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Examination Report of Civil Works

Karnaphuli Third Unit
Kaptai, Bangladesh

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EXAMINATION REPORT OF CIVIL WORKS

1981

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UNITED STATES DEPARTMENT OF THE INTERIOR
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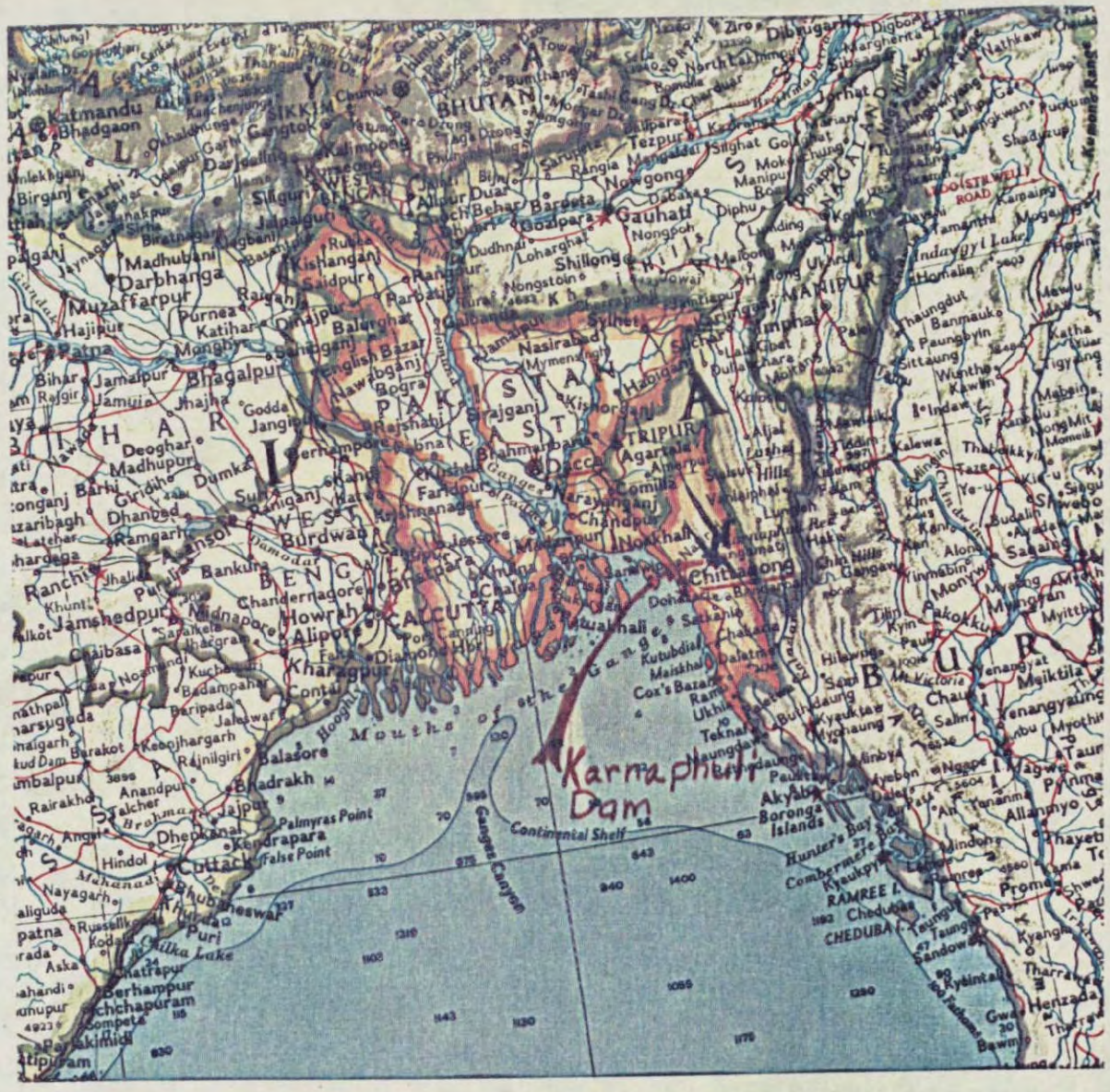
Karnaphuli Dam
Mouths of the Ganges
Continental Shelf
Ganges Canyon
Palmyras Point
False Point
Chilka Lake
Gauhati
Shillong
Dacca
CALCUTTA
Howrah
Jamshedpur
Ranchi
Darbhanga
Muzaffarpur
Patna
Bhagalpur
Cuttack
Bhubaneswar
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Midnapore
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Durgapur
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Ranchi

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Memorandum, October 22, 1981

I. INTRODUCTION

This report of the examination of Civil works at Karnaphuli Hydro Station is based upon an onsite inspection by Messrs. Ralph O. Atkinson and Richard W. Kramer[1/] during the period September 22-26, 1981, discussions with personnel of USAID/Dacca and Bangladesh PBD (Power Development Board), Dacca, and review of the material listed in the section "References".

Summary

The U.S. Agency for International Development Mission to Bangladesh (USAID/Dacca) requested the services of the Bureau of Reclamation to review and comment on a scope of work prepared for the repair and rehabilitation of the civil works of the Karnaphuli hydropower generating plant and dam located at Kaptai on the Karnaphuli River in Bangladesh.

Our examination of the civil works indicated no serious problems. The problems encountered, both reported and observed, are not uncommon to projects 20 years of age. This report contains our recommendations of maintenance and/or modifications required to solve the existing problems. Some of the problems should be remedied as soon as climate, funds, and facilities permit, while other repairs or modifications may be delayed for a reasonable amount of time.

The reported horizontal "cracks" in the spillway chute were determined to be construction joints between the original concrete and the concrete placed for the reconstruction after the 1961 spillway chute failure. We have recommended a core drilling program through the spillway chute concrete to establish the present conditions of the concrete and the interface between the concrete and foundation.

In addition, it is important that the existing spillway design be evaluated for the hydraulic and structural conditions established by an updated IDF (inflow design flood) and the core drilling program.

The project's operation and maintenance of the structures have been outstanding. Instrumentation readings and data collection have been excellent. However, the instrumentation data have not been plotted which makes it difficult to follow the performance of the dam and to identify developing problems.

Our recommended "Scope of Work" for the civil works is included in the appendix to this report. It is based upon our field examination of the works and review of all available information. We discussed methods for implementing the necessary repairs with USAID/Dacca before leaving Bangladesh.

1/ Ralph O. Atkinson - Head, Concrete Dams, Spillways and Outlets Section; Richard W. Kramer - Assistant Chief, Dams Branch; Bureau of Reclamation, Engineering and Research Center, Denver, Colorado, U.S.A.

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II. SPILLWAY

General

The condition of the spillway was of greatest concern because of its failure during its first year of operation. At that time, a modest flood release of 120,000 ft^3/s caused a failure of the center chute slab resulting in severe erosion across most of the spillway width. A horizontal "crack" has now been reported that crosses the entire spillway at approximately 5 feet down the chute from the contraction joint between the gate structure and the top chute slab. An intermittent horizontal "crack" was also reported about 4 feet up the chute from the chute blocks (dentates).

An examination of the entire structure was conducted. A sampan was supplied so that we could access and examine the gate structure, chute, and exposed portions of the stilling basin. It was reported that the basin will be dewatered for examination this year during the dry season.

Hydrology and Spillway Operation

During the examination, Mr. Islam raised a question about whether water could be temporarily held at a higher level, particularly in the monsoon season, to preclude a large spill which would increase flooding downstream. We were also told that there were provisions for raising the dam. The spillway was built to accommodate this raise. We did not have time to study nor did we have explained to us the operating procedures during the flood periods.

It has probably been 20 to 25 years since the IDF has been developed. Since that time, additional hydrologic data have been collected and the state-of-the-art for interpreting the data for establishing an IDF has changed.

Conclusions

1. Update the IDF.

2. Using the updated IDF, the operation of the spillway and outlets should be reviewed with regard to reservoir elevations and the downstream effect of releases.

3. The dam can be raised fairly easily by excavating part of the dam crest to make a good bond with the existing core, and raising the dam toward the downstream. Such a scheme would minimize any need for lowering of the reservoir.

Gate Structure

The condition of the gate structure concrete was excellent with no signs of distress or movement noted. The piers, crest, drainage gallery, and bridge concrete contained only a few hairline cracks (photos 1 and 2). The drainage gallery had about 2 inches of water on the floor (photo 3). No drainage was noted from the outflow ends of either the drainage galley or drain outlets. Water was standing in the 4-inch-diameter cleanout pipes at each drainage hole to a depth of about 9 inches below the gallery floor. The readings from piezometers in the piers indicated pressures in the normal range expected. Survey measurements (vertical and horizontal) indicated no apparent movement of the gate structure had taken place. An additional survey was made while we were at the site.

Conclusions

1. The structural condition of the gate structure appears excellent.

2. The gate structure has apparently not experienced any movement or rotation.

3. The drain lines from the drainage gallery and drainage holes require cleaning as soon as practicable to ensure that they are working properly.

Chute

The walls that could be examined above the tailwater level appeared to be in excellent condition. The top two floor slabs were above the tailwater. The slab surfaces show some minor areas of weathering and erosion (photo 4). Some small holes are present where pieces of aggregate have been plucked out. Some short hair line cracks are scattered over the slabs but they appear to be shrinkage motivated and not structural related.

The horizontal "crack" in the top slab appears to be the construction joint between the original concrete and the replacement concrete constructed to repair the 1961 spillway failure (photo 5). The (crack) joint appears, for the most part, very tight except for some areas where weathering and erosion have increased the surface width and as a result has become more visually apparent (photo 6). The joint had been filled earlier for part of its length but the filler has been mostly eroded or dislodged by flowing water and weathering effects (photo 7). It appears that when the chute was reconstructed, the concrete was not saw cut and it was apparently broken to as straight a line as possible using available

impact tools (photo 8). This resulted in a wavey line appearing to meander like a crack. The joint does not extend into the walls, and terminates at the longitudinal joints defining the edge of the wall foundations on each side of the spillway.

The lower reported horizontal "crack" was under the tailwater at the time of the examination.

Each chute slab contains a pair of 2-inch pipe drains as is shown on the drawings for reconstruction of the spillway. These were not a part of the original design. A few of the drains were probed. Some were clear to a depth of 10 feet while others to only 2 feet in depth and presumed to be plugged with silt because the end of the probe brought out a silty material.

Our examination noted that the downstream side of the contraction joint between the gate structure and the chute slab at spillway station 9+44.52 was higher than the upstream side in many bays (photo 9). No evidence of cavitation related to the joint condition was evident although many spills have occured.

Contraction joints in the chute are filled and sealed annually and they wash out every year (photo 8). Some of the original asphalt impregnated cork joint filler was still in place. At several locations, the joint could be probed to a depth of 24 inches. A mortar type filler was also noted in some joints. We were told that this material had been used during past maintenance work. From photographs of the spillway failure, it was obvious that the foundation is very erodible.

It is believed that the piezometers beneath and at the surface of the center bay chute slabs, Drawing FL-13-1233R1, were read during earlier spills after the reconstruction (photos 10 and 11). These data should be located at the project office. We discussed the reasons for the piezometers with project personnel and expect they will read them for future spills. During the demonstration spill, in our presence, an attempt was made to read three of the piezometers. All were dry at about a 62-foot length from the top of the pipes. The spill was not large enough to create pressures that could be read in the piezometers.

Conclusions

1. The walls and floor of the chute appear to be performing in a satisfactory manner.

2. Small holes and weathered areas in the chute floor slabs require patching with epoxy bonded mortar and/or with epoxy bonded concrete. The appendix contains procedures and recommendations for materials.

3. The horizontal "crack" which is located 5 feet downstream of the contraction joint at spillway station 9+44.52 appears to be no more than the construction joint between the original concrete and the 1961 slab replacement (see Drawings FL-13-1234R1 and FL-13-1235R1).

4. The lower horizontal "crack", which is located 4 feet up the slab from the chute block dentates, should be examined when the stilling basin is dewatered. It is assumed that this "crack" is the lower construction joint between the 1961 slab replacement concrete and the original concrete.

5. The horizontal construction joints (cracks) should be sealed. In the appendix are recommended procedures and types of material for this purpose.

6. Review the adequacy of the existing slab as shown on Drawing FL-13-1234R1 and FL-13-1235R1 considering transient pressures, after determining the adequacy of the foundation. Data from the chute piezometers should be utilized in the review.

7. To ensure that there is an adequate foundation, we recommend a core drilling program be undertaken. This program should consist of a series of 4-inch-diameter holes drilled through the concrete slab to a depth of 3 feet into the foundation. These cores will indicate the present condition of the concrete, foundation, and foundation-concrete interface. These holes should be drilled in spillway bays 4, 9, and 12 at about 4.5 feet right of the slab centerline. The holes should be located at spillway stations 9+55 ±, 9+67 ±, 9+86 ±, 10+08 ±, and 10+24 ±. If these cores indicate an unsatisfactory foundation condition, a redesign and remedial construction may have to be undertaken. However, no evidence of foundation problems were evident in our examination. The core holes should be filled with concrete rodded to ensure good density. The surface finish should be as smooth as possible to prevent cavitation.

8. The misalinement in the spillway grade at the contraction joint located at station 9+44.52 has not shown any cavitation during prior spills. Therefore, we recommend not modifying the joint until cavitation has been noted and then treat the condition locally.

9. The contraction joints in the chute slabs need to be filled with filler material and a sealant. The appendix contains information about filler-sealer combinations and recommendations for materials and procedures.

10. The 2-inch pipe drains in the chute slabs need to be cleaned.

Stilling Basin

A large portion of the stilling basin was under water and could not be examined. The walls above the tailwater appeared in good condition. Minor local cavition of the basin floor and dentates were repaired in 1980 which was the last time the basin has been dewatered. Cavitation and surface erosion occur in most basins and they need periodic repair. However, a large amount of money can be spent on trying to keep it like new. Unless the basin has eroded to a condition where a considerable amount of reinforcement is exposed, the repair should only consist of

patching deep holes and exposed areas of reinforcement. Repair of local erosion or cavitation damage in a basin can usually be made by using epoxy-bonded epoxy mortar or epoxy-bonded concrete. If severe damage has occurred, a concrete overlay slab would be required. "Standard Specifications for Repair of Concrete" has been included in the appendix.

Conclusions

1. Dewatering and examination should be scheduled at periodic intervals such as every three years. Underwater examination by divers could also be used.

2. When erosion and cavitation damage extends over a large area of the slab, an overlay of reinforced concrete should be considered. A minimum slab thickness should be 6 to 9 inches. A minimum layer of No. 6 reinforcement bars at 12-inch centers, each way, should be placed in the overlay.

3. Installation of No. 8 reinforcement anchors should be considered to anchor basin floor to the foundation if an overlay is ever considered necessary.

Channel Downstream of Stilling Basin

From our examination of the stilling basin and downstream channel, it was noted that many of the cubic-yard-sized concrete riprap have been moved from their original position and were deposited in the downstream river channel (photos 12 and 13). Many large depressions were noted where the riprap had washed out (photo 14).

Conclusions

1. The channel protection must be repaired prior to any additional large flows to fully protect the downstream end of the concrete basin.

2. The crushed-brick concrete blocks are not of adequate size to protect against most yearly spills.

3. A reinforced concrete slab could be placed downstream of the basin but would require an extensive underdrain system to minimize uplift. If a slab were used, we would recommend using No. 8 reinforcement anchors at 10 foot centers each way grouted approximately 8 feet into the foundation. Moreover, to ensure adequate strength and erosion resistance, a slab with a thickness of no less than 2 feet should be used.

Another alternative to consider would be the casting of new interlocking concrete blocks which could also be anchored to the foundation. Alternatively, the existing riprap blocks could be utilized again if they were placed between a series of parallel concrete walls or lattice work walls to hold them in place. These are all schemes which should be considered in a cost comparison study to determine the most feasible option.

Right Bank Slope Stability

The right slope of the spillway channel downstream of the spillway crest has eroded by at least 10 feet since the dam was constructed (photo 15). The residences at the top of the slope will be affected if the erosion continues (photo 16). Some cracks now appear on the level area between the top of the slope and the row of buildings. A number of grouted reinforcement type rock bolts are projecting from the slope. The slope is composed of shale that is continuing to weather and erode by falling off along the closely spaced vertical joints through the shale beds (photo 17).

Conclusions

1. The slope will continue to deteriorate; however, the process can be slowed by covering the face with a mesh reinforced shotcrete. Rock-bolts should be used to fasten the mesh to the shale slope. Drains are required to prevent high water pressures from building up behind the shotcrete.

2. There should be some consideration given to moving the buildings from above the right slope if the erosion continues.

III. MAIN DAM

A thorough examination of the main dam found no serious deficiencies. The structure is being well maintained and monitoring data are being meticulously collected. The road on the crest of the dam is paved with concrete. All joints between the slabs of pavement were well sealed with asphalt, no differential displacement was noted between adjacent slabs, and no signs of distress such as cracking were noted in the slabs (photo 18).

On the downstream slope of the dam is a system of longitudinal and transverse surface runoff collection ditches (photo 19). The ditches are paved with concrete slabs of 3- by 1-foot size. All of the ditches were in alinement and grade, and no distress was observed between the paving slabs (photo 20). An excellent stand of grasses covers the entire face. The grass is cut for fodder and used for grazing. Evidence of mole tunnels was found in some areas. These animals only disturb the surface. Very few wet areas were found on the abutment and these seeped only minor amounts. We were told that they practically dry up after the monsoon season.

Slope protection on the upstream face was in excellent condition (photo 21). The protection consists of cast concrete cubes of about 1/2 cubic yard chinked with cobbles and hard bricks. No signs of erosion, beaching, or settlement were found and we were told that there has never been wave damage to the slope protection.

The instrumentation is well maintained. Periodic readings are taken and meticulously recorded. We observed the measurement of the piezometric level for one of the crest piezometers. The instrumentation data have not been plotted however, which makes it difficult to follow the performance of the dam and identify developing problems. We reviewed the data and discussed

graphical displays of the data with Mr. Mukaddas. Examples of Bureau graphical displays have been transmitted to USAID, Dacca for forwarding to PDB, Kaptai.

Conclusions

1. The main dam is in excellent condition with no evidence of detrimental settlement or movement.

2. Monitoring has been exceptional, however, the data should be displayed graphically.

3. Continue the present program of maintenance, but increase the program for clearing woody vegetation from the abutments for a distance of about 25 feet beyond the perimeter drainage ditches.

4. The relief wells should be inspected to check if cleaning is now required. This should be done periodically. Examination of the flow data may also indicate requirements for cleaning.

5. An evaluation of the stability and performance of the dam should be made using the data from all of the instrumentation, surveys and seepage measurements.

IV. POWER FEATURES

General

We examined the powerplant, intake structure, slope upstream of powerplant and tailrace area.

Powerplant

The powerplant was well managed and maintained. The people working in the powerplant appeared to be very dedicated to the project and take much pride in their work. The third unit was being installed by the Vinnell Corporation and the work was reported to be progressing satisfactorily. Mr. Jim Hill, Vinnell Corporation, indicated that the unit appeared to meet or surpass all required tolerances and should operate with minimal vibrations. He indicated that the vibrations from the unit should be no greater than those of the other units.

Conclusions

1. The concrete in the substructure and operating deck appeared in excellent condition and nearly crack free.

2. No areas of movement or distress were noted.

3. The structural steel superstructure appeared to be in excellent condition and well maintained.

Intake Structure

The concrete in the intake structure was in excellent condition. No areas of cracking or other signs of distress were noted. The metalwork and equipment were in satisfactory condition and repair, except that some are in need of painting. Continual maintenance is required to maintain good operation. No problems with the operation of equipment were reported. We examined the forebay area and discussed the possibility of increasing the structure size for two more units.

Conclusions

The intake structure is in good condition and should continue to operate properly if well maintained.

Tailrace Channel Slopes

The left tailrace slope was originally supported with grouted anchor bars and face plates. The left bank slopes from the channel bottom to a berm at the approximate elevation of the top of the retaining wall immediately downstream of the plant retaining wall (photo 22). It is then vertical to the top of the cut which is at approximately the elevation of the power-plant entrance. The berm appears to coincide approximately with a change in the angle of the joints cutting the horizontally bedded rock. Below the berm, the joints are at a small angle from the vertical, sloping into the channel; while above they are vertical. The rock has slipped out from behind the face plates for about a distance of 5 feet at the level of the berm.

The right tailrace slope geologic structure is the same as the left except that the top of the slope is about 50 feet higher and a fault cuts through the slope at the end of the right retaining wall (photo 23). Some small areas of vertical slabs of the approximately horizontally bedded rock have fallen into the channel. A large block of rock above the fault has also recently dropped into the channel. The block was defined by the fault, vertical joint set and down dipping of the bedding planes due to the fault shear. Downstream of the fault area, the right slope is almost vertical. Rock falls from the slope in vertical slabs of 6- to 12-inch thickness. Weathering of the almost vertical joint system governs the width and thickness of the slabs (photo 24). Several temporary structures and a tower carrying lines to the switchyard are at the top of the slope. The tower is presently about 50 feet from the edge and could be moved about 40 feet further away from the slope. Operation of the third unit might cause increased rockfall until a more stable configuration is again achieved. Water was standing over a large area at the top of the slope near the tower.

Conclusions

1. The tailrace channel slopes will continue to experience ravelling but this is not of large concern.

2. Surface drainage from the top of the slopes should be improved and maintained to minimize infiltration.

3. At some future time, moving the tower may be desirable when slope ravelling has come closer to the tower.

4. With the third unit in operation, if scour of the base of the right side of the channel becomes a problem, a masonry wall could be constructed underwater by stacking large blocks of concrete. The space between the wall and slope would be filled with free-draining material. A cast concrete wall would be considerably more expensive.

5. Installation of horizontal drains into the mass above the fault plane and through the fault would enhance the stability of the area by relieving the excess pressures.

Slope Upstream of Powerplant

The slope upstream of the powerplant was excavated in four rises. The first rise from the powerplant entrance level was vertical to the first berm. Then the other rises had a slight slope to the remaining two berms and top of the excavation (photo 25). During construction there was apparently a stability problem with the slope in back of the left end of the powerplant requiring additional excavation and redesign. Here there is only one berm at about the level of the second berm on the right side. A concrete retaining wall was constructed on the berm and retains a slope of stacked handplaced rock which is capped at the top by a concrete slab (photos 26 and 27). Mostly grass-type vegetation grows on the natural slopes and berms, but some trees are starting to grow (photos 25 and 26). Weathering and erosion of the first rise cause a continual cleanup problem during the rainy season (photo 28). Erosion has progressed in some locations to where there is only one slope to the second berm. Measures can be taken to slow the weathering process, but periodic reconstruction of protection will be necessary to minimize slope erosion

Conclusions

1. Treatment of the lower shale slope can reduce the erosion and cleanup problems. The slope should be cleaned back to sound shale. Short anchor bolts with wire mesh and shotcrete applied will reduce the erosion. Weep holes need to be provided through the shotcrete to prevent buildup of water pressure.

2. Infiltration of surface drainage should be minimized. This may be accomplished by stripping each berm of vegetation and paving the surface and ditch at the back of the berm. Slope the paving to drain into the ditch.

3. All vegetation other than grasses should be kept from growing on or near the slope.

Drainage Gallery

We examined the access tunnel and the drainage gallery in the hill upstream of the powerplant. Both the tunnel and gallery are in shale. Vertical drains pierce the roof of the gallery (photo 30). The drains are gravel

packed, 4-inch PVC or steel slotted pipes. The tunnel and gallery walls for the most part are in excellent condition (photo 31). The gallery to the north of the access tunnel has fewer supports than to the south. There were more spalls and small rock falls in the south gallery (photo 32). There were no large areas of spalls noted. About 16 gal/min were flowing from the tunnel. Mineral encrustation of the drains was visible from the gallery and ranged from minor to severe (photo 33). The electric lighting system in the tunnel and gallery was out of order.

Conclusions

1. The tunnel and gallery are in generally excellent condition. Both should, however, be surveyed to locate areas of potential rockfall. Loose material should be removed and the surface shotcreted or additionally supported in problem areas.

2. All the vertical drains should be cleaned. Design drawings show the drains to exit through the top of the hill. Examination of the drains from in the gallery also indicated that they were originally drilled from the ground surface. If the tops can be located, cleaning would be facilitated.

Access Road Slope

The portion of the access road of concern is along the curve immediately before the powerplant entrance gate. The road lane closest to the slope down to the river has an arcing crack pattern which is about 50 feet long and extends about 9 feet into the lane (photo 29). The cracks have been sealed with asphalt. There is only a very small offset at the crack. No evidence of vertical displacement could be detected in the grassed area between the road and the slope. The slope to the river is steep, and sloughing could be seen from the edge of the slope. The undergrowth, however, was too dense to make a detailed examination of the slope.

Conclusions

1. Instability of the slope mass, with a very small slope movement, could be responsible for the arcing crack pattern in the pavement. The instability could be seasonal and dependant on water infiltration.

2. Horizontal drains installed into the hillside below the road would enhance the stability of the slope. The drains should penetrate the hill to a location approximately beneath the drainage ditch along the east side of the road.

3. Survey monuments should be placed in the crack area and in the surrounding pavement to monitor changes in elevation and movement toward the river.

4. Design of any additional remedial construction will depend upon the characteristics of a potential slide, i.e., does the potential slide encompass the full distance to the river or exit up on the slope? Is

the slide in soil or rock? Relocation of the access road further into the hillside may prove to be the simplest solution.

V. CARGO TRANSFER SYSTEM

The primary examination of the cargo transfer system included the slope above the river, the top of the slope, and the tower footings. The second tower up from the river (photo 34) had foundation rock exposed beneath the left side of the footing when looking up the slope (photo 35). Temporary measures have been employed to attempt to hold the soil. Exposure of the soft rock will hasten weathering and erosion, and eventual loss of support for the tower footing. Examination of the concrete members of all the towers revealed no distress whatever. All appeared structurally sound and without differential movement. No cracking of the concrete was evident where the steel structure attached to the concrete. The steel superstructure needs cleaning and painting. There are surface drainage ditches to carry flow away from the footings, but they need cleaning. Uncontrolled surface runoff was also apparent (photo 36). Woody growth had established itself on the slope. Such growth will aid the break up and deterioration of foundation rock on the slope.

We were additionally asked to examine the monorail beam. At some locations a plate which was welded under the lower flange has horizontally separated from the monorail beam. Grease and sheared metal did not allow a close examination. We were told that the system has many breakdowns and delays. It was down during our examination due to repairs of the hoisting mechanism.

Conclusions

1. The concrete towers and footings are in excellent condition with no signs of distress.

2. The foundation for the second tower footing should be protected to decrease deterioration of the soft rock. This can be accomplished by constructing a cribbing system to hold protective soil against the hillside rock. Before covering the exposed foundation rock with soil, it should be cleaned to a sound surface and a protective coating such as shotcrete applied.

3. Surface drainage features must be maintained and improved where there is concentrated runoff eroding the slope.

4. Woody vegetation must be kept from growing any where near the tower footings.

5. The monorail beam should be cleaned and examined by a structural engineer. Fabrication drawings should be reviewed and an evaluation made of the capability of the monorial to support the trolley.

6. Inspect steel superstructure for signs of member and connection distress.

VI. OUTLET WORKS

General

The upstream tunnel and intake could not be examined because they were under the water. We examined the downstream end of the tunnel by the use of a sampan. The tunnel could be examined with only the light from the downstream portal. We entered the gate shaft from the control building near the right abutment of the dam.

Control Building and Access Shaft

The building contained a reservoir level gauge and the operating controls for the outlet gate. The equipment appeared, in general, to be in satisfactory condition. We climbed down a spiral staircase to examine the gate bonnet. The shaft was dark because many of the light bulbs had been removed. The low level outlet works is an important feature used for reservoir evacuation in an emergency to ensure dam safety. Without proper lighting, it was difficult to fully examine the gate bonnet and other equipment. However, it appeared that the shaft and equipment should be cleaned and maintained. The missing ventilation fan should be repaired and replaced as soon as practicable.

Downstream Diversion Tunnel

The concrete in the tunnel appeared in good condition. Some rock pockets and voids could be seen in the walls downstream of the portal. These voids, although unsightly, will not affect the adequate operation of the structure. The downstream walls and tunnel lining contained very few small cracks and the structure showed no areas of distress.

Conclusions

1. The outlet works and diversion tunnel appeared to be in satisfactory condition.

2. The light bulbs and ventilation fan need to be replaced.

3. The shaft and equipment need to be constantly cleaned and maintained.

APPENDIX

BANGLADESH POWER DEVELOPMENT BOARD
OFFICE OF THE MANAGER (POWER)
KARNAPHULI HYDRO STATION

P.O. Kaptai
CTG. Hill Tracts

NO:M-10/81/4031(12)

September 23, 1981

MINUTES OF THE MEETING HELD ON SEPTEMBER 22, 1981

A meeting was held on September 22, 1981 at 4:00 p.m. at Biddyut Bhaban. The following gentlemen attended the meeting:

PDB

1. Mr. A.F.M. Moeenul Islam, Manager, KHS
2. Mr. A.K.M. Mukaddas, Dy. Manager, Plant Engineer, KHS

Bureau of Reclamation, U.S.A.

1. Mr. Richard W. Kramer, P.E., Asst. Chief, Dams Branch Division
2. Mr. Rolph Atkinson, Head, Concrete Dams and Spillway

USAID

1. Mr. Shamim Rahman, General Engineer

The following discussions were held and decision taken:

1. All the problems of civil nature faced by Karnaphuli Hydro Station should be investigated per the following program and advice provided accordingly.

2. Scheduled the following program of work during the stay of the Bureau of Reclamation team:

22-9-81 Morning	-	Visit of spillway, powerhouse and other places to have a general idea about the work involved (already done)
Afternoon 4:00 p.m.	-	Study of drawings, photographs, and discussion on connected matters
23-9-81 Morning 8:00 a.m.	-	Inspection of spillway chute and the crack by going on the spot from downstream, inspection of riprap, erosion at the tailrace, etc.
	-	Inspection of spillway drainage gallery
Afternoon	-	Inspection of Main Dam
Evening	-	Study/survey data of spillway and piezometer readings, instrumentation data of the dam, etc.

24-9-81 Morning	-	Inspection of Cargo Transfer System and the erosion at that place
	-	Drainage gallery in the hill behind the powerhouse
Afternoon	-	Inspection of hillside behind powerhouse
	-	Inspection of erosion at tailrace of powerhouse
	-	Inspection of erosion beside approach road to powerhouse
25-9-81 Morning	-	Inspection of diversion tunnel gate shaft and downstream side
	-	Operate spillway and study restriction in operation of the same
Afternoon	-	Discussion and study of drawings and reports
26-9-81 Morning	-	Discussion on the inspection done
12:00 (Noon)	-	Departure for Dacca

A.F.M. Moeenul Islam
Manager (Power), K.H.S.

cc: 1) The Member (G&T), PDB, Dacca
2) The Addl. Chief Engineer, (G&T)
3) The Chief Engineer, USAID, Dacca
4) The Plant Engineer, K.H.S.
5) Mr. Rolph Atkinson, Head, Concrete Dams and Spillway and Outlets Section
6) Mr. Richard W. Kramer, P.E., Asst. Chief, Dams Branch - Division of Design

Photo 1. - Spillway gate structure access bridge.

Photo 2. - Spillway gate structure drainage gallery.

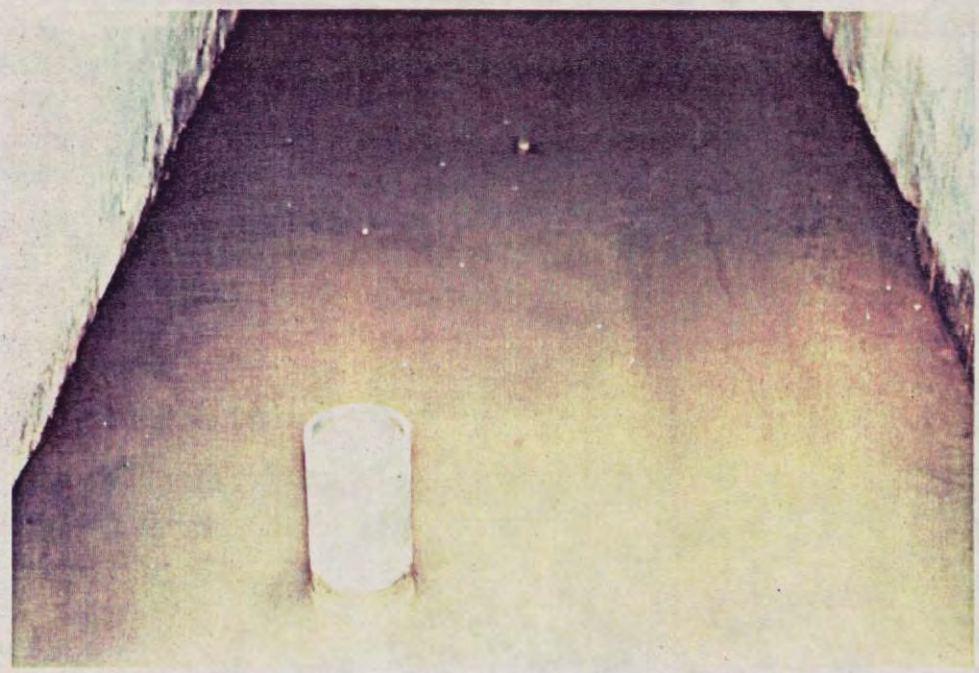


Photo 3. - Water standing in spillway gate structure drainage gallery.

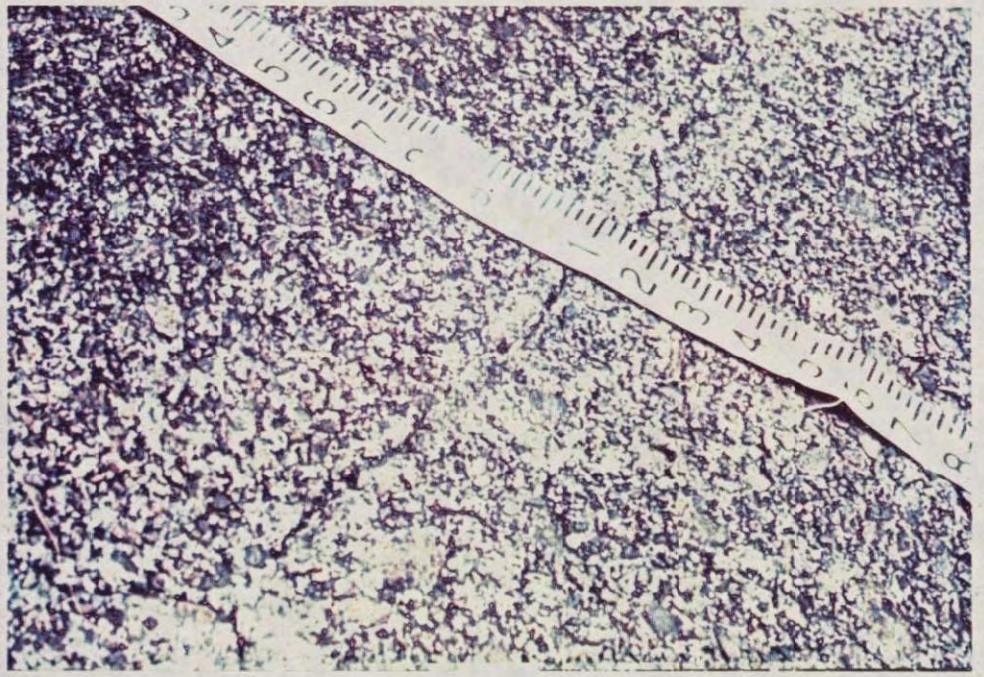


Photo 4. - Spillway chute slab surface showing slight erosion and the "horizontal crack."

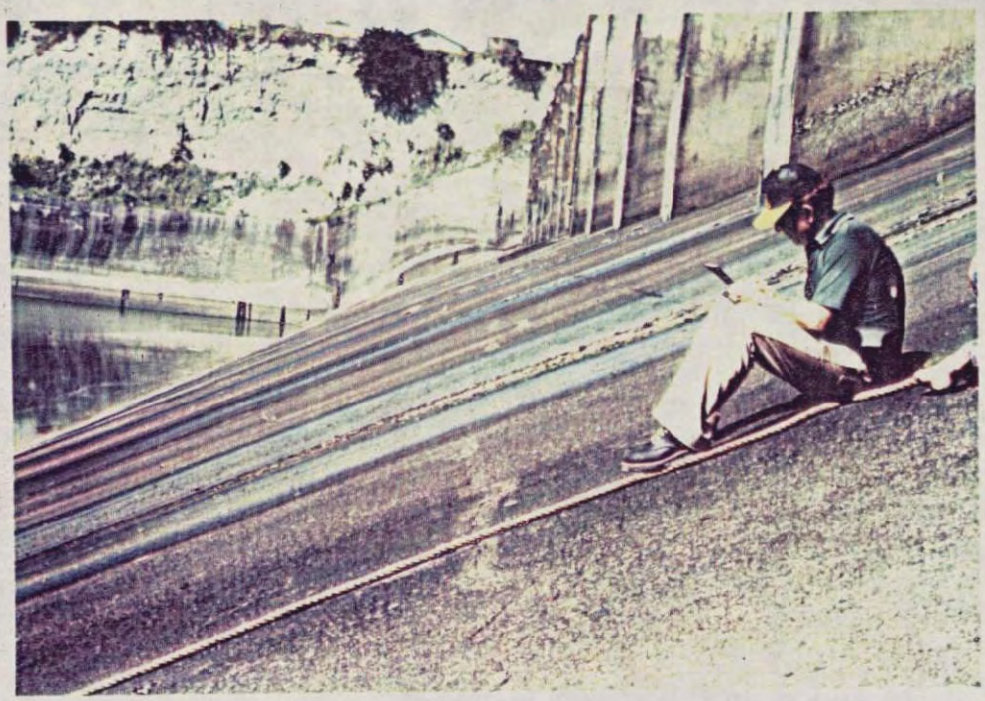


Photo 5. - Horizontal "crack," joint between original concrete and 1961 reconstruction, runs up center of photo. Contraction joint between gate structure and chute slab at spillway station 9+44.52 is to the right, up the chute.

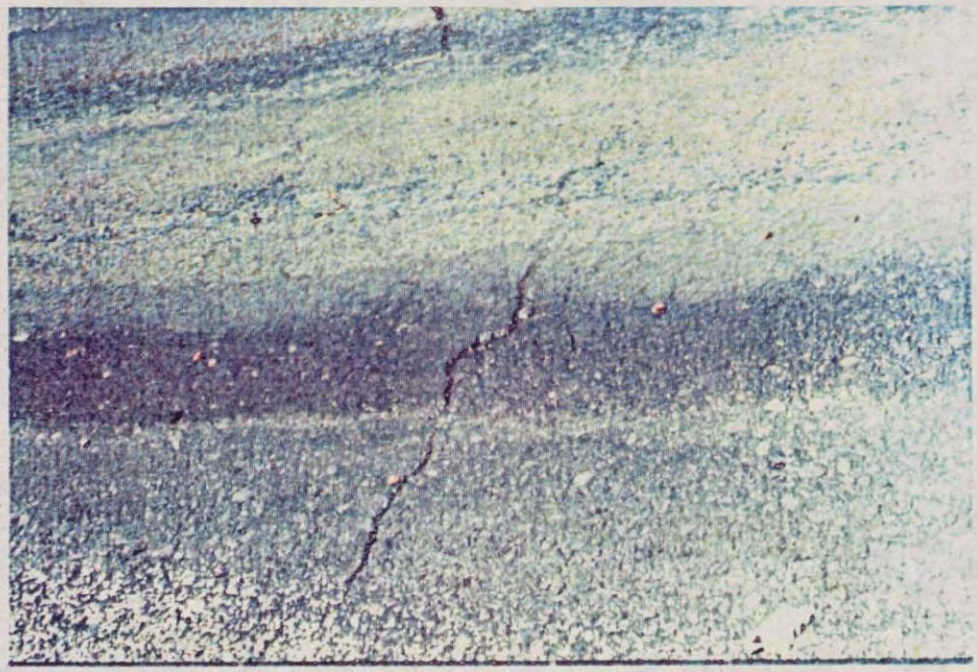


Photo 6. - Construction joint between original spillway chute slab concrete and 1961 slab replacement.

Photo 7. - Horizontal construction joint (crack) with some portions still having filler in place. This is the only offset in the crack and appears to be the original shape.

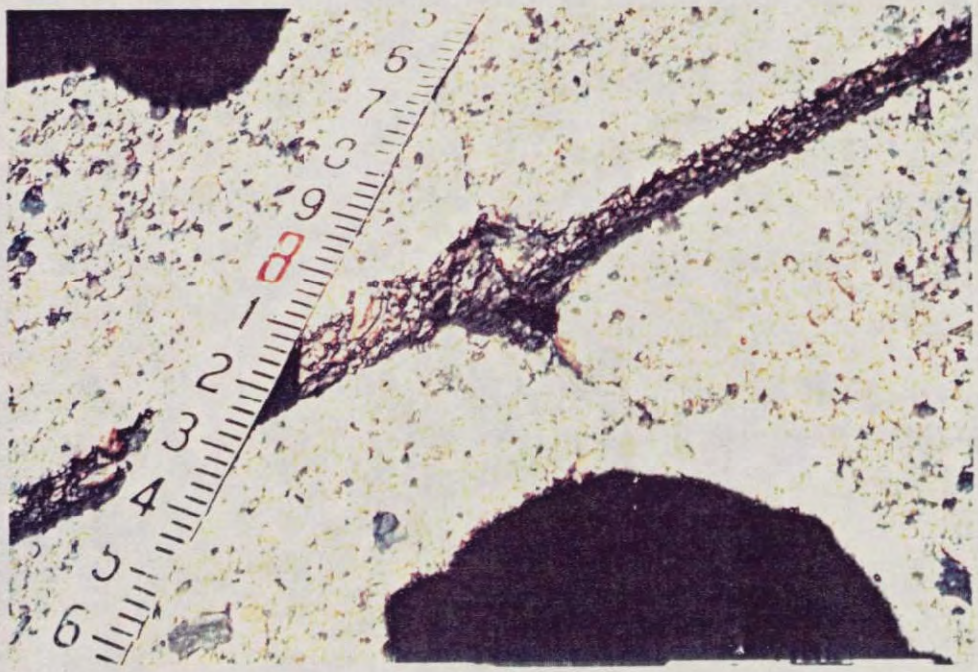


Photo 8. - Horizontal construction joint at one of the longitudinal contraction joints. Note that aggregate is not broken across joint and the lower (left) slab concrete was placed over the upper slab at the joint where the concrete was broken away.

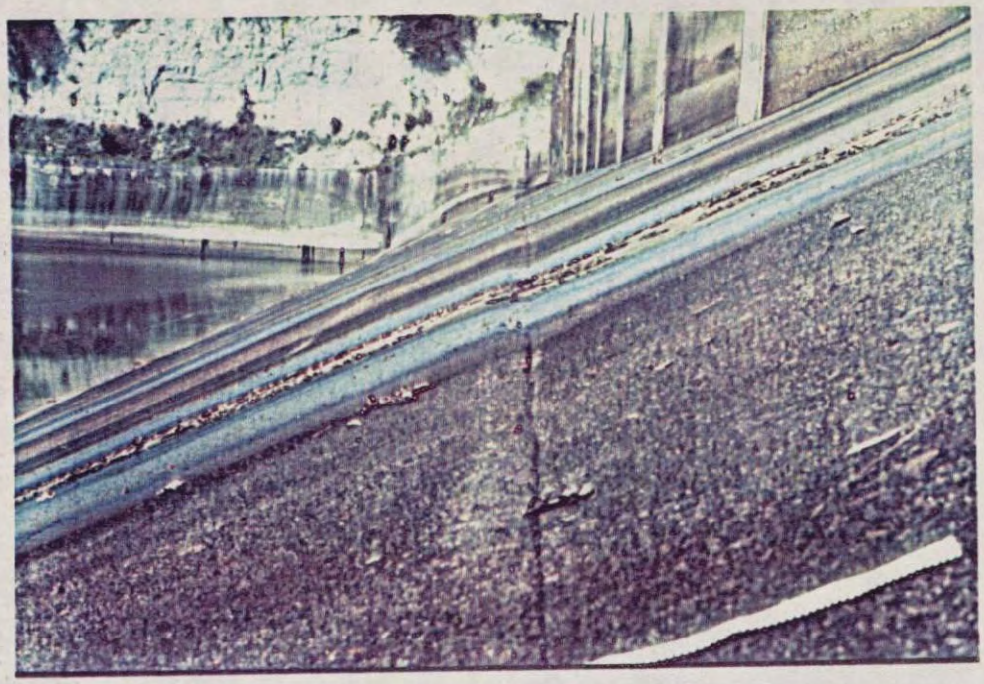


Photo 9. - Contraction joint between gate structure and chute slab.

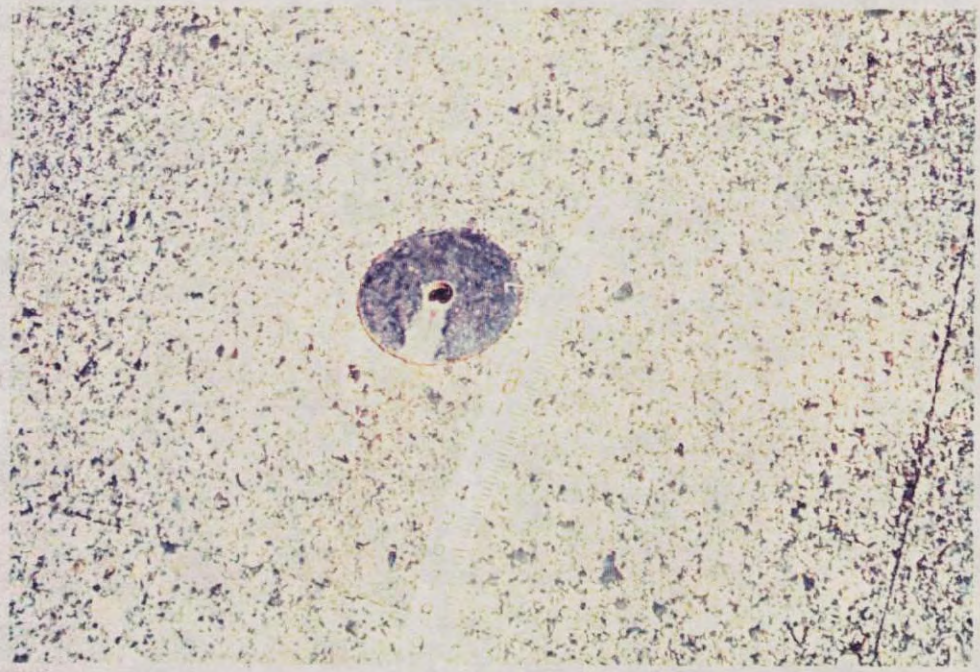


Photo 10. - Piezometer in surface of chute slab.

Photo 11. - Piezometer pipes extending up center bay pier to reading station.

Photo 12. - Channel downstream of spillway stilling basin showing the riprap blocks which have been washed from immediately below the stilling basin.

Photo 13. - Cubic-yard concrete riprap blocks as placed. These are along the left bank below the stilling basin.

Photo 14. - Sandstone along left side slope of spillway outlet channel. Downstream of the stilling basin, large depressions have been eroded into similar bedrock.

Photo 15. - Right slope of spillway adjacent to chute and stilling basin. Note anchor bars protruding 10 to 12 feet from face.

Photo 16. - Right spillway slope adjacent to chute and stilling basin.

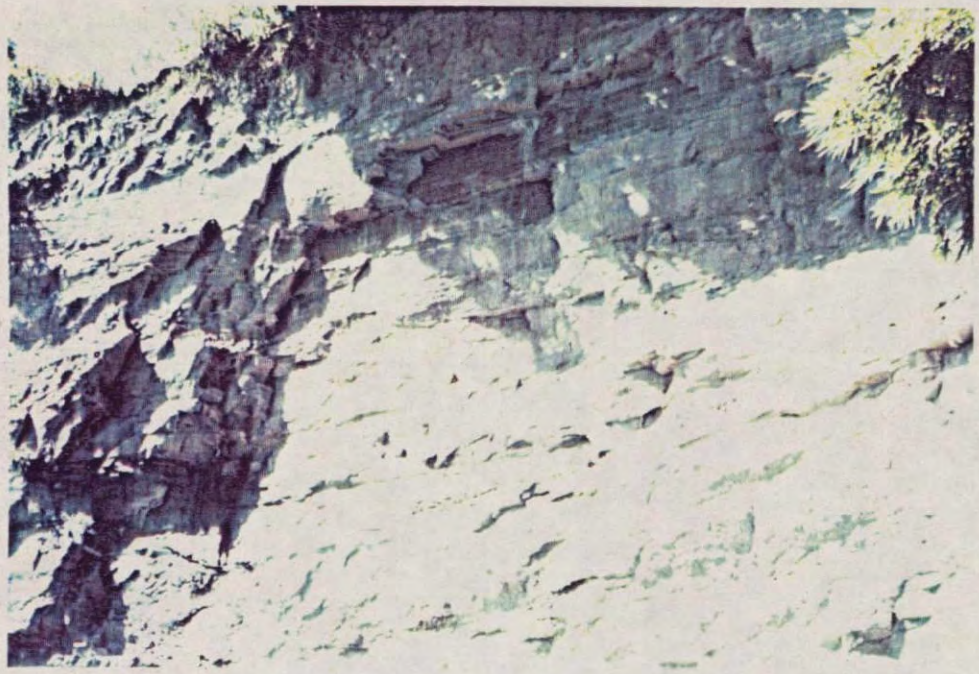


Photo 17. - Right spillway slope showing nature of exfoliation of material.

Photo 18. - Road pavement on dam crest looking toward left abutment.

Photo 19. - Downstream face of dam with surface drainage ditches.

Photo 20. - Drainage ditches.

Photo 21. - Slope protection on upstream face. Growth at waterline is water hyacinths. They are a continual maintenance problem.

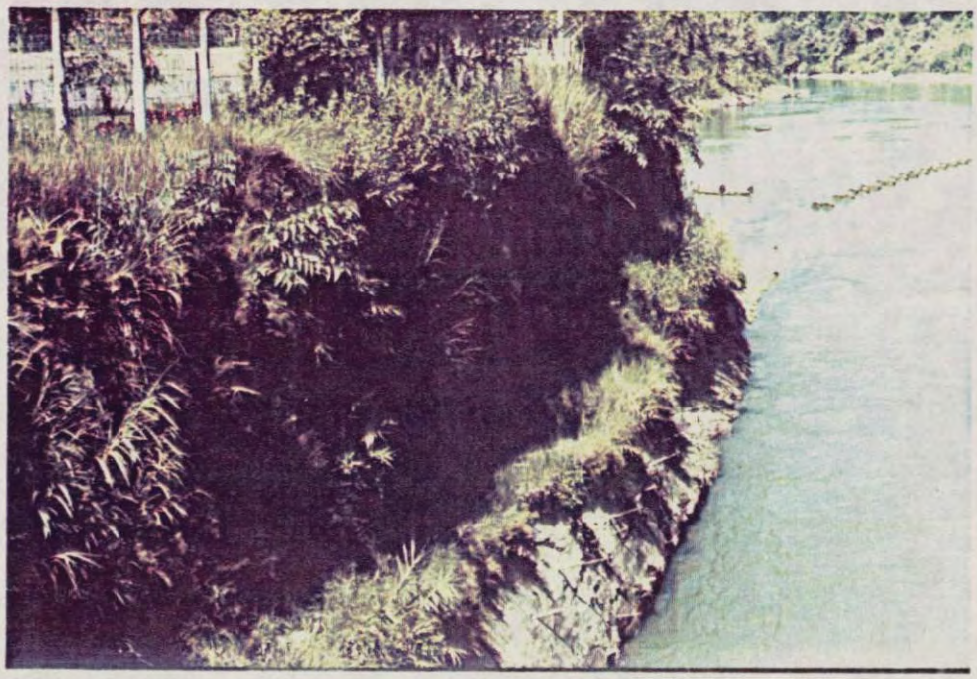


Photo 22. - Left tailrace slope. Note anchors with face plates on slope below berm.

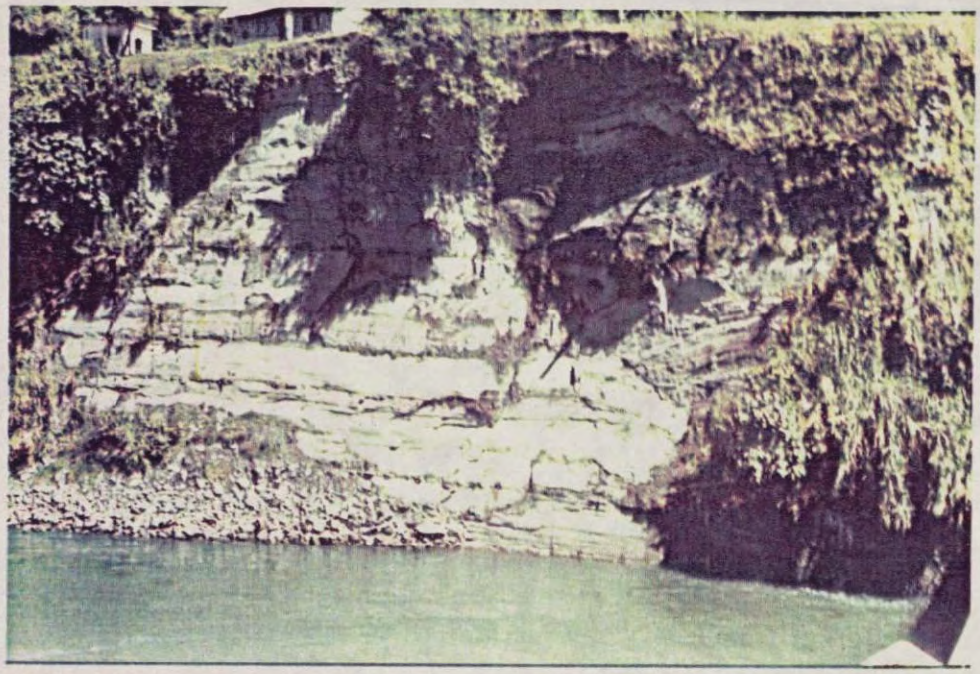


Photo 23. - Right tailrace slope. Note fault and hole where block dropped out into the tailrace. Lower right side of photo is at about end of plant retaining wall.

Photo 24. - Right tailrace slope downstream of the fault.

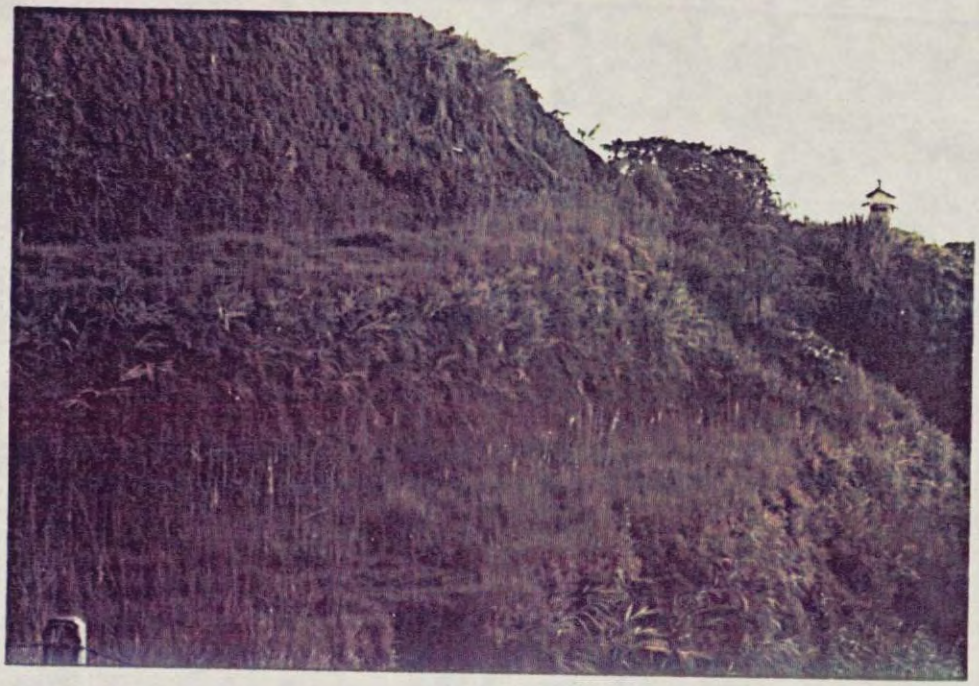


Photo 25. - Upper two berms on slope upstream of the right side of powerplant.

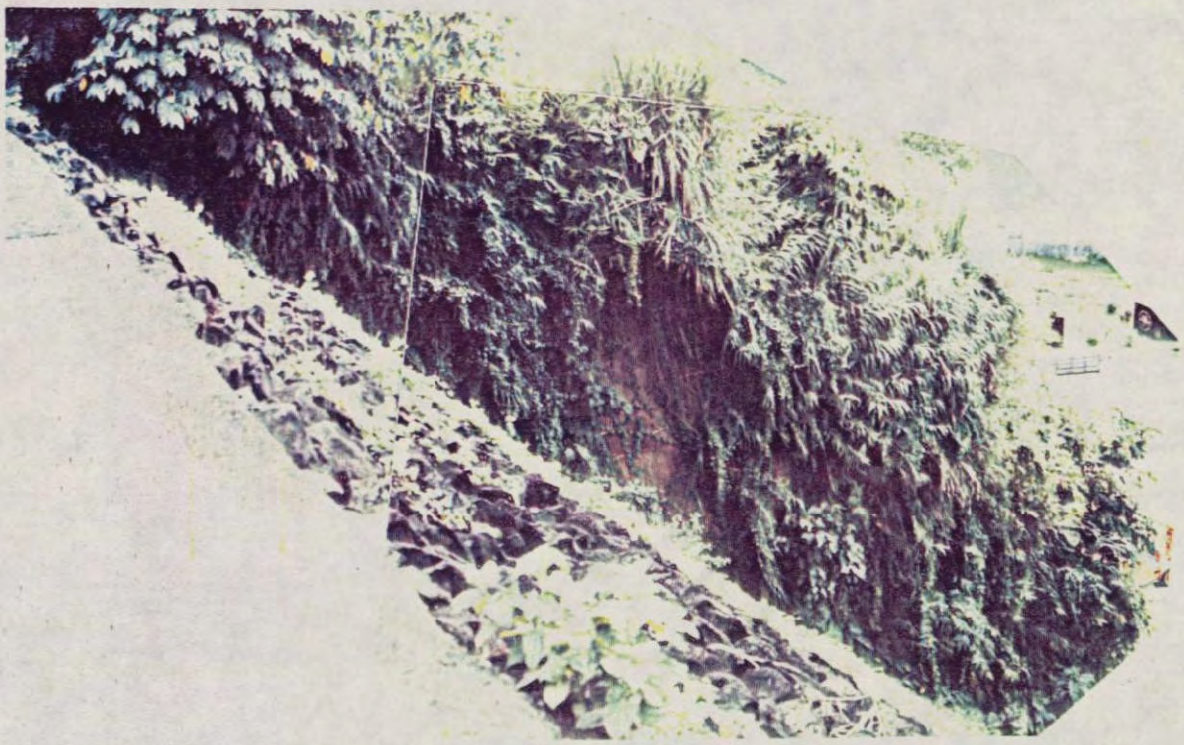


Photo 26. - Slope upstream of the left side of powerplant with hand-placed rock above retaining wall.

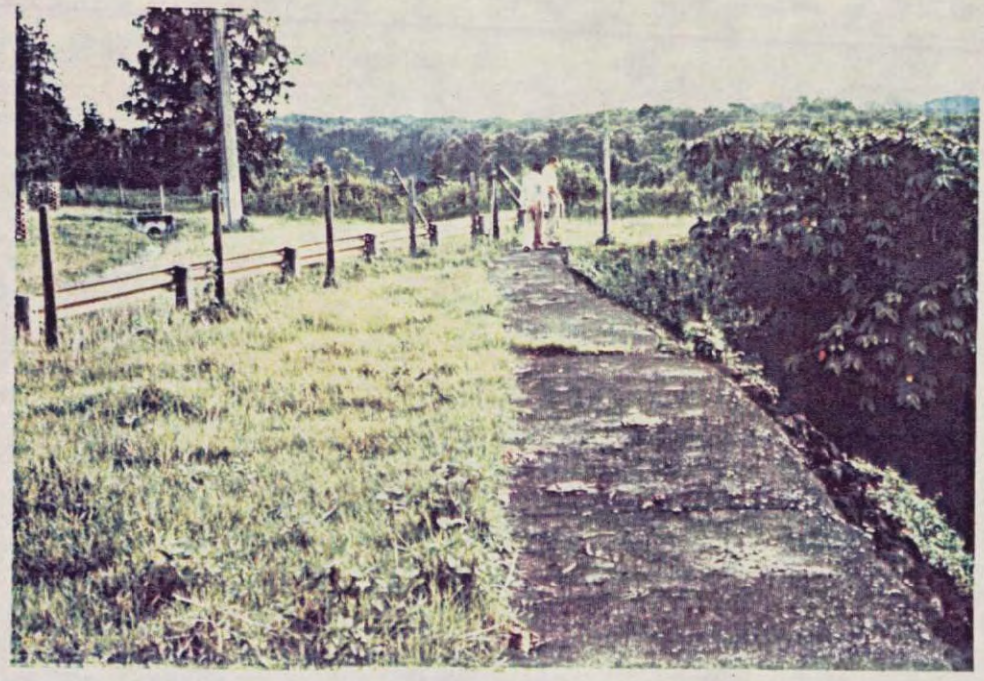


Photo 27. - Concrete cap on top of slope upstream of the left side of powerplant. Note surface drainage at top of excavation.

Photo 28. - First rise in slope upstream of the powerplant. Note progress of erosion at far end of slope and cleanup in progress.

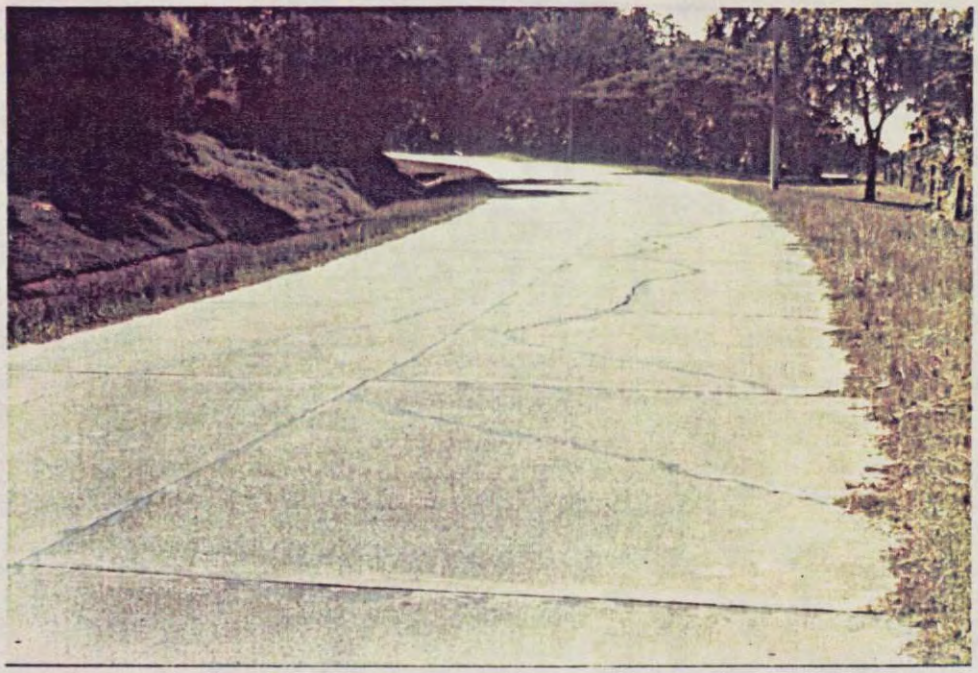


Photo 29. - Cracking in powerplant access road.

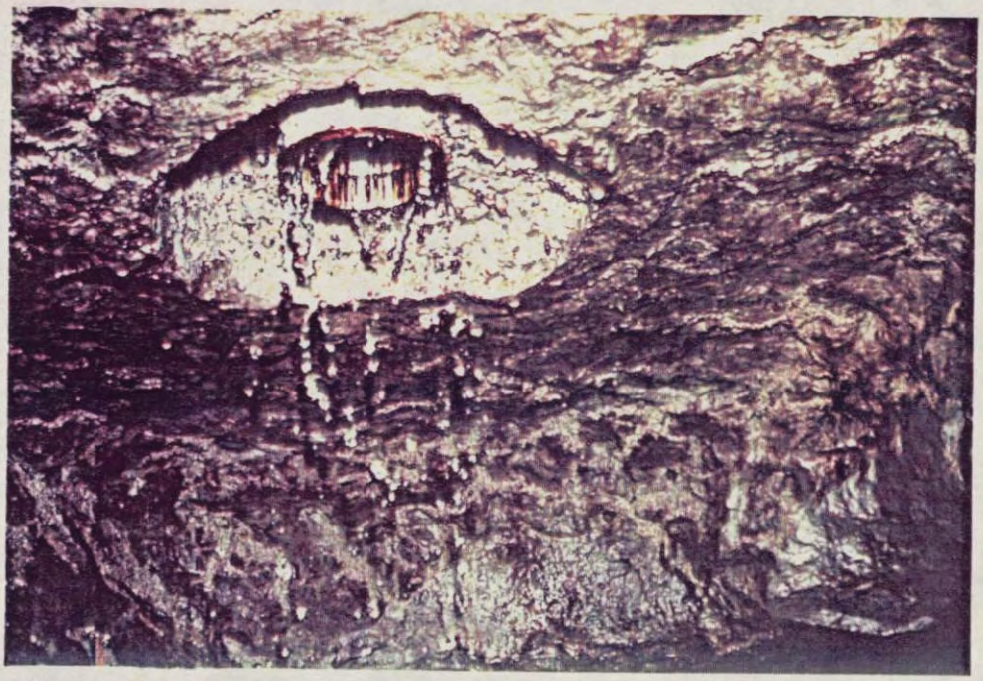


Photo 30. - Vertical drain piercing roof of drainage gallery in hillside upstream of the powerplant.

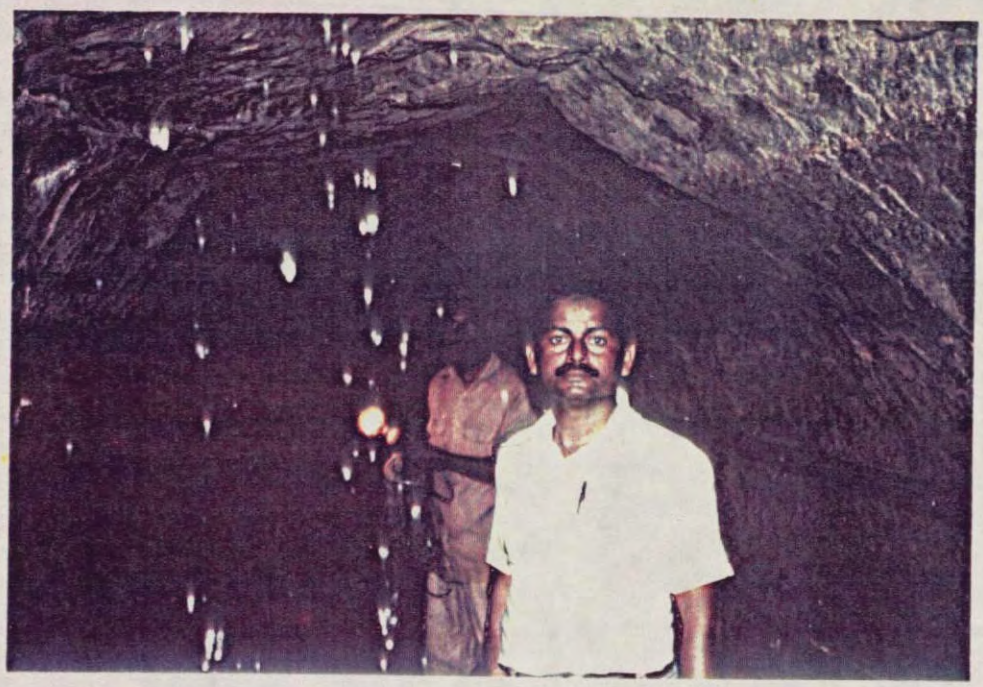


Photo 31. - Drainage gallery upstream of power-plant. Shale is generally in excellent condition.

Photo 32. - Minor rock falls in south end of drainage gallery.

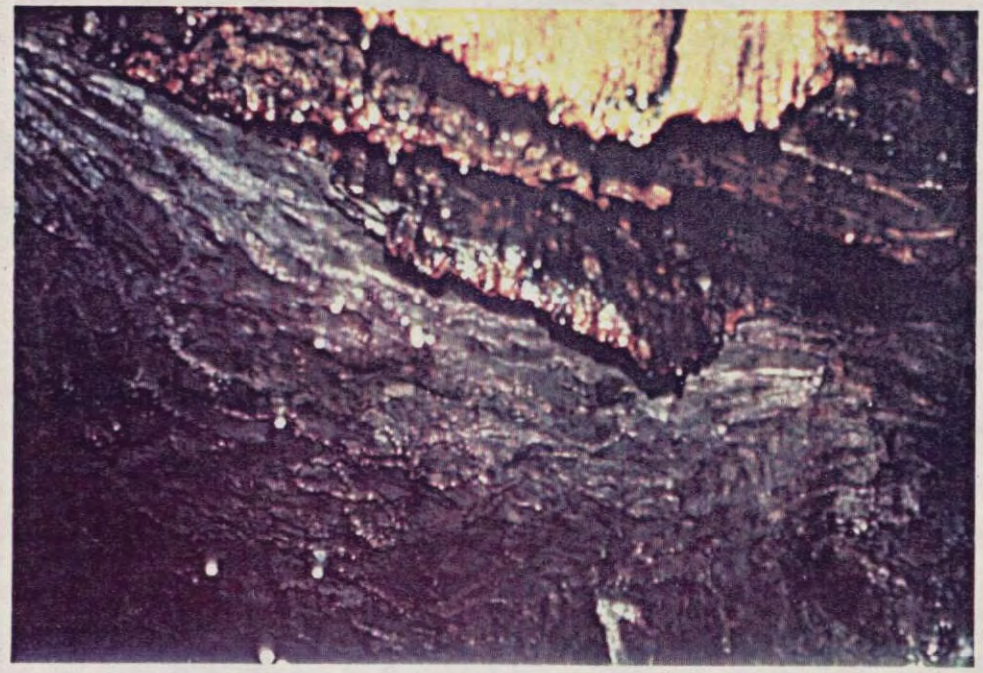


Photo 33. - Mineral encrustation of lower portion of vertical drains.

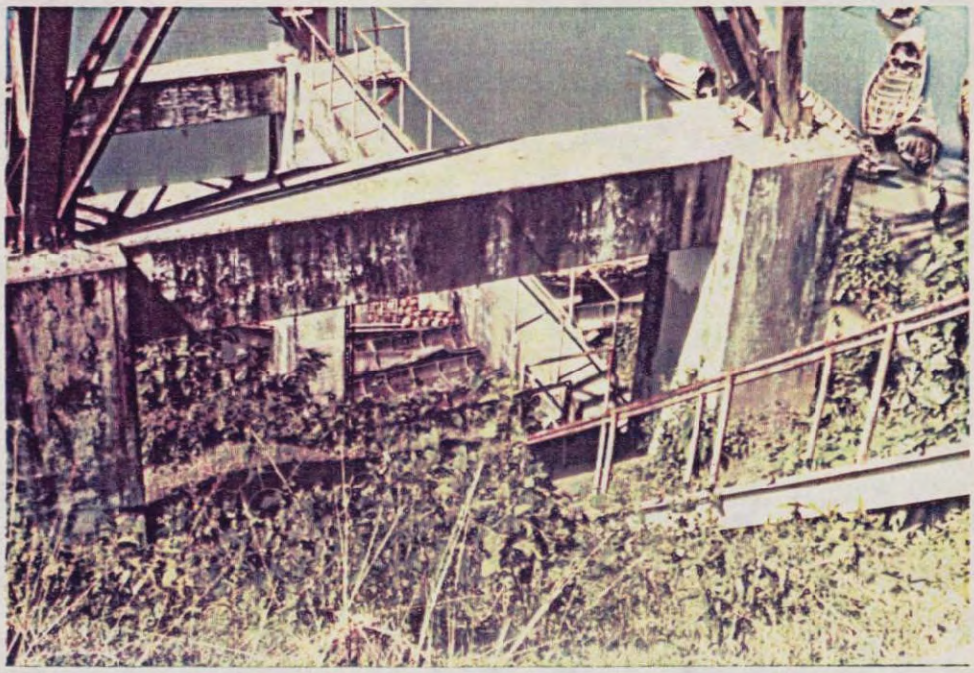


Photo 34. - Cargo transfer system tower footings. Second tower is in the foreground. Boats are waiting to be lifted to reservoir.

Photo 35. - Footing for second tower. Foundation exposure is at left side. Note temporary retaining scheme to hold soil on slope.

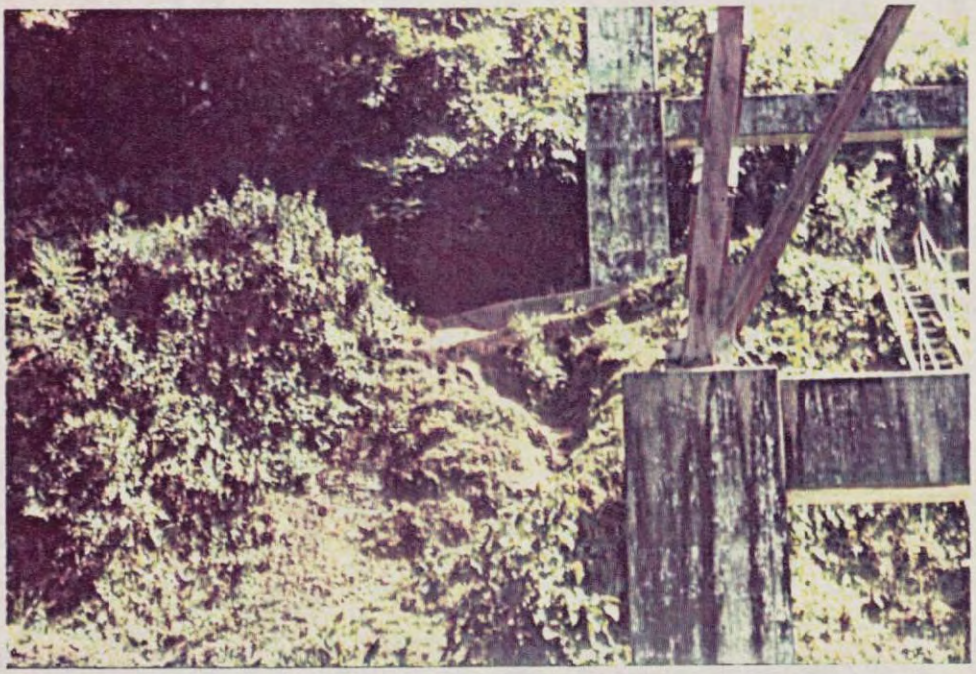
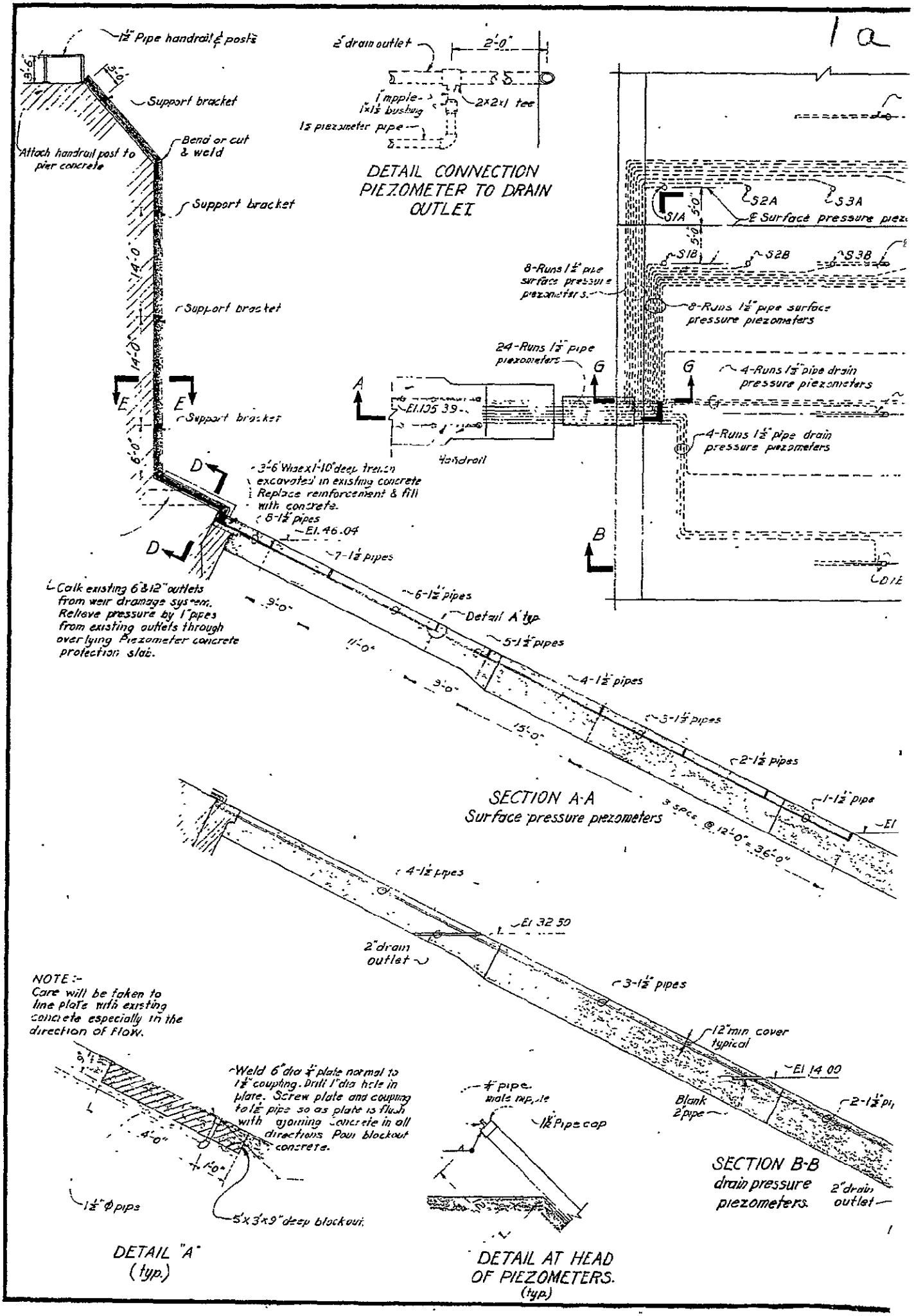
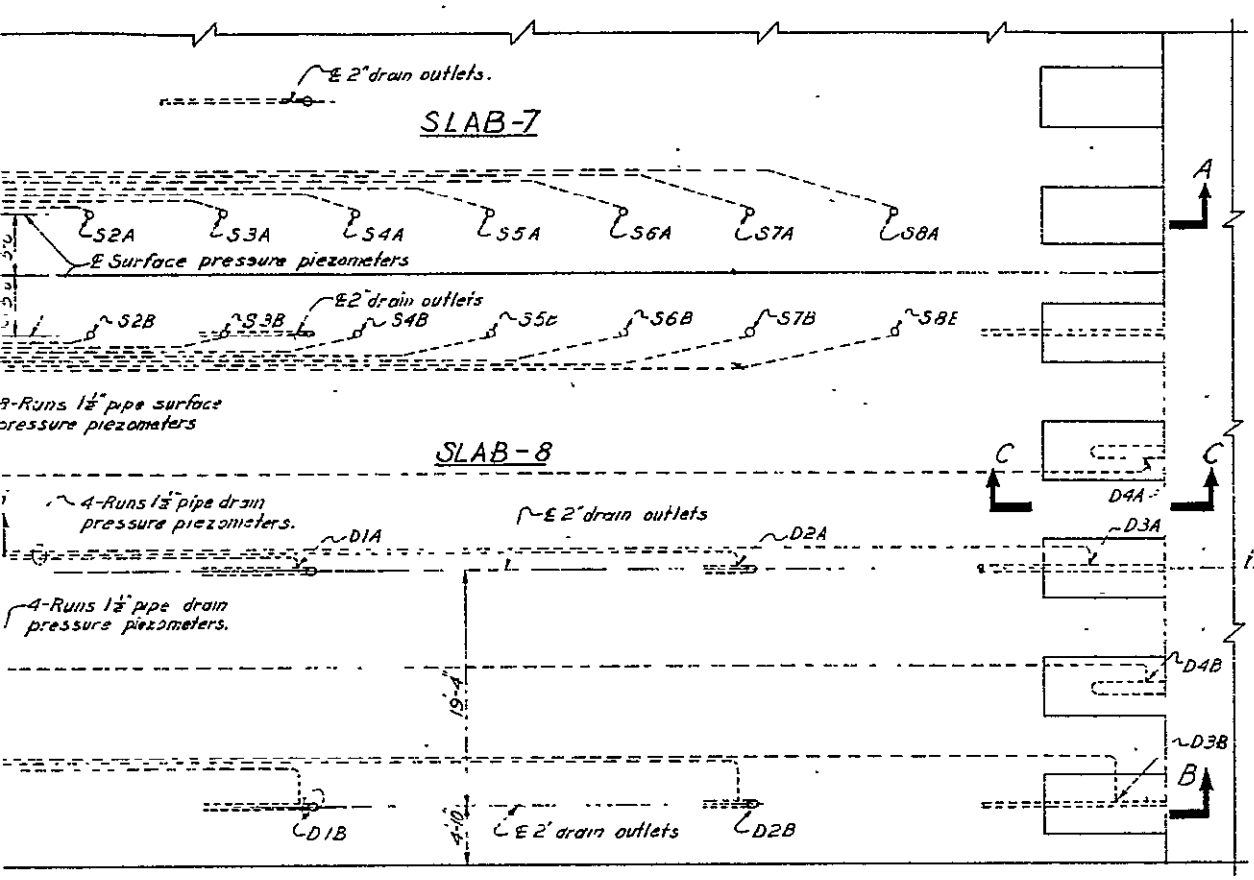


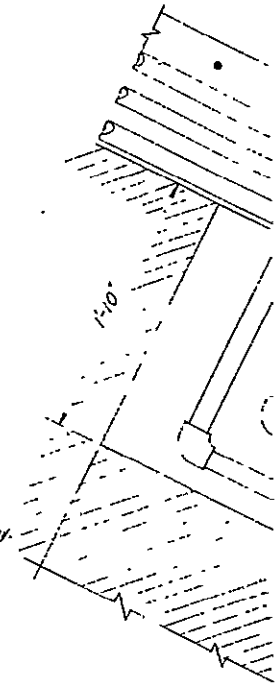
Photo 36. - Soil erosion and buildup of woody growth.


1a
1½" Pipe handrail & posts
Support bracket
Attach handrail post to pier concrete
Bend or cut & weld
Support bracket
Support bracket
Support bracket
14'-0"
14'-0"
6'-0"
E
E
D
D
3'-6" Wide x 1'-10" deep trench excavated in existing concrete Replace reinforcement & fill with concrete.
8-1½" pipes
El. 46.04
7-1½" pipes
Calk existing 6" & 12" outlets from weir drainage system. Relieve pressure by 1" pipes from existing outlets through overlying Piezometer concrete protection slab.
6-1½" pipes
Detail A typ
5-1½" pipes
4-1½" pipes
3-1½" pipes
2-1½" pipes
1-1½" pipe
9'-0"
11'-0"
9'-0"
15'-0"
3 spcs @ 12'-0" = 36'-0"
2" drain outlet
2'-0"
1" nipple
1"x1½" bushing
2x2x1 tee
1½ piezometer pipe
DETAIL CONNECTION PIEZOMETER TO DRAIN OUTLET
S1A
S2A
S3A
℄ Surface pressure piez
S1B
S2B
S3B
8-Runs 1½" pipe surface pressure piezometers.
8-Runs 1½" pipe surface pressure piezometers
24-Runs 1½" pipe piezometers
4-Runs 1½" pipe drain pressure piezometers
4-Runs 1½" pipe drain pressure piezometers
A
B
G
G
El. 105.39
Handrail
SECTION A-A
Surface pressure piezometers
4-1½" pipes
El 32.50
2" drain outlet
3-1½" pipes
12" min cover typical
El 14.00
Blank 2" pipe
2-1½" pi
SECTION B-B
drain pressure piezometers.
2" drain outlet
NOTE:-
Care will be taken to line plate with existing concrete especially in the direction of flow.
Weld 6" dia ¼" plate normal to 1½" coupling. Drill 1" dia hole in plate. Screw plate and coupling to 1½" pipe so as plate is flush with ajoining concrete in all directions. Pour blockout concrete.
4'-0"
1'-0"
1½" Φ pipe
5'x3'x9" deep blockout.
DETAIL "A"
(typ.)
¼" pipe male nipple
1½" Pipe cap
DETAIL AT HEAD OF PIEZOMETERS.
(typ.)

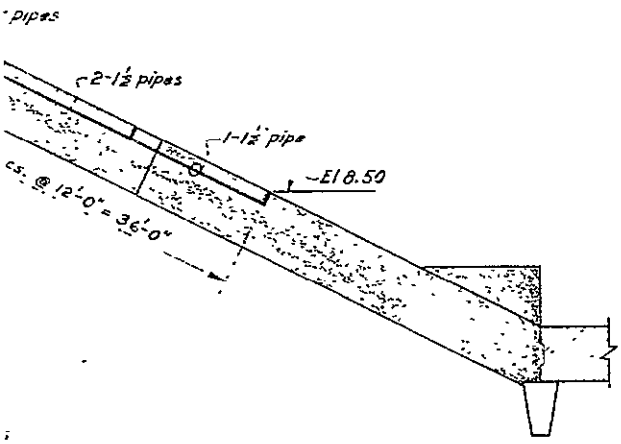
1 b

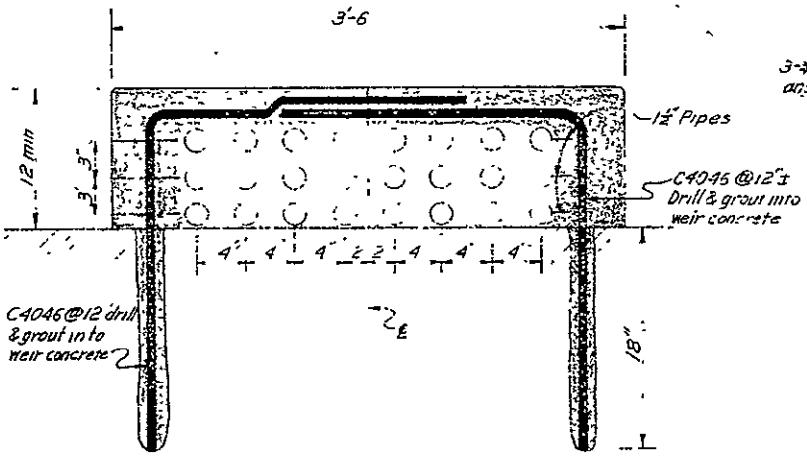


PLAN
Pipe runs shown schematically

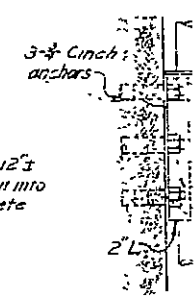


SECTION G-G

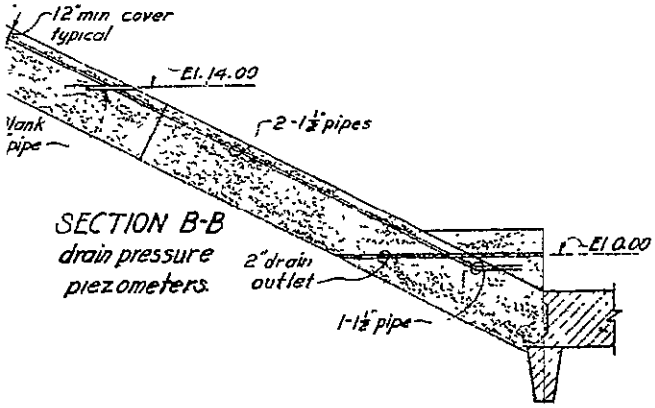




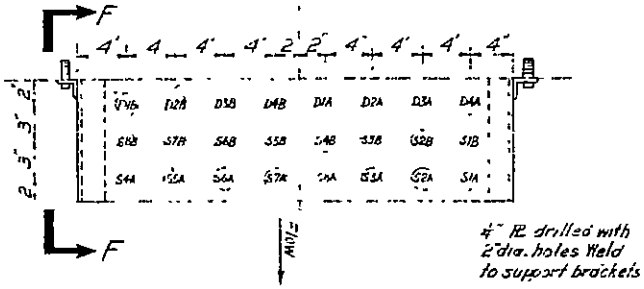
SECTION D-D



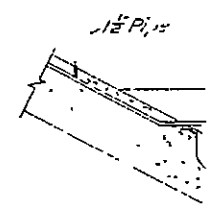
ELE



SECTION B-B
drain pressure piezometers.

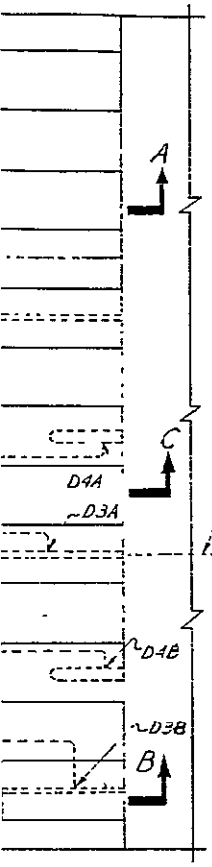


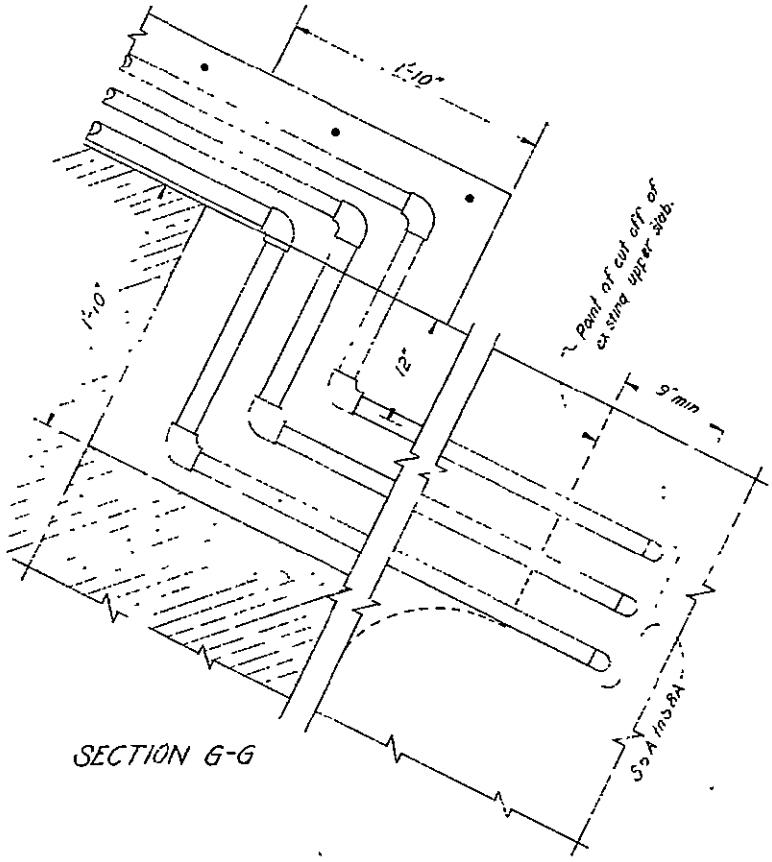
SECTION E-E



SECTION
drain pressu
to stilling L

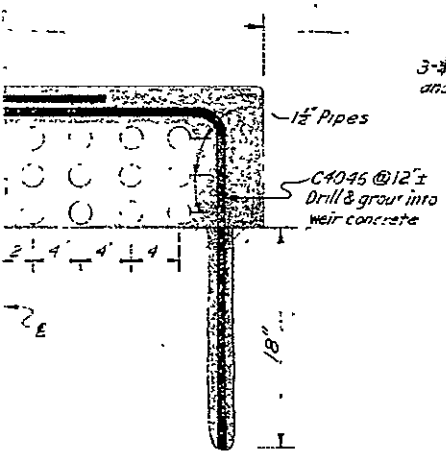
1 C



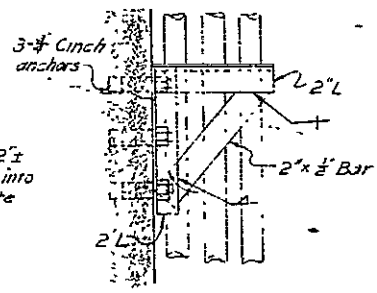


SECTION G-G

PIEZOMETER ELEVATION.	
Piezometer number	Elevation
S 1 A	44.249
S 2 A	40.229
S 3 A	35.255
S 4 A	31 333
S 5 A	24 524
S 6 A	19. 143
S 7 A	13 771
S 8 A	8. 619
S 1 B	44 245
S 2 B	40 259
S 3 B	35. 260
S 4 B	31. 145
S 5 B	24 535
S 6 B	19 168
S 7 B	13. 370
S 8 B	8 495
D 1 A	32.490
D 2 A	14. 01
D 3 A	-0 93
D 4 A	-0 74
D 1 B	32. 510
D 2 B	14. 06
D 3 B	-0. 92
D 4 B	-0. 81



N D-D



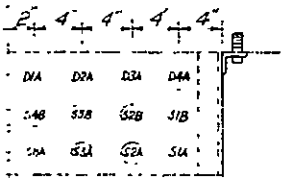
ELEVATION F-F

NOTES :-

Surface Piezometer outlets shall be normal to and flush with chute surface.
After installation Center line Elevation of all Piezometers and outlets shall be measured and recorded.
Paint exposed piezometer runs and metal supports with primer coat 33.
Heads of all piezometer runs shall be both stamped and tagged with piezometer number as shown on the plan.

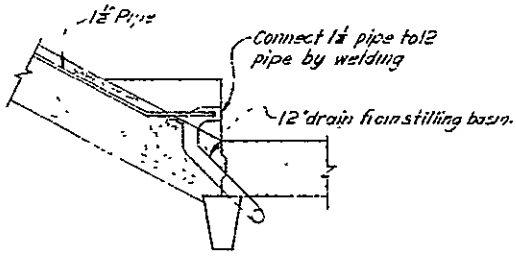
REFERENCE DRAWINGS :-

Spillway chute and Spillway basin slabs Reinforce. sheet-2, KFL-13-404
Spillway repair to chute Outline & Reinforcement ---FL-13-1234
Spillway repair to chute typical details -----FL-13-1235



¼" PL drilled with 2" dia holes Weld to support brackets

TION E-E



SECTION C-C
drain pressure piezometer to stilling basin drains

Scale - ⅛"=1'-0" & 1½"=1'-0"

GOVERNMENT OF PAKISTAN
MINISTRY OF INDUSTRIES

KARNAFULI PROJECT
SPILL WAY
CHUTE AND DRAIN
PRESSURE PIEZOMETERS.

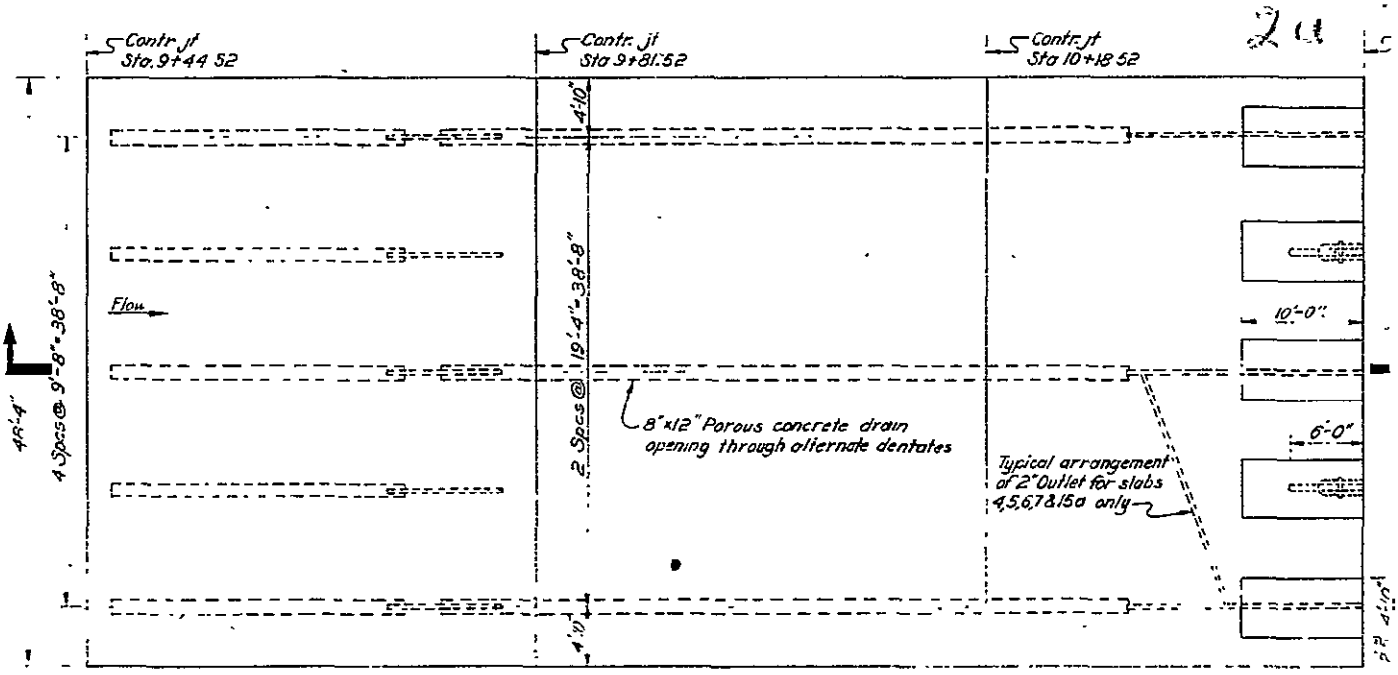
INTERNATIONAL ENGINEERING CO., INC. — ENGINEERS

NO.	DATE	MARK	CHKD.	APPD.
4				
3				
2				
1	Mar 27, 1962	ALAM	PH.	E
	As built			

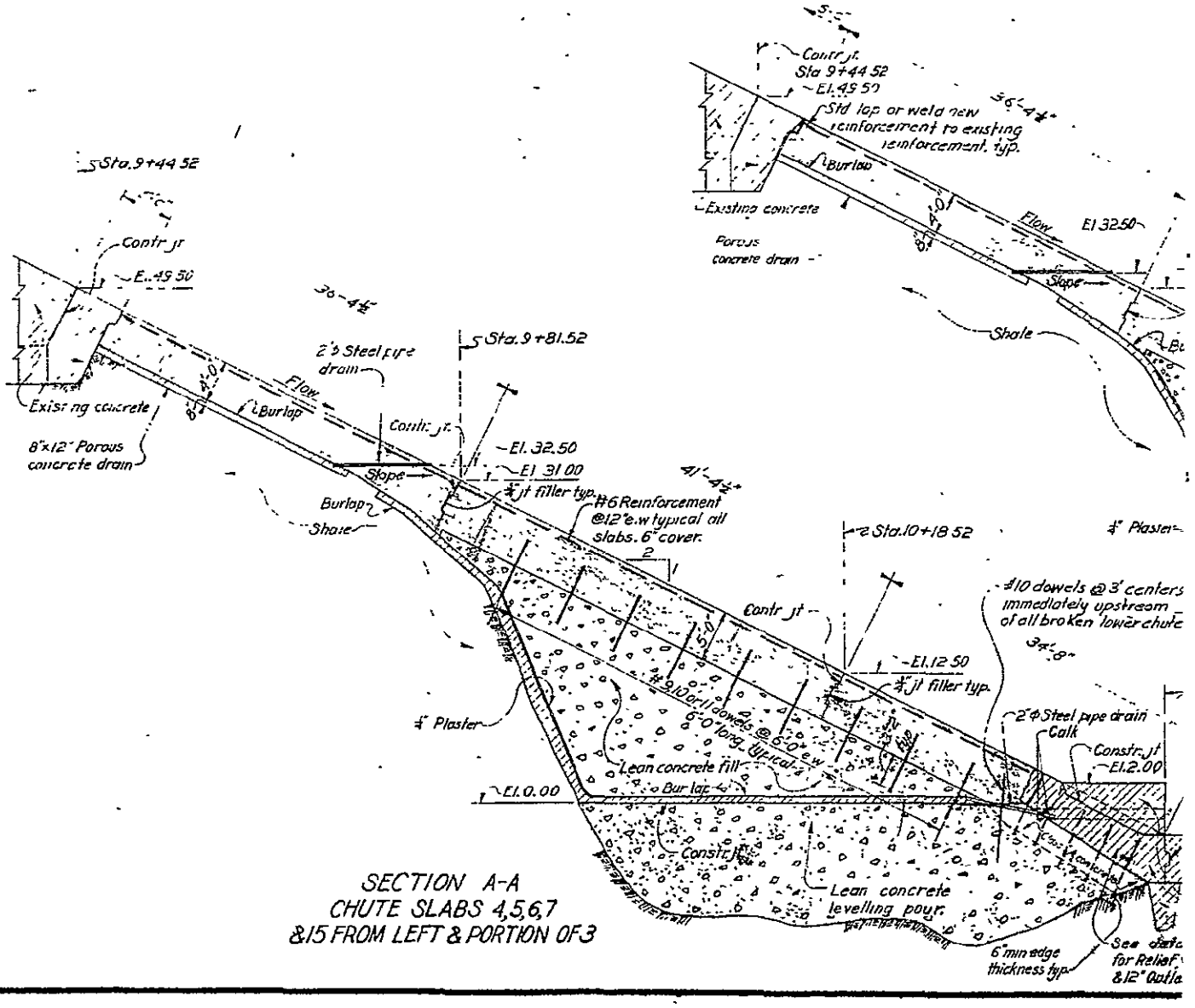
REVISIONS

DESIGNED I E Co. CHKD. PH SUBMITTED
DRAWN M A K. INSP. RECOMMENDED
APPROVED

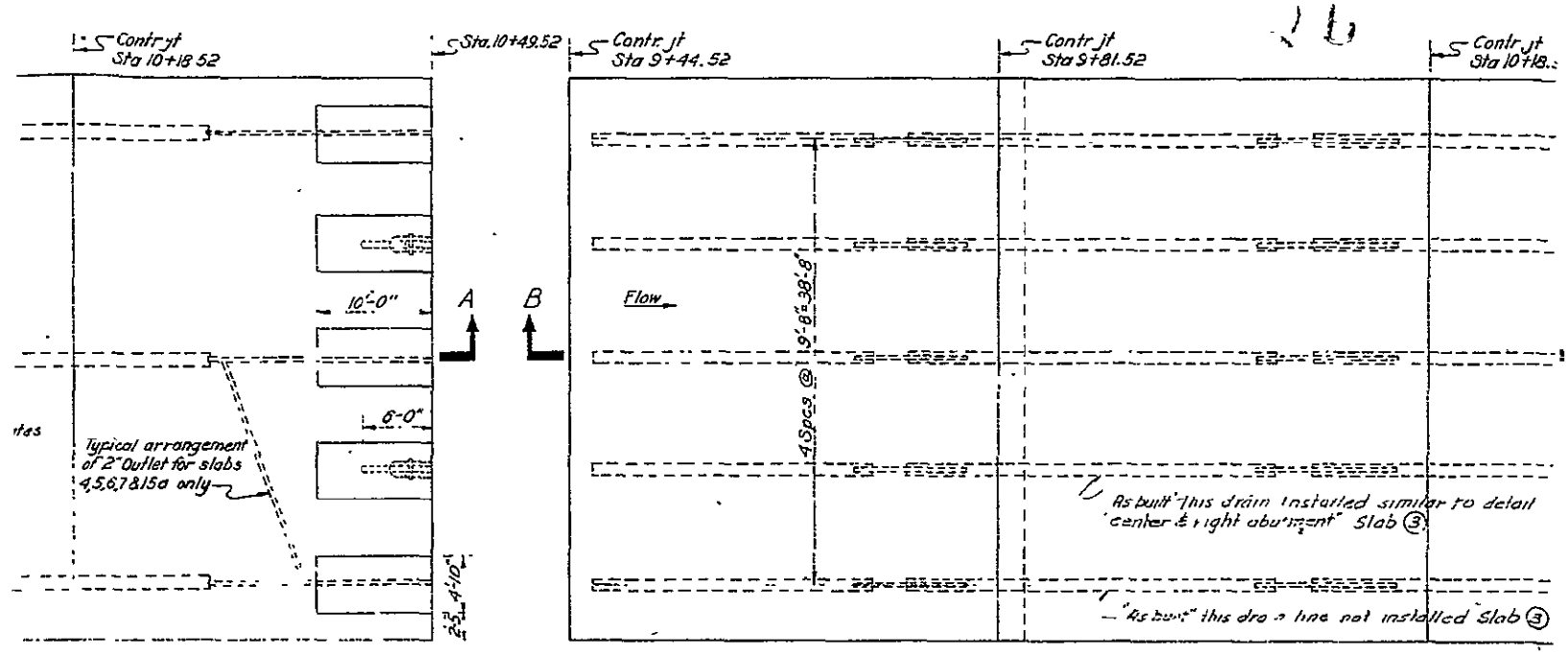
ICA-X-1 KAPTAL EAST PAKISTAN DATE Nov 30, 1961 FL-13-1233R1



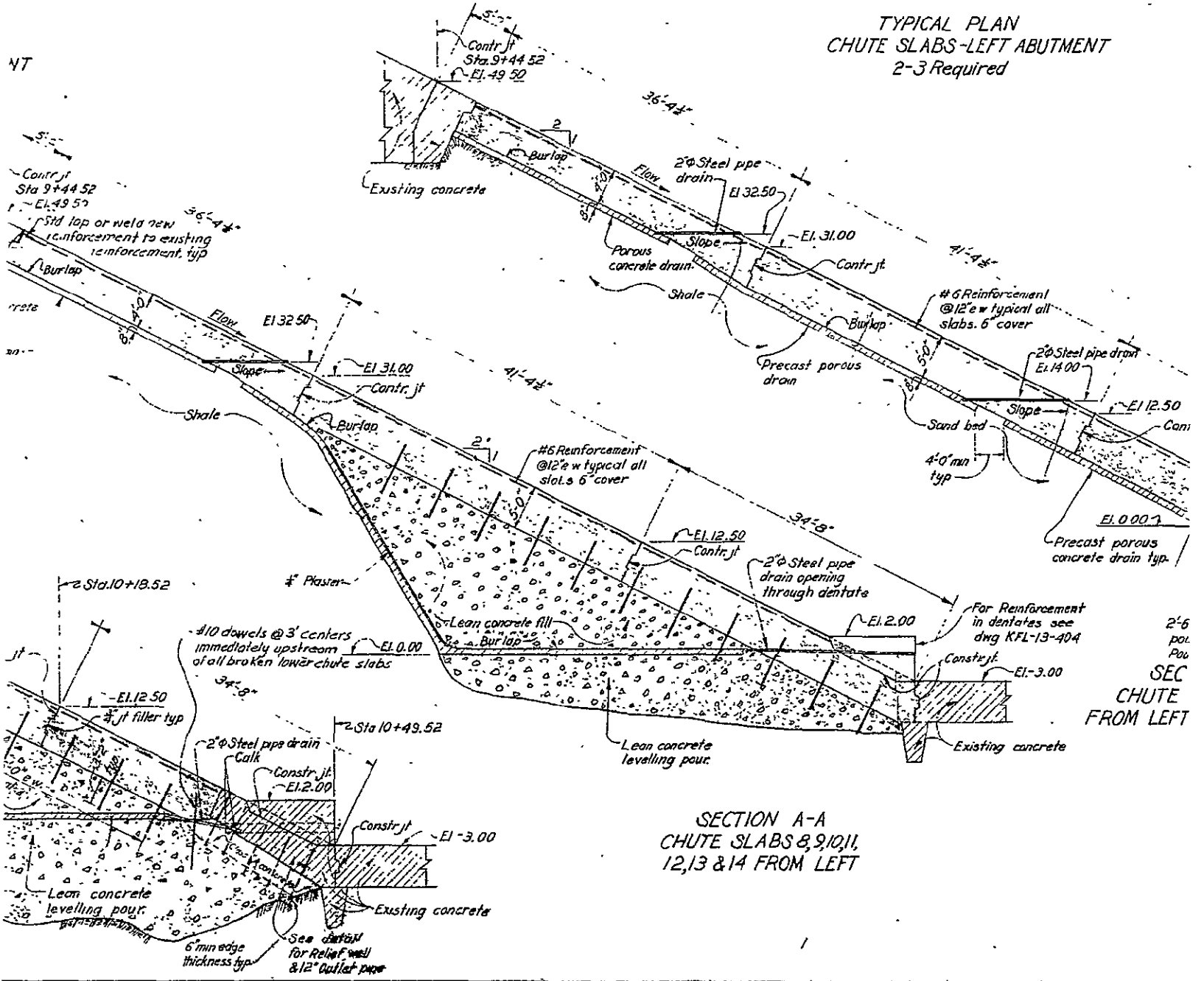
TYPICAL PLAN
CHUTE SLABS
CENTER & RIGHT ABUTMENT
12-13 Required



SECTION A-A
CHUTE SLABS 4,5,6,7
& 15 FROM LEFT & PORTION OF 3



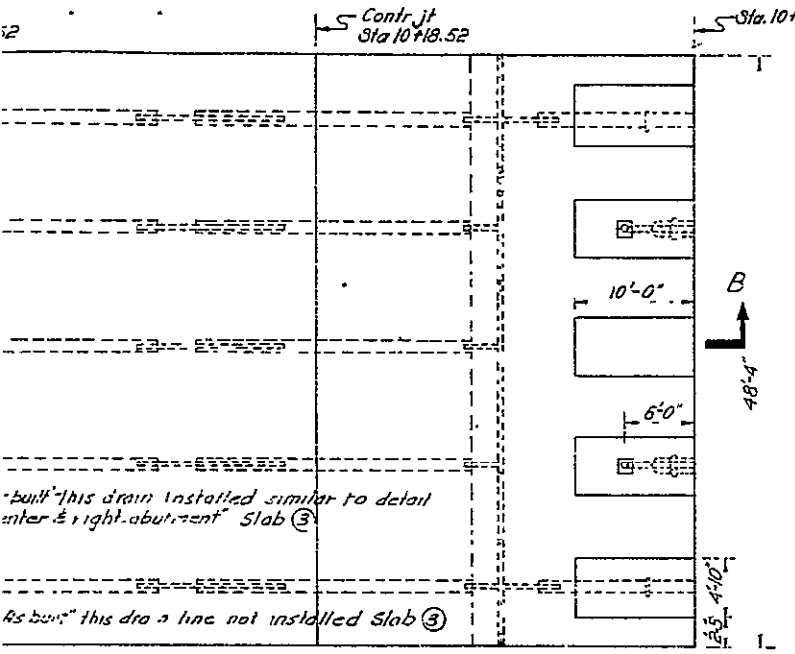
TYPICAL PLAN
CHUTE SLABS-LEFT ABUTMENT
2-3 Required



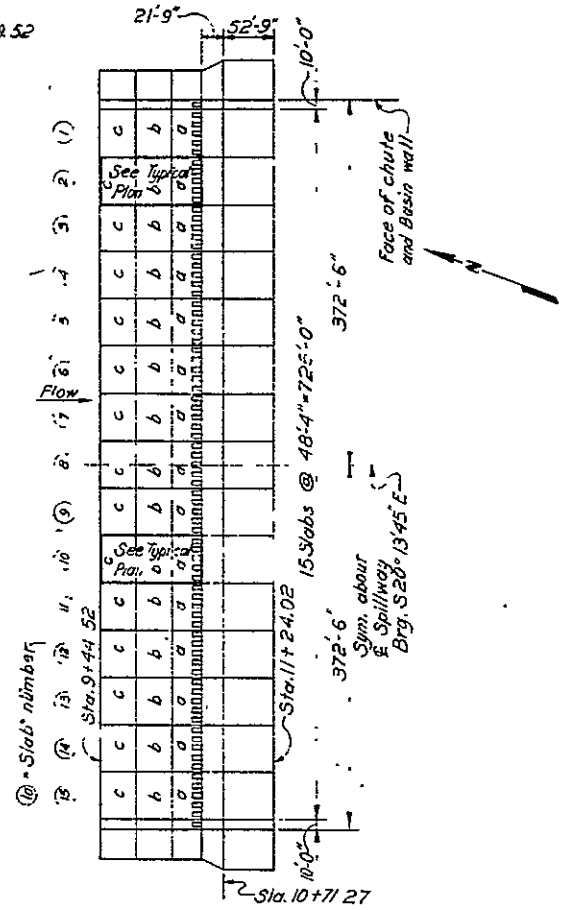
SEC
CHUTE
FROM LEFT

SECTION A-A
CHUTE SLABS 8,9,10,11,
12,13 & 14 FROM LEFT

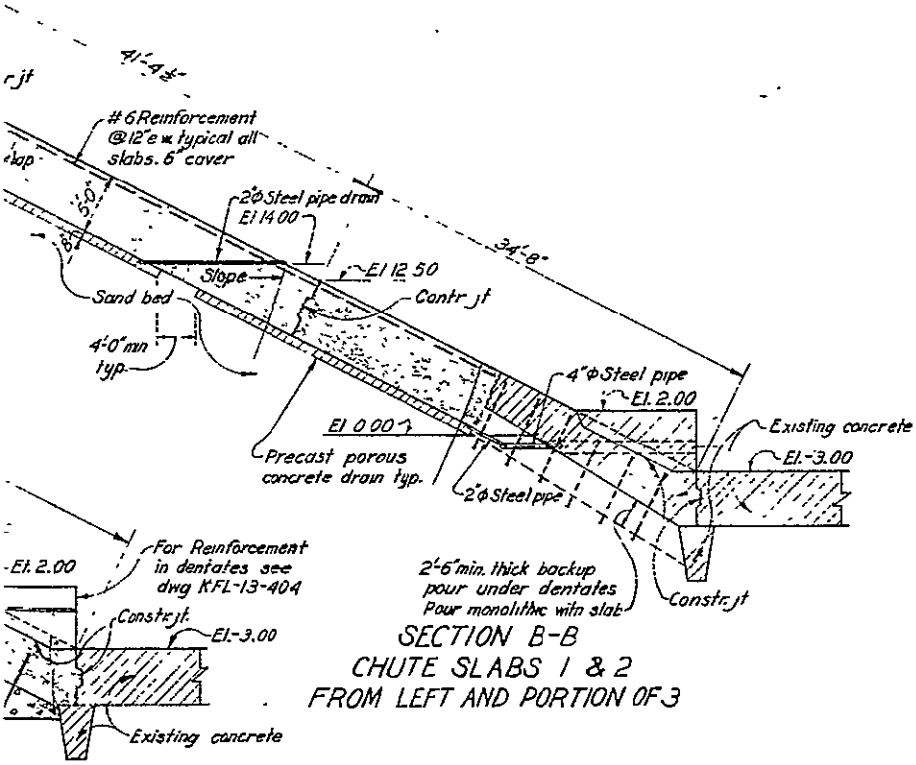
2C



TYPICAL PLAN
TE SLABS-LEFT ABUTMENT
2-3 Required



KEY PLAN
Scale - 1" = 100'



SECTION B-B
CHUTE SLABS 1 & 2
FROM LEFT AND PORTION OF 3

NOTES :-

Feather edges are to be avoided in placing lean concrete fill.
All construction joints used in lean concrete fill shall be cleaned and treated as normal construction joints.
Porous concrete drains under slabs a & b through alternate dentates shall be arranged so as 3 drains will fall under slab 8a & b
Slabs 1a to 3a & 15a shall be supported prior to cutting slab.

REFERENCE DRAWINGS :-

Spillway chute and drain pressure piezometers FL-13-1233
Spillway repairs to chute typical details - - - - FL-13-1235
Spillway chute and stilling basin slabs reinforcement - Sheet 2 - - - - - - - - - - - - - - KFL-13-404

Scale - 1/8" = 1'-0"
Except as noted

NO.	DATE	MARK	CHKD.	APR.
4				
3				
2				
1	26-3-62	Alam	PH	E
	As built			

REVISIONS

GOVERNMENT OF PAKISTAN
MINISTRY OF INDUSTRIES

KARNAFULI PROJECT
SPILLWAY
REPAIRS TO CHUTE
OUTLINE & REINFORCEMENT

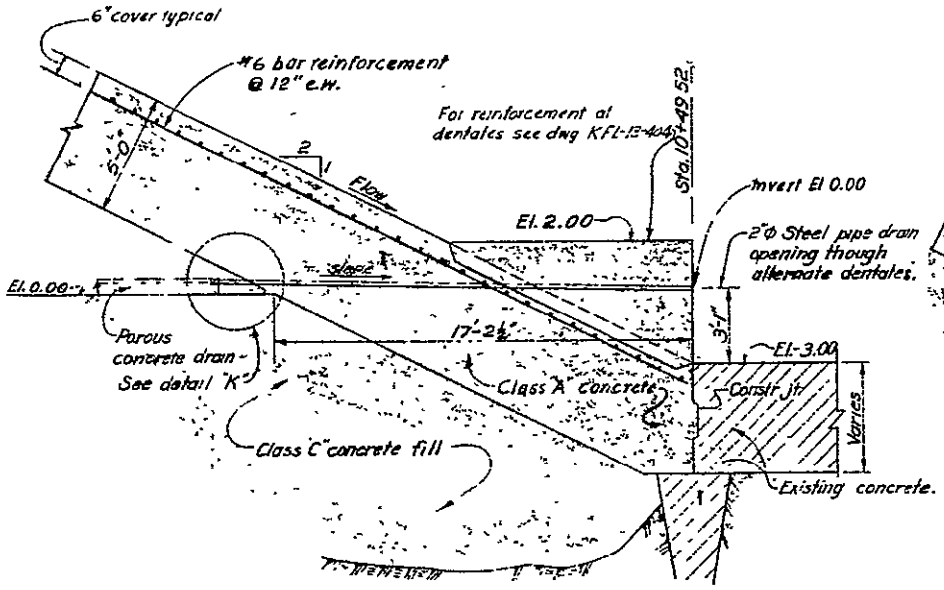
INTERNATIONAL ENGINEERING CO., INC. — ENGINEERS

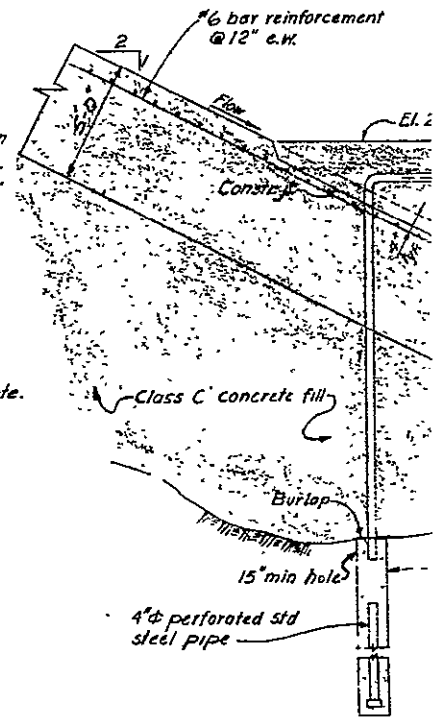
DESIGNED I.E.Co. DRAWN M.A.K. CHKD. PH DISP. SUBMITTED RECOMMENDED APPROVED

ICA-X-1 KAPTAI, EAST PAKISTAN DATE Nov. 26, 1961 FL-13-1234R1

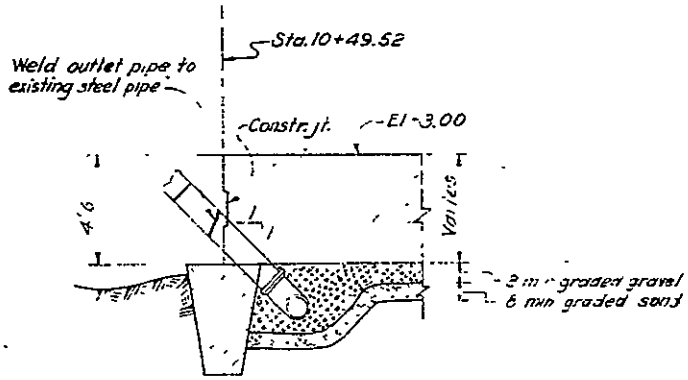
3a

Note · For reinforcement in dentals see dwg. KFL-13-404

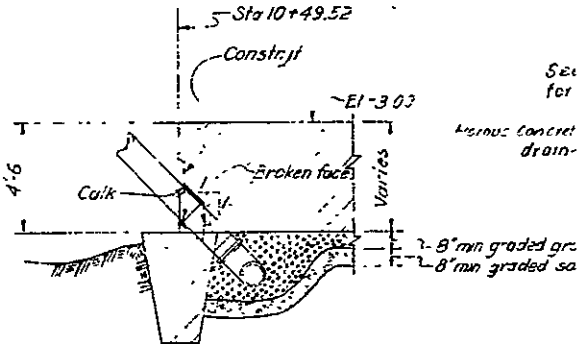




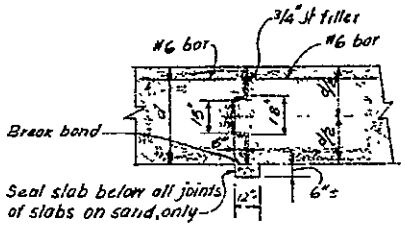
TYPICAL DETAIL
Showing porous concrete drain outlet pipes.
(Slabs 8, 9, 10, 11, 12, 13, & 14 from left)



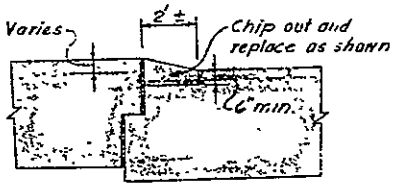
TYPICAL DETAIL
for broken stilling basin drainage pipes projecting beyond the basin slabs



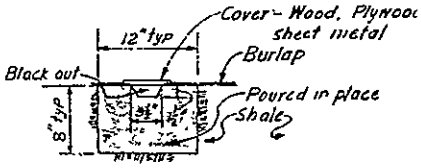
TYPICAL DETAIL
for Stilling basin drainage pipes pulled out of the basin slabs



TYPICAL JOINT BETWEEN SLABS

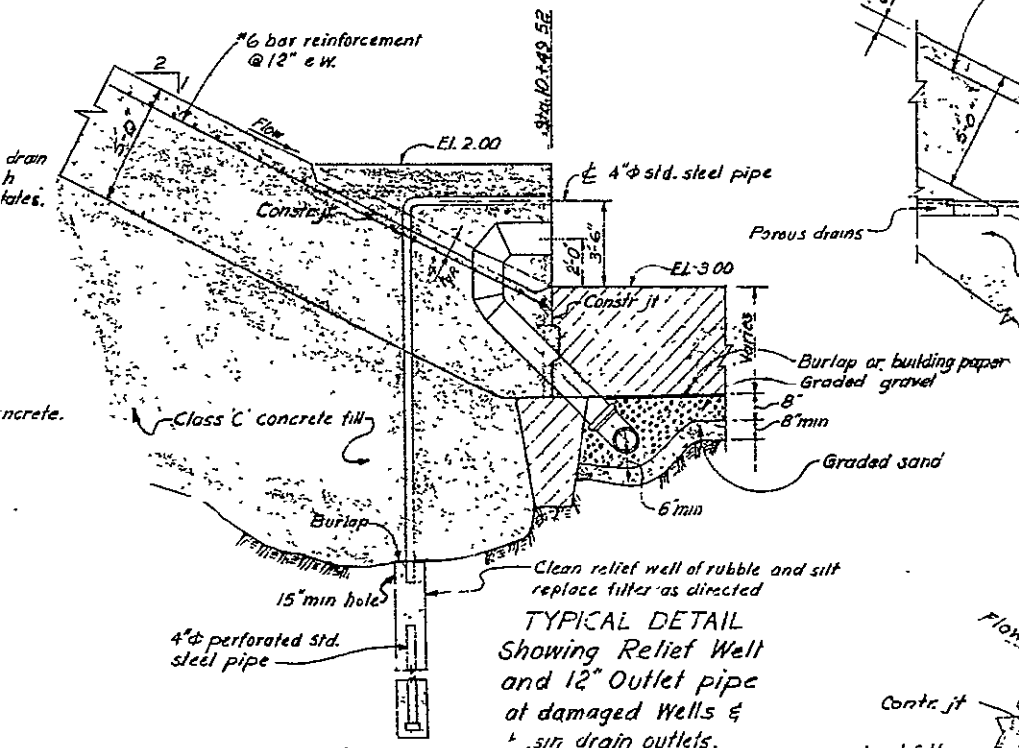


DETAIL AT SLIGHTLY DEPRESSED DENTATE

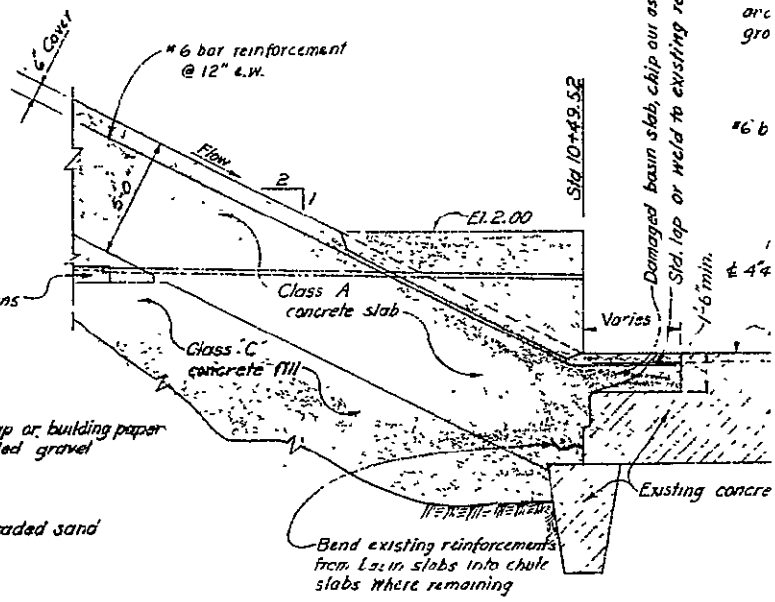


DETAIL POROUS CONCRETE DRAIN IN SHALE
SCALE: 1" = 1'-0"

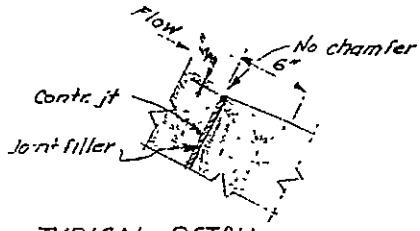
. Note . For reinforcement in dentates see dwg. KFL-13-404



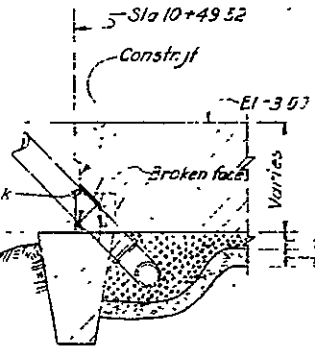
TYPICAL DETAIL
Showing Relief Well and 12" Outlet pipe at damaged Wells & basin drain outlets.



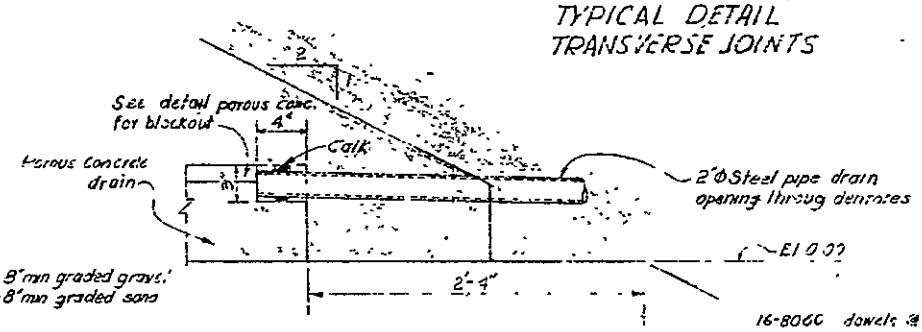
TYPICAL DETAIL
Showing Damaged basin slab



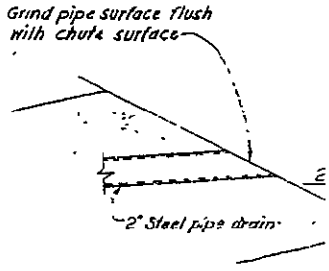
TYPICAL DETAIL
TRANSVERSE JOINTS



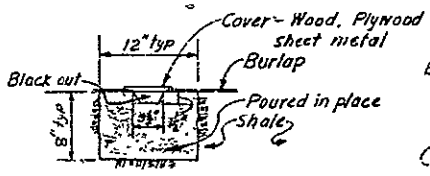
TYPICAL DETAIL
ng basin drainage pipes pulled
the basin slabs



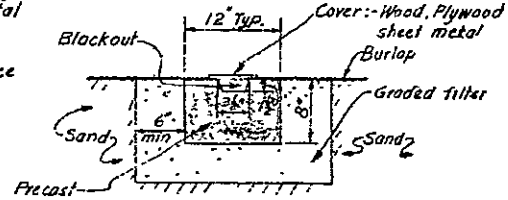
DETAIL K
SCALE: 1½" = 1'-0"



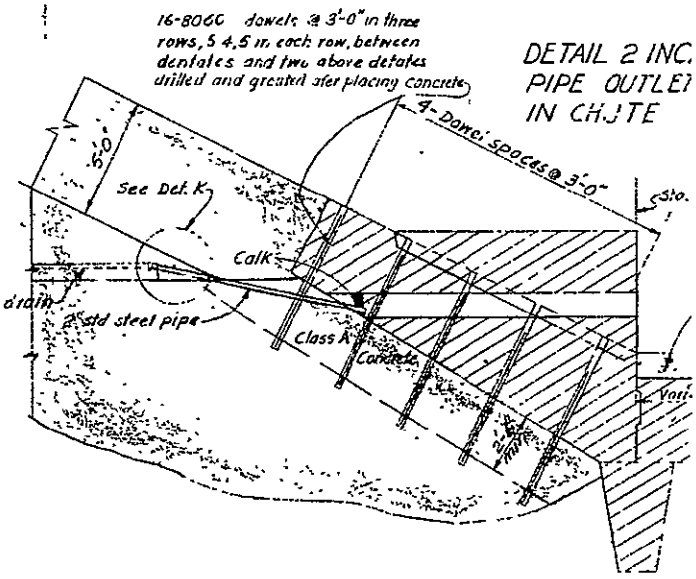
DETAIL 2 INC.
PIPE OUTLET
IN CHUTE



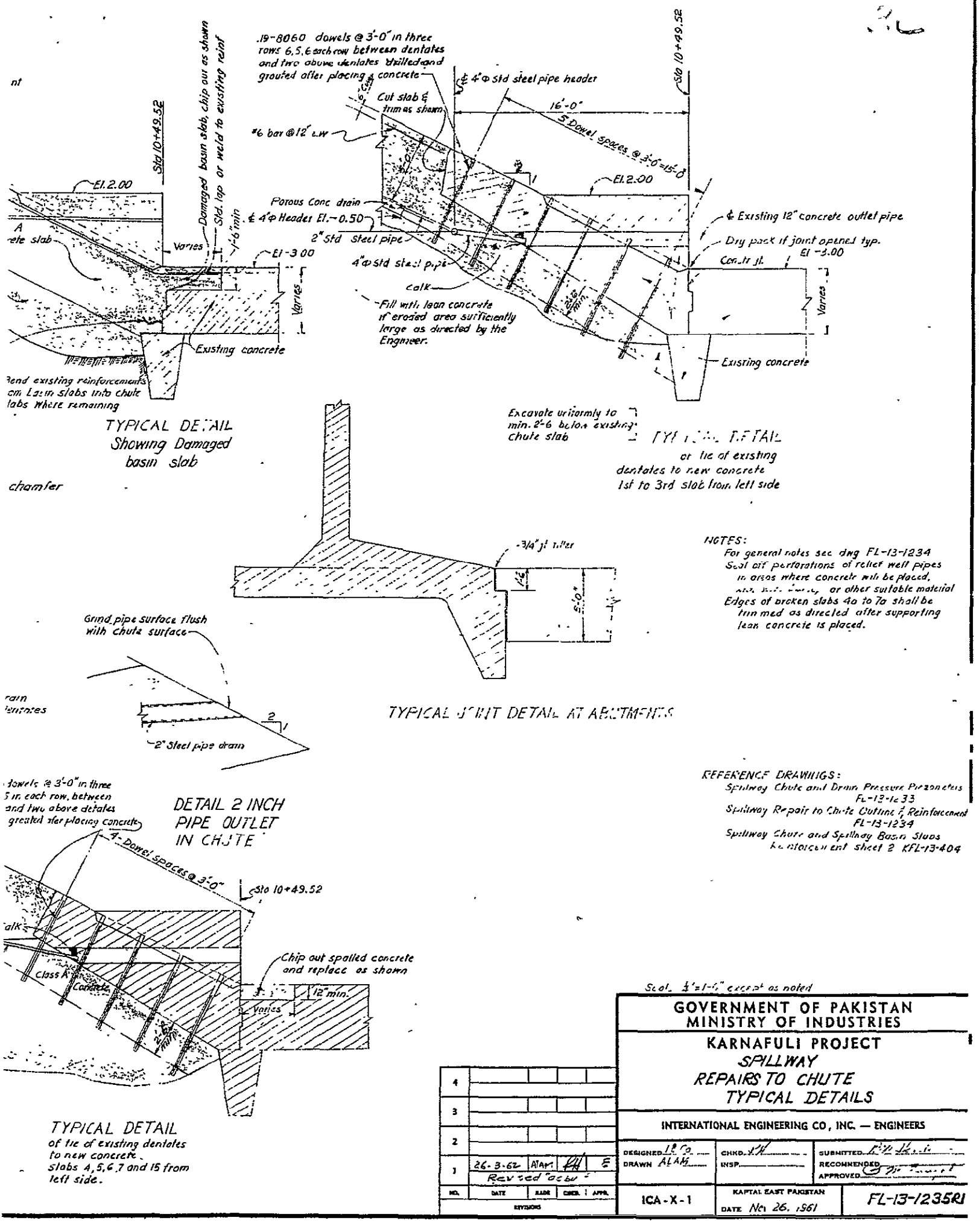
DETAIL POROUS CONCRETE
DRAIN IN SHALE
SCALE: 1" = 1'-0"



DETAIL POROUS CONCRETE
DRAIN IN SAND
SCALE: 1" = 1'-0"



TYPICAL DETAIL
of tie of existing dentates to new concrete.
Slabs 4, 5, 6 7 and 15 from left side.



NOTES:
For general notes see dwg FL-13-1234
Seal off perforations of relief well pipes in areas where concrete will be placed, [illegible] or other suitable material
Edges of broken slabs 4a to 7a shall be trimmed as directed after supporting lean concrete is placed.

REFERENCE DRAWINGS:
Spillway Chute and Drain Pressure Piezometers FL-13-1233
Spillway Repair to Chute Outline & Reinforcement FL-13-1234
Spillway Chute and Spillway Basin Slabs Reinforcement sheet 2 KFL-13-404

Scale ¼"=1'-0" except as noted

NO.	DATE	MADE	CHKD.	APPR.
4				
3				
2				
1	26-3-62	ALAM	[illegible]	E
	Revised "as bu"			

REVISIONS

GOVERNMENT OF PAKISTAN
MINISTRY OF INDUSTRIES

KARNAFULI PROJECT
SPILLWAY
REPAIRS TO CHUTE
TYPICAL DETAILS

INTERNATIONAL ENGINEERING CO, INC. — ENGINEERS

DESIGNED I.E.Co. DRAWN ALAM | CHKD. [illegible] INSP. | SUBMITTED [illegible] RECOMMENDED APPROVED [illegible]

ICA-X-1 | KAPTAI EAST PAKISTAN | DATE Nov 26, 1961 | FL-13-1235R1

TECHNICAL SPECIFICATIONS AND STANDARDS

(1) Standard Specifications for Repair of Concrete (M47), Bureau of Reclamation, Denver, Colorado, April 1981

(2) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete, ANSI/ASTM C 881-78 American Society for Testing and Materials, Philadelphia, Pennsylvania, 1978

(3) Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete, ANSI/ASTM C 882-78; American Society for Testing and Materials, Philadelphia, Pennsylvania, 1978

(4) Standard Test Method for Effective Shrinkage of Epoxy-Resin Systems Used with Concrete, ANSI/ASTM C 883-80 American Society for Testing and Materials, Philadelphia, Pennsylvania, 1980

These standards and specifications have not been included in this copy of the report. They are listed for informational purposes only.

KARNAPHULI HYDRO STATION
CIVIL WORKS

SCOPE OF WORK

1. Spillway

   a. Accomplish core drilling program on chute slabs

   b. Review the adequacy of the replacement slab, as shown on Drawing FL-13-1234R1 and FL-13-1235R1

   c. Conduct hydrologic study to review Inflow Design Flood

   d. Review operation of spillway, using updated IDF, for reservoir elevations and effect downstream of releases

   e. Clean drain lines from drainage holes and drainage gallery

   f. Repair small holes and erosion pockets on spillway slabs

   g. Seal horizontal construction joints in spillway chute slabs

   h. Seal contraction joints in chute and stilling basin slabs

   i. Repair floor of stilling basin if required

   j. Design and construct channel protection downstream of stilling basin

   k. Design and construct slope protection on right downstream side of spillway

   l. Develop schedule for dewatering and examining basin

2. Powerhouse

   a. Clean lower slope in back of powerhouse and install wire mesh shotcrete and weeps

   b. Pave berms and ditches in back of powerhouse

   c. Design horizontal drains for draining mass above fault plane at right tailrace channel

   d. Improve surface drainage from top of right tailrace slope

   e. Remove all woody vegetation from slopes and above slopes around the powerhouse

   f. Design revetment along base of right tailrace channel for implementation when necessary

   g. Design horizontal drains for draining back of potential slide mass beneath access road

h. Install bench marks at access road slide to monitor for movement

i. Investigate nature of slide below access road and design remedial treatment (most practicable solution maybe that the road should be moved if movements become untolerable)

3. Main Dam

a. Inspect and clean relief wells as necessary

b. Evaluate performance of dam

c. Clear woody vegetation back from toe of dam

4. Cargo Transfer System

a. Apply protection to exposed footing foundation and design structure (cribbing) to maintain a protective soil cover on foundation

b. Clean and improve surface drainage on slope

c. Remove woody vegetation from slope near system

d. Review fabrication drawings for monorail; closely examine the monorail, especially the areas of purported failure of monorail components, and design remedial work

e. Inspect superstructure for signs of member and connection distress

5. Outlet Works

a. Improve housekeeping in access shaft, and clean and paint gate surfaces as required

OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

Memorandum

TO : Head, Concrete Dams, Spillways, and Outlet Works Section

Denver, Colorado
DATE: October 22, 1981

FROM : Head, Concrete Section

SUBJECT: Civil Works Repair - Karnaphuli Hydro Station, Karnaphuli Third Unit, Kaptai

This memo is in response to your recent request for assistance in selecting methods to seal construction and contraction joints in the spillway chute. Specifically, This addresses two types of joints which are to be sealed:

A. Construction joints where the chute was previously replaced because of failure due to erosion of underlying earthen materials - These joints are somewhat irregular in alinement, probably due to the original method of excavation. Moreover, these cracks are quite small (about 1/16 inch on the average).

B. Contraction joints purposely placed in the massive chute floor - These joints are approximately 1 inch wide and very deep (to the limit of visibility in the darkness of the crack).

The following recommended procedures are based on our evaluation and discussions with you and representatives of the Materials Science Section.

A. Construction joint cracks

There are two recommended methods for sealing the cracks at the construction joints:

1. The first method consists of removing a 24-inch-wide, 3-inch-deep transverse strip of concrete from the area at the construction joint, sealing the crack with a flexible sealer, laying a thin sheet material 6 inches wide over the crack, filling the excavated strip with epoxy-bonded concrete, and cutting a 2-1/2-inch-deep saw-blade-width joint in the center of the hardened replacement concrete (fig. 1).

2. The second method consists merely of sealing the crack at the existing surface with a flexible sealant (fig. 2).

The first alternative method would be a more durable and reliable method of sealing the construction joints. The second alternative method would be much simpler, less time consuming, and less expensive. The duration of acceptable performance of the second alternative method would depend on many factors including care in application, extent of crack movement, amount of exposure to the sun, and the extent of abrasion from the flow, therefore, making it inappropriate for us to predict a service life beyond several years.

5010-116

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

B. Contraction joint cracks

Contraction joints should be sealed by pushing a flexible foam-type rod into the crack to provide a backing and applying a flexible sealant 3/4- to 1-inch thick, with a recess depth (from concrete surface to exposed surface of the sealant material) of about 1 inch (fig. 3).

1. Materials

a. Flexible sealer should be an amine-cure silicone rubber similar to Dow 790 or G. E. Silpruf.*

b. Flexible rod should be similar to polyethylene foam rod (square or round) and should be of the size to fit snugly into the contraction joint. It should be firm enough to provide a tight backing for the flexible sealer, yet flexible enough to easily compress to less than half its original in-place thickness.

c. The thin sheet material for use in repairing construction joints may be any inert material which is strong enough to be glued to the excavated concrete surface and withstand subsequent placement of concrete over it. It should be flexible enough to conform to larger surface irregularities, yet stiff enough to resist conformance to minor surface features, thus providing a slip surface for subsequent crack movement.

d. Epoxy for bonding fresh concrete to hardened concrete should meet the requirements of ASTM Specification C 881 (copy enclosed) for a Type II system.

e. Replacement concrete should contain a maximum size aggregate between 3/8-and 3/4-inch. Its water-cement ratio should be less than 0.45, and the percent sand should not exceed 60 percent by volume of total aggregate.

2. Procedures

a. The 24-inch-wide strip of concrete to be excavated at the construction joint should be removed by saw cutting the edges and chipping out concrete in between. The saw cuts should be 8 to 16 inches from the actual construction joint, and 1-1/2 to 2 inches in depth. The saw cuts should be as straight as possible, given the actual location of the construction joint, and at an inward bevel (about 15°) to key the replacement section into the excavation. Concrete should be chipped out to a depth of 2-3/4 to 4 inches. The center 8 inches of the excavation should be as flat as practical.

b. Each construction joint to be sealed with flexible sealant, including both the surface crack and the excavated crack (figs. 1 and 2), shall be prepared by routing out a triangular or rectangular shape section at the crack. This section may have a width of 1/4 to 3/8 inch and a depth of at least 1/4 inch but not greater than the width. A width up to 1 inch may be used if the edges of the crack are spalled. Special tools are available for routing out the concrete at the crack.**

c. The contraction joint cracks must be thoroughly cleaned to a depth of at least 2 inches. Cleaning shall consist of removing all foreign material and stripping the surfaces at the side of the cracks of all coatings, leaving a bare, clean concrete surface. We expect sandblasting with a small nozzle to be necessary.

d. The flexible type rod should be pushed into the contraction joints to a depth of 1-3/4 to 2 inches from the surface. If necessary, the crack should be cleaned again to remove foreign material.

e. The flexible sealant should be applied only to dry, clean concrete surfaces. It should be tooled into the concrete surfaces to facilitate bond to the concrete. It should be finished to a slightly concave surface 1 inch $\pm$ 1/8 inch below the concrete at contraction joints and should be finished flush with the concrete at the construction joints. It should be allowed to cure for 48 hours before exposure to moisture.

f. After the flexible sealant is applied in the construction joint crack in the excavated section (fig. 1) and allowed to cure for 48 hours, the thin sheet material should be centered in the excavation and lightly glued in place to secure it for subsequent repair procedures.

g. At the construction joints (alternate 1) epoxy bonded concrete should be placed and cured as specified in the Standard for Repair of Concrete (copy enclosed). Epoxy bond coat should not be applied to the underlying thin sheet material.

h. At the construction joints (alternate 1) a saw cut expansion joint should be cut midway in the hardened replacement concrete to a depth of 2-1/2 to 3 inches.

Enclosures

Copy to: D-1511
D-1520

10/23 Werner D-1511

* See attached page for alternative materials.

** See attached page for a recommended router.

Attached Page

*The material recommended in the memorandum is most resistant to weathering; however, if material is to be under water, one of the following (urethane) materials is recommended:

1. "Sikaflex 1A," Sika Chemical Corp.
2. "Vulchem 203," NAMECO International
3. "Sonolastic NP-1," Sonneborn - Contech

**One satisfactory router is model JA-1 produced by the Windsor Machinery Corporation.

Fig. 1 - Construction joint repair - alternative 1

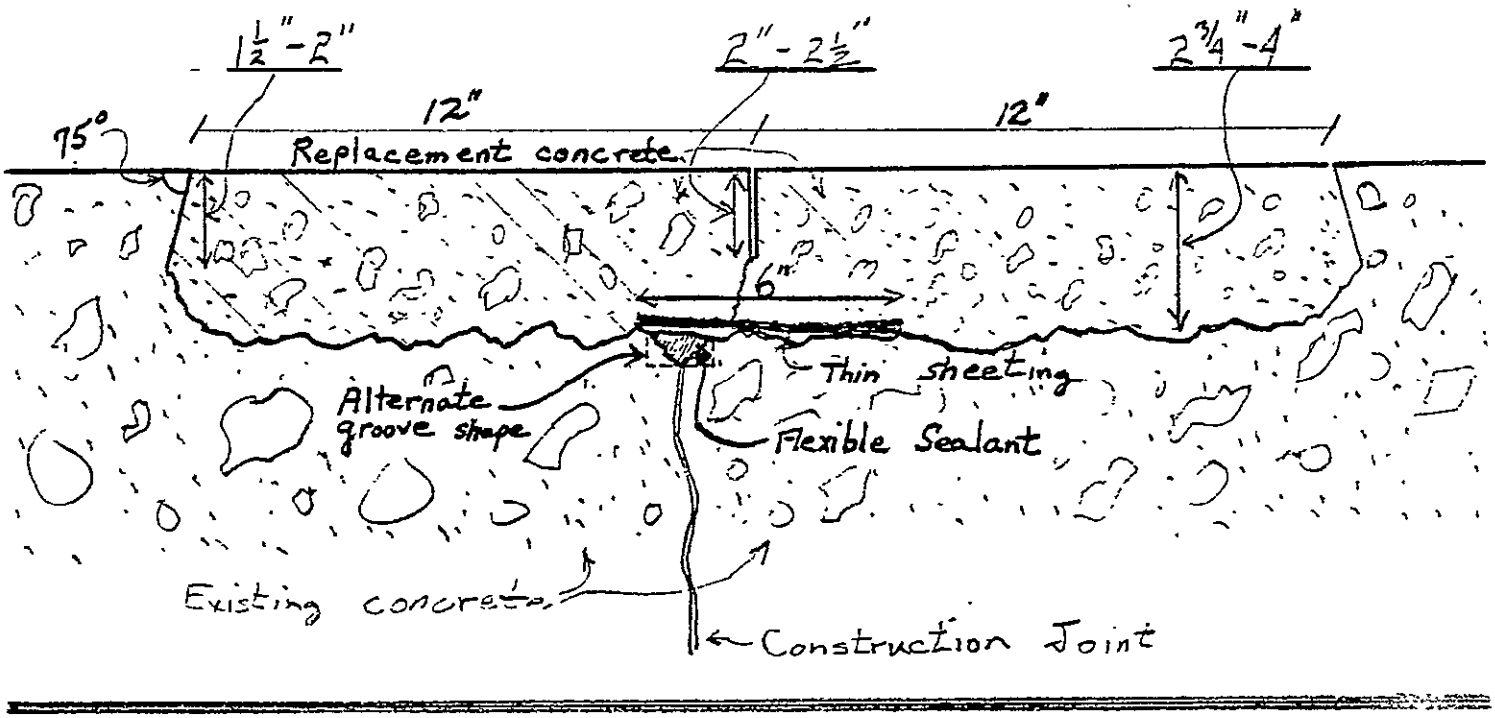


Fig. 2 - Construction joint repair - alternative 2

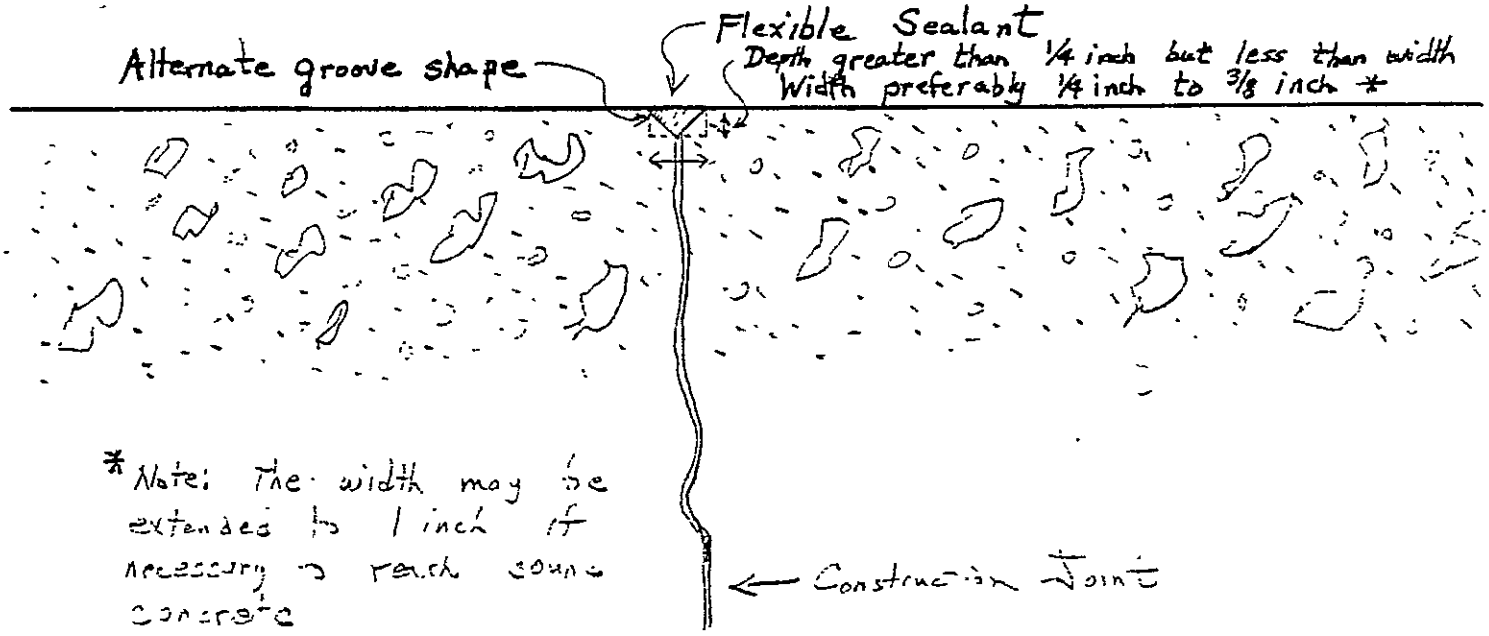
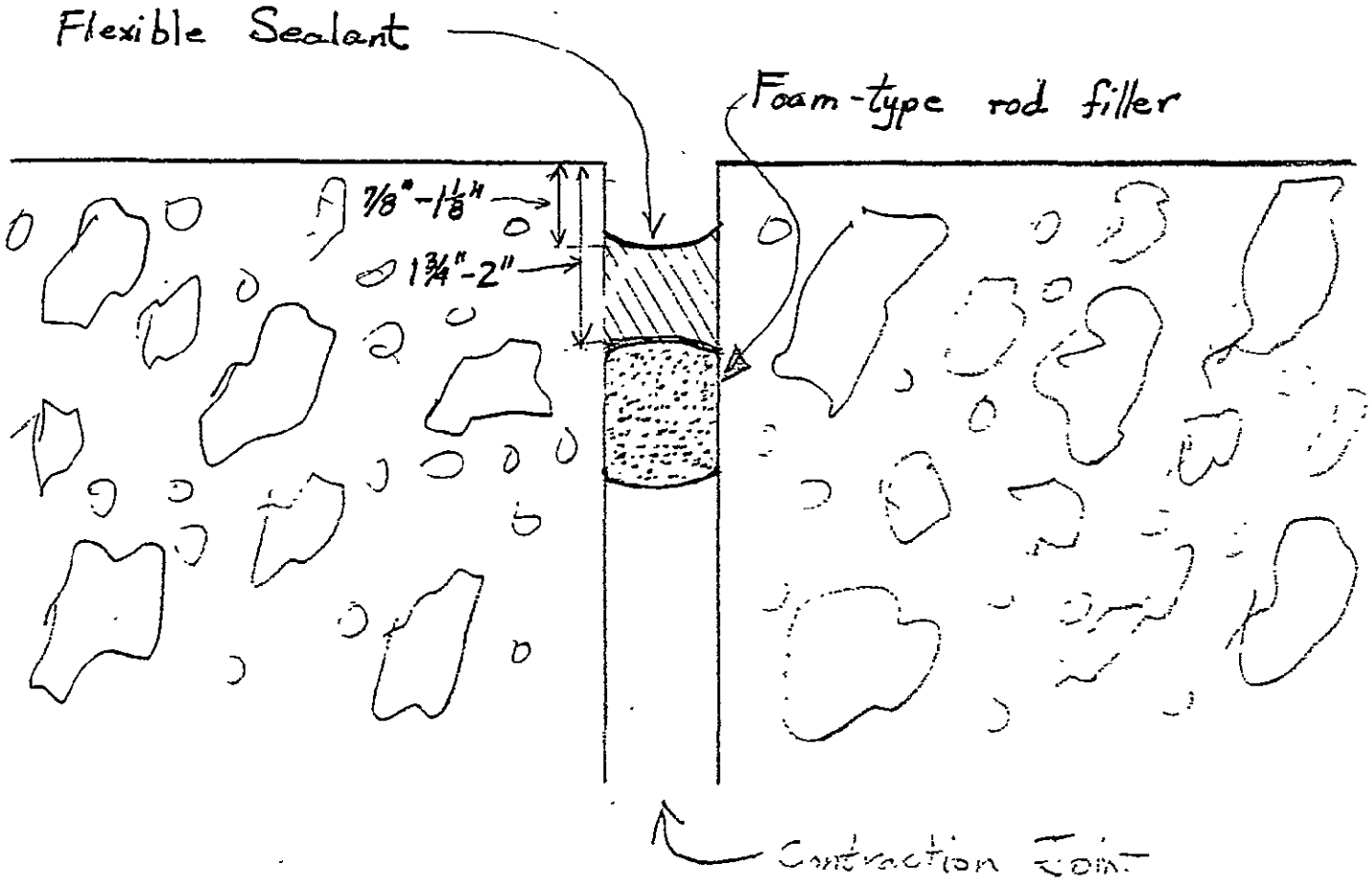
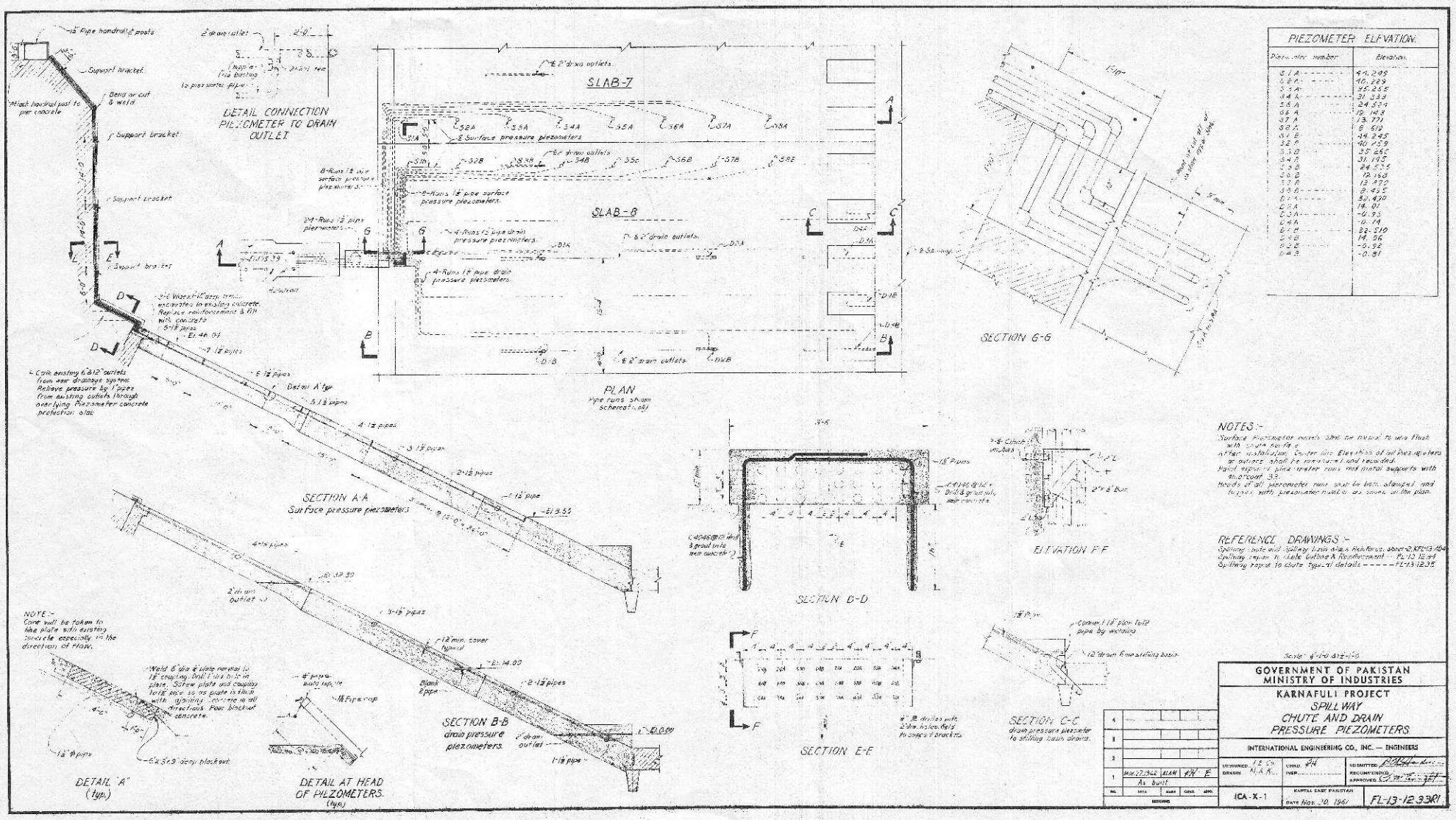


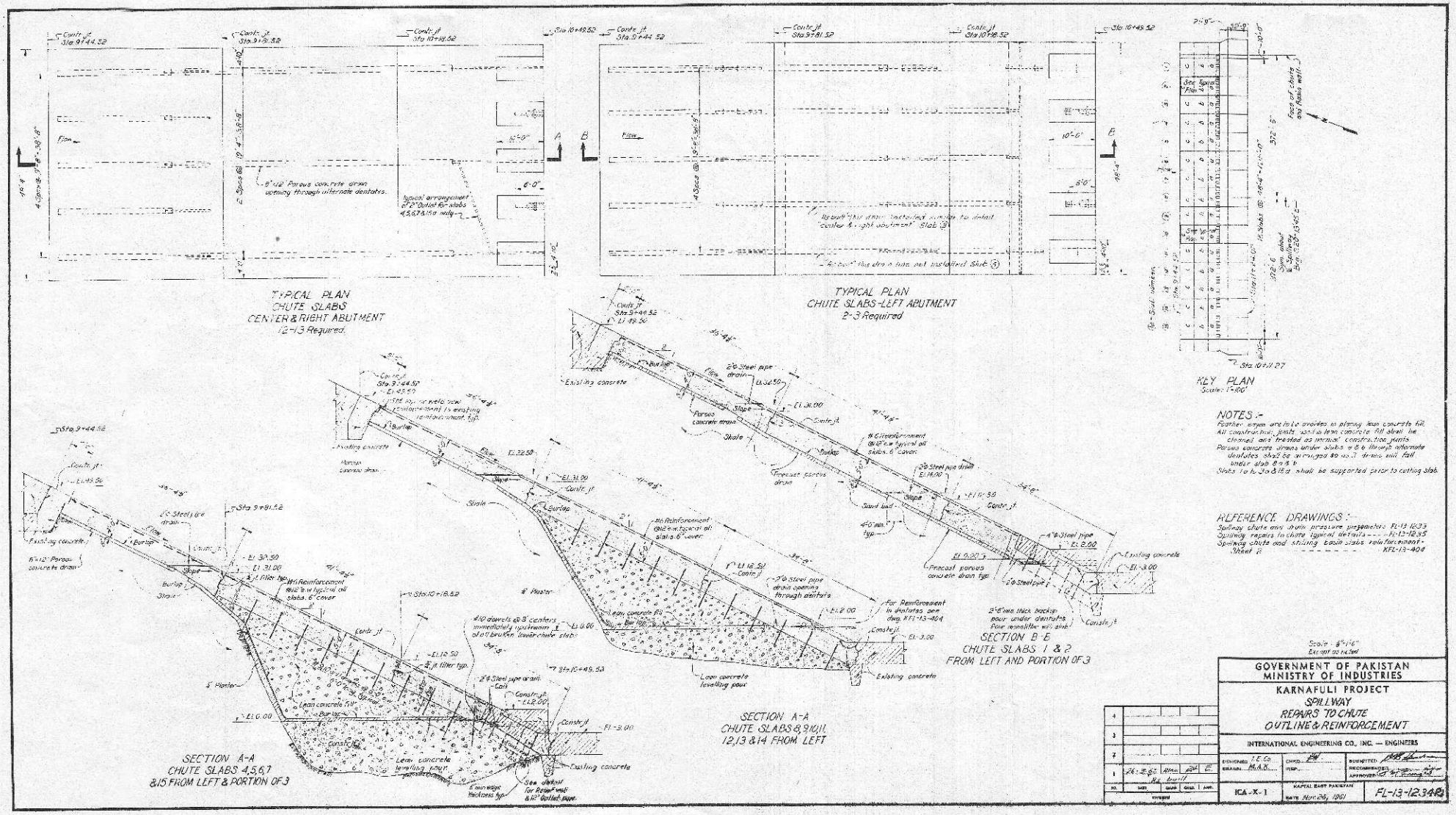
Fig. 3 - Contraction joint sealant system

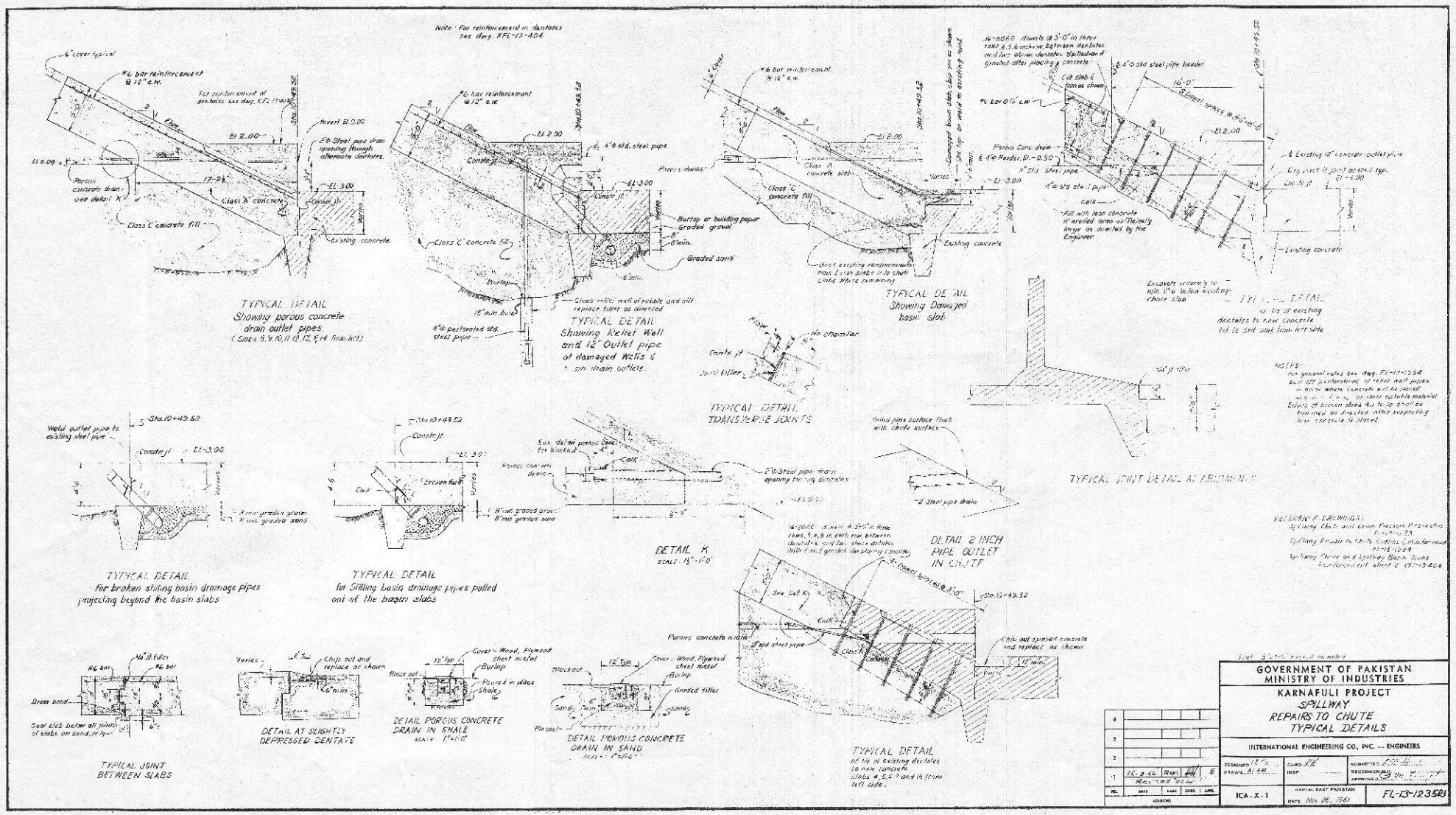




PIEZOMETER ELEVATION.

Piezometer number	Elevation.
S1A	44.205
S2A	40.289
S4A	35.255
S4A	31.334
S5A	24.304
S6A	19.148
S7A	13.771
S8A	8.510
S1B	44.245
S2B	40.258
S3B	35.260
S4B	31.195
S5B	24.535
S6B	19.150
S7B	13.372
S8B	8.435
D1A	50.430
D2A	14.01
D3A	-0.93
D4A	-0.14
D1B	33.510
D2B	14.06
D3B	-0.92
D4B	-0.81


TYPICAL PLAN
CHUTE SLABS
CENTER & RIGHT ABUTMENT
12-13 Required.
TYPICAL PLAN
CHUTE SLABS-LEFT ABUTMENT
2-3 Required
KEY PLAN
Scale: 1"=100'
SECTION A-A
CHUTE SLABS 4,5,6,7
&15 FROM LEFT & PORTION OF 3
SECTION A-A
CHUTE SLABS 8,9,10,11,
12,13 & 14 FROM LEFT
SECTION B-B
CHUTE SLABS 1 & 2
FROM LEFT AND PORTION OF 3
NOTES:-
Feather edges are to be avoided in placing lean concrete fill.
All construction joints used in lean concrete fill shall be cleaned and treated as normal construction joints.
Porous concrete drains under slabs a & b through alternate dentates shall be arranged so as 3 drains will fall under slab a & b.
Slabs 1 to 3a & 15a shall be supported prior to cutting slab.
REFERENCE DRAWINGS:-
Spillway chute and drain pressure piezometers FL-13-12.33
Spillway repairs to chute typical details - - - - FL-13-12.35
Spillway chute and stilling basin slabs reinforcement - Sheet 2 - - - - - - - - KFL-13-404
Scale: 1/8"=1'-0"
Except as noted
GOVERNMENT OF PAKISTAN
MINISTRY OF INDUSTRIES
KARNAFULI PROJECT
SPILLWAY
REPAIRS TO CHUTE
OUTLINE & REINFORCEMENT
INTERNATIONAL ENGINEERING CO., INC. — ENGINEERS
DESIGNED I.E.Co.
DRAWN M.A.K.
CHKD.
INSP.
SUBMITTED
RECOMMENDED
APPROVED
ICA-X-1
KAPTAI EAST PAKISTAN
DATE Nov. 26, 1961
FL-13-12.34
REVISIONS



Note: For reinforcement in dentates see dwg. KFL-13-404
TYPICAL DETAIL
Showing porous concrete drain outlet pipes.
TYPICAL DETAIL
Showing Relief Well and 12" Outlet pipe of damaged Wells & basin drain outlets.
TYPICAL DETAIL
Showing Damaged basin slab
TYPICAL DETAIL
TRANSVERSE JOINTS
TYPICAL DETAIL
for broken stilling basin drainage pipes projecting beyond the basin slabs
TYPICAL DETAIL
for Stilling basin drainage pipes pulled out of the basin slabs
DETAIL K
DETAIL 2 INCH PIPE OUTLET IN CHUTE
TYPICAL DETAIL
of tie of existing dentates to new concrete slabs 4, 5, 6, 7 and 16 from left side.
TYPICAL JOINT BETWEEN SLABS
DETAIL AT SLIGHTLY DEPRESSED DENTATE
DETAIL POROUS CONCRETE DRAIN IN SHALE
DETAIL POROUS CONCRETE DRAIN IN SAND
GOVERNMENT OF PAKISTAN
MINISTRY OF INDUSTRIES
KARNAFULI PROJECT
SPILLWAY
REPAIRS TO CHUTE
TYPICAL DETAILS
INTERNATIONAL ENGINEERING CO., INC. — ENGINEERS
ICA-X-1
KARNAFULI EAST PAKISTAN
DATE Nov. 26, 1961
FL-13-1235R1

PROJECT NUMBER:

PROCESS:	ACTION:	DATES:	INITIALS:
CATALOGUE	– for shelf list – 1636		
ABSTRACT			
FICHE	L RAND		

COMMENTS:

HD

DS/DIU