



# CENTERLINE

## PAVEMENT DESIGN & TECHNOLOGY

### NCAT Study Suggests Ratios for Durable, Impermeable Pavements

**Permeability is related to pavement density, and optimum density levels can be more easily achieved as lift thickness increases**

PROPER COMPACTION IS CRITICAL TO the long-term stability and durability of pavement. If the paving mix is not adequately compacted, high in-place air voids result, which allow air and water to penetrate the pavement, and can lead to water damage, oxidation, raveling and cracking. Conversely, if the pavement density is too high (meaning in-place air voids are low), rutting, bleeding and shoving can occur.

Recognizing the detrimental effects of air and water penetration on pavement, permeability has been studied extensively. One study concluded that permeability depends not only on the percentage of air voids in the pavement, but the size of the voids (Hudson and Davis, 1965). Another study suggested that particle distribution (or gradation), particle shape and density affect permeability (Ford and McWilliams, 1988). Work by the Florida Department of Transportation revealed size and interconnectivity of voids to be a factor. Yet another study showed that the nominal maximum aggregate size (NMAS) and lift thickness for a given NMAS affect permeability, and that increased lift thickness reduces the possibility of interconnected voids (Mallick, Cooley and Teto, 1999).



*For roads that go on and on, achieving optimum density is critical to minimizing air and water infiltration, and the damage that results*

What is certain is that permeability is related to pavement density (the percentage of in-place air voids), and optimum

way that desired density and impermeability can be obtained with sufficient compaction.

The National Center for Asphalt Technology received federal funding to investigate the relationship between lift thickness and permeability. One objective of the study was to determine the minimum t/NMAS (lift thickness to nominal maximum aggregate size ratio) required to achieve optimum density, and thus impermeable pavements.

The most reliable results from the NCAT study were derived from the test track. Mix was applied to several sections at dif-

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ferent density levels can be more easily achieved as lift thickness increases. Adequate lift thickness enables aggregate particles to arrange themselves in such a

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## NCAT Ratios - Continued

ferent thicknesses, varying from relatively thin to relatively thick, and a reasonable compactive effort was applied with conventional rollers.

The results clearly show the t/NMAS ratio to have an effect on compactibility. A minimum ratio of 4 seemed optimum for coarse-graded mixes, while a minimum of 3 was desirable for fine-graded mixes. Lower ratios may be used, though a stronger compaction effort must be applied to achieve the density required for impermeability.

The NCAT study also clearly demonstrates that as NMAS increases, the percentage of in-place air voids must decrease (meaning more compactive effort must be applied) to achieve

impermeability. For example, a 1/2" dense mix becomes impermeable with 7-8% in-place air voids, whereas a 3/4" dense mix must be compacted to an in-place air void percentage of 6 or less. This is important, and suggests that 1/2" dense mixes will make better wearing courses.

Final recommendations from NCAT are expected soon, and according to Mike Remily, Pavement Quality Engineer for the Oregon Department of Transportation, those recommendations will likely bring changes for the agency when specifications are reviewed this fall.

"We are currently applying 1.5" lift thickness with our 1/2" dense mixes, and 2" lift thickness with our 3/4" dense mixes,"

**"We've performed studies locally on compaction and permeability that validate NCAT's research."**

Mike Remily, ODOT

Remily said. This practice results in t/NMAS ratios of 3 and 2.67 respectively, which are at or below the minimum suggested by preliminary NCAT research findings.

"We've performed studies locally on compaction and permeability that validate NCAT's research. It is likely that we will

increase lift thickness to 2" for our 1/2" size dense mixes, and 2.5" for our 3/4" size dense mixes, bringing the ratios to 4 and 3.33," Remily said, adding he expects local agencies will follow suit.

Remily noted that the effectiveness of increasing lift thickness does dissipate at some point, and traffic control requirements or additional construction requirements may limit the thickness that can be applied in specific situations.

"(Increasing lift thickness) is a pretty simple modification for the contractor," Remily said. "It may even make their job easier, with thicker layers facilitating the compaction process." ▲

From NCHRP 9-27 Studies conducted by the National Center for Asphalt Technology, Auburn University

### BITS & PIECES



*N.E. Sandy Boulevard in Portland, Oregon, was one of the busiest strips in the Pacific Northwest. The boulevard was dotted with small stores, gasoline stations, and houses until the late 1940s, when large shopping centers, supermarkets, and new car dealerships changed the landscape.*

"Postcard view of the Hollywood District of Sandy Boulevard, Portland, Oregon, late 1940s" by Gerald Risberg

Image from [www.americanhistory.si.edu/onthemove/](http://www.americanhistory.si.edu/onthemove/), protected by copyright of the National Museum of American History, Smithsonian Institution

#### "America on the Move" Opens at Smithsonian Institute

"America on the Move," a new, 26,000 square-foot exhibit at the Smithsonian's National Museum of American History in Washington D.C., opened November 22, 2003. The exhibit, sponsored in part by the American Road and Transportation Builders Association (ARTBA) and the National Asphalt Pavement Association (NAPA), chronicles transportation in America from 1800 to the present. More than 300 objects, including a Chicago Transit Authority "L" car, a 92-foot Southern Railway locomotive, and a 40-foot stretch of Route 66 populate the exhibit's 19 historic settings.

Though the exhibit covers all major transportation modes, much focus is on the advent of the

automobile and how it shaped the American landscape. Early initiatives for better roads are documented, as well as efforts of the Lincoln Highway Association, which ultimately lead to completion of America's first transcontinental highway in the 1930s.

"The transportation construction market depends on continued public support for increased infrastructure investments," ARTBA president and CEO Pete Ruane said. The exhibit will go a long way in raising public awareness about the need for increased investment, efficiency and safety, he added.

For more information, visit the exhibit's website: [www.americanhistory.si.edu/onthemove/](http://www.americanhistory.si.edu/onthemove/)

#### Updated Design Guide Available

The APAO's Design Guide is a reference tool for pavement designers. It covers structural design, materials and mix design, high-performance specifications and maintenance requirements for a variety of "non-highway" applications.

The Guide was updated in 2003 to include revision of the Materials and Mix Design chapter, and new chapters covering porous pavements, high-performance intersections, long life pavement designs and rut susceptibility testing. Improved guidelines for mix selection are also included. ▲

The Design Guide is available for \$50 plus \$5 S&H. Call 503.363.3858 for more information, or download the order form at [www.apao.org](http://www.apao.org).

## MISSION STATEMENT

The Asphalt Pavement Association of Oregon, Inc., (APAO) is dedicated to promoting the use of asphalt concrete by developing customer driven programs to enhance quality and excellence in all aspects of asphalt technology. We believe that the key to growth and prosperity in the industry is continuous quality improvement obtained through active association membership, positive customer relationships, education, and training.

## MEMBERS

### For quality asphalt projects, call one of our members.

**Regular Members:** Baker Rock Resources; Bayview Transit Mix, Inc.; Benge Construction Co.; Blue Mountain Asphalt Co.; Brix Paving Co.; Central Oregon Pavers, Inc.; Clean-Sweep Maintenance; Copeland Paving, Inc.; Eagle-Elsner; Eugene Sand & Gravel, Inc.; H & H Paving Co., Inc.; Hap Taylor & Sons, Inc.; Harney Rock & Paving Co.; High Desert Aggregate & Paving, LLC; Hooker Creek Asphalt & Paving LLC; Humbert Asphalt; J.C. Compton, Contractor Inc.; Jefferson State Asphalt; K.F. Jacobsen & Co., Inc.; Klamath Pacific Corp.; Lakeside Industries; Laskey-Clifton Corp.; LTM, Inc.; LTM Bracelin-Yeaeger; LTM Roseburg Division; LTM Umpqua River Navigation Co.; McCafferty-Whittle Const. Co.; Morse Bros., Inc.; Mt. Hood Asphalt Products; North Santiam Paving Co.; Pacific Paving, Inc.; Parker Northwest Paving Co.; Pioneer Asphalt, Inc.; Porter W Yett Co.; Portland Road & Driveway Co., Inc.; Rinker Materials; Road & Driveway Co.; Rogers Asphalt Paving Co.; Rowell & Wickersham Contr., Inc.; Roy L. Houck Construction; S-C Paving Co.; Salem Blacktop & Asphalt Paving; Salem Road & Driveway Co.; South County Asphalt, LLC; Tidewater Contractors, Inc.; Vancouver Paving Co.; Vic Russell Construction; Wildish Sand & Gravel Co.

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## APAO NEWS

# APAO's 2003 Annual Meeting Brings Awards, Scholarships and New Board of Directors

THE APAO'S 34TH ANNUAL Meeting was held December 4 and 5 at the Embassy Suites in Downtown Portland. Leaders from the Oregon Department of Transportation (ODOT), the American Road and Transportation Builders Association (ARTBA), the National Asphalt Pavement Association (NAPA), and our own state economist, Tom Potiowsky, addressed the group. Discussions ranged from OTIA III and TEA-21 Reauthorization to industry regulations, the bid practices audit and Oregon's current economic outlook.

A dinner banquet capped the two-day event, with presentation of awards and scholarships, and introduction of the new board of directors.

The Department of Environmental Quality (DEQ) presented its annual award for environmental stewardship, the longest-running award of its kind in Oregon. This year's honor went to Morse Brothers, for "generously dedicating resources, in the form of Fred Bond, to train Oregon's asphalt paving industry about the environmental importance and economic benefits of keeping



Fred Bond of Morse Bros., Inc. accepts an award for environmental stewardship from Linda Hayes-Gorman of DEQ



Scholarship recipients Corey Westermann (l) and Kevin Linderman (r) with Gary Baker of Baker Rock Resources

asphalt plants in tune."

DEQ expects the training to result in significant reductions of air-contaminant emissions from asphalt paving operations statewide, as well as significant fuel cost reductions for those operations.

"Fred did an outstanding job, not only in teaching the nuts and bolts of a proper tune-up, but also in advocating the benefits and importance of doing the right thing," said Linda Hayes-Gorman, air quality business assistance program coordinator for DEQ, and presenter of the award.

DEQ also surprised APAO executive director Jim Huddleston with a plaque during the program. The agency recognized Huddleston and the APAO for efforts to train state paving professionals on DEQ requirements.

Gary Baker, of Baker Rock Resources, presented two \$1200 scholarships. Recipients were Corey Westermann, a senior in civil engineering at Oregon State University, and Kevin Linderman, a junior in construction engineering management at Ore-

gon State University. Gary A. and Dal L. Baker scholarships are presented annually to Oregon students entering their junior, senior or fifth year in a civil engineering or construction-related bachelor's degree program. These scholarships are made possible by the National Asphalt Pavement Association's scholarship program, with an endowment from the Baker family. ▲



Outgoing president Ron Myers (l) welcomes incoming president Ron Depue (r)

## 2004 Board Members

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Ron Depue,  
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## EDUCATION

# OIT Enhances Learning Experience with Help from Industry

WHEN ROGER LINDGREN ARRIVED at the Oregon Institute of Technology in Klamath Falls four years ago, he found the pavement laboratory populated with antiquated equipment – not very helpful in teaching students about modern applications of pavement technology.

For the last three years, Lindgren, an assistant professor in the Department of Civil Engineering and Geomatics, says there has been a focus on modernization of the civil engineering labs at the university, with particular attention paid to the pavement lab.

“Equipment has changed dramatically in the last 5 years,” Lindgren said. “There was a need to update the labs for teaching modern mix design procedures and have the labs actually test the mixtures.”

With assistance from the

Asphalt Pavement Association of Oregon, the Oregon-Columbia Chapter of Associated General Contractors, the civil engineering department, and student resource fees, the school is making great strides in its lab upgrades. Funds contributed by APAO in 2002, for example, went toward the purchase of a gyratory compactor for use in the asphalt mix design process. Funds provided by the organization in 2003 helped purchase an asphalt mixer and dispenser.

“Previously, students were pouring liquid asphalt by hand, which can be dangerous,” said Jim Huddleston, APAO executive director.

OIT’s 4-year civil engineering degree program is nationally accredited and keeps its class sizes small by design. The average graduating class numbers between 20 and 25 students, pro-

viding ready access to staff and other critical resources like time in the laboratory.

Lindgren attributes OIT’s success in placing graduates to its hands-on approach to engineering studies. “Employers like the fact that we are not only teaching theory, but we are putting it to work in the lab. They can hire employees who are productive almost immediately, without having to train them in application aspects,” he said.

Typical placement rates for OIT civil engineering graduates are in the mid to high 90s, with students taking positions at government agencies, consulting engineering firms and contracting construction companies.

“Anyone interested in working is working,” said Lindgren.

Lindgren stressed the important role of partnerships with

companies, alumni and organizations like APAO in ensuring a curriculum that is relevant to the needs of industry employers. ▲



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Roger Lindgren, OIT