Background

State highway agencies (SHAs) are entering a challenging era defined by a number of restraints that are, most likely, here to stay. These include:

1. New demands related to sustainability including demands for using new or emerging materials
2. Diminished funding for construction and maintenance significantly increasing the need for durability and long-term performance
3. Significantly reduced resources (i.e. people and funds) to establish the performance of new materials, and related technologies, or perform infrastructure research in general
4. A limited number of universities where applied research is performed in a timely, cost effective manner

Each of these will be discussed in more detail.

1. New demands related to sustainability including demands for using new or emerging materials

The portland cement concrete (PCC) industry is increasingly developing new technologies that offer opportunities for reduced first costs and life-cycle costs, improved performance, and significant improvements in sustainability. Sustainability improvements associated with new PCC technologies typically center on reductions in greenhouse gas emissions and the embodied energy of as-constructed structures. Most notable of these new PCC technologies are materials introduced to supplement or replace the portland cement, coal fly ash, and natural aggregates currently used to produce PCC. In most cases, current specifications do not allow for use of these emerging materials. To develop specifications for these materials, long-term performance must be established through a combination of laboratory and field tests.

2. Diminished funding for construction and maintenance significantly increasing the need for durability and long-term performance

In general some owners, architects, and engineers are able to capitalize on new PCC technologies in ways that present a minimal risk to all stakeholders. Unfortunately, a SHA typically cannot assume the risk of adopting new technologies and first must fully establish the cost effectiveness, constructability, durability, operational efficiency and safety of the resulting structure. As stewards of what is becoming limited taxpayer money, SHAs are obligated to achieve the lowest possible first cost and life-cycle cost without sacrificing safety or long-term performance. That is, even though sustainability goals are important, classic performance metrics must still be met before moving to any new material or technology.

3. Significantly reduced resources (i.e. people and funds) to establish the performance of new materials, and related technologies, or perform infrastructure research in general

Although it is fair to state that SHAs are “risk adverse”, and rightfully so, SHA engineers do clearly realize that adopting new technologies may facilitate their mission to achieve the lowest possible first cost and life-cycle cost without sacrificing safety or long-term performance. However, in today’s economy an individual state does not have the resources to vet new technologies, either in-house or through sponsored external research. Even if the research and development funds are available, most SHA engineers are occupied with the day-to-day operations of construction and maintenance leaving little to no time for managing or conducting studies of new products. Looking forward, federally sponsored research is shifting towards areas such as safety, asset management, and alternative fuels. Support for infrastructure research will most likely remain flat at best. Given the constraints on people and funds, any solution to this problem will in some way need to be a cooperative effort of many states.

4. A limited number of universities where applied research is performed in a timely, cost effective manner

Currently, SHAs turn to universities for research, which could include the evaluation of new materials and technologies. Success under this model is on a case-by-case basis with some very notable successful relationships. However, the anecdotal evidence indicates these successes may be the exception. The classic university research model simply does not serve the needs of a typical SHA. This stems from the general fact that universities and SHAs have very different needs and goals. Where an SHA engineer is looking for applied research using proven testing methods that provide engineering data to correlate new material performance with existing material performance, a university faculty member is often seeking cutting edge results that bear scientific merit without respect to the immediate engineering implementation of the results. The university is, in general, looking for basic research *grants* that have very limited deliverables, if any, but lead to numerous publications and provide external support for graduate students. SHAs need the skill level found at a university with respect to research, but need work performed under *contract* with very specific deliverables and on a budget that makes supporting graduate students quite difficult. Another issue between universities and SHAs is the time to complete the necessary research. Universities generally work in two-year blocks where a Master's student takes approximately two years and a Doctoral student takes approximately four years to complete their respective degrees. As a result, research projects are tied to this same timetable and often projects take longer than required to complete. It's worth noting that some of this time is spent training students, which is both beneficial and problematic. The beneficial outcome is the transportation workforce is enhanced through this training but the problematic outcome is a transient, untrained workforce is doing the research being performed. Most successes with respect to university-conducted SHA research can be traced to those universities where an established staff-based research center at the university has conducted the research outside of the academic constraints of scholarship or the need to support graduate students. Unfortunately, like SHAs, universities are also under-resourced and need to look at sponsored research as a means of supporting their core business: education. Therefore, universities do not typically invest in professional research staff or allocate other resources (e.g. space, equipment, and funding for laboratory accreditation) without the guarantee of a program to support those investments.

To summarize, SHAs have a need for applied research performed by highly skilled researchers but done in an environment where the investment supports only the conduct of the research, not broader university needs. Also, the results need to be provided with the shortest possible turn around time, and the quality of the work must not be in question (i.e. accredited laboratories by trained and experienced technicians). In addition to current research needs within each state, the looming national need is to evaluate and implement new materials and related technology to positively affect sustainability without sacrificing performance. With respect to this last point, an alternative approach is for the SHA to allow the champion (i.e. producer) of a new material or technology to seek their own testing results and demonstrate to the SHA the performance of their technology. However, the history is that such testing is rejected out of hand by the SHAs because it was not conducted under the SHAs supervision, a requirement to establish the veracity of the results. Compounding the problem, if a producer were to collaborate with a SHA to have the testing performed, there is then a need for a mutually acceptable, independent laboratory to conduct the testing in a manner where both parties can have input into the testing regime, have access to the data, and most importantly both parties are willing to accept the results as being a "fair assessment". Although commercial laboratories exist that are willing and able to perform this work, and a handful of universities are also capable of providing this service, none have been sanctioned by the SHAs as being acceptable for this task, leaving no clear options for having the testing performed. Without SHA support for a materials evaluation program at either a private lab or university, there is no clear path forward to move new materials into transportation infrastructure construction.

Proposal

It is proposed that a Concrete Materials Technology Research and Implementation Program (CMTRIP) be established as a pooled fund effort to address the needs of SHAs with respect to concrete materials applied research and evaluation of emerging materials and technologies. The program would be supported by a combination of funding sources that must include industry but be led by the participating states through a pooled-fund process. Other possible sources of support include the Federal Highways Administration (FHWA) and the Research and Innovative Technology Administration (RITA). The laboratory contracted would perform research under the guidance of a Technical Panel established by all stakeholders (e.g. SHAs, Industry, FHWA, RITA) but with a majority representation of SHA personnel. Any single stakeholder, or combination of stakeholders could fund research, but the Technical Panel would direct the research program. The Technical Panel would establish an annual research program for the CMTRIP, and the CMTRIP researchers would be accountable to the Technical Panel. The annual program would be designed to accomplish a longer (i.e. three – five years) strategic and tactical plan also defined by the Technical Panel.

Benefits

- The CMTRIP would provide the participating states with a means to leverage their limited research dollars with funding from other states and from industry.
- Producers will have a clear process for introducing new materials into transportation construction.
- SHAs and industry will have access to a laboratory capable of performing applied research using proven testing methods that provides engineering data to correlate new material performance with existing material performance.
- The CMTRIP would operate as a staff-based research entity capable of providing results in the shortest possible time, thereby accelerating adoption of new technologies.
- Research and testing conducted by the CMTRIP would facilitate adoption of new materials that offer opportunities for reduced first costs and life-cycle costs, improved performance, and significant improvements in sustainability.
- Deliverables from CMTRIP research would include draft specifications and test methods necessary for adoption of new technologies.
- The CMTRIP would interface with the CP Tech Center and other entities to facilitate technology transfer to the member states.

Discussion

The CMTRIP could take on many different forms but at a minimum, there are two different models. The first is to establish a staff-based research center at a university, or group of universities, to perform the required research. The second option is to contract with a private laboratory to perform the required research. Each model has pros and cons and will be discussed here.

1. Establish a staff-based research center at a university, or group of universities, to perform the required research

Although universities in general are not always the best research partners for a SHA, and vice versa, as stated previously some successful models exist and these typically are associated with a professional staff-based research center at a university. A staff-based research center offers a combination of two worlds where on the one hand, the advanced technological resources of the university are at the disposal of the researchers (e.g. electron microscopes, state-of-the-art library resources, etc.) while on the other hand, the individuals doing the research are not tied to the tenure process, scholarly productivity, and graduate education. In some respects, this model is attractive but there are also other considerations. First, most universities simply would not allocate space or other resources to such a laboratory as its focus diverges from the core mission of graduate education and scholarly research. However, some universities will support such a laboratory being established at their institution so it is not a moot point. Those universities who will enter into a CMTRIP partnership will likely do so only with some level of guaranteed funding (i.e. a 3-5 year program at a guaranteed funding level). Unlike private sector laboratories where higher indirect costs and fees are levied to assist in supporting staff between projects, universities are limited to a federally audited Facilities and Administration rate (i.e. overhead rate) that by design, does not recoup all of their true indirect costs. Therefore, there is no mechanism to support staff beyond a project duration and attracting quality staff with only a few months guarantee of work is next to impossible; hence the need for a guaranteed program. As a first estimate, a $250K – 400K dollar per year research program would be needed to support by the CMTRIP at a university, depending upon the final technical scope of the program. This support would in essence represent "pre-paying" for services. That is, once the center is funded, individual projects would be executed with little or no additional costs. Examples of additional costs might include materials or travel. Further, as a center, rather than having multiple contracts for multiple research projects, the pooled-fund would be responsible for overseeing the center only and the CMTRIP would perform most of the required project administration as part of the contract. Therefore, the administrative burden on the pooled-fund lead state would be lessened. Another advantage of a university-based center is the option for including some undergraduate students as hourly employees working with technical staff on a project thereby exposing new engineers entering the work force to the latest technology.

It is worth nothing the Midwest Roadside Safety Facility (MwRSF), part of the University of Nebraska-Lincoln, is a successful university-based facility that could be used as a model for the CMTRIP. The MwRSF performs joint-development of crash safety systems for the 17 states supporting the Midwest States Pooled Fund Crash Test Program TPF-5(193). They also perform specific testing and development for individual member states in the pooled fund that is of unique interest and solely supported by that state with additional funding above their annual pooled fund commitment. Last, they perform product evaluation, development, and research for private industry. The pooled-fund accounts for about 1/3 of their total research portfolio and is managed as a separate program from the individual state projects and the industrial supported projects.

2. Contract with a private laboratory to perform the required research

This model offers the distinct advantage of a lower initial cost. A private sector laboratory would expect to only receive individual projects, not a program. Therefore, if the pooled-fund was unable to support a university-based program, this is an equally acceptable alternative. The private sector lab would have professional staff, accredited labs, and supervision by professional engineers. Being private sector, the lab would be very responsive to the SHAs needs and their effort would not be diluted by other duties or responsibilities, as is the case at a traditional university laboratory. Although portions of the project cost would be higher than costs at a university, an advantage is every dollar spent goes towards completing the project, unlike most universities where a significant portion of the research supports graduate student class tuition over and above their stipend (i.e. compensation).

A common reaction to a private sector laboratory is concern over the laboratories independence. That is, if a private sector laboratory is working for both a material provider and an SHA, then the laboratory is not impartial. It is worth considering this argument in detail as it is often the only argument against a private laboratory. First, a professional engineer will stamp any report coming from a private laboratory. This is not the case at all universities. Therefore, if falsified or erroneous results are provided, the SHA has legal recourse to pursue malpractice claims against the laboratory. Second, by definition a private-sector lab is in business and relies on repeat customers. Providing biased results to one client in an attempt to favor another is a sure recipe for failure. The only option for a private sector laboratory is to do the best work possible and report it truthfully, letting the chips fall where they may. Next, the evaluation of new materials will result in picking winners and losers. Therefore, it is difficult for any publicly funded institution to place themselves in that role. It almost has to be a private sector endeavor. And last, if you think universities are impartial, think about how an unrestricted monetary gift from a company to a university might affect the thinking of a university faculty member or administrator. Overall, whether the CMTRIP is conducted through a university laboratory or through a private sector laboratory, it is the oversight of the Technical Panel that will ensure impartiality in any research conducted.

Issues to Be Considered

To move forward with the CMTRIP concept, there are a number of issues to be resolved. The list provided here is not all-inclusive but identifies the key areas to address in forming the CMTRIP.

Should the CMTRIP be based in the public sector (i.e. university) or private sector (i.e. for-profit testing laboratory)? In the end, the funding model will likely determine this. Project funding tends to favor a private sector approach while program funding could be used in either a public or private sector approach. Other considerations are the required startup resources that include staffing, equipment, laboratory accreditation, and reporting structure. Each of these will be dependant upon the model adopted.

How to establish the contract (i.e. program, projects, sole source, open RFP)? Regardless of where the CMTRIP is based, there is a need for some level of predictability in the workflow to help establish the resource allocations committed by the CMTRIP laboratory. A sole source contract would allow for such predictability, but the process for selection of the laboratory needs to be determined. It is reasonable to expect that a hybrid model could be adopted where research that is more basic in nature be provided on a project basis, to either a university or appropriately staffed private lab. In turn, a private sector laboratory would provide the more applied research and testing. However, other models would equally suffice and the final determination will become more evident as a program scope is developed.

Role of the CP Tech Center and NCC, if any, in managing the CMTRIP? Clearly, the CP Tech Center will be integrated into the CMTRIP activities with respect to technology transfer, training, and conduct of field trials. Given its leadership role in concrete materials, the NCC will also play a key role in stewardship of the program, identifying research needs, technology transfer and field trials. As part of formalizing the CMTRIP, the roles of the CP Tech Center and the NCC need to be defined.

Scope of research program and intellectual property? The scope of the CMTRIP will in large part be determined by the combination of available resources and SHA needs. However, given the proposed approach of including industry and federal partners, multiple resource streams and needs must be melded into a coherent long-term plan. The challenge initially is determining how to establish a program scope while also maintaining the flexibility to address new technologies as they become available that will be evaluated at the expense of the manufacturer, but under the direction of the SHAs overseeing the CMTRIP. Additionally, agreements with respect to the intellectual property of the research also need to be addressed. If industry supports the evaluation of a new product, there will be a desire for access to the data either exclusively or on a non-exclusive basis.

Conclusion

Once established, the CMTRIP offers a new option for SHAs to access applied research to help support development of a more sustainable infrastructure. The need is strong, and the opportunities for success are many. The approach outlined here offers a new way to approach applied research and it can serve as a model for how other research needs are addressed by SHAs. This represents a significant opportunity for the NCC to take a leadership role in shaping how the business of transportation is done. In a time of very limited resources but high demands on success, it is necessary to identify new ways to solve the challenging problems facing SHAs. As the saying goes, “If you do what you have always have done, you will get what you always got.” Considering new approaches and partnerships is vital to changing, for the better, how the business of transportation is done.