THE UNIVERSITY OF TEXAS AT AUSTIN ✦ COCKRELL SCHOOL OF ENGINEERING

TEXAS PAVEMENT PRESERVATION CENTER Newsletter

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IRF Pavement Preservation Workshop

TPPC Board of Directors

Our Mission

The mission of the TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost. The executive sponsor for the TPPC is the Texas Department of Transportation (TxDOT).

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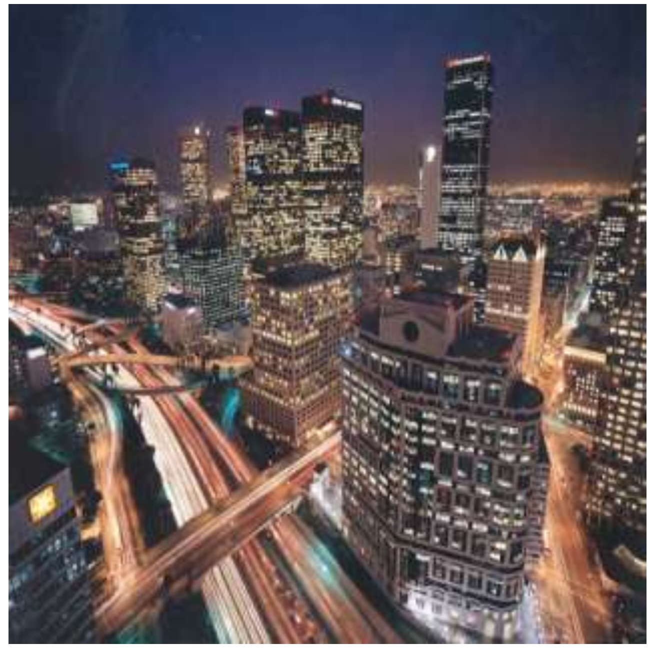


Past and Upcoming Events

Hot In-Place Recycling

The Hot In-Place Recycling (HIR) Open House and Workshop was held in Fort Worth on October 29. The workshop was jointly sponsored by Cutler Repaving, Inc., Martin Asphalt Company, the City of Fort Worth, FP2, and the Texas Pavement Preservation Center. The implementation methods and potential benefits of hot in-place recycling were presented by John Rathbun, and Bill O'Leary described the additives used in HIR. Yetkin Yildirim described HIR in relation to pavement preservation, and Najib Fares, infrastructure manager for the City of Fort Worth, described his first-hand experience with hot in-place recycling methods. Videos of this workshop and additional instructional materials regarding hot in-place recycling will be available for use online at:

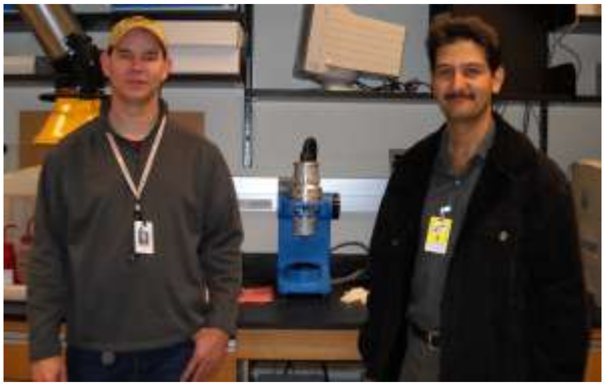
http://www.utexas.edu/research/tppc/conf/HotInPlace/index.html

TPPC Seal Coat Training Courses

Seal Coat training courses will continue to be offered by the TPPC. The course designed for inspectors, entitled "Seal Coat Inspection and Applications," focused on proper inspection methods and the equipment used during chip seal construction. The other, "Seal Coat Planning and Design," instructed engineers on planning, designing, and constructing chip seals.

For more information on the Seal Coat courses, please contact Dr. Yetkin Yildirim, P.E. at yetkin@mail.utexas.edu or (512) 232-3084.

TPPC Interview with TxDOT's Gerald Peterson



Gerald Peterson, TxDOT and Yetkin Yildirim, TPPC

The Pavement Preservation Center recently interviewed Mr. Gerald Peterson, Asphalt and Chemical Branch Manager of TxDOT's Construction Division, about some of the recent asphalt technologies that have been implemented in Texas. According to Mr. Peterson, Performance Graded (PG) specifications have been instrumental in addressing rutting in Texas roads. First developed in 1997, PG specifications include more information about the properties of the binder than older specifications, allowing engineers to use much stiffer binders than could be typically used under the Asphalt Concrete (AC) system. These specifications were initially designed according to local climate conditions, while subsequent experience has found that a 64-22 binder could be used with 95% confidence rating for 80% of the state. Almost all of the other grades are essentially bumped up from the 64-22 specification, according to the needs of the local traffic conditions. Now, engineers typically select binder grades based on their own experience and familiarity with the PG specifications. The stiffening of the binders facilitated by the PG specifications has significantly reduced rutting problems in Texas, but this kind of "grade-bumping" would theoretically not significantly impact the cracking resistance of the asphalt.

The TxDOT central laboratory monitors the quality of the asphalt from all of the major binder sources in Texas, receiving samples of every grade twice a month from each producer. There is no requirement for regular field testing; it is up to the project engineer to decide how frequently field tests should be conducted. But it is recommended that engineers conduct sample testing in the field in order to corroborate the laboratory results and generate enough field data to be able to sufficiently analyze problematic regions. The specification book does not mention any steps to be taken in case of the failure of a binder. In such cases, districts generally negotiate with their contractors for a pay reduction, but still there is some uncertainty among engineers as to what the appropriate action is in this scenario.

The PG specifications were modified in 1999, and the polymers used for each grade were specified in the binder name. This was an attempt to keep engineers from bumping the grade of their binder simply to get a polymer in the mix, but the material codes became too confusing. In 2002, the PG system was modified again, allowing polymers to be specified in the plan notes rather than the binder specifications. Also, an intermediate temperature test was introduced, independent of the specification's higher temperature. This modification distinguished the PG specifications from AASHTO specifications, so that grade-bumping would not affect the intermediate temperature of the binder. Then in 2003, the elastic recovery test was added to the requirements in the PG specification book.

Rubber modified asphalt is another new technology that TxDOThas been using for a number of years now. There are two basic types of rubber modified asphalts: asphalt rubber and tire rubber. Asphalt rubber, which is generally blended on site, consists of a minimum of 15% tire rubber, and is cured at a low temperature for a short period of time. On the other hand, tire rubber is blended by the supplier, is highly cured, and can be used like any other modifier. Mr. Peterson observed that tire rubber has performed particularly well in seal coats and hot mixes.

In 2005, more scrap tires were used in Texas than were produced. Around 6% of all waste tires recycled in Texas were used in Crumb Rubber Modified (CRM) rubber projects: approximately 10,000 tons of tires per year. In Texas, the wet process is the preferred method for the production of rubberized asphalt concrete. Rubberized asphalt concrete can be manufactured by either a wet or dry process. The wet process is used in Texas, and involves the blending of crumb rubber with asphalt cement (18-25%) before the addition of aggregates.

The PG specification for such a recycled asphalt material is difficult to determine. Initially, binder from the recycled material was extracted and blended with the proposed binder in the proper proportions. The specifications of this blend would then closely approximate the PG specifications of the recycled material. However, this procedure was cumbersome and often inaccurate. Instead, a maximum limit has been set on the amount of recycled material that can be used in a binder. If the binder includes less than 20% recycled material, the PG specification of the binder does not need to be altered. TxDOT encourages the use of recycled materials (RAP or shingles) for binder hardening by allowing "grade dumping." In other words, TxDOT specifications allows a lower grade binder to be substituted for a higher grade if the mixture still passes the Hamburg Wheel Tracking test.

Warm-Mix Asphalt (WMA) has also been gaining popularity in Texas in the past few years. As the name suggests, this method reduces the temperature at which asphalt mixes are produced and placed. Warm-mix methods are now allowed for in the specifications: as long as mixture requirements are met, it is not a concern with TxDOT whether the mix is produced via hot or warm mix processes. Foaming and EVOTHERM are the two most popular warm-mix methods for lowering the viscosity of the asphalt mix without severely increasing the temperature. Even though there are questions about the long term performance of warm mix asphalt, this process has been generally well accepted because of its potential economic and environmental benefits.

Mr. Peterson also discussed the benefits of Open Graded Friction Courses (OGFC). These pavements help to reduce wet weather accidents, as they allow for water to drain off the road surface quickly. However, they are unsuitable for regions with heavy snowfall, since the clearing of snow and ice from open graded pavements is difficult, and these pavements often respond poorly to freeze and thaw.

What is Successful Pavement?

Dr. Chang, representing the **University of Texas, El Paso**, gave a brief summary of a TxDOT sponsored project to create a database for flexible pavement sections in Texas. After reviewing the pavement performance characteristics, life cycle information and deterioration models, Chang proposed the definition of successful pavement as "a pavement structure that has met performance expectations over its service life with only normally expected levels of maintenance for its age, materials, traffic loads, and local conditions." This TxDOT project proposes to define successful flexible pavement performance and create a database of representative, particularly successful flexible pavements in Texas, which would serve as successful examples for future analysis and planning. For this database, the primary considerations for pavement selection included geological and climate parameters, pavement structure type, traffic levels, age and degree of success of pavement. Successful performance was attributed to a judicious combination of average annual maintenance expenditure and average condition, distress and ride scores. A Tier Two list of flexible pavements is currently in development. This has adequate representation of both thick and thin Asphalt Concrete Pavements (ACPs), pavements subjected to different traffic levels and a variety of ACP mixture layers. When completed, this database will be publicized statewide, and could be used to address future TxDOT design challenges, as well as provide a means for documenting innovative maintenance-placed experimental pavement sections.

Asset Management Lessons for Pavement and Bridge Preservation

Butch Wlaschin, Director of the **Federal Highway Administration**'s Office of Asset Management, highlighted the need for integration of Transportation Asset Management, based on business and engineering practices for resource allocation and utilization, in decision making. It is a systematic process that helps analyze tradeoffs between objectives and maximize returns in the upkeep of a transportation infrastructure. To accomplish this, quality information based on accurate data, sound engineering and economic analysis is a prerequisite. Effective and timely monitoring of systems supplement the data collected. Ageing infrastructure, growing congestion, funding shortfall and increased focus on system performance are challenges that make the use of Asset Management a necessity.

More than just a performance management system, asset management accounts for the entire network over the whole life-cycle. Wlaschin notes that the most successful asset management programs are renouncing the "worst first" investment strategy, in favor of investment principles that are based on life cycle costing. Furthermore, successful programs undertake scenario analysis showing the consequences of various investment decisions on performance measures. The challenges to the implementation of Asset Management System include the collection of right data for performance measure, linking it to decision making and bringing about an acceptance for the system among the top management. The benefits of asset management approach will ensure that public funding is invested wisely, and will assist government providers and operators of transportations systems in minimizing long term costs, without compromising the achievement of desired service level.

Environmentally Friendly Pavements

Masahiko Iwama of the **Nippo Corporation** gave a detailed summary of the implementation of environmentally friendly pavements. Warm-mix asphalt, enhanced by the additive agent ECOFINE, reduces the mixing temperature by 30 to 50°C. This results in reduction of CO_2 emission by about 14 to 23%. The ECOFINE additive also improves the workability of the asphalt, especially in winter, thereby causing lesser disruption of traffic. Use of ECOFINE also makes it possible to increase the Reclaimed Asphalt Pavement (RAP) ratio by 40% without RAP heating.

Masahiko also explained the invention of solar heat-blocking pavements. Pavement, like concrete structures, is a source of heat, with surface temperatures often reaching 60°C or higher in the summers. Hotter pavements have been linked with the urban heat island phenomenon and the high temperatures are likely to impact the health of the pedestrian. Solar heat-blocking pavements were developed in response to public demand in Japan to reduce the temperature of road pavements, and have been successful in reducing road temperatures by about 16°C. Use of a highly reflective pigment sensitive to the near infrared rays and hollow ceramic particles to reflect the infrared part and solar radiations respectively results in considerable reduction of pavement temperature. The visible part of light remains unaffected by the above reflectors hence visibility is not hampered in any way. Also, the surface coating did not adversely affect the performance of the pavement. Rather the use of this technology decreased the rate of rut depth by 50% as compared to conventional pavements. Masahiko indicated that in future NOx reducing pavements and Vibration reducing pavements are the subject of research at NIPPO.

Dense Cold Mixes: Preservation of Low Volume Roads

Eric Jorda of **Akema Inc,** describes a process used in Europe, especially France for pavement preservation: dense cold mix asphalt emulsion. Dense cold mix consists of emulsion mix asphalt comprising selected aggregates totally coated with binder and is used exclusively as wearing course. When compared to standard Hot Mix Asphalt (HMA) mixes, dense cold mixes demonstrate global energy savings of over 30%. Also cheap and easy to produce, dense cold mixes are particularly suitable for pavement preservation applications. This technology has been in use for more than 20 years in France. However, the mix should not be applied before a complete and accurate laboratory study is conducted to adapt emulsion to aggregate for this type of application. In this study, the engineer must define the aggregate gradation curve and properties, the minimum total water content, the total emulsifier content, the pH adjustment as a function of aggregate properties, and the minimum emulsion content. Then the final composition can be optimized considering the mechanical properties of the mix. The use of dense cold mixes does not require the road to be closed during application as the road can be reopened to traffic just after compaction.

Asphalt Pavement Crack Sealing Field Performance: 25 Year Review

In this presentation, **Patricia Irrgang** of **Crafco Inc**, reviewed the evolution of crack sealing technology over the last 25 years, cataloguing the results of various significant research projects. Before 1970, crack sealing was rarely performed, although research conducted throughout the 1950's and 1960's led to the development of various materials for the sealing of cracks in bituminous pavements and the first categorization of crack types: reflective and random. In the late 1970's and 1980's, as crack sealing was adopted as a commonplace practice, lab and field evaluations of crack sealing materials became more frequent as well. The Utah DOT, the Ontario Ministry of Transportation, and the Sweden National Testing Institute conducted important early tests contributing to, among other things, the designing of the heat lance, the standardization of sealant material and methodology, and the determination of daily and seasonal crack movement rates. In the 1990's the SHRP H-106 Project, led by Smith and Romine, monitored crack movements and configurations for seven years in order to determine the service life and cost-effectiveness of various sealant materials. The study determined that rubberized asphalt provided the best performance, while emulsions and asphalt cement proved to be ineffective crack sealant material. Also, with appropriate project design, materials, installation geometry, installation procedures, and quality control, service lives of at least 7 years could be achieved with both crack filling and crack sealing processes. The most recent research on crack sealant materials has focused on refinement, implementation, and appropriate project design for existing conditions and has defined new criteria for successful crack sealing. For instance, the pavement conditions must be appropriate for crack treatment, and

the sealant properties must be matched to climate. Agencies that have studied and designed the crack sealing process for their climate and pavement conditions have demonstrated maximum success, sometimes extending pavement life up to four years.

New Asphalt Technologies for Pavement Preservation

Microsurfacing and slurry seal

Jack Van Kirk of the **Valley Slurry Seal Company** reviews the use of slurry seals, scrub seals, fog seals, cape seals and microsurfacing in pavement preservation. Slurry seals have been used successfully in a wide variety of environments, including interstates, city streets, and parking lots in coastal, desert, and mountain climates. Microsurfacing is a specialized form of slurry surfacing that can be placed anywhere that slurry surfacing is placed. However, microsurfacing sets faster than slurry seals, and can be placed in much thicker layers. Also, microsurfacing treatments are typically stronger than slurry seals due to the use of higher quality aggregates. Thus the advantages of using slurry seal and microsurfacing include rapid application, extended pavement life, excellent surface texture among various other things.

Van Kirk also discussed the use of cape seals with slurry seals and microsurfacing treatments. A cape seal is a chip seal plus a slurry seal or microsurfacing application, providing both micro and macro surface texture for maximum skid resistance. Cape seals improve the ride and extend the service life of typical chip seals, thereby providing an economic alternative to costly overlays. Fog seals and scrub seals are mainly used to rejuvenate older slurry or cape seals.

Considerations for Flexible vs. Rigid Pavements

Carlos Chang of **University of Texas, El Paso**, explains how the state Departments of Transportation have begun to implement the practice of including rigid versus flexible pavement structure alternatives in construction plans in order to provide flexibility in contractor competition. Ideally, the inclusion of alternate pavement designs early in the bidding process would allow DOT's to achieve a best-value bid price, but there is concern that alternative pavement designs might not be truly equivalent. Several Life-Cycle Cost Analysis (LCCA) studies have been conducted in order to determine whether the alternate designs included in contracts will display comparable performance lives. In California, pavement design alternatives are analyzed for design lives of 10, 20, and 40 years, in order to determine the most cost-effective alternate pavement design life. Furthermore, the Colorado Department of Transportation recommends a 40-year analysis period when comparing flexible and rigid pavements, and the Alternate Design – Alternate Bid (ADAB) procedure developed by the Louisiana DOT appears to have been adopted as standard industry practice. TxDOT project 0-6085 has been conducted to develop a protocol for designing pavement structure alternatives and to provide guidelines for the inclusion of alternate designs in pavement plans. This protocol includes an analysis of general project information, an LCCA comparison of flexible and rigid pavement designs, and a final engineering project evaluation. Equivalent pavement designs should be considered for major highway projects, and projects with a high volume of trucks.

Asphalt Modification Processes

Delmar Salomon, representing **Pavement Preservation Systems LLC**, provided a classification and overview of various asphalt modifiers, explaining their benefits in terms of performance, workability, and adhesion. Asphalt can be modified in order to improve rutting resistance, reduce mix/compaction temperatures, or improve water resistance, and to generally address traffic load and climate variations in order to extend the service lives of pavements. Asphalt modifiers can be broadly classified into chemical, polymer and hybrid formulations. Common asphalt modifiers include block polymers, latex SBR, plastomers, recycled tire rubber, polyphosphoric acid, and gilsonite. Modifiers increase the modulus of asphalt, which results in increase in softening point and reduction in penetration. This improves the workability of the mix. Polymers used as modifiers only alter the physical nature of asphalt and do not combine with it chemically. The polymer used should be ascertained to be compatible with asphalt for best results.

Additives in asphalt thus are used to modify binder performance in order to provide resistance to environmental stresses, improve asphalt-aggregate adhesion resulting in improved water resistance and to enhance the workability of mix by lowering the mixing and compaction temperature.

Sulphur Enhanced Asphalt for the 21st Century

Gary Fitts of **Shell Sulphur** Solutions made a case for the use of sulphur enhancement in asphalt mixes. The potentially negative environmental impact of sulphur usage requires strict management and regulation of this resource, and the proposed use of sulphur in enhanced asphalt hopes to remove sulphur from systems in to which it does not contribute value (e.g. fuels) and introduce it into new technologies that will provide a greater benefit to consumers at a lower environmental cost. In the 1970's and early 1980's, the energy crisis disrupted the traditional bitumen asphalt binder supplies, forcing engineers to incorporate sulfur as a practical means of extending a limited bitumen supply. Shell Thiopave functions in a similar way; the additive replaces up to 25% of the bitumen in the asphalt mix. Sulphur as an additive in asphalt increases stiffness at high service temperatures, reduces temperature sensitivity, improves resistance to rutting, and enhances the load-spreading capability of a pavement surface. Sulphur-enhanced asphalt can be applied in structural courses for thick pavement structures, for instance as an asphalt stabilized base. The limitations with using Thiopave is that strict temperature control is required during production and it cannot be used in thin-surfaced flexible pavements or with bitumen modified with polymers that can cross link with sulphur.

Warm Asphalt Mix Technologies

Eric Jorda of **Akema Inc**, reminded the group that, while relatively simple to produce, hot mix asphalts (HMA) have a severe impact on the environment besides the social and economical concerns it raises. High temperature (320°F) though necessary to remove the liquid water in aggregates and to reduce bitumen viscosity to a workable level, results in practical environmental and safety concerns. Continued efforts to reduce the asphalt mixture fabrication temperature without compromising quality and strength have identified that decreasing the temperature of aggregate could be a viable solution to the problem as aggregates comprise 95% of the mixture.

Three techniques currently exist for the fabricating warm mix asphalt (WMA): foam based processes, wax based chemicals addition, and surfactant addition. In foam based processes, water is added (directly or via zeolite, emulsion, etc.) to form foam that improves aggregate coverage at a lower temperature (195°F to 280°F). Another option involves wax based additives that reduce the viscosity of the asphalt binder at processing conditions. These results in better coverage of the mineral aggregates at lower temperature (70°F), but addition of waxes may change the bitumen characteristics. Finally, surfactant addition improves workability of the asphalt mixtures at lower temperatures (70°F), requires no process modification or addition of water or binder rheology modifier. Thus the shift from HMA to WMA would be accompanied by a reduction in fuel consumption, a reduction in pollutant emissions that results from fuel combustion and bitumen, extended pavement life due to the decrease of bitumen ageing during production.

New Construction Testing Equipment

Rammi Kauppi of **Troxler Electronic Laboratories** presented the latest Troxler gauges and compactors, designed to provide the proper compaction and mix design that are critical to the lasting pavement performance. Gauges measure the moisture content, density, and percent compaction of construction materials, and help engineers save time and avoid costly errors, re-compacting, or patching pavements. According to developers, if 20% of failed pavements are prevented through the use of improved soil-compaction measurement devices, the estimated industry savings would be $3.3 million per year. In addition, use of gyratory compactors lead to improved asphalt quality and Kauppi claims that Troxler compactors simulate wear better than the Marshall method. The Troxler New Technology Ovens (NTO) is expected to improve asphalt quality claims; to use lesser energy than conventional ovens and return results in as little as 25 minutes. All the equipments marketed by Troxler are fully automatic and software managed thereby almost eliminating human error.

An Overview of Rubberized Asphalt Technology

Douglas Carson, Executive Director of the **Rubber Pavements Association**, outlined the engineering benefits and opportunities made available by rubberized asphalt development. Since the development of rubberized asphalt equipment in the 1970's, rubberized asphalt technology has become a relatively familiar method for pavement preservation, although misperceptions persist. ASTM defines Asphalt-rubber as "a blend of asphalt cement, reclaimed tire rubber, and other additives, in which the rubber component is at least 15% by weight of the total blend and has reacted in the hot asphalt cement, causing the rubber particles to swell". Poor quality control and absence of standard specifications obstruct the widespread adoption of this method. Asphalt rubber can be used anywhere that asphalt is used, but particulate rubber is not recommended for dense graded mixes. Asphalt rubber can provide open and pervious mixes that reduce splash and spray on roadways, reduce tire noise, and can last 5-7 years without modifiers. High asphalt prices make rubber a cost-efficient alternative, and pavement maintenance costs will be lowered due to the reduced cracking in rubberized asphalt. These pavements may last up to twice as long as conventional materials before requiring maintenance or replacement.

Using Crumb Rubber Modifier to Meet Demand in High Performance Asphalt

Cecelia Mancero of **Ecopath**, described the benefits of crumb rubber modified (CRM) binder in pavement construction. Asphalt rubber composed of 20% crumb rubber and 80% asphalt binder provides longer lasting road surfaces, reduced road maintenance, shorter breaking distances, and lower road noise.

Chip seal job with tire rubber

Addition of CRM to modern mixes such as Open Graded Friction Course (OGFC), Stone Matrix Asphalt (SMA) or Superpave results in considerable improvement in crack resistance, resistance to permanent deformation and resistance to ageing. By raising the upper failure temperature, decreasing the lower failure temperature, and increasing the viscosities, addition of crumb rubber to binder greatly improves binder performance. The extent of modification achieved would be a factor of base binder and crumb rubber properties. An Accelerated Loading Facility (ALF) study performed by the FHWA recently compared the performance of different Polymer Modified Asphalts (PMA) including SBS, terminal blend, and asphalt rubber. The results of this study demonstrated that over a wide range of load passes, asphalt rubber resisted cracking better than any other tested PMA.

Increasing the Awareness of Pavement Preservation

Yetkin Yildirim, Director, **Texas Pavement Preservation Center (TPPC)**, gave a brief overview of the various pavement preservation awareness projects that the organization has led. Established August 11, 2005, as a collaboration between Center for Transportation Research (CTR) of The University of Texas at Austin and Texas Transportation Institute of Texas A&M University, the TPPC has been actively involved in promoting awareness of pavement preservation methods at the state, national, and international levels. TPPC offers training in pavement preservation methods and practices to TxDOT personnel, contractors and material producers, engineering students, and even elected officials. Online courses in pavement preservation are available at the TPPC website, free and open to the public. Additionally, the TPPC offers classroom courses in seal coats and microsurfacing to engineers and inspectors for CEU credit. Other endeavors for creating awareness for pavement preservation among members of the highway community include the quarterly Pavement Preservation Journal (PPJ) and TPPC Newsletter. The PPJ is published in collaboration with the Foundation for Pavement Preservation and it attracts research from around the world in the area of pavement preservation. Yildirim also presented the most recent research work conducted by the TPPC in the area of seal coats and crack sealing. Out of this research, the TPPC has developed the possibility of stress absorbing layers designed for seal coat application. This method would enhance the performance life of seal coats by preventing the reoccurrence of existing cracks on the newly applied seal coat surface.

Pavement Management Overview

Carlos Chang of **University of Texas, El Paso**, described pavement management as a coordinated, systematic process for carrying out all activities related to providing a healthy pavement network. Pavement management primarily addresses maintenance, rehabilitation, and reconstruction projects by using decision making method to deal with the variety of project options. The standardized decision making process of a pavement management system allows state or national agencies to find cost-effective treatments and apply these treatments at the appropriate times to achieve desired levels of service. A typical pavement management system comprises of an asset inventory, a central database, and analysis and report modules. The system allows for road condition assessments to be analyzed effectively, and the determination of needed work and funds thereby leading to the identification of candidate projects. Data collected from the roadway is calculated into the Pavement Condition Index (PCI), an indicator of pavement health that serves as a ranking and communication tool among pavement engineers. PCI can be used to project the future condition of the pavement, establish a rate of deterioration, and determine maintenance and rehabilitation needs. The trigger points in the pavement management system establish specific levels at which treatments should be applied. Higher trigger value indicates a need for Maintenance and Rehabilitation. Multiple trigger values can be used to allow for a more flexible approach to backlogged pavement needs or to complex pavement challenges. Performance models or optimization methods can be used as alternative trigger based approach in pavement management system.

Asset Management for the 21st Century: Accountable Performance

Puneet Singh of **Poly-Carb** articulated the challenges faced by the US infrastructure and the need for asset management. In the United States, there are nearly 4 million miles of public roads that are rapidly ageing and under increased stress. Additionally, AASHTO estimates that 1 out of 4 bridges in the US need updates or repairs that would cost an estimated $140 billion. Under the current infrastructure model, repairs are conducted reactively. Puneet argued for a shift from this repair-oriented mindset to a truly preventative approach that seeks to proactively extend life cycles and consider the long term rather than the short term costs of pavement maintenance. A proactive infrastructure model would ensure future quality and preservation and provide increased safety and performance. This key to achieving this is increased accountability in order to maximize the limited resources of road agencies. The model is ideal for high value assets that are sizeable and cause great inconvenience to close. If performance is assured for every dollar invested, the unforeseen costs of rehabilitation or reconstruction will no longer inflate construction costs and put financial pressure on state DOTs. The allocated funds will be used efficiently to deliver the maximum value from limited resources.

Asset Management at the Regional Level

Theresea Rommel of **Metropolitan Transportation Commission**, presented the results of a case study evaluating the San Francisco Bay area pavement management system. In this area, a population of 7.1 million uses 42,000 lane miles of roadway. Local streets and roads, which support all modes of transportation, compose the biggest and most expensive piece of transportation infrastructure with an estimated $40-$50 billion replacement value. The Metropolitan Transportation Commision (MTC) developed the Regional Streets and Roads program to proactively manage this seminal portion of the pavement infrastructure. The program costs over $1.5 million annually, as opposed to the $1 million cost of reconstructing a single lane mile of roadway. The MTC uses StreetSaver software as its network level system in order to document needs and conditions and determine which projects should be given priority. Furthermore, the Pavement Management Technical Assistance Program (PTAP) is a federal grant program that provides $800,000 annually for the collection of quality road data that can assist in pavement management decision making. Rommel concludes that spending money on new construction is wasteful without having in place the appropriate infrastructure to ensure the preservation and maintenance of the new roadway. Asset management programs also provide the means for regulatory and financing agencies to ensure accountability and track progress.

Road Maintenance in Developing Countries: The World Bank Perspective

Ben Gericke of **The World Bank,** discussed the World Bank's Project Cycle for road improvement in developing nations, and the possible ways that this cycle could be better coordinated to the client country's internal project cycle. The World Bank typically merges its process of identification, preparation, appraisal, approval, supervision and completion with the client's project cycle of planning, design, construction, and maintenance. Through this cooperation, the Bank hopes to ensure efficient utilization of resources. Also, the middle income and International Development Association (IDA) require best practices to be included, such as institutional improvements, improved transparency, road safety and output and performance-based contracting. Case studies in the Philippines, Zambia, and Liberia demonstrate the value of partnering with local road agencies for development projects.