The Strategic Highway Research Program (SHRP)

Damian J. Kulash

Executive Director, SHRP

The Strategic Highway Research Program (SHRP) is a five-year, $150 million research program that focuses on some of the biggest, most expensive problems facing highway agencies in the United States and around the world.

The program was authorized by the U.S. Congress in the 1987 highway bill. It was first proposed in 1984 by the Strategic Transportation Research Study (STRS) — Highway Committee, which was administered by the Transportation Research Board. Chaired by Thomas B. Larson, who is currently the U.S. Federal Highway Administrator, the STRS committee examined the focus and structure of U.S. highway research programs.

At a time when the deterioration of U.S. transportation and public works systems was very much in the public spotlight, the STRS committee offered innovative technology as a solution. The STRS committee proposed SHRP as a highway research program that would concentrate on a short list of high-payoff activities, where even modest progress would yield savings many times in excess of the research costs. It proposed that SHRP focus on four major technical research areas:

- Improved performance of asphalt materials;
- Improved concrete and the protection of reinforced concrete structures;
- Efficient methods of highway maintenance, including control of snow and ice (Highway Operations); and
- Long-term durability of pavements.

SHRP was planned as a different kind of research program. Four distinguishing features of SHRP have been:

Accelerated: The research was initiated as quickly as possible, and the program was structured to sustain intensive activity throughout its five-year life, and to complete its activities during that period.

Dollar-driven and Performance-oriented. The research topics were chosen because they can result in technologies and performance improvements that have the potential to generate large financial savings.

Management-directed. The research topics were selected in response to the stated needs of highway agency managers, and these managers also play an active role in steering the research toward usable results.

Product-oriented. SHRP mobilized existing and new scientific expertise to develop pragmatic products of immediate use to highway agencies. Many of these research products will fall into four general categories: new materials, new tests, new specifications, and new equipment.

Some 94 separate products are being developed within SHRP (Table 1). More than half of these planned products are improved specifications and test methods; thirty-three new specifications that will help identify better-performing materials and designs; and twenty-six new test methods that will support more performance-oriented specifications. Other products include new materials, new equipment, computer software, manuals, and training aids.

TABLE 1
Summary of Major SHRP Products
(Separate Products Planned Under Contracts in Each Research Area)

	Asphalt	Concrete& Structures	Pavement Performance	Highway Operation	Totals
Equipment	—	2	—	9	11
Materials	4	3	—	2	9
Specifications	6	5	17	5	33
Test Methods	9	14	3	—	26
Software	—	—	2	—	2
Manuals	1	5	2	2	10
Training Aids	—	—	—	1	1
Other	—	—	2	—	2
Totals	20	29	26	19	94

A rough preliminary analysis of the most important products revealed that widespread adoption of these could save the United States more than $500 million annually (Table 2).

SHRP is a unit of the National Research Council (NRC), a private, non-governmental organization created to bring scientific and technological information to bear on government decisions and operations. SHRP works closely with state and federal agencies, as well as with many overseas, municipal, and other organizations. The numerous field experiments being performed within SHRP are conducted in collaboration with operating highway agencies.

At this point, SHRP is a little over halfway through the research program, both in terms of time and in terms of expenditures. Due to the enormous scope of activity, I cannot possibly summarize here all that we are doing and all that we have learned. Instead, I'd like to highlight just a couple of areas where we're making strong progress and have already produced useful results, as examples of the type of progress we are making throughout the program.

In the asphalt area, SHRP is using a wide range of advanced materials characterization techniques that have not been applied to asphalt previously to determine how asphalt material properties affect pavement performance. SHRP is applying this greater scientific understanding to the development of two key research products: performance-based specifications for asphalt binders; and performance-based specifications for asphalt-aggregate mixtures. Work is progressing well, and we are reaching convergence both scientifically — regarding the chemistry and mechanics of asphalt performance; and organizationally — regarding the form that the specifications will take.

TABLE 2
Expected Annual Savings Attributable To Key SHRP Products
(in millions)

Product	Potential Annual Savings	Percent Probability of Success	Expected Annual Savings
1. Binder specification	300	90	270
2. Mixture specification	300	90	*
3. Phenolic-resin coating	25	60	*
4. Blister test	60	65	*
5. Electrochemical chloride removal	20	50	10
6. GPR evaluation of covered decks	5	60	3
7. Concrete curing table	3	90	3
8. Aggregate durability test	10	40	4
9. Cathodic-protection manual	20	90	18
10. Preventive-maintenance manual	45	90	41
11. Patching & crack-filling specification	5	90	4
12. Worker protection barrier	5	60	3
13. Work-zone warning device	5	70	4
14. Improved deicing chemical reaction	10	70	7
15. Road weather information systems	30	60	18
16. National traffic database	30	70	21
17. Distress identification manual	64	75	48
18. Drainage specifications	40	90	36
19. Rehabilitation guidelines	50	75	38
Total Annual Dollar Savings 19 Key Products			528

*Included in estimate for Product 1, above.

On the scientific front, we are gaining understanding regarding the specific chemical components that are the keys to asphalt performance. Working with ion exchange chromatography, researchers at Western Research Institute first noticed that performance characteristics were closely linked to the strong acid fraction of the asphalt. They later realized they were actually measuring several different types of polar materials, including amphoterics. They then separated out the amphoterics, and found them to be a key performance factor.

An amphoteric material is one that can act as either an acid or a base, depending on its surroundings. Although these materials constitute only ten to fifteen percent of asphalt, they appear to control its resistance to rutting, its aging, its moisture sensitivity, its adhesion, and its viscosity.

When the amphoterics are removed, the asphalt's performance changes. Viscosity drops dramatically, and other performance-enhancing features are diminished. Based on a large volume of research results from several SHRP projects, we're hypothesizing that they also control adhesion (to aggregates), and its response to traffic and climate-related stresses. Moisture sensitivity, too, is related. We still have to prove that, but it's a consistent hypothesis. The researchers currently are searching for simple ways to exploit this new knowledge about amphoterics, using inexpensive tests.

Preliminary drafts of the specifications have been released and reviewed by asphalt producers, highway agency users, construction contractors, and other interested parties. Based on the pragmatic and technical input of these potential specification users, the drafts are being refined. This iterative process will continue during the remainder of the research so that those who will be using the specifications will be familiar with them and will support their use. To date, SHRP has released two drafts of the binder specification, and one of the mixture specification.

The specifications will define materials requirements in terms of limits — or ranges — of test results for measurable performance characteristics. Each specification will include specialized standard test methods and/or conditioning schemes to address six pavement performance factors: permanent deformation, fatigue cracking, low-temperature (thermal) cracking, adhesion, moisture sensitivity, and aging. These six factors are among the most common causes of pavement failures.

Each of the six performance factors is influenced to a greater or lesser extent by physical and chemical properties of the asphalt binder, and by engineering properties of the asphalt-aggregate mixtures. The proper specification of these properties will permit the selection of materials with improved performance. For example, these specifications will assist engineers in selecting combinations of existing materials that are suited to a project's specific site demands. Or, they may assist in the selection of materials that have been specially modified to achieve high performance. In both instances, they will make it easier for engineers to work with high-performance materials.

Not all of SHRP's products depend upon complex, state-of-the-art chemical characterization, however. Often, even simple, low-cost tools can help us do a more cost-effective job.

In the concrete area, for example, SHRP has just released the *Handbook for the Identification of Alkali-Silica Reactivity in Highway Structures*, which is intended for use by highway engineers and bridge inspectors to help them spot and fix this very damaging and difficult-to-detect problem.

Alkali-silica reactivity (ASR) occurs when silica or silicates in aggregates react with alkali in the cement to form a gel-like substance. The gel absorbs water and expands. Within a few years, this expanding gel can crack the concrete. The process is irreversible, and often leads to serious structural damage.

Some areas of the country are more susceptible to ASR problems than others. The regional variations are due to the fact that ASR requires the presence of both moisture and reactive aggregates. Pavements in wet climates are more likely to develop ASR earlier, but pavements in very dry climates are often affected too, due to moisture from the subgrade. Of the many aggregates that contain silica, only some contain the potentially harmful reactive silica substances. When in doubt about the reactivity of an aggregate, an engineer can test its ASR propensity before using it.

Accurate detection of ASR is important. It is the key to choosing the best rehabilitation strategy. It also helps highway agencies avoid making the same mistake again. But ASR often goes undetected. It is easy for inspectors to confuse the cracks caused by ASR with other types of damage. Similar-looking damage can be caused by improper curing, corrosion, or freeze-thaw damage, for example. Often more than one problem is present at the same time. A bridge may be suffering from corrosion-induced damage as well as ASR.

If the problem is misdiagnosed, the treatment will be inappropriate. For example, cathodic protection (an effective treatment for combatting corrosion) would not prevent the spread of ASR damage in bridges. In fact, cathodic protection of an ASR-damaged structure could aggravate the ASR problem. Yet it would be easy for an inspector to overlook ASR problems once chloride corrosion has been spotted.

Correct diagnosis of ASR also is essential to prevent repetition of the same mistake in new construction. Reactive cement-aggregate combinations can be avoided by using available tests. Quicker and more reliable screening tests will be available soon.

Proper diagnosis and assessment involves two steps: visual inspection and chemical testing. In the early stages of reactivity, or under conditions where only small quantities are produced, ASR gel usually cannot be seen by the unaided eye, and is revealed only with difficulty by a skillful observer using a microscope. Because the early stages of ASR are not apparent, ASR may go unrecognized for years before associated severe distress develops.

SHRP has developed a field test for detecting ASR prior to the development of serious distress. The field test uses a uranyl acetate fluorescence method to detect whether an ASR product has formed in the portland cement concrete.

The uranyl acetate solution will cause the ASR gel to fluoresce, imparting a yellowish-green glow, when viewed in the dark under an ultraviolet light. This method is both rapid and economical.

IMPLEMENTATION OF THE RESEARCH RESULTS

From the beginning, SHRP has been a practical, product-oriented program. The research agenda was developed based on practical needs, and the research plans stress useful products. In selecting the research contractors, we considered their ability to reduce results to practice.

Research progress is overseen by practically-oriented highway agency officials, who are a dominant voice on SHRP's Executive Committees, Advisory Committees, and Expert Task Groups.

The interim products of the research are evaluated and refined through field trials. All fifty states are involved in field tests for the Long-Term Pavement Performance program. In addition, forty-six states are involved in pilot testing of prototypes and "early models" of various products. In total, there are about 370 instances of these state field trials of SHRP products now planned or underway.

This hands-on participation is critical. It gives our research team valuable information about what works well, and about what does not. It stimulates useful product refinement. It also gives potential users full and realistic knowledge of the product, and helps to speed product implementation.

These are important steps, and I am pleased at the level of state involvement in product assessment. These are essential steps to ensure that SHRP's products will be implemented. But will they be able to complete the job?

No. In spite of SHRP's heavy emphasis on usable products, SHRP's resources always have been concentrated on product development, recognizing that

implementation needs would extend beyond SHRP's scope and time frame. The report that originally proposed SHRP, *America's Highways; Accelerating the Search for Innovation*, noted:

> ...its proposals are only one part of successful implementation. It seems certain that the widespread and effective application of innovative materials and techniques will also require changes in training, procurement practices, and other phases of implementation that cannot be thoroughly addressed until the findings of the proposed research are known.

SHRP is now at a stage where attention is being given to those next phases of implementation. In August of 1990, the SHRP Executive Committee forwarded an implementation plan to the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and the National Research Council. This plan included seven implementation activities:

Field Trials and Demonstrations. Grassroots support, which is vital to successful implementation, can be accelerated by providing state engineers with the opportunity to pilot test SHRP products, or to demonstrate them in their individual circumstances, working with contractors and suppliers as appropriate. These test and demonstration activities provide all parties involved with a realistic, hands-on opportunity to learn about and evaluate new products.

Training. Courses on SHRP products, jointly developed with contractor associations and industry groups, and coordinated by FHWA and AASHTO, can be an efficient way to reach a greater number of product users and to keep all parties coordinated as implementation proceeds.

Audio-Visual Materials. Videotapes, manuals, and other published materials will be needed to support all aspects of the implementation effort. Clear and useful audiovisual materials can be used to spread know-how to thousands of agency staff members, supervisors, contractor personnel, and suppliers who could not be reached through training programs or other activities.

New Test Equipment. Many SHRP products involve the use of new tests, often requiring new testing apparatus. Taken together, and arising at approximately the same time, these costs could constitute a major implementation barrier. Implementation could be accelerated by providing funding for the acquisition of SHRP test equipment.

Acceleration of Standards Adoption. The use of SHRP products can be accelerated by encouraging AASHTO, ASTM, and other standards-setting groups to adopt these standards on an expedited basis. It is prudent to reserve some resources for stimulation of industry awareness, and to accelerate the testing programs that underpin the standards-setting processes.

Adaptation to Changing Conditions. Wherever possible, future needs have been anticipated in product design. It is to be expected, however, that the next five years will bring some unforeseen shifts in conditions surrounding highway construction and maintenance. Some continuing support is needed to refine SHRP products to fit changing future conditions, and, where appropriate, to advise regulatory agencies on the implications of potential changes under consideration.

The Executive Committee recommended that $50 million be devoted to SHRP implementation in the 1992-1997 period (Table 3). FHWA, AASHTO, and the NRC currently are developing a way to accomplish this goal using FHWA facilities and preserving SHRP's state-oriented perspective.

TABLE 3
Key Aspects of Successful Implementation

	($ in millions)
Field trials and demonstrations	14.5
Training	7.0
Audiovisual materials	4.0
New test equipment	10.0
Acceleration of standards adoption	4.0
Commercialization	5.0
Adaption to changing conditions	5.5
Total	50.0

CONCLUSION

The unique organizational features of SHRP — that it is accelerated, dollar-driven, management-directed, and product-oriented — have not always been easy to achieve, but they have helped to generate extraordinary professional participation and broader understanding of pragmatic concerns. The highway industry leaders who created SHRP posed a difficult and important challenge. In response, professionals in state organizations, industry, universities, and elsewhere have risen to the challenge, and have kept SHRP on the ambitious course that was set for it. SHRP has become the largest single highway research program now under way in the United States. The early results are promising, but much remains to be accomplished before SHRP achieves its goals. We remain confident that innovative technology will improve the performance and durability of our highways.