MICHIGAN OHIO UNIVERSITY TRANSPORTATION CENTER
Alternate energy and system mobility to stimulate economic development.

Report No: MIOH UTC TS42 2012-Final

Innovative Contracting Methods and Construction Traffic Congestion

FINAL REPORT

PROJECT TEAM

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DISCLAIMERS

INNOVATIVE CONTRACTING METHODS
AND
CONSTRUCTION TRAFFIC CONGESTION

ABSTRACT

Increasing travel demand and lack of sufficient highway capacity are serious problems in most major metropolitan areas in the United States. Large metropolitan cities have been experiencing increased traffic congestion problems over the past several years. The total delay that drivers experience has increased from 0.7 billion hours in 1982 to 3.7 billion hours in recent years. Combining the 3.7 billion hours of delay and 2.3 billion gallons of fuel consumed due to congestion, leads to a total congestion cost of $63 billion dollars for drivers in 85 of the largest metropolitan areas of the nation.

In spite of the implementation of many demand management measures, congestion in most urban areas is still increasing. In many areas congestion is no longer limited to two peak hours in a day; it is extended to two to three hours in the morning, afternoon and evening. Thus, the congestion experienced on urban and suburban freeways and arterial streets results in delays to the motorist, excess fuel consumption and a high level of pollutant emission not only during the peak hours in a day, but also for several hours throughout the day. Road construction and duration of construction are considered to be factors responsible for a significant portion of traffic congestion.

Innovative contracting approaches (such as A+B, Lane Rental, Incentive/disincentive (I/D) etc. methods) have been in use by various State Departments of Transportation (DOT) to reduce construction duration. As a part of this approach, the contractor is paid an incentive to complete a project earlier than the time specified in the contract. If the contractor completes the project later than the time allowed, a penalty is charged by contractual agreement where disincentive money is subtracted from the payment due to the contractor. The use of an incentive may be cost effective in certain projects but may not be effective in other projects. Its use must be justified by comparing the cost of the incentive with savings in Road Users Costs (RUC) value. Michigan Department of Transportation has been using the innovative contracting approach for a number of years. In order to determine the effectiveness of the innovative contracting approach, a model was developed to establish a functional relationship between construction duration and construction cost using Michigan's construction data. Two Measure of Effectiveness (MOEs) variables, "Project Time Crashing Index (TCI)" and "Project Cost Increment Index (CII)", were established as a part of this research. Regression technique was used to correlate CII and TCI. The final model was a non-linear model. Also as a part of this effort, a road user cost computation template and a screening template to determine the suitability of a project to be considered for the innovative approach were designed. These two templates should assist state DOTs in computing construction incentive dollars as well as in determining the candidacy of a project for the innovative approach.

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1. INTRODUCTION

Increasing travel demand and lack of sufficient highway capacity are serious problems in most major metropolitan areas in the United States. Large metropolitan cities have been experiencing increased traffic congestion problems over the past several years. The total delay that drivers experience has increased from 0.7 billion hours in 1982 to 3.7 billion hours in 2003. [1] Combining the 3.7 billion hours of delay and 2.3 billion gallons of fuel consumed due to congestion, leads to a total congestion cost of $63 billion dollars for drivers in 85 of the largest metropolitan areas of the nation. [1]

In spite of the implementation of many demand management measures, congestion in most urban areas is still increasing. In many areas congestion is no longer limited to two peak hours in a day; it is extended to two to three hours in the morning, afternoon and evening. Thus, the congestion experienced on urban and suburban freeways and arterial streets results in delays to the motorist, excess fuel consumption and a high level of pollutant emission not only during the peak hours in a day, but also for several hours throughout the day. Road construction and duration of construction are considered to be factors responsible for a significant portion of traffic congestion.

Accelerated contracting approaches (such as A+B, Lane Rental, Incentive/Disincentive (I/D) etc. methods) haves been in use by various State Departments of Transportation to reduce construction duration and thus reduce total construction related traffic delay as shown in Figure 1. While the State of Florida ranks first in sponsoring projects using I/D technique, the State of Michigan ranks within the top ten states in the country that have used this technique in reducing construction delay. To what extent, if any the use of I/D techniques by Michigan Department of Transportation (MDOT) has been successful in attaining the desired goal is the objective of this research.

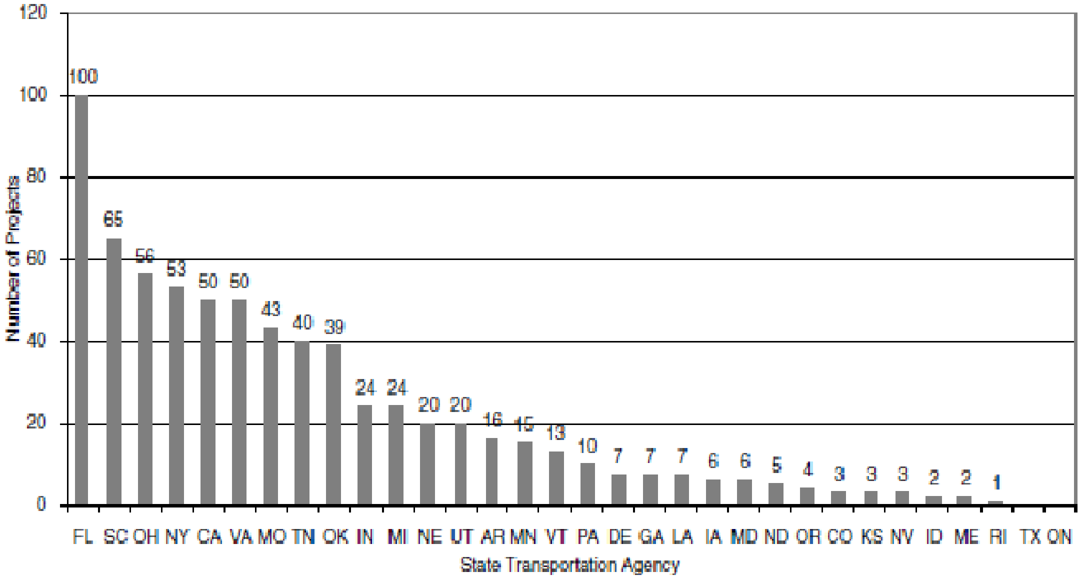


Figure 1. Number of I/D Projects by Agencies (2008-2009) [2]

In some innovative contracting projects, the contractor is paid an incentive to complete a project earlier than the time specified in the contract. If the contractor completes the project later than the time allowed, a penalty is charged by contractual agreement where disincentive money is subtracted from the payment due to the contractor. MDOT used this type of incentive during the Lodge Freeway re-construction. In other instances, contractors work about 24 hours a day and seven days a week at an extra cost of overtime so that the job would be completed sooner and total construction related delay would be minimized. In 2010, MDOT completed an overpass bridge at Nine Mile Road on I-75 freeway at a cost of close to 12 million dollars. Benefits of the incentive approach include reduced construction time resulting in reduced construction related delay, potential for lower contract administration costs, improved public relations by informing businesses/residents that MDOT is committed to completing the project as quickly as possible etc. Drawbacks are that such projects may require additional funds and contract changes can lead to disputes regarding incentive payment. Thus, the use of incentives may be cost effective in certain projects but may not be effective in other projects. Its use must be justified by comparing the cost of the incentive with savings in Road Users Costs (RUC) value.

It is our understanding that the impact of the use of incentives on long term pavement performance has not been determined by the MDOT, nor has a determination been made concerning the cost effectiveness of the use of incentives. Therefore, there is a need to quantify the effectiveness of innovative contracting techniques in reducing construction related traffic delay as well as the comparative performance evaluation of the accelerated construction project with the standard construction project over a longer time frame. In order to justify the use of the innovative contracting technique in any project the following questions should be answered.

- Is the Road User Cost (RUC) for a project higher than the incentive amount?
- Is there any functional/quantitative relationship between construction cost and duration of construction?
- Is there any trade-off between incentive dollars and users' delay cost?
- Is there a difference between the performance levels (long run) of pavements built using incentive techniques and those built using standard construction approach?

2. PROJECT SCOPE

The objectives of this research:

- Develop a model to establish a functional relationship between construction cost and time using Michigan's innovative construction data
- Develop a road user cost computation template
- Identify characteristics associated with a project appropriate for contract incentive based on the literature review.
- Design a template to be used by state DOTs to determine the suitability of using incentive based contracting for a project based on the existing literature

2.1. Review of Incentive Related Studies

The innovative contracting methods share the basic concept of applying a cost to the value of time. This method has placed a heavy premium on time value, thus requiring the general contractor to be much more aware of construction time. The innovative contracting methods do provide greater profits and a higher degree of risk both to owners and contractors. These methods have proved to be valuable techniques for decreasing overall project duration and seem to be extremely cost effective [3,4]. Time reductions of 20-50% can be attainted at an incremental cost of 5% in comparison to similar projects using conventional contracting method.

There are a number of innovative construction contracting methods that may help expedite construction activities and minimize user delay. Some of them are:

Standard Incentive/Disincentive (I/D): In this approach the contractor is paid for early completion of the project as documented in the contract. If the contractor completes the project later than the time specified, disincentive money is deducted from the payment due. The standard incentive/disincentive is typically based on the rate of liquidated damages specified in the standard specification for construction. Incentive/Disincentive (I/D) contracts not only provide incentive to the contractor for early completion but also provide disincentive for late completion. I/D contracts are designed to reduce total contract time by giving the contractor a time indexed incentive for early completion. The I/D amount set for each project should be supported via an estimated cost of the damage that is expected to be mitigated by early completion of the total project. This determination is made during the development of the daily I/D payment. The daily I/D is calculated on a per project basis.

A+B contracting method: Also known as cost plus time bidding, is intended to encourage contractors to more actively manage their schedule and adopt an innovative management process that will shorten the construction duration when necessary and thus reduce inconvenience to the public. Each contract consists of two parts:

- The "A" portion of contract is the sum of the bid for the contract work items.
- The "B" portion of the bid is the time in calendar days proposed by the bidder to complete the project multiplied by a daily road user cost determined by the department.

The A+B contracting method is used for projects with a significant level of road user impact. This method can potentially reduce contract time. A dollar value must be calculated for each contract day before advertising the project. Ideally, a maximum number of days for which the contractor may bid should be provided.

Time Cost (TC) represents the cost of delays to the owner. In most cases the TC will include the direct cost resulting from construction delays, such as temporary facilities, moving cost etc. Indirect cost items encompassing both job overhead and general overhead can also be considered in TC calculation.

No Excuse Incentive: A no-excuse incentive may reduce contract time by adding an incentive to the completion of specific construction activities by a set date, which may or may not be the contract completion date. As a part of this method, completion date can not be changed for any reason and a penalty is not applied if the contractor fails to meet the completion date. The amount of incentive is determined based on estimated road user delay cost.

Accepted For Traffic Incentive/Disincentive (AFT): The department will pay the contractor a fixed amount of incentive if the work in the contract is accepted for traffic on or before the AFT date. The contractor would be assessed a penalty if they failed to meet the AFT date. Similar to other methods, the rate is based on estimated user delay costs.

Lane Rental: The contractor is charged a fee for occupying a lane or shoulder to complete construction work and can earn an incentive or disincentive based on the number of days they occupy the lane/shoulder versus the original lane rental lump sum bid. The hourly assessment is charged by the hour and is based on estimated road user delay cost.

Interim Completion Date Incentive/Disincentive: Similar to the standard I/D, the contractor is paid an incentive for completing a specified amount of work on or before the interim completion date. A penalty is applied if work is not completed by the interim completion date. The I/D is typically based on the rate of liquidated damages specified in the DOT's standard specification of construction.

2.2. Impact of Innovative Contracting

Cost Components of Contract:

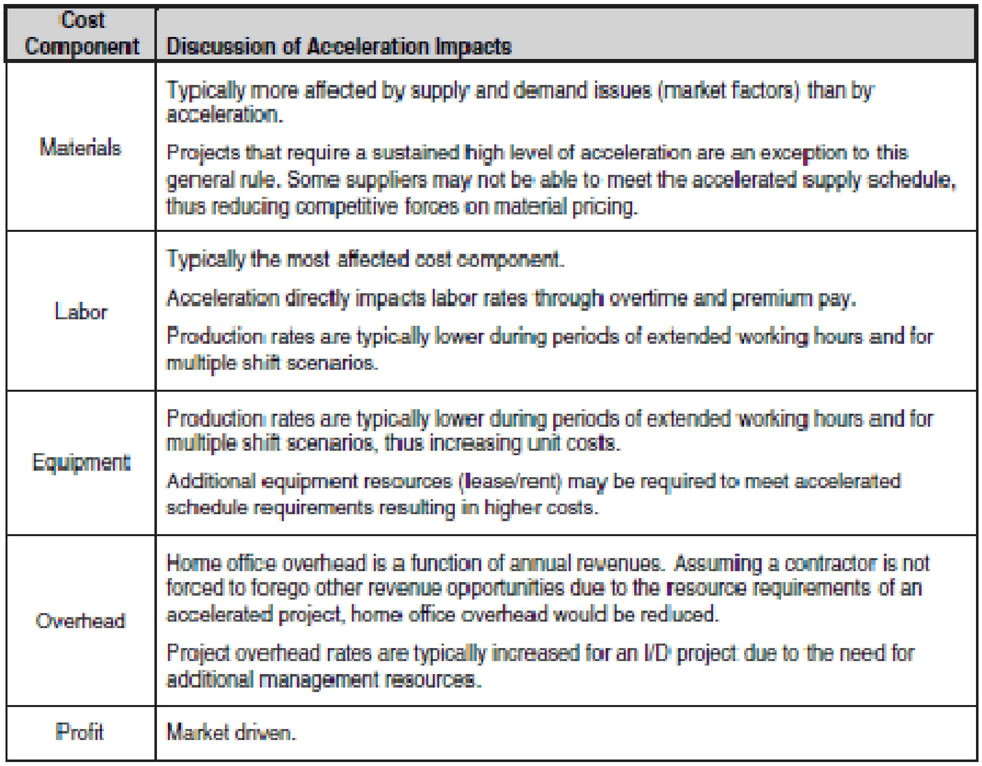
Acceleration associated with construction projects increases cost. A typical unit price found in a contract is the sum of four unique unit cost components, such as materials, labor, equipment and overhead. Profit is added to the sum of these components. Table 1 presents a list of cost components and brief description of the acceleration impacts on each cost component. As noted in Table 1, labor cost is predominantly affected by the innovative approach.

Acceleration impact on cost will also vary by the nature of work. For example, a unit of structural concrete will be impacted to a larger extent than a unit of paving, since the structural concrete has a relatively a larger labor component per unit as shown in Figure 2.

Cost and Time Overrun:
A growing number of state highway agencies (SHA) are using some form of innovative contracts for highway construction. Florida DOT has been using innovative contracting extensively since 1987. Their experience indicated that the magnitude of cost and time overruns reduced significantly with projects constructed under an innovative contracting approach. The innovating contracting method showed a reduction of 8.8 percent cost overrun and 23.6 percent time overrun when yearlong data were reviewed by the FDOT as illustrated in Table 2.

Performance Effectiveness of Different Incentive Contracting Techniques:
A Survey was conducted by the Iowa State researchers by contacting all 50 DOT construction engineers [5]. The project team ranked each incentive approach using a scale of 1-3, by analyzing Iowa state survey finding. The summarized rankings are presented in Table 3. It is observed that A+B contracts always scored highest among all three contracting techniques. Lane rental did not score higher in compare to not only A+B, but also against the traditional technique. Lane rental scored higher than traditional contracting approach in only in Mill and overlay and unbounded concrete overlay projects.

Table 1. Impact of Accelerated Contracts on Cost Components [2]



Cost Component	Discussion of Acceleration Impacts
Materials	Typically more affected by supply and demand issues (market factors) than by acceleration. Projects that require a sustained high level of acceleration are an exception to this general rule. Some suppliers may not be able to meet the accelerated supply schedule, thus reducing competitive forces on material pricing.
Labor	Typically the most affected cost component. Acceleration directly impacts labor rates through overtime and premium pay. Production rates are typically lower during periods of extended working hours and for multiple shift scenarios.
Equipment	Production rates are typically lower during periods of extended working hours and for multiple shift scenarios, thus increasing unit costs. Additional equipment resources (lease/rent) may be required to meet accelerated schedule requirements resulting in higher costs.
Overhead	Home office overhead is a function of annual revenues. Assuming a contractor is not forced to forego other revenue opportunities due to the resource requirements of an accelerated project, home office overhead would be reduced. Project overhead rates are typically increased for an I/D project due to the need for additional management resources.
Profit	Market driven.

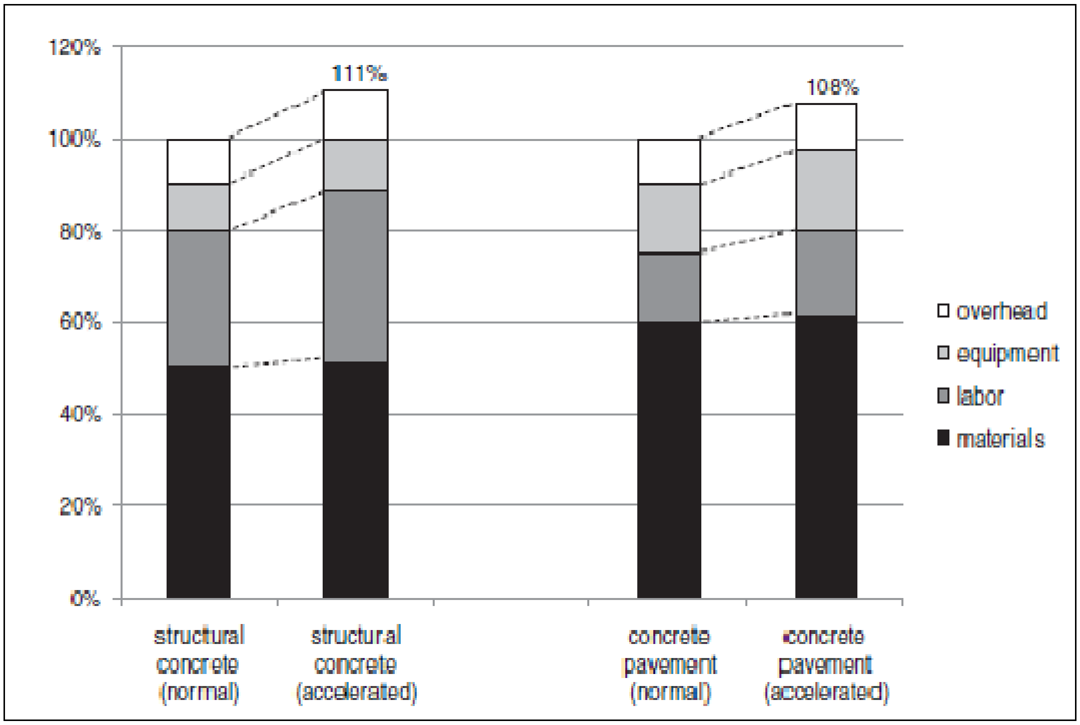
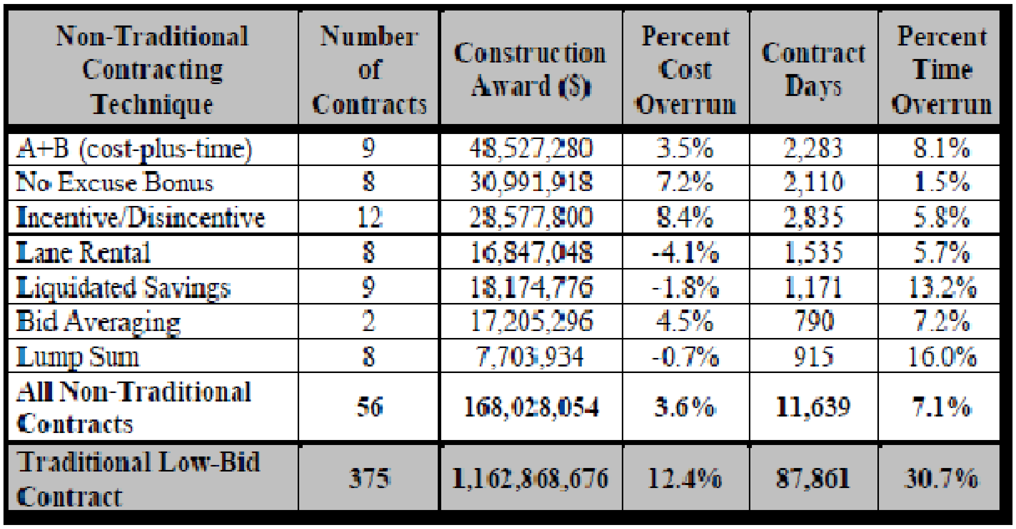


Figure 2. Example of Acceleration Cost Impact [2]

Table 2. Florida DOT Cost and Time Overruns Experience (1997-98) [7]



Non-Traditional Contracting Technique	Number of Contracts	Construction Award ($)	Percent Cost Overrun	Contract Days	Percent Time Overrun
A+B (cost-plus-time)	9	48,527,280	3.5%	2,283	8.1%
No Excuse Bonus	8	30,991,918	7.2%	2,110	1.5%
Incentive/Disincentive	12	28,577,800	8.4%	2,835	5.8%
Lane Rental	8	16,847,048	-4.1%	1,535	5.7%
Liquidated Savings	9	18,174,776	-1.8%	1,171	13.2%
Bid Averaging	2	17,205,296	4.5%	790	7.2%
Lump Sum	8	7,703,934	-0.7%	915	16.0%
All Non-Traditional Contracts	**56**	**168,028,054**	**3.6%**	**11,639**	**7.1%**
Traditional Low-Bid Contract	**375**	**1,162,868,676**	**12.4%**	**87,861**	**30.7%**

Table 3. Performance Ranking of Various Innovative Contracting Techniques

Project Type	Performance Ranking by incentive type (Scale 3-1)		
	A+B	Lane Rental	Traditional
Major Expansion project	3	1	2
Multilane Rehabilitation projects with detour	3	1	2
Multi-lane Highway Rehab. Through cities with traffic	3	1	2
Rural bridge replacement project	3	1	2
Two-lane highway resurfacing project	3	1.5	1.5
Metropolitan bridge replacement project	3	1	2
Mill and overlay project	3	2	1
Unbonded concrete overlay	3	2	1
Preservation project with culvert replacement	3	1	2
Average	3	1.25	1.73

*Note: scale 3 represents highest ranking

Michigan Experience:

Since 1995 Michigan DOT has awarded at least 113 projects using the accelerated contracting approach and paid more than $26 million in incentives. MDOT has maintained a database of all incentive related projects since 1995.

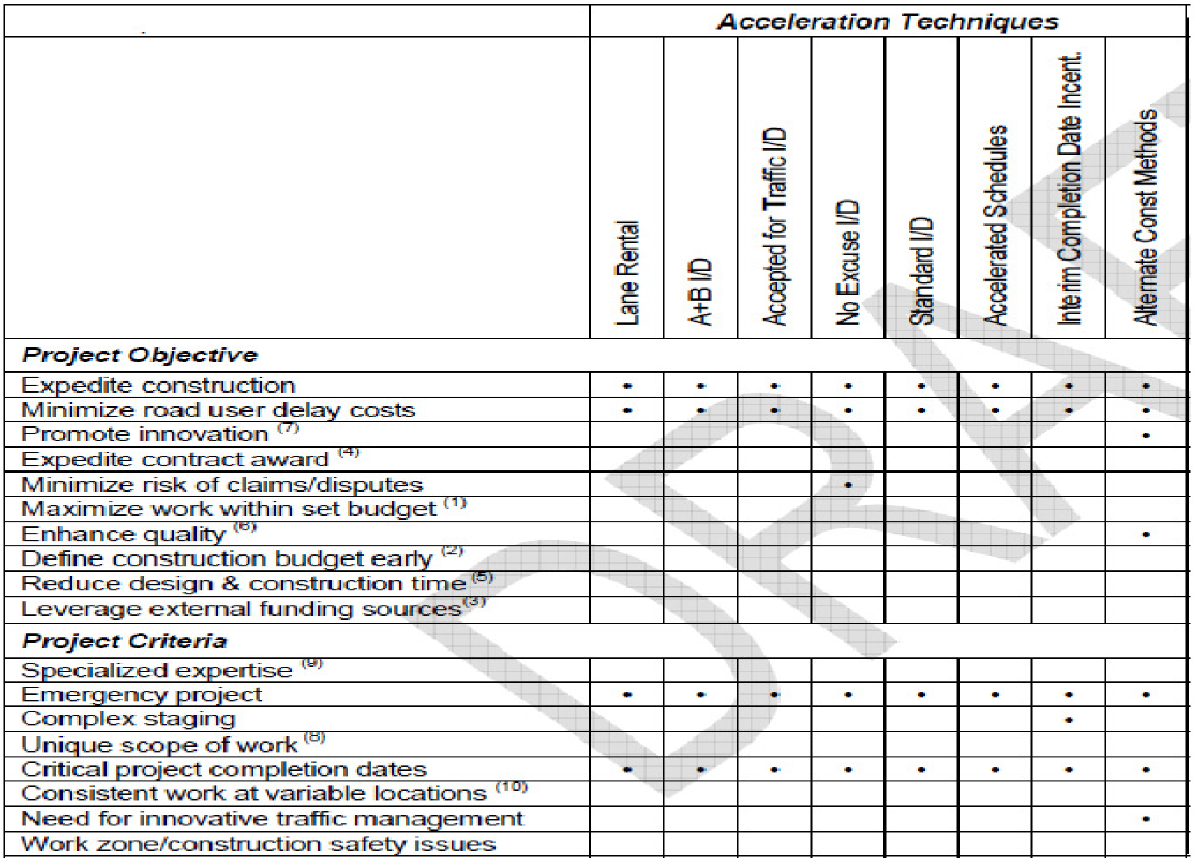
In 2006, MDOT evaluated 26 I/D projects completed between 1998 and 1999. According to report entitled "Primer in Contracting for the Twenty-First Century" project time and performance were found as follows [6].

- 65% of I/D projects were completed early
- 12% were completed on time
- 23% were completed late
- Average rate for all I/D projects was $18,508
- Average project delay saving were $610,500

As stated previously, the experience of the innovative contracting approach has shown a positive impact for a number of states. A limited study by the MDOT has also reported net saving for projects constructed using the innovative approach. However, the previous study was a very limited one dealing with only 26 I/D project and no long term pavement performance evaluation by construction methods has yet been performed. Thus, developing a relationship between RUC and incentive dollars should justify the use of the innovative approach.

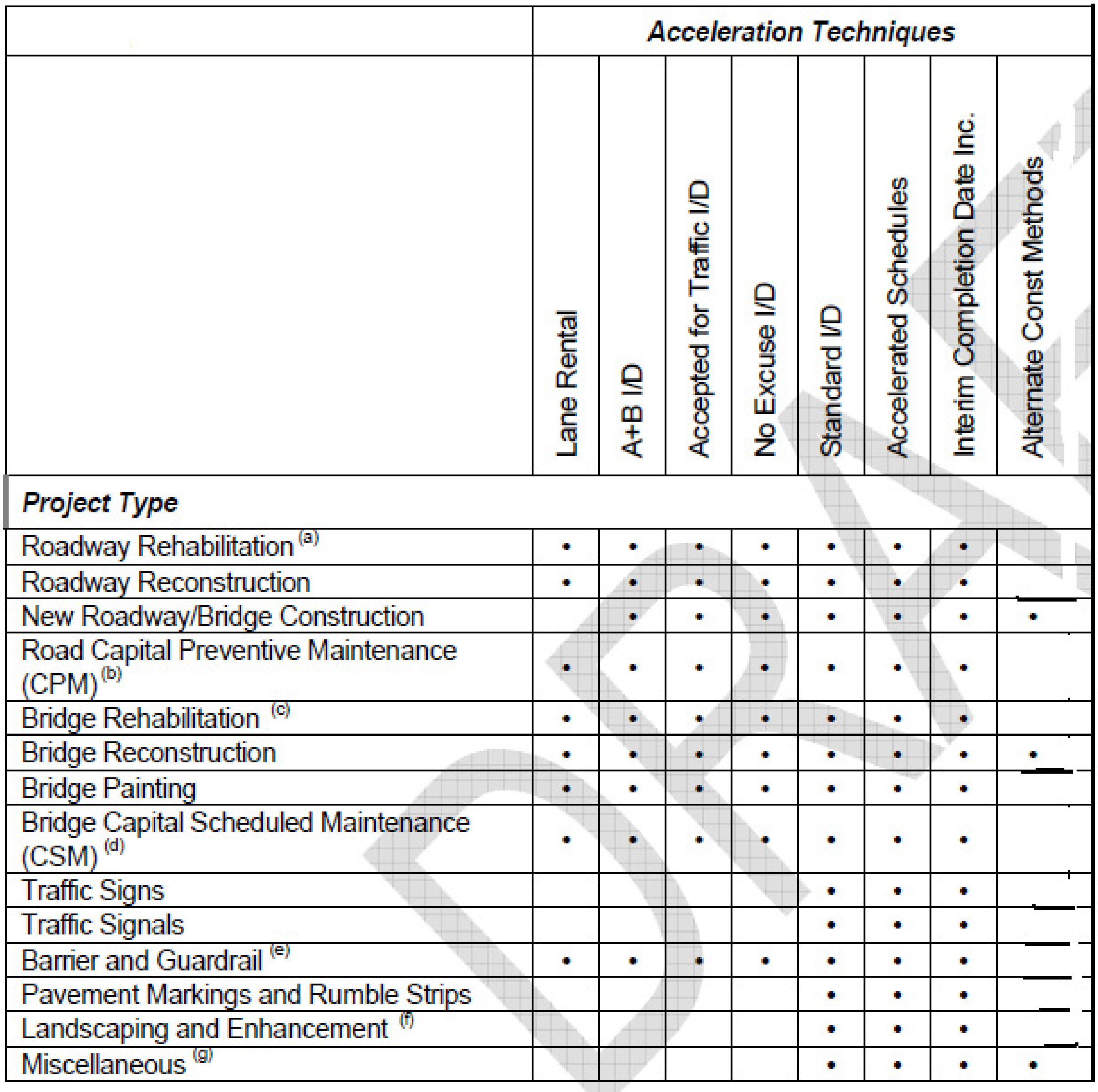
The Michigan Department of Transportation has published a guide, “Innovative Construction Contracting,” documenting application of innovative contracting project [7]. In this document, MDOT has identified a set of matrix to be used while considering various types of innovative contracting methods as presented in Table 4.

Table 4. Innovative Contracting Recommendation by MDOT [7]



	Acceleration Techniques							
	Lane Rental	A+B I/D	Accepted for Traffic I/D	No Excuse I/D	Standard I/D	Accelerated Schedules	Interim Completion Date Incent.	Alternate Const Methods
Project Objective								
Expedite construction	•	•	•	•	•	•	•	•
Minimize road user delay costs	•	•	•	•	•	•	•	•
Promote innovation (7)								•
Expedite contract award (4)								
Minimize risk of claims/disputes				•				
Maximize work within set budget (1)								
Enhance quality (6)								•
Define construction budget early (2)								
Reduce design & construction time (5)								
Leverage external funding sources (3)								
Project Criteria								
Specialized expertise (9)								
Emergency project	•	•	•	•	•	•	•	•
Complex staging							•	
Unique scope of work (8)								
Critical project completion dates	•	•	•	•	•	•	•	•
Consistent work at variable locations (10)								
Need for innovative traffic management								•
Work zone/construction safety issues								

Table 4. Innovative Contracting Recommendation by MDOT [7] Continued



	Acceleration Techniques							
	Lane Rental	A+B I/D	Accepted for Traffic I/D	No Excuse I/D	Standard I/D	Accelerated Schedules	Interim Completion Date Inc.	Alternate Const Methods
Project Type								
Roadway Rehabilitation [(a)]	•	•	•	•	•	•	•	
Roadway Reconstruction	•	•	•	•	•	•	•	
New Roadway/Bridge Construction		•	•	•	•	•	•	•
Road Capital Preventive Maintenance (CPM) [(b)]	•	•	•	•	•	•	•	
Bridge Rehabilitation [(c)]	•	•	•	•	•	•	•	
Bridge Reconstruction	•	•	•	•	•	•	•	•
Bridge Painting	•	•	•	•	•	•	•	
Bridge Capital Scheduled Maintenance (CSM) [(d)]	•	•	•	•	•	•	•	
Traffic Signs					•	•	•	
Traffic Signals					•	•	•	
Barrier and Guardrail [(e)]	•	•	•	•	•	•	•	
Pavement Markings and Rumble Strips					•	•	•	
Landscaping and Enhancement [(f)]					•	•	•	
Miscellaneous [(g)]					•	•	•	•

3. STUDY APROACH

3.1. Development of the Incentive Model

In order to establish a relationship between Incentive cost and time, the project team has develop two variables namely Project Time Crashing Index (TCI) representing rate of change of project duration and Project Cost Increment Index (CII) representing rate of change of project cost relating actual and contract duration and also actual and contract cost as presented below.

$$\text{Project Time Crashing Index (TCI)} = \frac{\text{Actual Duration} - \text{Contract Duration}}{\text{Contract Duration}} \tag{1}$$

$$\text{OR} \quad \text{TCI} = \left(\frac{D - D_O}{D_O}\right) \tag{2}$$

$$\text{Project Cost Increment Index (CII)} = \frac{\text{Actual Cost} - \text{Contract Cost}}{\text{Contract Cost}} \tag{3}$$

$$\text{OR} \quad \text{CII} = \frac{(C - C_O)}{C_O} \tag{4}$$

Where:
C= Actual Cost
C_O= Contract Cost (Bid award)
D= Actual Duration
D_O = Contract Duration
C-C_O= represents incentives/disincentive

It is to be noted that in most cases TCI will be a negative quantity, where as CII will be positive quantities with a few exception where disincentives were applied.

3.1.1. Michigan Incentive Data

The research team met with the MDOT and Southeast Michigan Council of Government (SEMCOG) officials to collect their input regarding incentive projects. To develop functional connectivity between TCI and CII, the researchers collected incentive contracting project data of the Michigan Department of Transportation from 1998 to 2010. However, due to missing information, the project team had to discard a number of data points. Data information includes actual completion date, bid cost and actual cost.

3.1.2. Modeling Approach

In order to establish a relationship between CII and TCI, regression technique was used. Regression analysis is technique used to determine the relationship between variables and often considered when historical databases are available. It is a statistical tool used to establish the relationship between two or more variables Models can be linear or nonlinear depending on the relationship between variables as shown in Figures 5 and 6.

A series of linear, log and nonlinear models were run to establish a relationship between CII and TCI. The following model resulted in the highest R^2. The final model is a nonlinear model as presented by equation 5.

$$CII = b_0 + b_1 * TCI + b_{2*} TCI ** 3 \qquad (5)$$

Where:
b_0 = Regression Constant
$b_1, b_2,$ = Regression Coefficients

Table 5 summarizes the analysis of variance result. In this analysis CII was considered as dependent variable and TCI was designated as an independent variable. The final model yielded a R^2 value of 0.72, indicating that the model has the ability to explain 72 percent variability in the data. Also observed was that corresponding p-values of the intercept, TCI and TCI Cube are 0.04, .0000016 and 0.0096 respectively. Therefore, all parameters are significant at the 95 percent confidence level

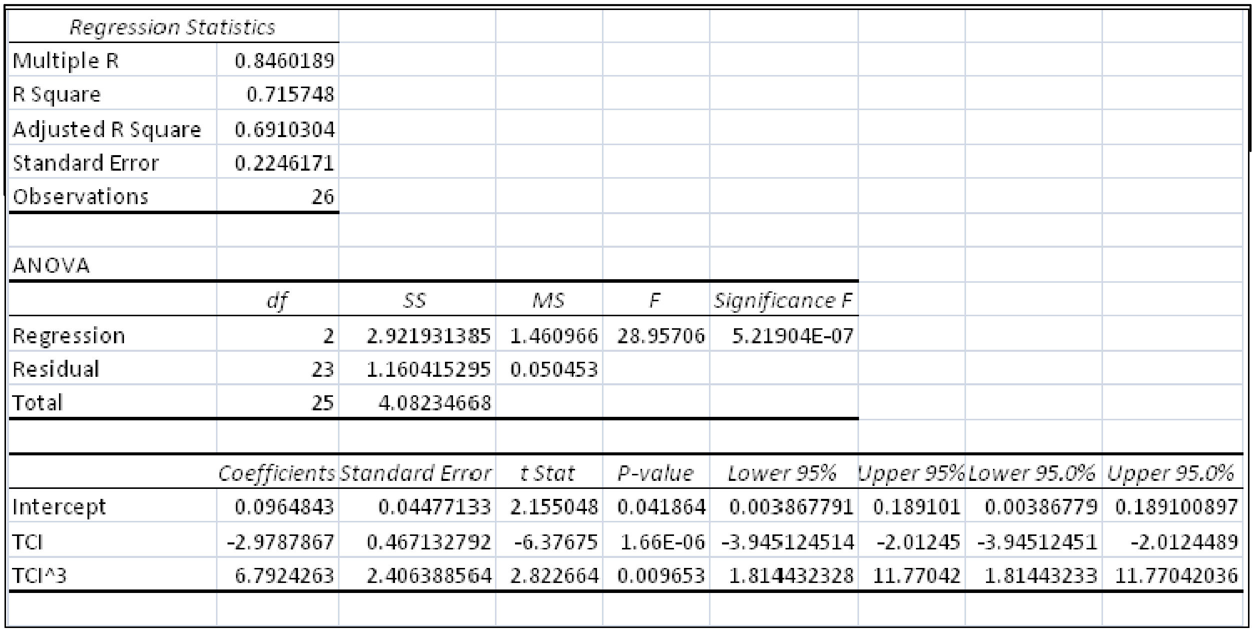
<u>**Final Model is:**</u>

$$CCI = 0.09648 \quad - 2.9788TCI + 6.7924TCI ** 3 \qquad (6)$$

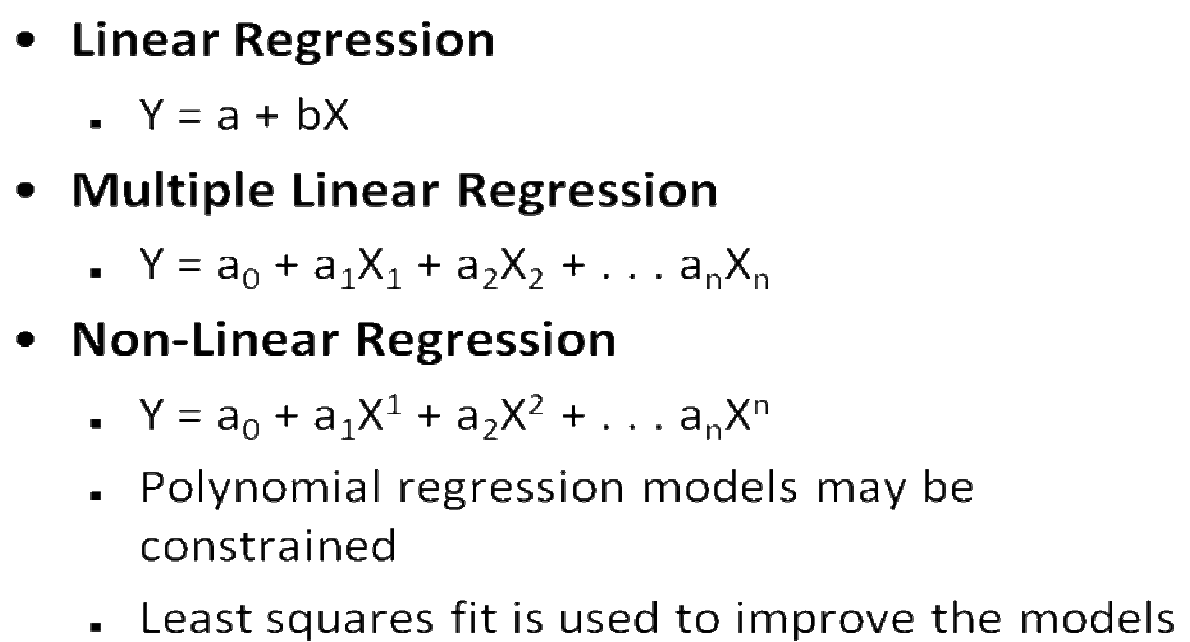
And $R^2 = 0.7157$

As stated before P-values of "intercept", as well as coefficient of TCI and TCI cube are significant, which means the model is a robust one.

Table 5. Summary of Analysis of Variance of Final Model



Regression Statistics								
Multiple R	0.8460189							
R Square	0.715748							
Adjusted R Square	0.6910304							
Standard Error	0.2246171							
Observations	26							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	2	2.921931385	1.460966	28.95706	5.21904E-07			
Residual	23	1.160415295	0.050453					
Total	25	4.08234668						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.0964843	0.04477133	2.155048	0.041864	0.003867791	0.189101	0.00386779	0.189100897
TCI	-2.9787867	0.467132792	-6.37675	1.66E-06	-3.945124514	-2.01245	-3.94512451	-2.0124489
TCI^3	6.7924263	2.406388564	2.822664	0.009653	1.814432328	11.77042	1.81443233	11.77042036



- **Linear Regression**
  - $Y = a + bX$
- **Multiple Linear Regression**
  - $Y = a_0 + a_1X_1 + a_2X_2 + \ldots a_nX_n$
- **Non-Linear Regression**
  - $Y = a_0 + a_1X^1 + a_2X^2 + \ldots a_nX^n$
  - Polynomial regression models may be constrained
  - Least squares fit is used to improve the models

Where
Y is the dependent variable
X_1……………X_n are independent variables
A_0 is the intercept
A_1………A_n are the co-efficient of independent variables

Figure 5. Standard Family of Regression Models

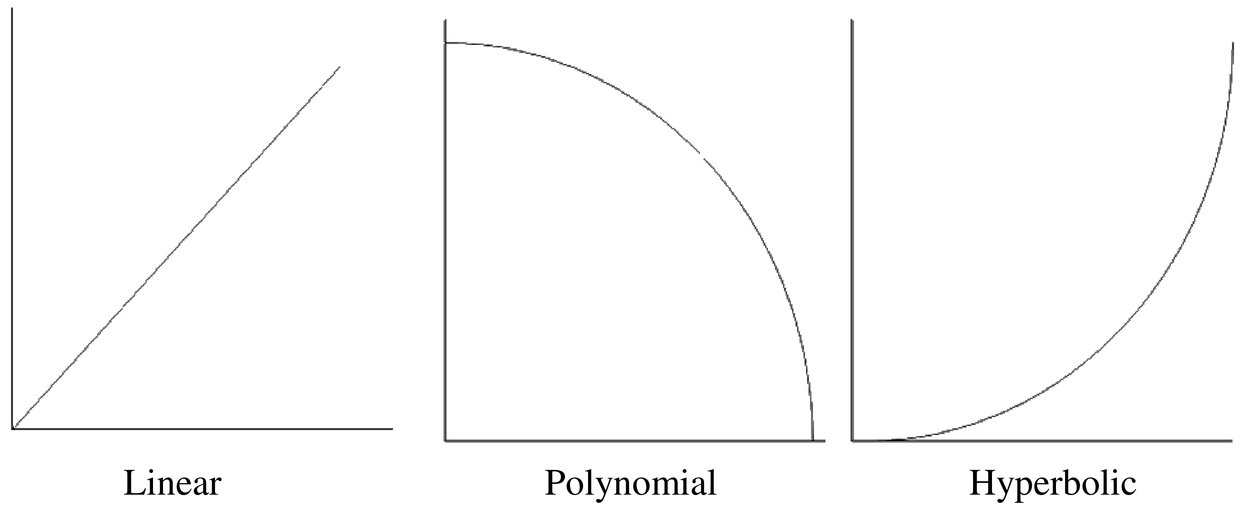


Figure 6. Different Forms of Regression Models

3.2. Application of Incentive Model

In order to assist state highway agencies in their selection of incentive projects along with the incentive amount three utility tools are developed.

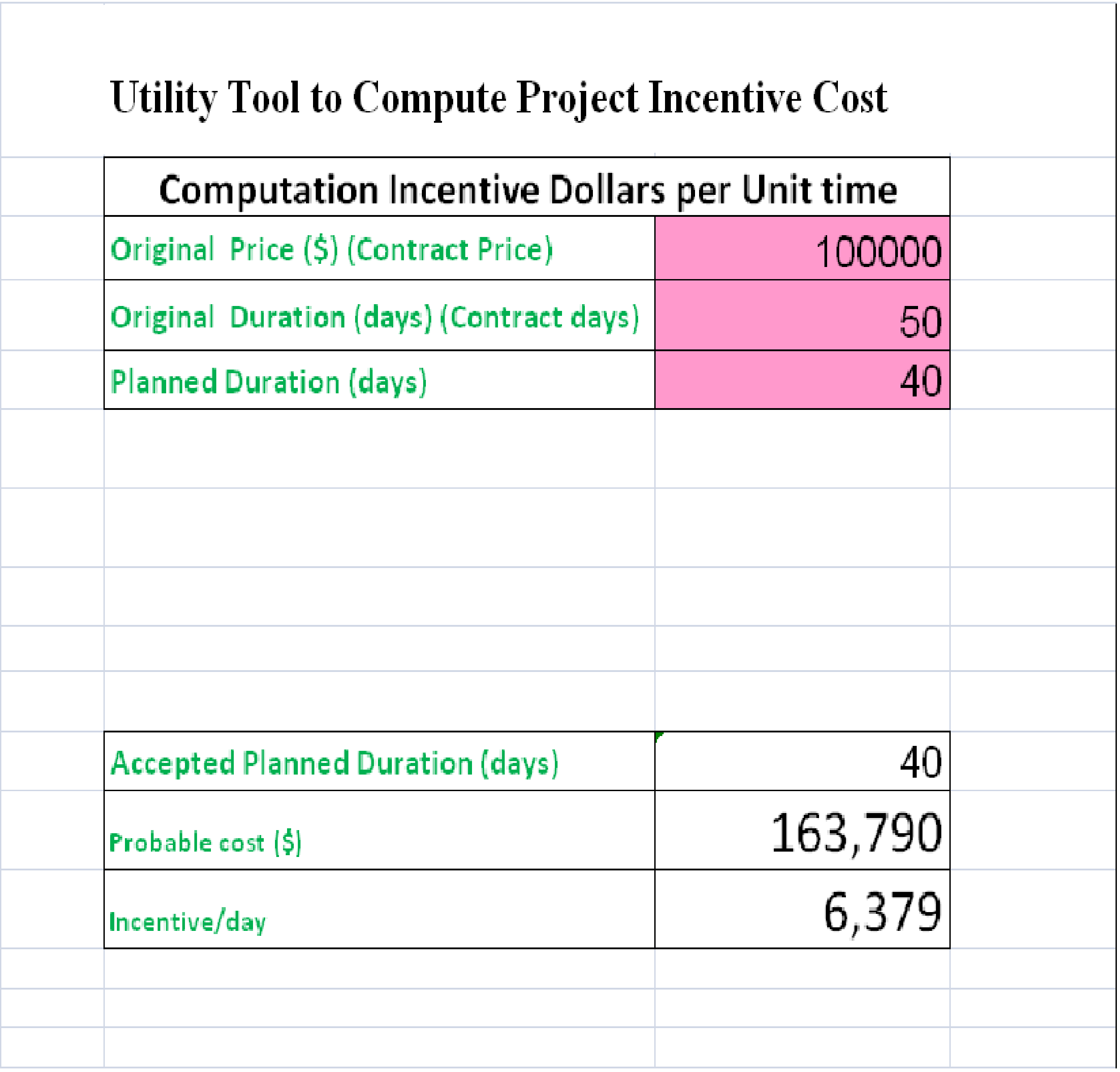
Incentive amount per unit time Utility: The purpose of this tool is to determine incentive amount given that bid cost and bid duration are known. This tool will compute a new contract cost based on the proposed or planned duration. It is to be noted that planned duration cannot be less than the 65 percent of bid duration. The project team strongly believes that a maximum amount of crash time beyond 35 percent is not reasonable. In this effort, the regression model presented before is used to compute incentive cost per unit time. A display of this utility is presented in Figure 7.

Road User Cost (RUC) Computation Utility The tool is designed to compute Road User Cost (RUC) due to delay during construction or detour. Inputs of this tool include:

1. Year of construction
2. Data year
3. Average Annual Daily Traffic (AADT)
4. Percent of Truck
5. Yearly traffic growth
6. Inflation rate per year
7. Car cost per hour
8. Truck cost per hour
9. Normal travel speed Expected speed during construction

10. Normal travel time
11. Travel time during construction
12. Normal length of travel in miles
13. Length of travel during construction in miles

It is to be noted that either travel time or travel speed should be used as input and not both at the same time. This tool computes total cost considering the duration of travel. A display of this utility is shown in Figure 8.

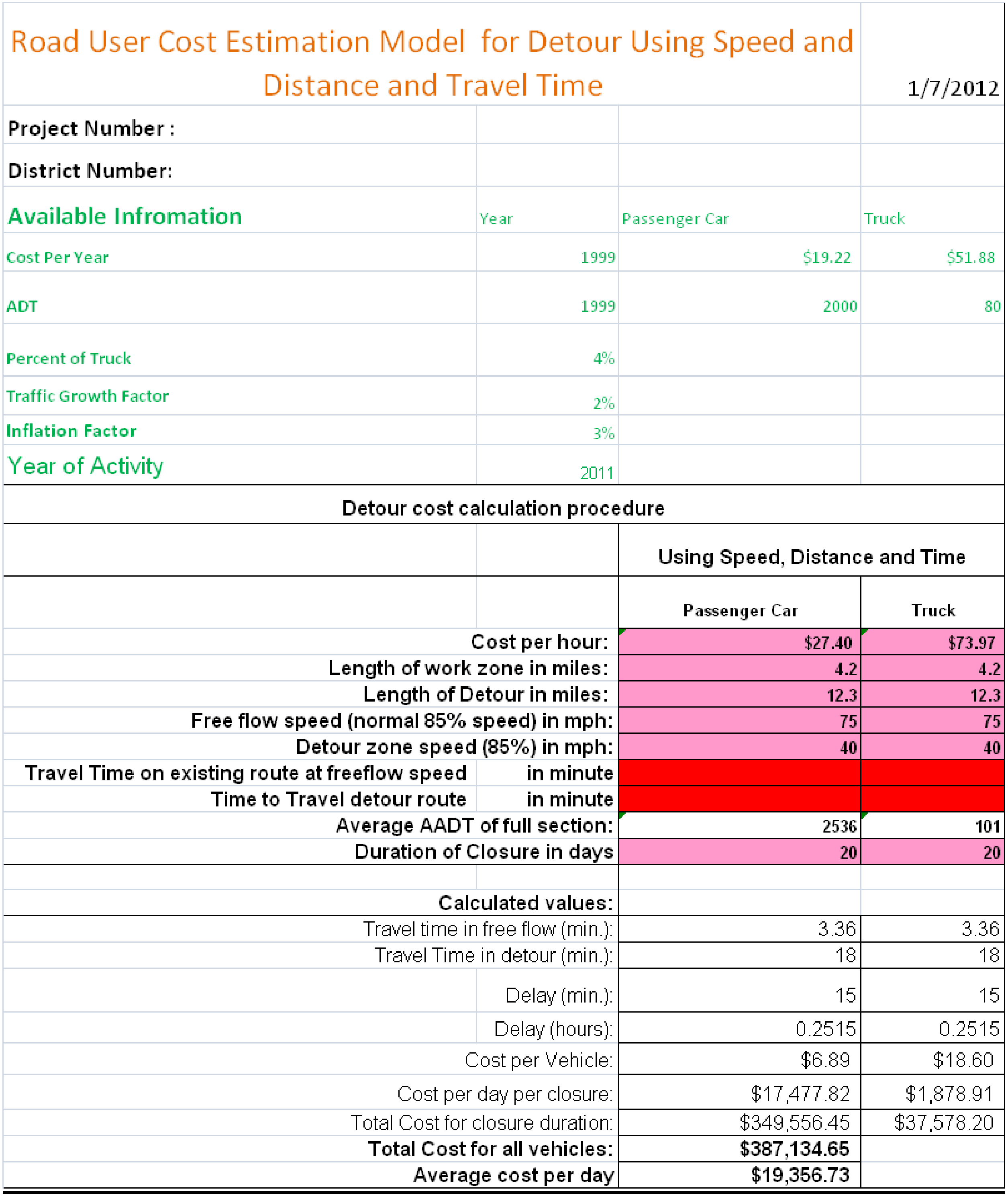


Utility Tool to Compute Project Incentive Cost

Computation Incentive Dollars per Unit time	
Original Price ($) (Contract Price)	100000
Original Duration (days) (Contract days)	50
Planned Duration (days)	40

Accepted Planned Duration (days)	40
Probable cost ($)	163,790
Incentive/day	6,379

Figure 7. Incentive Cost Utility Tool



Road User Cost Estimation Model for Detour Using Speed and Distance and Travel Time			1/7/2012
Project Number :			
District Number:			
Available Infromation	Year	Passenger Car	Truck
Cost Per Year	1999	$19.22	$51.88
ADT	1999	2000	80
Percent of Truck	4%		
Traffic Growth Factor	2%		
Inflation Factor	3%		
Year of Activity	2011		
Detour cost calculation procedure			
		Using Speed, Distance and Time	
		Passenger Car	**Truck**
Cost per hour:		**$27.40**	**$73.97**
Length of work zone in miles:		**4.2**	**4.2**
Length of Detour in miles:		**12.3**	**12.3**
Free flow speed (normal 85% speed) in mph:		**75**	**75**
Detour zone speed (85%) in mph:		**40**	**40**
Travel Time on existing route at freeflow speed	**in minute**		
Time to Travel detour route	**in minute**		
Average AADT of full section:		**2536**	**101**
Duration of Closure in days		**20**	**20**
Calculated values:			
Travel time in free flow (min.):		3.36	3.36
Travel Time in detour (min.):		18	18
	Delay (min.):	15	15
	Delay (hours):	0.2515	0.2515
Cost per Vehicle:		$6.89	$18.60
Cost per day per closure:		$17,477.82	$1,878.91
Total Cost for closure duration:		$349,556.45	$37,578.20
Total Cost for all vehicles:		**$387,134.65**	
Average cost per day		**$19,356.73**	

Figure 8. User Cost Computation Utility Tool

Incentive Project Candidacy Selection Utility Based on the literature review, a utility template is developed to examine various attributes of a project to determine its suitability to be a candidate for consideration as an incentive project [8]. Each project is examined along a set of 15 attributes, if a project is scored more than 12 points out of 17, then it can be considered for incentive contracting. A display of derived template is presented in Figure 9.

Is My Project Suitable For Incentive?			
Right Of Way			Soil Conditions
1	Will all right-of-way be secured prior to letting date?	1	There is **little** risk of contaminated or poor soils adding significant extra work.
1	If not, do the staging plans allow the contractor to sequence work around the conflicts and is a right-of-way time determination schedule in the special provision?		Traffic Conditions
Plans		1	Do construction traffic impacts relate to any of the following conditions?
1	Is there high confidence in the design?		• Lengthy detours
1	Has a thorough field review been conducted?		• Significant delays to motorists
1	Has design coordinated with construction at various stages (e.g. 30%, 90%)?		• Significant impacts to businesses, schools, or emergency services
1	Has a constructability and bid-ability review been conducted by design and construction?		Staffing Considerations
Utilities		1	Do you have the staff available if the contractor has an aggressive schedule?
1	There is **little or no chance** that utilities will significantly delay the contractor.	1	Do you have the budget for any additional overtime?
1	Are utility conflicts clearly identified in the plan and special provisions?		Contractor Bidding
Third-Party Agreements		1	Can the contractor accurately predict the duration of activities that will impact a lane?
1	Will all permits be secured by the letting date?		Design Uncertainties
1	Will all municipal agreements be secured by the letting date?	1	The plan and/or special provisions can accurately insure that the safety of the construction operations will not be jeopardized by using lane-rental.
Program Impacts			
1	Have you considered the district wide impacts of using an accelerated schedule? Have you considered the potential cost and delivery to other projects?		
17	**Total**		Project is good candidate for Incentive

Figure 9. Candidacy Selection Template

4. CONCLUSION

Time based incentive and disincentive techniques have been used in various road construction projects by a number of state DOTs. This project's focus was to compile data related to incentive projects completed by the Michigan Department of Transportation to develop a model relating incentive duration and incentive cost. More than 10 years of project data were collected as a part of this effort. Two variables namely project Cost Incentive Index (CII) and project Time Crashes Incentive Index (TCI) were established to develop a relation between construction duration and construction cost. The study has attempted to develop a set of tools based on the literature review and analyzing MDOT incentive contract data. The finding of this study is summarized below

- A non-linear regression model (power of 3) was developed considering CII as a dependent variable and TCI and TCI power of 3 as independent variables. A R^2 of 0.72 was achieved along with appearance of TCI and TCI power of 3 as significant variables at 95 percent confidence level .
- A utility tool was derived considering regression relationship, to compute probable actual cost for various incentive durations, given that bid duration and bid price were known.
- In order to assist state DOTs, a User-cost calculator was designed to compute user cost due to construction delay.
- Based on the literature review , a template was develop to assist DOTs, in determining the candidacy of a construction project to be considered as an incentive project by examining various related attributes of the project other than cost and time.

It is to be noted that model developed as a part of this effort is based on the Michigan DOT's construction data thus caution should be taken while using this model in other regions.

5. ACRONYMS

AADT	Average Annual Daily Traffic
AFT	Accepted For Traffic Incentive/Disincentive
CII	Cost Increment Index
DOT	U.S. Department of Transportation
I/D	Incentive/Disincentive
MDOT	Michigan Department of Transportation
MIOH UTC	Michigan Ohio University Transit Center
MOEs	Measure of Effectiveness
RUC	Road Users Costs
SEMCOG	Southeast Michigan Council of Governments
SHA	State Highway Agencies
TCI	Time Crash Index

6. REFERENCES

1. 2007 Urban Mobility Report, Texas Transportation Institute, September 2007.
2. National Cooperative Highway Research Program "Time-Related Incentive and Disincentive Provisions in Highway Construction Contracts", Transportation Research Board Report# 652, 2010
3. Chan, A.P.C. "Time cost Relationship of public sector projects in Malaysia ", International Journal of Project management, Vol. 19, 2001
4. Florida DOT "Alternative Contracting Program Preliminary Evaluation", Tallahassee, FL, 19997-1998
5. Strong, K, et. al "Cost Effectiveness of Design Build, Lane Rental, and A+B Contracting Technique " Proceeding of the 2005 Mid-Continent Transportation Research Symposium, Ames, Iowa, 2005
6. AASHTO " Primer on Contracting for the Twenty-first Century", Report, Washington DC, 2006
7. Michigan Department of Transportation "Innovative Construction Contracting", Draft Report, June 2010.
8. Mn/DOT Innovative Contracting Summary List, Office of Construction and Innovate Contracting, 2000-2005
9. Battelle "Performance-Based Contracting for the Highway Construction Industry, Final Report, Columbus, Ohio, 2003
10. Michigan DOT OBRP site
11. Callahan, M. T. et. al "Construction Project Scheduling ", McGraw-hill, New York, 1992
12. Pyeon, J. et. al "Traffic Impact on Project Time Performance During Incentive Construction Project ", A PowerPoint Presentation, San Jose State University
13. Kent, David "Innovative Contracting Technique that consider Driver Impacts ", A paper presented at NYDOT Work zone workshop, 2009
14. Website -- http://www.fhwa.dot.gov/construction/contract/t508010.cfm
15. Mineta Transportation Institute (MTI) "Improving Transportation Construction Performance …….", Final Report , March, 2010
16. Oppenlander, J.C., "Sample Size Determination for Travel Time and Delay Studies", Traffic Engineering Journal, September 1976.
17. Bhargava, A. et. al "Three-Stage Least-Square Analysis of Time and Cost Overruns in Construction Contracts., ASCE Journal of Construction Engineering and Management, Vol. 136, No. 11, Nov. 1, 2010