Soil Excavation Lesson Plan

Concept/principle to be demonstrated:

This lesson provides a systematic approach to calculate soil volume percent changes using data tables. Understanding is demonstrated by selecting factor from data table and applying formula to solve additional construction related problems using a calculator.

Lesson objectives/Evidence of Learning:

- Comprehends concept of percent of change and multipliers
- Knows meaning of terms
- Extracts data from tables
- Applies formulas to solve variety of construction problems
- Uses calculator to compute accurately

How this math connects to construction jobs:

Percent of change is used extensively by laborers, operating engineers and project estimators in construction. This lesson will help students comprehend how percent of change and multipliers are used to determine volume for removal and replacement of soils.

- **Project engineers** use percent of change data in establishing the cost estimates for soil movement.
- **Laborers** use multipliers to determine the amount soil needed to refill an excavated trench after the pipe has been laid.
- **Operating engineers** use formulas to select the correct size and number of pieces of equipment needed to move soil.

Teacher used training aids:

- 1 gallon zip-lock bag stuffed with packing (foam) peanuts with air removed.

Materials needed per student:

- Pencil
- Calculator with √ key & memory +/- functions
- ***Soil Data Tables*** handout
- ***Soil Excavation Worksheet***

Terms:

- **Cubic yard:** volume of a cube measuring 3 feet tall, 3 feet wide and 3 feet deep
- **Multiplier:** another name for the decimal conversion of a percent.
- **Percent:** per hundred parts

Lesson Introduction:

When soil is disturbed during excavation, the volume is increased. Compressed soil (also called loaded or loading soil to compact it) has a smaller volume. Different types of soil expand and shrink at predictable rates. These rates of change are found on data tables used in the field to calculate the volume of soil being moved.

Lesson Components:

1. **Demonstration:** Show the compacted bag of packing peanuts. Explain how soil is also compacted. Open bag to show expansion when disturbed similar to digging.

2. Digging a hole makes a pile of dirt that is larger than the volume of the hole dug. This is because loose stock-piled soil takes up more volume than compacted soil. In the garden, soil continues to compress around a recently added plant. Loosening the surrounding soil aids the root system in reaching through otherwise hard soil.

3. Knowing how much the volume changes is necessary to correctly estimate cost associated with excavation, especially hauling costs. Swelling and shrinkage of soils follows a predicable pattern based on the soil type.

4. The calculations of loose or compacted soil are percentage changes. Percent is simply the decimal value (per hundredths) of the change.

5. There are two approaches to complete the math calculations. The first one uses the percent of increase or decrease and adds this increase to the original volume.

   Example:

   - Excavating compacted sand will increase by 15% when loaded on a truck.
   - 0.15 is the decimal value of 15% (move decimal two places to the left).
   - 8 cubic yards of sand is being excavated.
   - What is the volume that will be hauled away?

   Write this Example on the board:

   8 cubic yards x 0.15 = 1.2 additional cubic yards of sand
   (This is added to the original 8 cubic yards to determine total volume.)
   8 + 1.2 = 9.2 total cubic yards to haul away

6. Another way to calculate percent of change is to combine the percents. The volume increased by 15%. The volume to haul will be 115% of the sand. All of the original volume (100%) plus the expanded volume (15%).

   Write this Example on the board:
   8 cubic yards x 1.15 = 9.2 total cubic yards to haul away

Here's another example:

Loose clay has a volume that is 35% larger than compacted clay. What is the volume of 7 cubic yards of compacted clay that has been excavated?

Write this Example on the board:

7 cubic yards x 1.35 = 9.45 total cubic yards to haul away

7. Another name for the decimal conversion of the percent is "multiplier." There are three key mathematical relationships of multipliers:

   - When something increases in size based on the percent change, the multiplier must be greater than 1.
   - When something decreases in size, the multiplier is less than 1 and greater than 0.
   - 1 is the boundary between increasing and decreasing values. A multiplier of 1 doesn't change anything – it has the same value back as the one started with.

8. A 25% increase provides a multiplier of 1.25. This is the sum of 25% and 100%. This is greater than 1.

9. A decrease of 25% is subtracted from 100% leaving a remained of 75%. The multiplier is 0.75. This is less than 1.

Write the following practice problems on the board.

Determine the multiplier for these percent changes:
+32% **(1.32)** -35% **(0.65)** +8.2% **(102.8)** -13% **(0.87)**

Determine the percent change on these multipliers:
1.24 **(+24%)** 0.86 **(-14%)** 1.061 **(+6.1%)** 0.64 **(-36%)**

10. Most data tables regarding soils do not provide the percent of change. Instead, the tables provide a multiplier or factor to use.

    - When changing from a small (compacted) volume to a larger (loose material), multiple with the factor as is (must be larger than 1).
    - When changing from a large (loose) volume to a smaller (compacted), use the factor to divide 1.
    - Dividing provides a multiplier smaller than 1 to use.

11. Distribute **Soil Data Tables** handout

Write the following practice problems on the board.

7 yards of clay soil excavated becomes how many cubic yards to be hauled?
7 x 1.35 = 9.45 cubic yards

5 cubic yards of loose sand will have what volume when compacted?
1/ 1.18 = 0.847 x 5 ≈ 4.24 cubic yards

12. Complete ***Soil Excavation Worksheet*** in teams.

Review:

1. What is the boundary number between increasing and decreasing value? One
2. When calculating compacted materials being loosened, the multiplier is greater than or less than 1? Greater than 1.
3 Calculations for loose soil compacting uses a multiplier greater than or less than 1? Less than 1.
4. How do you convert a factor that is greater than 1 to multiplier less than one? Divide 1 by the factor.
5. Questions?

Name _____

Soil Excavation Worksheet

Using the **Soil Data Tables,** solve the following problems:

Problem #1

If there are 16 cubic yards of sandy-loam soil, what is the volume of the soil when it is compacted?

Problem #2

If 12 cubic yards of clay soil needs to be excavated, what is the volume of loose clay soil that needs to be hauled away?

Problem #3

A bank is developed using 28 cubic yards of clay. Estimated loss during transportation and construction is 10%. What size will the bank be when the clay is compacted?

Problem #4

Moving sandy-loam soil to another site incurs a $5 per yard dumping fee. If 22 cubic yards is excavated, what is the cost of dumping the soil?

Soil Excavation Worksheet

Using the **Soil Data Tables,** solve the following problems:

Problem #1

If there are 16 cubic yards of sandy-loam soil, what is the volume of the soil when it is compacted?

13 cubic yards **1/1.23 = 0.81 x 16 ≈ 13.0**

Problem #2

If 12 cubic yards of clay soil needs to be excavated, what is the volume of loose clay soil that needs to be hauled away?

16.2 cubic yards **12 x 1.35 = 16.2**

Problem #3

A bank is developed using 28 cubic yards of clay. Estimated loss during transportation and construction is 10%. What size will the bank be when the clay is compacted?

18.9 cubic yards **1/1.48 = 0.68 x 28 ≈ 18.9**

Problem #4

Moving sandy-loam soil to another site incurs a $5 per yard dumping fee. If 22 cubic yards is excavated, what is the cost of dumping the soil?

$132 **22 x 1.20 = 26.4 x $5 = $132**

Soil Data Tables

Swellage Factors

Soil Type	100% relative compaction	Excavated and loose
Sand	1	1.15
Sandy-Loam	1	1.20
Clay-Loam	1	1.30
Clay	1	1.35

Shrinkage Factors

Soil Type	Loose-stockpiled	Normal Shrinkage
Sand	1	1.18
Sandy-Loam	1	1.23
Clay-Loam	1	1.43
Clay	1	1.48