MASS
INTERCHANGE

Volume 13, Number 1 Winter 1999

Compaction Satisfaction

What is Compaction?

With compaction, soil particles are moved and rearranged closer to each other, and the air or water trapped between these particles is forced out. Compaction removes air from sand, loose gravel and dry soils, and water from clay and moist cohesive soils.

With increased soil density, the soil is better able to support a load without settling. This is particularly important when fill is placed in an area such as a road, sidewalk or floor, and then is paved over with concrete or asphalt. Without compacting, the fill originally supporting the load will slowly settle, causing a void. The concrete or asphalt will crack and fall into the void.

Three factors govern the extent to which soil can be compacted:

1. The type of soil and its compatibility;
2. The moisture content of the soil being compacted;
3. The type of compacting effort required - pressing, ramming or vibration.

Soils are divided into three groups: granular, clay, and organic.

Granular: sand and gravel consisting of grains down to .002 inch (0.5 cm).
Clay: very fine scale-shaped particles.
Organic: loam, peat; made up of moss, leaves, or vegetable matter; top soil; used in construction only when mixed with large quantities of granular or clay material.

Once the basic terms are understood, selecting the correction compaction equipment is easier. The following terms refer to properties and characteristics of soil materials.

Shear Resistance
Soil resistance to movement when pressure, impact, or vibration is applied is shear resistance. This resistance comes from the friction between the soil particles when they slide by each other. Therefore, the higher the shear resistance, the greater the force required to compact the soil. Clay has a high shear resistance, while granular material has a low resistance.

Elasticity
As the term implies, elasticity is a soil's ability to return approximately

Quick Soil-Typing Guide

What to look for	Granular soils, fine sands, silts	Plastic (cohesive) soils, clays
Visual appearance and feel	Coarse grains can be seen; feels gritty when rubbed between fingers.	Grains cannot be seen by naked eye; feels smooth and greasy when rubbed between fingers.
Movement of water in the spaces	When a small quantity is shaken in the palm of the hand, water will appear on the surface of the sample. When shaking is stopped, water gradually disappears.	When a small quantity is shaken in the palm of the hand, it shows no signs of water moving out of the voids.
Plasticity when moist	Very little or no plasticity.	Plastic and sticky; can be rolled.
Cohesion in dry state	Little or no cohesive strength in dry state; will crumble readily.	Has a high dried strength; crumbles with difficulty and disintegrates slowly in water.

to its original form after the load is removed. Soils of this type are very undesirable in construction and road building. For example, as automobiles roll over a road surface, the material gives way to the load and rebounds upon removal, continually flexing, which eventually causes road surface breakdown.

Cohesion
The degree to which particles stick to one another is termed cohesion. Soils can be either cohesive or non-cohesive. Cohesion is apparent in clay, as the particles resist pulling away from each other. Granular soils are non-cohesive and pull away and slide by each other more easily than clay.

Moisture Content
The correct amount of water is necessary so the soil particles slide by each other. The water, in effect, acts as a lubricant. If there is too much water in the soil, the water will take up space between the particles and prevent them from bonding together.

The graph below illustrates the effect of moisture on soil density. It uses one density as an example. Actual soil densities will vary, and so will the optimum moisture content.

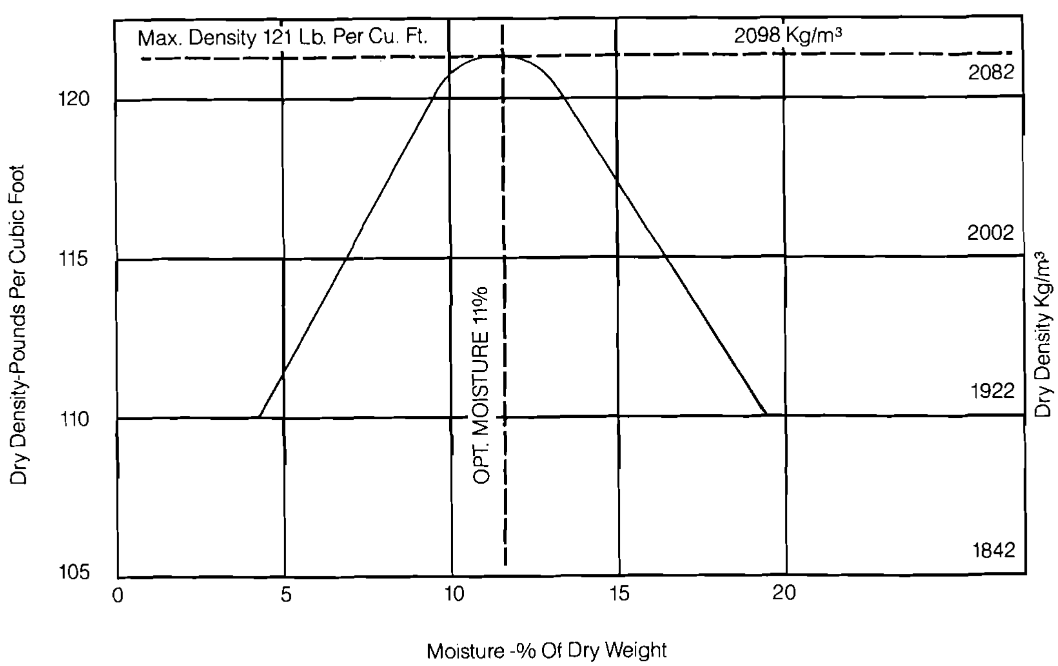
As the moisture content is increased up to the optimum percentage, density increases. If too much moisture is added, the soil's density decreases.

Compaction Factors
Two factors determine the type of force a compaction machine produces:

1. Frequency
2. Amplitude

Frequency
Frequency is the speed at which the eccentric shaft rotates (or machine jumps). Each machine is designed to operate at a predetermined frequency for maximum efficiency, since this is how maximum force is generated.

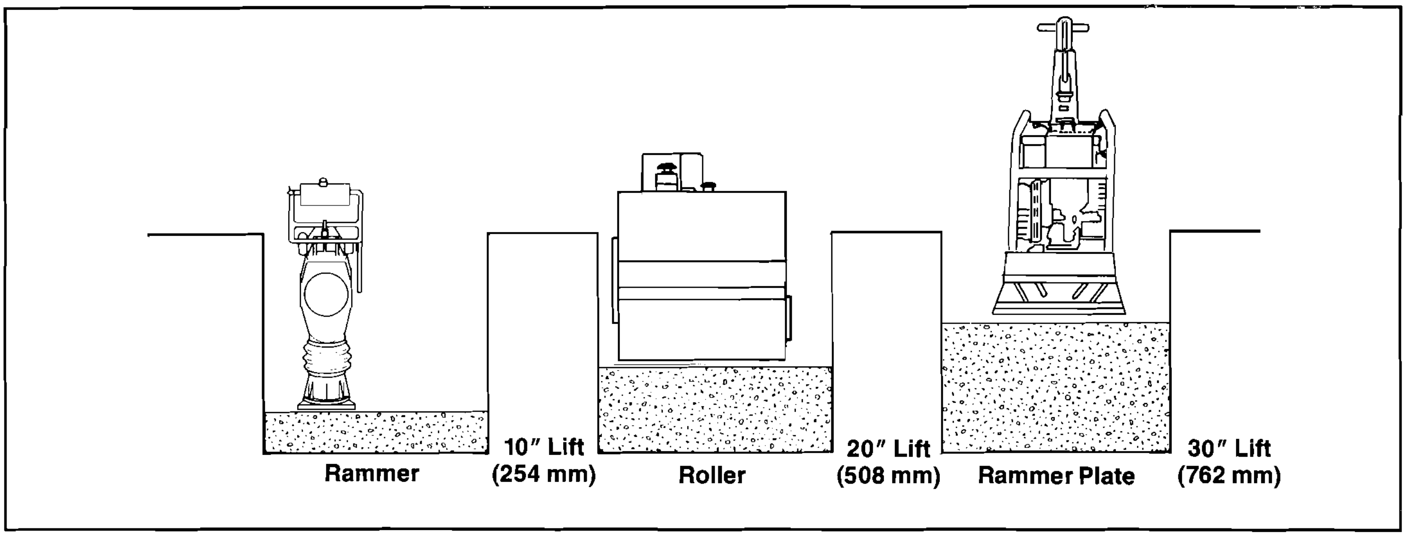
Amplitude
Amplitude is one-half of the total vertical distance that the vibrating drum or baseplate travels. The amplitude of any given machine will vary, depending on soil conditions. The amplitude, or the height the machine lifts itself off the ground, gradually increases as the soil becomes more dense and compacted.



Compaction Methods and Machine Selection

Clay Soils

Since clay is cohesive and the particles stick together, you must use a machine with an impact force to ram the soil, force out the air and water, and rearrange the particles. For clay soils a rammer-type machine is best.



Granular Soils

Granular material is not cohesive and particles require shaking or vibratory action to move them. Vibratory plates and vibratory rollers are ideal for compacting sand, sand/clay mix and asphalt. **Rammers can also be used for granular soil if the soil being compacted is in a confined area, such as a trench. If the area is not confined, the rammer will push the granular soil to the sides, rather than compact it. Rammer plates can also be used on granular materials in confined areas, or on open areas with extension plates.**

An important factor in choosing the right machine for your compaction job is lift height, or the depth of the soil being compacted. Soil is compacted in layers, called lifts. A lift of loose soil is placed in a trench, compacted, and then another loose layer, or lift, is added. This continues until the trench is filled with compacted soil.

Vibratory and ramming-type machines both compact the soil in the same direction, from the bottom of the lift to the surface. As the machine hits the soil, the impact travels to the hard surface and returns upward. This action sets the particles in motion and compaction takes place. As the soil becomes compacted, the impact has a shorter distance to travel so more force returns to the machine, making the machine bounce higher off the ground.

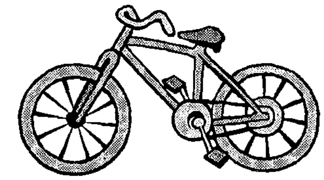
If the lift is too deep, the machine will take longer to compact the soil and a non-compacted layer will remain.

No set lift-depth for soil compaction exists, since the depth is determined by the machine used and the type soil being compacted. For example, of a trench that is 32 inches (813 mm) wide could be compacted by several different machines, each having a different lift-height capability. (*See diagram.*)

Each of these three units could perform the compacting job, but the fastest and most economical choice is the rammer plate because of its wide plate and deep compaction. It, therefore, can compact the highest lift.

Adapted with permission from ***Understanding Soil Compaction****, Form No. UD17886, published by J.I. Case Corporation, 700 State Street, Racine, WI 53404 .*

MassHighway Bike Workshops Successful

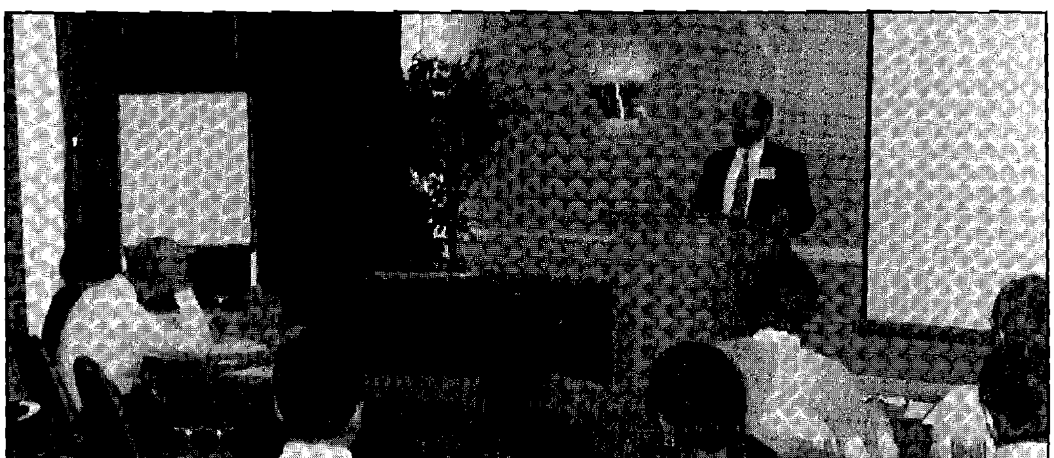


In October and November, MassHighway, supported by the Baystate Roads Program, held four workshops. The purpose of these workshops was to introduce municipalities to the MassHighway Bicycle Accommodation Policies and Initiatives. Workshops were held in Northampton, Worcester, Hyannis and Andover. Each location was well attended and based on the enthusiastic evaluations, well received. MassHighway provided knowledgeable speakers including :

- Astrid Glynn, Deputy Secretary, Executive Office of Transportation and Construction
- Kara Viola, Chief of Staff
- Josh Lehman, Bicycle and Pedestrian Coordinator
- Bob Fay, Supervisor of Signs and Pavement Markings
- Jim Silveria, Bicycle and Pedestrian Accommodation Engineer
- Thomas DiPaolo, Assistant Chief Engineer
- David Phaneuf, Assistant Highway Design Engineer and
- Stanley Wood, Highway Location and Design Engineer.

Throughout the morning, speakers presented information on various bicycle and pedestrian initiatives. After each speaker finished audiences were asked for feedback. One of the key goals of the workshop series was to gain enough feedback to help guide future initiatives. All four audiences were excellent and more than willing to offer suggestions. We had many informative discussions, both during the workshops and during the working lunches which followed each workshop. MassHighway will now use this information to develop and refine its initiatives.

We extend our thanks to all those who attended and will keep you informed of future developments.



Some highlights from the Statewide Bicycle Transportation Plan:

The Plan's goals are to:

- Plan, promote, and provide safe travel for bicyclists and pedestrians, in a manner appropriate for each group, recognizing that bicycling and walking have distinct operational characteristics and safety requirements.

- Provide bicycle and pedestrian facilities and encourage bicycle and pedestrian travel as viable transportation modes.

- Reduce demands placed on highway facilities by encouraging the use of Transportation Demand Management and increasing the use of modes such as bicycles.

The plan consists of four basic components:

- Vision, Goals, Objectives & Performance Measures
- Current and Future Demand
- Opportunities and Needs
- Recommendations for Project & Policy Implementation

A major focus of the plan was the development and testing of a methodology to enhance bicycle accommodation on roadways. Roadway characteristics, such as, traffic volume and speed, width of travel lanes and shoulder, and truck volume were inventoried at sample locations throughout the state. This methodology is available to Regional Planning Authorities and municipalities to perform more detailed local analyses.

Copies of the ***Massachusetts Statewide Bicycle Transportation Plan*** *are available from Baystate Roads Program.*

Agreement Reached on Street Cuts

Municipal and utility company representatives have reached an agreement that would establish standards for the repair of local roads after excavations by utilities.

The agreement establishes standards for the repair of local street excavations and grants municipalities the authority to inspect work in progress. Utility contractors would be required to correct any deficiencies identified during the inspections and to respond to all trench restoration requests by the local authority within 48 hours. If the utility fails to respond, the community could make the repairs and bill the utility company, which would be required to pay the bill within 30 days.

The MMA and the Massachusetts Highway Association maintain that an important issue still to be addressed is the establishment of a fee structure to cover the cost of inspections.

The Department of Telecommunications and Energy is now reviewing the agreement, which it is expected to adopt through a rule-making proceeding or by issuing an order.

In its ruling or order, the DTE must also address the use of control density fill, which provides for superior compaction under roads, and the use of infrared pavement repairs, a method that heats road materials to create a bond between old and new material. Municipal representatives have argued for the use of both methods in order to achieve a better quality result, while utility representatives have argued for other, less costly methods, which they claim will provide equal results when done properly.

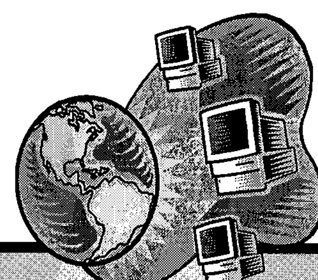
The MMA has also filed legislation that would accomplish these municipal road repair objectives. Joseph Sullivan, House Chair on the Joint Committee on Transportation, and Dan Bosley, House Chair of the Joint Committee on Government Regulations, have signed on as cosponsors of the legislation. They are both key legislators because the legislation is likely to be brought before both of their committees.

The MMA would ask the sponsors to modify or pull the bill if necessary pending the outcome of the DTE proceedings.

Copied with permission from The Beacon, Vol. XXV, No. 1, published by the Massachusetts Municipal Association, http://www.mma.org.

The proposal is listed under "Municipal Streets" on the Baystate Website listed below.

Helpful Websites



Flowable Fill Information Page:
http://www.irmca.com/flowfill/ff_home.htm
Recommended Flowable Fill Specifications:
http://www.concretepages.com/flo_spec.html
Compaction Grouting/Soil Stablization & Slab Jacking:
http://www.geotechnical.com/slabjack.htm
Massachusetts Municipal Page:
http://www.mma.org
Proposed Document on Utility Cut Agreement between MassHighway Association , Utility Companies, and DTE:
http://baystate.ecs.umass.edu

What is Flowable Fill?

Flowable fill (also known as controlled density fill, controlled low-strength materials, or unshrinkable fill) is a semi-fluid material mixture usually combining:

Fly Ash
Fly ash is used as a base with 3 to 15% (3-5% for utility trenches) Portland Cement (by dry weight) added to develop strength. Sometimes fine aggregates are used to add additional strength to mixture.

Low Strength Concrete
Specifications utilize the normal aggregate gradation for concrete but greatly reduce the amount of Portland Cement (approximately 50 pounds cement per cubic yard). The intention is to use just enough cement to bind the aggregates together.

Strength Requirements

The maximum strength after 28 days is typically limited to 30.5 to 77 psi (3-5% cement for fly ash flowable fill). After 90 days the maximum allowable is 100 psi. Since backfill material must be able to be removed for maintenance purposes, it is important to use MHD specification M4.08 ECDG, Type 2E and to have good inspection to insure that the maximum strength is not exceeded. The maximum limit specified herein would allow for removal by hand (if necessary).

Advantages

Consistent Performance
Due to varying nature of fill material and difficulty in obtaining proper compaction, performance can be quite variable for standard backfilling, but it provides consistent performance with minimal inspection.

No Compaction Required
Fill material requires placement in thin lifts followed by compaction. Flowable fill is self-consolidating, similar to concrete. Used as fill material, there are no special finishing requirements and it fills hard-to-reach places.

Easy to Mix and Place with Normal Equipment
Flowable fill (especially fly ash based) is very easy to handle with no special requirement. It can be pumped like a grout or poured like a wet concrete mixture flowing around pipe structures and into hard-to- reach spaces that would be difficult to fill and compact.

No Soils Testing and Less Inspection
Standard fill material requires extensive testing to assure proper compaction and soil moisture content must be monitored. Since flowable fill is self-consolidating and does not need special finishing or curing techniques, field testing is not usually necessary. As for inspection, only spot checking is typically required.

Reduces Time and Labor
Flowable fill's extra expense is offset by the elimination of compaction and density testing as well as less labor and inspection, thereby reducing costs when proper construction and inspection requirements are followed.

Fly Ash Flowable Fill Is Lightweight
Compacted backfill material weighs between 100 - 120 pounds per cubic foot whereas fly ash flowable fill has a wet weight of about 90 pounds per cubic foot, and dry weight of approximately 70 pounds per cubic foot.

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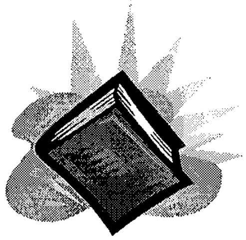
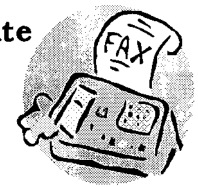
Yet Another FreeVideo!

Baystate Roads has a limited number of copies of an 11-minute videotape on "**Utility Cuts: Doing It Right**." This video, produced by the Minnesota Local Roads Research Board, explains that lack of soil compaction is the usual cause of pavement failure and then describes correct methods such as excavation permits, size, and safety plans, notification of Dig Safe, set-up of right traffic layout, choice of saws or tools, installation of shoring, proper backfill, compaction or flowable fill and closing up.
Minnesota LTAP requests that all viewers complete an evaluation form which should be returned to them postage paid.
If you would like to receive a ***free*** copy which your organization can keep for future training, please FAX us and request a complimentary "keeper" copy.

publications and videos



Please FAX your requests by code number to Baystate Roads at 413-545-6471 or call 413-545-2604.



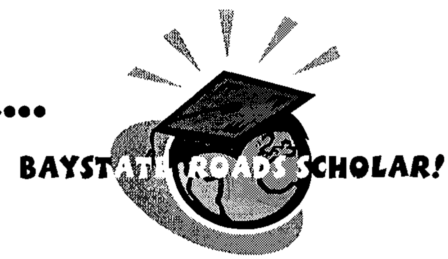
PUBLICATIONS

🕮 (CDF) Controlled Density Fill - (Flowable Fill)	COC-36
🕮 Flowable Fill - The Engineered Backfill	COC-42
🕮 Understanding Soil Compaction	SOI-21
🕮 Soils Manual: For Design of Asphalt Pavement Structures	SOI-42

VIDEOS

Utility Cuts in Paved Roads Part 1 & 2	DC-159
Utility Cut Repair: Doing It Right	DC-158
Flowable Fill	DC-139
Paving and Compaction Training	DC-149

You too can be a...



We have had quite a few graduates from the Baystate Roads Scholar and you might just qualify to be the next! To become an official Scholar, you merely need to complete SEVEN Baystate Roads Workshops as of July 1995.

NOTE: 1. **FIVE** of these workshops must be **CORE COURSES**. The remaining TWO may be of any workshops of your choice.
2. These seven workshops must be **FULL-DAY** workshops. Each workshop flyer indicates the type of course -- elective or core.

Once you have attended the workshops, just mail copies of your certificates from each of the seven workshops along with your address, phone number and your supervisor's name and address to Baystate Roads. You can impress your friends by being listed in the newsletter AND you will also receive:

One **FRAMED** Baystate Roads Scholar **CERTIFICATE**
One Baystate Roads Scholar **T-SHIRT**
One **LETTER OF RECOGNITION** to your town or city!

We have also initiated the ***MASTER Scholars Program***! Completion of this program requires the attendance at **22 courses** attended after July 1995. **SIXTEEN** workshops must be CORE COURSES. The workshops used toward the Scholar certificate CAN be used toward the MASTER Certificate! Master Scholars will receive an ARTICLE of recognition in "Mass Interchange" and the presentation of an appropriate gift. So save those certificates and keep learning at the Baystate Roads Workshops!

In memorium...

William H. Dalton, 57, MHD District 5 Project Engineer and a founding member of the Massachusetts Organization of State Engineers and Scientists (MOSES), died on his boat, "No Problem" on Sunday, November 15, 1998. He was on his way to go oystering.

Born in Lawrence, Mr. Dalton was a 1958 graduate of Methuen High School. He served in the Marine Corps Reserve and graduated from Wentworth Institute of Technology in Boston. For several years, Mr. Dalton worked as a survey chief for Charles E. Cyr Construction in Lawrence, and was employed as a civil engineer for the Massachusetts Department of Highways for 33 years, working in the Holyoke, Worcester, and Taunton Districts. He moved from Westboro to Buzzards Bay in 1991. He was active in town as a member of the Bourne Planning Board and Democratic Town Committee.

To say Bill Dalton was an avid fisherman would be an understatement - fish trembled at the sound of his name. He took many people fishing and never returned empty handed. The last striped bass he caught won a local tournament.

Bill will be missed by many. His ashes were spread in the water of Buzzards Bay.

Congratulations!

to our Newest Baystate Roads Scholars!

Richard J. Kirby
Town of Princeton

John DePriest
City of Chelsea

Jack P. Lowe
Town of Whitman

Michael Ahordini
MassHighway

in this issue

The Baystate Roads Program, which publishes *Mass Interchange* each quarter, is a Technology Transfer (T2) Center created under the Federal Highway Administration's (FHWA) Local Technical Assistance Program (LTAP). FHWA is joined by the Massachusetts Highway Department, the Department of Civil and Environmental Engineering at the University of Massachusetts/Amherst, and local public works departments in an effort to share and apply the best in transportation technologies.

In addition to publishing *Mass Interchange*, the Baystate Roads Program facilitates information exchange by conducting workshops, providing reports and publications and videotapes on request, and offering one-to-one technical assistance on specific roadway issues. Because the program relies on input from many sources, inquiries, articles, and ideas are encouraged.

LTAP Local Technical AssistanceProgram

To contact the Baystate Roads Program call (413) 545-2604 or FAX 413-545-6471.

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