AITF-RU4474

Feasibility and Design of an Accelerated Infrastructure Testing Facility (AITF)

Final Report
October 2010

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In cooperation with

U.S. Department of Transportation
Research and Innovative Technology
Administration

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TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
AITF-RU4474		

4. Title and Subtitle	5. Report Date
Feasibility and Design of an Accelerated Infrastructure Testing Facility (AITF)	October 2010
	6. Performing Organization Code CAIT/Rutgers
7. Author(s) Dr. Ali Maher, Dr. Pat Szary, Andrés Roda, PE, Dr. Emin Aktan, Dr. Franklin L. Moon, Malcolm G. Mclaren, PE	8. Performing Organization Report No. AITF-RU4474
9. Performing Organization Name and Address Center for Advanced Infrastructure & Transportation (CAIT) Rutgers, The State University 100 Brett Rd. Piscataway, NJ 08854	10. Work Unit No.
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address Federal Highway Administration U.S. Department of Transportation Washington, D.C.	13. Type of Report and Period Covered Final Report 2/26/2009 - 10/14/2010
	14. Sponsoring Agency Code

15. Supplementary Notes

U.S. Department of Transportation/Research and Innovative Technology Administration
1200 New Jersey Avenue, SE
Washington, DC 20590-0001

16. Abstract

The Accelerated Infrastructure Testing Facility (AITF) would be the first facility in the world to enable accelerated scientific study of deterioration processes on full-scale bridges and also would offer state-of-the-art advanced pavement materials evaluation and testing capabilities. Specifically, the AITF would be composed of several interdependent laboratories within a single facility. Work done at the AITF would directly support the national strategy to maintain and repair our aging highway system in order to promote economic growth and mobility. Within the next decade, substantial bridge maintenance and replacement will be necessary, as will ongoing highway rehabilitation. These efforts will significantly affect congestion and commerce, negatively impacting the competitiveness of our nation's manufacturing sectors, shipping/trucking capabilities, and port/maritime operations. The AITF would be an internationally recognized, preeminent facility for the accelerated life-cycle testing and validation of a broad range of current and emerging bridge and pavement technologies—similar to Underwriters Laboratories—for bridge and pavement materials, technologies, and processes. The knowledge gained in the AITF would directly assist owners in decision making and management of their transportation assets. The AITF would be valuable to all those engaged in the design, development, supply, construction, and maintenance of bridge and pavement infrastructure worldwide.

17. Key Words	18. Distribution Statement
Infrastructure, Accelerated, bridge, testing facility	

19. Security Classif (of this report)	20. Security Classif. (of this page)	21. No of Pages	22. Price
Unclassified	Unclassified	16	

Form DOT F 1700.7 (8-69)

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Abstract

Planned Scientific Research and Need for the Facility

The Accelerated Infrastructure Testing Facility (AITF) would be the first facility in the world to enable accelerated scientific study of deterioration processes on full-scale bridges and also would offer state-of-the-art advanced pavement materials evaluation and testing capabilities. Specifically, the AITF would be composed of several interdependent laboratories within a single facility. Work done at the AITF would directly support the national strategy to maintain and repair our aging highway system in order to promote economic growth and mobility.

The primary laboratory would focus on accelerated bridge testing. It would house an innovative load testing machine inside a variable-environment chamber large enough to encapsulate full-scale bridge superstructures. This facility would, for the first time, allow the combined effects of live load (e.g., traffic) and environmental influences (temperature, precipitation, deicing chemicals, etc.) to be studied on full-scale bridge systems. It is expected to foster significant breakthroughs related to the development, evaluation, and standardization of technologies for bridge design, assessment, maintenance, and preservation. Due to the operational environment (machinery operation, vibration, heat, cold and moisture) of the load testing and environmental chamber, the AITF also would consist of a separate space that would serve as a Data Control/Evaluation and Advanced Materials Testing Lab. The combined facility would enable far more rapid development and evaluation of innovative technologies, advanced materials, state-of-the-art systems for maintenance and repair of bridge structures, construction technologies, quality control, pavement performance, and demonstration projects.

Within the next decade, substantial bridge maintenance and replacement will be necessary, as will ongoing highway rehabilitation. These efforts will significantly affect congestion and commerce, negatively impacting the competitiveness of our nation’s manufacturing sectors, shipping/trucking capabilities, and port/maritime operations.

The AITF would be an internationally recognized, preeminent facility for the accelerated life-cycle testing and validation of a broad range of current and emerging bridge and pavement technologies—similar to Underwriters Laboratories—for bridge and pavement materials, technologies, and processes. The knowledge gained in the AITF would directly assist owners in decision making and management of their transportation assets. The AITF would be valuable to all those engaged in the design, development, supply, construction, and maintenance of bridge and pavement infrastructure worldwide.

The AITF would also have great potential to impact the U.S. economy and promote U.S. innovation and industrial competitiveness in ways that would enhance economic security and improve our quality of life. The AITF would address the nation’s needs with respect to supporting infrastructure health and rapidly evaluating and standardizing new technologies for assessment of deterioration, safety, new materials, and construction techniques to enhance the preservation and life spans of our nation’s bridges.

Introduction

The proposed Accelerated Infrastructure Testing Facility (AITF) is envisioned as a national hub for research, development, and standardization of technologies and materials to support infrastructure systems engineering, operations, and management. The AITF would be a unique facility where the most critical aspects of the highway transportation system (bridge super-structures, decks, and pavement systems) would be constructed and evaluated by applying realistic traffic and environmental loading conditions in a greatly compressed timeframe.

Figure 1 - Conceptual rendering of AITF

Bridge deck repair and/or replacement accounts for over 80 percent of federal and state resources spent on bridge maintenance. While most current bridges are designed for a 75-year service life, bridge decks rarely last more than 25 years. Typically, even in the case of the most poorly performing deck, it is 10 to 20 years before there are visible signs of deterioration. Deterioration starts much earlier but cannot be observed without the use of specialized equipment. There are many competing causes for deterioration including environmental (freeze/thaw damage, water containing corrosive salts), mechanical (concrete cracking, fatigue, abrasion), and electrochemical (deicing chemicals, steel corrosion, and certain failures of protective coatings).This is especially true in the case of rebar corrosion, which is identified as one of the main culprits in deck deterioration. How can we understand and find solutions for bridge decks without having to observe the process over a decade or more?

The FHWA Long-Term Bridge Performance (LTBP) program, also led by Rutgers' CAIT, is capable of addressing these challenges given its 20-year duration. However, it cannot do so in the short term. The AITF would incorporate equipment capable of simulating long-term environmental and physical stresses on bridge deck segments and superstructures in an extremely condensed timeframe. To develop the feasibility of such a complex research facility, CAIT formed an expert advisory committee consisting of stakeholders from FHWA, Rutgers CAIT, the Long-Term Bridge Performance Program (LTBP), Rutgers Facilities and others. Based on the high priority deterioration mechanisms and parameters identified, and the subsequent feasibility analysis, the committee developed a preliminary concept for the full-scale test bed of the AITF.

Bridge Deterioration Process

Bridge deterioration begins immediately after construction, and poor construction techniques may exacerbate deterioration. While bridge deterioration is critical to all elements of a bridge, decks in particular, are especially vulnerable. Exposure to the elements and physical loading cycles constantly barrage the bridge deck causing internal cracking, delaminations, surface cracking and eventual failure of the deck. In focusing on the basic components of the process, bridge deck deterioration can be classified into three main categories[1]:

Table 1 – Overview of Degradation Mechanisms (Bien et al., 2007)[2]

Chemical deterioration	Physical deterioration	Biological deterioration
- corrosion - carbonation - alkali-silica reaction - crystallization - leaching - oil and fat influence - salt and acid actions	- creep - fatigue - influence of high temperature - modification of founding conditions - overloading - shrinkage - water penetration	- accumulation of dirt and rubbish - living organisms activity

Chemical attacks on bridge decks are particularly damaging. Whether in cold-weather climates or in coastal regions, salts and dissolved salts are the principal chemical deterioration process. When dissolved in water, sodium chloride forms a highly corrosive solution of sodium ions and chloride ions. The very mobile chloride ions penetrate through the concrete pores and where they reach the reinforcing steel and attack the thin passive layer of Ferric Hydroxide (Fe_2O_3) formed on the surface of reinforcing steel during the initial stages of concrete setting. This protective layer is undermined when chloride concentrations attack the Ferric Hydroxide film. The process continually enriches the oxygen levels in a saturated bridge deck. The reinforcing steel gets pitted

[1] Gucunski, N., Romero, F., Kruschwitz, S., Feldmann, R., Parvardeh, H., *Comprehensive Bridge Deck Deterioration Mapping of Nine Bridges by Ground Penetrating Radar and Impact Echo*, (2011)

[2] Bien, J., Elfgren, L. and J. Olofsson (Eds.), *Sustainable Bridges – Assessment for Future Traffic Demands and Longer Lives*, (TIP3-CT-2003-001653) within the 6th Framework Programme of EU, ISBN 978-7125-161-0, Wroclaw, Poland (2007).

and can even disintegrate completely. The chloride ions are not consumed during this reaction, but remain fully effective afterwards[3].

The two most common steel corrosion processes are the chloride induced pitting corrosion and carbonation. The rate of corrosion is dependent on numerous factors including the composition of the metal as well as humidity, temperature, water pH, and exposure to pollution and salt. Wet and dry cycles accelerate the corrosion process. Studies have shown that the corrosion rate is the highest during the spring season and lowest during the winter. These rates can vary by a factor of about four or five times during the year[4].

The combination of chemical, physical and biological attacks creates a complex deterioration phenomenon that reduces the design-life of our infrastructure. Natural deterioration processes progress slowly over many years, the ability to significantly accelerate the cumulative advance of realistic deterioration of bridge superstructures, decks, and pavement systems is highly desirable. In order to fully understand the deterioration process and thus develop reliable performance models and early-detection and intervention technologies—the fundamental mechanisms and root causes of deterioration need to be clearly identified. To reliably accomplish this it is necessary to: 1) identify potentially influential parameters that contribute to deterioration and 2) vary these parameters in controlled circumstances and observe performance/deterioration over time. In this manner, the causal relationships among parameters (freeze-thaw, temperature cycles, repetitive live-load actions, applications of deicing chemicals, materials, including coating systems, etc.) can be discerned.

AITF Concept Development

There is a grave importance in overcoming challenges associated with aging and deteriorating highways and bridges. The AITF would be the first facility in the world that would enable controlled, compressed scientific study of aging and deteriorating processes on full-scale bridges and materials for highway infrastructure. In general, three lines of inquiry are urgently needed and would be addressed by the proposed facility:

1) **Evaluating numerous technologies, materials, and components being developed to enhance the performance and durability of infrastructure (bridges and pavements):** The pressing needs in this area—and the recent advances in material science and related fields—have mobilized a growing industry that is providing owners with ever-increasing options. Currently, these developments are greatly outpacing our ability to evaluate their effectiveness, so owners are faced with the dilemma of either foregoing such advances in the favor of proven traditional approaches or adopting new approaches/materials with little evidence of their efficacy. Testing and studies done at the proposed AITF would allow realistic and reliable estimates as to the effectiveness of new technologies,

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[3] Gucunski, N., Romero, F., Kruschwitz, S., Feldmann, R., Parvardeh, H., *Comprehensive Bridge Deck Deterioration Mapping of Nine Bridges by Ground Penetrating Radar and Impact Echo*, (2011)

[4] Smith, J. L. and Virmani, Y. P., *Performance of Epoxy Coated Rebars in Bridge Deck*, Report FHWA-RD-96-092, Federal Highway Administration, Washington D.C., USA, (1996).

methods, and materials in a timely and repeatable manner. This would directly assist owners in decision making, as well as help developers refine their products since it would provide a basis for standardization—something critically needed in evaluating performance of advanced materials in the infrastructure arena.

2) **Validating new technologies being developed for augmenting infrastructure inspections:** New nondestructive evaluation (NDE) techniques and sensor technologies require benchmark testing of specimens with realistic distribution of invisible and visible defects and damages occurring through ongoing deterioration processes. The proposed AITF would enable validation of new inspection technologies by maintaining full-scale bridge superstructures with well-documented and realistic deterioration, defects, and damage that are common in various types of bridges. As a result, the facility would provide a unique and realistic basis for the rapid standardization of assessment technologies for highway infrastructure inspections.

3) **Developing reliable prediction models to determine the remaining service life of primary bridge components, especially bridge decks:** Based on a recent survey of state departments of transportation (DOTs), the USDOT-FHWA Long-Term Bridge Performance (LTBP) program led by Rutgers' CAIT found that more than 80 percent of bridge maintenance funds are spent on the maintenance, repair, and rehabilitation of bridge decks. The survey confirmed that DOTs experience significant uncertainty about how to accurately estimate the remaining life and safety of bridge decks. The research done at the AITF could provide a means to reliably forecast and estimate deck performance and safety, giving owners critical information and tools to make informed decisions about prioritizing various maintenance activities and eventual replacement. This is especially germane as they continue to deal with the difficult trade-offs due to dwindling financial resources.

Sharing this knowledge is a critical first step toward developing a sustainable highway system. Through the development and construction of this facility, research in a compressed time frame can be quickly developed and deployed to state and federal agencies in order to be implemented nationwide.

Accelerated Load-Testing Theory

Physical Loading

According to the AASHTO-LRFD Bridge Design Specification (section C3.6.1.2) the estimated maximum daily truck traffic per lane on an interstate bridge is 4,000 trucks. During repeated environmental loading cycles, the load testing equipment would apply approximately 7,000 truck passes per day at a loading level that far exceeds the legal truck weight limit. Research supports the fact that overweight trucks cause significantly more damage to highway infrastructure than legal or underweight trucks and passenger vehicles. This is universally accepted. It is also accepted that the damage imposed is nonlinear such that significantly more severe damage occurs as the weight increases.

Combining simulated high-volume significantly overweight truck loading with environmental loading cycles in a condensed timeframe would accelerate deterioration of the test bridge specimens. Compared to normal wearing conditions, the AITF would be able to accelerate deterioration at a rate 30 times faster than in situ; however, taking into account the complex interactions at play, plus the overweight loading, it is likely that this rate would be even higher.

Environmental Loading

Deck deterioration—specifically in the forms of concrete delamination and spalling—occurs through a variety of complex phenomena that are mainly attributed to water and deicing salts infiltrating the concrete. Formation of cracks in concrete and areas with shallow cover expedites exposure of rebar to chloride ions in salts, which would break down a protective passive film on the rebar surface and initiate corrosion. In addition, concrete scaling caused by formation of ice sheets or lenses near the deck surface creates superficial deterioration and in many cases a more severe freeze/thaw damage that makes the concrete even more vulnerable to continuous salt penetration. During elevated temperatures in the summer, penetrated salts, heat, rain, and high humidity further increase the rate of corrosion. Rust on the corroded rebar expands and creates additional cracks that allow water and salts to penetrate deeper into the concrete. During the next winter cycle, trapped water freezes and exacerbates the problem with newly added deicing salts. Truck traffic loads on the bridge cause deck deflections, which creates and opens even more cracks. The stress exerted by traveling vehicles, particularly heavy trucks, accelerates deterioration by pulling delaminated concrete from the deck and creating potholes or spalling.

By accelerating the deterioration processes researchers would be able to understand and analyze the complex deterioration phenomena that eventually lead to decay and potential failure of bridge elements including: decks (excessive wearing of traveling surface, corrosion of rebar, potholes, spalling); deck protective systems (waterproofing membranes, overlays, concrete sealers, crack sealers, corrosion inhibitors); deck joints; bearings; joint compounds; advanced reinforcing/structural materials; steel protective coatings; high-performance steel; weathering steel; tensioned high-strength structural wires (post-tensioned, pre-tensioned, cable-stayed, suspension cables); and comprehensive repair materials and systems or procedures. Accelerated testing in the AITF also would facilitate rapid but effective validation of new technologies and advanced materials. In addition, various types of NDE technologies and health monitoring sensors also could be evaluated in conjunction with progressive changes toward more deteriorated states of test specimens.

Description of Proposed Facility

The AITF project includes a testing building and an integral Data Control/Evaluation and Advanced Materials Testing Laboratory. The site is envisioned as a perpetual construction site, with bridge decks being constructed and demolished on a continual basis as experiments are conducted. The two buildings may need to be separated and setback to provide and comply with life and safety code requirements (specifically turning radii of emergency vehicles). A conceptual site layout is provided below:

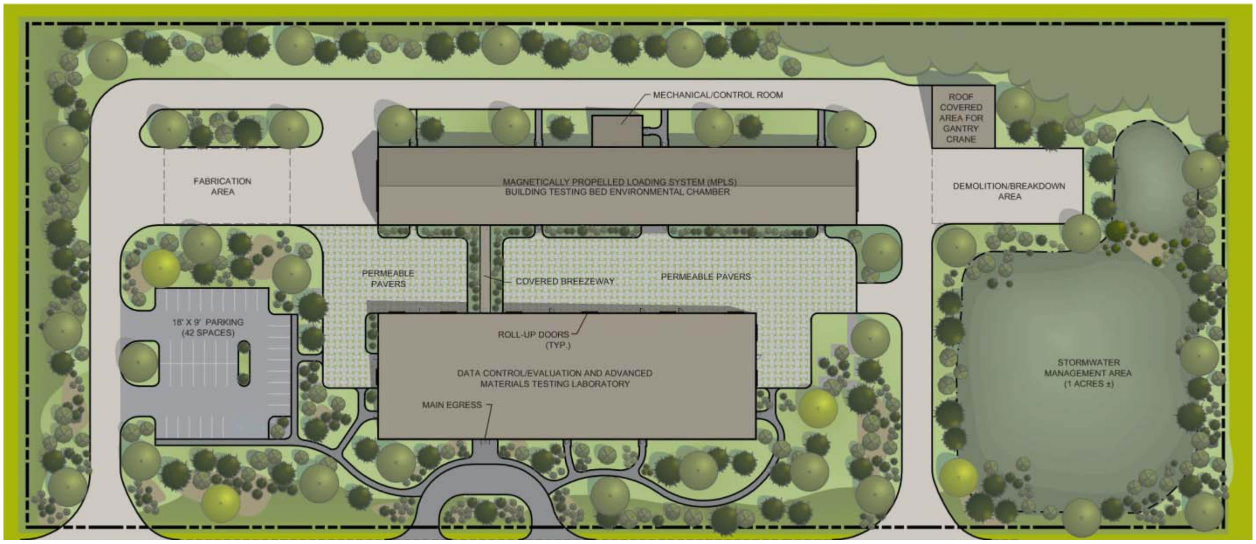

Figure 2 - Conceptual Layout of AITF

The facility is laid out to optimize the workflow of experiments including a fabrication area at the entrance of the testing building, a demolition area, a driveway that "horseshoes" around the facility to provide truck access for ingress/egress, a breezeway to connect the two buildings and other amenities that are envisioned to serve the facility.

Testing full-scale bridges in an enclosed variable-environment, requires large, warehouse-like structures, with sufficient space to allow for adequately sized bridge sample spans. In addition to the bridge sample, the building is envisioned to enclose a custom-built environmental chamber, which would isolate the bridge sample from the ambient warehouse temperature.

Despite the size of the testing building, the majority of the space would be occupied by full-scale bridge samples and the custom-built environmental chamber. Researchers would need a separate space to control the flow of data, evaluate test results, perform analytics, train technicians and graduate-level students and perform other highly-skilled tasks. This became the impetus for segregating space for custom/specialized laboratory space, identified in this report as the Data Control/Evaluation and Advanced Materials Testing Laboratory. As the name implies, the building would supplement the work being performed in the testing building but also provide sufficient laboratory space for independent testing of materials.

The following subsections describe the proposed facility in greater detail as it has been envisioned:

Testing Building

The testing building would require a specially designed reaction floor and foundation system that is rarely used in typical building design. The need for this unusual foundation stems from the specialized bridge testing to be performed. Because repeated load cycles would be transmitted to piers supporting the loaded bridge specimens, the foundation for these piers must have no discernable movement. Also, since the testing bed would allow for various spans and skews by changing the location of piers, the foundation under the test bed must be substantial. A concrete mat approximately 3.5ft thick would be required. Since the variable-environmental chamber would be enclosed in this building, the floor within the footprint of the chamber would need to be sealed to resist the corrosive environment.

Environmental Chamber Design

The custom environmental chamber would impose extreme thermal and RH conditions on full-size bridge test specimens. It is anticipated that an environmental chamber may be able to simulate seasonal temperature fluctuations (0^oF to 104^oF), RH variations (40 to 95%.), UV ray, and seasonal maintenance practices (e.g., application of deicing chemicals).

The chamber is designed as a structure unto itself, capable of conditioning the samples as well as able to withstand the harsh corrosive environment and its own thermal expansion. The environmental chamber also must be large enough to fully enclose the test specimens, gantry crane, and the load-testing equipment as well as facilitate operation of the equipment. The chamber is envisioned to incorporate large access doors on both ends to allow ingress/egress of the specimens and the gantry crane that would position them.

Data Control/Evaluation and Advanced Materials Testing Laboratory

The separate laboratory would be comprised of several compartmentalized sub-laboratories that each provided an explicit function within the overall composition of the facility. The following key sub-laboratories are envisioned:

1. Testing Building Support
2. Evaluation, Advanced Materials Testing, and New Technologies
3. Research/Pavement Technician, Machine, and Training/Meeting Rooms

Testing Building Support – These areas would include monitoring and control room for the testing building, concrete testing room, concrete curing room, and petrographic (dirty, chemical, thin slice, and clean) rooms. These rooms would support the overall mission of evaluating the loading and environmental influences related to the development, evaluation, and standardization of technologies.

Evaluation, Advanced Materials Testing, and New Technologies – This space would consist of the asphalt binder room, corrosion testing lab, bulk materials room, pavement mix lab, material sampling room, beam fatigue lab, pavement acoustics lab, compaction room, loose aggregate room, NDE testing lab, scour/sediment testing lab, and the aggregate testing lab. These laboratories would support research on new and innovative materials, remaining service life evaluation, new NDE technologies, and bridge deck rebar corrosion.

Research/Pavement Technician, Machine, and Training/Meeting Rooms – This research space would accommodate the materials lab supervisor as well as technicians doing computational/computer analysis, research design, and data analyses in support of the research. The machine rooms would be used for fabrication and support of the testing. The training/meeting rooms would be the only common meeting space within the facility and would be used for training and disseminating new information and technological advances to agencies, industry, and other academic institutions; thus facilitating the creation of new graduate research programs.

Technical Capabilities of the Facility

Three fundamental objectives that would be investigated within the facility are:

- **Develop a *standard* to define bridge performance:** Bridge performance relates to overall highway system performance, which is often expressed in terms of safety, efficiency, environmental impacts, cost, and organizational effectiveness. The principal challenge in establishing standards for bridge performance is developing quantitative, measurable indices that strongly correlate to the desired global performance of the entire system. The AITF would, for the first time, make it possible for critical parameters and inputs that affect bridge performance to be controlled under realistic (but accelerated) operating conditions. This would enable scientific study to clearly establish in the near term the influences and compounding effects on long-term bridge performance.
- **Identify critical parameters and how they impact bridge lifecycle performance:** Building on the definition of a bridge performance standard, the root causes and mechanisms of deterioration and damage that lead to undesirable performance would be identified and understood. Developing a facility for accelerated and climate-controlled load testing would be the only practical way to achieve timely and scientific understanding and modeling of the root causes of deterioration, how deterioration impacts performance over time, and how one may effectively mitigate these impacts through proper operational and maintenance management.
- **Evaluate and develop advanced materials:** The AITF also would enable evaluation, testing, and development of efficient, longer-lasting roadways of the future. The AITF would house research on a wide range of materials, material testing systems and procedures, construction quality control methods, and asset management areas that support the national strategy of maintaining and repairing our aging highway system and would therefore promote economic growth as it relates to the efficient movement of people and goods.

Under normal wearing conditions in northern states where structures are subjected to freeze/thaw and application of deicing agents, concrete bridge decks exhibit deterioration severe enough (i.e., delamination and spalling in 10–15% of the deck surface) to require repair within the first 15 to 25 years. **The AITF would be able to produce in 24 weeks of accelerated testing the same level of deterioration that an in-service bridge would experience over 15 years.**

Potential impacts of the facility

There are many groups that would benefit from the proposed AITF. Primary stakeholders include a large and diverse population of transportation infrastructure owners; practicing engineers; suppliers and developers of performance enhancing systems; federal and state governments; and the LTBP project team. In addition to all its positive impacts on bridge materials, design, and policy, the AITF also could benefit numerous secondary stakeholders, including researchers and practitioners involved in condition assessment (NDE, instrumentation, St-Id, etc.); performance modeling and forecasting; infrastructure asset and risk management; deterioration science; advanced/innovative materials engineering; and more. Advances in these areas ultimately hold benefits for U.S. taxpayers as well by supporting more robust and durable transportation infrastructure, which is one of the key components of continuous economic growth of our nation.

Comparing results from an initial series of AITF experiments with LTBP midterm results would help identify critically time-dependent mechanisms and modifications to AITF procedures (e.g., changes to specimen geometry, materials, live load, environmental inputs, etc.) so they are in line with the *in situ* observations. Understanding what happens during the period from construction to the onset of deterioration is arguably of paramount importance because of its implications on accurate forecasting, proactive asset management, and decision making. Once calibrated and verified in more absolute terms, AITF test results would significantly aid near-term planning efforts by enhancing bridge owners' ability to predict, for example, time-to-corrosion initiation and time-to-corrosion propagation and thus anticipate maintenance needs. Also, other types of bridge deterioration would be better understood through up-close monitoring of degradation processes taking place under realistically created environmental and mechanical loading conditions. By using approaches such as experiment design, the AITF would facilitate empirically-validated, science-based deterioration/performance models for a suite of common systems, components, and input environments.

The LTBP program is identifying a number of management practices, policies, and maintenance activities that can be correlated with bridge performance. The link between organizational/policy systems and performance is critical (since those decisions may be the single most important influence on long-term performance). However, due to the challenges described earlier, it is not possible to discern the resulting causal factors from field observations alone. The AITF would give us the ability to simulate the influences of various human-bridge interactions (related to policy, bridge management, etc.) in a compressed timeframe and provide sound input to owners regarding how best to maintain their structures. For instance, in the case of different types of rebar, this guidance may involve recommendations based on the reinforcement employed such as adopting more proactive assessment methods to identify early-age deterioration (GPR, impact echo, etc.); using various sealants; or even using or developing different deicing chemicals.

In the long term (±20 years), the LTBP program would develop meaningful data and observations on complete deterioration processes, especially for bridge decks. At this stage, the AITF may be fine-tuned to simulate actual measured complete service lives of superstructures all the way through late-stage deterioration. Within a few years, the AITF would be able to provide quality scientific data relating to the long-term performance of numerous bridge types depending on their environmental and live load inputs. This would be a great help to owners for long-term planning that inevitably involves considerations for bridge deck rehabilitation and replacement.

The significant implications range from reliable service-life predictions to lifecycle cost models and even the ability to test new materials/systems and give vendors the confidence to offer meaningful warranties. In the long term, we envision integration of the AITF and the LTBP program would help develop and justify important new policies. The outcome of these two programs could provide input for new-construction policies but also may further promote use of lifecycle cost management approaches and revise policies relating to existing bridges. Any practical information that directly leads to cost-effective practices is invaluable, since it is likely that owners would continue to face budget shortfalls in the future that demand difficult trade-offs.

In conjunction with improving pavement design models and concepts, the paving industry is undergoing a change of its own. There is a greater research emphasis in "green" pavements and longer-lasting asphalt mixtures. AITF would have a role to play in moving these innovations forward by providing much needed assurances to federal and state agencies that are reticent to apply unproven technologies on roads being used by the driving public.

Challenges and Considerations

Developing the physical load testing equipment remains an area to be finalized. While there are a number of existing technologies that employ various means of applying physical loads to specimens, the full-scale nature of testing requires a specialized design that identifies a loading mechanism as well as a drive mechanism.

In addition, developing the unique environmental loading chamber remains a challenge. There is no "off-the shelf" technology available anywhere on earth that is capable of producing the extreme load conditions described in this document. The military and auto manufacturers are the closest sectors to have developed chambers to suit their environmental-load testing. However, these chambers are not nearly long or wide enough to encapsulate full-scale bridges.

Once the facility and its testing equipment are in place, the design and fabrication of test specimens, execution of the tests, instrumentation and monitoring in the course of testing and the interpretation of the measurements and observations will offer another set of complex challenges beyond those posed in common civil engineering laboratory experiments. The first test specimens should be designed after specific prototypes that will be instrumented and monitored in the field so that the similitude and the time compression capabilities of the AITF may be calibrated through comparison with actual bridge performance. The research will require a coordinated multi-disciplinary effort including experts specializing in fundamentals of structural behavior, bridge design and construction, physical model testing, bridge maintenance and repair, materials and chemical engineering, amongst others. The research team will also need to incorporate an extensive set of corresponding analytical and numerical modeling, instrumentation, measurement and information technology expertise. Establishing and coordinating such an expert team of researchers will be a challenge requiring considerable resources.

Conclusions

Within the next decade, substantial bridge maintenance and replacement will be necessary, as will ongoing highway rehabilitation. These efforts will significantly affect congestion and commerce, negatively impacting the competitiveness of our nation's manufacturing sectors, shipping/trucking capabilities, and port/maritime operations.

The AITF would be an internationally recognized, preeminent facility for the accelerated life-cycle testing and validation of a broad range of current and emerging bridge and pavement technologies—similar to Underwriters Laboratories—for bridge and pavement materials, technologies, and processes. The knowledge gained in the AITF would directly assist owners in decision making and management of their transportation assets. The AITF would be valuable to all those engaged in the design, development, supply, construction, and maintenance of bridge and pavement infrastructure worldwide.

The AITF would also have great potential to impact the U.S. economy and promote U.S. innovation and industrial competitiveness in ways that would enhance economic security and improve our quality of life. The AITF would address the nation's needs with respect to supporting infrastructure health and rapidly evaluating and standardizing new technologies for assessment of deterioration, safety, new materials, and construction techniques to enhance the preservation and life spans of our nation's bridges.