General excavation

This data sheet discusses problems involved in general excavating operations where the excavation walls are vertical or nearly so, except shoreline excavating, shaft work and trench excavation.

1. Shoreline excavating and shaft work involve special problems such as flooding due to overflow or cofferdam failure, damage to temporary structures from ships or barges, compressed air work and emergency escape facilities. Trench excavation and protection against failure in trenches is usually accomplished by the relative narrowness and shallowness of the cut. Also, trenches generally are backfilled in a comparatively short time and are not subjected to the changing soil conditions that may occur when excavations are open for long periods.

2. Soil includes all earth material between the ground surface and bedrock. The soil mass is a complex and variable mixture of solids, water and air. Because of inherent construction hazards, the soil mass must be treated as an important and distinct engineering problem in the planning and execution of any job that requires excavation work of appreciable magnitude.

3. The principal hazard of excavation work is death by suffocation or crushing when exposed soil fails and buries the workers. Workers also are subjected to hazards of falling materials, tools and equipment and hazards involving utilities—electricity, water, steam and gas, natural gases and oxygen-deficient atmosphere. Muddy conditions, common to excavations, increase dangers of slips and falls. Hazards of striking against or being struck by objects are increased by congestion of personnel, materials and equipment.

4. Unguarded or unlighted excavations, and lack of or inadequate barricades, fences and warning signs increase hazards to the public. Damage may occur to structures, streets or highways, public walks, utility installations or to any other adjacent property because of soil changes due to various complex causes.

5. Most excavation failures occur as a result of one or more of the following causes:
   • Taking a risk without proper and adequate investigation
   • Failure to use methods and install safeguards indicated by an engineering analysis of the
soil structure and of the soil’s ability to resist shear and support the weight to which it will be subjected

- Improper or improvised shoring
- Defective shoring materials
- Failure to recognize and compensate for loads imposed by surrounding structures
- Failure of apparently adequate support due to superimposed transient loads (excavated material, equipment or traffic, and excessive vibration)
- Improper maintenance of shoring during operations
- Changing weather conditions and the effect on the ground water and the soil

6. Death, injury and property damage during or resulting from excavation work can be eliminated—but only if adequate protective measures are made a part of the job. This requires a complete study of all pre-excavation conditions to evaluate changes in soil conditions that might develop. Bracing of adequate strength must be designed or soil stabilization must be provided for, in some other manner. Such study, design and planning generally require the services of a competent soils engineer.

7. Because the problem of falls is present in any excavation, the deeper the excavation, the more serious the problem. Every precaution should be taken to prevent falls of people, materials, equipment and tools. Handrails, barricades, toeboards, fences, warning signs, personal protective equipment and apparel should be used to minimize the hazards. Necessary personal protective equipment may include goggles, rubber boots, respirators, safety lines and belts. Wearing safety hats should be mandatory.

8. Health hazards should not be overlooked in excavation work. Health hazards may arise from the presence of silica dust, methane or other natural gas of a toxic or flammable nature, oxygen deficiency, or poisonous or irritating substances. All such possibilities should be considered both in the planning stage and when the work is being executed. Necessary respiratory and resuscitation equipment should be available for emergency use.

9. Every excavation 4 feet or more in depth should have ladders, stairways or ramps for entry and exit. Such facilities should be in sufficient number and should be so spaced that no worker in the excavation will be more than 25 feet from one of them.

10. Every area of the job should be properly illuminated. For night work, the lighting intensity should be not less than 3-foot candles with a minimum of glare and intensity contrast. Appropriate warning lights should be installed where special hazards exist.

11. Public utility companies, municipal departments or private owners should be asked to furnish all data on known underground facilities. In order to protect utility lines when excavating, a utility company representative should be present. Understandings should be reached with respect to disconnecting or protecting service on both above- and below-ground service lines, or other appropriate arrangements should be made.

12. The data and understandings should not, however, be considered conclusive. Positive controls should be established to prevent contacts with overhead distribution lines and known underground facilities. Care should be exercised at all times in order to minimize the possibility of contact with uncharted underground facilities.

13. Careful planning and close supervision of the work to prevent congestion of personnel and equipment are essential. Because space is limited in most excavations, every precaution should be taken to minimize congestion in the area and the dangers resulting from the movement of workers and equipment.

14. Excavation equipment such as cranes, shovels, draglines and trucks should be tested regularly and properly maintained. Schedules for regular maintenance and inspection by fully qualified
personnel should be established. Servicing of any equipment or machine while it is operating or in motion should be prohibited.

15. Employees should be carefully selected for the work they are to perform. New, as well as long-term employees should be made aware of all hazards of the job. Equipment operators should be tested for competency prior to assignment. Qualifications should never be assumed.

16. While the hazard of fire is unusual in excavation work, potential hazards can be created where combustible materials are extensively used in bracing, guarding or facilitating the work. Where such conditions exist, ample and suitable first aid firefighting equipment should be provided and properly maintained.

17. Construction work of any nature, and excavation work in particular, attracts the public and is classed as an “attractive nuisance” to children. Every possible precaution suitable to the project should be taken to ensure public safety. Walks, rails, barricades, fencing, overhead protection and warning signs are means of control. In some cases, guard service, traffic controls and the assistance of local law enforcement authorities may well be used. Warning lights and proper illumination also are essential.

18. The critical strength of any material is its minimum resistance per unit area to sliding along its internal planes. In terms of self-support, soils may be roughly classed as cohesive or cohesionless (noncohesive). Clear sands and gravels or mixtures of the two, are easily recognized and, lacking any cohesive qualities, receive prompt attention in excavation work. Cohesive soils generally are the source of most excavation troubles because they may appear to be stable at the time of excavating.

19. Soil mass failure occurs when stresses exceed soil strength. In determining if a soil failure is likely to occur, it is necessary to study factors that increase and decrease soil strength. Soil stress is increased by the following:

20. Soil strength may be reduced by the following:

21. Water is a major factor in most excavation soil failures although failures occur from any combination of circumstances affecting the relationship between the soil strength and stress. Failures can develop slowly through time, or they can occur suddenly with little forewarning.

22. There are four types of failures in a vertical excavation slope (see Figure 2).

1. Sliding, the most common failure, is the downward and outward movement of a fairly well-defined mass.

2. Sloughing is the release of material from the surface of an excavated face usually due to drying and cracking, or freezing and thawing.

3. Slumping is the bulging of the lower excavation face surface. Because this is generally the location of the maximum shear stresses, slumping indicates an overstressed condition.
4. Squeezing is the uplifting of the base or bottom. It may cause other types of failures as well.

23. In most cases, failures give some warning sign before they occur. Signs of failure in the excavation wall are subsidence of the adjacent ground surface, tension cracks parallel to the wall and spalling from the face.

24. Bottom heave generally occurs slowly. Warning signs are subsidence of the ground surface and, in some instances, the need to remove more soil than the volume would indicate. Occasionally, small boils give warning.

25. Preventing soil failures is based on this principle: Prevent stress increase or decrease in soil strength. This problem cannot be handled haphazardly. The procedure should be as follows:

- By exploration and tests, determine soil characteristics and variations in the area of the proposed excavation.
- Study the various factors and variables that may be encountered in the excavation work.
- Study the sources and control of both ground and surface water.
- Analyze all factors and, on the basis of the engineering findings, solve the problems and arrive at a work method.

26. Each job is an individual problem requiring attention to all job variables. Some of such variables are:
- Type of soil and soil structure, including ground water level and method of drainage, if drainage is required
- Underground utilities, sewers, tanks and other subsurface installations in and adjacent to the excavation area.

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**Figure 1** Construction details of a double cleat ladder that is substantial for entry and exit in an excavation. The rails are made of 2 x 4 lumber to a height of 12 feet; from 2 x 6 lumber from 12 to 24 feet in length.
• Superimposed loads—fixed loads such as adjacent buildings, towers, tanks, highways, railways and transient loads caused by excavating equipment, handling and disposal of excavated materials, subsequent construction necessities (pile driving, equipment, materials) and highway and rail travel
• Weather expectations and control of surface water
• Length of time the excavation will be open
• Local laws and regulations relative to blasting and public protection, and any rule or restriction that might affect the job

27. A system of shoring and bracing is the method generally used to compensate for the unbalanced stresses resulting from soil removal. Shoring and bracing design is a basic engineering problem that involves both structural design and soil mechanics. To maintain stability in the area surrounding an excavation, the bracing must be designed to withstand the variable stresses caused by changing soil conditions, and the bracing must be installed according to the design. The bracing system should be maintained at design strength by occasional stressing, by correcting faults that may develop, or by reinforcing where indicated. Correction or reinforcement is required if one or more braces show evidence of movement or buckling; also, if any sheeting or wales start to bulge or bend. Either condition indicates adjacent soil subsidence.

28. Superimposed loading is subject to control and is dependent on the strength of the soil surrounding the excavation. As a general rule, excavated material, equipment, trucks and other loads should be kept back from the edge a distance equal to one-half the depth of the excavation. In all instances the excavated material should be kept back far enough to ensure that none of the rubble will fall back into the excavation, or the edges should be protected in a manner that will effectively contain the excavated material. In excavations that workers may be required to enter, excavated or other material shall be effectively stored and retained at least 2 feet or more from the edge of the excavation.

Figure 2. Types of vertical embankment failures.
29. Shock or vibration can be controlled. Small charges and millisecond delay detonators when blasting, light hammers for pile driving, and elimination of unnecessary movement of heavy equipment will keep shock and vibration at a low magnitude.

30. Because water is a major factor in most excavating troubles, the sources and control of water, both surface and ground, should be a major consideration in planning the work. Surface water should be diverted away from excavated and denuded areas. Prolonged drainage, either because of seepage into the excavated area or pump removal of ground water from the surrounding area, will lower the water table and tend to dry out the surrounding soils. The drainage system should not remove sand and small particles from the soil surrounding the excavation. Drying may result in soil shrinkage, and removal of sand and small particles can create a void, either of which might cause settlement of adjacent surface areas, including structures.

**Source of information**

OSHA 29 CFR 1926 Subpart P Safety and Health Regulations for Construction, Excavations

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