Implementation of Research

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INTRODUCTION

In the highway business, change is essential. Across this nation we have thousands of miles of highways which need maintenance and rehabilitation, and state and local highway agencies are struggling to find the funds necessary to do the work. The Interstate Highway Program began in 1956. Many of the early interstate sections are over 20 years old and many have carried traffic volumes far beyond their original design life. Design standards have evolved, and safety hardware is continually being improved. As I drove here on I-65, I was reminded of the diversity of the vehicles on the road today—mini-cars and macro-trucks. Twenty years ago we designed guardrail and breakaway devices for 4,000 or 5,000 lb. automobiles; today we have cars which weigh only 1,500 lbs. In the trucking industry the rising petroleum prices have had the opposite effect, with trucks becoming larger and heavier. Recently a state engineer mentioned a logging truck which was stopped for a weight check. The weight was 150,000 lbs., and the driver was fined for being overweight. One week later the same truck was caught again. This time it weighted out at 176,000 lbs. Can you imagine the effect of this overload on a country road, to say nothing of the effect on older bridges and culverts?

What about the bridge deck problem? "Concrete bridge decks throughout Indiana are suffering from premature and accelerated deterioration due to spalling. This is traceable to corrosion of reinforcing steel, and aggravated by extensive use of salt on bridges as required by Indiana winters. The current bridge deck reconstruction and repair program in Indiana is conservatively estimated at $37 million per year, and is not keeping up with accelerating needs." Now I know this figure sounds high, but it comes from a very reliable source, a 1977 Purdue research study for the Indiana Department of Highways.

How about the urban traffic control problem? In another Purdue study, the application of our Urban Traffic Control System (UTCS-1) for West Lafayette was investigated. The study indicated that "each weekday of the year the savings to motorists in this single city would total 173 hours, 150 gallons of gasoline and nearly 100 kilograms of carbon monoxide emission. These benefits could be obtained by simply resetting the signal controller timing dials as indicated by a computer printout.

Now that I've suggested a few of the problems that you and other highway officials across the country are facing, I'd like to describe some of the research which is attacking these problems, and some of the solutions which have been found.

HIGHWAY SAFETY

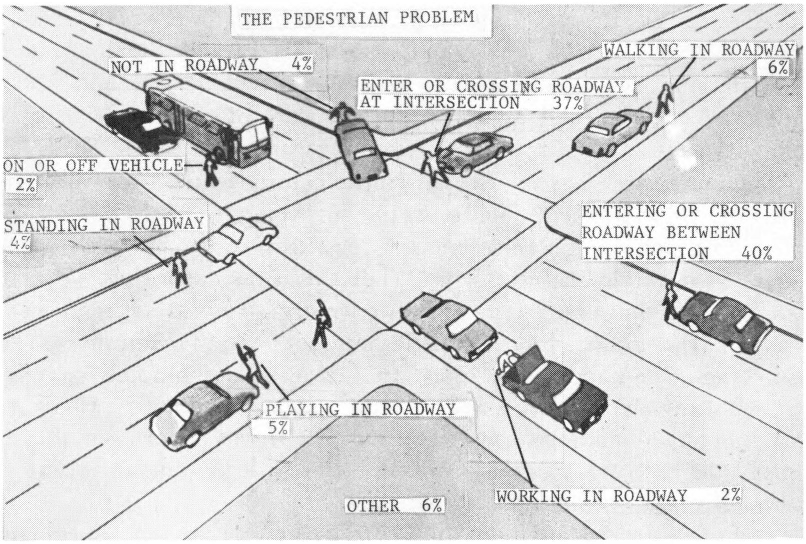
I'll start with the highway safety area. On average, one person is killed every 10 minutes in this country in a traffic accident, and one person is injured every 10 seconds. Research in highway safety is mandated by the Congress, our Administrator has stressed the importance of safety as an integral part of every highway design, and every highway engineer and administrator is aware of the potential legal liability associated with unsafe highway features.

Our research has shown that traffic control features are very important. Measurements made at 140 low-volume intersections show that stop signs produce the highest road user costs while yield signs resulted in the lowest user costs. While this is not surprising, we were surprised to find that the more restrictive stop signs did not reduce accidents. In another study, nine cities were surveyed to determine excess directional and regulatory signs. In 112 miles of randomly selected streets, only 20 of nearly 5,600 signs were found unnecessary. Contrary to popular opinion, excessive signing of city streets is not a significant problem. However, there are still problems with the amount of information contained on some signs.

Trucks are getting larger and cars are getting smaller. This helps our fuel consumption problem but aggravates the safety problem. Much of the roadside safety hardware was designed to handle impacts by the past vehicle fleet. We are now conducting crash tests and other research to extend the ability of this hardware to handle the smaller cars and larger trucks. Specific items being tested include concrete median barriers, new guardrail and bridge rail designs, and new slip base designs for wooden utility poles.

The self-restoring barrier, or SERB, guardrail has a tubular three-beam rail attached to the posts with hinged rods. Cables position the strong, stiff rail about one foot away from the posts. When the rail is impacted by a vehicle, it moves towards the posts and upward, simultaneously softening the impact and providing backspin that counters the tendency of the vehicle to roll towards the guardrail. After impact, the rail drops back to its original position and is automatically prepared for the next collision. Maintenance would not ordinarily be required for passenger car impacts. The SERB guardrail has been successfully tested at 60 m.p.h. with vehicles ranging from an 1,800 lb. Honda Civic to a 40,000 lb. intercity bus. Three states have agreed to install, maintain, and evaluate the SERB in high exposure locations.

Over 9,000 pedestrians are killed each year. See Fig. 1. To reduce this problem, New York, Baltimore, San Francisco and Boulder are using our model pedestrian safety program manual to help select pedestrian improvement measures. Three cities are also using our recommendations to develop pedestrian corridors for the elderly and handicapped. I should note that our pedestrian measures are useful for small as well as large cities.



Road Revenue Sources for State and Local Government.

TRAFFIC OPERATIONS

In the traffic operations area we are continuing to develop and refine computer programs for traffic simulation and control. The objectives of an enhancement project are:

- Minimize Cost of Implementation
- Increase Reliability and Improve Performance
- Standardize Software
- Minimum 10-Year Service Life

I've already indicated that the original version of the Urban Traffic Control System was tested in West Lafayette. We have been working for several years to improve this program and our enhanced version is now being field tested in Birmingham, Alabama. I regret the delays which have occurred in this work, but feel that we must have the program debugged before it is put into full operation. The program printout stands 6 ft. high and contains over 500,000 lines of code, so one can imagine the time required to get a program that is both clean and portable. Portability of computer software is an important issue. We are making a strong effort to ensure that our computer progmams are readily adaptable to the large variety of main frame computers which are in-place in state and local highway agencies.

Another area that we are investigating is the use of mini and micro-computers for traffic control. Right now the technology is advancing rapidly and there is no universal program language available. One of the reasons for the technology explosion is the strong R&D effort by private industry. A recent feature article in *Time* magazine indicated that one of the companies which produces desk top computers is spending $20 million per year on R&D. This represents 10 percent of their gross sales.

We have found an additional problem with computer programs. When your experts start using them, they find additional modifications and improvements which can be made. To keep track of these improvements, and to provide technical assistance when needed, we have worked with our Office of Traffic Operations to determine the feasibility of a traffic software support facility. The OTO support center is now expected to be in operation this summer.

MATERIALS

Even before the last round of oil shortages, we had work underway to reduce the requirements for petroleum based materials in highway construction and maintenance. Sulfur, with appropriate modifications, has been investigated as a substitute for asphalt and numerous test sections have been placed around the country. At the current cost of approximately $140 per ton, sulfur substitutes are not economically feasible for wide scale application. By the middle of this decade, however, the price comparisons between asphalt and sulfur could change substantially. When that time comes, we expect to have good information on the sulfur, and field test data on the durability of the pavements constructed with these materials.

In my opening remarks I mentioned the bridge deck problems here in Indiana. All of the states with snow and ice control programs have experienced problems with steel corrosion and concrete deterioration. We have conducted substantial research to solve this problem. Outdoor exposure tests on large salt-contaminated slabs continue to show that epoxy-coated reinforcing steel provides long-term protection against widespread corrosion in bridge decks and other concrete members. But what about the decks which already have chloride contamination and corrosion? We've studied various rehabilitation actions, such as conventional overlays, membranes, and sealers, and found none of these stops corrosion. Our data show that experimental restoration procedures currently in widespread use do little to reduce corrosion and actually provide only structural repair and improved ride quality.

But the picture is not bleak. Tests in both the laboratory and the field have shown cathodic protection stops corrosion regardless of the salt content of the concrete. The technology associated with cathodic protection of bridge decks has been advancing rapidly. Sufficient information is available now to ensure that applying properly engineered cathodic protection to a reinforced concrete deck will not adversely affect structural integrity and will provide long-term protection. It is now possible to apply cathodic protection to an existing deck without using an overlay or to combine cathodic protection with the overlays typically used in deck rehabilitation. We have recently analyzed the cost implications of applying cathodic protection to bridge decks which now show only minor distress, and have estimated up to 20 billion dollars can be saved by preventing high cost concrete removal in the future.

We would also like to eliminate the problem of chloride contamination at the source; by finding an acceptable substitute for rock salt or other chlorides for highway deicing. A compound called calcium magnesium acetate (CMA) has been identified as the most promising substitute because it does not contain the corrosion-accelerating chloride ion nor the water-polluting sodium ion. Research is planned to develop an efficient method for commercial production of CMA (there are no current commercial sources), to further determine its environmental acceptability, and to determine the most efficient methods for its application and use. In the future, you may be sending out CMA crews rather than salt trucks in the winter.

Many engineers have questioned whether paving grade asphalts have changed because of new crude oil sources and modified refining techniques. Data provided by the states for 97 asphalts show that significant changes in asphalt properties occurred between 1950 and 1980. Temperature susceptibility has increased and limited data show an increase in shear susceptibility. In addition, the chemical composition of asphalts has changed and there is more variability. Several new predictive techniques are being developed to help pavement designers work with the newer asphalts.

STRUCTURES

Our structural research program includes both bridge and pavement structures.

Many of the older through-truss highway bridges have been found structurally inadequate for present traffic. An upcoming report will describe ways to upgrade the structural capacity of these bridges, thus precluding the need for early bridge replacement at many locations.

Controlling overweight vehicles is a continual problem in some areas. Fixed weigh stations can be easily avoided and portable scales require time losses for both the truckers and the enforcement officials. Working with state highway officials, we have used a new FHWA bridge weigh-in-motion (WIM) system during the past year to get moving vehicle weights on bridges in nine states. The complete WIM system can be housed in a small van or trailer and can be operational at a bridge site in a few hours.

Although most of the motoring public only sees the top of the bridge, engineers realize that piers and abutments can be affected by stream changes and movements. When it is determined that a stream is unstable effective countermeasures, must be used. We have some good information available describing stream problems and solutions.

MAINTENANCE

In the maintenance area, we have been testing various formulas and applications for polymer concretes. The material has been used successfully to repair potholes in PCC pavement. After the deteriorated concrete is jackhammered and sandblasted, the polymer concrete is placed like conventional PCC. The finished product looks like conventional concrete but there are several differences. It cures in 1 hour or less at temperatures ranging from 0-100°F and reaches a compressive strength of 8000 psi. It has been successfully used by many states with few problems. I must warn that the current cost is $600 per cubic yard, so it must be used selectively. The material can also be used to repair cracks in PCC pavements.

Another type of polymer-concrete material is a built-up overlay for bridge decks. Polyester or vinyl ester resin is placed on a cleaned bridge deck and fine silica aggregate is broadcast on the resin. After the resin has cured, the process is repeated 3 times and a final thickness of 1/2 in. is reached. The completed overlay is impermeable to deicing salts and extremely skid resistant. Skid numbers in the high 50's and 60's have been maintained for 3 years in our current field test sections. The 4 layers are easily placed in 1 day and the in-place cost is $20-25 per sq. yd. The overlay material is particularly useful when combined with cathodic protection. The material appears to have a good future.

Another activity I would like to mention is our value engineering (VE) series for maintenance. In this program several states form a team to evaluate selected maintenance practices and determine unnecessary and inefficient activities. In the past 6 years, 30 states have been involved in 12 different studies, and they have estimated annual cost savings over $8 million because of the value engineering recommendations.

The first two VE studies focused on snow and ice control. The four states involved in these studies determined they could reduce the amount of deicing materials by 20 percent as a result of these studies.

Another VE study covered bituminous patching. The states in this study found that proper hole preparation and compaction will increase the life of the patch. Our only problem with the VE series has been production of enough reports to meet the requests for copies from county and other local highway agencies.

The final item that I will describe affects highway safety, traffic operations and your maintenance budgets. Nationwide, state and local highway agencies use 30 million gallons of traffic paint and, with the initial painting and maintenance costs, spend over $200 million annually for pavement markings. A new, more durable epoxy themoplastic (ETP) pavement marking material has been developed and field tested. The material consists of two epoxy resins, calcium carbonate, pigment, and premixed glass beads. The composition of the epoxy themoplastic pavement marking material is as follows:

60 lb	Solid Epoxy Resin (Araldite 7097 or Equivalent)
40 lb	Liquid Epoxy Resin (Araldite 6010 or Equivalent)
20 lb	TiO_2 (white) or $PbCrO_4$ (yellow) Pigment
20 lb	Calcium Carbonate Filler
28 lb	Premixed Gradation Beads
168 lb	TOTAL DENSITY 13.1 lb/Gallon

The material is heated to 450°F and sprayed to a thickness of 15-20 mils. Since it is a 100 percent solids formulation, the dry thickness is the same. In field tests the no-track time was 5 seconds, eliminating the need for coning during application.

Presently, the ETP material costs twice as much as conventional traffic paint. However, under the worst test conditions, ETP lasted twice as long as paint, and on the average it last 5 times as long. Under a wide range of conditions, the use of ETP can result in a 60 percent savings over traffic paint. With nationwide use, this translates to a potential savings of $120 million per year.

SUMMARY

I emphasize change because that's what the implementation of research is all about. Nationwide, nearly $50 million a year is spent on highway research, development, and technology transfer. This money is wasted if the new technology is not put into practice by state, county and city highway officials. We're going to do our part to develop technology that you need, and to get it to you. I hope that you will do your part.