International Conference on Dam Safety, 2023

CURTAIN GROUTING & CUT-OFF TRENCH ALONG U/S RIGHT BANK OF JOSHIYARA BARRAGE OF MANERI BHALI, STAGE-II HEP-304 MW, TO PREVENT WATER LOGGING IN GYANSU VILLAGE AREA IN DISTT-UTTARKASHI (UTTARAKHAND) EXECUTED UNDER DRIP PHASE-II: A CASE STUDY

by

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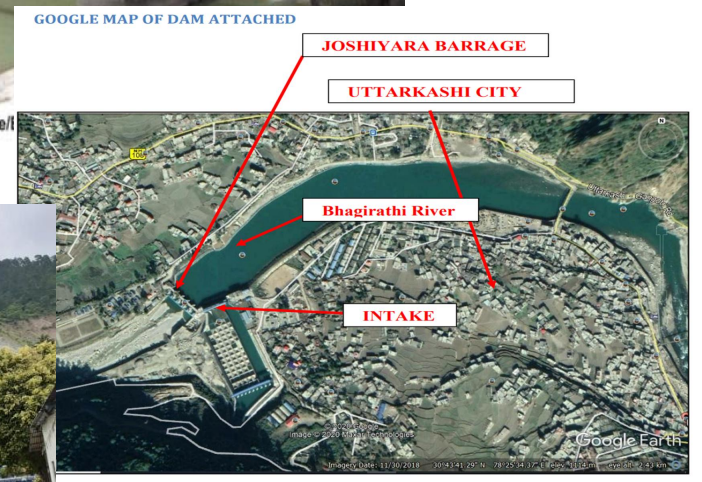
BRIEF HISTORY OF PROJECT:

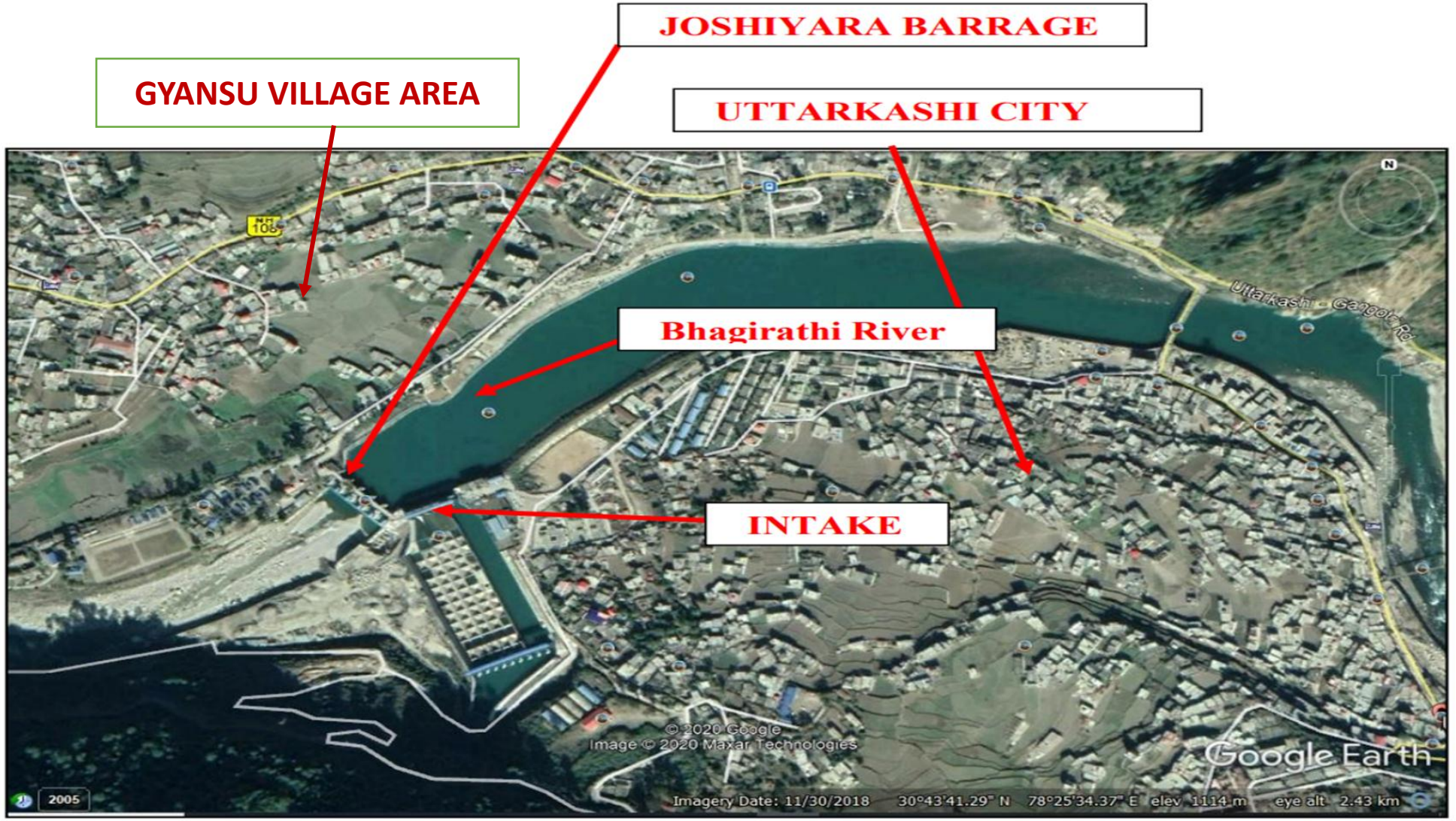
- The construction of Maneri Bhali Project, Stage-I was started in 1981.
- The project work stopped during 1992-2001 due to paucity of fund.
- After creation of Uttarakhand State the Project restarted in 2002 to complete the balance work.
- There after project commission in Feb 2008.
- It is a run of the River Scheme on River Bhagirathi in District-Uttarkash (Uttarakhand) having a
  - Barrage (81 Meter Length, 5 no. spillway bays with 5 radial Gates),
  - Sedimentation Tank(93 M Width X 182 meter Length,97 Hoppers),
  - HRT(6 Meter Dia and 16 KM length) ,
  - Surge Tank (Restricted Orifice type 172 Meter Height and 13.7 Meter Dia),
  - Power House (4 Nos Frances Turbine each 76 MW capacity) with annual generation is nearly 1300 MU.

Radial Gate/I



PLAN OF JOSHIYARA BARRAGE:

GOOGLE MAP OF DAM ATTACHED



What was the problem ?

- Waterlogging in the agricultural land (level < 1105 m).
- Seepage of water inside floors of residential houses of Gyansu village.
- Overflow of septic tanks of houses.

Causes of the problem :

- The foundation rock of right embankment is of highly fractured phyllite nature.
- High permeability of overburden strata in the affected areas to the tune of 10^{-1} cm/sec.
- The existing cut-off trench was not sufficient deep to catch the seepage line
- The affected area having EL 1105m – 1102m is lower than the FRL (EL 1108 m) of reservoir.

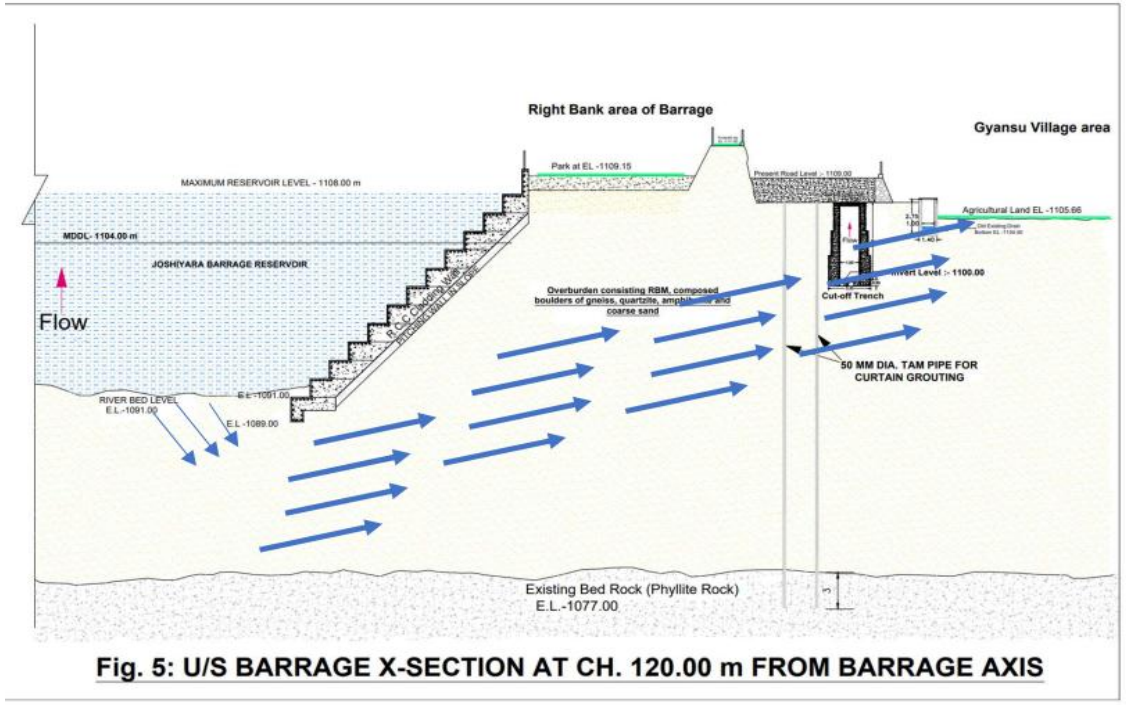
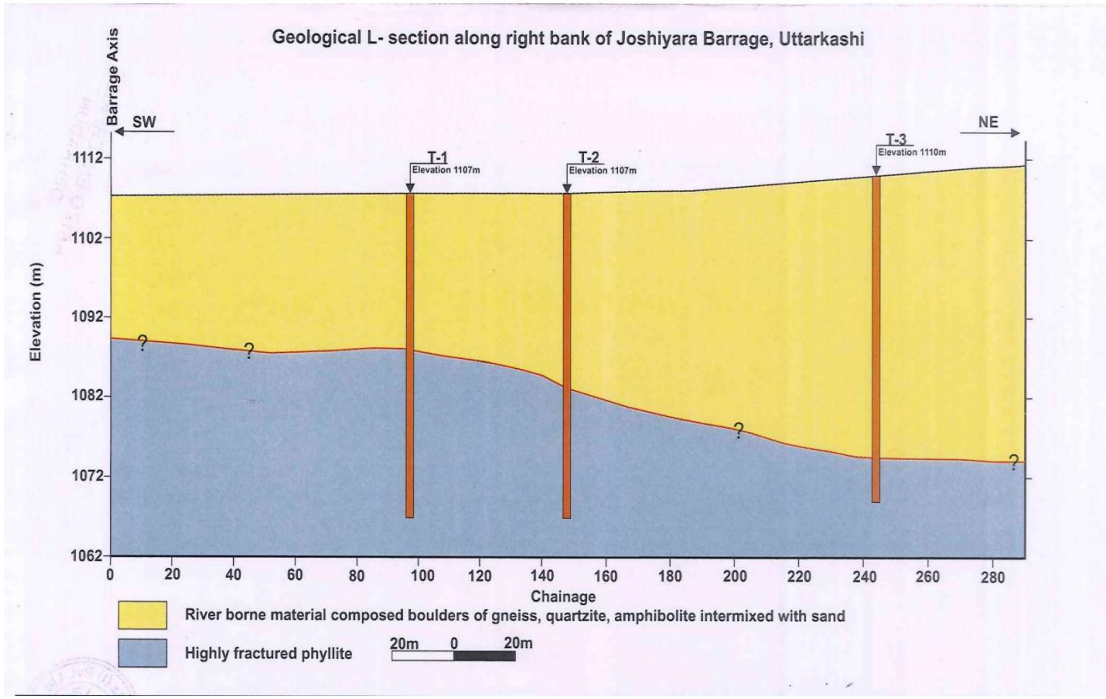


Fig. 5: U/S BARRAGE X-SECTION AT CH. 120.00 m FROM BARRAGE AXIS



Experts suggestions:

1. Deepen the already provided cut off Trench along its full length.
2. Provide a cut off wall on the peripheral side outside the compound wall of the houses so that the seepage is checked & water level is pushed down and guided towards downstream side.
3. Provide relief wells at two locations on the open ground/field and then arrange for draining the collected water.
4. To provide open Jointed drains in the area wherever possible and to connect these with the existing cut off drain.
5. Fill low laying area with RBM so the seepage water passes below the surface
6. To provide a sewar line with STP to sort out the problem of overflow from sceptic tanks in affected low laying houses.
7. To partially acquire the bare minimum area of houses and land adjacent to cut off drain and improve the existing cut off drain by lowering and widening of the same by making it deeper to catch the seepage line.
8. Install grout curtains in the entire length of the affected reach on the right bank embankment

Remedial measures adopted:

Providing two rows of cement grout curtain.

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Construction of a deep cut off trench along the right embankment.

- The distance between two row 2.5 m.
- The grout holes in each row is @ 2.5m c/c spacing.
- Holes in inner & outer row are staggered with each other.
- The depth of grout hole is 35m from ground level to foundation rock. Holes were extended upto 3m depth in foundation rock.
- **As overburden strata consist of RBM, boulders & coarse sand, Tube-a-Manchatte (TAM) grouting technique was found most suitable and adopted for making cement grout curtain.**

- Average invert level of cot-off trench is kept at EL 1100 m with downward slope of 1 in 100 to allow the seepage water flow under gravity into the river at downstream of barrage.
- The invert level of cut-off trench at discharge end is at EL 1098.50 m.

Sub-surface soil investigations:

Sl No	Investigation	Purpose/Findings
1-	Geo-Electrical Resistivity Test (ERT)	Mapping vertical as well as horizontal variations of electrical resistivity to enable detection of the boundaries between unconsolidated material and rocks of different resistivity. To establish bed rock profile and to identify high permeability zones in embankment.
2-	Self-Potential Survey (SP)	
3-	Seismic Refraction Tomography (SRT)	To determine stratigraphy along proposed route i.e soil, weathered rock, and rock interface.
4-	Drilling & Core test	To determine the overburden material property & to establish bed rock depth. Core drill logs upto 40 m depth of strata were collected in 03 set of test triangles at three different locations.
5-	Permeability Test	In-situ permeability test was performed in over burden by constant head method as per Indian standard 5529 (part-1). Based on these results the pre-grouting permeability of strata is calculated around 10^{-1} cm/sec.
6-	Groutability Test	Groutibility test was conducted by equilateral triangle method.

Findings of ERT & SP test:

(barrage axis has taken chainage 0.0m)

- One highly water saturated zone from chainage 15m at a depth of 21m below ground level
- Second highly water saturated zone from chainage 100m to 180 m at a depth of 16m below ground level
- Most of the portion of SP curve showing –ive values means presence of water saturation in that zone.

Profile-1: Towards reservoir side
Profile-2: Towards agricultural land & houses
Survey conducted in 250m length in affected reach and results interpreted for 35m depth

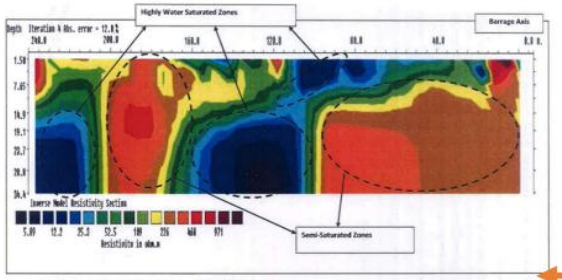
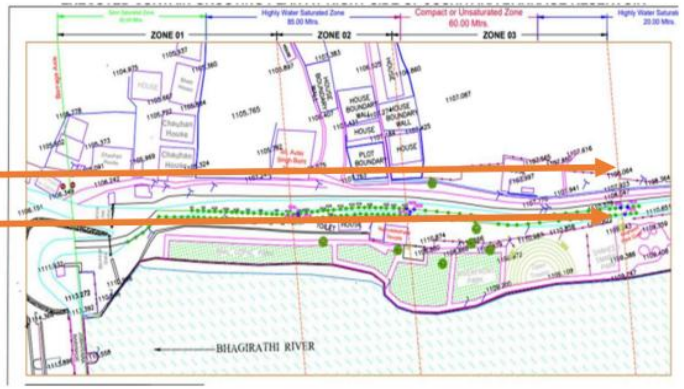


Fig. 7b: Resistivity Tomogram section for Profile-2



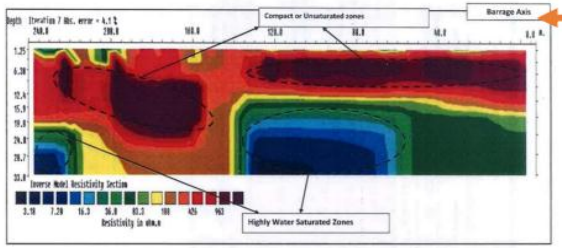
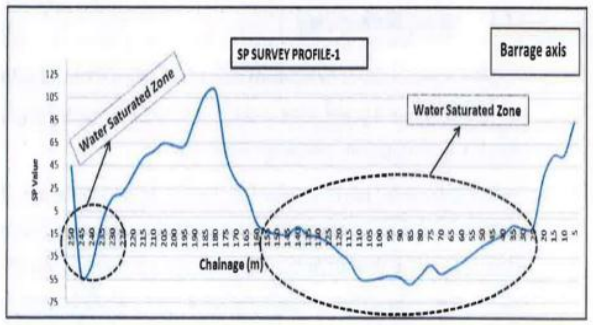
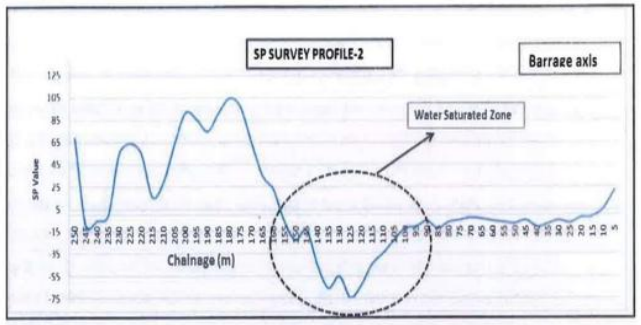


Fig. 7a: Resistivity Tomogram section for Profile-1





Findings of Seismic Refraction Tomography Test:

- ERT was performed in 276 m length of 02 segment each 138m length along the reservoir near proposed grouting zone
- Upper layer of soil/dense unconsolidated overburden varies in thickness of approximately 12m.
- Highly to moderately weathered rock that rests below the upper layer of soil has been projected to a maximum depth of 35m.
- Beyond 35m depth there exist a better strength of rock i.e bed rock

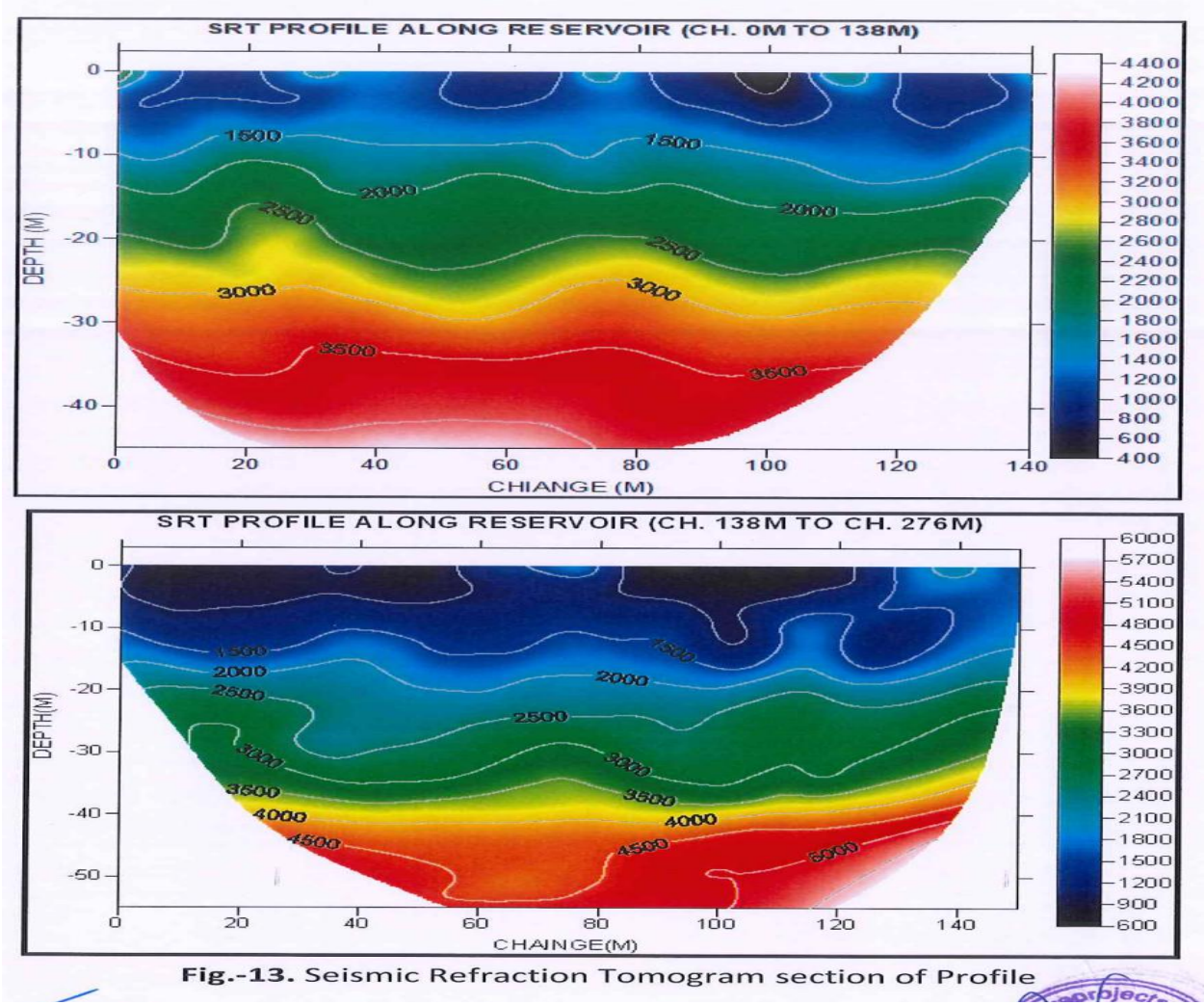


Fig.-13. Seismic Refraction Tomogram section of Profile

Findings of Core Test:

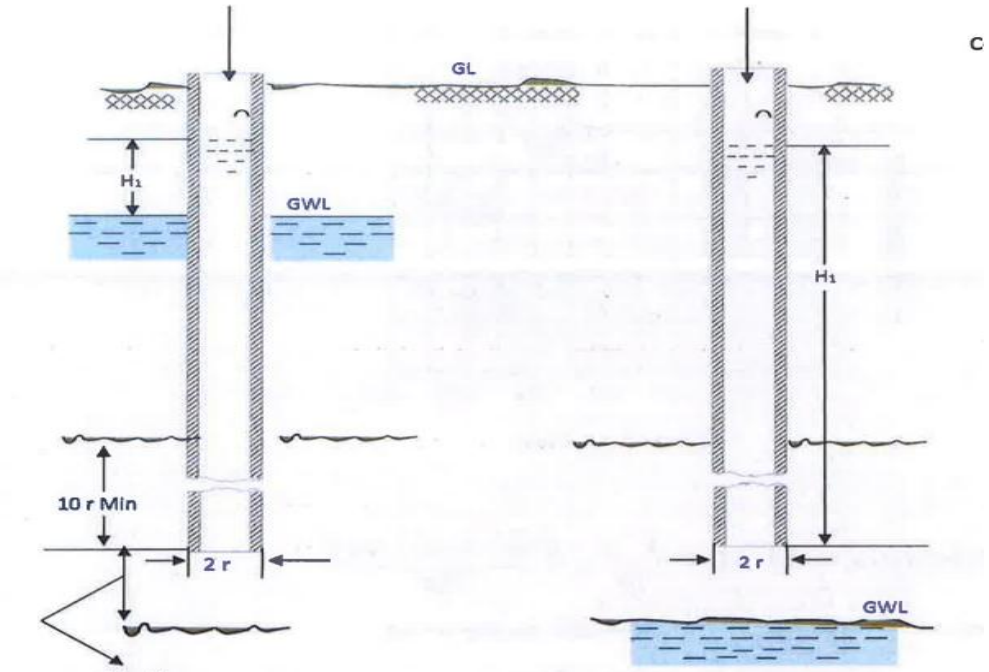
(Triple tube core barrel used)

- From 0m to 27m depth boulders of quartzite, gneiss and amphibolite are occurred intermixed with coarse sand. After 27m depth highly fractured phyllite was encountered
- Due to presence of sand & pebbles core recovery was 10 to 45%.
- RQD cannot determined as, no core obtained more than 10 cm.
- The core recovery was very poor due to high angle of foliation & core bit was parallel to foliation

Core samples obtained from diamond core drilling

In-situ Permeability Test (pre-grouting):

- Based on ERT, SP & SRT test 03 vulnerable zones selected for permeability test.
- Due to high permeable strata containing RBM & composed boulders constant head permeability test used.
- Based on these results the pre-grouting permeability of strata is calculated around 10^{-1} cm/sec to 10^{-2} cm/sec



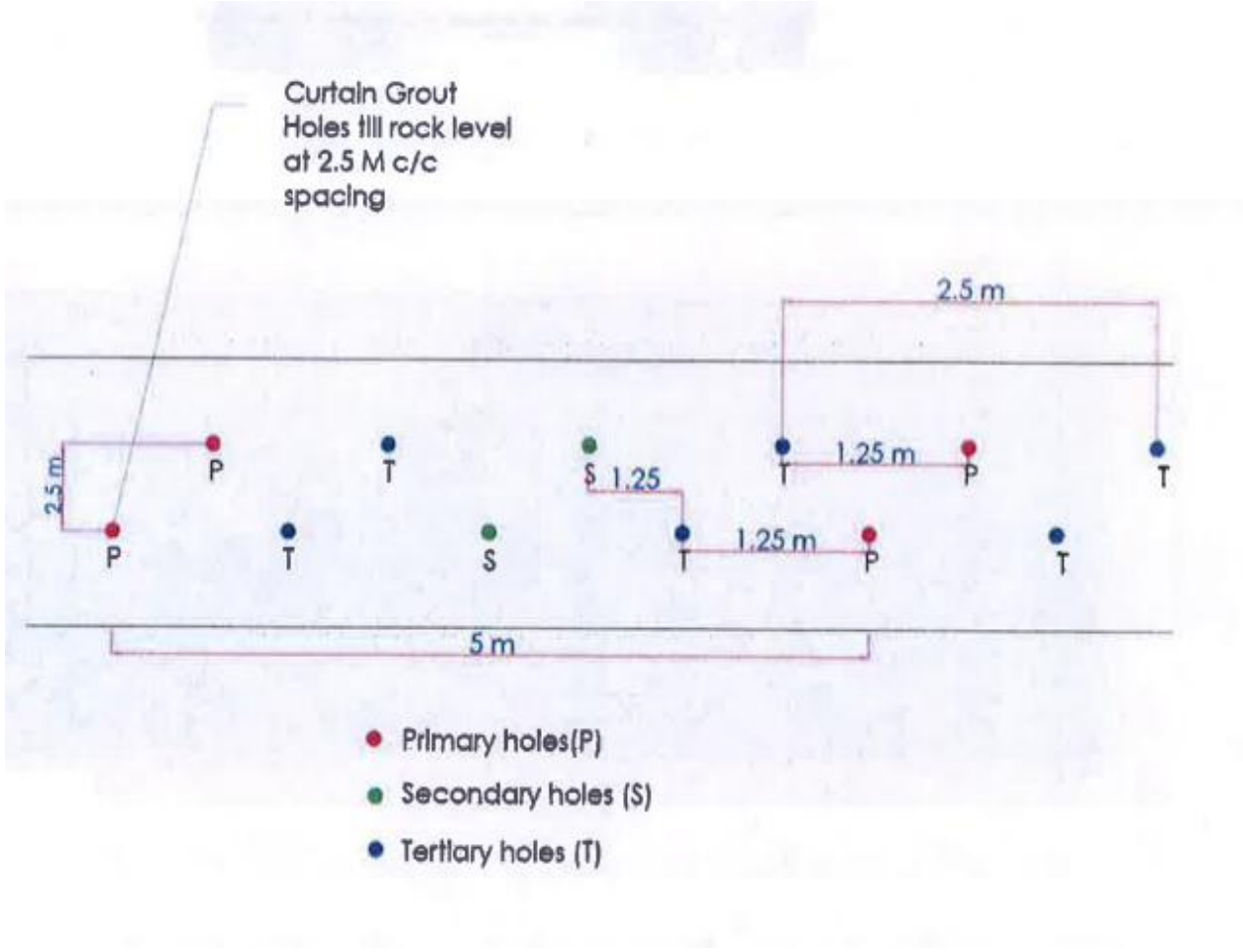
efficient of permeability 'K' is given by:

$$K = C_1 \times Q/H$$

K	=	Co-efficient of permeability in cm/sec
C_1	=	Varies with the size of casing and rods, the valves are given in the table below
Q	=	Discharge in l/m
H	=	Head in meter = H_1 (Gravity head) – H_F (Head loss due to friction)

Groutibility Test (triangle method):

- 1st Primary hole of 35 m depth were drilled at corner position of triangle & grouted in ascending order by double packer
- 2nd & 3rd Primary holes of 35 m depth were also drilled at corner position of triangle of 2.5m side & grouted in ascending order by double packer
- Test hole was drilled in centre position & tested for permeability & traces of grout material



Grout Material, Mix Design of Grout & Grout Pressure:

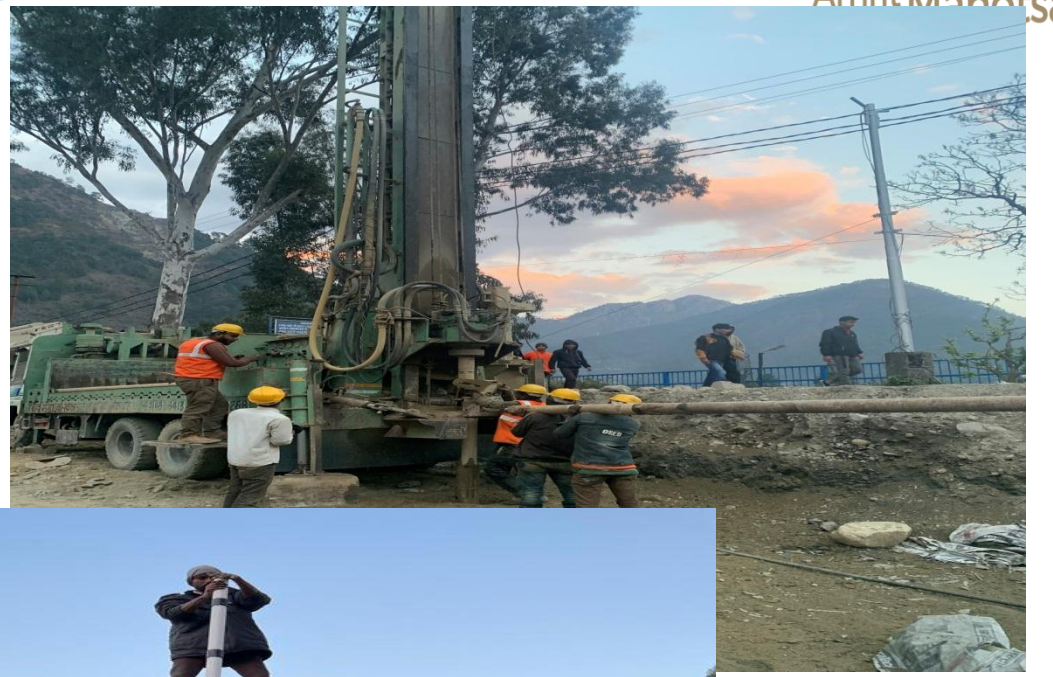
- Cement is most suitable grouting material for strata having RBM, boulder and sand.
- To make the cement grout colloidal, bentonite was added.
- Combination of cement-bentonite was selected as grouting material.
- Based on the tested triangle data and drill logs the design consultant & field geologist has suggested following mix design for grouting given in Table-1.
- Coarse sand was also to be added in case the grout intake is excessive.
- Grout pressure was limited to 5 kg/cm^2 to avoid hydraulic fracture of strata.

Table-1: Mix Design of Grout

Mix No	Cement (by weight in kg)	Sand (by weight in kg)	Bentonite (by weight in kg)	Accelerator (by weight in kg)	Water in Ltr
M1	96	-	4	-	100
M2	93	-	7	-	100
M3	90	-	10	-	100
M4	65	25	8	2	100
M5	62	25	8	5	100
M6	80	10	8	2	100

Execution of TAM Grouting:

- As overburden strata consist of RBM, boulders & coarse sand, Tube-a-Manchatte (TAM) grouting technique was found most suitable and adopted for making cement grout curtain.
- As strata was in collapsible nature, MS casing pipe was lowered simultaneously with drilling



- Depth of bore hole: 35m-40m
- Diameter of bore hole : 172 mm
- Diameter of MS casing pipe: 168 mm
- Diameter of TAM pipe: 62 mm

Site Pics:

Site visit of CPMU, CWC

Site visit of CSMRS

Executed x-section of curtain grouting:

In affected reach of 250 m length

- 70 Nos. holes @ 2.5m c/c were drilled in inner row and
- 57 Nos holes @ 2.5m c/c were drilled in outer row.
- The depth of holes was 35m-40m depth including 3m in bed rock.

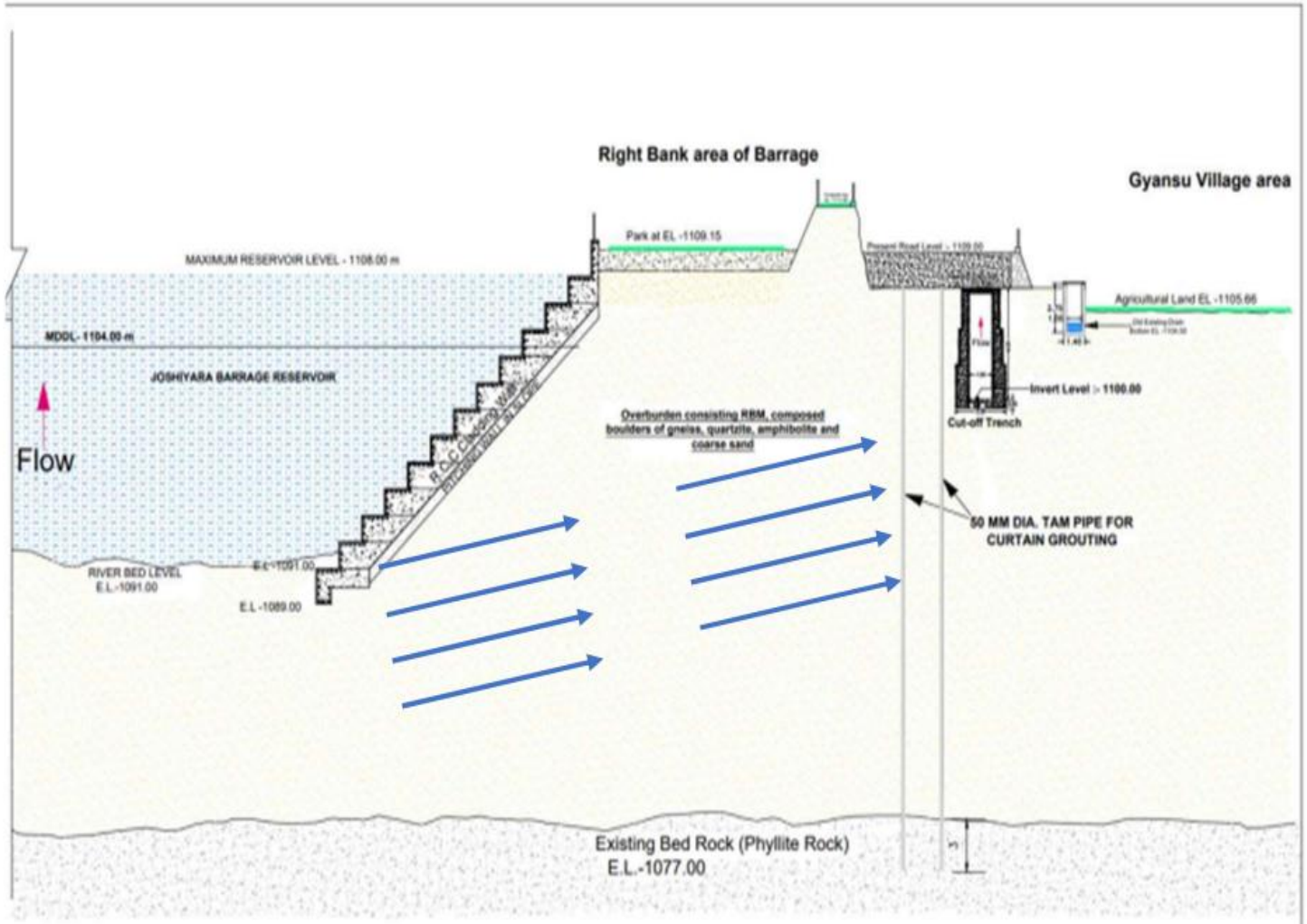
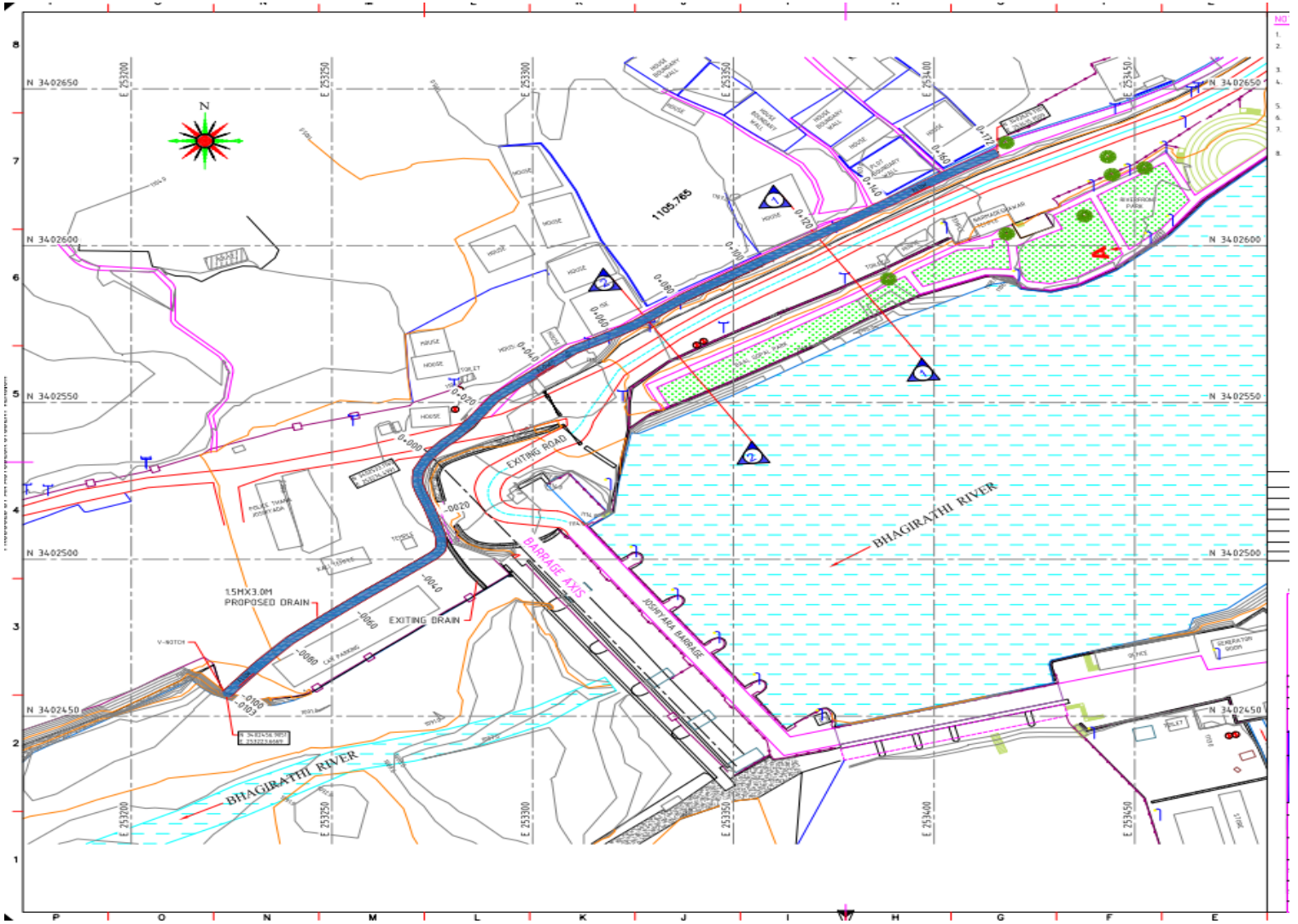


Fig. 5: U/S BARRAGE X-SECTION AT CH. 120.00 m FROM BARRAGE AXIS

Execution plan of cut-off trench:

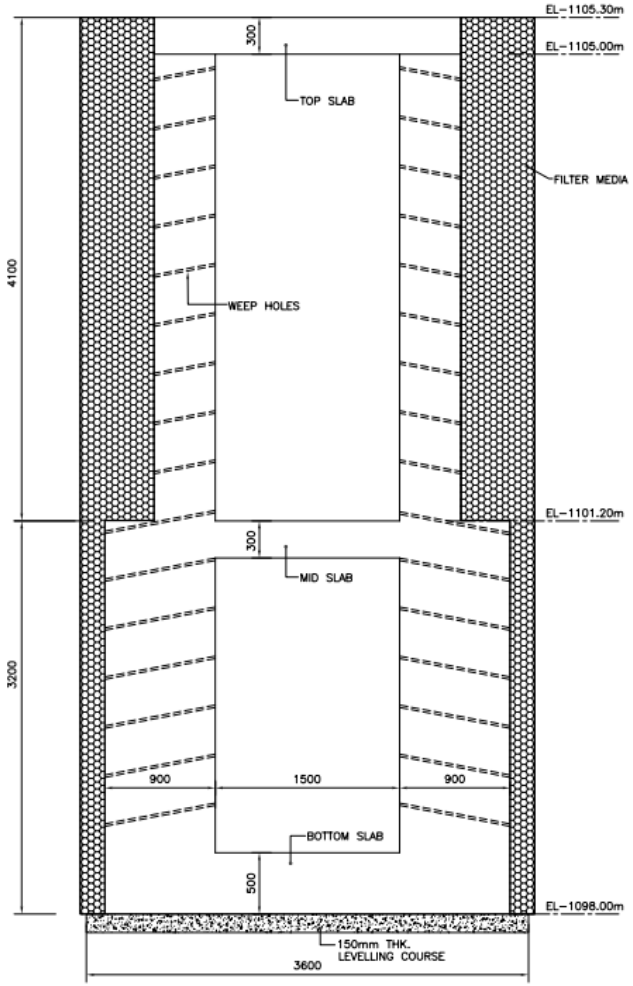
A deep cut off trench of 300m length along the right embankment has been constructed.

- At start point the invert level of trench was at EL 1101.50 m with downward slope of 1 in 100.
- The invert level of cut-off trench at discharge end near downstream of barrage is at EL 1098.50 m.
- The river bed level in Joshiyara reservoir is at EL 1092m and FRL of reservoir is EL 1108m. The head is 16m (1108m-1092m).
- The average bed level of cut-off trench is more than H/2.

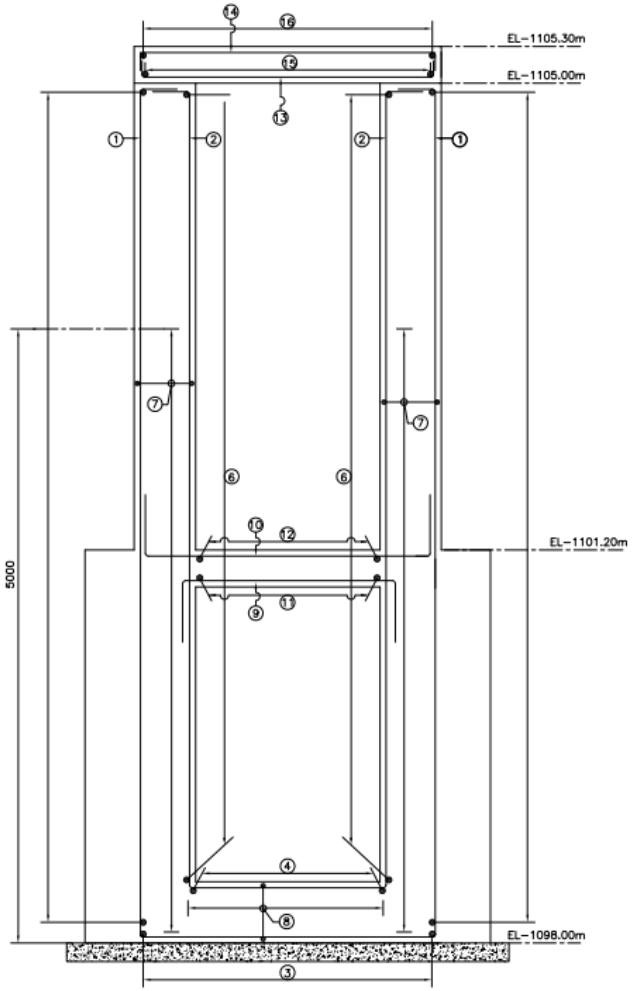


Execution of cut-off trench:

Construction drawing of cut-off trench:



TYPICAL CROSS SECTION OF MANHOLE
(SHOWING DIMENSIONS ONLY)
(SCALE 1:30)



TYPICAL CROSS SECTION OF MANHOLE
(SHOWING REINFORCEMENT ONLY)
(SCALE 1:30)

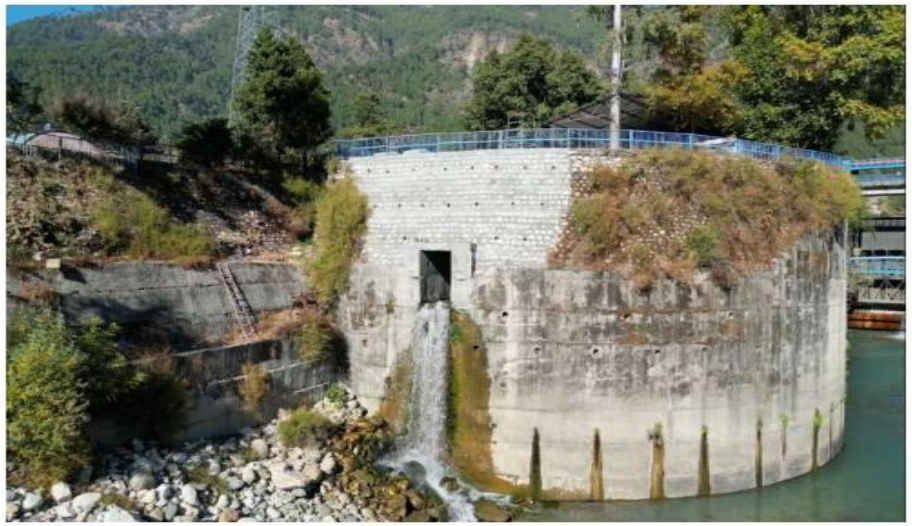
NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE FOR PRECAST RCC SLAB SHALL BE M-20 AND FOR LEVELLING COURSE SHALL BE M15.
4. REINFORCING STEEL SHALL BE HSD BARS (GRADE DESIGNATION FE:500D) CONFORMING TO IS:1786.
5. BARS SHALL BE LAPPED IN SUCH A WAY THAT NOT MORE THAN 50% OF THE BARS ARE LAPPED AT ANY SECTION. UNLESS OTHERWISE NOTED, LAP LENGTH FOR BARS AT TOP OF TOP, MID & BOTTOM SLAB SHALL BE '109XD' & FOR OTHER IT SHALL BE '76XD', WHERE 'D' IS THE DIAMETER OF SMALLER BAR.
6. MINIMUM CLEAR COVER
   a) TOP SLAB —— 40mm
   b) WALLS —— 50mm
   c) BOTTOM SLAB —— 75mm

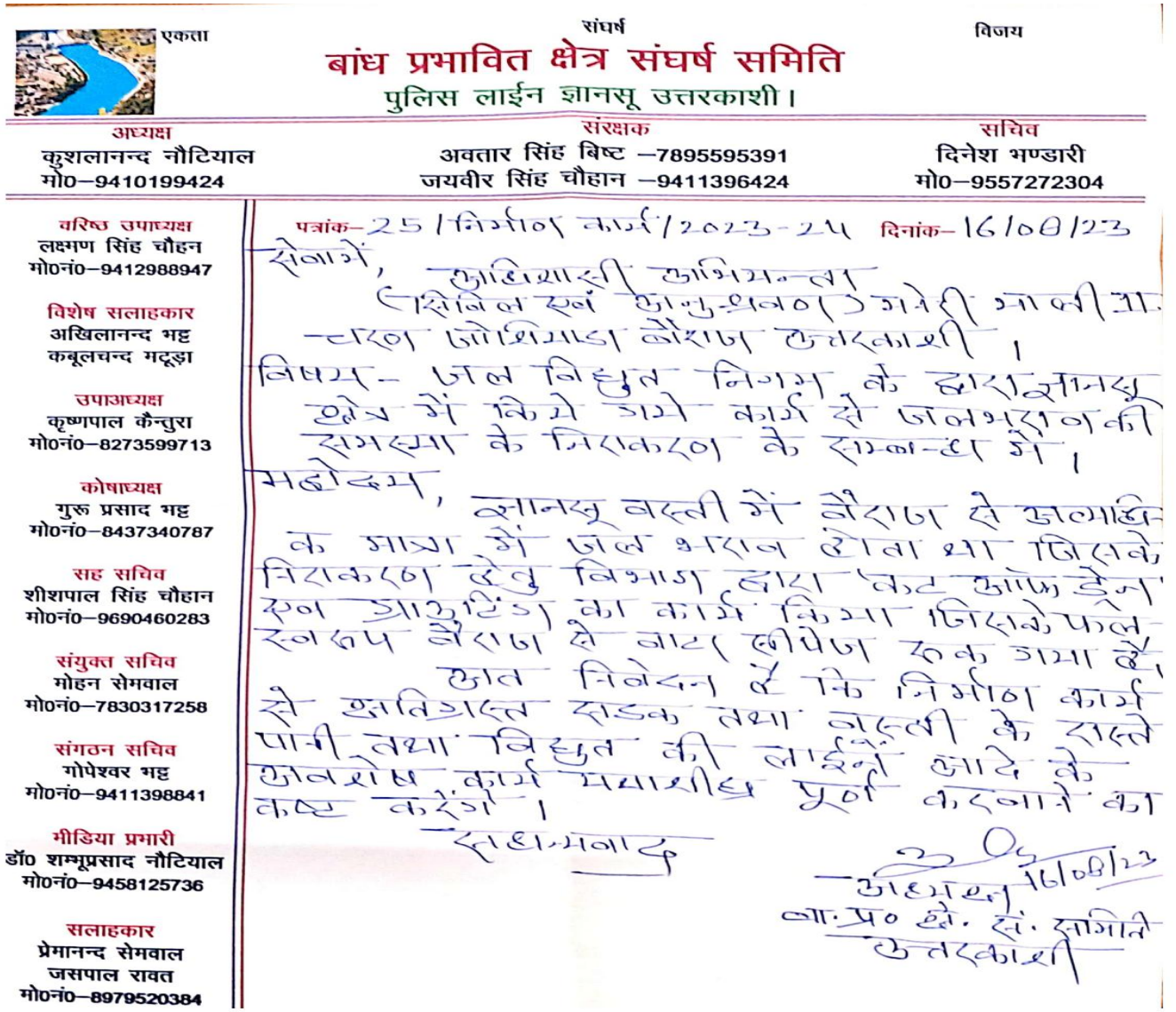
REINFORCEMENT DETAILS:

BAR MARKED	DIA. OF BAR IN (mm)	SPACING/NO.	SHAPE
1	16	100 c/c	300
2	12	100 c/c	300
3	10	150 c/c	300
4	10	150 c/c	300
5	10	150 c/c	300
6	10	150 c/c	300
7	10	300 c/c @ VERTICAL DIRECTION 200 c/c @ TRANS. DIRECTION	
8	10	300 c/c @ LONG. DIRECTION 200 c/c @ TRANS. DIRECTION	
9	12	100 c/c	500
10	12	100 c/c	500
11	10	150 c/c	200
12	10	150 c/c	200
13	12	150 c/c	200
14	12	150 c/c	200
15	10	200 c/c	200
16	10	200 c/c	200

Cut-off trench in its function:



All is well if end is well_Problem Resolved



एकता संघर्ष विजय

बांध प्रभावित क्षेत्र संघर्ष समिति

पुलिस लाईन ज्ञानसू उत्तरकाशी।

अध्यक्ष	संरक्षक	सचिव
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पत्रांक–25/निर्माण कार्य/2023-24 दिनांक–16/08/23

सेवामें,

अधिशासी अभियन्ता
एसेंबिल एवं आनु-श्रवण (1) गंगोत्री जल
-चरण जोशियाड़ा बौरागढ़ उत्तरकाशी।

विषय– जल विद्युत निगम के द्वारा ज्ञानसू
क्षेत्र में किये गये कार्य से जलभराव की
समस्या के निराकरण के सम्बन्ध में।

महोदय,

ज्ञानसू बस्ती में बैराज से जलाधिक
क मात्रा में जल भराव होता था जिसके
निराकरण हेतु विभाग द्वारा कट ऑफ ड्रेन
एवं ग्राउटिंग का कार्य किया जिसके फल-
स्वरूप बैराज से बाट (बीच) एक गया है।
अत निवेदन है कि निर्माण कार्य
से अतिरिक्त डाक तथा बस्ती के रास्ते
पानी तथा विद्युत की लाईनें आदि के
अवशेष कार्य यथाशीघ्र पूर्ण करवाने का
कष्ट करेंगे।

धन्यवाद

–अधिशासी 16/08/23
वा.प्र० क्षे. सं. सागली
उत्तरकाशी

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