APTs Applications in Non-Pavement Research

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Accelerated pavement testing (APT) facilities are traditionally used for pavement evaluation under in-service conditions of traffic, environment, and other pavement design parameters. “APT is defined 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. The acceleration of damage is achieved by means of increased repetitions, modified loading conditions, imposed climatic conditions, the use of thinner pavements with a decreased structural capacity and thus shorter design lives, or a combination of these factors.

Keywords: accelerated pavement testing ; bridges ; sustainability ; non-pavement testing

1. Introduction

Accelerated pavement testing (APT) facilities are widely known for evaluating pavement response and performance under in-service conditions in a compressed time interval [1]. These facilities are generally developed with the overall intention to provide cost-effective solutions to improve pavement performance and reduce life-cycle costs. Even though the focus of research efforts has centered on pavement systems, APTs have effectively been utilized by various agencies for non-pavement research to address strategic issues confronting society. They have been applied in the areas of transportation infrastructure and operations; automobile systems; traffic safety; national security assessments and for environmental impact evaluations [2][3][4][5]. Therefore, APTs can be described as multipurpose facilities that can be used for various research applications in different disciplines. Thus, APTs can be described as applicable and beneficial to both pavement and non-pavement industries.

Due to benefits associated with APT facilities, the Wyoming Department of Transportation (WYDOT) intends to build a state-of-the-art test road facility to monitor pavement performance and spearhead sustainability and innovations in pavement design, construction, and preservation research unique to the dry-freeze climatic region. A full-scale road track is proposed along the existing Interstate 80 (I-80) in Wyoming. The test road facility will allow for a comprehensive long-term performance evaluation of pavements under real world traffic loading, climate, and layer material properties. The test road will consist of experimental test sections built of asphalt, Portland cement concrete and composite pavements to carry existing real-world traffic of approximately two million equivalent single axle loads (ESALs) per day. The objective of the test road initiative is to improve pavement performance and reduce life-cycle cost of pavements in the dry-freeze climate. It will be the foremost full-scale test road in the dry-freeze climate region of the United States (U.S). WYDOT and the University of Wyoming (UW) are currently conducting a feasibility study to evaluate the effectiveness of constructing the test road facility in Wyoming. Part of the feasibility study involves exploring opportunities to use the test road for non-pavement research.

This paper presents a review of the applications of APT facilities for non-pavement research based on experiences from around the world. The applications of APT in non-pavement research over the years are put under nine broad categories for the purposes of this paper: (1) bridge experiments; (2) transportation technology; (3) drainage experiments; (4) geotechnical engineering experiments; (5) automobile experiments; (6) environmental experiments; (7) highway safety; (8) calibrations, measurement, and testing devices; (9) other miscellaneous applications. Publications on APTs have primarily focused on pavement performance evaluations with little attention to the non-pavement aspect of it. This paper provides a review with an intent to fill that gap and raise the awareness and familiarity of applying APTs for non-pavement research activities. The paper further makes suggestions for the proposed Wyoming test road facility and other APTs regarding non-pavement research applications.

2. A Review of APT Applications in Non-Pavement Research

Another significant contribution of APTs is in the area of truck platooning, which is regarded as the future of freight transportation. The NCAT test track facility was used to develop and evaluate truck platooning technology, according to [6]. The benefits of truck platooning include lower fuel consumption, improved driver output, fewer crashes, less congestion, and reduced carbon emissions [7]. The PTI test track was also utilized for comprehensive testing of new bus models, trucks, and train. The facility has been recognized as a designated testing ground for autonomous vehicles by the U.S DOT since 2017 [3].

Drainage significantly affects the pavement performance [8] due to the effect of moisture on soil strength and properties. According to [9], proper drainage systems increase the service life of pavements by 50%. It also impacts the safety of motorists as water that remains on the surface of pavement can cause hydroplaning. Therefore, proper drainage is important to ensure the long life of pavement and the safety of users. A survey found that several APT programs explored the effects of water on pavement performance [1]. Research on drainage systems complements the overall research efforts on pavements. With regards to drainage structures, a study conducted at MnROAD evaluated the performance of large thermoplastic (e.g., corrugated polyethylene) culverts for three and half years. Recommendations for the minimum depth of covers for culverts were made based on the findings of the study. The researchers found that culverts could perform well and showed no signs of increased deflections [5][10].

In addition, a study mentioned that the APT facility operating at the Federal University of Rio Grande do Sul, in Porto Alegre, Brazil, was used to evaluate the performance of PVC pipes used in culverts [11]. Highway agencies continue to explore ways to improve drainage designs and maintenance. The Florida Department of Transportation (FDOT) has recently built a 4.0-km (2.5 mile) concrete test road, which is expected to open for real traffic in 2023. The research will consist of in-service evaluation of concrete pavement technologies and innovations, including dedicated test sections that would be used to investigate the effectiveness of edge drains. The drainage research will consist of 16 test sections [12].

The circular facility of the University of Los Andes in Colombia investigated various techniques used in soil stabilization using accelerated pavement testing [11]. In order to provide geosynthetic solutions to weak formations, the authors of [1] reported that APTs have made significant impacts in terms of advancements in the field stabilization of marginal materials to improve pavement performance and promote the implementation of geofabrics for ground reinforcement purposes.

3. Future Research for the Proposed Test Track in Wyoming and Other APTs

This section explores the potential application of APT facilities for non-pavement research. APTs facilities have shown success in other areas outside of the traditional testing of pavement structures.

APTs can explore opportunities to evaluate and get a clear understanding of the potential effects of truck platoons on bridges, in terms of loading models, truck configurations, stress ranges, travel speed of platoons, braking effects of platoons, etc.

Innovative storm water drainage systems could be installed and evaluated at test track facilities to optimize road drainage and minimize flooding risks, which are easy to transport, handle, and install and, more importantly, reduce differential settlements. Technologies could be explored to inspect, rehabilitate and manage drainage assets cost-effectively.

The proposed testing facility in Wyoming will present a great opportunity to monitor bridge structures under real-world traffic conditions while exploring new technologies to build and maintain bridge decks with better performance. Bridge decks require frequent maintenance and rehabilitation compared to the other bridge components [13]. Monitoring and inspections are important to achieve bridge performance objectives and goals and maximize returns on investment. While promoting the use and understanding of bridge management systems, future APTs could include bridges with detailed inspection programs. These programs will help determine the cause of deterioration and strain, and recommend necessary corrective actions and maintenance, distinct to the dry-freeze climate. Other experiments will evaluate the cost-effectiveness of using innovative techniques for bridge inspections, such as real-time monitoring sensors and unmanned aerial systems (UASs). The experiments can be implemented with various structural features and design spans, depending on regional research needs. When the proposed Wyoming test road becomes fully operational, it will be the only test road with real-world traffic conditions to evaluate bridge responses and performance since the AASHO Road Test in the 1950s.

4. Summary and Conclusions

The versatility of APTs is evident. Successful applications of APT facilities for non-pavement research have been reviewed in this paper. Some APT facilities have been able to balance pavement and non-pavement research without undercutting the objectives that established them. The decision for APTs to engage in non-pavement research is a management initiative that promotes research diversity and the image of the facility. The overall intent of this paper is to raise awareness and encourage the participation of APTs in non-pavement research. Different APT types have the capacity and the expertise to meet the needs of different customers. Moreover, the staff of APT facilities have demonstrated the capacity to adjust to different research fields. However, it appears that the test roads have been explored more extensively for non-pavement research than HVS, ALFs and MLS. It is evident that both HVS and test road tracks are effective in evaluating bridge responses and performance. APT facilities can effectively evaluate road markings, pavement markers and rumble strips, geotechnical experiments, and electric road systems (ERS). Test roads appear to be more ideal for connected and autonomous vehicle technology, truck platooning testing, drainage testing, emergency response demonstrations, and intelligent compaction technologies; however, it is evident that very few APTs have been utilized for bridge research, though the topic of bridges appears to be very popular. From the text analytics of the literature review conducted in this paper, all the APT techniques appear to often be involved in investigating, developing, or evaluating non-pavement topics related to bridges, autonomous vehicles, and markings. The paper suggests non-pavement research areas where the proposed Wyoming test road facility could be utilized for incorporating non-pavement research initiatives in APT programs, diversifying funding sources, and promoting partnerships for successful operations, longevity, resilience and the image of APT facilities.

References

1. Hugo, F.; Martin, A.E. Significant Findings from Full-Scale Accelerated Pavement Testing: A Synthesis of Highway Practice; NCHRP synthesis; Transportation Research Board: Washington, DC, USA, 2004; ISBN 978-0-309-06974-8.
2. Jones, D.; Wu, R.; Holland, T.J. Accelerated Traffic Load Testing of Seismic Expansion Joints for the New San Francisco–Oakland Bay Bridge. In Advances in Pavement Design through Full-Scale Accelerated Pavement Testing; Al-Qadi, I., Ed.; CRC Press: Boca Raton, FL, USA, 2012; ISBN 978-0-415-62138-0.
3. Penn State Engineering: Test Track. Available online: https://www.larson.psu.edu/about/test-track.aspx (accessed on 23 July 2021).
4. Worel, B.; Vrtis, M.; Buzz Powell, R. Guidance for the Next Generation Accelerated Pavement Testing Facilities. In Accelerated Pavement Testing to Transport Infrastructure Innovation; Chabot, A., Hornych, P., Harvey, J., Loria-Salazar, L. G., Eds.; Springer International Publishing: Cham, Switzerland, 2020; pp. 40–48.
5. Worel, B. Non-Pavement Research at MnROAD. Available online: Dot.state.mn.us (accessed on 23 July 2021).
6. National Center for Asphalt Technology. Available online: https://eng.auburn.edu/research/centers/ncat/ (accessed on 23 July 2021).
7. Janssen, G.R.; Zwijnenberg, J.; Blankers, I.J.; de Kruijff, J.S. Truck platooning: Driving the future of transportation. 2015. Available online: https://repository.tno.nl/islandora/object/uuid%3A778397eb-59d3-4d23-9185-511385b91509 (accessed on 23 July 2021).
8. Gurjar, J.; Kumar Agarwal, P.; Kumar Sharma, M. A Framework for Quantification of Effect of Drainage Quality on Structural and Functional Performance of Pavement. Int. J. Eng. Res. 2013, 2, 259–265.
9. Rokade, S.; Agarwal, P.K.; Shrivastava, R. Study on drainage related performance of flexible highway pavements. Int. J. Adv. Eng. Technol. 2012, 3, 334–337.
10. Tompkins, D.; Khazanovich, L. MnROAD Lessons Learned; Minnesota Department of Transportation, Research Services Section: Saint Paul, MN, USA, 2007.
11. Mateos, A.; Balay, J.M. Implementation of APT Facilities in Developing Countries Development of Improved Guidelines and Designs for Thin Bonded Concrete Overlays of Asphalt Pavements (BCOA) View Project Implementation of APT Facilities in Developing Countries. In Proceedings of the 3rd International Conference on Accelerated Pavement Testing, Madrid, Spain, 1–3 October 2008.
12. Greene, J. Florida Department of TRANSPORTATION FDOT's Concrete Test Road. 2016. Available online: https://www.fdot.gov/materials/quality/programs/materialsacceptance/documentation/concrete.shtm (accessed on 23 July 2021).
13. Sanders, D.H.; Zhang, Y.J. Maintenance of the Highway Infrastructure; National Academy Press: Washington, DC, USA, 1994; p. 169.