EXPLORATORY ADVANCED RESEARCH

Breakthrough Ideas for Highway Research

Understanding Material Durability

Workshop Examines Aging of Composite Materials

CORROSION DECAY is an expensive and ongoing challenge throughout the U.S.-highway network. To mitigate this problem, advanced composite materials are used in a wide range of infrastructure applications. These materials are lightweight, high strength and offer high-fatigue and corrosion resistant properties; however, accurately understanding how these materials degrade and age over time is critical for safe and economical implementation. Accordingly, a workshop supported by the Federal Highway Administration's Exploratory Advanced Research (EAR) Program and the National Science Foundation was held to discuss state-of-the-art understanding and future research directions on aspects of aging of composites.

Discussing Composite Materials

The 2-day International Workshop on Aging of Composites was held September 25–26, 2013, at the National Transportation Safety Board Training Center in Ashburn, VA. Thirty-five leading researchers, designers, and owners of infrastructure systems with advanced fiber reinforced polymer (FRP) composite materials, including eight participants from the international community, met to discuss and summarize the state of the knowledgebase on the aging behavior of FRPs. Workshop participants discussed FRP material and component resistance factors based on available data, suggested effective methods to collect additional data, and identified procedures to refine and integrate information. Participants also sought to identify research needs for future research, development, and evaluation programs dealing with durability and design issues. It is hoped identifying these needs will lead to realistic design, construction, evaluation, and rehabilitation guidelines.

Fiber Reinforced Materials

For over 30 years, FRPs have been gradually accepted as advanced and durable materials for infrastructural applications. FRPs have been used in structures for highways, railways, waterways, utility poles, wind-turbine blades, and pipelines. Hundreds of pedestrian and vehicular bridges have been built worldwide using FRP composite materials. To better understand and accurately determine how durable these composite materials are, and how they will degrade, accelerated aging tests on composites can be conducted under controlled laboratory conditions. Data from these tests can then be correlated with the field data from in-service FRP composite bridges and other infrastructure systems.

Focused Discussion

During the workshop, over 20 presentations examined topics including critical areas of durability, available aging data, durability assessment methods, and durability design. Each presentation concluded by looking at areas in need of further research. Workshop participants were then divided into four working groups for focused brainstorming discussions. Each group discussed and examined a specific topic, including internal and external reinforcements; shapes; test methods; and material degradation and life prediction models. The workshop presenters then asked each group to come to an understanding of the currently available research for its topic, identify specific issues that are hindering implementation, consider current research gaps and funding sources, and identify which research projects would have the most immediate impact. The research needs from all groups were then integrated and prioritized in terms of their importance and impact on composites infrastructure.

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Group Recommendations

Workshop participants identified four overall research topics that were considered to be high priority. The first topic area was "Mechanisms of Deterioration." Participants suggested research should focus on reductions in strength, stiffness, and durability at micro, meso, and macro levels. It was noted a multiscale approach is needed for characterizing and developing a better understanding of the mechanisms of bond and bond degradation caused by moisture. Participants also suggested a focus on interface characterization, moisture effects, and static and cyclic fatigue.

The next research topic was "Test Methods and Modeling." It was noted that aging data should be collected from structures in the field and combined with laboratory accelerated aging test data to develop predictive models. Participants also suggested there should be standardization of basic durability and fire test methods. Another research priority was "Investigation of Synergistic Effects on Long-Term Performance." Here, participants recommended further research into temperature and moisture, as well as static and fatigue loads. Additional focus areas included researching interactions between stress, temperature, and chemicals. The manufacturing process was also identified for further research to better understand the constituent materials and effect on long-term performance.

Participants suggested the final priority research topic should be "Correlation of Short-Term and Long-Term Performance." Participants highlighted it is important to relate short-term durability in laboratory tests to long-term performance in the field. They suggested the development of simple and accurate techniques for field monitoring and inspection and evaluation guidelines. Finally, it was recommended that a searchable knowledge database should be developed to cover laboratory and field tests and experimental results.

Future Research

It was widely agreed that the workshop accomplished its goal to further understanding of aging of composites, assess state of the art, and consider research and development needs for future studies. Workshop participants agreed that it is time to evaluate the performance of FRP structures by collecting field samples and testing for property degradation. It was noted that accelerated aging data and predictive models will lead to accurate life-cycle assessment of FRPs. Additionally, it was suggested FRP composites have great potential as a sustainable material with a high strength-to-weight ratio to design durable, efficient, and safer infrastructure systems.

It is anticipated that, equipped with the future research directions identified in this workshop, the larger community interested in research and development for highway transportation FRP applications could ultimately develop an interdisciplinary research program.

Learn More

For more information on the EAR Program and FRP composite materials, contact Lou Triandafilou at 202-493-3059 or visit www.statler.wvu.edu/cfc/research/projects/aging.php.

What Is the Exploratory Advanced Research Program?

FHWA's Exploratory Advanced Research (EAR) Program focuses on long-term, high-risk research with a high payoff potential. The program addresses underlying gaps faced by applied highway research programs, anticipates emerging issues with national implications, and reflects broad transportation industry goals and objectives.

To learn more about the EAR Program, visit the Exploratory Advanced Research Web site at www.fhwa.dot.gov/advanced-research. The site features information on research solicitations, updates on ongoing research, links to published materials, summaries of past EAR Program events, and details on upcoming events. For additional information, contact David Kuehn at FHWA, 202-493-3414 (email: david.kuehn@dot.gov), or Terry Halkyard at FHWA, 202-493-3467 (email: terry.halkyard@dot.gov).

Photo caption, front page: Mr. David Kuehn addresses questions from the audience on the morning of September 26, 2013

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