Paper No. 320

Foundation Treatment of the Baran Dam of Kurram Garhi Multipurposes Scheme Bannu.

By

MR. D. M. KHANZADA (1)

I.—Introductory

The present irrigation system of Bannu District is based on the Saroba - Paina rights i.e., the irrigators on the upstream have a prior right to the water in the River than those whose lands are situated further downstream. Brushwood boulder bunds in the river bed are constructed to divert the water into the zamindari channels on the right and left banks of the river Kurram. The work done by "Tinga" labour supplied by the tenants and the total labour list during floods is colossal, when work which is done by thousands is some times washed away before their very eyes by the floods, the result is wastage of irrigation days and employment of Kamara labour. The landlords have always opposed the scheme on the basis of vested interests. The Kurram river with its main tributary Kaitu comes from Safed Koh and has a catchment area of 4215 square miles. The maximum flood discharge is 1.5 lac cusecs and the perenniel works out to an average of 558 cusecs during low months.

II.—History :—

The idea of construction of a weir at Kurram Garhi Tangi the remodelling and extending the existing system of irrigation was first conceived and investigated by J. C. Davis Executive Engineer in 1907. It had to be dropped because the vested Saroba interest could not be persuaded to part with water surplus to their own requirements for the benefit of lands proposed for further development.

III.—The Present Scheme :—

The proposed scheme consists of :—

(a) A diversion work in the form of weir undersluices and a canal head regulator at the Kurram Garhi Tangi. "A" on the Plan I.

---

1. D. M. Khanzada, Superintending Engineer, Southern Development Circle, Bannu.

(b) Two tunnels one 450 ft: long on the Upper Main Canal and the other 300 ft; long on the Feeder Channel to the Baran Reservoir. The lined Main Cana s, the lined Katchkot Canal and the Right Bank Canal . (B on the Plan I).

(c) Two Hydel Falls of 60 ft: each on the Katchkot Canal capable of producing a firm total power of 4000 Killowatts (P1 & P2 on the Plan).

(d) The Baran Storage Reservoir.

The Reservoir site is at the debouchment of Baran River which has a catchment of 154 square miles and the maximum recorded flood of 40000 cusecs. The Reservoir is connected with the Kurram River through the Baran Feeder Channel and the Upper Main Canal. The capacity of these two channels is 3000 cusecs. Surplus flood water from the Kurram River can be fed into the Baran Reservior when supplies are available The requirement of Katchkot Canal on which the hydel falls are situated is 600 cusecs. The Right Bank Canal which takes 800 cusecs will be supplied from the river Kurram when water is available and during short supplies in river the supply in the canal will be supplemented through an Intake from the Baran Storage Reservoir.

The Reservoir has a capacity of 87,000 acre ft.

The dam is 112 ft. high on an average and is 3200 ft. long at the top. The cross section of the dam is given in Plan II.

The capacity of the Reservoir is limited due to its situation. It will have 55 days supplies at 800 cusecs. The Reservoir will be filled twice a year, once during Monsoon and again in Spring.

(e) The distribution system and remodelling of the existing canals.

The scheme provides for flood irrigation which will account for 40% flow irrigation. The floods besides adding to the extent of irrigation being in nutritious and manuring silt on which the over all prosperity of the district depends.

IV.—**Benefits of the scheme.**

The scheme is multipurpose based on considerations stated below:—

1. Besides stablizing supplies to the existing irrigated area of 1.12 lac acres the scheme irrigates a new virgin area of 1.5 lac acres of the District.

2. Production of 4000 Kw firm power which is considered sufficient for Bannu and D. I. Khan Districts.

3. Afforestation of 20,000 acres in the Khads and various catchments.

4. Providing drinking water to the very arid Marwat Area of the District where at present water has to be brought on animals from great distances.

5. Political :—

A large number of wazir tribesmen living near could be usefully settled on the land. This will reduce the Political problem of the area. The Government also has acquired land under the scheme for Model Cooperative Farms and settlement of ex-soldiers, refugees and dependents of Police Officers.

V.—**Baran Dam :—**

(a) The Dam site and reservoir are recent alluvial deposits of clay silt sand, gravels and boulders resting unconformably on bed rock of the "Siwalik age". These bed rocks are conglomerates, pseudo conglomerate sand stones, silt stone and clays which can be considered sufficiently impervious to excluded the possibility of heavy losses through percolation. Both shoulders of the dam are on conglomerate rocks. In the valley, bottom conglomerates are buried under a thick layer of alluvions attaining at certain points 100 ft., thickness. The thickness of alluvions has ensured the stability of the dam. The danger of uplift pressure is not very important on account of this thickness. The main problem is the water losses as the capacity of the reservoir is already very limited and the conservation of stored water is of the utmost importance. Grouting work was decided on this issue. The 30 cusecs which were calculated to be the losses through the alluvions when water was stored was reduced to negligible quantity through the grouting treatment.

(*b*) The work of grouting was done by Swissboring Overseas Ltd., Karachi. The work was done through a contract and amounts to about 6·5 lacs. The long section of the dam under ground is given in *Plan III*.

(*c*) The average permeability of the alluvions was determined by means of five large field permeability tests in situ. It gave permeability as 0·607 Cm/Sec. To control the seepage through the dam a large central trench was dug upto a depth of 30 ft. below actual ground level This central trench was 60 ft. wide at the top and 20 ft. wide at the bottom. From the bottom of the central trench a cut off 5 ft. wide was dug through the previous alluvions to a depth of 50 ft. The cut off was filled back with suitable and tested red clay in horizontal layers and compacted at the optimum moisture content according to Proctor.

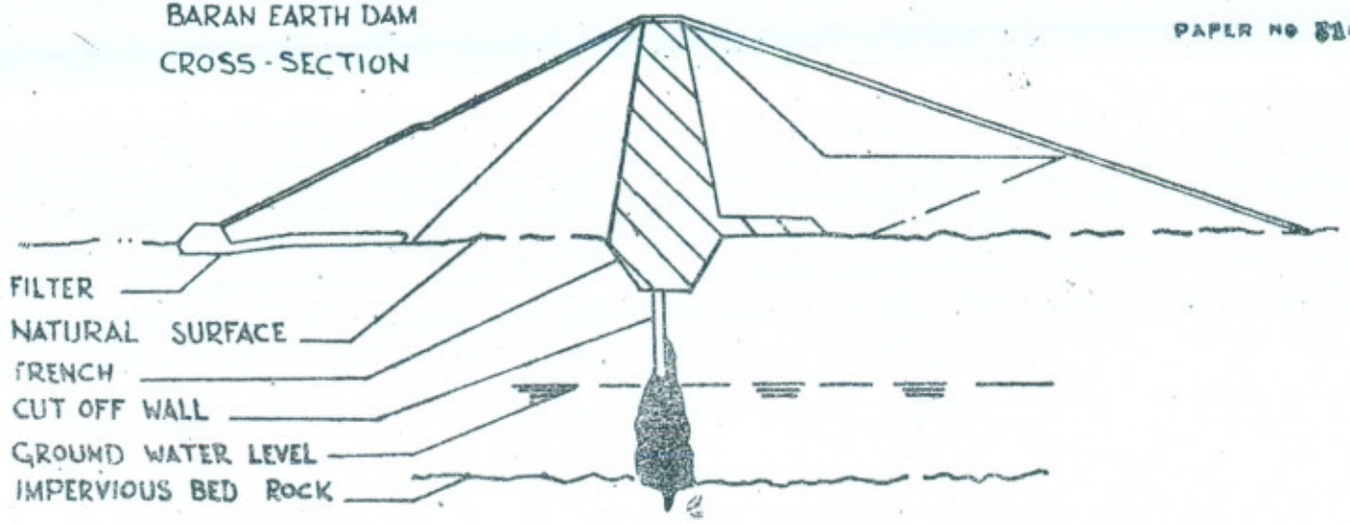
Towards the middle of the dam the impervious cut off wall could not be placed on the bed rock because alluvion was more in depth than 50 ft. and because the ground water at this depth could not be pumped-out for various reasons. The gap of 755 ft. length was left which was braced before the refill between the bottom of the cut off wall and the impervious bed rock which was to be treated carefully and thoroughly with grout.

To prevent seepage through this gap and to obviate the danger of piping it was decided to reduce the permeability of the alluvions to an admissible value. The only technical solution for reducing the permeability at that depth consisted of grouting. This work of high pressure grouting of the alluvions was done by the Swissborings.

During the execution of the cut off wall, working joints were left, at certain distances. These working joints were also grouted as well as the upstream and downstream faces of the cut off wall in order to seal them perfectly into the alluvions. This note explains the principles of these grouting works and gives data showing the absorption of grout in different sections. (Appendix A).

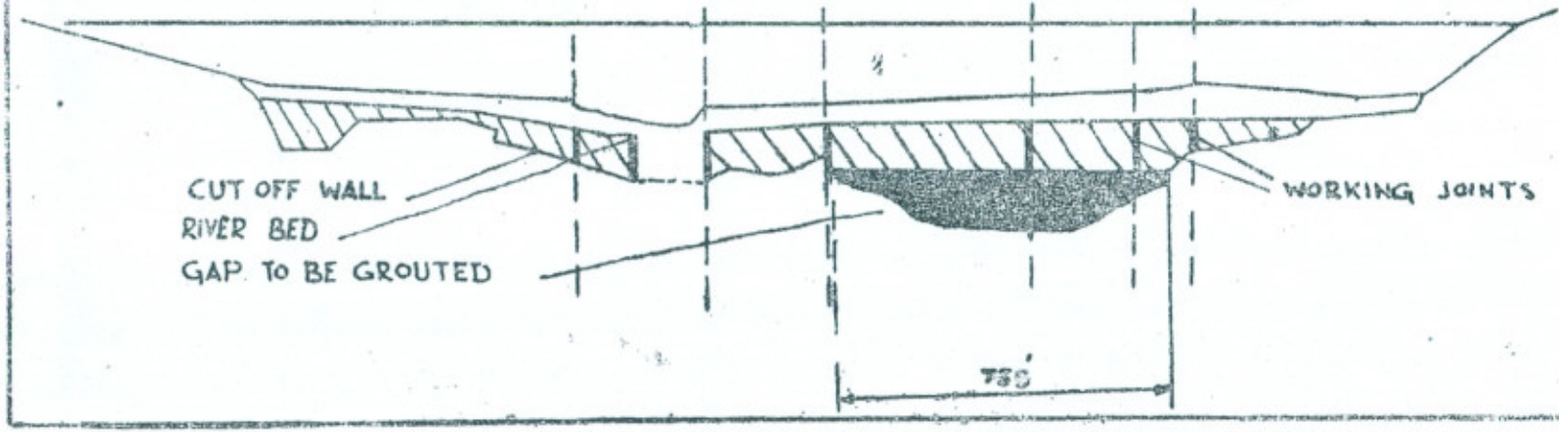
BARAN EARTH DAM

CROSS - SECTION



LONGITUDINAL SECTION

VIEW FROM THE WATER SIDE



Grouting Work.

The grouting plant was set up in the middle of the section of 755 ft. to be grouted. (Fig 4) In order to provide sufficient water for grouting and drilling, a water compensation tank was erected at site. The dry clay was broken, pulverised and placed in suspension tanks. The clay from bed deposits in the main canal was also used for grouting.

The grouting plant consisted of two sets of stirring double mixtures driven electrically on low pressure Duplex pump upto 280 lbs/m^2 and horizontal high pressure injection upto 1100 lbs/m^2. The necessary drilling work was carried out by means of two Svenska A B drilling machines driven electrically or by diesel engines. The grout holes had to be drilled through the cut off wall before drilling into the alluvions because the work on the cut off wall could not be postponed for the fear of rains damaging the cut inspite of the fact that bracing was done. The impervious diaphragm had to be placed soon in the cut, as the drying of the exposed sides of the cut was encouraging the slipping of stones and sand out of the formation, and this could have led to a collapse of the cut ; the cut off wall was therefore completed in record time, working day and night under very difficult conditions. After drilling 2 ft. into the conglomerate the boring was stopped. Special steel bits were used for drilling work and this drilling work did not allow any core recovery because of the bits used.

The grouting work in the alluvions was carried out with high pressure. while the grouting work in the cut off was done under low pressure. The grouting pressure recorded and controlled by two manometers which was fitted on the pump or on injector while the other manometer was fixed on the drilling rig. The grouting mixture contained 5% cement 15% clay and 80% water which corresponds to 1 : 3 of dry materials and to a density 1 : 4 in water. The density of the grout was constantly checked by aerometers and was to be adopted to the absorption of the alluvions within a wide range *i.e.*, from 1 : 3 to 1 : 10 if required. The grouting was done in two steps. The first line of grout holes was located on the middle axis of the cut off wall with a spacing of 10 ft. in order to consolidale the large pores, gravel without filling mateaial, pockets of boulders and other weak sections. When the first line of grout holes was completed and the grout was given time to harden a second line of bore holes was drilled between the upstream side of the cut off wall and the first line of grout holes. This second line of grout holes was grouted with higher pressures in order to reduce the permeability through the smaller voids of the alluvions.

VII. Grouting Tests.

(*a*) In order to check the efficiency of grouting for the ground to be treated a large grouting test must be carried out. The tests determines the following important items :—

(*a*) The permeability of the subgrade in different depths before treatment.

(*b*) The best density of the grout according to the grain size of the sub surface.

(*c*) The most economical spacing of the grout holes.

(*d*) Reduction of the permeability of the sub-surface after treatment by grouting.

For a magnitude of this work a well point grouting should have been executed in the manner below.

In the centre of the area to be grouted, a tube well of large diameter fitted with strainer and pump is carried to the bed rock. Round the well a net work of peizometric pipes for the grouting work has to be executed. From the well a certain amount of water is pumped until a stationery flow towards the well can be observed.

From these results of the ground water lowering the everage co.efficient K af permeability according to Darcy-Law can be calculated on the following assumptions :—

1. Absolute homogeneity of the sub.grade.
2. Un-lowered ground water is perfectly horizontal.
3. Tube well has been sunk into the impervious bed rock.

The present conditions do not ful-fil all the three assumptions. When the permeability of the sub-grade before the treatment is determined the sub-surface can be grouted by means of 8 drill holes forming a grouted cylinder in the centre of which is located the well. At this moment pumping from the well can be started again and the difference of permeability after grouting of the sub-surface determined. The co-efficient of permeability can also be obtained by Thiem Method. The formula applied by him is :—

$$K = \frac{q \log_{10} \frac{r_1}{r}}{20.4m\ (s - s_1)}$$ Where

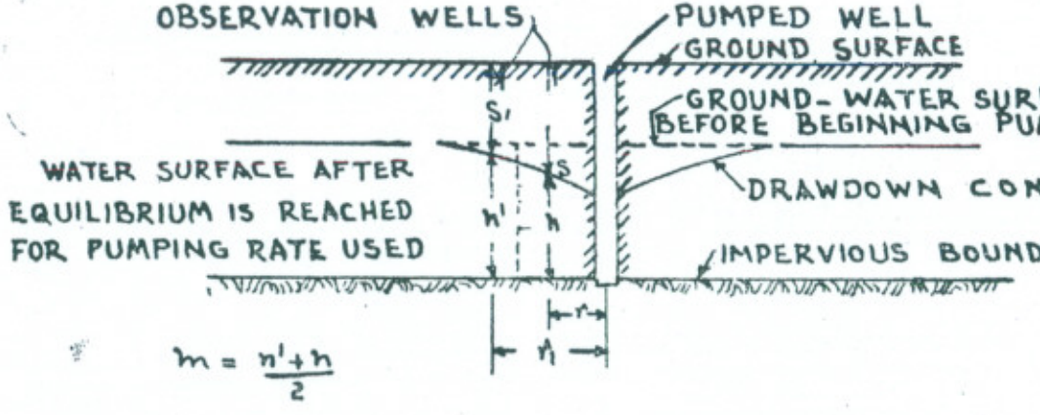
K=the permeability co-efficient in feet per minute (strictly cubic feet per minute per square foot on a1 to 1 gradient) at a temperature of 54° F.

q=the rate of pumping in gallons per minute $r1$ and r are the distances of two observation wells from the pumped well in feet

m=the average verticle thickness of the saturated portion of the water-bearing bed between the two observation wells as shown in fig. 5

FIG. 5

PAPER NO. 330



FACTORS IN THIEM FORMULA FOR DETERMINGNG COEFFICIENT OF PERMEABILITY FROM FIELD PUMPING TESTS.

FIG. 6 A

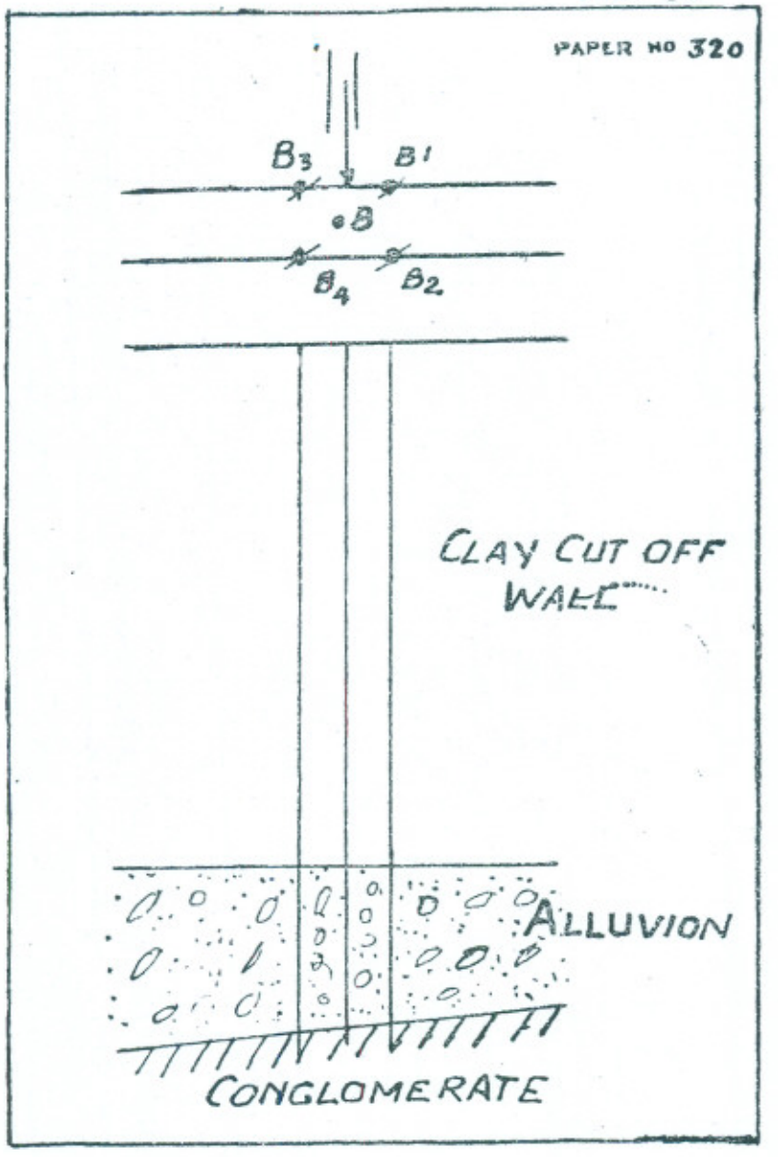
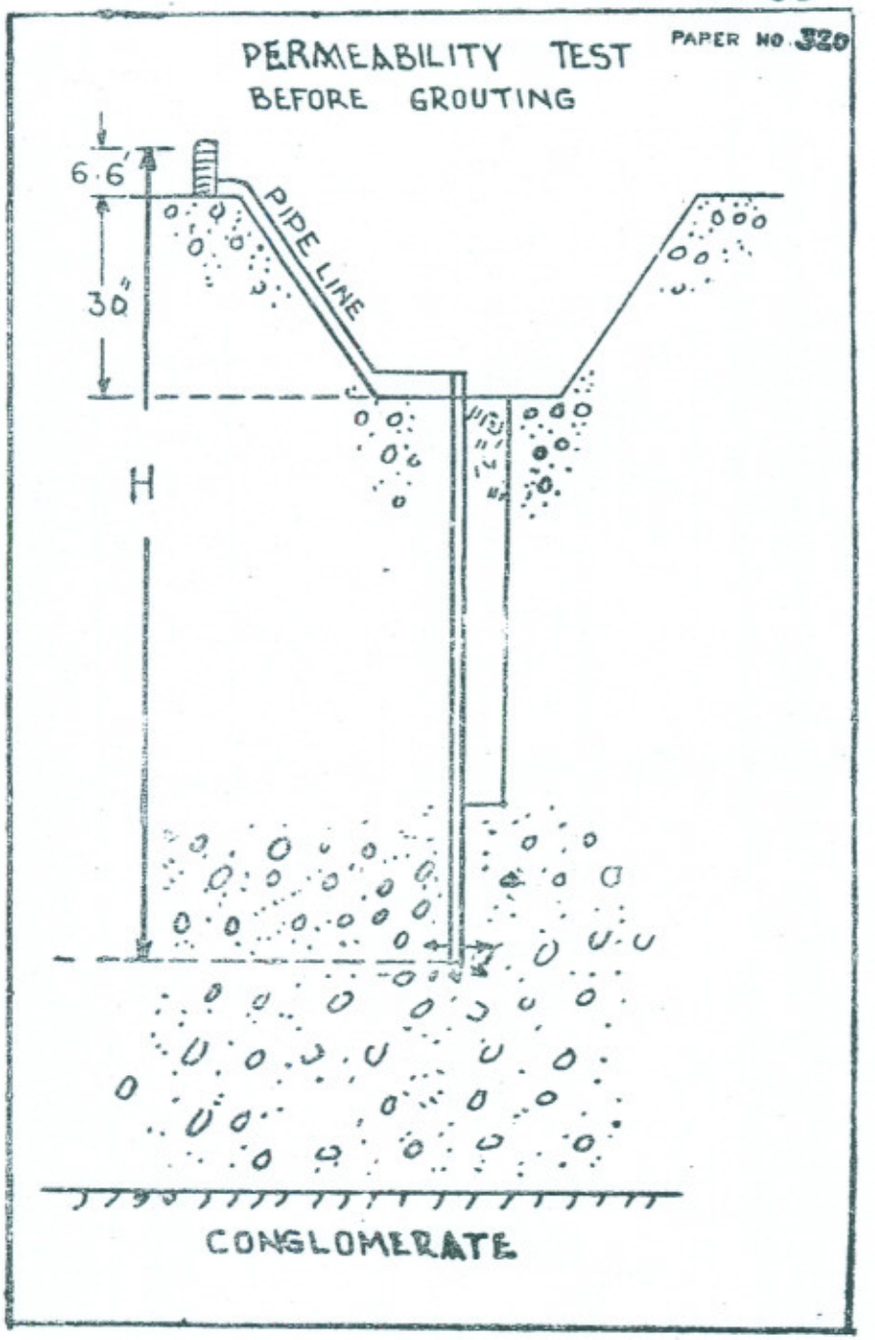

PAPER NO 320
B3
B1
B
B4
B2
CLAY CUT OFF WALL
ALLUVION
CONGLOMERATE

FIG. 6 B

PAPER NO. 320



Another method employed is called the Electrolytic Determination of Permeability Co-efficient. These two methods were employed for determination of the permeability of the foundation at Kingsley Dam in Nebraska.

In our case due to an advanced stage of work and to avoid delaying the work any further this test was not made. In its place simplified grouting test was carried out in the following way :—

Four grout holes forming a square of 5 ft. were drilled down to the bed rock and tested with water under the static pressure in order to determine the permeability of the alluvions every 5 ft. depth, after this water absorption test these holes were grouted with mixture of binary grout containg 25% of cement and 75% of suitable clay. A period of 15 days was given to the grout to settle and harden in the alluvions before a new hole was drilled in the centre of the square and water absorption was checked again. After grouting the first drill holes it was found that the best mixture of cement and suitable clay was the following :—

15 to 30% of cement and 85 to 70% of clay according to the permeability of the sub surface. The density of the grout mixture was chosen in such a way that the grout will not be washed out by the flowing ground water.

The grouting test was carried out at R. D. 1520. The boring B 2 was done first (Figure 6 A). At the depth of 59 ft., 64 ft., 69 ft. and 74 ft. permeability tests were made (Figure 6 B).

Darcy's formula used is given below :—

$$K = \frac{Q}{A\,i}$$

$$A = 4\pi\, r_o^2$$

$$V = \frac{Q}{A} = \frac{Q}{4\pi\, r_0^2}$$

$$i = \frac{H}{r_o}$$

therefore

$$k = \frac{Q}{4\pi\, r_o^2} \times \frac{r_o}{H} = \frac{Q}{4\pi\, r_o^2\, H}$$ where

Q = Absorption (Cm^3 / Sec.)

r_0 = Radius of pipe (Cm) = 0·7 Cm

H = Static Head (Cm.)

The absorption for each boring was :—

Boring No.	Absorption in Cm^3 / second			
	Depths.			
	59	64	69	74
B 1	410	254	230	182
B 2	330	373	352	560
B 3	260	237	323	400
B 4	320	245	169	80

The borings were executed in the following order B_2 B_3 B_1 B_4. First of all they were tested with water at the static level and later on grouted.

Coefficient of permeability at various depths (before grouting) was:—

K (in Cm/Sec)

Depth	59 ft.	64 ft	69 ft.	74 ft,
K (Cm/Sec)	1.29×10^{-2}	1.4×16^{-2}	1.27×10^{-2}	1.92×10^{-2}
K (inch/Sec)	0.52×10^{-2}	0.56×10^{-2}	0.51×10^{-2}	0.75×10^{-2}

The tests were good enough to show that the permeability of thc over burden is 1.47×10^{-2} Cm/Sec or 0.58×10^{-2} inc/Sec. in confirmation of the field permeability tests executed by means of test pits.

The bore hole No. B in the middle of the grouted area was tested and it was found that the work was satisfactory. The Darcy formual $K = \frac{Q}{A\,i}$

$A = 2\pi\,rh$

$V = \frac{Q}{A} = \frac{Q}{2\pi\,rh}$

$1 = \frac{H}{r}$, therefore

$$K = \frac{Q}{2\pi\, rh} \times \frac{r}{H} = \frac{Q}{2\pi\, hr}$$ where

Q = Absorption Cm^3/Sec.

r = Radius of pipe (C m) =2.5 cm

H = Height of the tank to the point of the test (in cm)

h = Height of the tested section = 61 cm= 2ft.

The measured absorptions are as below:—

Absorption into the boring test No. B Cm^3/Sec.

Depth from the bottom of the cut off trench.	59 ft.	64 ft.	69 ft.	74 ft.
Absorption Cm^3/Sec.	8	41	25	30

And the coefficient of permeability of the under ground after the grouting works at different depths was.

Depth from the bottom of the trench.	59 ft.	64 ft.	69 ft.	74 ft.
Coefficient of permeability				
Cm / Sec.	7.5×10^{-6}	3.5×10^{-5}	2.07×10^{-5}	2.5×10^{-5}
K (in / Sec.	2.95×10^{-6}	1.38×10^{-6}	0.82×10^{-5}	1.0×10^{-5}

Therefore K is 2.21×10^{-5} Cm/Sec. or
0.87×10^{-5} in/Sec.

or 655 Times lower than before the grouting work where K is 1.47×10^{-2}

Besides we consider that the dispersion of water is in four directions while in the working conditions the grouting curtain is working in one direction.

The permeability tests with constant gradient were therefore completed.

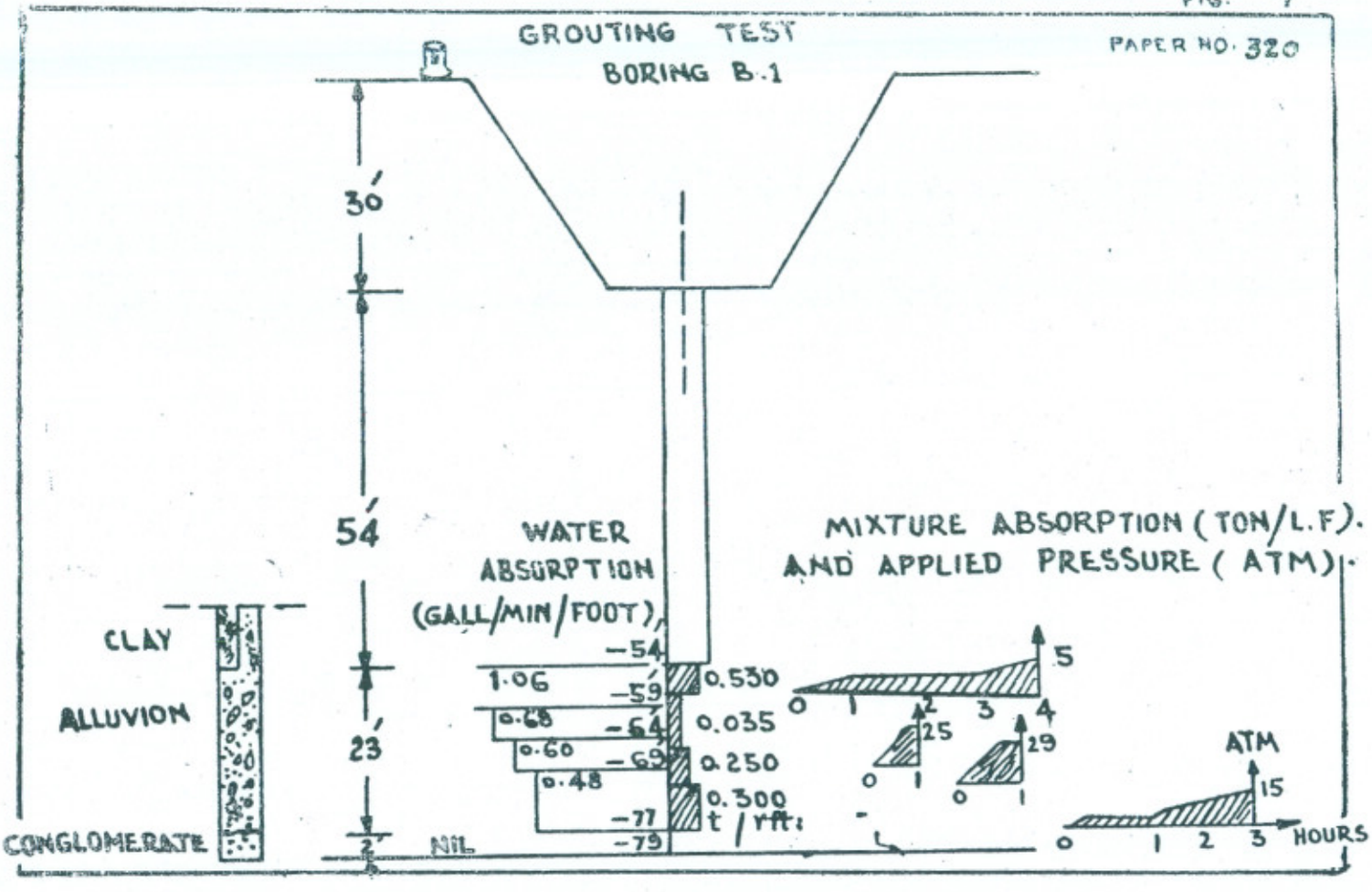
(b) **Pressure Absorption Tests :—**

The water was pumped into the alluvions at various pressures by means of a Duplex Pump working at 108 Revolutions per minute i. e., with practically a constant pressure. It was noticed that only very little water was going into the grouted area under-ground as the static pressure was reduced from 20 atmospherics to 8 atmospherics and this meant that the grouted ground was practically impervious. The table below is the water pumped under pressure into the test boring at the depth of 69 ft. from the bottom of the cut off trench.

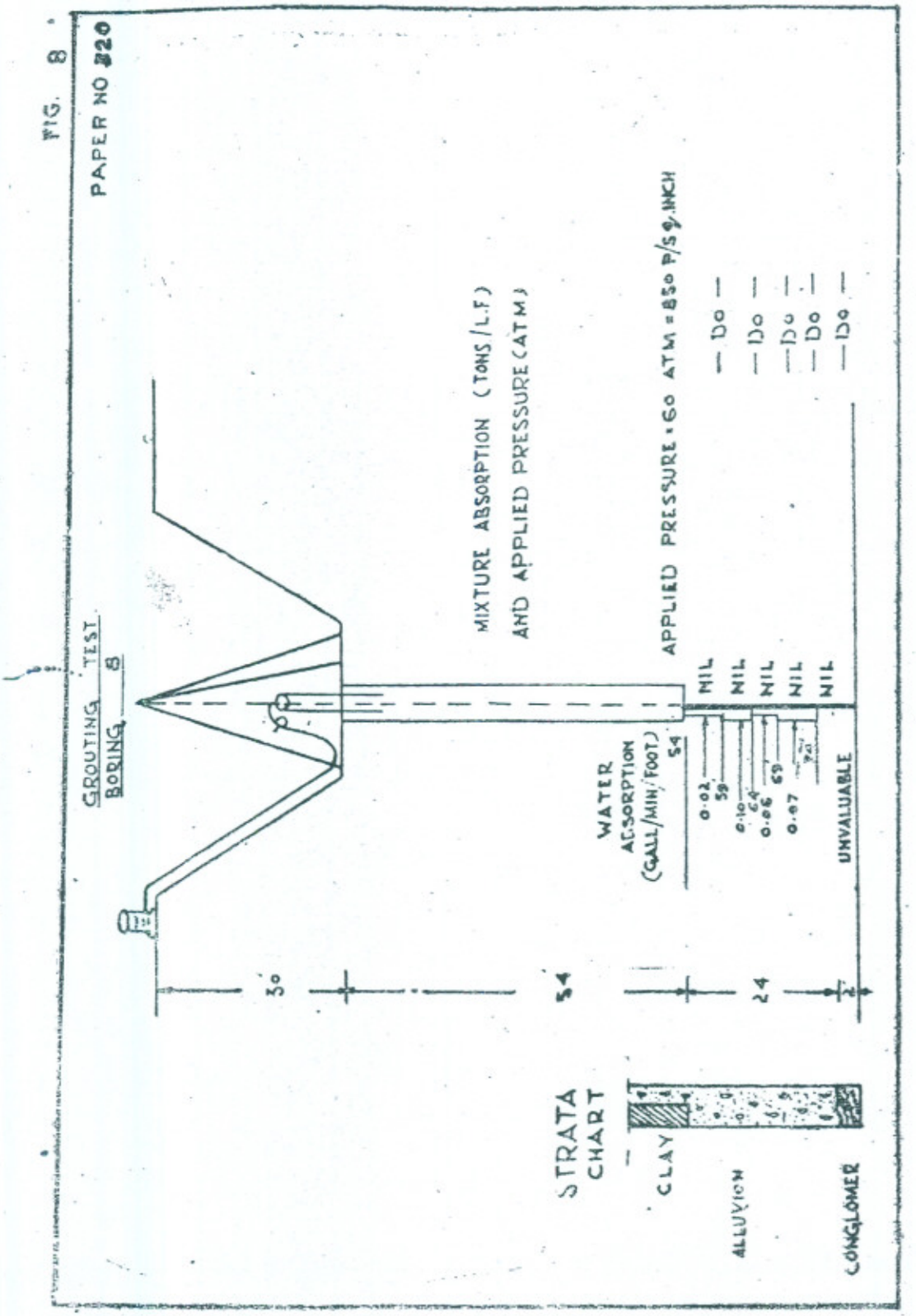
Time	Pressure (atm) (1 atm = 14.2 lb/Sq. inch)	Pump.
0	0	working stopped
25″	20	,,
35′	18	,,
45′	13	,,
1′	10	,,
2′	8	,
3′	7	,,
4′	6	,,
5′	5	,,
6′	5	,,
7′	5	,,
7′ 20″	20	,,
8′	13	,,
9′	9	,,
10′	8	,,

FIG. 7

PAPER NO. 320



The grouting tests on B 2, B 3 & B 4 were made in the same way. The result of grouting test of boring B is given in Figure 8 below :—



Time	Presure (atm) (1 atm = 14.2 lb/Sq. inch)	Pump.
10′ 15″	over 20	working stopped
11′	16	,,
12′	12	,,
13′	10	,,
14′	8½	,,
15′	8	,,

VIII.—Conclusions are :—

(*a*) With grouting, the permeability of the alluvions was reduced from $1{\cdot}47 \times 10^{-2}$ to $2{\cdot}21 \times 10^{-5}$ *i.e.*, 665 times.

(*b*) The ground was groutable in all the stratification because no great differences were observed on the absorption of all the borings.

From experience gained on many works in similar conditions it is assumed that with grouting a reduction of 70—100 times of the permeability has been obtained. This means that the calculated seepage through the alluvions of 30 cusecs after the grouting will be 70—100 times less which is negligible.

It was noticed at some places in the cut off wall that water used for drilling was lost due to fissures and shrinkage of materials as a result of settlement and lateral earth pressure. After grouting at low pressure these fissures were sealed with the alluvions. This meant the complete imperviousness of the clay cut off wall through all the treated length and this was checked up to a pressure of more than 300 lbs/in².

The pressure for filling the fissures in the cut off wall ranged from 0-50 lbs./in². It ranged for the first row of borings in the alluvions from 0 to 400 lbs/in² and for the second row from 0 to 1100 lbs/in².

IX.—Result.

The information on all the borings is given in the Appendix A.

SUMMARY OF THE WORKS EXECUTED.

(1) Total Length of borings.

Through the compact clay ... 11.105 ft.
Through the alluvions ... 5.670 ft.

(2) Total Dry Material Grouted.

Clay .. 1055.95 tons
Cement .. 365.00 tons

Total ... 1420.95 tons

(3) Average Water/Cement ratio of the grouting mixture.

Into the clay cut-off wall ... 1.2 : 1
Into the alluvions ... 1.5 : 1

(4) Average absorption of dry material into the clay cut off wall.

Per running foot of boring ... 0.051 tons
Per square foot of joint surface ... 0.005 tons

(5) Average absorption of dry material into the alluvions.

Per running foot of boring ... 0.152 tons
Per square foot of curtain ... 0.030 tons

(6) First row of borings:

Perforation through the clay cut-off wall ... 5.554 ft.
Perforation through the alluvions : ... 2.896 ft.
Dry material grouted into the clay cut-off wall.
535.85 tons ... 92 %
Dry material grouted into the alluvions 690.85 tons ... 81.4 %
Total absorption ... 1226.65 tons ... 85.6 %
Dry material grouted into the clay cut-off wall per running foot of boring : $\frac{535.85}{5.554}$ = ... 0 096 tons.
Dry material grouted into the alluvions.
Per running foot of boring $\frac{690.80}{2896}$ = ... 0.238 tons.

Second row of borings.

Perforation through the clay cut-off wall ... 5.551 ft.
Perforation through the alluvions ... 2.774 ft.

Dry material grouted into the cut-off wall :
46.24 tons ... 8%

Dry material grouted into the alluvions :
157.86 tons ... 18 6%

Total absorption : 204.10 tons ... 14.4%

Dry material grouted into the clay cut-off wall per running foot of borings : $\frac{46.24}{5551}$ = ... 0.008 tons.

Dry material grouted into the alluvion per running foot of boring : $\frac{157.86}{2774}$ = ... 0.057 tons

Grouting executed at particular week points.

Boring No.	Length (Feet) Clay	Alluvion	R.D.	Grouting (tons.)	
1 S	45	...	380	0.79	Discontinued.
3 S	47	...	760	149.80	
Pipe No. 2	...	...	1112	2·20	
Pipe No. 3	...	...	1129	38.58	
Pipe RD. 1136			1136	18.35	
3 D	76	17	1157	2.96	
4 D	77	...	1280	145.90	

Clay / Cement Ratio 3 : 1

Water / Mixture Ratio 1.2 : 1

Maximum pressure applied 56 lbs/sq. inch.

Appendix—A

KURRAM GARHI SCHEME — GROUTING WORKS AT BARAN DAM

Boring No.	Length of boring			Grouting				
	Through the clay (ft)	Through the alluvion (feet)	Total (feet)	Absorption into the clay cut off wall. (tons.)	Absorption into the alluvion (tons.)	Total Absorption (tons)	Average absorption into the clay cut off wall (t/1. ft)	Average absorption into the alluvion. (t/1. ft.)
1	50	6	56	0.00	0.19	0.19	0.000	0.031
1a	50	2	52	2.52	0.00	2.52	0.050	0.000
2	50	4	54	4.16	1.19	5.35	0.083	0.300
2a	52	4	56	7.60	7.56	15.16	0.146	1.890
3	52	6	58	0.37	0.52	0.89	0.007	0.087
3a	53	10	63	1.83	16.44	18.27	0.035	1.644
4	53·5	11	64·5	8.70	0.82	9.52	0.162	0.075
4a	51	12	63	3.40	7.94	11.34	0.066	0.660
5	53 5	16·5	70	1.52	26.28	27.80	0.028	1.590
5a	53	19	72	0.53	0.88	1.41	0.010	0.046

6	53	19	72	0.18	8·28	8.46	0.003	0.438
6a	53	21	74	0.45	1.47	1.92	0.008	0.070
7	53	23	76	0.50	1.64	2.14	0.010	0.071
7a	53	24	77	0.65	1.61	2.26	0.012	0.067
8	54	25	79	0.26	0.50	0.76	0.005	0.020
8a	54	25	79	0.00	0.00	0.00	0.000	0.000
9	54	26	80	0.47	0.94	1.41	0.009	0.036
9a	54	27	81	0.65	1.70	2.35	0.012	0.063
10	53	27	80	0.21	0.96	1.17	0.004	0.035
10a	54	28	82	0.47	3.90	4.37	0.008	0.140
11	54	29	83	0.59	1.50	2.09	0.010	0.052
11a	54	35	89	3.13	1.73	4.86	0.058	0.049
12	54	36	90	0.00	3.53	3.53	0.000	0.098
12a	52	44	96	0.00	6.70	6.70	0.000	0.153
13	53·5	36.5	90	25.81	36.60	62.41	0.482	1·000
13a	52	42	94	0.24	0.50	2.79	0.004	0·060
14	53	42	95	27.60	7.74	35.34	0.522	0·184
14a	53	44	97	0.18	6.90	7.08	0.003	0·157

Appendix A—(*contd.*)

KURRAM GARHI SCHEME—GROUTING WORKS AT BARAN DAN—(*contd.*)

Boring No.	Length of boring			Crouting				
	Through the clay (feet)	Through the alluvion (feet)	Total (feet)	Absorption into the clay cut-off wall. (tons).	Absorption into the alluvions (tons)	Total Absorption	Average Absorption into the clay cut-off wall (t/1 ft,)	Average absorption into the alluvion (t/1 ft)
15	52	42	94	0.79	1.16	1.95	0.015	0·027
15a	53	43	96	0·39	0.31	0.70	0.007	0·007
16	53	43	96	7.40	21.41	28.81	0.140	0·500
16a	54	42	96	0.24	0.90	1.14	0.017	0·021
17	53	41.5	94.5	0.53	1.50	2.03	0.028	0·036
17a	54	41	95	0.39	1.64	2.03	0.030	0·039
18	51	43.5	94.5	0.42	48.77	49.19	0.008	1·124
18a	54	42	96	0.57	2.38	2.95	0.010	0·057
19	81	44	125	0.80	4.35	5.15	0.010	0·099
19a	81	44	125	0.20	1.20	1.40	0.002	0·027

20	81	40	121	3.25	12.20	15.45	0.040	0·304
20a	81	44	125	0.80	0.75	1.55	0.010	0·017
21	81	44	125	0.20	1.60	1.80	0.002	0·037
21a	81	44	125	0.35	2.45	2.80	0.004	0 054
22	81	42	123	1.00	5.75	6.75	0.012	0·137
22a	81	43	124	0.20	0.60	0.80	0.002	0·014
23	81	42	123	0.60	6.40	7.00	0.007	0·152
23a	81	44	125	0.20	1.35	1.55	0.002	0·031
24	81	43	124	0.40	0.40	0.80	0 005	0·009
24a	81	44	125	0.20	3.40	3.60	0.002	0·078
25	81	44	125	0·40	3·60	4·00	0·005	0·082
25a	81	44	125	0·20	0·40	0·60	0·002	0·009
26	81	42	123	0·40	5·00	5·40	0·005	0·119
26a	81	44	125	0·20	3·05	3·25	0·002	0·069
27	81	44	125	0·20	1·20	1·40	0·002	0·027
27a	81	44	125	1·20	0·95	2·15	0·015	0·022
28	81	44	125	0·40	3·60	4·00	0·005	0·082
28a	81	43	124	0·20	2·45	2·65	0·002	0·057

Appendix A—(*contd.*)

KURRAM GARHI SCHEME — GROUTING WORKS AT BARAN DAM

Boring No.	Length of boring			Grouting				
	Through the clay (ft)	Through the alluvion (feet)	Total (feet)	Absorption into the clay cut off wall. (tons.)	Absorption into the alluvion (tons.)	Total Absorption (tons)	Average absorption into the clay cut off wall (t/1. ft)	Average absorption into the alluvion. (t/1. ft.)
29	81	43	124	57.58	27.65	85.23	0.710	0.643
29a	81	43	124	0.20	1.40	1.60	0.002	0.033
30	80	46	126	0.48	0.96	1.44	0.006	0.021
30a	81	44	125	0.20	1.95	2.15	0.002	0.044
31	81	44	125	41.73	57.58	99.31	0.515	1.310
31a	81	45	125	0.20	1.35	1.55	0.002	0.030
32	81	44	125	0.72	6.37	7.09	0.009	0.145
32a	81	44	125	0.20	0.60	0.80	0.002	0.014
33	81	46	127	0.66	14.30	14.96	0.008	1.312
33a	81	44	125	0.20	0.20	0.40	0.002	0.004

34	81	44	125	0.21	2·43	2.64	0.002	0.055
34a	81	43	124	0.20	0.40	0.60	0.002	0.009
35	80	44	124	0.24	2.33	2.57	0.003	0.053
35a	81	40	121	0.20	0.20	0.40	0.002	0.004
36	81	41	122	1.26	25.82	27.08	0.015	0.631
36a	81	41	122	0.20	0.20	0.40	0.002	0.004
37	81	42	123	0.20	7.20	7.40	0.002	0.171
37a	81	42	123	0.20	0.80	1.00	0.002	0.019
38	80	40	121	0.21	4.29	4.50	0.002	0.107
38a	81	40	121	0.40	1.50	1.90	0.005	0.037
39	81	40	121	1.10	11.40	12.50	0.014	0.286
39a	81	40	121	0.20	2.80	3.00	0.035	0.070
40	81	39	120	0.20	0.50	0.70	0.002	0.013
40a	81	41	122	0.40	0.40	0.80	0.005	0.010
41	81	39	120	0.20	3.60	3.80	0.002	0·092
41a	81	41	122	1.60	0.40	2.00	0.020	0·010
42	81	41	122	0.40	6.80	7.20	0.005	0·166
42a	81	41	122	0.20	0.20	0.40	0.002	0·005

Appendix A—(*contd.*)

KURRAM GARHI SCHEME — GROUTING WORKS AT BARAN DAM

Boring No.	Length of boring			Grouting				
	Through the clay (ft.)	Through the alluvion (feet)	Total (feet)	Absorption into the clay cut off wall. (tons.)	Absorption into the alluvion (tons.)	Total Absorption (tons)	Average absorption into the clay cut off wall (t/1. ft)	Average absorption into the alluvion. (t/1. ft.)
43	81	40	121	0.20	2.45	2.65	0.002	0.061
43a	81	40	121	0.40	2.55	2.95	0.005	0.064
44	81	39	120	70.04	44.19	144.23	0.865	1.130
44a	81	39	120	0.20	1.20	1.40	0.002	0.031
45	81	40	121	0.20	1.40	1.60	0.002	0.035
45a	80	41	121	0.20	0.20	0.40	0.002	0.005
46	81	39	120	0.20	0.60	0.80	0.002	0.015
46a	80	40	120	0.60	3.40	4.00	0.007	0.085
47	81	40	121	0.20	0.60	0.80	0.002	1.015
47a	80	41	121	0.40	1.20	1.60	0.005	0.030

48	81	40	121	0.20	8.20	8.40	0.002	0·205
48a	80	41	121	0.20	0.60	0.80	0.002	0·015
49	81	40	121	0.20	5.85	6.05	0.002	0·146
49a	80	42	122	0.60	2.20	2.80	0.007	0 052
50	81	40	121	0.20	2.60	2.80	0.002	0·065
50a	80	41	121	0.20	1.60	1·80	0.002	0·039
51	81	41	122	78.25	36.85	115.10	0.965	0·898
51a	80	41	121	0.80	1.20	2.00	0.015	0·029
52	80	41	121	0.60	8.00	8.60	0 007	0·195
52a	80	42	122	0.40	1.20	1.60	0.005	0·029
53	81	41	122	0·40	2·40	2.80	0·005	0·059
53a	81	42	123	0·20	1·20	1·40	0·002	0·029
54	81	41	122	0·40	7·15	7·55	0·005	0·175
54a	80	40	120	1·00	8·35	9·35	0·012	0·208
55	81	40	121	3·35	3·60	6·95	0·042	0·090
55a	80	41	121	0·20	1·40	1·60	0·002	0·034
56	81	41	122	0·20	9·55	9·75	0·002	0·233
56a	80	40	120	0·20	1·20	1·40	0·002	0·030

Appendix A—(*contd.*)

KURRAM GARHI SCHEME—GROUTING WORKS AT BARAN DAM—(*contd.*)

Boring No.	Length of boring			Grouting				
	Through the clay (feet)	Through the alluvion (feet)	Total (feet)	Absorption into the clay cut-off wall. (tons).	Absorption into the alluvions (tons)	Total Absorption (tons)	Average Absorption into the clay cut-off wall (t/1 ft.)	Average absorption into the alluvion (t/1 ft)
57	81	39	120	0·20	2.95	3.15	0.002	0·075
57a	80	40	120	0·20	0.40	0.60	0.002	0·010
58	81	40	121	0.40	4.35	4.75	0.005	0·109
58a	80	41	121	1 60	4.00	5.60	0.020	0·097
59	81	40	121	0.20	2.40	2.60	0.002	0·060
59a	80	40	120	0·60	4.40	5.00	0.007	0·110
60	81	41	122	44.99	64.59	109.58	0.556	1·570
60a	81	41	122	0.60	5.40	6.00	0.007	0·132
61	81	41	122	0.20	0.55	0.75	0.002	0·013
61a	81	41	122	0.20	0.40	0.60	0.002	0·010

62	81	41	122	0.20	4·20	4.40	0.002	0.102
62a	81	40	121	0.80	4.15	4.95	0.010	0.102
63	81	38	119	0.20	0.20	0.40	0.002	0.005
63a	81	38	119	0.20	0.40	0.60	0.005	0.005
64	81	41	122	0.20	4.60	4.80	0.057	0.112
64a	81	41	122	2.45	2.25	4.70	0.028	0.055
65	81	41	122	0.20	0.90	1.10	0.011	0.022
65a	81	39	120	0.20	1.35	1.55	0.002	0.039
66	80	40	120	0.40	1.80	2.20	0.005	0.043
66a	81	39	120	0.20	0.40	0.60	0.002	0.010
67	81	39	120	2.40	15.40	17.80	0.030	0.396
67a	81	38	119	0.20	1.20	1.40	0.002	0.032
68	81	41	122	0.00	1.70	1.70	0.000	0.042
68a	81	42	123	0.20	0.20	0.40	0.002	0.005
69	81	44	125	39.20	1.20	41.40	0.482	0·027
69a	81	39	120	0.20	1.60	1.80	0.002	0·041
70	81	39	120	1.00	4.35	5.35	0.012	0·111
70a	81	34	115	0.20	1.85	2.05	0.002	0·054

Appendix A—(*contd.*)

KURRAM GARHI SCHEME—GROUTING WORKS AT BARAN DAM—(*contd.*)

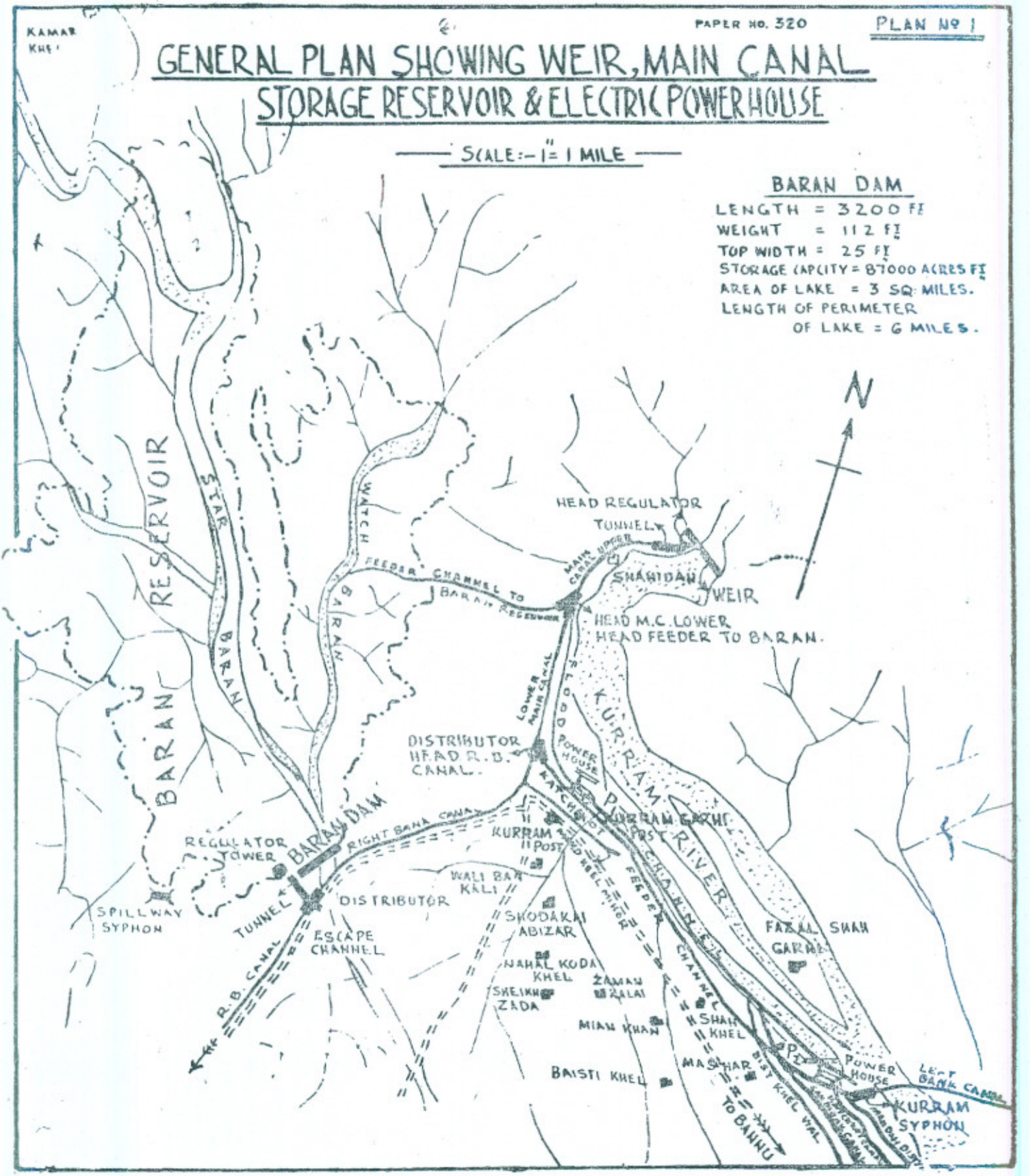
Boring No.	Length of boring			Grouting				
	Through the clay (feet)	Through the alluvion (feet)	Total (feet)	Absorption into the clay cut-off wall. (tons).	Absorption into the alluvions (tons)	Total Absorption (tons)	Average Absorption into the clay cut-off wall (t/1 ft.)	Average absorption into the alluvion (t/1 ft)
71	80	32	112	0·55	3.35	3.90	0.007	0·105
71a	80	30	110	0·20	1.20	1.40	0.002	0·040
72	81	25	106	112.45	22.40	134.85	1.390	0·895
72a	80	25	105	0 20	0.60	0.80	0.002	0·024
73	80	26	106	0.40	2.50	2.90	0.005	0·096
73a	80	25	105	0·20	1.85	2.05	0.002	0·082
74	80	22	102	0.20	0.40	0.60	0.002	0 018
74a	80	18	98	0.40	2.55	2.95	0.005	0·142
75	80	13	93	0.20	0.40	0.60	0.002	0·013
75a	80	10	90	0.40	2.60	3.00	0.005	0·260

76	80	7	87	0.80	2.60	3.40	0.010	0·372
B 1	54	25	79	7.20	5.99	12.19	0.133	0·240
B 2	54	26	80	2.13	14.76	16.89	0.040	0·566
B 3	54	26	80	3.85	11.26	15.11	0.071	0·432
B 4	54	25	79	0.58	5.65	6.23	0.011	0·226

PLAN NO 1

GENERAL PLAN SHOWING WEIR, MAIN CANAL STORAGE RESERVOIR & ELECTRIC POWER HOUSE

SCALE:- 1" = 1 MILE



BARAN DAM

LENGTH = 3200 FT
WEIGHT = 112 FT
TOP WIDTH = 25 FT
STORAGE CAPCITY = 87000 ACRES FT
AREA OF LAKE = 3 SQ. MILES.
LENGTH OF PERIMETER OF LAKE = 6 MILES.

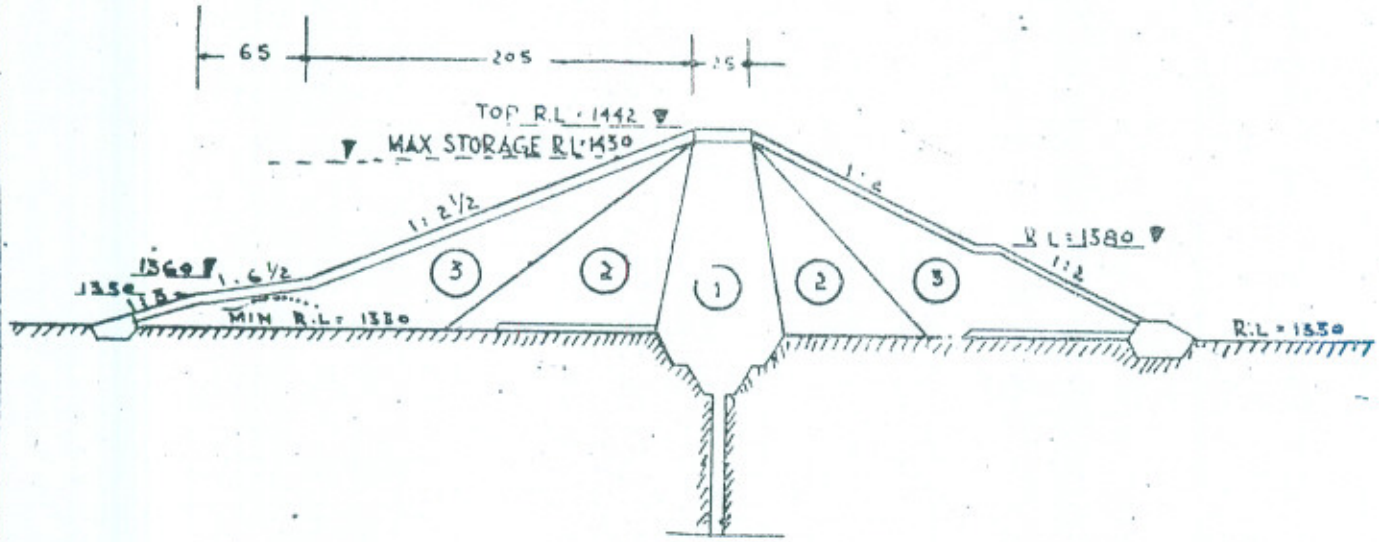
PLAN II

PAPER NO 320

KURRAM GARHI IRRIGATION SCHEME

FINAL SECTION OF THE BARAN DAM

SCALE : 1" = 120'



LENGTH AT CREST R.LEVEL 1442 = 320'

HEIGHT = 112 FT.

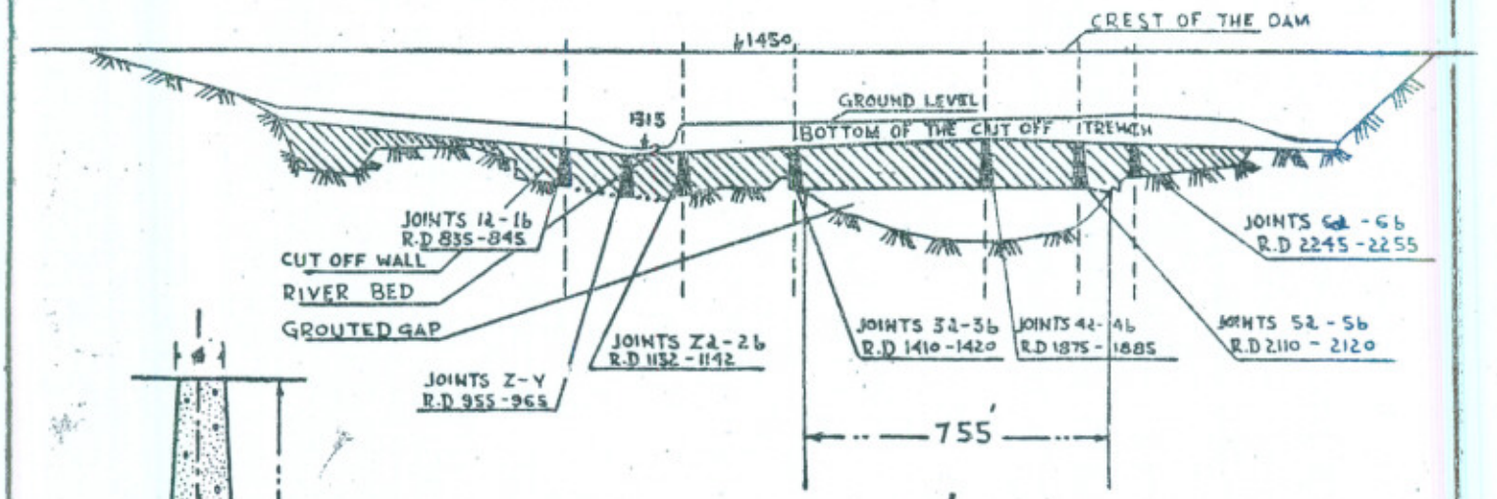
TOTAL QUANTITY OF FILL = 85 MILLION CFT.

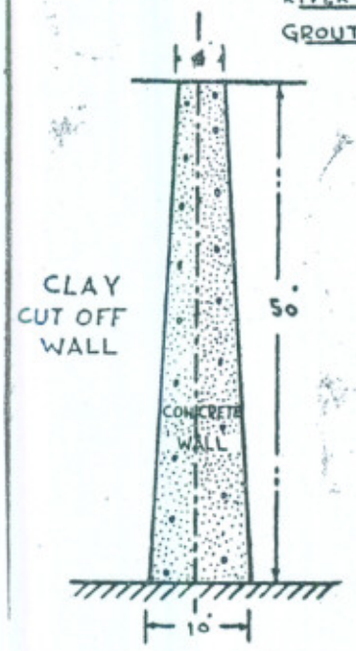
PLAN No. III

PAPER NO 320

-KURRAM GARHI SCHEME, BARAN DAM-

-LONGITUDINAL SECTION-





-PLAN OF BORINGS-

