Railroads operate under tight maintenance budgets and need to extend the life of their existing assets from large ballast regulators and tamping machines to the small stones of the ballast. Suppliers are delivering better and more-efficient equipment and services, while researchers, such as Erol Tutumluer, associate professor at the University of Illinois at Urbana-Champaign, are striving to understand ballast behavior.

**Discrete Element Modeling**
A few years ago, Tutumluer, along with Youssef Hashash and Jamshid Ghaboussi, also with the University of Illinois, applied a technique, Discrete Element Modeling that had been used with success in geotechnical engineering, to transportation applications. Tutumluer, who specializes in working with aggregate materials, and his team thought DEM could provide valuable information and a better understanding of ballast behavior.

"The purpose of DEM is to investigate the effects of ballast aggregate size,

by Mischa Wanek-Libman, assistant editor
The graph above shows the tie lateral resistance results from pull-out tests for 11 aggregate samples.

shape, angularity, disturbance and tie texture on strength and lateral stability. All the particles in railroad ballast have many contact points. What we’re studying in this approach is the equilibrium of these contact forces within the assembly,” said Tutumluer.

Tutumluer noted that a better basic understanding of the ballast behavior was needed for mitigating track problems/failures due to ballast breakdown, fouling, excessive deformation and rail buckle. He also pointed out that, while lateral track stability is an essential component for preventing rail buckle and railroad derailments, it decreases dramatically after maintenance activities such as tamping.

Tutumluer and Ghaboussi proposed a project called Discrete Element Modeling of Ballast for Strength, Stability and Improved Manufactured Crosstie Design and were given a grant from AAR.

“The scope of the first period started with the initial setting up and building up the aggregate layers in a typical ballast layer, along with doing the initial compaction process,” said Tutumluer. “The second year, we started establishing a library of aggregate shapes, with different angularities and shape properties. We have an aspect ratio that’s the largest dimension divided by the smallest dimension of the aggregate, like a length-to-width ratio. In the shape categories we had four or five different angularity classes. Altogether, we established 11 shape libraries.

“We then analyzed all those libraries in a typical layer built with discrete elements of those 11 different shapes for lateral stability,” said Tutumluer. “We studied how, right after tamping, the ballast strength goes down. We were able to simulate this using the models for the 11 different shape libraries. We were able to come up with general findings. For example: Angular stones are preferred, but angular stones
have the biggest strength loss after tamping, which makes them the most to be concerned about from a lateral stability or track buckle point.”

He continued: “In 2005-2006, we started studying the actual train loading scenario. We started running repeated load simulations in order to understand how, as number load applications increase, permanent deformations accumulate and cause alignment problems. We also studied the crotstie design, how the manufactured texture designs increased friction properties.

“We found some interesting results in terms of density and how that aspect controls the permanent deformation with the frequency of loading or speed of the train changes,” said Tutumluer. “We found that rounded stones were more resistant to permanent deformation in the repeated loading scenario since angular particles have higher voids and lower density for a given volume and, therefore, more room to shakedown and deform. But, if you go with equal density, the compaction procedures have to be different and the level of compaction makes the angular stones more resistant to the repeated loading, which we were able to demonstrate.”

The study also provided a way to account for fouled ballast.

Aggregate contact forces predicted in the ballast before (top) and after (bottom) tamping.
"In our DEM simulations, we use a surface friction angle and normal and shear loads to define the behavior at the contact between aggregate particles. Ballast fouling can get to be at such a high level that individual rock particles can be separated and the contact between the aggregate particles is lost, which reduces the strength of the layer. When we brought the surface friction angle down to almost 10 degrees from 35-40 degrees from two non-fouled rocks touching, we were able to simulate fouled ballast," said Tutumluer.

Next, according to Tutumluer, is studying aggregate movements and ballast fouling under moving loads to better understand ballast deformation.

"The final step we are envisioning is designing field sections with the findings of this study where we will put the results of the simulations and our understanding of how ballast behaves into a real test," said Tutumluer.

He is planning on conducting field tests at track stiffness transition zones where there are excessive settlements due to higher load impact.

Tutumluer will present his findings during the Track Functional Group session at the Annual AREMA Conference & Exposition next month.

**Georgetown Rail**

"Railroad executives and managers have realized that they can no longer depend solely upon the sophisticated muscle of their purchasing arms to control the costs of their most basic track component," said Lynn Turner, vice president marketing and sales at GREX. "The per-ton cost of quality rock at the quarry continues to tick upward and railroads are looking to supplier contractors for innovative solutions and tools in controlling these costs.

"Today's most-cost-effective solution is to demand every delivered ton be placed exactly where it is needed without unnecessary train delays. Georgetown Rail Equipment Company is providing flexible and cost-effective alternatives by combining the technology of Solaris (its automated, remote unloading hardware) with GateSync (synchronized ballast-gate unloading system) to deliver the exact and required tonnages for precise placement at speeds of up to 10 miles per hour. Add to that the benefit of safety in automated delivery and it adds up to reducing overall delivered costs," said Turner.

He continued that GREX added flexibility in design when it engineered its ballast-unloading system to function with individual cuts of cars in any multiple of two to 50. "Finally, and possibly most impressive, is that GREX is partnering to utilize the railroads' existing assets and converting them to more efficient use by adding Solaris/GateSync technology. In every case, the benefit is a smaller overall fleet doing more work, more efficiently," Turner.

GREX anticipates more than 770 cars will be in operation for BNSF, CSXT and

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**The result: A quality track with on-time performance, increased capacity and a longer lasting infrastructure.**

Plasser, providing ballast cleaning technology with decades of know-how and worldwide experience.
Understanding ballast behavior

Top view of ballast being placed on track using GREX’s Solaris/GateSync technologies.

Conrail, delivering these technological advantages in 2007.

“Contractors are now participating in the biggest surge in maintenance spending in recent times. It’s our responsibility as contractors to provide tools that incorporate effective, reliable, efficient and safer results,” said Turner.

Herzog
Herzog Contracting Corp. engineers and manufactures products that enhance the cost effectiveness and productivity of ballast operations and places the ballast in specified locations. The company is involved in the distribution of ballast using the PLUS Train, which uses special computer software and GPS coordinates that automatically open and close ballast doors for ballast distribution at the exact location needed at speeds up to 20 mph.

“Because of increased tonnage and new construction projects on Class 1 railroads, most major railroads will be increasing the amount of ballast distributed each year,” said George Farris, vice president marketing at Herzog. “In addition to the PLUS Train, Herzog also produces a remote-controlled solar- or generator-powered electric-over-hydraulic automated ballast door system, which is being used by several of the major railroads. For undercutting operations, Herzog has a ballast car train with patented automated plows. These plows strike off the ballast to the top of rail and can also be equipped with automated extendable plows, which project approximately one foot either side of the main plow to eliminate any windrow build up.”

Herzog has a full line of maintenance equipment, which ranges from the Self Propelled Multi-Purpose Machine, or MPM, which provides ditching to allow water to drain away from the ballast structure, to other quick-disconnect attachments such as a magnet and tie grapples, which are also included. Herzog’s equipment can be found on every Class 1 railroad, including a recent contract with Kansas City Southern.

“It appears that undercutting and shoulder ballast cleaning will be increasing over the next several years due to increased tonnage and axle loadings on all Class 1 railroads. This will also increase the need for more ballast usage,” said Farris.

Knox Kershaw
Knox Kershaw Inc. points out that it has experienced a positive reception for its new KBR-925 Ballast Regulator, resulting in a substantial increase in sales volume.

The machine has all the features of the KBR-900 such as a tilt cab, rear-mounted engine, superior visibility and service-
ability, but at a lower price. Knox Kershaw notes that it also has some exclusive features not found on any other ballast regulators: The first is a completely flat roof with adjustable lights mounted inside the machinery; the second is a self-contained, rear-mounted MacBone hydraulic air conditioner. The KBR-925’s front plow has been redesigned and it is now fabricated from heavier steel plate.

Knox Kershaw, president of Knox Kershaw Inc., says that railroads have purchased more equipment this year and that the sales volume for 2008 should be higher than 2007 for all types of machines.

“In addition to the replacement of older equipment to upgrade an aging fleet of track maintenance equipment, we are seeing an increase in programs that require additional sets of equipment,” said Kershaw.

Loram

Loram Maintenance of Way, Inc., points out that the increase in the cost of ballast affects the economics regarding cleaning of in-track ballast.

“The ratio of recovered ballast versus wasted material in a cleaning operation can be reduced and still be the economical alternative. This certainly increases the value of our shoulder ballast cleaning and undercutter cleaning operations through the recovery of good cleaned ballast, not to mention the value of improved drainage and track stability provided by clean ballast,” said Jim Perkins, manager of railway services at Loram.

Perkins notes the most important thing is to allow the ballast to perform the functions intended such as supporting the loaded track, distributing the load, maintaining track geometry and facilitating correction and acting as a medium for good drainage of the track structure.

“It is also important to improve general track drainage to enhance the performance of the ballast section. Therefore, we are continuing to provide our comprehensive approach to ballast and drainage maintenance by providing services for ditching, shoulder ballast cleaning, full-section undercutter cleaning and specialty vacuum excavating,” said Perkins.

The company has noticed an increase in the amount of ballast cleaning work performed over the past few years, both shoulder cleaning and undercutting.

“IT’s certainly no secret that the increased traffic loads are a double-edged sword for track maintenance in that more wear and tear is being applied to the track, while less time is available to perform maintenance. We feel this has led to an increase in the use of shoulder ballast cleaning since this maintenance practice is very effective in improving ballast section performance, improving tie gang productivity and is also very productive in terms of track miles treated during the available track time,” said Perkins.

Loram anticipates an increase in spending from railroads for maintaining ballast in-track.

“With the increase in the cost of pur-

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Special track works are among the most expensive part of any railroad yet commonly the most neglected. Loram now offers RAILINC™, the most productive and versatile machine available for some of the toughest challenges including removal of fouled ballast and debris from tunnels, cleaning and installing drain lines and culverts, and removal of ballast from bridge decks and grade crossings without removing ties or rail. The RAILINC™ is also used for undercutting of switches and mud spots and removal of contaminated material from yards and stations. It even offers the ability to safely expose delicate communication and signal cables and installations. Call Loram today, for more information on tough maintenance of way solutions.
chasing ballast, it makes good economic sense to maximize the use of the existing ballast. Increased car loadings and tonnage will require increased emphasis on the health of the ballast section,” said Perkins.

Miner

Miner Enterprises, Inc., has noticed the demand for ballast cars is on the rise and offers three ballast discharge devices: The Manual AggreGate®, the Air Powered AggreGate®, and the Electric AggreGate®. Miner is currently supplying Aggregate unloading systems to three Class I railroads. In addition, the company is currently supplying a stand-alone remote control AggreGate unloading system equipped with new powered retractable ballast plows to a major Class I railroad.

NORDCO

NORDCO Inc. notes that regardless of the cost of rock, railroads still have to maintain their tracks, including ballast. Because of this, its machinery business has not been affected.

The company points out that it is always open to suggestions from the industry and that its ballast regulating machinery is just one element in a complete selection of track maintenance solutions that it provides to the railroads.

“We’re always looking at ways we can add functionality to our equipment,” said Greg Spilker, director of sales and marketing at NORDCO. “For example, the NORDCO M2-14 Ballast Regulator actually does double duty. It can be quickly converted to a snow fighter, which means you can use it to maintain ballast one day and clear snow from the tracks the next.”

Spilker continued: “At NORDCO we understand that ballast literally forms the foundation of good track maintenance. It’s our job to help the railroads move it and groom it.”

PlaSSer American

PlaSSer American Corporation notes it has worked together with the railroads to find innovative and efficient solutions that increase ballast management capabilities for years. One of the latest achievements is the Ballast Profile Measuring System offered on PlaSSer Track Recording Cars. It measures the existing ballast profile at high speed and compares it to a standard ballast profile that is determined by the railroad. PlaSSer points to another breakthrough and highly-cost-effective solution, the PlaSSer Ballast Distribution System, which has the ability to reach far out on the shoulders and reclaim ballast that would otherwise be left on the wayside using conventional ballast regulators. The use of the BDS reduces the need for new ballast to be unloaded for tamping. Cost savings are experienced immediately.

Introduced in 2006, the PBR-2005 high-capacity, single-pass ballast regulator has also gained attention on
Understanding ballast behavior

Progress Rail's ballast regulator on track.

various railroads. Fitted with Platter's shoulder plow and center X-plow assemblies and ballast broom, the machine is designed to regulate ballast and keep up with most of Platter's high-production tamping machines in a single pass. By the end of the year, ten units will be in service, with four more on order for 2008.

Plasser has noticed the amount of undercutting/cleaning has been increasing every year, which is shown in the increased inquiries for purchase of new ballast undercutting/cleaning machines and ballast cleaning services. The most-recent machines delivered were the RM-2003 to Union Pacific and two RM-80-800s, which are working under contract on BNSF.

Progress Rail

Progress Rail's Kershaw division produces several models of ballast regulators. The company points out it has continued to improve the machines to make them more reliable and safe to use on the railroads.

Patrick Jansen, vice president sales and marketing at Progress Rail, said, "Our biggest challenge over the past couple of years has been controlling our costs from energy, steel and other raw material increases that have obviously affected every other manufacturing company across the country."

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