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भारतीय मानक

नदी घाटी परियोजनाओं के निर्माण, प्रचालन और रखरखाव — सुरक्षा दिशानिर्देश

भाग 11 भूमिगत उत्खनन

(IS 10386 भाग 11 *का पहला पुनरीक्षण*)

Draft Indian Standard

CONSTRUCTION, OPERATION AND MAINTENANCE OF RIVER VALLEY PROJECTS — SAFETY GUIDELINES

PART 11 UNDERGROUND EXCAVATION

[(*First Revision* of IS 10386 (Part 11)]

Safety in Construction, Operation and Maintenance of River Valley Project Sectional Committee, WRD 21

Last date for Comments: 21 October 2025

FOREWORD

(*Formal clauses of the foreword will be added later*)

With large scale increase in construction activity on river valley projects involvinghazardous construction jobs, there has been an increase in the number of accidents, both major and minor ones. Further, increased construction activity in the underground jobs has created health hazards for the persons working under such conditions. In order to minimize such accidents and health hazards, it is the overall responsibility of the project authorities and contractors to provide necessary measures for the safety and health protection of all employees working on the projects.

It shall be the responsibility of the employer that is government or contractor, to initiate and maintain such programs in respect of their employees working on a project scheme.

Each employer/department, contractor and employee shall comply with the different safety regulations in force on a project and shall be alert at all times to eliminate hazards to themselves and/or to others.

This standard was first published in 2012 and the first revision of this standard has been brought out based on the technological advancements taken and experiences gained in the use of this standard. The major changes included in this revision are:

a) Update of clauses ‘General Safety Requirements’ and ‘Investigation, Data and Surveying’;
b) Modification of title of clause ‘Design Data’ to ‘Planning and Design' and addition of additional subclauses under the same;
c) Modification of the titles of clause 6 and its subclauses;
d) Deletion of subclause ‘Rock Bolts’ under clause 6;
e) Replacement of subclause ‘Instrumentation’ with ‘Support Systems and Monitoring’ under clause 6;
f) Update of clause ‘Safety Officer’; and
g) Update of clause ‘Fire Risk’.

This Indian Standard is published in 11 parts. The other parts in this series are:

Part 1	General aspects
Part 2	Amenities, protective clothing and equipment
Part 3	Plant and machinery
Part 4	Handling, transportation and storage of explosives
Part 5	Electrical aspects
Part 6	Construction
Part 7	Fire safety aspects
Part 8	Open excavation
Part 9	Canals and cross drainage works
Part 10	Storage, handling, detection and safety measures for gases, chemicals and flammable liquids.

For the purpose of deciding whether a particular requirement of this standard is compliedwith the final value,observed or calculated, expressing the resultof a test or analysis shallbe rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values(*second revision)’.*The number of significant places retained in the rounded off value shouldbethesameas thatofthespecifiedvalueinthis standard.

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1 SCOPE

This standard (Part 11) lays down requirements for the safety aspects to be taken during underground excavation for structures like underground power house, transformer cavern, tunnels, shafts such as surge shaft, pressure shaft and cable shaft, additionally driven intermediate tunnels (ADITs) and such other structures associated with river valley projects. Safety measures that should be followed during their operation and maintenance are also described.

2 REFERENCES

The standards listed in the Annex A contain provisions which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on these standards are encouraged to investigate the possibility of applying the most recent editions of the standards.

3 GENERAL SAFETY REQUIREMENTS

3.1 The matter of safety and accident prevention is the responsibility of personnel on the job and of the organizations. All persons need to be alert to dangerous conditions and to take necessary precautions for their own safety as well as that of others working at the site.

3.2 The safety requirement during excavation for any structure may vary according to the type of structure, type of construction methodology, type of strata encountered and number of men and type of machinery deployed at site.

3.3 Proper education and organization is necessary for safety requirements to be implemented in a proper manner. The workmen are required to be made aware of the importance of observing the safety rules (*see* also 14). A security check post shall be maintained at each portal and detailed record of men/machinery entering/leaving the tunnel shall always be maintained.

3.4 The contractor/engineer/consultant/owner/department/organization carrying out the work should employ a safety engineer/manager who should be familiar with all

potential hazards on the job and whose duty would be to educate the workmen as well as to supervise installation and maintenance of safety equipment, first aid stations, machinery guards and other safe guards.

3.5 The hazards of going underground are the greatest the engineer has to face. Underground excavation is always a dangerous and unpredictable business. Hazards cannot be entirely removed, but can be greatly reduced by adopting suitable and adequate precautions.

4 INVESTIGATION, DATA AND SURVEYING

4.1 Before proceeding with the work of underground excavation, sufficient knowledge of sub-surface strata is essential. Insufficient geological data will not only lead to delay in completion of work and increase in cost, but also of a great concern to safety. Geological surprises are to be anticipated and adequate measures for such eventualities should be made available in advance. Planning of underground hydropower projects and tunnels should be based on sufficient geotechnical aspects. This will form the basis of excavation and rock support, etc. Latest advancements should be taken in to consideration.

4.2 Details of geological strata using geophysical mapping methods supplemented by exploratory drilling to establish fissure systems, faults, folds, etc, are essential. The final geological map should provide information on the extent of soil and rock formation, zones of weakness, the dip and strike, etc, of the strata.

4.3 Adequate measures such as fore-poling, pipe-roofing, pre-drainage hole or weep hole, pre-grouting, probe hole etc, should be taken for any geotechnical problems in case of blind/unexplored geological regions.

4.4 Preliminary and detailed surveys should be carried out as per standard practices with modern instruments. During execution of work, accuracy should be maintained in alignment, length and breadth, and levels, etc.

5 PLANNING AND DESIGN

5.1 Excavation size is a key parameter in the stability of underground openings in rock and larger the excavation, lesser the stability of roof. The principal objective in the design of a support system is to help the rock mass to support itself. The use of rock bolts helps to form homogeneity in rock mass. The use of rock bolts is a flexible method that can be combined with wire mesh; shotcrete and concrete lining to cope with most situations encountered during underground excavation.

5.2 A professional engineer should be engaged for preparation of design and drawings. Due consideration in design process should be given to the experience gained in underground works of nearby areas. Field design and changes should be documented and vetted by a competent engineering person.

5.3 Latest available data from the relevant standards and outputs of nearby seismic stations should also be considered for design of underground structures (*see* IS 4967). Actual data obtained from a nearby strong motion network or micro seismic

telemetry network should be considered in seismically active areas/region, if necessary.

5.4 Tunnel excavation may generate subsidence or deformation around the structure causing enhanced stress levels. The safety of the existing structures may also be endangered. Special consideration on the safety aspects should be taken in the design/execution. Execution of earth tunnels/tunnels through soft strata pose a great hazard. Support system and drilling operation shall be formulated with extra care and caution [*see* IS 5878 (Part 3)].

5.5 Safety of tunnel near entry portal with less rock cover should be taken care of during the investigation/ design stage itself. Normally the vertical cover should be twice the diameter of the tunnel. If the vertical cover is less than twice the diameter, then cut and cover system should be adopted. Necessary concrete cover at the crown as well as the sides with anchor rods, if necessary, should be provided in the initial stretch from the portal.

5.6 The arrangement of underground power house and transformer caverns are normally planned adjacent to each other and it should be ensured that there is enough lateral rock cover in-between them for the stability of both the cavities based on the rock mass characteristics.

6 EXECUTIONS

6.1 Handling Explosives

During blasting operation proper precautions should be taken for the protection of persons, work and property.

All government laws and regulations relating to the design and location of the explosive magazines, the transportation and the handling of explosives and other measures evolved for the prevention of accidents should be strictly observed. Warning sign of Do’s and Don’ts should be displayed on the magazines and warning signal should be given for each blast. Explosive should be stored in a safe place at a sufficient distance from the work site and under the special care of a watchman [*see* IS 10386 (Part 4)].

IS 10386 (Part 4) for handling, transportation and storage of explosives, IS 4081 for blasting and related operations and IS 4138 for working in compressed air, shall be adhered to in this regard. Copies of the above standards shall be widely circulated and kept available at site office. Training shall be imparted to workers to inform everyone with respect to provisions of IS 10386, IS 4081, IS 4138 and other safety related standards.

6.1.1 Whenever blasting operation is to be conducted, workmen/supervisors should be kept at sufficient distance in a safe shelter/pocket. Left over and un-blasted detonators should be removed safely. It is to be ensured that no un-blasted detonators are left over in the area before next operations starts. If the hole drilled for blasting is damp, the junction of the fuse and detonators should be made water tight by means of tough grease, white lead or tar. Proper insulated wire should be used

for blasting to be carried out by electrical detonators. Electric, non-electric and electronic blasting should be resorted to in all underground works.

6.1.2 *Precautions Against Lightning*

a) Necessary safety measures should be taken in order to provide protection from direct stroke lightning and secondary action of the lightning; and

b) During a thunderstorm, no blasting operation including charging should be carried out. If in case of electrical shot-firing, the firing circuit has to be set-up before thunderstorm appears and the blast lines should be disconnected from the trunk line and thoroughly insulated with tape. At the same time, all persons must be withdrawn from the danger zone.

6.2 Blast Vibration Monitoring

Monitoring the vibrations caused by underground blasting plays a vital role since they induce transient or vibratory displacements which could be permanent (*see* IS 14881).

6.2.1 Tunnel face stability is a severe problem while tunneling, especially in non-cohesive strata. Buildings and services over the excavation and the workers inside the tunnel are under continuous risk due to this problem. There may be sudden falls of soil, creating large cave-ins up to the surface. Falling material could endanger workers. Such endangered areas should be supported, barricaded or effectively guarded.

6.2.2 Safety of tunnel entry near portal with less rock cover should be taken care of during the investigation/ design stage itself. Normally the soil cover should be twice the diameter of the tunnel. If the overburden is less than twice the diameter, then cut and cover system should be adopted. Necessary concrete cover at the crown as well as the sides with anchor rods, if necessary, should be provided in the area not having adequate cover.

6.3 Rock Bursting

The energy within the rock, as inherent stresses begin to relax on excavation, can be enormous and powerful enough to expel large chunks of rock causing rock burst/ spalling. There are various methods for determining the rock pressure for support design of underground excavation which should be utilized. (*see* IS 4878 (part 2) and IS 4880)

6.4 Excavation Slope

The slopes in the underground excavation such as entry/exit of tunnels, adits, pressure shafts, etc, should be decided on suitable engineering practice based on the geological strata, geo-techniques and geo-physical data.

6.4.1*Sequence of Excavation*

Sequence of excavation should be carefully planned, specifying the charge and strength of explosives. Where multiple work fronts/junctions exist involving crossing over of components, abundant care should be exercised in blasting operation and mucking and guiding the vehicles / equipment.

6.5 Disposal of Excavated Earth/Muck

6.5.1 Excavated muck should be cleared as soon as the excavation process of each cycle is completed and de-fuming has been done. The free-falling muck in the pressure shafts should be removed as frequently as possible, otherwise it may choke up the shafts. Choking of the lower end of the shaft may cause the mucking operations to prove hazardous to the mucking crew and the equipment. After the blasting and before mucking is started, the pollution shall be checked on face of mucking as per relevant Indian Standards. Radioactive pollution, if any, shall be checked for permissible limits and the working area shall be cleared before proceeding for next cycle of excavation.

6.5.2 No inflammable materials or oil and grease should be stored inside or near the tunnels or shafts and all combustible rubbish from the tunnel or shaft should be promptly removed.

6.6 Overhangs

6.6.1 Overhangs in the excavated face are hazardous as these may come down unexpectedly and result in fatal accidents to persons working at lower levels. Hence, such overhangs should be removed before continuation of further work in that area. Adequate precautions should be taken while removing the overhangs.

6.6.2 All excavated faces, on which work is in progress or work is temporarily suspended, should be maintained or left at safe slopes, so that the danger caused by caving or sliding is eliminated.

6.7 Support Systems and Monitoring

6.7.1 In underground excavation, safety of workers is paramount due to risk of hazards such as collapses, rockfalls, and sudden ground movements. Support systems play a crucial role in ensuring stability and protection, and they are generally classified into two types: passive and active. These are essential for reinforcing the excavation and safeguarding workers from potential dangers.

a) *Passive Systems* — include rock bolts, shotcrete, steel mesh, timber/steel ribs, and lattice girders. Passive systems rely on the natural resistance of the surrounding rock mass and provide stability without exerting additional forces. Regular inspections and proper installations are crucial to maintain their effectiveness over time. (*see* IS 11309)

b) *Active Systems* — such as tensioned rock bolts, ground freezing techniques,

struts, and reinforced shotcrete, actively reinforce the ground and provide immediate control in unstable conditions. Continuous monitoring and timely adjustments are necessary to ensure their reliability. (*see* IS 13219)

6.7.2 Monitoring support systems using instruments aid in additional safety. In this, strata monitoring techniques shall be implemented using instruments such as borehole extensometers, closure meters, and piezometers to track rock deformation, stress variations, and water pressure. Support monitoring tools like load cells and pull-out testers shall be employed to assess the load-bearing capacity and performance of support systems. (*see* IS 13414)

6.7.3 Micro-seismic and nano-seismic monitoring shall be utilized to detect micro-cracking and ground displacement in real time. This allows for immediate corrective action to prevent accidents and maintain structural integrity.

6.8 Service Lines

Service lines, such as power cable, water line, airline, dewatering line, etc, of the owner and contractor, should be segregated and laid/run on opposite face of the tunnel/cavern.

6.8.1 *Power Lines*

live wires and cables are laid in the area of excavation for blasting operations, drilling of holes and other operations involving the use of electric power. Where such cables are laid, care should be taken to see that these cables are not laid haphazardly. The supervisors, foreman and the construction staff should ensure that workmen or visitors are kept away from live wires. Wherever necessary, warning signals should be posted. Cables which are cut or open should be promptly replaced [*see* IS 10386 (Part 5)]. All electric wiring should be properly insulated and of sufficient capacity supported on insulators of approved type and not looped on or tied to spikes, ventilating pipes, or other makeshift supports. All switches should be of automatic trip type. Lines should be located so as not to create any electricity or tripping hazard to workers.

6.8.2 *Water Lines*

Water Lines Water lines are laid for different purposes such as drinking water, fire fighting, construction purpose, etc. Each line should be properly distinguished by a system of colour coding as per the relevant Indian Standards and should be well maintained. Adequate pressure levels should be checked regularly in water lines to fulfill the desired requirements.

6.9 Lighting, Warning Signals, etc.

6.9.1 Adequate lighting arrangements should be provided at the underground excavation worksite in the access tunnel, ADITs (additionally driven intermediate tunnels), pathways.

6.9.2 Danger lights should be provided at machinery locations and turning points in the access path for guidance of transport vehicles. At bend/crossings of pathways/roadway proper indications should be displayed.

6.9.3 Whenever a workman is required to climb up/ down on an excavation slope for working on shuttering, reinforcement at shafts, inclined tunnels, etc, he should do so with a safety rope tied securely to a safety belt and wearing safety helmet. Safety net should be provided below the work spot.

6.9.4 Single person should not be permitted in the area of underground excavation alone. All entry and exits that is, check-in and check-out times should be recorded.

6.9.5 Flame-proof electrical installations shall be used in situation where methane or other flammable gas is encountered.

6.10 Dewatering

6.10.1 During excavation work, adequate arrangements should be provided for dewatering and bailing out water from the excavated area to prevent slippery surfaces and sliding of slopes due to standing water.

6.10.2 Adequate measures should be taken to drain away the water from the upper surfaces of excavated slopes or benches. This prevents saturation of soil which could result in slips of the excavated slopes.

6.10.3 Temporary drainage system as well as permanent ones, such as ducts, should be constructed.

6.10.4 Necessary full-proof reliable arrangements should be made so that the surface/storm water from valleys nearby tunnels, shafts, additionally driven intermediate tunnel (ADIT), etc, do not gain entry into the work area. In pumped storage power houses there is always a threat of flooding if there is leakage or damage to the draft tube gate. Pumps alone may not be able to pump out the water and provision of drainage tunnels to nearby valleys should be considered.

6.10.5 Drainage holes should be provided in the crown, as well as on either side of the cavern, shafts, etc, so that the seepage water can be drained through these holes.

6.10.6 Following measures should be taken whenever adverse geo-thermal conditions are encountered during underground excavation:

a) Monitoring of temperature inside the tunnel especially where rock cover is very high and where there is history or evidence of occurrence of hot water springs;

b) Provision of additional ventilation including blowing of cool air, etc., at worksite;

c) Provision of ice-jackets to workers; and

d) Reduced working hours inside the cavern.

6.11 Ventilating the Tunnel

a) Ventilating duct/pipe of suitable diameter as per approved norms should be provided inside the tunnel for diffusing the fumes after blasting;

b) In addition to the ventilating pipe, a sufficient supply of fresh air should be provided at all times, in all places underground and provision should be made for quick removal of toxic gases and dust;

c) The concentration of various gases inside the tunnel should adhere to the limits given in clause 7.2.2 of IS 4756;

d) Provision for additional ventilation may be made in situation where methane or other flammable gas is encountered.

6.12 Noise Control

6.12.1 The noise polluting should be controlled:

a) At the source;

b) By enclosure;

c) By sound absorbing materials; and

d) By ear protection.

6.12.2 Control of noise by ear protection should be affected by the following methods depending upon the sound intensity level of the noise:

a) Cotton;

b) Impregnated cotton;

c) Soft rubber;

d) Muffs and helmets; and

e) Any of the above combinations.

6.13 Welding

Welding equipment and the structure to be welded should be properly earthed. General exhaust system should be available to take care of the evacuation of fumes. Unused gas cylinders should be kept at a safe place.

No welding should be done when concentration or methane or other flammable gas is encountered.

6.14 Winch/Wire Rope

Winch is important equipment which conveys men and material. It should be operated and maintained with extreme care and caution. Periodical checks for the wire rope, gear box, braking system etc, should be carried out as per relevant standards where exist.

Inspection of the wire rope system should be carried out as frequently as possible to locate any kinking, twisting of rope, loosening of the strands and any other damage. Obstruction in the movement of the rope/wires should be eliminated to avoid accident.

Log books should be maintained properly recording hours of operation, details of trips, number of men and load carried, problems noticed, repairs carried out, periodical inspections, mandatory checks and maintenance works.

There should not be any overlapping of wire ropes in the winch drums which may lead to sudden fall/jerk of the winch/jhula in the shaft. This sudden jerk of winch may hit the side rock in the case of small diameter shafts such as power cable shaft, ventilation shafts leading to serious accidents. Comparatively, confined space creates a hazard.

The following Indian Standards may be referred for material of different components of winch and for its maintenance:

Steel-wire rope	IS 2266
Maintenance of wire rope	IS 3973
Preferred size for wrought metal products (trolley wheels)	IS 1136
Gears	IS 2458 IS 2467 IS 2535 (Part 1) IS 2535 (Part 2) and IS 4460 (Part 1 to 3)
Motor	IS 12615
Socking of wire rope with molten metal	IS 3937 (Part 1 to 3)

6.15 Tools, Plant and Machinery

Proper care should be taken in the operation and maintenance of transport vehicles such as loaders, dumpers, tippers and trailers, cranes/winches.

Numbers of serious accidents have been associated with transport. The use of trucks/wagons and heavy machinery should be done under the supervision of experienced personnel. Care should be exercised when guiding vehicles for loading so that they don’t collide with side cutting and other vital installations such as cables, lights, ventilation ducts, pumps etc. Vehicle pockets should be provided at suitable intervals (say every 750 m) along the tunnel.

The underground excavation of inclined shaft is normally done by raise climber or similar machine. Great care should be taken in the operation and maintenance of such machine [*see* IS 10386 (Part 3) and IS 7293].

6.16 Access and Escape Ways

6.16.1 Pathways, if required, should be non-slippery and of adequate width. They should be strong enough to withstand the movement of workers and hand carried tools and equipment.

6.16.2 Gangways, if required, should be strong and of proper construction. Planks used should be of uniform and sufficient thickness and free from knots. Gangways should be kept clear of excavated materials or other obstruction.

6.16.3 Proper level steps should be provided where the gradient of roadway exceeds 15°. It is desirable that proper steps be provided in wet and/or slippery roadways, irrespective of the gradient of such roadways, so that the workers can conveniently use protective footwear even under adverse conditions.

6.16.4 Escape routes from different sections or parts of underground power house, underground transformer cavern, tunnels, etc, should be prominently designated by suitable markings so that they are clearly visible underground. This is in addition to the usual mock drills/ rehearsals once in a quarter.

7 TUNNEL WATERPROOFING

7.1 One of the most persistent problems encountered both during construction and the operation of any tunnel is that of water leakage/seepage.

7.2 Primary and secondary linings are the main defense against water ingress or leakage but these can be weakened by a faulty method. Grouting techniques and grout composition have become extremely sophisticated during the past few years with the development of modern injection techniques as well as the growing use of additives, such as resins and plasticizers and these should be considered for use appropriately.

8 WATER CONDUCTOR SYSTEM — SAFE FILLING AND EMPTYING

During these operations, the stresses in surrounding rock mass of water conductor system gets increased, released or rearranged. These are critical operations involving high risk and due processes. Safeguards should be followed as detailed in IS 12633.

9 FAILURES

In certain sections, although the supports are provided as per the rock conditions as stated by the designers, failure of roof and side walls may occur in the form of falling blocks, roof cave-in, crown settlement, buckling of ribs, shotcrete cracking, etc. The possible causes of failure in certain sections could be due to the following:

a) Assumption of improper classification of the rock by the wrong choice of support for identified rock class;

b) Insufficient thickness of applied shotcrete layer;

c) Incorrect rock bolting pattern and / or insufficient number of rockbolts;

d) Shotcreting applied after considerable delay that is after loosening of

surrounding rockmass, insufficient shotcrete in crown, initial layer of shotcrete omitted;

e) Steel supports not positioned properly and no back-filling behind the steel support;

f) Non-identification of rock blocks/wedges which are free to fall or free to slide under their own weight;

g) Failure to insert rockbolts to stabilize the rock;

h) Additional layer of shotcrete omitted in weak ground; and

j) Incorrect grouting of rockbolts and untensioned rockbolts.

10 EMERGENCY PLANNING

10.1 Workers at the face of a long tunnel are deprived of quick access to a medical center. For this, each member of the work force should be given at least some basic first-aid training. A special team of highly trained advanced first aiders is also essential. They should be provided with first-aid kits. Presence of doctors in project area is also important. Safety officers, with a mines safety background, should inspect machinery, monitor for hazards and give regular instruction on safe methods.

When there is a fatality or serious untoward incident, each such occurrence should be thoroughly investigated and the management should decide on how to deal with such situation and to avoid re-occurrence of a similar incident. It is essential for immediate shut down and examination of machinery and all similar equipment involved.

In case of major accidents, it is also necessary to inform immediately various levels of management, nearby disaster management agency, in addition to fire and rescue team. The respective contact numbers should be readily available and displayed. Review meetings should be held as frequently as possible to sort out and plan for any shortcoming.

10.2 Means of Exit/Escape

During excavation work, adequate means of exit/escape for work force from the hazardous areas/situations should be planned, and kept clear.

10.3 Evacuation Plan

Suitable evacuation plan, should be planned and made known to all the personnel involved in underground excavation work. Evacuation plan for the complete site shall be displayed at suitable location with clear visibility for the information of all.

10.4 Training & Communication

Reliable communication system should be maintained during and after excavation work. It is desirable to have loud phones or megaphones readily available for announcement of any impending emergency like fire, collapse, etc.

11 HEALTH AND SAFETY

Supervisory health and safety course should be conducted and attended by engineers/supervisor/foremen. Written check lists should be displayed at all work locations for compliance.

The rescue team should be highly trained and well equipped. Proper personal protective equipment should be made available to operators. The level of diesel fumes within underground excavation area should be closely monitored by gas analyzer.

12 PERIODIC INSPECTION

Periodic inspection of underground excavation areas after commissioning of power house plays a vital role and should be made mandatory specifying periodicity. Necessary periodic maintenance of ladders, landing platforms, top cover grills of various shafts, lining in tunnels, winches for shafts, etc, are very important in the long run. Vegetation growth in the unlined shafts, etc, should be completely cleared. After commissioning, the tunnels, shafts, underground power house and transformer cavern side walls, roof, etc, should be periodically inspected and repairs attended to immediately during shut down period, etc.

13 COMMUNICATION

Proper communication system should be established to facilitate communication between workplace and the management, worker and the safety manager and between various work fronts. Walkie-talkie, wireless mike system and similar equipment should be installed.Close circuit TV should also be installed to keep watch of critical components, critical locations, auxiliaries, cable routes, transformer cavern, and other vulnerable areas.

14 SAFETY OFFICER

It is essential to employ a qualified safety officer/engineer-in-charge to supervise the safety measures and to ensure the safety of personnel, employees, workers employed at site of underground excavation, equipment, during the excavation, operation and maintenance period.

a) To impart education and training to the workers and employees engaged in the underground excavation works;

b) To comply with relevant safety rules and regulations;

c) To undertake all steps to reduce risk to employees, property, machine, and surrounding areas;

d) To check all machine, equipment, firefighting water piping system, electrical appliances, first-aid station and to keep them in good working condition;

e) To take immediate action during any emergency situation, floods, etc;

f) Sustaining the efforts and continual improvements;

g) To evolve safety planning and conduct review meeting with site management, contractors and workers;

h) To arrange for displaying the warning signals /boards at vulnerable area;

j) To avoid excessively and unnecessary strenuous work position and movement;

k) To conduct internal safety audit half-yearly/annually, and to conduct external safety audit twice or thrice during the excavation process;

m) To prepare safety manuals for each specific component;

n) To ensure mandatory inspection and compliance and monitoring at higher management levels; and

o) To hire traffic regulator on site and placed at suitable places for mobilizing site transport of light and heavy vehicle in a safer way.

14.1 Accident Reporting

Any accident fatal/non-fatal (injuries) should be reported to the top management and law enforcing authorities within a time frame as below:

Reporting time:	
Fatal	Immediate (detailed report should follow)
Non-fatal	Within 3 days
Non-fatal damage to costly equipment	Within 2 days (preliminary report) and detailed report after due inspection of experts and assessment

14.2 Cause for Accidents

Cause for accident should be reviewed/investigated and remedial measures monitored. Necessary safety measures should be adopted. Existing measures, if found deficient, should be modified and corrected and suitable guidelines should be issued, to avoid reoccurrence. Accident event should be recorded with complete final report for reference to mitigate accident for future.

14.3 Disaster Management

Close co-ordination should be maintained with the district disaster management cell at all times especially at the aftermath of occurrence of fatal accidents, floods, fire, epidemics and other natural calamities.

15 FIRE RISK

Smoking by workers increases the risk of fire. Smoking shall be strictly prohibited in work spot. Cooking in and around the vicinity of work place shall be prohibited. As there is danger of fire and smoke resulting from rubbish, litter during construction operations, they shall be removed and taken out in every shift. Safety code for electrical aspects [IS 10386 (Part 5)] and for fire safety [IS 10386 (Part 7)] shall be adhered to.

15.1 Fire Alarm/Smoke Detection Alarm System

After excavation work, vulnerable areas in the underground space should be provided with automatic fire detection and alarm system (including manual fire alarm call points) conforming to IS 2189.

15.2 Extinguishers

Fire extinguishers, of various types suitable for the areas of fire risk covered should be provided in conformity with IS 2190.

15.3 Fire hydrant

Fire hydrants, along with suitable pump and riser systems for the working areas to address fire risks, shall be provided in accordance with IS 3844.

16 VISITORS

Visitors should not be permitted to enter the area of underground excavation. In unavoidable cases, they should be accompanied by a supervisor. They should be kept at sufficient distance from the cutting edge, running machinery and other potentially dangerous areas. All visitors should be provided with safety gadgets, and their details noted in the entry register. Details of all persons including workers/supervisors, their time of entry into the site and exit should be recorded.

17 BUDGET

As the safety aspects of underground structures are of paramount concern to the nation/state/owner, the safety system should be kept alert and reliable and a reasonable budget provision should be allocated, especially during the maintenance period.

18 DOCUMENTATION

Proper documents should be prepared indicating problems encountered during the excavation works, such as accidents, flooding, rock fall, if any, and other difficulties encountered during excavation etc. The outcome and action taken on periodic inspections should also be documented. This document will be useful for future underground excavation works.

ANNEX A

(*Foreword)*

LIST OF REFERRED STANDARDS

IS No.	*Title*

IS 1136 : 2008	Preferred sizes for wrought metal products (*third revision*)
IS 2189 : 2008	Selection, installation and maintenance of automatic fire detection and alarm system — code of practice (*fourth revision*)
IS 2190 : 2024	Selection, installation and maintenance of first-aid fire extinguishers – portable and mobile — code of practice (*fifth revision*)
IS 2266 : 2019	Steel wire ropes for general engineering purposes — specification (*fifth revision*)
IS 2458 : 2001/ISO 1122-1 : 1998	Vocabulary of gear terms — definitions related to geometry (*first revision*)
IS 2467 : 2002/ISO 701:1998	International gear notation — symbols for geometrical data (*first revision*)
IS 2535 (Part 1) : 2004/ ISO 53 : 1998	Cylindrical gears for general and heavy engineering : standard basic rack tooth profile (*third revision*)
IS 2535 (Part 2) : 2004/ ISO 54 : 1996	Cylindrical gears for general and heavy engineering – (part 2) module (*third revision*)
IS 3844 : 1989	Code of practice for installation and maintenance of internal fire hydrants and hose reels on premises
IS 3937 (Part 1) : 2022	Recommendations for socketing of wire ropes – (part 1) socketing with zinc (*second revision*)
IS 3937 (Part 2) : 2022	Recommendations for socketing of wire ropes – (part 2) socketing with white metal (*second revision*)
IS 3937 (Part 3) : 2022	Recommendations for socketing of wire ropes – (part 3) socketing with resins (*first revision*)
IS 3973 : 2022	Code of practice for the selection installation and maintenance of wire ropes (*second revision*)
IS 4081 : 2013	Blasting and related drilling operations — code of safety (*second revision*)
IS 4138 : 1977	Safety code for working in compressed air (*first revision*)
4460 (Part 1 to 3) : 1995	Gears – spur and helical gears – calculation of load capacity (*first revision*)
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IS 4880 : 2025 (Part 1)	Design of tunnels conveying water part 1 : general requirements – code of practice
IS 4880 : 1976 (Part 2)	Code of practice for design of tunnels conveying water, part 2: geometric design
IS 4880 : 1976 (Part 3)	Code of practice for design of tunnels conveying water, part 3: hydraulic design
IS 4880 : 1971 (Part 4)	Code of practice for design of tunnels conveying water, part 4 : structural design of concrete lining in rock
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