SECTION – X

The performance strips of impermeable material, which are to be embedded in the concrete construction so as to span across the joint and provide a permanent wave length seal during the whole range of joint movement. The most useful forms of water bars are strip with a central longitudinal corrugation and a central longitudinal holding tube with thin walls with stiff wings. The material used for the water bar are synthetic rubbers and plastics have very considerable advantage in handling, splicing and in making intersections.

With all water bars, it is important to ensure proper compaction of the concrete. The bar should have such shape and width that the water path through the concrete round the bar should not be unduly short. The water bar should either be placed centrally in the thickness of the wall or its distances from either side of the wall should not be less than half of the width of the bar. The fill concrete cover to all reinforcement should be maintained.

10.2 Joint sealing compound: Joint sealing compounds are impermeable ductile materials, which are required to provide a watertight seal by adhesion to the concrete throughout the range of the joint movement. The commonly used materials are based on asphalt, bitumen, or coal tar pitch with or without filters, such as lime stone or slate dust, asbestos fibre, chopped hemp, rubber or oilier suitable material. These are usually supplied after construction or just before the reservoir /delivery chamber is put into service by pouring in the hot or cold state. These may also be applied during construction such as by packing round the corrugation of water bar. For detailed specification refer IS 3370 (Part-I-1965).
10.3 MEASUREMENT AND PAYMENT

Payment shall be made on running meter of the water stopper. The unit rate quoted shall include the cost and conveyance of all materials such as water stopper, joint sealing compound and placing and providing joint sealing compound in accordance with the above specification and all other incidental charges.

G.I. PIPE HAND RAILS

10.4. G.I. Pipes of approved quality, confirming to the relevant IS code of 40mm dia. in three rows shall be fixed to RCC posts of CC M-15 grade of size 100mm x 100mm at top and 150mm x 150mm at bottom placed at a distance of 2 mtr. intervals at a height of 750mm including curing, finishing etc. as directed by Engineer-in-charge.

Handrails shall be properly jointed and installed and painted with two coats of paint as approved by Engineer-in-charge.

10.5 MEASUREMENT AND PAYMENT

The measurement of handrails including posts shall be made on running meter basis. The rates quoted for the item shall include supplying, transporting, casting. Installing and painting and other incidental charges.
SECTION – XI

11.0 PRESSURE RELIEF VALVES/DRAINAGE SPOUTS

11.1 Scope of work

Item includes providing and fixing properly pressure relief valves at suitable **. Drainage spouts near at structure locations as per drawings and I.S. 455850 mm in the pressure relief valve of G.I. pipe of approved quality of the required length with suitable sealing ring, bush, and hinged lids as per drawing so as to release water from bed/sides. It includes drilling 25mm dia holes one meter deep in rock. It includes fixing the pipe in concrete I.U.C.R. masonry with anticorrosive painting as directed by the Engineer-in-charge.

11.2 Materials

Metal, sand shall be as per para of specifications for materials, Lid shall be of aluminum plate of approved quality, Hinges, bushes and pin of gun metal of approved quality. G.I. pipes 50mm dia shall be of approved quality.

11.3 Mode of Construction

Pressure relief valves of 0. 1 pipes length required for the bed sides with necessary fittings are to be fixed in concrete. U.C.R. masonry including, painting with anticorrosive paint as per the directions of the Engineer-in-charge, The lengths are only approximate and may vary during execution for which no extra payment will be made. Before fixing the pipe a hole of 25 mm dia one metre deep should be bored beneath the pipe. Before fixing the pipe the hole should be got inspected by the Engineer-in-charge.
The pipes should be fixed so that it will be complete in flush with the finished slopes of the canal sides and the bed without any projections whatsoever. The fixing of pipe should be done simultaneously with laying the concrete far the bed, U.C.R. masonry for the sides.

11.4 Mode of payment

Full payment will be made on Number of pipes, fixed upto satisfaction of Engineer-In-charge that the work has been carried out as described above according the specification.
SECTION – XII

FILTER DRAINS

Scope of work

It includes providing constructing vertical / inclined graded filter drains behind bed and side wing.

This item includes for providing and fixing 50 mm pressure relief values with perforated G.I. pipe 30 cm long for properly at suitable intervals behind PCC lining. This item includes the excavation of pits of size 35 cm x 35 cm x 40 cms and filling the same with filter material of graded sand and graded metal of size 10 mm to 40 mm s as to satisfy the filter criteria between adjacent layers as specified in paragraph 6.00 to 6.11. The filter material shall be hand packed and compacted the perforated GI pipe shall be fixed in the filter pockets. The gradation of each filter layer shall meet the following requirements with respect to the materials to be protected and also with respect to the adjacent filter layers. The specifications of sand and aggregates for the filter shall conform to para 2.2 to 2.4 of materials.

1. D 15 of the filter should be less than 4 times the D 85 of the material to be protected.

2. D 15 of the filter should be greater than 5 times the D 15 of the material to be protected and that the filter does not contain more than 5% of material finer than 0.075 mm.

3. The grain size curve of the filter should be roughly parallel to that of the base material in the filter range.
12.2. Materials

1. Metal and sand shall be as per para of specification for materials.
2. Lid shall be of aluminum plate of approved quality.
3. Perforated G.I. pipe of 50 mm dia shall be of approved quality.
4. Hinges, bushes and pin of gun metal of approved quality.

12.3 Mode of construction

The drain pit of required size shall be excavated with the side vertical in bed drains normal to the side slopes for sides and the excavated stuff shall be disposed off as directed by the engineer-in-charge. Any loose or disturbed material on the sides shall then be well compacted. The graded filter material satisfying filter criteria shall then be carefully placed and compacted in layers as per drawings or as directed by the Engineer-in-charge. The approved pressure relief valves and perforated G.I. pipe with, hinges, lids as per drawings and specifications shall be supplied by the contractor and the same embedded with filter materials. The entire exposed surface of the filter material shall be covered with tar-paper so as to prevent the water from the bed concrete entering into the filter. No extra payment will be made on this account. The pressure relief valves should be so fixed that it will be completely true with the finished slope of the canal sides and bed without any projections whatsoever.

12.4. Mode of Payment

Full payment will be made on Number of pipes fixed, and the filter drains provided upto the satisfaction of Engineer-in-charge that the work has been carried out as described above according to the specification as per items of Schedule “B”.
13.0 GUARD STONES / BOUNDARY STONES / CHAINAGE STONES

13.1. All stones shall be quarried from the approved quarry only. The stones shall be durable, dense, tough and shall be free from decay, whethered portions, skin, cracks, cavities, vesicules and other defects. Stone shall be as far as possible uniform texture. Stone shall be of fine medium graded and shall give ringing sound when struck with a hammer. They shall be of the required size and shall be dressed neatly on the exposed faces. The guard stones shall be hammer dressed.

The stones shall be fixed on both the sides of canal at intervals as directed by the engineer-in-charge. The size of stones shall be 75 cm x 20 cm x 20 cm and the comet above the ground level shall be dressed to the required size and directed by the engineer-in-charge. Arrow marks shall be engraved for boundary stones as directed. The stones shall be fixed by the excavating a pit and back filled with excavated material. The stones shall be white coated as directed. The rate quoted by contractor for this item shall include easy and conveyance of all material, with all leads and lifts, dressing to the required size and shape including engraving arrow mark (for boundary stones) and white washing as directed by Engineer-in-Charge fixing in position by excavating a pit of required size and refilling with excavated materials including consolidation, watering etc., complete.

13.2. Measurements shall be taken after fixing the stones in position in terms of numbers and payment will be made on the basis of unit price quoted in the Schedule “B”.
SECTION – XIV

EXPANSION POINTS AND CONTRACTION JOINTS

Premoulded expansion joint filter to be used in the expansion joints shall be of approved quality prepared ships of fibre mastic and bitumen and having a thickness of 20mm and depth to the thickness of the concrete where it is used. The prepared filler must be of such quality that it will have the necessary adhesive properties which will not be deformed by ordinary handling during the hot-summer months prior to placing and contain sufficient filler incorporated in the bitumen in order to reduce to a minimum its brittleness at freezing temperature. The filler shall be cut to conform to the cross section of the canal lining. The premoulded joints can be prepared in the following manner.

Composition: The mastic used should be composed of

Very fine sand - 60% by wt;   Suitable grade of Asphalts - 30% by wt;
Cement - 8 % by wt;          Chopped hemp - 2% by wt;

The sand should be heated in a large flat pan to a temperature of 400 F. The binder should be heated separately, in a suitable container, to a temperature of about 3600 F. The requisite quantity of binder should then be added to the heated sand and thoroughly stirred. The weighed quantities of cement and chopped hemp are to be added again mixed thoroughly and mixture should be immediately poured in to moulds before it has time to cool appreciably.
14.3 **Mould and method of Filling**

The mould should consist of a plane board about 30 cm longer if necessary. The board should be about 30 cm wide, which is usually sufficient for most expansion joints. Wooden battens should be made to the exact thickness of the expansion joint required and clamped to the board, the distance between the battens corresponding to the width of expansion joint. A strip of brown paper of preferably waxed or oiled paper cut to the width of the expansion joint should be laid between the battens. The inner faces of the battens should then be painted with the solution made of soft soap and water to prevent the bitumen adhering to them. Mastic is then filled in between the battens and struck off smooth with a wide and heavy spatula. Another piece of brown or oiled paper should then be spread over the mastic and gently pressed into it. When the mastic has cooled the clamps are loosened and battens removed. The expansion joint material is then ready to be cut into requisite.

Lengths with a sharp hot knife. The purpose of the oiled brown paper is to prevent the mastic from becoming sticky.

14.4 **Mode of Construction**

Premoulded expansion joint filler of 20mm thickness shall be properly hammered into the joint between adjacent bed concrete, slabs and finished flush with the surface of bed concrete.

Care shall be taken to see that no cavities are left in the joints. The premoulded expansion joint filler shall be such size and shape as to exactly fit in
the joint. In case there are any small cavities left they are to be filled properly; with suitable liquid bituminous mixture as directed by the Engineer-in-charge. Any premoulded filler joints sold in the market under different pattern and found suitable to this work may be used with’ the specific approval of the Engineer-in-charge. Similarly, 12mm thick filler to be used for UCR masonry as directed by Engineer-in-charge.

143 Mode of Payment

Payment will be made on running meters of the joints and shall be at unit rates in Schedule “B” in respective items includes cost of all materials, conveyance manufacturing and filler strips and fixing the same with all leads and lifts.
SECTION XI

Installation of flume

Normal site condition 20 cm to 30cm excavation below CBL is sufficient. In black cotton soil addition excavation for B.C. soil treatment if required. Fill up 20 to 30 cm excavated by M-100 grade concrete. Keep 3 times slope to hump to US and DIS side. Lay cement lurry to back side of flume and rub slowly on hub concrete to remove air. Keep weights the flume temporarily for smooth jointing. Cut throat flumes are in one piece but Parshall are in two to ten pieces depending oil capacity. In parshall flume first set convergent flat in surface and adjust other joints by taking levels. Use vibrator in the holes of bottom for an concreting. Construct sidewall to both sides of flume and hold fast in brick masonry or K. or in cement concrete M 150 grade. Give transition upto hump slope length to both ends 30cm key portion at U/S end.
SECTION XVI

16. DISMANTLING WORKS

16.1. CEMENT CONCRETE / RCC / BRICK OR TILE WORK / RUBBLE PASS

Dismantling cement concrete 1:2:4 mix and precast cement concrete blocks or plain to concrete work, rubble masonry work, RCC of all grades with chisels including remio clearing the debris and stacking the reusable materials viz., steel, shabhad slab etc., as directed by the Engineer -in -Charge of work.

16.2. MEASUREMENT AND PAYMENT

Measurement for Payment of work shall be made on cubic meter basis and paid at unit rate of Schedule-B which shall include the cost of labour, materials, tools, scaffolding, curing, other expenses incidental to the work.
GENERAL INFORMATION ON TUNNELING

Item No. 1.

Excavation for tunneling in all type of strata by adopting standard practices, including drilling, blasting, defuming, disposal of the excavated muck in specified dump yards with all leads and lifts, including dewatering and desilting, lighting, ventilation etc, complete in all respects, as per detailed specification and as directed by Engineer in charge.

Before proceeding with the work of excavation of approach or exit canals, triangulation survey has to be carried out at the field by the contractor. The purpose of the survey is as under:

a. To determine the exact length of the tunnel.

b. To fix reference points outside the tunnel for day-to-day marking out of Tunnel alignment

Both the above objectives have to be achieved by carrying out triangulation survey with the help of precision theodolite. Broad alignment of the tunnel shall be based on detailed topographical maps. After fixing the obligatory points, like portal points, shaft location, etc. on topographical maps, the run of the tunnel may be decided.

The two end points of the tunnel shall then be located on the ground and the stations from which driving lines shall be set out shall be fixed precisely. These points shall be permanent reference points and shall be fixed on concrete pillars.
Beginning from the portal point, the alignment of the tunnel should be marked on the ground with help of Asian Theoadlite. Concrete pillars shall be erected at all intermediate points used for tunnel alignment.

After marking the alignment of the tunnel on the ground, triangulation survey should be carried out to achieve the above two objects. A minimum of two permanent reference points shall be established at all faces, from which tunneling is to progress. These reference points should be outside the working area and any zone of disturbance.

It is necessary that permanent bench marks are established near all faces from which tunneling is proposed to be done. Bench marks have to be established with the help of double instruments, levels carried from nearest GTS bench mark.

Having finalized the coordinates of the alignment of the tunnel at the faces where tunneling is to be started and also by finalizing the levels at faces, tunneling is to be commenced from various faces. On the faces of excavation at portals and shaft, alignment of the tunnel shall be marked with reference to the permanent reference point and the centre line outside the tunnel.

The procedure shall be carried out for marking the alignment of the tunnel as the work progress from the faces, till the face of the tunnel is visible from the initial reference points.

As the tunneling progresses and marking the alignment from outside reference points is not possible, reference points shall be constructed in the tunnel roughly at even, 300m interval. Repeated observations have to be made to mark the correct alignment on each of such reference points.
In case of shafts, transfer of alignment at the invert of the tunnel and the level is of utmost importance. Transfer of alignment of the tunnel, shall be done as per standard method described in relevant Indian Standards or its latest version. Levels shall be transferred from the vertical shaft by means of steel binds, chain or invert wires on a calm non-windy day. Repeated measurement shall be made to ensure higher accuracy. Utmost care is to be taken to see that at the meeting point of the faces there is no error, either in the alignment or the invert level of tunnel. Error if any up to 50mm should be adjusted in the erection of shuttering for concerting itself. In general precision survey and setting out of tunnel shall be carried out in accordance with IS 5878 (part D9~7 or its latest version

**Tunneling methods**

The method of tunneling generally depends upon the size and shape of the tunnel, the equipment available, the condition of rock formation, the extent up to which supports are necessary and over all economics. Most common methods of tunneling are Fall face, top heading benching and the drift method.

The actual operations in the construction of the tunnel may vary with size and type of tunnel, method of attack and the kind of formation encountered.

Following shall be the sequences of operations to be adopted in the Tunneling

a. Marking tunnel profile

b. Setting up and drilling

c. Loading explosives and blasting

d. Removing the foul gasses.
e. Checking misfires
f. Scaling
g. Mucking and
h. Guniting, erecting supports, or rock bolting and lining when necessary.

**Tunneling through soft strata**

This will depend on the softness of the strata, the subsoil water conditions and the facilities available far construction. The choice of tunneling, method to be adopted would depend upon the response of the strata to the technique adopted. Various tunneling methods in vogue for soft strata are classified based on following categories of strata.

a. Firm ground: Ground where seasonable bridging period is available for installing conventional supports.

b. Soft ground: Ground where bridging period is so short that conventional supports cannot be installed.

Though the gee-physical investigations and exploratory drilling carried out have indicated that the entire alignment of the tunnel passes through good rock without any geological discontinuity, surprises in sub surface work cannot be ruled out. In case any strata of any of the above two type is encountered, established methods of tunneling will have to be adopted to pass through such strata. No extra payment shall be allowed for such a contingency.
**Tunneling through rock**

For tunneling through rock, it is essential to drill holes for charging the explosives. The drilling pattern should be worked out by experiment for each particular work as it depends on texture and formation of rock, size and shape of the tunnel, the strength of explosives and also the fragmentation of the rock required so as to make it suitable for handling by mucking equipment. The drilling should be so as to ensure minimum over break and least amount of explosives per unit volume of excavation.

Holes shall be drilled by using pneumatically operated rock drills in conjunction with pneumatic pushers with loaders or drifters, mounted on column bars or drill carriages may be found suitable. Only wet drilling shall be adopted. Number of drills to be engaged is governed by the area of the face of the tunnel and shall generally be at the rate of one for 4 to 5 sq. m. of face area.

**Drilling patterns**

The drilling pattern to be adept Pt aisiotf the following

a. Cut holes

b. Erasers and

c. Trimmers

Cut holes shall be provided in the center of section of tunnel and 15 cm to 30 cm deeper than the other holes and are drilled converging towards the center of the face, so as to produce an initial cane or wedge as a free face for breaking off succeeding holes.
Function of the easer holes is to blast the area around the cane/wedge created by cut holes, there by reducing the burden on other holes. Charges in these holes are lesser Wan in cut holes which carry the heaviest change. These shall be located around the cut holes.

Trimmers are the holes drilled along the periphery of the profile. Te purpose of these holes is to give the section the required shape. These are charged lighter as compared to other holes to avoid excessive over break.

**Blasting**

High explosives are used for tunneling operation. Several types of explosives are available in the market. Depending upon the type of rock, type of explosive to be used is decided.

Generally special gelatin 90% to 40% is used. Depending upon the actual rock condition the strength of gelatin to be used has to be decided. In tunnel excavation, only electrical delay detonators shall be used. These delay detonators are available in delay number of 0 to 6, with nominal delay 25 milliseconds.

The electric detonator provides the means of initiating explosive charge electrically. The detonator consists of aluminium or copper tube containing a small explosive charged, with its open end sealed with a neoprene plug through which the leading wires of the fuse head assembly pass. The explosives change it initiated by the flash of the fuse head, which occurs when electric current passes through the fuse head. The leading wires are generally 1.8 M long.
It is absolutely necessary to test every electric detonator and also the circuit. For this purpose and safety ohmmeter is used. To test an electric detonator, it should be placed inside an iron pot or tube to guard against accidental explosion. The open ends of the ‘Loading wares are to be connected with terminals of the ohmmeter and if the needle deflects and shows the correct resistance of the detonator, it indicates that the circuit is complete and detonator is in order.

**Loading and Stemming**

Before loading is started, each hole shall be blown out with a high pressured air jet to remove loose cuttings and water. In tunnels equipped with drill carriages, when holes are loaded from the platforms, all light and power lines shall be disconnected from the carriage. For lighting the face of the tunnel during loading, food lights are required to be fixed at safe distances.

For loading of holes, a fall cartridge shall be inserted first, tamped well into the bottom, then a primer shall be placed with the end containing the detonator pointing towards the bottom of the hole. Both the primer and the next placed cartridge shall be tamped lightly to prevent jamming of the detonator. The remaining, cartridges shall then be tamped firmly in place with a wooden pole, taking care to prevent breaking of the detonator wires. In no case iron or steel device shall be used for tamping. The remaining portion of the hole not occupied by explosive shall be filled with an inert material and tightly tamped. A damp mixture of sand and clay either packed in paper bags or loose may also be used.

For electrical blasting the wires used are, leading wires or leg wires, connecting wires and shot firing cable. The leading wires are insulated wires that
extend from the end of the detonator. Lengths of leading wires range from 1.8 M to 10 M depending upon the requirement. The bare ends of the leading wires shall be kept short circuited at precaution against accidental detonation due to stray current. Connecting wires are insulated wires which are required to complete the circuit between the leading wires of adjacent detonators or between the detonator and the shot firing cable. To connect the source of power to the detonating circuit shot firing cables are used. These should be well insulated and two core cable, each core consisting of conductor and at least four copper wires not less than 0.46 mm diameter. The length of this cable shall be at least 300 M.

For blasting the charge, either in series or parallel and a combination may be adopted. The connection between the leading wires of detonators and the shot firing cable shall be made tightly and kept away from the ground and water. After all the connections are made the circuit shall be checked with an ohm-meter. If the meter does not show the appropriate reading of the resistance of the circuit, it is an indication of a fault in the circuit. After the fault is detected and connections are made once again, the circuit shall be connected to the source of power and fired, leaving the faulty detonator. The connecting wires shall be connected to the two cores of main shot firing cable that is carries on the side of the tunnel opposite to the location of light and power lines.

The location of firing station should be safe. In short tunnels where the heading is short, the firing switch shall be located outside the portal cleat of possible flying rock. In long headings, the switch shall be at least 300 M away from the face. Current for firing the blast may be obtained from power circuit or an exploder. Storage or dry cell batteries shall not be used because of their low
Voltage and deterioration. In case of firing from power lines, in order to avoid fluctuation in voltage and current, it is advisable to use individual underground circuit and not the same line that supplies current to other equipment. Adequate safety precautions shall be taken during transportation, storage and use of explosives.

Immediately after the smoke is cleared away from the blast, the results shall be inspected by a competent tunnel foreman. All loose rock shall be removed carefully by barring, so as to ensure that access to the face is safe. A careful inspection of the face shall be made to check misfires. Working near a misfired hole is most dangerous operation in tunneling. Investigation and correction shall be left to an experienced person.

**Ventilation**

The purpose of ventilation is to make the working space in the tunnel safe for workers by keeping the air fresh and respirable free from obnoxious gases and dust. Ventilation also serves the purpose of bringing down high temperature especially at the working space.

Mechanical ventilation shall be adopted to force air in or out form the working space through ventilation ducts. Among the several methods of ventilation, the combined system of ventilation is desirable. This may be achieved by providing reversible ventilation fans, whereby with the installation of duct and blowers, the exhausting and blowing in air can be achieved.
Ventilation ducts shall be of metal. Duct line shall be laid either on the floor or hung from the sidewall excavation. Care shall be exercised to see that all the joints of duct line are air tight. Ventilation fans shall be reversible type, axial blowers with fan fitted directly on totally enclosed electric motors. It is normal practice to fit two units in one shell to increase the total output.

In the use of ventilation system, the pressure under which air is to be pumped shall be determined based on site conditions. The diameter of the pipe shall be fixed taking into account the volume of air required on consideration of purity of air, dust control and also the frictional resistance of the pipes. Some length of air duct near the working face shall be kept flexible from the penal and no elaborate system is necessary. For longer length of tunnel, addition of boosters at suitable locations may be necessary.

**Lighting**

Adequate lighting shall be provided at the face and at any other point where work is in progress and at equipment installations. A minimum illumination of 100 lux shall be provided at the tunnel and shaft headings during drilling, mucking and scaling. Along the length of tunnel adequate lighting is to be provided. Any obstruction such as formwork, etc shall be lighted to avoid accidents during movement of hauling equipment.

Lighting at the face of the tunnel shall be adequate. However no single light shall be so powerful as to cause temporary blinding effect when looked at. Voltage of supply line in the tunnel shall be reduced to 110 volts for lighting. Incandescent lamps shall be used in the center of the roof of the tunnel. In case lamps are fixed
on the sides of the tunnel, they shall be as high as possible, and well above ventilation ducts so that the shadow of the duct is not formed on the road surface.

Electric circuits of the lighting tunnel shall be divided into number of independent circuits with separate isolators and fuse boxes. With the separation of the circuits switching off the desired while the other circuits are in operation can easily do the repair work on the electric lighting system. In addition to the fixed lighting system, all hauling equipment shall have their own lighting system. In addition to normal lightings, provision of floodlights shall also be made at suitable intervals for detailed inspection of any particular length of spot in the tunnel.

At all faces where tunneling is in progress, installing diesel generators shall provide alternate arrangement for power supply. In case of tunnel faces, the alternate power supply should be capable of keeping the ventilation and lighting in working condition. In ease of faces through shafts, in addition to lighting and ventilation, the alternate power supply shall be capable of operating the elevator also. Source of alternate power supply shall be out side of the tunnel.

**Mucking**

Capacity of the equipment for loading the muck shall be fixed such that immediately after defuming, mucking is completed in shortest possible period. This will depend upon haulage equipment that can be deployed in the tunnel of the size under construction and its speed. In general the combination of loading and hauling equipments shall be so as to be able to complete mucking in a period of not more than 10 hours. In all conditions the loading and hauling equipment may be driven by diesel electrical or compressed air. It is preferable to use electric driven equipment for loading and haulage of muck. Equipment driven by petrol shall not be used inside in side the tunnel.
Dewatering

Water that accumulates in the tunnel shall be effectively removed either by gravity flow or pumping, depending upon conditions and circumstances met with. Where a tunnel is excavated on a flat or downward gradient, the water accumulated shall be pumped out. Depending upon the length of the tunnel, the gradient pumping may be either made in single stage or multistage. The pumping equipment to be used for dewatering shall be of the type, which is non clogging, as the water to be pumped will be charged with dist particles. Dewatering at the working face of the tunnel shall be carried out by means of pneumatic motors.

Dewatering arrangement to be done shall be such that there is no interruption of any of the tunneling operations on account of its failure. For this purpose necessary standard equipment shall be kept ready very close to the face of operation. There should also be alternative power supply available for this operation. The installation should be such that it should be possible to switch over to alternative system with minimum loss of time. Under no circumstances, there should be interruption in this activity and that other activities of tunneling area is not affected.

Nitches

For the purpose of speedy completion of tunnel excavation works, nitches are to be excavated in tunnel at an interval of 500 M, only on one side. These have to be for turning of machineries, equipment and trucks. When tunnel is through and before lining is taken, the nitches nave to be filled back in UCR masonry of 1:5 proportion to the profile of tunnel. No payment shall be made for such backfill.
Measurement and payment:

The payment will be made on volumetric basis for the quantities excavated to the required extent. The cross sections shall be taken initially being commencement of excavation. Lines, levels and grades of excavation shall be marked for excavation. On completion of excavation, final cross sections shall be taken. These sections will be marked on the initial cross sections taken prior to commencement of work.

The quantities between initial and final cross sections limited to pay lines shall be worked out for different soil classifications and paid for at the appropriate rate quoted in Schedule B. The rate for excavation of canal is inclusive of dewater and desilting.

The rates for excavation include the conveyance and excavated materials for use in the works and / or for disposal in spoil banks and where so directed, placing the materials for bank work in layers of specified thickness with all leads, all lifts and all incidental charges. It also includes cost of backfilling over excavation if any. The payment for excavation will not be made in full until over excavations are satisfactorily backfilled.

The rate of excavation shall include cost of controlled blasting to obtain smooth rock profile and to control vibration and fly rocks. Except in certain specified reaches extra payment towards controlled blasting to control vibrations and fly rocks would not be payable.
**Item No 2:**

Removing and hauling the over fallen muck fallen from beyond the pay line due to natural calamities like geological fault etc., out of tunnel and disposing off the same in specified dump areas including dewatering and desilting, cost of the ventilation, drainage and lighting and all other ancillary operation etc., with all leads and lifts, complete as per detailed specifications, as directed by the Engineer in charge of works.

Scope of work provides for removing and hauling the over fallen muck due to natural causes like geological faults out of the tunnel.

In case of over fall or collapses due to natural causes like Geological joints, etc., occurring in patches over and above, the pay line, only the cost of disposing the muck to the specified dump area shall be paid for as per the rates quoted in Schedule B.

All operations and conditions from items 1, 3 to 6 and 8 to 10 of schedule to apply to this item also except for the blasting operation which is not required for this case.

Wherever cavities are formed due to over falls as mentioned above, the same shall be filled either by UCR masonry or cement concrete. No additional payments will be made this filling.
**Item No 3: Temporary Supports**

Providing and fixing temporary supports during the tunneling including removal after fixing permanent supports/concrete lining, including cost of all materials, fabricating, placing in position including dewatering and desilting, ventilation, lighting etc., complete as per detailed specification as directed by the Engineer in charge of works etc.

3.1. These shall be erected by the contractor, where so directed by the Engineer in writing. It shall however, be the contractor’s responsibility to bring the same requirement in writing to the notice of the Engineer and locations where the contractor may consider the provision of temporary supports necessary. Consequences if any, for his failure to do so in good time shall be the sole responsibility of the contractor.

3.2. The method, the extent of supporting, sizes and spacing of supports, etc., shall be as approved by the Engineer. This shall also include temporary supports or propping that may be needed before fixing supporting bolts. The stipulation given in permanent supports shall apply in case of temporary supports also. The supports may be of steel or timber. They shall be removed before placing concrete lining. They will be allowed to be left in place provided they are of steel and conform to the provisions under permanent supports and do not reduce the minimum thickness of concrete lining as shown in the typical supported sections of the drawings.

3.3. This item also includes cost of lighting, dewatering, drainage and ventilation.
3.4. Measurement and payment

Such temporary supports used shall be paid at unit rates quoted in Schedule B. Lagging if used, will not be paid for separately. The rate shall hold good for the first erection as well as for the subsequent additions if necessary. This rate shall include cost of furnishing the materials, fabricating, erecting, maintaining and removing the supports. The material will be the contractor’s property after removal. However, any steel supports are allowed to be left as specified, the same xviii be paid for as permanent supports instead of temporary supports. Such supports shall not however, be left in place unless at the specific direction of the Engineer in writing.

Item No 4: Permanent Supports

Providing and fixing permanent supports during the tunnel including lagging/blocking with cut jungle wood of hard variety wherever necessary, including dewatering and desilting, cost of materials, fabrication and fixing in position, including ventilation, lighting, drainage etc., complete with all leads and lifts as per detailed specification and drawing as directed by Engineer in charge of works.

4.1. Rock tunnel supports of steel may be of type continuous ribs, rib and post, rib and wall plate, rib, wall plate and post. The selection of the type of support system shall depend upon method of tunneling and characteristics, the size and shape. Any type of support system as suitable for full face tunneling and where required stand up time for supports are provided is available. If tunneling by heading and benching meted becomes necessary
due to Geological reasons, rib and wall plate or rib, wall plate and post type of support system shall be adopted. Due to geological reasons, if it becomes necessary to first drive the heading only, rib and wall plate type of support system shall be adopted.

4.2. Ribs shall be of ISMB 200 structural steel. Channel sections shall not be used. Posts to be provided shall be of the same section as that. Spacing or ribs shall be as per drawings and specification. Spacing of posts shall be the same as of ribs. Wall plate if required to be provided shall be either of double beam or single beam, depending upon requirement. Longitudinal bracing shall be provided to increase the resistance of ribs and posts against buckling and to prevent displacement during blasting. Where the space between the ribs or posts is bridged by lagging, which is firmly attached to the webs, branches may not be necessary.

4.3. In case the excavation of tunnel is done beyond the concrete lining blocking shall be done, generally by use of timber pieces tightly wedged between the rock and the rib. Blocking combined with lagging is necessary to provide protection from falling rock and to receive and transfer the load to the ribs. This also serves the purpose of providing a smooth surface against which back packing is to be placed. Lagging shall be either of steel, pre-cast concrete or timber. As far as possible care shall be taken to see that use of timber lagging is avoided, since timber once fixed can be rarely removed and if nor removed, will become a weak point.
4.4. The spacing of lags shall be closest at the crown, increasing down to spring tine. On the side only an occasional lagging may be used. Close lagging shall be adopted where rock conditions make it necessary.

4.5. In case excavation of tunnel has taken place such that there is gap between the support system and the rock, the gap shall be filled with tunnel excavation muck. This packing is to be done simultaneously with the erection of lagging. Where considerable rock loads are anticipated concrete racking shall be used. Concrete packing may be of grade M 10 concrete shall be placed manually or by pneumatic placer. In case the situation warrants or the main concrete lining is likely to be delayed considerably grouting at low pressure shall be done after packing.

4.6. Ribs shall generally be bent cold. The accuracy of fabrication shall be such that each segment shall confirm to true template at ends. Intermediate portions may vary from true template by not more than +/-10 minutes. The web shall be true and wrinkles or buckles shall not exceed 5 minutes when measured from straight edge.

4.7. Steel supporting system shall be erected a spacing shown in the drawing and kept blocked and wedged lightly until concrete lining is done. These may be erected either vertical or at right angles to the slope of the tunnel. The erection shall be done within the tolerances as per IS 5875 (Part-IV)-1971.

4.8. Before commencement of tunneling operations steel supports shall be fabricated and kept ready near the site of work atleast one full length of system has to be followed during the period tunneling.
4.9. For the purpose of these specifications, permanent supports are defined as steel supports which shall be left in place, be embedded in the concrete lining and shall include structural steel supports complete with all rivets, plates, spikes, drift pins, dowels, wedges, tie-rods, temporary timber spreaders, wrenches and other accessories required for assembling the supports, erecting and supporting them in place until the concrete lining is placed. Included also are all permanent blocks, lagging and sills for the steel support, etc. All these materials shall be supplied and provided by the contractor.

4.10. The steel supports shall where approved or directed by the Engineer be installed in a workman like manner true to line and grade and as directed by the engineer. The same shall be maintained by the contractor in proper condition and alignment until concrete lining is placed. The contractor shall adjust any supports placed improperly within 48 hours after the defects are brought to his attention. Temporary timber spreaders shall be removed before concrete lining.

In situations where there is danger of yielding of rock, the same shall be immediately and adequately supported. Concrete slabs, if used, shall be of quality not inferior to the lining concrete, packing with pieces of sound rock may be used and fully grouted later.

4.11 Measurement and Payment

Measurements and payment for furnishing and installing the permanent steel supports as specified above shall be made on the quantity of steel in
structural sections used in the supports proper and tie rods on weights and not lengths and sizes. Quantity utilized for supports shall be from unit weights, Bolts, nuts, rivets, plates, etc. used to fabricate structural supports will not be included in calculating weight of steel to be paid and shall be considered included in the rates for steel supports.

No separate payment shall be made for tie lagging, supporting, blocking of grouting used, which shall be considered included in the item of steel supports. Payment for lining concrete placed later will, however be made upto the pay line as for excavation irrespective of whether or not any supports fall within that line.

The rate accepted in the schedule of prices for steel supports will also hold good for any additional steel supports that may be needed and erected as described above. This item includes cost of dewatering, lighting and ventilation charges.

**Item No. 5 : Lining of Tunnel; arch and sides**

Providing and laying in situ vibrated M-20 (28 days cube compressive strength not less than 20 N/sq mm) grade cement concrete using 40mm and down size approved clean, hard, graded aggregate crushed from tunnel excavated muck for sides and arch lining including cost of all materials, machinery, labour, formwork, batching, mixing, conveying upto placing point in agitator car, placing in position, levelling, vibrating, finishing, curing, ventilation, lighting, drainage and all other ancillary operations etc., complete with all lead and lift and as directed by the Engineer-in-charge of the work.
5.1. All specification for course and fine aggregates, cement, water and concrete grading shall confirm to respective specifications mentioned elsewhere in this document. On account of curvature and irregularities in rock profile and thin sections, placing of concrete has to be done either through a concrete pump or placer. The concrete to be used for lining has to flow to avoid segregation and to ensure proper filling in. The slump of concrete should not be less than 10 cm. The cement content of concrete shall also be suitably increased, slightly more than what is indicated by laboratory tests. For concrete at the invert placed directly, slump shall be reduced to 5 cm. Maximum size of course aggregate shall not exceed 20 mm. To improve the workability of concrete, air-entraining agent can be used to entrain up to 4% air.

5.2. Appropriate time for placing concrete lining will be governed by the condition of rock tunnelled through. It is a general practice to commence concrete lining after tunneling is through from face to face. In case the rock is likely to deteriorate in structure, placing of a thin layer of concrete between the steel ribs, to support full surface of rock and transfer load to the steel supports would become necessary, blocking concrete has to be placed with minimum time lag after exaction. In case where rock condition is better, concrete lining can be taken up at any time convenient to suit the construction program and practical considerations.

5.3. The sequence of placement of concrete lining shall be from the curb, first, followed by sidewalls and arch and finally invert. Curb shall be built in a section of sufficient width to serve as base for erection of forms, and shall be properly menaced and made stable to withstand loads of concrete lining and form work, with sides of radial to their respective curvatures.
5.4. After the curb is constructed, lining of sides and arch shall follow. This sequence has the advantage that all operations of concreting curb placing if shutters and forms and lining of sides and arch can be done with minimum disturbance to the track lines on the floor and for movement of other traffic. The invert concreting is done last after removing the track line and other services. An additional advantage in this is that it permits of concreting the sides and arch simultaneously with excavation with suitable gap.

5.5. Generally for tunnel lining, steel forms have to be used. The steel formwork shall be traveling non-telescoping or telescopic. In this case whole formwork shall be pro-assembled and mounted on a traversing frame with wheels running on tracks. Screw jacks shall be provided lb collapsing formwork when required. The jacks to be fixed to the formwork are required for bracing and aligning the formwork. In the use of such work concrete for sides and arch shall be placed in one operation. The traveler, which carries the form structurally, shall be struck and reassembled quickly depending upon the requirement of construction, traffic and matching concrete equipment.

5.6. All formwork should have inspection windows of size 50 cm x 30 cm and not more than 3 M apart. Horizontal and vertical intervals of spacing shall depend on the size and shape of tunnel. For the tunnel in question windows shall be used for placement and vibration of concrete. The shutter of these windows shall be strong, easy to operate, and shall be well fining as not to pewit cement slurry to flow out or leave projections in the finished concrete surface. Flexible shaft internal type vibrators shall be used through these
windows. All forms, except where continuous non-stop concreting is adopted shall be provided with a bulkhead shuttering at the other end and shall be made out of timber. The bulkhead is necessary to get a neat construction joint. In tunnel bored through rock and where concrete is placed mechanically forms may be removed after 16 to 24 hours from the time of placement of the last batch of concrete.

5.7. For concrete lining of tunnel a batching and mixing plant shall be used for manufacture of concrete. The size of the batching and mixing plant shall be commensurate with the progress to be achieved and also the size of the formwork such that placement of concrete is continuous up to the end of the formwork.

5.8. From the batching and mixing plant, concrete shall be transported to the site of placement as quickly as possible by use of agitator cars. From the agitator car concrete shall be poured in to the hopper of concrete pump or placer kept close to the location of concreting. Utmost care has to is taken to see that placement of concrete shall he completed, before initial set begins As the time of transportation increases due to distance in the tunnel and there is possibility of initial set taking place, before placement suitable retarders shall be used with permission of Engineer. Use of retarders shall be avoided to the extent possible. In case it becomes necessary to use a construction shaft for concrete lining of tunnel, concrete shall be lowered through the shaft by using on “Elephant trunk”, the drop of concrete from bottom of the trunk shall not be more than one meter. Concrete can also be lowered through buckets of suitable size and winches.
5.9. During concreting by pump or placer behind form work for sides and arch, in case placement is interrupted for a period of more than one hour, a batch of cement mortar sufficient to cover the area by 15 mm thick layer shall be pumped to cover the cold joint.

5.10. The proportion of mortar shall be the same as in the lining concrete. While pouring concrete through side windows care shall be taken to see that no hollow pockets remain.

5.11. Placement of concrete behind the forms shall be either through pump or placer, the discharge end of the concrete delivery pipe shall be kept buried inside the freshly laid concrete as far as practicable to avoid segregation, pumps and placers are sensitive to the pressure of the compressed air supply. In case of long air supply lines, air chambers of adequate capacity shall be provided a suitable intervals to reduce crop in air pressure.

5.12. In concrete lining of tunnel, two types of construction joints are necessary, necessary, one join will be at the bulkhead and the other shall be longitudinal. Bulkhead joints have to be provided at the end of each shatter. Longitudinal joints are necessary at the sides and invert or the sides. Where the curb becomes an integral part of either the invert or the sides where the curbs are laid separately there shall be two such joints of at each curb. No separate treatment is necessary at such joints except general cleaning and where necessary a layer of cement sand mortar of the same proportion as that of concrete.
5.13. Flexible shaft immersion type vibrators having a vibrating needle of 50 mm dia, and 8000 vibrations per minute frequency shall be used for vibration and compaction of concrete. In addition, external form vibrators of minimum 0.5 KW capacities fixed on the formwork shall also vibrate concrete behind the forms. The spacing of the vibrator shall depend on the size of vibrators, mass of formwork and thickness of concrete. The spacing shall be adequate to ensure satisfactory compaction of concrete. The spacing of vibrators shall be closer crown portion.

5.14. Curing of concrete shall be done by spraying water at short intervals to maintain a wet surface. Under no circumstances concrete shall be allowed to dry. It is desirable to keep water storage tank of suitable capacity to account for any break down of water supply system when a Length of tunnel lining is under curing. Stand by arrangement shall exist, for supply of water for curing of concrete. This arrangement shall be adequate to meet the requirement of at least one day of curing.

5.15. Measurement and payment

Measurement and payment will be made as per drawing and specification. Except otherwise specially provided for in the specifications, measurements of concrete for payment shall be made on the basis of the volume of concrete measured and calculated as being contained within the prescribed concrete outlines shown on the relevant drawings.

No measurements shall be made for the concrete backfill beyond the minimum lines of excavation shown on the drawings except where such payment
is specifically authorized. Measurement of concrete shall be made after deducting to volume of all recesses, passageways, chambers, openings, cavities and depression but without deductions for rounding of corners or beveled edges or space occupied by electrical and reinforcement.

**Item No. 6 : Steel reinforcement of tunnel RCC work**

Providing, fabricating and placing in position reinforcement steel for tunnel RCC works including cleaning, straightening, cuffing, bending, hooking, lapping I welding joints wherever required, tying with 1.25 mm diameter soft annealed steel wire, including cost of all materials, labour, machinery, ventilation, lighting, drainage etc., complete with all lead and lift and as directed by the Engineer-in-charge of the work.

6.1. The specification for this item is detailed in page 280 in this document. The seine may be referred for all technical details and also far measurement and payments.

**Item No. 7 : Drilling Grout Holes**

Drilling grout holes in tunnel section, in rock, concrete lining or masonry (wherever required) of .35 mm minimum dia including drainage, ventilation; dewatering, desilting, lighting etc., as per specification, as directed by Engineer in charge or works.
7.1. Drilling grout holes

7.1.1. Grout holes shall be drilled either directly into rock, through the concrete lining or through masonry and then into rock as may be directed by the engineer.

7.1.2. The holes shall be ordinarily drilled in a direction normal to the surface of the underground excavation, concrete lining as the case may be. In case where seams in the rock, if any have to be intercepted the holes shall be drilled at inclinations as may be directed by the engineer.

7.1.3. While drilling these holes, utmost care shall be taken to ensure that the reinforcement, if any, in the concrete lining shall not be cut through. Percussion drilling shall be adopted by use of wagger drills.

7.1.4 Location, direction and order of drilling grout holes shall be as directed by the Engineer. The depth is not ordinarily expected to exceed 2.5 M.

7.1.5 Each hole shall be protected from becoming clogged or obstructed by a grout connection pipe fixed suitably into the hole and the holes shall be suitably capped or otherwise protected until the hole is grouted. Any hole that becomes obstructed before being grouted shall before grouting be opened by at the expense of the contractor and in a manner satisfactory to the Engineer.
7.2. Measurement and Payment

7.2.1. Grout holes driven in rock and concrete will be measured for payment after the holes are drilled and only the holes drilled to the specified depths and at the directions of the Engineer shall be entitled for measurement and payment. Holes drilled deeper than specified, shall also be paid only up to specified depth.

7.2.2. Except as otherwise specifically provided, all holes so measured will be paid for at the unit rate accepted for drilling grout holes and drainage holes, which unit rate shall include the cost of labour, material, dewatering, desilting, light and ventilation, after operations required in drilling the holes, maintaining them till being grouted as specified and all the necessary operations within the intent and purpose of this item of work.

Item No. 8 : Clearing Grout Holes

Clearing the grout hole with water under pressure and conducting water tests including dewatering and desilting, the cost of watering, operating equipment, labour, drainage, ventilation and, lighting etc., and all other necessary operations connected there with, as per specification, etc., complete, as directed by Engineer in charge or works.

8.1. Cleaning holes

Before grouting, the drilled holes shall be sufficiently cleaned with water and air under pressure to allow for free flow of grout
8.2. Pipes and fittings

8.2.1. Metal pipes for grout connection shall be set in the holes drilled at such points as may be directed by the Engineer. The pipes shall be fixed into the holes with suitable caulking to the satisfaction of Engineer so as to prevent loss of grout out of the mouth.

8.2.2. Pipes, if placed prior to placing of concrete lining, shall be capped or plugged with suitable material to prevent entry of obstructing materials prior to grouting.

8.2.3. The pipe shall be black (iron) pipe of thickness not less than 3 mm strong enough to stand the grout pressure. The contractor shall furnish pipe and fittings for the grout connections and the packing and caulk by materials required.

8.2.4. The pipe shall be cut and fabricated as approved by the Engineer payment for all works provided in the clause shall be deemed to be included in the unit rate accepted for grouting in schedule of rates.

8.3. Measurement and Payment

Payment for cleaning grout holes will be made at the unit rate accepted there for under item No. 8 of Schedule B. The clearing of grout holes and the pipe and fittings required for grouting will be deemed to have been included in the rate of grout hole cleaning.
**Item No. 9 : Grouting cement into Grout Holes**

Grouting cement into the grout holes under pressure as per specification including cost of drainage, dewatering, desilting, ventilation and, lighting etc., complete with all leads and lifts as directed by Engineer in charge or works.

9.1. Grouting shall be carried out to fill discontinuities in the rock so improve the stability of the tunnel roof, and to improve the properties of the rock. Grouting may be necessary to reduce the permeability. Grouting is also necessary to ensure proper contact of rock with the lining. The grouting procedure shall aim at satisfying the requirements, economically and in conformity with construction schedule. Two types of grouting required to be carried out are:

a. Backfill grouting and

b. Contact grouting

9.2. Backfill grouting shall be carried out to fill the space left unfilled with concrete between the concrete lining and the rock surface in the arch portion of the tunnel or cavities. Such grouting shall be done after the concrete lining had gained strength. The minimum interval between placement of lining and commencement of grouting shall not be less than 28 days. The location and depth of holes shall be as shown in the drawing and as directed by the Engineer. The mortar to be used for backfill grouting shall normally consist of cement, sand and water mixed in the proportion of 1:1:1 by weight. The proportion may however by modified by Engineer if it becomes necessary and use of sand in the grout may also be deleted.
9.3. Contact grouting shall be done as per drawings or as directed by the Engineer. This work shall be commenced after the concrete has attained sufficient strength to withstand the grouting pressure and shrinkage if any has taken place.

9.4. Pressure to be used for grouting shall depend on the rock characteristics, the design requirement and the cover. For backfill grouting the pressure to be used for grouting shall generally be 2 kg/cm² and shall not exceed 5 kg/cm². For pack grouting also generally same grouting pressure shall be adopted. As long as grouting is in progress watch shall be kept on tile pressure gauge constantly so that the pressure of grouting is regulated as per requirement. Changing the speed of tile grout pumps shall attain any required increase or decrease in the grout pressure. In case the grout in the supply line becomes sluggish the grout hole valve should be closed and the blow off value shall be opened so that the supply line is flushed or washed.

9.5. The size of the holes to be drilled for grouting shall be as shown in the drawing. In the tunnel, attempt shall be made to see that drilling of holes through the lining concrete is avoided to the maximum extent possible. As the location and portion of holes to be drilled is earlier decided, CI or GI pipes could be placed at the locations while concreting. For all types of grouting drilling shall be done by using percussion drilling equipment. The drilling machine is to be equipped to provide for a continuous water or air flushing.
9.6. It is preferable to drill a hole and complete grouting in that hole, before drilling the adjoining hole in the same plane as in another plane, so as to avoid blocking of holes by flow of grout, in case inter connection is established. In case of pack grouting the side holes shall be drilled and grouted first, before drilling and grouting the crown holes. In case of consolidation grouting, chilling and grouting shall be done from invert upwards and the crown holes last.

9.7. Grout shall be injected into the holes by direct connection to the grout pump. Each hole after drilling is completed shall be provided with a short stand pipe, threaded at the outer end to accept a manifold. The manifold shall be provided with pressure gauge a relief valve and also a valve enabling the delivery from the pump to be cut off from the hole. A return grout line equipped owed with pressure relief valve set to open at any required pressure shall also be connected to manifold against the application or excessive pressure. The return line shall be led back to the grout mixing tanks in order to avoid unexpected discharge of grout in the working area. The valve from the return He shall be operated manually.

9.8. Once grouting of hole is commenced, grouting shall be continued without interruption until completion. Generally grouting shall be treated as complete when the intake of grout at the specified pressure is less than 2 liters /mm averaged over a period of 10 minutes fin pressure more than 2.5 kg / 1 Sq cm, or one litre / mm for pressures lower than 2.5 kg/ Sq cm.
9.9. As far as practicable continuous flow of grout shall be maintained at the specified pressure and grouting equipment shall be operated to ensure continuous and efficient performance throughout the grouting operations. In case any hole takes large quantity of the thickest pumpable grout at low pressure, grouting shall be suspended over night and resumed next day.

9.10. During grouting, in case any other hole gets interconnected, grout shall be allowed to escape from the connected hole, till the flow is of the same consistency as that being pumped. Such hole shall be capped and the combined holes brought up to specified pressure and grouting continued till refusal. It may not be necessary to grout again through the inter-connected hole. Grouting shall be stopped whenever pressure gauge registers a sudden drop in pressure or rate of grout intake increases abruptly or if there is an indication of upheaval leakage or disturbance. In such cases grouting may be resumed at a lower pressure after temporary interruption. As a general principle, grout consistency shall not be thickened if pressure starts to rise after continuous injection of grout over a period of 10 minutes. After completing grouting of hole till refusal, the hole shall be closed by means of valve to maintain the grout pressure for a period of not less than an hour so as to prevent escape of grout due to back pressure and flow reversal.

9.11. Equipment for grouting shall be of sufficient size capable of supplying the maximum demand of grout continuously. It should be capable of being operated at anticipated maximum pressure for long periods. Continuity of grouting operation is mandatory not only for efficiency cut also for effectiveness of grouting. Grout mixers shall be cylindrical in shape with a
vertical axis, equipped with a system of power driven peddles for mixing of grout. The pump to be used for grouting shall permit close control of pressure, allow a flexible rate of injection and shall be designed to minimize clogging of system. Most commonly used is air driven duplex, double acting pump. Pneumatic grouting machines shall not be used for consolidation grouting because they do not readily admit of control on grouting pressure.

9.12. For grouting, cement to be used shall confirm to the relevant I.S. specification. Grout mixes shall vary from this mixture of 5:1 to thick mixture of 0.5:1 (ratio of weight of water and cement). The normal range of grout mix shall be between 5:1 to 0.80:1, the choice of grout mix at the start of grouting operation shall be based on the results of water tests prior to grouting or intake of holes already grouted. It is a general practice to start grouting for 10 minutes after two batches of cement have been injected. In case of contact grouting the mix generally used shall be the thickest mix 0.5:1.

9.13. Both pack grouting and consolidation grouting shall be carried out with mixture of cement and water only. If the intake is heavy and if ordered by the Engineer, mix shall be thickened by use of inert material like pozzolona, fine sand, rock powder, that will not accept cement or where it is necessary to block flowing water, chemical grouts with or without cement shall be tried. Additives to accelerate the setting time of cement it ordered shall also be used. In case additives are used, they shall be added at the manifold and not in the grout mixer. It is necessary that accurate records of grouting shall be maintained regularly so as to enable the Engineer to make changes that may be required in grouting patterns or sequences.

Grouting shall be done in excavated areas where leakages, seepages, springs, etc. are required to be stopped by tightening the surrounding rock as well as concrete lining in tunnels and at other locations as directed by the Engineer. The grout shall be applied for pressure grouting at pressure not exceeding 5 Kg/cm\(^2\) as may be directed by Engineer. These pressures shall be at pump. This work of grouting shall include maintaining and cleaning surface, fining connections and forcing the grout, drilling test holes including all labour, plant, material etc. required for grouting and all necessary operations within the intent and purpose of this work.

9.15. Test of grouting work

9.15.1. To test the efficiency and penetration of grouting, fresh holes shall be drilled as directed by the Engineer after the grouting operations are completed. These holes shall be tested by water under pressure equal to the maximum grout pressure adopted and at the rate of leakage, if any, measured in each such hole. If the Engineer so directs such holes shall be grouted at pressures specified by the Engineer. If not, they shall be left open. Drilling of such holes will be paid for under Item No.7 of Schedule B.

9.15.2. No extra payment will be made for testing the holes by water. If such holes are grouted under direction of the Engineer, such pouting will be paid for at the unit rate accepted in Schedule B of the contract.
9.16. Keeping record of drilling, and grouting operations

9.16.1. Records shall be maintained by the contractor of drilling, grouting and testing, in a manner approved by the Engineer. The exact location of all holes in relation to proper reference lines and accurate logs of all operations he detailed in the records. Records, map and sections shall be compiled showing all conditions of holes grouted. All information regarding the grouting operations amount of grout taken, affect observed in the surrounding holes or rocks. Observation about behavior of holes under air and water pressure, appearance of wash water, quantity and proportion of ground used, time and pressure of grouting operations shall be noted for each hole.

9.16.2. A copy of such record shall be submitted to the Engineer daily during the drilling and pouting operations.

9.16.3. Cost of this shall be considered included in the tendered unit rate for grouting. Grouting must be done in the presence of the Engineer or his authorized representative.

9.16.4. Whenever pouting is to be done, the contractor will give due notice to the Engineer to enable him or his authorized representative to be present during the pouting operations which will always be done in his presence.

9.17. Finishing

The grout mix that might flow out or otherwise get split on the concrete lined surface shall be removed expeditiously without allowing any time for
grout to set on the concrete surface. After the grout has set, the grout holes shall be plugged with cement mortar in the proportion one to two by volume and the surface finished smooth. The unit rate for grouting shall be deemed to include all operations involved in finishing as stated above.

9.18. Measurement and Payment

9.18.1. Measurements for the payments of grouting will be made on the basis of the metric tonne of cement, weighed and measured separately actually forced into the holes at the direction of the Engineer. The volume of sand that may be used if and when approved by the Engineer for blocking the seams shall not be paid for its cost being considered as included in the unit rate for item of grouting.

9.18.2. Payment for grouting will be made at the until rate accepted there for under Item No. 9 of Schedule B. the clearing of grout hole and the pipe and fittings required for grouting will be deemed to have been included in the rate of grouting.

9.18.3. Grout mix flowing out of the holes or joints to a reasonable extent anti act due to any negligence on the cart of the contractor in temporary capping or caulking by hole or joint will be taken as grout forced and will be paid for as such. The quantity of grout that may flow out due to the negligence of the contractor and for which no payment shall be made shall be assessed by the Engineer and his assessment shall be unquestioned, final and binding on the contractor.
9.18.4. Unit rate quoted for cement and stone dust shall include the cost of materials labour plant and all operations including light and ventilation required for grouting as directed.

**Item No. 10 : Rock bolts**

Providing and fixing 2 M long MS rock bolts of 25 mm dia for securing roof rock to adjoining rock including cost of drilling 35 mm dia holes, cost of 10 mm MS plate wedges, nuts, as per specifications including cost of ventilation, lighting, dewatering, desilting, transportation and machinery, labour e5c., complete with all leads and lifts for all materials as per detailed specification, as directed by Engineer in charge or works.

10.1. Rock bolting follows the principle of fastening the lose rock near the surface to solid rock above by means of anchor bolts instead of supporting if from below. Rock bolts not only support the surface rock but also assist it to act as a load carrying elements. This shall consists of a mild steel rod of specified length and size, one end threaded and the other end split into halves for about 125 m length. A wedge made 20mm square steel about 150mm long shall be inserted into the slot and bolt driven into the hole. Hammering the outer end of the bolt shall expand the spilt end and fit / grip tight in to the hole forming the anchorage. There after a 10mm plate of siie-200 mm x 200 mm shall be placed and tightened with a nut.

10.2. After operations of tunneling from marking of the tunnel profile up to mucking is completed, the profile of the tunnel as excavated shall be carefully inspected and examined by an experienced foreman. If it appears
that pieces of rock are likely to fall down, either during drilling or blasting operation in further reaches of the tunnel, such locations shall be undertaken with the approval of Engineer. Utmost care is to be exercised during drilling and anchoring the rock bolt so that no collapse of rock takes place, causing damage to equipment and workmen. Drilling holes for fixing rock bolts shall be done in direction normal to the curvature of the tunnel profile. The size of the hole for fixing the rock bolt shall generally be one and or half times the size of the bolt

10.3. Measurement and Payment

10.3.1. Measurement for payment for furnishing and installing rock bolts and wedges, etc. will be made per meter length of the bolt installed at the direction of the Engineer and at the rate tendered which shall include the cost of drilling the hole of the materials of the bolts, driving the bolts and also of the temporary timber supports including dewatering, desilting, lighting & ventilation and all other work in connection, therewith, provided that any bolt furnished and installed of a length less than two meters deep at the direction of the Engineer shall be paid for as a bolt of two meters length.

Item No. 11: Drilling drainage holes

Drilling drainage holes 47 mm dia by percussion method vertical or inclined upto 2 M depth in rock or masonry or in concrete as directed including cost and conveyance of all materials and equipments, watering, ventilation, lighting, all lead, all auxiliary operations, etc, complete, as directed by Engineer in charge of works.
11.1. Drilling for draining the rock

When directed by the Engineer the contractor shall drill holes around the periphery of the excavation for draining the surrounding rock.

11.2. The minimum diameter of the hole shall be 47 mm. The location direction, length which will not exceed 2 M and number of holes to hr drilled shall be as ordered by the Engineer Similar holes shall be driven if directed after the completion of the work to serve as weep holes and / or grout holes. These will be paid for at unit rate accepted for drilling grout holes.

11.3. The holes shall be ordinarily drilled in a direction normal to the surface of the undergo excavation or concrete lining as the case may be. In case where seams in the rock, if any, have to be intercepted the holes shall be drilled at inclinations as may be directed by the Engineer.

11.4. case where seams in the rock, if any, have to be intercepted the holes shall be drilled at inclinations as may be directed by the Engineer.

11.5. Location, direction and order of drilling drainage holes shall be as directed by the Engineer. The dent is not ordinarily expected to exceed 2 M.

11.6. Each hole shall be protected from becoming clogged or obstructed by a connection pipe fixed suitably into the hole and the holes shell be suitably capped.
11.7. Measurement and Payment

11.7.1. Drainage holes driven in rock and concrete will be measured for payment after the holes are drilled and only the holes drilled to specified depths and the directions of the engineer shall be entitled for measurement and payment. Holes drilled deeper than specified shall be paid only upto specified depth.

11.7.2. Except as otherwise specifically provided, all holes so measured will be paid for at the unit rate in Schedule B for drilling drainage holes, which unit rate shall include the cost of labour, material, dewatering, desilting, lighting and ventilation, all the operations required in drilling the holes,, maintaining them as specified and all the necessary operations within the intent and purpose of this item of work.