81st Purdue Road School
Research and New Technologies

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Thank you for the opportunity to speak at the 81st Annual Purdue Road School on the subject of Research and New Technologies. I will address my comments from the perspective of the Indiana Transportation System.

Overview of Research Investment (A history lesson):

At the 73rd Purdue Road School, Damian Kulask, then Director of the newly formed Strategic Highway Research Program (SHRP) made the following statement:

- The biggest problems our roads face is not corrosion by salt, not wear by heavy trucks, not cracking during sub-zero weather, nor rutting in intense heat. The biggest problem our roads face is indifference -- indifference about the people who manage them, and indifference about the new ideas going into roads.

Indifference resulted in road research investments decreasing from $110 million/yr. in the 1970's to $55 million/yr. in the 1980's. Engineering students that chose civil engineering majors also decreased from 20% in the middle 1970's to 13% in the 1980's.

There was an awaking of sorts in 1982 when Congress established the $150 million, 5 year, Strategic Highway Research Program to look at hot topics such as performance based specifications, long term pavement performance, new materials, and work zone safety. Further, ISTEA legislation required the

utilization of at least 25% of SPR monies to be devoted to transportation research.

Though very modest initiatives, why was this done? In part, because United States expenditures for highway transportation, private and public -- are twice as great as our expenditures for defense. One sixth of our GNP goes into the highway transportation system. More than 90% of our industrial output moves over our road system - our roads are our economic backbone.

Yet in the 1980's, the United States was spending about one fifth of one percent (.2%) of its highway-construction resources on research - which is neglect by any measure. High Tech industries, like computers and aerospace, spend 10 to 50 times as much of their gross sales revenue on research than we do. Even low-tech industries like mining, steel, and paper spend about 8 times as much of their gross sales revenue on research as we do.

So What! So what if more money should be spent on research. The question I want to address today, however, is whether it's one dollar or one million dollars spent for research, what did it buy and what problems did it solve. Furthermore, good research to be useful must be implemented and successful implementation requires everyone's efforts.

Using this criteria let's look at the INDOT Research Program which includes the Joint Highway Research Project headquartered here at Purdue, and works closely with the Highway Extension and Research Project for Indiana Counties and Cities (HERPICC), the Indiana Rural Technical Assistance Program (RTAP), headed by Dr. Scholer. What do we see?

As an overview, then specifically, we see the following: For the current 72 ongoing research projects the expected average Benefit/Cost ratio is 50:1 with benefit cost ratios ranging from 5:1 to 200:1.

For the 46 projects completed (and completed means implemented or in the implementation process) the actual Benefit/Cost ratio averaged 30:1, or for every dollar spent solving Indiana transportation problems, $30 dollars worth of solutions or savings were obtained.

What did we get from the completed projects? By category and noting some projects had multiple benefits, we find:

- 14 projects resulted in developed Specifications/ Special Provisions or Testing Procedures,
- 27 projects resulted in Better Methods/Improved Performance,
- 19 projects resulted in Improved Policy/Procedure Changes,
- 9 projects resulted in Training Developed/ Provided,
- 5 projects resulted in New Materials added to Certification/Approved for Use Lists,
- 24 projects results in Known or Anticipated Savings,
- 33 projects resulted in New Technology or Information/ Equipment/Computer Programs, and
- 1 project has no implementation as yet.

Only 1 project out of 46 projects completed over the last 3 years has not been implemented or stated another way, 98% of completed research from the last 3 years has been implemented, in some form.

FHWA reviews consistently find Indiana's Research Program one of the best in the country. Why! One reason is the Joint Highway Research Project which networks INDOT and Industry practitioners with some of the best minds in Indiana, towards solving Indiana's transportation problems. Credit goes to Dr. Vincent Drnevich and Dr. Kumares Sinha from Purdue and Dr. Bill Black from the IU Transportation Research Center for heading this effort.

Another reason for a successful research program is the strong support and involvement by INDOT Executive Staff, in particular the Commissioner and the Chief Highway Engineer's Office. Credit goes to Mr. Don Lucas, Chief Engineer, who serves as Chairman of the Joint Highway Research Board, along with Mr. Dave Pluckebaum, Deputy Chief Engineer.

Credit also goes to Messrs. Lloyd Bandy, Asphalt Pavement Association of Indiana; Mike Byers, Indiana Ready Mix Concrete Association; Bruce Mason, Indiana Mineral Aggregates Association; and Charles Kahl, Indiana Contractors, Inc. for involving their association members in research projects and providing their personal expertise to the JHRP Board. Currently, the Indiana Research Program has seven projects involving partnering and pooling of resources with Indiana industries and associations. Partnering between INDOT and FHWA practitioners, academia, and industry will be the precedent for maintaining a successful transportation research program into the 21st century.

A final reason for a successful transportation research program is the support and guidance provided by FHWA, in particular

Mr. Larry Tucker and Mr. Don Johnson. Of course, the money they provide helps make for a successful research program too!

Let's now look at some specific examples of new technology and cost effective research:

In 1989, INDOT and Purdue embarked on development of an Accelerated Pavement Testing Facility. The goals were the capability of testing full scale pavement sections, in a controlled environment, in at least 1/10th the time over placing a test section out in the field, and at a cost of 1/5 to 1/10 the cost of alternate devices, such as the FHWA Accelerated Loading Facility, which has a current price tag of $1.5 million.

With this vision, Dr. Tom White and various INDOT staff members, such as the current APT Supervisor, Dr. Brian Coree, developed and brought to fruition an Accelerated Pavement Tester which began operation in the Spring of 1992 and has now ran successfully for 2 years. The facility and pavement tester cost $260,000 or 1/6 the cost of alternate devices and can test a pavement section in about 2 weeks at a cost of approximately $4500 per test section, both very well below the time and cost of a field trial. The potential for this facility is enormous, and it is up to us to fully exploit it. Imagine being able to quickly and relatively cheaply evaluate new designs, additives, and materials before placement on the roadway, avoiding potential costly failures in the field and further displacing and inconveniencing the travelling public.

The Accelerated Pavement Tester is housed in a 2000 sq. ft. environmentally controlled facility and includes a full scale test

pit. The loading mechanism is able to simulate a half standard axle, 9000 lbs., and up to a peak load of 20,000 lbs., or the equivalent of a 40 kip single axle. By controlling the testing speed and temperature, the effects of 35 million ESAL's, Equivalent Single Axle Loads, can be compressed into just a few days.

The first research project evaluated in this facility was with the Indiana Mineral Aggregate Association, defining the minimum degree of crushed aggregate in asphaltic surface mixtures to reduce permanent deformation, or rutting. Though the project has drug alone and is just now finishing, due to the large number of sections tested, finding mix suppliers, etc. our impression and expectations for the Accelerated Pavement Testing Facility have not diminished rather increased. Furthermore, the device works.

In fact, INDOT will receive a contract from FHWA for a national pooled fund study looking at Validation of SHRP Mix Designs using Accelerated Testing with pledges of $570,000 in new money, even though only $350,000 was requested. Imagine receiving outside money to do something we were going to have to do anyway - everyone benefits - other contributing states, FHWA, and certainly Indiana. This would not have been possible without the Accelerated Pavement Testing Facility. There is a national and international interest in this facility.

Credit again should go to the Chief Engineer's Office for pushing this project through during tough economic times. JHRP and INDOT would be wise to continue to explore and market the Accelerated Pavement Testing Facility.

Another example of new technology introduction by INDOT and JHRP is Indiana was selected from amongst 14 states and 2 Canadian provinces to house the new state-of-the-art North Central SUPERPAVE Center.

The Strategic Highway Research Program (SHRP) developed a new, performance-based method for specifying asphalt binders and designing asphalt mixtures. These new procedures are expected to improve and prolong asphalt pavements, but new test methods are very complex and require expensive test equipment, a $350,000-$500,000 investment.

FHWA, to encourage broad implementation of the new SHRP specs, has established five regional SUPERPAVE centers one of which will be housed in Indiana and headed by Dr. Jan Olek from Purdue and assisted by Dr. Brian Coree, Mr. Dave Andrewski, and Ms. Rebecca McDaniel from INDOT.

The new technology includes state-of-the-art binder testing equipment, such as the Dynamic Shear Rheometer which measures high temperature stiffness as it relates to rutting. The Brookfield Viscometer, Rolling Thin Film Oven, and Pressure Aging Vessel used to measure asphaltic binder properties, and the Bending Beam Rheometer, which performs a cold temperature test, measuring thermal cracking.

Superpave mix design equipment includes the SHRP Shear Tester measuring permanent deformation or pavement rutting, the Indirect Tensile Testing, Gyratory Compactor, and equipment measuring moisture sensitivity.

High tech - yes, but a modest investment if you consider Indiana spends an average of $1.2 million/mile for interstate asphalt resurfacing, according to HIP program data. We are spending Indiana taxpayers dollars and they deserve the best Return-on-Investment that we can provide.

Another example of New Technology is INDOT's multimedia training development by Dr. Bob McCullouch, Mr. Walter Land, and Dr. Tommy Nantung. Today's technology for training delivery provides the option of more efficient and effective training known as interactive multimedia training. Multimedia is a combination of media such as audio sound, video tape, animation and graphics in the display of information. This technology has emerged as a very effective solution to increase workplace learning and performance with the development of multimedia computers.

For INDOT, continued professional success of its design engineers can be ensured through a program of aggressive educational development via multimedia training. Design analysis, specifications, design standards, and constructability information can be included in the multimedia form. In addition, construction processes and techniques, contractor equipment capabilities, and contractor materials such as standard formwork sizes can be included as well. Knowing the exact design or procedures will save time and money. For example, a design engineer knowing about economical design of bridges can eliminate the cost of overruns with comprehensive multimedia training. Multimedia training brings the training to the designer without the designer spending large

amounts of time going from project to project, learning by trial and error.

Mr. Stan Smith, then Deputy Commissioner, now Commissioner, with his background from IBM, knew the potential of multimedia training and saw its potential in other areas. In response to the Commissioner, the Research Division and JHRP have finished a synthesis study to identify potential training applications in technical and non-technical areas. They are: metric training, highway and bridge plan reading, orientation of new employees, an employee performance support system for the design division, and permitting procedures. Other possibilities are environmental compliance training, such as Hazmat training. These training applications are in addition to the INDOT multimedia constructability project which is close to finishing.

Multimedia with its ability to use various media forms, provides a richer environment to learn. Learning improves significantly when multimedia is used. Research has shown trainees complete training in one-third the time over traditional instruction methods while reaching up to 50% higher competency levels.

Over the last two weeks I received over 100 research reports. These reports are from TRB, NCHRP, FHWA, other states, universities, and internal reports. Many contain timely, pertinent, useful information. Yet accessing this information is not easy and often not timely, leaving solutions or new information sometimes setting on the shelf.

When anyone in this room contacts the Research Division for an information search via Dialog's +350 databases, about the best we can currently do now, unless an on-line search is performed, is provide the requestor with a list of abstracts and available reports in about two weeks. This may not be timely or as accessible to you as it should be.

Currently, the Research Division, HERPICC, and FHWA are working together under Dr. Tommy Nantung's leadership in providing major reports in CD-Rom form. Remember a CD-Rom has 680 megabytes of memory and two CD-Roms can contain all the phone numbers in the United States. One CD-Rom can hold the entire Encyclopedia Britannica.

The user will be able to load the CD-Rom on his/her computer, scan reports of interest, and print just the pages they need. Many new computers come with CD-Rom readers. Also many agencies are beginning to provide reports in electronic form and paper reports may become a thing of the past or limited in their use. Research is also evaluating pen based computers to automate field data collection activities, thereby reducing paperwork and errors, and the data can easily be downloaded to other systems or programs.

In this fast paced, information age engineers, road supervisors, designers, contractors, and planners need timely information to make decisions and avoid costly delays and mistakes. New technology is available, we would be wise to use it.

Each of you in this room will be or have been approached sometime in your career about reusing a waste material in your road system, perhaps as an embankment or fill material, or in the

pavement itself. There are some strong associations and industries in Indiana facing large landfill costs and costly regulations, wanting you to reuse the waste materials they generate. I believe we should recycle when it makes economic sense, provides good roads, and the waste materials are environmentally safe.

Be advised all waste materials are not equal. Some provide good physical properties and are clean. Industry's often are willing to provide these materials to you at no cost, saving them landfill costs and reducing your material costs, thereby, making the reuse of the waste material economical.

However, we have found some waste types containing toxic products. In some cases waste streams within a particular plant or from a particular plant, within an industry, may contain toxins. If you bury material which contains hazardous material and it releases, or there is a threat of a release, you are liable under national Superfund legislation, just as the generator and transporters. Even contractors may be liable. You are, in essence, forever on the proverbial hook. Furthermore, what waste material you use today may be deemed safe by EPA or IDEM, but if later they are deemed hazardous you are then on the hook. Superfund was not meant to be fair rather to find deep pockets to pay for site remediation. There may also be OSHA concerns.

This is complicated by some state legislatures mandating the use of certain waste materials after being approached by industry associations. In 1991, the Indiana State Legislature mandated INDOT to conduct a feasibility study on the reuse of coal ashes, foundry sand, recycled materials, waste tire, building rubble and

Ebonite. Reuse of waste materials or recycling may sound politically correct, but you better know what your using! Costly litigation with scarce tax dollars, personal liability, and environmental cleanup can result.

These comments are not meant to dissuade you from reusing waste materials, rather to be informed. We should recycle our waste materials and we can minimize our risks through knowledge, good research and good planning. Through research between INDOT, Purdue and Industry, such as PSI, NIPSCO, and the Indiana Cast Metals Association, we are researching or considering over 21 applications of waste materials including the reuse of coal ashes, green ferrous foundry sand, waste tires, roofing shingles, rubber in soil as a lightweight fill, and recycled concrete and asphalt, which have been used for some time. Credit should be given to Dr. Bill Lovell and Mr. Dave Ward from INDOT for their work in this research.

We recognize all waste materials are not equal and some wastes may have toxins. Furthermore, we recognize that the current test methods or industry standards, such as the Toxicity Character Leachate Procedure, or TCLP, have shortcomings towards predicting performance of a waste material in a roadbed. Research was instigated with Purdue's Environmental Engineering Department under the direction of Dr. James Alleman and Mr. Chad Bastian to evaluate current test methods and develop new test methods to evaluate the environmental properties of waste materials prior to use to minimize the risk of using unsafe materials in road construction.

The test Dr. Alleman proposes (which is used in addition to the TCLP test) uses living bacteria in a Whole Effluent Toxicity (WET) test to determine their survival in the effluent from the waste material. The test is a bioassay test using Microtox test equipment. Simply stated if the bugs live there is an absence of toxins in the waste material. Quantification of test results is now underway and the test may be required when considering all waste materials. The new Bioassay test cost approximately $200 while a TCLP test may cost +$1000. The actual bioassay test can be ran in 30 minutes.

INDOT also has several waste material reuse demonstration projects in progress or planned. Last construction season INDOT placed an embankment on SR-12 in Gary, IN, utilizing 16,000 cubic yards of bottom ash as an embankment material, at a cost reduction to INDOT since there were minimal local borrow pits. Also last construction season, asphalt roofing shingles from roofing manufacture production waste was used in a Hot Mixed Asphalt (HMA) binder and surface, resurfacing project on SR-61 north of Booneville, IN.

Next construction season, use of commingled bottom and fly ash from the coal combustion process at the Indianapolis Stout Generating Plant will be used on I-465 and 56th Street as an embankment material. Industry will be providing the ash to the job site at no cost to INDOT.

Discussion is also underway towards using green ferrous foundry sand in an embankment project in the Fort Wayne area where a significant amount of clean sand is available. Eight flowable

fill projects using natural sand and possibly foundry sand are being planned for this summer.

Finally, this summer a Crumb Rubber Modified asphalt, made with shredded waste tires, will be placed on two miles of I-65 utilizing a "wet process" in an open graded (5C) base mix. And for the 1996 construction season, we are trying to find a project to use rubber soil in a lightweight fill application.

INDOT has also developed a 7 step process for considering new waste materials for reuse in highway construction. INDOT's short term goal is to consider and encourage the reuse of waste materials which are safe, cost-effective, beneficial, and practical, which are high reuse or high emphasis waste materials generated by Indiana industry or INDOT. It's long term goal is to define and consider other reuses.

Time is running short, but let me briefly mention some very cost effective ongoing research. In the cracksealing area, INDOT spends over $2.5 million annually for sealing transverse thermal cracks to prolong pavement life and to reduce the intrusion of water into the pavement system. This is a labor intensive operation, often requiring subdistrict crews to spend considerable time in high traffic areas. Some of the old seals last less than 6 months though cracksealing is programmed on a 2 year cycle.

Research conducted by INDOT and other states has demonstrated that new sealants have the potential to last up to eight years. Most of these sealants are hot poured polymers or crumb rubber modified asphalts which are applied at temperatures above 280°F. The crumb rubber asphalts are moderately priced and have been shown

to last at least three years, or six times longer, than INDOT's cold poured sealant. Research to assist in the implementation of these new hot poured sealants is ongoing. INDOT has purchased seven hot poured double boiler melters to apply the new sealants classified as ASTM D-3405 materials. It is expected that the implementation of these new sealants and equipment will result in a cost effective seals which should last up to 10 times longer than the old seals.

Another project with Dr. Jeff Wright of Purdue and Mr. Larry Goode and Mr. Bill Holloway of INDOT, developed a Computer Aided System for Planning Efficient Routes for snow removal called CASPER. Efficient winter snow and ice control in Indiana is heavily reliant on the efficiency of service routes reducing dead time, providing adequate manpower and trucks, and logistics. In Indiana, service routes must be specified for some 1200 routes located on a network of over 30,000 lane miles. CASPER optimally designs these service routes for maximum efficiency. In a period of just over 5 months, a redesign of approximately 75% of the state's routes has been completed with carefully measured and documented results, both tangible and intangible.

According to Mr. John Passey, Fort Wayne District Director, CASPER has reduced the number of snow routes in Fort Wayne by 8, resulting in about $400,000 in initial savings, mainly in equipment costs. In addition 8 routes are expected to be reduced in the Fort Wayne district resulting in additional savings in equipment, labor, and materials costs.

Statewide CASPER is estimated to save Indiana $8-10 million and actually improve the service level of highway snow removal and ice control for Indiana motorists. Furthermore, CASPER will allow for continued redesign of snow routes when there are changes to the system, and there are high expectations CASPER-like modelling can be done for other route-related maintenance activities, such as pavement stripping and mowing.

Another research project with Dr. James Morre of Purdue University has resulted in a cost-effective program of chemical mowing and roadside vegetation control. Currently INDOT has approximately 75,000 acres of roadside which are mowed each year with annual costs exceeding $5 million. Costs for mechanical mowing is $20-25/acre, per mowing cycle. Currently, 3 cycle mowing to maintain adequate site distance and visual appearances would cost between $60 and $75 per acre annually.

With chemical mowing, a single spring application of a combination of environmentally safe new materials gives season-long control of seedheads in bluegrass and fescue as well as control of broad-leaf weeds and suppression of grass growth.

Prior research with chemical mowing has already resulted in reductions from 5 cycle mowing to the current 3 cycle mowing, at an annual savings of over $2.5 million. Current research suggests present mowing costs may be reduced by an additional 50% or more.

Time also fails to describe a dozen other projects in detail which have resulted in cost savings, new technology, and improved service to Indiana taxpayers.

To mention a few by title and brief comment, such as the Borman Expressway Intelligent Transportation System currently being developed, and the existing Hoosier Helper program on the Borman Expressway. The LaPorte District uses incident response crews to keep traffic moving on the Borman thereby reducing further incidents and resulting accidents. Its been a huge success with credit going to Mr. Dan Shamo of the LaPorte District, Dr. Kumares Sinha from Purdue, and Mr. Dave Pluckebaum, Deputy Chief Engineer, who heads the INDOT-academia-industry Intelligent Transportation Systems Task Force.

The Friction Retesting Program and the Skid Accident Reduction Programs have used new technology advancements in INDOT's skid testers in the last 18 months to provide almost real time data to the districts, on potentially slippery roads and potential accident sites, thereby allowing the districts to take timely, remedial action. INDOT is involved in approximately 15-20 lawsuits each year as a defendant in wet weather accidents. Friction data has been used repeatedly to show INDOT was not negligent, but proactive in assuring the safety of Indiana roadways. Lawsuits often go after anyone with deep pockets, yet in some instances INDOT has been dropped out of the lawsuit when the plaintiff discovered we had the friction data, which is rigidly collected. Probable millions have been saved to Indiana taxpayers in lawsuits alone and more importantly lives have been saved through identifying potential accident sites.

INDOT also saves between $1.2-2.0 million per year in its undersealing program resulting from past research. The savings in

this case from undersealing that was not required, which may have been required under old test methods, in the past. This does not include savings resulting from prolong pavement life, from good subgrade support. Additional savings are expected from new overlay design procedures using the Falling Weight Deflectometer to design overlays for specific site conditions.

Two final research projects demonstrating savings and new technology are Dr. Luh Chang's research developing a Quality Acceptance System for Steel Bridge Painting and Dr. Mark Bowman's research regarding Fatigue Strength of Girders with Tapered Covered Plates.

Dr. Chang's work on QA for bridge painting resulted in revised specifications for bridge painting, new testing equipment and procedures, and training for INDOT bridge inspectors and engineers. A 50-75% increase in the service life of paint systems is anticipated.

Dr. Bowman's work with tapered covered plates developed repair methodologies for various cracked cover plate end details and developed an analytical model to predict fatigue behavior of the tapered cover plates.

In conclusion, we note that a strong transportation research program can be very cost effective and provide timely answers to real life problems. The savings from any one of the dozen projects mentioned today more than would pay for the entire cost of the INDOT Research Program.

Perhaps the real success is the close cooperative working relationship between industry, academia, and FHWA and INDOT

practitioners, towards solving mutual problems. The success of the Joint Highway Research Project is the resultant of many individuals and the support of the Commissioner's Office has been instrumental. Future successes are already on the horizon.

The real winner, however, is the Indiana taxpayer, our final customer, who reaps a return on his/her investment in an efficient/quality transportation system.

Thank you for your interest.

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