

INTRODUCTION

Structures made of concrete are some of the most permanent made by man. However, it is vital that the ground upon which these structures are built is properly prepared. If you've ever used a shovel to dig a hole, you've probably noticed that no two holes are alike. Sometimes the soil is soft and it's easy to fill the shovel full of dirt. At another site you might not be able to penetrate more than an inch or two. Variations in soil conditions have prompted builders to develop ways to test the soil and determine its suitability as a construction site. Even if unsuitable soil conditions are found to exist, builders have developed ways of packing or compacting the soil until it can withstand the weight of a concrete building, bridge, or other structure.

FOCUS ASSIGNMENTS**FOCUS ASSIGNMENTS**

1. Read the Handout about building projects that have had problems because of soil conditions or improper subgrade preparation.
2. Participate in a class discussion about how the building site in Pisa would be prepared today. Also, participate in a discussion of the process of creating a manmade island in the middle of a bay.



Reading

Oral
Communication**UNIT OBJECTIVE**

After completing this unit, you will show the following competencies by mastering the activities on the Assignment and Job Sheets and by scoring at least 85% on the Written Test.

SPECIFIC OBJECTIVES

1. Discuss reasons for preparing a building site.
2. Select from a list consequences of building on soil that has not been properly compacted.
3. Select from a list the primary goals of compacting.
4. Name factors that affect the degree of compaction.



5. Describe the three types of soils.
6. Describe the effects of moisture on soil compaction.
7. Identify methods of soil compaction.
8. Match types of compactors to the jobs for which they are designed.
9. Compare methods of testing soil compaction.
10. Select compacting equipment given site conditions.
(Assignment Sheet)
11. Determine soil type. (Job Sheet)



OBJECTIVE 1

Optional Activities/
Resources in Instructor's
Guide

Discuss reasons for preparing a building site.

WORDS YOU SHOULD KNOW	
compaction	process of squeezing together all of the particles in the soil to make it suitable for construction
cut	to remove material from an area to bring it to proper grade
fill	to add material to an area to bring it to proper grade
load-bearing capacity	the ability of a subgrade to support weight
subgrade	compacted material upon which concrete will be poured or other structures placed

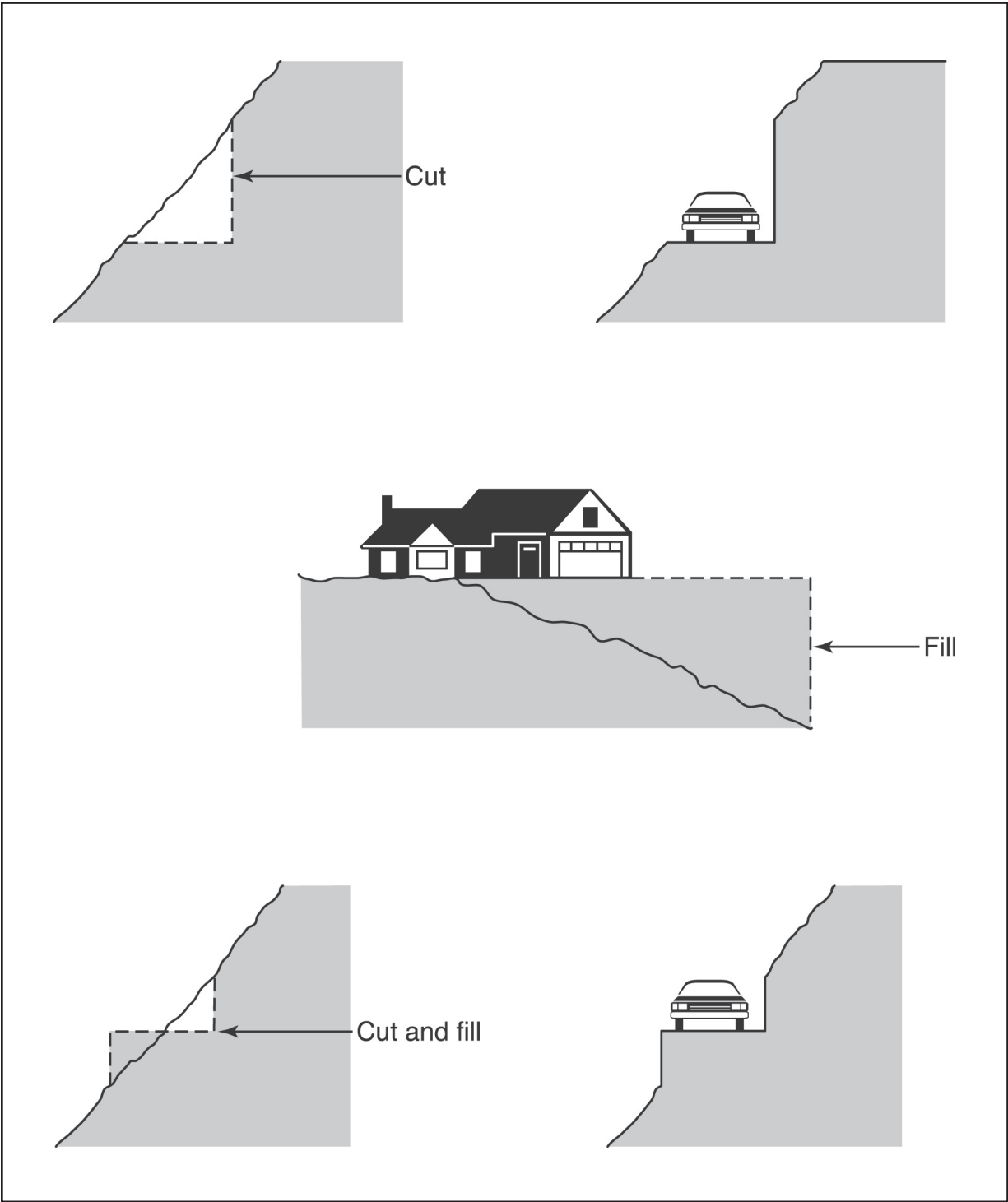
A building site should be level and have the load-bearing capacity to support the weight of whatever is being built without sinking. Since these factors rarely exist in nature, the site must be prepared before any type of construction can begin.

The type of soil at a building site must be evaluated. The topsoil is the first layer made up of not only the soil, but the grass, weeds, and roots that may be growing there. Because of its makeup, this layer of soil cannot be compacted so it is always removed. Soil is made up of many particles of different sizes separated by pockets of air. Compacting the soil causes it to become more tightly packed and have a greater load-bearing capacity. Some soils are densely packed by nature and don't require further compacting.

If a building site isn't level it may need to be cut or filled, or both (Figure 1). If material is brought to the building site it must be systematically compacted and tested until it has the load-bearing capacity of the surrounding area.



FIGURE 1



OBJECTIVE 2

Optional Activities/
Resources in Instructor's
Guide

Select from a list consequences of building on soil that has not been properly compacted.

- Cracked pavement
- Structural failure
- Water penetration

✓ **NOTE:** The air voids left in soil that is not properly compacted allow water to penetrate which can swell and contract in wet and dry seasons. Water in the subgrade can also freeze, causing heaving and cracks in pavements and foundations.

OBJECTIVE 3

Optional Activities/
Resources in Instructor's
Guide

Select from a list the primary goals of compacting.

- To reduce air voids in the soil
- To increase soil density
- To increase load-bearing capacity

OBJECTIVE 4

Optional Activities/
Resources in Instructor's
Guide

Name factors that affect the degree of compaction.

- Type of soil being compacted
- Amount of moisture in the soil
- Type of equipment used

OBJECTIVE 5

Optional Activities/
Resources in Instructor's
Guide

Describe the three types of soils.

Soils vary in their capacity to be compacted. When preparing a building site, builders must analyze the soil and determine its type. Knowing the type of soil allows the builder to develop a plan for leveling and compacting. There are three basic soil types:

- **Organic or topsoil** — The first few inches of most soils contain plant roots, dead and decaying plant and animal material, air, and other organic material that makes it ideal for plant growth. It is darker in color than the subsoil beneath it. The properties that make organic soil so valuable for growing plants also make it unsuitable as a building site. When weight is applied to organic soil, all the materials in the soil are pressed together and air is expelled. When the weight is removed the air is reabsorbed and the soil returns to its previous volume. For this reason, topsoil is always removed as part of the subgrade preparation.

✓ **NOTE:** Even if a site requires fill, the topsoil is removed before filling operations are begun.



- **Granular or course-grained soil** — These soils contain particles of different sizes and have a gritty feel when rubbed between thumb and forefinger. Because of the variety in the sizes of soil particles, granular soils compact very well.
 - **Cohesive or fine-grained soil** — These are very-fine grained soils that have the texture of clay. They contain soil particles that can only be seen through a microscope. These soils can be difficult to compact depending on their moisture content.
- ✓ **NOTE:** Most soils are made up of varying combinations of these basic soil types.

OBJECTIVE 6

Optional Activities/
Resources in Instructor's
Guide

Describe the effects of moisture on soil compaction.

It is difficult or impossible to compact dry soil. Moisture in the soil lubricates the soil particles and allows them to be packed more densely. There is always some amount of moisture in the soil but there may not be enough to allow for optimum compaction. In these cases, water must be added during the compaction process. But, too much water can saturate the soil. When this happens the water begins to take up space in the soil that could be occupied by soil particles.

OBJECTIVE 7

Optional Activities/
Resources in Instructor's
Guide

Identify methods of soil compaction.

WORDS YOU SHOULD KNOW

stroke

travel between the upper and lower limits of the compaction plates of a vibratory rammer; usually expressed in inches

There are three methods of compacting soil depending upon soil type and job site conditions.

- **Impact force** — uses a series of high impact blows to the surface; this method is best for cohesive soils but can be used on any soil type.
- ✓ **NOTE:** Hand-operated rammers can deliver 500 blows per minute with a stroke of 1½ to 4 inches.
- **Vibration force** — delivers high-frequency vibration to the soil through a base plate or a roller drum
- ✓ **NOTE:** Vibratory compactors can operate at different frequencies from 3,000 to 6,000 vibrations per minute, suitable for a wide range of soil types and conditions.



OBJECTIVE 8

Optional Activities/
Resources in Instructor's
Guide

- **Static force** — uses the weight from a heavy machine to press the soil particles together and expel air voids

✓ **NOTE:** Static force compaction has become largely obsolete as other methods have become more efficient.

Match types of compactors to the jobs for which they are designed.

Cement masons face a wide range of conditions when preparing a subgrade. On a highway construction project the soil type may change daily. On a building construction project there may be room for only walk-behind compactors. It is important to know the types of compactors and their capabilities.

Impact Force

- **Vibratory rammers** (Figure 2) — these machines are available in sizes ranging from 115 to 160 pounds. Most use gasoline or diesel-powered engines, but are also available powered by electricity or air. Different sized shoes make them suitable for work in trenches. They can be used on any compactible soil but are especially effective on cohesive soils.

FIGURE 2



Vibratory Force

- **Vibratory Plate** (Figure 3) — These machines were designed to compact granular soils in smaller or hard-to-reach areas. They come in a relatively wide-range of sizes and are powered by gasoline or diesel engines. Lighter machines can



operate at a higher frequency and are used on fine-grain or medium-weight soils. Heavier machines that operate at lower frequencies are used on soils with a larger particle size, such as coarse sands and gravels. Some vibratory plate machines are reversible, which is ideal for trench work.

FIGURE 3



- **Ride-on vibratory smooth-drum roller** (Figure 4) — These machines are used to compact large areas of granular soil. The operating weight is around 2400 pounds. They operate with either a gasoline or diesel engine. The front drum can be operated in either a vibrating or nonvibrating mode.

FIGURE 4



- **Walk-behind vibratory roller** — Similar to the ride-on vibratory smooth-drum roller but consisting of only one roller that can operate with or without vibration engaged. The operating weight is around 1000 pounds. These machines are powered by either gasoline or diesel and controlled by a walk-behind operator.
- **Vibratory sheepfoot roller** (Figure 5) — These machines combine vibration and a kneading action to compact large areas of cohesive or mixed soils. Each has a vibrating drum that has a series of protruding padfeet or lugs. Some models are offered with lugs of different heights to use on different soil types. They are powered by a diesel engine.

FIGURE 5



OBJECTIVE 9

Optional Activities/
Resources in Instructor's
Guide

Compare methods of testing soil compaction.

Two of the most widely-used methods of testing soil compaction in the field are the sand-cone test and the nuclear test. Both methods measure soil moisture and soil density to determine if the soil has been compacted at the optimum moisture content. Results are expressed as a percentage that may be more than 100 percent.

In the sand-cone test, a sample of the compacted soil is taken. The sample is weighed and then dried in an oven. By comparing the weight of the sample before and after it is dried, a percentage of moisture can be determined. The hole that the sample is taken from is filled with sand from a container of known volume. When the hole is full, the sand remaining in the container is weighed. From this the exact volume of the hole can be determined.



This test is a widely accepted method of measuring soil density. However, great care must be taken to attain accurate results and the entire procedure may take several hours to perform.

The nuclear test is performed by an instrument that measures density and moisture content by means of a probe inserted into the test site. A hole is driven into the ground using a hammer and a rod. The testing device is placed over the hole and the source rod is inserted. Gamma radiation is directed through the soil back to the test device. A microprocessor converts the data and displays it.

The initial cost of the nuclear test equipment is high, but since the procedure is performed in minutes, equipment and worker time is not lost waiting for test results.

OBJECTIVE 10

Complete the Assignment Sheet.

OBJECTIVE 11

Complete the Job Sheet.



Name _____ Score _____

OBJECTIVE 10

Select compacting equipment given site conditions.

BASIC SKILLS



Critical Thinking



Employability

EQUIPMENT AND SUPPLIES

- Pen or pencil

INSTRUCTIONS

Read each scenario and determine what you would do if you were supervising the preparation of each building site. Write down the equipment and techniques you would use and briefly explain your reasons in the blanks provided.

1. You are preparing to pour a parking lot for a new mall. the soil type over the entire site is granular and coarse-grained.

2. You are working in a narrow trench compacting the soil for a foundation. The soil is mostly clay.



3. You are pouring curb and gutter and it has been raining for several days. The subgrade is mud.



Name _____ Score _____

OBJECTIVE 11

Determine soil type.

BASIC SKILLS

Critical
Thinking

Employability

EQUIPMENT
AND SUPPLIES

- Samples of four different soil types
 - ✓ **NOTE:** The samples should be free of gravel and debris.
- Water

PROCEDURE

Yes No

1. Wet the soil sample until it is uniformly moist and is workable.
2. Feel the soil between the thumb and forefinger.
 - ✓ **NOTE:** Sand will be gritty, not sticky. Granular or coarse-grained soil will have a wide range of textures. Clay soils have very little grit and are sticky.
3. Try to form a ribbon with the soil.
 - ✓ **NOTE:** Sandy soils will form a short, fragile ribbon. Clay soils will form a long, stable ribbon.
4. Determine the soil texture by putting your observations together.
5. Repeat the procedure for each soil sample.
6. Have the instructor check your work.
7. Clean the work area and return tools and equipment to proper storage.



SKILL TEST RECORD

PRODUCT EVALUATION

Evaluator note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of “3” or higher to demonstrate student mastery. (See Key below.) A student who is unable to demonstrate mastery should review the material and submit another product for evaluation.

Criteria:

Ribbon squeezed	4	3	2	1
Texture determined	4	3	2	1

AVERAGE RATING

Evaluator note: To obtain an average rating for the Profile of Training Mastery, total the points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Key.

KEY

- 4 Skilled** — Can perform job with no additional training
- 3 Moderately Skilled** — Has performed job during training program; limited additional training may be required
- 2 Limited Skill** — Has performed job during training program; additional training is required to develop skill
- 1 Unskilled** — Is familiar with process, but is unable to perform job

EVALUATOR'S COMMENTS

