Full-Scale/Accelerated Pavement Testing: Current Status and Future Directions

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Full-scale and accelerated pavement testing (FS/APT) began as early as 1909 with a test track in Detroit, as identified by Metcalf in *NCHRP Synthesis of Highway Practice 235: Application of Full-Scale Accelerated Pavement Testing* (*1*). Various other facilities have been developed and used worldwide to pursue this activity, defined in *NCHRP Synthesis 235* as "the controlled application of a prototype wheel loading, at or above the appropriate legal load limit to a prototype or actual, layered, structural pavement system to determine pavement response and performance under a controlled, accelerated accumulation of damage in a compressed time period" (*1*). These facilities, as well as the testing performed by them, generally have had a fairly specific focus or scope. In addition, FS/APT facilities traditionally have been operational for limited periods.

Results from FS/APT research activities created significant advances in pavement engineering practice. Historically, probably the most notable of these in terms of the effect on highway pavement engineering is the Road Test conducted by the Association of State Highway Officials (AASHO) in the late 1950s. For airfield pavements, tests at the U.S. Army Corps of Engineers (USACE) Waterways Experiment Station (WES) since 1940 essentially defined the state of engineering practice. During the 1970s and 1980s, worldwide FS/APT activities and results in other countries were significantly more productive than those in the United States, with important contributions being made by Australia, Denmark, South Africa, France, Britain, and the Netherlands, among others.

Current efforts are marked by the renewed and resurgent interest in FS/APT programs worldwide since the mid-1980s. In the United States alone, major investments in FS/APT programs have been committed by FHWA, USACE (both at WES and at the Cold Regions Research and Engineering Laboratory [CRREL]), and the states of Minnesota, California, Texas, and Louisiana. In addition, the Federal Aviation Agency (FAA) is currently commissioning the largest APT machine in the world. The state of Florida and the National Center for Asphalt Technology (NCAT), in collaboration with the Alabama Department of Transportation, have both initiated major FS/APT efforts, which are likely to be the first new APT programs of the 21st century. It is primarily this surge of interest that motivated the formation by TRB of the A2B52 Task Force on FS/APT, which has the following objectives:

1. To assimilate and summarize historical and current FS/APT activities,
2. To evaluate and outline recommended approaches for FS/APT, and
3. To improve communications and the flow of information about FS/APT.

CURRENT STATUS

NCHRP Synthesis 235, published in 1996, indicates that 35 FS/APT facilities exist worldwide, of which 19 have active research programs. Subsequently, at least six additional facilities (by USACE-CRREL, USACE-WES, and FAA, and in Ohio, Finland, and Sweden) have become active, and one more (in Florida) is scheduled to commence research in early 2000. The planned test road in Alabama (at NCAT/Auburn) will also commence research activities shortly.

Although the nature of these many FS/APT programs varies, there is no question that, in order to be successful, any ongoing FS/APT program requires significant and sustained funding as defined by typical pavement research standards. By far the majority of FS/APT efforts are focused on highway pavement research, with the primary exceptions being those of FAA, WES, and Japan. For highway pavements, full-scale test roads such as MnRoad, WesTrack, and the planned NCAT facility probably require the highest level of funding. It should be noted that a distinction is made between “test roads,” where loading is achieved by actual traffic or actual vehicles, and “test tracks,” where loading is achieved by specially designed mechanical systems, even though both facilities involve full-scale, full-size pavement construction. Major test track facilities, such as those of the Laboratoire Central des Ponts et Chaussées (LCPC) in France and Centro de Estudios de Carreteras (CEDEX) in Spain, probably rank next in terms of funding requirements.

The most common approach uses mobile linear loading devices that apply loads to small sample areas on full-scale pavements. Although somewhat less costly than test roads, this approach requires significant financial commitment. Mobile linear loading devices are used in many programs, including those of USACE-CRREL, the Texas Mobile Load Simulator (TxMLS), California Department of Transportation (the program is CalAPT), the FHWA Pavement Testing Facility (PTF), Louisiana, Finland and Sweden, South Africa, Australia, and China. Finally, the fixed linear and circular test devices such as the Danish Road Testing Machine (RTM), Lintrack (Netherlands), the Canterbury Accelerated Pavement Testing Indoor Facility (CAPTIF), and those of the Indiana Department of Transportation/Purdue and Ohio may be the least costly. It is generally accepted that there is a trade-off between cost and capability. The popularity of mobile devices probably results from the flexibility of application, particularly in terms of the ability to test in-service pavement sections that have been constructed under routine construction contracts. Tests conducted at the various facilities are essentially designed and constructed to meet the current high-priority interests of the funding agency, with primary attention given to pavement performance. A recent survey by Hugo et al. (*2*), performed for this task force and contained in *TRB Circular E-C004: Report on APT Data Survey*, collected information from FS/APT programs related to approaches, equipment, instrumentation, test pavements, and data collection procedures. On the basis of survey responses from nine FS/APT facilities, *Circular E-C004* provides an overview and some details of standard data collection practices for these existing programs, three of which are located in the United States. These programs are consistent with others worldwide in evaluating distress and damage parameters (e.g., cracking and rutting of flexible pavements), but it is clear that the classification of severity and definition of failure vary widely. It is also clear that some duplication of effort occurs, but because of differences in distress criteria used for data collection, it is sometimes difficult to compare or apply results outside of the FS/APT program. A new NCHRP study, *Accelerated Pavement Testing: Data Guidelines*, currently in the proposal stage, will attempt to address these issues.

In summary, the existence of these facilities worldwide calls for a concerted and sustained effort to broadly coordinate FS/APT research programs and to share information so that each project can gain from the expanding knowledge base. FS/APT is expensive, and much can be gained from conscious efforts at close cooperation. The facilities also provide an opportunity to pool resources to address some of the underlying fundamental problems in pavement design and performance evaluation and prediction. However, this cooperation can be focused to optimize the use of FS/APT for such issues as wheel and load equivalency, dynamic effects, load cycle timing, climatic parameters, and performance assessment technologies.

FUTURE DIRECTIONS

It is expected that the current popularity of FS/APT approaches will assure their continued use and growth. Assuming that the predominance of a transportation mode relying on pavements to carry wheel loads continues, there will probably be an increased demand for improved pavement performance. Increased travel demand and the associated increased congestion will exacerbate the problem of reducing delays caused by pavement maintenance and repair.

In the immediate future, probably the most beneficial development that could occur for FS/APT in the United States and worldwide would be improved coordination of effort to ensure the most effective application of resources without duplication. Feasibility of this goal essentially requires significant standardization of distress definition and data collection procedures. Future developments in FS/APT technology alone generated by pavement engineers are likely to be incremental for the loading hardware, although developments in computing and modeling (of both pavement system and materials) may reduce the importance of the hardware. Finite and discrete element methodology, as well as other approaches, and improved materials characterization are enabling advances in analytical approaches to solve this difficult problem. To ensure that the solutions are reasonable, FS/APT provides the opportunity for quick validation. Future hardware developments related to FS/APT appear to hold the most promise in the field of instrumentation and measurement of pavement response, which currently lacks the sophistication that is common in other engineering and scientific specialties.

In the near term, evaluating the load-related performance of new pavement materials or designs is likely to rely heavily on FS/APT because of its ability to obtain much-needed rapid results. This includes, for example, validation of solutions for the design of overlays to mitigate reflection cracking on both asphalt concrete and portland cement concrete pavements. In addition, FS/APT affords an excellent opportunity to quickly evaluate potential solutions in a number of current and enduring problem areas, including asphalt concrete rutting, quality control–quality assurance procedures, warranty construction, performance-based specifications, improved maintenance procedures, and nondestructive pavement evaluation procedures.

In the long term, bigger and more far-reaching advances in FS/APT—and in pavement engineering in general—will result from a stronger working linkage between vehicle and pavement experts. Test road approaches such as WesTrack, MnRoad, and NCAT are particularly significant for this concern. Integrated and cooperative efforts are likely to evolve as experts in both fields see that FS/APT can illuminate the shared frontier that confronts both vehicle and pavement engineering, benefiting these two areas that traditionally have been separate spheres of technical activity. Forces such as globalization, the North American Free Trade Agreement, and advanced information technology that have shaped vehicle and freight movement technology in the 1990s will expand their ripple effect to pavement engineering, increasing the need for ever-faster yet more reliable performance predictions of the pavement-vehicle system, which FS/APT is uniquely equipped to study.

The nature, extent, and impacts from future collaboration between vehicle and pavement experts are hard to imagine beyond the next few years. However, it seems very likely in the long term that future combined efforts will boost FS/APT contributions beyond an incremental level, creating quantum jumps in FS/APT and great benefits for pavement technology. This, finally, translates into higher-quality pavements and greater productivity, as well as economic efficiency in the movement of people and goods and a significant cost reduction to the taxpayer in terms of both direct pavement construction and maintenance costs and reduced vehicle operating costs.

REFERENCES

1. Metcalf, J. B. *NCHRP Synthesis of Highway Practice 235: Application of Full-Scale Accelerated Pavement Testing*. TRB, National Research Council, Washington D.C., 1996.
2. Hugo, F., A. de Fortier Smit, and P. Warren. *TRB Circular E-C004: Report on APT Data Survey*. TRB, National Research Council, Washington D.C., Feb. 1999.