

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET i OF ii

Contents

12 Grouting.....	1
12.1 Scope Of Work.....	1
12.2 Submittals	2
12.3 Definitions	4
12.4 Standards.....	8
12.5 Grouting Methods.....	9
12.5.1 General	9
12.5.2 Plant And Equipment.....	9
12.5.3 Embedded Pipes And Fittings For Grouting.....	12
12.5.4 Site Laboratory.....	13
12.6 Grouting Materials.....	14
12.7 Grout Mixes.....	16
12.7.1 Pure Cement Slurries	16
12.7.2 Stable Bentonite-Cement Grouts.....	16
12.8 Execution	19
12.8.1 General	19
12.8.2 Grouting Procedure	19
12.8.3 Underground Grouting.....	22
12.8.4 Contact Grouting Between Concrete And Rock.....	23
12.8.5 Contact Grouting Between Backfill Concrete And Steel Lining	24
12.8.6 Contact Grouting Between New Plug Concrete And Old Conduit Concrete	26
12.8.7 Fill Grouting.....	26
12.8.8 Consolidation Grouting.....	27
12.8.9 Curtain Grouting.....	30
12.8.10 Crack Grouting	31

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET ii OF ii
<div> <div>12.8.11 Protection Of Drainage System During Grouting 32</div> <div>12.8.12 Closure Of Holes And Clean-Up..... 32</div> <div>12.8.13 Simple Water Pressure Testing 32</div> <div>12.8.14 Comprehensive Water Pressure Testing 33</div> <div>12.9 Measurement And Payment..... 35</div> <div>12.9.1 General 35</div> <div>12.9.2 Water-Pressure Testing..... 36</div> <div>12.9.3 Exclusions - Grouting 37</div> </div>		
	<div>ISSUE</div> <div>P0</div>	


	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 1 OF 37


12 **GROUTING**


12.1 **SCOPE OF WORK**

- i) Drilling for grouting is covered under the separate Chapter, "Drilling".
- ii) The work under this Chapter includes all labour, materials, plant, equipment, operations and services required for grouting in the holes from the surface and from underground construction sites, and for the execution of water-pressure tests, at locations shown on the Drawings or as directed by the Project Manager.
- iii) Grouting operations shall include the following:
 - a) Contact grouting to fill voids between concrete and rock, between backfill concrete and steel lining, and in the concrete plugs in the tunnels and construction sluices,
 - b) Consolidation grouting of dam foundation and concrete structures, and of the rock surrounding the tunnels and caverns, which shall commence after placing of the concrete lining and completion of contact grouting,
 - c) Curtain grouting to a sufficient depth below the core of the dam and from appurtenant structures in order to create a zone with a low permeability; curtain grouting shall be executed from the surface and from galleries,
 - d) Fill grouting of drainage trench, conduits and sump pits, and of exploratory drill holes and drain holes,
 - e) Consolidation grouting in the heading zone during tunnel excavation to consolidate the heading face before further advance in zones of sheared and disturbed material and/or in zones of high water inflow,
 - f) Crack grouting, at pressures as directed by the Project Manager, to seal open cracks and joints in the structural concrete lining,

ISSUE
P0


	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 2 OF 37
<div> <div> g) </div> <div> Chemical grouting in zones of fine sands and soils, and to control the water inflow and increase the stability and strength of the formation that are too tight to be grouted with a cement grout. </div> </div> <div> <div>iv)</div> <div>The whole temporary drainage system in the underground works shall be filled with grout after completion of the inner lining.</div> </div> <div> <div>12.2</div> <div><u>SUBMITTALS</u></div> </div> <div> <div>i)</div> <div>At least 56 days prior to the start of the grouting works, the Contractor shall submit for approval fully detailed proposals and a detailed layout of his proposed arrangements for grouting, including specifications of all equipment, tools and all grouting materials to be used, and qualification and experience of the proposed personnel.</div> </div> <div> <div>ii)</div> <div>An overall grouting program shall be drawn up jointly between the Contractor and the Project Manager. Grouting mixes, pressures, pumping rates, and sequencing will be selected, subject to modifications, to meet local conditions encountered during the performance of the work. Grouting works shall be planned in such a manner that they can be carried out according to the approved plan concurrently with other activities. Modifications to the grouting program shall be implemented as directed by the Project Manager.</div> </div> <div> <div>iii)</div> <div>Prior to each phase of grouting, the Contractor shall submit for approval a detailed program for the particular grouting works along with information relating to the methods he proposes to use and details of grout mixes. No grouting work shall be executed without prior written approval by the Project Manager.</div> </div> <div> <div>iv)</div> <div>During the performance of the grouting works, the Contractor shall keep complete daily records of all grouting operations. These grouting records shall be compiled on an approved form and shall be submitted weekly to the Project Manager. Results of water pressure tests and grout takes shall be presented in tabular form as well as graphically. Drilling, washing, pressure, testing and grouting records shall be kept neatly and systematically as work</div> </div>		
		<div>ISSUE</div> <div>P0</div>


	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 3 OF 37
<p>proceeds. The exact location of all holes with reference to axis and chainage along the tunnels or dam shall be recorded and an accurate log of all operations kept. Record maps and sections shall be completed showing all sub-surface conditions as found and corrected by grouting operations. Representative cores shall be suitably boxed and referenced. All information regarding, the grouting, amount of grout taken, effects observed in the surrounding holes or rock etc., shall be systematically collected and filed. The records shall contain all the information as per guidelines of IS: 6066, and shall include the following:</p> <ol style="list-style-type: none"> Number and location of the drill holes, chainage in tunnels, chainage along the dam axis with distance upstream and downstream of the dam axis, Type of hole, method of drilling and grouting method, Date and time of commencement of grouting and of each change in grouting operations, Top level and depth, Date of completion, Rate of pumping, Grouting pressures and gauge reference number, Water-cement ratio and its variations, Separate quantities of cement, sand, bentonite, fly ash, admixtures and chemicals consumed in each specified hole, Observation during grouting, concerning the behaviour of holes under air and water pressure, appearance of wash water, quantity and proportion of the grout used, time and pressure of grouting, application and retention of grout pressure, connection to and effect on adjacent holes, as well as any surface leakage of water or grout; crack location, how it was caulked and the success of caulking shall be described and approximate station and offset of each surface leak shall be recorded where it occurs in the dam foundation, 		
<div> <div>ISSUE</div> <div>P0</div> </div>		


	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 4 OF 37
<div><div><div>k)</div><div>Method of application of grout, stage grouting etc., and the conditions noted while drilling and grouting to enable compilation of complete record of the foundation,</div></div><div><div>l)</div><div>Number of holes and depth of holes left for re-drilling,</div></div><div><div>m)</div><div>Results of water-pressure tests,</div></div><div><div>n)</div><div>Name of the foreman in charge.</div></div><div><div>v)</div><div>The Project Manager reserves the right to require any additional information deemed necessary to be included in the documents to be submitted.</div></div></div> <div><div>12.3</div><div><u>DEFINITIONS</u></div></div> <div><div>i)</div><div>GROUTING is defined as injecting a mixture of cement and water with the addition of admixtures, sand, bentonite, and fly ash, if required, or similar approved mixture under pressure into overburden or rock mass or between rock/concrete contact through a system of boreholes by means of a pump designed for such a purpose. Cement grouts are subdivided into stable and unstable mixtures:<div><div>a)</div><div>STABLE mixtures are colloidal suspension dissolved in water which grain size is so small that no appreciable sedimentation occurs during the grouting operation. These suspensions are obtained by high speed mixing of cement with addition of bentonite.</div></div><div><div>b)</div><div>UNSTABLE mixtures are simple suspensions of cement in water. These suspensions are only homogeneous as long as they are in movement and the sedimentation starts as soon as the movement is stopped,</div></div></div></div> <div><div>ii)</div><div>ZONE is part of the impervious curtain grouting or consolidation grouting where all the drill holes have the same depth or the same inclination or where a level for the depths of holes is specified. In a zone, Project Manager may adjust and drill holes as required by the topographical and geological conditions to ensure a continuous grouting curtain.</div></div> <div><div>ISSUE</div><div>P0</div></div>		


ISSUE

P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 5 OF 37
<div> <div>iii)</div> <div>STAGE is a section of a drill hole in which grouting or water pressure testing is performed.</div> </div> <div> <div>iv)</div> <div>PACKER GROUTING consists of drilling a hole to its full depth in a single operation, cleaning and washing, water-pressure testing if required and grouting the hole in successive stages in any desired sequence of section, which are isolated by use of packers from the un-grouted sections, this method shall generally be used.</div> </div> <div> <div>v)</div> <div>STAGE GROUTING consists of drilling and grouting a hole by stages. First a hole is drilled to a limited depth, cleaned, subjected to water pressure tests if required and then grouted. Just after the initial set of grout, the hole is cleaned by washing or by other appropriate means. Then the hole is drilled to another limited depth, cleaned, subjected to water pressure tests if required and grouted and so continued in successive stages until satisfactorily grouted to its full depth. This method is to be used only when directed by Project Manager.</div> </div> <div> <div>vi)</div> <div>SINGLE-STAGE GROUTING is carried out by introducing the grout at either the collar of the hole through a nipple or by means of a grout supply pipe at the bottom of the hole. The entire length of the hole is grouted in one operation.</div> </div> <div> <div>vii)</div> <div>MULTIPLE-STAGE GROUTING is carried out by introducing the grout into a predetermined section of the hole, which is blocked off by a packer. The grouting of the entire length of hole is performed in successive stages either in ascending or descending arrangement.</div> <div> <div>a)</div> <div>The terms ascending or descending arrangement mean only the sequence of the grouting stages, either from bottom to the collar of the hole or in reverse, irrespective of the effective direction of inclination of the hole,</div> </div> <div> <div>b)</div> <div>When grouting is done in ascending arrangement, the hole is drilled to its full depth, washed out, and the packer is set at the top of the deepest section to be grouted. The section is then water-pressure</div> </div> </div>		
<div> <div>ISSUE</div> <div>P0</div> </div>		

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 6 OF 37
	<p>tested and grouted at the required pressure through the grout supply pipe. The packer is allowed to remain in place until there is no backpressure and then withdrawn to the top of the next section to be grouted. The water-pressure testing and grouting is repeated successively, section by section, until the entire length of the hole is filled with grout,</p> <p>c) When grouting is done in descending arrangement the Work is accomplished in sections from the collar of the hole. The hole is drilled to a limited depth, washed out and the packer is set just above the section to be grouted. The section is then water-pressure tested and grouted at the required pressure. The grout within the hole is removed before it takes a hard set while the grout surrounding the hole is allowed to obtain its initial set, before the hole is drilled to an additional depth. Repeating thus successively drilling, water-pressure testing, and grouting at various depths until the entire length of hole is completely drilled and grouted</p> <p>viii) FULL DEPTH GROUTING means that each hole is drilled to the full desired depth, washed, pressure tested and grouted in one operation. This method is usually limited to short holes 5 m or less or holes up to 10 m that have only small cracks and joints and there is no risk of surface leakage.</p> <p>ix) SPLIT SPACING consists of progressively closing curtain or consolidation grouting by drilling and grouting holes midway between holes that have previously been drilled and grouted. The spacing between primary and secondary holes may vary from one zone to another depending upon geological conditions encountered.</p> <p>x) CONSOLIDATION GROUTING is the drilling of shallow holes and grouting of the rock in foundation of the dam, spillway, intake and in rock surrounding concrete lining of tunnels and shafts.</p> <p>xi) CURTAIN GROUTING is the grouting executed to form a continuous impervious wall. In principle, this curtain shall consist of a single row of holes divided into zones of variable depths, inclinations and spacing.</p>	<div style="border: 1px solid black; padding: 5px; text-align: center;"> ISSUE P0 </div>

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 7 OF 37
<div> <div>xii)</div> <div>CONTACT GROUTING is drilling and grouting at low pressures required to fill the voids between concrete and rock surface or between concrete and steel lining.</div> </div> <div> <div>xiii)</div> <div>OPEN END WASHING is the process of cleaning drill cuttings and sludge from a drill hole by injecting water or water and air at the bottom of the hole and returning the fluid and suspended matter to the top of the hole.</div> </div> <div> <div>xiv)</div> <div>GROUTING PRESSURE shall mean the pressure of grout injection as measured at the pressure gauge near the collar of hole while the grout is being pumped into the hole.</div> </div> <div> <div>xv)</div> <div>EFFECTIVE PRESSURE shall mean the actual pressure of grout at the packer end, taking into consideration the difference of elevation between the packer end and the nearest pressure gauge or the water table.</div> </div> <div> <div>xvi)</div> <div>SUCCESSFUL CONNECTION means the completion of all operations necessary to achieve a proper seating of a packer assembly that can sustain the required pressure without leakage or loss of pressure during pressure water testing or grouting to refusal.</div> </div> <div> <div>xvii)</div> <div>GROUT TAKE OR GROUT ABSORPTION is the quantity of materials injected in a hole expressed in units of kg of dry cement/bentonite and of sand.</div> </div> <div> <div>xviii)</div> <div>WATER CEMENT RATIO is the ratio of the mass of water to the mass of cement.</div> </div> <div> <div>xix)</div> <div>CEMENT GROUT is defined as a mixture of cement and water with the addition of admixtures, sand and bentonite, if required, which is forced under pressure into prepared holes or pipes in order to fill voids or consolidate the rock mass as a whole.</div> </div> <div> <div>xx)</div> <div>CHEMICAL GROUT is defined as a mixture of two or more solutions, which combine chemically and form a gel or a solid matter. The solutions may react either prior to pumping into, or within the void.</div> </div>		
		ISSUE P0


	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 8 OF 37

12.4 STANDARDS

Materials for grouting and performance of grouting work shall conform to the latest revisions of the following Indian Standards or where not covered by these Standards, to the equivalent International Standards:

IS: 269	33 grade ordinary Portland cement.
IS: 383	Coarse and fine aggregate from natural sources for concrete.
IS: 2645	Integral cement waterproofing compounds.
IS: 4464	Code of practice for presentation of drilling information and core description in foundation investigation.
IS: 4880	Code of practice for design of tunnels conveying water.
IS: 4999	Recommendations for grouting of pervious soils.
IS: 5878	Code of practice for construction of tunnels conveying water.
IS: 6066	Pressure grouting of rock foundations in river valley projects.
IS: 8112	43 grade ordinary Portland cement.
IS: 9103	Admixtures for concrete.
IS: 9429	Code of practice for drainage system for earth and rockfill dams.
IS: 11293	Guidelines for the design of grout curtains.
IS: 12584	Bentonite for grouting in civil engineering works,
IS: 11105	Code of practice for design aspects of tunnel plugs,
IS: 13912	Closure of diversion channel and open cut or conduit in the body of the dam – code of practice.

ISSUE P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 9 OF 37

12.5 GROUTING METHODS


12.5.1 GENERAL


- i) Grouting shall be performed under the direction of Project Manager. This may include, but not be limited to detailed design and establishment of procedures to be adopted for determination of grout hole locations, orientation and sequence of drilling and washing holes, material, additives, pressure and pumping rate to be used for grouting, mixture modifications to be made in all aspects of grouting procedures. Such adjustments and modifications required by Project Manager shall be executed by Contractor without causing any undue delay in the construction programme.
- ii) The extent of the proposed drilling and grouting programme is tentative. The Project Manager reserves the right to increase or decrease any part of the drilling and grouting programme should conditions indicate that this is required.

12.5.2 PLANT AND EQUIPMENT

- i) All grouting equipment shall be of a type and capacity and in mechanical condition approved by the Project Manager and suitable for performing the work in an efficient and workman like manner. The Contractor shall supply all valves, gauges, packers, fittings and all tools necessary to provide a continuous supply of grout and an accurate pressure control.
- ii) The washing and water pressure testing plant shall include pumps, gauges, valves, and all other accessories, necessary to complete the works as specified. The pumps furnished shall be of gear, centrifugal, or other acceptable types, with a minimum output of not less than 280 l/min. at 1.4 N/mm² gauge pressure and shall be capable of maintaining constant pressure. The Contractor shall supply water storage tanks sufficient for the pumps in addition to flow metres and pressure gauges for calibration and checking purposes.

ISSUE
P0


	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 10 OF 37
<div> <div>iii)</div> <div>The packers shall be of the mechanical rubbing ring or pneumatically expandable rubber types. Packers shall be capable of sealing holes up to the maximum grouting pressures without leakage. These packers shall be capable of being used either single or double. Double packers shall be separated by up to 3 m of perforated pipe. The diameter of pipes used for separating the packers and for placing the packers in holes shall be the maximum possible for the size of the holes.</div> </div> <div> <div>iv)</div> <div>Grout materials shall be mixed, utilising a mechanically operated colloidal high speed mixer of approved quality and adequate capacity. Facilities shall be provided at the mixer for the accurate measurement of grout materials so that mix proportions can be carefully controlled.</div> </div> <div> <div>v)</div> <div>Grout materials shall be maintained in suspension in mechanically agitated tank, equipped with screens to remove lumps not passing a 4.75 mm IS sieves. The tank shall be graduated in litres.</div> </div> <div> <div>vi)</div> <div>Grout headers shall be provided for feeding grout into the hole. The header shall include a supply connection, a connection with a valve to the hole, and a return line with a valve. Two 150 mm Bourdon type pressure gauges for the appropriate pressure range shall be installed. One shall be installed to indicate the pressure of supply at the pump and the other to measure the pressure at the hole.</div> </div> <div> <div>vii)</div> <div>Each grouting unit shall be provided with acceptable storage for adequate supply of cement, additives, water and other materials so that grouting can be carried out without interruption. External grouting unit shall be provided with suitable housing for protection against inclement weather.</div> </div> <div> <div>viii)</div> <div>Only modern, properly operating grouting equipment approved by the Project Manager and operated by trained and experienced crew shall be used for the performance of the work. This shall be specifically observed when dealing with chemical products.</div> </div> <div> <div>ix)</div> <div>The grouting equipment required to carry out the work shall include mixers, grout pumps, packers, pipes, grout lines, fittings, pressure gauges,</div> </div>		
		ISSUE P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 11 OF 37

telephones, lighting circuits, trolley grout platforms and miscellaneous supplies. Sufficient grouting equipment shall be provided to meet the construction schedule and each plant shall be capable of satisfactorily supplying, mixing, stirring, pumping and injecting grout mixes of various viscosities as specified herein. The equipment shall be maintained in good operating condition at all times and any grout hole that is lost or damaged due to mechanical failure of equipment or inadequate delivery of grout shall be replaced by another grout hole by Contractor at no additional cost to corporation.

- x) The grouting equipment for mixing and placing the grout shall be such as to provide a continuous circulation of grout throughout the system and to permit accurate volume and pressure control. It shall be capable of effectively mixing and stirring the grout and forcing it into the hole in a continuous uninterrupted flow at any desired pressure up to the maximum required grouting pressure for a flow rate of 150 litre/min.
- xi) Grout pumps shall be of the progressive cavity type and shall be capable of pumping at least 150 litres/min of grout at a discharge pressure of 1,700 kPa (1.7 N/mm²).
- xii) Sump or holding tanks having a minimum capacity of 0.5 m³ shall be mechanically operated and designed to keep the mixed grout agitated and in suspension. All grout should be discharged from the mixer into the agitator and from the agitator into the pump panel through a 2.36 mm screen to remove lumps and large particles.
- xiii) Pressure gauges of the approved brand shall be of such calibration to cover a range of pressures from 0 to 0.5 N/mm² (500 kPa) and from 0 to 2.0 N/mm² (1500 kPa), An adequate number of spare gauges shall be provided at each grout plant. Contractor shall provide a standard master gauge against which all other gauges shall be checked periodically for accuracy and satisfactory operation. All the pressure gauges shall be numbered for identification.

ISSUE
P0


	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 12 OF 37

- xiv) A double line circulating system shall be used and the inside diameter of all lines, walls and connections shall be not less than 25 mm. Hoses and supply lines shall be capable of withstanding pressure 50% greater than those specified for grouting.
- xv) Contractor shall furnish, install, maintain and operate satisfactory communication system between grout plants and the holes being grouted regardless of grout area locations.
- xvi) Contractor shall supply sufficient operating personnel, supervisors, labour, spare tools, to carry out each phase of the work properly and expeditiously.
- xvii) The grouting units shall be mobile and of size suitable to the dimensions of the galleries/drifts.

12.5.3 EMBEDDED PIPES AND FITTINGS FOR GROUTING

- i) Standard mild steel pipes and fittings for grouting shall be set in the rock and concrete as directed by the Project Manager or where shown on the drawings. The pipes and fittings embedded in concrete shall be cleaned thoroughly of all dirt, grease, grout and mortar immediately before embedment and shall be firmly held in position and protected from damage or displacement while the concrete is being placed. The size of the pipes embedded in concrete lining for drilling holes for grouting shall be 50 mm in internal diameter or as shown on the drawings. A standard coupling and nipple wrapped to facilitate eventual removal shall be attached to the grout pipe where embedded in concrete. No portion of the pipe shall be allowed to remain within 50 mm of the concrete surface and the resulting recess, after removal of the pipe or fitting, shall be filled with dry-pack mortar.
- ii) Care shall be taken to avoid premature blockage of pipes. Any pipe that becomes blocked before completion of operations shall be cleaned out in a satisfactory manner or replaced by the Contractor.


ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 13 OF 37

12.5.4 SITE LABORATORY

- i) The Contractor shall have a laboratory specially equipped for studies and tests for drilling and grouting works being done at Site. The laboratory shall be manned by experienced laboratory staff familiar with conventional grout tests.
- ii) In addition to the usual general laboratory equipment such as scales, oven, permeability meter and the like, it shall be equipped for the following required tests:
 - a) Laboratory tests:
 - Grain size distribution and moisture content of sand
 - Atterberg limits
 - Chemical analysis of water and solids
 - Compressive strength
 - Viscosity (by fan-viscosimeter and Marsh cone, and Prepack)
 - Density
 - Decantation and setting time (by Vicat needle)
 - Shrinkage of the grout
 - b) Field tests:
 - Density by hydrometer or mud balance
 - Viscosity by Marsh cone
- iii) The Project Manager shall be given free access to the laboratory and shall be entitled to carry out any studies and measurements he deems necessary.
- iv) The Contractor shall prepare and test the trial mixes as directed by the Project Manager at least 28 days before commencement of any grouting. Materials for use in grout mixes shall be tested for compliance with the applicable requirements stipulated in "Grouting Materials" of this Chapter. Tests shall be performed on the grout mixes proposed for use in the Works, to establish the consistencies in mixes, practical mixing ratios, initial and

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 14 OF 37

final setting times, and such other properties as may affect the quality of the grout.


- v) During the actual grouting operations the Contractor shall carry out tests on grout mixes at the same time as grouting, and shall plot values of viscosity, sedimentation limits, compressive strength, and maximum viscosity possible for the grouting on a diagram. The frequency of testing will be once for each grouting job site or until acceptance criteria have been met. However, if a significant change in the cement source occurs, sampling and testing must be repeated and the new mix approved by the Project Manager.


12.6 **GROUTING MATERIALS**


- i) Water used for all drilling, washing and water testing and as an ingredient of grout mixtures shall be fresh, clean and free from deleterious amounts of silt, organic matter, alkali, acids, salts, oil and other impurities.
- ii) Cement used in the grout mixes shall be Portland cement, conforming to IS: 8112. The fineness shall be such that 99.0 percent passes the 74 micron IS sieve and that the Blaine fineness is not less than 3,500 cm²/gm. The cement shall be free from lumps.
- iii) Whenever sand is added to the grout mix, it shall consist of clean, hard and durable particles free from lumps or clay and objectionable foreign matter. A supply of 5 cubic metres of sand shall be kept in proximity of the work at all times. Sand shall conform to the following grading requirement:


Sieve size (mm)	Percentage passing by weight
2.360	100
1.800	95-100
0.600	60-85
0.300	30-50
0.150	10-30

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 15 OF 37
<div> <div>0.075</div> <div>0-5</div> <div> <div>iv)</div> <div>Bentonite may be required in grout mixes. The bentonite used shall be conforming to IS: 12584.</div> </div> <div> <div>v)</div> <div>Approved admixtures shall be used by Contractor in the grout mix to optimise the strength, viscosity, density, decantation, setting time and shrinkage. The admixtures shall be commercially available retarding or accelerating agents or grout plasticizer for water reduction and expansion during the plastic stage. Only admixtures proved by testing prior to the start of grouting may be used, when approved by the Project Manager. Manufacturer's certificates or guarantees will not be accepted as relieving the Contractor of his responsibility for the suitability of any admixture.</div> </div> <div> <div>vi)</div> <div>The Contractor shall handle, store and protect all cement and additives in such a manner that these materials will not be subject to deterioration or contamination. Deteriorated or contaminated materials shall not be used in the Works.</div> </div> <div> <div>vii)</div> <div> <div>The Contractor shall be required to prepare and inject the following grout mixes:</div> <div> <div>a)</div> <div>Cement/sand mix with admixture for contact and fill grouting,</div> </div> <div> <div>b)</div> <div>Cement/water mix, possibly with addition of bentonite and admixtures, for consolidation grouting after placing of concrete lining and for consolidation and curtain grouting for the dam,</div> </div> <div> <div>c)</div> <div>Cement/water mix with admixture for grouting in the heading zone during excavation,</div> </div> <div> <div>d)</div> <div>Cement/water mix with admixture for crack grouting.</div> </div> </div> </div> <div> <div>viii)</div> <div>Any grout mixture not used within one hour after mixing shall be rejected.</div> </div> <div> <div>ix)</div> <div>The Project Manager may require the addition of materials other than those specified above, the use of any chemicals used in combination with cement or clay grouts shall be non toxic and subjected to testing before use and approved by the Project Manager.</div> </div> </div>		
<div> <div>ISSUE</div> <div>P0</div> </div>		

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 16 OF 37
<p>x) The Contractor shall perform tests, as required by the Project Manager on the grout mixes proposed for use in the work to establish the consistencies of mixes, practical mixing rates, initial and final setting times, and such other properties as may affect the quality of the grout.</p> <p>12.7 <u>GROUT MIXES</u></p> <p>12.7.1 <u>PURE CEMENT SLURRIES</u></p> <p>i) Water/cement slurry mixes are defined in terms of the W/C (water/cement) ratio by weight, and may vary from 5.0, for the thinnest mixes, to 0.67 or even 0.4 for thick mixes.</p> <p>ii) High-turbulence mixing of these slurries shall last at least three minutes after pouring of the full cement weight into the mixer.</p> <p>12.7.2 <u>STABLE BENTONITE-CEMENT GROUTS</u></p> <p>i) Stable bentonite/cement grouts shall be laboratory tested prior to use. The following graphs, in particular, shall be drawn:</p> <p>a) Equiviscosity curves,</p> <p>b) Bleed limit curves,</p> <p>c) Curves of equal mechanical strength,</p> <p>d) Curve of maximum possible viscosity for grouting.</p> <p>ii) These figures shall be obtained with a mixer that reproduces the high turbulence of the site mixers and with the same materials (cement, bentonite, water) as will be used on the site. Bentonite/cement mixes for grouting shall not bleed more than 5%, expressed in terms of the volume of water visible above the grout after setting and the total volume prior to setting, as measured in a 1 litre, 6 cm diameter test tube.</p> <p>iii) Viscosity shall be measured with a Marsh cone or equivalent method.</p> <div style="border: 1px solid black; padding: 5px; text-align: center;"> ISSUE P0 </div>		

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 17 OF 37
<div> <div>iv)</div> <div>Unconfined compressive strength after 7 and 28 days shall be measured on 5 cm cubes stored in water. 28 days compressive strength shall be no less than 1 MPa.</div> </div> <div> <div>v)</div> <div>The time to initial set shall not be longer than 24 hours.</div> </div> <div> <div>vi)</div> <div>Preparation: <div> <div>a)</div> <div>The bentonite/cement grout shall be made by first mixing a bentonite/water parent slurry in a high- turbulence mixer and storing it, once adjusted to the defined w/c ratio, for approximately 24 hours in a large tank where it shall be kept in gentle movement, after which a quantity of parent slurry shall be taken and mixed with additional water and cement in a high-turbulence mixer,</div> </div> <div> <div>b)</div> <div>Grout shall be mixed in batches of suitable volume and in such a way as to enable water-cement ratios and the composition of suspension grout to be changed to ensure continuous flow and minimum wastage. Grouts shall be mixed for a minimum of 3 minutes before injection,</div> </div> <div> <div>c)</div> <div>The final mixing of the parent slurry with cement shall last at least two minutes after addition of all ingredients,</div> </div> <div> <div>d)</div> <div>The same mixing drum shall under no circumstances be used for mixing both bentonite/cement grouts and bentonite/water slurries. Bentonite shall not be suspended in water, which contains even the slightest amount of cement,</div> </div> <div> <div>e)</div> <div>The Contractor shall provide detailed information regarding the material and batching, mixing and grouting plant he proposes using in his submission for the Project Manager's approval.</div> </div> </div> </div> <div> <div>vii)</div> <div>Grout Types: <div> <div>a)</div> <div>Three stable grouts with different batching proportions shall be developed on site to respect the above conditions: they shall be the thinnest possible mix (grout A), a mix of average viscosity (grout B), and the thickest possible pumpable mix (grout C). For Bentonite</div> </div> </div> </div>		
<div> <div>ISSUE</div> <div>P0</div> </div>		

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 18 OF 37


cement grout the composition of these mixes for one cubic meter of grout should be approximately as given in the table below:

	Grout A	Grout B	Grout C
Water	850 l	848 l	846 l
Bentonite	30 kg	40 kg	50 kg
Cement	425 kg	424 kg	422 kg
Total volume	1,000 l	1,000 l	1,000 l
Density	1.30	1.31	1.32
Viscosity (Marsh)	35 s	40 s	50 s
Bleed	4 %	2.5 %	1 %
28 day strength	1.2 MPa	1.2 MPa	1.2 MPa

These compositions are given as a guide only and shall be adjusted to suit the materials used. A greater variety of mixes may be required.

- b) If grout intake is high, and for cavity grouting behind tunnel lining, the Contractor shall be prepared to grout with cement/sand/water mixes. Such colloidal grouts, such as "Colgrout", "Haute Turbulence" and the like, shall not segregate noticeably before setting, nor shall they bleed more than 2% by volume,
- c) Mixes for rock grouting shall generally contain up to twice the weight of sand as of cement,
- d) The seven-day strength of both grout types shall be at least 10 Mpa,
- e) Generally the grout mix used for the underground works shall be composed of cement, bentonite, water and where required other additives such as sand.

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 19 OF 37

12.8 EXECUTION


12.8.1 GENERAL


- i) In order to ensure efficient and satisfactory performance, The Contractor shall employ competent and experienced grouting supervisors who shall execute directions of the Project Manager and supervise the work to be done.
- ii) During grouting, washing and pressure testing operations, the Contractor shall keep concrete and rock surfaces free and clean of oil, grease, drill cuttings, grout, cement, excess of water or any kind of waste. At all times during the progress of the work, the Contractor shall protect all open drill holes from becoming plugged or filled with oil, grease, drill cuttings, grout or waste. The Contractor shall clean up; and remove all waste upon completion of the work in each area before he vacates that area.
- iii) Modifications to drilling and grouting techniques may be required as the knowledge and experience of rock and foundation conditions are gained. The Contractor will be required to alter his operations properly to meet such modifications as per instructions of the Project Manager.


12.8.2 GROUTING PROCEDURE

- i) Unless otherwise stated, grout holes shall not - except with permission from the Project Manager - be grouted until the concrete/shotcrete within a radius of 12 m from the grout hole has been completed and cured for 28 days.
- ii) Full depth grouting shall be limited to 5 m depth of hole in rock, however with latest information about rock geology, experience and pre-grouting results the Project Manager may allow full depth grouting up to 10 m depth.
- iii) For deeper grout holes, more than 5 m length the grouting shall be performed in stages of not more than 5 m length of grout holes as directed by the Project Manager.

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 20 OF 37
<div> <div>iv)</div> <div>Once the grouting of a stage of a hole has been commenced it should be continued without interruption until completion. In general a stage may be considered complete when absorption of grout at the desired limited pressure is less than 2 lit/min. averaged over a period of 10 minutes.</div> </div> <div> <div>v)</div> <div>As far as practical, a continuous flow of grout should be maintained at the desired pressure and the grouting equipment shall be operated to ensure continuous and efficient performance throughout the grouting operation. The Contractor shall respond quickly and effectively to manipulate the desired changes in the grout mix consistency, rate and pressure of injection, etc., as directed by the Project Manager during the grouting operation.</div> </div> <div> <div>vi)</div> <div>When grouting is interrupted due to plant break down, about 500-1,000 liters of clean water should be run into the hole and allowed to stand.</div> </div> <div> <div>vii)</div> <div>Should any hole connect to another during injection, the grout should be allowed to escape from the coupled hole until it is of the same consistency as that being injected; the coupled hole should then be capped and the combined holes brought up to pressure. After the first hole has been grouted, all the other holes are successively connected to the grouting header to subject them to the full pressure.</div> </div> <div> <div>viii)</div> <div>During the grouting of hole, adjacent ungrouted holes shall be left uncapped to facilitate the escape of air and water. If sufficient grout flows from those holes to interfere with grouting, those holes are capped until refusal is reached. Grouting shall be resumed on the capped holes in a single continuous operation.</div> </div> <div> <div>ix)</div> <div>Grouting shall be stopped whenever pressure gauges register a sudden drop of pressure or the rate of grout absorption increases abruptly or there is any indication of upheaval, disturbance or leakage. Additional holes may have to be drilled and grouted in the vicinity or sealing cracks which might have been left due to premature blocking of holes by interruption of grouting operation.</div> </div>		
		<div>ISSUE</div> <div>P0</div>

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 21 OF 37
<div><div><div>x)</div><div>It is advisable to begin with a low initial pressure of 0.1 - 0.25 kg/cm² of overburden and build up pressure gradually. The pressure shall be raised only when the intake rate falls below 5 lit/min. or as specified otherwise.</div></div><div><div>xi)</div><div>The true pressure at any depth should take into account the pressure head caused by weight of the grout in the hole as explained in IS: 6066 - 1984.</div></div><div><div>xii)</div><div>The control of pressure shall be exercised according to the guidelines of IS: 6066 - 1984.</div></div><div><div>xiii)</div><div>When pressure does not build up even after grouting appreciable quantities, a thick grout i.e. with water cement ratio lesser than 0.6:1 by weight or by grout with filler such as sand and bentonite, shall be injected before stopping grouting. This shall be done after predetermined limit of consumption as approved by the Project Manager is reached. Additional holes shall have to be drilled and grouted in the vicinity of such holes.</div></div><div><div>xiv)</div><div>All grout holes shall be backfilled with grout mix 0.7 water: 1 cement with 3% bentonite or by mix as approved by the Project Manager after the grouting. A minimum 25 mm diameter delivery pipe is lowered to the bottom of the hole. Grout is pumped in the delivery pipe until it flows from the hole, then the delivery pipe is slowly withdrawn while pumping continues. If settlement of grout occurs after initial set, the holes shall be again backfilled by grout.</div></div><div><div>xv)</div><div>The Contractor shall caulk, dry pack or seal any surface leaks in rock or concrete before continuing grouting operation.</div></div><div><div>xvi)</div><div>In areas of high grout consumption and for filling voids in the concrete crown of the area, sand may be required in the mix. The proportion of sand permitted will depend on the permeability of the rock and size of the voids to be grouted, and its actual quantity in the mix shall be decided by the Project Manager, The proportions of the sand permitted shall normally not exceed 2 parts of sand for 1 part of cement with approved plasticizer.</div></div><div><div>xvii)</div><div>All grout, which cannot be injected within one hour of mixing, shall be rejected at no additional cost to OWNER.</div></div></div>		
<div>ISSUE P0</div>		



	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 22 OF 37



- xviii) In general, for all grouting work, the grout mixes, pressure and procedures to be used in the work shall be varied by Project Manager according to conditions encountered in the field. For most grout holes, except void filling, injection will be started using a thin mix which will be maintained for a period of 10 minutes or as required by the Project Manager after which the mix ratio may be changed depending on the rate of grout acceptances. Grouting in a hole will always be in one continuous operation from start to end.
- xix) Refusal criteria for grouting shall be as per I.S. Codes and/or as directed by the Project Manager.
- xx) The temperature of grout shall not exceed 27° C throughout the mixing and agitation period up to the time of injection.


12.8.3 UNDERGROUND GROUTING


- i) All pressure grouting operations shall be performed in the presence of the Project Manager or his representative.
- ii) In the Underground Works, the grouting Works and other operations shall be carried out in the following sequence, unless otherwise directed by the Project Manager.:
 - a) Consolidation grouting and impermeabilization of the rock ahead and around the heading face as needed, before further advance,
 - b) Fill grouting of exploratory and drain holes, which may be required during underground excavation prior to placing of concrete lining,
 - c) Contact grouting in the crown of the tunnel after placing of concrete lining,
 - d) Contact grouting between steel liner and backfill concrete, wherever applicable,
 - e) Contact grouting in the completed concrete plug in access adits and diversion tunnel shall be performed through the pipe system embedded into the body of the plug,
 - f) Fill grouting of drainage conduits and sump pits,

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 23 OF 37
<div> <div> g) Consolidation grouting of rock surrounding the excavated space. Depending on the rock conditions, the Project Manager may direct to carry out this grouting in two stages, first at low pressure and the second at high pressure as per Indian Standards, </div> <div> h) Control grouting, </div> <div> i) Installation of one-way check valves, if required </div> <div> j) Crack grouting as directed. </div> </div> <div> iii) The above sequence is not exhaustive and the Contractor shall plan his operations in such a way that he is flexible to adapt to the conditions encountered. </div> <div> iv) The utmost care and precautions shall be taken to ensure that the concrete does not get damaged during the grouting operations. </div> <div> v) If the Project Manager considers necessary to carry out an additional grouting in any section of the Works, the Contractor shall reinstall the necessary equipment and perform the grouting to the satisfaction of the Project Manager. </div> <div> 12.8.4 <u>CONTACT GROUTING BETWEEN CONCRETE AND ROCK</u> </div> <div> i) Low pressure contact grouting shall be carried out between concrete and rock over the entire length of concrete lined tunnels and caverns to fill voids between the rock surface and the following: <div> a) Structural concrete in the crown of the tunnel, </div> <div> b) Backfill concrete in the crown of the steel-lined sections of the tunnel, </div> <div> c) Concrete in any other zone within the Underground Works where conditions so require and as the Project Manager may direct. </div> </div> <div> ii) Contact grouting shall normally be performed from holes drilled in the crown of the tunnel or as directed by the Project Manager, and shall be carried out in advance of consolidation grouting operation. </div>		
<div> <div>  TATA CONSULTING ENGINEERS LIMITED </div> <div> <div>ISSUE</div> <div>P0</div> </div> </div>		

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 24 OF 37
<div> <div> iii) Washing and water pressure testing will not be required prior to contact grouting. iv) In any section of the underground structure, the concrete lining of that section shall have been in place for at least 28 days before grouting commences. v) Contact grouting shall be carried out at low pressure of 2 kg/cm² or as specified by the Project Manager, using a cement-sand grouting and shall continue until all voids are filled. Vent pipes for the release of air and water during grouting shall be provided in locations directed or approved by the Project Manager. vi) In sections of underground structures where permanent lagging has been installed during excavation, spaces between the rock surface and the lagging shall be filled with grout by contact grouting where directed by the Project Manager. vii) After the grouting of any hole is completed, the pressure shall be maintained, by means of a stopcock or other suitable device, until the grout has set. viii) Control grouting shall be carried out, when directed by the Project Manager, to verify that voids have been completely filled with grout. Grouting will be regarded as being satisfactory if the pressure can be maintained for at least 5 minutes without further grout intake. </div> <div> 12.8.5 <u>CONTACT GROUTING BETWEEN BACKFILL CONCRETE AND STEEL LINING</u> </div> <div> i) Grouting between the steel lining and the backfill concrete in any section of the tunnel shall not commence until the backfill concrete of that section has been in place for at least 28 days. ii) Low pressure contact grouting shall be carried out until all voids between the steel lining and backfill concrete are thoroughly filled. The maximum grouting pressure shall be 5 kg/cm² or as directed by the Project Manager. A </div> </div>		
<div> <div>  TATA CONSULTING ENGINEERS LIMITED </div> <div> <div>ISSUE</div> <div>P0</div> </div> </div>		

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 25 OF 37
<p>special air chamber and safety valve shall be incorporated into the grouting system to smooth out pressure fluctuations and limit maximum pressure.</p> <p>iii) Only stable, cement-water mixture with addition of plasticiser shall be used for this grouting.</p> <p>iv) Pre-tapped holes for grouting, complete with threaded steel plugs, shall be provided in the steel lining. The Contractor shall provide threaded pipes to protect the thread of the grouting hole during the drilling and grouting operation, as shown on the drawings and/or as directed by the Project Manager.</p> <p>v) After completion of grouting, the Contractor shall clean the threaded holes and screw the plugs back into position. The plugs shall be welded permanently into the steel lining and stub heads ground off flush. When this Work is complete, the Contractor shall thoroughly clean the whole steel lined surface of all grout remnants and other debris.</p> <p>vi) After conclusion of the grouting, the Project Manager will inspect the effectiveness of the grouting. In case of detection of any voids, the Contractor shall open additional holes and inject grout until all voids are completely filled, to the satisfaction of Project Manager.</p> <p>vii) Caution shall be exercised by the Contractor during the grouting operations to prevent any damages to already applied corrosion protection of the steel lining.</p> <p>viii) Care should be taken to notice any distress, Cavity in rock or leakage of grout from any surface. In case of detection of any such phenomenon grouting may be stopped and matter be reported to the Project Manager. All remedial measures as suggested by the Project Manager shall be taken by the contractor.</p>		
<div>ISSUE P0</div>		

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 26 OF 37


12.8.6 CONTACT GROUTING BETWEEN NEW PLUG CONCRETE AND OLD CONDUIT CONCRETE


- i) Concrete plugs in Tunnel or Construction Adit shall be carried out in accordance with the provisions of IS: 11105 and Construction Drawings.
- ii) Concrete plugs in Construction Sluices in the body of dam shall be carried out in accordance with the provisions of IS: 13912 and Construction Drawings.


12.8.7 FILL GROUTING


- i) Fill grouting of exploratory and drain holes shall be carried out before placing of the concrete lining and shall normally be back-filled with grout immediately after drilling and tests have been completed
- ii) Core holes left unfilled shall be reopened and cleaned to the extent possible by jetting and washing with water immediately before filling.
- iii) Holes shall be filled with sand cement mortar mixed in the following preparations by volume:
 - 1 part water
 - 1 part cement
 - 3/4 part sand
- iv) Materials shall be mixed in a suitable mixer for not less than 3 minutes. No mortar shall be used if allowed to stand for more than one hour before use.
- v) The mortar shall be placed by means of an injection pipe extended to the bottom of the hole. The injection pipe shall be raised as the hole is filled and shall be kept buried in the fresh mortar throughout the entire filling operation. Mortar shall be placed up to the grout surface. To ensure that grout mortar is of acceptable standard, it should get hardened within 90 cm of grouted surface within 24 hours after filling of the hole.

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 27 OF 37
<div> <div>vi)</div> <div>After completion of contact grouting, the entire system of temporary invert drains and sump pits in the tunnel shall be filled by grouting with a cement-sand grout at a suitable pressure directed by the Project Manager.</div> </div> <div> <div>vii)</div> <div>The Contractor shall use a systematic procedure for fill grouting of the invert drains and sump pits to ensure displacement of water and complete filling of the drains and pits.</div> </div> <div> <div>12.8.8</div> <div><u>CONSOLIDATION GROUTING</u></div> </div> <div> <div>i)</div> <div> Consolidation grouting shall be carried out as shown on the Drawings or as directed by the Project Manager underground or from the surface at the following locations: <div> <div>a)</div> <div>Tunnels and caverns,</div> </div> <div> <div>b)</div> <div>Dam foundation,</div> </div> <div> <div>c)</div> <div>Retaining wall foundation,</div> </div> <div> <div>d)</div> <div>Consolidation grouting may also be directed by the Project Manager, during the excavation Works in order to consolidate the heading face or seal off the inflow of groundwater,</div> </div> <div> <div>e)</div> <div>In any other zone within the construction sites where conditions so dictate and as the Project Manager may direct.</div> </div> </div> </div> <div> <div>ii)</div> <div>Consolidation grouting in the foundation of any surface structure shall first commence 14 days after concrete placement. Grouting for rock consolidation in any section of the completed underground structure shall not start earlier than 28 days after completion of contact grouting 40 m of that section.</div> </div> <div> <div>iii)</div> <div>Consolidation grouting shall normally be performed in a single stage through a nipple or packer installed at the collar of the hole within the concrete lining, but if geological conditions so dictate, multiple-stage grouting either in ascending or descending arrangement shall be performed in particular holes. The grouting pressure for each stage shall be determined by the Project Manager.</div> </div>		
<div> <div>ISSUE</div> <div>P0</div> </div>		

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 28 OF 37
<div> <div>iv)</div> <div>Consolidation grouting of the dam core foundation shall be performed in certain areas by drilling and grouting holes to a depth of approximately 5 m at a spacing of 3 m or as directed by the Project Manager. Grouting shall be done in a continuous operation avoiding disturbance of zones grouted within the previous 24 hours. The grout pressure shall not exceed 5.0 kg/cm² or as instructed by the Project Manager. This consolidation grouting shall be performed before commencing the curtain grouting. Shotcreting or slush grout will precede consolidation grouting whenever necessary to seal the surface cracks and to prevent grout leakage. In general, the grouting holes will be located in two rows, one on each side of the grout curtain line.</div> </div> <div> <div>v)</div> <div>Grout holes adjacent to a grout hook-up shall be left open during grouting operations to facilitate the escape of air and water from pockets in surrounding rock. Where, during grouting of any hole, grout is found to be flowing from adjacent holes or cracks of any kind, such openings shall be capped temporarily by plugging or caulking.</div> </div> <div> <div>vi)</div> <div>When performing the multiple-stage grouting in descending arrangement, the grout that is within the hole shall be removed from each stage except the deepest one, by washing, or by the use of a chopping or a "fishtail" bit before the grout sets.</div> </div> <div> <div>vii)</div> <div>In the event of a sudden drop in pressure or a sudden increase in grout take, grouting operations shall be temporarily halted until the crack or opening causing the loss is located and caulked. During this time the drill hole shall be continuously washed to avoid a premature grout set, which would inhibit grouting to resume. If such a pressure drop or increase in grout take can be related to hydro-fracturing, grout pressure shall be reduced.</div> </div> <div> <div>viii)</div> <div>If surface grout leaks cannot be located and successfully caulked, or the cause for the pressure loss cannot be determined, within 1 hour, the washing of the drill hole will be stopped and the grout in the rock formation shall be allowed to set for 24 hours. After setting, the drill hole shall be hooked onto again and grouted. If the hole, or stage, does not accept grout</div> </div>		
<div> <div>ISSUE</div> <div>P0</div> </div>		

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 29 OF 37
<p>the hole shall be re-drilled or a replacement hole shall be drilled, as directed by the Project Manager.</p> <p>ix) If, during grouting, there is a communication between the holes the Contractor shall either set packers in the communicating holes, which shall be bled of accumulated air frequently and continue grouting one hole after another, or he may pressure grout the communicating holes simultaneously.</p> <p>x) Consolidation grouting of the rock surrounding the excavated hollow space shall be carried out in sections of the underground structures as directed by the Project Manager.</p> <p>xi) Grout shall normally consist of a water-cement slurry ($W/C = 0.7$) with admixtures and possibly with bentonite, as directed by the Project Manager. Grout to seal off the inflow of groundwater may also include a filler or a chemical to be approved by the Project Manager. Unless specifically directed by the Project Manager, the grouting pressure shall be 5 kg/cm^2 but this pressure may be increased up to 10.0 kg/cm^2 or more in special cases provided that there is adequate cover and the joints in the rock are not likely to open up by this pressure.</p> <p>xii) Immediately before grouting, the grout holes shall, be thoroughly washed out under pressure, until the returning water is clear, and then as the Project Manager may direct, pressure tested.</p> <p>xiii) Where, during grouting of any hole, grout is found to be flowing from adjacent holes or cracks of any kind, such openings shall be capped temporarily by plugging or caulking.</p> <p>xiv) Grouting of a hole will be considered to be complete when the rate of grout intake is less than 0.03 cubic metre of grout mixture per 20 minutes, if pressure 3.50 kg/cm^2 or less being used, in 15 minutes if pressure between 3.50 to 7 kg/cm^2 are being used, in 10 minutes if pressure between 7 kg/cm^2 and 14 kg/cm^2 are being used.</p> <p>xv) After completion of grouting, the packers shall remain in the hole and the pressure shall be maintained until the grout has attained its initial set.</p>		
<div>ISSUE P0</div>		


	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 30 OF 37


- xvi) The results of water-pressure testing and all information obtained during the performance of grouting will be used for the determination of whether the grouting is done in a satisfactory manner, or whether additional grouting in separate drill holes is required. The termination of grouting work in any sequence in any section of the Work will be decided by the Project Manager.

12.8.9 CURTAIN GROUTING

- i) Curtain grouting beneath the dam core and the spillway structure shall be performed from excavated surfaces, from the galleries and in diversion tunnel plug from inside the tunnel as indicated on the Drawings, or as directed by the Project Manager. Hole depths, inclinations, sequence of grouting, method of grouting, whether single or multi-stage, in ascending or descending arrangement will be adapted by the Project Manager based on information from exploratory drilling or current operations. The holes shall be drilled and grouted by the split-spacing method.
- ii) Normal sequence of grouting shall be ascending from bottom to top of hole in stages determined from water-pressure tests. Where the permeability exceeds 15-20 Lugeons, grouting shall generally be performed in descending arrangement.
- iii) When performing the multiple-stage grouting in descending arrangement, the grout that is within the hole shall be removed from each stage except the deepest one, by washing, or by the use of a chopping or a "fishtail" bit before it takes a hard set.
- iv) Stage length shall be a maximum of 5 m.
- v) Unless otherwise directed, air, wash water, and grout pressures shall not exceed 5 bar plus 0.25 bar per linear meter of the depth measured from the collar of the hole to the bottom of the packer. In no cases shall grouting result in heave or hydro-fracturing (sudden increase of take). Grout pressure shall not be released nor packers moved until the grout in each successive stage has achieved an initial set.

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 31 OF 37
<div> <div>vi)</div> <div>The curtain grouting shall be performed from one or several grout stations. If several such stations are used, each shall be equipped complete, with mixers, agitator sumps, pumps, gauges and measuring devices, and shall have a sufficient supply of grouting materials.</div> </div> <div> <div>vii)</div> <div>In case when the required pressure is not reached even when injecting maximum volume, the Project Manager will decide whether the grouting will be interrupted, or the grout mixture is to be changed, or accelerator added.</div> </div> <div> <div>viii)</div> <div>Where grout is found to be flowing from adjacent holes or cracks of any kind, such openings shall be capped temporarily by plugging or caulking. If this does not bring satisfactory results, further grouting shall be interrupted and the injected material allowed to harden.</div> </div> <div> <div>ix)</div> <div>Grouting injection will be deemed to be completed when the take has become 0.03 m³ or less per stage of hole being grouted during 10 minutes at the specified grouting pressure and mixture.</div> </div> <div> <div>x)</div> <div>After the conclusion of the grouting program, the Contractor shall drill inclined check holes. Unless otherwise directed, the check holes shall be drilled at the spacing of 30 m, and two-thirds the depth of the grout curtain. Check holes may also be drilled in areas of complex hydrogeology, which require particular treatment. These holes shall be filled with grout. Based on the results obtained in the check holes, the Project Manager may order additional grout holes or a new line of grout holes to be executed.</div> </div> <div> <div>xi)</div> <div>The general target of permeability of the grouted dam foundation is 0-5 Lugeons.</div> </div> <div> <div>12.8.10</div> <div><u>CRACK GROUTING</u></div> </div> <div> <div>i)</div> <div>Crack grouting shall be performed to seal the cold joints, construction joints, shrinkage cracks, honeycombs, poorly closed grout holes etc., in the structural concrete linings of underground structures as directed by the Project Manager.</div> </div>		
<div> <div>ISSUE</div> <div>P0</div> </div>		

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 32 OF 37

- ii) Crack grouting shall consist of injecting a stable, cement-water mix with admixture through holes specially drilled into cracks or joints. Preventive measures shall be taken by plugging the joint with wooden wedges, cardboard, cement-gypsum mortar or other suitable means to prevent the grout from flowing out of, the crack.

12.8.11 PROTECTION OF DRAINAGE SYSTEM DURING GROUTING

The Contractor's grouting plan shall be such as to afford maximum protection against blockage of temporary and permanent drains. If necessary, the Contractor shall maintain a flow of water through the drains likely to be affected during grouting operations. Should leakage of grout into drains occur, the Contractor shall remove grout from the affected drains.


12.8.12 CLOSURE OF HOLES AND CLEAN-UP


- i) Upon completion of grouting work, each hole shall be filled with thick grout and connections not embedded in the concrete shall be removed. The drilled holes in the concrete lining shall be reamed or redrilled to a depth corresponding to the 2/3 of theoretical concrete lining thickness and filled with dry-pack mortar, as stipulated in "Repair of Concrete" in Section "Concrete", flush with the concrete surface. In the steel lined sections, the holes shall be closed as described hereinabove in "Contact Grouting between Backfill Concrete and Steel Lining".
- ii) After completion of the grouting works the internal surface of the concrete or steel lining shall be cleaned and restored to its original condition.

12.8.13 SIMPLE WATER PRESSURE TESTING

- i) Immediately before grouting or pressure testing, the hole shall be thoroughly washed with water as explained in IS: 6066 - 1984 or any other standard practice as approved by the Project Manager.

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 33 OF 37
<div> <div>ii)</div> <div>For routine grouting operations, simple water tests shall be conducted immediately prior a stage of any grout hole is grouted.</div> </div> <div> <div>iii)</div> <div>A simple water pressure test involves isolating a segment of a hole generally 3 to 5 m in length by means of a single or double packers and pumping in water at constant pressure for a period of 15 minutes. The tests shall be carried out as per IS: 6066 or any other standard procedure or code of practice approved by the Project Manager.</div> </div> <div> <div>iv)</div> <div>On completion of drilling, all drill holes shall be thoroughly washed to remove any accumulation of fines, sludge or foreign materials. Holes shall be washed out by water injected through a wash pipe at the bottom of the holes until clear water returns. Contractor shall continue flushing for 2 minutes after the return water becomes clear. For grout holes, washing shall also be required immediately before water testing and grouting.</div> </div> <div> <div>v)</div> <div>Water pressure tests with double packer apparatus approved by the Project Manager shall be carried out only on those grout holes required by Project Manager. The actual spacing will be determined by Project Manager. Water pressure shall then be applied to the test section for a minimum period of 5 minutes.</div> </div> <div> <div>vi)</div> <div>The maximum pressure for water testing shall correspond to the pressure specified for grouting. Water loss shall be measured in litres.</div> </div> <div> <div>vii)</div> <div>Based on the results of the water pressure tests, the Project Manager may require additional grouting. Such grouting shall be carried out by the Contractor at the pressure specified by the Project Manager.</div> </div> <div> <div>12.8.14</div> <div><u>COMPREHENSIVE WATER PRESSURE TESTING</u></div> </div> <div> <div>i)</div> <div>During and after drilling of the holes or during or after grouting of the holes, they shall be water tested as required and as directed. The grout holes shall be tested with clean water at a pressure up to the required grouting pressure. Drill cuttings and slurry shall be removed before pressure testing by applying water and air into the bottom of the hole and returning the ash</div> </div>		
		<div>ISSUE</div> <div>P0</div>


 KHUTANI POWER	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 34 OF 37

water through the hole to the surface. All holes sufficiently tight to build up the maximum required pressure shall be washed at such pressure and the washing shall continue as long as there is any increase in the rate at which water is taken, such increase indicating that fractures are being opened by washing operations. In all grout holes, when abnormal gain or loss of drill water is observed, the drilling shall be discontinued the holes water pressure tested and grouted before proceeding further with the drilling. If, during drilling, caving of the hole or jamming of the bit occurs or the drill rocks fall suddenly as through an open cavity, it may be required that drilling is discontinued, the debris cleared the effected position of the hole filled with thick cement slurry and drilling continued after the slurry sets.

- ii) A record of the time, pressure and quantities of water used for testing a section of hole shall be maintained, before use and shall be periodically tested for accuracy and satisfactory operation.
- iii) The existing water level in the hole to be tested shall be established and recorded before commencement of pressure testing.
- iv) The procedure for a comprehensive water pressure testing is specified hereunder.
 - a) If the hole is drilled to full depth, the section of the hole to be tested shall be isolated by sealing it off with double packers. If stage drilling method is followed a single packer may be used to isolate the section to be tested. Water then shall be pumped into the test section under the pressure and for the periods specified below:

Step No.	Pressure	Elapsed time (minutes)
1.	1/3 p	5
2.	2/3 p	5
3.	p	10
4.	2/3 p	5
5.	1/3 p	5

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 35 OF 37


- b) Note: The pressure “P” shall be determined based on the geological conditions and on the depth of the upper packer. This pressure is not expected to exceed 15 kg/cm² at the gauge,
- c) The pressure, for step number three, shall be equal to the grouting pressure for the stage,
- d) In some cases after steps 4 and 5, the hole valve shall be closed and the pressure drop observed and recorded for a maximum period of 3 minutes in each instance.
- v) The length of the test section shall be measured parallel to the direction of hole. Hole shall generally be tested in 3 metre sections. The pressure testing apparatus shall be subject to the periodic tests for accuracy and satisfactory operation.

12.9 MEASUREMENT AND PAYMENT

12.9.1 GENERAL

- i) The estimates of the quantities for grouting given in the Bill of Quantities are to be considered as merely a guide on which the contractor is to prepare his bid and not as an accurate indication of the quantity of the work.
- ii) The quantities for each of the pay items will be varied to suit the conditions disclosed in the course of the work, and the Contractor shall not be entitled to any extra payment over and above the Unit Prices entered in the Bill of Quantities by reason of changes of the amount and length of holes to be grouted and amount of material absorbed, by reason of the location of the grouting required by the Project Manager, or by reason of the timing of the grouting in relation to excavation, concreting or other works.
- iii) Measurement and payment for grouting will not be made separately for 'placing grout' and for 'grouting materials'.
- iv) Unit Prices for grouting as indicated in BOQ shall include, but not limited to, the entire cost of supply, handling, transportation, storage, and testing grout materials and the entire cost of labour, equipment, processing, mixing,

ISSUE
P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 36 OF 37

hooking-up to the hole (where appropriate), injecting grout, hole closures and clearing up, and shall be independent of the volume or weight of materials injected. Unit prices should also be inclusive of the cost of embedded standard mild steel pipes and fittings for Grouting in rock and concrete. Where multiple-stage grouting is employed, this item shall also include cleaning grout from the holes at the completion of a grouting stage. No distinction will be made for consolidation or curtain grouting, grouting of shear zones.


- v) No payment will be made for grout that is lost due to improper anchorage of grout pipes or for grout rejected by the Project Manager on account of improper mixing.
- vi) No extra payment will be made for admixtures and chemicals, which will be supplied by the contractor.

12.9.2 WATER-PRESSURE TESTING

- i) Measurement of water-pressure tests will be of the number of tests satisfactorily performed, irrespective of size, length, or inclination of hole, or whether carried out in holes drilled from the surface or underground.
- ii) Separate measurement and payment will be made for simple and comprehensive water pressure tests.

Payment will be made at the Unit Price per test entered in the Bill of Quantities, which shall include the entire cost of labour, equipment, and materials used for carrying out the water-pressure test, the provision of test records and reports to the Project Manager, and all costs associated with interruptions to the drilling caused by the intermittent nature of the testing work.

ISSUE P0

	Khutani Power Company Private Limited, (KPCPL)	SECTION: XII
SPEC. NO. TCE.7784A-3057- 01	Khutani Hydroelectric Project (21MW), Uttarakhand	SHEET 37 OF 37

12.9.3 EXCLUSIONS - GROUTING

- i) All costs for grouting of the rock bolts, grouted anchor bar post-tensioned rock anchors are excluded from this Chapter and will be measured and paid for in accordance with the provisions of the Chapter "Rock Supports".
- ii) No extra measurement for payment or payment will be made for following:
 - a) Crack grouting
 - b) Connections made to the grout holes (hook-up)
 - c) Admixtures and chemicals, which will be supplied by the contractor
 - d) Preparation and testing of trial mixes,
 - e) Grouting materials used in contact grouting in the crown of the tunnel, shaft and cavern, either concrete or steel lined,
 - f) Grouting materials used in mixture which has been prepared more than one hour prior to injecting or which have been lost due to improper handling or rejected due to improper mixing,
 - g) Supply and injection of water,
 - h) Plugging and caulking leaks during grouting,
 - i) Protection of drainage system, if any, during grouting,
 - j) Communication facilities required during grouting,
 - k) Closure of the holes as specified and clean-up,
 - l) Preparation and submission of records and reports on grouting operations.

End of Chapter

ISSUE P0
