DRAFT TANZANIA STANDARD

TBS/MMDC1 (5182) P3 Subsurface Exploration by Pits, Trenches, Drifts and Shafts - Code of Practice

TANZANIA BUREAU OF STANDARD

1st edition

Subsurface Exploration by Pits, Trenches, Drifts and Shafts - Code of Practice

0. Foreword

This draft Tanzania Standard is being prepared by the Exploration Technical Committee (MMDC 1), under the supervision of the Mining and Minerals Standards Divisional Committee (MMDC).

In preparation of this draft Tanzania standard main assistance was drawn from IS 3764:1992 Code of safety for excavation work and IS 4453:2009 Subsurface Exploration by Pits, Trenches, Drifts and Shafts - Code of Practice

1. Scope

This standard lays down the method for subsurface exploration by means of pits, trenches, drifts and shafts.

2. Terms and definition

For the purposes of this standard, the following terms and definitions shall apply:

2.1 Attitude
Description of orientation of geological structure (i.e. fault, shear zones) in 3D space and normally consists of strike and dip of that geological structure.

2.2 Barricade
Temporary wall, fence, or similar structure that is built to prevent people from entering a place or area

2.3 Bedding
The surface that separates one stratum, layer, or bed of stratified rock from another

2.4 Drift/Tunnel
An underground opening, dug through the surrounding soil/ rock and enclosed except for entrance and exit, commonly at each end

2.5 Foliation
Repetitive layering in metamorphic rocks. Each layer may be as thin as a sheet of paper, or over a meter in thickness

2.6 Frustum
Portion of a cone or pyramid that remains after its upper part has been cut off by a plane parallel to its base, or that is intercepted between two such planes

2.7 Geological log
Detailed description of all underground features (depth, thickness, type of formation) from logging data

2.8 Insitu
Situated in the original, natural, or existing place or position

2.9 Reduced Level (RL)
vertical distance between survey point and adopted datum plane

2.10 Shear zone
Volumes of rock deformed by shearing stress under brittle-ductile or ductile conditions, typically in subduction zones at depths down to 10-20 km. Shear zones often occur at the edges of tectonic blocks, forming discontinuities that mark distinct terranes

2.11 Slate
Low grade metamorphic rock generally formed by the metamorphosis of mudstone / shale, or sometimes basalt, under relatively low pressure and temperature conditions

2.12 Standard Penetration Test (SPT)
An in-situ dynamic penetration test designed to provide information on the geotechnical engineering properties of soil

2.13 Strata/ Stratum
Layer of sedimentary rock or soil with internally consistent characteristics that distinguish it from other layers

2.14 Trench
Type of excavation or depression in the ground that is generally deeper than it is wide (as opposed to a wider gully, or ditch), and narrow compared to its length (as opposed to a simple hole)

2.15 Weathering
Breakdown of rocks at the Earth's surface, by the action of rainwater, extremes of temperature, and biological activity. It does not involve the removal of rock material. There are three types of weathering, physical, chemical and biological

3. Exploration by Pits

3.1 Pits are dug manually but mechanical equipment may also be used. The depth of the pit should be according to the requirements of investigation and is generally limited by the ground water table. Pits are normally of the shape of an inverted frustum of a pyramid. The top of the pit is usually a square of size 3 m x 3 m and its bottom is also a square of 1.2 m x 1.2 m providing sufficient space. The depths of such pits are around 3 m in softer soil with sloping cut walls. The walls may be kept near vertical in case of hard soil and the depth of the pit may also be increased to 6 m. Additional space for sheeting and supports, hoisting arrangements, ladder, in-situ tests, sampling for laboratory tests, etc, should be provided *(see* Fig. 1).

3.2 During excavation, the bottom of the pit should be kept at a level so that each lift may represent the corresponding portion of the deposit in quality and quantity. The excavated material should be placed around the pits as stockpiles, separated when significantly different materials are encountered, and marked stakes should be driven into the stockpiles to indicate the depth from which the materials were excavated in order to facilitate logging and sampling later on. Based on design requirements, SPT tests wherever required, may also be conducted at regular intervals of 1.0 m to 1.5 m at the change of the strata for determination of potentiality of liquefaction of material and modelling of deformation.

3.3 Deep test pits should be ventilated to prevent accumulation of dead air. For this purpose, connected lengths of pipe starting slightly above the floor and extending about one metre above the mouth of the pit have been found satisfactory. Canvas sheeting may also be used to deflect wind into the pit. When there is likelihood of the presence of obnoxious gases, special precautions shall be taken for ventilating the pit.

3.4 Test pits left open for inspection shall be provided with covers or barricades for safety. Pits and trenches shall be suitably fenced. Trenches and pits should be filled back properly, when exploration and physical inspections are completed and the relevant records have been obtained.

3.5 When water is encountered in a pit, a suitable dewatering system may be required for further progress. Where suction pumps are used, it is desirable that the suction horse be 10 mm larger in diameter than the discharge opening of the pump and the suction head not more than 4.5 m. This requires resetting the pump in the pit (on a frame attached to the cribbing) at intervals of about 3.5 m. When an internal combustion engine is used in the pit, it would be necessary to lead the exhaust gases well away from the pit.

3.6 Undisturbed samples may be obtained from open pits from each stratum if the nature of the deposit permits. For this purpose, a pillar of suitable dimensions, say, 40 cm x 40 cm should be left undisturbed at

the centre of the pit to collect undisturbed samples of required size from each layer showing a change of formation. If the thickness of each layer exceeds 2 m, a second sample may be taken. These undisturbed samples will be useful for the determination of several characteristics of the in-situ materials. Special care shall be taken to preserve the natural moisture content of the samples.

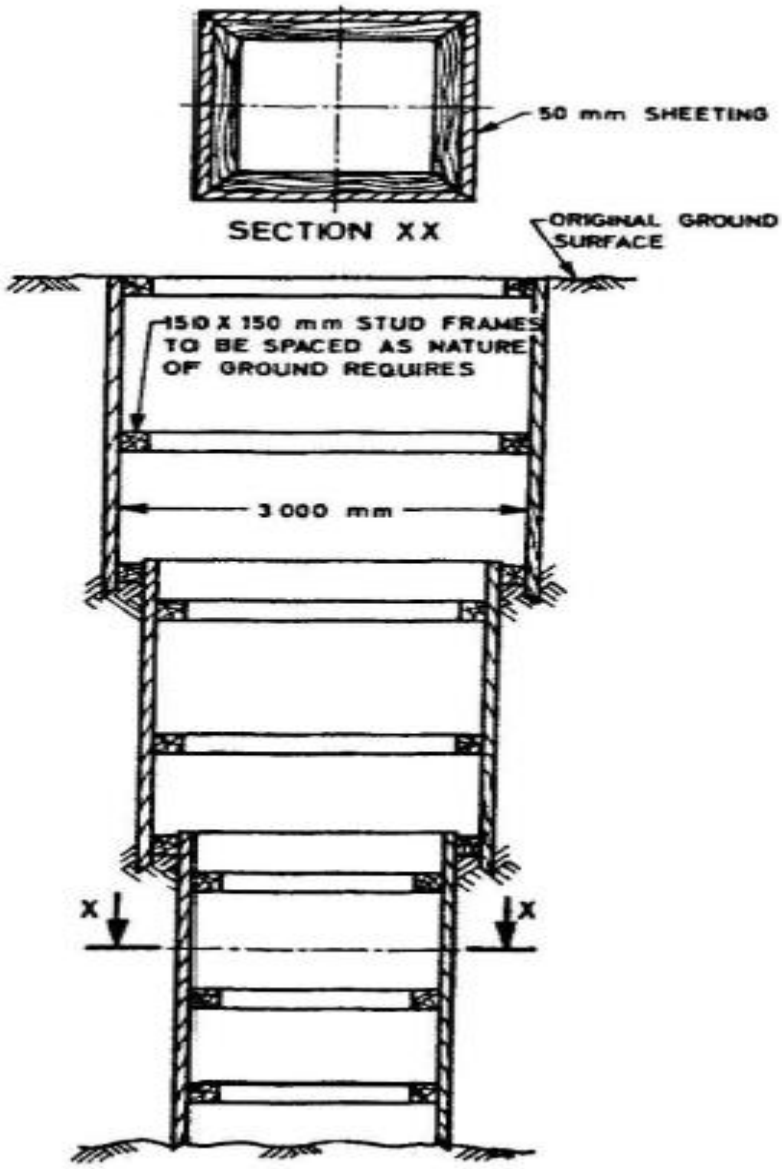


Figure 1 Typical test pit showing arrangement of sheeting and bracing (illustrative sketch).

4. Exploration by Trenches

4.1 Trenches are similar to test pits in all aspects, except that they are continuous over a length and provide a continuous exposure of the surface along a desired line or section. They are best suited for exploration on slopes.

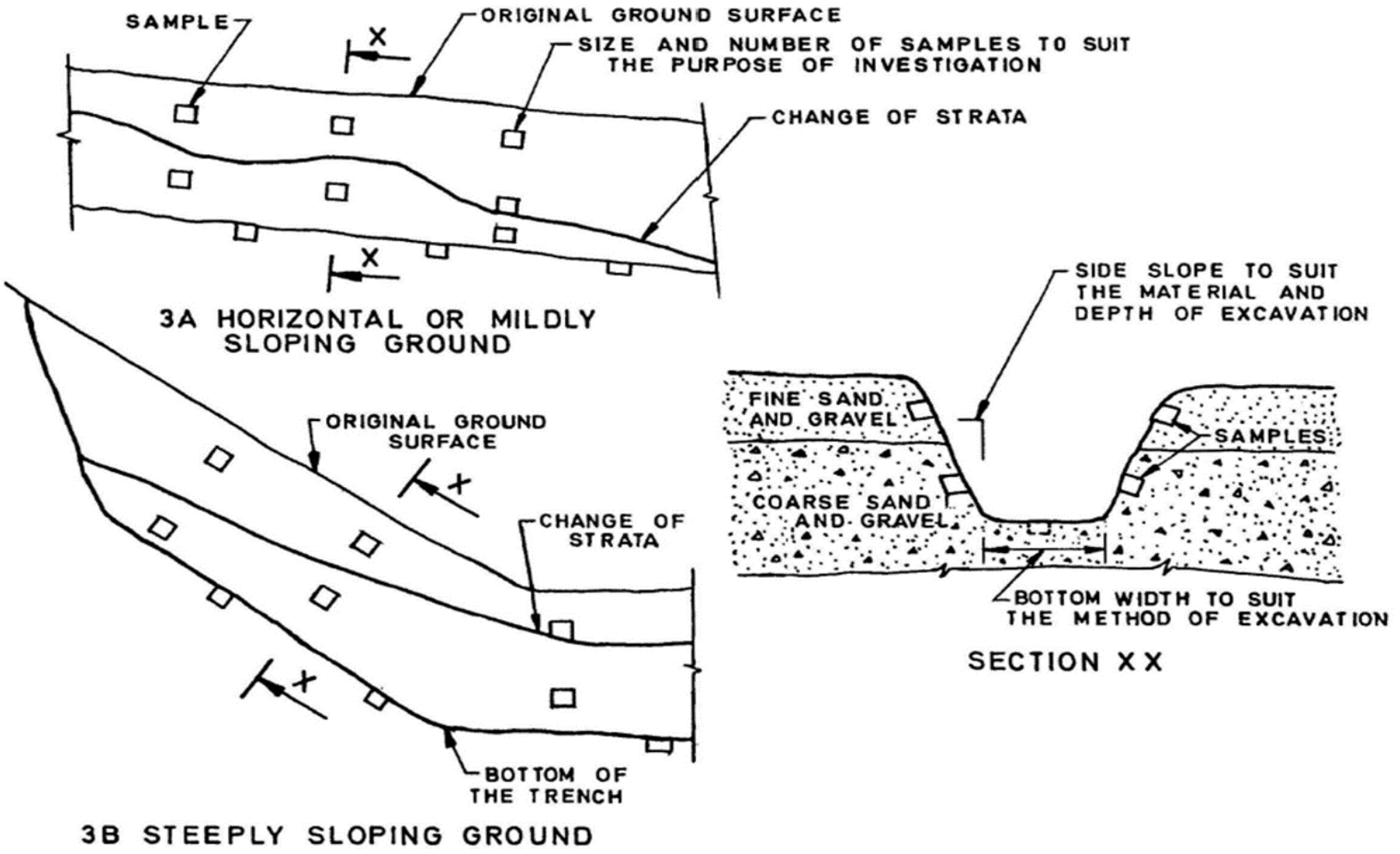


Figure. 2 Typical trenching layout (illustrativ

4.2 The field work consists of excavating an open trench from the top to the bottom of the slope to reach representative undisturbed material. Either a single slot trench down the face of the slope or a series of short trenches spaced at appropriate intervals along the slope may be excavated. Depending on the extent of the investigation required, use may be made of picks and shovels, bulldozers, ditching machines, back hoes or dragline. A trenching layout suitable for materials investigations is shown in Fig. 2.

4.3 Safety precautions shall be taken as in the case of deep test pits to prevent accidents caused by caving ground *(**see*** **Annex A**). All the instructions for pits given in 3 shall apply to trenches.

5. Exploration by Drifts or Tunnels

5.1 Drifts or test tunnels should be provided with a gentle/low outward slope of the floor in order to be self-draining. A rectangular section with minimum clear dimensions of 1.8 m width and 2.1 m height is adopted in hard rock. In soft rock, however, it will be advantageous to provide an arched roof with the dimensions as above.

5.2 The roof and the sides shall be adequately supported, wherever the ground is unable to stand. The size and spacing of the supports will depend on the character of the formation and the spacing and altitude of joints therein. Wherever blocky and hard rock is to be tunnelled through, it may be advantageous to use rock bolts to hold together the jointed blocks of rock.

5.3 Ventilation by air from a compressor or a blower depending on the length of the drift may be resorted to, for removing pockets of foul air or blast gases when explosives are used.

5.4 Adequate lighting arrangement shall be provided for proper examination and recording of data in drifts or tunnels.

5.5 Proper approach to the drift shall be made for proper transportation of men, testing equipment and other materials/accessories. Proper ropeway shall be provided for crossing the river for testing rock mass on the other bank of the river.

6. Exploration by Shafts

6.1 Shafts may be rectangular or circular in section depending upon the investigation requirement and the ease of construction and should have minimum dimension of 2.4 x 2.4 m or of 2.4 m diameter in case of circular section, to provide space for movement of men, equipment and other accessories.

6.2 In hand dug shafts, the materials are removed by buckets operated by hoists or windlass, which should be equipped with a ratchet device for safety.

6.3 Deep shafts should be ventilated to prevent accumulation of dead air or blast gases when explosives are used. For this purpose, connected lengths of stove pipe starting slightly above the floor and extending one metre into open air above the mouth of the shaft should be used. Air from a compressor or blower may also be used.

6.4 When water is encountered, a pumping system should be used to enable further progress. Electrical pumps should be preferred to ones with internal combustion engines to avoid pollution of air, otherwise it would be necessary to lead the exhaust gases well above the mouth of the shaft.

6.5 In weak and caving ground, the sides of the shafts shall be adequately supported to prevent accidents. The spacing and the size of the support will depend on the nature of the strata. Shafts left open for inspection shall be provided with covers grills or barricades for safety.

7. Recording of information

Besides proper supervision of the work, careful and systematic records should be kept and made available at project site for consultation. Inaccurate observation and incomplete records may result in serious errors of geological correlation of formations and ineffective expenditure of time and money.

7.1 Drifts

Geological logging and sampling of exploratory drifts should proceed concurrently with the operation of excavation after proper cleaning of side walls and crowns. The drifts should be mapped showing the geological formations indicating extent of weathering and details of structural features, such as the direction and magnitude of dip, extent and attitude of fault or shear zones and clay seams. A longitudinal section of a drift is given in Fig. 3. A three-dimensional geological log is shown in Fig. 4. For preparing a three-dimensional log of an exploratory drift, the perimeter of the section is assumed to be opened out at the junctions of invert and walls; walls and crown (spring line) up to centre of crown so that the length of the diagram represents the length of the drift to a suitable scale and the width of the diagram represents the perimeter to the same or other convenient scale. The boundaries of geological units and weaker zones and the trend of other geological features like joints. beddings, foliations, etc, should be recorded in the spread-out section of the drift. This recording should be done by measuring the distance of any particular geological feature at the junction of the half-crown and the wall, the spring line (mid-point line of the wall) and at the junction of the wall with the floor of the drift. Before logging, the distances are usually marked along the spring line (or centre line) of the drift, from a reference point which is usually taken at the portal of the drift, or at the starting point of the open-out section of the drift, if any. The log of the drift thus obtained on a spread-out section is folded back (to the original rectangular shape of the drift) to give a three-dimensional model of the drift, showing the actual disposition of the geological features.

7.2 Shafts

The shafts are concurrently mapped with excavation in the same way as drifts giving the type of rocks encountered at various elevations, direction and magnitude of dip, extent and attitude of bedding/folia] plane, fault or shear zones, clay seams, etc. For preparing a three-dimensional (3D) log of a circular shaft, the depths should be marked from the ground level downwards along four lines (shown for one line in Fig. 5); the north-south (or upstream-downstream) and east-west (or right-left) diameters of the shaft. The perimeter of the shaft on any suitable scale should be taken to have been spread out in the vertical plane parallel to the east-west (or right-left) diameter of the shaft and passing through the south (or downstream) edge of the shaft. half of the spread-out section lying to the east (or right) side and the remaining half to the west (or left) side. The intercepts of the various geological features on the four reference lines should be recorded on the spread-out log. When this log is folded back to the circular shape, a three-dimensional model of the exploratory shaft is obtained, showing the actual disposition of the geological features. A typical example of the plot of a three-dimensional log for circular shaft is given in Fig. 5. Plans and sections illustrating exploratory features should generally be drawn to the scale of 1: 1000. Geological logs should be drawn 1:100 scale. The information given in 7.2.1 and 7.2.2 should also recorded.

7.2.1 General

i. Organization responsible for the work.

ii. *Location on map* - If a co-ordinate system has been established the location should be given by co-ordinates easting or northing or chain stations. The location shall be defined by the number of the exploratory feature, its co-ordinates and elevation. In the case of drifts, direction should also be mentioned. At site a permanent pillar should be erected at the portals of drifts and near the mouths of pits with the grid co -ordinate lines and number inscribed thereon.

iii. *Elevation of ground surface or other reference point* - The elevation with respect to mean sea level or reduced level, of the ground surface and of the bottom or end of excavation along with intermediate elevations and corresponding depths from the top or start of the excavation should be indicated for all points of change of formation, to demarcate the boundaries of different types of materials penetrated.

iv. Dates of starting and completing the work.

v. Name of persons responsible for the preparation of plans and sections with signature.

vi. Scales of plans or sections in linear representation.

vii. On plans, the north point, either true or magnetic, should clearly be marked.

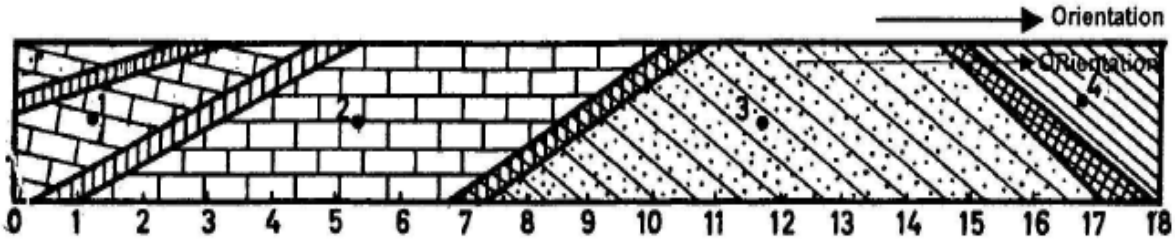
7.2.2 Geotechnical details

i. Soil or rock type should be recorded giving brief, but complete description of the nature and condition of the materials penetrated. Different formations and their physical condition should be shown by appropriate symbols or colours.

ii. Disposition and attitude of contacts, faults, joints, shear zones and clay seams.

iii. *Inflows of water and ground water fluctuations* - Records should be kept showing the elevation and fluctuations in ground-water level, water inflows during excavation or any other information bearing on the ground-water conditions, such as pumping record of percolation tests.

iv. *Record of material collected for testing* - The points from which samples were taken, date and methods of sampling, purpose of sampling and by whom should be recorded. Sufficient information should be given on the samples to permit their ready identification at a future date. The name of project, dam site pit or drift number, date, depth and other pertinent information should be indicated. Each sample bag or container should be provided with two tag cards showing these particulars. One tag should be put inside and the other outside the bag or container.



Bedding and Foliation DIPS : (Points 1 to 4 in the section)

1. At RD ..... m dipping ..... due .....
2. At RD ..... m dipping ..... due .....
3. At RD ..... m dipping ..... due .....
4. At RD ..... m dipping ..... due .....

Joints:

1. Joint at RD ..... m dipping ..... due .....
2. Joint at RD ..... m dipping ..... due .....
3. Joint at RD ..... m dipping ..... due .....

RD = Reduced distance in metres.

NOTES

1 In addition details about other structural discontinuities like bedding (So), foliation (S_1), Joints (J_1) etc, should also be given on the section.

2 Weathering/distressing limits $W_3 - W_4$ (highly weathered), W_2 (moderately weathered) and W_1 (slightly weathered) should also be given along RDs.

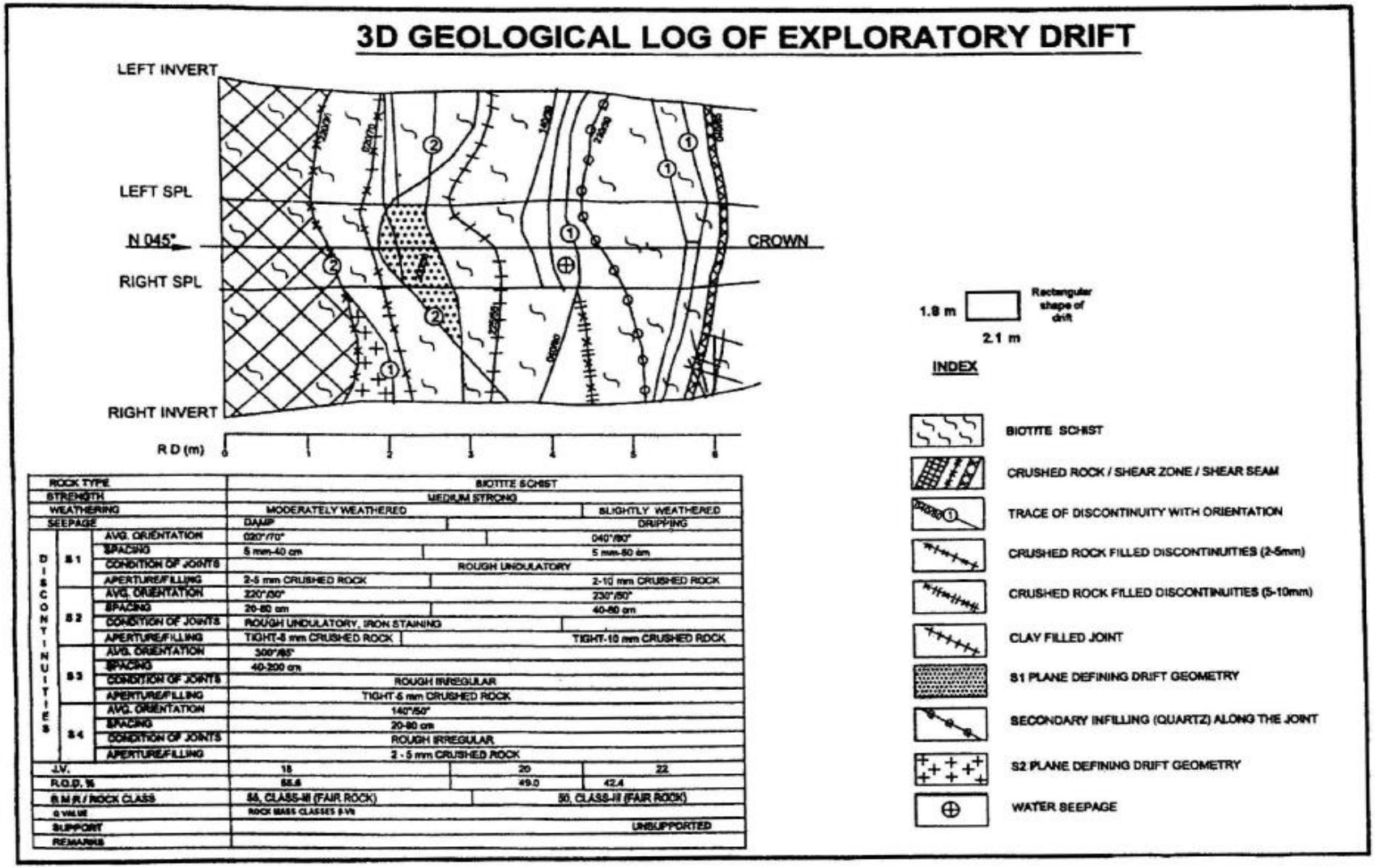
3 The gaps should be stuitably filled in giving information about drift.

4 For purpose of representation a uniform height of drift should be assumed.

5 The wall of the drift which the geological cross-section represents should be specified.

6 The horizontal and vertical scales used should be specified.

Figure. 3 A generalized geological longitudinal section of the wall of a drift in a geologically simple environment.



ROCK TYPE			BIOTITE SCHIST		
STRENGTH			MEDIUM STRONG		
WEATHERING			MODERATELY WEATHERED		SLIGHTLY WEATHERED
SEEPAGE			DAMP		DRIPPING
DISCONTINUITIES	S1	AVG. ORIENTATION	020°/70°		040°/80°
		SPACING	5 mm-40 cm		5 mm-80 cm
		CONDITION OF JOINTS	ROUGH UNDULATORY		
		APERTURE/FILLING	2-5 mm CRUSHED ROCK		2-10 mm CRUSHED ROCK
	S2	AVG. ORIENTATION	220°/50°		230°/60°
		SPACING	20-80 cm		40-80 cm
		CONDITION OF JOINTS	ROUGH UNDULATORY, IRON STAINING		
		APERTURE/FILLING	TIGHT-5 mm CRUSHED ROCK		TIGHT-10 mm CRUSHED ROCK
	S3	AVG. ORIENTATION	300°/65°		
		SPACING	40-200 cm		
		CONDITION OF JOINTS	ROUGH IRREGULAR		
		APERTURE/FILLING	TIGHT-5 mm CRUSHED ROCK		
	S4	AVG. ORIENTATION	140°/50°		
		SPACING	20-80 cm		
		CONDITION OF JOINTS	ROUGH IRREGULAR		
		APERTURE/FILLING	2 - 5 mm CRUSHED ROCK		
J.V.			18	20	22
R.Q.D. %			58.8	49.0	42.4
R.M.R./ ROCK CLASS			54, CLASS-III (FAIR ROCK)		50, CLASS-III (FAIR ROCK)
Q VALUE			ROCK MASS CLASSES & VS		
SUPPORT					UNSUPPORTED
REMARKS					

Figure. 4 Typical example of a three-dimensional (3D) geological log of exploratory d rift

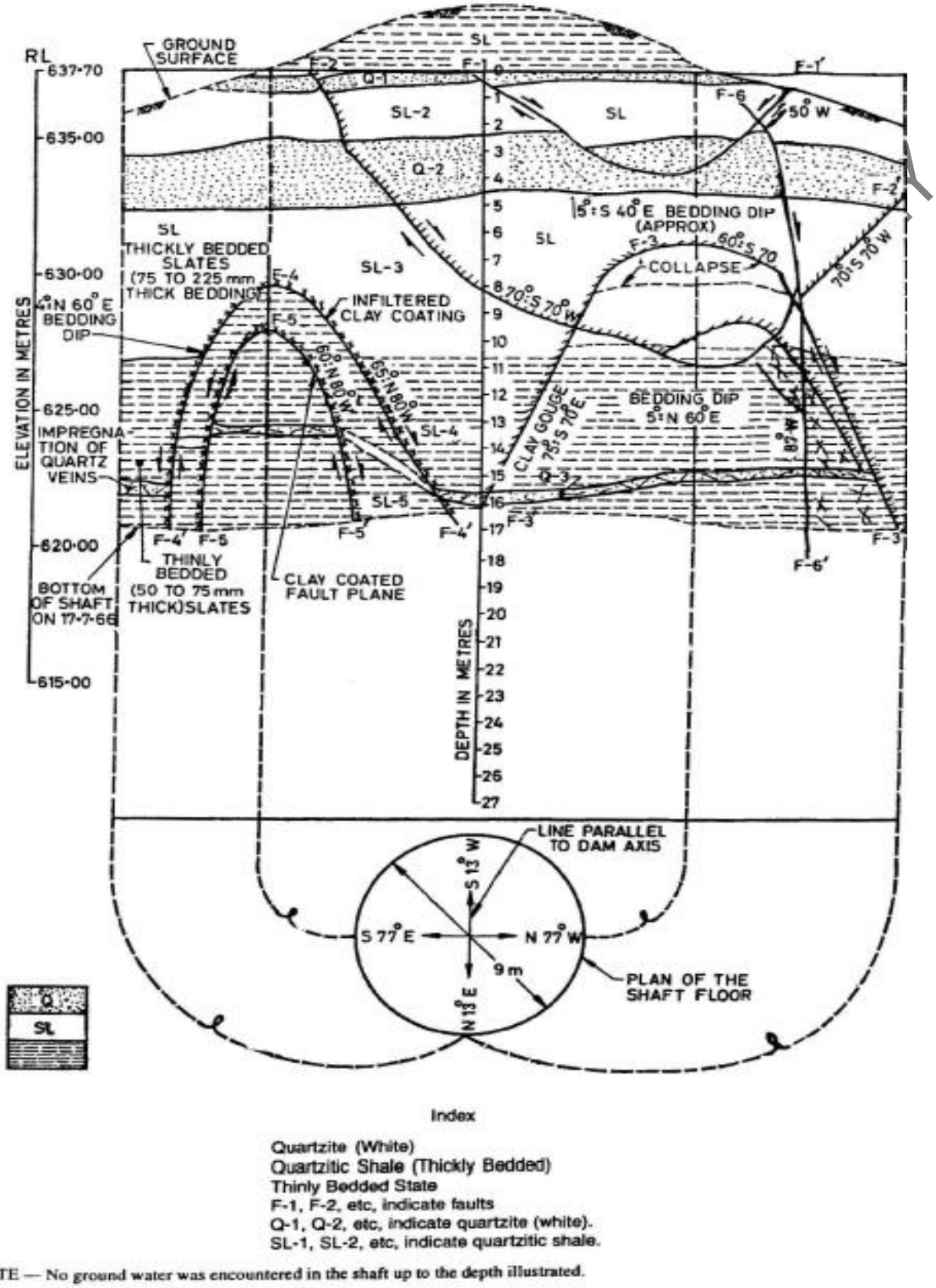


Figure. 5 A typical example of three-dimensional (3D) log of a shaft

ANNEX A

(normative)

Safety consideration in subsurface exploration by Pits, Trenches, Drifts and Shafts

A.1 Responsibilities of Foremen and Supervisors

In all works, an experienced and competent foreman or supervisor shall be placed in charge of the work whose authority and responsibilities have been made clear to him and his subordinates. The foreman or supervisor shall be made responsible for the strict observance of the safety rules. He shall have full authority to enforce the rules, guard against the use of defective safety appliances, rigging, tools and materials, to see that no man is permitted to do work for which he is not qualified, and to brief all workmen on the plan of work before work is started with special emphasis on all potential hazards and on the ways to eliminate or guard against them.

A.1.1 Sides of excavation shall be inspected by foreman or supervisor during the course of excavation from time to time and after every rain, storm or other hazard-increasing occurrence and protection against slides and caving shall be increased, if necessary.

A.1.2 Complete information on the underground structures (such as water pipelines, sewers, gas mains, electrical conduit system and other civic facilities) is essential before doing the excavation work. Proper precautions shall be taken to prevent accident to the workmen engaged in excavation work and calamities for the general public.

A.1.3 First aid facilities like a first-aid kit shall be maintained at the site of work. This shall be kept at a conspicuous place in the charge of trained person(s). The kit shall be recouped periodically.

A.2 Workers

A.2.1 Workers shall be instructed to use safety devices and appliances provided to them whenever it is necessary to do so.

A.2.2 Workers who are not aware of the hazards peculiar to the work shall not be permitted to proceed with the work without being properly instructed. They should preferably be under the close watch of a properly qualified and authorized person whose instructions shall be obeyed by these workers.

A.2.3 In case any worker feels that he/she cannot perform a work safely, he shall immediately inform the foreman or supervisor of his inability to carry on with the work.

A.2.4 Safety helmets shall be worn by all persons entering trench where hazards from falling stones, timber or other materials exist.

A.2.5 Appropriate safety footwear (rubber boots, protective covers, etc) shall be worn by workers/ employees who are engaged in work requiring such protection.

A.3 Supporting of excavations

All excavations into which personnel enter for working must be properly supported depending on the available technology.

A.4 Inspection and Examination

A.4.1 No person shall work in any excavation unless all supports used therein are inspected by a competent person before work is started and also after explosives have been used in or near the excavation.

A.4.2 When open excavations with steep side slopes are carried out by means of blasting, after every blasting operation, side slopes of excavations shall be carefully examined by a competent person to prevent rock falls. Work inside the excavations shall not commence until all loose rock on the sides is first removed. All workers engaged in such excavations shall use helmets.

A4.3 Inspection shall be carried out after heavy rain or storms to ensure safe working conditions.

A.5 Provision of lighting and warning signals

A.5.1 Excavation areas shall be adequately lighted for night work.

A.5.2 During the hours of darkness all public sidewalks and walkways shall be adequately illuminated and warning lights shall be placed in proper sites to ensure safety of pedestrians and the vehicular traffic.

A.5.3 At all approaches and exits of the sites of excavations, danger and warning signals shall be placed. In busy or otherwise risky locations a flagman with a red flag shall be posted to warn the public and the approaching trucks and to guide them in proper direction. At every part of a trench likely to be frequented by public, suitable warning signal/red light to prevent a person from falling into the trench shall be provided and maintained in place at all times.

A.5.5 Where inflammable substances are stored or present, all electrical installations shall be explosion proof. Portable lamps/flash lights, if required, shall be of approved explosion-proof type.