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Overcoming Performance Based Practical Design implementation issues

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Abstract

Performance Based Practical Design aims to deliver maximized system performance by addressing more miles of roadway than traditional design approaches, as highway agencies throughout the world are facing reduced budgets. A number of highway agencies have implemented some type of this approach and past research has focused on applications and documentation of benefits. However, few have examined the effectiveness of the policies and guidance needed to achieve an effective practical design program. This paper identifies several implementation challenges that must be overcome by a highway agency for long term success of these programs, including effective programming to capture cost savings at the local level, creating incentives for project engineers, district administrators or area legislators to evaluate and optimize projects, providing adequate staffing to meet the increased project demands due to the need for more detail evaluations of a greater number of possible alternatives and options, and development of consultant contracts that incentivize innovative designs aimed at reducing construction costs, without decreasing the design awards. These challenges and issues are explored here and approaches are identified to address them in order to improve the project development process through the use of Performance Based Practical Design.

Keywords – highway design, practical design, performance based design

1. Introduction

The recent trends of increased travel demand and the need for on-going road preservation, safety and mobility projects has increased the number of highway projects to be designed and constructed. On a global scale, highway agencies face economic constraints that do not allow for meeting these needs while maintaining the current level of transportation funding. It is therefore essential to reconsider the planning and prioritization of transportation infrastructure to meet these challenges with the existing limited financial resources while still delivering a reasonable system to the users.

In a typical transportation program, projects are prioritized from a system perspective during the planning stage. During the design phase though, this prioritization is lost since the project is considered in isolation and the intent is to deliver the best or optimum project. This most likely will result in an over-designed roadway segment within the system. As an example, a study of Kentucky's roadway system identified over 600 miles of rural four-lane roadways with an average daily traffic (ADT) of less than 10,000 vehicles per day (vpd) among the 1,690 miles of

rural four-lane roads [1]. Moreover, almost 10 percent of the total mileage was on roads with an ADT of less than 5,000 vpd. Such projects, in a state that maintains an "unfunded project needs list," exemplify the development of local optimum solutions with little regard to overall system improvement. It is therefore imperative to reconsider how projects are designed and move away from optimized local solutions and search out solutions that would allow increased optimization of the entire transportation system. This approach should aim to achieve the maximum rate of return on the individual project.

Performance Based Practical Design was created in 2005 in the USA to design more appropriately sized roadways though an effort to develop projects that are "'right-sized' to meet the project purpose and need, avoiding the desire to arbitrarily bring the facility up to a maximum level for all design elements." Each state has developed this form a different perspective and has focused on different aspects of the project development process. For example, Missouri [2] focused on cost reductions (Practical Design), Kentucky (Practical Solutions) [1] and Indiana (Open Roads) [3] developed a project development emphasis using the existing conditions as baseline, and Oregon [4] approached it from a system-wide improvement by meeting purpose and need goals. Currently, only eight states have adopted the general concept of Performance Based Practical Design [5]. The survey conducted as part of the NCHRP Synthesis Report 443 [5] indicates that a common thread for all states in the implementation of Performance Based Practical Design is the difficulties they faced in implementing the approach and the barriers they had to overcome to ensure the proper application of the concepts.

Past research on Performance Based Practical Design has mainly focused on the engineering guidance and aspects of the concept as well as required training to ensure delivery of design projects. Critical to implementation though are the institutional barriers to be overcome and those have been largely overlooked.

NCHRP Synthesis 443 on Practical Design states: "None of the states voiced any significant barriers that were not overcome through training, education, and communication among the stakeholders. State legislatures embraced the program as a practical way to achieve improvement projects across the state within limited budgets [5]." Contrary to this statement, the authors of this paper through their technical assistance to various highway agencies for implementing Performance Based Practical Design concepts have observed that several challenges and barriers currently exist.

This paper explores these various challenges and issues as they relate to the wider implementation of Performance Based Practical Design and identifies approaches to address them in order to improve the project development process through a review of current l practices.

2. Performance based practical design concepts

A review of the eight highway agencies practicing Performance Based Practical Design indicates that all approaches share common tenets despite their differences in focus or concentration of efforts. These tenets are presented and discussed below.

The purpose and need statement of every project is critical in Performance Based Practical Design approaches and clarity in its definition is central to all approaches reviewed. In order to deliver a truly "practical" design, the purpose and need statement should serve as the target, not the lowest threshold of acceptable performance.

Design element guidelines provide designers with a range of values to select the most appropriate one for the context of the project. The full range of values should be considered including the lower end of the ranges, avoiding the mind-set that "bigger is better."

The Policy of Geometric Design of Highways and Streets (also known as the *Green Book*) provides guidance and ranges for the design elements allowing for design flexibility [6]. Even though the values provided in the *Green Book* are considered adequate for developing a safe, comfortable, and aesthetically pleasing roadway, there are cases where additional flexibility is necessary and the implications from such flexibility should be evaluated. The recently published Highway Safety Manual (HSM) provides such a tool for designers to evaluate design element trade-offs [7]. The Guide for Achieving Flexibility in Highway Design is another good resource for identifying recommended values based on the context of the project for each of the design elements [8].

Each project should be viewed as an investment and it should be always considered under a cost-benefit prism requiring an understanding of the returns to be realized. Any financial investment has a point of diminishing returns, i.e., greater investment will have no or little effect on increasing the return. The same is true for transportation projects. Once the desired target is reached, increasing the investment (i.e., over-designing a project) will accrue little or no additional benefits. This concept is even more critical due to economic issues that several highway agencies throughout the world face, since funds expended inappropriately in overdesigned projects could have been used in other projects generating a greater return on the investment. The use of Performance Based Practical Design allows for distribution of the limited funds among more projects for improvement, thus resulting in a greater system wide improvement and return of investment. Applying Performance Based Practical Design does not only improve specific projects with a reasonable solution but it allows for greater system wide distribution of the available funds, i.e., more projects are completed.

3. State of practice

Historically, Performance Based Practical Design started with a top down approach where project budgets had to be reduced by a set amount. In order to develop a sustainable program, this approach has evolved into a bottom up approach whereby the project is designed to fit the context and project needs and not initially being overdesigned and then cut to fit budgetary restrictions.
An issue central to Performance Based Practical Design is the incremental nature of improvements that in some cases result in large improvement gains.

The choice of delivering a 2-lane or a 4-lane cross section would result in significant differences in capacity levels. The choice here becomes difficult due to its binary options and therefore flexibility in the performance metric is needed to address this issue. In this example, if the target is to provide a Level of Service (LOS) D, then the choice is between LOS E and B. In this case, and assuming that the choice is to exceed the target value, the resulting design will be the 4-lane option delivering LOS B.

However, several highway agencies, such as the one for Kentucky, have viewed these values as targets, not necessary minimums. Instead of defaulting to the solution that delivers the LOS B, under Performance Based Practical Design it may be decided that the LOS E is closer to the target in order to deliver a “right-sized project”.

A critical component of this application is providing engineering judgment and risk assessment in evaluating alternative designs. For instance, if a lowered design year is deliberated, it should be considered in the context of the confidence of the forecast. The design engineers must then determine the likelihood that the forecast demand will be achieved earlier because of the potential adjacent development. If sufficient potential exists, it may then be the “right-sized” approach to choose an alternative that provides a longer design life. If a corridor is fully built out and confidence in forecasts is high, a lower design year may be more appropriate.

The Washington Department of Transportation (WSDOT) is perhaps a leader in Risk Analysis for highway projects as practices from there may be considered for use in Performance Based Practical Design applications. Risk assessment is integral to any evaluations of design alternatives and designers should recognize the impacts of their alternatives though the utilization of available tools, such as the HSM [7]. However, risk assessment should also consider the benefit-cost ratio of the project and its life in order to truly estimate the appropriate metrics for the evaluation of the alternatives.

Another component of performance analysis that must be addressed is the identification of appropriate measures of effectiveness (MOEs) and how to establish benchmarks that meet these needs.

Identification of appropriate MOEs is critical in ensuring that all alternatives are equally considered. For instance, the metric number of lane miles of highway added does not provide for evaluation of alternatives that maintain existing facilities to meet transportation needs. Each performance measure should have an established benchmark or target that the project achieves which should be included in original project scoping or purpose and need statement. In doing so, it can be readily identified in the purpose and need statement and when it is met, so that a design can move forward, eliminating overdesign and constant improvement of a project.

The Kentucky Transportation Cabinet (KYTC) has recently adopted this practice in a new traffic engineering guidance for highway design projects [9]. In the policy, traditional MOEs of Level of Service are removed as they do not allow for cross-comparison of alternatives (for example, 2-lane vs. 4-lane roadways) and instead volume-to-capacity (v/c) measures are used exclusively. In addition, a target design year *v/c* ratio of 0.9 for rural roads and 1.0 for urban facilities has been identified. Documented justification is then required if a project proposes a solution with a *v/c* ratio of less than 0.7 and 0.8 for rural and urban roads respectively. This policy drives the designers to consider the ultimate need for excess capacity and in light of the cost needed to achieve it (i.e. practical design).

The Indiana Department of Transportation (InDOT) chose to label their practical design efforts as “Open Roads” [3]. They implored their designers to employ a “design up” philosophy to project design. Rather than starting with the “desirable” condition and often being forced to remove items to meet scope and budget, the designer should consider the existing condition of the facility as the baseline condition, and “design up” from that point to meet the project’s purpose and need. At the onset of their Open Roads initiative they set an aggressive 10% programmatic redistribution in construction budget for projects with a letting date after January 1, 2015 [3]. In order to meet this goal InDOT had meetings on these projects to discuss them from a “design up” paradigm and sanctioned design changes that would reduce construction cost while still delivering a suitable project. In order to incentivize the workforce, InDOT is planning to return the monies saved backed to the local District Offices to be used for projects in their area.

The end result of this process is often expressed in terms of cost savings or rather project cost savings. For instance, Missouri Department of Transportation (MoDOT) reports a $400 million savings out of a $3.1 billion budget [10]. However, in reality the result is not saved money, but rather more projects completed as project cost savings are reinvested into previously un-budgeted project needs. The Director of MoDOT Kevin Keith summarized this well when he stated, “Building good projects everywhere--rather than perfect projects somewhere--will yield a great transportation system in the end” [10]. This concept was further demonstrated when Kentucky adopted Practical Solutions and demonstrated the improved system mobility and safety optimization when individual project expenditures were reduced.

4. Implementation challenges

As noted above, past research on Performance Based Practical Design has focused on documentation of initial efforts and concepts. The issues described below are a summary of topics identified through implementation efforts in Kentucky and discussions with various DOT staff to promote and establish it in other states. As a result of these efforts, several challenges and barriers have been identified that must be addressed to fully implement and embrace Performance Based Practical Design. These include the following:

- Institutional challenges that deal with how the highway agency can address issues relative to their structure in order to implement Performance Based Practical Design.
- Budgetary issues that deal with how and where the cost savings can be realised.
- Staffing issues that deal with the need for experienced staff and greater staff numbers.
- Issues of how to incorporate Performance Based Practical deign with other design initiatives.

4.1. Institutional challenges

Several highway agencies with established Performance Based Practical Design process establish their improvement programs by legislative bodies with initial project concepts and budgets established for each phase of the project. As an example, in Kentucky, a Highway District may submit a list of project needs and concepts and budgets, but the final priority listing is made by the legislature. Additionally, the highway budget is cost constrained from a state-wide perspective and not distributed among the 12 Highway Districts. The result of this programming model is that Districts and legislators fight to increase funding within their own respective District and advocate for problems and issues to be addressed. Wie et al. examined this point in an effort examining the role of organizational structure in DOT capital management efficiencies [11].

The researchers stated: “Perhaps more than most other state agencies, DOTs confront a geographically based political threat to their performance. Elected officials in state legislatures represent local districts and frequently want to bring projects to their district or region, regardless of whether their particular district has the greatest technical need for the limited funds available for the construction and maintenance of transportation infrastructures. The choice of projects may be influenced by the political power of specific legislators or various interest groups. Under these circumstances, it is possible for local interests to trump the general interest.” [11].

The paradox in this scenario results from the conflict between the aims of each entity: highway districts and legislators fight to address local problems and issues, while Performance Based Practical Design seeks to minimize the extent of the improvement of the local project to better serve the overall system. Central to this is also of what happens to the cost savings realized from such an approach. In Kentucky, if cost savings are realized, that money is returned to the general transportation fund to address the next project on the list, which may not be within the same Highway District or area. However, if project “needs” are discovered that are over budget there is an opportunity to justify costs for additional funding. Through this budgetary programming process, cost decreases are de-incentivized, even if they may benefit the system as a whole, while cost overruns are incentivized. Furthermore, many politicians and citizens view Performance Based Practical Design as a way to take money away from their project and their area. People struggle to embrace the philosophy of minimizing project expenditures so that the system may be improved. Once their project gets authorized they do not approve of “cost saving measures” and seem to push for “bigger, better, more.”

MoDOT credits a large part of their success to their organizational structure and key programming/planning initiatives. In Missouri, the Transportation Improvement Plan is assembled and approved by a bipartisan Highway Commission and not the legislature. The Missouri Highways and Transportation Commission is a six-member bipartisan board that guides MoDOT. Commission members are appointed by the governor and confirmed by the Missouri Senate. No more than three commission members may be of the same political party. The State Highway Commission charter states that the road problem in Missouri is not one involving one political party against the other, or involving one area or section of the state as against another, or involving metropolitan areas as against rural areas. The highway problem is state-wide and involves all the people of Missouri [12]. Oregon DOT, which has also seen early success in implementation of Practical Solutions is also overseen through a commission. The Oregon Transportation Commission establishes state transportation policy and guides the planning, development and management of a state-wide-integrated transportation network that provides efficient access, is safe, and enhances Oregon's economy and livability [13]. Of all the DOT Performance Based Practical Design Manuals developed, only Oregon identifies the role of Strategic Transportation Program Management in the process (Figure 1) [4]. In establishing a bipartisan/geographically diverse governing board to assemble the state Transportation Improvement Program, a broader view of system performance can be provided that can assist in the implementation of system wide optimization strategies. This finding is consistent with the research by Wie et al., which found that commissions can improve management by increasing the openness and transparency of transportation decision making [11]. Moreover, a positive association between the number of commission roles and responsibilities increased the efficiency of capital management.

MoDOT has applied the idea of releasing realized cost savings within the geographic region or highway district. The districts were challenged to deliver their entire 5-year program for 10% less money than budgeted during the initial application of Performance Based Practical Design. The savings would be turned back to each district for additional projects. While this approach may not provide the fullest system optimization if money were returned to the next greatest "need" within the system, it provides significant incentive to the local design team to investigate cost reduction measures so that other local needs may be met; rather than needs in another area of the state. Furthermore, it assists in reducing political pressure to not "cut-back" on local projects as funds and improvements are kept within the local geographic region and likely the legislative district.

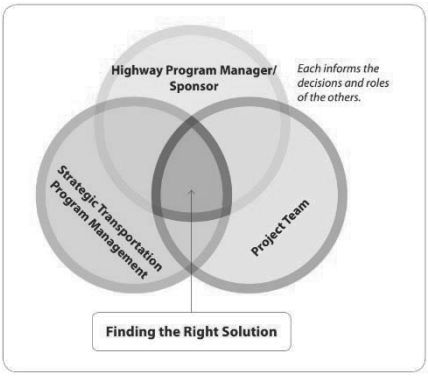

Fig. 1 - Oregon DOT Roles and Responsibilities [4]