International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 07
June 2017

A Review of Advance Technology: Transportation Engineering

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Abstract: *Transportation engineering is a major component of the civil engineering profession. It involves planning, design, construction, maintenance, and operation of transportation facilities. Advanced technologies in the area of information systems, automation, and telecommunications have the potential of achieving cost savings and productivity improvements as well as enabling new developments in transportation. The purpose of this paper is to review the areas where advanced technologies can significantly affect the way transportation engineering is practiced. Strategies for implementation of the necessary changes in practice are also discussed, along with the expected impact on civil engineering curriculum. The emphasis of the paper is on surface transportation.*

Keywords: Transport Engineering, ASCE, TRB, NAVSTAR, KBES.

Introduction:

Transportation engineering is a major component of the civil engineering discipline. The importance of transportation engineering within the civil engineering profession can be judged by the number of divisions in ASCE that are directly related to transportation. There are six such divisions (Aerospace; Air Transportation; Highway; Pipeline; Waterway, Port, Coastal and Ocean; and Urban Transportation) representing one-third of the total 18 technical divisions within the ASCE. Considering the national economy as a whole, transportation represents 20% of the U.S. gross national product. About one of seven or roughly 14,000,000 of 100,000,000 U.S. workers is employed in some aspect of transportation (Transportation Research Board [TRB]). Most civil engineers engaged in the practice of transportation engineering are employed by transportation agencies and associated contractors and consultants. Nationwide there are about 174,000 civil engineers and about 100,000 works in transportation at least some of the time.

Objective of the Study:

Transportation engineering, as practiced by civil engineers, primarily involves planning, design, construction, maintenance, and operation of transportation facilities. The facilities

support air, highway, railroad, pipeline, water, and even space transportation. A specific indication of the sub components of the transportation engineering field with current importance to civil engineers can be obtained by examining the topics of the technical committees of the six transportation related divisions. There are 37 technical committees and most of them involve the physical infrastructure of surface transportation modes. A review of descriptions of the scope of various committees indicates that while facility planning and design continue to be the core of the transportation engineering field, such areas as operations planning, logistics, network analysis, financing, and policy analysis are also important to civil engineers, particularly to those working in highway and urban transportation.

A recent workshop sponsored by the National Science Foundation to examine the state of the art and research opportunities in transportation indicated that the ultimate objective of research in the areas of transportation facilities is to develop technological innovations that will result in substantial improvement in the quality of transportation services, including productivity and performance. Some of the major areas that can greatly benefit from the use of advanced technologies include the following: facilities condition assessment; repair, maintenance, and rehabilitation techniques; materials; and management of facilities. It should be pointed out that technological innovations are needed not only for better planning and design of transportation facilities, but also for improved operation and delivery of transportation services in terms of increased efficiency and safety.

Some Advanced Technologies and Transportation:

- **Knowledge-Based Expert Systems:** Knowledge-based expert systems (KBES) evolved from research in artificial intelligence with the overall objective of producing intelligent behavior with computers. Numerous artificial intelligence research areas exist, including theorem proving, automatic programming, vision, learning, natural language processing, and others. KBES differ from these other areas by the restriction to a limited problem solving domain such as diagnosis of malfunctions in particular equipment types. These systems are finding a wide range of suitable application areas. Several reviews of transportation and civil engineering

applications exist. Applications have included a variety of areas such as design, diagnosis, vehicle control and operations control. As computer hardware and software develops and as more experience is accumulated, KBES will become a common alternative to conventional programming. The integration of expert systems and conventional programming approaches is likely to be particularly rewarding in this regard.

- **Vehicular Navigation, Control, and Location:** Recent advances in technology provide some significant new opportunities in the vehicular control area and, by extension, to the entire area of vehicle operations. New sensors and control procedures make continuous monitoring of locations possible and even introduce the possibility of widespread automated vehicle control. For example, several railroads have installed NAVSTAR satellite receivers so that precise locations of all locomotives are available at all times. Transit agencies have experimented with passive signpost systems to provide similar information on bus locations. The use of autonomous ground vehicles has become economical in applications such as warehousing and factory materials movement. With these hardware developments, a variety of control and other operations information becomes of interest. Immediate dispatching and routing of vehicles in response to current locations and demands requires new management strategies. Integration of sensing and control procedures provides many new challenges. Although operation of automated vehicles in uncontrolled roadways may still be a distant prospect, applications in automated guide ways, or maintenance activities are realistic possibilities. Better sensing and control of roadways may prevent the familiar backward-bending congestion phenomenon prevalent on roadways. For the transportation engineer, these new technologies present challenges to devise effective vehicle control strategies, to design more efficient and capable transportation systems, and to improve system operations over a travel network. Under the Automated Highway System (AHS), a system of vehicles was developed that uses both conventional roads under manual control and special guide ways under automatic control. The design goals of AHS are to increase lane capacity and improve travel time performance. However, the problems of decision making network, computer-to-vehicle communication, and roadway devices still remain to be solved.

- **Computer Based Route Finding**: The first simulates human thinking and can be employed on a smart vehicle. The second uses an electronic control system installed on the vehicle to trail the two-wire guided route by detecting the signal phase difference. Additional applications of automation in transportation include methods for reducing the demand, such as electronic road pricing and automatic vehicle monitoring that can be used to dispatch, monitor, and control vehicles to optimize a fleet performance. Traffic control strategies can be classified as retimed and on-line (real time).
- **Computer Aided Planning and Design:** Traditionally, transportation has been a test bed for new theories and methods of design. Transportation applications provided a context for new developments such as mathematical programming or econometric models of discrete choice analysis. As a new wave of computer-aided planning and design theory develops, transportation can provide another important application area. With limited budgets, effective planning and design have become more important. Computer-aided planning and design system are evolving to incorporate a constellation of analysis, evaluation, and synthesis application programs with shared data and inter process communication. Graphic displays, knowledge-based expert systems, and databases, as well as conventional analysis programs, are all important components. Theories of design synthesis and creativity are finding an important role in the design of such systems. Both technological developments to aid computer performance as well as new concepts of design are appearing and available for application and further development. After considerable effort devoted to planning and design system development in the past 30 years, transportation has not experienced widespread application of the new integrated design systems. This is now changing, particularly for private-sector operations planning. A similar effort in traffic systems, transit providers, port facilities, and other systems of interest to transportation engineers can be expected.
- **Robotics and Automation:** While construction and maintenance have seen considerable mechanization over time, the use of robotics and automation for these purposes is in its infancy. These technologies offer the potential for productivity improvements, cost savings, quality improvements, and increased workforce safety. Given the enormous investment and maintenance needs evident

for transportation infrastructure, vigorous pursuit of these technologies is extremely important for civil engineering. Introducing robots and automation into transportation will be a challenging task. Construction robots must be hardened for extreme conditions of vibration and environment distress. Maintenance robots should be designed and operated to avoid conflict with the users of facilities. In addition to the technical problems, institutional and organizational impediments to the introduction of automation might be expected from existing workers and managers. It is likely that widespread introduction of robots in the transportation domain will require the use of smart or cognitive robots that can sense, model the world, plan, and act to achieve working goals.

Machine Vision and Image Processing for Vehicle Detection:

The advantages of vehicle detection through image processing over detection by existing loop detectors are several. In particular, an imaging detection system has multitasked capabilities, i.e., it can simultaneously detect traffic, derive traffic measurements, perform surveillance, detect incidents, recognize special vehicles, and alert a human operator, among others. The system does not disturb the pavement thus improving reliability, and can perform the function of multiple detectors. In addition, it can vary detection location and this flexible detection configuration accommodates future development of advanced truly dynamic control strategies for both arterial networks and freeway corridors. Application of advance image processing technology to traffic surveillance has been pursued by the Federal Highway Administration. In Europe, eleven countries participated in a joint project for research and development of electronic traffic aids. In Japan, University of Tokyo conducted research on measuring traffic flow using real time video processing. The major problem with all existing systems, all experimental, is that they employ "fixed geometry" sensors; this implies that the points of the roadway being measured cannot be changed unless the camera is physically moved. Therefore, existing systems cannot extract all the necessary traffic information and, therefore, are not better than loop detectors. Moreover, existing experimental systems do not extract all the traffic parameters needed for surveillance and control in real time. In short, no practical cost-effective imaging detection system is available today.

Conclusions: Advanced technologies in the area of information systems, automation, and telecommunications provide civil engineers with extraordinary opportunities for improving planning, design, construction, maintenance, and operation of transportation systems. New tools and techniques have the potential of achieving cost savings and productivity improvements as well as enabling new developments in transportation. There is a general feeling among transportation engineers that much of the future growth and development in transportation engineering would depend upon how effectively these new technologies are adopted in the field. The basic purpose of the paper was to review the areas where advanced technologies can significantly affect the way transportation engineering is practiced. The strategies for implementation of the necessary changes in the practice were also discussed along with the expected impact on civil engineering curriculum. Transportation accounts for the major portion of infrastructure investment. In order to maintain and preserve the highways, bridges, railroads, ports, harbors, pipelines, and airports as well as to plan for future developments in space transportation, civil engineers must seize the opportunities presented by the emerging technologies in information systems, automation, and telecommunications. A concerted effort in this area by government, private industry, and universities can make a significant impact on productivity and performance of transportation systems.

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