The Impact of Project Delivery Methods Used on Public Highway-Rail Intersection Projects in New York State

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Abstract

Project delivery method is used for infrastructure developments based on cost effective and efficient solutions to meet project requirements. This study investigated the impact of project delivery methods used by railroad organizations in 256 selected public highway rail intersection (HRI) projects that have similar scope and were completed within a period of ten years in New York State. Specifically, the study sought to assess possible difference between the total costs of HRI when design-build (DB) and design-bid-build (DBB) methods are used by railroad organizations to complete the projects. Public HRI projects are performed at locations where the railroad bisects highway that is used by the public and maintained by a municipality. Project improvements are funded by the federal government and matched by the states in the USA for safety of the public using the intersections. Available funds have almost remained the same over the years while project costs have escalated. In addition, projects that are similar in scope are being implemented by different project delivery methods that impact the number of projects approved. Data for this study were sourced from NYSDOT and analyzed with SPSS. The hypothesis was tested with a non-parametric test (Mann-Whitney U) to determine the statistical significant difference between the total costs of HRI projects when DB and DBB methods are used. Findings indicated that there was a statistical significant difference between the total project costs when DB and DBB methods were used based on p=0.004 (p<0.05). Recommendations are provided to assist the New York State Department of Transportation (NYSDOT) as well as other state DOTs in sustaining and improving public HRI projects.

Introduction

Project delivery method is a process that defines the relationship between parties involved in a specific project. The method could have effect on the project, its budget, schedule, quality as well as the extent of the owner's involvement. While it is applicable in private developments, it is very applicable in providing efficient public projects. Public highway-rail intersections are located at different points along railroad corridors where the railroad bisects the highway (roadway). A highway-rail intersection (HRI) is an infrastructure that impacts the traveling public that uses the rail and road systems. In countries like Australia, the UK and Nigeria, HRI is called a level crossing. In this study, the term "highway-rail intersection" is used interchangeably with railroad grade crossing. It involves two completely different modes of transportation with different operating authorities and operation characteristics [1]. In United States, different railroad companies own the right-of-way along respective corridors of operation. Highways bisect the railroad tracks, and this warranted improvements to provide warning devices at the bisected locations to alert and bar public users from crossing when a train is approaching the crossing. However, most railroad crossings have been created over the years, but they require continuous improvements. These improvements have been based on different project delivery methods used by railroad organizations. The improvements are necessary to avoid fatalities and injuries to users of the systems.

Federal funds for highway-rail intersections are provided to reduce hazards or risk exposure to the traveling public [2]. It is a cooperative effort between the Federal Highway Administration, states, railroad companies, and municipalities where required. These funds are matched by each state to progress full upgrade of warning devices. The highway-rail intersections in need of improvements are selected based on a suitable method for a state, using a hazard index such as the USDOT Accident Prediction Formula to prioritize and rank potential high risk intersections; these are then placed on statewide funding list. The hazard index is the primary initial factor used to rank and select Section 130 projects [3]. The highest ranked project locations are funded but limited by the appropriated amount available each fiscal year. Because of the inadequate funding for all candidate crossings, available funds were only targeted for implementing projects among those that were ranked at the top of the list.

This study considered HRI projects that consist of installing flashing lights, gates, and stanchions with their foundations, equipped with signal houses and circuitry systems. The projects have similar scope and were fully funded by the government. The railroad crossings are located at freight and passenger rail corridors, while other projects are being initiated by the states in conjunction with railroad companies that owned the tracks and/or operated the tracks. There is no targeted cost or specific delivery method applicable to all highway-rail intersection projects except that it has been based on capability, where the railroad uses its workforce to design and build or to use conventional methods. The bottom line is that recently, NYSDOT experienced funding constraints to implement all candidate HRI projects. New York State has 2,679 public railroad grade crossings [4]. High risk locations at these crossings will continuously require circuitry upgrades and improvements of warning devices, surfaces as well as interconnections between highway traffic devices, and railroad circuitry systems.

Literature Review

Stakeholders in HRI projects are usually the railroad organizations/ contractors/designers and the federal/state/local governments. Ghavamifar (2009) defined PDM as a framework of all project stakeholders' legal relationships and responsibilities [5]. It is also defined as a system used within the industry to define processes for accomplishing project phases, the contractual relationships and the parties involved in each phase. In analyzing the performance by the City of Los Angeles Bureau of Engineering, project costs were compared based on phases between the DBB method and an in-house construction method. The projects analyzed differed in scope. Further research was recommended for projects with equivalent design, construction scope, and complexity [6]. This study engaged HRI projects that had similar scope.

PDM is a system designed to achieve satisfactory completion of a construction project from conception to occupancy. However, several fundamental project considerations are impacted by the delivery method selected for a given project. These include adherence to realistic budget, a schedule that accurately presents the performance period, responsive and efficient design processes that lead to a quality set of documents, thorough risk assessment followed by the proper allocation of risk by the owner, and recognition of the level of expertise within the owner's organization or available to it [7].

The four main criteria for the success of any project delivery method are cost, quality, time, and safety. The responsibilities for meeting these criteria vary by methods and level of risk a PDM offers to owners or providers [8]. Constraints can allow use of any contracting formats to achieve the delivery. The methods include design-bid-build, design-build, construction management at risk, integrated project delivery, public-private partnership, build operate and transfer, turnkey, fast tracking, partnering, and job order. Each of these project delivery systems has varying responsibilities and risk allocation. In essence, different project delivery systems organize the building process and allocate risks differently [9].

An HRI is either a private or public crossing. Public HRIs are infrastructures, which, when created and/or improved, are funded by the government. Public infrastructures are physical investments such as roads, water and sewage systems, electric power plants, telecommunication facilities, railroads, and airports that are traditionally provided by the public sector to private households and businesses [10]. The HRIs selected for this study are public infrastructures that are funded by the government to provide safety measures to the public using the crossings.

Limitations of public funds available for infrastructure improvements have led governments to invite private sector entities into long-term contractual agreements for the financing, construction and/or operation of capital intensive projects [11]. HRIs are public projects that can only require collaboration between state agencies and railroad organizations so as to share costs for improving high-risk HRI projects. Such collaboration will sustain current number of project improvements or improve more candidate crossings. Therefore, while there is limited relative research for this study, the results would fill the gap on constraints encountered from the use of different project delivery methods on serial projects, such as HRIs, that have similar scope.

Methodology

This study was conducted to assess the impact of PDMs used on public highway-rail intersection projects in New York State. The study considered all completed projects with the same scope, which were contracted between NYSDOT and railroad organizations within a

10- year period. In order to assess the impact of PDM, the authors used a total population sampling to select the HRI projects, a type of purposive sampling technique that involves examining the total population that has a particular set of characteristics [12]. The authors selected 256 public HRI projects from 368 closed projects. These projects are those installed with flashers and gates and were completed between 2002 and 2012. These projects have similar scope, were installed at independent locations, and were not repeated.

The data for the 256 HRI projects were sourced from NYSDOT project database. The limitation in the study scope was that the database did not distinguish the type of circuitry used for these projects. However, the projects were representative of project delivery methods used to accomplish them. The data types were continuous and categorical. The variable with continuous data for this study was the total project cost (TPC), while variable with categorical data was the PDM. The PDM was classified based on the method used by the railroad organizations to accomplish the projects. It was classified into DB and DBB. The projects with bid documents used DBB methods, while those without bid documents were completed with DB. The TPC was measured by a ratio scale, while the PDM was measured by a nominal scale.

These data were copied into an Excel spreadsheet, then sorted and checked for errors. They were imported into SPSS 20 statistical software for statistical inferences. With targeted project population data for the 10-year period, box plots were used to investigate the presence of outliers. Because of the presence of any outliers and/or extreme outliers, unrelated to data errors, a non-parametric test (Mann Whitney U) was used to check the hypothesis. Mann-Whitney was used because the dependent variable, TPC, was continuous while the independent variable, PDM, was categorical with two levels. The non-parametric test utilizes mean ranks and reports the median. The alpha level was set at 0.05 to determine the statistical significance of the data. Hence, the following hypothesis was tested:

Hypothesis

$H_0 1$: There is no statistically significant difference between the total cost of highway-rail intersection projects when design-bid-build method and design-build method are used by railroad companies.

$H_1 1$: There is a statistically significant difference between the total cost of highway-rail intersection projects when design-bid-build method and design-build method are used by railroad companies.

Findings

Table 1 below shows that 256 projects were analyzed. Approximately 74% of the completed projects were performed with design-build method while 26% of the completed projects were performed with design-bid-build method.

Table 1. Projects performed with different PDMs between 2002 and 2012

PDM	Frequency	%
DB	189	73.83
DBB	67	26.17

Note: N = 256

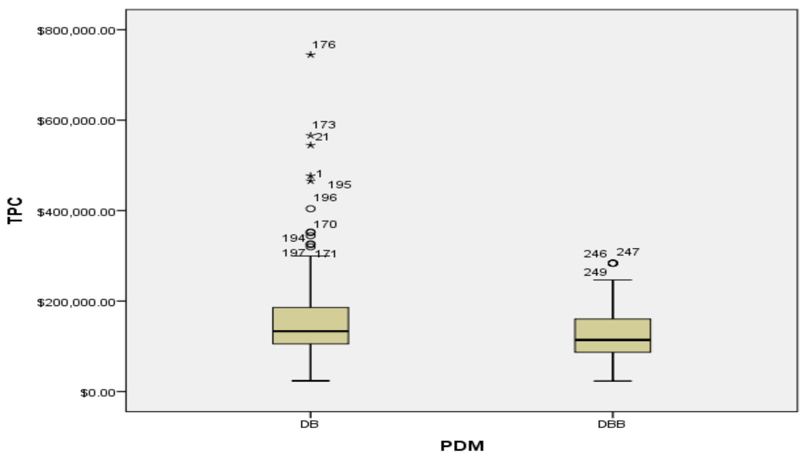


Figure 1. Box plots of TPC for methods of project delivery

The box plots indicate outliers across levels of PDM. The DB has outliers and extreme outliers while DBB has only outliers. The total outliers shown in the box plots were 13. All outliers indicated in the box plots are total project costs that were not gathered in error and cannot be removed. These outliers will cause failure of statistical tests on normality and other parametric assumptions.

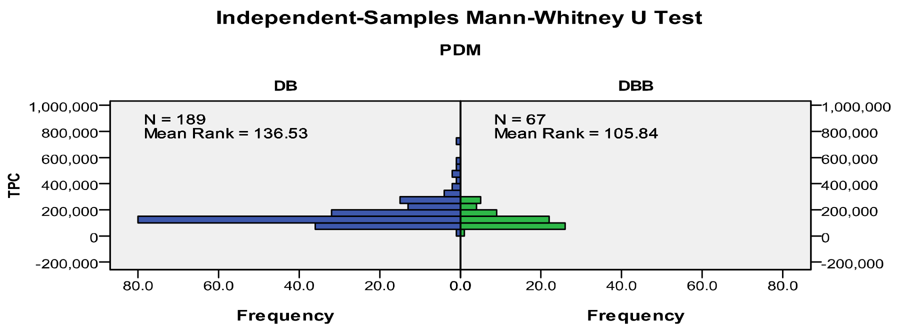
A non-parametric test, Mann-Whitney, was used to test the hypothesis and to determine a statistically significant difference between the total cost of highway-rail intersection projects when design-bid-build method and design-build method were used by railroad organizations. Figure 2 is an SPSS output for the Mann Whitney U test, which was embedded with a table. It shows the mean ranks and shape of distributions for total project costs for DB and DBB. The mean rank for DB (136.53) is higher than the mean rank for DBB (105.84). The table indicates that Mann-Whitney test statistic, “U”, is 4813. This reflects the difference between the two rank totals. The “U” can be easily reported for small sample data. It also indicates the standardized test statistics, “Z”, that are converted from “U”. The Z score is -2.916. It is less than the critical value (-1.96) for the set alpha (0.05) for two-tail test and falls in the rejection region. The “p” value shown is 0.004. This value was less than the set alpha of 0.05. However, the p value of 0.004 indicated was less than the alpha level.

Table 2 reports the median of the TPC when DB and DBB methods were used. It indicates that the median of TPC reported for DB was 19,177, more than the median of TPC reported for DBB.

Therefore, based on Figure 2 and Table 2, the total project cost of HRI when DB (mean rank = 136.53, median 133,316) and when DBB (mean rank = 105.84, Median 114,139) were used is a statistically significantly difference, U = 4,813, z = -2.916, p = 0.004. The DB indicates a higher median cost than DBB. The DB was also ranked higher than DBB. Based on the p value (0.004<0.05), the null hypothesis was rejected. Therefore, there is a statistically significant difference between the total cost of highway-rail intersection projects when the DBB method and DB method are used by railroad companies.

Table 2. Median report for PDM based on TPC

PDM	TPC
DB	$133,316.00
DBB	$114,139.08
Total	**$129,898.99**



Total N	256
Mann-Whitney U	4,813.000
Wilcoxon W	7,091.000
Test Statistic	4,813.000
Standard Error	520.766
Standardized Test Statistic	-2.916
Asymptotic Sig. (2-sided test)	.004

Figure 2. Mann-Whiney U test

Discussion and Recommendations

This study was conducted to provide recommendations on ways that HRI projects can continue to improve warning devices to mitigate risks and provide safety for users of railroad grade crossings in New York State. The result in Table 1 indicated that most of the projects were based on the DB method as compared to DBB. The use of DB basically a result of the capacity of railroad organizations that used their workforce to complete the projects. In essence, most of the projects improved are those of large or commuter railroad organizations. The result indicated statistically significant difference between the total cost of highway-rail intersection projects when DB and DBB methods are used by railroad companies. The DB methods allow a comany to develop the design and perform the construction at the same time. However, that same company assumes design and construction risks, which eventually influence project cost. Moreover, larger railroads' administrative costs and overhead can be higher than those charged by regional or short-line railroads. Furthermore, the project initiation period and the period of cost reimbursement could be financial risk factors considered by the railroad organizations.

Large railroad organizations (Class 1) and regional (Class 2) railroad organizations mostly use the DB methods to perform HRI projects because of their resources and workforce. Short-line railroads, which are local and switching railroad organizations, use DBB methods to perform the HRI projects. This study did not recommend a particular PDM to choose for HRI projects for installation of warning devices. Similarly, the NYSDOT cannot mandate a railroad organization to use a particular PDM for completing an HRI project because the property belongs to the railroad; project implementation was based on railroad capability and the state/railroad agreement was to use the funds to reimburse costs, irrespective of the PDM used.

Hence, in order to sustain and improve HRI projects with available funds, it was recommended that NYSDOT partner with railroad organizations using the DB method in New York State so as to share costs relative to labor, equipment, and materials. The state agency should adequately monitor railroad organizations, particularly those using the DB method so that they do not charge for HRI projects simultaneously when performing routine railroad work. A long-term plan could be developed between the NYSDOT and railroad organizations using the DB method to close some crossings at railroad corridors and/or grade separate HRIs so that the railroad can derive safety and maintenance benefits. These will encourage railroad organizations to fund HRI improvements. Finally, NYSDOT should ensure that the billing for cost reimbursement by railroads using DB and DBB methods is standardized.

These recommendations will help NYSDOT and other state Departments of Transportation to use available funds to sustain the current number of projects implemented and also implement more candidate high-risk HRIs. Furthermore, it would help maintain and improve the overall safety level at highway-rail intersections in New York State.

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