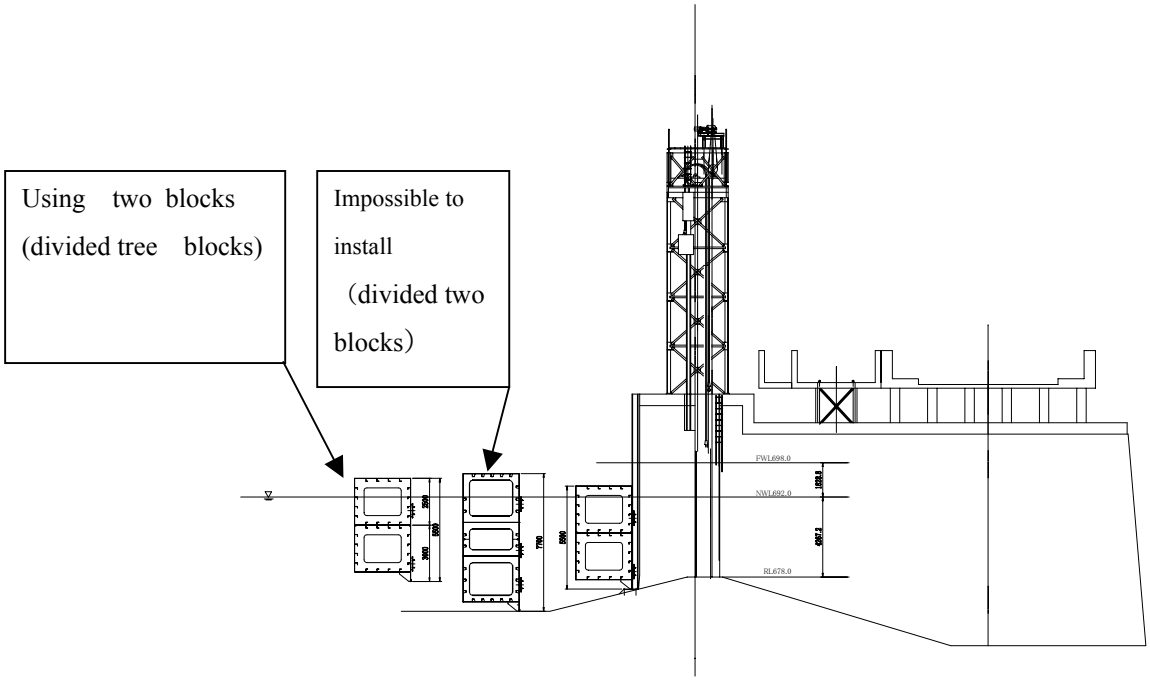
Gate Type	Steel floating gate
Dimensions	Clear span 18.29 m x gate leaf height 7.70 m
Number of Gates	5 units
Design Maximum Water Depth	7.70 m
Sill Elevation	RL 423.00 ft [Under Sluice Gate] RL 426.00 ft [Weir Gate]
Design Water Level	RL 448.26 ft
Storage Method	Winching using a platform car and inclined plane
Water Tightness Method	Rubber sealing on three sides at the back

Each gate leaf of the bulkhead gate will be divisible by three (3) both vertically and horizontally so that it is actually composed of nine (9) blocks to allow its use for other barrages and these blocks will be joined with bolts.

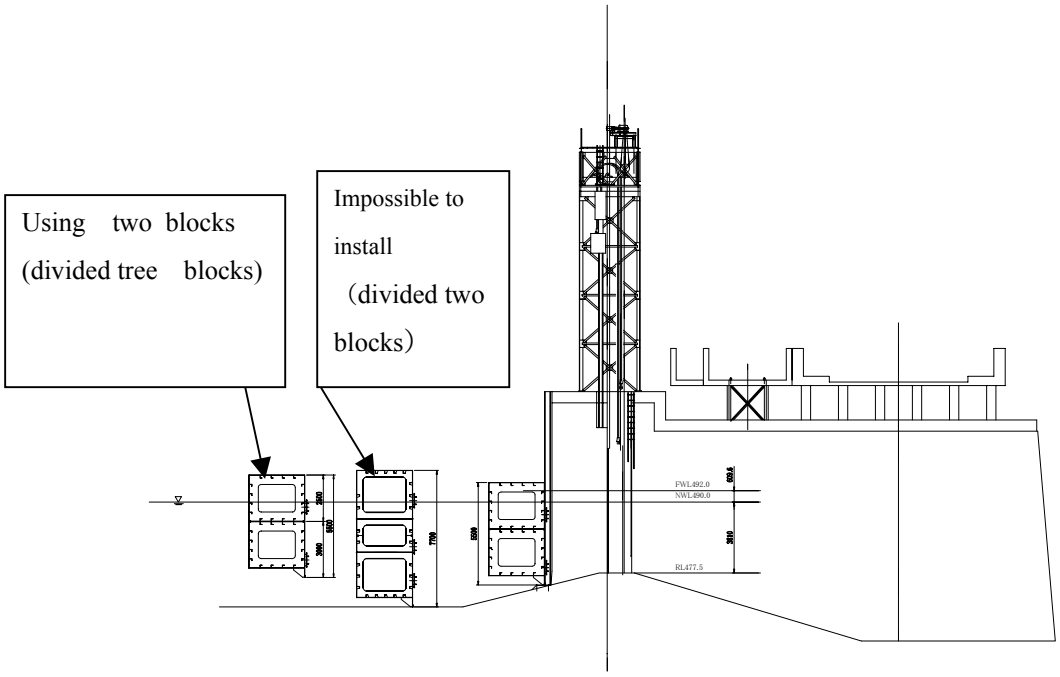
Table 2-2-2.10 shows the stress calculation results for the main members of the bulkhead gate. The gate depth is set at 3.00 m to ensure its stability when the gate is floating upright. The cross-section of the main girder is determined based on the minimum member thickness of the shell structure.

Table 2-2-2.10 Stresses for Main Members of Bulkhead Gate

Inspection Item		Dimensions	Type of Stress	Generated Stress (N/mm^2)	Allowable Stress (N/mm^2)	Material
Main Girder	Upper Block	Box shaped cross-section 2,500 x 3,000 x 10	Bending	15	177	SS400
			Shearing	12	102	SS400
			Composite with skin plate	47	195	SS400
	Middle Block	Box shaped cross-section 2,200 x 3,000 x 10	Bending	43	177	SS400
			Shearing	24	102	SS400
			Composite with skin plate	113	195	SS400
	Lower Block	Box shaped cross-section 2,500 x 3,000 x 10	Bending	92	177	SS400
			Shearing	67	102	SS400
			Composite with skin plate	186	195	SS400
	Maximum Deflection		Deflection 1/1,535 < allowable deflection 1/600			



（1）Jinnah barrage



（2）Trimmu barrage

Figure 2-2-2.4 Installation Plan for Other Barrages

2-2-2-6 Tug Boats, Boats, Crane and Spare Parts

Table 2-2-2.11 shows the specifications for tug boats and others which are required for bulkhead gate operation.

Table 2-2-2.11 Specifications for Auxiliary Equipment for Bulkhead Gate Operation

Item	Purpose of Use	Specifications	Remarks
Tug Boat	Towing of bulkhead gate	150 PS x 2	
Boat	Transportation of bulkhead gate installation equipment	Boat capable of carrying 1.2 tons x 3 units	
Main Crane	Assembly and disassembly of bulkhead gate	50 ton truck crane x 1 unit	
Spare Parts	Repair and maintenance	Bolts, nuts, packing, paint, crane, tug boat maintenance tools and others	See 2.2.10 for details

The provision of spare parts needed in the three (3) years period, i.e. two (2) years for the on-site work and one (1) year for operation and maintenance period, will be considered.

2-2-2-7 Bulkhead Gate Stockyard

(1) Layout of Bulkhead Gate Stockyard

① Location of Bulkhead Gate Stockyard

Regarding the stockyard of bulkhead gates, two places of stockyard storing 3 gates each at both right and left banks have been proposed in the "Feasibility Study on Taunsa Barrage Irrigation System Rehabilitation" report prepared by JICA Study Team in August 1998. However the Government of Pakistan at the request stage of JICA Grant Aid Programme for this project revised the above plan to lump stock plan with 5 gates at the left bank considering their storages and O&M.

Location of bulkhead gate stockyard was decided at 450 m upstream from the Taunsa Barrage, and the reasons for its selection are as follows.

- The water rout is near the left bank side, and sedimentation on the inclination is considered to be a few.
- O&M Office of the Taunsa Barrage is located at the left bank side. This is convenient as far as storage, management, and the O&M works for the bulkhead gates is concerned.
- Left bank side is in the extents of erosion areas, and it is easy to secure the necessary draft depth for towing the bulkhead gates.

② Scale of Bulkhead Gate Stockyard

The scale of the stockyard is as follows.

- Length of stockyard: 160.0 m

(Inclination length: 58.4 m + stockyard length: 81.6 m + width of passage: 10.0 m+ width of dike road: 10.0 m)

- Width of Stockyard: 90.0 m

  (Width of dike road: 10.0 m x 2 rows + width of passage: 10.0m x 2 rows + gate loading space: 13.0 m+ width of stockyard: 27.0 m+ width of working space: 10.0 m)

- Scale of stockyard: 14,400 m^2

  (Length: about 160 m x width: about 90 x embankment height: 6.0 m)

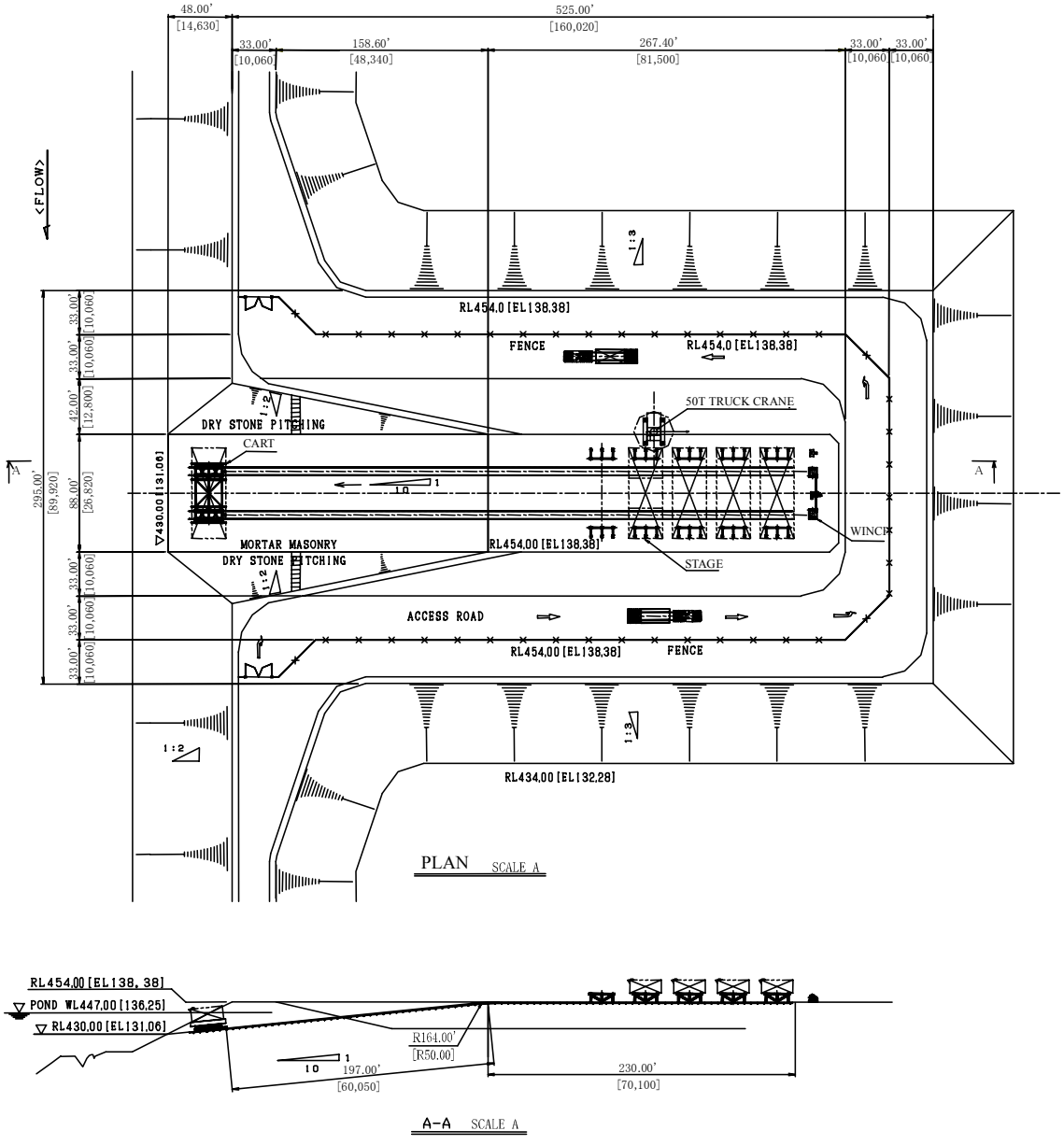


Figure 2-2-2.5 Layout of Bulkhead Gate Stockyard

(2) Equipment Plan

① Inclination

1) Slope of Inclination

As to the slope of inclination facilities for the bulkhead gate stockyard, careful study would be needed because when the gentle slope is applied for the inclination, embankment volumes of the bank would be increased. Also when the steep slope is selected, the winch capacity would accordingly increase resulting in the increase of the project costs, especially equipment costs. Also there should be more concern on safety aspects.

a) Examination Conditions

i) There is fear of damage to the main body of the gate or sinking to the riverbed caused by the influence of sudden discharge by the gate operation mistakes or the collision of driftwood and the ship and etc. when the bulkhead gate is moored in the river through the night due to unfinished installation work of the bulkhead within one day. If the bulkhead gate gets damages, no works can be advanced. Therefore, it is very essential to complete the works from launching to installation at the prescribed place within one day to avoid damages to the bulkhead gate.

ii) The bulkhead gate installation work is examined assuming that the works would be completed within one day. Working hours considered is 8 hrs.

iii) The work procedures and the time required for the installation of the bulkhead gate are as follows.

①	Launching from inclination equipment	
②	Towing	0.5hr
③	Bulkhead gate upright work preparation	1.0hr
④	Bulkhead gate careening and upright work	1.5hr
⑤	Bulkhead subsidence work	1.0hr
⑥	Prescribed, positional horizontal movement (attraction by rope)	0.5hr
⑦	Bulkhead gate subsidence minute adjustment work and fixation	1.0hr
	Total	5.5hr

iv) The time required for launching work from the inclination equipment is set as 2.5 hrs from the above-mentioned time.

v) There are regulations of making the inclination in less than 45° (1:1) in case of dealing with light equipment such as motorboats. However, because of the heavy weight of the inclination facilities (more than 100 tons), incidents such as running into foreign materials on rails of the inclination, or influence of slight impacts caused by water flow and driftwood, it may cause the bulkhead gates to slip and fall-down from the truck in case of steep slope. It is therefore difficult to adopt steep inclination considering high risk and extent of possible damage that may occur.

vi) The inclination is set to about 10° in this examination based on comparative study of the following three cases of inclination alternative of 1/15, 1/10, and 1/5.

b) Examination Results

Result of the examination shows that (refer to Table 2-2-2.12), in case of Plan-1(slope:1/15) installation works of bulkhead gates cannot be completed within a day. In case of Plan-3 (slope:1/5) winch capacity is increased because of steep slope of inclination, leading to increase in equipment costs and consequently increase in total project cost inclusive of earth works. From the results of the examination, Plan-2 (slop:1/10), has been recommended because it has adequate inclination slope, installation work schedule is not affected and project cost is lowest.

2) Scale of Inclination

The outline of the recommended inclination is shown below.

- Top elevation of inclination: R.L. 431.00 ft (EL. 131.37 m)
  (Design maximum water level: R.L 447.00 ft, required draft depth: 10.00 ft, truck height: 3.00 ft, allowance: 3.00 ft)
- Crest elevation of inclination: R.L. 455.00 ft (EL. 138.68 m)
  (Flood water level: R.L 448.00 ft + dike freeboard: 7.00 ft)
- Slop of Inclination: 1/10
  (Implemented sample of Kotri Barrage: 1/10=10%)
- Length of Inclination: 240.00 feet (73.15 m)
  (Difference of elevation: R.L 455.00 ft – R.L 431.00 ft = 24.00 ft, length: 24.00 x 10.0)

Table 2-2-2.12 Study Results on Inclination Slope of Inclination Facility for Bulkhead Gate Stockyard

		Plan-1: Inclination slope 1:15 (3.8° in angle of inclination)	Plan-2: Inclination slope 1:10 (5.7° in angle of inclination)	Plan-3: Inclination slope 1:5 (11.3° in angle of inclination)
Outline		The hoisting load becomes small though the inclination length becomes long because the inclination angle is loose.	This plan is an intermediate plan among 3 Plans.	Civil work costs are decreased with less volume of earth works, though the hoist loads becomes large.
Length of inclination		110 m	73 m	37 m
Site area		L: 211.6 m x B: 90 m = 19,044 m^2	L: 174.6 m x B: 90 m = 15,714 m^2	L: 138.6 m x B: 90 m = 12,474 m^2
		The site area broadens to the extent because inclination length becomes long.	The site area is smaller than that of Plan-1.	The site area is small because inclination length becomes short.
Required launch time		3.0 hr (hoisting length : 180 m)	2.2 hr (hoisting length: 130m)	1.7 hr (hoisting length 100m)
Bulkhead gate installation Influence on work		Because of long hoisting length, required launching time is 3 hr, which does not satisfy the target launching time of 2.5 hr. Therefore, it is difficult to complete the installation work within a day.	In case of this slope, required launch time is estimated at 2.2 hr, which satisfy the time of 2.5hr for the launch work target. Work schedule is not affected.	The installation schedule is not affected as required launch time is greatly shorter than targeted time frame of 2.5hrs.
Outline of Equipment	Hoisting load	160 kN	214 kN	370 kN
	Motor output	4.0 kw	5.5 kw	10.0 kw
	Capacity of Generator	37 KVA	50 KVA	90 KVA
	Winch weight	15 ton	20 ton	30 ton
	Earth work volume	10,840 m^3	7,200 m^3	3,600 m^3
Economy	Initial costs	Mechanical equipment: 25.8 million yen (winch, generator, and switchboard) Earth work: 33.6 million yen total: 59.4 million yen	Mechanical equipment: 33.3 million yen(winch, generator, and switchboard) Earth work: 22.3 million yen total: 55.6 million yen	Mechanical equipment: 51.1 million yen(winch, generator, and switchboard) Earthwork: 11.2 million yen total: 62.2 million yen
	Running costs	Mechanical equipment: 4.7 million yen(fuel and update expense)	Mechanical equipment: 6.2 million yen(fuel and update expense)	Mechanical equipment: 10.2 million yen(fuel and update expense)
	Life cycle costs	64.1 million yen	61.8 million yen	72.4 million yen
Judgment		As wider site is needed, installation work of bulkhead gate is affected and project cost becomes higher. ×	This Plan is adopted because it will not affect bulkhead gate installation work schedule and economically feasible due to lower cost. ◎	More expensive and therefore not economically viable. ○

Calculation background:

1) For calculation of hoisting volumes and electric motor capacity, refer to the attached paper "Winch Study for Inclination Equipment ".
2) For calculation of generator capacity, refer to attached paper "Study on Winch Generator ".
3) The winch weight is calculated on the basis of second power root of the ratio of the experience value and the capacity of the motor based on the volumes of the Plan-2.
4) Earth work volumes are calculated by multiplying inclination length by inclination width of 27 m. Because of rough estimation, the volumes are estimated only by the volumes of embankment.
5) The running costs of the mechanical equipment are estimated on the basis of fuel fee for 50-year and replacement costs of necessary equipment (boards, generators, electric motors, and decelerators).
6) Replacement year: Generator: 20-25 years, switchboard 20 years, electric motor 30 years, decelerator 30-40 years

② Winch for Lifting-up Bulkhead Gate

1) Lifting-up Speed

The faster is the gate lift-up speed, the shorter is the time required and the bulkhead gate installation working hours is shortened, a generator, and switchboard results in efficient work progress. However, because the capacity of the electric motor increases, it becomes uneconomical. It is therefore necessary to select an appropriate gate lifting-up speed.

a) Setting of Examination Conditions

i) The time required for launching work from the inclination facilities is set as 2.5 hr.

ii) There are regulations of assuming 10m/min or less if regulations of the opening and shutting speed for the light inclination facilities such as motorboats. ("The Engineering Design Manual for Dam and Weirs (draft)"). However, the weight of this inclination facility is 100 ton or more , so that gate lifting-up speed should be low, because deposits of obstacles on rail, slight impacts by flow and drifting-woods would cause unexpected accidents such as gate slip and falling down from truck in case of fast speed.

iii) According to "the Engineering Design Manual for Gates and Penstocks", lifting-up speed for the high gates is set at 0.5 -1.5 m/min. The speed in case of dive gate closing time is set as 1.0 -2.0 m/min (6.0 m/min in maximum), considering the damages of impact at the arrival of floor.

iv) Since a lot of gate repairing works should be completed within a limited period, work progress control is deemed to be essentially important matter in the project. If gates would be damaged by means of falling-down from truck, such accidents would affect significantly the overall work progress of the project. Therefore, high lifting-up speed could not be recommended, and 2.0 m/min is decided as the most adequate lifting-up speed.

v) Three alternative cases were examined for gate lifting-up as follows: 0.5 m/min, 1.0 m/min, and 2.0 m/min,

b) Examination Results

The results of examination are as follows (Refer to Table 2-2-2.13).

① In case of gate lifting-up speed of 0.5 m/min, the required time for launching would be 4.3 hrs, which does not meet the objective time of 2.5 hrs. Furthermore, hazardous nature of work interruption is expected, so that this speed is not recommended.

② In case of gate lifting-up speed of 2.0 m/min, no obstacle effects on gate works are expected, however, this case is less economical.

③ In case of gate lifting-up speed of 1.0 m/min, the required launching for the gate is 2.2 hrs within the objective time of 3.5 hrs. Also, required cost is relatively low as compared with the other plans.

Therefore, the gate lifting-up speed is decided at 1.0 m/min.

Table 2-2-2.13 Examination of Gate Lifting-up Speed of Inclination Facilities for Bulkhead Gate Stockyard

		Plan-1: V=0.5 m/min	Plan-2: V=1.0 m/min	Plan-3: V=2.0 m/min
Outline		This speed is usually used for high gates, and it is a very slow speed. This Plan is the safest among 3 Plans.	This speed is an intermediate one between Plan-1 and Plan-2.	This speed is adopted for sudden gate closing time. It is easy to receive the influence of the impact.
Required launch time		4.3 hrs (hoisting length: 180m)	2.2 hrs (hoisting length: 130m)	1.1 hrs (hoisting length: 100m)
Bulkhead gate installation Influence on work		Because of low speed, required launching time is 4.3 hr, which does not satisfy the target launching time of 2.5 hr. Therefore, it is difficult to complete the installation work within a day.	In case of this speed, required launch time is estimated at 2.2 hr, which satisfy the target time of 2.5hr for the launch work. Therefore, no effect on work schedule is expected	The installation process is not affected because it is shorten than the target of time 2.5hr of the launch work .
	Hoisting Load	216 kN	216 kN	216 kN
	Capacity of electric motor	3.0 kw	5.5 kw	13.0 kw
	Capacity of generator	37 KVA	50 KVA	125 KVA
	Winch weight	15 ton	20 ton	30 ton
Economy	Initialed costs	25 million yen (winch, generator, and board)	33.3 million yen (winch, generator, and board)	53.0 million yen(winch, generator, and board)
	Running costs	Fuel costs: 0.2 million yen (0.04×50 years) Replacement costs: 4.5 million yen and 4.7 million yen in total	Fuel costs: 0.14 million yen (0.028×50 years) Replacement costs: 6.0 million yen and 6.14 million yen in total	Fuel costs: 0.15 million yen (0.03×50 years) Replacement costs: 11.7 million yen and 11.85 million yen in total
	Life cycle costs	29.7 million yen	39.59 million yen	64.85 million yen
Judgment		This plan will affect bulkhead gate installation process, though it is economically cheap. △	This Plan is adopted because of no effect on the bulkhead gate installation work and relatively cheaper therefore economically viable. ◎	It is relatively more expensive though there is no expected effect on bulkhead gate installation work schedule. ○

1) For calculation of hoisting volumes and electric motor capacity, refer to the attached paper " Study for Inclination Equipment ".
2) For calculation of generator capacity, refer to attached paper "Study on Winch Generator ".
3) The winch weight is calculated on the basis of second power root of the ratio of the experience value and the capacity of the motor based on the volumes of the Plan-2.
4) The running costs of the mechanical equipment are estimated on the basis of fuel fee for 50-year and replacement costs of necessary equipment (boards, generators, electric motors, and decelerators).
5) Each equipment cost: derived from experimental data and market survey results
6) Replacement year: generator: 20-25 years, board 20 years, electric motor 30 years, decelerator 30-40 years

2) Scale of Winch

The scale of winches is shown below.

- Gate lifting-up speed: 1.0 m/sec
- Gate lifting-up power: About 30 tons (inclusive of cart)
- Motor capacity: 5.5 kw (11.5 ps. for engine)

Electrical power sources for winch will be studied based on the following alternative plans from the viewpoint of reliability, costs, etc., that is, 1) Plan-1: commercial electric power + motor, 2) Plan-2: generator + motor, and 3) Plan-3: generator

(3) Revetment for Loading

The design of the revetment of Indus River's bank for loading bulkhead gate is presented below taking into consideration current situation;

- Scale of slope protection for loading：about 75m length x 0m～5.1m height x 2rows
- Structure of slope protection for loading ：Slope protection with dry masonry (1 : 2.0 in slope, 50cm in thickness)

(4) Civil Works

Specifications of the stockyard for bulkhead gate are presented below;

- Land reclamation：Land improvement work 19,500 m^2
- Earthwork：Removal of dry masonry 1,900 m^2, excavation 5,600 m^3, embankment 100,500m^2
- Foundation work：Crushed stones 930m^2, reinforced concrete 890 m^3
- Pavement work：Concrete pavement 2,160 m^2
- Revetment work：Dry masonry 2,300 m^2

Table 2-2-2.14 Examination Table on Electric Source for Winch for Stockyard of Bulkhead

		1 st Plan：Commercial Power + Motor	2 nd Plan：Generator + Motor	3 rd Plan：Engine Motor
Capacity		Motor：5.5kw Commercial power：AC400V, 50Hz, 3 φ	Motor：5.5kw Generator：40KVA×1unit	Engine：11.5ps
Outline & Equipment Composition		The plan will use electric power. Standby generator will be used only in case of power stoppage to back up electric supply for whole Barrage. Winch will be driven with motor and reducer.	The plan uses generator as electric source. The winch will be driven with motor and reducer.	The plan will use motor oil to start. No electricity required. Winch will be driven with engine, clutch, gear shifter and reducer, no operating pane needed.
Operational Efficiency		To be used only when turning on the breaker which makes operation easy. Advantage in operational efficiency.	The generator needs startup but not so troublesome.	Needs to startup engine in neutral position and also needs to reverse speed of rotation when building up speed.
Reliability on Operation		Reliability is high since this system can supply power for whole Barrage even in electric stoppage. It has standby generator. Electricity use can be controlled and be effective.	Reliability is high since this system can be use any time even with stoppage of commercial power. Electricity use can be controlled and be effective.	・Can be used even with stoppage of commercial power. ・Low reliability because the plan needs monitoring and control ay all times by operator to ensure safe operation.
Easiness for Maintenance		Not necessary to maintain the equipment but needs for regular replacement to lengthen life of the electrical parts.	Generator needs maintenance.	Needs maintenance for engine etc.
Hours	Operation hours	2.2hr（one way）×2×2 gates＝8.8hrs	2.2hr（one way）×2×2 gates＝8.8hrs	2.2hr（one way）×2×2 gates＝8.8hrs
	Frequency	2times/year	2 times/year	2 times/year
	Total	17.6hr/year	17.6hr/year	17.6hr/year
Consumption		5.5kW×17.6hr＝96.8kWh	8 lit./hr×17.6hr=140.8lit.	2.3 lit./hr×17.6hr=40.5 lit.
Economical Efficiency	Initial Cost	Operating panel 300 thousand Yen Cost for electrical work（overhead wire 500m） 3.7 million Yen Total 4 million Yen	Operating panel 300 thousand Yen Generator 3,000 thousands Yen Total 3.3 million Yen	Engine clutch 800 thousand Yen Gear shift equipment 3.5 million Yen Total 4.3 million Yen
	Running Costs	In case of 1kWh=11 Yen (in Japan); （assumed that basic rate includes in the running cost of gate because the motor will not be operated simultaneously with the gate） Annual cost 96.8×11＝1.1 thousand Yen Cost for 50 years：1.1×50 years=55 thousand Yen	In case of 1lit.＝50Yen; Annual cost 140.8×50 Yen＝7.1 thousand Yen Cost for 50 years：7.1×50 years=355 thousand Yen	In case of 1lit.＝50Yen; Annual cost 40.5×50 Yen＝2.1 thousand Yen Cost for 50 years：2.1×50 years=105 thousand
	Life Cycle costs	Initial cost：4,000 thousand Yen Running cost：55 thousand Yen Life cycle cost：4,055 thousand Yen	Initial cost：3,300 thousand Yen Running cost：355 thousand Yen Life cycle cost：3,655 thousand Yen	Initial cost：4,300 thousand Yen Running cost：105 thousand Yen Life cycle cost：4,405 thousand Yen
Evaluation		○：High reliability but inefficient in maintenance and economy. No merit could be found for its use.	◎：Most suitable among the three (3) plans due to good economical efficiency and high reliability.	△ ：No merit can be found due to problem in operation and low economical efficiency.

2-2-2-8 Electrical Facilities

Capacity calculations for electrical facilities are as follows.

(1) Motors for Under Sluice Gate and Weir Gate

According to the earlier assessment of hoist motor output, rated output shall be 2.2 kW of under sluice gates, 1.5 kW of weir gates.

(2) Transformer for Receiving Equipment

Conditions : Simultaneous operation shall be possible up to 10 gates of under sluice gate.

$$Ptr = [\{Po/(\eta \cdot Pf)\} + Pi]\ \alpha$$

Where,

- Ptr : Transformer capacity (kVA)
- Po : Output of each load (kW) (2.2kW x 10 =22kW)
- η : Efficiency of each load
- Pf : Power factor of each load
- Pi : Load capacity other than Po (kVA)
  - for Local Control Panel: 0.5kVA x 10 = 5kVA
  - for LV Panel: 2kVA (Total: 7kVA)
- α : Demand factor

$$Ptr = [\{22 / (0.85 \times 0.80)\} + 7] \times 1.0$$
$$= 39.3 \text{ (kVA)}$$

From the above, based on standard capacity of the nearest transformer, 50 kVA shall be selected.

(3) Backup Generator for Gates

Assessment of the backup generator is shown in Appendix-A6-8. As a result of the examination, 50 kVA is selected.

(4) BHG Winch Motor

According to the earlier assessment of BHG winch output, rated output shall be 5.5 kW (refer to 2-2-2-1).

(5) Generator for BHG winch

Assessment of the generator is shown in Appendix-A6-9. As a result of the assessment, 50 kVA is selected.

Table 2-2-2.15 Specifications of Main Electrical Equipment

Main Equipment	Quantity to be Procured	Outline Specifications
(1) Power receiving equipment		
Terminal pole	1 set	Electric pole, assembling fittings, naked wire
Fused disconnecting switches	3 sets	11kV, 10A
Lightning arrester	3 sets	11kV, 5kA, gapless type
Transformer	1 unit	11/0.4-0.23kV, 50kVA Outdoor installed type, oil-immersed
(2) Power distribution equipment		
Low voltage switchboard	1 unit	Outdoor self-standing type
(3) Switchgear	29 sets	
Local Control panel		Outdoor self-standing type, IP54
Motor		Cage 3-phase induction motor, outdoor type, with electromagnetic brake, 1.5 kW for weir gate and 2.2kW for under sluice gate
Gate position meter		Electric type
Limit switch box		Fitted with 2 limit switches
(4) Backup generation equipment (for gates)		
Generator	1 unit	Diesel engine 400-230V, 50kVA
(5) BHG storage equipment		
Generator (for BHG)	1 unit	Diesel engine 400-230V、50kVA
Motor	1 unit	Cage 3-phase induction motor, outdoor type, 5.5 kW
Operation panel	1 unit	Outdoor self-standing type, IP43

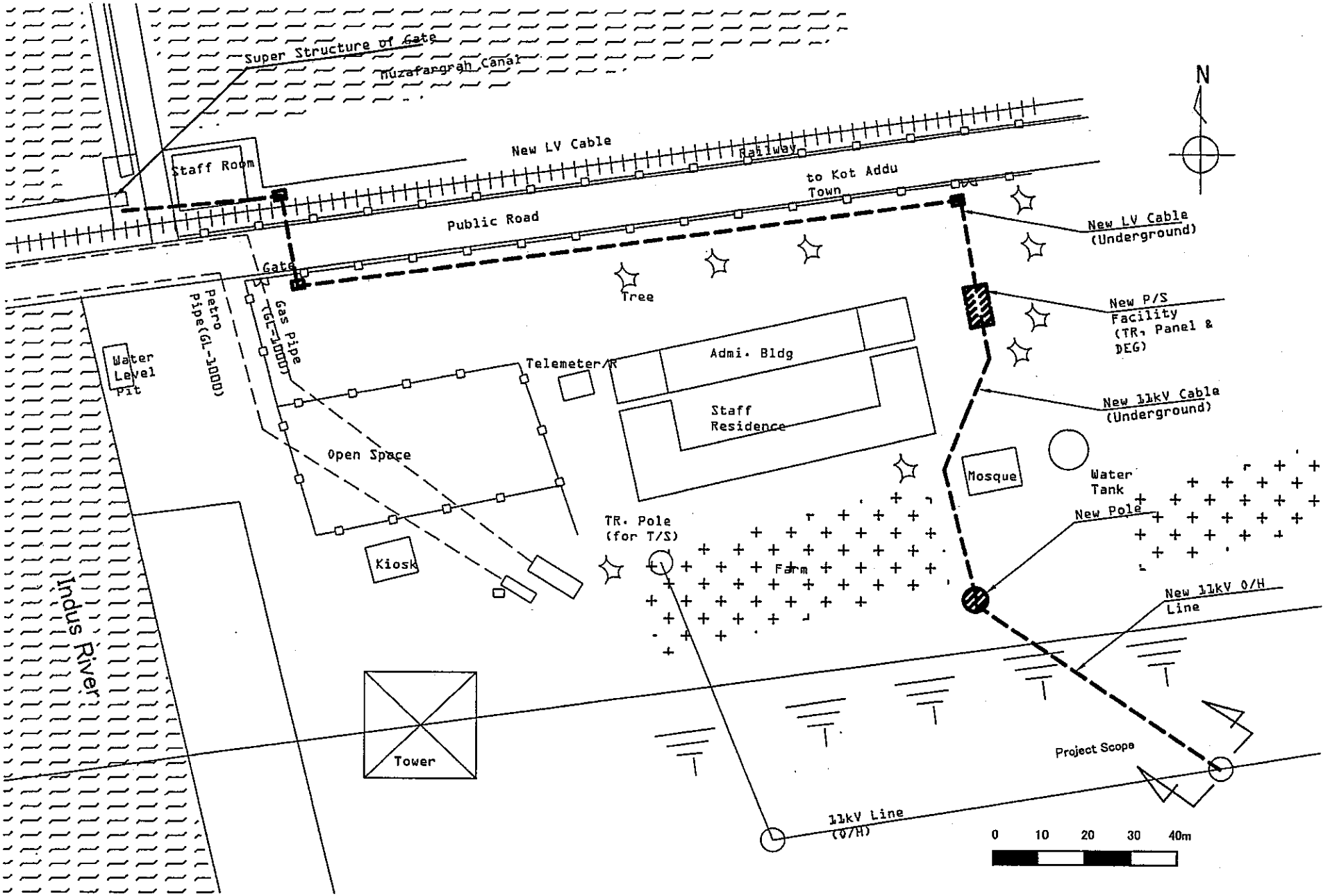


Figure 2-2-2.6 Power Supply Diagram for Gate Control Panel

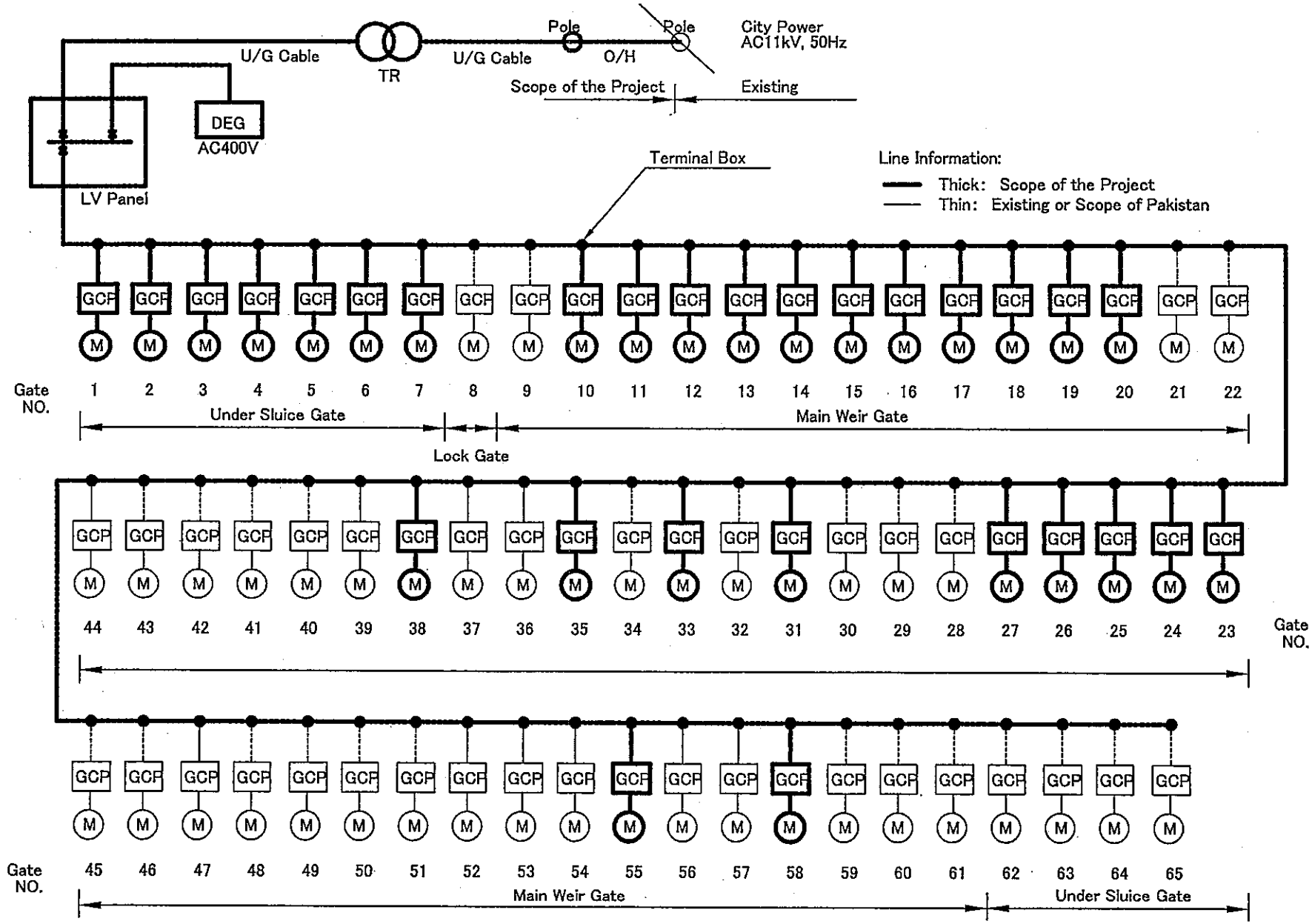


Figure 2-2-2.7 Electrical Equipment Layout

2-2-2-9 Temporary Facilities

(1) Temporary Diversion Channel

Temporary facilities are needed to flow river discharge to downstream safely in parallel with the rehabilitation works in the River. The Taunsa Barrage will be provided with 53 weir gates (60ft=18.3m span each) and 11 under sluice gates (60ft=18.3 span each). The weir gates and under sluice gates will be kept away more than one gate from those being rehabilitated and will be used as temporary diversion channel in order to flow river discharge safely.

If opening fully 12 gates, objective flood discharge that will take place during rehabilitation works could be discharged. However, the regulation concerning gate operation of the Taunsa Barrage, namely "2 ft rule" has been applied to control difference of gate opening of less than two (2) ft for two (2) neighboring gates. Therefore detail gate operation will be planned for actual works in accordance with the "2 ft rule".

(2) Cofferdam Work at Downstream for Gate Rehabilitation

① Water Level at Downstream of Cofferdam for Gate Rehabilitation

Water level during gate rehabilitation works will be D/S WL. 429.60ft = D/S WL. 130.94m, which are those after construction of subsidiary weir at downstream.

② Crest Elevation and Structure of Cofferdam at Downstream

Crest elevation of cofferdam at downstream will be D/S WL. 429.60 ft = D/S WL. 130.94m + 0.5m of free board at downstream of barrage.

- Water level at downstream：D/S WL. 429.60 ft = D/S WL. 130.94m
- Crest elevation of cofferdam at downstream：R.L. 432.00ft = EL. 131.67m
- Elevation of existing incline apron：weir gate R.L. 425.00ft = EL. 129.50m
  Under sluice gate R.L. 422.00ft = EL. 128.60m
- Height of the cofferdam：Weir gate 7.00ft = 2.13m
  Under sluice gate 10.00ft = 3.05m

Since the cofferdam will be constructed on the existing inclined apron due to the height of the cofferdam which is relatively low, from 2.13m to 3.05m., the proposal is to utilize large size sandbags for the structure of the cofferdam for easier construction and better water sealing.

(3) Temporary Road and Temporary Bridge

① Temporary Road

The existing main local road from Indus highway to the project site located at the right bank will be used as temporary road. Power line with 4.5m height crossing road is higher than the limited height for road construction (international standard). Accordingly there is no need to construct temporary road.

② Temporary Bridge

The existing attached bridge of the Taunsa barrage, the bridge at RD 7,500 Silt Ejector point, the existing bridge at the intake of Muzaffarugarh and T.P.Link Canal, will be used as temporary bridge because these were constructed to meet the design load for Class AA (design live load for 70tons tank) bridge.

There is no need to construct temporary bridge for weir gate and under sluice gate rehabilitation works because construction works are planned to be undertaken from road bridge of the Taunsa Barrage or by using a pontoon at the upstream.

(4) Temporary Jetty

The temporary pier for shipment of construction materials will be proposed because the construction works are supposed to be done at the upstream by using a pontoon. Location of temporary jetty will be selected at upstream of right bank because temporary stockyard for material and products is also planned at upstream of right bank. Scale of the temporary jetty proposed is presented below;

- Structure of temporary jetty：steel structure（H-300 x 300 L = 14.00m H-beam steel abutment、steel cover plates）
- Width of temporary jetty：10.00 m（5.00 m x 2 lane）
- Length of temporary jetty：30.00 m（inclined part：16.00 m、horizontal part：14.00 m）

2-2-2-10 Specifications and Quantities of Incidental Facilities and Equipment

Tables 2-2-2.16 and 2-2-2.17 show the specifications and quantities of incidental facilities and equipment for the Project.

Table 2-2-2.16 Specifications of Bulkhead Gate Equipment

Equipment	Purpose of Installation	Specifications	Remarks
Tug boat	Towing of the bulkhead gate	150 PS x 2 vessels	
Boat	Transportation of equipment for installing the bulkhead gate, etc.	1.2 tons Capable of carrying work boat x 3 boats	3 boats for transporting compressors, etc.,
Main crane	Assembly and disassembly of the bulkhead gate	50 t truck crane x 1 unit	
Bulkhead gate Stockyard	Bulkhead gate storage and lifting at times of use	Concrete slope Winch 5.5 kW x 1 unit Generator 50 kVA x 1 unit	
Spare parts	Maintenance and repair work	Bolts, nuts, packing, coating, maintenance tools for crane, etc., and so on	See Table 2-2-2.17 for details

Table 2-2-2.17 Bulkhead Gate Spare Parts

Name	Specifications	Quantity	Remarks
Tug boat maintenance tools	Spanners, wrenches, etc.	1 set	Planned for installation on each boat
Filter	For use with engines, oil and air	5 sets	Boat filters scheduled for replacement every year
Engine oil	For tugboat and boat use	2 sets	Replacement expected once per annum
Crane maintenance tools	Spanners, wrenches, etc.	1 set	
Crane oil	Engine, mission, brakes	2 sets	Planned for replacement every year
Crane filters	Engine, oil, air	2 sets	Planned for replacement every year
Crane element		2 sets	Planned for replacement every year
Brake oil		4 lit.	Planned for replacement every 2 years
Brake hose		1 set	Planned for replacement every 2 years
Electrical parts	Fuses, lamps, etc.	1 set	
Bolts, nuts, packing		1 set	Replacement expected once

2-2-2-11 Scope of the Project

On the basis of the proposal of the Preliminary Survey and present study results, the proposed scope of the grant aid project is shown below.

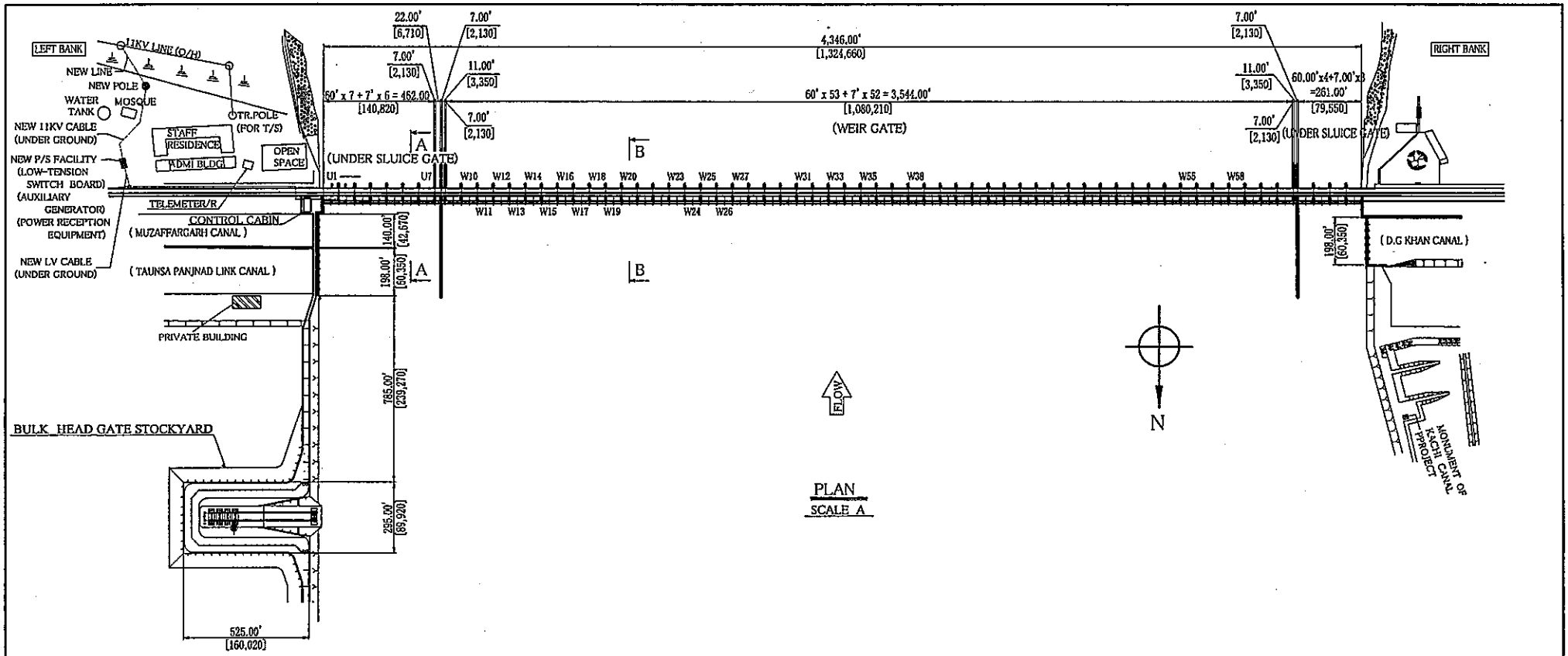
Table 2-2-2.18 Scope of the Grant Aid Project

No	Kind of Works	Application by Pakistan Government	Proposal in the Preliminary Survey (Alternative 1)	Scope of Grant Aid Project
1	Replacement of the under sluice gate at left bank	7gates	7gates	7gates
2	Rehabilitation of the weir gate facilities	24gates	24gates	22gates
3	Replacement of old-type gate hoist to new type and rehabilitation	60gates（under sluice gate：7gates, weir gate：53gates）	31gates（under sluice gates：7gates, weir gate：24gates）	29 gates（under sluice gates：7gates, weir gate：22gates）
4	Electrification of gate hoist	31gates（under sluice gate：7gates, weir gate：24gates）	31gates（under sluice gate：7gates, weir gate：24gates）	29 gates（under sluice gate：7gates, weir gate：22gates）
5	Rehabilitation of deck on superstructure	60gates（under sluice gates：7gates, weir gate：53gates）	65gates（under sluice gate：11gates, weir gate：53gates, navigation lock：1gate）	65gates（under sluice gate：11gates, weir gate：53gates, navigation lock：1gate）
6	Provision of bulkhead gate for temporary cofferdam works	6 gates	6 gates	5 gates (including side frames and sill beams for 29bays)
7	Construction of stockyard for bulkhead gate and slope protection works for loading way	1set	1set	1set
8	Provision of construction machinery	One (1)set of 80t & 30t cranes, two (2) tugboats and three (3) boats	One (1)set of 80t & 30t cranes, two (2) tugboats and three (3) boats	One (1)set of 50 t crane, two (2) tugboats 150ps and three (3) boats
9	Spare parts for item 8	1set	1set	1set

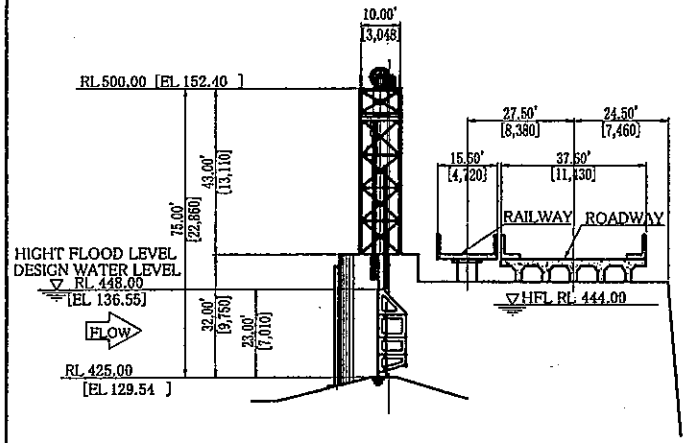
2-2-3． Basic Design Drawings

List of Basic Design Drawings

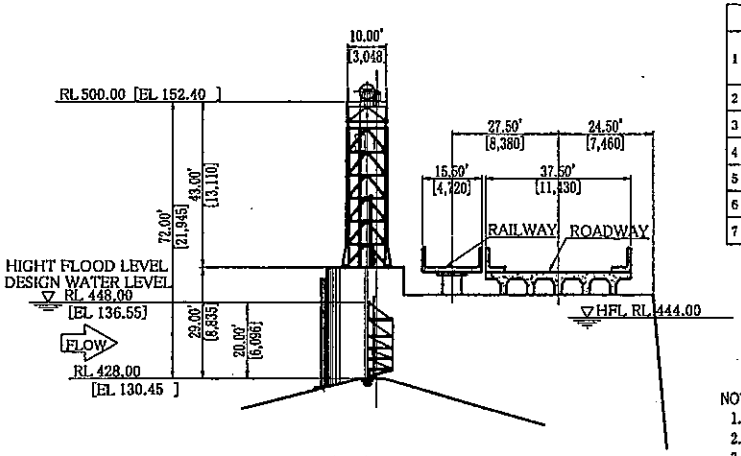
Drawing No.	Drawing Title
DWG-1	General Layout of Taunsa Barrage Rehabilitation Project
DWG-2	General Elevation of Taunsa Barrage
DWG-3	General Profile of Taunsa Barrage
DWG-4	General Layout of Under Sluice Gate Facilities
DWG-5	Layout of Under Sluice Gate Leaf
DWG-6	Layout of Under Sluice Gate Hoist
DWG-7	General Layout of Weir Gate Facilities
DWG-8	General Layout of Weir Gate Hoist
DWG-9	General Layout of Bulkhead Gate Facilities
DWG-10	Layout of Bulkhead Gate Leaf
DWG-11	Layout of Bulkhead Gate Stockyard
DWG-12	Layout of Deck Plate Rehabilitation
DWG-13	Low Voltage Switchboard Outline and Single Diagram
DWG-14	Local Control Panel Outline and Single line Diagram



PLAN
SCALE A

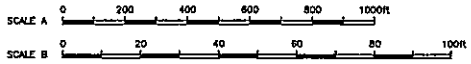


SECTION A - A
SCALE B
(UNDER SLUICE GATE)



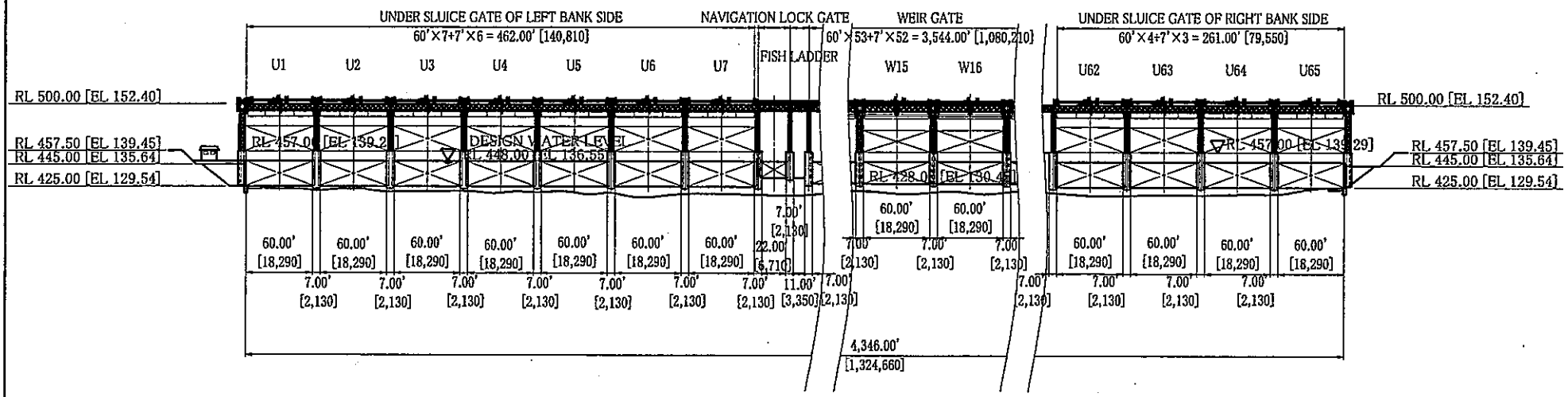
SECTION B - B
SCALE B
(WEIR GATE)

SCOPE OF REHABILITATION		
1	REPLACEMENT OF THE UNDER SLUICE GATE LEAVES	SEVEN (7) SETS ON THE LEFT BANK
2	REHABILITATION OF THE WEIR GATES	22 OF THE 53 SETS
3	ELECTRIFY GATE HOIST	29 OF THE 64 SETS
4	REHABILITATION OF THE HOIST DECK	ALL 65 OF THE 65 SETS
5	PREPARATORY WORK FOR USING BULK HEAD GATES	FIVE (5) SETS
6	INSTALLATION OF THE BULK HEAD GATE GUIDE	29 OF THE 64 SETS
7	CONSTRUCTION OF THE BULK HEAD GATE STOCKYARD	ONE (1) SET



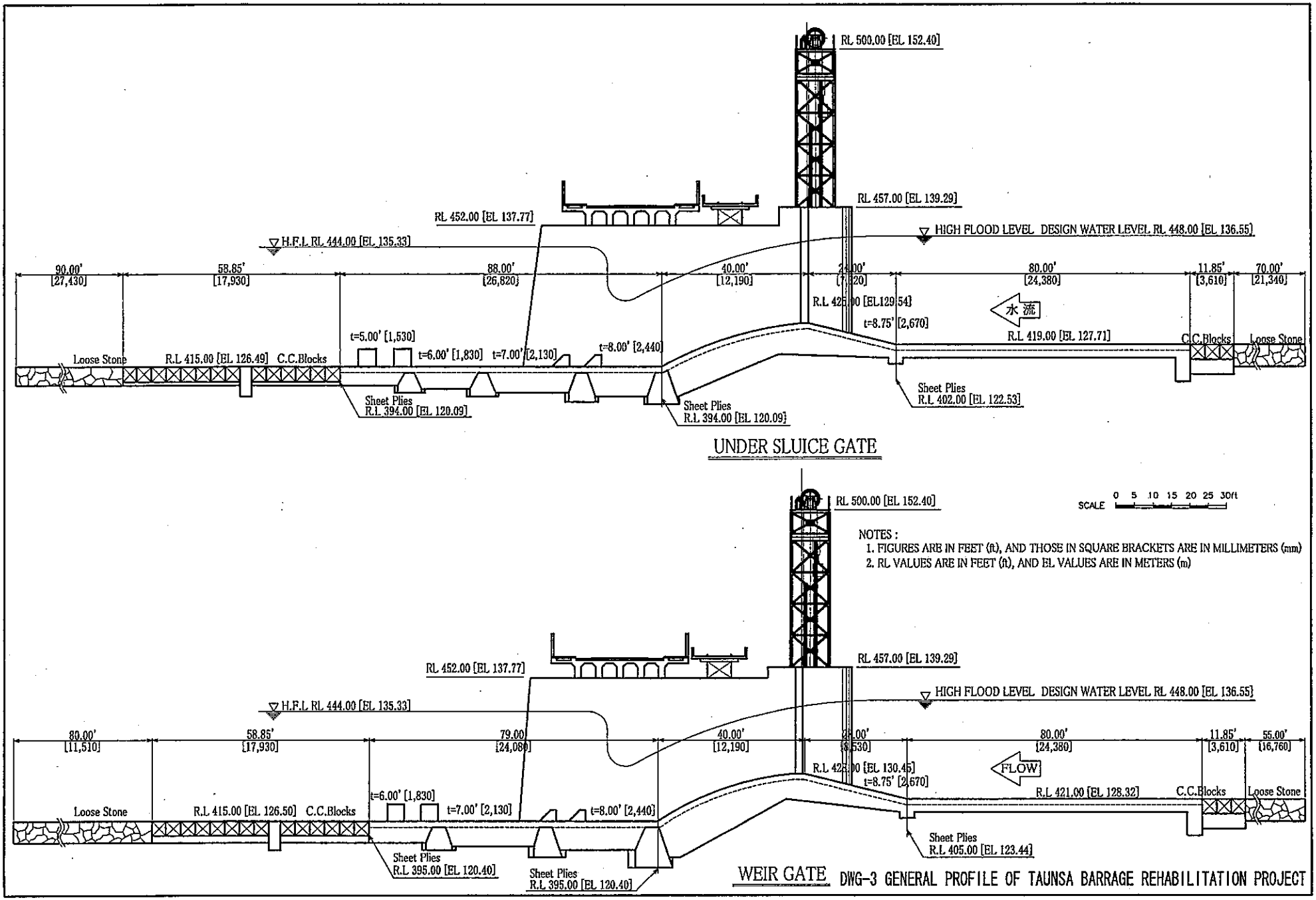
NOTES :
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm)
2. RL VALUES ARE IN FEET (ft), AND EL VALUES ARE IN METERS (m)
3. U1-U7, W10 AND OTHER SIMILAR CODES INDICATE THE GATES TO BE REHABILITATED DURING THE CURRENT WORKS.

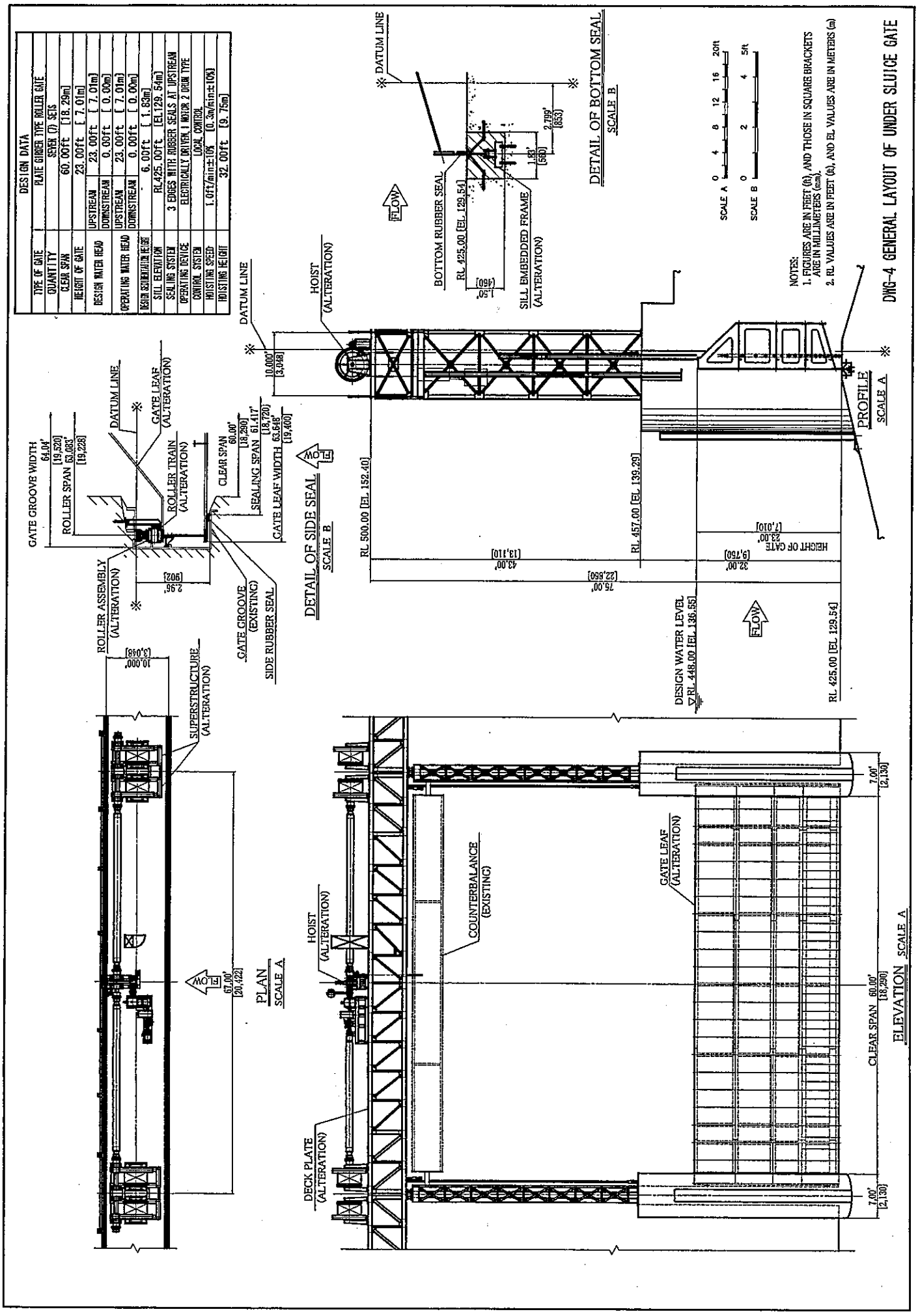
DWG-1 GENERAL LAYOUT OF TAUNSA BARRAGE REHABILITATION PROJECT

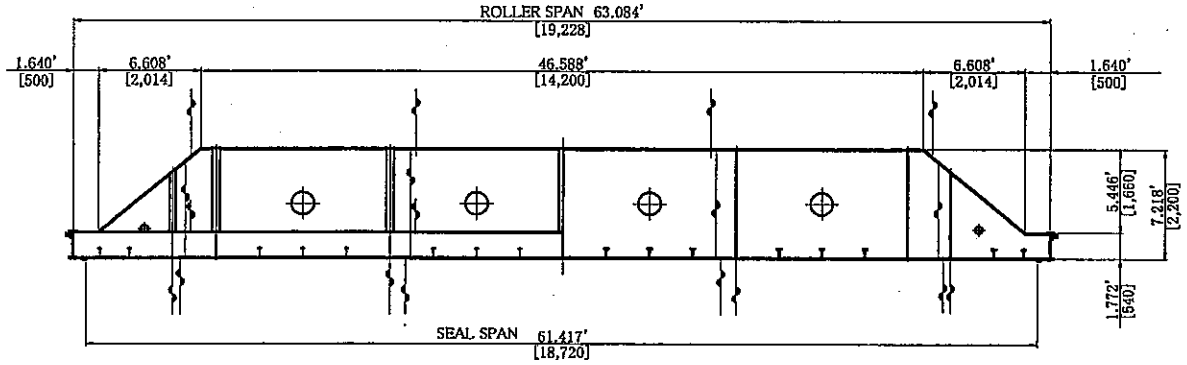


NOTES :
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm)
2. RL VALUES ARE IN FEET (ft), AND EL VALUES ARE IN METERS (m)

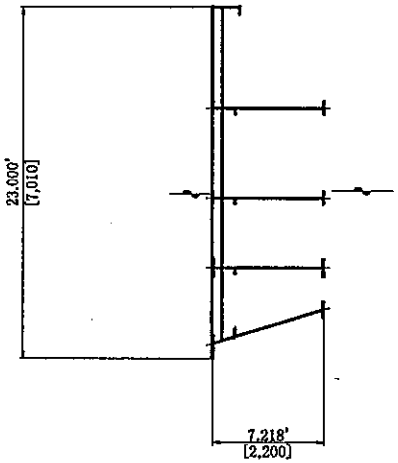
DWG-2 GENERAL ELEVATION OF TAUNSA BARRAGE REHABILITATION PROJECT


RL 500.00 [EL 152.40]
RL 457.00 [EL 139.29]
RL 452.00 [EL 137.77]
H.F.L RL 444.00 [EL 135.33]
HIGH FLOOD LEVEL DESIGN WATER LEVEL RL 448.00 [EL 136.55]
90.00' [27,430]
58.85' [17,930]
88.00' [26,820]
40.00' [12,190]
80.00' [24,380]
11.85' [3,610]
70.00' [21,340]
R.L 419.00 [EL 127.71]
水流
t=8.75' [2,670]
t=5.00' [1,530]
t=6.00' [1,830]
t=7.00' [2,130]
t=8.00' [2,440]
Loose Stone
R.L 415.00 [EL 126.49]
C.C.Blocks
Sheet Plies R.L 394.00 [EL 120.09]
Sheet Plies R.L 402.00 [EL 122.53]
UNDER SLUICE GATE
RL 500.00 [EL 152.40]
SCALE 0 5 10 15 20 25 30ft
NOTES :
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm)
2. RL VALUES ARE IN FEET (ft), AND EL VALUES ARE IN METERS (m)
RL 457.00 [EL 139.29]
RL 452.00 [EL 137.77]
H.F.L RL 444.00 [EL 135.33]
HIGH FLOOD LEVEL DESIGN WATER LEVEL RL 448.00 [EL 136.55]
80.00' [11,510]
58.85' [17,930]
79.00' [24,080]
40.00' [12,190]
80.00' [24,380]
11.85' [3,610]
55.00' [16,760]
R.L 421.00 [EL 128.32]
FLOW
t=8.75' [2,670]
t=6.00' [1,830]
t=7.00' [2,130]
t=8.00' [2,440]
Loose Stone
R.L 415.00 [EL 126.50]
C.C.Blocks
Sheet Plies R.L 395.00 [EL 120.40]
Sheet Plies R.L 405.00 [EL 123.44]
WEIR GATE
DWG-3 GENERAL PROFILE OF TAUNSA BARRAGE REHABILITATION PROJECT

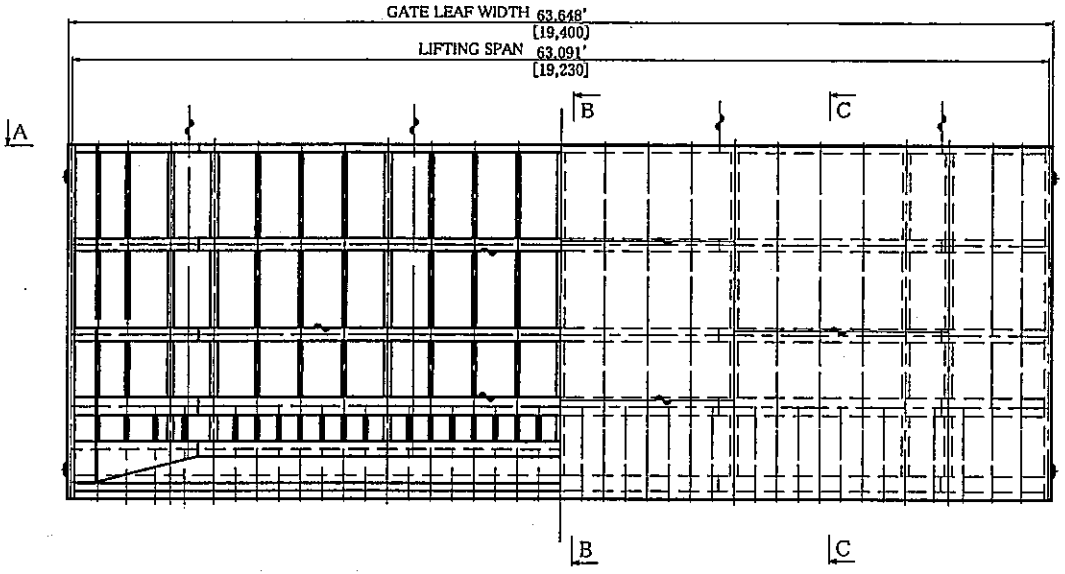

DESIGN DATA
TYPE OF GATE
PLATE GIRDER TYPE ROLLER GATE
QUANTITY
SEVEN (7) SETS
CLEAR SPAN
60.00ft (18.29m)
HEIGHT OF GATE
23.00ft (7.01m)
DESIGN WATER HEAD
UPSTREAM 23.00ft (7.01m)
DOWNSTREAM 0.00ft (0.00m)
OPERATING WATER HEAD
UPSTREAM 23.00ft (7.01m)
DOWNSTREAM 0.00ft (0.00m)
MAIN SQUAREING HEIGHT
6.00ft (1.83m)
SILL ELEVATION
RL425.00ft (EL129.54m)
SEALING SYSTEM
3 EDGES WITH RUBBER SEALS AT UPSTREAM
OPERATING DEVICE
ELECTRICALLY DRIVEN, 1 MOTOR 2 DRUM TYPE
CONTROL SYSTEM
LOCAL CONTROL
HOISTING SPEED
1.0ft/min±10% (0.3m/min±10%)
HOISTING HEIGHT
32.00ft (9.75m)
DETAIL OF BOTTOM SEAL
SCALE B
DATUM LINE
FLOW
BOTTOM RUBBER SEAL
RL 425.00 [EL 129.54]
SILL EMBEDDED FRAME
(ALTERATION)
HOIST
(ALTERATION)
DETAIL OF SIDE SEAL
SCALE B
GATE GROOVE WIDTH
64.04'
[19,520]
ROLLER SPAN 63.083'
[19,228]
GATE LEAF
(ALTERATION)
ROLLER TRAIN
(ALTERATION)
CLEAR SPAN
60.00'
[18,290]
SEALING SPAN 61.417'
[18,720]
GATE LEAF WIDTH 63.648'
[19,400]
ROLLER ASSEMBLY
(ALTERATION)
GATE GROOVE
(EXISTING)
SIDE RUBBER SEAL
RL 500.00 [EL 152.40]
RL 457.00 [EL 139.29]
DESIGN WATER LEVEL
RL 448.00 [EL 136.55]
RL 425.00 [EL 129.54]
HEIGHT OF GATE
23.00'
[7,010]
43.00'
[13,110]
32.00'
[9,750]
76.00'
[22,860]
PROFILE
SCALE A
SCALE A 0 4 8 12 16 20ft
SCALE B 0 2 4 5M
NOTES:
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm).
2. RL VALUES ARE IN FEET (ft), AND EL VALUES ARE IN METERS (m)
DWG-4 GENERAL LAYOUT OF UNDER SLUICE GATE
SUPERSTRUCTURE
(ALTERATION)
PLAN
SCALE A
HOIST
(ALTERATION)
COUNTERBALANCE
(EXISTING)
GATE LEAF
(ALTERATION)
DECK PLATE
(ALTERATION)
CLEAR SPAN 60.00'
[18,290]
ELEVATION
SCALE A



SECTION A – A



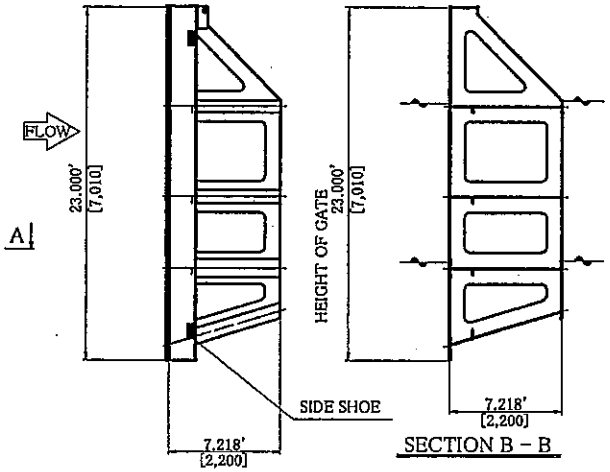
SECTION C – C



DOWNSTREAM VIEW

UPSTREAM VIEW

ELEVATION



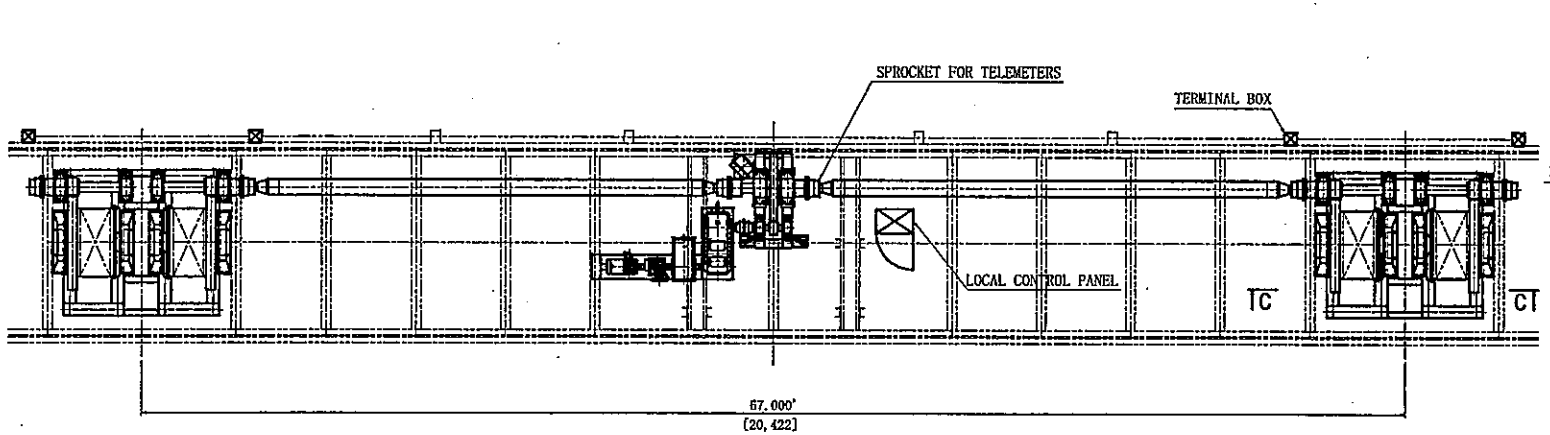
PROFILE

SECTION B – B

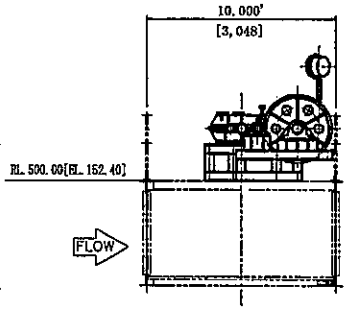
SCALE 0 2 4 6 8 10ft

NOTES :
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUAR E BRACKETS ARE IN MILLIMETERS (mm).
2. CONNECTIONS MARKED WITH SYMBOL ~ ARE LOCATIONS TO BE FIELD WELDED.

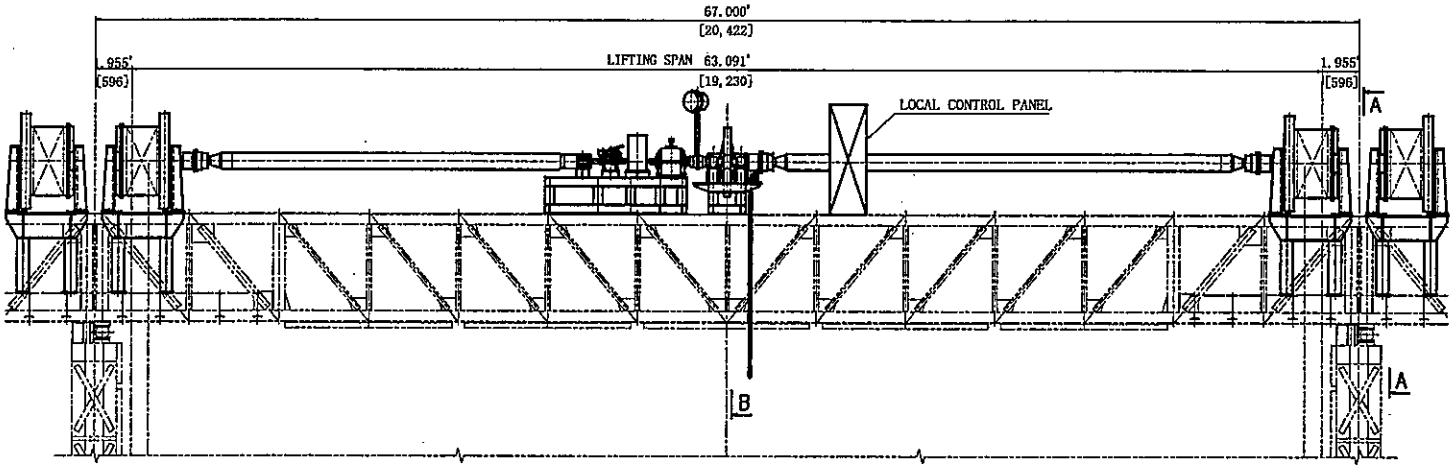
DWG-5 LAYOUT OF UNDER SLUICE GATE LEAF



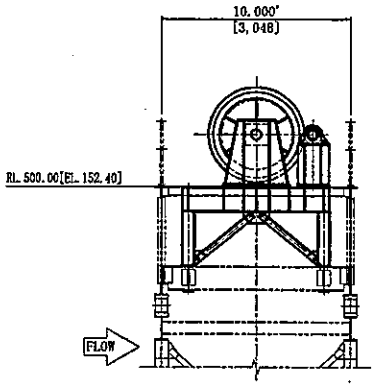
PLAN



SECTION B - B



ELEVATION

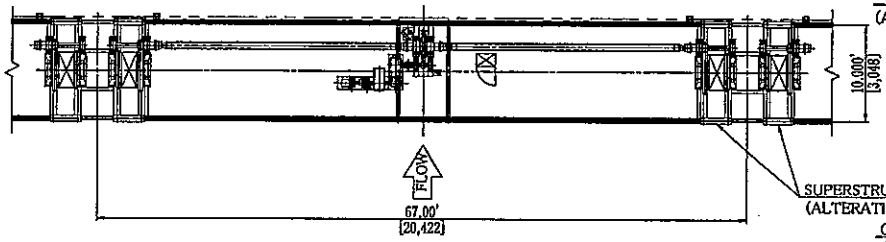


SECTION A - A

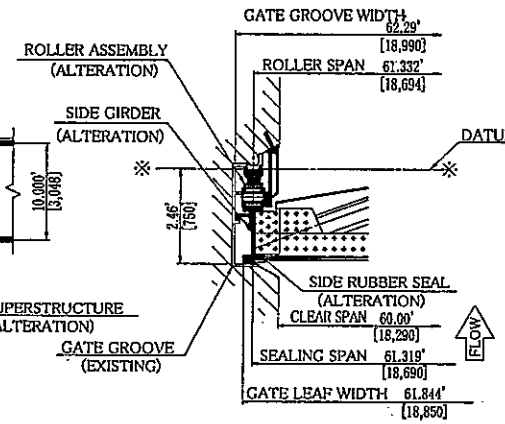
SCALE 0 2 4 6 8 10ft

NOTES :
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm)
2. RL VALUES ARE IN FEET (ft), AND EL VALUES ARE IN METERS (m)

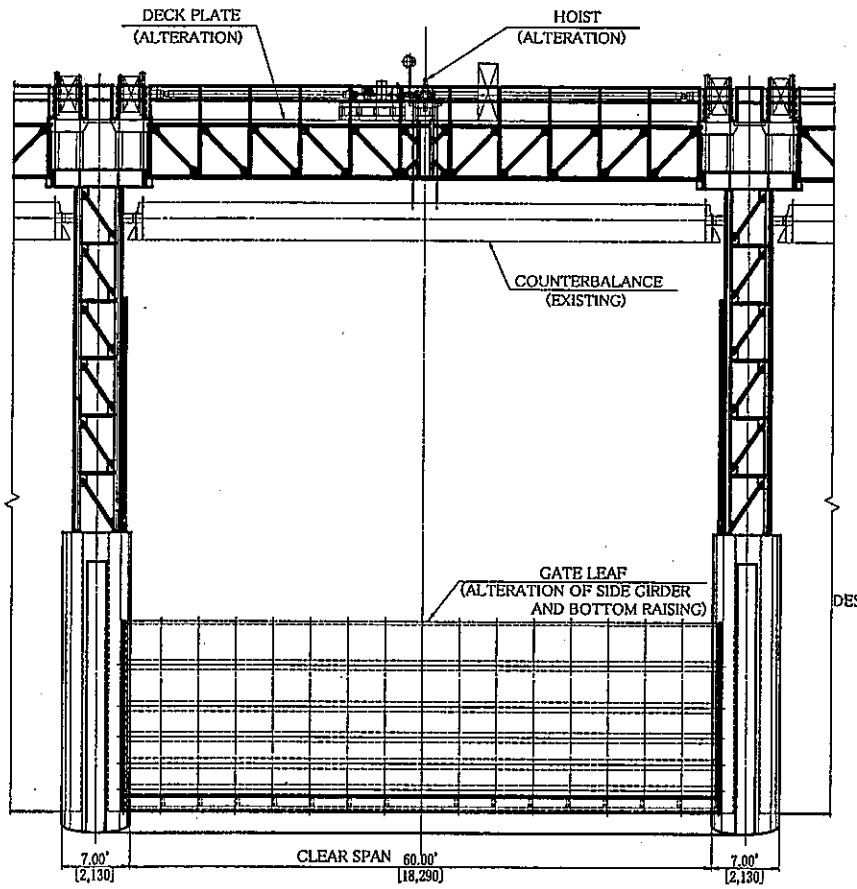
DWG-6 LAYOUT OF UNDER SLUICE GATE HOIST



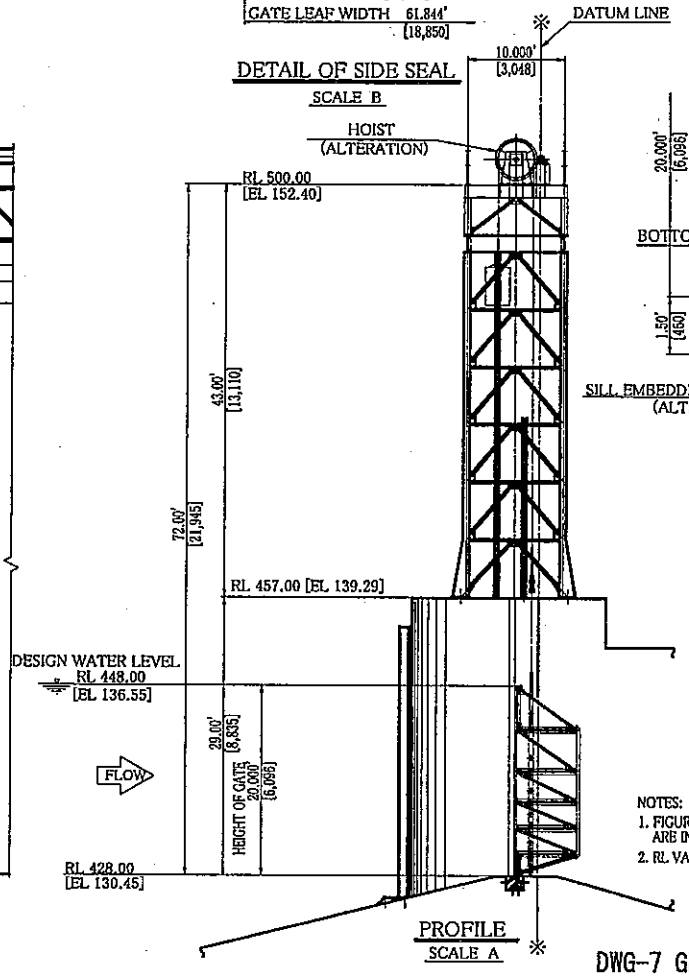
PLAN
SCALE A



DESIGN DATA		
TYPE OF GATE	TRUSSED TYPE ROLLER GATE	
QUANTITY	TWENTY TWO(22) SETS	
CLEAR SPAN	60.00ft [18.29m]	
HEIGHT OF GATE	20.00ft [6.10m]	
DESIGN WATER HEAD	UPSTREAM	20.00ft [6.10m]
	DOWNSTREAM	0.00ft [0.00m]
OPERATING WATER HEAD	UPSTREAM	20.00ft [6.10m]
	DOWNSTREAM	0.00ft [0.00m]
DESIGN SEDIMENTATION HEIGHT	3.00ft [0.91m]	
SILL ELEVATION	RL428.00ft [EL130.45m]	
SEALING SYSTEM	3 EDGES WITH RUBBER SEALS AT UPSTREAM	
OPERATING DEVICE	ELECTRICALLY DRIVEN, 1 MOTOR 2 DRUM TYPE	
CONTROL SYSTEM	LOCAL CONTROL	
HOISTING SPEED	1.0ft/min±10% [0.3m/min±10%]	
HOISTING HEIGHT	29.00ft [8.84m]	

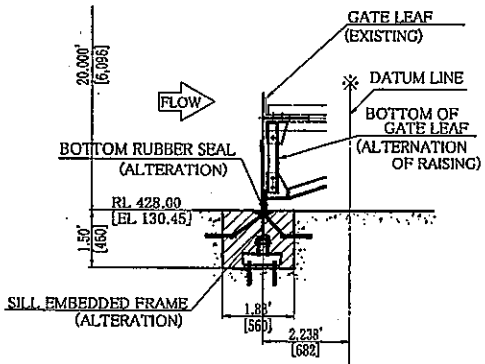


ELEVATION
SCALE A



DETAIL OF SIDE SEAL
SCALE B

PROFILE
SCALE A



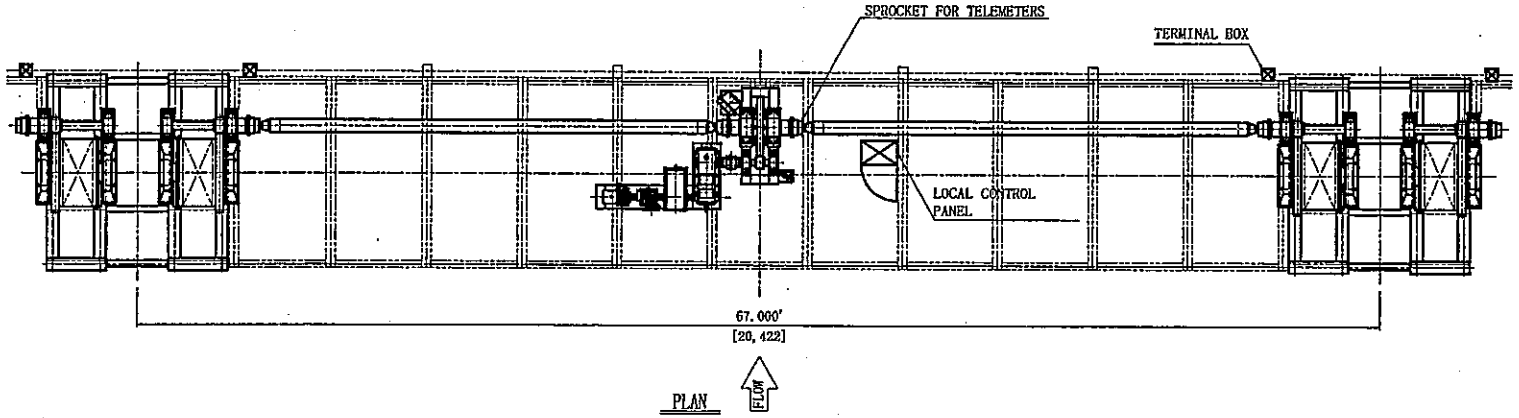
DETAIL OF BOTTOM SEAL
SCALE B

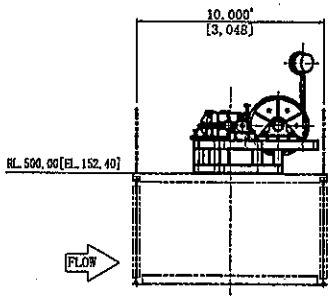
SCALE A 0 4 8 12 16 20ft

SCALE B 0 2 4 5ft

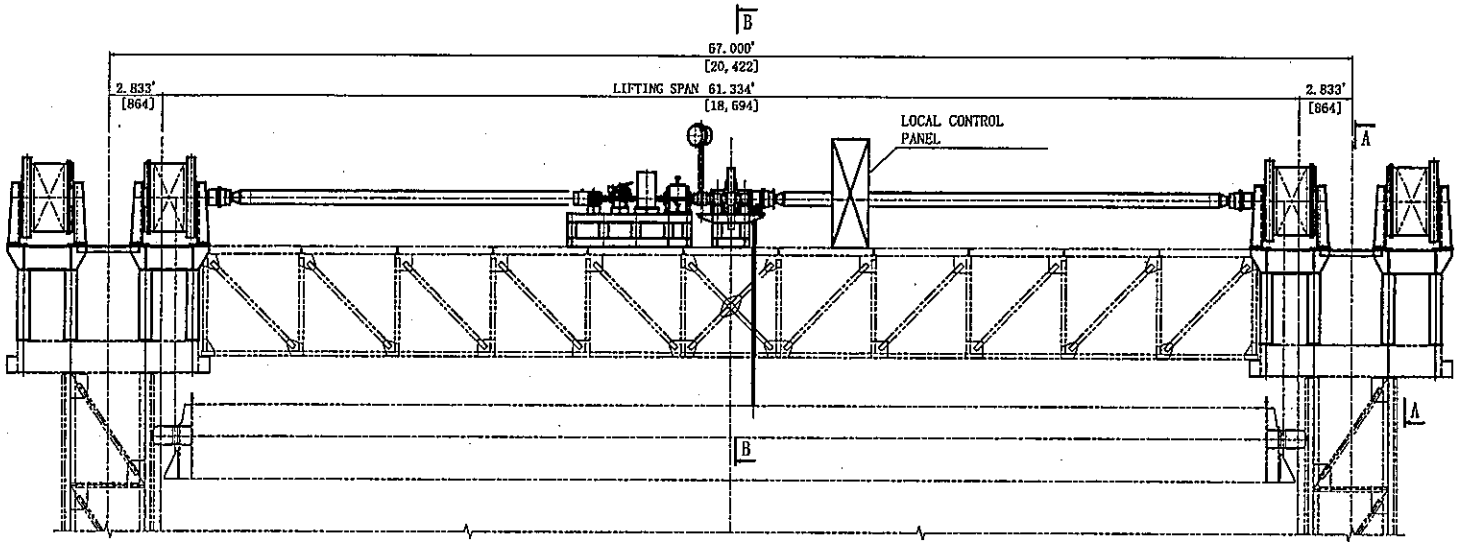
NOTES:
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm).
2. RL VALUES ARE IN FEET (ft), AND EL VALUES ARE IN METERS (m)

DWG-7 GENERAL LAYOUT OF WEIR GATE

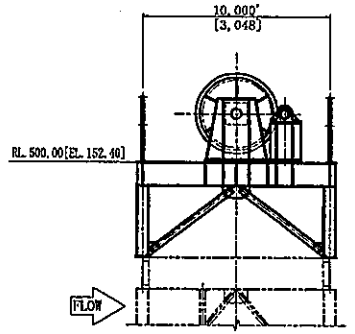




SECTION B - B



ELEVATION

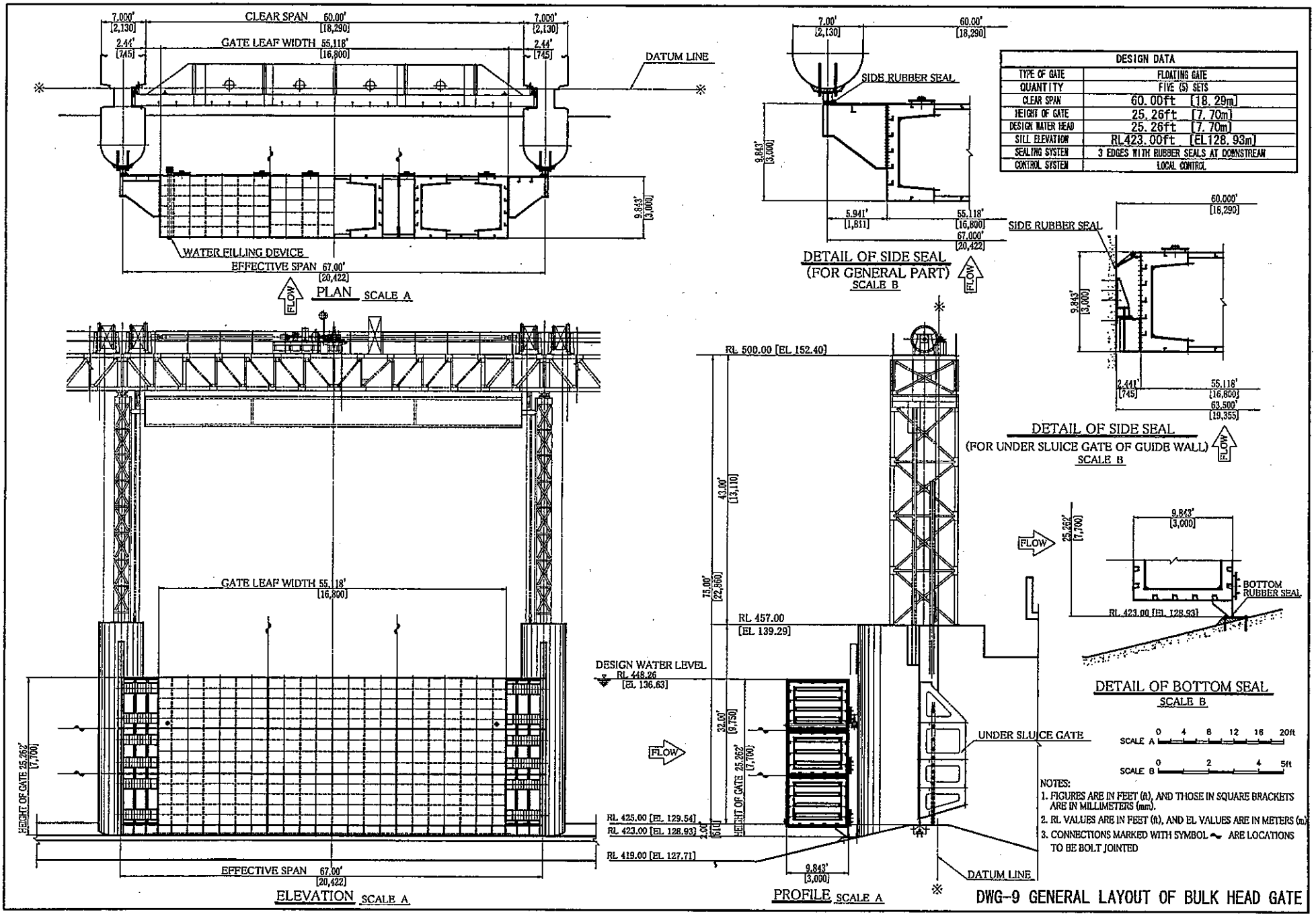


SECTION A - A

SCALE 0 2 4 6 8 10ft

NOTES :
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm)
2. RL VALUES ARE IN FEET (ft), AND EL VALUES ARE IN METERS (m)

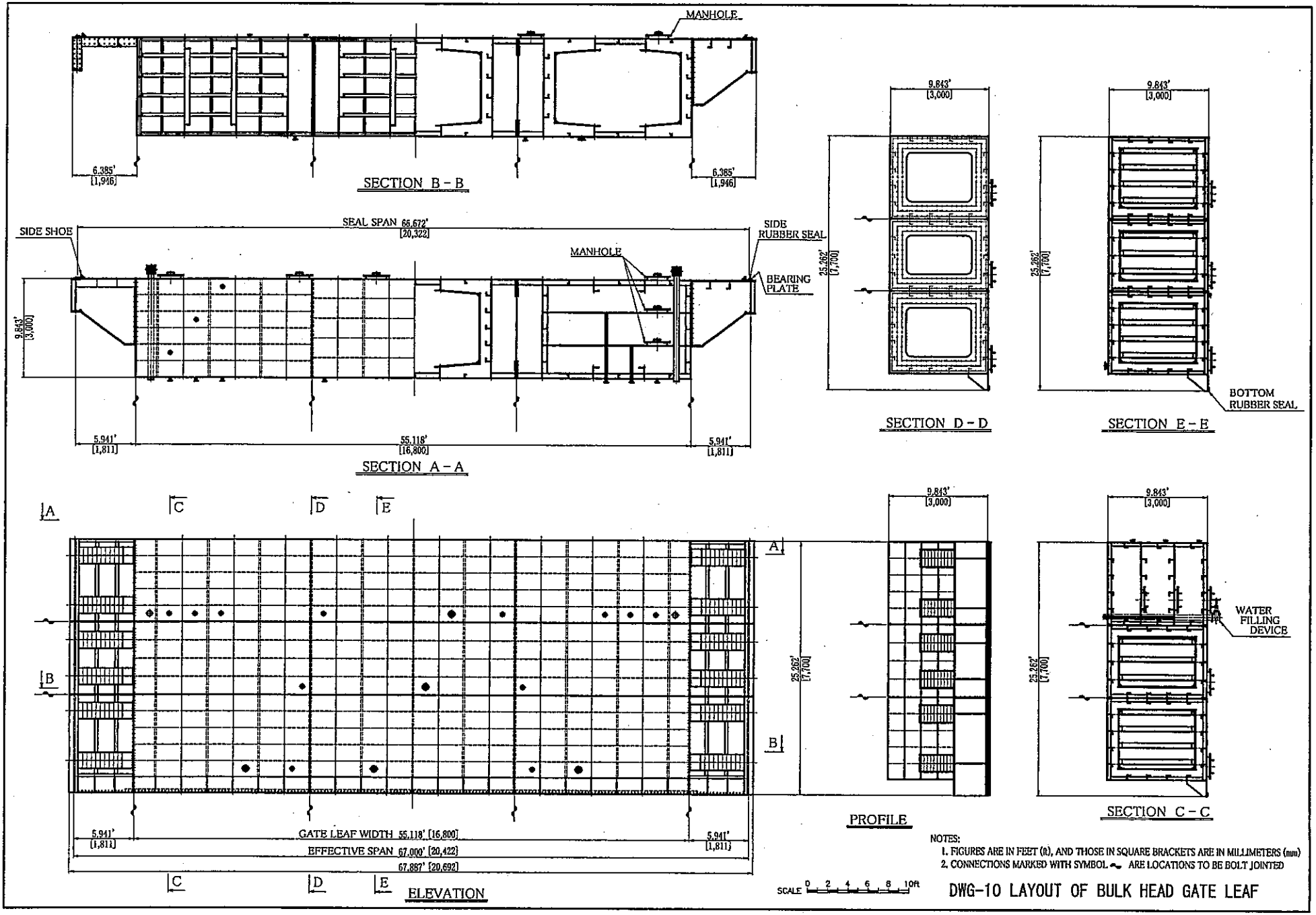
DWG-8 LAYOUT OF WEIR GATE HOIST

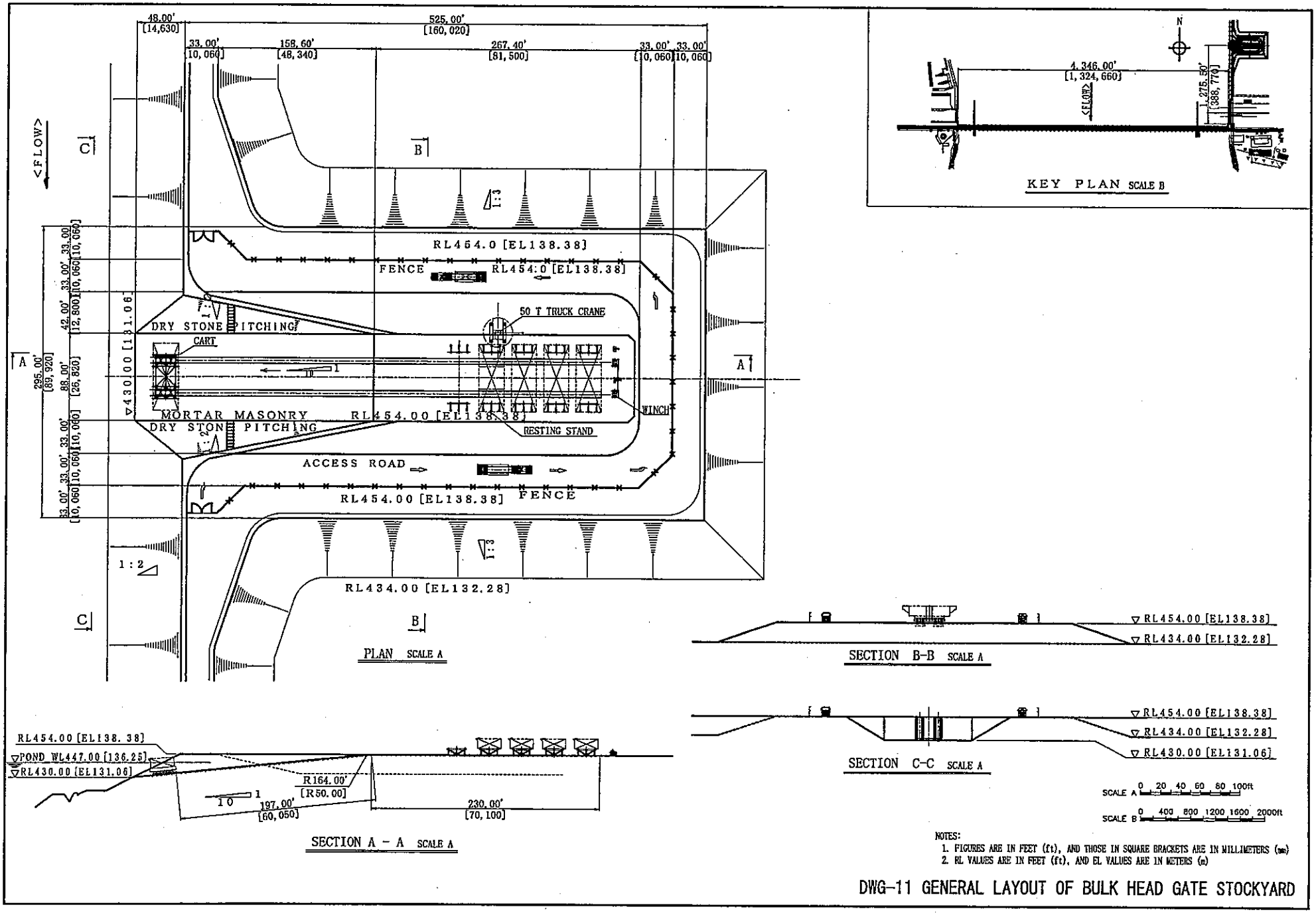


DESIGN DATA	
TYPE OF GATE	FLOATING GATE
QUANTITY	FIVE (5) SETS
CLEAR SPAN	60.00ft [18.29m]
HEIGHT OF GATE	25.26ft [7.70m]
DESIGN WATER HEAD	25.26ft [7.70m]
SILL ELEVATION	RL423.00ft [EL128.93m]
SEALING SYSTEM	3 EDGES WITH RUBBER SEALS AT DOWNSTREAM
CONTROL SYSTEM	LOCAL CONTROL

NOTES:
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm).
2. RL VALUES ARE IN FEET (ft), AND EL VALUES ARE IN METERS (m).
3. CONNECTIONS MARKED WITH SYMBOL ~ ARE LOCATIONS TO BE BOLT JOINTED

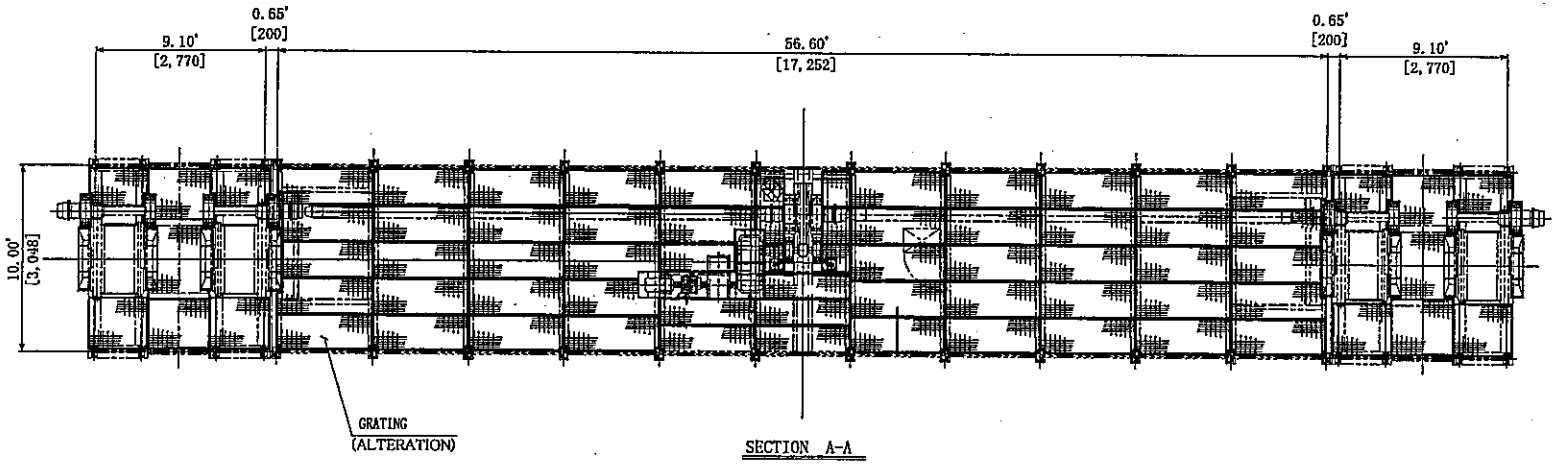
DWG-9 GENERAL LAYOUT OF BULK HEAD GATE


MANHOLE
6.385'
[1,946]
SECTION B - B
SEAL SPAN 66.672'
[20,322]
SIDE SHOE
SIDE RUBBER SEAL
MANHOLE
BEARING PLATE
9.843'
[3,000]
5.941'
[1,811]
55.118'
[16,800]
SECTION A - A
9.843'
[3,000]
25.262'
[7,700]
SECTION D - D
BOTTOM RUBBER SEAL
SECTION E - E
A
C
D
E
B
GATE LEAF WIDTH 55.118' [16,800]
EFFECTIVE SPAN 67.000' [20,422]
67.887' [20,692]
ELEVATION
PROFILE
WATER FILLING DEVICE
SECTION C - C
SCALE 0 2 4 6 8 10ft
NOTES:
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm)
2. CONNECTIONS MARKED WITH SYMBOL ~ ARE LOCATIONS TO BE BOLT JOINTED
DWG-10 LAYOUT OF BULK HEAD GATE LEAF

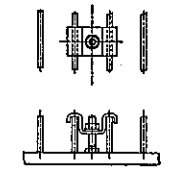


NOTES:
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm)
2. RL VALUES ARE IN FEET (ft), AND EL VALUES ARE IN METERS (m)

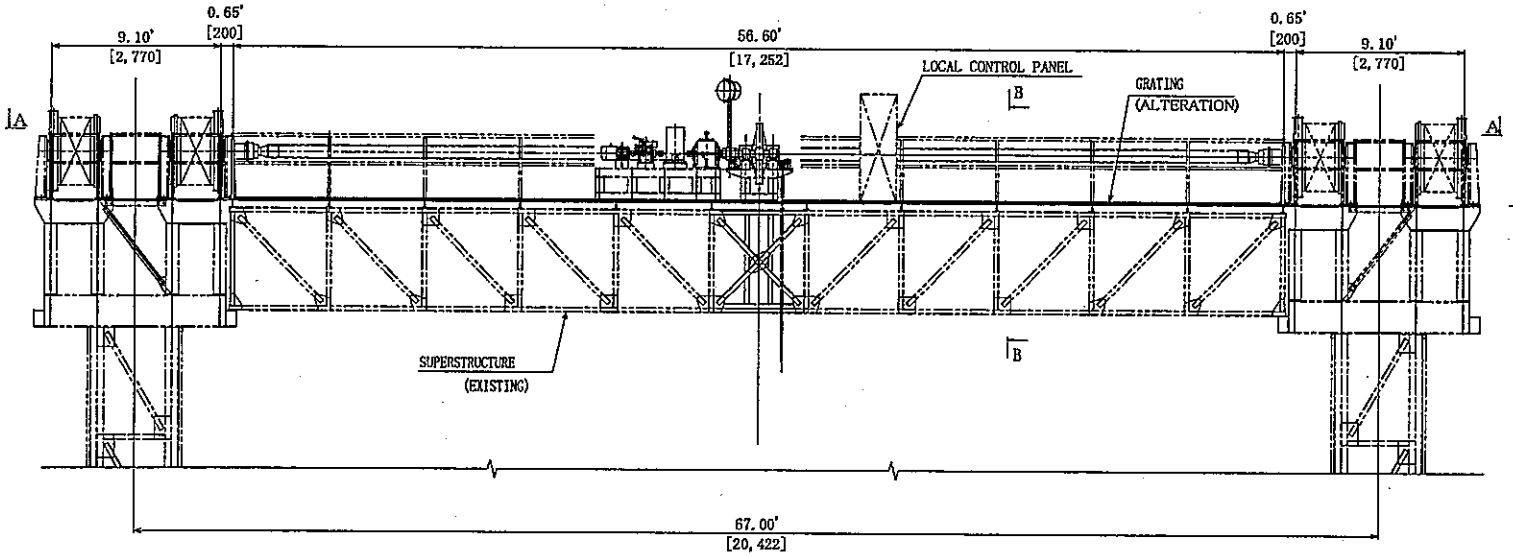
DWG-11 GENERAL LAYOUT OF BULK HEAD GATE STOCKYARD



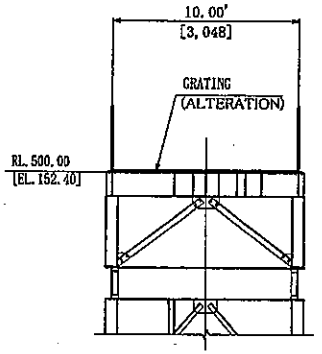
SECTION A-A



DETAIL OF GRATING



ELEVATION

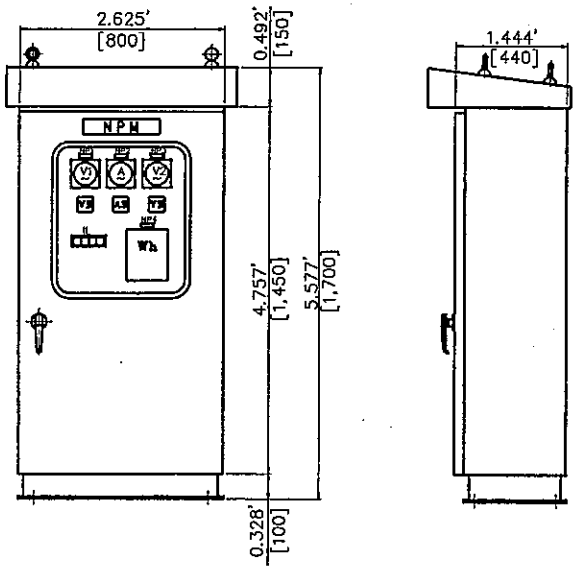


SECTION B-B

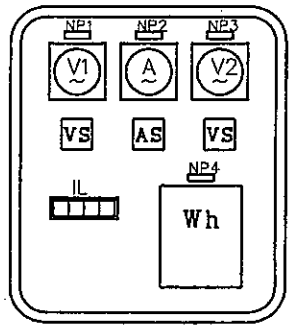
SCALE 0 2 4 6 8 10ft

NOTES:
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm)
2. RL VALUES ARE IN FEET (ft), AND EL VALUES ARE IN METERS (m)

DWG-12 LAYOUT OF DECK PLATE REHABILITATION



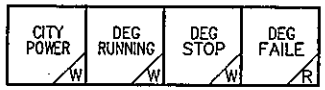
OUTLINE DRAWING



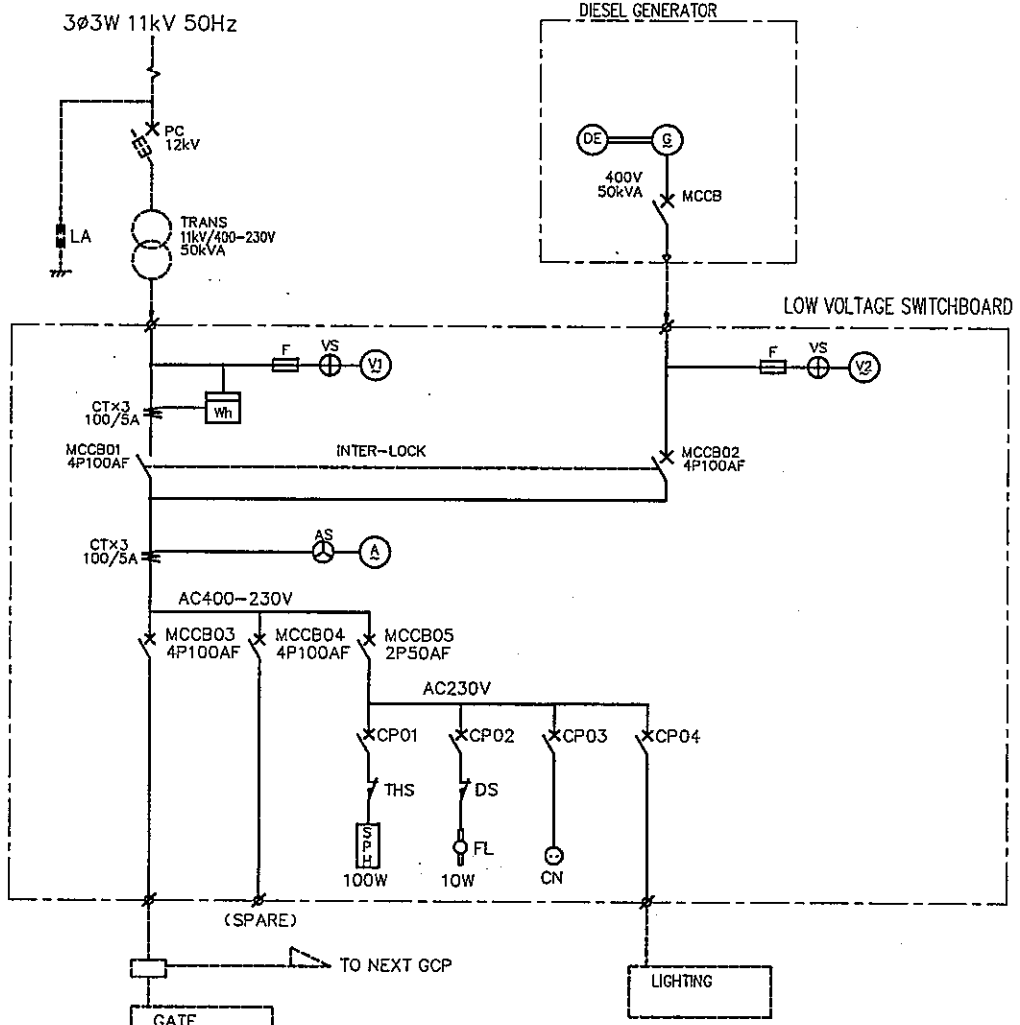
INDICATING INSTRUMENTS

SYMBOL	DEVICE NAME
NPM	LOW VOLTAGE SWITCH BOARD
NP1	SOURCE VOLTMETER1
NP2	AMMETER
NP3	SOURCE VOLTMETER2
NP4	WATT-HOUR METER
(AS)	AMMETER CHANGEOVER SWITCH
(VS)	VOLTMETER CHANGEOVER SWITCH

DEVICE NAME



INDICATING LAMPS

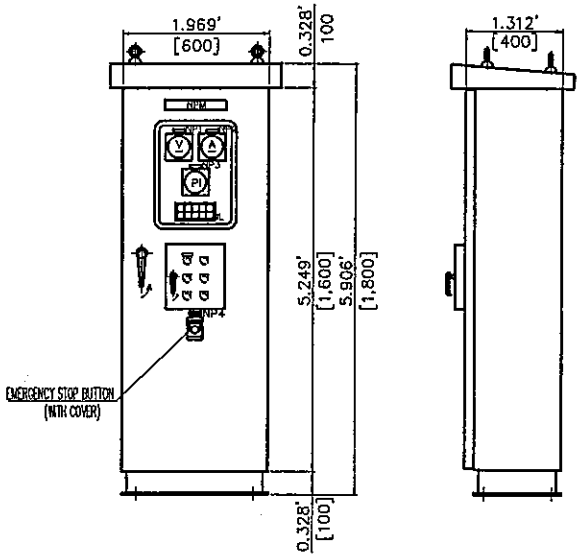


SINGLE LINE DIAGRAM

SCALE 0 2 4 5ft

NOTES:
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm)

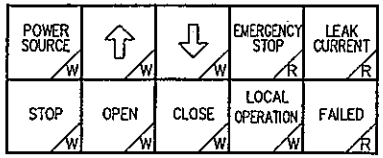
DWG-13 LOW VOLTAGE SWITCHBOARD OUTLINE AND SINGLE LINE DIAGRAM



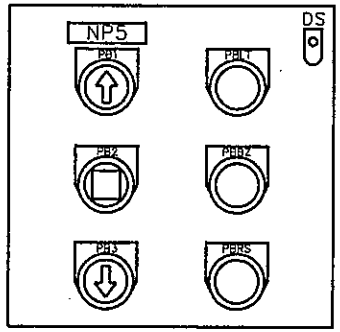
OUTLINE DRAWING

SYMBOL	DEVICE NAME
NPM	GATE CONTROL PANEL
NP1	VOLT METER
NP2	AMMETER
NP3	GATE POSITON INDICATOR
NP4	EMERGENCY STOP BUTTON
NP5	GATE OPERATION BUTTON
PB1	GATE OPEN BUTTON
PB2	STOP BUTTON
PB3	GATE CLOSE BUTTON
PBLT	LAMP TEST BUTTON
PBBZ	ALARM STOP BUTTON
PBRS	ALARM RESET BUTTON

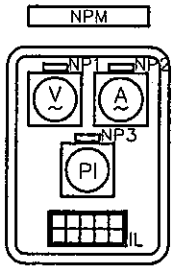
DEVICE NAME



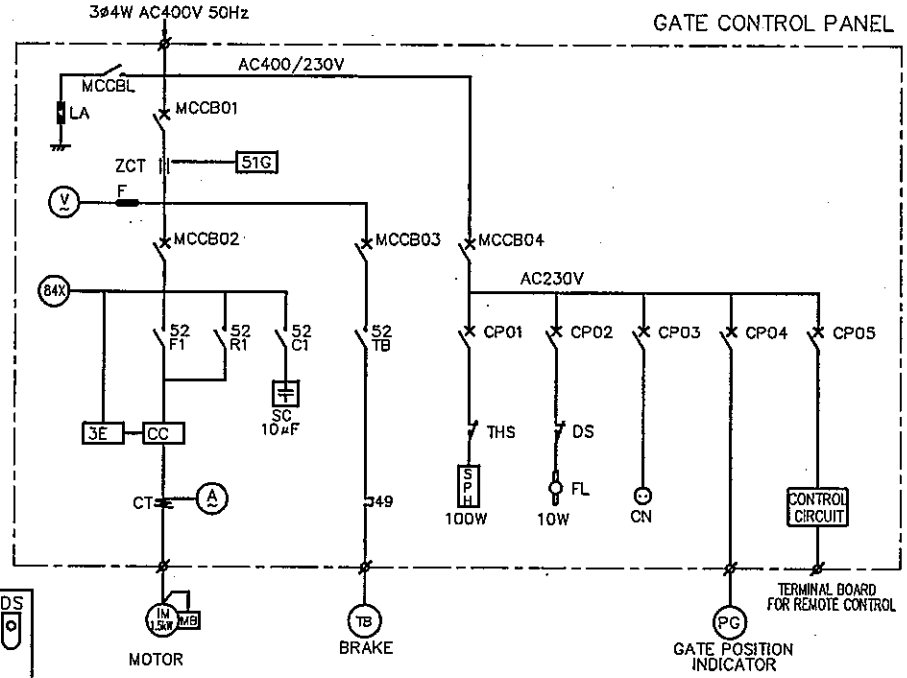
INDICATING LAMPS



PUSH BUTTON



INDICATING INSTRUMENTS



SINGLE LINE DIAGRAM (WEIR GATE)

SCALE 0 2 4 5ft

NOTES:
1. FIGURES ARE IN FEET (ft), AND THOSE IN SQUARE BRACKETS ARE IN MILLIMETERS (mm)
2. TERMINAL BOARD IS INSTALLED INSIDE THE LOCAL CONTROL PANEL FOR FUTURE USE OF REMOTE CONTROL.
   - THE INCOMING SIGNALS ARE "RISE","DOWN","STOP","EMERGENCY", ETC.
   - THE OUTPUT SIGNALS ARE "LOCALLY OPERATED","GATE POSITION","FAILED","RISING", "LOWERING","HALTED",ETC.

DWG-14 LOCAL CONTROL PANEL OUTLINE AND SINGLE LINE DIAGRAM

2-2-4 Implementation Plan

2-2-4-1 Implementation /Procurement Policy

The proposed item of works for the gate rehabilitation of Taunsa Barrage includes the following: 1) rehabilitation of weir gates, 2) replacement of under sluice gates, 3) rehabilitation and electrification of gate hoist, 4) rehabilitation of deck on superstructure, 5) installation of bulkhead gates, and 6) construction of stockyard for bulkhead gates. The item of works proposed to be rehabilitated will be carried out under the Japan's Grant Aid Scheme. The implementation agency from the government of Pakistan is the Irrigation and Power Department (IPD).

(1) Notices in Construction

① River Flow Control and Discharge Management under Construction

The number of gates to be rehabilitated is as follows:

1) Weir gate; 22 out of existing 53 numbers.
2) Under sluice gate; 7 out of existing 11 numbers.

During gate rehabilitation works, the control of both flows of Indus River and of downstream at Taunsa Barrage shall be done by using the remaining existing weir gates.

② Cofferdam Construction

Upstream of the Taunsa Barrage

The cofferdam of the upstream part that will block the river flow will be undertaken by using the bulkhead gates that will be procured in this Project. To ensure the function of water seal and stability of bulkhead gate, careful planning and supervision will be required.

Downstream of Taunsa Barrage

The cofferdam at the downstream will be established by putting large size sandbags on the existing inclined apron. To avoid causing damages to the apron and to secure stability of the large size sandbags installed, careful planning and supervision will be required.

③ Measures for Existing Public Facilities

The Taunsa Barrage is equipped with several facilities such as railway, road bridge, electricity, pipelines for domestic water and gas, and communication facilities. These facilities will still be operated even during construction of the Project. Therefore, the construction / rehabilitation works will require the advance approval of agencies concerned.

④ Environment control measure

During construction, measures to minimize environmental impact such as water pollution and others

are required to be taken into consideration.

⑤ Temporary Yard

IPD will be responsible to secure necessary permissions and approval for the use of temporary yard for construction/rehabilitation works before commencement of the Project. Therefore, the permissions concerning land use for temporary yard shall be secured in advance according to the drawings of the basic design.

(2) Application of Local Steel Structure Manufacture

There are local manufacturers/plants within the area with sufficient experience in steel works. Hence, the gate that will be required for the Project such as bulkhead gate, under sluice gate, weir gate and etc., will be locally manufactured.

(3) Local Contractor's Participation

Local contractors will also be tapped to participate in the construction works of the Project in terms of undertaking inland transportation, supplying construction equipment, undertaking earth works, steel structure construction, and supplying the construction material and labor.

(4) Dispatch Plan of Japanese Technician

In Pakistan, there are only very limited number of local people with experience in the installation of gate works. Under the Project, technical experts from Japan will be dispatched to provide necessary training and on-the-job experiences to the local staff/ laborers in the installation and operation of the gates that will be provided. Initially, there will be a larger number of technicians from Japan that will be dispatched to provide support, assistance and training to local staff/labor. Eventually, as the work progresses and is completed, the number of technicians will be decreased, accordingly.

Table 2-2-4.1 Scope of Work for Technicians to be Dispatched

Job classification	Number of Technician to be dispatched	Period	Scope of works
Civil Engineer	1	10 M/M	1) Take charge of installation of sheet pile and H-beam of temporary jetty
Technician for installation of gate equipment	1～8	96.5 M/M	1) Assembly of bulkhead gate and installation of guide frames 2) Installation of under sluice gates 3) Rehabilitation of weir gates 4) Installation of gate hoist
Technician for installation of electrical equipment	1～2	14 M/M	1) Installation of power receiving and transformer facilities (Including standby generator facilities) 2) Installation of electric gate hoist for under sluice gates and weir gates
Gate operation instructor	1	5.5 M/M	1) Confirmation of function and operating instruction for gate facilities

2-2-4-2 Conditions on Implementation/Procurement

(1) Construction Period and Actual Working Days

Since the gate rehabilitation will be made using bulkhead gate, the construction period of the work will be limited to the dry season, which is eight (8) months from middle of September to middle of May. Since rainfall is usually minimal during this period, there is no need to consider idle days due to rainfall.

Sundays and Friday afternoons are usually considered holidays in Pakistan. Since work schedule for the maintenance works of the barrage is concentrated in January (annual closure period), the construction and rehabilitation works of the project should be done continuously even during the above-mentioned holidays. It is also noteworthy to consider in the work plan that labor capability decreases around November, which is the period of Ramadan.

(2) Water Level Rising of Downstream in the Indus River by the Subsidiary Weir

The river water level at the downstream of the Barrage is expected to rise due to the subsidiary weir, which is to be constructed at downstream area of the barrage by Pakistan side. Since the construction of the subsidiary weir will be set by river diversion method which closes half of the river width, degree of the river water level is supposed to be relatively high during construction period of the subsidiary weir. When the Indus River discharge increases during the period, the water level of river downstream should be carefully watched.

(3) Utilization of Installation Section of the Local Mill Manufacturer and Welder

Welders and installation workers who will be engaged in the gate rehabilitation work have to pass required qualification criteria of JIS or AWS to be technically eligible. In view of this, it is planned to tap the expertise of local mill manufactures and/or technicians in the production and installation work of gates, plant facilities and so on.

(4) Utilization of Local Steel Materials Available in Pakistan

Considering the manufacturing period for steel structure, local-made steel material available should be used as much as possible. However, local materials that will be used should meet ASTM, BS, and JIS etc. Standards. Furthermore, to control quality of manufactured gates using mill sheets and/or materials, necessary inspection as needed will have to be undertaken.

2-2-4-3 Undertaking in Implementation and Procurement

(1) Land Acquisition and Land Rental

The Government of Pakistan will be responsible for preparing the land for temporary works. The temporary yard (1,500m^2) for keeping construction materials is proposed to be located at the right bank at the upstream of the Taunsa Barrage. The proposed offices, lodgings and laboratory, etc. (2,700m^2) is planned to be constructed along the left bank of the TP Link Canal that is placed at the upstream of the

Taunsa Barrage. Both lands mentioned above belong to the Government, hence, it will not be necessary to compensate for the land that will be used during construction and rehabilitation works.

Based on Guideline of the Japanese Grant Aid Scheme, cost of land and land leveling are considered counterpart contribution to be provided by the Government of Pakistan. Backfilling and restoration works are to be provided under the Government of Japan assistance.

(2) Undertaking of Electric Power Receiving Facilities

Power from the existing 11KV high voltage power line running near the Taunsa Barrage will be tapped for the Project. This existing power line is drawn into the site of Taunsa Barrage O&M office. In the site of the management office, the power receiving facility is planned to be obtained from the existing 11KV high voltage power line through the connecting line (L=50m), which will be newly drawn by diverting from the existing line. The electricity will be transmitted from the power receiving facility to the barrage through the low voltage power cable.

Undertaking of Electric Power Receiving Facilities

The connecting line which will be newly established from the existing 11KV high voltage power line to the site of the Barrage O&M office.	To be undertaken under Japan's Grant Aid
The power receiving facility to be constructed near the Barrage O&M office and the low voltage power cable to be connected from the power receiving facility to the Barrage	To be undertaken under Japan's Grant Aid

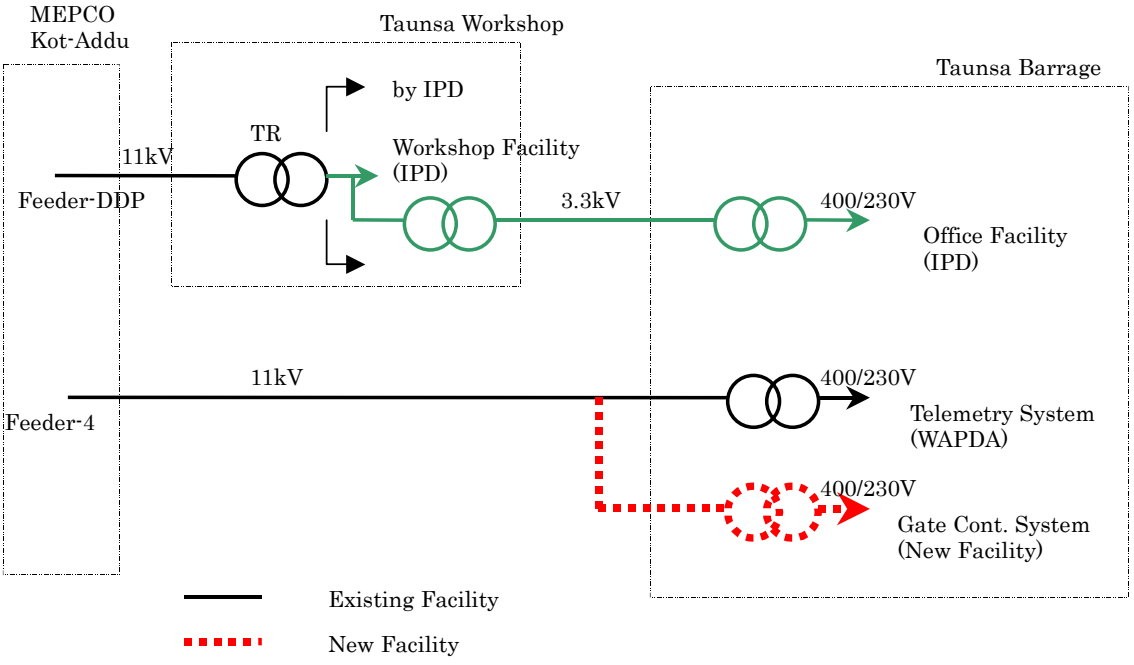


Figure 2-2-4.1 General Power Supply Diagram

2-2-4-4 Consultant Supervision and Procurement Supervision Plan

(1) Contractor's Supervision plan

This plan consists of the procurement of the shop fabrication of the gate leaves and the guide frames for the large gates, the rehabilitation work of the removal/installation and the repair, along with the corresponding civil work.. Rehabilitation works of the large gates will require experienced mechanical and electrical engineers, as it will need careful safe management and progress/quality control. Civil works will require civil engineers, with sufficient construction skill of this kind and construction experience in Pakistan, because local material will be used for nearly all material, and they can employ local subcontractors or local laborers to implement the construction.

The construction works for the proposed projects will require chief engineers that can lead and take actions and quick decision at the site, as needed. The work will require strict control and supervision of work progress because each repair work has to be finished within four (4) months between the annual closure period and the flood season, and adjustment of the rehabilitation work of main body of the Barrage, which is carried out by the Government of Punjab province.

The proposed dispatch of Japanese engineers/experts is planned based on the above mentioned consideration (refer to Table 2-2-2.2).

Table 2-2-4.2 Residential Specialists Engineers Assignment Plan

Post	Grade	Period	Scope of works
Manager	2	39 Months	Overall management of the whole construction works; safety and security control; coordination, deliberation and adjustment with a client;, and adjustment and negotiation with the provincial Government for the repair work of the Barrage
Chief Engineer	2	37 Months	Overall construction plan of the repair work of the Barrage by the provincial Government; Construction supervision and progress control/adjustment
Civil Engineer	3	32 Months	Construction plan and supervision, quality and safety control of the whole civil works
Civil Engineer	3	14 Months	Quality and progress control when construction plan of incline works and temporary works are executed at the same time
Mechanical Engineer A	3	38 Months	Construction plan of mechanical works, and quality and construction supervision for gates works
Mechanical Engineer B	3	15 Months	Quality and construction supervision for gates works when two works are executed at the same time
Electrical Engineer	3	12 Months	Construction plan of electrical works, and quality and construction supervision
Quality Control Engineer	3	8 Months	Confirmation of function of the gate, and instruction and guidance of gate operation
Clerical Manager	4	39 Months	Custom clearance and transport of equipment and materials, labor management and public relations

(2) Liaison and Communication Management

It is planned to establish a liaison office in Lahore city for shop fabrication, procurement and

transportation arrangement of equipment and materials from Lahore, and maintaining communication link with the client.

(3) Safety Control Management

The Japanese Government does not consider the project site area in Punjab province as security risks as compared with other areas in Pakistan. No cases of terrorism targeting foreigners have recently been reported and troops, which were deployed near the border between India and Pakistan, have already withdrawn. Therefore, the area has no security problem so far.

(4) Detail Design and Supervision Management by Consultants

For the detailed design and preparation of tender documents, it is proposed to assign the following Japanese staffs as shown in Table 3-2-4-4.2.

Table 2-2-4. 3 Detailed Design Staff Plan

Post	Grade	Duties
Manager (Chief Engineer)	2	Compilation of design outputs and finalization of design and tender documents
Design Engineer for Hydraulic structures/Civil	3	Site investigation and design of civil (design drawings)
Design Engineer for Steel structures (A)	3	Site investigation and design of steel structures, determination of gates specification (under sluice gates and weir gates), Examination of Equipment & installation specifications
Design Engineer for Steel structures (B)	3	Design of steel structures (Hoisting devices and decks works of superstructure), Examination of Equipment & installation specifications
Design Engineer for Steel structures (C)	3	Determination of gates specification, structure design calculation, design drawings and quantities calculation for bulkhead gates
Design Engineer for Steel structures (D)	4	Structure design calculation, design drawings and quantities calculation for under sluice gates and weir gates
Design Engineer for Steel structures (E)	4	Structure design calculation, design drawings and quantities calculation for operating facilities and decks of upper works
Electrical Equipment Engineer (A)	3	Determination of electrical equipment specification, calculations, design drawings and quantities calculation
Electrical Equipment Engineer (B)	4	Compilation of detailed design of electrical equipment and preparation of specification
Cost estimate and procurement specialist	3	Cost estimation based on detailed design and review of cost estimate made at the time of basic design
Specification specialist on Civil Works	3	Preparation of Specifications of civil works in accordance with the results of the detailed design
Specification specialist on gate manufacturing (A)	3	Preparation of Specifications of gate manufacturing in accordance with the results of the detailed design
Specification specialist on gate manufacturing (B)	3	Preparation of Specifications of gate manufacturing in accordance with the results of the detailed design
Tender document specialist	3	Compilation of all detailed design outputs and preparation of tender documents
Drawing expert	6	Preparation of detailed design drawings
Assistant engineer	6	Assist quantities calculation and cost estimation

This project is mainly planned to repair steel structures, replace existing under sluice gates, change side girder of weir gates, repair guide frames, replace gate hoists, and so on. Resident supervisor that will be assigned by the consultants shall be one with adequate knowledge and experience on steel structures such as a gate.

Details of construction supervision works for the gate to be executed by the consultants including works in Japan and in Pakistan are shown in Table 2-2-4. 4.

Table 2-2-4. 4 Construction Supervision Works for the Gate

Work site	Contents
In Japan	Drawing approval, inspection of shop fabrication, inspection of packing and confirmation of documents on export.
In Pakistan	Drawing approval, inspection of shop fabrication, inspection of packing, issuance of work progress certificates, inspection on completion and issuance of completion certificates.

For the construction supervision by the Consultants, the following staffs from Consultants are proposed as shown in Table 2-2-4.5.

Table 2-2-4. 5 Staffs for Construction Supervision

Post	Grade	Duties
Manager (Chief engineer)	2	Pre-qualification in tender process and technical evaluation of tender
Resident supervisor	3	Inspection at site and advice on coordination, schedule, quality and safety for all over works of shop fabrication civil, mechanical and electrical equipment works. Drawing approval and design change approval for civil, mechanical and electrical equipment works, and advice on maintenance and operation.
Electrical design engineer (by spot)	3	Staggered assignment as required and necessary during construction works for advice and guidance. Approval of drawings for electrical works.
Mechanical design engineer (by spot)	3	Staggered assignment as required during construction for advice and guidance. Approval of drawings for mechanical works.
Inspector (in Japan)	3	Inspection in Japan for domestic fabrication

For the supervision of procurement such as bulkhead gate, truck crane, tugboat, work boat, which will be tendered as equipment supply project separately, staffs from Consultants are proposed as shown in Table 2-2-4.6.

Table 2-2-4.6 Staffs for Supervision of Equipment Procurement

Post	Grade	Duties
Manager (Chief engineer)	2	Pre-qualification in tender process and technical evaluation of tender
Tender document Expert	3	Compilation of tender document for equipment supply project
Inspector (In Pakistan)	3	Inspection in Pakistan for equipment supply project
Inspector (in Japan)	3	Inspection in Japan for equipment supply project

2-2-4-5 Quality Control Management

Quality control for the works is planned as shown in Table 2-2-4.7.

Table 2-2-4. 7 Quality Control Plan (Construction)

Works	Items to be controlled	Method	Frequency
Excavation bed	Soil condition Width/height	Visual Measurement of dimension/height	For major parts For major parts
Embankment	Compaction degree	In-site density test	Every 400m^2
Concrete	Aggregate Cement Fresh concrete Concrete strength	Grain-size analysis test Physical test/Chemical test Slump/Air content/Chloride Compressive strength test	Every 3,000m^3 Every 1,000ton Every placement Every 200m^3
Reinforcement bar	Strength Assembling condition	Tensile strength test Rebar assembling inspection	Every 200ton Every part
Structure as built	As built dimension	Measuring dimension	For major parts
Mechanical equipment	Installation accuracy Function	Installed position measurement Loaded operation test	For all equipment For all equipment on operation test

Table 2-2-4. 8 Quality Control Plan (Fabrication)

Items to be controlled	Method	Inspection equipment	Inspection site
Confirmation of material and equipment parts	Collation of mill sheet Inspection report of parts maker Material test		Fabricating Factory
Confirmation of welding	Visual inspection Non-destructive inspection	X ray camera	Factory and on-site
Confirmation of dimension	Measuring major dimension	Steel tape, Scale	Factory and on-site
Confirmation of temporary assembly	Visual inspection Measuring major dimension	Steel tape, Scale, Level, Transit	Factory
Confirmation of painting	Measuring coating thickness and photograph	Coating thickness gauge	Factory and on-site
Confirmation of Installed position	Installed position measurement	Steel tape, Level, Transit	On-site
Confirmation of functions	Measuring of speed, electric current/voltage, temperature rising at driving part through test runs Confirmation of water-stops	Ammeter, Voltmeter, Stopwatch, Thermometer	Factory (hoists) and on-site

2-2-4-6 Procurement Plan

(1) General-Purpose Construction Materials

Cement, reinforcement bar, timber, general-purpose building material, electric cable, piping material etc are available in Pakistan. Majority of construction materials are planned to be procured in Lahore city. Course and fine aggregate for concrete and crushed stone for masonry are planned to be procured in D. G. khan.

(2) Pontoon

Pontoon unit float type will be used for repair work of under sluice gates, which is possible to be assembled and disassembled over a short period of time. It is planned to procure this equipment in Japan because it is hard to procure it in Pakistan and neighboring nations.

(3) Gates, Operation Facilities, Electrical Equipment

① Weir Gates, Under Sluice Gates

Weir gates and Under Sluice gates is planned to be procured dispersedly including Pakistan and third country to assure quality and process. In addition, steel material as well as particular parts needed for gate manufacturing will be procured in Japan.

② Gate Hoist

Gate hoist is planned to be procured in Japan. Pakistan has only experience in the manufacturing of manual gate hoist but have no experience in dealing with electrical gate hoist. Hence, it will be difficult to manufacture gate hoist conforming to "Technical Standards for Gate and Penstocks of Japan" in Pakistan.

③ Electrical Equipment

Power receiving and transforming facilities are planned to be procured in Pakistan as there are several firms / companies in Pakistan dealing with the required electrical facilities. Also, considering future maintenance, it would be more practical to procure in Pakistan. On the other hand, local control panel of gate hoist are planned to be procured in Japan because it will require special specification for tropical condition and there is none available in the country

(4) Materials

① Bulkhead Gate

The bulkhead gates are planned to be manufactured at the factories in Pakistan, third world country and Japan to secure quality and schedule. Steel material and the parts needed for gate manufacturing will be procured in Japan.

② Track Crane (50 ton)

The truck crane (50 ton) is planned to be procured in Japan.

③ Tug boat (150 ps), Boat (Work Boat)

Tugboats (150 ps) and work boats are planned to be procured in Japan, as there are many shipbuilding companies in Japan that can design, procure the materials and build the boats within the required short period of time. Though there is one (1) state owned company building steel ships in Karachi, the main work of the company is just manufacturing based on required design. However, design and procurement

of materials are being done by their clients.

2-2-4-7 Implementation Schedule

In the implementation schedule, it is planned that:

1) Detailed design and preparation of tender documents will require 5.5 months
2) Tendering and selection of contractor for rehabilitation main works will require 3.5 months

It is proposed to conduct tender and selection of contractor for procurement of Bulkhead gates, Truck Crane, Tug Boat and Work Boat as soon as possible, taking into account the tight schedule until commencement of the main works which is planned to use the Bulkhead Gate. The repair works of gates are planned to commence from February 2007 because the guide frames for bulkhead gates is indispensable for the implementation of the gates repair that are to be installed during the annual closure period.

It is necessary to provide all five (5) gates by the time construction starts on February 2007, due to Bulkhead gates being assembled 9-separated pieces into one (1) component at the site. Considering the assembly days required for a gate, start of assembly for the first gate will be by October 2006. Therefore, it is planned that the period for procurement of Bulkhead gate shall be 11.5 months for the first gate from Contract to Procurement to the site, and 14.5 months for last gate (No.5 gate). Other equipment to be fabricated at the factory will not affect the overall schedule since there is sufficient time for procurement.

On the other hand, the schedule of the gate rehabilitation works is very tight. It will be carried out using the procured five (5) bulkhead gates to the maximum use, and should be undertaken between the annual closure period and the flood season of 3.5 months (one construction period). The rehabilitation works include 22 weir gates and seven (7) under sluice gates, a total of 29 gates and it is expected to commence from February 2007 to December 2008 (four (4) construction phases).

The gates that will be repaired in each construction period are planned as shown in Table 2-2-4.9. The clearance and others will require about 2.5 months. Therefore the total construction period is 41 months from the Contract to the Completion, including fabrication, construction and site clearing.

Table 2-2-4. 9 Schedule of Gates Repair Works

Phasing	Duration	Target Gates to Repair		
		Number of Gates	No. of Weir Gates	No. of Under Sluice Gates
1st Construction Period	February - May, 2007	8	10,12,14,16,18,20,24,26	—
2nd Construction Period	September - December, 2007	8	11,13,15,17,19,23,25,27	—
3rd Construction Period	February - May, 2008	7	31,33,35,38	2,4,6
4th Construction Period	September - December, 2008	6	55,58	1,3,5,7

The detailed design and the tendering period are 9 months, while the rehabilitation works is 41 months, a total of 50 months. Implementation schedule is shown in Figure 2-2-4.2.

(Detail Design)

Lapsed Months	1	2	3	4	5	6	7	8	9	10	11	12
Cabinet Approval	EN											
	▼▼ (Agreement on Detail Design)											
Detail Design	(Detail Design / Preparation of Tender Document)											
	(Approval of Tender Document)											
	(Total **5.5** months)											

Figure 2-2-4. 2 Implementation Schedule

(Implementation)

Lapsed Months	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Cabinet Approval		EN																																															
	▼▼ (Agreement on Supervision on Implementation)																																															
Supervision on Implementation	(PQ / Tender / Evaluation of Tender / Contract)																	(Supervision of Procurement / Supervision of Constructior)																																		
	(Total **44.5** months)																																															
Construction / Procurement	Contract																																															
	▼ (Preparation Work)																											(Installation of Tentative Jetty)																					
	BulkHead Gate: (Construction of Stockyard) (Assembly)																																														
	Bulk Head Gate: (Procurement of Materials / Manufacturing / Transportation)																																														
	Gate Hoist (Procurement of Materials / Manufacturing / Transportation)																																														
	Side girder & and Guide Frame of Weir Gate: (Procurement of Materials / Manufacturing / Transportatior)																																														
	Gate Leaf of Under Sluice Gate: (Procurement of Materials / Manufacturing) (Transportation) (Transportation)																																														
	Electricity Supply Facilities: (Construction)																																														
	Guide Frame for Bulk Head Gate / Sill Beam for Weir Gate / Sill Beam for Under Sluice Gate: (Installation)																																														
	Weir Gate: (Repair Work) (Repair Work) (Repair Work) (Repair Work)																																														
	Under Sluice Gate: (Repair Work) (Repair Work)																																														
	Deck of Superstructure: (Repair Work) (Repair Work) (Repair Work)																																														
	(Clean-Up, Handover)																																														
	(Total **41.0** months)																																														

2-3 Obligations of Recipient Country

In order to secure smooth implementation and maintenance, outline of the measures to be undertaken by the government of Pakistan during preparation, procurement of equipment, construction and operation and maintenance is as follows.

2-3-1 General Obligations

1) To secure land necessary for the Project prior to commencement of the installation of the materials and equipment,
2) To provide facilities of electricity and others needed for the Project in and around the sites,
3) To bear the necessary commission to the bank based on the Bank Arrangement,
4) To ensure prompt execution of customs clearance of the materials and equipment for the Project,
5) To exempt Japanese nationals from customs duties, internal taxes, and other fiscal levies which are imposed in Pakistan with respect to the supply of materials, equipment and services or to bear the same,
6) To accord Japanese nationals who offer services for the Project to facilitate their entry into Pakistan and stay therein for the performance of their works,
7) To operate and maintain the facilities and equipment provided under the Grant Aid properly and effectively, To inform the condition of the operation and maintenance of the facilities and equipment as Japanese side request,
8) To bear all the expenses other than those to be borne by the Grant Aid, necessary for the implementation of the Project.

2-3-2 Obligations Prior to and during the Implementation of the Project

1) To complete the embankment works (about 100 thousand m^3) of the stockyards for the bulkhead gates before the beginning of the Project (October 2005),
2) To relocate the telemeter board (DAU) to appropriate place on the deck on responsibility of Pakistan side after discussion with WAPDA in accordance with the installation works of the replacement of gate hoist and the reinforcement works of the superstructures,
3) To inform the neighboring people completely that the bridge is going to close about 8.00-12.00 in the morning and 13.00-17.00 in the afternoon during the construction except the flood season, using a newspaper advertisement or a signboard,
4) Land acquisition and Land rental for temporary yard:
   - To arrange the provision of land, cost for land and land leveling for the temporary yard (4,200m^2) neighboring to the site,
   - To prepare land for disposal area of surplus soil materials,
5) To discuss matters with the Japanese persons concerned as the occasion demands in the construction period in order to adjust the progress of the constructions and so forth between the Grant Aid Project and the Punjab Barrages rehabilitation and modernization project by Pakistan.

2-4 Project Operation Plan

2-4-1 Organization of Executing Agency

(1) Organization of Executing Agency

The executing agency for the Project from the Government of Pakistan is the Irrigation and Power Department, Government of the Punjab (hereinafter referred as IPD). The Department consists of seven (7) Divisions holding about 52,400 staff in the whole Department. Organization chart of the Department is presented below.

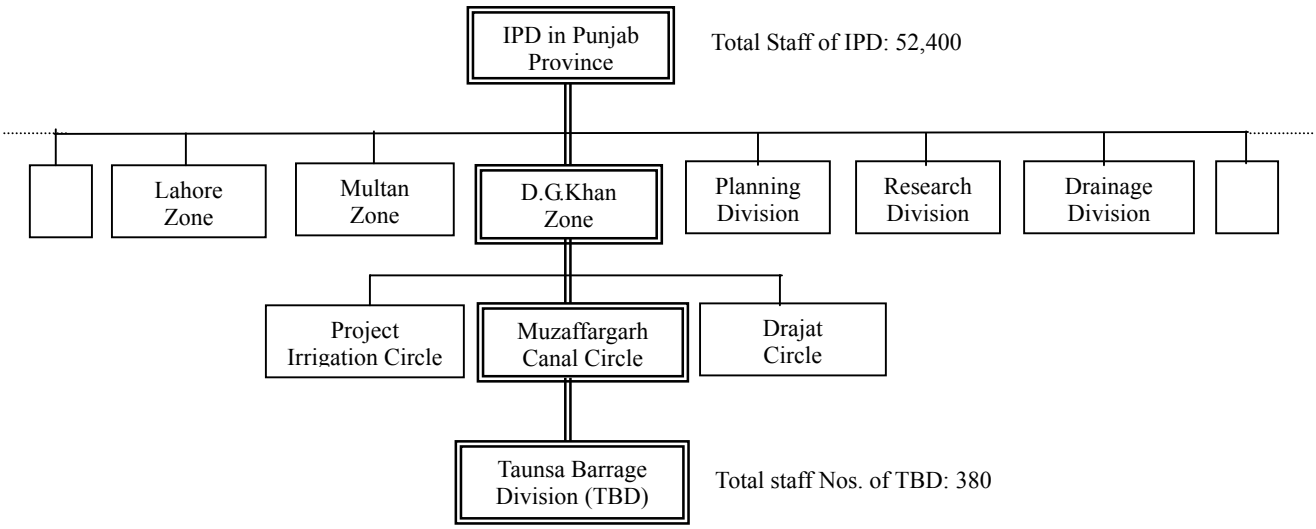


Figure 2-4.1 Organization Chart of IPD (2003/04)

The Taunsa Barrage Division (TBD) shown below will be responsible for operation and maintenance (O&M) works for the improved equipment and materials. The Taunsa Barrage Division functions under the DG Khan Zone Office. Its total staff is about 380.

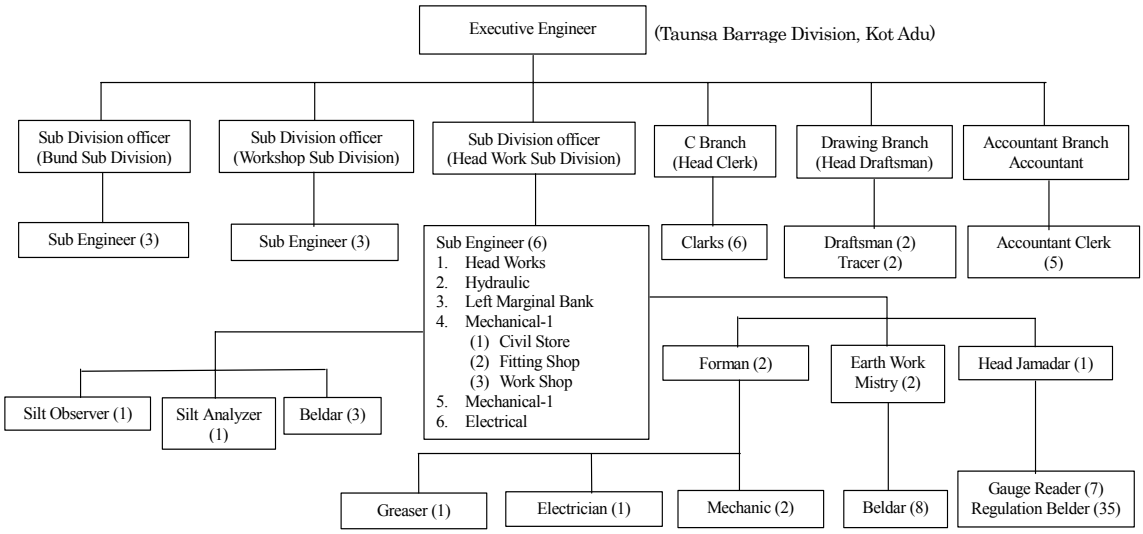


Figure 2-4.2 Organization Chart of TBD

The major activities of TBD are; a) O&M works for Taunsa Barrage and river management facilities such as river banks and spur dikes, etc. in the vicinities of the Barrage, b) O&M works for irrigation canals covered by the Taunsa Barrage, c) collection and recording of climatological and hydrological data, d) periodical observation of river conditions and shifting conditions of water route, etc, e) overall management for functions of Taunsa Barrage. These activities will continually be undertaken even after the Project.

(2) Staff Arrangement

The Taunsa Barrage is presently operated and managed under the jurisdiction of TBD shown in Figure 2-4.2. With the total of 380 staff, the Division will still be able to cope with their existing functions and still undertake the necessary O&M of the facilities and equipment that will be provided under the Project taking into account the fact that TBD has been functioned in the O&M of the immense structures over about fifty years. The TBD's capacity with regards to O&M even in the future is considered good. The other required staff needed for the newly installed facilities and the procured equipment such as electrification of gate operation systems, five (5) units of bulkhead gate, inclination facilities, tugboats, cranes and etc., the TBD can program an efficient and sufficient assignment system on rotating basis without adding to many staff as follows.

1) Gate Operation Staff Numbers

Current gate operation staff in the TBD is 35 in total, 10 to 12 staff are normally stationed in the Barrage on three (3) shifts. However, during the flooding period, temporary operation staffs are sometimes employed. This Project principally consists of the improvement of necessary equipment for the existing Taunsa Barrage, and operation and management works but even after the completion of the Project the current organization and staff will still be able to cope with the O&M activities. However, with the introduction of electrification of gate hoisting equipment, current gate operation staff could be reduced. The number of gate operation staff may therefore be reduced. Based on survey of other existing facilities within the country, the number of staff for similar facilities in other projects within the area are as follows:

- Marala Barrage（weir gates: 46、under sluice gates: 20、total 66 gates、all radial gates, span:60 ft）
  - Gate operation staff : about 5 staff x 3 rotations ＝ 15 staff
    Temporary staff would be employed at flooding period.
  - Mechanical staff（mechanic, greaser, assistant）: 10 staff
  - Electric engineer: 3 staff
- Chashma Barrage（weir gates: 41, under sluice gate :11, total 52 gates, all radial gates, span: 60 ft）
  - Gate operation staff: 4 staff
  - Foreman: 1staff
  - Electric engineer: 4 staff
  - Helper: 10staff（for cleaning, etc.）

For the Project, 29 gates will be electrified, and remaining gates will be electrified with the implementation of "the Punjab Barrages Rehabilitation and Modernization Project"to be undertaken by the

Government of Pakistan. Therefore, if all of the gates would be electrified, the total recommended staff will be about 15 operation staff (3 shifts with about 5 staff each shift), equivalent to almost half of present staff of 35. The reduced staff will be able to undertake O&M works, operation and management of the gates. There is also the need to increase the number of electrical engineers and technicians because to be able to undertake their work activities. The other TBD staff can take turns in the undertaking of the required work.

2) O&M Works for Bulkhead Gates and Their Operation Staff

For the O&M and management works of the new installed bulkhead gates of the Taunsa Barrage under the Project, additional staff would be needed. The total bulkhead gates that will be introduced are 5 sets. About 20 staff will be required for this facility. In addition, around 15 common laborers would be needed for installation and removal of the gates during gate operation periods. For the operation and maintenance works of the boats, which are related facilities for the operation of the bulkhead gates, five (5) captains would also be needed. However, the current TBD staff in the fields of Head Boat Man, Boat Man, Motor Launch Driver, Motor Launch Attendant, etc. maybe utilized instead for these required staff. Though electrical and technical engineers and mechanics will be needed for the operation of the equipment (inclinations, cranes, etc.), the required staff may be tapped from the TBD.

Necessary technical transfer of the O&M of the Bulkhead Gate and other newly provided equipment will be undertaken through "On the Job Training (OJT)". Examples of possible OJT activities will include assembly and usage of the crane procured, towing by the tugboats and working boats, installation and removal at a bay of barrage, maintenance at the stockyard, and so forth.

2-4-2 Components of Operation and Maintenance Works

Operation and maintenance works for the equipment to be introduced by the Project are summarized below. Maintenance and inspection works of the equipment would be required to be done periodically once a year.

Table 2-4.1 Components of O&M Works of the Equipment

Name of Equipment and Materials			Contents of Maintenance and Inspection		Remarks
Class	Medium Class	Subclass	Item	Methods	
Under Sluice Gates	Gate	Whole gate leaf	Painting conditions	Visual observation	Repainting every 7-years
			Board thickness	Board thickness measurement	
			Gate leaning	Visual observation/ confirmation	
		Watertight rubber	Damages and degradation	Visual observation/confirmation	Replacement when needed
		Roller train	Roller damages and abrasion	Surface visual confirmation and confirmation	
			Roller rolling condition	Operation confirmation	
	Guide Frame	Side guide frame	guide fram and abrasion	Surface visual observation and confirmation	
		Sill beam	Damages and degradation	Surface visual confirmation and confirmation	
	Gtae Hoist	Motor and related equipment	Operation confirmation	Abnormal noise/temperature rise confirmation during operation	
			Electric current and voltage	Visual observation/ confirmation	
		Drum gear	Refuel conditions	Oil film confirmation	
			Tooth bearing	Visual observation/ confirmation and measurement	
		Wire lope	Refuel conditions	Visual observation/confirmation	Repainting when needed
			Wire cutting	Visual observation/confirmation	
		Support unit	Painting	Repainting	Repainting every 7-years
Weir Gates	Gate	Whole gate leaf	Painting conditions	Visual observation/ confirmation	Repainting every year
			Board thickness	Board thickness measurement	
			Gate leaning	Visual observation/ confirmation	
		Watertight rubber	Damages and degradation	Visual observation/confirmation	Replacement when needed
		Roller train	Roller damages and abrasion	Surface visual observation and confirmation	
			Roller rolling condition	Operation confirmation	
	Guide Frame	Side guide frame	Girder damages and abrasion	Surface visual observation and confirmation	
		Sill beam	Damages and degradation	Surface visual observation and confirmation	
	Gtae Hoist	Motor and related equipment	Operation confirmation	Abnormal noise/temperature rise confirmation during operation	
			Electric current and voltage	Visual observation/ confirmation	
		Drum gear	Refuel conditions	Oil film confirmation	
			Tooth bearing	Visual observation/confirmation and measurement	
		Wire lope	Refuel conditions	Visual observation/ confirmation	Repainting when needed
			Wire cutting	Visual observation/confirmation	
		Support unit	Painting	Repainting	Repainting every 7-years
Bulkhead Gates	Gate	Whole gate leaf	Painting conditions	Visual observation	Repainting every 7-years
			Board thickness	Board thickness measurement	
			Damages	Visual observation/confirmation	
		Watertight rubber	Surface conditions	Visual observation/confirmation	Replacement when needed
	Compressor	Compressor	Operation confirmation	Abnormal noise/temperature rise confirmation during operation	
			Insulation resistance value	Measurement	
Bulkhead Gate Stockyard	Inclination & Winch	Motor and related equipment	Operation confirmation	Abnormal noise/temperature rise confirmation during operation	
			Electric current and voltage	Visual Observation/ confirmation	
		Drum gear	Refuel conditions	Oil film confirmation	
			Tooth bearing	Visual confirmation and	
		Wire lope	Refuel conditions	Visual observation/ confirmation	Repainting when needed
			Wire cutting	Visual observation/confirmation	
		Support unit	Painting degradation	Visual observation/ confirmation	
	Cart	Truck	Painting conditions	Visual observation	Every 7-years
			damages	Visual observation/ confirmation	
	Resting Stand	Support unit	Painting conditions	Visual observation	Every 7-years
	Tug boat	Engine	Operation confirmation	Abnormal noise/temperature rise confirmation during operation	
			Oil and filter replacement	Replacement	
Super Structures	Footboard	Footboard	Appearance deformation and damages	Visual observation/ confirmation	
	Structural	Structural member	Painting	Repainting	Every 7-years
Electric Equipment	Generator	Engine	Operation confirmation	Abnormal noise/temperature rise confirmation during operation	
			Oil and filter replacement	Replacement	
		Generator	Insulation resistance value	Measurement	
	Electric Panel	Control Panel	Electric current and voltage	Visual observation	
		Control Panel	Insulation resistance value	Measurement	

Note 1) The contents of maintenance and inspection indicate the items for annual periodical matters only.

2-5 Project Cost

2-5-1 Project Cost

Total cost needed for implementation of the Project under the Grant Aid is estimated at 5,469 million yen. Based on the above, the itemized cost shares to be undertaken by Japan and Pakistan is estimated as follows;

Total project cost estimation Approx. 5,469 million yen

(1) Cost to be Undertaken by the Government of Japan Approx. 5,281 million yen

Items				Total (Million Yen)
Facilities	Rehabilitation of gate facilities and others	Replacement of Under Sluice Gates Repair of Weir Gates Replacement & Electrification of Hoist Improvement of Deck on Superstructure Incline	7 gates 22 gates 29 gates 1 lot 1 lot	3,676
Equipment/Materials		Bulk-Head-Gate Tug boat 150ps Boat 50 ton Truck Crane	5 gates 2 unit 3 unit 1 unit	1,192
Detailed Design and Construction Supervision				413
Total				5,281

(2) Cost to be Undertaken by the Government of Pakistan Approx. 188 million yen

	Thousand Rs	Million Yen
Total	98,804	(Approx. 187.6)
①Reclamation of the Stockyard for Bulkhead Gate	14,808	(Approx. 28.1)
②Removal of control panel of telemeter system	353	(Approx. 0.7)
③Construction of Fence around the Stockyard for Bulkhead Gate	257	(Approx. 0.5)
④Bank Service Charges	83,384	(Approx. 158.3)

(3) Estimation Basis

(a) Price level : As of September, 2004

(b) Foreign exchange rate : 1 USD = 109.51 yen, 1 Rs = 1.90 yen

(c) Construction period : Based on implementation schedule.

(d) Others : The projects shall be implemented in conformity with the provisions of the Japan Grant Aid Scheme. The above total cost estimation shall not necessarily mean the limits of the grant amount to be specified in the E/N.

2-5-2 Operation and maintenance Cost

(1) Increasing and Decreasing of Personal Cost

The numbers of gate operation staff would be decreased to 15 staff (-20) from the original of 35 staff with the electrification of gate. However, additional 20 staff will be required for the O & M of the bulkhead gate and its incidental facilities. Accordingly, the total number of staff of TBD will not be changed from the previous and no increase in cost is expected for the personal cost in TBD after the Project. Also, about 15 temporary staff would be required at the time of installation and removal of the bulkhead gate. These costs are estimated and included in the cost of "Inspection and Maintenance" (refer to Table 2-5-2.2).

(2) Electric Power Costs for Gate Operation under Electrification

Motor output under the introduction of gate electrification is 1.5 kw/gate for the weir gate and 2.2kw for the under sluice gate. Gate operation records for the past 10-years at the Taunsa Barrage are shown below.

Table 2-5-2.1 Annual Gate Operation Records（per gate）

Year	Left.Under S. 7gates (ft)	Weir 54gates (ft)*	Right.Under S 4gates (ft)	Overall (ft)
1994	63.08	90.64	57.75	85.65
1995	58.07	95.91	53.00	89.20
1996	131.12	170.33	129.75	163.61
1997	82.26	100.60	85.15	97.68
1998	80.23	141.98	74.75	131.19
1999	84.57	74.75	67.50	75.36
2000	69.74	90.65	74.00	87.38
2001	45.14	82.65	39.83	75.98
2002	111.51	94.51	51.28	93.68
2003	51.63	99.82	81.68	93.51
Average	77.74	104.18	71.47	99.32
per day	0.213	0.285	0.196	0.272

Note* : "54gates" of weir includes one navigation lock gate.

Annual Gate Movement Accumlated (GM)

GM for Under Sluice Gates = 7 x 77.74 + 4 x 71.47 = 830 ft/yr

GM for Weir Gates = 54 x 104.18 = 5,626 ft/yr

Daily average gate operation volume by manual power for the whole 65 gates is estimated at about 0.3 ft at the Taunsa Barrage according to the operation records indicated above. However, with the introduction of gate electrification in the Project, gate operation will be able to meet the required fluctuation of stable upstream water level in a more accurate way and with more ease. Gate operation volume is estimated to become twice the present operation volume.

Since opening and closing speeds of gates after the electrification is about 1.0 ft/min, annual motor operation hours with 2.2 kw (under sluice) and 1.5 kw (weir) capacities could be estimated as shown below.

Annual 2.2 kw motor operation hours = 830 ft/annum x 2 / (1 ft/min.)

= 1,660 min/year = 28 hr/year

Annual 1.5 kw motor operation hours = 5,626 ft/annum x 2 / (1 ft/min.)

= 11,252 min/year = 188 hr/year

On the assumption that efficiency and power factor of the electric motor are 70 percent and control power sources are 500 kw/unit for a local control panel and 2.0 kw for distribution panel, hourly power consumptions could be estimated as follows.

Hourly power consumption of 2.2kw W = 2.2 / 0.7 +0.5 +2.0 = 5.643 kwh

Hourly power consumption of 1.5kw W = 1.5 / 0.7 +0.5 +2.0 = 4.643 kwh

Therefore, annual electricity costs could be estimated as shown below on the basis of the unit price of A2-grade of 9 Rs/kwh.

Annual electricity costs = 9 Rs/kwh x (5.643 kwh/hr x 28 hr/year +

4.643 kwh/hr x 188 hr/year)

= 9,278 Rs/year

(3) Inspection and Maintenance Costs for Taunsa Barrage Equipment

The following inspection and maintenance costs are required to inspect and maintain equipment provided at Taunsa Barrage. These estimations were made on the contract made by TBD with private contractors, and are considered as initial and approximate estimation.

Table 2-5-2.2 Inspection and Maintenance Costs

Items			Q'ty	Unit	Unit Cost (Rs/gate)	Amount (Rs)	Interval of Inspection and Maintenance Works	Annual Average Amounts (Rs/yr)
Under Sluice Gates	1	Gate Repainting	7	gate	610,980	4,276,863	7yr	610,980
	2	Hoist and Base Repainting	7	gate	61,991	433,937	7yr	61,991
	3	Watertight Rubber Replacement	7	gate	647,263	4,530,841	10yr	453,084
	4	Annual Inspection	7	gate	54,834	383,836	1yr	383,836
Weir Gates	5	Gate Repainting	22	gate	542,988	11,945,741	7yr	1,706,534
	6	Hoist and Base Repainting	22	gate	65,616	1,443,544	7yr	206,221
	7	Watertight Rubber Replacement	22	gate	638,856	14,054,839	10yr	1,405,484
	8	Annual Inspection	22	gate	50,682	1,115,014	1yr	1,115,014
Bulkhead Gates	9	Gate Repainting	5	gate	930,248	4,651,239	7yr	664,463
	10	Watertight Rubber Replacement	5	gate	743,652	3,718,259	10yr	371,826
Bulkhead Gate Stockyard	11	Wire Lope Oil Application	1	LS	59,919	59,919	1yr	59,919
	12	Cart and Resting Stand Repainting	1	LS	159,037	159,037	7yr	22,720
	13	Winch Equipment Base Repainting	1	LS	16,958	16,958	7yr	2,423
	14	Operational and Observation Inspection for Motorboat, Tugboat, etc. (done by TBD 20 staff)	1	LS	0	0	1yr	0
Super Structure	15	Visual Observation Inspection	65	gate	708	46,027	1yr	46,027
Electric Equipment	16	Generator Operational Inspection	2	unit	23,106	46,211	2yr	23,106
	17	Board Operational Inspection (Local Control Board and Switchboard)	30	board	4,664	139,909	1yr	139,909
							Total	7,273,536

Cost estimation conditions;

1 Repainting of under sluice and weir gates would be done using bulkhead gates.

2 Repainting of bulkhead gates would be done when they are stored in stockyard.

3 Required costs for maintenance and inspection activities are only limited to the rehabilitated gates under the Project

In the above estimation, required inspection and maintenance costs for the under sluice gates, weir gates, and super structures, which have been undertaken by the TBD, are included. These works would be implemented continuously and will be the same as the previous one.

Additional inspection and maintenance costs after the project are those related to the bulkhead gates and electric equipment corresponding to items of 9-14 and 16-17 in the above table.

Total annual inspection and maintenance costs of the above items are estimated at about 1,284 thousand Rs/annum which will be newly needed after the Project.

(4) TBD O&M Costs

As a result of the above estimations of items 1) to 3), the O&M costs to be shouldered by the TBD are as follows.

Personal costs (reduction)	0 thousand Rs/annum
Electricity costs for gate operation	9 thousand Rs/annum
Inspection and maintenance costs for bulkhead gates	1,284 thousand Rs/annum
Total	1,293 thousand Rs/annum

Therefore, 1,293 thousand Rs of O&M costs are expected to be increased annually after the Project. However, related rehabilitation costs for the gate facilities would largely reduce annually, because of the implementation of rehabilitation works by the Project for the 29 gates out of the total gates of 69.

Reduction of gate rehabilitation costs = 1,161 thousand Rs/yr / 65 gates x 29 gates

= 518 thousand Rs/yr

(Details of annual gate rehabilitation costs of 1,161 thousand Rs/yr are referred to Appendix-6,A6-2).

When considering the above reduction costs of gate rehabilitation, annual O&M costs would increase as much as 775 thousand Rs. This amount corresponds to only 1.6 % of the annual average expenditures of 48.60 million Rs for the past 10-years, and future management and O&M works for the Taunsa Barrage could be fully correspondence by means of further rationalized progress. Under these considerations, it could be concluded that the Project implementation would not be disadvantageous to the Taunsa Irrigation Systems even in the future.

Table 2-5-2.3 O&M Budgets and Required Expenditures for Taunsa Barrage and Related Facilities

(Unit：Million Rs)

No.	Items	Fiscal Year										Averrage
		1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	
1.	**Budget**	36.48	20.70	22.80	22.25	30.76	20.71	37.72	57.07	92.20	145.98	48.67
1-1	Taunsa Barrage & Canal	26.40	11.90	16.90	12.57	23.37	6.22	18.92	10.66	82.42	124.38	33.37
1-2	Bund and Drainage	6.50	0.50	4.97	7.63	6.30	7.29	5.25	10.07	6.63	18.46	7.36
1-3	Others	3.58	8.30	0.93	2.05	1.09	7.20	13.55	36.34	3.15	3.20	7.94
2.	**Expenditure**	36.47	20.24	22.71	22.19	30.76	20.71	37.68	57.06	92.20	145.96	48.60
2-1	Taunsa Barrage	25.31	10.82	9.92	9.89	18.92	5.26	11.92	10.30	80.77	115.09	29.82
2-2	Irrigation Canal	1.09	1.09	6.98	2.68	4.45	0.96	6.99	0.36	1.66	9.23	3.55
2-3	Bund and Drainage	6.50	0.50	4.89	7.63	6.30	7.29	5.22	10.07	6.62	18.46	7.46
2-4	Others	3.57	7.83	0.92	1.99	1.09	7.20	13.55	36.33	3.15	3.19	7.39
3.	**Budget (1.)－Expenditure (2.**	0.01	0.46	0.09	0.06	0.00	0.00	0.04	0.01	0.00	0.02	0.07
4.	**Expenditure (2.)/Budget (1.)**	100%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Note： Fiscal year of Government of Pakistan : 1st July - 30th June

Source : Taunsa Barrage Division (TBD)

Chapter 3 Project Evaluation and Recommendations

Chapter 3 Project Evaluation and Recommendation

3-1 Project Effect

The implementation of the Project will directly benefit about 823 thousand hectares of irrigation area consisting of the three irrigation canals of D.G. Khan, Muzaffargah and T.P.link, under the Taunsa Barrages Irrigation System. The project will also benefit about 1.8 million populations. The expected benefits of the Project are presented and discussed in the succeeding items below.

3-1-1 Direct Effect

(1) Restoration of Originally Designed Water Intake

Intake volume of irrigation water from Taunsa barrages has decreased due to silting-up sedimentation of irrigation canals. To ensure a stable irrigation water supply and to restore the original intake discharge of the Taunsa Barrage irrigation system, it will be necessary to heighten the water level by one foot from WL.446.00ft to 447.00ft. For this purpose, the 29 gates will be heightened for one foot under the Project. This will also be undertaken for the other gates that will be rehabilitated by the Pakistan Government.

- The existing intake of irrigation water to D.G. Khan irrigation canal at the right bank of Taunsa Barrage is at present limited to 9,047 $ft^{3/}$sec (256 m^3/sec) due to sedimentation of the canal. This is expected to increase to the design discharge of 11,564 $ft^{3/}$sec (327 m^3/sec) * after implementation of the Project.
- The existing intake volume of irrigation water to Muzaffargah irrigation canal at the right bank of the Taunsa Barrage is limited to 7,476 $ft^{3/}$sec (212 m^3/sec) due also to the sedimentation of the canal and this is expected to increase to the design discharge of 8,300 $ft^{3/}$sec (235 m^3/sec) * after implementation of the Project.

Notes: "*" means water right volume

Table 3-1. 1 Restoration of Intake Volume of Irrigation Water (D.G.Khan Irrigation Canal)

Item	Intake water level (ft)	Canal siltation Height (ft)	Intake water vol.($ft^{3/}$sec)	Countermeasure / Evaluation
Original Design	446.00	0.00	12,074	**Water right vol.=11,564 $ft^{3/}$sec**
Existing	446.00	2.80	9,047	·Existing irrigation canal capacity is limited to 78 %of water right volume due to siltation.
With Project ·Heightening by 1.0ft ·Canal Dredging by 0.8ft	447.00	2.00	11,564	·Heightening of all gates by 1.00ft ·Dredging of segmented soils by 0.8 ft under regular O&M

Table 3-1. 2 Restoration of Intake Volume of Irrigation Water (Muzaffargah Irrigation Canal)

Item	Intake water level (ft)	Canal siltation Height (ft)	Intake water vol.($ft^{3/}$sec)	Countermeasure / Evaluation
Original Design	446.00	0.00	8,396	**Water right vol.=8,300 $ft^{3/}$sec**
Existing	446.00	1.50	7,476	· Existing irrigation canal capacity is limited to 90 % of water right volume due to segmentation
With Project ·Heightening by 1.0ft	447.00	1.50	8.300	·Heightening of all gates by 1.00ft

(2) Improvement of Gate Operation Speed by Electrification and Reduction of Flood Damage

At present, the manually operated gates of Taunsa Barrage have low efficiency in gate operation due to deterioration of gate facilities, which become obstacle for timely operation of gates during river flooding. Accordingly the intrusion of flooding water threatens to damage farm land and residential areas in polder dike areas.

As a simulation result of the gate operation on the existing largest flood occurred on September 14, 1992, gate operation speed of 32ft/hr (=0.16m/min) for lifting gate is required in the rising period of flood and 54ft/hr (=0.27m/min) for lowering gate is required in the subsiding period of flood. The present manually operated gates have the speed at about 10ft/hr (=0.05 m /min) at lifting and 20ft/hr (a=0.10 m/min) at lowering. It means that the existing gate operation speed is too slow to control flooding water. The delay of gate operation is accumulated about 15 hours in this case. Accordingly, the high water level will occur, which may cause flood damage in the upstream of Taunsa Barrage.

The gate operation will be improved with gate speed at 60ft/hr (=0.3m/min) by electrification under the Project. It makes possible to operate gate easily and to flow down flood water safely and efficiently.

Table 3-1. 3 Comparison of Gate Operation Hours for the Largest Flood (September 14, 1992) between Present and with Project

Stage of Flood	Requirement of gate operation speed (m/min)	Existing gate operation speed (Manual operation) (m/min)	Gate operation speed with Project
Rising Flood	0.16	0.05	0.30
Subsiding Flood	0.27	0.10	0.30

(3) Safety improvement with well-maintenance of Barrage

After the implementation of the Taunsa Barrage, the safety of the facilities is assured as the introduction of bulkheads will enable that periodical operation and maintenance works will be done at the most efficient and appropriate period of time. The present gate maintenance and rehabilitation works is being done within the limited period of 20 days in January, (during the "Annual Closer Period"). Under these conditions, it would be difficult to do full-scale rehabilitation works of the Barrage within the very limited period of time.

3-1-2 Indirect Effect

(1) Use of Bulk Head Gates for Rehabilitation of Other Barrages than Taunsa Barrage

The Punjab Government has also plans to rehabilitate other barrages after implementation of the Project. It is possible to use the bulk head gates, which will be introduced in the Project, for the rehabilitation projects of Jinna and Trim Barrages after use in the Project. It may contribute to the reduction of the construction period and construction cost for these Barrages.

(2) Non Irrigation Sector Benefit

Other than irrigation purposes, the Taunsa Barrages has various functions such as domestic and industrial water supply, traffic with bridges for road and railroad, supply of oil and gas with pipelines and provision of other lifeline of electricity and communication. Moreover, there are many tourists who visit the barrage. The implementation of the Project will work at securing safety of the Taunsa Barrage and ensuring that all the above-mentioned functions will be realized in the future.

3-2 Recommendations

To achieve expected benefits of the Project effectively, the following points will adequately be taken into consideration in the execution of the Project.

(1) Raising of Taunsa Barrage gates by one foot (0.31m)

The 29 gates that will be rehabilitated under the grant aid project will be heightened by one foot (0.31m). However, it will also be necessary to heighten the other remaining gates under Punjab Barrages Rehabilitation and Modernization Project because if this will not be done, then, it will not be possible to restore intake discharge to the originally designed one. Therefore, heightening of remaining gates should immediately be undertaken after implementation of the Project.

(2) Electrification of Taunsa Gates

It is also necessary that the other gates not included under the grant aid project shall also be immediately rehabilitated by undertaking the same electrification process of gates under the Punjab Barrages Rehabilitation and Modernization Project. Without electrification of these other gates, it will not be possible to operate Taunsa Barrage gates safely and effectively for the purpose of flood control.

(3) Construction of Taunsa Downstream Sub Barrage

Since the Taunsa Barrage was constructed, the river bed has been lowering yearly at the downstream of Taunsa Barrage. This is the reason for the damaged apron structures at the downstream, endangering the barrage with piping of foundation. Under this condition, the difference in water level between the upstream and the downstream shall be controlled and kept at less than 22ft (about 6.7m) in gate operation. On the contrary, it is planned to maintain the water level at WL447ft to restore water intake by heightening gates in the rehabilitation of the barrage under the grant aid Project and Punjab Barrages Rehabilitation and Modernization Project. However, this will lead to the increase in the gap of water level between the upstream and the downstream with loosing safety. To cope with this problem, the Government of Punjab has a plan to construct a subsidiary weir at the downstream of Taunsa Barrage under the Punjab Barrages Rehabilitation and Modernization Project. It is necessary to construct the subsidiary weir in order to secure safety of Taunsa Barrage operation and also to restore the originally designed irrigation water intake.

(4) Improvement in Operation and Maintenance of Taunsa Barrage Division

It is estimated that the operation and maintenance cost of Taunsa Barrage Division will increase by about two (2) percent of the average cost of the past ten years because of the introduction of bulk head gates. It is therefore necessary for the Government of Pakistan to prepare adequate budget for operation and maintenance or to carry out appropriate operation and maintenance undertakings by further making rationalization efforts.

[Appendixes]

Appendix-1 Member Lists of the Study Team

1-1 Study Team for Basic Design Study

Mr. KAYUMI, Shigetada	Team Leader	Senior Adviser, Institute of International Cooperation, JICA
Mr. KUGE, Katsuya	Project Coordinator	Rural Development and Environment Team, Project Management Group Ⅱ, Grant Aid Management Department, JICA
Mr. MORI, Tatsuhiko	Project Manager／Operation and Maintenance Planning	Sanyu Consultants Inc.
Mr. KOMADA, Fumihiko	Hydraulic Structure／Civil Design	Sanyu Consultants Inc.
Mr. HASEGAWA, Kiyoshi	Steel Structure Design	Yachiyo Engineering Co., Ltd.
Mr. NAGATA, Kenji	Fluvial Hydraulics	Yachiyo Engineering Co., Ltd.
Mr. URUNO, Atsuhito	Electric Facilities Design	Yachiyo Engineering Co., Ltd.
Mr. HIROTA, Kosuke	Construction Planning／Quantity Survey	Sanyu Consultants Inc.

1-2 Study Team for Explanation of the Draft Basic Design Report

Mr. KAYUMI, Shigetada	Team Leader	Senior Adviser, Institute of International Cooperation, JICA
Mr. KUGE, Katsuya	Project Coordinator	Rural Development and Environment Team, Project Management Group Ⅱ, Grant Aid Management Department, JICA
Mr. MORI, Tatsuhiko	Project Manager／Operation and Maintenance Planning	Sanyu Consultants Inc.
Mr. KOMADA, Fumihiko	Hydraulic Structure／Civil Design	Sanyu Consultants Inc.
Mr. HASEGAWA, Kiyoshi	Steel Structure Design	Yachiyo Engineering Co., Ltd.

Appendix-2 Study Schedule

2-1 Basic Design Study

No.	Date	day	Officials	Consultants					
			Team Leader Project Coordinator	Project Manager / Operation & Maintenance Planning	Steel Structure Design	Fluvial Hydraulics	Electric Facility Design	Hydraulic Structure/ Civil Design	Construction Planning/ Quality Survey
1	5/28	Fri		PK853 Tokyo1400→Islamabad2105					PK853 Tokyo1400→ Islamabad2105
2	29	Sat		Preparation of Consignment Contract of Topo-survey and Baseline survey					Preparation of Consignment Contract of Survey
3	30	Sun		Preparation of Approval of Consignment Contract of Topo-survey					Preparation of Consignment Contract of Baseline Survey
4	31	Mon		Consignment of Contract of Baseline Survey	Consignment of Contract of Baseline Survey	Consignment of Contract of Topo Survey			Consignment of Contract of Topo Survey
				Courtesy call on JICA office					Courtesy call on JICA office
5	6/1	Tue		PK385Islamabad830→Lahore920、Discussion with IPD					PK385Islamabad830→ Lahore920、Discussion with IPD
6	2	Wed		Discussion with IPD (Inception Repor)					Discussion with IPD (Inception Report)
7	3	Thu		PK385Lahore1000→Multan1055→CarTaunsa）、Site Survey					PK385Lahore1000→ Multan1055→ CarTaunsa）、Site Survey
8	4	Fri		Explanation and discussion of Inception Report with TBD, Site survey					Site Survey
9	5	Sat		Explanation and discussion of Inception Report with D.G.khan Zone Office, Site survey of D.G.Khan Canal, Hill Torrent of Mithawan and beneficial irrigation area.					Site Survey
10	6	Sun	JL717Tokyo1055→ Bangkok1555,CX701Bangkok2000→Karachi2220)	Data Collection	Data Collection	Data Collection			Data Collection
11	7	Mon	PK300Karachi0700→ Islamabad0855, Courtesy Call to JICA, EOJ, EAD	Site Survy and Data Collection at TBD, Kot Adu	Site Survey (Gate Facility of Taunsa Barrage)	Site Survy and Data Collection at TBD, Kot Adu			Site Survy and Data Collection at TBD, Kot Adu
12	8	Tue	PK385Islamabad830→ Lahore920、Courtesy Call to PPDB、Discussion with IPD	Site Survy and Data Collection at TBD, Kot Adu	Site Survey (Gate Facility of Taunsa Barrage)	Site Survy and Data Collection at TBD, Kot Adu	JL717Tokyo1055→ BKK1555,TG505BKK2000 →Lahore2240)	JL717Tokyo1055→ BKK1555,TG505BKK2000 →Lahore2240)	Site Survy and Data Collection at TBD, Kot Adu
13	9	Wed	PK385Lahore1000→ Multan1055→Taunsa by Car、Site Survey	Site Survey with Officials	Site Survey with Officials	Site Survey with Officials	PK385Lahore1000→ Multan1055→Taunsa by Car、Site Survey	PK385Lahore1000→ Multan1055→Taunsa by Car、Site Survey	Site Survey with Officials
14	10	Thu	Site Survey	Site Survey	Site Survey	Site Survey	Site Survey	Site Survey	Site Survey
15	11	Fri	Taunsa→PK386Multan1145→ Lahore1305	Taunsa→PK386Multan1145→ Lahore1305	Taunsa→PK386Multan1145→ Lahore1305	Taunsa→PK386Multan1145→ Lahore1305	Taunsa→PK386Multan1145→ Lahore1305	Taunsa→PK386Multan1145→ Lahore1305	Taunsa→PK386Multan1145→ Lahore1305
16	12	Sat	Discussion with IPD、Inspection of Moghalpura Irrigation Workshop	Discussion with IPD、Inspection of Moghalpura Irrigation Workshop	Discussion with IPD、Inspection of Moghalpura Irrigation Workshop	Discussion with IPD、Inspection of Moghalpura Irrigation Workshop	Discussion with IPD、Inspection of Moghalpura Irrigation Workshop	Discussion with IPD、Inspection of Moghalpura Irrigation Workshop	Discussion with IPD、Inspection of Moghalpura Irrigation Workshop
17	13	Sun	Inspection of Hydraulic Research Station Nandipur, and Marala Barrage	Inspection of Hydraulic Research Station Nandipur, and Marala Barrage	Inspection of Hydraulic Research Station Nandipur, and Marala Barrage	Inspection of Hydraulic Research Station Nandipur, and Marala Barrage	Inspection of Hydraulic Research Station Nandipur, and Marala Barrage	Inspection of Hydraulic Research Station Nandipur, and Marala Barrage	Inspection of Hydraulic Research Station Nandipur, and Marala Barrage
18	14	Mon	Discussion with IPD	Discussion with IPD	Discussion with IPD	Discussion with IPD	Discussion with IPD	Discussion with IPD	Discussion with IPD
19	15	Tue	Signing M/M, PK388Lahore2020→ Islamabad2110	Signing M/M, Discussion with Punjab Barrage Consultant	Signing M/M、PK387Lahore1640→ Multan1800)	Signing of M/M, Discussion with Punjab Barrage Consultant	Signing M/M、PK387Lahore1640→ Multan1800)	Signing M/M、PK387Lahore1640→ Multan1800)	Signing M/M、PK387Lahore1640→ Multan1800)
20	16	Wed	Discussion with MWP	Data Collection at the Related Offices	Site Survey (Gate Facility of Taunsa Barrage)	Data Collection at the Related Offices	Site Survey and Data Collection concerning Electricity	Site Survey(Baseline Survey) and Data Collection	Site Survey for Procurment
21	17	Thu	Report to EOJ,JICA、MWP,EAD、PK381Islamabad1930→ Lahore2020、TG506Lahore2350→ BKK0620(+1)	Discussion with IPD about Data Collection, Interium report of Topo-Survey	Site Survey (Gate Facility of Taunsa Barrage)	Discussion with IPD about Data Collection, Interium report of Topo-Survey	Site Survey and Data Collection concerning Electricity	Site Survey(Baseline Survey) and Data Collection	Site Survey(Baseline Survey) and Data Collection
22	18	Fri	JL708BKK0830→ Tokyo1610)	Meeting with IPD and WB	Site Survey (Gate Facility of Taunsa Barrage)	Meeting with IPD and WB	Data Collection and Analysis	Site Survey and Data Collection concerning Taunsa Barrage	Site Survey for Procurment
23	19	Sat		Data Collection（Survey D,.WAPDA、IPD)、PK387Lahore1640→ Multan1800	Data Collection and Analysis	Data Collection（Survey D,.WAPDA、IPD)、PK387Lahore1640→ Multan1800	Data Collection and Analysis	Site Survey（Bulkhead Gate Stockyard, Jetty)	Site Survey for Procurment
24	20	Sun		Internal Meeting、Data Collection and Analysis	Internal Meeting、Data Collection and Analysis	Internal Meeting、Data Collection and Analysis	Internal Meeting、Data Collection and Analysis	Internal Meeting、Data Collection and Analysis	Internal Meeting、Data Collection and Analysis
25	21	Mon		Site Survy and Data Collection at TBD, Kot Adu	Site Survey (Gate Facility of Taunsa Barrage)	Site Survey (Gate Facility of Taunsa Barrage)	Site Survey (Gate Facility of Taunsa Barrage)	Site Survey (Taunsa Barrage)	Site Survey (Taunsa Barrage)
26	22	Tue		Site Survy and Data Collection at D.G.Khan Office	Site Survey (Gate Facility of Taunsa Barrage)	Site Survy and Data Collection at TBD, Kot Adu	Site Survey (Gate Facility of Taunsa Barrage)	Site Survey (Canal)	Site Survey (Taunsa Barrage)
27	23	Wed		Site Survey (Upstream, Hill Torrent)	Site Survey (Gate Facility of Taunsa Barrage)	Site Survey (Upstream, Hill Torrent)	Data Collection and Analysis	Site Survey (Upstream, Hill Torrent)	Site Survey (Upstream, Hill Torrent)
28	24	Thu		Site Survy and Data Collection at Muzaffargah Office	Taunsa→PK386Multan1145→ Lahore1305	Site Survey(Environment, River Maintenance Facilities)	Site Survey(Location Planning of Electric Facilities)	Site Survey (Canal)	Taunsa→PK386Multan1145→ Lahore1305
29	25	Fri		Site Survy and Data Collection at TBD, Kot Adu	Factory Survey（DESCON)	Site Survey(River Maintenance Facilities)	Data Collection and Analysis	〃	Factory Survey（DESCON)
30	26	Sat		Site Survy and Data Collection at TBD, Kot Adu	Factory Survey（Bhalwal Irrigation Workshop)	〃	Site Survey(Location Planning of Electric Facilities)	Data Collection and Analysis	Factory Survey（Bhalwal Irrigation Workshop)
31	27	Sun		Analisis of Collected Data	Analisis of Collected Data	Taunsa→PK386Multan1145→ Lahore1305	Taunsa→PK386Multan1145→ Lahore1305	〃	Analisis of Collected Data
32	28	Mon		Site Survy and Data Collection at TBD, Kot Adu	Factory Survey（PEKO)	Data Collection at IPD & WAPDA（TM System)	Data Collection and Analysis	Data Collection and Analysis (Design Criteria of Barrage)	Factory Survey（PEKO)

No.	Date	day	Officials	Consultants					
			Team Leader Project Coordinator	Project Manager / Operation & Maintenance Planning	Steel Structure Design	Fluvial Hydraulics	Electric Facility Design	Hydraulic Structure/ Civil Design	Construction Planning/ Quality Survey
33	29	Tue		Site Survy and Data Collection at D.G.Khan Office	Analisis of Collected Data	Environmental Survey（Library、EPD）	Data Collection and Marketing Survey of Electrical Equipment	Data Collection and Analysis (Design Criteria of Barrage)	Data Collection of Baseline Survey
34	30	Wed		Inspection of Chashima/Jinnah Barrages	Inspection of Chashima/Jinnah Barrages	Inspection of Chashima/Jinnah Barrages	Inspection of Chashima/Jinnah Barrages	Inspection of Chashima/Jinnah Barrages	Inspection of Chashima/Jinnah Barrages
35	7/1	Thu		Site Survy and Data Collection at TBD, Kot Adu	Inspection of Trimmu Barrage	PK390Lahore1340→ Islamabad1430)	Data Collection and Marketing Survey of Electrical Equipment	Analisis of Collected Data	Data Collection and Marketing Survey of Electrical Equipment
36	2	Fri		Site Survy and Data Collection at TBD, Kot Adu	Analisis of Collected Data	Data Collection at Survey Depart. and Depart.of Statistic	Analisis of Collected Data	Evaluation and Receiving of Baseline Survey Result	Data Collection for Cost Estimation & Procurment
37	3	Sat		PK386Multan1145→ Lahore1240）	Discussion with IPD (Design of Gate, Procurement)	Data Analysis, PK381Islamabad1930→ Lahore2020	Analisis of Collected Data	PK386Multan1145→ Lahore1240）	Survey at IPD（Cost Estimation・ Procurement）
38	4	Sun		Analisis of Collected Data & Internal Meeting	Analisis of Collected Data & Internal Meeting	Analisis of Collected Data & Internal Meeting	Analisis of Collected Data & Internal Meeting	Analisis of Collected Data & Internal Meeting	Analisis of Collected Data & Internal Meeting
39	5	Mon		Discussion with IPD (Works done by Pakistan & Budgetary Plan)	PK315raho-ru0830→ Karachi1015→ (Car)haiderabad）、Kotri Barrage→(Car)Karachi, PK305karachi1900→ Lahore2045)	Preparation of Summary Report of the Site Survey	Preparation of Summary Report of the Site Survey	PK315raho-ru0830→ Karachi1015→ (Car)haiderabad）、Kotri Barrage→(Car)Karachi, PK305karachi1900→ Lahore2045)	Discussion with IPD(Budgetary Plan, Work Costs borne by IPD)
40	6	Tue		Discussion with IPD	Discussion with IPD	Discussion with IPD	TG506Lahore2350→ BKK0620(+1))	Preparation of Summary Report of the Site Survey	Data Collection at Relevant Office for Cost Estimation
41	7	Wed		Report and Discussion with IPD	Report and Discussion with IPD	Report and Discussion with IPD	JL708BKK0830→ Tokyo1610	Report and Discussion with IPD	Report and Discussion with IPD
42	8	Thu		Report and Discussion with IPD IPD PK390Lahore1625→Islamabad1715				Report and Discussion with IPD、Inspection & Receiving of Topo survey result	Report and Discussion with IPD、Data Collection at Relevant Office for Construction Planning
43	9	Fri		Report to JICA、				Analisis of Collected Data	〃
44	10	Sat		Factory Survey（HMC)、 PK369Islamabad1705→Karachi1900） TG502Karachi2330→BKK0630(+1))				〃	〃
45	11	Sun		JL708BKK0835→Tokyo1635				〃	Analisis of Collected Data
46	12	Mon						〃	Data Collection at Relevant Office for Construction Planning
47	13	Tue						Preparation of Summary Report of the Site Survey	Preparation of Summary Report of the Site Survey
48	14	Wed						〃	〃
49	15	Thu						〃	〃
50	16	Fri						〃	〃
51	17	Sat						Report and Discussion with IPD	
52	18	Sun						TG506Lahore2350→BKK0620(+1))	
53	19	Mon						TG774BKK0820→ Osaka1530）	JL708BKK0830→ Tokyo1610

2-2 Explanation of the Draft Basic Design Study Report

No.	Date	day	Officials	Consultants					
			Team Leader Project Coordinator	Project Manager / Operation & Maintenance Planning	Steel Structure Design	Fluvial Hydraulics	Electric Facility Design	Hydraulic Structure/ Civil Design	Construction Planning/ Quality Survey
1	9/14	Tue		JL5113Osaka1145→ BKK1535,TG505BKK2000 →Lahore2240）	JL717Tokyo1100→ BKK1530,TG505BKK2000 →Lahore2240			JL5113Osaka1145→ BKK1535,TG505BKK2000 →Lahore2240）	
2	15	Wed		Explanation and discussion with IPD on the Draft Basic Design Report				Explanation and discussion with IPD on the Draft Basic Design Report	
3	16	Thu		Explanation and discussion with IPD on the Draft Basic Design Report				Explanation and discussion with IPD on the Draft Basic Design Report	
4	17	Fri		Explanation and discussion with IPD on the Draft Basic Design Report				Explanation and discussion with IPD on the Draft Basic Design Report	
5	18	Sat		Explanation and discussion with IPD on the Draft Basic Design Report				Explanation and discussion with IPD on the Draft Basic Design Report	
6	19	Sun	PK387Islamabad1410→ Lahore1500）、Intenal Meeting	Data Analysis,Internal Meeting	Data Analysis,Internal Meeting			Data Analysis,Internal Meeting	
7	20	Mon	Corutesy Call to PPDB、Explanation and discussion with IPD on the Draft Basic Design Report					Corutesy Call to PPDB、Explanation and discussion with IPD on the Draft Basic Design Report	
8	21	Tue	Explanation and discussion with IPD on the Draft Basic Design Report					Explanation and discussion with IPD on the Draft Basic Design Report	
9	22	Wed	Discussion with IPD、Signing M/M、					Discussion with IPD、Signing M/M、	
			PK386Lahore1340→ Islamabad1430	Discussion with IPD				Discussion with IPD	
10	23	THu	Discussion with EAD and MWP	Discussion with IPD	Discussion with IPD			Discussion with IPD	
				PK388Lahore2020→ Islamabad2110)					
11	24	Fri	Report to EOJ,JICA、		Data Analysis			Data Analysis	
			PK381Islamabad1930→Lahore2020、 TG506Lahore2350→BKK0620(+1))		TG506Lahore2350→ BKK0620(+1))			TG506Lahore2350→ BKK0620(+1))	
12	25	Sat	JL708BKK0830→ Tokyo1610	JL728BKK0910→ Osaka1635	JL708BKK0830→ Tokyo1610)			JL728BKK0910→ Osaka1635	

Appendix-3 List of Parties Concerned in the Government of Pakistan

Name	Position
Irrigation and Power Department (IPD), Government of Punjab (GOP)	
Javed Majid	Secretary, IPD, GOP
Asrar-ul-Haq	Additional Secretary (Technical), IPD, GOP
Zaka Ullah Bhatti	Chief Engineer, Irrigation Development Zone, IPD, GOP
Ehsan Ullah Sardar	Chief Engineer, Research Zone, IPD, GOP
Rao Mohammad Riaz	Director Regulation, IPD, GOP
A. Sattar Malik	Superintending Engineer, IPD, GOP
Mian Javaid	Mechanical Engineer, Moghalpura Irrigation Workshop (MIW), IPD, GOP
Riazul Haq	Assistant Engineer MIW, IPD, GOP
Tariq Rauf Qureshi	Executive Engineer, Bharwal Irrigation Workshop (BIW), IPD, GOP
Prof. Ghulam Qadir	Irrigation Research Institute, IPD, GOP
M. Younis Ansari	Senior Engineer, Mechanical Circle Lahore, IPD, GOP
Mahmood Ahmad Awan	Assistant Design Engineer, Department Zone, IPD, GOP
Amjad Saeed	Executive Engineer, Marala Barrage Division, IPD, GOP
Naveed Alam	Sub Division Officer, Jinnah Barrage, Kalabagh Division, Thal Canal Circle, Sargodha Irrigation Zone, IPD, GOP
Waqar Khan	Chief Engineer, Lahore Zone, IPD, GOP
Muhammad Saeed	Superintending Engineer, *U.C.C.Link Circle*
Irrigation D. G. Khan Zone, IPD, GOP	
Dr. Bagh Ali Shahid	Chief Engineer, Irrigation D. G. Khan Zone
Masud Anwar Chughtai	Executive Engineer, Irrigation D. G. Khan Zone
Rafif Ansari	Divisional Head Draftsman, Irrigation D. G. Khan Zone
Muzaffargarh Canal Division, Irrigation D. G. Khan Zone, IPD, GOP	
Ch. Muhammad Aslam	Sub Division Officer, Muzaffargarh Canal Division
Taunsa Barrage Division (TBD), Irrigation D. G. Khan Zone, IPD, GOP	
Mehr Muhammad Amin	Executive Engineer, TBD
Rana Muhammad Afzal	Assistant Executive Engineer, TBD
Chudrie Afzal	Sub-Engineer (Hydraulics), Head Works Sub Division, TBD
Inayat Ullah Shah	Sub Engineer, Head Works Sub Division, TBD
Shahid Hassan	Head Draftsman, TBD
M. Maghas Bhutta	Computer Operator, TBD

Name	Position
Muhammad Muneer Anjum	Sub Divisional Officer, Workshop Sub Division, TBD
Malik Khadin Hussain	Sub Division Officer, Bund Sub Division, TBD
Saleem Bhaffi	Sub Engineer, Left Marginal Bank (1), Head Works Sub Division, TBD
Other Organization Concerned in Lahore	
Muhammad Ahsan Raja	Secretary, Planning and Development Department (PDD), GOP
Wasif Sultan Ali Khan	Chief of Water and Power, Planning and Development Department, Lahore, GOP
Chaudhry Ahmad Nadeem	Deputy Director (EIA), Environment Protection Department
Abdur Rabbani Qureshi	Director of Water Resources Management Directorate (room No. 227), WAPDA home, Lahore
Jawed Iqbal Bhatti	Executive Engineer, Maintenance and Communication Division, Hydrology Research Directorate, WAPDA
Muhammad Riaz	Director of RNC, Pakistan Meteorological Department, Lahore
Shar Muhammad	Assistant Director, Survey of Pakistan, Lahore
Syed Mansoob Ali Zaidi	Project Manager, Punjab Barrage Consultants
Shamsher Khan Bhatti	Principal Mechanical Engineer, Punjab Barrage Consultants
Other Organization Concerned in Multan	
Avid Hussan Buzdar	Assistant Manager, MEPCO（Multan Electric Power Co.）
Ch. Mond Sabir	Electric Inspector, Multan, WAPDA
Other Organization Concerned in Islamabad	
Mahjabeen A. Hamid	Planning Coordination Section, Planning and Development Division, Ministry of Planning and Development
World Bank Mission	
Xiaokai Li	Senior Water Resources Specialist, Rural Development Sector Unit, South Asia Region
William T. Smith	Consultant, Land and Water Resources
Punjab Barrage Consultants	
Syed Mansoob Ali Zaidi	Project Manager
Shamsher Khan Bhatti	Mechanical Engineer

Appendix 4. Minutes of Discussion

MINUTES OF DISCUSSIONS
ON
THE BASIC DESIGN STUDY
ON
THE PROJECT FOR REHABILITATION OF GATES OF TAUNSA BARRAGE
IN
ISLAMIC REPUBLIC OF PAKISTAN

Based on the results of the Preparatory Study, the Government of Japan decided to conduct a Basic Design Study on the Project for Rehabilitation of Gates of Taunsa Barrage (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to Islamic Republic of Pakistan (hereinafter referred to as "Pakistan") the Basic Design Study Team (hereinafter referred to as "the Team"), which is headed by Mr. Shigetada KAYUMI, Senior Adviser, Institute for International Cooperation, JICA, and is scheduled to stay in the country from 28 May to 18 July, 2004.

The Team held discussions with the officials concerned of the Government of Pakistan / the Government of the Punjab and conducted field survey at the study area.

In the course of discussions and field survey, both parties confirmed the main items described on the attached sheets. The Team will proceed to further works and prepare the Basic Design Study Report.

Lahore, 15 June, 2004

Shigetada Kayumi
Leader
Basic Design Study Team
Japan International Cooperation Agency
Japan

Javed Majid
Secretary
Irrigation and Power Department Board
The Government of the Punjab
Islamic Republic of Pakistan

Muhammad Ashraf Khan
Joint Secretary
Ministry of Economic Affairs and Statistics
Islamic Republic of Pakistan

Muhammad Ahsan Raja
Secretary
Planning and Development Department
The Government of the Punjab
Islamic Republic of Pakistan

ATTACHMENT

1. Objectives of the Project

Objectives of the Project are as follows;

(1) To improve the present serious operational conditions of the gates of Taunsa Barrage to recover smooth operational conditions.

(2) To contribute to secure the necessary irrigation water volume, and not to cause flood damage to the surrounding area by ensuring proper and timely operation of Taunsa Barrage.

2. Project Site

The Project Site is at Taunsa Barrage in Punjab Province, Pakistan.

3. Japan's Grant Aid Scheme

The Pakistani side understood the Japan's Grant Aid Scheme and the necessary measures to be taken by the Government of Pakistan as explained by the Preparatory Study Team and described in ANNEX-1 and 2 of the Minutes of Discussions signed by both parties on 15 September, 2003.

4. Responsible and Implementing Agency

The responsible and implementing agency is the Irrigation and Power Department of the Government of the Punjab (hereinafter referred to as "IPD"). The organization chart of IPD is shown in Annexure-1 to 3.

5. Project Management Office

The Pakistani side shall set up the Project Management Office (hereinafter referred to as "the PMO") for coordination and supervision for the smooth implementation of the Project by the end of June, 2004. The organization chart of the PMO is shown in Annexure-4.

6. Items proposed by the Preparatory Study Team

Both side agreed that the components of Draft Final Report would be built on the items recommended by the Preparatory Study as follows.

(1) Replace the Under Sluice Gates

1) Replace the under sluice gates (7 gates at left bank side)

2) Improve the deck structure (7 gates at left bank side + 4 gates at right bank side)

3) Renew the gate hoists (7 gates at left bank side)

4) Electrify the gate hoists (7 gates at left bank side)

(2) Improve the Weir Gates

1) Improve the attached facilities for sliding parts of the gates (24 gates)

2) Improve the deck structures (54 gates)

3) Renew the gate hoists (24 gates)

4) Electrify the gate hoists (24 gates)

Note : These 24 gates are not identified yet.

(3) Provide Floating Bulk Head Gates and Relating Items

1) Provide floating bulk head gates (6 gates)

2) Construct a jetty and stock yard for the floating bulk head gates (1 place)

3) Tug boat (2 units)

4) Boats (3 units)

5) 80-Ton crane (1 unit)

6) 30-Ton crane (1 unit)

7) Spare parts (1 set)

7. Schedule of the Study

7-1 The Team will proceed to further survey and study in Pakistan until 18 July, 2004.

7-2 JICA will prepare the draft report in English and dispatch a mission in order to explain its contents around September, 2004.

7-3 In case that the contents of the report are accepted in principle by the Government of Pakistan /the Government of the Punjab, JICA will complete the final report and send it to the Government of Pakistan/the Government of the Punjab by January, 2005.

8. Punjab Barrages Rehabilitation and Modernization Project

8-1 The Pakistani side explained that, by the ongoing Feasibility Study for "the Punjab Barrages Rehabilitation and Modernization Project" (hereinafter referred to as "the PBRM Project") by IPD, the Government of the Punjab acknowledged necessity and urgency for the structural improvement of Taunsa Barrage with giving top priority among the barrages in Punjab. As the result of it, the Government of the Punjab will commence the execution of the work of Taunsa Barrage of the PBRM Project commencing around January, 2005 by World Bank loan.

8-2 Both side agreed that mutual communication and coordination between the Project and the work of Taunsa Barrage of the PBRM Project was very important and that the Technical Coordination Team (hereinafter referred to as "the TCT") should be established for the smooth implementation of both Projects, and would be monitored by the Embassy of Japan, JICA and IPD.

9. Other Relevant Issues

9-1 The Pakistani side promised that, in case the need for revision of the Project arises, then the Project shall be got approved by Executive Committee of National Economic Council by the end of November, 2004.

9-2 The Pakistani side promised that IPD would complete the necessary procedure for environmental and social considerations in Pakistan and would report the results to JICA Pakistan Office by the end of August, 2004. The Team explained that the results would be

checked on the "JICA Guidelines for Environmental and Social Considerations" and would forward the results to IPD by the end of September, 2004.

9-3 The Pakistani side explained that the additional operation and maintenance cost by this Project and the work of Taunsa Barrage of the PBRM Project were fully allocated by the Provincial budget and not by the beneficiaries sharing. The Team promised that the additional operation and maintenance cost for the Project would be estimated and reported to IPD in the Draft Final Report.

9-4 The Pakistani side explained that the bulk head gates would be used for the rehabilitation of other barrages in Punjab after the Project. The Team will survey their design and structure to evaluate the possibility of the use.

9-5 The Pakistani side requested the technical support and capacity building for design, manufacturing, operation and maintenance of the bulk head gates. The team will consider the necessity, appropriateness and contents of the technical support in further study.

9-6 The Pakistani side explained that the responsibility for the operation and maintenance for the Project was Taunsa Barrage Division, D.G.Khan Irrigation Zone, IPD, as shown in Annexure-3. The operation and maintenance budget of Taunsa Barrage is shown in Annexure-6.

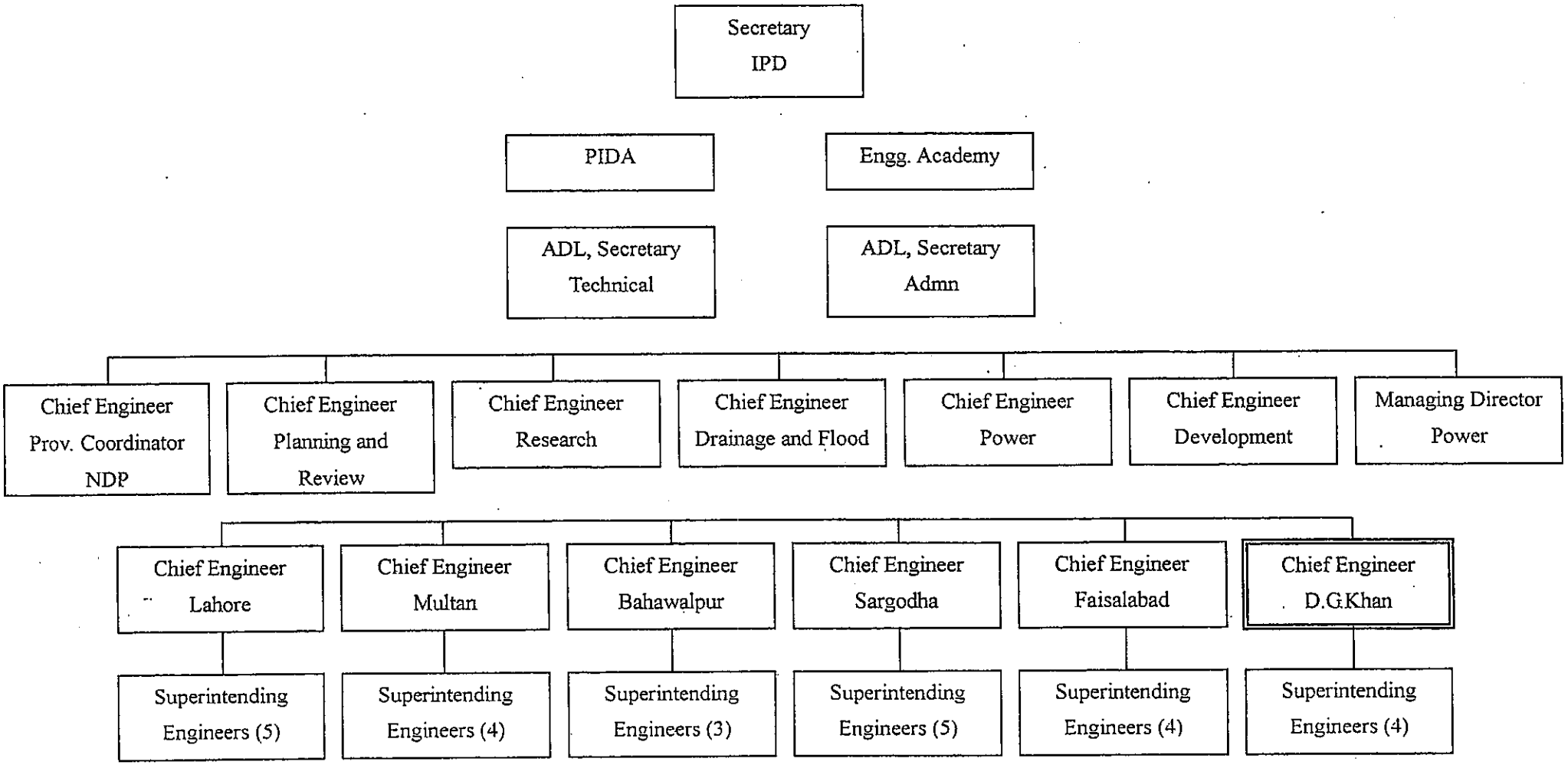
The mechanical or electrical troubles of gates are repaired at the following workshops. The organization chart of each workshop is shown in Annexure-7.

- Small-scale mechanical troubles are repaired at the Taunsa Workshop
- Large-scale mechanical troubles are repaired at the Moghalpura and Bhalwal Workshop
- Electrical troubles are repaired at the Moghalpura Workshop

9-7 The Team conveyed the understanding from the Ministry of Agriculture, Forestry and Fisheries of Japan, that Japanese Grant Aid for the agriculture sector should be provided for a project in which production of rice, vegetables and fruits are not for export to Japanese market and are for domestic supply under the current situation in Japan.

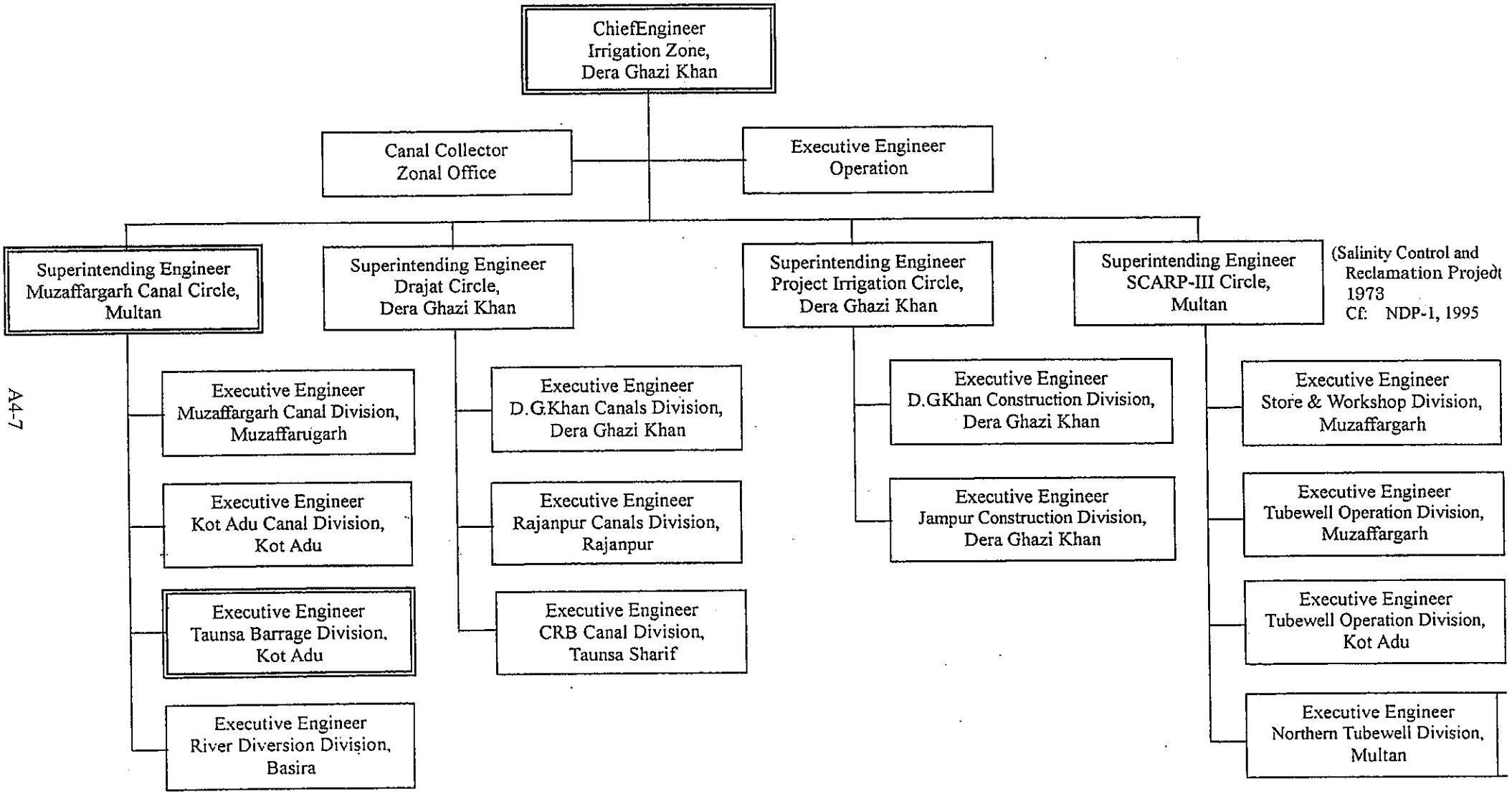
The Pakistani side understood it and expressed that the agricultural products which will benefit from the Project and give some negative impact to the agricultural producers in Japan by their export would not be exported to Japanese market.

(Annexure-1)



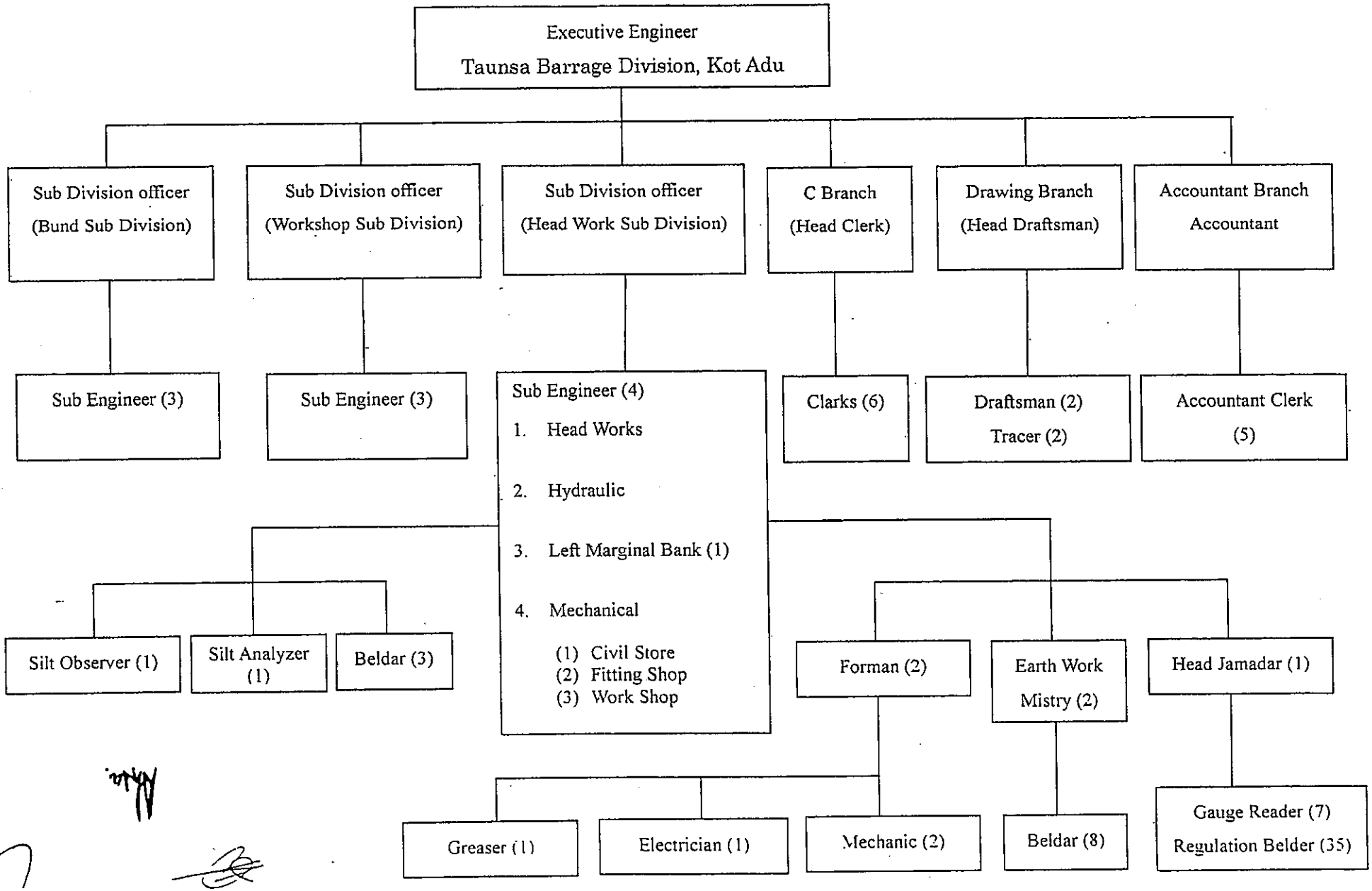
IPD Organization

(Annexure-2)



D.G.Khan Irrigation Zone Organization

(Annexure-3)



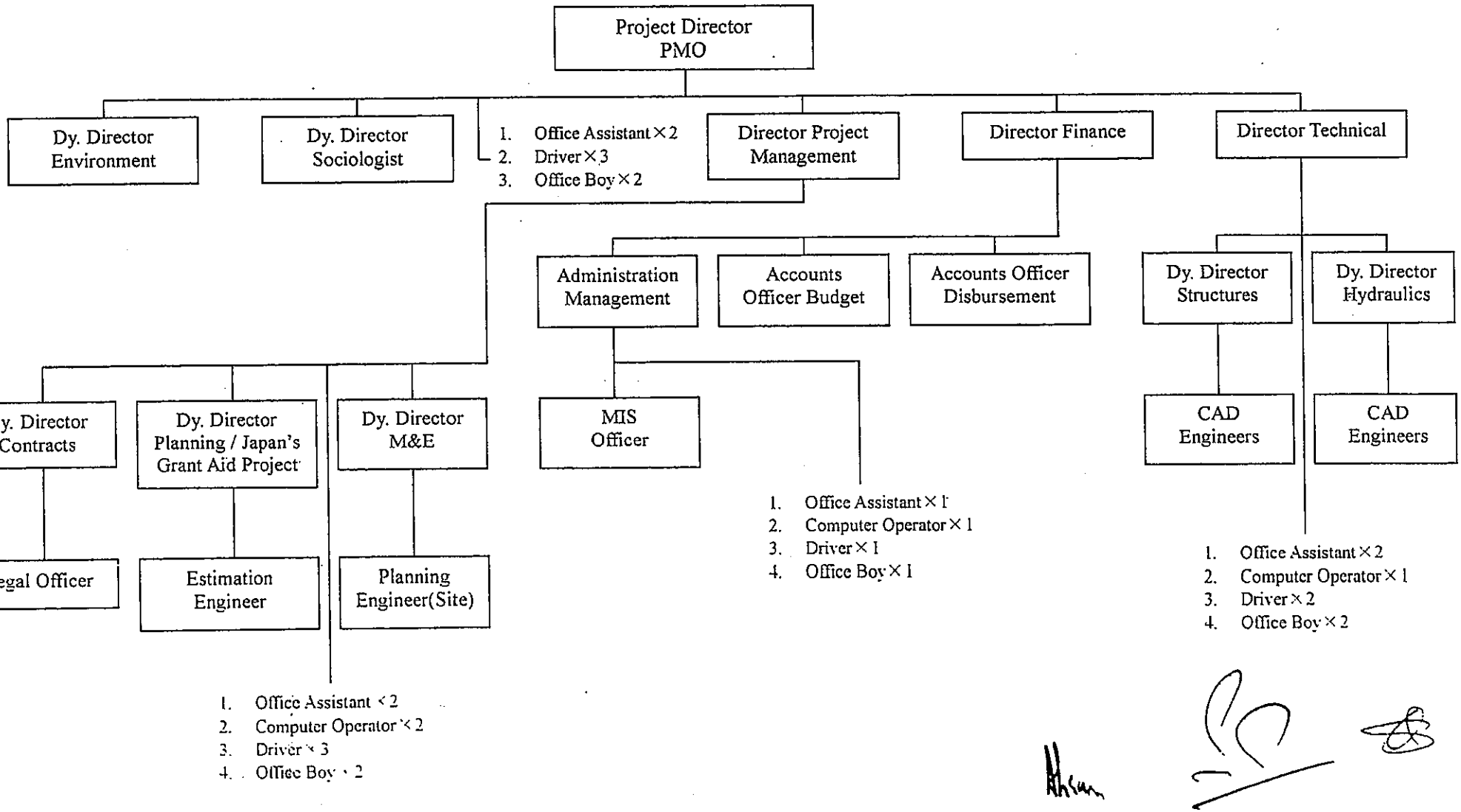
TAUNSA BARRAGE DIVISION ORGANIZATION

A4-8

(Annexure-4)

Project Management Office (PMO)

The Project for Rehabilitation of Gates of Taunsa



PUNJAB BARRAGES REHABILITATION AND MODERNIZATION PROJECT.

SCOPE OF WORK

- Constructing Subsidiary weir.
- Improvement of D/S Floor
- Constructing Silt excluder in Right Pocket.
- River Training Works
- Mechanical Component Gates/Gearing etc.

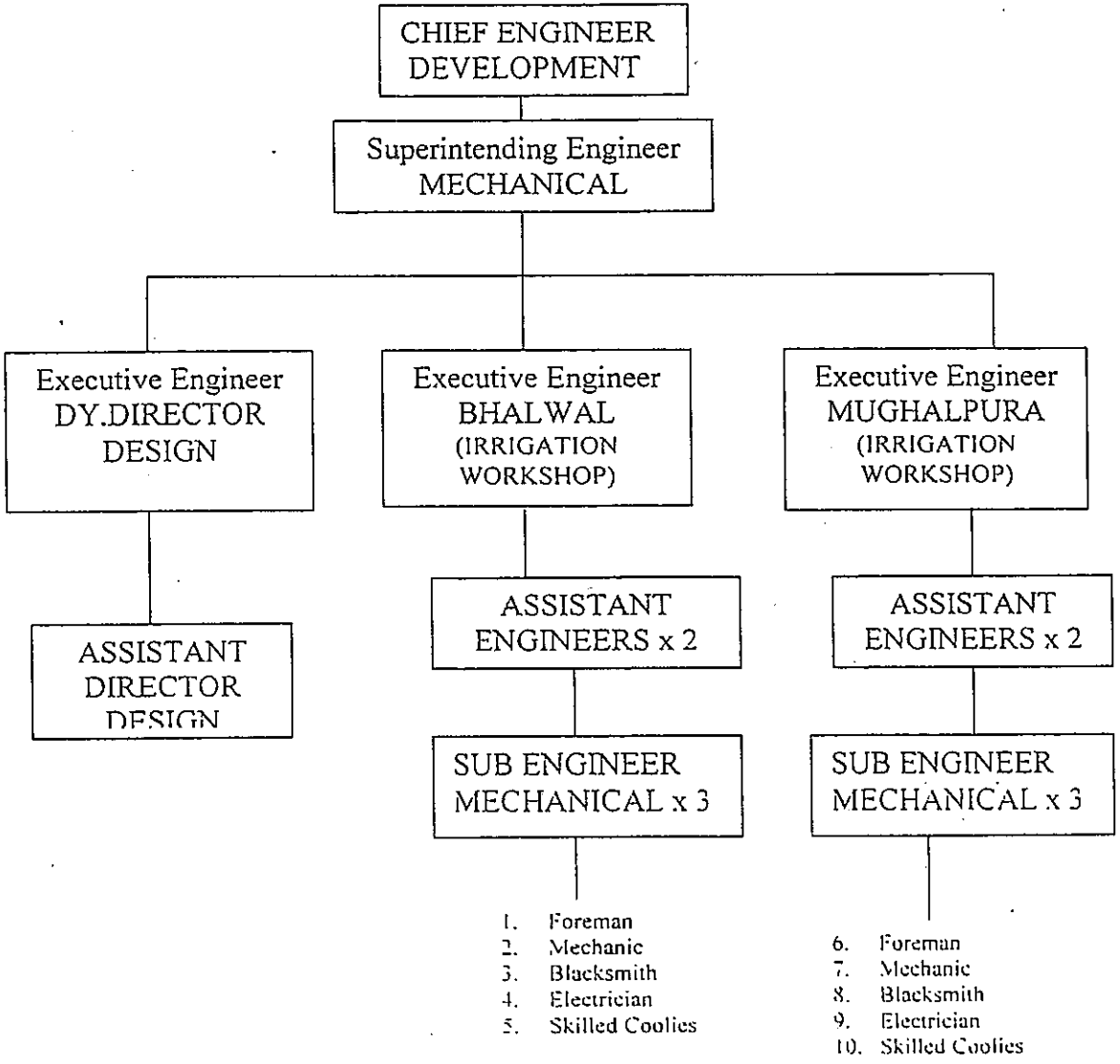
M&R EXPENDITURE OF TAUNSA BARRAGE DIVISION KOT ADU.

For the year 1994-95 to 2003-04

Sr. NO.	Year	Expenditure of Major Repairs (Rs. in Million)	Expenditure of Minor Repairs (Rs. in Million)
01.	1995-96	6.72	0.80
02.	1996-97	14.48	2.10
03.	1997-98	12.56	1.80
04.	1998-99	15.34	3.35
05.	1999-2000	6.21	2.20
06.	2000-2001	14.24	4.15
07.	2001-2002	22.57	3.75
08.	2002-2003	50.91	5.25
09.	2003-2004	92.00	27.50
	Total	**235.03**	**27.50**

(Annexure –7)

ORGANIZATION SETUP OF IRRIGATION WORK SHOPS.



MINUTES OF DISCUSSIONS
ON
BASIC DESIGN STUDY
ON
THE PROJECT FOR REHABILITATION OF GATES OF TAUNSA BARRAGE
IN
ISLAMIC REPUBLIC OF PAKISTAN
(EXPLANATION ON DRAFT FINAL REPORT)

In June 2004, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Basic Design Study Team on the Project for Rehabilitation of Gates of Taunsa Barrage (hereinafter referred to as "the Project"), and through discussion, field survey, and technical examination of the study in Japan, JICA prepared a draft final report of the study.

In order to explain and to consult Islamic Republic of Pakistan (hereinafter referred to as "Pakistan") on the components of the draft final report, JICA sent to Pakistan the Draft Final Report Explanation Team (hereinafter referred to as " the Team "), which is headed by Mr. Shigetada KAYUMI, Senior Adviser, Institute for International Cooperation, JICA and has been scheduled to stay in the country from 14 to 24 September, 2004.

As a result of discussions, both parties confirmed the main items described on the attached sheets.

Lahore, 22 September, 2004

Shigetada Kayumi
Leader
Basic Design Study Team
Japan International Cooperation Agency
Japan

Javed Majid
Secretary
Irrigation and Power Department Board
Government of the Punjab
Islamic Republic of Pakistan

Muhammad Ashraf Khan
Joint Secretary
Ministry of Economic Affairs and Statistics
Islamic Republic of Pakistan

Dr. Muhammad Abid Bodla
Member (Engineering)
Planning and Development Department
Government of the Punjab
Islamic Republic of Pakistan

ATTACHMENT

1. Components of the Draft Final Report

The Government of Pakistan agreed and accepted in principle the components of the Draft Final Report explained by the Team.

2. Japan's Grant Aid scheme

The Pakistani side understood the Japan's Grant Aid Scheme and the necessary measures to be taken by Government of Pakistan/Government of the Punjab as explained by the Preparatory Study Team and described in ANNEX-1 and 2 of the Minutes of Discussions signed by both parties on 15 September, 2003.

3. Schedule of the Study

JICA will complete the final report in accordance with the confirmed items and send it to Government of Pakistan/Government of the Punjab by around January, 2005.

4. Gate Height of the Taunsa Barrage

4-1. The Pakistani side requested to the Team officially, as shown in Annex-1, that the height of all gates of Taunsa Barrage would be increased by 1ft. The Team explained that the request shall be considered in Japan and shall report the results including the estimated Project cost to the Pakistani side by the middle of October, 2004.

4-2. The Pakistani side confirmed that IPD shall obtain the anticipatory approval by Executive Committee of National Economic Council for the revision of the PC-1 for the Project by the end of November, 2004.

4-3. The Pakistani side explained that IPD had completed the necessary procedure for environmental and social considerations in Pakistan including the impact by increase the gate height and had obtained the clearance and approval by the Environment Protection Department, Government of Punjab on 6 September, 2004, as shown in Annex-2. The Team explained that the results would be checked on the "JICA Guidelines for Environmental and Social Considerations" and would forward the results to IPD by the end of October, 2004.

5. Punjab Barrages Rehabilitation and Modernization Project

5-1. The Pakistani side explained that the draft PC-1 for the work of Taunsa Barrage of "the Punjab Barrages Rehabilitation and Modernization Project" (hereinafter referred to as "the PBRM Project") by the Government of the Punjab using the World Bank Loan shall be submitted to JICA Pakistan Office by the end of September, 2004.

5-2. The Team and the Pakistani side agreed that mutual communication and coordination between the Project and the work of Taunsa Barrage of the PBRM Project was very important and that

the Technical Coordination Team, described the Minutes of Discussions signed by both parties on 15 June, 2004, should be used for it if necessary.

6. Other Relevant Issues

6-1. As the results of survey on procurement and maintenance condition in the Punjab Province, the Team explained that the minimum regular cost for the operation and maintenance in the Project under proper use was estimated as shown in the Draft Final Report. The Pakistani side promised to allocate the necessary budget and personnel for operation and maintenance based on the PC-1 for the Project.

6-2. The Team and the Pakistani side agreed that the reclamation and embankment at the stockyard for the bulkhead gates shall be completed by the Pakistani side by the end of December, 2005.

6-3. The Team and the Pakistani side agreed that the IRSA's telemetry panel and gate positioning indicator on the deck of the superstructure shall be adjusted by Pakistani side to cater for the changes in the gate height.

6-4. The Team and the Pakistani side confirmed that IPD was responsible for the management and monitoring for the road closure on the Taunsa Barrage from 8 to 12 o'clock and 13 to 17 o'clock during dry season in 2007 and 2008. The public announcement about the road closure shall be carried out by IPD in advance by mass media.

Annex-I

From

Provincial Coordinator Barrages/
Chief Engineer (Research)
Irrigation & Power Department,
Lahore

To

Mr. Yamaura Nobuyuki
Resident Representative
Japan International Cooperation Agency
Pakistan Office Islamabad

No. 507 /52-M Dated 21-09-2004.

SUBJECT: GATE AND CREST HEIGHTS OF TAUNSA BARRAGE

Panel of Expert's (POE's) appointed in consultation with the World Bank for Punjab Barrages Rehabilitation & Modernization Project reviewed the feasibility study and design parameters prepared by the consortium of consultants M/S NDC & NESPAK and it was decided to keep the normal pond level at RL 447.0 and not to raise the crest (cill) level at Taunsa Barrage in order to avoid the possible adverse impacts on river morphology and consequent effects on Barrage capacity and permanent rise in water level compatible with the requirement of ecology and environment.

The pond level of RL 447.0 is also the operational requirement to feed DG Khan Canal since last three decades. Accordingly we would like to request the JICA Team to consider incorporating the needed raising of gates height by 1.0 ft for Taunsa Barrage Gates Rehabilitation Project.

We appreciate your continued cooperation in this regard.

With best wishes.

ENGR. EHSAN ULLAH SARDAR
Provincial Coordinator Barrages/
Chief Engineer (Research),
I&P Department, Lahore

C.C.

1. Mr. Shigetada Kayumi, Leader Basic Design Study Team, JICA.
2. Mr. Tatsuhiko MORI, Project Manager Basic Design Study Team, JICA, Sanyu Consultants Inc.
3. Secretary, Government of the Punjab, I&P Department, Lahore

Annex-2

ENVIRONMENT PROTECTION DEPARTMENT

Government of the Punjab
4 - Lytton Road; Lahore.

REGISTERED

NO. 352 /E-9/M/0609/EIA

Dated 06 / 09/ 2004

To

The Chief Engineer (Research),
Irrigation & Power Department,
Government of the Punjab,
Lahore.

Subject:- DECISION ON ENVIRONMENT IMPACT ASSESSMENT (EIA)

Description of Project:	The project of rehabilitation and modernization of Taunsa Barrage consist of the following scope of work: • Ensuring structural stability of existing barrage, construction of a subsidy weir downstream to provide a cushion water to mitigate the effect of hydraulic jump. • Remodeling of Right Pocket by adding three more bays. • Construction of four J-shaped spurs to address problem of oblique river approach of Indus. • Gate gearing system to be made electronic. • Enhancement of availability of canal water.
Location of Project:	The Taunsa Barrage, built over River Indus is located at 30° 31 feet N and 70° 51 feet E in the south-west of the Punjab in Tehsil Kot Adu of District Muzaffargarh.

3. The Environmental Protection Agency (EPA), Punjab has decided to accord its approval for construction phase of the project subject to the following conditions:

(i) Hazard of soil erosion will be minimized with the proper provision for resurfacing of exposed areas.

(ii) Monitoring shall be carried out during the entire period of the project activities. Monitoring reports of the whole operation should be submitted to EPA, Punjab on monthly basis.

(iii) Mitigation measures and environmental guidelines recommended in the EIA report and Environment Management Plan should be strictly adhered to minimize negative environmental impacts of the project.

(iv) All the un-skilled and to the extant possible skilled jobs shall be given to locals after providing them proper training.

(v) Extensive tree plantation, especially the plantation of indigenous species, must be carried out in the area to enhance environmental conditions.

(vi) Camping sites should be located at least 500 meters away from any settlement to avoid disturbance to the local people. Sewage generated from camping sites should be treated in septic tanks and soak pits if drainage system is not available. These should be constructed at a minimum distance of 300 meter from any permanent or seasonal water source. Septic tank and soak pits should not be located in the areas where high ground water table exists.

(vii) The proponent shall ensure that strict and efficient health and safety measures are in place for protection of workers backed by a comprehensive emergency response system.

4. This approval shall be treated as null and void if all or any of the conditions, mentioned in para 3 above are not complied with.

5. The proponent shall be liable for compliance of Section 13, 14, 17 and 18 of IEE/EIA Regulations 2000, regarding approval, confirmation of compliance, entry, inspections and monitoring. (P.T.O)

6. This approval is accorded only for construction phase of the project. Before commissioning of the Barrage, the proponent is liable to obtain approval in accordance with Section 13(2)(b) and Section 18 of the EIA/IEE Regulation, 2000.

7. Any change in the approved project shall be communicated to EPA, Punjab and shall be commenced after obtaining the approval.

8. This approval does not absolve the proponent of the duty to obtain any other approval or consent that may be required under any law in force.

ASSISTANT DIRECTOR (EIA)
for D.G EPA, Punjab

Endst. No._____/F-93/0609/2K4/EIA

Dated._____/09/2004

A copy is forwarded for information to:

1. The Director (P&C), EPA, Punjab, Lahore.
2. The Director (ML&I), EPA, Punjab, Lahore.

ASSISTANT DIRECTOR (EIA)
for D.G EPA, Punjab

Appendix-5 List of Data Collected

No.	Name	Form	Original / Copy	Publisher	Year
1	STATEMENT SHOWING YEAR WISE SERIOUS DAMAGES AT TAUNSA BARRAGE	Paper	Copy	IPD, TAUNSA Barrage Division Office	
2	A BRIEF NOTE ON FAN MANAGEMENT OF MITHAWAN HILL TORRENT IN D.G.KHAN DISTRICT	Book	Original	D.G.KHAN Irrigation office	
3	Presentation to Pakistan Development Forum "Infrastructure for Accelerated Growth" March 17 – 19, 2004 Water Sector Improvement Programme in Sindh By Chairman, Sindh Irrigation & Drainage Authority	Paper	Copy	JICA Pakistan Office	
4	PC - 1 PROFPRMA PUNJAB BARRAGE REHABILITATION AND MODERNIZATION PROJECT VOLUM-1	Paper	Copy	IPD, Pumjab (JICA Pakistan Office)	May, 2003
5	PC-1 PROFPRMA TAUNSA BARRAGE IRRIGATION SYSTEM REHABILITAION PROJECT	Paper	Copy	IPD, Pumjab (JICA Pakistan Office)	August, 2002
6	PRESENTATION ON WATER SECTOR PROGRAM N.W.F.P BY MUHAMMAD SHEHZAD ARBAB SECRETARY IRRIGATION & POWER DEPARTMENT	Paper	Copy	JICA Pakistan Office	
7	PAKISTAN DEVELOPMENT FORUM WATER SECTOR: DEVELOPMENT STRATEGIES	Paper	Copy	IPD, Pumjab (JICA Pakistan Office)	

No.	Name	Form	Original / Copy	Publisher	Year
8	PRESENTATION ON WATER SECTOR DEVELOPMENT By AFTAB AHMAD KHAN SHERPAO Minister for Water and Power At Pakistan development Forum March 18, 2004	Paper	Copy	JICA Pakistan Office	
9	WATER RESOUCE DEVELOPMENT PLAN	Paper	Copy	IRRIGATION AND POWER DEVELOPMENT GOVERNMENT OF N.W.F.P (JICA Pakistan Office)	March, 2004
10	DRAFT SPEECH BY THE MINISTER FOR WATER AND POWER AT PAKISTAN DEVELOPMENT FORUM, MARCH 18, 2004	Paper	Copy	JICA Pakistan Office	
11	CHALLENGES IN THE WATER SECTOR Pakistan Development Forum Presentation by M. Ali Shah, Country Director, ADB Pakistan Resident Mission	Paper	Copy	JICA Pakistan Office	March , 2004
12	BRIFFING TO THE CHIF SECRETARY PUNJAB	Paper	Copy	JICA Pakistan Office	
13	PAKISTAN WATER SECTOR STRATEGY MEDIUM TERM INVESTMENT PLAN (2003 –2011) Volume 3	Paper	Copy	IPD (JICA Pakistan Office)	October, 2002
14	TAUNSA HYDROPOWER PROJECT 120 MW	Paper	Copy	WAPDA (JICA Pakistan Office)	
15	Schematized Drawing of Indus Irrigation System	Drawing	Copy	IPD, TAUNSA Barrage Division Office	
16	TAUNSA CANAL COMMAND	Drawing	Copy	IPD, TAUNSA Barrage Division Office	

No.	Name	Form	Original / Copy	Publisher	Year
17	INNDEX PLAN OF KOT ADU CANALS DIVISION KOT ADU	Drawing	Copy	IPD, Kot Adu Canals Division Office	
18	STATEMENT SHOWING GRANT / FUNCTION WISE LIST OF VACNCIES OF TAUNSA BARRAGE DIVISION, KOT ADU FOR THE MONTH OF / 2004	Paper	Copy	IPD, TAUNSA Barrage Division Office	
19	FEASIBILITY STUDY FOR PUNJAB BARRAGES REHABILITATION PROJECT PLOPOSED WORK SCHEDULE	Paper	Copy	IPD	
20	Monthly Meteorological Data（Rainfall、Rainfall Days、Average / Maximum Temperatures、Humidity、Wind Direction / Speed）：D.G.Khan（2003）、Multan（1994-03）	Computer File	Copy	Meteorological Department of Punjab, Lahore	—
21	Daily Rainfall Data at Taunsa Barrage（1994-2003）	Computer File	Copy	Taunsa Barrage Division, IPD	Yearly
22	Indus River Discharge Data in 10days average：1994-2003 (Tarbela, Kalabagh, Chashma, Taunsa)	Paper	Copy	WAPDA	Yearly
23	Register of Silt Entry, Hydraulic Section, Taunsa Barrage (Daily SS data at the intake of D. G. Khan Canal)	Computer File	Copy	Taunsa Barrage Division, IPD	1994-2003
24	Silt Soundings of Right Pocket, Taunsa Barrage	Computer File	Copy	Taunsa Barrage Division, IPD	1994-2003
25	Master Feasibility Studies for Flood Management of Hill Torrents of Pakistan, November 1998", Main Report, Supporting Vol. II and Supporting Vol. III	Report	Copy	Federal Flood Commission, Ministry of Water and Power	1998
26	National Flood Protection Plan 1978	Report (a part)	Copy	Government of Punjab, Federal Flood Commission	1978

No.	Name	Form	Original / Copy	Publisher	Year
27	Feasibility Study Scarp Dera Ghazi Khan Phases I and II (Surface and Subsurface Drainage) Final Report Volume I Main Report June 1995	Report	Copy	WAPDA	1995
28	TOR of Feasibility Study for Punjab Barrages Rehabilitation Project Phase-I [Taunsa, Khanki and Suleimanki], Agreement between the Government of Punjab Irrigation and Power Department and Joint Venture Comprising, November, 2003"	Report	Copy	Government of Punjab	2003
29	Feasibility Study for Punjab Barrages Rehabilitation Project Phase-I (Taunsa, Khanki & Suleomanki Barrages), Design Criteria, April 2004, GoP, IPD Punjab	Report	Copy	Government of Punjab	2004
30	PC-1 Proforma for Checking Serious Embayment by Re-constructing J-Head Spur 1-B, RD:29000 Shahwala Groyne,	Paper	Copy	D. G. Khan Irrigation Zone, IPD	—
31	Flood Fighting Plan of Taunsa Barrage, April 2004	Report	Original	Taunsa Barrage Division, IPD	2004
32	Walkway lighting layout & Schematic diagram	Drawing	Copy	IPD, TAUNSA Barrage Division Office	
33	Lighting Details	Drawing	Copy	IPD, TAUNSA Barrage Division Office	
34	Feeder Load and Energy Data at Grid Station	Paper	Copy	MEPCO（Power Company, Taunsa）	
35	Tripping record of feeder no. 4	Paper	Original	MEPCO（Power Company, Taunsa）	

No.	Name	Form	Original / Copy	Publisher	Year
36	Feeder Demand Data	Paper	Copy	MEPCO（Power Company, Taunsa）	
37	Single Line diagram of 11kV feeder No.4	Paper	Copy	MEPCO（Power Company, Taunsa）	
38	Site Plan of Beldar's Quarters at Taunsa Barrage	Paper	Copy	IPD, TAUNSA Barrage Division Office	
39	Technical Data of Feeders	Paper	Copy	MEPCO（Power Company, Taunsa）	
40	Base map of 11kV T/well feeder No.4	Paper	Copy	MEPCO（Power Company, Taunsa）	
41	Hard-copy on display on Tele-metering system	Paper	Copy	Siemens (Taunsa)	
42	Tariff Rate (hand writing memo)& Electricity Consumer Bill	Paper	Copy	MEPCO（Power Company, Taunsa）	
43	Standardized Specification of Stores	Paper	Copy	IPD, MIW	
44	TERMS OF REFERENCE of AGREEMENT (ANNEXRE-B), Feasibility Study for Punjab Barrages Rehabilitation Project Phase-1 (Taunsa, Khanki and Sulemanki)	Paper	Copy	IPD	
45	Letter of Approval of "TAUNSA BARRAGE IRRIGATION SYSTEM REHABILITATION PROJECT" approved by the ECNEC Meeting held on 23.04.2003	Paper	Copy	JICA	

No.	Name	Form	Original / Copy	Publisher	Year
46	Minute of the EXECUTIVE COMMITTEE OF THE NATIONAL ECONOMIC COUNCIL MEETING HELD ON 7.1.2004, AT ISLAMABAD including DECISION of "Punjab Barrage Rehabilitation and Modernization Project"	Paper	Copy	IPD	
47	-ditto-	Paper	Copy	JICA	
48	Brief on Punjab Irrigation & Power Department, October 2003	Paper	Copy	IPD	
49	IPD Expenditure 1997/98 to 2001/02	Paper	Copy	IPD	
50	TEN YEAR PROSPECTIVE DEVELOPMENT PLAN 2001-11(Excerption)	Paper	Copy	PDD	
51	Organization Chart of Bureau of Statistics Punjab	Paper	Copy	Bureau of Statistics Punjab	
52	Feasibility Study SCARP DERA GHAZI KHAN Phase I and II, Final Report (Main & Annexes) *	Book	Copy	D.G.Khan Zone Office	
53	Feasibility Report Control of Waterlogging Hazards in MUZAFFARGARH CANAL COMMAND, Final Report (Main & Annexes) *	Book	Copy	D.G.Khan Zone Office	
54	Feasibility Study for Punjab Barrages Rehabilitation Project Phase –1 (Taunsa, Khanki & Suleimanki Barrages) Volume I – Main Report	CD	Copy	Punjab Barrage Consultant	2004.7
55	Feasibility Study for Punjab Barrages Rehabilitation Project Phase –1 (Taunsa, Khanki & Suleimanki Barrages) Volume II – Appendixes	CD	Copy	Punjab Barrage Consultant	2004.7

Appendix-6 Other Relevant Data and Information

A6-1. Cost Estimation born by the Recipient Country

= ¥1.9

Item	Unit	Q'ty	Unit Cost (1000 Rs)	Amount (1000 Rs)	Conversion to Yen (Million Yen)	Remarks
1) Embankment of the Stockyard for Bulkhead Gate	lot	1.0	14,809	14,809	28.1	
2) Construct Fence around Stockyard for Bulkhead	lot	1.0	258	258	0.5	
3) Removal of Telemeter Panel	lot	1.0	353	353	0.7	
4) Bank Service Charges	lot	1.0	78,316	78,316	148.8	3% of grant aid project cost
Total				**93,736**	**178.1**	

	Item	unit	Amount	Unit Cost (Rs)	Amount (Rs)	Convert into Yen (JY)	Remarks
Reclaim of the Stockyard for Burlkhead Gate							
	Direct cost	m^3	100,500				
	Excavation soil for	m3	111,667	24	2,680,001	5,092,002	Unit cost No 3-4
	Hauling soil about 10km	m3	111,667	42	4,690,001	8,911,002	Unit cost No 1-2
	Embankment	m3	100,500	12	1,206,000	2,291,400	Unit cost No 3-25
	Saping the slope	m2	9,000	1	9,000	17,100	Unit cost No 3-19
	Sub total				8,585,002	16,311,504	
	Overhead Cost & others (50% of direct cost)				4,292,501	8,155,752	
	Total Round by 1000Rs				12,877,000		
	TAX 15%				1,931,550		
	Grand Total 110.0 \/$				14,808,550	28,136,245	
	1.9 \/R						

	Item	unit	Amount	Unit Cost (Rs)	Amount (Rs)	Convert into Yen (JY)	Remarks
Construction of Fence around Stockyard for Bulkhead Gate							
		m	370				
	Fence (H=1.8m)	m	370	216	79,920	151,848	Unit cost No 25-50
	Gate of fence(W=2m×2)	no	2	34,919	69,838	132,692	Unit cost No 25-31
	Sub total				149,758	284,540	
	Overhead Cost & others (50% of direct cost)				74,879	142,270	
	Total Round by 1000Rs				224,000	425,600	
	TAX 15%				33,600	63,840	
	Grand Total 110.0 \/$				257,600	489,440	
	1.9 \/R						

	Item	unit	Amount	Unit Cost (Rs)	Amount (Rs)	Convert into Yen (JY)	Remarks
Removal of Telemeter Panel							
		place	**9**				
	Remove panel	place	9	12,100	108,900	206,910	
	Remove cable	place	9	2,100	18,900	35,910	
	Remove cable rack	place	9	5,300	47,700	90,630	
	Remove pullbox	place	9	3,300	29,700	56,430	
	Sub total				205,200	389,880	
	Overhead Cost & others (50% of direct cost)				102,600	194,940	
	Total Round by 1000Rs				307,000	583,300	
	TAX 15%				46,050	87,495	
	Grand Total 110.0 ¥/$				353,050	670,795	

	Item	unit	Amount	Unit Cost (Rs)	Amount (Rs)	Convert into Yen (JY)	Remarks
Remove panel		**place**	**1**				
Replace		Piece	1				
	Electric Engineer	man-day	0.8	3,000	2,400	4,560	
	Electrician	man-day	2.2	1,000	2,200	4,180	
Setting							
	Electric Engineer	man-day	1.3	3,000	3,900	7,410	
	Electrician	man-day	3.6	1,000	3,600	6,840	
	Total				12,100	22,990	
Remove cable		**place**	**1**				
Replace		m	4				
	Electrician	man-day	0.3	3,000	900	1,710	
Setting							
	Electrician	man-day	0.4	3,000	1,200	2,280	
	Total				2,100	3,990	
Remove cable rack		**place**	**1**				
Replace		m	4				
	Electrician	man-day	0.6	3,000	1,800	3,420	
Setting							
	Electrician	man-day	0.9	3,000	2,700	5,130	
	Cable	m	4	200.00	800	1,520	
	Total				5,300	10,070	
Remove pullbox		**place**	**1**				
Replace		piece	2				
	Electrician	man-day	0.4	3,000	1,200	2,280	
Setting							
	Electrician	man-day	0.7	3,000	2,100	3,990	
	Total				3,300	6,270	

A6-2. Economic Analysis of Bulk Head Gate Numbers to be introduced to the Project

1 **Bulk Head Gate Units, Cost and Rehabilitation Period including Punjab Project**

BHG No.	Investment Cost (M.Rs)	Taunsa Barrage 29 units (Grant.A.P)	Taunsa Barrage 36 units (Punj. P)	Total 65 units
4 units	118.00	2.5 yr	4.5 yr	7 yr
5 units	143.00	2 yr	2.5 yr	4.5 yr
6 units	174.00	2 yr	2.5 yr	4.5 yr
7 units	205.00	1.5 yr	2 yr	3.5 yr

Note : Rehabilitation Periods indicated above do not include the period of fablication of Bulk Head Gates which is regaerded as the common period required for every cases.

2 **Investment Cost (Million Rs.)** Ex. Rate Rs. 1.00 = ¥2.000

BHG Unit Cost J\ 50 million M.Rs. 25.00

SV Unit Cost J\ 12 million/No M.Rs. 6.00

(SV: Supervisor for Gate Fablication)

BHG Nos.	BHG Cost (M. Rs)	SV Nos.	SV Cost (M. Rs)	Investment Cost (M. Rs)
4	100.00	3	18	118.00
5	125.00	3	18	143.00
6	150.00	4	24	174.00
7	175.00	5	30	205.00

3 **BHG Maint. Cost** (Paint & Seal Rubber Change) 1.5 M. Rs/Unit/time @ 7 years

4 **Gate Maint. Cost (M.Rs)** 0.023M.Rs/unit 0.67 0.83 1.50

Ref. Annual Gate Maintenance Cost of Taunsa Barrage

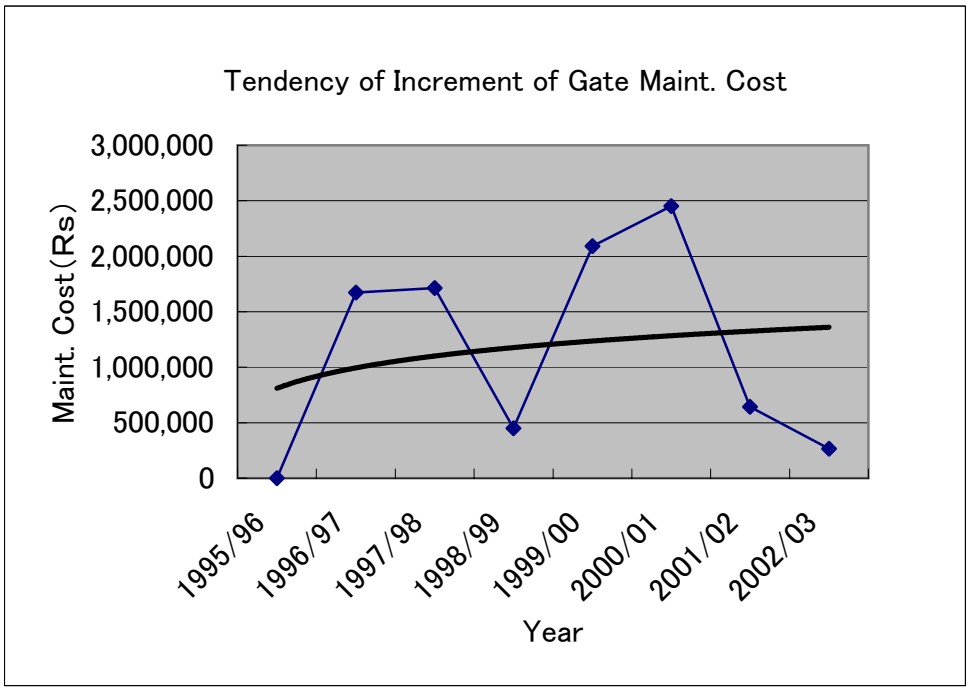
F. Yr	Total Maint. Cost in TBD (Rs)	Gate Maint. Cost (Rs)	Persentage (%)
1995/96	4,173,588	0	0.0
1996/97	14,556,940	1,673,613	11.5
1997/98	6,303,947	1,714,880	27.2
1998/99	11,247,346	449,036	4.0
1999/00	3,964,042	2,092,475	52.8
2000/01	24,274,061	2,450,702	10.1
2001/02	7,534,751	642,780	8.5
2002/03	49,964,065	265,000	0.5
Average	15,252,343	1,161,061	7.6

Gate Maintenance Cost has been required 1.161M.Rs in average during last 8 years. As indicated in the figure below, maintenance cost for gate required in future without the project is estimated at 1.5 million Rs /yr /65 gates in consideration of recent tendency of cost increment.

Accordingly,

Maintenance Cost for One Gate = 1.5 M. Rs /65 gates
= 0.023 M. Rs/gate

After rehabilitation, maintenance cost 0.023 M Rs will be reduced per one gate.



5 Supervision Cost of Project Implementation

Grant Aid Project M.Rs. 28.41 per yr
Punjab Project M.Rs. 8.55 per yr

Staff		Months	Unit Cost (M. J\)	Annual Cost (M. J\)	(M. Rs)
Grant Aid Project per year					
Japanese	Manager	12	1.15	13.80	6.90
	Civil Eng.	9	0.87	7.83	3.92
	Mechanical Eng.	9	0.87	7.83	3.92
	Electrical Eng.	6	0.87	5.22	2.61
	Accountant	12	0.87	10.44	5.22
	Sub total			45.12	22.56
Local	Mechanical Eng.(2)	18	0.15	2.70	1.35
	Electrical Eng. (2)	12	0.15	1.80	0.90
	Accountant (1)	12	0.10	1.20	0.60
	Others (3)	36	0.05	1.80	0.90
	Sub total			7.50	3.75
Office Expences		L..S.		1.80	0.90
Air Fee		6	0.40	2.40	1.20
Total				56.82	28.41

Pumjab Project per year

Local	Manager	12	0.25	3.00	1.50
	Civil Eng. (1)	9	0.15	1.35	0.68
	Mechanical Eng.(3)	27	0.15	4.05	2.03
	Electrical Eng. (3)	18	0.15	2.70	1.35
	Accountant (2)	24	0.10	2.40	1.20
	Others (3)	36	0.05	1.80	0.90
	Sub total			15.30	7.65
Office Expences		L..S.		1.80	0.90
Total				17.10	8.55

6 **Consultant Fee**

Grant Aid Project per year

Japanese	Manager	12	1.91	22.92	11.46
	Expert	8	1.91	15.28	7.64
Office Expences		L..S.		6.19	3.10
Air Fee		5	0.40	2.00	1.00
Total				46.39	23.20

Pumjab Project per year

Local	Manager	12	0.4	4.80	2.40
	Expert	8	0.4	3.20	1.60
Office Expences		L..S.		1.80	0.90
Total				9.80	4.90

7 **Calculation Result of N.P.V.**

BHG (Nos)	N. P. V. (M. Rs)	Ratio
4	276	1.01
5	275	1.00
6	307	1.12
7	313	1.14

Intarest = 12%

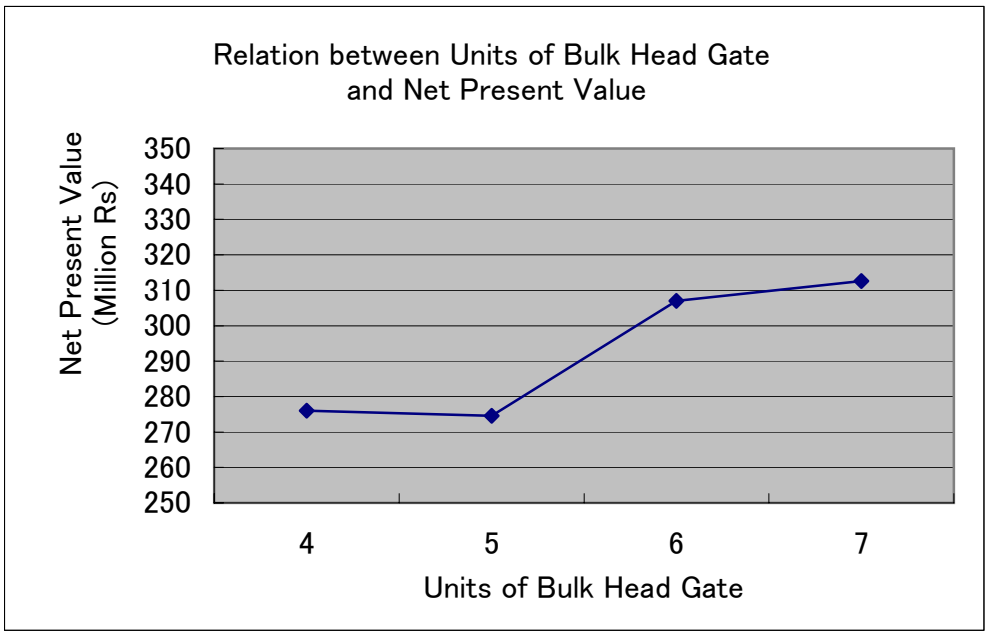


Table A6-2.1 Calculation of Net Present Value

Bulk Head Gate 4 units (Unit:M.Rs

Year		Cost					Discount Rate	Net Present Value	Remarks
Project Year	A.D.	BHG Cost	BHG Maint. C	Gate Maint. C 0.023MRs	Indirect Cost	Total Cost	Interest	I = 12%	
1	2007	118.00		1.23	51.61	170.84	1.000	170.842	
2	2008			0.96	51.61	52.57	0.893	46.941	
3	2009			0.71	32.53	33.24	0.797	26.500	
4	2010			0.47	13.45	13.92	0.712	9.911	
5	2011			0.24	13.45	13.69	0.636	8.698	
6	2012			0.00	13.45	13.45	0.567	7.632	
7	2013		6.00	0.00	0.00	6.00	0.507	3.040	
8	2014			0.00	0.00	0.00	0.452	0.000	
9	2015			0.00	0.00	0.00	0.404	0.000	
10	2016			0.00	0.00	0.00	0.361	0.000	
11	2017			0.00	0.00	0.00	0.322	0.000	
12	2018			0.00	0.00	0.00	0.287	0.000	
13	2019			0.00	0.00	0.00	0.257	0.000	
14	2020		6.00	0.00	0.00	6.00	0.229	1.375	
15	2021			0.00	0.00	0.00	0.205	0.000	
16	2022			0.00	0.00	0.00	0.183	0.000	
17	2023			0.00	0.00	0.00	0.163	0.000	
18	2024			0.00	0.00	0.00	0.146	0.000	
19	2025			0.00	0.00	0.00	0.130	0.000	
20	2026			0.00	0.00	0.00	0.116	0.000	
21	2027		6.00	0.00	0.00	6.00	0.104	0.622	
22	2028			0.00	0.00	0.00	0.093	0.000	
23	2029			0.00	0.00	0.00	0.083	0.000	
24	2030			0.00	0.00	0.00	0.074	0.000	
25	2031			0.00	0.00	0.00	0.066	0.000	
26	2032			0.00	0.00	0.00	0.059	0.000	
27	2033			0.00	0.00	0.00	0.053	0.000	
28	2034		6.00	0.00	0.00	6.00	0.047	0.281	
29	2035			0.00	0.00	0.00	0.042	0.000	
30	2036			0.00	0.00	0.00	0.037	0.000	
31	2037			0.00	0.00	0.00	0.033	0.000	
32	2038			0.00	0.00	0.00	0.030	0.000	
33	2039			0.00	0.00	0.00	0.027	0.000	
34	2040			0.00	0.00	0.00	0.024	0.000	
35	2041		6.00	0.00	0.00	6.00	0.021	0.127	
36	2042			0.00	0.00	0.00	0.019	0.000	
37	2043			0.00	0.00	0.00	0.017	0.000	
38	2044			0.00	0.00	0.00	0.015	0.000	
39	2045			0.00	0.00	0.00	0.013	0.000	
40	2046			0.00	0.00	0.00	0.012	0.000	
41	2047			0.00	0.00	0.00	0.011	0.000	
42	2048		6.00	0.00	0.00	6.00	0.010	0.058	
43	2049			0.00	0.00	0.00	0.009	0.000	
44	2050			0.00	0.00	0.00	0.008	0.000	
45	2051			0.00	0.00	0.00	0.007	0.000	
46	2052			0.00	0.00	0.00	0.006	0.000	
47	2053			0.00	0.00	0.00	0.005	0.000	
48	2054			0.00	0.00	0.00	0.005	0.000	
49	2055		6.00	0.00	0.00	6.00	0.004	0.026	
50	2056			0.00	0.00	0.00	0.004	0.000	
Total		118.00	42.00	3.62	176.10	339.72	9.301	276.053	

Table A6-2.2 Calculation of Net Present Value

Bulk Head Gate 5 units (Unit:M.Rs)

Year		Cost					Discount Rate	Net Present Value	Remarks
Project Year	A.D.	BHG Cost	BHG Maint. C	Gate Maint. C 0.023MRs	Indirect Cost	Total Cost	Interest	I = 12%	
1	2007	143.00		1.17	51.61	195.78	1.000	195.775	
2	2008			0.83	51.61	52.44	0.893	46.821	
3	2009			0.50	13.45	13.95	0.797	11.119	
4	2010			0.17	13.45	13.62	0.712	9.692	
5	2011			0.00	6.73	6.73	0.636	4.274	
6	2012			0.00	0.00	0.00	0.567	0.000	
7	2013		7.50	0.00	0.00	7.50	0.507	3.800	
8	2014			0.00	0.00	0.00	0.452	0.000	
9	2015			0.00	0.00	0.00	0.404	0.000	
10	2016			0.00	0.00	0.00	0.361	0.000	
11	2017			0.00	0.00	0.00	0.322	0.000	
12	2018			0.00	0.00	0.00	0.287	0.000	
13	2019			0.00	0.00	0.00	0.257	0.000	
14	2020		7.50	0.00	0.00	7.50	0.229	1.719	
15	2021			0.00	0.00	0.00	0.205	0.000	
16	2022			0.00	0.00	0.00	0.183	0.000	
17	2023			0.00	0.00	0.00	0.163	0.000	
18	2024			0.00	0.00	0.00	0.146	0.000	
19	2025			0.00	0.00	0.00	0.130	0.000	
20	2026			0.00	0.00	0.00	0.116	0.000	
21	2027		7.50	0.00	0.00	7.50	0.104	0.778	
22	2028			0.00	0.00	0.00	0.093	0.000	
23	2029			0.00	0.00	0.00	0.083	0.000	
24	2030			0.00	0.00	0.00	0.074	0.000	
25	2031			0.00	0.00	0.00	0.066	0.000	
26	2032			0.00	0.00	0.00	0.059	0.000	
27	2033			0.00	0.00	0.00	0.053	0.000	
28	2034		7.50	0.00	0.00	7.50	0.047	0.352	
29	2035			0.00	0.00	0.00	0.042	0.000	
30	2036			0.00	0.00	0.00	0.037	0.000	
31	2037			0.00	0.00	0.00	0.033	0.000	
32	2038			0.00	0.00	0.00	0.030	0.000	
33	2039			0.00	0.00	0.00	0.027	0.000	
34	2040			0.00	0.00	0.00	0.024	0.000	
35	2041		7.50	0.00	0.00	7.50	0.021	0.159	
36	2042			0.00	0.00	0.00	0.019	0.000	
37	2043			0.00	0.00	0.00	0.017	0.000	
38	2044			0.00	0.00	0.00	0.015	0.000	
39	2045			0.00	0.00	0.00	0.013	0.000	
40	2046			0.00	0.00	0.00	0.012	0.000	
41	2047			0.00	0.00	0.00	0.011	0.000	
42	2048		7.50	0.00	0.00	7.50	0.010	0.072	
43	2049			0.00	0.00	0.00	0.009	0.000	
44	2050			0.00	0.00	0.00	0.008	0.000	
45	2051			0.00	0.00	0.00	0.007	0.000	
46	2052			0.00	0.00	0.00	0.006	0.000	
47	2053			0.00	0.00	0.00	0.005	0.000	
48	2054			0.00	0.00	0.00	0.005	0.000	
49	2055		7.50	0.00	0.00	7.50	0.004	0.033	
50	2056			0.00	0.00	0.00	0.004	0.000	
Total		143.00	52.50	2.66	136.85	335.00	9.301	274.593	

Table A6-2.3 Calculation of Net Present Value

Bulk Head Gate 6 units (Unit:M.Rs)

Year		Cost					Discount Rate	Net Present Value	Remarks
Project Year	A.D.	BHG Cost	BHG Maint. C	Gate Maint. C 0.023MRs	Indirect Cost	Total Cost	Interest	I = 12%	
1	2007	174.00		1.17	51.61	226.78	1.000	226.775	
2	2008			0.83	51.61	52.44	0.893	46.821	
3	2009			0.50	13.45	13.95	0.797	11.119	
4	2010			0.17	13.45	13.62	0.712	9.692	
5	2011			0.00	6.73	6.73	0.636	4.274	
6	2012			0.00	0.00	0.00	0.567	0.000	
7	2013		9.00	0.00	0.00	9.00	0.507	4.560	
8	2014			0.00	0.00	0.00	0.452	0.000	
9	2015			0.00	0.00	0.00	0.404	0.000	
10	2016			0.00	0.00	0.00	0.361	0.000	
11	2017			0.00	0.00	0.00	0.322	0.000	
12	2018			0.00	0.00	0.00	0.287	0.000	
13	2019			0.00	0.00	0.00	0.257	0.000	
14	2020		9.00	0.00	0.00	9.00	0.229	2.063	
15	2021			0.00	0.00	0.00	0.205	0.000	
16	2022			0.00	0.00	0.00	0.183	0.000	
17	2023			0.00	0.00	0.00	0.163	0.000	
18	2024			0.00	0.00	0.00	0.146	0.000	
19	2025			0.00	0.00	0.00	0.130	0.000	
20	2026			0.00	0.00	0.00	0.116	0.000	
21	2027		9.00	0.00	0.00	9.00	0.104	0.933	
22	2028			0.00	0.00	0.00	0.093	0.000	
23	2029			0.00	0.00	0.00	0.083	0.000	
24	2030			0.00	0.00	0.00	0.074	0.000	
25	2031			0.00	0.00	0.00	0.066	0.000	
26	2032			0.00	0.00	0.00	0.059	0.000	
27	2033			0.00	0.00	0.00	0.053	0.000	
28	2034		9.00	0.00	0.00	9.00	0.047	0.422	
29	2035			0.00	0.00	0.00	0.042	0.000	
30	2036			0.00	0.00	0.00	0.037	0.000	
31	2037			0.00	0.00	0.00	0.033	0.000	
32	2038			0.00	0.00	0.00	0.030	0.000	
33	2039			0.00	0.00	0.00	0.027	0.000	
34	2040			0.00	0.00	0.00	0.024	0.000	
35	2041		9.00	0.00	0.00	9.00	0.021	0.191	
36	2042			0.00	0.00	0.00	0.019	0.000	
37	2043			0.00	0.00	0.00	0.017	0.000	
38	2044			0.00	0.00	0.00	0.015	0.000	
39	2045			0.00	0.00	0.00	0.013	0.000	
40	2046			0.00	0.00	0.00	0.012	0.000	
41	2047			0.00	0.00	0.00	0.011	0.000	
42	2048		9.00	0.00	0.00	9.00	0.010	0.086	
43	2049			0.00	0.00	0.00	0.009	0.000	
44	2050			0.00	0.00	0.00	0.008	0.000	
45	2051			0.00	0.00	0.00	0.007	0.000	
46	2052			0.00	0.00	0.00	0.006	0.000	
47	2053			0.00	0.00	0.00	0.005	0.000	
48	2054			0.00	0.00	0.00	0.005	0.000	
49	2055		9.00	0.00	0.00	9.00	0.004	0.039	
50	2056			0.00	0.00	0.00	0.004	0.000	
Total		174.00	63.00	2.66	136.85	376.50	9.301	306.975	

Table A6-2.4 Calculation of Net Present Value

Bulk Head Gate 7 units (Unit:M.Rs)

Year		Cost					Discount Rate	Net Present Value	Remarks
Project Year	A.D.	BHG Cost	BHG Maint. C	Gate Maint. C 0.023MRs	Indirect Cost	Total Cost	Interest	I = 12%	
1	2007	205.00		1.05	51.61	257.66	1.000	257.663	
2	2008			0.62	32.53	33.15	0.893	29.600	
3	2009			0.21	13.45	13.66	0.797	10.888	
4	2010			0.00	6.73	6.73	0.712	4.787	
5	2011			0.00	0.00	0.00	0.636	0.000	
6	2012			0.00	0.00	0.00	0.567	0.000	
7	2013		10.50	0.00	0.00	10.50	0.507	5.320	
8	2014			0.00	0.00	0.00	0.452	0.000	
9	2015			0.00	0.00	0.00	0.404	0.000	
10	2016			0.00	0.00	0.00	0.361	0.000	
11	2017			0.00	0.00	0.00	0.322	0.000	
12	2018			0.00	0.00	0.00	0.287	0.000	
13	2019			0.00	0.00	0.00	0.257	0.000	
14	2020		10.50	0.00	0.00	10.50	0.229	2.406	
15	2021			0.00	0.00	0.00	0.205	0.000	
16	2022			0.00	0.00	0.00	0.183	0.000	
17	2023			0.00	0.00	0.00	0.163	0.000	
18	2024			0.00	0.00	0.00	0.146	0.000	
19	2025			0.00	0.00	0.00	0.130	0.000	
20	2026			0.00	0.00	0.00	0.116	0.000	
21	2027		10.50	0.00	0.00	10.50	0.104	1.089	
22	2028			0.00	0.00	0.00	0.093	0.000	
23	2029			0.00	0.00	0.00	0.083	0.000	
24	2030			0.00	0.00	0.00	0.074	0.000	
25	2031			0.00	0.00	0.00	0.066	0.000	
26	2032			0.00	0.00	0.00	0.059	0.000	
27	2033			0.00	0.00	0.00	0.053	0.000	
28	2034		10.50	0.00	0.00	10.50	0.047	0.492	
29	2035			0.00	0.00	0.00	0.042	0.000	
30	2036			0.00	0.00	0.00	0.037	0.000	
31	2037			0.00	0.00	0.00	0.033	0.000	
32	2038			0.00	0.00	0.00	0.030	0.000	
33	2039			0.00	0.00	0.00	0.027	0.000	
34	2040			0.00	0.00	0.00	0.024	0.000	
35	2041		10.50	0.00	0.00	10.50	0.021	0.223	
36	2042			0.00	0.00	0.00	0.019	0.000	
37	2043			0.00	0.00	0.00	0.017	0.000	
38	2044			0.00	0.00	0.00	0.015	0.000	
39	2045			0.00	0.00	0.00	0.013	0.000	
40	2046			0.00	0.00	0.00	0.012	0.000	
41	2047			0.00	0.00	0.00	0.011	0.000	
42	2048		10.50	0.00	0.00	10.50	0.010	0.101	
43	2049			0.00	0.00	0.00	0.009	0.000	
44	2050			0.00	0.00	0.00	0.008	0.000	
45	2051			0.00	0.00	0.00	0.007	0.000	
46	2052			0.00	0.00	0.00	0.006	0.000	
47	2053			0.00	0.00	0.00	0.005	0.000	
48	2054			0.00	0.00	0.00	0.005	0.000	
49	2055		10.50	0.00	0.00	10.50	0.004	0.046	
50	2056			0.00	0.00	0.00	0.004	0.000	

A 6-3 Structural Calculation of the Under Sluice Gate

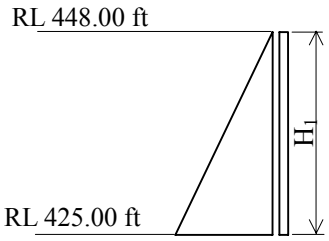
1-1 Design Condition

Gate Type	:	Plate Girder Type Roller Gate
Gate Quantity	:	7 sets
Clear Span	:	60.00 ft [18.29 m]
Leaf Height	:	23.00 ft [7.01 m]
Design Water Head	:	Upstream 23.00 ft [7.01 m] Downstream 0.00 ft [0.00 m]
Operating Water Head	:	Upstream 23.00 ft [7.01 m] Downstream 0.00 ft [0.00 m]
Design Sedimentation Height	:	6.00 ft [1.83 m]
Gate Sill Elevation	:	RL 425.00 ft [EL129.54 m]
Sealing Type	:	3 Edges With Rubber Seals at Upstream
Hoist Type	:	1 Motor 2 Drum Wire Winch
Operating Method	:	Local Control
Operating Speed	:	1.0 ft/min±10 % [0.3 m/min±10 %]
Lifting Height	:	32.00 ft [9.75 m]
Corrosion Allowance	:	One Side 0.5 mm
Allowable Stress	:	By Technical Standard for Gate and Penstocks
Allowable Deflection	:	Bellow 1/600

1-2 Load

1-2-1 Design Load

Hydrostatic Load



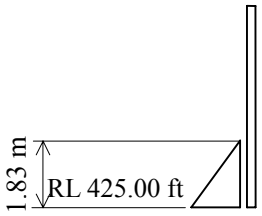
$$P_s = \frac{\gamma_1}{2} \cdot (H_1^2 - H_2^2)$$

$$= \frac{9.807}{2} \times (7.01^2 - 0.00^2) = 240.96 \ \text{kN/m}$$

Total Hydrostatic Load

$P_s = P_s \cdot B = 240.96 \times 18.72 = 4{,}511$ kN

Sediment Load



$$P_m = \frac{1}{2} \cdot C_e \cdot W_1 \cdot h_m^2 \cdot B$$

$$= \frac{1}{2} \times 0.40 \times 9.807 \times 1.83^2 \times 18.72$$

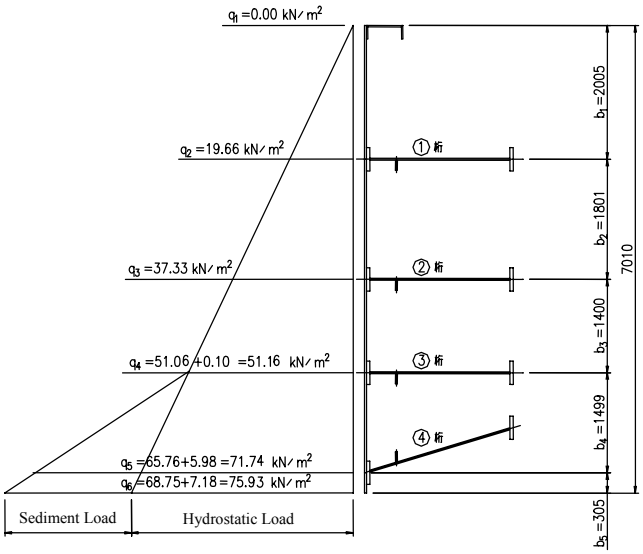
$$= 123 \ \text{kN}$$

Total Load

$P = P_s + P_m$

$= 4{,}511 + 123 = 4{,}634$ kN

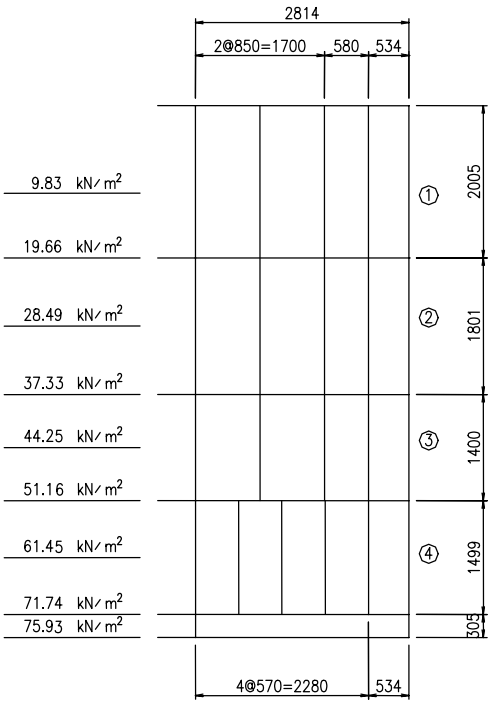
1-2-2 Assignment Load of Main Girder



Total of Unit Load

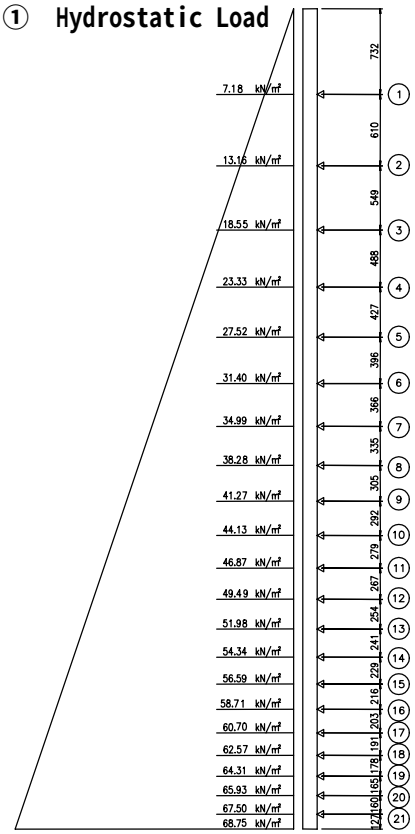
	Hydrostatic Load (kN/m)	Sediment Load (kN/m)	Total (kN/m)
① Ra	50.04		50.04
② Rb	50.33		50.33
③ Rc	72.37	1.34	73.71
④ Rd	68.23	5.23	73.46

1-2-3 Mean Pressure Worked on Skin Plate

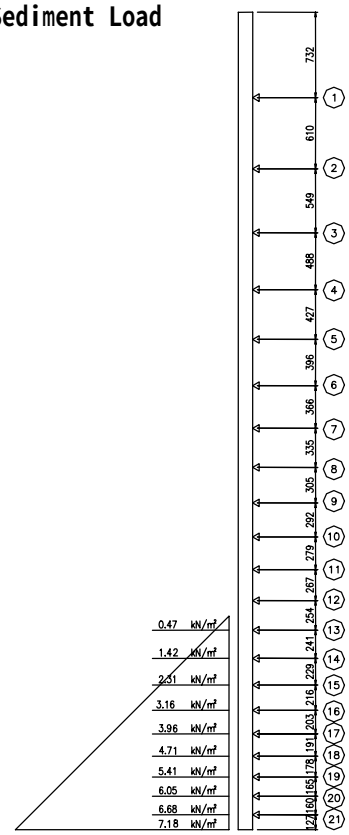


1-2-4 Reaction Force of Roller

① Hydrostatic Load



② Sediment Load



Reaction Force of Roller (kN)

Rolller No	Hydrostatic Pressure	Sediment Pressure	Total
①	51	0	51
②	70	0	70
③	89	0	89
④	99	0	99
⑤	106	0	106
⑥	112	0	112
⑦	114	0	114
⑧	114	0	114
⑨	115	0	115
⑩	118	0	118
⑪	120	0	120
⑫	121	0	121
⑬	120	1	121
⑭	119	3	122
⑮	118	5	123
⑯	115	6	121
⑰	112	7	119
⑱	108	8	116
⑲	103	9	112
⑳	100	9	109
㉑	131	13	**144**

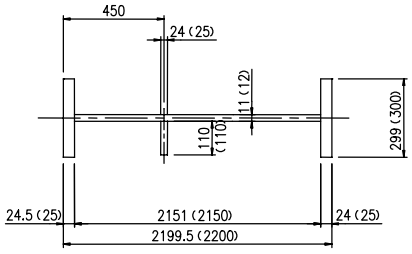
1-3 The result of Strength Consideration for Main Parts

1-3-1 Gate Leaf

① Bending Stress，Shearing Stress，Deflection and Ratio of Deflection

Main Girder ③ Cross Section H-2,200×300×12/25(SM490)

Corrosion Allowance One Side 0.5 mm



Moment of Inertia of Area $I = 2{,}730{,}842 \times 10^4$ mm^4

Modulus of Section $Z = 23{,}838 \times 10^3$ mm^3

Area of Web $A = 236.6 \times 10^2$ mm^2

Bending Stress and Shearing Stress of Main Girder

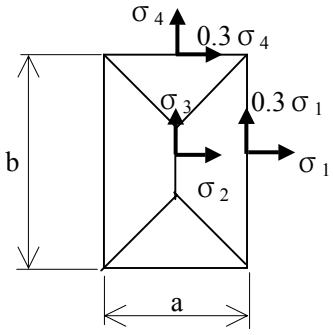
	Unit Load(kN/m)	Bending Moment(kN･m)	Shearing Force(kN)
③ Rc	73.71	3,404	690

No	Stress				Ratio of Deflection λ	Allowable Ratio of Deflection λ_a
	Bending		Shearing			
	σ N/mm^2	Allowable Stress σ_a N/mm^2	τ N/mm^2	Allowable Stress τ_a N/mm^2		
③	143	158	29	91	1/ 825	1/ 600

② Stress of Skin Plate

$$\sigma = \frac{1}{100} \cdot k \cdot a^2 \cdot \frac{p}{t^2}$$

σ ：Bending Stress (N/mm^2)
k ：Factor
a ：Short Side of a Rectangle (mm)
b ：Long Side of a Rectangle (mm)
p ：Pressure (N/mm^2)
t ：Plate Thickness (mm)



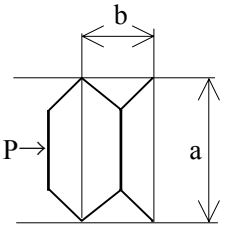
Stress Distribution of Skin Plate

	Short Side of a Rectangle a mm	Long Side of a Rectangle b mm	B/a	Factor k	Pressure p N/mm^2	Plate Thickness t mm	Stress σ N/mm^2	Allowable Stress σ_a N/mm^2
③	850	1,400	1.65	47.4	0.0443	11	125	158

③ Bending Stress and Shearing Stress of Vertical Girder

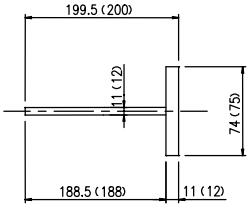
1）Sub Vertical Girder

$$M = \frac{p \cdot b}{24} \cdot (3 \cdot a^2 - b^2) \qquad S = \frac{p \cdot b}{2} \cdot (a - \frac{b}{2})$$



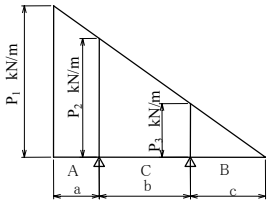
No	a	b	Pu(kN/m^2)	Pd(kN/m^2)	p(kN/m^2)	M(kN・m)	S(kN)
④	1.499	0.570	51.16	71.74	61.45	9.36	21

Cross Section　BT-200×75×12/12 (SM400)　Corrosion Allowance　One Side 0.5 mm



Moment of Inertia of Area　$I = 1{,}187 \times 10^4$ mm^4
Modulus of Section　$Z = 97 \times 10^3$ mm^3
Area of Web　$A = 20.7 \times 10^2$ mm^2

2）Side Girder



$$M_A = \frac{1}{2}(P_1 + P_2) \cdot a \cdot x$$

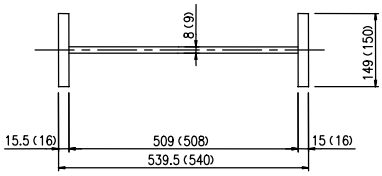
$$M_B = \frac{c}{2} \cdot P_3 \cdot x$$

$$M_c = R_1 \cdot x - \frac{P_3 \cdot x^2}{2} - \frac{P_2 - P_3}{6b} \cdot x^3$$

$$R_1 = \frac{2 \cdot P_3 + P_2}{6} \cdot b \qquad R_2 = \frac{P_3 + 2 \cdot P_2}{6} \cdot b$$

Maximum Bending Moment　6.00 kN・m（①）
Maximum Shearing Moment　62 kN（⑭）

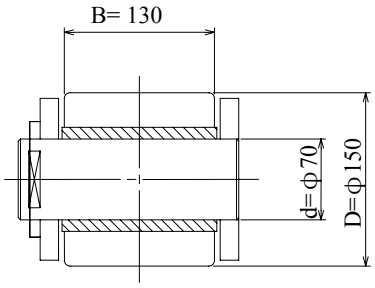
Cross Section　H-540×150×9/16 (SM400)　Corrosion Allowance　One Side 0.5 mm



Moment of Inertia of Area　$I = 40{,}036 \times 10^4$ mm^4
Modulus of Section　$Z = 1{,}472 \times 10^3$ mm^3
Area of Web　$A = 40.7 \times 10^2$ mm^2

	Stress			
	Bending		Shearing	
	σ N/mm^2	Allowable Stress σ_a N/mm^2	τ N/mm^2	Allowable Stress τ_a N/mm^2
Sub Vertical Girder	96	118	10	68
Side Girder	4		15	

1-3-2 Roller



Working Load of Main Roller	P	= 144 kN
Diameter of Roller	D	= φ150 mm
Clear Seating Width of Roller	B	= 130 mm
Diameter of Wheel Pin	d	= φ 70 mm
Material of Roller	SCMn3B	
Rollers Brinel Hardness	HB	= 200

Strength of a Roller

Contact Stress p （for Line Contact）

$$p = 0.591 \cdot \sqrt{\frac{P \cdot E_1 \cdot E_2}{Bo \cdot R \cdot (E_1 + E_2)}}$$

P ：Hertz Contact Stress (N/mm^2)
P ：Working Load of Roller = 144,000 N
E_1 ：Modulus of Elasticity of Roller = 20.6×10^4 N/mm^2
E_2 ：Modulus of Elasticity of Rail = 19.3×10^4 N/mm^2
Bo：Clear Seating Width of Roller = 130 mm
R ：Radius of Roller = 75 mm

Contact Stress p= 717 N/mm^2 ＜ Allowable Contact Stress Pa＝754 N/mm^2

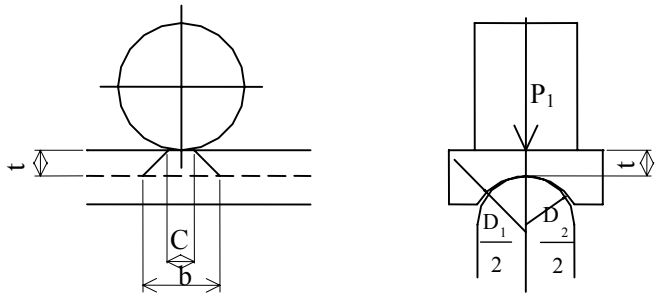
Bearing Pressure of Wheel Pin

$$\sigma_P = \frac{P}{d \cdot b}$$

P：Working Load of Roller = 144,000 N
d：Diameter of Wheel Pin = 70 mm
b：Clear Width of Bearing = 130 mm

σ_p= 16 N/mm^2 ＜ 23 N/mm^2 (Oil less metal)

1-3-3 Gate Guide



Contact Stress $\sigma_c = 910\ N/mm^2 < \sigma_{all} = 1{,}029\ N/mm^2$

1-4 Hoisting Load

Item	Opening	Closing	Downward Load at Raising
Weight of Gate Leaf	520 ↓	520 ↓	520 ↓
Frictional Force of Wheel Rotation	62 ↓	62 ↑	62 ↓
Frictional Force of the Rubber Seal	27 ↓	27 ↑	27 ↓
Frictional Force between Sediment and Metal	49 ↓	0 ↑	49 ↓
Counter Weight	395 ↑	395 ↑	0 ↑
Total	263 ↓	36 ↓	658 ↓

Opening Load 265 kN , Closing Load 40 kN , Downward Load at Raising 660 kN

1-5 Hoist

1-5-1 Design Condition of Hoist

Type of Hoist	Electrically Driven, 1 Motor 2 Drum Type
Quantity of Hoist	7 set
Hoisting Load	Raising 265 kN
Hoisting Speed	0.3 m/min ± 10 %
Lifting Height	9.75 m
Operating Method	Local Control
Number of Rope Falls	1 at each side,2 at both side
Power Source	Three-phase Ac 400V 50 Hz
Safety Factor	By Technical Standard for Gate and Penstocks

1-5-2 Mechanical Efficiency of Machinery

	Start
Total Efficiency η	0.658

1-5-3 Design Date of Wire Rope

Construction	IWRC 6×P･WS（36）
Diameter of Rope	d = φ 60 mm
Breaking Strength	F_a = 2,780 kN

1-5-4 Diameter of Drum

$D_d \geq 19d$

Diameter of Drum $D_d = \phi 1{,}140$ mm

1-5-5 Required Capacity

$$P_M = \frac{W \cdot V}{60 \cdot \eta}$$

P_M : Required Capacity kw
W : Hoisting Load = 265 kN
V : Hoisting Speed = 0.3 m/min
η : Efficiency of Machinery at start = 0.658

$$P_M = \frac{265 \times 0.3}{60 \times 0.658} = 2.02 \text{ kW}$$

Therefore we employ the rating of 2.2 kW as the nearest capacity of more 1.5 kW.

Design Date of Motor

Type	TEFC
Capacity	2.2 kW
Number of Poles	6 P 50 Hz
Rated Number of Rotation	940 r.p.m

A 6-4 Structural Calculation of the Weir Gate

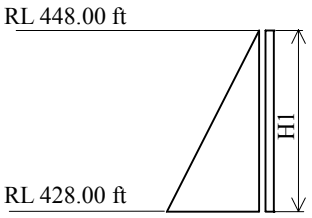
1-1 Design Condition

Gate Type	:	Trussed Type Roller Gate
Gate Quantity	:	22 set
Clear Span	:	60.00 ft [18.29 m]
Leaf Height	:	20.00 ft [6.10 m]
Design Water Head	:	Upstream 20.00 ft [6.10 m]
		Downstream 0.00 ft [0.00 m]
Operating Water Head	:	Upstream 20.00 ft [6.10 m]
		Downstream 0.00 ft [0.00 m]
Design Sedimentation Height	:	3.00 ft [0.91 m]
Gate Sill Elevation	:	RL 428.00 ft [EL130.45 m]
Sealing Type	:	3 Edges With Rubber Seals at Upstream
Hoist Type	:	1 Motor 2 Drum Wire Winch
Operating Method	:	Local Control
Operating Speed	:	1.0 ft/min±10 % [0.3 m/min±10 %]
Lifting Height	:	29.00 ft [8.84 m]
Corrosion Allowance	:	One Side 0.5 mm
Allowable Stress	:	By Technical Standard for Gate and Penstocks
Allowable Deflection	:	Bellow 1/600

1-2 Load

1-2-1 Design Load

Hydrostatic Load



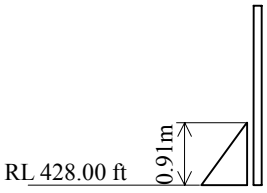
$$P_s = \frac{\gamma_1}{2} \cdot (H_1^{\,2} - H_2^{\,2})$$

$$= \frac{9.807}{2} \times (6.10^2 - 0.00^2) = 182.46 \ \text{kN/m}$$

Total Hydrostatic Load

$$P_S = P_S \cdot B = 182.46 \times 18.69 = 3{,}410 \ \text{kN}$$

Sediment Load



$$P_m = \frac{1}{2} \cdot C_e \cdot W_1 \cdot h_m^{\,2} \cdot B$$

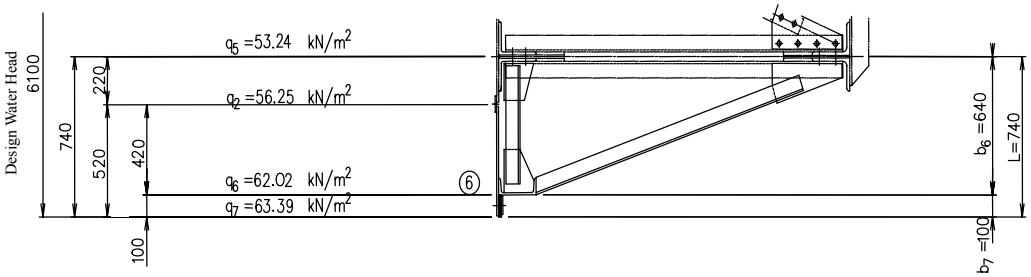
$$= \frac{1}{2} \times 0.40 \times 9.807 \times 0.91^2 \times 18.69$$

$$= 30 \ \text{kN}$$

Total Load

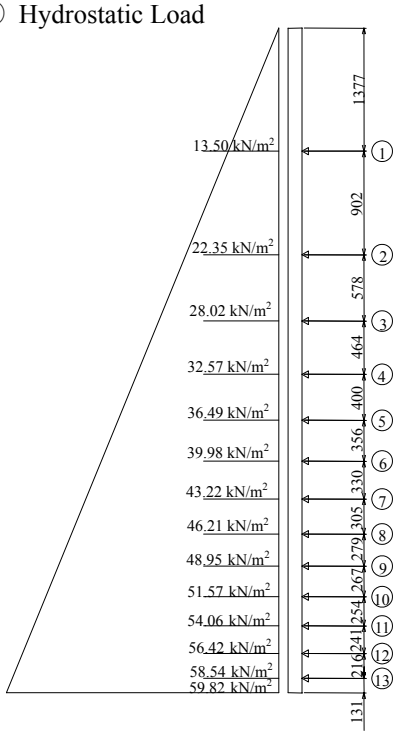
$$P = P_s + P_m = 3{,}410 + 30 = 3{,}440 \ \text{kN}$$

1-2-2 Hydrostatic Load of Bottom Raising

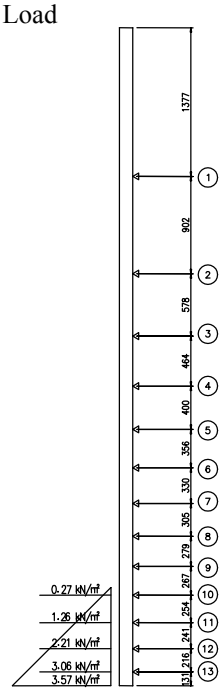


1-2-3 Reaction Force of Roller

① Hydrostatic Load



② Sediment Load



(kN)

Roller No	Hydrostatic Presssure	Sediment Pressure	Total
①	156	0	**156**
②	147	0	147
③	135	0	135
④	131	0	131
⑤	129	0	129
⑥	128	0	128
⑦	128	0	128
⑧	126	0	126
⑨	125	0	125
⑩	126	1	127
⑪	125	3	128
⑫	120	5	125
⑬	131	7	138

1-3 The result of Strength Consideration for Main Parts

1-3-1 Gate Leaf

① Existing Main Girder

Cross Section

Downstream Girder 2-L-203×152×19（ASTM A36）

Upstream Girder 2-L-152×152×16 PL9.5×425（ASTM A36）

Stress (N/mm^2)

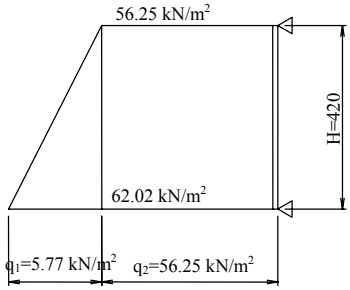
Main Girder	Downstream	Upstream	Allowable Stress
Lowest Girder	102	123	124

Ratio of Deflection

Main Girder	Deflection (mm)	Ratio of Deflection	Allowable Deflection
Lowest Girder	28.0	1/668	1/600

② Bottom Raising

1）Skin Plate



Bending Moment

$$M = \frac{H^2}{16}(q_1 + 2q_2)$$

$$= \frac{0.42^2}{16}(5.77 + 2\times 56.25) = 1.30 \text{ kN·m/m}$$

Modulus of Section (per unit width)

$$Z = \frac{b \cdot t^2}{6} = \frac{1.0\times 8.5^2}{6} = 12 \text{ mm}^3$$

Bending Stress $\sigma_b = \frac{M}{Z} =$ 108 N/mm^2 ＜ σ_a = 118 N/mm^2 (SM400)

2）Bending Stress of Girder ⑥

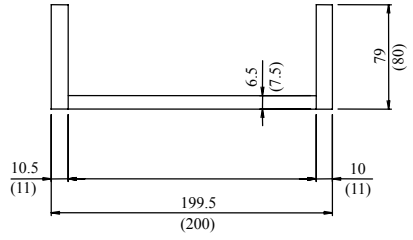
Working Load of Girder ⑥

$$R_6 = \frac{(q_5 + 2\cdot q_7)}{6\cdot b_6}\cdot L^2 = 25.67 \text{ kN/m}$$

Bending Moment

$$M = \frac{R\cdot B^2}{8} = 4.38 \text{ kN·m}$$

Cross Section ⌊-200×80×7.5/11 (SS400) Corrosion Allowance One Side 0.5 mm

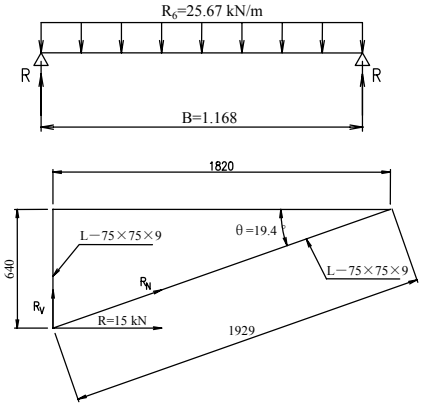


Moment of Inertia of Area $I = 1{,}774\times 10^4 \text{ mm}^4$

Modulus of Section $Z = 175\times 10^3 \text{ mm}^3$

Bending Stress $\sigma_b = \dfrac{M}{Z} =$ 25 N/mm^2 $<$ $\sigma_a =$ 118 N/mm^2

3）Slanting Material

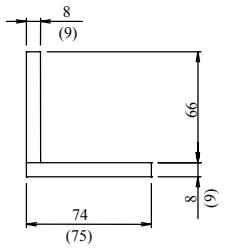


$$R = \frac{R_6 \cdot B}{2} = 15 \text{ kN}$$

$$R_N = \frac{R}{\cos\theta} = 16 \text{ kN}$$

$$R_V = R \cdot \sin\theta = 5 \text{ kN}$$

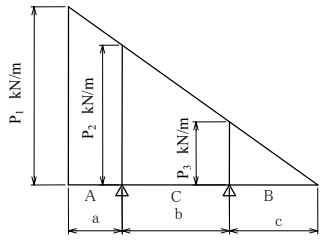
Cross Section L-75×75×9 (SS400) Corrosion Allowance One Side 0.5 mm



Moment of Inertia of Area $I = 58 \times 10^4$ mm^4
Modulus of Section $Z = 11 \times 10^3$ mm^3

Compression Stress $\sigma_t = \dfrac{M}{Z} = 14$ N/mm^2 $<$ $\sigma_a =$ 71N/mm^2

③ Side Girder



$$M_A = \frac{1}{2}(P_1 + P_2) \cdot a \cdot x$$

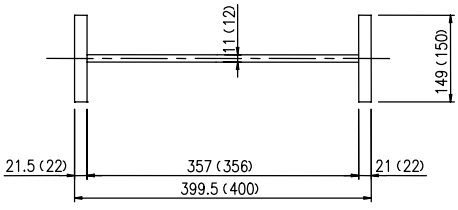
$$M_B = \frac{c}{2} \cdot P_3 \cdot x$$

$$M_c = R_1 \cdot x - \frac{P_3 \cdot x^2}{2} - \frac{P_2 - P_3}{6b} \cdot x^3$$

$$R_1 = \frac{2 \cdot P_3 + P_2}{6} \cdot b \qquad R_2 = \frac{P_3 + 2 \cdot P_2}{6} \cdot b$$

Maximum Bending Moment 39.88 kN·m (①)
Maximum Shearing Moment 82 kN (①)

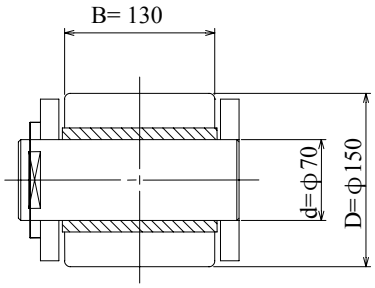
Cross Section H-400×150×12/22 (SM400) Corrosion Allowance One Side 0.5 mm



Moment of Inertia of Area $I = 26{,}846 \times 10^4$ mm^4
Modulus of Section $Z = 1{,}336 \times 10^3$ mm^3
Area of Web $A = 39.3 \times 10^2$ mm^2

	Stress			
	Bending		Shearing	
	σ N/mm^2	Allowable Stress σ_a N/mm^2	τ N/mm^2	Allowable Stress τ_a N/mm^2
Side Girder	30	118	21	68

1-3-2 Roller



Working Load of Main Roller	P	= 156 kN
Diameter of Roller	D	= φ150 mm
Clear Seating Width of Roller	B	= 130 mm
Diameter of Wheel Pin	d	= φ 70 mm
Material of Roller	SCMn3B	
Rollers Brinel Hardness	HB	= 200

Strength of a Roller

Contact Stress p （for Line Contact）

$$p = 0.591 \cdot \sqrt{\frac{P \cdot E_1 \cdot E_2}{Bo \cdot R \cdot (E_1 + E_2)}}$$

p ：Hertz Contact Stress (N/mm^2)
P ：Working Load of Roller = 156,000 N
E_1 ：Modulus of Elasticity of Roller = 20.6×10^4 N/mm^2
E_2 ：Modulus of Elasticity of Rail = 19.3×10^4 N/mm^2
Bo ：Clear Seating Width of Roller = 130 mm
R ：Radius of Roller = 75 mm

Contact Stress p= 746 N/mm^2 ＜ Allowable Contact Stress Pa＝754 N/mm^2

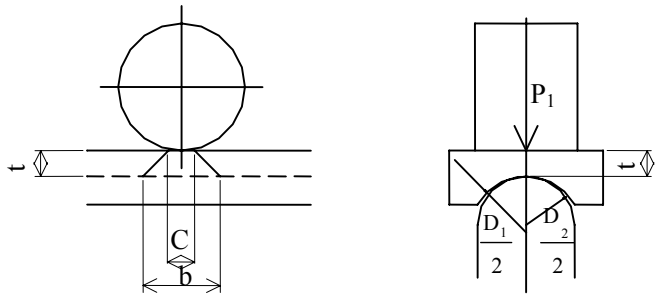
Bearing Pressure of Wheel Pin

$$\sigma_P = \frac{P}{d \cdot b}$$

P：Working Load of Roller = 156,000 N
d：Diameter of Wheel Pin = 70 mm
b：Clear Width of Bearing = 130 mm

σ_p= 17 N/mm^2 ＜ 23 N/mm^2 (Oil less metal)

1-3-3 Gate Guide



Contact Stress $\sigma_c = 946$ N/mm^2 ＜ $\sigma_{all} = 1{,}029$ N/mm^2 （SUS304N$_2$）

1-4 Hoisting Load

Item	Opening		Closing		Downward Load at Raising	
Weight of Gate Leaf	430	↓	430	↓	430	↓
Frictional Force of Wheel Rotation	46	↓	46	↑	46	↓
Frictional Force of the Rubber Seal	21	↓	21	↑	21	↓
Frictional Force between Sediment and Metal	12	↓	0	↑	12	↓
Counter Weight	345	↑	345	↑	0	↑
Total	164	↓	18	↓	509	↓

Opening Load 165 kN , Closing Load 20 kN , Downward Load at Raising 510 kN

1-5 Hoist

1-5-1 Design Condition of Hoist

Type of Hoist	Electrically Driven, 1 Motor 2 Drum Type
Quantity of Hoist	22 set
Hoisting Load	Raising 165 kN
Hoisting Speed	0.3 m/min ± 10 %
Lifting Height	8.84 m
Operating Method	Local Control
Number of Rope Falls	1 at each side,2 at both side
Power Source	Ac 400V 50 Hz
Safety Factor	By Technical Standard for Gate and Penstocks

1-5-2 Mechanical Efficiency of Machinery

	Start
Total Efficiency η	0.658

1-5-3 Design Date of Wire Rope

Construction IWRC 6×WS（36）特種
Diameter of Rope d = φ 56 mm
Breaking Strength F_a = 2,230 kN

1-5-4 Diameter of Drum

$D_d \geq 19d$

Diameter of Drum $D_d = \phi 1{,}120$ mm

1-5-5 Required Capacity

$$P_M = \frac{W \cdot V}{60 \cdot \eta}$$

P_M ：Required Capacity kW
W ：Hoisting Load = 165 kN
V ：Hoisting Speed = 0.3 m/min
η ：Efficiency of Machinery at start = 0.658

$$P_M = \frac{165 \times 0.3}{60 \times 0.658} = 1.25 \text{ kW}$$

Therefore we employ the rating of 1.5 kW as the nearest capacity of more 0.75 kW.

Design Date of Motor

Type	TEFC
Capacity	1.5 kW
Number of Poles	6 P 50 Hz
Rated Number of Rotation	880 r.p.m

【Reference】Three Dimensions Analysis for Existing Structure of Weir Gate

1. Design Condition

Gate Type	:	Trussed Type Roller Gate
Gate Quantity	:	22 set
Clear Span	:	60.00 ft [18.29 m]
Leaf Height	:	20.00 ft [6.10 m]
Design Water Head	:	Upstream 20.00 ft [6.10 m]
		Downstream 0.00 ft [0.00 m]
Operating Water Head	:	Upstream 20.00 ft [6.10 m]
		Downstream 0.00 ft [0.00 m]
Design Sedimentation Height	:	3.00 ft [0.91 m]
Gate Sill Elevation	:	RL 428.00 ft [EL130.45 m]
Sealing Type	:	3 Edges With Rubber Seals at Upstream
Hoist Type	:	1 Motor 2 Drum Wire Winch
Operating Method	:	Local Control
Operating Speed	:	1.0 ft/min±10 % [0.3 m/min±10 %]
Lifting Height	:	29.00 ft [8.84 m]
Corrosion Allowance	:	One Side 0.5 mm
Allowable Stress	:	By Technical Standard for Gate and Penstocks
Allowable Deflection	:	Bellow 1/600

2. Main Girder

Cross Section	Downstream Girder	2－L203×152×19（ASTM A36）
	Upstream Girder	2－L152×152×16 PL9.5×425（ASTM A36）

3. Unit Load

Highest Girder 5	:	24.379 kN/m
Main Girder 4	:	25.871 kN/m
Main Girder 3	:	32.351 kN/m
Main Girder 2	:	17.920 kN/m
Lowest Girder 1	:	83.325 kN/m

4. Results of Calculation

Stresses (N/mm^2)

Main Girder	Main Girder of Downstream Side	Main Girder of Upstream Side
5（most upper section）	92	-85
4	85	-93
3	91	-94
2	89	-124
1（most lower section）	102	-123

Deflection （mm）

Main Girder	Deflection	Deflection Intensity
5（most upper section）	24.4	1/766
4	24.7	1/757
3	25.4	1/736
2	26.1	1/716
1（most lower section）	28.0	1/668

Show the Drawings of Deflection and Stress Range to next Appendix.

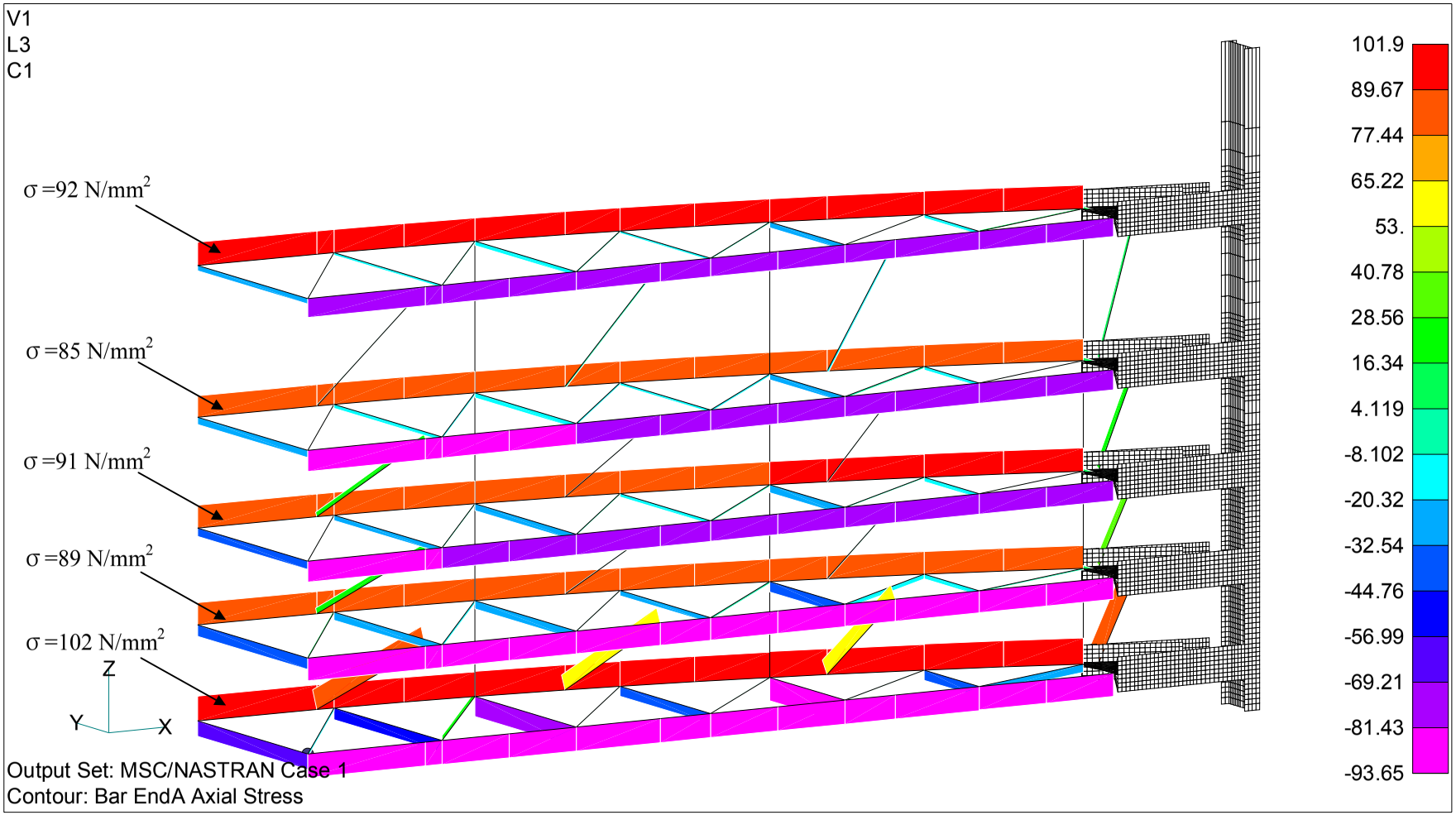


Figure-1 Drawings of Stresses of Main Girder for Downstream Side (N/mm^2)

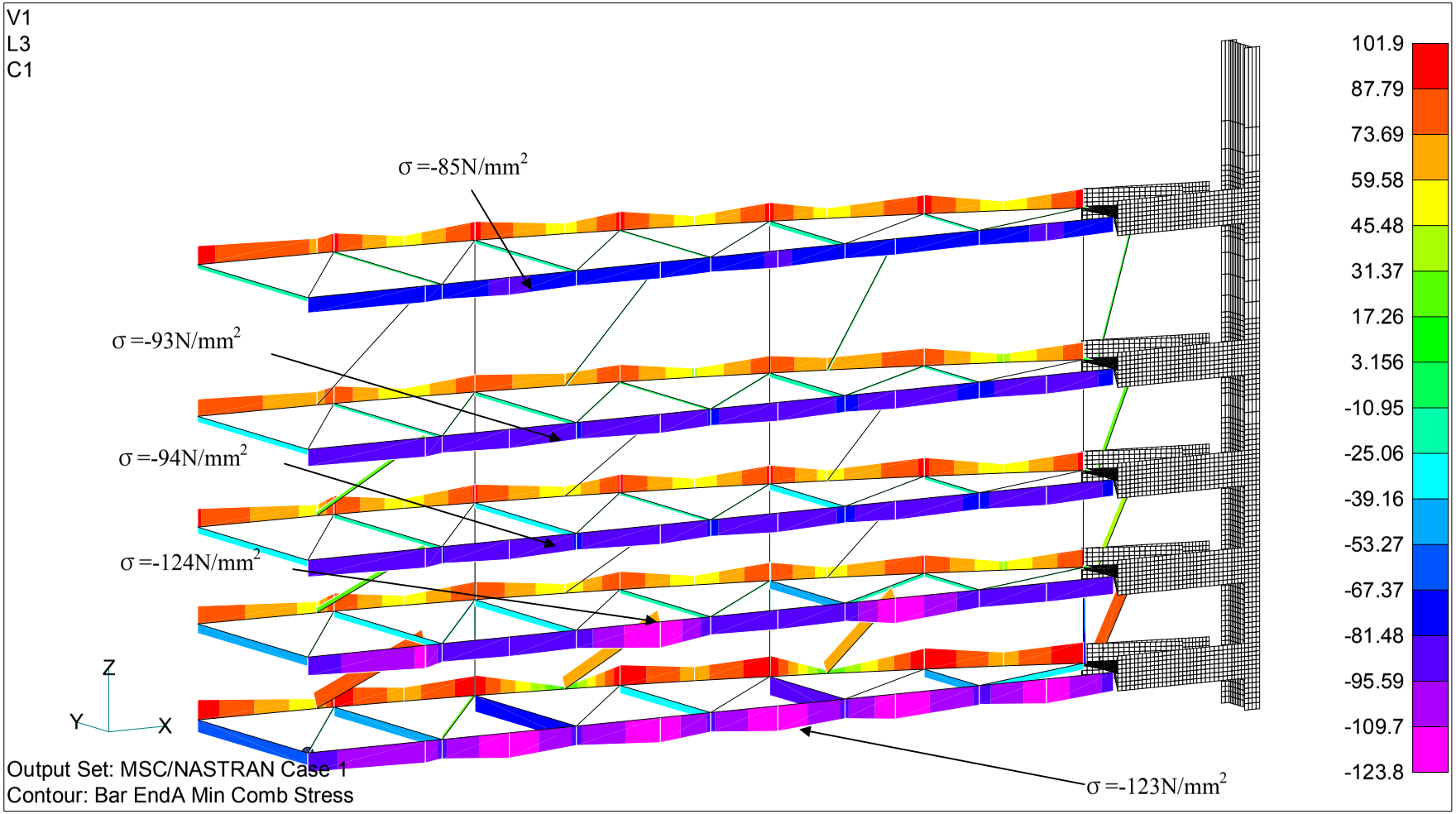


Figure-2 Drawings of Stresses of Main Girder for Upstream Side (N/mm^2)

Deflection

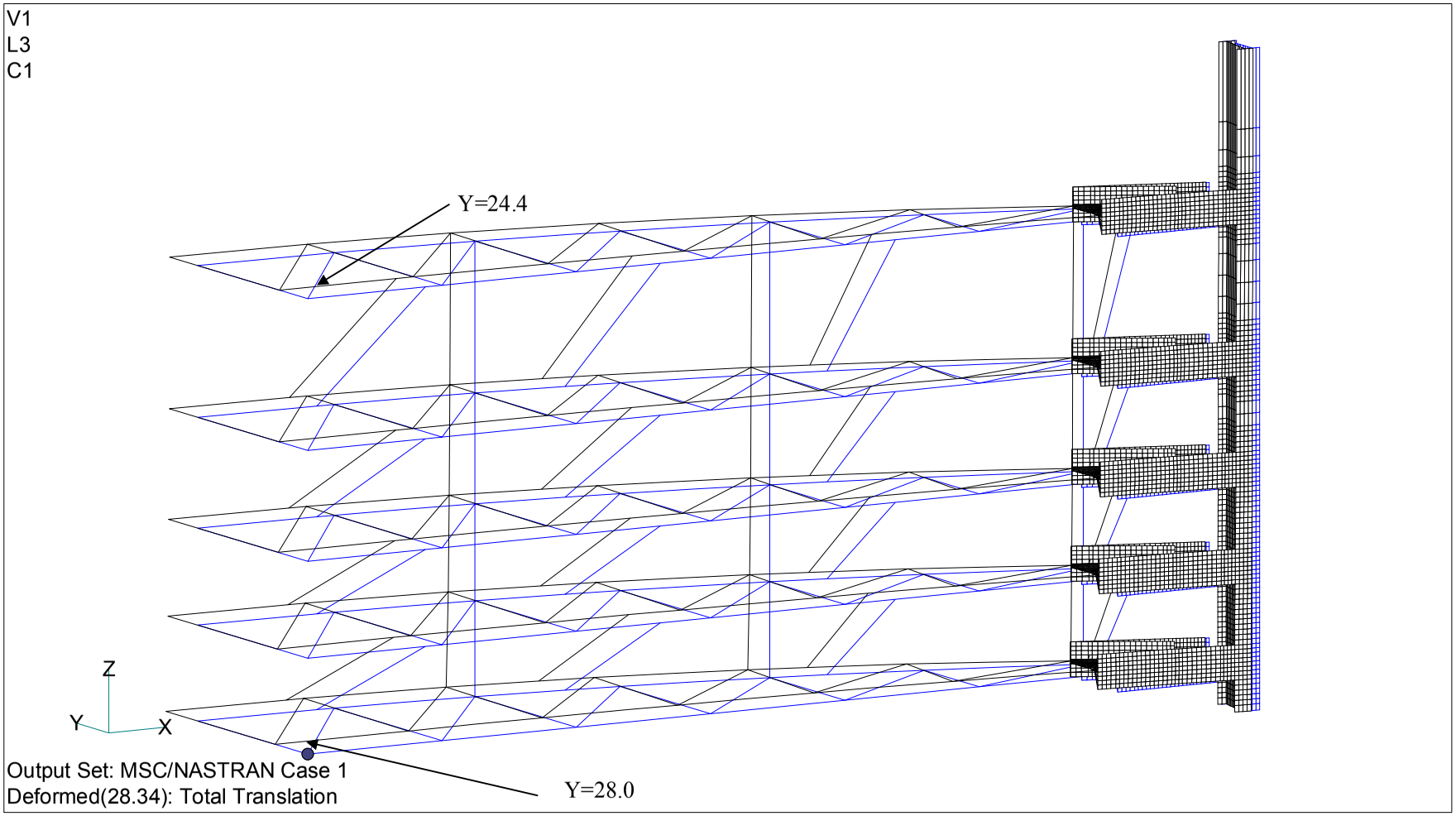


Figure-3 Drawings of Deflection

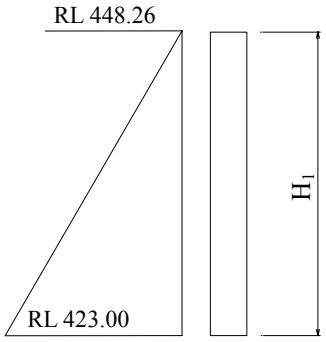
A 6-5 Structural Calculation of the Bulk Head Gate

1-1 Design Condition

Gate Type	Steel Floating Gate
Gate Quantity	5 set
Clear Span	60.00 ft [18.29 m]
Gate Height	25.26 ft [7.70 m]
Design Water Head	25.26 ft [7.70 m]
Gate Sill Elevation	RL 423.00 ft [EL128.93 m]
Sealing Type	3 Edges With Rubber Seals at Downstream
Corrosion Allowance	One Side 0 mm (side where it touches water)
Allowable Deflection	Below 1/600

1-2 Load

1-2-1 Design Load



$$p_s = \frac{\gamma_1}{2} \times H_1^{\,2}$$

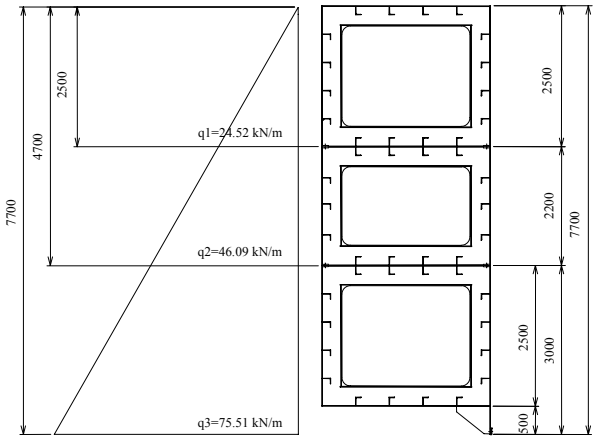
p_s	：Hydraulic Load	(kN/m)
H_s	：Sealing Height	= 7.70 m
H_1	：Design Head at Upstream	= 7.70 m
B_s	：Sealing Span	= 20.32 m
γ_1	：Weight of Water Per Unit Volume	= 9.807 kN/m^3

$$p_s = \frac{9.807}{2} \times 7.70^2 = 290.73 \ \text{kN/m}$$

Total Load

$$P_s = p_s \cdot B_s = 290.73 \times 20.32 = 5{,}908 \ \text{kN}$$

1-2-2 Assignment Load



Water Head of Upper Block Bottom h_1 = 2.500 m Pressure of bottom q_1 = 24.52 kN/m^2
Water Head of Middle Block Bottom h_2 = 4.700 m q_2 = 46.09 kN/m^2
Water Head of Lower Block Bottom h_3 = 7.700 m q_3 = 75.51 kN/m^2

Height of Upper Block b_1 = 2.500 m
Height of Middle Block b_2 = 2.200 m
Height of Lower Block b_3 = 3.000 m

Load of Upper Block

$$W_g = \frac{q_1}{2} \cdot b_1 = \frac{24.52}{2} \times 2.500 = 30.65 \ \text{kN/m}$$

Load of Middle Block

$$W_g = \frac{q_1 + q_2}{2} \cdot b_2 = \frac{24.52 + 46.09}{2} \times 2.200 = 77.67 \ \text{kN/m}$$

Load of Lower Block

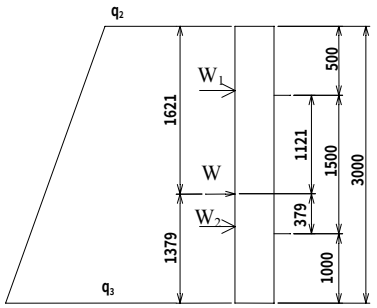
$$W_g = \frac{q_2 + q_3}{2} \cdot b_3 = \frac{46.09 + 75.51}{2} \times 3.000 = 182.40 \ \text{kN/m}$$

1-3 The result of Strength Consideration for Main Parts（Lower Block）

1-3-1 Gate Leaf

① Stress

Load



Arrangement and Hydraulic Pressure of Side Girder

q_2 = 46.09 N/mm^2
q_3 = 75.51 N/mm^2
L = 3.000 m

Center of Bottom (from Bottom)

$$ho = \frac{(2q_2 + q_3)\cdot L/3}{(q_2 + q_3)} = \frac{(2\times 46.09 + 75.51)\times 3.000/3}{46.09 + 75.51} = 1.379 \text{ m}$$

Total Load

W = 182.40 kN/m

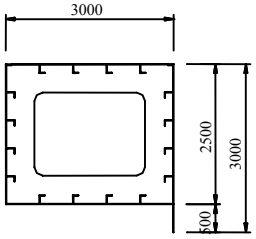
Assignment Load

$$W_1 = \frac{W\cdot a}{L} = \frac{182.40\times 379}{1{,}500} = 46.09 \text{ kN/m}$$

$$W_2 = \frac{W\cdot b}{L} = \frac{182.40\times 1{,}121}{1{,}500} = 136.31 \text{ kN/m}$$

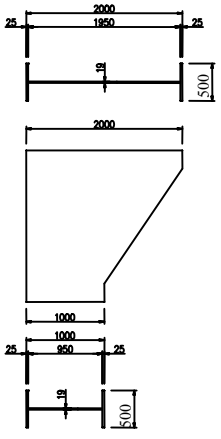
Cross Section Property

Central Part



Moment of Inertia of Area $I = 15{,}558{,}765\times 10^4$ mm^4
Modulus of Section $Z = 103{,}905\times 10^3$ mm^3
Area of Web $A = 596\times 10^2$ mm^2

Side Part



Moment of Inertia of Area $I = 3{,}612{,}043\times 10^4$ mm^4
Modulus of Section $Z = 36{,}120\times 10^3$ mm^3
Area of Web (Side Part) $A = 181\times 10^2$ mm^2

	Stress				Ratio of Deflection λ	Allowable Ratio of Defrection λ_a
	Bending		Shearing			
	σ N/mm²	Allowable Stress σ_a N/mm²	τ N/mm²	Allowable Stress τ_a N/mm²		
Central Part	92	177	26	102	1/ 1,535	1/ 600
Side Part	54		67			

② Bending Stress and Shearing Stress of Stiffeners

1）Horizontal Stiffener

Working Load

$P_3 = 6.700 \times 9.807 \times 0.500 = 32.85$ kN/m

h ：Design Water Head = 6.700 m

w_o ：Weight of Water Per Unit Volume = 9.807 kN/m³

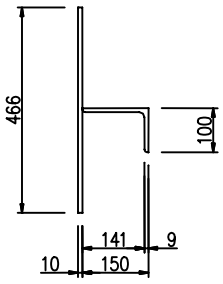
L_1 ：Horizontal Stiffeners' Pitch = 0.500 m

Bending Moment(M) and Shearing Moment(Q)

$$M = \frac{1}{8} \cdot P_3 \cdot L_2{}^2 = \frac{1}{8} \times 32.85 \times 1.55^2 = 9.87 \text{ kN·m}$$

$$Q = \frac{1}{2} \cdot P_3 \cdot L_2 = \frac{1}{2} \times 32.85 \times 1.55 = 25 \text{ kN}$$

L_2 ：Vertical Stiffener's Pitch = 1.550 m



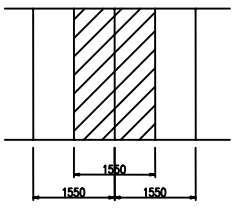
Moment of Inertia of Area $I = 2{,}192 \times 10^4$ mm⁴

Modulus of Section $Z = 563 \times 10^3$ mm³

Area of Web $A = 12.7 \times 10^2$ mm²

2）Vertical Stiffener

Working Load



$W_3 = 5.950 \times 9.807 \times 1.550 = 90.45$ kN/m

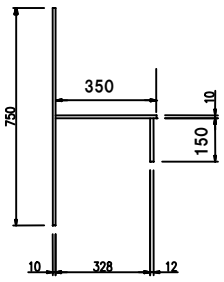
Vertical Stiffener's Pitch L = 1.55 m

Bending Moment(M) and Shearing Moment (Q)

$$M = \frac{1}{8} \cdot W_3 \cdot L^2 = \frac{1}{8} \times 90.45 \times 2.500^2 = 70.66 \text{ kN·m}$$

$$Q = \frac{1}{2} \cdot W_3 \cdot L = \frac{1}{2} \times 90.45 \times 2.500 = 113 \text{ kN}$$

L ：Height of Lower Block = 2.500 m



Moment of Inertia of Area $I = 23{,}565 \times 10^4$ mm^4
Modulus of Section $Z = 913 \times 10^3$ mm^3
Area of Web $A = 35.0 \times 10^2$ mm^2

	Stress			
	Bending		Shearing	
	σ N/mm^2	Allowable Stress σ_a N/mm^2	τ N/mm^2	Allowable Stress τ_a N/mm^2
Horizontal Stiffener	55	177	20	102
Vertical Stiffener	77		32	

③ Skin Plate

1) Minimum of Plate Thickness

$$t = \frac{b}{56 \cdot f \cdot n}$$

Where, b : Width of Stiffener
N : The Number of Panels
F : The Factor by the Stress slope

Central Part

$$t = \frac{2{,}500}{56 \times 1 \times 5} = 8.9 \text{ mm} < 10 \text{ mm}$$

Side Part

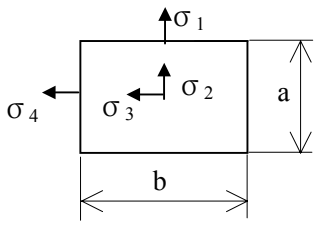
$$t = \frac{3{,}000}{56 \times 1.156 \times 5} = 9.3 \text{ mm} < 10 \text{ mm}$$

∴Minimum of Plate Thickness 10 mm

2) Stress

Bending Stress of Skin Plate

$$\sigma = \frac{1}{100} \cdot k \cdot a^2 \cdot \frac{p}{t^2}$$



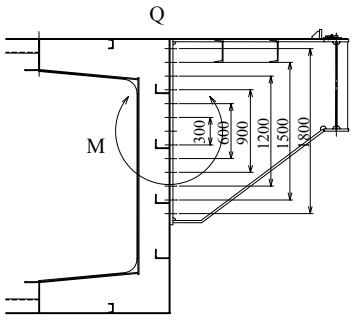
Where、
σ : Skin Plate Stress (N/mm^2)
k : Factor in Below Table b/a
a : Short Side of a Rectangle (mm)
b : Long Side of a Rectangle (mm)
p : Hydraulic Pressure (N/mm^2)
t : Plate Thickness (mm)

Skin Plate Stress

A (mm)	b (mm)	p (N/mm^2)	t (mm)	k_1	k_2	k_3	k_4	σ_1	σ_2	σ_3	σ_4
								(N/mm^2)			
500	775	0.0682	10	46.2	22.6	11.9	34.3	79	39	20	58

1-3-2 Gate Leaf Joint Part

① Joint of Girder and Box



Bending Moment $M = 1{,}948.82 \times 10^6$ N·m
Shearing Force $Q = 966 \times 10^3$ N

Working Load on a Bolt

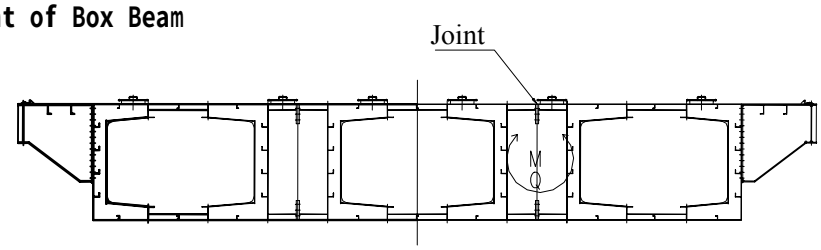
Tensil Load

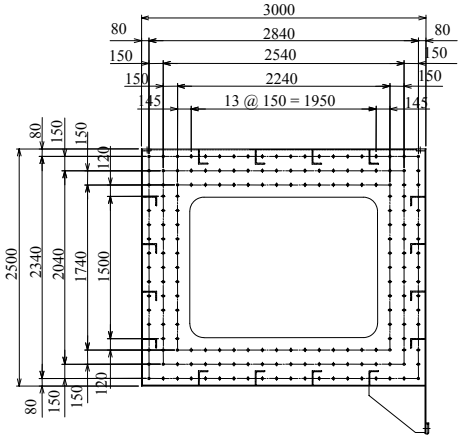
$$P = \frac{M}{2 \cdot (L + \frac{Ln^2}{L}) \cdot N} = 71 \times 10^3 \ \text{N}$$

Shearing Force

$$F = \frac{Q}{No} = 13 \times 10^3 \ \text{N}$$

② Joint of Box Beam





Working Load on a Bolt

Tensil Load

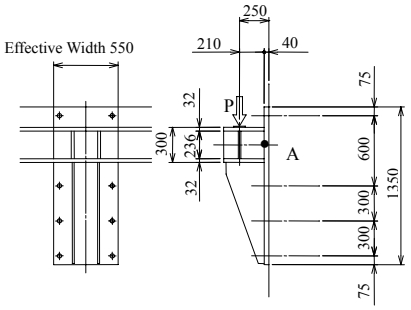
$$P = \frac{M}{2 \cdot (N \cdot L + \Sigma Nn \cdot \frac{Ln^2}{L})} = 66 \times 10^3 \ \text{N}$$

Shearing Force

$$F = \frac{Q}{No} = 3 \times 10^3 \ \text{N}$$

	Stress					
	Bending		Shearing		Combined	
	σ N/mm^2	Allowable Stress σ_a N/mm^2	τ N/mm^2	Allowable Stress τ_a N/mm^2	σ_g N/mm^2	Allowable Stress σ_{ga} N/mm^2
Girder and Box	210	259	38	150	220	285
Box and Box	195		9		196	

1-3-3 Gate Guide



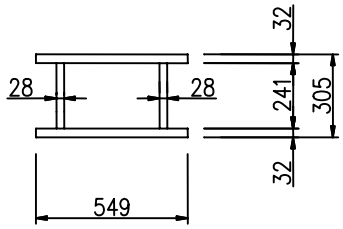
Working Load on a Gate Guide

Reactions

Upper Beam	209 kN
Middle Beam	434 kN
Lower Beam	1,210 kN

Bending Moment at Point A

$$M_A = P \cdot L = 1{,}210 \times 0.210 = 254.1 \ \text{kN} \cdot \text{m}$$



Moment of Inertia of Area $I = 72{,}298 \times 10^4$ mm^4

Modulus of Section $Z = 4{,}741 \times 10^3$ mm^3

Area of Web $A = 135.0 \times 10^2$ mm^2

Stress			
Bending		Shearing	
σ N/mm^2	Allowable Stress σ_a N/mm^2	τ N/mm^2	Allowable Stress τ_a N/mm^2
55	177	92	102

A 6-6 Structural Reinforcement calculation of Existing Deck Frame

1-1 Design Condition

Live Load ：3.5 kN/m^2 on all area of deck
Wind Load ：1.5 kN/m^2
Allowable Stress ：By Technical Standard for Gate and Penstocks
Allowable Deflection ： Bellow 1/1,000

Considerable Condition

	Shed, Gate tower and other self weights	Live Load	Gate Operation Load	Wind load	Remarks
During Gate Operation	○	○	○		
Under Wind Load	○	○	○	○	Allowable stress is 1.5 times larger.
Under Maximum Torque	○	○	○	○	Allowable stress under maximum torque is 90% of the yield point.

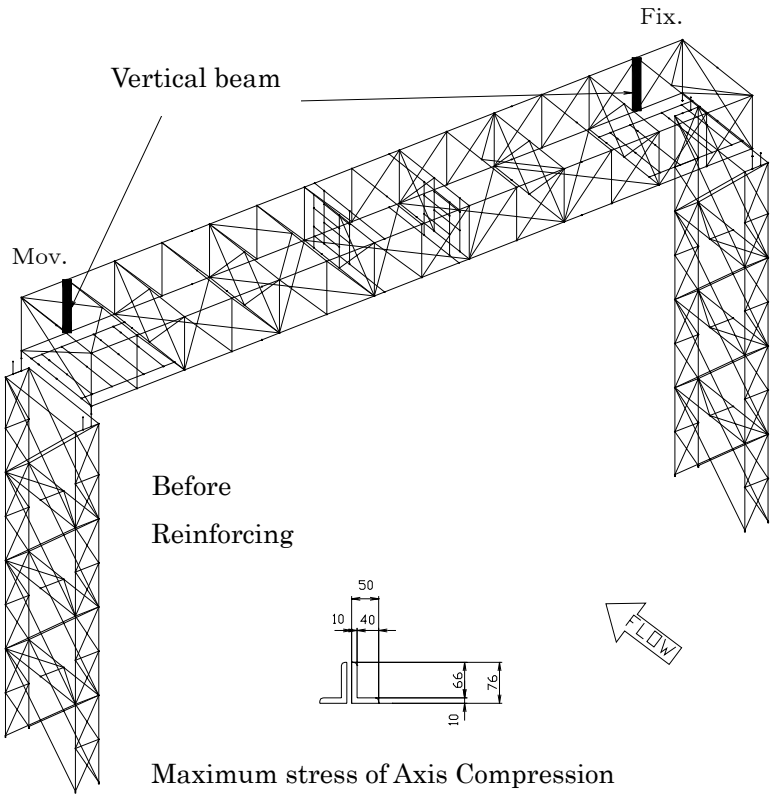
1-2 Reinforcement Plan of Under Sluice Gate

1-2-1 Stress Beam－Vertical Beam

Material：2－L76×50×10(SS400)

Maximum Load Case ： Case of Hoist Operation

(Dead Load+Live Load+Rating Hoisting Load)

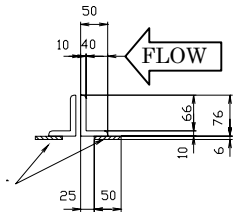


Before Reinforcing

Maximum stress of Axis Compression

$\sigma_c = 76\ N/mm^2 \quad > \quad \sigma_{ca} = 74\ N/mm^2$ OUT

After Reinforcing



Section of Reinforcement Material

2-PL50x6 (SM400)

Reinforcement Material

Maximum Stress of Axis Compression

$\sigma_c = 60\ N/mm^2 \quad < \quad \sigma_{ca} = 86\ N/mm^2$ OK

1-2-2 Deflection

	Vertical Displacement
	$\delta < \delta a$ (mm)
Live Load ＋ Rated Torque Load	1/1,148＜ 1/1,000

1-3 Reinforcement Plan of Weir Gate

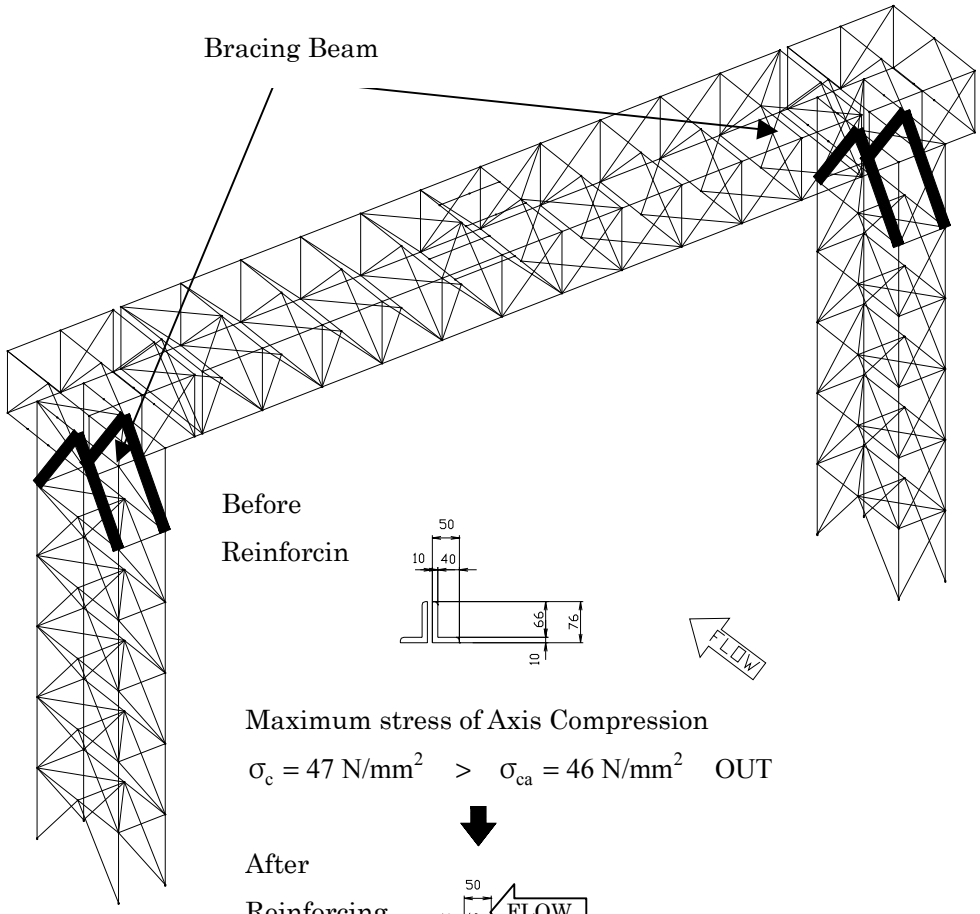
1-3-1 Stress Pillar－Bracing Beam (Side)

Material：2－L76×50×10(SS400)

Maximum Load Case ： Case of Maximum Torque (↑)

(Dead Load+Live Load+Wind Load(Water Flow Direction ↑)

+Maximum hoisting Load)

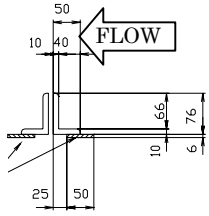


Maximum stress of Axis Compression

$\sigma_c = 47\ N/mm^2$ > $\sigma_{ca} = 46\ N/mm^2$ OUT

After

Reinforcing



Section of Reinforcement Material

2-PL50x6 (SM400)

Reinforcement Material

Maximum Stress of Axis Compression

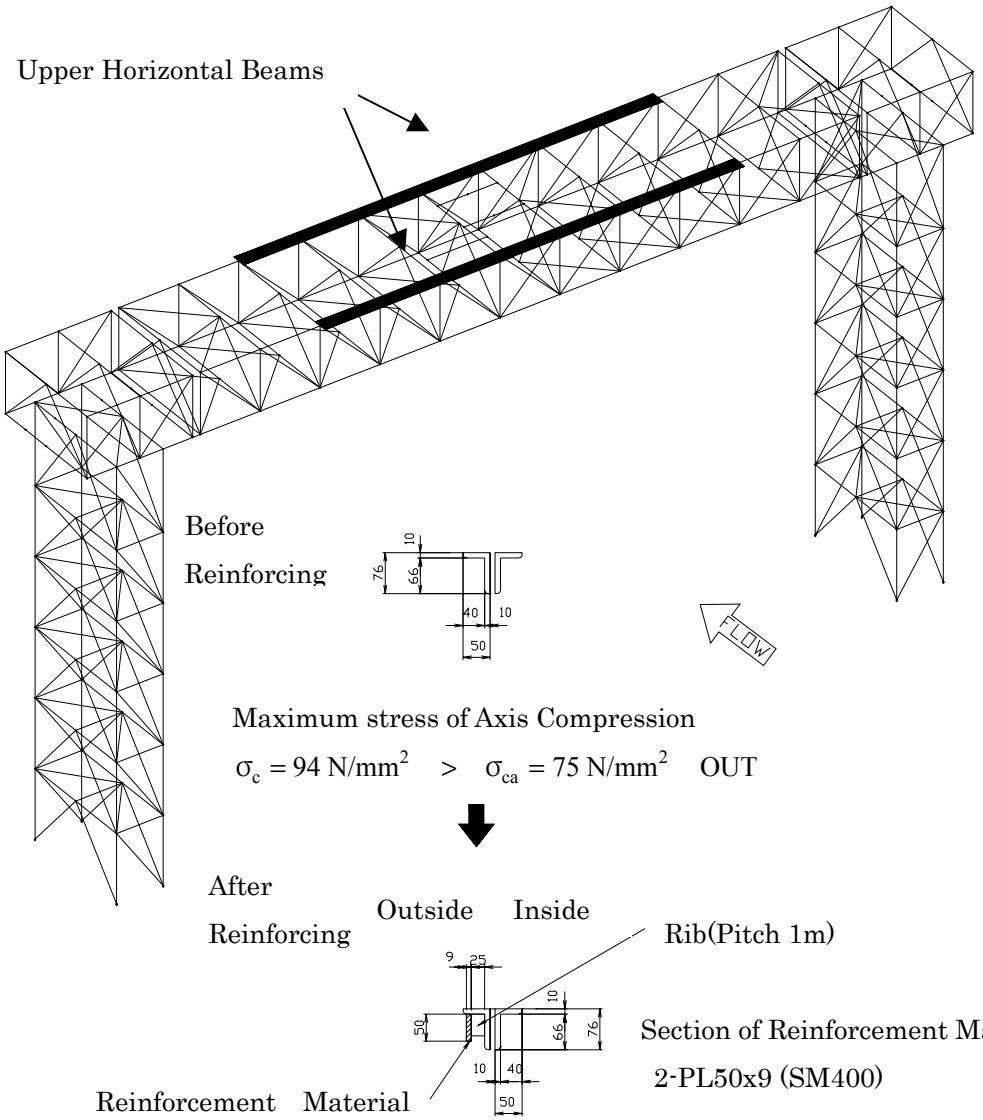
$\sigma_c = 37\ N/mm^2$ < $\sigma_{ca} = 61\ N/mm^2$ OK

1-3-2 Stress Beam－Upper Horizontal Beam

Material：2－L76×50×10(SS400)

Maximum Load Case ： Case of Hoist Operation

(Dead Load+Live Load+Rating Hoisting Load)



Maximum stress of Axis Compression

$\sigma_c = 94\ N/mm^2 \quad > \quad \sigma_{ca} = 75\ N/mm^2$ OUT

After
Reinforcing

Maximum Stress of Axis Compression

$\sigma_c = 79\ N/mm^2 \quad < \quad \sigma_{ca} = 84\ N/mm^2$ OK

1-3-3 Deflection

	Vertical Displacement
	$\delta < \delta a$ (mm)
Live Load ＋ Rated Torque Load	1/1,292 ＜ 1/1,000

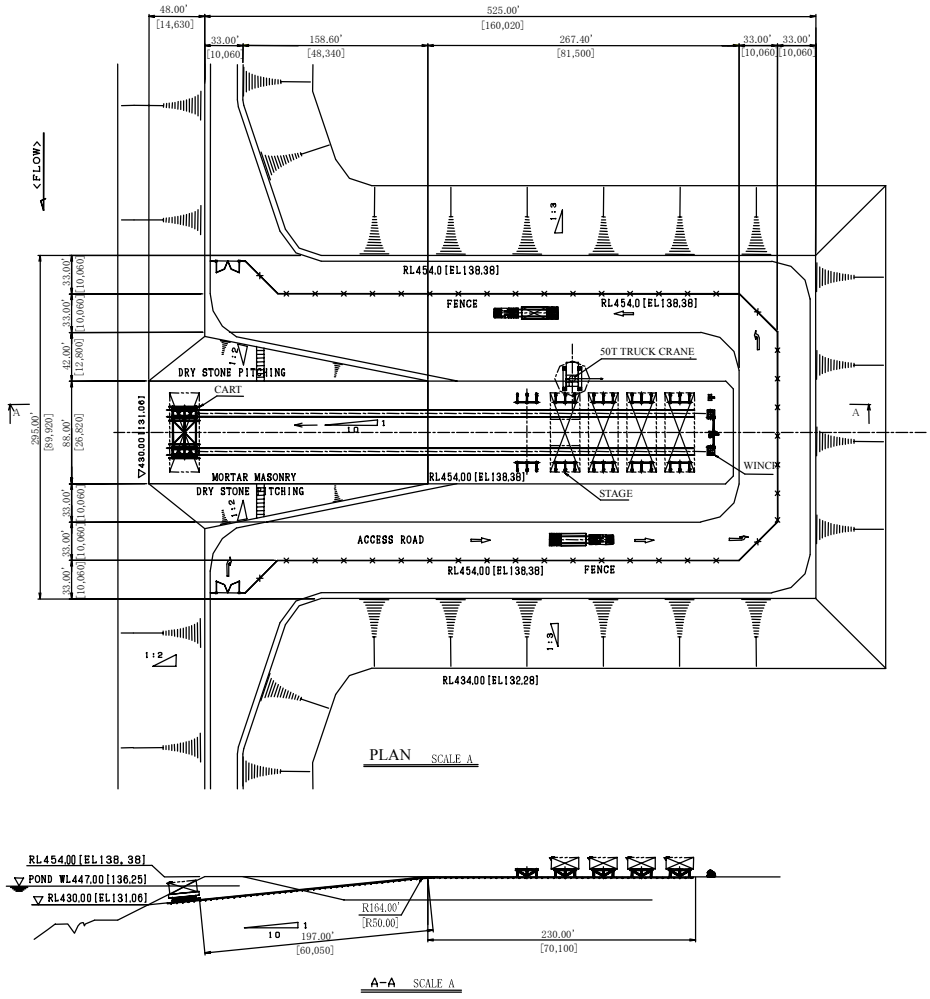
A 6-7 Incline Design Calculation in Bulk Head Gate Stockyard

1-1 Design Condition

Type	Incline with Rails
Quantity	1 unit
Top End Elevation	RL 454.00 ft [EL 138.38 m]
Bottom End Elevation	RL 430.00 ft [EL 131.07 m]
Gradient	5.7° (1:10)
Traveling System	1Motor 2Drum Wire Winch
Traveling Speed	3.3 ft/min ± 10% [1.0 m/min ± 10%]
Operating Method	Local control
Number of Rope Falls	2 at each side, 4 in total
Power Source	3Phase AC400 V, 50 Hz
Safety Factor	By Technical Standard for Gate and Penstocks

1-2 Schematic Diagram

Fig. A6-7-1.1 Bulk Head Gate Stockyard Incline Schematic Diagram



1-3 Load

1-3-1 Deadweight and Live Load (Vertical Load)

Bulk Head Gate Deadweight	1,304 kN
Cart Deadweight	334 kN
Total	W = 1,638 kN

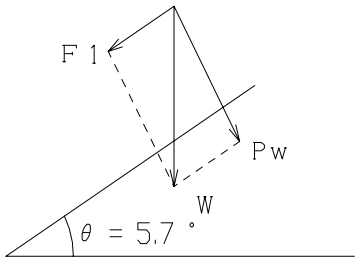
1-3-2 Deadweight and Live Load Component Force in the Direction of the Inclination

$F_1 = W \bullet \sin\theta$

where, W： Deadweight and Live Load, W = 1,638 kN

θ ： Angle of Incline, θ = 5.7 °

$F_1 = 1,638 \times \sin 5.7° = 163$ kN



1-3-3 Deadweight and Live Load Component Force in the Direction Perpendicular to the Inclination

$P_W = W \bullet \cos\theta$

where, W： Dead and Live Load, W = 1,638 kN

θ ： Angle of Incline, θ = 5.7°

$P_W = 1,638 \times \cos 5.7° = 1,630$ kN

1-3-4 Rolling Friction Resistance of the Wheels

$$F_2 = \frac{(\mu_1 + \mu_2 \cdot r)}{R} \cdot P_w$$

where, μ_1：Coefficient of Rotational Movement of the Wheel, $\mu_1 = 0.1$

μ_2： Coefficient of Rolling Friction of the Wheel axle, $\mu_2 = 0.01$

r ： Radius of the Wheel axle, r = 6.0 cm

R ： Radius of the Wheel, R = 30.0 cm

P_W： Deadweight and Live Load Component Force in the Direction Perpendicular to the Inclination, $P_W = 1,630$ kN

$$F_2 = \frac{(0.1 + 0.01 \times 6.0)}{30} \times 1,630 = 9 \text{ kN}$$

1-3-5 Wind Load

$F_W = q \bullet A \bullet C$

where, q：Wind Load Per Unit Projected Area at the Design Wind Velocity During the Use of the Incline (converted using the velocity ratio since the value is proportional to the square of the velocity; kN/m^2)

$$q = q_0 \cdot \left(\frac{v}{v_0}\right)^2$$

where, q_0 ： Wind Load per Unit Projected Area at the Design Wind Velocity (40 m/s), $q_0 = 2.94$ kN/m^2

v_0 ： Design Wind Velocity, $v_0 = 40$ m/s

v ： Design Wind Velocity during the Use of the Incline, v = 15 m/s

$$q = 2.94 \times \left(\frac{15}{40}\right)^2 = 0.41 \text{ kN/m}^2$$

A：Vertical Projected Area of the Bulk Head Gate and Cart (m^2)

$A = B_1 \cdot H_1 + B_2 \cdot H_2$

Where, B_1 ： Gate Leaf Width of Bulk Head Gate,$B_1 = 20.7$ m

H_1 ： Gate Leaf Depth of Bulk Head Gate,$H_1 = 3.0$ m

B_2 ： Width of Cart,$B_2 = 13.8$ m

H_2 ： Height of Cart,$H_2 = 2.0$ m

$A = 20.7 \times 3.0 + 13.8 \times 2.0 = 89.7$ m^2

C：Shape Factor, C = 1.2 (for the Planar Shape)

$F_W = 0.41 \times 89.7 \times 1.2 = 44$ kN

1-3-6 Hoisting Load

Unit：kN

Item		Hoisting
Deadweight and Live Load Component Force in the Direction of the Inclination	F_1	163 ↓
Rolling Friction Resistance of the Wheels	F_2	9 ↓
Wind Load	F_W	44 ↓
Total	F	216 ↓

Hoisting Load：216 kN

1-4 Operating Device Motor Capacity

$$P_M = \frac{F \cdot V}{60 \cdot \eta}$$

where, P_M ： Required Capacity (kW)

F ： Hosting Load = 216 kN

V ： Hoisting Speed = 1.0 m/min

η ： Efficiency of Machinery at Start = 0.668

$$P_M = \frac{216 \times 1.0}{60 \times 0.668} = 5.4 \text{ kW}$$

We employ the rating of 5.5 kW as the nearest capacity of more 3.7 kW.

Design Data of Motor

Type	TEFC, outdoor type (brake)
Capacity	5.5 kW (continuous cruising power)
Number of Poles	6 P, 50 Hz
Rated Number of Rotation	950 r.p.m.

A 6-8 Capacity Calculation of Emergency Generator for Gate Operation

1-1 Generator capacity calculation

Operating condition should be possible to operate ten(10) sets of under sluice gates motor as maximum.
(If should be possible to start two(2) sets of under sluice gates motor at the same time, when the eight(8) sets of under sluice gates motor is operating.)
Also power source of local control panel is turned on during gate operating, and maximum are ten(10) sets.
Determine the generator capacity from the loads of this equipment (see Table A 6-8-1.1 Table of loads).

Table A6-8-1.1 Table of loads

No.	Description of load	Output power (kW)	Quantity of the device	Quantity of the device to be operated	Factors		Input capacity (kVA)	Total (kVA)	Remarks
					Efficiency	Power			
1	Weir gate motor	1.5	50	0	0.85	0.8	2.2	0.0	Three-phase
2	Under sluice gate motor	2.2	14	10	0.85	0.8	3.2	34.2	Three-phase
3	Local control panel control supply	0.5	64	10	1	1	0.5	5.0	Single-phase
4	Low voltage switch board control supply	2	1	1	1	1	2.0	2.0	Single-phase

1-1-1 Steady-state load capacity

$$PG1 = [\ P_o / (\ \eta \times P_f\ )\ \ + P_i\ ] \times \alpha \ (kVA)$$

where,

PG1 ： Steady-state load capacity (kVA)

P_o ： Output of each load (kW)
Maximum number are ten (10) sets of under sluice gate motor.
2.2 kVA x 10 unit = 22 kVA

η ： Efficiency of each load = 0.85

P_f ： Power factor of each load = 0.80

P_i ： Load capacity (kVA) other than P_o
Local control panel load capacity： 0.5 kVA x 10 panels = 5.0 kVA
Switchboard load capacity： 2.0 kVA x 1 board = 2.0 kVA
Total load capacity： 5.0 kVA + 2.0 kVA = 7.0 kVA

α ： Demand factor = 1.0

$$PG1 = [(\ 22.0 / (0.85 \times 0.80\ )\ ) + 7.0] \times 1.0 = 39.4\ (kVA)$$

1-1-2 Capacity for transient maximum voltage drop

$$PG2 = P_s \times [\ (1 / Vd\ ) - 1\ ] \times Xd'\ (kVA)$$

where,

PG2 ： Capacity for transient maximum voltage drop (kVA)

P_s ： Starting capacity of the motor with the largest starting capacity (kVA)

$P_s = P_m \times \beta \times C = 4.4 \times 7.2 \times 1.0 = 31.7$ (kVA)

P_m ： Output of the motor with the largest value after multiplying the output (kW) by factors β and C

Maximum capacity is under sluice gates motor which start at the same time

2.2 kVA x 2 unit = 4.4 kVA

β ： Motor starting capacity per 1 kW = 7.2 (kVA) .

C ： Starting factor by starting system (see Table A 6-8-1.2) Use 1.0 for full-voltage starting.

Xd' ： Average of the generator's transient reactance and initial transient reactance = 0.25

Vd ： Allowable momentary voltage drop rate =use 0.2 for normal condition.

Table A 6-8-1.2 Starting factor for the squirrel-cage induction motor

Starting system	C
Full-voltage startng	1.0
Y — Δ	（at switch operation） 2/3
Rector	X / 100
Kondorfer	(X / 100)2

Notes： X ： Tap used (%)

$PG2 = 31.7 \times [\ (1 / 0.2\ ) - 1\ ] \times 0.25 = 31.7$ (kVA)

1-1-3 Capacity for transient peak output

$$PG3 = \sqrt{(PB + P_{ms})^2 + (QB + Q_{ms})^2}/KG3 \quad (kVA)$$

where,

PG3 ： Capacity for transient peak output (kVA)

PB ： Base load active power (kW)

$PB = P_n - P_m = 29.0 - 4.4 = 24.6$ (kW)

QB ： Base load reactive power (kvar)

$QB = Q_n - Q_m = 16.3 - 3.2 = 13.1$ (kVA)

P_{ms} ： Starting active power of the load with the largest starting capacity (kW)

$P_{ms} = Ps \times P_{fs} = 31.7 \times 0.4 = 12.7$ (kW)

Q_{ms} ： Starting reactive power of the load with the largest starting capacity (kvar)

$$Q_{ms} = P_s \times \sqrt{1-(P_{ms})^2} = 31.7 \times \sqrt{1-(0.4)^2} = 29.0 \quad (kVA)$$

KG3 ： Generator short-time capacity (Use 1.5 for normal condition.)

P_n ： Sum of active power of the loads (kW)

active power of ten (10) motors and panels supply：

2.2x10+0.5x10+2 = 29 kW

P_m ： Active power of the load with the largest starting capacity (kW)

two (2) motors： 2.2kWx2=4.4 kW

Q_n ： Sum of reactive power of the load (kvar)

Reactive power of under sluice gate's ten (10) motors

$= \text{input capacity} \times \text{efficiency} \times \sqrt{1 - (P_f)^2} \times \text{quantity} = 3.2 \times 0.85 \times \sqrt{1 - (0.8)^2} \times 10 = 16.3 \text{(kvar)}$

(Reactive power per one(1) motor is 16.3/10=1.6 kvar).

Q_m ： Reactive power of the load with the largest starting capacity (kvar)

Q_{ms} = two (2) motors： 1.6x2=3.2 kvar

P_s ： Starting capacity of the motor with the largest starting capacity (kVA)

= 31.7kVA

P_{fs} ： Starting power factor of P_s =0.4

$$PG3 = \sqrt{(24.6 + 12.7)^2 + (13.1 + 29.0)^2} / 1.5$$

$$= 37.5 \text{ (kVA)}$$

1-1-4 Generator output correction

Calculation results for the above (1) to (3) are：

PG1 = 39.4 (kVA)

PG2 = 31.7 (kVA)

PG3 = 37.5 (kVA)

Since these calculations are made for standard environment, output correction is necessary to fit the actual site.

① Output correction by intake air temperature

When the intake air temperature exceeds 30°C, output drops by 2% per 5.5°C increase.

When the field temperature is set to 55°C, output drops by about 9%.

(55-30)/5.5 x 2 (%) = 9.1(%)

② Output correction by ambient temperature and humidity

At an ambient temperature of 55°C and 50% humidity, output drops by about 7%.

(Reference： At an ambient temperature of 55°C and 80% humidity, output drops by about 12%.)

Correct the output values with an output drop of about 20%, taking above ① and ② plus margin into account.

PG1' = 39.4 (kVA) x 1.2 = 47.3 (kVA)

PG2' = 31.7 (kVA) x 1.2 = 38.0 (kVA)

PG3' = 37.5 (kVA) x 1.2 = 45.0 (kVA)

1-2 Prime mover output calculation

1-2-1 Steady-state load capacity output

$$PE1 = (PG1 \times PEL) / (0.736 \times \eta_G) \text{ (PS)}$$

where,

PE1 ： Steady-state load capacity output(PS)

PG1 ： Generator capacity required for normal operation (kVA) PG1' = 47.3 (kVA)

PEL ： Combined efficiency of the load = 0.8

η_G ： Commercial efficiency of the generator (Use 84.5% as specified as the commercial efficiency for 50 kVA in Table A 6-8-2.1)

Table A 6-8-2.1 Generator standard output and commercial efficiency

Generator capacity	Commercial efficiency
(kVA)	% orabove
20	79
37.5	82.5
50	84.5
62.5	85.2
75	85.7
100	86.7
125	87.6
150	88.1

$$PE1 = (43.7 \times 0.8) / (0.736 \times 0.845) = 56.2 \text{ (PS)}$$

1-2-2 Momentary making capacity output

$$PE2 = P_{ms} / (0.736 \ \eta_G \times K_1) \text{ (PS)}$$

where,

PE2 ： Momentary making capacity output

P_{ms} ： starting active power of the load with the largest starting capacity, 12.7 (kW)

K_1 ： momentary making load factor of the prime mover

For diesel engines, use：

1.0 when the average effective pressure is below 8 kgf/cm^2;

$$PE2 = 12.7 / (0.736 \times 0.845 \times 1.0) = 20.4 \text{ (PS)}$$

1-2-3 Transient peak output

$$PE3 = (PB + P_{ms}) / (0.736 \ \eta_G \times K2) \text{ (PS)}$$

where,

PE3 ： Transient peak output (PS)

PB ： base load active power (kW) 24.6 (kW)

K2 ： short-time overload capacity of the prime mover

1.1 for diesel engines

PE3 = (24.6 + 12.7) / (0.736 x 0.845 x 1.1) = 54.5 (PS)

1-3 Specifications of Emergency Generator

Emergency generator capacity should satisfy the following requirements based on the above calculations. Arrange the calculation results in table A 6-8-3.1.

Table A 6-8-3.1 Calculation results

Generator capacity		Prime motor capacity (PS)	
Condition	Result	Condition	Result
PG1'	47.3	PE1	56.2
PG2'	38.0	PE2	20.4
PG3'	45.0	PE3	54.5

From the maximum values in the table above：

Generator capacity ： 47.3 kVA or above

Prime mover capacity： 56.2 PS or above

Therefore the generator with the capacity immediately above these maximum values is the one with the standard output of 50 kVA in Table A 6-8-2.1

And prime mover capacity is 56.2PS or above.

A 6-9 Capacity Calculation of Generator for Winch in the Bulk head Gate Stockyard

1-1 Generator capacity calculation

Determine the generator capacity from the loads of this equipment (see Table A 6-9-1.1 Table of loads).

Table A 6-9-1.1 Table of loads

No.	Description of load	Output power (kW)	Quantity of the device	Quantity of the device to be operated	Factors		Input capacity (kVA)	Total (kVA)	Remarks
					Efficiency	Power			
1	Hoist motor	5.5	1	1	0.85	0.8	8.1	8.1	Three-phase
2	Local control panel control supply	0.5	1	1	1	1	0.5	0.5	Single-phase

1-1-1 Steady-state load capacity

$$PG1 = [\ P_o / (\ \eta\ x\ P_f\ )\ \ +P_i\ ]\ x\ \alpha\ \ (kVA)$$

where,

PG1 ： Steady-state load capacity (kVA)

P_o ： Output of each load (kW)

Hoist motor output： 5.5 kVA x 1 unit = 5.5 kVA

η ： Efficiency of each load = 0.85

P_f ： Power factor of each load =0.80

P_i ： Load capacity (kVA) other than P_o (e.g. lighting load given in input kVA.)

Local control panel load capacity： 0.5 kVA x 1 panel = 0.5 kVA

α ： Demand factor = 1.0

$$PG1 = [\ (\ 5.5 / (0.85\ x\ 0.80\ )\ ) + 0.5]x1.0 = 8.6\ (kVA)$$

1-1-2 Capacity for transient maximum voltage drop

$$PG2 = P_s\ x\ [\ (1 / Vd\ ) - 1\ ]\ x\ Xd'\ (kVA)$$

where,

PG2 ： Capacity for transient maximum voltage drop

P_s ： Starting capacity of the motor with the largest starting capacity (kVA)

$P_s = P_m\ x\ \beta\ x\ C = 5.5\ x\ 7.2\ x\ 1.0 = 39.6$ (kVA)

P_m ： Output of the motor with the largest value after multiplying the output (kW) by factors β and C

Hoist motor output： 5.5 kVA x 1 unit = 5.5 kVA

β ： Motor starting capacity per 1 kW = 7.2 (kVA/kw)

C ： Starting factor by starting system (see Table A 6-9-1.2) Use 1.0 for full-voltage starting.

Xd' ： Average of the generator's transient reactance and initial transient reactance = 0.25

Vd ： Allowable momentary voltage drop rate =use 0.2 for normal condition.

Table A 6-9-1.2 Starting factor for the squirrel-cage induction motor

Starting system	C
Full-voltage startng	1.0
Y — Δ	(at switch operation) $^{2/3}$
Rector	X / 100
Kondorfer	$(X / 100)^2$

X ： Tap used (%)

PG2 = 39.6 x [(1.0 / 0.2) - 1.0] x 0.25 = 39.6 (kVA)

1-1-3 Capacity for transient peak output

$$PG3 = \sqrt{(PB + P_{ms})^2 + (QB + Q_{ms})^2} / KG3 \quad (kVA)$$

where,

PG3 ： Capacity for transient peak output (kVA)

PB ： Base load active power (kW)

$PB = P_n - P_m = 6.0 - 5.5 = 0.5$ (kW)

QB ： Base load reactive power (kvar)

$QB = Q_n - Q_m = 4.1 - 4.1 = 0$ (kVA)

P_{ms} ： Starting active power of the load with the largest starting capacity (kW)

$P_{ms} = Ps \times P_{fs} = 39.6 \times 0.4 = 15.8$ (kW)

Q_{ms} ： Starting reactive power of the load with the largest starting capacity (kvar)

$$Q_{ms} = P_s \times \sqrt{1 - (P_{ms})^2} = 39.6 \times \sqrt{1 - (0.4)^2} = 36.3 \quad (kVA)$$

KG3 ： Generator short-time capacity (Use 1.5 for normal condition.)

P_n ： Sum of active power of the loads (kW)

Active power of one (1) motor and one (1) panel supply：5.5 + 0.5 = 6.0 kW

P_m ： Active power of the load with the largest starting capacity (kW)

One (1) motor： 5.5 kW

Q_n ： Sum of reactive power of the load (kvar)

$$= \text{input capacity} \times \text{efficiency} \times \sqrt{1 - (P_f)^2} = 8.1 \times 0.85 \times \sqrt{1 - (0.8)^2} = 4.1 \text{(kvar)}$$

One (1) motor： 4.1 kvar

Q_m ： Reactive power of the load with the largest starting capacity (kvar)

Q_{ms} = one (1) motor： 4.1 kvar

P_s ： Starting capacity of the motor with the largest starting capacity (kVA) = 39.6kVA

P_{fs} ： Starting power factor of P_s =0.4

$$PG3 = \sqrt{(0.5 + 15.8)^2 + (0.0 + 36.3)^2} / 1.5$$

= 26.5 (kVA)

1-1-4 Generator output correction

Calculation results for the above (1) to (3) are：

PG1 = 8.6 (kVA)

PG2 = 39.6 (kVA)

PG3 = 26.5 (kVA)

Since these calculations are made for standard environment, output correction is necessary to fit the actual site.

① Output correction by intake air temperature

When the intake air temperature exceeds 30°C, output drops by 2% per 5.5°C increase.

When the field temperature is set to 55°C, output drops by about 9%.

(55-30)/5.5 x 2 (%) = 9.1(%)

② Output correction by ambient temperature and humidity

At an ambient temperature of 55°C and 50% humidity, output drops by about 7%.

(Reference： At an ambient temperature of 55°C and 80% humidity, output drops by about 12%.)

Correct the output values with an output drop of about 20%, taking above ① and ② plus margin into account.

PG1' = 8.6 (kVA) x 1.2 = 10.3 (kVA)

PG2' = 39.6 (kVA) x 1.2 = 47.5 (kVA)

PG3' = 26.5 (kVA) x 1.2 = 31.8 (kVA)

1-2 Prime mover output calculation

1-2-1 Steady-state load capacity output

$$PE1 = (PG1 \times PEL) / (0.736 \times \eta_G) (PS)$$

where,

PE1 ： Steady-state load capacity output(PS)

PG1 ： Generator capacity required for normal operation (kVA) PG1'

= 15.8 (kVA)

PEL ： Combined efficiency of the load = 0.8

η_G ： Commercial efficiency of the generator (Use 84.5% as specified as the commercial efficiency for 50 kVA in Table A 6-9-2.1)

Table A 6-9-2.1 Generator standard output and commercial efficiency

Generator capacity (kVA)	Commercial efficiency % orabove
20	79
37.5	82.5
50	84.5
62.5	85.2
75	85.7
100	86.7
125	87.6
150	88.1

PE1 = (10.3 x 0.8) / (0.736 x 0.845) = 13.2 (PS)

1-2-2 Momentary making capacity output

$$PE2 = P_{ms} / (0.736 \ \eta_G \times K_1) \ (PS)$$

where,

PE2 ： Momentary making capacity output

P_{ms} ： starting active power of the load with the largest starting capacity, 15.8 (kW)

K_1 ： momentary making load factor of the prime mover

For diesel engines, use：

1.0 when the average effective pressure is below 8 kgf/cm^2;

PE2 = 15.8 / (0.736 x 0.845 x 1.0) = 25.4 (PS)

1-2-3 Transient peak output

$$PE3 = (PB + P_{ms}) / (0.736 \ \eta_G \cdot K2) \ (PS)$$

where,

PE3 ： Transient peak output (PS)

PB ： base load active power (kW) 0.5 (kW)

K2 ： short-time overload capacity of the prime mover

1.1 for diesel engines

PE3 = (0.5 + 15.8) / (0.736 x 0.845 x 1.1) = 23.9 (PS)

1-3 Specifications of generator

Generator capacity should satisfy the following requirements based on the above calculations. Arrange the calculation results in table A 6-9-3.1.

Table A 6-9-3.1 Calculation results

Generator capacity		Prime motor capacity (PS)	
Condition	Result	Condition	Result
PG1'	10.3	PE1	13.2
PG2'	47.5	PE2	25.4
PG3'	31.8	PE3	23.9

From the maximum values in the table above：

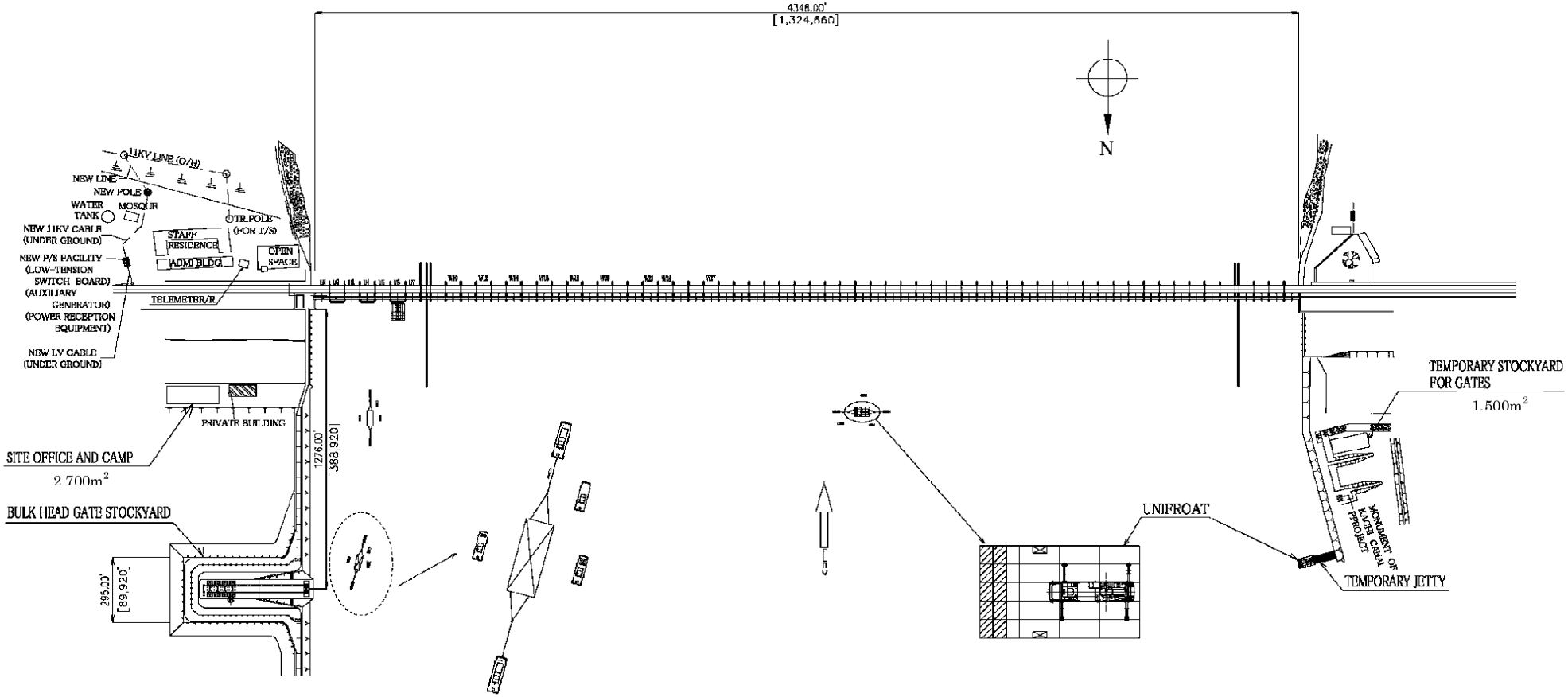
Generator capacity： 47.5 kVA or above

Prime mover capacity： 25.4 PS or above

Therefore the generator with the capacity immediately above these maximum values is the one with the standard output of 50 kVA in Table A 6-9-2.1.

And prime mover capacity is 25.4PS or above

A6-10 Figures for Construction Manner

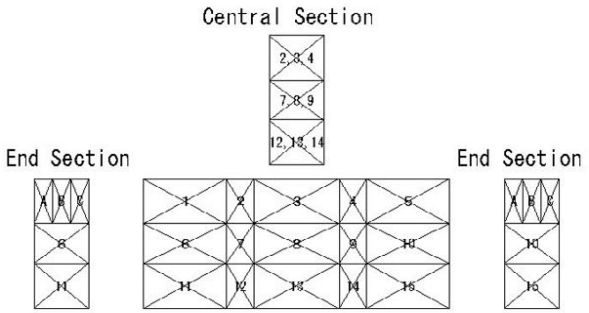


PLAN

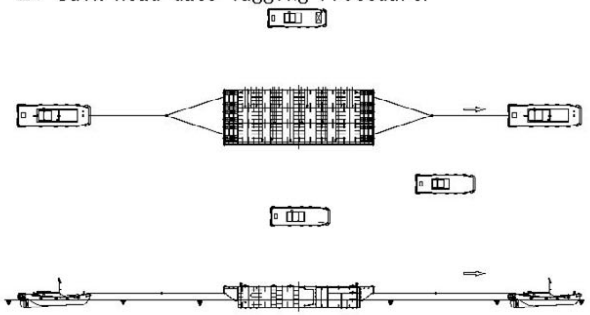
TEMPORARY FACILITY LAYOUT OF TAUNSA BARRAGE REHABILITATION PROJECT

Bulk head Gate Installation Procedure Diagram

1. Bulk head Gate Cells to Injection Water.

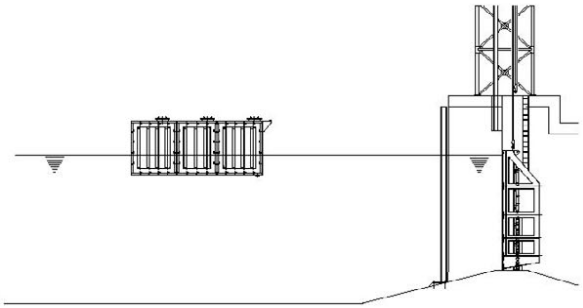


2. Bulk head Gate Tugging Procedure.



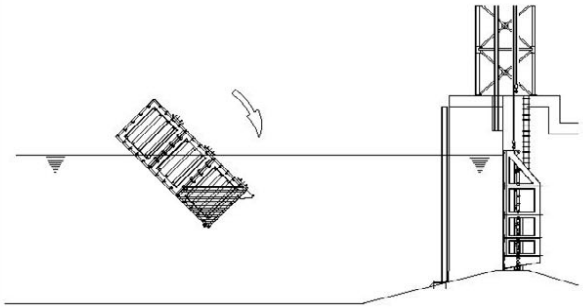
Step 1

・Tow the bulk head gate close to the installation position.



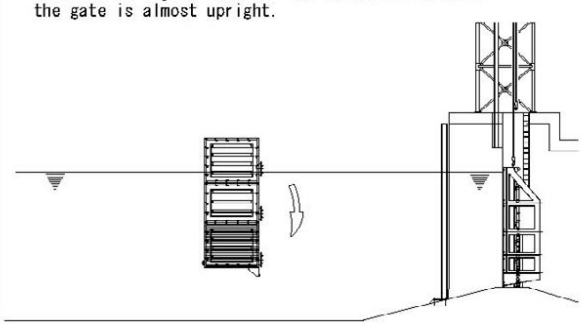
Step 2

・Start injecting water in the bottom cells(11--15).



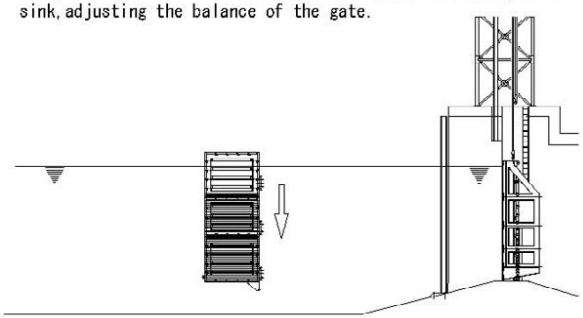
Step 3

・Cotinue to inject water in the bottom cells until the gate is almost upright.



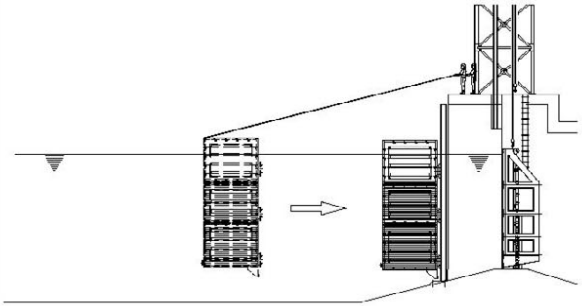
Step 4

・Inject water in the middle cells(7--9)to allow the gate to sink,adjusting the balance of the gate.



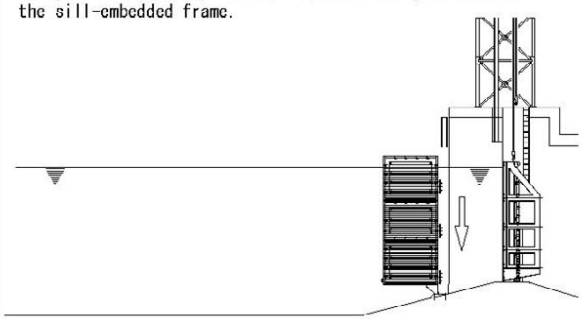
Step 5

・Move the bulk head gate to the installation position.

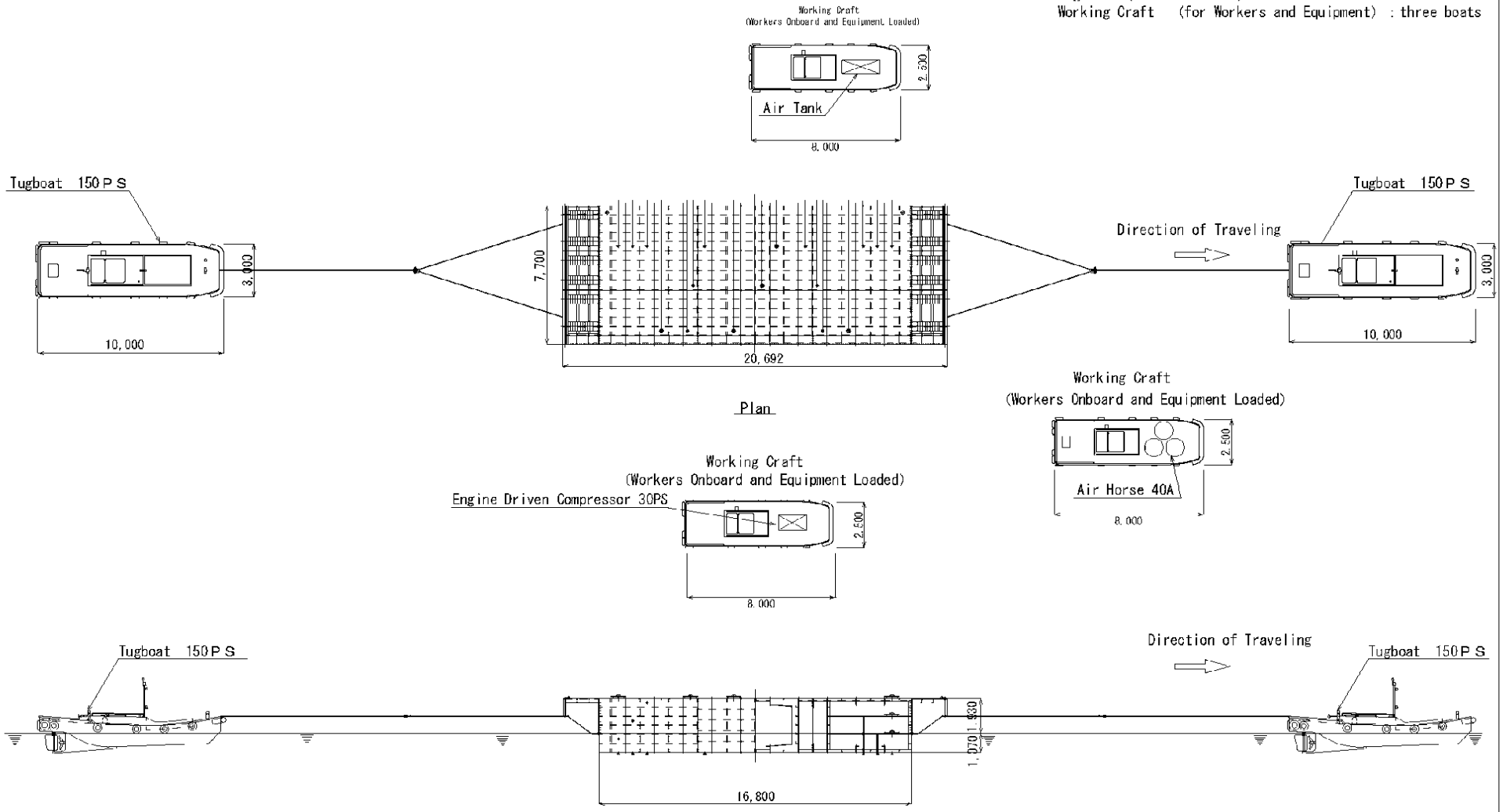


Step 6

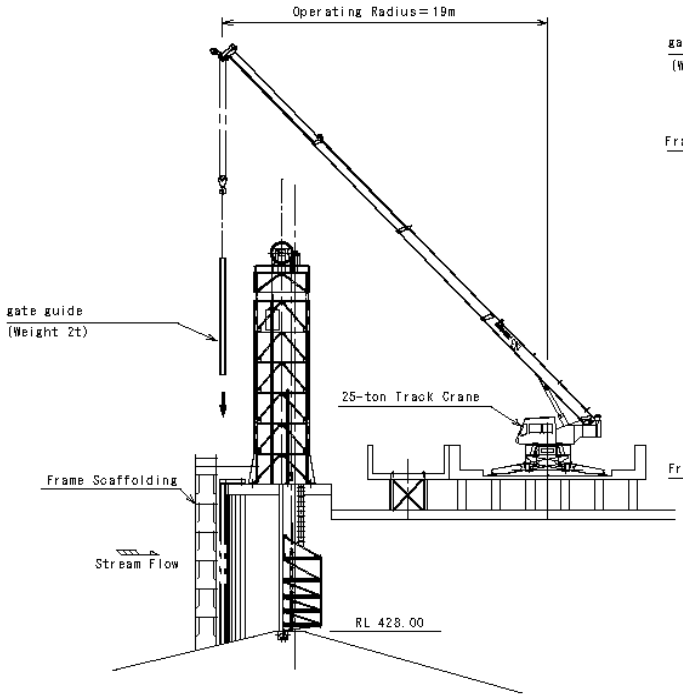
・Inject water in top cells(1--5)until the gate sits on the sill-embedded frame.



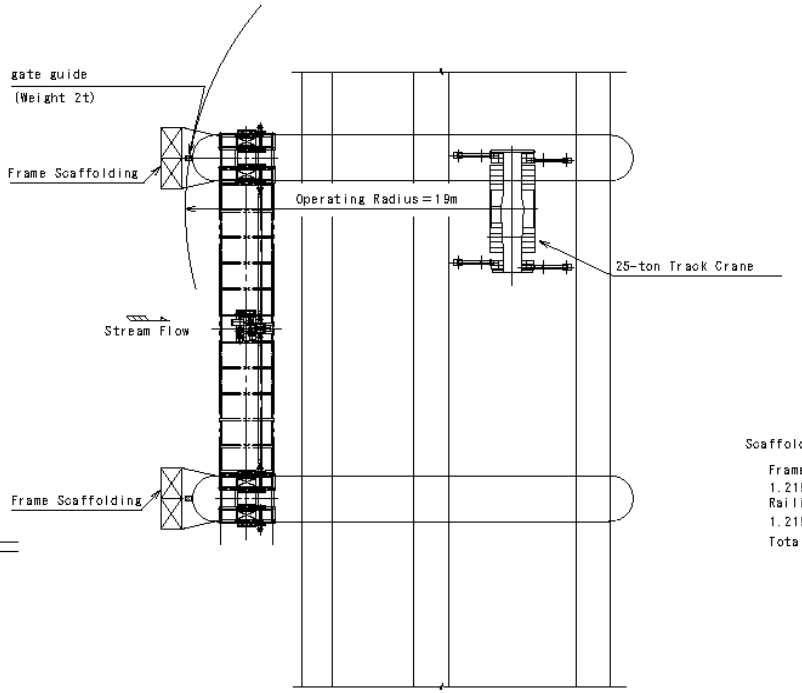
Tugging Fleet Cofiguration
Tugboats (Front and Rear) : two boats
Working Craft (for Workers and Equipment) : three boats



BULK HEAD GATE TUGGING PROCEDURE DIAGRAM



Profile



Plan

25-ton Track Crane
Performance Chart (ton)

Operating Radius \ Boom	24.4 m	31.5 m
14 m	3.9	3.9
15 m	3.15	3.45
16 m	2.95	3.30
17 m	2.6	3.0
18 m	2.3	2.6
19 m	2.0	2.3
20 m	1.75	2.05
21 m	1.5	1.8
22 m	1.35	1.6

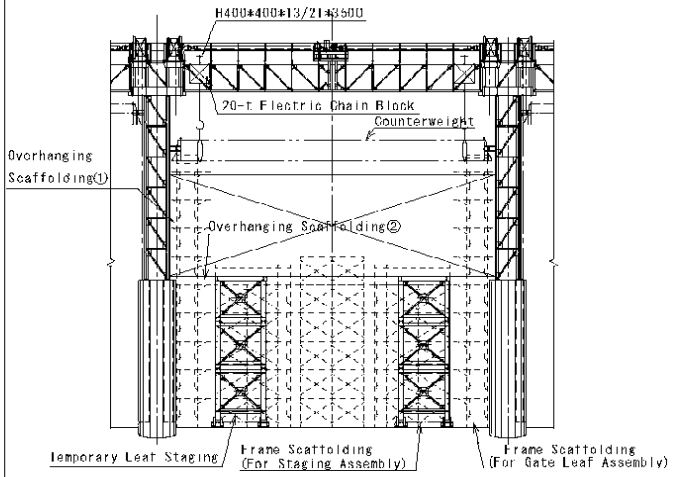
Scaffoldings

Frame Scaffoldings
1.219*1.829*1.7*24＝91.0(space volume)
Railing
1.219*1.829*1*4＝45.5(space volume)
Total＝136.5m3(space volume)

〔Primary Equipment〕

Description	Specification	Quantity
Track Crane	Capacity:25ton	One(1) unit

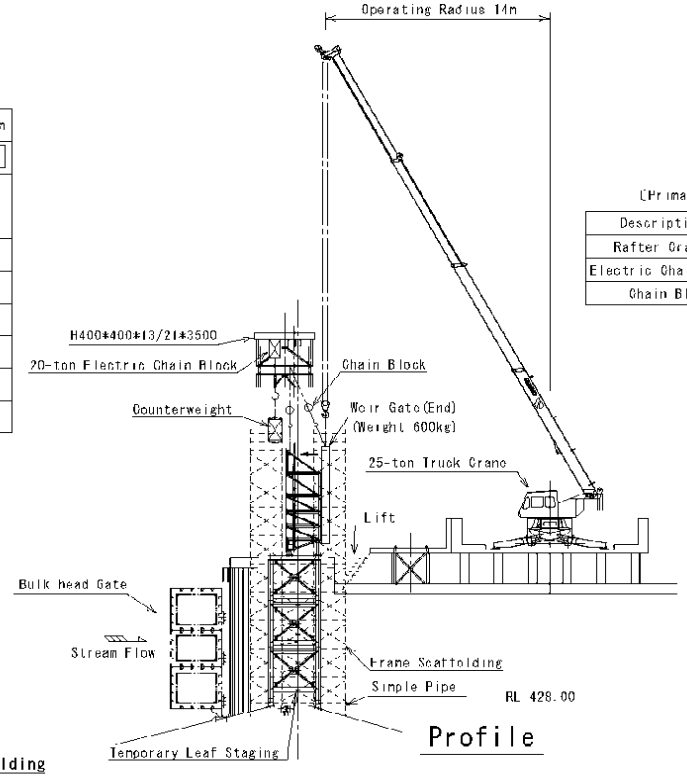
BULK HEAD GATE GUIDE PROCEDURE DIAGRAM



Elevation

25-ton Rafter Crane
Performance Chart (ton)

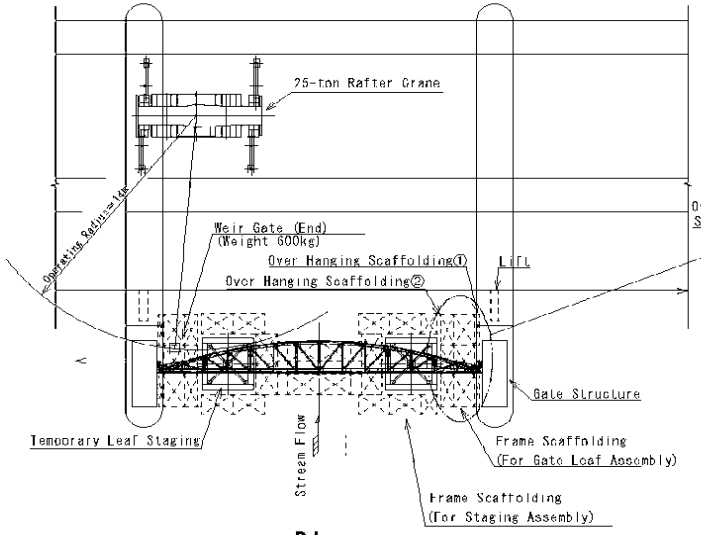
Operating Radius \ Boom	23.5 m	30.5 m
14 m	4.1	4.15
15 m	3.6	3.8
16 m	3.15	3.45
17 m	2.8	3.05
18 m	2.45	2.7
19 m	2.15	2.45
20 m	1.9	2.2
21 m	1.7	1.95
22 m	—	1.75



Profile

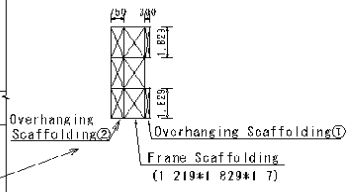
[Primary Equipmennt]

Description	Specification	Quantity
Rafter Crane	Capacity : 25-ton	1
Electric Chain Block	For 20-ton	2
Chain Block	For 1.5-ton	1



Plan

Overhanging Scaffolding



Scaffoldings
Frame Scaffoldings
For Gate Leaf Assembly
1.219*1.829*1.7*58－219.8m3(space volume)
For Staging Assembly
1.219*1.829*1.7*60－227.4m3(space volume)
Railing
1.219*1.829*1*20＝44.6m3(space volume)
Overhanging Scaffolding①
0.3*1.829*1.7*16＝14.9m3(space volume)
Overhanging Scaffolding②
0.75*1.829*1.7*20＝46.6m3(space volume)
Total－553.3m3(space volume)

[Temporary Equipment]

Electric Chain Block Beam

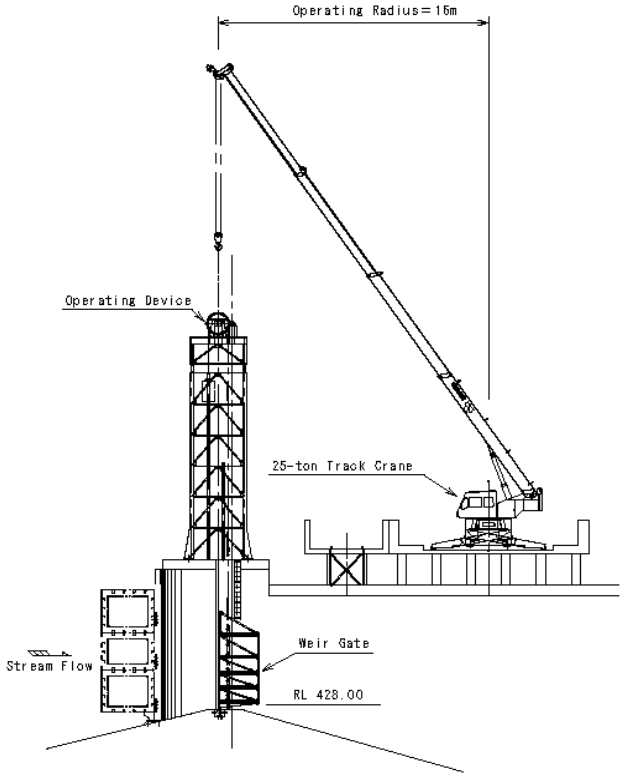
Description	Specification	Quantity	Unit	Unit Weight	Gross Weight	Remarks
H Steel	H400*400*13/21*3500	2	Pieces	602kg	1204kg	For Chain Block

Temporary Leaf Staging(per Set)

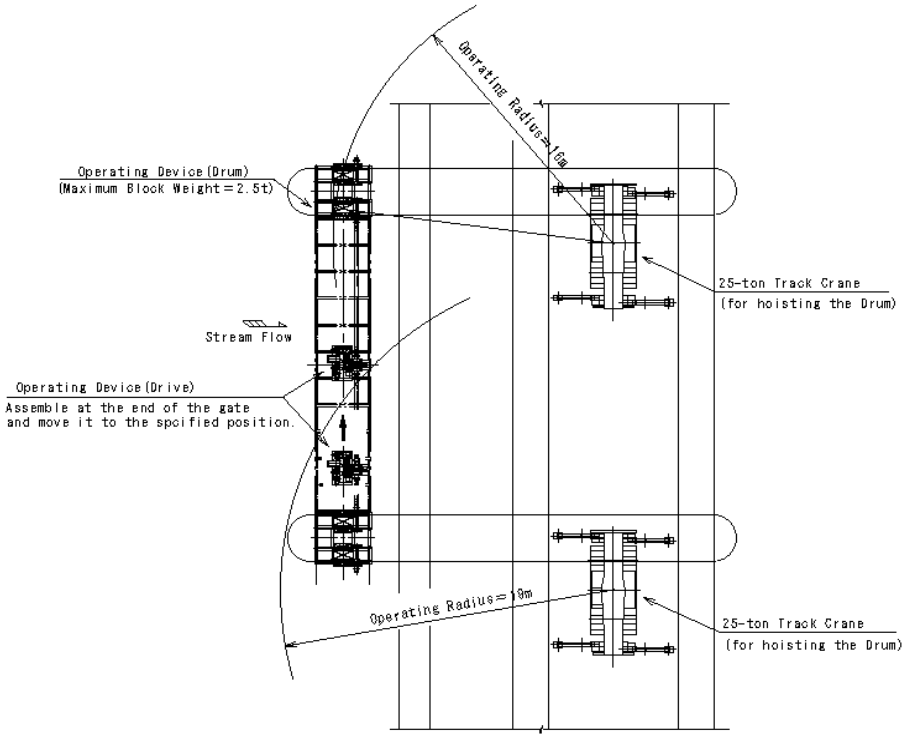
H Steel	H300*300*10/15*2370	22	Pieces	220kg	4849kg	Gate Leaf Staging
H Steel	H300*300*10/15*2400	4	Pieces	223kg	893kg	Gate Leaf Staging
H Steel	H300*300*10/15*2800	4	Pieces	260kg	1042kg	Gate Leaf Staging
H Steel	H300*300*10/15*2970	2	Pieces	276kg	552kg	Gate Leaf Staging
H Steel	H400*400*13/21*3200	4	Pieces	298kg	1190kg	Gate Leaf Staging
Angle	L100*100*10*1250	24	Pieces	19kg	450kg	Gate Leaf Staging
Angle	L100*100*10*1450	12	Pieces	22kg	261kg	Gate Leaf Staging
Angle	L100*100*10*2800	12	Pieces	42kg	504kg	Gate Leaf Staging
Angle	L100*100*10*3140	6	Pieces	47kg	283kg	Gate Leaf Staging
Plate	PL250*12L	72	Sheets	6kg	432kg	Gate Leaf Staging
Plate	PL500*12L	18	Sheets	24kg	432kg	Gate Leaf Staging

Subtotal＝10888kg
Two(2)sets＝21776kg
Total＝22980kg

WEIR GATE LEAF ASSEMBLY PROCEDURE DIAGRAM



Profile



Plan

25-ton Track Crane
Performance Chart (ton)

Operating Radius \ Boom	24.4 m	31.5 m
14 m	3.9	3.9
15 m	3.15	3.45
16 m	2.95	3.30
17 m	2.6	3.0
18 m	2.3	2.6
19 m	2.0	2.3
20 m	1.75	2.05
21 m	1.5	1.8
22 m	1.35	1.6

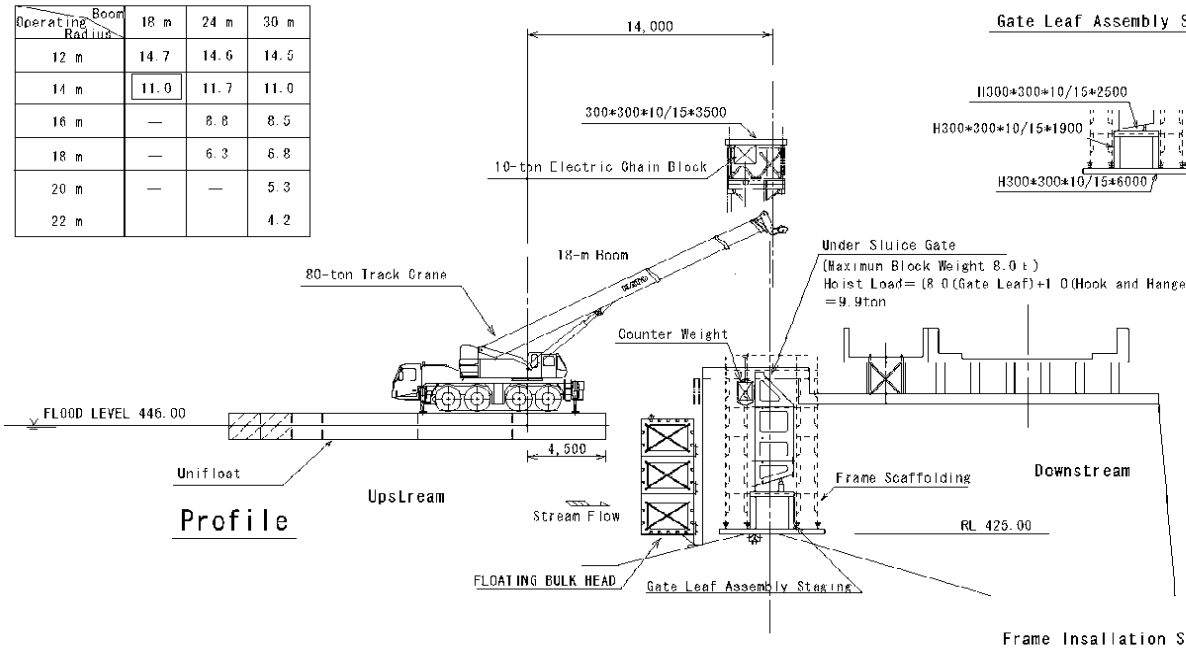
〔Primary Equipment〕

Description	Specification	Quantity
Track Crane	Capacity:25ton	One(1) unit

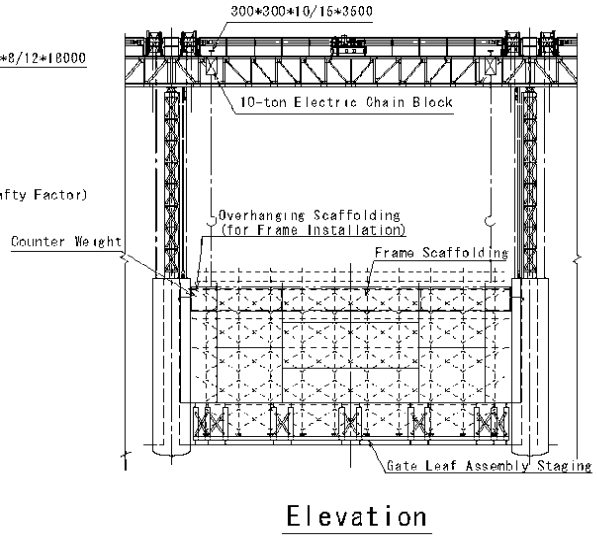
GATE OPERATING DEVICE HOISTING PROCEDURE DIAGRAM

80-ton Track Crane
Performance Chart (ton)

Operating Radius \ Boom	18 m	24 m	30 m
12 m	14.7	14.6	14.5
14 m	11.0	11.7	11.0
16 m	—	8.8	8.5
18 m	—	6.3	6.8
20 m	—	—	5.3
22 m			4.2

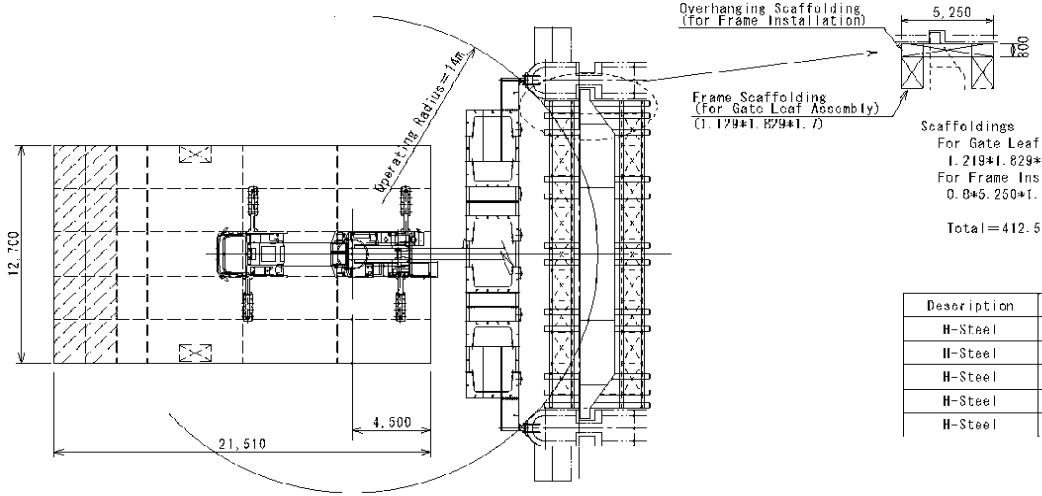


Gate Leaf Assembly Staging



Elevation

Frame Insallation Scaffolding



Plan

[Primary Equipment]

Description	Specification	Quantity
Track Crane	Capacity:80ton	1 unit
Electric Chain Block	For 10ton	4 units

Scaffoldings
For Gate Leaf Assembly
1.219*1.829*1.7*90=341.1m3(space volume)
For Frame Installation
0.8*5.250*1.7*10=71.4m3(space volume)

Total=412.5m3(space volume)

[Temporary Materials]

Description	Specification	Quantity	Unit	Unit Weight	Gross Weight	Remarks
H-Steel	H300*300*10/15*1900	24	Pieces	177kg	4241kg	Gate Leaf Staging
H-Steel	H300*300*10/15*2500	12	Pieces	233kg	2790kg	Gate Leaf Staging
H-Steel	H300*300*10/15*6000	12	Pieces	558kg	6696kg	Gate Leaf Staging
H-Steel	H200*200*8/12*2500	4	Pieces	326kg	651kg	Gate Leaf Staging
H-Steel	H300*300*10/15*3500	2	Pieces	900kg	3600kg	For Chain Block

Total=17327kg

UNDER SLUICE GATE LEAF ASSEMBLY PROCEDURE DIAGRAM

A6-10.8