

# *Tech Brief*

## Review of Improved Compaction Equipment and Technology

FHWA-NJ-1999-011-TB

November 1998

### HERE'S THE PROBLEM

Compaction is one of the major factors that impact the structural performance of asphalt pavements. Suitable compaction is a necessity in the underlying layers of a pavement system. Improper compaction may cause unexpected failure of roadways. Little attention has been given to improving compaction techniques. Determining the best practices for compaction techniques will ensure improvement in compaction methodologies employed by the New Jersey Department of Transportation.

### AND, HERE'S THE SOLUTION

Construct a summary of both existing, and new, vibratory equipment and technology from a literature search inclusive of all available United States and international sources, and identifying new technologies that will help establish modern state-of-the-art practices for improved compaction.

### THESE ARE OBJECTIVES...

- To review the existing and new vibratory roller equipment and technology for improved compaction of subgrade, base, and surface courses in the State of New Jersey.
- To identify a state-of-the-art compactor for use in asphalt pavement construction

### HERE IS WHAT WE DID...

This research study began with an extensive literature search. The history of compaction technology was reviewed. It was determined that the purpose of compaction of sub-layers in road construction are as follows: (1) to increase the shear strength, (2) to reduce compressibility, (3) to control swelling and shrinkage, 4) to reduce permeability, and (5) to prolong durability.

The second phase of this study was exploration of the current state of compaction practices, in New Jersey and other locations, with similar types of soil conditions. Compaction equipment reviewed included the Smooth Steel Roller, Grid Rollers, Pneumatic Rollers, Sheepsfoot Rollers, Vibratory Rollers, and Plate Compactors. It was determined that

Vibratory Rollers	are the most effective means for compacting cohesionless soils.
Grid Rollers	suitable for compacting weathered rock, such as stone, but not clayey soils
Smooth Steel Rollers	worked most effectively on uneven surfaces
Pneumatic Rollers	were most suitable for use with coarse-grained soils with some fines
Sheepsfoot Rollers	were most suited to fine-grained soils with a significant amount of fines
Plate Compactors	were designed for when the other rollers could not be used and the area to be compacted is confined

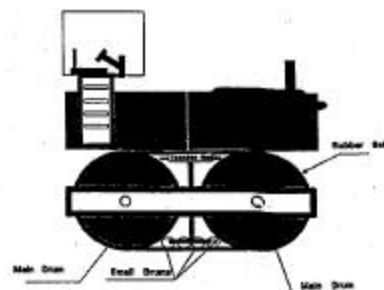
The New Jersey Department of Transportation's compaction specifications were reviewed, and a table was comprised outlining material type and gradation, proposed lift thickness, suggested type of roller(s) and the required density, in comparison with the standard used for compaction of a particular layer.

The current standard specifications for twenty-four other states with relatively similar soil conditions to New Jersey were collected and reviewed. A table was compiled to diagram specifications of different road layers and pin point significant similarities to those compared with New Jersey. In addition, this same type of comparison was done with compaction practices relating to Europe, Japan, and other countries.

An analytical model was used to determine the interaction between rollers and the soil during compaction, in order to verify the correlation between a measurable quantity at the drum of the roller and the state of soil compaction. It is important to establish the interdependence between the state of roller operation and the state of compaction of building materials. An accurate description of this could be achieved through analytical modeling of the roller and a mathematical model describing the qualities of the soil relative to compaction.

This analytical model could be built as a set of discrete mechanical elements such as masses, springs, and dampers; or, it can be described as continuous. Such calculations are approximations of the actual vibration and compaction behavior. The technical data of a particular roller would be used as model parameters. The soil parameters model requires the determination of the vibrating soil mass, the stiffness of the springs, and the parameters of the additional system (ie, the roller).

Finally, this project concluded with establishing state-of-the-art technology and equipment that could be utilized in compaction works through a new



compactor able to be utilized for asphalt pavement construction. A new compactor, the Asphalt Multi-Integrated Roller (AMIR), was analyzed. This is a self-propelled prototype roller designed in Canada and completed in 1989. The AMIR replaces the cylinder shape of other rollers with a flat plate, and provides a flexible material at the asphalt/compactor interface. The design of the AMIR lends itself to having a more uniform pressure distribution, and thus results in less construction cracks.

The AMIR was tested in several field trials using asphalt cores divided into two groups. The first group was tested to determine the fatigue tensile resistance to transverse cracking. The test load was applied perpendicular to the rolling direction. The second group was loaded parallel to the direction of rolling to determine the fatigue tensile resistance to longitudinal cracking. Results indicated that the fatigue life of AMIR-compacted asphalt sections was consistently higher than that of the same asphalt mix when compacted with current equipment. The coefficients of the AMIR compacted samples were consistently lower than those compacted for the other methods.

In addition, the AMIR compaction method provided an asphalt layer with the same strength in both vertical and horizontal directions, thus providing protection against surface cracking. The occurrence of surface hairline cracks is found to create a conducive condition to stripping. This results in a detrimental effect on tensile strength and fatigue resistance, because the roller checking increases vulnerability to stripping. However, the AMIR compacted section showed a remarkably crack free surface with tighter texture. Thus, the AMIR compactor supports fatigue performance.

#### CONCLUSION:

Using the proper compaction technique and equipment will control in-place density, impermeability, moisture, and durability. These factors are the source of poor roadway performance. The proper type of roller or compactor must occur with proper consideration of maneuverability, environment, and versatility. It was also found that a new compactor known, as the Asphalt Multi-Integrated Roller (AMIR), was superior in that it does not create construction cracks that are often the result of conventional compactors. Such cracks are detrimental to long-term pavement performance.

#### WHAT IS THE NEXT STEP?

The next step would be establishing set guidelines to be followed for compaction best practices. These criteria would be based on factors such as soil mediums, bituminous materials, and trench compaction. In addition, laboratory experiments to perform plastic and elastic analysis of soils under vibratory compaction can occur through use of a mathematical model.

**FOR MORE INFORMATION CONTACT:**

NJDOT PROJECT MANAGER:	<b>Mr. Nicholas Vitillo</b>
PHONE NO.	<b>(609) 530-5637</b>
e-mail	<b>Nick.Vitillo@dot.state.nj.us</b>
UNIVERSITY PRINCIPAL INVESTIGATORS	<b>Dr. Ali Maher</b>
UNIVERSITY:	<b>Rutgers University</b>
PHONE NO.	<b>732-445-2232</b>
e-mail	<b>mmaher@rci.rutgers.edu</b>

A final report is available online at <http://www.state.nj.us/transportation/research/research.html>

If you would like a copy of the full report, please FAX the NJDOT, Bureau of Research, Technology Transfer Group at (609) 530-3722 or send an e-mail to [Research.Bureau@dot.state.nj.us](mailto:Research.Bureau@dot.state.nj.us) and ask for:

Report Title: Review of Improved Compaction Equipment and Technology

NJDOT Research Report No: FHWA-NJ-1999-011