SOIL COMPACTION, GRADING AND RELATED EQUIPMENT

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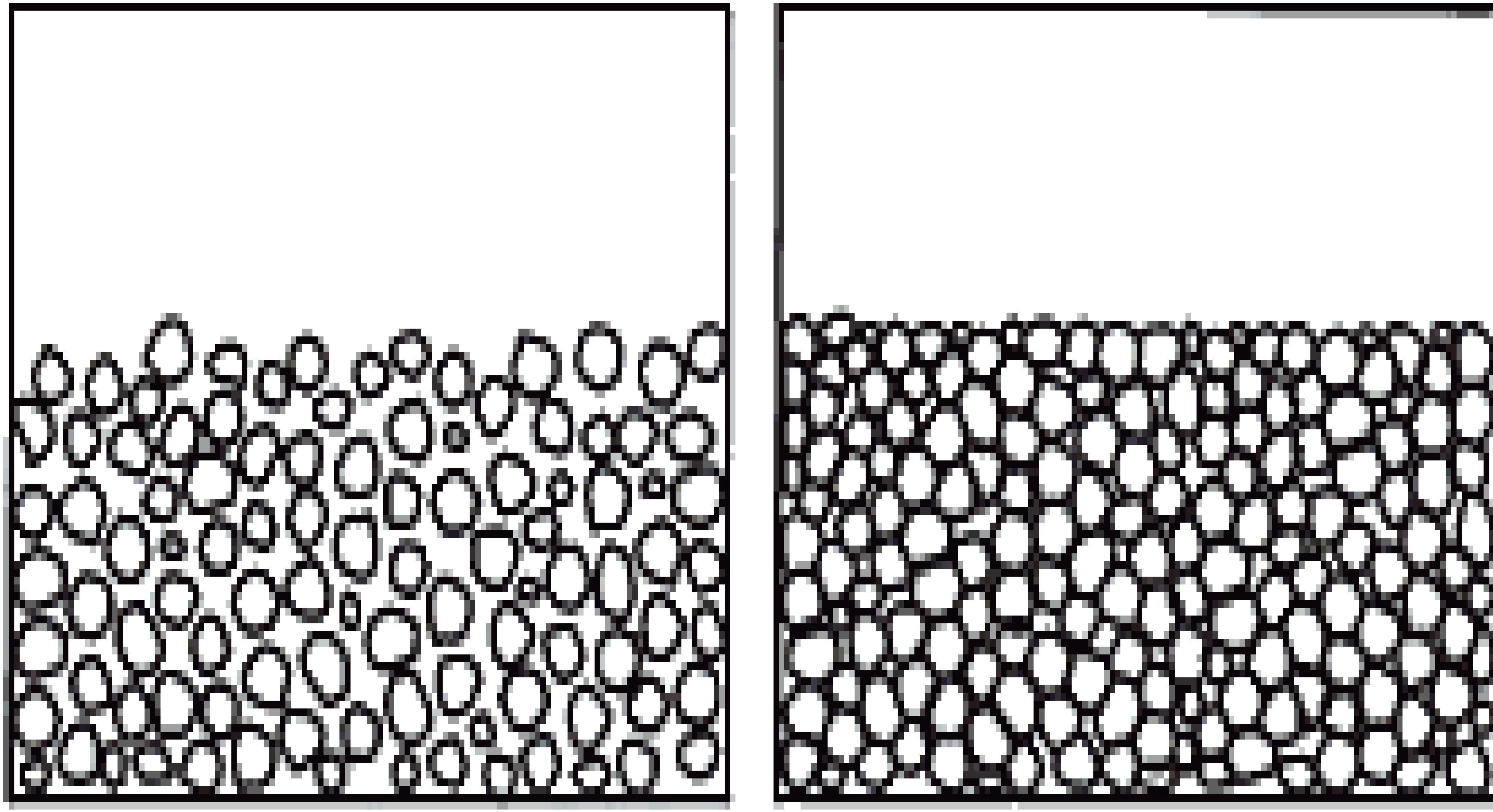
Soils are used in civil engineering as:

- to support structures
- pavement for highways and airports
- to resist the passage of water (spillways or dams)

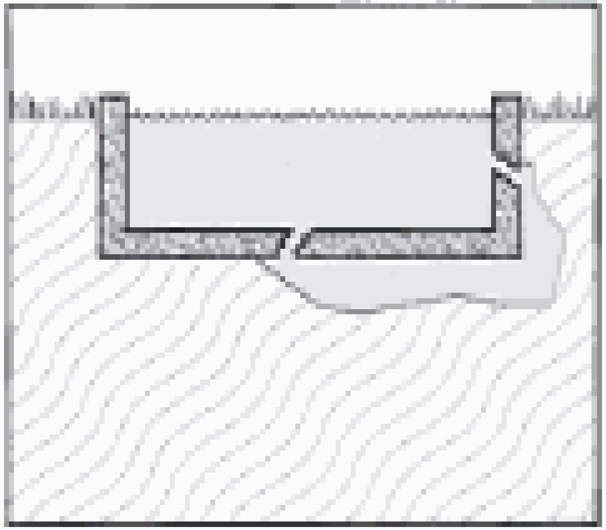
Soil is compacted to perform its job better. Compacting of soil means bringing it to its maximum density. Soil can be brought to its maximum density when it has an optimum moisture content. Optimum moisture content of soil can be obtained in Laboratories by undertaking the experiment, **proctor test.**

Soil Density

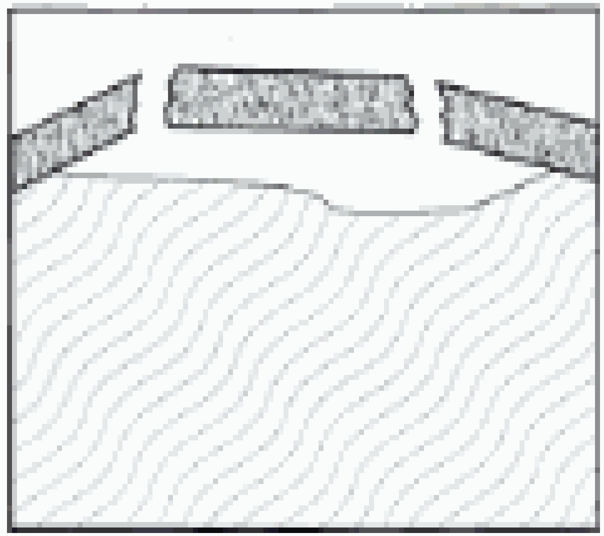


Loose Soil
(poor load support)

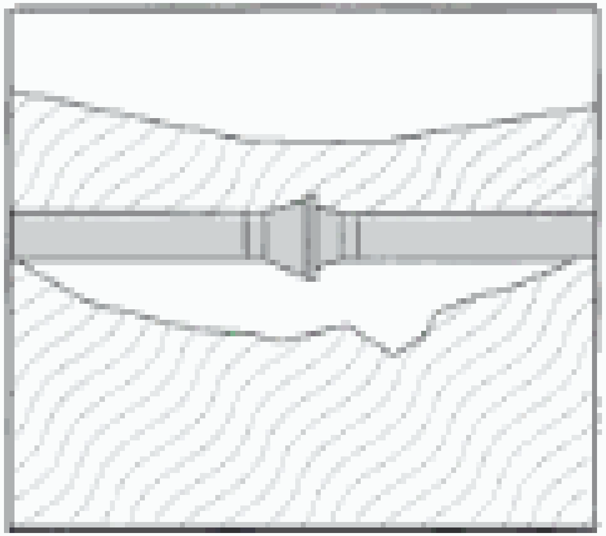
Compacted Soil
(improved load support)



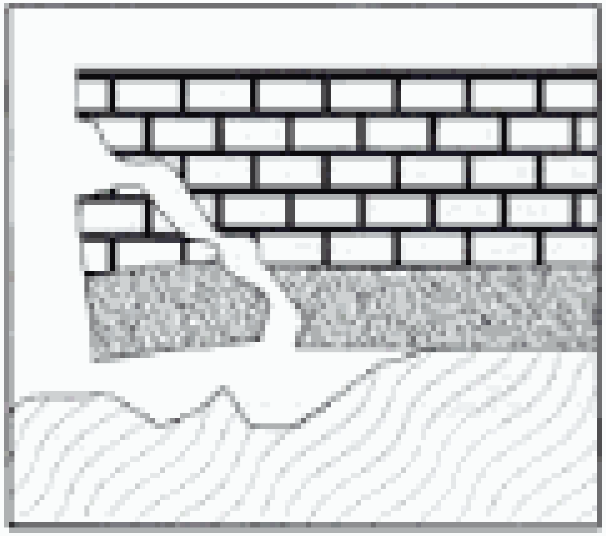
Basement and Pool Cracks and Leaks



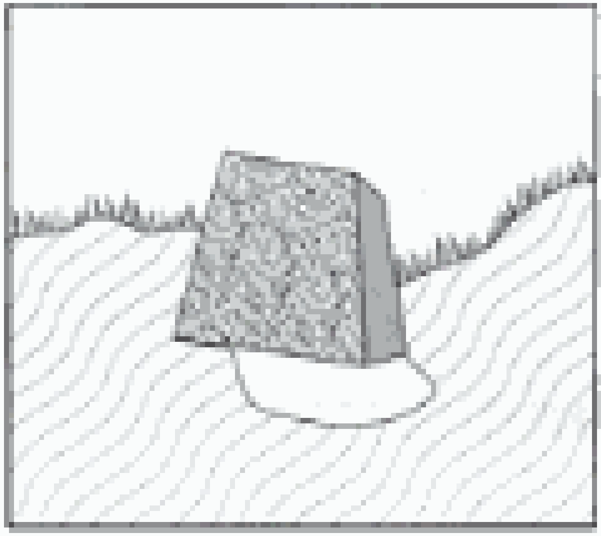
Slab Cracks



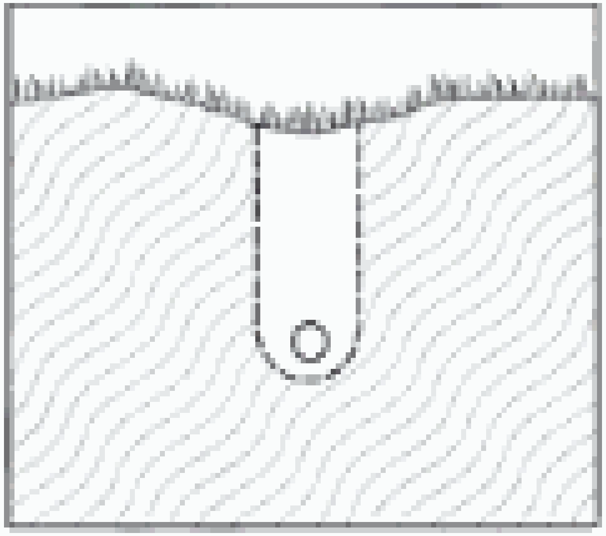
Pipe Leakage and Breaks



Foundation Erosion



Under Abutments Erosion Gullies



Utility Trench Settling

Proctor Test

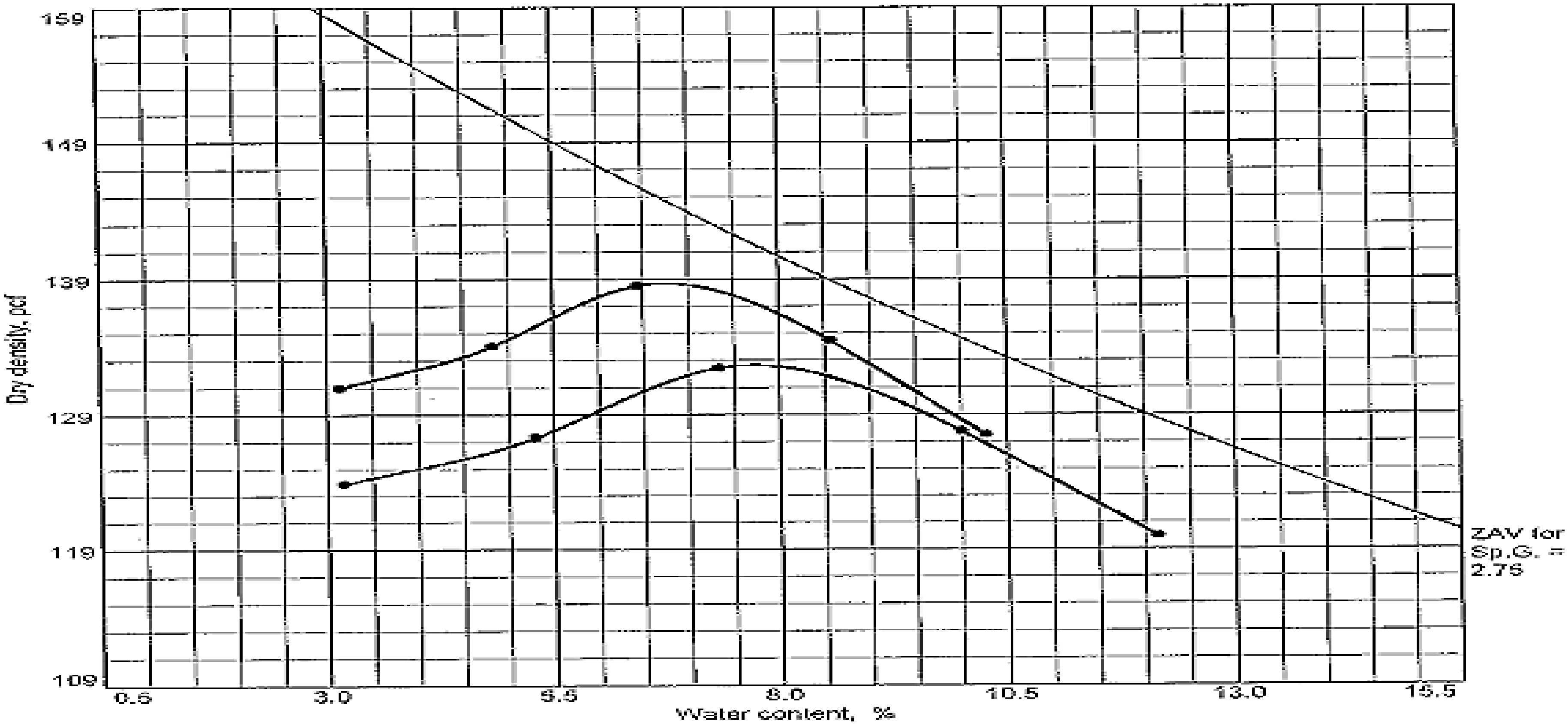
1. **Standard proctor:** Weight of hammer to be dropped on soil is 2.50 kg (25 times).

2. **Modified proctor:** Weight of hammer to be dropped on soil is4.54 kg (25 times).

The experiment is repeated for varying moisture contents of soil and the following figure is drawn.

In the field, normally Standard proctor test is used assuming it simulates site conditions better than Modified test.

PROCTOR TEST REPORT



Test specification: ASTM D 698-91 Procedure C Standard
Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
							20.5	

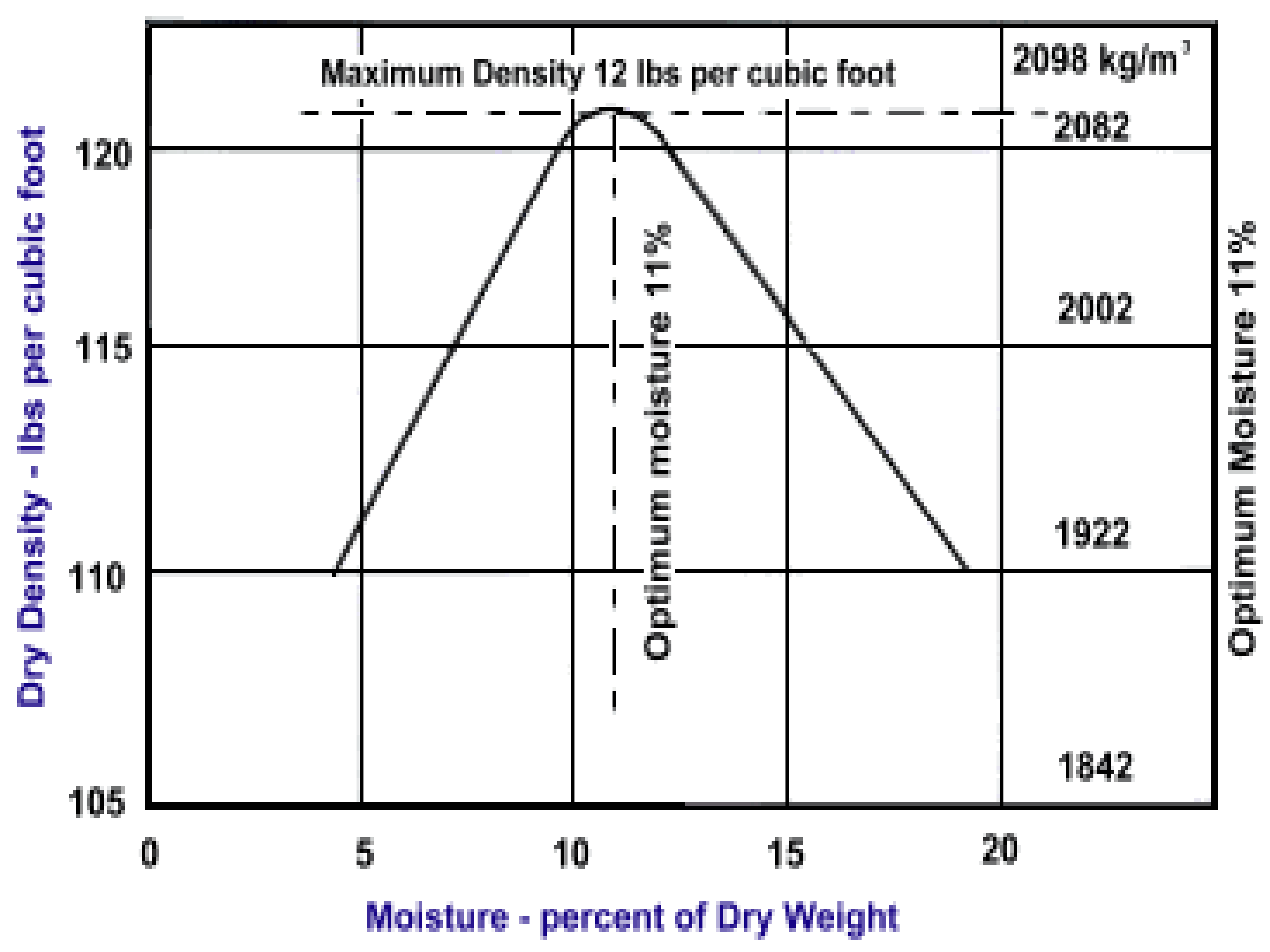
ROCK CORRECTED TEST RESULTS	UNCORRECTED	MATERIAL DESCRIPTION
Maximum dry density = 138.7 pcf	132.6 pcf	Brn. Silty Sand and Gravel
Optimum moisture = 6.8 %	7.7 %	-

Project No. 9001 Client:
Project: Alliance Landfill, Pad 10

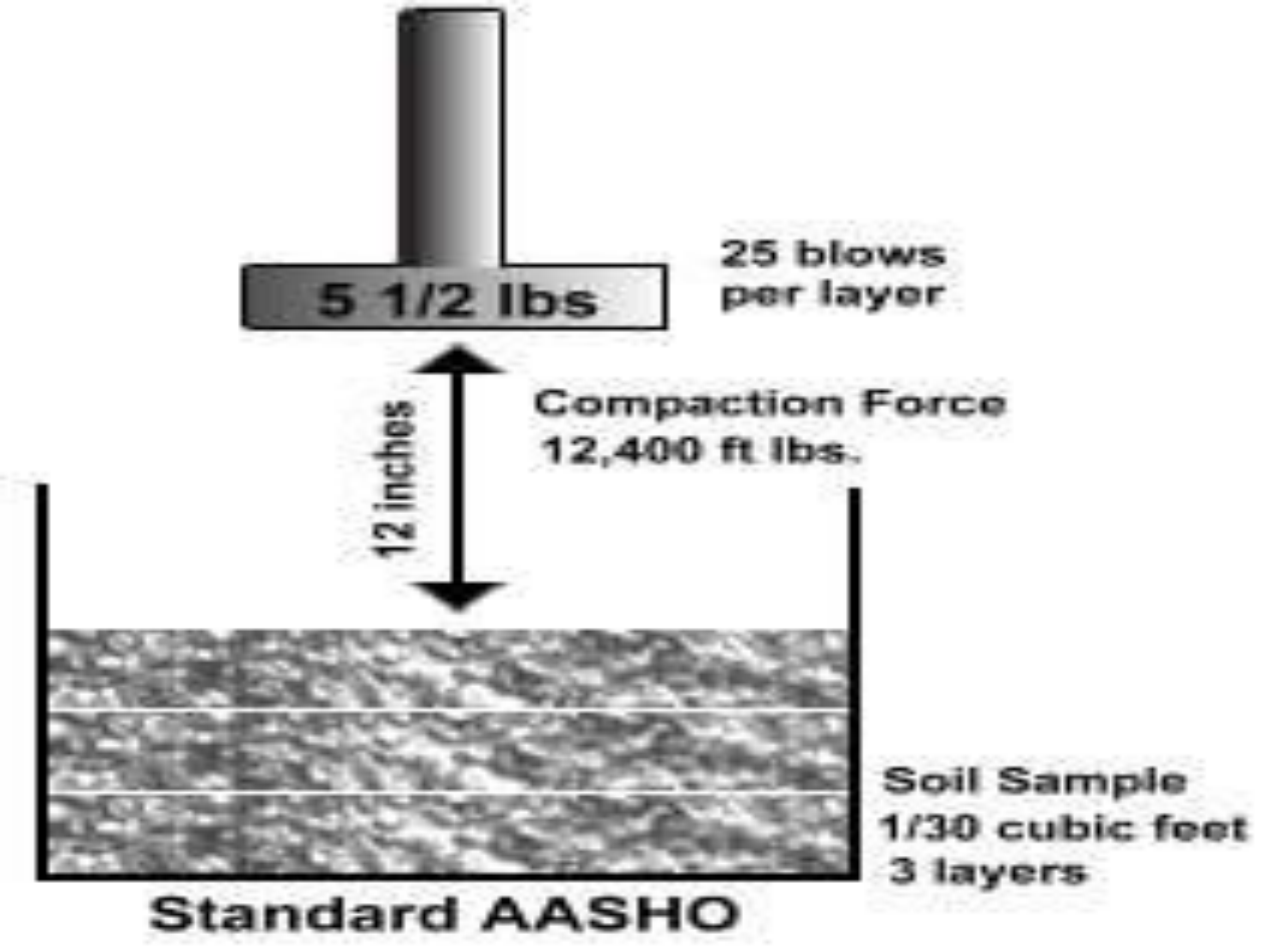
● Location: Taylor Borough, Ransom Township, Lackawanna Co., PA

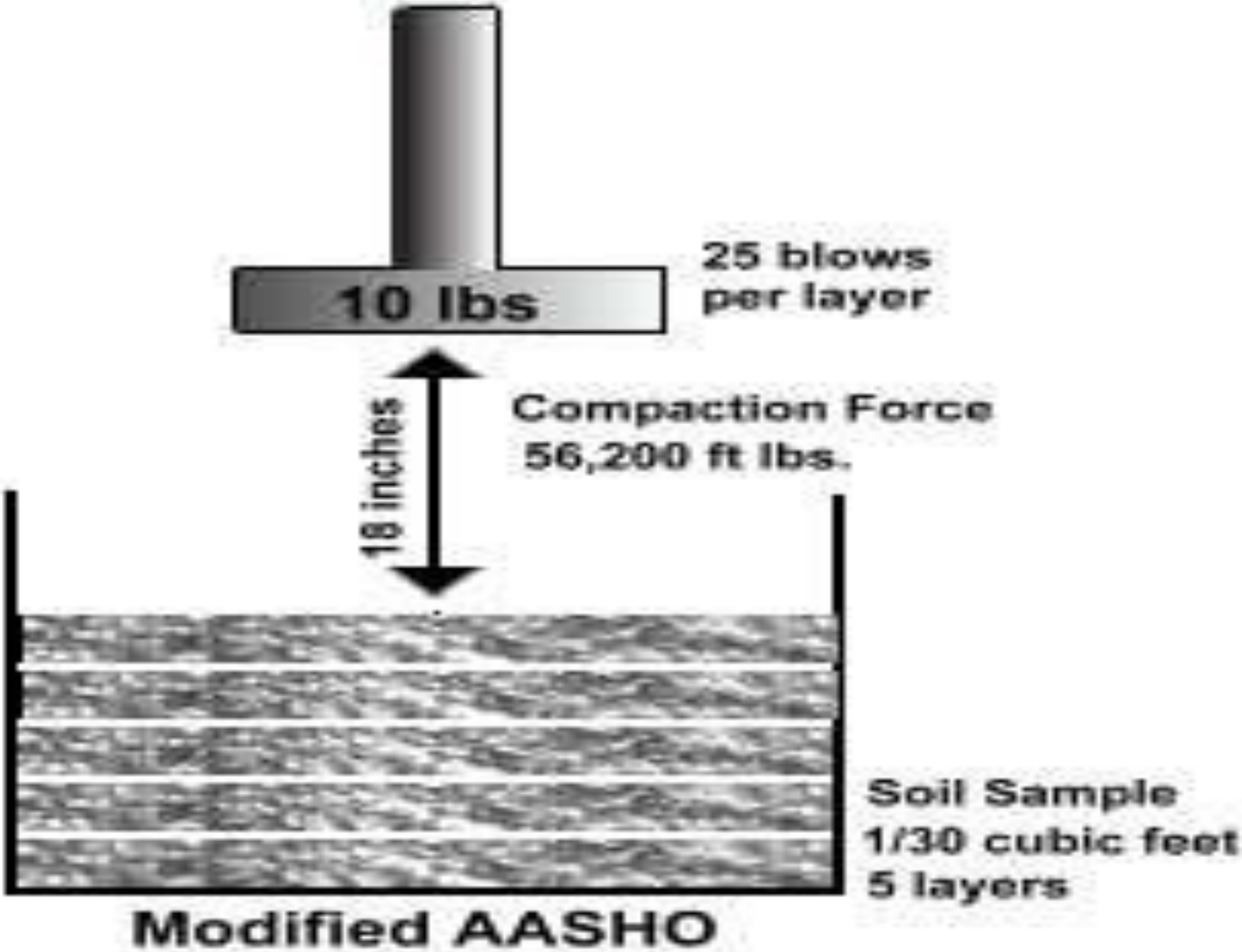
Remarks:
Onsite Structural Fill
Material, Sample No. 1
Cut - Middle of Pad 10

PROCTOR TEST REPORT
CUMBERLAND GEOTECHNICAL
CONSULTANTS, INC.



Maximum Density 12 lbs per cubic foot
2098 kg/m³
2082
2002
1922
1842
Optimum moisture 11%
Optimum Moisture 11%
Dry Density - lbs per cubic foot
120
115
110
105
0
5
10
15
20
Moisture - percent of Dry Weight


5 1/2 lbs
25 blows
per layer
12 inches
Compaction Force
12,400 ft lbs.
Soil Sample
1/30 cubic feet
3 layers
Standard AASHO


10 lbs
25 blows
per layer
18 inches
Compaction Force
56,200 ft lbs.
Soil Sample
1/30 cubic feet
5 layers
Modified AASHO

Proctor Test Cont…

- Once the optimum moisture content is obtained, soil is compacted by any means of compacting equipment. However, different equipments will produce different compaction curves at a specific moisture content.

- On the other hand, different soils have different optimum moisture content. So the best thing to do is to decide which equipment is suitable for which type of the soil (see Figure 5.10 – p. 139).

- In practice, 90-95% Laboratory results (Standard Proctor) is accepted as good enough compaction.

- Modified Proctor test is mostly used in runway construction where higher density is required for larger loads for big aircrafts.

COMPACTION METHODS

Compaction of soil is attained by applying energy to soil by one of the methods given below.

1. Static Weight
2. Impact
3. Vibration
4. Kneading action

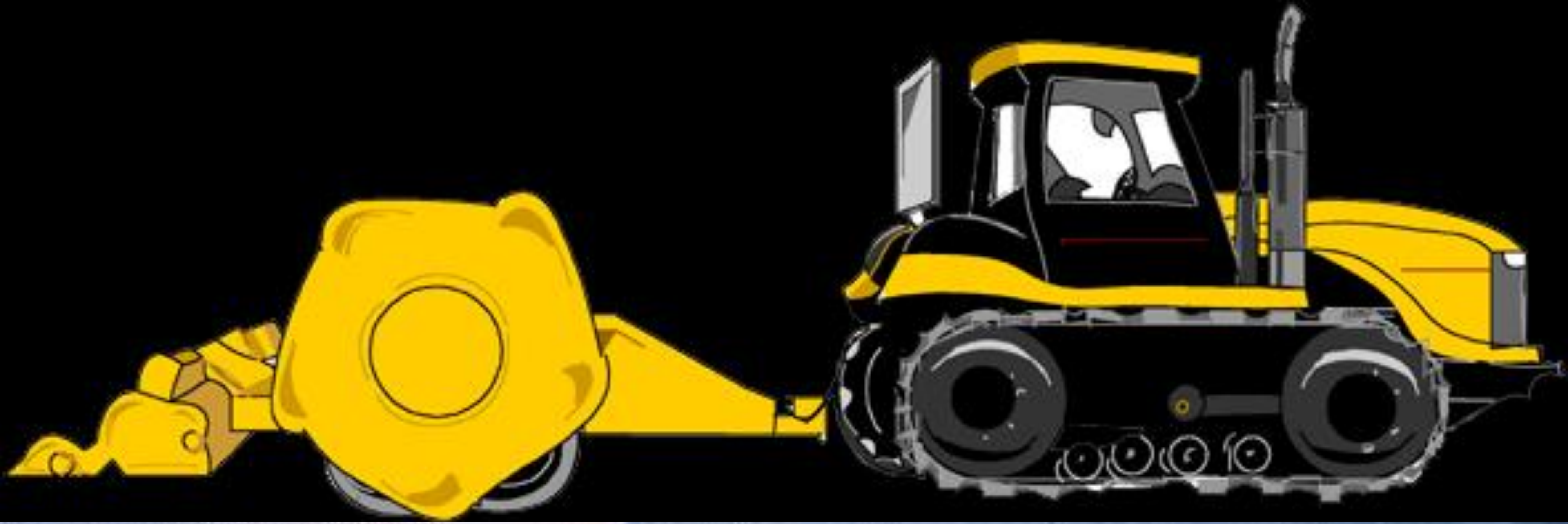
Static Weight

- Applied by smooth wheel rollers and pneumatic-tyred rollers. Compaction can not reach lower strata because of internal friction of soil. So this compaction is especially good for granular soils.

Impact Compaction

- The equipment used for impact compaction are tamping rollers and rammers. Impact reduces the internal friction of soil and particles start moving towards voids easily.

- (Dropping an object from a height of 20 cm produces a compaction 50 times larger than the static force produced by the same object.)




Vibrating

- Vibrating rollers and vibrating plates are used. Frequency is 1000-5000 cycles/min. In this system impact force penetrates down to great depth. Vibration minimises the internal friction of particles and smaller particles move down to voids easily. Internal friction forces are 13 times less in sandy soils and 42 times less in gravely soils when they are vibrated than when they are still.

Vibrating

- In clayey soils, the vibration damages the internal structure of clay and its strength drops to a low level after stopping vibration. In other soils (non-cohesive), after stopping vibration the strength reaches to its original level. This is why vibration is used only in non-cohesive soils.


WACKER



Kneading Action

- In this system the compaction starts from a lower level and comes upward.

- Kneading action is actually the application of shear stress to soil. Sheep's foot roller (tamping rollers) and pneumatic tired rollers are used.

Compaction Equipment

1. Tamping rollers (Sheep's foot roller)

2. Smooth rollers

3. Pneumatic-tyred rollers

4. Vibrating rollers

Tamping Rollers

- They can be self-propelled or towed.
- Contains a steel drum including a number of projecting steel feet.
- Compaction with kneading action starts at the depth of the soil.
- In later passes the penetration of steel feet into the soil is getting less and less.
- Once the soil is compacted, the feet almost do not penetrate.
- One or more than one of them (side by side or one after the other) could be towed.


CAT

Smooth Rollers

- Classified according to their weight.
- Self propelled or towed (self propelled: front wheel is steering wheel).
- It creates a crust under the wheel.
- Not good for cohesive soils, but used for granular materials.
- Used to smooth the surface after using tamping rollers.


CATERPILLAR


CATERPILLAR

Pneumatic-tyred rollers

- Compaction starts from bottom and goes to top with kneading action.
- Self propelled or towed are possible.
- The rear and front tyres are so arranged that in one pass all the width is compacted.


GO


BOMAG
BOMAG

Vibrating Rollers

- Very useful for granular materials.
- Combination of vibration and pressure is applied.
- Not good for cohesive soils.

They could be:

- Vibrating tamping rollers
- Vibrating steel-drum rollers
- Vibrating pneumatic rollers
- Vibrating plates or shoes (manually operated rammers)


GALION VIBRATORY ROLLER
DETROIT 4-53 POWER


CHANGLIN
CHANGLIN
CHANGLIN
YZ20JJ-3


BOMAG
BOMAG

Compaction Equipment Output Calculation

$$\text{Production}\left(cm^3/hr\right) = \frac{10 \times W \times S \times L \times E}{P}$$

Where

W : Width of roller (m)
S : Average Speed of the Equipment (km/hr)
L : Depth of loose layer to be compacted (cm)
E : Efficiency
P : Number of passes to reach maximum density

Example

- Estimate the production of smooth steel wheel roller which is compacting a road under the following conditions: average speed of the roller is 7.6 km/hr, compacted lift 25 cm, effective roller width is 2.2m, number of pass required is 8 and job efficiency is 50 min/hr.

Solution

- Production $= \dfrac{10 \times W \times S \times L \times E}{P}$

$$= \frac{10 \times 2.2 \times 7.6 \times 25 \times 0.833}{8}$$

$= 435.4 \ cm^3/hr$

GRADING

Grading is the process of bringing earthwork to the desired shape and elevation.

Finish grading (*finishing*) involves smoothing slopes, shaping ditches, and bringing the earthwork to the elevation required by the plans and specifications.

Finishing follows excavation, compaction, and grading and is followed usually by seeding to control soil erosion.

The equipment most widely used for grading and finishing is the motor grader.


CASE


VOLVO


G990


CAT


CASE

MOTOR GRADERS

Motor grader is not an excavating machine.

Usages :

1. Shaping and final grading in road construction

2. Maintaining haul roads

3. Mixing and spreading surface material

4. Contour grading

5. Backfilling

Output calculation

- The necessary time to complete the job is calculated by using the following relation:

$$T = \sum \frac{n \times d}{V \times E}$$

Where : T : Total time (hrs)

n : Number of passes

d : Distance to travel in each pass

V : Speed (km/hr) (From Table 5-6 p.151)

E : Efficiency

Example

- 8 km of gravel road requires reshaping and leveling. You estimate that 5 passes of a motor grader will be required. Based on operator skill, machine characteristics, and job conditions, you estimate 1st and 2nd passes at 2.06, 3rd 4th passes at 4.0 km/hr, and 5th pass at 4.82 km/hr. If job efficiency is 0.80, how many grader hours will be required for this job?

Solution

$$T_{1,2} = \frac{2\times 8}{2.06\times 0.8} = 9.71\,\text{hr}$$

$$T_{3,4} = \frac{2\times 8}{4.0\times 0.8} = 5\,\text{hr}$$

$$T_{5} = \frac{1\times 8}{4.82\times 0.8} = 2.1\,\text{hr}$$

$$\sum = 16.81\,\text{hr}$$


LOADALL
JCB


53 AF 405