Paper No. 172

# KUNDAL SHAHI HYDEL SCHEME

BY

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## INTRODUCTION

A large number of mini-hydropower plants have been installed worldwide, often providing the only source of power in remote regions. The wealth of experience gathered by those who implemented these schemes has rarely been documented. One purpose of this publication is to enable remote area communities implementing their own mini-hydropower schemes to benefit from the experiences of others by recording some of these experiences.

## VILLAGER-IMPLEMENTED MINI-HYDROPOWER SCHEMES IN PAKISTAN

In the mid-1970s, the Appropriate Technology Development Organization (ATDO), with the technical consulting services and support of the North-West Frontier Province (NWFP) University of Engineering and Technology, Peshawar, launched a program to disseminate micro-hydropower technology and install micro- hydropower plants in remote rural villages in northern Pakistan. Their objective has been to create appropriate designs whose technology and cost can be absorbed by the local population. Ranging from about 5 to 15 KW, nearly 40 plants have been installed to date, at a pace quickening with time as news of these installations spreads. A number of plants ranging in size upto 50 KW are also under construction. Shaft power is used to generate electrical power primarily at night to replace wood or expensive fossil fuels used for lighting.At about a quarter of the sites, it is also used to drive a variety of tools and agro- processing equipment during the day.

Beyond the accomplishment of implementing viable hydropower schemes in remote rural villages, this undertaking features the unusually low cost of US$ 700 to 1000/kW (in 1988 dollars) including distribution. This low cost is attributable primarily to three factors:

-nonconventional use of readily available materials;

- design suited to local conditions; and

-community involvement in the initiation, implementation, management operation, and maintenance of the hydropower schemes.

At a time when the high cost generally associated with microhydropower schemes is often

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* Crescent Group Services (Pvt) Ltd.

used as an argument against their appropriateness, especially in a rural setting, the Pakistan exception to the rule prompts a more detailed description of their experience.

## BACKGROUND

In stark contrast to the flat plains that extend over a large portion of Pakistan, the northern part of the country presents physical as well as demographic obstacles to extending roads and the electricity grid and developing the infrastructure necessary to serve its people. The steep, rugged, stone-studded mountains, rendered even more austere by the dearth of trees, discourage inroads. Among these mountains, villagers in scattered and isolated communities eke out a living off the inhospitable terrain. Greener irrigated plots of land are generally restricted to narrow strips on the slopes bordering perennial streams in the valleys. The areas farther removed,if cultivated at all, must make the most of the low rainfall in the region.

NWFP ENGINEERING SCHOOL involvement in micro-hydropower projects was triggered by the 1973 oil crises. After the first OPEC oil embargo, an incrasing number of organizations and programs worldwide began to address the problems caused by a dependence on imported oil. Because of the enormousness of the problem, however, governments in numerous countries showed little concern or capacity for meeting the relatively insignificant energy needs of those in the rural areas. These include replacing costly fuels, especially kerosene and diesel already in use, and providing these people with some of the basic amenities available to those the urban areas.

In Pakistan, two alternatives for providing electrical energy to the remote areas without relying on imported fossil fuels were apparent. To the extent that the national grid relied on large- hydropower generation of electricity, grid extension to these areas provided one such alternative. However, the annual development plan of the Water and Power Development Authority.(WAPDA) the agency responsible for electricity generation, transmission, and distribution in Pakistan, envisions rural electrification proceeding at the rate of about 1000 villages annually. With three-quarters of the country's 43,000 villages still not electrified, it may take decades to provide electricity to most of them.

The remoteness of the villages, their small population, and the lack of income-generating enterprises combine to making rural electrification by grid extension uneconomical. Under the present system, the average cost of electrifying a village, even one only several kilometers from the main grid, approaches Rs.1,000,000. This figure covers only the cost of distribution, not transmission.

Another alternative for providing electricity to the rural areas was onsite autogeneration of power. In the early 1970s, the Ministry of Water and Power installed several small-hydropower plants along conventional lines , at US$ 5000-6000/kw, but this alternative proved equally uneconomical.

Both the high costs implicit in pursuing either grid extension or autogeneration and the logistical and organizational difficulties involved seemed to preclude the possibility of electrifying the rural areas. If this end was to be achieved, it appeared necessary to develop a new approach, one designed to address the specific conditions encountered in electrification of remote rural areas more appropriately.

# KUNDAL SHAHI PROJECT

## LOCATION

Kundal Shahi Hydel Scheme is located on right bank of Jagran nullah about 1.32 miles upstream of its confluence with Neelum river. The project area generally lies at an altitude of 4200 feet above mean sea level.

Kundal Shahi village is located about 36 miles north-east of Muzaffarabad. It is an important village of Tehsil Authmuqam of District Muzaffarabad. It is a commercial centre also. It is widely spread on flat flanks of Jagran nullah and adjoining hill slopes well.

## OBJECTIVE

Reconnaissance of Neelum catchment was actively undertaken during September - October 1982 and followed by Jhelum. This resulted in identification of ten (10) sites for detailed studies as per priority fixed by the AJ&K Govt. Accordingly work was first taken up for Kel Hydel Scheme then followed Kundal Shahi Hydel Scheme.

Objective of the Kundal Shahi Scheme is to provide hydro-electric facility to Kundal Shahi and following villages situated in its vicinity within a radius of about eight (8) miles.

1. Authmuqam
2. Palri
3. Katha Piran
4. Shah Kot
5. Salkhala
6. Chanjhat
7. Jagran
8. Bugna
9. Ban Chhatar
10. Dulur
11. Salam Pura
12. Sandok
13. Kuttan
14. Bata
15. Kayan

Till 1983 population of these villages was estimated at 20,230 including the increase in population after 1981 while total number of houses are 3,049.

## WAPDA PROPOSAL FOR 1200 KW

Hydrological data of Jagran nullah was not recorded in the past. However, WAPDA observed its low/high flow discharges during 1982-83. Based on these observations, field/office studies and discussions with the government of AJ&K, a hydel scheme with installed capacity of 1200 kW on Jagran nullah was proposed. For this development, 190 cusecs of water would be diverted from right bank of Jagran nullah into the head race channel formed by 950 feet long approach channel and 2740 feet long power channel ultimately discharge into 13' x 25' size forebay. Water from the forebay would be conveyed to the power house through 2 No. steel penstocks each 3.5 feet internal diameter, under a gross head of 120 feet. These two penstocks would be further bifurcated into 2.5 feet internal diameter penstocks leading to four compact

horizontal shaft, direct coupled turbo-generating sets rated at 300 kW capacity each.

Power house building would be constructed in stone masonry and concrete. Releases from power house would outfall into Jagran nullah by a 120 feet long tail race channel.

## EBASCO-CRESENT PROPOSAL FOR 2000 KW WITH THE CUT IN COST AND INCREASE IN POWER

Since the fundamental key to the success of small hydel schemes is hydrology, this element of the WAPDA PROPOSAL was given early review. Since no stream flow or sediment measurement observations existed for the Jagran River at the time the study commenced, the Surface Water Hydrology Project of WAPDA was asked to make low flow and sediment measurements for use in establishing project design parameters. Discharge measurements were made in the Jagran River at Kundal Shahi during the period 2 November 1982 through 17 April 1983 for use in preparing the Feasibility Report. Supplementry readings were later taken during the period 18 August 1983 through 24 February 1984. It is noted that the great majority of thse measurement were made during the winter or low flow season and therefore produced a record of quite low discharges with the lowest known to Ebasco being 63.7 cusecs which was measured on 24 February 1985. This is significantly below the estimated 85 cusecs which was used to establish a firm capacity of 750 kw.

On the basis of the foregoing data and an apparent philosophy that the Kundal Shahi Hydel Scheme should be planned to meet the load requirements of Kundal Shahi and other nearby localities for the period through 1994 as an isolated system, the installed capacity of 1200 kw (having a machine overload capacity of 1440 kw) is a supportable but quite conservative recommendation.

In further pursuit of a design providing for optimum use of water potential available, rating curves for the Neelum River at Mugaffarabad and Dhudhnial (short record) were prepared from available data. Maps of the Neelum drainage as well as a flow duration curve prepared for a relatively nearby tributary to the Neelum and studied in conjunction with the aforementioned rating curves - given an adequate level of accuracy for the nearby flow duration curve and on the basis of the correlation techniques employed, the answer was clear; the Jagran River at Kundal Shahi could support substantially more capacity and produce considerably more energy.

The scheme was redesigned for 2000 kw with 2 x 1000 Fransis turbine Generator sets for a net head of 140 feet with the special consideration to project Hydraulics, Flood Flow Analysis, Trash & sediment, and surge & excess flow.

The construction of the civil works maximizes the use of local materials. Not only does this reduce costs, but it permits the use of materials and construction techniques with which the villagers are familiar. Once involved in the construction, the villagers then understand the operation of the system's various components and are better able to maintain the civil works on a continuing basis.

## PROJECT COMPONENTS

### WEIR:

The diversion weir is located on the Jagran River about 1.32 miles from its confluence with the Neelum River. Approximately 90 feet upstream there is an existing bridge and a large, in-place rock mass. The rock mass would serve as a protective shield against floating large debris. The weir would be built from on - site lose stones having a diameter between 12 to 18 inches with the Gabions on top. The downstream and upstream sides of the weir will have slopes of 1.4:1. The weir will be approximately 7.0 feet in height, 12.0 feet wide at the top and placed on a stone subbase having a depth of 1.5 feet. In order to seal the upstream face and reduce seepage, a polyvinyl chloride (PVC) membrane will be placed having a nominal thickness of 30 mils. In addition, sand bags having a minimum length of 1.5 feet will be placed over the membrane for protection. Maintenance of the weir will be provided by permanent local employees. Refer to drawing No.3&4 for the plan and section views of the weir.

### INTAKE AND HEAD REGULATOR

The intake and head regulator, a reinforced concrete structure, would take in water from the Jagran River as directed from the weir at elevation 4466.60 and R.D. O + 000. At the entrance of the structure there is a debris deposition area which would store out large debris from the river. A manually operated sluice gate measuring 7'-0" x 4'-9" is provided which would send the debris into the debris sluiceway and then back into the river. Aligned in a parallel manner are two manually operated collecting gates measuring 6'-0" x 4'-9". Before entering the collecting gates, the water passes through a 12'-8" x 12'-0" trashrack which would be set on a 60 degree incline for manual raking. Sluiceway would be built from stone masonary with plain concrete as a subgrade and will include a spillway section for release of surge flows to the Jagran River. At the both ends of the spillway there are ladders for access to both sluice gate and canal. The stone masonry will have cement pointing on the outer sides and cement plaster on the inner sides, bottom and top. At R.D. O. + 080 the intake and head regulator structure then feeds into the power canal. Refer to drawings 3,4 and 5 for a plan and section view of the intake and head regulator structure.

### POWER CANAL

The power canal starting at R.D. 0 + 080 would be of stone masonry with 3/4 inch thick cement plaster on the inner sides, bottom and top. The canal's bed is placed over a one foot plain cement subgrade. The power canal will have a bed slope of 1:1200 from R.D. 0 + 080 + to the forebay structure.

The section area of the canal delivering the water to the forebay and wasteway structure will have a bed width of 9 feet by 6 feet in water depth. It will develop 142 feet of net head and ultimately generate 2000 KW with 2-1000W Fracis turbine- genrators groups. From R.D. 0 + 080 to R.D. 1 + 630 the canal line will follow contour elevation 4470: from R.D. 1 + 630 to R.D. 1 + 900 contour elevation 4475; from R.D. 1 + 900 to R.D. 2 + 230 it will cross contours; from

R.D. 2 + 230 to 2 + 670 contour elevation 4470: and R.D. 2 + 670 to R.D. 3 + 807 it will follow contour elevations 4470 to 4475.

At elevation 4457.60 and approximately R.D. 1 + 600, the power canal will change in cross section to a masonry cut and cover section. A portal facing built of stone masonry would be placed at the start and end of the horseshoe tunnel. At the end of the covered section, R.D. 2 + 055 the tunnel returns to the original open canal section. After construction, grading in the area would be restored to the original contours. The canal also goes through a slide from R.D. 2 + 747 to R.D. 3 + 115 approximate stabilizing features will be constructed in this area. At .R.D. 3 + 807, the power channel then joins the forebay structure. Refer to drawings 1, 2 and 3 for a plan section view of the power canal.

## FOREBAY AND WASTEWAY

The forebay is built to provide head pond to the power units and is located at the tail of the power canal, R.D. 3 + 807 and at a water elevation 4458.30. The forebay will be a reinforced concrete structure measuring a total length of 128 feet by 18 feet inner width. Adjacent to the forebay and separated from it by a spillway for release of surge flows from the forbay is the wasteway structure, also of reinforced concrete, which runs along side for a length of 95 feet by 5 feet inner width before it cascades down the mountain side. The cascade portion of the wasteway will be built of stone masonry. Two stop logs measuring 5'-9" by 6' will be located at the entrance of the forebay and wasteway. One sluice gate measuring 4' by 4' will be located at the downstream side of the forebay. The sediment accumulated in the foreby shall be occasionally flushed through this gate into the wasteway. Two safety-racks and stop logs will be located at the entrance of the penstocks to prevent any debris from entering the turbine.

## PENSTOCKS

The two structural steel penstocks would begin their descent at elevation 4461.4. The penstocks would be 40 inch in diameter, 0.33" in thickness, and 235 feet in length. Each will be supported with two concrete anchor block and 3 additional concrete supports spaced every 32 feet.

## POWERHOUSE

The powerhouse structure above floor elevation of 4323.5 will be constructed of stone masonry and concrete structure. The subsurface will be built from reinforced concrete. The overall dimensions of the powerhouse will be 73 feet in length, 40 feet wide and 21 feet in height above the floor elevation. The pit area encasing the draft tubes will be 12 feet deep. Roofing for the powerhouse will be provided by wooden trusses.

The structure will house two Francis turbine-generators capable of generating 1000 kW each. Also included as part of the structure are the following major items: two draft tubes, an operation and reception office, two motor control, two control panels, a battery and charger facility, a toilet and galley room, and two oil pressure units. Heating and ventilating will be provided with resistance heaters and ceiling fans. In addition, 400 feet of security fencing and gates will be placed around the power house. Power from the powerhouse would be supplied

through two 11 kV step-up transformers installed outside of the powerhouse. An auxiliary transformer is to be installed adjacent to the other two.

## TAILRACE CHANNEL

The tailrace channel, at elevation 4307.75, will be 10 feet wide, and 190 feet long. The channel would be built of stone masonry and will discharge the waters leaving the draft tubes into the Jagran River. Refer to drawing 6 for plan views



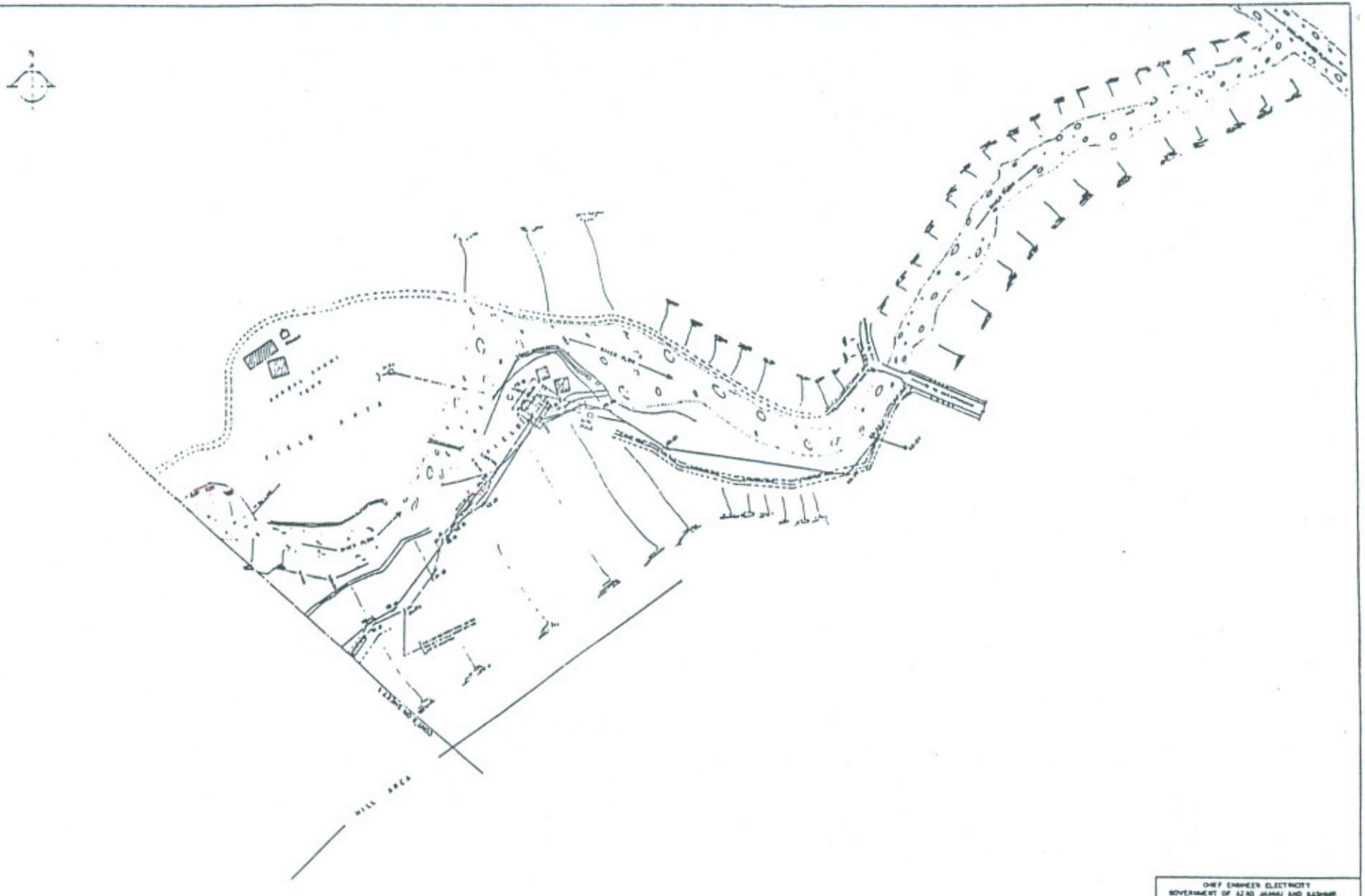

LEGEND

CHIEF ENGINEER ELECTRICITY
GOVERNMENT OF AZAD JAMMU AND KASHMIR
MUZAFFARABAD

CONTRACT FOR
DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING
OF 2 x 6/8 MVA 33/11 kV INDOOR, SPHERE HYDROELECTRIC STATION

PROJECT AREA MAP
SHEET-1

CE&ASCO OVERSEAS CORPORATION
TWO WORLD TRADE CENTER NEW YORK NY 10048 U.S.A




CHIEF ENGINEER ELECTRICITY
GOVERNMENT OF AZAD JAMMU AND KASHMIR
MUZAFFARABAD

CONTRACT FOR
DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING
OF 2 x 600 KW KUNDAL SHAHI HYDROELECTRIC STATION

PROJECT AREA MAP
SHEET-1

ESA-SCO OVERSEAS CORPORATION
TWO WORLD TRADE CENTER NEW YORK NY 10048 U.S.A.

ESP-623
6-004.

NOTES

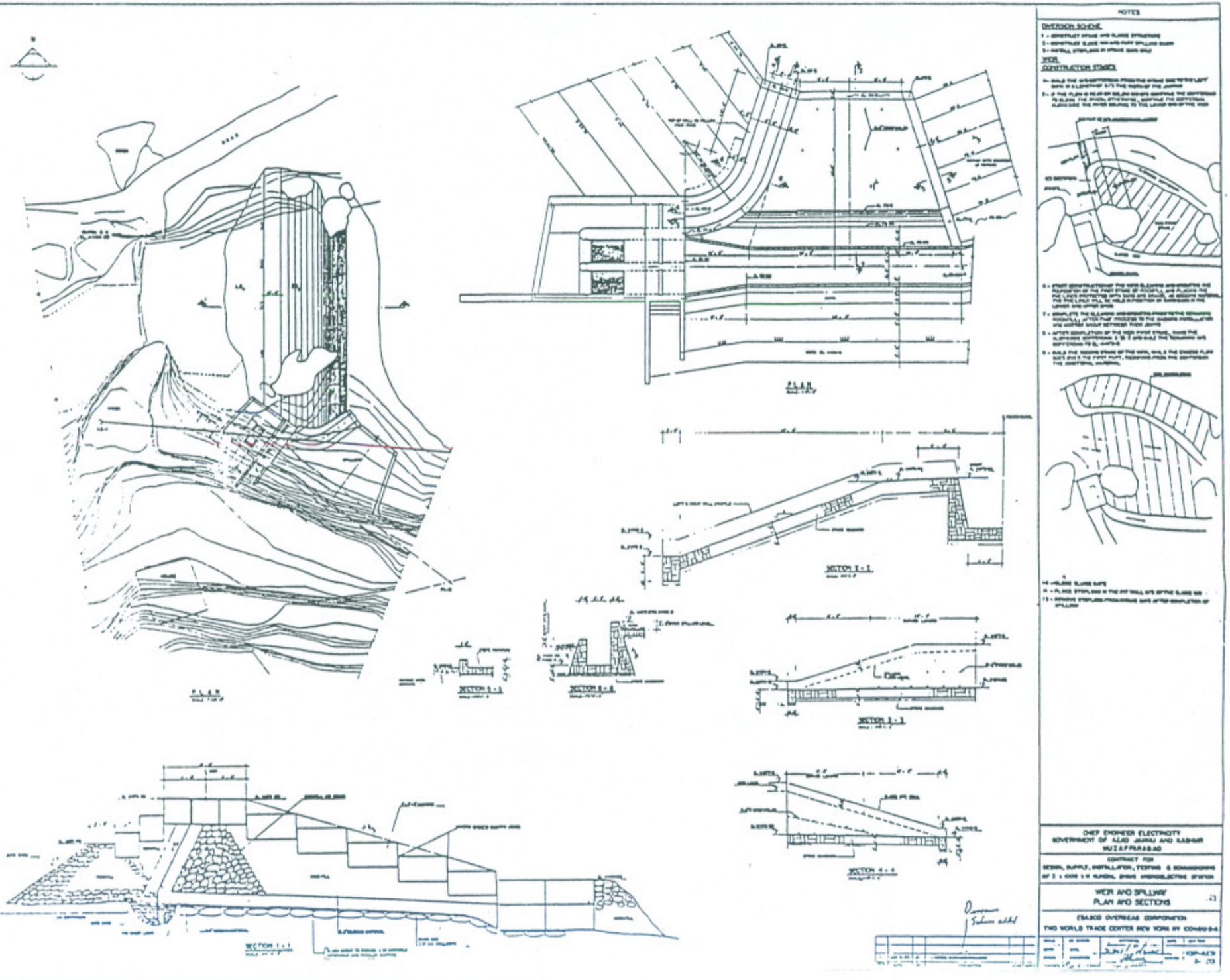
CHIEF ENGINEER ELECTRICITY
GOVERNMENT OF U.P.
MUZAFFARNAGAR

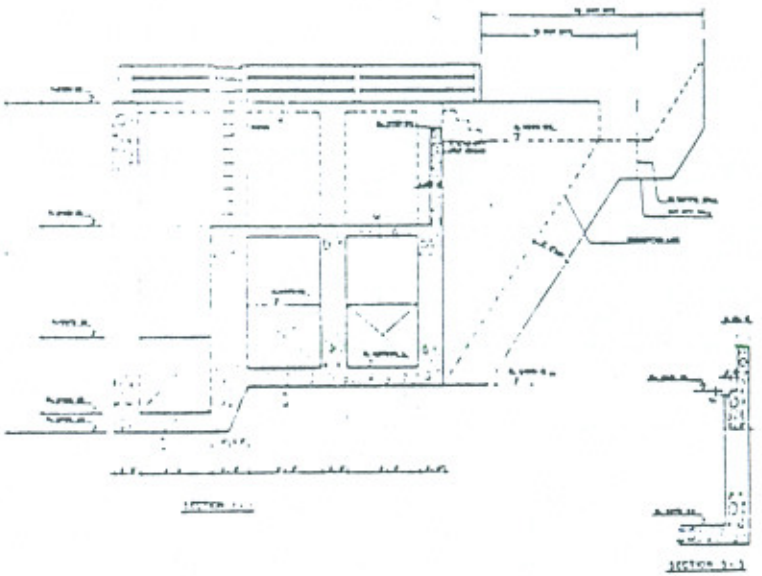
CONTRACT FOR
DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING
OF 2 x 5000 kW KAPLAN DRUM TYPE HORIZONTAL SHAFT

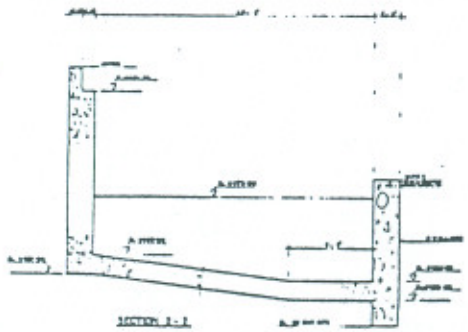
PROJECT LAYOUT
FOR 2 x 5 MW

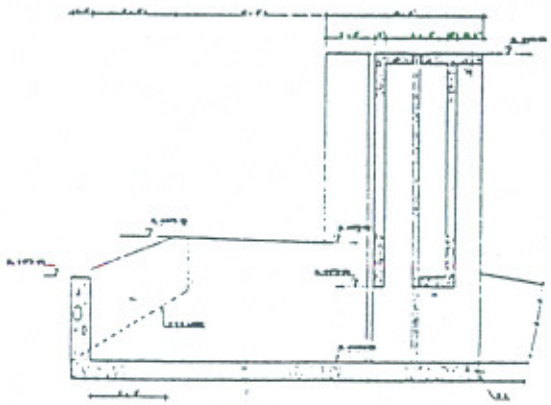
EMBED OVERHEAD CONVEYOR
FOR WORLD TRADE CENTER NEW YORK AT CONSTRUCTION

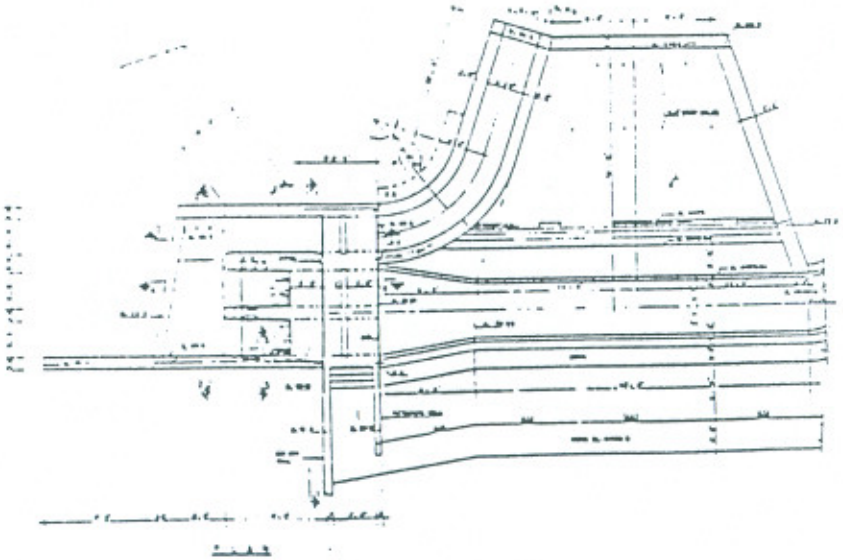
TYPICAL CANAL SECTION

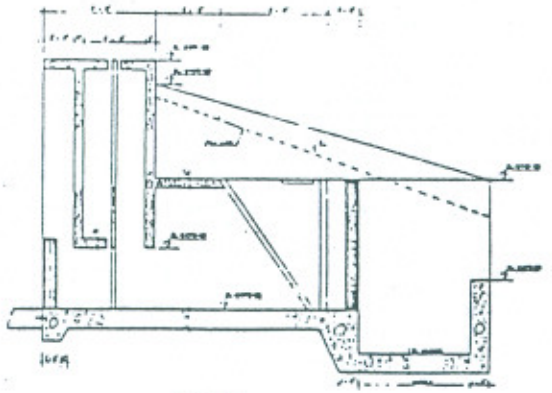

NOTES
DIVERSION SCHEME
WEIR
CONSTRUCTION STAGES
PLAN
SECTION 1 - 1
SECTION 2 - 2
SECTION 3 - 3
SECTION 4 - 4
CHIEF ENGINEER ELECTRICITY
GOVERNMENT OF AJAD JAMMU AND KASHMIR
MUZAFFARABAD
CONTRACT FOR
WEIR AND SPILLWAY
PLAN AND SECTIONS
TWO WORLD TRADE CENTER NEW YORK NY











STRUCTURAL CONCRETE

- Structural concrete shall meet the requirements of ACI 301-01

- Cement, aggregates, and reinforcing steel shall be in accordance with ACI 318-02

- Thickness of concrete to the exterior (wetted surface) shall be taken less 12 mm(½") after addition of mortar to the min. thickness of reinforced concrete shall not exceed 6 inches.

- All corrosion free thin reinforcement shall be accompanied and protected to Engineer for Permission

DETAILING STEEL

- Floating dimensions are given to center of bars unless noted

- All bottoms of reinforcement shall ensure with the requirements of ACI 318-02 with exception 12 to 18 inches, and it no case shall be less than 12 inches.

- All bars shall have 2 inch minimum concrete cover unless otherwise noted

- Units of bars must be clear except bolts, ferrule, wire sleeves and expansion parts.

- Cement Bolts, Plan sleeves, Elevation/ concrete, steel sleeves, and shall be set to position before concrete is placed.

CHIEF ENGINEER ELECTRICITY
GOVERNMENT OF AZAD JAMMU AND KASHMIR
MUZAFFARABAD

CONTRACT FOR
DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING OF 3 x 4000 kW HORIZONTAL SHAFT HYDROELECTRIC STATION

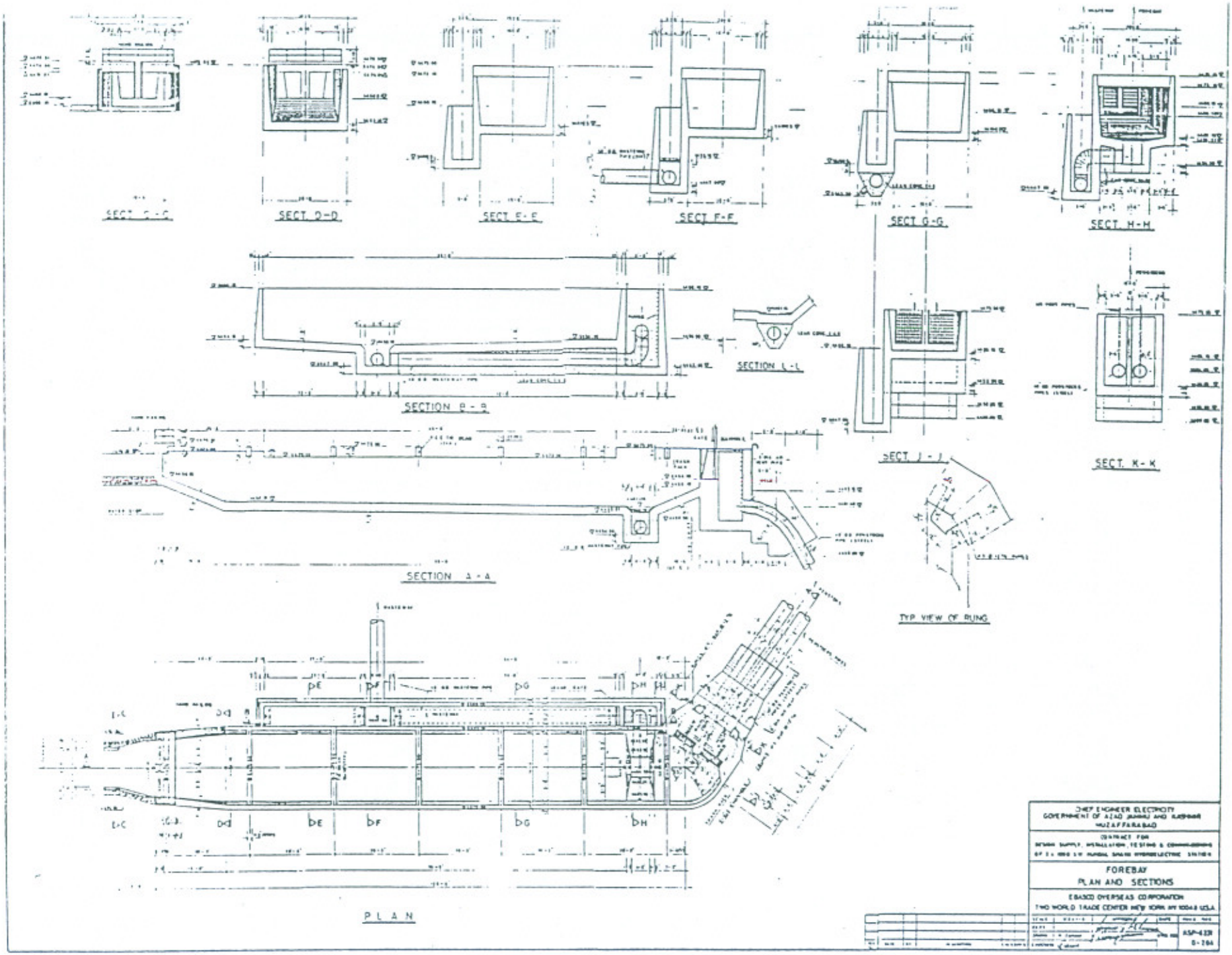
INTAKE AND SLUICE STRUCTURE
PLAN AND SECTIONS

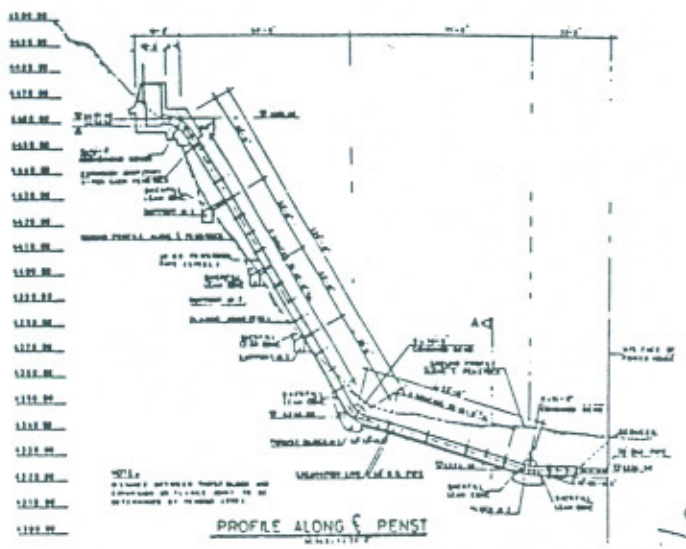
EMBASS OVERSEAS CORPORATION
TWO WORLD TRADE CENTER NEW JERSEY NY 10048-0-A

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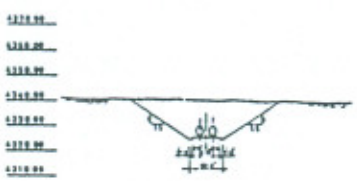
FIG 6



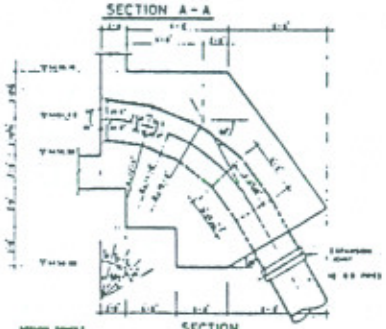

SECT C-C
SECT D-D
SECT E-E
SECT F-F
SECT G-G
SECT H-H
SECTION B-B
SECTION L-L
SECT J-J
SECT K-K
SECTION A-A
TYP VIEW OF RING
PLAN
CHIEF ENGINEER ELECTRICITY
GOVERNMENT OF A.[illegible]
MUZAFFARABAD
FOREBAY
PLAN AND SECTIONS
EBASCO OVERSEAS CORPORATION
TWO WORLD TRADE CENTER NEW YORK NY 10048 U.S.A.



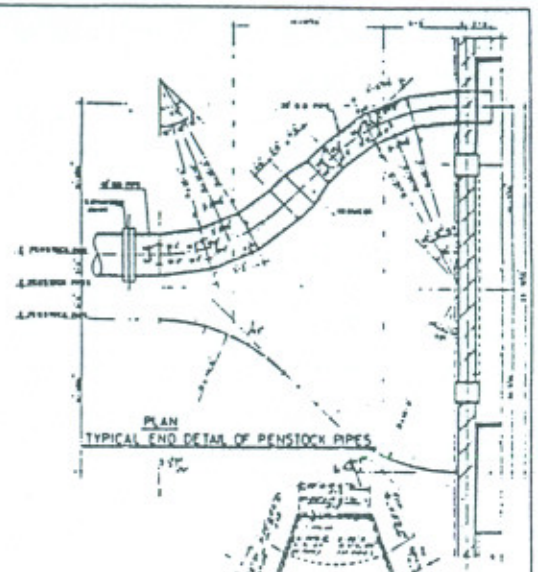
PROFILE ALONG ℄ PENST



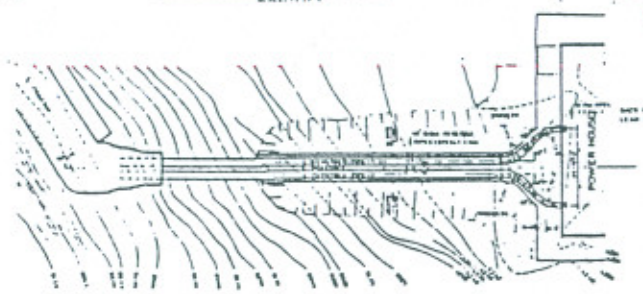
SECTION A-A



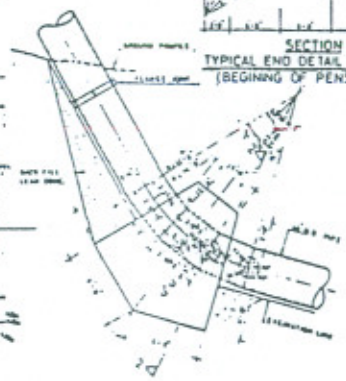
SECTION
TYPICAL END DETAIL OF FOREBAY
(BEGINING OF PENSTOCK PIPES)



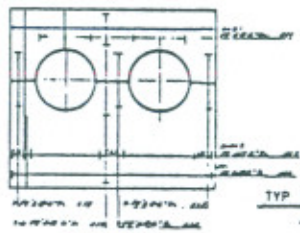
PLAN
TYPICAL END DETAIL OF PENSTOCK PIPES



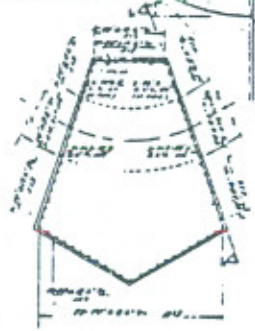
PLAN



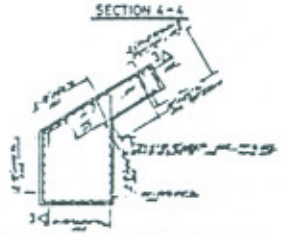
THRUST BLOCK #1



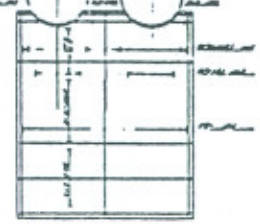
SECTION 4-4



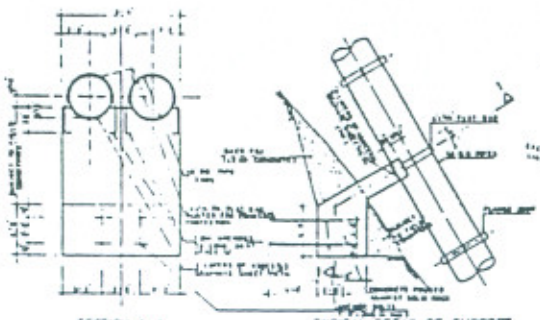
TYP REINF DETAIL - THRUST BLOCK # 1 & # 2



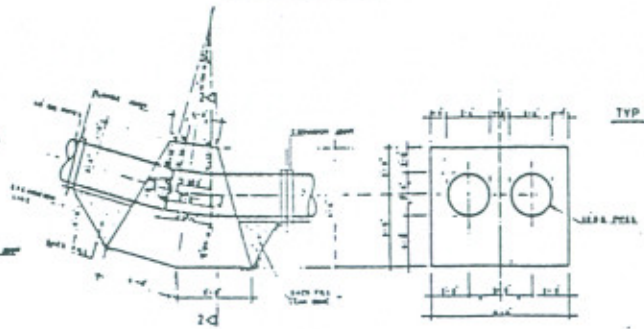
TYP REINF DETAIL - SUPPORT # 1 2 & 3



SECTION 3-3



SECTION 1-1 TYPICAL DETAIL OF SUPPORT



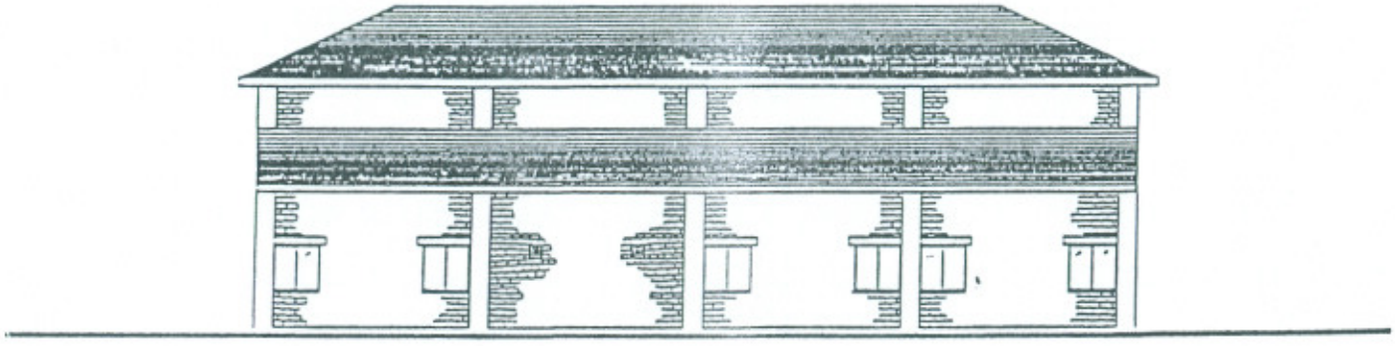
THRUST BLOCK # 2 SECTION 2-2

CHIEF ENGINEER ELECTRICITY
GOVERNMENT OF AZAD JAMMU AND KASHMIR
MUZAFFARABAD

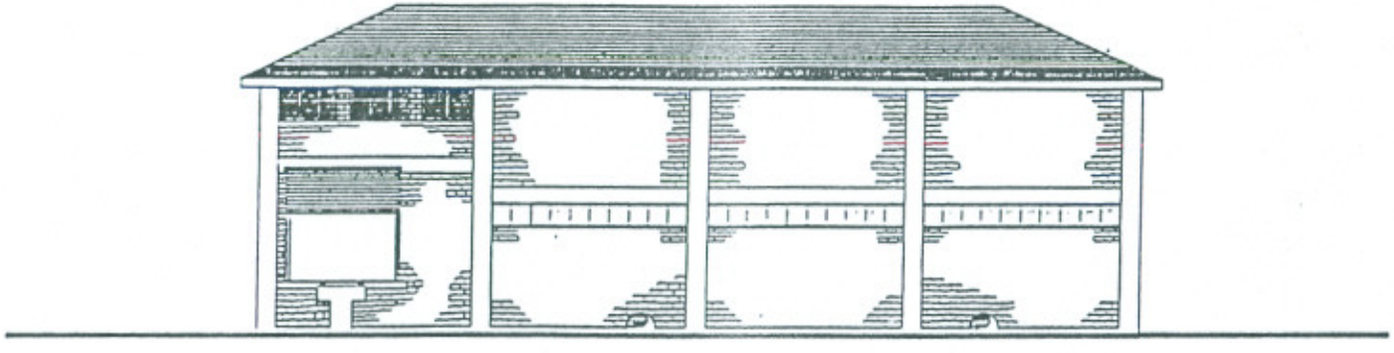
CONTRACT FOR
DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING
OF 2 x 1000 KW HORIZONTAL SHAFT HYDROELECTRIC SET-UP

PENSTOCK
PROFILE, SECTIONS & REINF. DETAILS

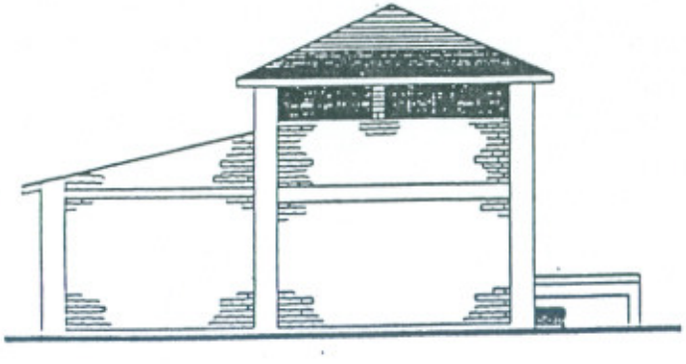
E BASCO OVERSEAS CORPORATION
TWO WORLD TRADE CENTER NEW YORK NY 10048 U.S.A.



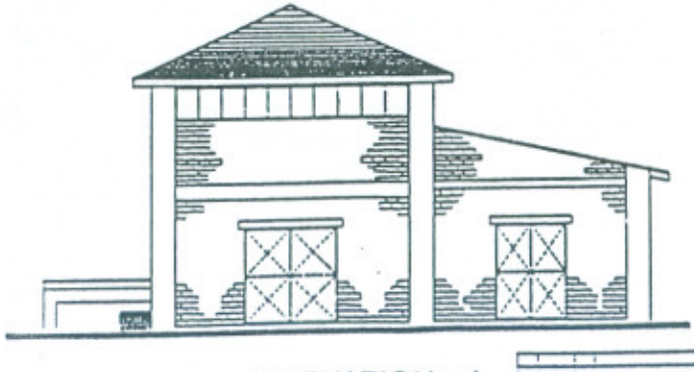
ELEVATION - 1



ELEVATION - 2



ELEVATION - 3



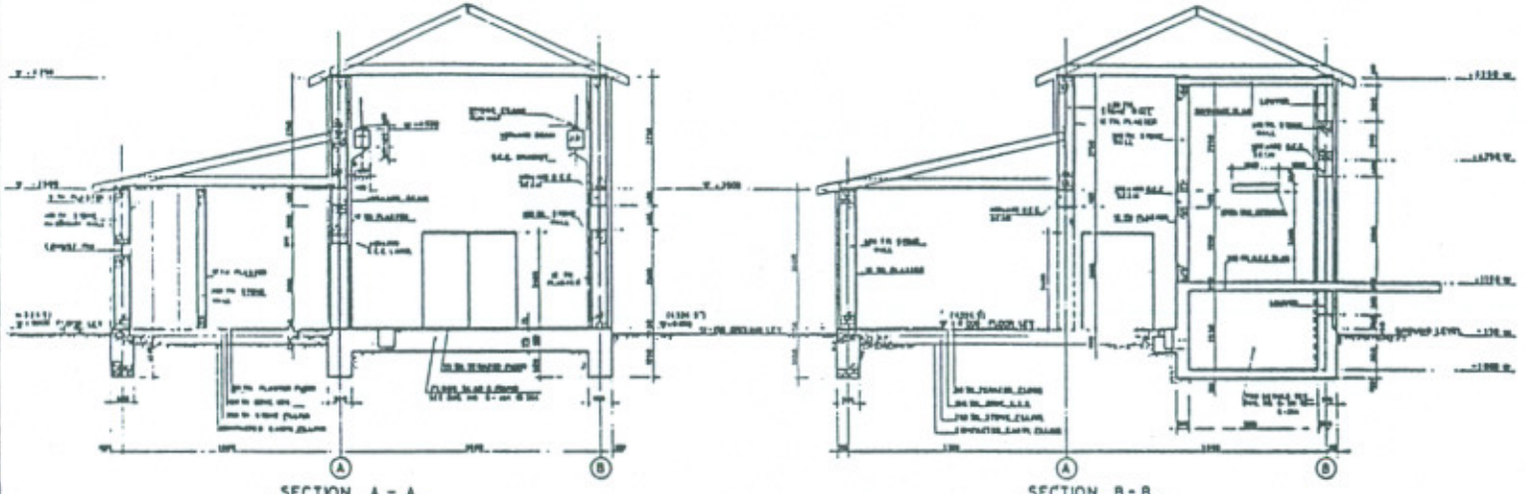
ELEVATION - 4

CHIEF ENGINEER ELECTRICITY
GOVERNMENT OF AZAD JAMMU AND KASHMIR
MUZAFFARABAD

CONTRACT FOR
DESIGN, SUPPLY, INSTALLATION, TESTING & COMMISSIONING
OF 2 x 1000 KW NATURAL DRAFT HYDROELECTRIC STATION

POWER HOUSE
ELEVATIONS

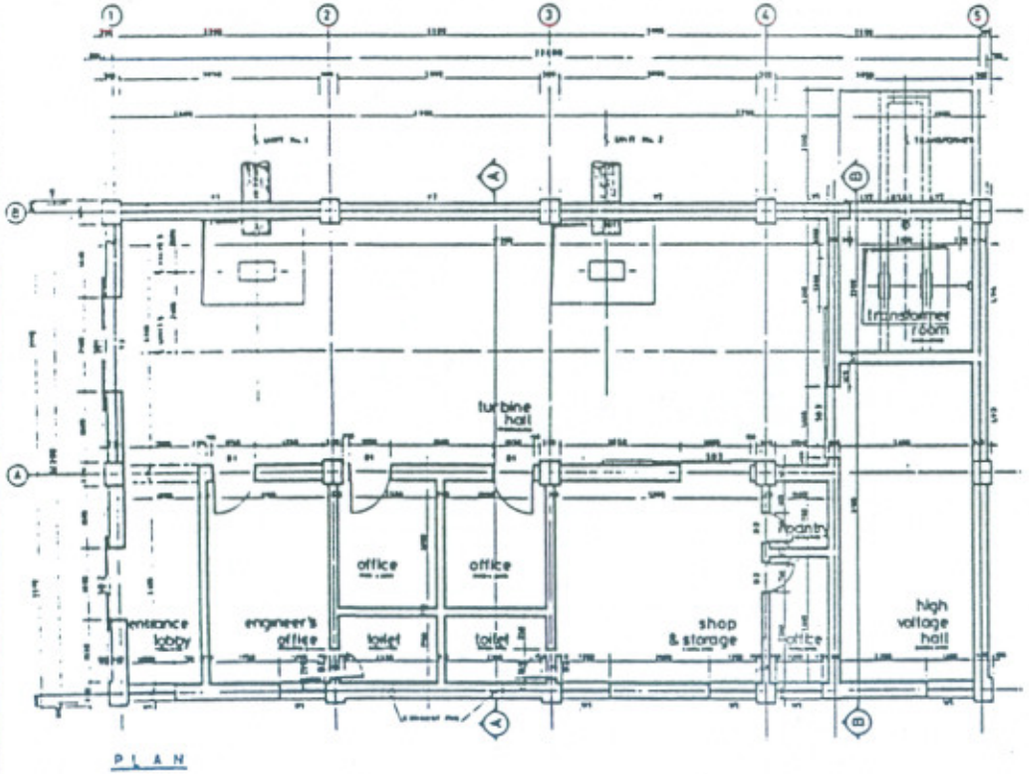
EBASCO OVERSEAS CORPORATION
TWO WORLD TRADE CENTER NEW YORK NY 10048 U.S.A.



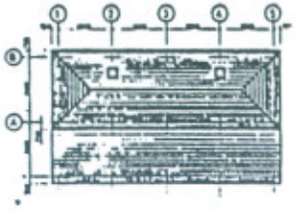
SECTION A - A



SECTION B - B




PLAN



ROOF PLAN

SCHEDULE OF DOORS WINDOWS & VENT.

| MARK | QTY | SIZE | DESCRIPTION |
|---|---|---|---|
| | | | |

CHIEF ENGINEER ELECTRICITY
GOVERNMENT OF AZAD JAMMU AND KASHMIR
MUZAFFARABAD

CONTRACT FOR

POWER HOUSE
PLAN SECTIONS & ELEVATIONS

EBASCO OVERSEAS CORPORATION
TWO WORLD TRADE CENTER NEW YORK NY 10048 U.S.A

## KUNDAL SHAHI HYDEL PROJECT

## DETAILED QUANTITIES ESTIMATE

| NO. | ITEM | UNIT | QUANTITY |
|---|---|---|---|
| A. | LAND COMPENSATION | | |
| B. | PRELIMINARY WORKS | | |
| | 1. Site Investigations | lump sum | 1 |
| | 2. Control and topography survey | lump sum | 1 |
| | 3. Access road 12 feet wide. | lump sum | 1 |
| | 4. Plain cement concrete 1:2:4 for one culvert 12 feet wide, 20 feet span | lump sum | 1 |
| | 5. One road bridge (suspension) 12 feet wide, 15 ton capacity, span 50 feet. | lump sum | 1 |
| | 6. Reinforcement | ton | 2.5 |
| C. | WEIR | | |
| | 1. Excavation in rock | cubic foot | 8,000 |
| | 2. Borrow Fill Material | cubic foot | 42,000 |
| | 3. Haul, Dump & Spread | cubic foot | 42,000 |
| | 4. Protection upstream face (PVC sheet 30 mills) and sandbags | square foot | 2,000 |
| D. | APPROACH CHANNEL | | |
| E. | INTAKE AND HEAD REGULATOR | | |
| | 1. Excavation in common | cubic foot | 44,000 |
| | 2. Backfill | cubic foot | 48,000 |
| | 3. Plain cement concrete 1:2:4 | cubic foot | 5,600 |

| NO. | ITEM | UNIT | QUANTITY |
|---|---|---|---|
| E. | INTAKE AND HEAD REGULATOR (Cont'd) | | |
| 4. | Plain cement concrete 1:4:8 | cubic foot | 600 |
| 5. | Stone masonry in 1:4 cement sand mortar | cubic foot | 6,400 |
| 6. | Pointing flush in 1:3 cement sand mortar | square foot | 2,200 |
| 7. | Cement plaster 3/4 inch thick, 1:2 | square foot | 2,200 |
| 8. | Reinforcement | ton | 13 |
| 9. | Gate 6 feet x 4'-7" feet with guides, supports and annual operator | lump sum | 2 |
| 10. | Sluice gate 3'-3 feet x supports and manual operator | lump sum | 1 |
| 11. | Trashracks and supports | lump sum | 1 |
| 12. | Sluice gate (7'-4'-9) | lump sum | 1 |
| F. | POWER CANAL | | |
| 1. | Excavation in common/hard | cubic foot | 925,755 |
| 2. | Excavation in rock | cubic foot | 308,585 |
| 3. | Backfill | cubic foot | 230,080 |
| 4. | Plain cement concrete 1:4:8 | cubic foot | 38,000 |
| 5. | Stone masonry in 1:4 cement sand mortar | cubic foot | 132,800 |
| 6. | Cement plaster 3/4 inch thick 1:2 | square foot | 91,000 |
| 7. | Cross drainage works at RD 667 for Spring | lump sum | 1 |
| G. | FOREBAY AND WASTEWAY | | |
| 1. | Excavation in common/hard | cubic foot | 48,000 |
| 2. | Excavation in rock | cubic foot | 68,000 |
| 3. | Backfill | cubic foot | 2,000 |
| 4. | Plain cement concrete 1:2:4 | cubic foot | 12,000 |
| 5. | Plain cement concrete 1:4:8 | cubic foot | 6,800 |
| 6. | Stone masonry in 1:4 cement sand mortar | cubic foot | 19,000 |
| 7. | Pointing flush in 1:3 cement sand mortar | square foot | 11,500 |

| NO. | ITEM | UNIT | QUANTITY |
|---|---|---|---|
| G. | FOREBAY AND WASTEWAY (Cont'd) | | |
| | 8. Cement plaster 3/4 inch thick 1:2 | square foot | 11,500 |
| | 9. Reinforcement | ton | 35 |
| | 10. Sluice gate 5.7 foot x 5.7 foot with guides, supports and manual operator | lump sum | 3 |
| | 11. Safety rack | lump sum | 2 |
| H. | PENSTOCKS | | |
| | 1. Excavation in common/hard | cubic foot | 1,000 |
| | 2. Excavation in rock | cubic foot | 200 |
| | 3. 2.5 foot diameter Penstock | ton | 28 |
| | 4. 2.5 foot diameter bends | ton | 2 |
| | 5. Stop Log (3'-6 x 7'-2) | lump sum | 2 |
| | 6. Plain cement concrete 1:2:4 18 for supports | cubic foot | 700 |
| | 7. Plain cement concrete 1:2:4 for 2 anchor blocks | cubic foot | 100 |
| | 8. Field joints (dresser couplers or field welds) | lump sum | 18 |
| | 9. Reinforcement | ton | 1.0 |
| I. | POWER HOUSE | | |
| | 1. Excavation in common/hard | cubic foot | 143,000 |
| | 2. Backfill | cubic foot | 16,000 |
| | 3. Plain cement concrete 1:2:4 | cubic foot | 11,000 |
| | 4. Stone masonry in 1:4 cement sand mortar | cubic foot | 2,600 |
| | 5. Roof and ceiling including wooden tuss and steel sheets, etc. (4" x 8" beam) 12 W steel beam | lump sum | 1 |
| | 6. Reinforcement | ton | 23 |
| | 7. Architectural Features | lump sum | 1 |
| | 8. Mechanical Systems | lump sum | 1 |
| | 9. Sanitary Systems | lump sum | 1 |
| | 10. Electrical systems | lump sum | 1 |
| | 11. Heating and Ventilating Systems | lump sum | 1 |
| | 12. Chain falls-5 ton | lump sum | 1 |

# List of Symposia

| Volume No. | Year | Subject |
|---|---|---|
| 1 | FEB. 1957 | HOUSING PROBLEMS OF WEST PAKISTAN |
| 2 | FEB 1958 | FLOOD IN WEST PAKISTAN |
| 3 | FEB 1959 | WATER LOGGING AND SALINITY IN WEST PAKISTAN |
| 4 | FEB 1960 | ENGINEERING EDUCATION IN PAKISTAN |
| 5 | MAR 1961 | PLANNING AND EXECUTION OF ENGINEERING PROJECTS IN PAKISTAN |
| 6 | APR. 1962 | SEDIMENTATION AS A RESULT OF INDUS BASIN WORKS. |
| 7 | OCT. 1963 | WATER LOGGING AND SALINITY IN WEST PAKISTAN |
| 8 | MAR. 1965 | CONSULTING AND CONTRACTING PRACTICES IN PAKISTAN |
| 9 | OCT. 1966 | ENGINEERING RESEARCH IN DEVELOPING ECONOMY OF PAKISTAN |
| 10 | 1968 | BRIDGES |
| 11 | 1969 | WATER RESOURCES DEVELOPMENT |
| 12 | 1969 | PROBLEMS OF ENGINEERING PROFESSION IN PAKISTAN |
| 13 | 1972 | PLANNING FOR NATIONAL OBJECTIVES |
| 14 | 1974 | UTILIZATION OF NATURAL RESOURCES IN PAKISTAN FOR SELF RELIANCE |
| 15 | 1975 | TARBELA DAM-PROBLEMS & SOLUTIONS |
| 16 | 1978 | LOW-COST STRUCTURES |
| 17 | 1982 | ENGINEERS ROLE IN PLANNING EXECUTION AND MANAGEMENT OF PROJECTS |
| 18 | 1985 | RURAL DEVELOPMENT |
| 19 | 1986 | ENERGY CRISIS |
| 20 | 1987 | QUALITY CONTROL AND MATERIALS |
| 21 | JAN 1989 | HYDRO ELECTRIC POWER IN PAKISTAN. |