PAPER NO. 452

DESIGN & CONSTRUCTION OF SIMLY DAM

BY

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DESIGN AND CONSTRUCTION OF SIMLY DAM PROJECT

BY

Dr. Izhar-ul-Haq(*)

1. INTRODUCTION

Simly Dam is a constituent part of proposed scheme for Bulk Water Supply for Islamabad. The scheme is being administered by Capital Development Authority (CDA) of Pakistan. It harnesses the flow of the Soan River by constructing an earthfill dam at Simly and creating a reservoir with live storage of 20,000 acre feet. The Soan River at Simly has a catchment area of 59 sq.miles.

It is estimated that the Simly reservoir would yield perenially 24 million gallons of drinking water per day for water supply. The potable water after filteration, would be transported under gravity flow, in a 12 mile long conduction main, to Islamabad. The filtration plant located near the dam site, and the conveyance system consisting of a twin R.C.C. pipe system of 39 and 36 inches diameter each, have already been constructed. The investigations for the preliminary design in shape of a Feasibility Report for the dam project was prepared by M/s. Tecsult International Limited Consulting Engineers from Montreal Canada. In 1970 for the detailed designs, CDA had entrusted the job to Central Design Office (Water) WAPDA. Salient features of the Simly Dam are:

(*) Director Design, Central Design Office WAPDA.

Location	North-East of Islamabad	24 miles
Project Volume	Total fills	2,586,800 cu.yds.
	Excavations	338,000 "
	Concrete	44,300 "
Reservoir	Length	7 miles
	Area	421 acres
	Usable Capacity	20,000 acre feet
	Dead Storage	8,750 " "
	Gross Capacity	28,750 " "
Embankment Dam	Length at crest El.2330	1030 feet
	Maximum height	263 feet
	i) Rockfill	1,808,000 cu.yds
	ii) Impervious fill	640,000 " "
Upstream Coffer Dam	Length at crest El. 2185	322 feet
	Maximum height volume	90 feet
	i) Random Rockfill	32,500 cu.yds
	ii) Impervious fill	84,900 cu.yds
Downstream Coffer Dam	Length at crest El.2130	211 feet
	Maximum height volume	35 feet
	Random Rockfill	16,700 cu.yds.
Spillway	Overflow weir	110 feet at crest
	Discharge Capacity	45,000 cusecs
	Concrete Volume	39,600 cu.yds.
Water Intake Structure	Tunnel diameter	6 feet
	Length	570 feet
	Discharge Capacity	44.5 cusecs
	Concrete Volume	1,790 cu.yds
Drainage Gallery with Drainage wells.	Size	5 x 7.5 ft.
	Length	432 feet.

2. INVESTIGATIONS

The geology of the dam site was mapped on a scale 1" = 40 ft. which was further supplemented by detailed mapping, showing the visible discontinuties. Refer to Geologic Plan Exhibit No.1.

During the preliminary investigations, 47 bore holes, totalling to 9,150 ft. of drilling were made out of which 21 holes amounting to 2,871 ft. were water pressure tested. In 1969 nineteen bore holes were drilled to confirm the rock formations, and their characteristics.

Two hundred and twenty tests pits were excavated for the exploration of Simly plain and Tamair valley borrow areas. Tests were carried out for the gradation analysis, Atterberg limits, dry density, optimum moisture content and normal moisture content . Shear tests were also conducted on samples from borrow areas for determining cohesion and friction angles.

3. GEOLOGY

3.1 Stratigraphy

The damsite is underlain by sediments of Chingi group of formation of Siwalik (Middle Miocene) age. The rocks of this formation consists of alternating beds of sandstone, siltstone and claystone. The layers of resistant sandstone form sharp ridges and are separated by depressions formed due to erosion of soft rocks which also include friable sandstone.

Upstream and downstream of the damsite, the river flows along the strike of the formations however, at the gorge, the flow of the river veers sharply and a canyon at right angle to

the strike of the formations is formed.

3.2 Structural Geology

These rocks have been folded into sharp anticlines and synclines trending northeast tc southwest. Simly plain and the reservoir occupies the axial region of one of those assymmetrical anticlines.

The rocks exposed at the abutments form the eastern limb of the major anticline and consist of sandstone interbedded with siltstone and claystone. The rocks have open bedding joints and cross joints in particular on the left abutment due to stress relief on the valley side, creep along the claystone beds and flexural folding. This type of folding althrough is a common feature where competent and incompetent beds alternate but this secondary folding in the left abutment area has caused opening up of the bedding planes strikewise and cross joints.

The strike of the rock formations as a whole is approximately N40° E, the dips averaging 80° to 85° to the southeast along the eastern limb of the anticline and from 50° to 70° to the northwest along the western limb.

3.3 Joints and Fractures

The sandstones are cut by several joints systems, one parallel to the stratification and two sets striking N40°W and dipping 45° to the northeast, the other 45° to 75° to the southwest. In addition to these there are also some random joints.

The stratification joints are well marked and cause open fractures in and near the w aker formations such as friable sandstone , siltstone and claystone . These joints

are, however, inconspicuous in the main body of sandstone. The cross joints have been widened by weathering and solution near the surface. At the damsite most of the joints and fractures are closely spaced, opened, partly coated with calcite and occasionally silkensided.

Most of the claystones show signs of shearing and the partings are generally coated with chlorite. This shearing appears to be very irregular in strike and dip. The sandstone/claystone, contact is sheared and at places upto 2 ft. claystone at the contact is crushed.

3.4 Cavern

A Cavern was found in the left abutment ridge, downstream of the most thick sandstone bed at river bed level aligned in the direction of the strike of the formation. The height of the opening at the entrance was about 10 feet and length 120 feet. The development of this cavern could have been due to enlargement by stooping of a tectonic void. The cave has been cleaned and backfilled with lean concrete, plugged at its end.

4. SEEPAGE CONTROL

A study of the water pressure tests in bore holes reveal that the rocks generally tend to be leaky (10-100 Lugeons or more at places) to a depth of about 75 ft. from the surface irrespective of their lithologic character. The high losses in claystone can be attributed to the bedding planes, bedding contacts and sheared zones. While water losses in sandstone as well as siltstone are through joint planes.

4.1 Investigational Grouting

A test grouting programme along the dam axis was carried out in 1971-72. In all 53 holes were drilled and 473 water pressure tests were conducted. The results of permeability are shown in Exhibit No.2.

The depth of holes was of the order of 100 ft. but holes I46 and I55 were drilled to a depth of 150 ft. The area between the holes I-1 to I-7 on the right bank and I-35 to I-38 on the left abutment indicate moderately open rock conditions, (permeability 10^{-4} to 10^{-3} cm/sec.). The area in the river bed tested by holes I-8 to I-34 indicate tight rock conditions permeability 10^{-5} to 10^{-4} cm/sec. Holes I-41 to I-51 present severally open rock conditions.

4.2 Curtain Grouting and Blanketing

It was considered that clay blanketing will be much more effective and positive method of seepage control than the grouting.As the rocks are steeply dipping and the rock overburden above the grout holes is not substantial, consequently it was not practicable to grout the rock effectively. On the other hand, the extent to which blanket may be extended on the left abutment is limited due to the presence of the diversion tunnel as well as intake structure of outlet tunnel. Considering these restraints, a three row grout curtain perpendicular to the dam axis was designed to arrest the flow of seepage water along the strike parallel to the dam axis so that seepage water should not find an easy access under the impervious core of the dam. The grout curtain was placed in a cut off trench at section 9+20 perpendicular to dam axis joining the two clay beds CL-I at RL-2140 and CL-III at RL-2270.Exhibit No.3.

The spacing of the primary holes was kept 10 ft. based on the experience that about 5 ft.of the area around the hole could be grouted.

The grouting has been done in descending order of 10, 15, 30 and 45 ft. stages starting from the top.

The depth of holes is of the order of 100 ft. which meets the criteria of $\frac{h}{3}$ + 75' and also the observation that the joints were open upto a depth of 75 ft. The grouting has been done under gravity flow.

The water solid ratio and grout mix was varied to meet the characteristics of each hole and each stage of the hole as revealed by the grouting operation. Where cavities were encountered, a mortar grout was used.

The grout consumption in Row A and Row B upto Stage III was extremely high in particular grout holes A4 to A6 and B4 to B7, the area underlying the claystone bed CL-II. The maximum grout take is of the order of 374.48 cft/foot. However, in Stage IV in both the rows the consumption is less than 10 cft/ft. except in B-3 where the grout take is 14.05 cft/ft. In Row-C, the grout consumption is relatively much lower than Row A and B.

4.3 Cavities and their Treatment

The beds in the left abutment in a limited area have undergone secondary folding in the form of flexure or anticlinal bend. This resulted in the opening up of bedding planes. These open planes are noted at many places e.g. foundation of intake tower, approach channel of spillway, cut off trench and at several locations in the abutment.

Wide open cavities have been encountered on the left abutment between el. 2165 to 2205 in a 40 ft. zone in sandstone underlying the claystone bed CL-II. A total of 42 cavities have been grouted. The cavities consumed high grout take. In a cavity the grout take was of the order of 30,500 cft. Keeping in view the above open conditions in the left abutment, it was decided to tremie grout all the open cavities which are exposed during the abutment preparation.

In the light of above condition of left abutment i.e. wide cavities, open bedding and cross joints in order to control seepage, a drainage arrangement has been provided downstream of the grout curtain.

5. DRAINAGE GALLERY

The design envisages an access adit cum drainage gallery at right angles to the dam axis starting from 312 feet d/s of the axis at Station 8+40 elevation 2150 and terminating at the centreline of the dam. Another adit (side gallery) has been excavated through the gallery 20' short of its terminal point. The side gallery runs parallel to the dam axis and extends upto Station 7+20 The total length of the horse shoe shaped galleries is about 432 ft. and finished size 5 ft. wide and 7'-6" high at crown.

Access adit and drainage galleries have sufficient number of drainage holes. The holes were drilled 8" in diameter and provided with 3" inner dia well screen. The annular space was filled with properly graded filters. The drainage arrangement has been shown in plan and section in Exhibit No.4.

6. DIVERSION WORKS

The diversion works consist of a diversion tunnel, upstream coffer dam and downstream coffer dam.

Diversion tunnel

The tunnel has been constructed at el. 2110 of diameter 35 ft. concrete lined and passes under the spillway. The tunnel will be plugged when impounding in the reservoir starts after lowering of stop logs.

Upstream Coffer Dam

The upstream Coffer dam has been constructed upto el. 2185 for the diversion of floods of 33000 cusecs through the diversion tunnel. The flood peak for non-monsoon flow had been estimated as 24,000 cusecs.

Downstream Coffer Dam

The downstream coffer dam was raised to el. 2130, to restrict entry of water from the downstream end. The downstream cofferdam will be removed after the construction of dam while the upstream cofferdam will merge into the main dam.

7. MAIN DAM

7.1 Construction Materials

About 2.6 million cu. yds. of construction material was required for the construction of embankments. Some of this material has become available from excavation at site but the major bulk of material has been taken from borrow areas and quarries.

a)

Impervious Materials

For impervious materials, two sources have been used. (i) Simly Plain and (ii) Tamair Valley Plain-. The Simly Plain is located at about 2,000 feet upstream of the Dam area. The thickness of impervious material deposit varies from 10 to 20 feet. The Tamair Valley is located on the west of Damsite, at an average haul distance of about 3.5 miles.

On the representative samples of impervious materials,following tests were carried out in the laboratory:

i) Grain Size Analysis.
ii) Atterberg Limits.
iii) Proctor Compaction.
iv) Triaxial Shear.

The material is clayey silt. About 45-95% passing sieve no 200 and plasticity index varies from 8 to 20. Max. dry density in Proctor compaction test was 120 lbs/ ft^3. and optimum moisture content was 13.5%. Triaxial test gave the following results C= 228 Psf and $\emptyset$ = 25°.

The impervious fill was placed in 6" layers and compacted by sheep foot rollers. It was endeavoured to attain the desired density 95% of Proctor density and at prescribed moisture content i.e. ± 2% of optimum preferably on the dry side.

b) Granular Material

The shell of the dam is being constructed with granular material consisting of rock and gravels.

For these materials following sources have been used :

i) Excavation for Structures

Considerable quantity of sandstone rock has been excavated from the spillway, diversion works and embankment foundation and cutting of abutments to desired slopes.

ii) Quarries

A number of quarries located on the d/s of dam have been used. Following tests were carried out on the rock samples:

a) Compressive Strength
b) Los Angles Abrasion
c) Specific Gravity and Absorption
d) Soundness Test.

The result of these tests indicate that average compressive strength of the sandstone is about 8000 to 9000 psi. The average abrasion loss is about 30% at 500 rpm. This sandstone has a specific gravity of about 2.58 and its absorption is of the order of 1.2 percent. In the Sulphate Soundness test, the percent loss is of the order of 6%.

iii) River Bed Material

Some gravel deposits in the terraces adjacent to the river bed were also used in the u/s shell. One of such terraces located about

5,000 feet downstream of the dam provided about 100,000 cu.yds of material.

) Transition Material

The sand required for first stage transition was brought from natural sand deposits, at Lawrencepur. The second transition layer was manufactured by crushing locally available sandstone rock or boulders.

7.2 Embankment Section

The dam has been constructed of earth and rock fill material. The upstream face of the main dam has a slope of 3(H) to 1(V). The downstream face has a slope of 1.75(H) : 1(V) with two berms 15 feet and 30 feet wide at El:2265 and El;2205 respectively, the 30 feet wide berm accomodates the pipeline from water supply outlet. Exhibit No.5 shows typical cross section of dam. The embankment consists of following zones: Riprap, rock shells, impervious core and transition filters. The gradation of different materials is shown in Exhibit No.6 and they are described below:

') Riprap

A layer of riprap on the upstream side has been provided. It consists of dumped rock about 3 ft. of required gradation.

ii) Core

An impervious core inclined on the upstream side and with a vertical downstream face. Seepage through the dam structure will be limited by the impervious core constructed with silty type of

material. The Core in the central gorge portion slopes at 1.5 horizontal to 1 vertical on the upstream side. The thickness of the impervious blanket over the abutment is at least 20 ft.

iii) Upstream Shell

The Upstream shall is composed of free drainage sandstone rock, obtained from foundation excavations of damsite, from quarries and boulder-gravel mixture deposits of the river bed. The material in the Upstream Zone has maximum particle size of 12 inch and % of fines passing No. 200 does not exceed 5. The rockfill has been placed in 12 inch layers and compacted by at least four passes of smooth drum vibratory roller of 10 ton static weight.

iv) Downstream Shell

The downstream part of the Embankment is constructed of sound, durable sandstone rock obtained from selected quarries. The grading limits of downstream shell is the same as for the upstream shell and the material will be rolled and placed in the same manner as for the upstream shell. A 20 feet wide Zone on the downstream slope of the Dam has been provided where the oversize rocks from the shell of the Dam can be dozed.

v) Transition

In order to prevent the migration of Core material into the rockfill zones, transition layers have been provided both on upstream and downstream.

The two types of transition layers T1 and T2 each 10 ft. consist of coarse sand and gravels respectively. They meet the filter criteria. They were compacted with four passes of 10 ton vibratory roller in the compacted layer thickness of 9 inches.

vi) Filter Blanket

A horizontal filter blanket in continuation of chimney drain T2 has been provided over the river bed under the downstream shell. This filter is about 200 feet wide and 3 feet thick sloping at 1 in 300. The filter blanket layers have been compacted by means of a vibratory roller.

7.3 Embankment Stability

The proposed embankment section has been adopted as an integrated design to satisfy seepage,.settlement and stability requirement and also for the optimum utilization of the materials from excavations at the Dam site and nearby quarries and borrow areas. The slope stability analyses were made for the most critical loading conditions which may be imposed during the construction and reservoir operation.

The possibility of shear failure of an embankment is most critical for conditions under which it is subjected to shear stresses in addition to those imposed by its own weight. The several cases which take these forces into account are designated as end of construction, sudden drawdown, steady seepage and earthquake. Stability

analysis were carried out with the Bishop's modified method of slices. The embankment section has been selected to provide a sufficient factor of safety when analysed on the basis of effective stress analysis for all the above conditions. Following minimum factors of safety were prescribed for the most critical conditions:

	Upstream Face	Factor of Safety
i)	End of Construction	1.4
ii)	End of Construction with Earthquake	1.1
iii)	Sudden Drawdown	1.2
iv)	Sudden Drawdown with Earthquake	1.00
	Downstream Face	
i)	End of Construction	1.4
ii)	End of Construction with Earthquake	1.1
iii)	Steady Seepage	1.4
iv)	Steady Seepage with Earthquake	1.1

All the above cases were checked with the combined effect of earthquake of 0.1g and 0.15g during the design stage and later on rechecked with an attenuated earthquake effect of 0.19g due to the Nelor (Rawalpindi) recorded earthquake of 5.8 magnitude in 1978. The following soil parameters were used in slope stability analysis:

Material	Unit weight (lb/ft.^{3})				O.M.C. %	C psi	Ø
	Dry	Wet	Sat	Sub			
Impervious Fill	118	137	139.5	77	16.5	1.5	25°
Rockfill	135	140	149.5	87	dry	0	35°

The computed factors of safety indicate that the requisite stability criteria has been fully satisfied and the adopted embankment slopes are adequate.

7.4 Foundation Design

In order to provide adequate foundation as regards stability and seepage control for the embankment, following considerations have been taken into account:

The layout of the Dam has been planned to take maximum advantage of two distinct geologic features. These geologic features are:

i) The thick sandstone ridge which will provide firm abutments.

ii) The bedrock zone comprising dominantly of fine grained rocks will provide a suitable foundation for tying the impervious core.

The core lies directly over the sound rock Foundation. The overburden and the weathered rocks have been removed from the entire foundation of the impervious core. As a measure to prevent the seepage through the abutments the core has been extended onto the flanks providing a blanket cover.

7.5 Foundation Preparation

The measures taken for the preparation of the foundation were as follows:

i). Overburden and weathered rocks have been removed from the entire foundation of the impervious core;

ii) Sharp knobs and rock bluffs have been removed;

iii) Large openings, like cave on the left abutment, and crevices have been backfilled with concrete, after clearing and cleaning;

iv) Small openings and cavities have been tremie grouted and covered with dental treatment;

v) Under the downstream shell, the softer rock units have been protected with a 3 feet thick layer of transition material before placement of rockfill; and

vi) The abutments under the core have been cut on 0.6 (H): I(V) or flatter. Under the rockfill, however, steeper slopes have been allowed.

8. OUTLET WORKS

The outlet works comprise an intake tower, control tower with bulkhead gates for controlling entry of water into the tunnel and an outlet tunnel 6 ft. diameter concrete lined about 600 ft. long. The tunnel will be plugged at downstream end and bifurcated into two 3 ft. dia pipes. The flow of water into these pipes will be controlled by two high pressure valves. These twin pipes passing over the downstream berm of the dam would finally convey water by gravity to filteration plant already constructed at an el. 2210.

The height of intake tower is 60'. The intake tower consists of four columns interconnected by beams. The column beam frame structure forms 7 bays on eachside. These bays are equipped with grill to restrict entry of boulders and gravels into the tunnel. Maximum drawdown level is 2233. An arrangement has been made to close the bays upto which level the

reservoir will be silted up and the intake tower will provide uninterrupted supply of water. Exhibit 7 gives details.

9. SPILLWAY

The Soan River, on which the dam is being built is a perennial stream and its flood discharge during the monsoon season, ranges between 4,000 to 5,000 cusecs. The surplus water would be stored to overcome the deficiency during the dry season. The average annual inflow of the river is 6506 acre ft. The storage capacity of reservoir is 28750 acre ft. for water level of 2320.00.

The spillway has been constructed as a free fall ogee of 110 ft. width between the abutments. Salient features of the structure are:

i) Approach Channel

A straight approach channel of trapezoidal section with bed width 110 ft. Side slope 1:1 and Bed Level = 2285.00.

ii) Spillway Crest

110 ft. wide with vertical abutments crest level is 2295.00.

iii) Upper Glacis

110 ft. wide, slope 1.2:1.

iv) Upper Stilling Basin

Length of basin is 231 ft. from toe of upper glacis to face of lower weir. Cistern level is 2140.00 and width is 110 ft.

v) Lower Crest

Crest level is 2172.60.

v) Lower Glacis

The lower glacis has been diverged from 110 ft. to 125 ft. and slope is 0.6:1.

vi) Lower Stilling Basin

Cistern level is 2074.00. Length of basin is 154 ft. and width is 125 ft.

9.1 Design Discharge

45000 cusecs.

9.2 Provision of Gates

After provision of gates, the present maximum reservoir level of 2285 will be raised to El. 2320 to further enhance the storage of the reservoir. This normal reservoir level can be maintained at El. 2320 by provision of gates in the spillway.

Two piers of 7 ft. width and 32 ft. clear spacing have been made and the gates would be installed at a later stage when required.

Plan and Cross Section of Spillway have been shown in Exhibit No.8.

10. INSTRUMENTATION

In order to monitor the behaviour of the fill, foundation and the abutments including the grout curtain and the drainage curtain, an eleborate instrumentation system

has been designed. Both electrical and hydraulic piezometers and settlement gauges have been installed.

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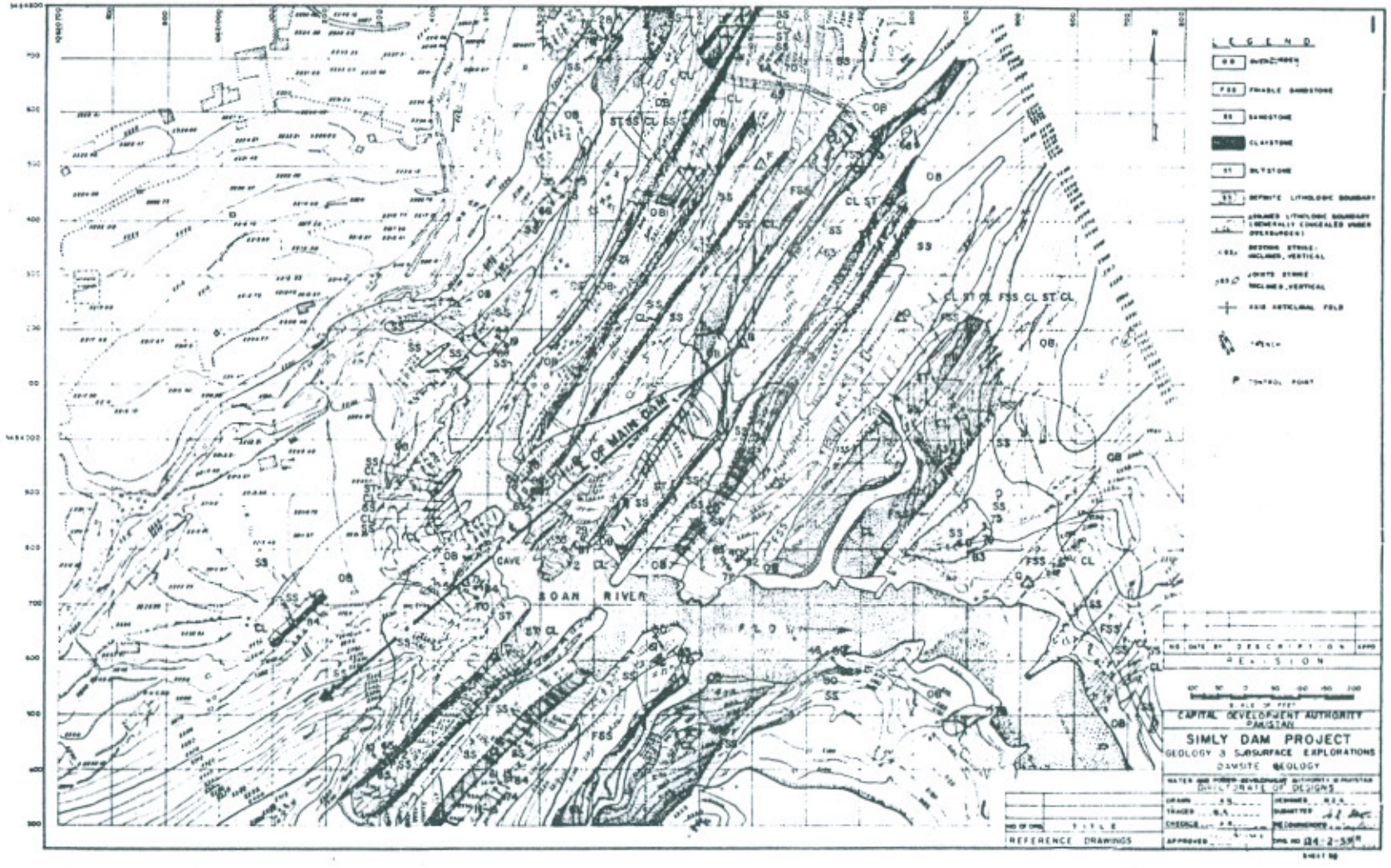
5- Especially Mr. Fazal Ali Shah Hashmi, Deputy Director, Central Design Office (W) WAPDA for his extremely useful constribution in making the paper a success.

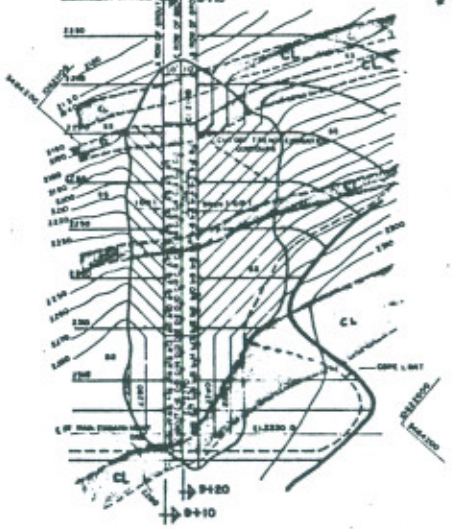
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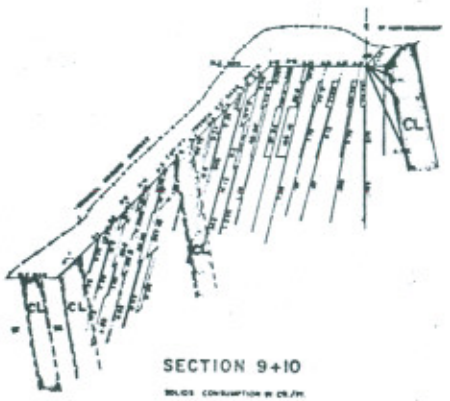
(List of Exhibits)

Exhibit No.	T I T L E
1	Geologic Plan
2	Test Grouting
3	Grout Curtain
4	Drainage Gallery
5	Typical Cross Section of Dam
6	Gradation of Materials
7	Outlet Works
8	Spillway Plan and Cross Section

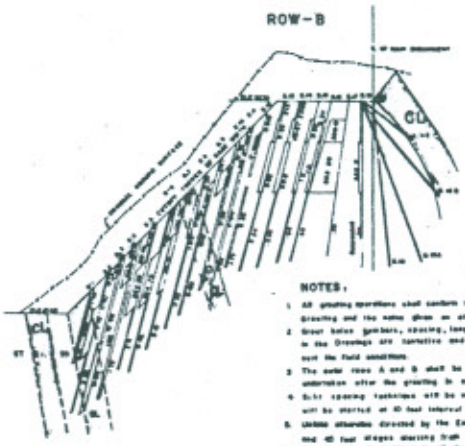

LEGEND
QB
FSS
SS
CLAYSTONE
ST
SILTSTONE
DEFINITE LITHOLOGIC BOUNDARY
JOINTS STRIKE
INCLINED, VERTICAL
AXIS ANTICLINAL FOLD
TRACE
CONTROL POINT
SOAN RIVER
CAVE
REVISION
CAPITAL DEVELOPMENT AUTHORITY
PAKISTAN
SIMLY DAM PROJECT
GEOLOGY & SUBSURFACE EXPLORATIONS
DAMSITE GEOLOGY
WATER AND POWER DEVELOPMENT AUTHORITY & MINISTRY
SIMLY INSTT. OF DESIGNS
DRAWN
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REFERENCE DRAWINGS



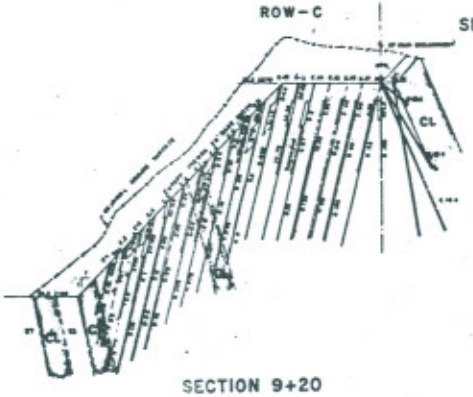
PLAN



SECTION 9+10



SECTION 9+30



SECTION 9+20

NOTES:

1. All grouting operations shall conform to the section "F" specifications for Drilling and Grouting and the notes given on drawing or as directed by the Engineer.
2. Grout holes (numbers, spacing, lengths, orientation, angle with vertical as shown in the Drawings are tentative and subject to modifications by the Engineer to suit the field conditions.
3. The outer rows A and B shall be grouted first the grouting in row C shall be undertaken after the grouting in outer rows is completed in a stage.
4. Split spacing technique will be used in opening the holes. The primary holes will be started at 40 feet interval.
5. Unless otherwise directed by the Engineer, the grouting shall be done in 10, 15, 20 and 40 feet stages starting from top.
6. The grouting in a stage in all the rows will be completed before the next stage grouting is taken up.
7. The grouting shall be done under the gravity flow. No pressure shall be applied for injection unless otherwise directed by the Engineer.
8. Unless otherwise directed by the Engineer, hole Nos. A-1,3, B-1,3 & C-1,3 shall be vertical and the orientation of all other holes shall be N 20° W, 11° W upstream.
9. Open cement grout will be used with the consumption in 4 stages remains 3 ml/lb of dry mix of consumption mortar grout will be introduced. Mortar grout will be pumped into the hole till refusal is obtained.
10. Grouting shall commence only after the foundation excavation has been completed. Grouting will not be permitted on the rock which has been grouted or is being grouted.
11. Holes shall normally be drilled directly into the rock in case where the rock is soft and it is anticipated that the packer will not set on it rigidly a concrete grout cap shall be constructed as specified in the Drawings and as directed by the Engineer. The drilling and grouting shall be done through the pipe embedded in this grout cap.
12. The grouting in a row upon commences from lower elevation and shall proceed upwards unless otherwise directed by the Engineer.
13. In order to prevent damage to the foundation rock the cutoff trench shall be excavated using controlled blasting methods like line drilling presplitting or cushion blasting.

0 5 0 0

SCALE OF FEET

CAPITAL DEVELOPMENT AUTHORITY
PAKISTAN

SIMLY DAM PROJECT

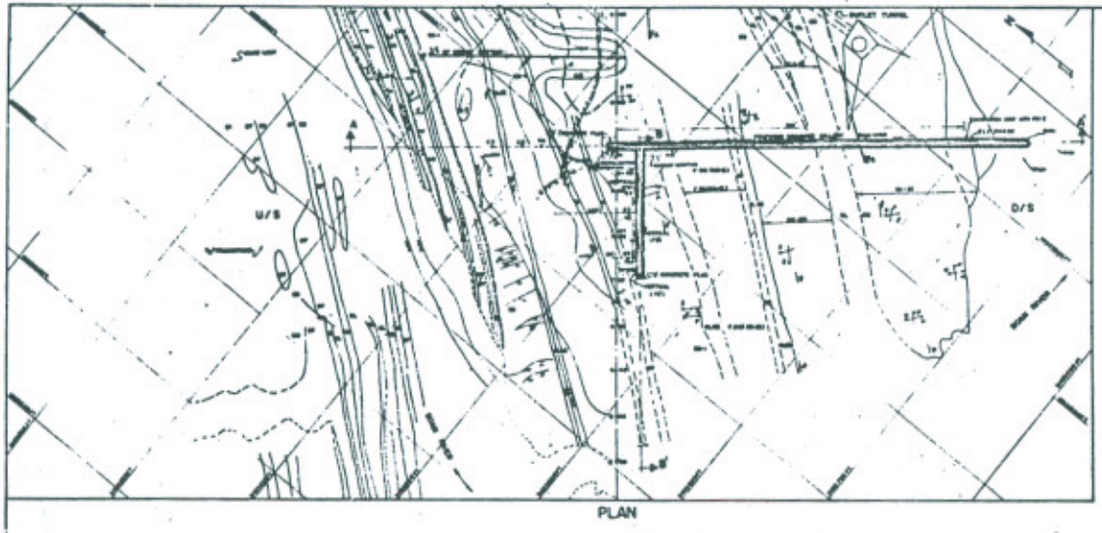
CUT-OFF TRENCH CURTAIN GROUTING PLAN SECTIONS ALONG GROUTING ROWS A,B,C

WATER AND POWER DEVELOPMENT AUTHORITY
CENTRAL DESIGN OFFICE (W)

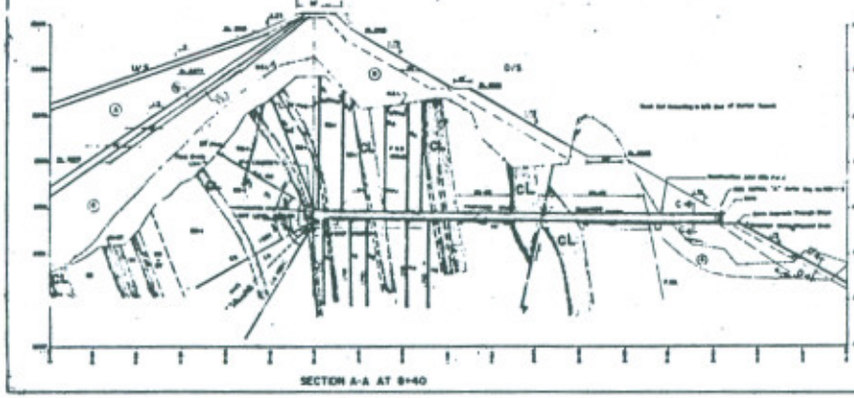
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CHECKED	RECOMMENDED
APPROVED	DRG NO.

DRG NO

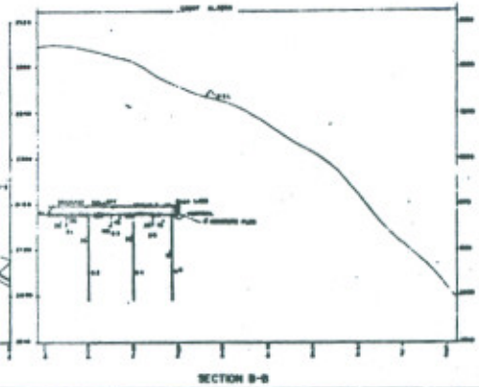
REFERENCE DRAWINGS



PLAN



SECTION A-A AT 0+40



SECTION B-B

SECTION D-D'
SEEPAGE WATER DISPOSAL DRAIN

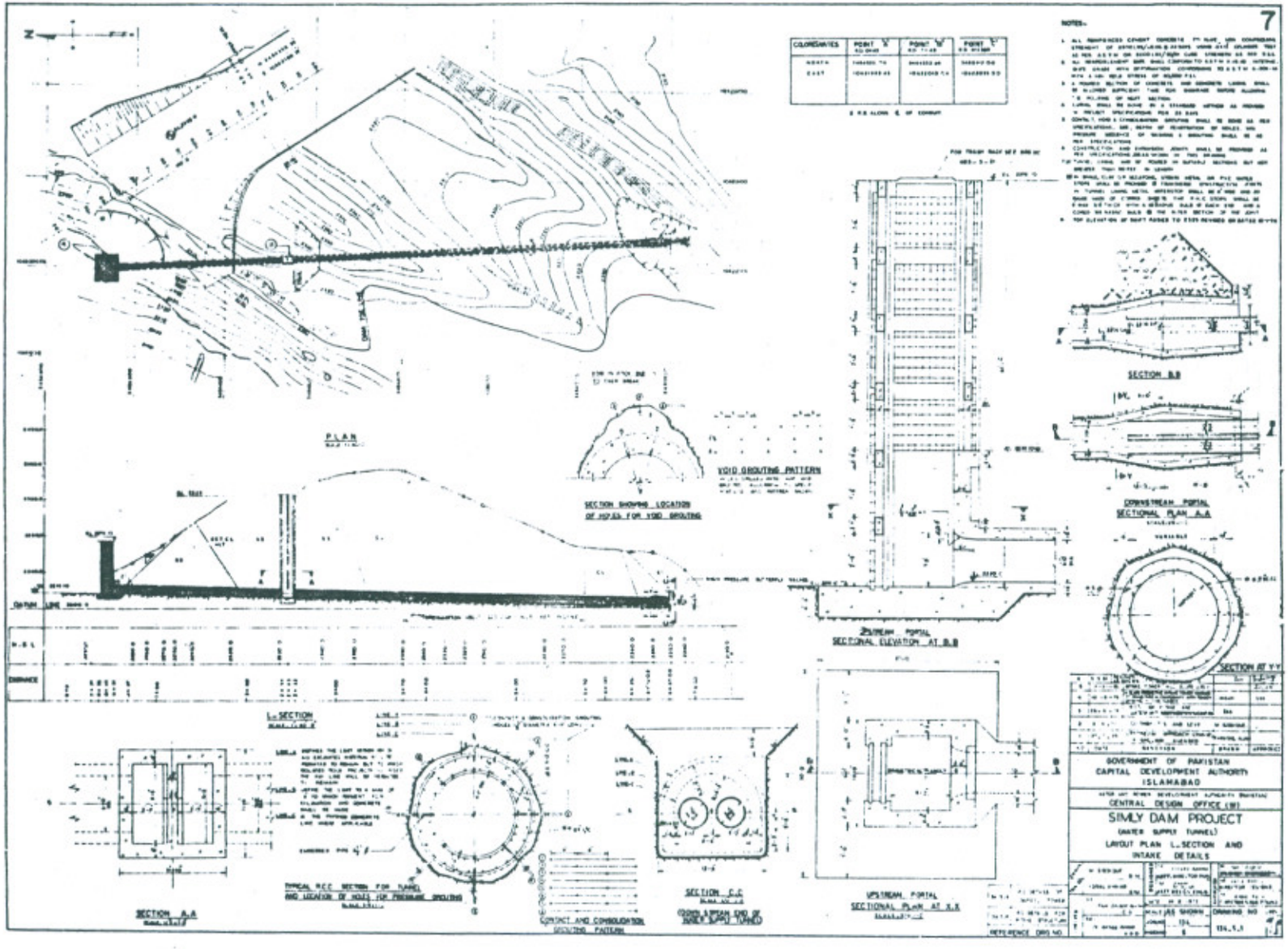
SECTION C-C'
R. C. C. CONDUIT

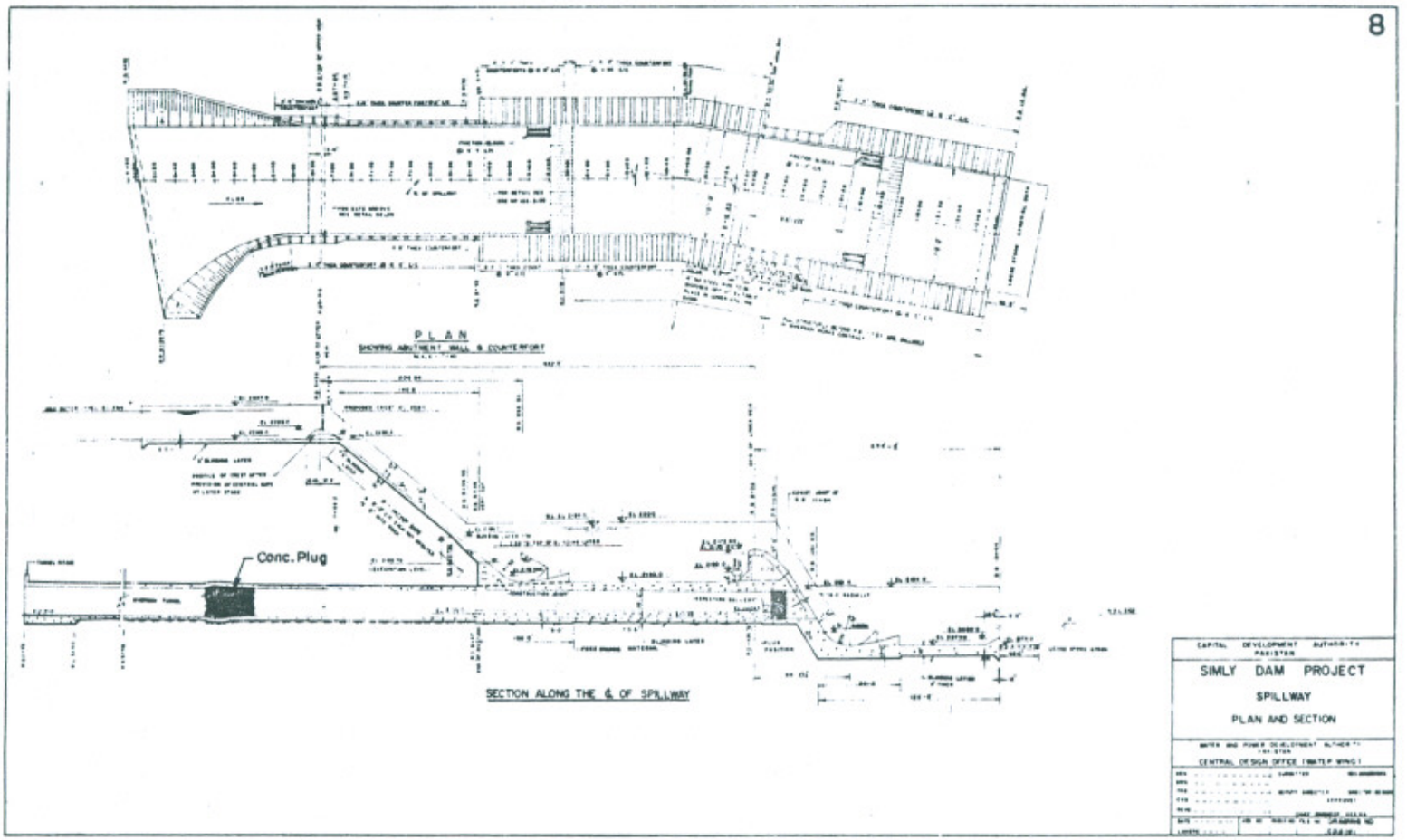
LEGEND

CAPITAL DEVELOPMENT AUTHORITY
PAKISTAN

SIMLY DAM PROJECT
DRAINAGE GALLERY
PLAN AND SECTIONS

CENTRAL DESIGN OFFICE (WATER WING)


7
PLAN
SECTION SHOWING LOCATION OF HOLES FOR VOID GROUTING
VOID GROUTING PATTERN
SECTION B.B
DOWNSTREAM PORTAL SECTIONAL PLAN A.A
SECTION AT Y-Y
DOWNSTREAM PORTAL SECTIONAL ELEVATION AT B.B
L-SECTION
SECTION A.A
TYPICAL R.C.C. SECTION FOR TUNNEL AND LOCATION OF HOLES FOR PRESSURE GROUTING
CONTACT AND CONSOLIDATION GROUTING PATTERN
SECTION C.C
UPSTREAM PORTAL SECTIONAL PLAN AT X.X
GOVERNMENT OF PAKISTAN
CAPITAL DEVELOPMENT AUTHORITY
ISLAMABAD
CENTRAL DESIGN OFFICE (WP)
SIMLY DAM PROJECT
(WATER SUPPLY TUNNEL)
LAYOUT PLAN L-SECTION AND INTAKE DETAILS



CAPITAL DEVELOPMENT AUTHORITY
PAKISTAN

SIMLY DAM PROJECT

SPILLWAY

PLAN AND SECTION

WATER AND POWER DEVELOPMENT AUTHORITY
CENTRAL DESIGN OFFICE (WATER WING)