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RESEARCH ARTICLE

A framework for classifying state DOT projects

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Abstract

On state DOT projects, practitioners want to know why a project was or was not completed on time, and why a project was or was not on budget. To answer these questions effectively, practitioners must have a framework that allows them to compare projects by type and look for performance patterns. The lack of a standardized method to classify state DOT projects may make it difficult for practitioners to identify trends, and patterns, and to use such information to inform and enhance practice. A standard classification of state DOT projects does not exist. Hence, the objective of this research is to develop a classification framework for state DOT projects based on several differentiating dimensions of state DOT projects. Following a qualitative synthesis research method, a framework that captured the key state DOT project differentiating dimensions was developed. The output of this research includes a classification framework for aggregating different types of state DOT projects. The significant contribution to the body of knowledge on classifying state DOT projects is that basic state DOT project performance analytics can be enhanced within and across the state DOTs by using the project classification framework developed from this research.

1. Introduction

Construction projects are unique. Shenhar et al. [1] argue that one of the fundamental misconceptions in the construction industry is that all projects are the same. However, it is common knowledge that not all roadway projects are the same and not all bridge projects are the same, and neither is a flat slab bridge the same as a box girder bridge. In addition, the resurfacing of existing roadway is not the same as the construction of a new roadway alignment. Gidado in [2] explains that project complexity results from the inherent nature of individual parts of a project and the connection of those parts.

Effective contract administration plays an important role in project outcomes. There is a large body of knowledge on contract performance with respect to various contract issues as captured by Zaneldin [3], and by Jagannathan and Delhi [4]. In contract administration, there are several areas of interest to practitioners that may have obscured understanding due to a lack of proper classification and categorization of projects. A valid and in-depth analysis of contract overruns, delays, designs, engineer's estimates, contractor bid amounts, project delivery methods, and realistic costs and time information could become possible if a standard project classification system becomes available to practitioners. A few state DOTs have some form of a project classification system, but

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they are limited in structure, depth, and application. The importance of project classification cannot be overemphasized, as it leads to a more in-depth understanding of project phenomena.

Research by Hinze and Selstead [5] and Cantarelli et al. [6] show that different categories of projects behave differently when it comes to the level of overruns. However, each of these studies used a different project classification system. It may be difficult for project administrators working for state DOTs to effectively look at trends and patterns within the projects they deliver. The lack of a project classification system for state DOT projects may result in obscured and exaggerated research findings in contract administration, and generalizations that fail to reflect project differences. Without considering the effect of different project types, research conducted to understand factors that affect project time and cost may have limited application in real-life situations. Such research fails to provide practical solutions to problems faced by state DOTs.

Given the gap, this study aims to propose a framework for classifying state DOT projects. Classification is aimed at making things more understandable. It is "not only a way of representing entities but is also a way of imposing order on them" as captured by Kwasnik [7]. Kwasnik posits that knowledge representation in the form of classification enables knowledge creation and discovery.

This research is significant because it would provide a standard project classification system that when applied will help practitioners get a better read on the unique nature of projects and how best to administer them. The classification framework follows key dimensions that drive project performance. The framework developed from this research could deeply enhance how practitioners evaluate and administer state DOT projects.

2. Literature review

2.1. Previous studies related to construction project classification systems

The work by Shenhar et al. in [1] captured ten years of studies on the differences among projects as they relate to project management techniques. Their research found that practitioners were not aware of project differences and the use of specific techniques to manage different types of projects. The research also found that the organizations did not have a framework for classifying projects. The classification framework by Shenhar et al. [1] is presented in Table 1.

The classification system differentiated projects based on system scope, where system projects involve a complex collection of interactive elements and subsystems, and this level of classification is related to construction projects. However, this classification system is designed for use at a high level and does not further breakdown a construction project to lower level dimensions.

Crawford et al. [8] conducted in-depth research to better understand the need and use of project classification systems. From the study, it was found that to date, classification systems for projects have been developed on an ad hoc basis for various uses, the authors found that some organizations have multiple project classification systems in use - both formal and informal classifications. While this research did not present a framework, they synthesized their findings to show common ways of categorizing projects from a big picture perspective which included:

- Projects by size, risk, or complexity
- Projects by strategic importance, stage of the life cycle, or sector
- Projects by contract form, payment terms, or risk ownership

Also, the research showed that projects could be categorized based on purpose which could include:

- Selection of an appropriate project management methodology
- Selection of an appropriate project organization
- Selection of appropriate project personnel
- Definition of management and assignment of risk
- Certification of project personnel
- Definition of project data requirements
- Selection of appropriate key performance indicators

Table 1. Summary of a framework for project classification developed by Shenhar et al. [1]

	Project Types	Users	Use
Strategic Goal	1. Extension 2. Strategic 3. Problem Solving 4. Utility 5. Research	Top Management Business Managers Functional Managers	Portfolio Managemen Priority Setting Resource Allocation Project Manager Selection
Market Uncertainty	1. Derivative 2. Platform 3. Breakthrough	Marketing Project Managers Engineering	Customer Requirements Market Research
Technological Uncertainty	A. Low-Tech B. Medium-Tech C. High-Tech D. Super High-Tech	Project Managers Engineering Designers	Design Methods Design Cycles Design Freeze Times Testing
System Scope	1. Assembly 2. System 3. Array	Project Managers Top Management	Project Organization Subcontracting Outsourcing Formality Coordination
Pace	1. Regular 2. Fast/Competitive 3. Blitz/Critical	Top Management Project Managers	

- Focus on appropriate success criteria and success factors
- Choice of appropriate legal, cultural, and philosophical systems
- Choice of appropriate contract and payment terms
- Transfer of knowledge.

The research by Crawford et al. [8] was pursued in recognition of the need for a project classification system, and while a framework was not developed, the research showed that a standardized classification system will benefit practitioners and organizations in the construction industry.

Several researchers have pointed to the need to develop a project classification system, and a few researchers have developed a project classification system, but with a limited focus.

Hancher et al. [9] used 14 categories of project types that were previously developed by Texas DOT. The 14 categories can be viewed as relating to types of construction and systems constructed by state DOT projects.

Werkmeister et al. [10] used categories of project types that were previously developed by Kentucky DOT. Similarly, the six categories can be viewed as relating to types of construction that state DOTs construct.

Tri-State Transportation Campaign - TSTC [11] developed a project type classification system to allow for a comparative evaluation of funding under STIP across all the state DOTs.

The work by Okere [12] resulted in the classification of Washington State DOT (WSDOT) project types based on 18 categories. The categories can be viewed as relating to types of construction and systems constructed by state DOT projects.

The research by Antoine and Molenaar [13] considered four variables that include complexity, award cost, facility type, and project type. Using a well-structured questionnaire to capture data from state DOT on four project characteristics Antoine and Molenaar [13] used latent class analysis (LCA) to develop a project categorization framework as shown in Table 2.

Table 2. Project type classification framework developed by Antoine and Molenaar [13]

Classes	Description			
	Complexity	Award Cost	Facility Type	Project Type
Class 1	Most Complex	Over $10M	Road & Drainage	New Cons. & Resurf.
Class 2	Mod. Complex	$0 - $50M	Bridge	Rehab.
Class 3	Non-Complex	$0 - $10M	ITS & Ancillary	Maintenance

The proposed project classification framework developed from this research extends previous research on project classification systems by considering other project differentiating dimensions.

2.2. Various categories of construction work used by the state DOTs

For various policy-related reasons, the state DOTs maintain and use various design and construction practice standards that define various categories of construction work. Fig. 1 is presented below to provide a view of the various categories of construction work used within and across the state DOTs and how they differ from.

2.2.1. Categories of state DOT facilities

A bridge is a facility built to provide passage over physical obstacles without the need to close or remove the obstacles, which might include a body of water, a gorge, a roadway, and a railway. Parsons Brinkerhoff and Engineering and Industrial Heritage [14] categories of bridge types include trusses, arch, slab/beam/girder & rigid types, moveable spans, suspension, trestles & viaducts, and cantilevers. There are several types of bridges in the US, and in 2006, the bridge counts as captured in Farhey [15].

Similar to the bridge classification system, there are also different highway and street classification systems referred to as functional classifications. The highway and street classification system as proposed by Stamatiadis et al. [16] considers both the geographical context (based on density, land use, and setback) and the roadway types. A similar classification of highways and streets was provided by Findley et al. [17] based on the amount of mobility and access they provide.

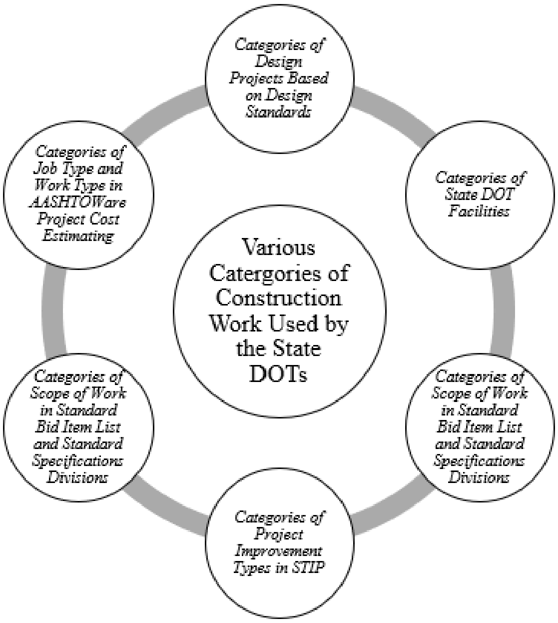

Fig. 1. A view of various categories of construction work used by the state DOTs

Retaining wall as a system is also classified and grouped based on inherent characteristics that differentiate one retaining wall from another. Florida DOT [18] classification of retaining walls is different from one found in Caltrans [19] which classifies retaining walls as gravity, semi-gravity, and non-gravity cantilevered and anchored walls. The classification of retaining walls used in Brockenbrough [20] is a blend of the classification used by Florida DOT and Caltrans, and Brockenbrough's category of retaining walls includes rigid retaining walls, MSE walls, non-gravity cantilever walls, anchored walls, soil nail walls, and prefabricated modular walls.

2.2.2. Categories of scope of work captured in standard specifications and standard bid item lists

State DOT projects are designed and constructed following the scope of work as captured in the contract specification, contract plan, and bid/pay items. For example, WSDOT [21] specifications are classified into divisions that include 1) general requirements, 2) earthwork, 3) aggregate production and acceptance, 4) bases, 5) surface treatment and pavement, 6) structures, 7) drainage structure, storm sewer, sanitary sewer, water mains, and conduits, 8) miscellaneous construction, and 9) materials. Oregon DOT [22] on the other hand categorizes the specifications as follows 1) general conditions, 2) temporary features and appurtenances, 3) roadwork, 4) drainage and sewers, 5) bridges, 6) bases, 7) wearing surfaces, 8) permanent traffic safety and guidance devices, 9) permanent traffic control and illumination systems, 10) right of way development and control, 11) water supply systems, and 12) materials.

All state DOTs maintain a master list of approved bid items (pay items). However, similar to the categories of the scope of work found in the specifications, the standard list of bid items and section of the bid items differ from one state DOT to another.

2.2.3. Categories of project improvement types in STIP

Each state DOT is required to document and report its statewide transportation improvement program (STIP) expenditure. A report by Tri-State Transportation Campaign (TSTC) [11] found that different DOTs categorize their projects differently, which makes it difficult to aggregate, report, and compare expenditures across all state DOTs. A common list of project improvement types/codes does not exist. For example, New Mexico DOT [23], Virginia DOT (VDOT) [24], and Mid-Region Metropolitan Planning Organization [25] documents include different categories of improvement types/codes. Alaska DOT & PF [26] primary work type category as used in their searchable eSTIP database is different from the other Pacific Northwest (PNW) state DOTs.

2.2.4. Categories of design projects captured in design standards

The state DOTs' design manuals guide the design of different projects, and each state DOT has its manual. Oregon DOT [27] uses four design standards that include 4R standard, 3R standard, 1R standard, and AASHTO's Policy on Geometric Design of Highways and Streets – 2011. These four standards guide the design of nine different design projects as depicted in Table 3. The different design manuals from the state DOTs cover specific projects, and Table 3 captures the differences in the projects identified by some of the state DOTs.

2.2.5. Categories of work classes captured in contractor's prequalification forms

On state DOT projects, contractors must go through a qualification process before they can bid on a project. Through this process, the areas of expertise and bonding capacity of a contractor are known, making it possible for the agencies to properly qualify the contractor for each project that is let out for bid or proposal.

Table 3. Categories of design projects found in State DOT's design manuals

OREGON DOT Design Manual	ALASKA DOT Design Manual	WSDOT Design Manual
Modernization [New Construction/ Reconstruction (4R)]	New Construction	New Construction
Preservation [Interstate Maintenance/ Resurfacing, Restoration, and Rehabilitation (3R)]	Reconstruction	Reconstruction
Bridge	Rehabilitation (3R)	Improvement projects
Safety		Preservation projects
Operations		
Maintenance		
Miscellaneous/ Special Programs		
Single Function		
ODOT Resurfacing 1R		

WSDOT [28] uses 58 standard work classes to include items such as clearing, grubbing, grading, and drainage; bridges and structures; tunnels and shaft excavation; demolition; earth retention and anchoring; railroad construction, and others. For project bidding purposes and qualification of contractors, South Dakota DOT [29] uses 15 standard work task categories.

2.2.6. Categories of job type and work type captured in AASHTOWare project cost estimation application

The NJDOT uses AASHTOWare Project Cost Estimation software for preparing construction cost estimates, and several other state DOTs use the same software. AASHTOWare is a suite of applications designed by and used by state DOTs. AASHTOWare provides for standardization and as such, some level of integration and collaboration. In addition, the applications allow the state DOTs to share best practices and conduct comparative analyses, aimed at improving performance. The AASHTOWare Project software comes with modules that include the project estimating module. Three data points captured within the project estimating module are job type, work type, and bid item groups. However, there is no alignment within the state DOTs in their classification of job type, work type, or bid item classes.

2.3. The differentiating dimensions to classify state DOT projects

With all the differences found in the literature on categories of construction work used by the state DOTs, a unifying system is necessary to properly classify state DOT projects. Projects are unique, and certain dimensions set one type of project apart from another. For example, PennDOT [30] uses the following dimensions to combine multiple projects of similar work to deliver those projects effectively: 1) type of work, 2) size, 3) location, 4) timeline, 5) level of impact, 6) construction material, 7) threshold to ensure competitive bids, etc. Shenhar et al. [1] used three dimensions to distinguish among projects, and the dimensions include uncertainty, complexity, and pace.

What differentiates one type of project from another may have more to do with the scope of work and the project settings. This section details those proposed differentiating dimensions for use in classifying state DOT projects.

2.3.1. Type of construction

Using the design manuals as a guide, the state DOT's design efforts include different types of construction. The type of construction is the starting point to understanding how one type of project may differ from another project. Some of the themes that emerge from the design manuals and state DOT literature as they relate to various types of construction designed and constructed by state DOTs include new construction projects, modernization projects, replacement projects, retrofit projects, safety improvement projects, widening projects, preventive maintenance projects, emergency repair projects, reconstruction projects, resurfacing projects, restoration projects, rehabilitation projects, and preservation projects.

2.3.2. The controlling system of work

Even when projects fall under the same type of construction, they may differ by the type of system that forms the design basis of the project. The controlling feature (system) of work is designed under various civil engineering areas of specialization. According to Cheah et al. [31], over the years, the field of civil engineering has grown to include several areas of specialization The controlling feature (system) of work represents the main product delivered/improved, which represents another way to differentiate one project from another. Youker [32] posits that the project product (deliverable) provides the most important classification for a project type. For example, in the case of the bridge system, there are various types of bridges as detailed in Farhey [15], and in the case of the roadway system, there are various types of roadways as detailed in Stamatiadis et al. [16], and the same applies to the other systems.

2.3.3. Controlling construction material for state DOT projects

The type of construction material is a dimension that makes one project differ from another even when the projects fall under the same type of construction and system of work. There are a few unique construction materials used on state DOT projects, and they are key factors in differentiating state DOT projects because they require different tools and techniques. A review of the state DOTs (Alaska, Idaho, California, Washington State, Oregon) standard specifications points to several construction materials used on projects, and a few of the predominant construction materials found in the specifications include, wood, concrete, asphalt concrete, structural steel, masonry units, geomaterials, illumination, and others.

2.3.4. Number of combined systems of works within the project

Some projects may involve only one type of system of work, while others may include more than one system of work. Wideman [33] proposed a project typology that helps to show the level of technological uncertainty based on the extent of the level of the project scope mix. The levels are defined by, an array of different systems (multi-system), a system, - a complex set of interactive elements, an element(s) of a system.

2.3.5. Physical size (scale) of project

There is a fundamental relationship between the size of a project and the associated cost, time, or resources needed. The larger the size of a project, the more resources and time it takes. The physical size (scale) of a project captures how much work is involved.

2.3.6. Size of contract value

Even when two state DOT projects are of the same type of construction, the same system, the same construction material, and the same physical size, the contract value is likely not going to be the same. WSDOT's [34] highway construction cost comparison survey shows that the same scope of work could result in different contract values. Based on contract value , SIO's [35] contractors' guide to surety bonding, has the following classification, small – less than \$10M, middle (medium) - \$10M - \$100M, large - \$100M - \$250M, mega – more than \$250M

2.3.7. Contract time

Contract time represents how long it takes to complete a project. Contract time is driven by many factors that include and are not limited to the type of construction, the system of work, material type, size, location, and several other factors. Contract time is a dimension that differentiates state DOT projects.

2.3.8. Geographical location of project site

All highway projects are constructed either on a new alignment or an existing alignment located somewhere in some part of the country. Geographical location is important to understand project setting and the level of traffic-related constraints that might be placed on a project. Stamatiadis et al.'s [16] work on classification systems for highways and streets provided improvements to the location classification, as in rural, rural town, suburban, urban, and urban core.

2.3.9. Project risks and complexity

Turner [36] presents project complexity within three levels that include low complexity, medium complexity, and high complexity level. Gransberg et al. [37] developed one of the project complexity measurement methods that have been adopted by Wisconsin DOT [38] and USDOT. The model is called the complexity footprint, and it is based on complexity rating in five dimensions that include cost, schedule, technical, context, and finance. VDOT's [39] category of project complexity is presented in Fig. 2. VDOT category of project complexity also includes an extensive list of projects that relate to each category of project complexity and risk.

2.3.10. Traffic control level

Maintenance of traffic in and around ongoing construction projects is of major concern on every heavy highway project, and the level of traffic control helps to classify projects based on traffic maintenance, staging, and phasing of work.

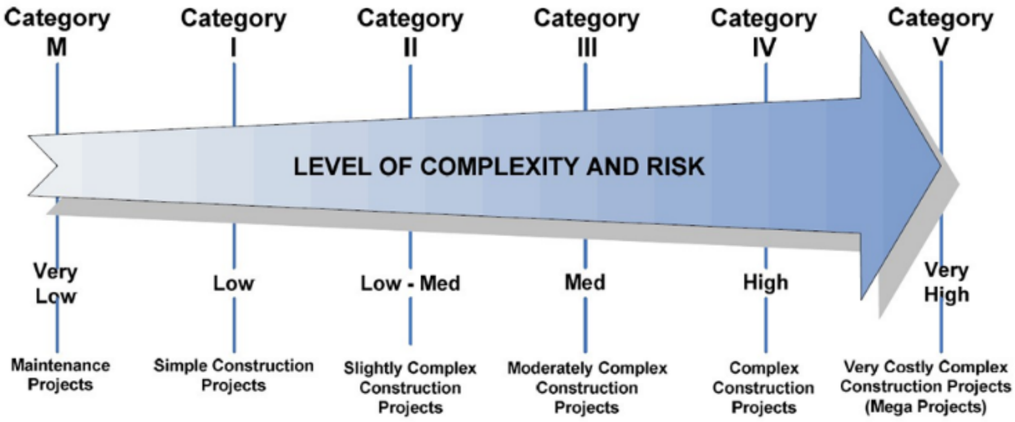

Fig. 2. Categories of project complexity and risk captured from VDOT [39]

British Columbia MOT [40] developed a classification for MOT that reflects the condition of similar highway projects executed in the US.

2.3.11. Level of Environmental Control Needs

Project environmental consideration begins with the project location. According to Massachusetts DOT [41], roadway design usually starts with the environmental context, which considers nearby natural resources, the terrain, and man-made environment. Environmental needs are specific to project settings and go beyond classification by area type.

Cunningham [42] explains how physical site conditions affect the cost of a project. Environment factors are major differentiators of projects and can be captured using SEPA classification of environmental conditions for a specific project, as in DS - Determination of Significance, DNS - Determination of Non-significance, and CE - Categorical Exempt.

2.3.12. Project Delivery Method

A major differentiator of projects is the project delivery method chosen. WSDOT [43] details the processes required for the selection, design, and construction of a design-build project. The resulting contracting environment created by different project delivery methods may affect project performance and project outcome. According to West Virginia DOT [44], some typical project delivery methods used on state DOT projects include the following, DBB – Design-bid-build, DB – Design-build, P3 – Public-private partnership, CMGC – Construction manager, general contractor, and others.

2.3.13. The Contractor

It is common knowledge in the construction industry that the success or failure of any construction project is largely dependent on the contractor chosen to build the project. Alhumaidi [45] posits that considering that contractors play a big role in any construction project, they have a major influence on the overall success of any project. The overall performance of a project depends on selecting the right contractor for the right project (Cristobal [46]). Both Alhumaidi [45] and Cristobal [46] agree that some of the key determinants of capable contractors include experience, availability of resources with technical capability, financial stability, good safety record, and ability to complete projects on time. Considering the production rate of different contractors and their impact on project time, the work by Yi and Wu [47] shows that for different items of work, the production rates differ by contractors.

3. Research Design and Method

This study was conducted to develop a framework for categorizing state DOT projects. The research follows a qualitative synthesis (qualitative systematic review) research design (Schick-Makaroff et al. [48]). The research conducted an in-depth and extensive review of literature on dimensions and differentiators of state DOT projects, and gathered and analyzed over 50 documents related to state DOT's policies and procedures. Accordingly, project characteristics were identified through an extensive literature review. The research evaluated current classification systems both formal and informal. The research developed a synthesized framework of project characteristics for use in categorizing state DOT projects.

4. Research Result – The Proposed Classification Framework

The resulting classification framework identified 13 dimensions (categories) with each dimension further broken down into corresponding measures (classes), giving practitioners a synthesized data-driven tool that could enhance how practitioners classify state DOT projects.

A hierarchical structure was developed to show that based on the dimensions chosen, several top-down evaluations could be conducted at a granular level. The level goes from type of construction to controlling system of work, to controlling materials, and to all the other dimensions. As shown in Figure 3, the proposed hierarchical structure is presented in this research to show that one of the options available for organizing the proposed framework is by using a hierarchical structure. Fig. 3 provides an example of the hierarchical structure of a typical state DOT project.

Table 4 below provides an in-depth and robust view of the proposed classification framework with all 13 dimensions (categories) and the applicable measures (classes) for each of the 13 dimensions.

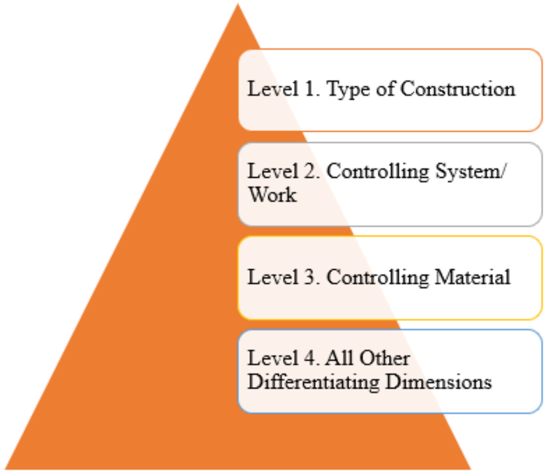

Fig. 3. Proposed hierarchical structure for organizing state DOT project types

4.1. Meeting the need for mutually exclusive and exhaustive categories of state DOT projects

The objective of this study is to propose a framework to categorize state DOT projects. However, the intention is not to prescribe a fixed, inflexible, narrow, and rigid grouping of projects, but instead to allow state DOTs to easily filter and categorize their projects according to the project scope of work and the corresponding characteristics (dimensions) defined in Table 4. Instead of specifying the categories of project types such as types M, I, II, III, IV, and V which is how VDOT categorized the level of project complexity and risk [39], in this research the recommendation is simple, that the project type category is defined by what is in the project scope as they relate to the dimensions and the measures defined in this framework. This means that the dimensions and measures defined in this framework will allow for mutually exclusive and yet exhaustive categories of projects. The proposed classification framework should allow practitioners to easily associate a project to a specific project category – be mutually exclusive and exhaustive in allowing practitioners to capture all applicable dimensions and measures. Mutually exclusive means that each project category is unique and does not overlap with one another, while exhaustive means that all possible project types will be captured with the classification framework.

Table 4. Proposed state DOT project classification framework with detail on the dimensions (categories), and the measures (classes) within each dimension

Type Of Construction	Controlling System/Work	Controlling Material Type	Number Of Combined System / Work Involved	Dimension And Scale Of Project Per	Size Of Contract Value	Contract Time In Working Days	Geographical Location Of Project Site	Traffic Control Category Of Project Site	Project Risk And Complexity Category	Site Environmental Assessment Type	Project Delivery Method	Number Of Years Of Experience Of Prime Contractor On Controlling System Of Work
New Construction Project	Roadway	Plain Concrete	2	End-To-End Length, Lf	Small	Working Days Within One Construction Season	Rural Roadway - New Alignment	Traffic Control Category 1	Category M	Ds - Determination Of Significance	Dbb – Design-Bid-Build	
Reconstruction Project	Interchange	Reinforced Concrete	3	Contact Surface Area, Sf	Medium	Working Days Within Two Construction Seasons	Rural Roadway - Existing Alignment	Traffic Control Category 2	Category i	Dns - Determination Of Non-Significance	Db – Design-Build	
Rehabilitation Project	Intersection	Structural Steel	4	Concrete Volume, Cy	Large	Working Days Within Three Construction Seasons	Rural Town Roadway - New Alignment	Traffic Control Category 3	Category ii	Ce - Categorical Exempt	P3 – Public-Private Partnership	
Retrofit Project	Bridge	Timber	5	Asphalt Concrete Weight, Ton	Mega	Working Days Within Four Construction Seasons	Rural Town Roadway - Existing Alignment	Traffic Control Category 4	Category iii		Cmgc – Construction Manager, General Contractor	
Safety Improvement Project	Retaining, Sound, Rock Slope Stabilization Wall	Concrete Pavement	6	Length Of Roadway, Mile		Working Days Within Five Construction Seasons	Suburban Roadway - New Alignment	Traffic Control Category 5	Category iv			
Emergency Relief Project	Tunnel	Hot Mix Asphalt	7	Roadway, Lane-Miles		Working Days Within Six Or More Construction Seasons	Suburban Roadway - Existing Alignment		Category v			
Preventive Maintenance Project	Storm Drainage	Geomaterial And/Or Soil Improvement Material		Structural Steel Weight, Ton			Urban Roadway - New Alignment					
Preservation Project	Utilities (Not Storm Drain)	Masonry		Geomaterial Volume, Cy			Urban Roadway - Existing Alignment					
	Electrical/Its	Prestressing Concrete					Urban Core Roadway - New Alignment					
	Building Facility	Storm Drain Material					Urban Core Roadway - Existing Alignment					
	Rail Transit	Piles (Drilled & Driven)										
	Landscape	Rock Slope Protection Material										
	Marine Structure & Facility	Electrical/Its Material										
	Miscellaneous	Bridge Expansion Joints And Bearings										
		Demolition And Removal Material										
		Landscape Material										
		Others										

This is based on the foundation that no two projects are the same, yet it should be easy to see projects that share common dimensions and measures. The classification framework would allow the agencies to select one or more types of construction, one or more types of systems/work, and one or more types of materials, and the same would apply to the other dimensions. The proposed framework should also allow for the agencies to select and aggregate the contributing percentage of the type of construction, the type of systems/work, the type of materials, as well as all the other dimensions. Implementing the proposed framework in an existing database or new database containing state DOT projects will involve tagging. This requires defining the dimensions and corresponding measures outlined in this framework and relating them to each project based on the scope of work. With the tags entered, practitioners can easily filter, sort, and slice the data per related attributes tagged.

5. Discussions

The conceptual framework developed in this research shows that state DOT projects could be classified by one or more contributing types of construction, one or more contributing systems of work corresponding to the type of construction, as well as one or more contributing materials corresponding to the systems of work. A state DOT project could be further defined by the size of the project, the contract value, the project contract duration, the physical sizes of various systems and components, the categories of traffic control required for the project site, the categories of geographical locations of the project site, and the site environmental assessment type. In addition, state DOT projects could be defined by the project risk and complexity level, the project delivery method used, and the experience of the prime contractor.

The question could be asked of who would use the framework developed from this research and how would they use them. Some of the areas where this framework could be incorporated are the following areas:

- An estimating database to allow for analysis and evaluation of project cost estimates based on different project types.
- A publicly accessible database of active and completed projects to help provide transparency and made project data available for researchers.
- A STIP (statewide transportation improvement program) report to allow for a consistent method for aggregating and reporting on statewide improvement at an in-depth level, thereby providing transparency and clarity.
- A database of project schedules to aggregate and analyze different project schedules based on the project types, thereby making data available to objectively estimate contract time based on known patterns from specific project types.
- A database of contract change orders to aggregate and analyze contract changes associated with various project types.

To help state DOTs implement the proposed framework, this section outlines some of the benefits and applications of this research. The benefits of using the project classification framework extend to and are not limited to the evaluation of:

- Project types and rate of/trends in project cost overruns
- Project types and rate of/trends in project time delays
- Project types and level of/trends in the accuracy of the engineer's estimate
- Project types and range of/trends in bid amount submitted
- Project types and design completeness – the level of/trends in design error and omissions
- Project types and sources of/trends in contract changes
- Project types and level of/trends in types of management resources needed
- Project types and completeness of /trends in contractual language and clauses
- Project types and impact on/trends in project delivery method
- Project types and the percentage of/trends in contingency allocated

- Project types and effectiveness of/trends in contract administration practices
- Project types and rate of/trends in safety performance during construction
- Project types and applicable WBS (work breakdown structure)/construction work tasks
- Project types and nature of/trends in project risk and complexity
- Project types and conceptual methods for determining contract time and cost
- Project types and trends in the bid submitted by a specific contractor

A standardized framework for the classification of state DOT projects could provide insights on trends and patterns that may not be evident in current practice where well-defined project type differentiators may not be considered when classifying state DOT projects. In addition, standardized classification of state DOT projects should provide the basis to evaluate and report on project performances.

The framework developed in this research could help improve, extend, and apply the research conducted in the construction industry, and help provide insight and deeper understanding. Here are a few examples.

Comu et al. [49] posit that the dynamic characteristics of construction projects make it difficult to meet project objectives. The research sought to determine the main factors that affect the choice of project delivery method in Turkey – as they relate to time, cost, scope, owner, project related issues. The work by Comu et al. could be enhanced by first aggregating the project types based on the key project dimensions identified in this research. This could help practitioners to easily identify the interplay of the factors that affect the choice of project delivery methods.

The research by Sumer and Arditi [50] points out that contract administration is an important aspect of effective management of any construction project. The research evaluated the impact of two different contracting formats on construction projects in Turkey. While the research agrees that more-balanced contracting languages would lead to project success, it also noted that project delays were not impacted by the type of contract used. Practitioners could extend this research by Sumer and Arditi by aggregating the project types based on the framework developed in this research. This could help practitioners to better understand how and why projects behave differently, which could lead to contractual languages that reflect project types.

Alemu and Thakur [51] sought to evaluate the impact of construction delays at different phases of the project life cycle. Arguably one would expect that the impact of a delay in the conceptual phase will be minimal when compared to the impact of the same delay in the construction phase. This research by Alemu and Thakur speaks to the importance of the project classification system because research like this could help practitioners to uncover more insight if the projects were first aggregated based on their uniqueness and their characteristics.

6. Conclusions

The construction industry captures a large amount of data related to projects, and the insight that could be derived from those projects may depend on how they are classified. Classifying a project could be as simple as relating a project with appropriate tags and attributes. To gain insights from projects, practitioners must have a framework to associate projects based on the scope of work and the characteristics that are aligned with project performance measures. The lack of a standardized classification of state DOT projects may obscure and exaggerate practitioners' understanding of contract administration. In the absence of a standard classification system of projects, practitioners take pragmatic and ad hoc steps to classify projects to meet their specific needs. The proposed project classification framework could help to focus practices and performance on state DOT projects. Previous project classification systems were not comprehensive and they lacked depth. This research was in-depth and developed dimensions and measures that could be applied to existing or new databases of state DOT projects to gain insights. The significant contribution to the body of knowledge is that basic project performance analytics can be conducted to enhance how practitioners evaluate and administer state DOT projects within and across state DOT. The use and application of the proposed project classification framework are limited to public projects completed by state DOTs. For future research on this topic, the recommendation would be to focus on evaluating how well the proposed classification framework enables better visibility and insight into project performance.

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