FINAL REPORT


**Principal Investigator:** **Dr. Ralph Ellis**
**Graduate Research Assistant:** **Duzgun Agdas**
**FDOT Research Coordinator:** **Ezzel Benghuzzi**


# Developing a Model to Estimate Maintenance of Traffic Quantities and Cost


**January 2009**
UF Contract Number 00067491
FDOT Contract Number FDOT BD-545 #83



**Department of Civil and Coastal Engineering**
**University of Florida**
**(352) 392-9537**
**http://www.ce.ufl.edu/**

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the State of Florida Department of Transportation.

Technical Report Documentation Page

| | | |
|---|---|---|
| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
| 4. Title and Subtitle<br>Developing a Model to Estimate Maintenance of Traffic Quantities and Cost | | 5. Report Date<br>January 2009 |
| | | 6. Performing Organization Code |
| | | 8. Performing Organization Report No.<br>**00067491** |
| 7. Author(s)<br>Dr. Ralph Ellis | | |
| 9. Performing Organization Name and Address<br>University of Florida<br>Department of Civil and Coastal Engineering<br>365 Weil Hall / P.O. Box 116580<br>Gainesville, FL 32611-6580 | | 10. Work Unit No. (TRAIS) |
| | | 11. Contract or Grant No.<br>BD545-83 |
| 12. Sponsoring Agency Name and Address<br>Florida Department of Transportation<br>Research Management Center<br>605 Suwannee Street, MS 30<br>Tallahassee, FL 32301-8064 | | 13. Type of Report and Period Covered<br>Final Report<br>5/10/2007 – 1/20/2009 |
| | | 14. Sponsoring Agency Code |
| 15. Supplementary Notes<br>Prepared in cooperation with the Federal Highway Administration | | |

16. Abstract

An investigation of the feasibility of developing a model to predict Temporary Traffic Control pay item quantities and costs from basic project descriptive information. A historical data base of project data was assembled as a basis for developing the models. Both linear and non-linear methods were employed. A software application was developed to demonstrate the model operation.

| | |
|---|---|
| 17. Key Words<br>Construction data management, XML, Schemas | 18. Distribution Statement<br>No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA, 22161 |

| | | | |
|---|---|---|---|
| 19. Security Classif. (of this report)<br>Unclassified | 20. Security Classif. (of this page)<br>Unclassified | 21. No. of Pages<br>95 | 22. Price |

Form DOT F 1700.7 (8-72)

# EXECUTIVE SUMMARY

## Background

Florida Department of Transportation spends a significant amount of effort determining MOT pay item quantities and cost for an assumed construction MOT plan. This is done for two purposes. One is to determine a reasonable comparative cost for awarding a project bid. The second is to show that the project is constructible while maintaining MOT.

Roadway designers have expressed for some time the concern that the project MOT bid items do not adequately reflect the actual items used nor quantities, because the contractor has the flexibility to change the MOT plan. Designers feel it is inappropriate to expect them to justify changes from their estimates and MOT scheme as a part of their contract. There is a need for a more efficient method of estimating MOT quantities.

## Objective

The primary objective was determining the feasibility of creating an estimation model for determining the MOT pay items and quantities with a secondary objective as to create a cost prediction model. The model is to be used as a pre-bid tool to satisfy both the consultant and contracting industry for predicting reasonable estimates of MOT pay items and quantities, and provide assist in the work program budget computations.

## Findings and Conclusions

Using a data base covering approximately 10 years of project data, prediction models were developed to estimate MOT quantities using basic project descriptive information. The following project input data were used:

- Project Work Mix (FDOT Work Mix Designation)
- Project Budget (Original Contract Amount $)
- Project Length (Total Project Length Miles)
- Project Location (Urban/Rural Category)
- Project Duration (Days Used)
- Transportation System
- Use of Cones vs. Type II Barricades
- Estimated Cross Street Frequency per Mile
- Number of Signalized Intersections
- Anticipated Drop Off Conditions
- Anticipated Letting Date

The modeling precision was estimated to be less than a **15%** average variation from the historical actual MOT quantities. The MOT model was tested using new project data provided by the FDOT. When the model was applied to predicting MOT quantities on new projects, the average precision was 11.99**%.** This variation in quantity represented less than **1.0%** of the estimated MOT costs to the projects.

## Benefits

This study has demonstrated the feasibility of estimating MOT pay item quantities using a prediction model. A prototype software application was developed to facilitate model interface. Further development of the model using more recent and verifiable project data and refinements to the software application offer the potential of significantly reducing engineering work hours in the roadway design process.

# TABLE OF CONTENTS

## List of Tables



## List of Figures

# Chapter 1 Introduction

## Problem Definition

Florida Department of Transportation spends a significant amount of effort determining Maintenance of Traffic (MOT) pay item quantities and cost for an assumed construction MOT plan. This is done for two purposes. One is to determine a reasonable comparative cost for awarding a project bid. The second is to show that the project is constructible while maintaining MOT. The consulting industry has expressed for some time the concern that the project MOT bid items do not adequately reflect the actual items used nor quantities, because the contractor has the flexibility to change the MOT plan. The consultants feel it is inappropriate to expect them to justify changes from their estimates and MOT scheme as a part of their contract. These post bid activities are taking a significant amount of additional time for which they feel in many cases is uncompensated work and for which there is additional liability. As such, the consulting industry proposed using a Lump Sum MOT pay item structure to satisfy the basic issue. In contrast, the construction industry is not willing to bid on a lump sum basis because of concerns that they will not be adequately compensated. A preliminary sample review of the factors involved for 1 year (2004 – 2005 projects) of data was accomplished. It was determined that the database was insufficient in population and there were many factors not accounted for that affect the accuracy of the desired outcome. For this reason, this proposed scope intends to expand the database and determine a sensitivity analysis to better develop a predictability model. It must be understood that the proposed model cannot predict constructability and therefore only potentially addresses part of the department's needs.

## Research Objective

The primary objective was determining the feasibility of creating an estimation model for determining the MOT pay items and quantities with a secondary objective to create a cost prediction model. The model is to be used as a pre-bid tool to satisfy both the consultant and contracting industry for predicting reasonable estimates of MOT pay items and quantities and provide assist in the work program budget computations.

# Chapter 2 Review of Current Mathematical Prediction Methods

## Prediction Models

The prediction methods can be broadly divided into two categories; parameter based prediction models and neural network based prediction models. Parameter base prediction methods were used for the purposes of this research project because of the linear characteristics of the transportation construction. In addition to parameter based prediction models being easier to develop, they can also be incorporated into different applications as the prediction development platforms allow the users to do so. For example, Microsoft Excel and Access can be programmed to be used in an application. The neural network prediction models, on the other hand needs standalone application platforms to be developed and cannot be easily incorporated into applications as parameter based systems can do.

## Regression Analysis

Of the available parameter based prediction models, multi-variable linear regression model was chosen to be the best method to be applied to MOT prediction case. Regression models are mathematical models aimed at determining the relation of independent variables to a dependent variable and using this relation to predict the dependent variable value given the values of independent variables. In this case, the research team collected project specific data and used those to develop models to predict the MOT requirements for different projects. The regression models can be broadly divided into two, single variable regression models and multi-variable regression models. The latter is to be more accurate as the increased number of variables improves the computing power of the model.

## Single Variable Linear Regression Models

The single variable regression models are models that use a single independent variable to predict a dependent variable. The model is in the form, $y=Ax+C$ where; y is the dependent variable to be predicted, x is the dependent variable to be used in prediction, A is the coefficient of the independent variable, and C is a constant number, the intercept. The independent variable data set can be transformed in order to have better predictions by mathematical operations. Similarly, for better prediction results, the intercept may or may not be included in the regression model.

## Multi Variable Linear Regression Models

Multivariable regression models essentially follow the same logic with single variable regression models, but instead of one there will be a number of independent variables. In this case the prediction equation will be $y=Ax_1+Bx_2+Dx_3+Ex_4+C$. Non-linear transformations can be employed to improve the accuracy of the models marginally but in this research they were discarded because of the following reasons:

- The transportation construction is linear construction and the application of MOT quantities is also generally linear
- There are no benchmarks as to do the transformations and trial and error is neither efficient nor scientific method to solve the problem. (There is no guarantee that the transformation is accurately representing the physical situation.)
- The trial of non-linear transformations has proven to improve the efficiency of the models only marginally, implying linear regression was to provide good results.

## Accuracy of Predictions

### Fitness of the developed models

In order to determine how well the developed prediction model relates to the dataset, a parameter, $R^2$, is used. It is a value between 0 and 1, and is defined as a measure of how successful the model in explaining the variation within the data set. i.e. $R^2$ value of .9 will imply that the developed regression model can explain 90% of the variation within the data set.

### Accuracy of the developed models

In addition to the fitness of the model to the data set, the accuracy of the point predictions must also be measured. A number of error terms defined in the literature, but for this research, mean absolute percent error (MAPE) was adapted. MAPE is defined as the average absolute percent error of the given data set. The formula of the MAPE is as follows:

$$\frac{1}{n}\sum_{i=1}^{n}\frac{|A_i - P_i|}{A_i}\times 100 \qquad (14).$$

Where, $A_i$ is the actual quantity value for a given project data and $P_i$ is the prediction value for the same data point. The main reason for selection was due to the fact that MAPE is a generic value and allows different data sets with differing means be compared.

# Chapter 3 Research Methodology

## Review and Analysis of Project MOT Data Base

### Original Input Data

Originally two data bases were furnished by the FDOT:

1. Access DB containing project ID numbers and pay item quantities for each project
2. Excel DB containing 10 year contract summary data

Table 1 provides a listing of the data field included in the original data base.

Our initial analysis of the data bases indicated that restructuring of the data would be required prior to commencing model development. Data from both data bases were combined into single data base using the project contract ID as the common element. Separate data files were constructed for each calendar year to keep file size manageable. However, while working with the data in our preliminary modeling we noted some irregularities in the data. These discrepancies were pointed out to the FDOT. Subsequently, the FDOT furnished a revised contract summary data base. Another data restructuring was carried out using the revised contract summary data.

Table 2 provides a listing of MOT Pay Items and the corresponding number of contracts in the data base.

Table 3 provides a listing of the Work Mix Codes and the corresponding number of contracts in the data base.

Table 1 Summary of the FDOT MOT Model data obtained

| Column Title | Description |
|---|---|
| Lead_Fin_Proj_ID | Financial Project Identification Number |
| Roadway Id | Roadway Identification Number |
| Begin Point | Project start point or project section start point |
| End Point | Project end point or project section end point |
| Length | Total project length |
| RCI Begin | Only used for retrieving Rural/Urban data from RCI database |
| RCI End | Only used for retrieving Rural/Urban data from RCI database |
| Rural/Urban | Rural/Urban categorization code |
| Rural/Urban Description | Rural/Urban Description |
| No. Lanes | Number of existing lanes |
| New Lanes Added | Number of lanes added |
| Transp. System | Transportation System categorization code |
| Transp. System Description | Transportation System description |
| Vendor_ID | Contractor vendor ID |
| Vendor_Name | Contractor name |
| Cont_Desc | Work Mix |
| FDOT_Estimate | FDOT Engineer's cost estmate |
| Letting_Date | Letting date |
| Begin_Work_DT | Work begin date |
| Final_Accept_DT | Final acceptance date |
| Bonding_Company | Bonding company |
| Original_Amt | Original contract amount |
| Total_Change_Amt | Total contract change amount |
| Final_Expenditure | Final cost |
| Original_Days | Original contract days |
| Days_Add | Extended days |
| Days_Used | Final time |
| Work Mix Code | Work Mix Code |
| Work Mix Name | Work Mix Name |

- Total number of data obtained: 4852 data rows
- Number of projects: 3100 projects
- Duplication of FIN project ID: 1752 projects (4852-3100=1752)
- Reasons of duplication: Each project has the starting point and the end point. Many of them have two or more segments of the total project length.

Table 2 MOT Pay Items and Numbers of Contracts

| | ITEM | DESCRIPTION | CONTRACTS | UNIT |
|---|---|---|---|---|
| 1 | 0102 1 | MAINTENANCE OF TRAFFIC | 112 | DA |
| 2 | 0102 2 1 | SPECIAL DETOUR 1 | 5 | LS |
| 3 | 0102 2 2 | SPECIAL DETOUR 2 | 4 | LS |
| 4 | 0102 2 3 | SPECIAL DETOUR 3 | 3 | LS |
| 5 | 0102 2 4 | SPECIAL DETOUR 4 | 3 | LS |
| 6 | 0102 2 5 | SPECIAL DETOUR 5 | 2 | LS |
| 7 | 0102 2 6 | SPECIAL DETOUR 6 | 1 | LS |
| 8 | 0102 2 7 | SPECIAL DETOUR 7 | 1 | LS |
| 9 | 0102 3 | COMMERCIAL MATL FOR DRIVEWAY MAINT | 32 | CY |
| 10 | 0102 14 | TRAFFIC CONTROL OFFICER | 52 | MH |
| 11 | 0102 60 | WORK ZONE SIGNS | 107 | ED |
| 12 | 0102 61 | BUSINESS SIGNS | 21 | EA |
| 13 | 0102 71 11 | BARRIER WALL,TEMP,F&I,CONCRETE | 26 | LF |
| 14 | 0102 71 12 | BARRIER WALL,TEMP,F&I,WATERFILLED | 4 | LF |
| 15 | 0102 71 13 | BARRIER WALL,TEMP,F&I,LOW PROFILE,CONC | 6 | LF |
| 16 | 0102 71 14 | BARRIER WALL,TEMP,F&I,TYPE K | 10 | LF |
| 17 | 0102 71 21 | BARRIER WALL,TEMP,REL,CONCRETE | 20 | LF |
| 18 | 0102 71 22 | BARRIER WALL,TEMP,REL,WATERFILLED | 4 | LF |
| 19 | 0102 71 23 | BARRIER WALL,TEMP,REL,LOW PROFILE,CONC | 5 | LF |
| 20 | 0102 71 24 | BARRIER WALL,TEMP,REL,TYPE K | 6 | LF |
| 21 | 0102 73 | TEMPORARY GUARDRAIL | 2 | LF |
| 22 | 0102 74 1 | BARRICADE,TEMP,TYPS I,II,DI,VP & DRUM | 102 | ED |
| 23 | 0102 74 2 | BARRICADE,TEMP,TYPE III, 6’ | 52 | ED |
| 24 | 0102 76 | ADVANCE WARNING ARROW PANEL | 75 | ED |
| 25 | 0102 77 | HIGH INTENSITY FLASH LI,TEMP,TYP B | 105 | ED |
| 26 | 0102 78 | REFLECTIVE PAVT MARKER,TEMPORARY | 63 | EA |
| 27 | 0102 79 | LIGHTS,BARR WALL MNT,TEMP,TYP C,STDY BRN | 30 | ED |
| 28 | 0102 89 7 | CRASH CUSHION/IMP ATTE,TEMP,REDIRECT OPT | 27 | LO |
| 29 | 0102 98 2 | BARRICADE, TYPE III, 6’,TO REMAIN | 1 | EA |
| 29 | 0102 98 2 | BARRICADE, TYPE III, 6’,TO REMAIN | 1 | EA |
| 30 | 0102 99 | CHANGEABLE-VARIABLE MESSAGE SIGN,TEMP | 87 | ED |
| 31 | 0102104 1 | TEMPORARY TRAFFIC CONTROL, PORT SIGNAL | 2 | ED |
| 32 | 0102104 2 | TEMPORARY TRAFFIC CONTROL, FIXED SIGNAL | 1 | ED |
| 33 | 0102107 | TEMP TRAFFIC DETECTION, INTERSECT | 30 | DA |
| 34 | 0102150 1 | PORTABLE REGULATORY,SIGN | 16 | ED |
| 35 | 0102150 2 | RADAR SPEED DISPLAY UNIT | 17 | ED |
| 36 | 0102911 1 | PAVT MARKING REMOVABLE,WH-BLK,SKIP | 8 | LF |
| 37 | 0102911 2 | PAVT MARKING REMOVABLE,WH-BLK,SOLID | 13 | LF |
| 38 | 0102911 3 | PAVT MARKING REMOVABLE,WH-BLK,OTHER | 5 | LF |
| 39 | 0102912 1 | PAVT MARKING REMOVABLE, YELLOW,SKIP | 1 | LF |
| 40 | 0102912 2 | PAVT MARKING REMOVABLE, YELLOW,SOLID | 14 | LF |
| 40 | 0102912 2 | PAVT MARKING REMOVABLE, YELLOW,SOLID | 14 | LF |
| 41 | 0102912 3 | PAVT MARKING REMOVABLE, YELLOW,OTHER | 1 | LF |
| 42 | 0710 11111 | PAINTED PAVT MARK,STD,WHITE,SOLID,6” | 56 | NM |
| 43 | 0710 11112 | PAINTED PAVT MARK,STD,WHITE,SOLID,8” | 7 | NM |
| 44 | 0710 11113 | PAINTED PAVT MARK,STD,WHITE,SOLID,12” | 1 | NM |
| 45 | 0710 11121 | PAINTED PAVT MARK,STD,WHITE,SOLID, 6” | 17 | LF |
| 46 | 0710 11122 | PAINTED PAVT MARK,STD,WHITE,SOLID, 8” | 33 | LF |
| 47 | 0710 11123 | PAINTED PAVT MARK,STD,WHITE,SOLID, 12" | 33 | LF |
| 48 | 0710 11124 | PAINTED PAVT MARK,STD,WHITE,SOLID, 18" | 40 | LF |

| | | | | |
|---|---|---|---|---|
| 49 | 0710 11125 | PAINTED PAVT MARK,STD,WHITE,SOLID,24" | 56 | LF |
| 50 | 0710 11131 | PAINTED PAVT MARK,STD,WHITE,SKIP, 6" | 41 | GM |
| 51 | 0710 11132 | PAINTED PAVT MARK,STD,WHITE,SKIP, 8" | 1 | GM |
| 52 | 0710 11141 | PAINTED PAVT MARK,STD,WHITE,SKIP, 6" | 23 | LF |
| 53 | 0710 11142 | PAINTED PAVT MARK,STD,WHITE,SKIP, 8" | 3 | LF |
| 54 | 0710 11151 | PAINTED PAVT MARK,STD,WHITE,DOTTED, 6" | 26 | LF |
| 55 | 0710 11160 | PAINTED PAVT MARK,STD,WHITE,MESSAGE | 41 | EA |
| 56 | 0710 11170 | PAINTED PAVT MARK,STD,WHITE,ARROWS | 52 | EA |
| 57 | 0710 11190 | PAINTED PAVT MARK,STD,WHITE,ISLAND NOSE | 14 | SF |
| 58 | 0710 11211 | PAINTED PAVT MARK,STD,YELLOW,SOLID,6" | 57 | NM |
| 59 | 0710 11212 | PAINTED PAVT MARK,STD,YELLOW,SOLID,8" | 1 | NM |
| 60 | 0710 11221 | PAINTED PAVT MARK,STD,YELLOW,SOLID,6" | 13 | LF |
| 61 | 0710 11222 | PAINTED PAVT MARK,STD,YELLOW,SOLID,8" | 14 | LF |
| 62 | 0710 11224 | PAINTED PAVT MARK,STD,YELLOW,SOLID,18" | 41 | LF |
| 63 | 0710 11231 | PAINTED PAVT MARK,STD,YELLOW,SKIP,6" | 16 | GM |
| 64 | 0710 11241 | PAINTED PAVT MARK,STD,YELLOW,SKIP,6" | 20 | LF |
| 65 | 0710 11251 | PAINTED PAVT MARK,STD,YELLOW,DOT,6" | 9 | LF |
| 66 | 0710 11290 | PAINTED PAVT MARK,STD,YELLOW,ISLAND NOSE | 28 | SF |
| 67 | 0710 11331 | PAINTED PAVT MARK,STD,BLACK,SKIP,6" | 3 | GM |
| 68 | 0710 11341 | PAINTED PAVT MARK,STD,BLACK,SKIP,6" | 1 | LF |
| 69 | 0710 11342 | PAINTED PAVT MARK,STD,BLACK,SKIP,8" | 2 | LF |
| 70 | 0710 11421 | PAINTED PAVT MARK,STD,BLUE,SOLID,6" | 1 | LF |

Table 3 Work Mix Codes and Numbers of Contracts

| WORK MIX CODE | WORK MIX NAME | NO. OF CONTRACTS |
|---|---|---|
| 0012 | RESURFACING | 1218 |
| 0213 | ADD LANES & RECONSTRUCT | 319 |
| 9917 | SAFETY PROJECT | 174 |
| 0024 | BRIDGE-REPAIR/REHABILITATION | 173 |
| 0421 | REPLACE LOW LEVEL BRIDGE | 151 |
| 0205 | SIDEWALK | 144 |
| 0221 | WIDEN/RESURFACE EXIST LANES | 113 |
| 0106 | BIKE PATH/TRAIL | 102 |
| 9924 | MISCELLANEOUS CONSTRUCTION | 99 |
| 1070 | LANDSCAPING | 90 |
| 0777 | LIGHTING | 89 |
| 0220 | FEDERAL AID RESURFACE/REPAVE | 63 |
| 0005 | FLEXIBLE PAVEMENT RECONSTRUCT. | 61 |
| 0549 | ADD LEFT TURN LANE(S) | 57 |
| 0218 | ADD LANES & REHABILITATE PVMNT | 55 |
| 0551 | ADD TURN LANE(S) | 54 |
| 0119 | INTERSECTION (MINOR) | 50 |
| 9915 | DRAINAGE IMPROVEMENTS | 50 |
| 0010 | TRAFFIC OPS IMPROVEMENT | 49 |
| 0002 | NEW ROAD CONSTRUCTION | 48 |
| 0121 | MULTI-LANE RECONSTRUCTION | 47 |
| 0716 | TRAFFIC SIGNALS | 46 |
| 0118 | INTERSECTION (MAJOR) | 41 |
| 0774 | SIGNING/PAVEMENT MARKINGS | 41 |
| 0543 | PAVE SHOULDERS | 35 |
| 0550 | ADD RIGHT TURN LANE(S) | 30 |
| 0714 | TRAFFIC SIGNAL UPDATE | 30 |
| 0541 | GUARDRAIL | 28 |
| 0925 | BRIDGE – PAINTING | 27 |
| 0217 | RIGID PAVEMENT RECONSTRUCTION | 26 |
| 0224 | MILL AND RESURFACE | 25 |
| 0717 | TRAFFIC CONTROL DEVICES/SYSTEM | 25 |
| 0103 | INTERCHANGE (MAJOR) | 24 |
| 0216 | SKID HAZARD OVERLAY | 24 |
| 225 | STATE PAVE SHOULDERS & RESURF. | 23 |
| 0109 | REST AREA | 22 |
| 0123 | TOLL PLAZA | 21 |
| 0544 | WIDEN BRIDGE | 19 |
| 029 | MISCELLANEOUS STRUCTURE | 18 |
| 0422 | REPLACE MEDIUM LEVEL BRIDGE | 18 |
| 0429 | BRIDGE REHABILITATION | 18 |
| 0008 | ACCESS IMPROVEMENT | 16 |
| 0323 | CONSTRUCT BRIDGE – HIGH LEVEL | 15 |
| 0767 | RAILROAD SIGNAL | 15 |
| 0022 | BRIDGE REPLACEMENT | 13 |

| | | |
|---|---|---|
| 8330 | RAIL CROSSING IMPROVEMENTS | 12 |
| 0215 | STATE RESURFACE/REPAVE | 11 |
| 0227 | RIGID PAVEMENT REHABILITATION | 11 |
| 9983 | CORRIDOR IMPROVEMENT | 11 |
| 0112 | MCCO WEIGH STATION STATIC/WIM | 10 |
| 9919 | CONSTRUCT/RECONSTRUCT MEDIAN | 10 |
| 0223 | STATE WIDEN AND RESURFACE | 9 |
| 0321 | CONST. BRIDGE – LOW LEVEL | 9 |
| 0775 | OVERHEAD SIGNING | 9 |
| 0222 | FARP-PAVE SHOULDERS & RESURF. | 8 |
| 0315 | FENDER WORK | 8 |
| 0328 | PEDESTRIAN/WILDLIFE OVERPASS | 8 |
| 0424 | REPLACE MOVABLE SPAN BRIDGE | 8 |
| 0754 | ADV TRAVELER INFORMATION SYSTM | 7 |
| 0046 | ENVIRONMENTAL TEST/MITIGATE | 6 |
| 0719 | INTERCONNECTION | 6 |
| 8250 | CLEAR ZONE CLEAR & GRUB | 6 |
| 9980 | PRELIMINARY ENGINEERING | 6 |
| 0102 | ROAD RECONSTRUCTION – 2 LANE | 5 |
| 0104 | INTERCHANGE (MINOR) | 5 |
| 0547 | ADD THRU LANE(S) | 5 |
| 0014 | HWY-ENHANCEMENT | 4 |
| 0061 | EMERGENCY OPERATIONS | 4 |
| 0110 | REST AREA (DUAL) | 4 |
| 0768 | RAILROAD CROSSING | 4 |
| 0423 | REPLACE HIGH LEVEL BRIDGE | 3 |
| 0425 | REPLACE RAILROAD BRIDGE | 3 |
| 0756 | ITS FREEWAY MANAGEMENT | 3 |
| 0020 | NEW BRIDGE CONSTRUCTION | 2 |
| 0122 | WELCOME STATION | 2 |
| 0324 | CONST. BRIDGE – MOVABLE SPAN | 2 |
| 0427 | REPLACE OR WIDEN BR CULVERT | 2 |
| 1053 | WETLAND MITIGATION/RESTORATION | 2 |
| 7093 | BRIDGE OPERATIONS | 2 |
| 8262 | CONST/RELOCATE SECURITY FENCE | 2 |
| 0004 | HWY-RECONSTRUCTION | 1 |
| 0023 | BRIDGE-REPLACE AND ADD LANES | 1 |
| 0041 | FUNDING ACTION | 1 |
| 0111 | MCCO WEIGH STATION STATIC ONLY | 1 |
| 0113 | WEIGH STATION (SINGLE) | 1 |
| 0117 | FRONTAGE ROAD | 1 |
| 0206 | PARKING FACILITY | 1 |
| 0226 | MAINTENANCE RESURFACING (FLEX) | 1 |
| 0231 | INTERCHANGE (MODIFY) | 1 |
| 0310 | CONSTRUCT SPECIAL STRUCTURE | 1 |
| 0327 | CONSTRUCT BRIDGE CULVERT | 1 |
| 0330 | CONSTRUCT CULVERT | 1 |

| | | |
|---|---|---|
| 0331 | REPLACE OR WIDEN CULVERT | 1 |
| 0542 | WIDEN ROAD | 1 |
| 0552 | FIX HORIZ. OR VERT. CURVE | 1 |
| 0718 | T.O.P.I.C.S. | 1 |
| 0720 | UPGRADE EXIST.TRAFFIC SIGNALS | 1 |
| 0752 | ITS SURVEILLANCE SYSTEM | 1 |
| 1039 | ENVIRONMENTAL PERMITS ACQ | 1 |
| 6060 | ROUTINE MAINTENANCE | 1 |
| 8301 | RAIL IMPROVEMENT | 1 |
| 916 | DREDGE | 1 |
| 9981 | SPECIAL SURVEYS | 1 |
| | TOTAL | 4038 |

## Work Mix Code Frequency

Due to the number of Work Mix Code (WMC) definitions, a sensitivity analysis was carried out in order to identify the most frequent projects and focus more on those. Additionally, sufficient numbers of projects were needed in a given Work Mix Code to adequately develop MOT quantity predictions. Eight of the Work Mix Code types were found to contain sufficient number of projects to model successfully. These Work Mix Codes represented more than 66% of the FDOT work program composition. Table 4 presents the results of the WMC frequency analysis.

In order to have a more efficient analysis, the WMC definitions to be used were confined to the 8 definitions.

Table 4 Analysis of Work Mix Type Contribution to Work Program

| WMC | Description | Total budget ($) | Cost fraction (%) |
|---|---|---|---|
| 2 | New road construction | 401,604,019.39 | 4.5% |
| 5 | Flexible pavement reconstruction | 322,089,788.65 | 3.6% |
| 12 | Resurfacing | 1,632,457,440.96 | 18.2% |
| 121 | Multi-lane reconstruction | 248,647,017.08 | 2.8% |
| 213 | Add lanes and reconstruct | 2,595,578,180.83 | 29.0% |
| 217 | Rigid pavement reconstruction | 81,349,106.88 | 0.9% |
| 218 | Add lanes and rehabilitate pavement | 411,223,234.62 | 4.6% |
| 221 | Widen/Resurface existing lanes | 232,683,198.10 | 2.6% |
| | Total Modeled | 6,516,215,536.90 | 66% |
| | Overall Program Total | 8,957,395,621.46 | 100% |

## Transportation System Types

Similar to WMC, FDOT defines transportation system definitions (TS) as project identifiers and these were used to further sort the data for MOT quantities. Different TS have shown to be significantly different from each other with regard to MOT quantities. Table 5 below presents the list of TS used in FDOT projects.

Table 5 Transportation System Types

| Definition | Notation |
|---|---|
| INTRASTATE INTERSTATE | TS1 |
| INTRASTATE TURNPIKE | TS2 |
| INTRASTATE STATE HIGHWAY | TS3 |
| INTRASTATE TOLL | TS4 |
| NON-INTRASTATE STATE HIWAY | TS5 |
| NON-INTRASTATE OFFSTATE HGW | TS6 |
| PINELLAS BAYWAY TOLL | TS7 |
| TRANSIT | TS8 |
| RAIL | TS10 |

## Initial Model Development

Our initial thinking was that the following project factors, available in the data base, were likely to affect the quantity of MOT items:

- Project Work Mix (FDOT Work Mix Designation)
- Project Budget (Original Contract Amount $)
- Project Length (Total Project Length Miles)
- Project Location (Urban/Rural Category)
- Project Duration (Days Used)
- Transportation System

Therefore these items were thought to offer the potential of successfully being used as independent variables in the model. Our initial exploration of modeling was focused on developing an appropriate modeling procedure with the following criteria:

- Maximizing precision
- Model aligned with the end user in mind
- Model development work efficiency

Based upon our preliminary investigation, we used the following initial procedures:

| | |
|---|---|
| Step 1 Project data will be separated and grouped by **Work Mix Code.** | This will be input by the estimator/user. |
| Step 2 The data subsets created in Step 1 will be separated and grouped by **Transportation System Code.** | This will be input by the estimator/user. |
| Step 3 Using a preliminary statistical analysis, **outliers** will be excluded from the data subset. | This will improve the precision of the resulting model. |
| Step 4 Linear regression of the data subsets created in Step 2 will be performed using the following independent variables:<br>**Final Expenditure**(contract amount in $)<br>**Rural or Urban** (planning category)<br>**Length** (length of project in miles)<br>**Days** (duration of project)<br>A regression model will be developed for each MOT item. | This will be input by the estimator/user. |
| Step 4 The model will be analyzed for precision and reasonableness. | We will analyze the model with regard to its engineering validity. |

The following example illustrates the modeling procedure for a specific pay item and project characteristics.

**Work Mix: 0213 Add Lanes and Reconstruct**
**MOT Item: Work Zone Signs 0102 60**
**Transportation System Code 03 Intrastate State Highway**

Table 6 provides the results of a 4 variable regression model for the above listed data.

Table 6 Data Subset (Work Zone Signs)

| Cont_ID | Original_Qty | Final_Exp | Rural/Urban | Length | Days_Used | Prediction | Percent Error |
|---|---|---|---|---|---|---|---|
| 20267 | 32130 | 6878271.52 | 0 | 5.452 | 560 | 4993.468828 | 84.46 |
| 20358 | 212635 | 21949563.8 | 1 | 3.836 | 1171 | 191345.7454 | 10.01 |
| 20406 | 22230 | 10176816.69 | 0 | 5.683 | 489 | 22278.6614 | 0.22 |
| 20479 | 316484 | 40307717.88 | 1 | 1.44 | 1042 | 290688.0212 | 8.15 |
| 20530 | 71092 | 10180099.64 | 1 | 3.411 | 664 | 86360.85289 | 21.48 |
| 20582 | 79680 | 9500840.98 | 1 | 4.11 | 691 | 86062.07958 | 8.01 |
| 20605 | 79570 | 13881512.81 | 0 | 3.916 | 1300 | 87140.84032 | 9.51 |
| 20662 | 70877 | 14614281.5 | 1 | 0.963 | 593 | 101671.8283 | 43.45 |
| 20763 | 29000 | 9875162.82 | 0 | 4.997 | 454 | 16004.19188 | 44.81 |
| 20944 | 118750 | 21875591.74 | 0 | 6.079 | 1191 | 138177.1455 | 16.36 |
| 21007 | 46180 | 9216532.26 | 0 | 7.271 | 504 | 22530.62193 | 51.21 |
| 21046 | 70351 | 8686694.07 | 1 | 2.471 | 605 | 70345.8316 | 0.01 |
| 21105 | 12595 | 2402708.71 | 1 | 0.746 | 320 | 8368.101115 | 33.56 |
| 21217 | 20180 | 6367321.41 | 1 | 2.159 | 318 | 37892.03444 | 87.77 |
| 21252 | 16562 | 2349775.19 | 1 | 0.47 | 404 | 12034.21667 | 27.34 |
| 21256 | 30675 | 15714574.23 | 0 | 2.724 | 556 | 50878.30828 | 65.86 |
| 21445 | 30712 | 15970204.7 | 0 | 8.87 | 594 | 75569.29521 | 146.06 |
| 21477 | 24360 | 11891339 | 0 | 5.036 | 453 | 28713.23533 | 17.87 |
| 21479 | 21516 | 11500794.8 | 0 | 6.79 | 375 | 27635.94194 | 28.44 |
| 21509 | 48000 | 7740246.21 | 0 | 6.433 | 483 | 9201.289405 | 80.83 |
| 21556 | 72396 | 7287985.68 | 1 | 3.639 | 478 | 58083.28888 | 19.77 |
| Total Average % Error | | | | | | | 38.34 |

Table 7 illustrates the improvement in $R^2$ values with increased number of variables (single variable vs. multi-variable).

Table 7 $R^2$ Values for Different Models

| | Variable 1 | Variable 2 | Variable 3 | Variable 4 | $R^2$ |
|---|---|---|---|---|---|
| 1-Variable model | Final expenditure | NA | NA | NA | .76 |
| 2-Variable model | Final expenditure | Location | NA | NA | .88 |
| 3-Variable model | Final expenditure | Location | Length | NA | .83 |
| 4-Variable model | Final expenditure | Location | Length | Days used | .92 |

As previously discussed, some outliers existed in the data set. Consequently the data set needed to be adjusted for outliers. The models in Table 8 are examples of results with outliers removed.

Table 8 $R^2$ values for different models (outliers excluded)

| | Variable 1 | Variable 2 | Variable 3 | Variable 4 | $R^2$ |
|---|---|---|---|---|---|
| 1-Variable model | Final expenditure | NA | NA | NA | .79 |
| 2-Variable model | Final expenditure | Location | NA | NA | .93 |
| 3-Variable model | Final expenditure | Location | Length | NA | .95 |
| 4-Variable model | Final expenditure | Location | Length | Days used | .96 |

The improvement in the modeling precision with outliers removed is illustrated by the following results:

- Mean percent error unmodified(outliers are not excluded)==>38%
- Mean percent error modified(outliers are excluded)==>24%

In this example, we were able to account for 96% of the variability in the quantity of this MOT pay item with a relatively low prediction error.

Nevertheless, we suspect that other project specific factors may exist that were not included in the project data base that may influence MOT quantities. Therefore, we performed a rational engineering analysis of the appropriate MOT quantities for a typical project from each work mix category. The relationship between pay item quantities and key project factors (Days, Length, Contract Amount) was determined. We also identified any additional factors that may influence a specific pay item. For example, significant differences in elevation may correlate with the use of barrier wall. The details of these analyses can be found in the following chapters.

## Initial Results

The preliminary WMC frequency analysis proved to be useful in improving the efficiency of the regression model development. A more detailed analysis to identify the project counts for WMC-TS combinations was carried out. Details of this analysis can be found in Appendix A. After the data was sorted out, a preliminary multi-variable regression models were developed and each checked for any outliers. A Mean Average Percent Error (MAPE) value of 50% and $R^2$ value of .5 were chosen to be the lower acceptability limits for developed regression models.
After the regression models were developed, each was compared to actual project quantities and upper and lower boundaries to each to be created by using engineering judgment and standard indexes.
The final equations were embedded to a software application to automate the MOT item selection and quantities for different project definitions.

### Improvements to the Model

Initial testing and follow up discussion with FDOT personnel further strengthened the research team's belief that additional project specific input data is needed to improve prediction accuracy. In an effort to demonstrate the feasibility for improving accuracy a number of trial improvements to the prediction model were made. Based upon discussions with experienced FDOT engineers and a critical review of FDOT design standards applicable to Maintenance of Traffic, the following modifications to the prediction model were made:

**Adding bid item costs in the predictions: T**he historic price averages for differing MOT bid items were used to calculate the predicted MOT item costs as well as the percentage of the MOT spending compared to the project budget. The maintenance of traffic was included in the MOT data set as a lump sum amount and the average of previous years broken down with respect to WMC and TS was used as the basis for future project predictions.

**Adjustments to the initial prediction equations:** To improve the prediction accuracy, upper and lower boundaries were set to the predictions using engineering judgment, the FDOT standard MOT indexes and additional project characteristics input by the user. The following additional information items to be input by the user were added:

- Use of Cones vs. Type II Barricades
- Estimated Cross Street Frequency per Mile
- Number of Signalized Intersections
- Anticipated Drop Off Conditions
- Anticipated Letting Date

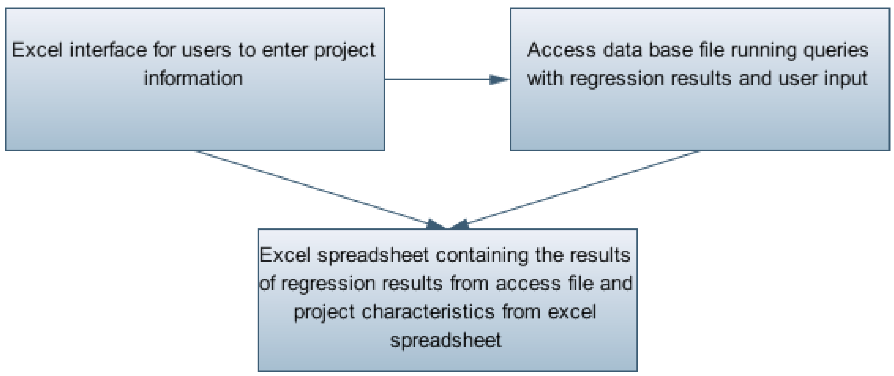
**The Inflation Adjustment:** The data set furnished by FDOT (used in regression model development) was through years 1993 and 2003, concentrated through 1998 to 2001. Considering the time difference between the current projects and these dates, it was necessary to adjust the project budgets to be used in MOT quantity prediction for the cost difference related to the time interval. The letting date was added to the input list and the difference between the letting date and the median date (1999) for historic projects was calculated. The adjustment factor was calculated using a cost index. The historic engineering news record (ENR) construction price index values and consumer price index (CPI) values were analyzed. As a result of the analysis an adjustment factor was developed to adjust current project budgets to the median year of the historical data base for model predictions. The average annual cost increase over the period was approximately 3.6%.

# Chapter 4 Application Platform Development and Testing

## Application Architecture

The initial regression models were developed for WMC-TS combinations and they were checked against both the outliers and the preliminary accuracy conditions. The complete documentation of regression results is provided in Appendix A.

After the regression coefficients were obtained they were placed in an Access data base file. The interface developed use an Excel file to interact with the users for data inputting. Below is the schematic representation of the application interface.




## Use of the application: Maintenance of Traffic Estimating System (MOTES)

Bid login form is the main application interface the users will be interacting with. It is designed to record some project characteristics about transportation projects and return the estimated MOT quantities. The file has been programmed using Visual Basic for Applications (VBA) and reaches the access file, which contains the required formulas and run queries to provide the required functionality. The details of the algorithms are beyond the scope of this tutorial but they can be found in the final report of this research project. Following are the steps the use the MOTES software.

The first step to start the procedure is to enter the project ID that has observed to be a string of numbers. Note that all the cells except the project ID cell are gray, they cannot be changed before the project ID is entered and the *Start* button is clicked.

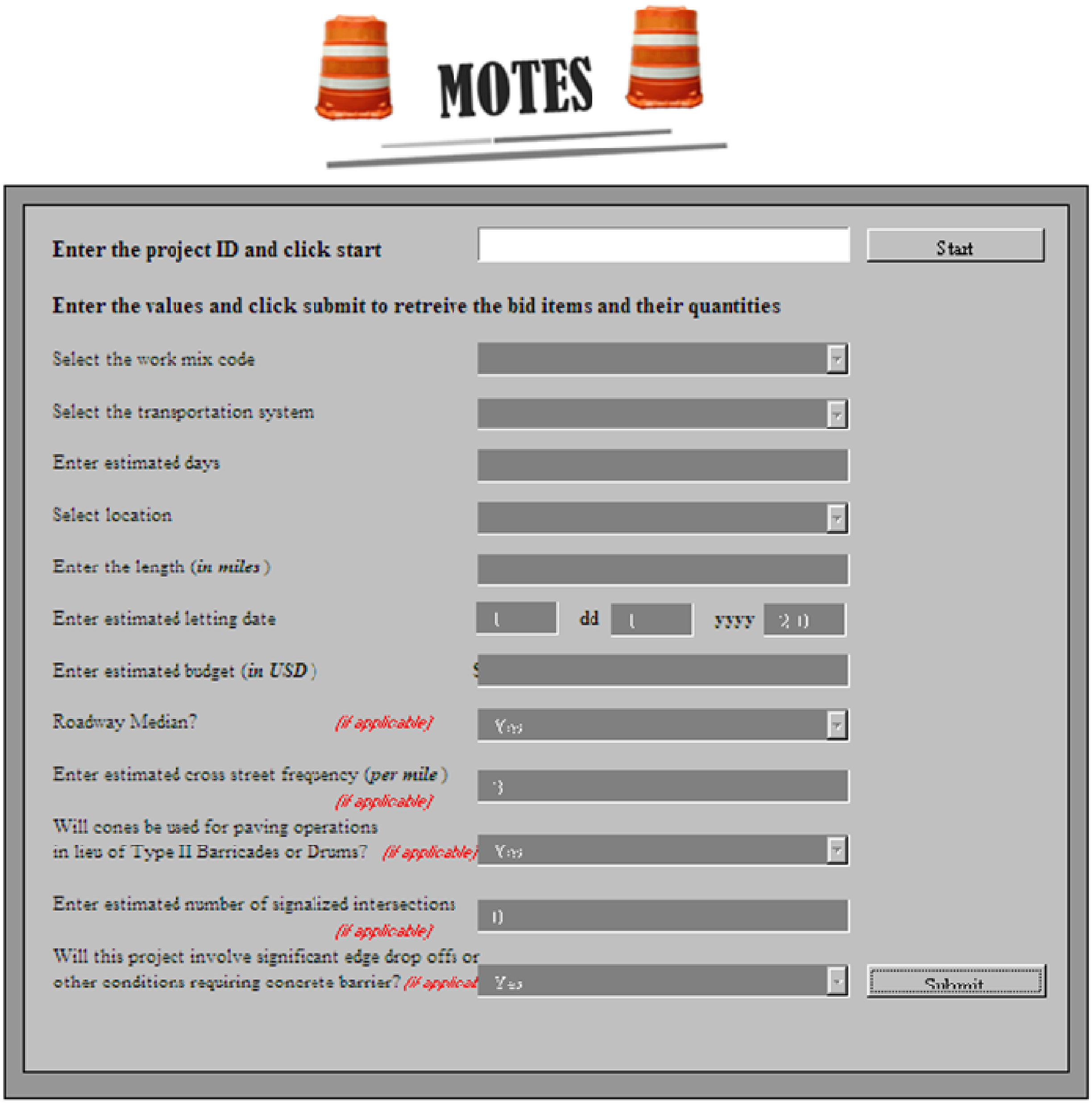



Figure 1 Initial Project Input Screen

Completing step 1 and will enable users to change the values of the other cells. Additionally, a spreadsheet will be created in a temporary drive. At this stage the user will not see the new spreadsheet.

The users now can input the project characteristics that will be used to calculate the MOT bid item quantities. The related work mix code, transportation system definition and the project location will be selected from a drop down menu. The other three variables, project days, project length in miles and project expenditure in USD dollars. When all the values are inserted the users are to click on *Submit* button to obtain the MOT bid item estimates and clear out the fields for different project quantity estimations.

The spreadsheet that created in step 2 will now be visible with the MOT estimates on it. That spreadsheet will named as the project ID entered-MOT, i.e. 1001-MOT. The output spreadsheet will include a complete list of MOT bid items, their predicted quantities and two legends providing extra information about the predictions. Details of these legends can be found in the project report.

The bid items and their quantities are as follows:

| Item Number | Item Description | Predicted Quantities | Unit Cost | Total Cost |
|---|---|---|---|---|
| 0102 76 | ADVANCE WARNING ARROW PANEL | 424 | 8.53 | 3615.87 |
| 0102 74 1 | BARRICADE, TEMPORARY, TYPES I, II, DI, VP & DRUM | 1120 | 0.19 | 209.69 |
| 0102 71 11 | BARRIER WALL,TEMPORARY,F&I,CONCRETE | 2288 | 22.53 | 51536.16 |
| 0102 61 | BUSINESS SIGN | 119 | 38.92 | 4632.12 |
| 0102 99 | CHANGEABLE-VARIABLE MESSAGE SIGN,TEMPORARY | 422 | 19.96 | 8419.00 |
| 0102 3 | COMMERCIAL MATERIAL FOR DRIVEWAY MAINTENANCE | 921 | 28.02 | 25804.21 |
| 0102 89 7 | CRASH CUSHION | 11 | 1465.46 | 15900.40 |
| 0102 77 | HIGH INTENSITY FLASHING LIGHTS,TEMP,TYPE B | 1855 | 0.47 | 868.14 |
| 0102 79 | LIGHTS,BARRIER WALL MOUNT,TEMP,TYPE C,STEADY BURN | 3653 | 0.17 | 607.79 |
| 0102911 3 | PAVEMENT MARKING REMOVABLE,WHITE-BLACK,OTHER | B | 4.35 | |
| 0102911 1 | PAVEMENT MARKING REMOVABLE,WHITE-BLACK,SKIP | B | 1.06 | |
| 0102911 2 | PAVEMENT MARKING REMOVABLE,WHITE-BLACK,SOLID | B | 1.58 | |
| 0102912 3 | PAVT MARKING REMOVABLE,YELLOW,OTHER | B | 1.56 | |
| 0102912 1 | PAVT MARKING REMOVABLE,YELLOW,SKIP | B | 2.08 | |
| 0102912 2 | PAVT MARKING REMOVABLE,YELLOW,SOLID | B | 1.45 | |
| 0102 78 | REFLECTIVE PAVEMENT MARKER,TEMPORARY | 5112 | 3.82 | 19511.96 |
| 0102104 2 | TEMPORARY TRAFFIC CONTROL,FIXED SIGNAL | B | 26.53 | |
| 0102 14 | TRAFFIC CONTROL OFFICER | 0 | 53.83 | 0.00 |
| 0102 60 | WORK ZONE SIGN | 3180 | 0.30 | 959.09 |
| 0102 1 | MAINTENANCE OF TRAFFIC | 1 | 94692.60 | 94692.60 |
| 0102104 1 | TEMPORARY TRAFFIC CONTROL,PORTABLE SIGNAL | B | 117.30 | |
| 102107 | TEMPORARY TRAFFIC DETECTION, INTERSECT | B | 15.64 | |
| 0102 73 | TEMPORARY GUARDRAIL | A | 25.63 | |
| 0102 71 12 | BARRIER WALL,TEMPORARY,F&I,WATERFILLED | A | 41.98 | |
| 0102 71 13 | BARRIER WALL,TEMPORARY,F&I,LOW PROFILE,CONCRETE | A | 50.56 | |
| 0102 71 14 | BARRIER WALL,TEMPORARY,F&I,TYPE K | A | 53.97 | |
| 0102 71 21 | BARRIER WALL,TEMPORARY,RELOCATE,CONCRETE | B | 6.36 | |
| 0102 71 22 | BARRIER WALL,TEMPORARY,RELOCATE,WATERFILLED | B | 10.11 | |
| 0102 71 23 | BARRIER WALL,TEMPORARY,RELOCATE,LOW PROFILE | B | 6.04 | |
| 0102 71 24 | BARRIER WALL,TEMPORARY,RELOCATE,TYPE K | B | 14.30 | |
| 0102 94 1 | GLARE SCREEN,TEMPORARY,F&I,WALL MATERIAL-CONCRET | B | B | |
| 0102 94 11 | GLARE SCREEN,TEMPORARY,RELOCATE,WALL MATERIAL | B | B | |
| 0102150 1 | PORTABLE REGULATORY, SIGN | A | 30.47 | |
| 0102150 2 | RADAR SPEED DISPLAY UNIT | A | 29.57 | |
| 0102 2 1-0102 2 30 | SPECIAL DETOUR(s) | B | B | |
| 0102 74 2 | BARRICADE, TEMPORARY, TYPE III, 6' | B | 0.38 | |
| 0102 98 2 | BARRICADE, TYPE III, 6', TO REMAIN | B | 150.80 | |

A => Insufficient data in data base to make prediction.
Must be determined by estimator.

B => Must be determined by estimator based on project specific criteria.

C => Pay item not found in current Master Pay Item List

**DETAILS ENTERED BY THE USER**

| | |
|---|---|
| WMC | 0012 - RESURFACING |
| TS | 5 - Non-Intrastate State Highway |
| Days | 265 |
| Rur/Urb | Rural |
| Length | 3.684 miles |
| Budget | ########## |

**MOT RESULTS**

| | |
|---|---|
| MOT Budget | $226,757.03 |
| % of Budget | 6.03377944 % |

Figure 2 Output MOT Estimate in Spreadsheet Form

If more than one project prediction is required, the user can simply go to the MOTES-Login spreadsheet and redo the steps 1-4 to obtain new predictions. A complete copy of the user instructions are provided in Appendix C.

## Testing of the Application

### Estimated Model Precision

An analysis of model estimating precision over the range of work mix types was performed by comparing the expected model prediction to the actual values in the data base. The average estimate precision was found to be **15%.** Table 9 presents the estimated model prediction precision. The absence of a numerical value in the table indicates that that the historical data base did not contain sufficient numbers of projects with this item to facilitate modeling. Additionally, the current MOT pay item listing includes a number of pay items that were not found in the historical project data. Modeling was not possible for these under represented items because there was no historical project data. However, the results given in Table 9 clearly indicate that predictions of MOT item quantities can be successfully made when sufficient historical project data is available. The conclusion is that with the addition of more recent project data, MOT quantity predictions can be made for all commonly used MOT items.

### Trial Testing of the Modeling Application

The MOT model was tested using new project data provided by the FDOT. These were projects that had been recently completed from three different FDOT Districts. The input information included the basic project descriptive information and MOT quantities for some of the MOT items. Table 10 presents the basic project information on the sample projects. The MOTS software application performed without execution errors.

### Results of the Quantity Estimate Precision for the Sample Projects

Two of the projects (project s F and J) were significantly different from the average project in the historical data base. We do not know specifically how the projects differed, but it is clear that they were outliers. For example: the contractor may have elected a non-typical work plan or the project work mix category may not have been representative of the scope of work. The quantity predictions for 8 of the 10 projects were within the expected range, providing an average MOT quantity estimate precision of **11.99%** and an average MOT cost estimate precision of **0.48 %.** The MOT quantity predictions for the two outlier projects provided an average MOT quantity estimate precision of 66.4% and an average MOT cost estimate precision of 2.74 %. Obviously, there will occasionally be projects that do not fit the norm. Table 11 presents the results of the estimate precision of the 8 typical sample projects. The detailed estimate predictions of all sample projects are included in Appendix C.

Table 9 Estimated Model Precision (% Variance)

| MOT Pay Item | 12-Resurfacing | 005-Flexible Pavement Reconstruction | 0217 - RIGID PAVEMENT RECONSTRUCTION | 0221 - WIDEN OR RESURFACE EXIST LANES | 213-Add Lanes and Reconstruct | 002-New Road Construction | 121-Multilane Reconstruction | 0218 - ADD LANES AND REHABILITATE PVMNT | **AVERAGE PRECISION BY PAY ITEM TYPE** |
|---|---|---|---|---|---|---|---|---|---|
| ADVANCE WARNING ARROW PANEL | 17 | 12 | 12 | 11 | 50 | 34 | 27 | 42 | **26** |
| BARRICADE, TEMPORARY, TYPES I, II, DI, VP & DRUM | 24 | 20 | 10 | 23 | 11 | 13 | 8 | 10 | **15** |
| BARRIER WALL,TEMPORARY,F&I,CONCRETE | 23 | 22 | 11 | 43 | 15 | 32 | | 19 | **24** |
| BUSINESS SIGN | 52 | | | | 23 | | | 12 | **29** |
| CHANGEABLE-VARIABLE MESSAGE SIGN,TEMPORARY | 13 | | 7 | 6 | 14 | 18 | 17 | 9 | **12** |
| COMMERCIAL MATERIAL FOR DRIVEWAY MAINTENANCE | 4 | 6 | | 10 | | 16 | 37 | 15 | **15** |
| CRASH CUSHION | 42 | | | | 29 | | | | **36** |
| HIGH INTENSITY FLASHING LIGHTS,TEMP,TYPE B | 21 | 17 | 8 | 19 | 17 | 19 | 24 | 16 | **18** |
| LIGHTS,BARRIER WALL MOUNT,TEMP,TYPE C,STEADY BURN | 2 | 1 | | 1 | 22 | 35 | | 8 | **11** |
| REFLECTIVE PAVEMENT MARKER,TEMPORARY | 3 | 2 | 1 | 2 | 34 | | 24 | 40 | **15** |
| TEMPORARY TRAFFIC CONTROL,FIXED SIGNAL | 7 | 14 | | | 16 | | | | **12** |
| WORK ZONE SIGN | 1 | 1 | | 1 | 3 | | | 2 | **2** |
| MAINTENANCE OF TRAFFIC | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **1** |
| TEMPORARY TRAFFIC DETECTION, INTERSECT | 46 | | | | 19 | | | | **33** |
| **AVERAGE PRECISION BY WORK MIX TYPE** | **18** | **10** | **7** | **12** | **20** | **21** | **20** | **16** | |

Average for All Work Mix Types = 15%

Note that the absence of a numerical value indicates that sufficient project data was not available to model that item.

Table 10 Project Characteristics on Initial Sample Projects

| Project | ID Number | Work Mix | Transportation System | Rural/Urban | Budget | Length (Miles) | Duration (Days) |
|---|---|---|---|---|---|---|---|
| A | 417643-1-52-01 | 012 Resurfacing | Intrastate Interstate TS 1 | Rural | $11,182,388.10 | 7.6 | 171 |
| B | 209596-1-52-01 | 421 Replace Low Bridge | Non-Intrastate State Highway TS5 | Rural | $17,430,221.39 | 1.446 | 716 |
| C | 208363-1-52-01 | 213 Add Lanes and Reconstruct | Non-Intrastate State Highway TS5 | Rural | $28,857,028.84 | 3.733 | 907 |
| D | 209513-8-52-01 | 0213 Add Lanes and Reconstruct | Non-Intrastate State Highway TS5 | Urban | $27,405,057.18 | 3.076 | 1192 |
| E | 208085-3-52-01 | 012 Resurfacing | Non-Intrastate State Highway TS5 | Rural | $6,738,408.98 | 5.324 | 376 |
| F | 210447-3-52-01 | 0012 Resurfacing | Non-Intrastate State Highway TS5 | Urban | $1,705,539.63 | 1.471 | 124 |
| G | 210067-2-52-01 | 0012 Resurfacing | Non-Intrastate State Highway TS5 | Rural | $4,232,694.86 | 8.789 | 112 |
| H | 208402-3-52-01 | 0012 Resurfacing | Non-Intrastate State Highway TS5 | Rural | $2,225,736.08 | 7.511 | 96 |
| I | 209411-2-52-01 | 0012 Resurfacing | Non-Intrastate State Highway TS5 | Urban | $7,194,273.34 | 10.173 | 360 |
| J | 209664-3-52-01 | 0012 Resurfacing | Non-Intrastate State Highway TS5 | Urban | $3,118,423.18 | 3.273 | 237 |

Table 11 MOT Estimate Precision Results for Sample Projects

| Project | ID Number | Work Mix | Average MOT Quantity Variance (%) | Average MOT Cost Variance (% of Expenditures) |
|---|---|---|---|---|
| A | 417643-1-52-01 | 012 Resurfacing | 13.79% | 0.12% |
| B | 209596-1-52-01 | 421 Replace Low Bridge | -5.50% | -0.58% |
| C | 208363-1-52-01 | 213 Add Lanes and Reconstruct | -5.18% | -0.11% |
| D | 209513-8-52-01 | 0213 Add Lanes and Reconstruct | -11.93% | -1.27% |
| E | 208085-3-52-01 | 012 Resurfacing | -10.50% | 0.90% |
| G | 210067-2-52-01 | 0012 Resurfacing | 13.33% | 0.05% |
| H | 208402-3-52-01 | 0012 Resurfacing | 11.86% | 0.18% |
| I | 209411-2-52-01 | 0012 Resurfacing | 23.83% | 0.63% |
| | **AVERAGE ABSOLUTE PREDICTION PRECISION** | | **11.99%** | **0.48%** |

# Chapter 5 Conclusions and Recommendations

## Conclusions

### Research Outcome

The results of this study clearly demonstrate that MOT item quantities can be successfully estimated from a model based upon basic project descriptive information. Analysis of the model precision using 8 new test projects resulted in an average MOT quantity variance of 3.71%, which represented only 0.001% of the estimated total MOT cost to the project. Analysis of the model precision over the range of project work mix types indicates an average estimate precision 15%.

However, in its current form the estimating modeling is constrained by certain limitations. Modeling is limited to work mix project types and MOT items that are represented in the project data base in sufficient numbers. Where we have sufficient project data, modeling is successful. Estimate precision is highly dependent upon the quantity and quality of the input project data.

### Limitations of the Input Data

#### *Age of Input Data Base*

The project history data used in modeling included projects from 1993 to 2003 (only a few projects were available from 2003). Approximately 78% of the projects were performed in 2000 or earlier. The average age of the projects used was approximately 10 years. It seems likely that the application of MOT within the FDOT has evolved over time. The information in the input data base may not precisely reflect current MOT usage. Pay Items, work mix codes and design standards have been revised. Given the age of the projects it is not practical to obtain additional critical project information on those projects. More current project data could be used to improve the prediction models.

#### *Limited Number of Projects in Certain Work Mix Categories*

Many of the project work mix categories apparently occur infrequently in the FDOT's work program. Consequently, there were insufficient numbers of projects in the input data base to support modeling. This may not be a serious concern because there may not be a need to model projects that occur only occasionally. However, the work program has evolved. For example, ITS projects which were minimally present in the input data base may occur more frequently in current and future years. More current project data could be used to improve the prediction models for certain work mix categories.

## Recommendations for Improvement – Moving Forward

### Expand and Refine the Model

The research team believes that the inclusion of more recent (and verifiable) project data offers the potential for greatest improvements. The implementation of a revised form of this prototype MOT Estimating System would benefit the FDOT in reducing the cost of preparing quantity estimates for MOT items. The application would provide more precise MOT estimates during project planning and preliminary design, and would reduce the time required to develop pay item quantities in the final design.

### *Input of New Current Project Data*

With more recent project data the model can be expanded to include all MOT Items and project work mix types of interest to the FDOT. The inclusion of current project data will also improve the estimate precision.

Clearly, estimate precision can be improved with an additional level of project information. Work Mix Code categories do not tell us enough about key project characteristics. The following examples are representative of the types of additional project information that would greatly improve model accuracy.

| Additional Project Information | MOT Items Affected |
|---|---|
| Number of travel lanes (Shoulder Modifications) | Barricades<br>Stripping Removal<br>Temporary Stripping<br>Reflective Pavement Markers<br>Advance Arrow Warning Panel |
| Median (yes or no) | Work Zone Signs<br>Barricades<br>High Intensity Flashing Lights |
| Cross street frequency | Work Zone Signs<br>Type III Barricades<br>Barricades (Type II, Drums, Type I)<br>High Intensity Flashing Lights |
| Edge Drop Off Conditions | Temporary Concrete Barrier<br>Lights Barrier Wall Mounted |
| Number of Signalized Intersections | Temporary Traffic Control Fixed Signal<br>Temporary Detection |

This information is not practically obtainable for the projects included in the original data base because of the age of the projects. However, this information could be readily obtained for projects performed in the last 1 to 3 years. The project administrator or engineer could be contacted directly by the researcher. A simple, phone call or e-mail is all that would be required to get the “rest of the story”. More recent data would also be more closely aligned with current MOT usage. This would permit identification of projects that are far from the norm and more precise filtering of the data. Several hundred projects with this additional level of information could be obtained.
The MOT designer using the model to estimate would of course have to provide the same level of information. This would not appear to be a burden for someone who has worked on the MOT design and if familiar with the project.

### *Obtain Additional Input from MOT Designers and Construction Project Managers*

Improvement of the prediction model can also be accomplished through input from experienced MOT designers and FDOT construction project managers. The development of a better understanding of the key project characteristics that influence MOT choices would greatly assist in refining the model. Obtaining this input would involve discussions with experienced MOT designers and construction project managers. This input would define that additional level of information needed for improvement and facilitate its inclusion in the model. Our preliminary thinking is that at least one designer and one construction manager should be contacted in each district.

### *Improvements to the User Interface*

Based upon the above input from MOT designers, the estimating software application can be improved to provide the most benefit for users. A graphical interface similar to that used in the LRE might be considered.

## References


Hua, G. B. (1996) Residential construction demand forecasting using economic indicators: a comparative study of artificial neural networks and multiple regression. C*onstruction Management and Economics,* 14, 25-34.

Garza, J. M., and Rouhana, K. G. (1995) Neural networks versus parameter-based applications in cost engineering. *Cost Engineering,* 37 (2), 14-18.

Ott, R. L., and Longnecker, M. T. (2004) *A First Course in Statistical Methods,* Brooks/Cole-Thompson Learning, Belmont, CA.

Financial Trend Forecaster (2008) *Historical CPI,* retrieved from http://inflationdata.com/inflation/Consumer_Price_Index/HistoricalCPI.aspx, 06/12/2008.

FDOT Specifications and Estimates Office (2008) *2009 Basis of Estimates Manual (on MOT bid items),* retrieved from http://www.dot.state.fl.us/specificationsoffice/Estimates/BasisofEstimates/BOEManual/Files/Chapter11.pdf, 05/10/2008.

FDOT Specifications and Estimates Office (2008) *Master Pay Item List,* retrieved from http://www.dot.state.fl.us/specificationsoffice/Estimates/BasisofEstimates/BOEManual/Files/Chapter21.pdf, 03/12/2008.

Armstrong, J. S., and Collopy, F. (1992) Error Measures for generalizing about forecasting methonds: Empirical comparisons. *International Journal of Forecasting, 8, 69-80.*

# Appendix A Initial Modeling Regression Results

**COMB.005- HWY-RECONSTRUCTION, FLEXIBLE PAVEMENT RECONSTRUCT.**

**TS-5**

**Advance Warning Panel**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.604194 |
| R Square | 0.36505 |
| Adjusted R Square | 0.042289 |
| Standard Error | 655.5168 |
| Observations | 13 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 2223430 | 555857.4 | 1.724783 | 0.237083 |
| Residual | 9 | 3867321 | 429702.3 | | |
| Total | 13 | 6090750 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -464.9214 | 516.6989 | -0.899792 | 0.39167 | -1633.78 | 703.9327 | -1633.78 | 703.9327 |
| X Variable 1 | -232.5895 | 308.6151 | -0.753656 | 0.470312 | -930.725 | 465.5464 | -930.725 | 465.5464 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| X Variable 2 | 0 | 0 | 65535 | #NUM! | 0 | 0 | 0 | 0 |
| | | | - | | | | | |
| X Variable 3 | -3.43E-05 | 6.87E-05 | 0.499393 | 0.629482 | -0.00019 | 0.000121 | -0.00019 | 0.000121 |
| X Variable 4 | 2.316167 | 1.10107 | 2.103559 | 0.064743 | -0.17463 | 4.806961 | -0.17463 | 4.806961 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.743966904 |
| R Square | 0.553486754 |
| Adjusted R Square | 0.293537894 |
| Standard Error | 1457942.45 |
| Observations | 13 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 2.37E+13 | 5.93E+12 | 3.718726 | 0.053871 |
| Residual | 9 | 1.91E+13 | 2.13E+12 | | |
| Total | 13 | 4.28E+13 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 18212103.62 | 9929802 | 1.834085 | 0.099846 | -4250669 | 40674876 | -4250669 | 40674876 |
| | - | | - | | | | | |
| X Variable 1 | 501838.5124 | 638384.4 | 0.786107 | 0.452005 | -1945964 | 942287.3 | -1945964 | 942287.3 |
| X Variable 2 | 0 | 0 | 65535 | #NUM! | 0 | 0 | 0 | 0 |
| | - | | - | | | | | |
| X Variable 3 | 1573199.529 | 785345.2 | 2.003195 | 0.076159 | -3349774 | 203374.8 | -3349774 | 203374.8 |
| X Variable 4 | 10989.86758 | 3468.135 | 3.168812 | 0.011388 | 3144.401 | 18835.33 | 3144.401 | 18835.33 |

**002-NEW CONSTRUCTION ROAD**

**TS-2**

**High_Intensity_Flash_Lights**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.644887 |
| R Square | 0.415879 |
| Adjusted R Square | 0.082096 |
| Standard Error | 4855.317 |
| Observations | 12 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 1.17E+08 | 29372289 | 1.245956 | 0.374036 |
| Residual | 7 | 1.65E+08 | 23574102 | | |
| Total | 11 | 2.83E+08 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | Upper 95.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | 1340.815 | 6163.404 | 0.217545 | 0.833989 | -13233.3 | 15914.95 | -13233.3 | 15914.95 |
| X Variable 1 | 682.2768 | 611.3757 | 1.11597 | 0.301273 | -763.397 | 2127.951 | -763.397 | 2127.951 |
| X Variable 2 | -2779.98 | 4715.686 | -0.58952 | 0.57404 | -13930.8 | 8370.845 | -13930.8 | 8370.845 |
| X Variable 3 | -0.00023 | 0.000265 | -0.8817 | 0.407194 | -0.00086 | 0.000392 | -0.00086 | 0.000392 |
| X Variable 4 | 13.50727 | 13.02965 | 1.036657 | 0.334374 | -17.3029 | 44.31749 | -17.3029 | 44.31749 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.7527083 |
| R Square | 0.5665697 |
| Adjusted R Square | 0.3188953 |
| Standard Error | 82535379 |
| Observations | 12 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 6.23E+16 | 1.55831E+16 | 2.287558 | 0.159908 |
| Residual | 7 | 4.77E+16 | 6.81209E+15 | | |
| Total | 11 | 1.1E+17 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -1.32E+08 | 1.16E+08 | -1.135419198 | 0.293576 | -4.1E+08 | 1.43E+08 | -4.1E+08 | 1.43E+08 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| X Variable 1 | 12951053 | 10463107 | 1.237782746 | 0.2557 | -1.2E+07 | 37692369 | -1.2E+07 | 37692369 |
| X Variable 2 | -52378267 | 73739432 | -0.710315575 | 0.500481 | -2.3E+08 | 1.22E+08 | -2.3E+08 | 1.22E+08 |
| X Variable 3 | -1.01E-07 | 6.45E-08 | -1.560935016 | 0.162507 | -2.5E-07 | 5.19E-08 | -2.5E-07 | 5.19E-08 |
| X Variable 4 | 324152.87 | 192535.2 | 1.683603557 | 0.136133 | -131120 | 779426.2 | -131120 | 779426.2 |

**COMB.215-MILL AND RESURFACE, RESURFACING, MAINTENANCE RESURFACING (FLEX), SKID HAZARD OVERLAY, FEDERAL AID RESURFACE/REPAVE, STATE RESURFACE/REPAVE**

**TS-1**

Advance Warning Panel

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.653335 |
| R Square | 0.426847 |
| Adjusted R Square | 0.331321 |
| Standard Error | 539.6342 |
| Observations | 29 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance* |
|---|---|---|---|---|---|

| | | | | | F |
|---|---|---|---|---|---|
| Regression | 4 | 5204892 | 1301223 | 4.468408 | 0.007694 |
| Residual | 24 | 6988922 | 291205.1 | | |
| Total | 28 | 12193814 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -424.224 | 295.0304 | -1.4379 | 0.163375 | -1033.14 | 184.6889 | -1033.14 | 184.6889 |
| X Variable 1 | 8.688447 | 34.90162 | 0.248941 | 0.805524 | -63.345 | 80.72185 | -63.345 | 80.72185 |
| X Variable 2 | 442.3011 | 207.9927 | 2.126523 | 0.04394 | 13.02534 | 871.5769 | 13.02534 | 871.5769 |
| X Variable 3 | 7.04E-05 | 6.69E-05 | 1.052732 | 0.302948 | -6.8E-05 | 0.000208 | -6.8E-05 | 0.000208 |
| X Variable 4 | 1.133732 | 0.776163 | 1.460687 | 0.15707 | -0.46819 | 2.735654 | -0.46819 | 2.735654 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.719093 |
| R Square | 0.517094 |
| Adjusted R Square | 0.43661 |
| Standard Error | 8.597597 |
| Observations | 29 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 1899.645 | 474.9113 | 6.424781 | 0.001159 |
| Residual | 24 | 1774.048 | 73.91867 | | |
| Total | 28 | 3673.693 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Intercept | -4.8274 | 6.964801 | -0.69311 | 0.494892 | -19.202 | 9.547244 | -19.202 | 9.547244 |
| X Variable 1 | 0.270745 | 0.462773 | 0.585049 | 0.563975 | -0.68437 | 1.225862 | -0.68437 | 1.225862 |
| X Variable 2 | 7.546787 | 3.398025 | 2.220933 | 0.036046 | 0.533607 | 14.55997 | 0.533607 | 14.55997 |
| X Variable 3 | 7.76E-14 | 5.87E-14 | 1.321426 | 0.198819 | -4.4E-14 | 1.99E-13 | -4.4E-14 | 1.99E-13 |
| X Variable 4 | 0.987959 | 0.358144 | 2.758551 | 0.01093 | 0.248786 | 1.727132 | 0.248786 | 1.727132 |

**Barricade_Temp_I_II_DI_VP_Drum**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.658483 |
| R Square | 0.4336 |
| Adjusted R Square | 0.342976 |
| Standard Error | 40821.15 |
| Observations | 30 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 3.19E+10 | 7.97E+09 | 4.784605 | 0.005267 |
| Residual | 25 | 4.17E+10 | 1.67E+09 | | |
| Total | 29 | 7.36E+10 | | | |

| | *Coefficients* | *Standard* | *t Stat* | *P-value* | *Lower 95%* | *Upper* | *Lower* | *Upper* |
|---|---|---|---|---|---|---|---|---|

| | | Error | | | | 95% | 95.0% | 95.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | 33867.26 | 20356.85 | 1.663679 | 0.108664 | -8058.46 | 75792.98 | -8058.46 | 75792.98 |
| | | | - | | | | | |
| X Variable 1 | -5272.337 | 3280.44 | 1.607204 | 0.120568 | -12028.5 | 1483.855 | -12028.5 | 1483.855 |
| | | | - | | | | | |
| X Variable 2 | -13074.37 | 28228.45 | 0.463163 | 0.647254 | -71212 | 45063.22 | -71212 | 45063.22 |
| X Variable 3 | 0.017764 | 0.005068 | 3.50538 | 0.001742 | 0.007327 | 0.028201 | 0.007327 | 0.028201 |
| X Variable 4 | -38.85732 | 61.72437 | -0.62953 | 0.534714 | -165.981 | 88.26641 | -165.981 | 88.26641 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.716324 |
| R Square | 0.51312 |
| Adjusted R Square | 0.435219 |
| Standard Error | 8.1E+09 |
| Observations | 30 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 1.73E+21 | 4.32E+20 | 6.586831 | 0.000918 |
| Residual | 25 | 1.64E+21 | 6.56E+19 | | |
| Total | 29 | 3.37E+21 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 8.17E+09 | 4.14E+09 | 1.973787 | 0.059555 | -3.6E+08 | 1.67E+10 | -3.6E+08 | 1.67E+10 |
| X Variable 1 | -5.63E+08 | 5.7E+08 | -0.98766 | 0.332784 | -1.7E+09 | 6.11E+08 | -1.7E+09 | 6.11E+08 |
| X Variable 2 | -6.16E+09 | 5.64E+09 | -1.0909 | 0.285718 | -1.8E+10 | 5.47E+09 | -1.8E+10 | 5.47E+09 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| X Variable 3 | 0.000234 | 5.64E-05 | 4.152608 | 0.000335 | 0.000118 | 0.000351 | 0.000118 | 0.000351 |
| X Variable 4 | 326212.1 | 10324158 | 0.031597 | 0.975044 | -2.1E+07 | 21589214 | -2.1E+07 | 21589214 |

**TS-2**

**work Zone signs**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.700781 |
| R Square | 0.491095 |
| Adjusted R Square | -0.52672 |
| Standard Error | 12139.86 |
| Observations | 7 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 2.84E+08 | 71109118 | 0.482501 | 0.758826 |
| Residual | 2 | 2.95E+08 | 1.47E+08 | | |
| Total | 6 | 5.79E+08 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | Upper 95.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | 33710.1 | 45757.34 | 0.736715 | 0.537994 | -163168 | 230588 | -163168 | 230588 |
| X Variable 1 | 3022.235 | 4080.254 | 0.740698 | 0.536033 | -14533.7 | 20578.15 | -14533.7 | 20578.15 |
| X Variable 2 | -7455.96 | 16943.22 | -0.44006 | 0.702885 | -80356.7 | 65444.82 | -80356.7 | 65444.82 |
| X Variable 3 | 0.01428 | 0.014878 | 0.959782 | 0.438444 | -0.04974 | 0.078296 | -0.04974 | 0.078296 |
| X Variable 4 | -391.182 | 479.7004 | -0.81547 | 0.500471 | -2455.17 | 1672.802 | -2455.17 | 1672.802 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.990993 |
| R Square | 0.982067 |
| Adjusted R Square | 0.946201 |
| Standard Error | 2278.884 |
| Observations | 7 |

ANOVA

| | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 4 | 5.69E+08 | 1.42E+08 | 27.38146 | 0.035545 |
| Residual | 2 | 10386628 | 5193314 | | |
| Total | 6 | 5.79E+08 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | Upper 95.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | 71161.55 | 9354.235 | 7.607415 | 0.016844 | 30913.52 | 111409.6 | 30913.52 | 111409.6 |
| X Variable 1 | 668.1168 | 488.8268 | 1.366776 | 0.305056 | -1435.14 | 2771.369 | -1435.14 | 2771.369 |
| X Variable 2 | 5918.153 | 2821.555 | 2.097479 | 0.170861 | -6222.02 | 18058.32 | -6222.02 | 18058.32 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| X Variable 3 | 4.2E-09 | 4.67E-10 | 8.994301 | 0.012137 | 2.19E-09 | 6.21E-09 | 2.19E-09 | 6.21E-09 |
| X Variable 4 | -600.408 | 76.82023 | -7.81575 | 0.015979 | -930.939 | -269.877 | -930.939 | -269.877 |

**COMB.213-ADD LANES & RECONS, ADD LANES & REHABILITATE PVMNT, WIDEN/RESURFACE EXIST LANES, FARP-PAVE SHOULDERS & RESURF, STATE WIDEN AND RESURF, STATE PAVE SHOULDERS & RESURF**

**TS-1**

**Barricade_Temp_I_II_DI_VP_Drum**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.701342779 |
| R Square | 0.491881694 |
| Adjusted R Square | 0.426318042 |
| Standard Error | 181442.257 |
| Observations | 36 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 9.88E+11 | 2.47E+11 | 7.502353 | 0.000239 |

| | | | |
|---|---|---|---|
| Residual | 31 | 1.02E+12 | 3.29E+10 |
| Total | 35 | 2.01E+12 | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 103029.7423 | 135549 | 0.760092 | 0.452942 | -173424 | 379483.7 | -173424 | 379483.7 |
| X Variable 1 | 28846.08469 | 14692.13 | 1.96337 | 0.058628 | -1118.71 | 58810.88 | -1118.71 | 58810.88 |
| X Variable 2 | -45598.9502 | 102318.2 | - 0.445658 | 0.658941 | -254278 | 163080.3 | -254278 | 163080.3 |
| X Variable 3 | 0.008345118 | 0.003324 | 2.510459 | 0.017487 | 0.001565 | 0.015125 | 0.001565 | 0.015125 |
| X Variable 4 | -146.386773 | 181.215 | - 0.807807 | 0.425357 | -515.977 | 223.2036 | -515.977 | 223.2036 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.72443811 |
| R Square | 0.524810575 |
| Adjusted R Square | 0.463495811 |
| Standard Error | 175464.5562 |
| Observations | 36 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 1.05E+12 | 2.63522E+11 | 8.559285514 | 8.96E-05 |
| Residual | 31 | 9.54E+11 | 30787810487 | | |
| Total | 35 | 2.01E+12 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | Upper 95.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | -41302.47067 | 118200.6 | -0.349426958 | 0.729131424 | -282374.2 | 199769.2 | -282374.2 | 199769.2 |
| X Variable 1 | 17387.65473 | 15492.68 | 1.122313852 | 0.270346801 | -14209.88 | 48985.19 | -14209.88 | 48985.19 |
| X Variable 2 | -59363.28639 | 98923.81 | -0.600091012 | 0.552807377 | -261119.7 | 142393.1 | -261119.7 | 142393.1 |
| X Variable 3 | 104.8254698 | 35.16262 | 2.981161816 | 0.00554706 | 33.11083 | 176.5401 | 33.11083 | 176.5401 |
| X Variable 4 | -217.1689736 | 180.2794 | -1.204624363 | 0.237464884 | -584.8513 | 150.5133 | -584.8513 | 150.5133 |

**TS-3**

**Business Signs**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.64094 |
| R Square | 0.410804 |
| Adjusted R Square | -0.17839 |
| Standard Error | 125.768 |
| Observations | 9 |

ANOVA

| | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 4 | 44113.87 | 11028.47 | 0.697228 | 0.632375 |

| | | | |
|---|---|---|---|
| Residual | 4 | 63270.36 | 15817.59 |
| Total | 8 | 107384.2 | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 139.1032 | 324.5537 | 0.428598 | 0.690288 | -762.002 | 1040.209 | -762.002 | 1040.209 |
| X Variable 1 | -23.379 | 81.61026 | -0.28647 | 0.788743 | -249.965 | 203.2074 | -249.965 | 203.2074 |
| X Variable 2 | 74.80357 | 208.1934 | 0.359298 | 0.737536 | -503.234 | 652.8411 | -503.234 | 652.8411 |
| X Variable 3 | -6E-06 | 9.24E-06 | -0.65359 | 0.549046 | -3.2E-05 | 1.96E-05 | -3.2E-05 | 1.96E-05 |
| X Variable 4 | 0.043296 | 0.513996 | 0.084235 | 0.936917 | -1.38378 | 1.470377 | -1.38378 | 1.470377 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.858213 |
| R Square | 0.736529 |
| Adjusted R Square | 0.473059 |
| Standard Error | 84.10201 |
| Observations | 9 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 79091.63 | 19772.91 | 2.795489 | 0.171672 |
| Residual | 4 | 28292.59 | 7073.147 | | |
| Total | 8 | 107384.2 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 2641.898 | 979.9635 | 2.695914 | 0.054324 | -78.9172 | 5362.713 | -78.9172 | 5362.713 |
| X Variable 1 | -25.0295 | 39.85215 | -0.62806 | 0.56404 | -135.677 | 85.61778 | -135.677 | 85.61778 |
| X Variable 2 | 151.8456 | 122.2432 | 1.24216 | 0.28203 | -187.556 | 491.247 | -187.556 | 491.247 |
| X Variable 3 | -176.657 | 72.72598 | -2.42908 | 0.072052 | -378.577 | 25.26243 | -378.577 | 25.26243 |
| X Variable 4 | 0.293412 | 0.272853 | 1.075348 | 0.342758 | -0.46415 | 1.050973 | -0.46415 | 1.050973 |

**BArricade_Temp_III**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.66112041 |
| R Square | 0.4370802 |
| Adjusted R Square | 0.35368467 |
| Standard Error | 18532.2177 |
| Observations | 32 |

ANOVA

| | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 4 | 7.2E+09 | 1.8E+09 | 5.241051 | 0.002951 |
| Residual | 27 | 9.27E+09 | 3.43E+08 | | |
| Total | 31 | 1.65E+10 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | Upper 95.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | -37505.85 | 14141.53 | -2.652177 | 0.013225 | -66521.9 | -8489.82 | -66521.9 | -8489.82 |
| X Variable 1 | 4822.32332 | 2570.031 | 1.876368 | 0.071453 | -450.944 | 10095.59 | -450.944 | 10095.59 |
| X Variable 2 | 7856.54037 | 8018.061 | 0.979855 | 0.335856 | -8595.16 | 24308.24 | -8595.16 | 24308.24 |
| X Variable 3 | 0.00040646 | 0.000583 | 0.696912 | 0.491815 | -0.00079 | 0.001603 | -0.00079 | 0.001603 |
| X Variable 4 | 46.1327306 | 18.09741 | 2.549135 | 0.016795 | 8.999916 | 83.26555 | 8.999916 | 83.26555 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.73872555 |
| R Square | 0.54571544 |
| Adjusted R Square | 0.47841403 |
| Standard Error | 50.5645657 |
| Observations | 32 |

ANOVA

| | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 4 | 82926.74 | 20731.6851 | 8.10852838 | 0.000198 |

| | | | |
|---|---|---|---|
| Residual | 27 | 69032.93 | 2556.7753 |
| Total | 31 | 151959.7 | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -69.62299 | 38.58472 | -1.8044187 | 0.08233279 | -148.7923 | 9.546317 | -148.7923 | 9.546317 |
| X Variable 1 | 11.7369114 | 7.012247 | 1.67377333 | 0.10572311 | -2.65103 | 26.12485 | -2.65103 | 26.12485 |
| X Variable 2 | 16.5157144 | 21.87703 | 0.7549342 | 0.45682356 | -28.37223 | 61.40366 | -28.37223 | 61.40366 |
| X Variable 3 | 1.391E-06 | 1.59E-06 | 0.87413293 | 0.38975501 | -1.87E-06 | 4.66E-06 | -1.87E-06 | 4.66E-06 |
| X Variable 4 | 0.16597347 | 0.049378 | 3.36126994 | 0.00232915 | 0.064658 | 0.267289 | 0.064658 | 0.267289 |

**High_Intensity_Flash_Lights**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.652179 |
| R Square | 0.425337 |
| Adjusted R Square | 0.348716 |
| Standard Error | 6003.946 |

| | |
|---|---|
| Observations | 35 |

ANOVA

| | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 4 | 8E+08 | 2E+08 | 5.551134 | 0.001817 |
| Residual | 30 | 1.08E+09 | 36047369 | | |
| Total | 34 | 1.88E+09 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | Upper 95.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | 196.6642 | 4336.25 | 0.045354 | 0.964126 | -8659.14 | 9052.468 | -8659.14 | 9052.468 |
| X Variable 1 | 348.8473 | 646.3694 | 0.539703 | 0.593386 | -971.215 | 1668.91 | -971.215 | 1668.91 |
| X Variable 2 | 4552.027 | 2514.686 | 1.810177 | 0.080296 | -583.647 | 9687.7 | -583.647 | 9687.7 |
| X Variable 3 | 0.000409 | 0.000193 | 2.124349 | 0.041996 | 1.58E-05 | 0.000803 | 1.58E-05 | 0.000803 |
| X Variable 4 | 5.370731 | 5.568669 | 0.964455 | 0.342528 | -6.00201 | 16.74347 | -6.00201 | 16.74347 |

After

SUMMARY OUTPUT

| Regression Statistics | |
|---|---|
| Multiple R | 0.7043353 |
| R Square | 0.49608822 |
| Adjusted R Square | 0.42889998 |
| Standard Error | 0.5730106 |
| Observations | 35 |

ANOVA

| | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 4 | 9.697303 | 2.424326 | 7.383558 | 0.00029 |
| Residual | 30 | 9.850234 | 0.328341 | | |
| Total | 34 | 19.54754 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | Upper 95.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | 5.38955994 | 1.801352 | 2.991953 | 0.0055 | 1.710708 | 9.068412 | 1.710708 | 9.068412 |
| X Variable 1 | 0.00345573 | 0.006776 | 0.51002 | 0.61377 | -0.01038 | 0.017294 | -0.01038 | 0.017294 |
| X Variable 2 | 0.42414462 | 0.225313 | 1.882465 | 0.069504 | -0.03601 | 0.884296 | -0.03601 | 0.884296 |
| X Variable 3 | 0.00026614 | 0.000137 | 1.949598 | 0.060626 | -1.3E-05 | 0.000545 | -1.3E-05 | 0.000545 |
| X Variable 4 | 0.41483987 | 0.312254 | 1.328533 | 0.19402 | -0.22287 | 1.052548 | -0.22287 | 1.052548 |

**Pave_MArk_Remov_Yellow_Solid**

Before

SUMMARY OUTPUT

| Regression Statistics | |
|---|---|
| Multiple R | 0.5566736 |
| R Square | 0.3098855 |

| | |
|---|---|
| Adjusted R Square | -0.084466 |
| Standard Error | 4250.5075 |
| Observations | 12 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 56788409 | 14197102 | 0.785811 | 0.569176 |
| Residual | 7 | 1.26E+08 | 18066814 | | |
| Total | 11 | 1.83E+08 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 5296.0231 | 6306.928 | 0.839715 | 0.428812 | -9617.49 | 20209.54 | -9617.49 | 20209.54 |
| X Variable 1 | 1892.8141 | 1190.404 | 1.590061 | 0.155846 | -922.043 | 4707.671 | -922.043 | 4707.671 |
| X Variable 2 | 542.05838 | 3990.495 | 0.135837 | 0.895774 | -8893.96 | 9978.08 | -8893.96 | 9978.08 |
| X Variable 3 | 0.0002136 | 0.000218 | 0.981458 | 0.359063 | -0.0003 | 0.000728 | -0.0003 | 0.000728 |
| X Variable 4 | -10.60029 | 9.900174 | -1.070718 | 0.319819 | -34.0105 | 12.8099 | -34.0105 | 12.8099 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8153402 |
| R Square | 0.6647797 |
| Adjusted R Square | 0.4732252 |

| | |
|---|---|
| Standard Error | 0.6530454 |
| Observations | 12 |

ANOVA

| | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 4 | 5.920142 | 1.480036 | 3.470447 | 0.072556 |
| Residual | 7 | 2.985278 | 0.426468 | | |
| Total | 11 | 8.90542 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 6.42168 | 0.778502 | 8.248766 | 7.49E-05 | 4.580816 | 8.262544 | 4.580816 | 8.262544 |
| X Variable 1 | 0.6088203 | 0.187637 | 3.244663 | 0.014161 | 0.165128 | 1.052512 | 0.165128 | 1.052512 |
| X Variable 2 | 1.4553535 | 0.607092 | 2.397253 | 0.047658 | 0.019809 | 2.890898 | 0.019809 | 2.890898 |
| X Variable 3 | 1.509E-15 | 6.55E-16 | 2.304603 | 0.054619 | -3.9E-17 | 3.06E-15 | -3.9E-17 | 3.06E-15 |
| X Variable 4 | -2.16E-06 | 8.3E-07 | -2.605803 | 0.035127 | -4.1E-06 | -2E-07 | -4.1E-06 | -2E-07 |

**TS-5**

**Barricade_Temp_I_II_DI_VP_Drum**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.592069778 |

| | |
|---|---|
| R Square | 0.350546622 |
| Adjusted R Square | 0.331990811 |
| Standard Error | 228284.8629 |
| Observations | 145 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 3.93804E+12 | 9.8451E+11 | 18.89147 | 1.93E-12 |
| Residual | 140 | 7.29596E+12 | 52113978620 | | |
| Total | 144 | 1.1234E+13 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -37123.60816 | 78588.30325 | -0.472380833 | 0.637391 | -192496.9 | 118249.6867 | -192496.903 | 118249.7 |
| X Variable 1 | -1710.51887 | 7020.232014 | -0.243655604 | 0.807854 | -15589.89 | 12168.85673 | -15589.89447 | 12168.86 |
| X Variable 2 | 13603.75793 | 68938.37509 | 0.197332152 | 0.843854 | -122691.1 | 149898.6267 | -122691.1109 | 149898.6 |
| X Variable 3 | 0.029283504 | 0.004571807 | 6.405236313 | 2.13E-09 | 0.020245 | 0.038322212 | 0.020244796 | 0.038322 |
| X Variable 4 | -52.06708793 | 90.28778904 | -0.576679178 | 0.565082 | -230.5709 | 126.4367185 | -230.5708943 | 126.4367 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.704459115 |
| R Square | 0.496262645 |

| | |
|---|---|
| Adjusted R Square | 0.48187015 |
| Standard Error | 157.6984213 |
| Observations | 145 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 3429969 | 857492.2 | 34.48065 | 5.1E-20 |
| Residual | 140 | 3481631 | 24868.79 | | |
| Total | 144 | 6911600 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 64.40562459 | 70.48137 | 0.913796 | 0.362395 | -74.9398 | 203.7511 | -74.9398 | 203.7511 |
| X Variable 1 | -0.449895875 | 0.286439 | -1.57065 | 0.118521 | -1.0162 | 0.11641 | -1.0162 | 0.11641 |
| X Variable 2 | 52.72793843 | 45.00419 | 1.171623 | 0.243339 | -36.2478 | 141.7036 | -36.2478 | 141.7036 |
| X Variable 3 | 7.02978E-13 | 1.08E-13 | 6.490548 | 1.38E-09 | 4.89E-13 | 9.17E-13 | 4.89E-13 | 9.17E-13 |
| X Variable 4 | 7.751508318 | 2.968706 | 2.611073 | 0.010009 | 1.882217 | 13.6208 | 1.882217 | 13.6208 |

**work Zone signs**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.703850264 |
| R Square | 0.495405195 |
| Adjusted R Square | 0.369715974 |
| Standard Error | 33707.77032 |
| Observations | 24 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 2.23E+10 | 5.58E+09 | 6.545254 | 0.001735 |
| Residual | 20 | 2.27E+10 | 1.14E+09 | | |
| Total | 24 | 4.5E+10 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -2171.17326 | 19040.78 | -0.114028 | 0.910353 | -41889.5 | 37547.2 | -41889.5 | 37547.2 |
| X Variable 1 | -9908.28406 | 7491.625 | -1.322581 | 0.2009 | -25535.5 | 5718.972 | -25535.5 | 5718.972 |
| X Variable 2 | 0 | 0 | 65535 | #NUM! | 0 | 0 | 0 | 0 |
| X Variable 3 | 0.004613198 | 0.002101 | 2.19574 | 0.040075 | 0.000231 | 0.008996 | 0.000231 | 0.008996 |
| X Variable 4 | 55.37717907 | 51.95618 | 1.065844 | 0.299193 | -53.0015 | 163.7559 | -53.0015 | 163.7559 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.751205534 |
| R Square | 0.564309754 |
| Adjusted R Square | 0.448956217 |
| Standard Error | 70.38777933 |
| Observations | 24 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 128340.6523 | 32085.16308 | 8.634724 | 0.000379 |
| Residual | 20 | 99088.78957 | 4954.439478 | | |
| Total | 24 | 227429.4419 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 71.68336832 | 39.76051305 | 1.802878354 | 0.086497 | -11.25561 | 154.6223 | -11.2556 | 154.6223 |
| X Variable 1 | -20.4866467 | 15.64383709 | -1.30956661 | 0.205187 | -53.11912 | 12.14583 | -53.1191 | 12.14583 |
| X Variable 2 | 0 | 0 | 65535 | #NUM! | 0 | 0 | 0 | 0 |
| X Variable 3 | 1.03824E-05 | 4.38721E-06 | 2.366509903 | 0.028161 | 1.23E-06 | 1.95E-05 | 1.23E-06 | 1.95E-05 |
| X Variable 4 | 0.13839026 | 0.108493673 | 1.275560649 | 0.216728 | -0.087924 | 0.364704 | -0.08792 | 0.364704 |

**COMB.24- BRIDGE-REPAIR/REHABILITATION, BRIDGE-REPLACE AND ADD LANES**

**TS-1**

**work Zone signs**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.591442 |
| R Square | 0.349804 |
| Adjusted R Square | -0.17035 |
| Standard Error | 752.118 |
| Observations | 10 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 1521678 | 380419.4 | 0.672498 | 0.638996 |
| Residual | 5 | 2828407 | 565681.4 | | |
| Total | 9 | 4350085 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 15.07499 | 588.2495 | 0.025627 | 0.980546 | -1497.07 | 1527.218 | -1497.07 | 1527.218 |
| X Variable 1 | 1821.125 | 1909.042 | 0.953947 | 0.38392 | -3086.23 | 6728.475 | -3086.23 | 6728.475 |
| X Variable 2 | 327.8432 | 758.083 | 0.432463 | 0.683421 | -1620.87 | 2276.558 | -1620.87 | 2276.558 |
| X Variable 3 | -0.00559 | 0.006733 | -0.83093 | 0.443869 | -0.0229 | 0.011713 | -0.0229 | 0.011713 |
| X Variable 4 | 16.53032 | 17.08623 | 0.967465 | 0.377746 | -27.3912 | 60.45186 | -27.3912 | 60.45186 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.735023 |
| R Square | 0.540258 |
| Adjusted R Square | 0.172465 |
| Standard Error | 1749481 |
| Observations | 10 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 1.8E+13 | 4.4959E+12 | 1.468917 | 0.336878 |
| Residual | 5 | 1.53E+13 | 3.0607E+12 | | |
| Total | 9 | 3.33E+13 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -2233582 | 2153568 | -1.0371543 | 0.347195 | -7769504 | 3302340 | -7769504 | 3302340 |
| X Variable 1 | 4430052 | 3428759 | 1.29202775 | 0.252839 | -4383854 | 13243957 | -4383854 | 13243957 |
| X Variable 2 | 1533426 | 1735279 | 0.88367686 | 0.41733 | -2927251 | 5994103 | -2927251 | 5994103 |
| X Variable 3 | -3.1E-05 | 2.88E-05 | -1.088059 | 0.326213 | -0.00011 | 4.27E-05 | -0.00011 | 4.27E-05 |
| X Variable 4 | 47950.33 | 41106.25 | 1.16649734 | 0.29602 | -57716.6 | 153617.3 | -57716.6 | 153617.3 |

**TS-5**

**Pave_Mark_Remov_Bl&Whi_Skip**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.572373 |
| R Square | 0.327611 |
| Adjusted R Square | -0.12065 |
| Standard Error | 1336.064 |
| Observations | 11 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 5218473 | 1304618 | 0.730851 | 0.602765 |
| Residual | 6 | 10710404 | 1785067 | | |
| Total | 10 | 15928877 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 1080.624 | 1621.595 | 0.666396 | 0.529933 | -2887.28 | 5048.524 | -2887.28 | 5048.524 |
| X Variable 1 | -1530.27 | 1409.897 | -1.08538 | 0.319427 | -4980.16 | 1919.624 | -4980.16 | 1919.624 |
| X Variable 2 | 1020.701 | 1469.073 | 0.694793 | 0.513178 | -2573.99 | 4615.394 | -2573.99 | 4615.394 |
| X Variable 3 | 0.000488 | 0.000405 | 1.204688 | 0.273681 | -0.0005 | 0.00148 | -0.0005 | 0.00148 |
| X Variable 4 | -5.54215 | 6.211839 | -0.89219 | 0.406646 | -20.742 | 9.657671 | -20.742 | 9.657671 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.717386 |
| R Square | 0.514642 |
| Adjusted R Square | 0.19107 |
| Standard Error | 1.221296 |
| Observations | 11 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 9.489349 | 2.372337 | 1.590503 | 0.290864 |
| Residual | 6 | 8.949382 | 1.491564 | | |
| Total | 10 | 18.43873 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 7.80634 | 2.027125 | 3.850941 | 0.008451 | 2.846142 | 12.76654 | 2.846142 | 12.76654 |
| X Variable 1 | -2.22786 | 1.578741 | -1.41116 | 0.207887 | -6.0909 | 1.635183 | -6.0909 | 1.635183 |
| X Variable 2 | 0.670222 | 1.316235 | 0.509196 | 0.628794 | -2.55049 | 3.890934 | -2.55049 | 3.890934 |
| X Variable 3 | 0.002069 | 0.001049 | 1.973379 | 0.0959 | -0.0005 | 0.004635 | -0.0005 | 0.004635 |
| X Variable 4 | -0.23865 | 0.159162 | -1.49942 | 0.184426 | -0.62811 | 0.150805 | -0.62811 | 0.150805 |

**119-INTERSECTION (MINOR)**

**TS-5**

**Changeable_Variable_MEssage_Sign**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.635112 |
| R Square | 0.403367 |
| Adjusted R Square | -2.38653 |
| Standard Error | 138.1488 |
| Observations | 5 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 12902.92 | 3225.729 | 0.225358 | #NUM! |
| Residual | 1 | 19085.08 | 19085.08 | | |
| Total | 5 | 31988 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 408.3345 | 438.7996 | 0.930572 | 0.522885 | -5167.14 | 5983.812 |
| X Variable 1 | -1048.87 | 1365.727 | -0.76799 | 0.583067 | -18402.1 | 16304.34 |
| X Variable 2 | 0 | 0 | 65535 | #NUM! | 0 | 0 |
| X Variable 3 | 0.001714 | 0.002893 | 0.592498 | 0.659482 | -0.03504 | 0.038472 |
| X Variable 4 | -10.4764 | 18.02688 | -0.58115 | 0.664855 | -239.53 | 218.5769 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.733185 |
| R Square | 0.537561 |
| Adjusted R Square | -0.6561 |
| Standard Error | 5.212808 |
| Observations | 6 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 63.1751 | 15.79378 | 0.774964 | 0.68058 |
| Residual | 2 | 54.34673 | 27.17337 | | |
| Total | 6 | 117.5218 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 6.206839 | 12.2863 | 0.505184 | 0.6636 | -46.6569 | 59.07054 | -46.6569 | 59.07054 |
| X Variable 1 | -81.0287 | 60.36116 | -1.3424 | 0.311548 | -340.742 | 178.6844 | -340.742 | 178.6844 |
| X Variable 2 | 0 | 0 | 65535 | #NUM! | 0 | 0 | 0 | 0 |
| X Variable 3 | 0.014715 | 0.034316 | 0.428792 | 0.709842 | -0.13294 | 0.162366 | -0.13294 | 0.162366 |
| X Variable 4 | -0.01578 | 0.082018 | -0.19237 | 0.865216 | -0.36867 | 0.337116 | -0.36867 | 0.337116 |

**121-MULTI-LANE RECONSTRUCTION**

**TS-3**

**Reflective_PAvet_Marker_Temp**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.601432 |
| R Square | 0.36172 |
| Adjusted R Square | -0.48932 |
| Standard Error | 22217.18 |
| Observations | 8 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 8.39E+08 | 2.1E+08 | 0.425034 | 0.786619 |
| Residual | 3 | 1.48E+09 | 4.94E+08 | | |
| Total | 7 | 2.32E+09 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -6633.84 | 36681.55 | -0.18085 | 0.868014 | -123371 | 110103.2 | -123371 | 110103.2 |
| X Variable 1 | 3601.425 | 11526.17 | 0.312456 | 0.775153 | -33080 | 40282.85 | -33080 | 40282.85 |
| X Variable 2 | -23846.1 | 20629.67 | -1.15591 | 0.331414 | -89498.9 | 41806.7 | -89498.9 | 41806.7 |
| X Variable 3 | -0.00032 | 0.001604 | -0.20235 | 0.852587 | -0.00543 | 0.00478 | -0.00543 | 0.00478 |
| X Variable 4 | 36.55122 | 45.91148 | 0.796124 | 0.484138 | -109.56 | 182.662 | -109.56 | 182.662 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.711256 |
| R Square | 0.505885 |
| Adjusted R Square | -0.15294 |
| Standard Error | 1.15E+09 |
| Observations | 8 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 4.06E+18 | 1.01E+18 | 0.767864 | 0.610894 |
| Residual | 3 | 3.97E+18 | 1.32E+18 | | |
| Total | 7 | 8.02E+18 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -1.1E+10 | 9.11E+09 | -1.16977 | 0.326575 | -4E+10 | 1.83E+10 | -4E+10 | 1.83E+10 |
| X Variable 1 | 3.09E+08 | 5.94E+08 | 0.519447 | 0.63934 | -1.6E+09 | 2.2E+09 | -1.6E+09 | 2.2E+09 |
| X Variable 2 | -1.5E+09 | 1.06E+09 | -1.44711 | 0.243671 | -4.9E+09 | 1.83E+09 | -4.9E+09 | 1.83E+09 |
| X Variable 3 | -1.3E-06 | 2.26E-06 | -0.58918 | 0.597166 | -8.5E-06 | 5.87E-06 | -8.5E-06 | 5.87E-06 |
| X Variable 4 | 1.76E+09 | 1.41E+09 | 1.254291 | 0.298569 | -2.7E+09 | 6.24E+09 | -2.7E+09 | 6.24E+09 |

**TS- 5**

**BArricade_Temp_III**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.6196792 |
| R Square | 0.38400232 |
| Adjusted R Square | 0.14666956 |
| Standard Error | 11988.245 |
| Observations | 16 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 1.08E+09 | 2.69E+08 | 2.493531 | 0.103888 |
| Residual | 12 | 1.72E+09 | 1.44E+08 | | |
| Total | 16 | 2.8E+09 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -25171.292 | 13862.23 | -1.815819 | 0.09445 | -55374.5 | 5031.905 | -55374.5 | 5031.905 |
| X Variable 1 | 2334.37094 | 3350.919 | 0.696636 | 0.499303 | -4966.65 | 9635.397 | -4966.65 | 9635.397 |
| X Variable 2 | 0 | 0 | 65535 | #NUM! | 0 | 0 | 0 | 0 |
| X Variable 3 | -0.0011659 | 0.001395 | -0.835946 | 0.41952 | -0.0042 | 0.001873 | -0.0042 | 0.001873 |
| X Variable 4 | 65.3142116 | 27.53558 | 2.371993 | 0.035273 | 5.319332 | 125.3091 | 5.319332 | 125.3091 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.747131 |
| R Square | 0.558205 |
| Adjusted R Square | 0.364423 |
| Standard Error | 4.17E+08 |
| Observations | 16 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 2.64E+18 | 6.59673E+17 | 5.053978 | 0.014714 |
| Residual | 12 | 2.09E+18 | 1.74034E+17 | | |
| Total | 16 | 4.73E+18 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -9.2E+08 | 4.5E+08 | -2.039344305 | 0.064065 | -1.9E+09 | 62791920.8 | -1.899E+09 | 62791920.8 |
| X Variable 1 | 3.4E+08 | 3.09E+08 | 1.099715643 | 0.293029 | -3.3E+08 | 1013597741 | -333616279 | 1013597741 |
| X Variable 2 | 0 | 0 | 65535 | #NUM! | 0 | 0 | 0 | 0 |
| X Variable 3 | -4.8E-06 | 3.18E-06 | -1.503182256 | 0.158645 | -1.2E-05 | 2.1455E-06 | -1.169E-05 | 2.1455E-06 |
| X Variable 4 | 2589.314 | 715.2736 | 3.620033498 | 0.003514 | 1030.867 | 4147.76157 | 1030.86707 | 4147.76157 |

**123-TOLL PLAZA**

**TS-2**

**Advance Warning Panel**

Before

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.597413 |
| R Square | 0.356902 |
| Adjusted R Square | -0.50056 |
| Standard Error | 251.986 |
| Observations | 8 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 105717.2 | 26429.3 | 0.41623 | 0.791816 |
| Residual | 3 | 190490.8 | 63496.93 | | |
| Total | 7 | 296208 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 32.64961 | 269.8481 | 0.120993 | 0.911346 | -826.127 | 891.4266 | -826.127 | 891.4266 |
| X Variable 1 | -29.0422 | 52.55846 | -0.55257 | 0.619062 | -196.307 | 138.2222 | -196.307 | 138.2222 |
| X Variable 2 | 149.2455 | 320.6891 | 0.46539 | 0.673354 | -871.33 | 1169.821 | -871.33 | 1169.821 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| X Variable 3 | 1.31E-05 | 2.51E-05 | 0.520452 | 0.638719 | -6.7E-05 | 9.3E-05 | -6.7E-05 | 9.3E-05 |
| X Variable 4 | 0.00146 | 0.603447 | 0.00242 | 0.998221 | -1.91898 | 1.921897 | -1.91898 | 1.921897 |

After

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.8446 |
| R Square | 0.713349 |
| Adjusted R Square | 0.331148 |
| Standard Error | 168.2342 |
| Observations | 8 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 4 | 211299.7 | 52824.93 | 1.866424 | 0.317691 |
| Residual | 3 | 84908.27 | 28302.76 | | |
| Total | 7 | 296208 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -7379.41 | 3549.19 | -2.07918 | 0.129103 | -18674.5 | 3915.692 | -18674.5 | 3915.692 |
| X Variable 1 | -92.6584 | 47.38165 | -1.95558 | 0.145479 | -243.448 | 58.13115 | -243.448 | 58.13115 |
| X Variable 2 | 604.4085 | 318.3302 | 1.898684 | 0.153831 | -408.66 | 1617.477 | -408.66 | 1617.477 |
| X Variable 3 | 515.3003 | 247.4045 | 2.082825 | 0.128655 | -272.051 | 1302.652 | -272.051 | 1302.652 |
| X Variable 4 | -1.04519 | 0.663639 | -1.57494 | 0.213345 | -3.15719 | 1.066802 | -3.15719 | 1.066802 |

# Appendix B Application Use Instructions

**Installation Notes Readme: October 2008**
PLEASE READ THIS DOCUMENT CAREFULLY; it contains important installation information about MOTES software.
**System Requirements**
Listed below are the minimum system requirements for installing MOTES.

- MOTES supports Intel and AMD processors only.
- Windows Vista or Windows XP Home Edition/Professional
- 300-MHz or higher processor
- 256 MB of RAM
- 180 MB of available disk space
- Internet Explorer 7.0 or later*
- Microsoft Access 97-2003 or 2007
- Microsoft Excel 2003 or 2007
- No permission restrictions on creating a folder in the C drive.
- Visual Studio 2008

**Set up:**

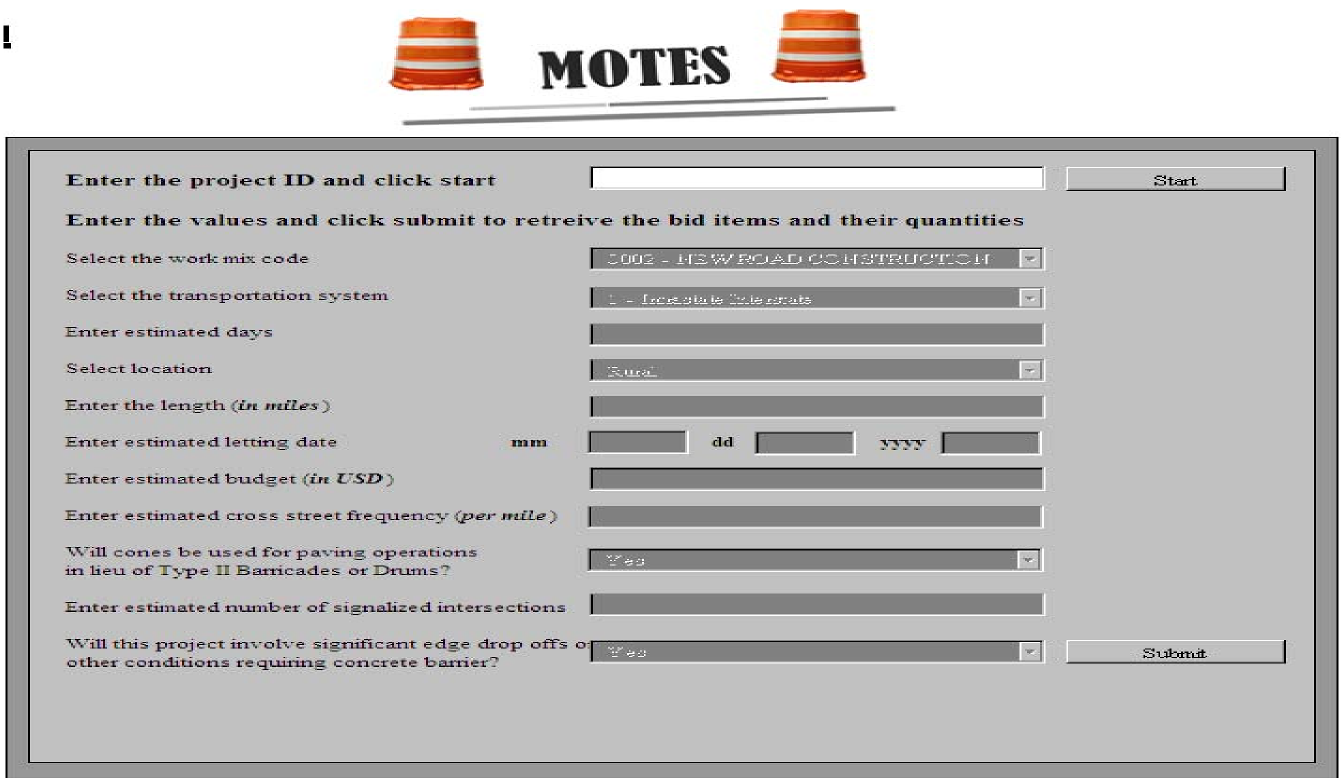
1. Unpack the zipped installation file
2. Double click on the *setup.exe* to execute the installation process
3. Follow the instructions on the pop-up window to complete the installation
4. The application file is to create a sub-folder under the local computer's *C drive* called "Bid-MOTES". i.e. C:\Bid-MOTES
5. The Bid-MOTES folder include:
    i. Bid_LoginForm.xls
    ii. Bid_MOT.mdb
    iii. Unins000.exe
    iv. 2 system required files that will not be of use for applications of the spreadsheet
6. Bid_LoginForm.xls is the main application interface the users will use to predict the MOT quantities. Bid_MOT.mdb is an access database file that includes the regression equations and the algorithms necessary for application to be functional. Unins000.exe un-installs the application software if required.
7. **Note that all the macros need to be enabled** when the file is first opened in order for the application to function properly.

**Using the Application**

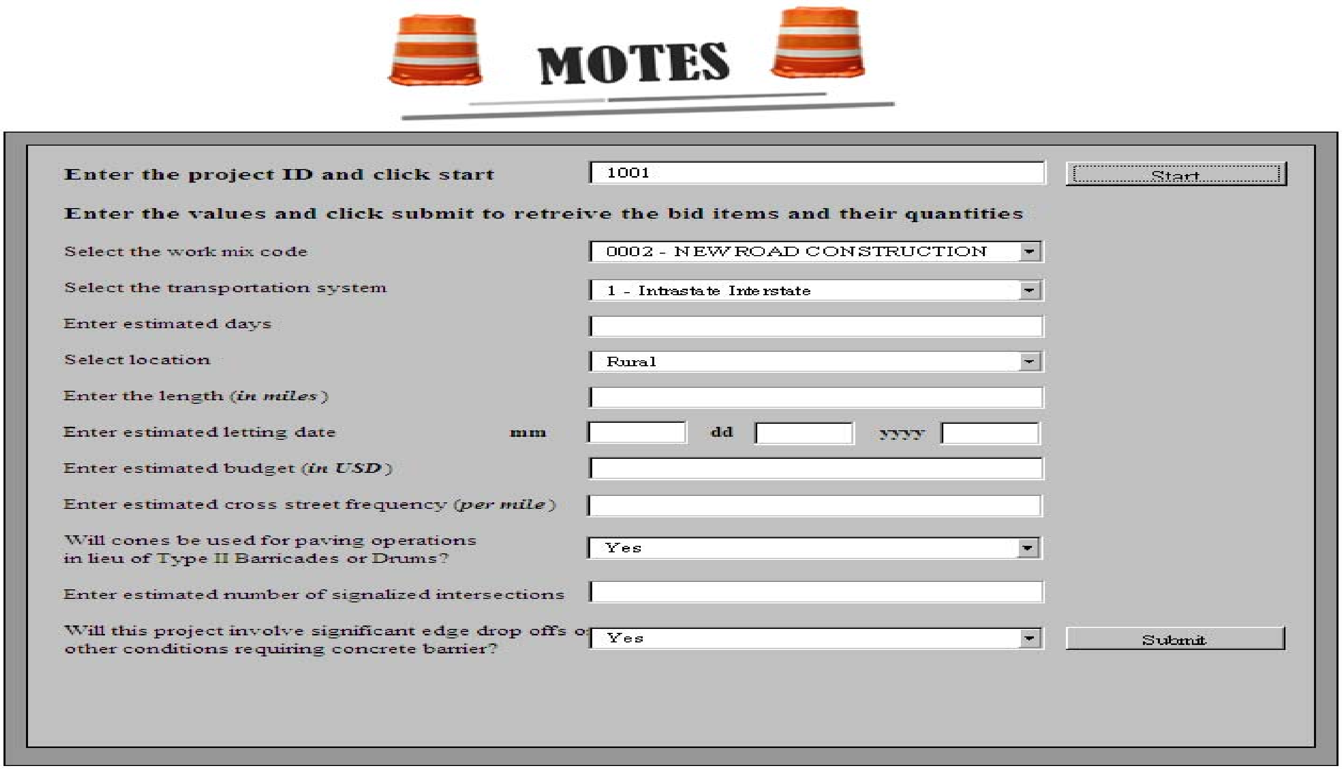
Bid login form is the main application interface the users will be interacting with. It is designed to record project characteristics about transportation projects and return the estimated MOT quantities. The file has been programmed using Visual Basic and reaches the access file (Bid_MOT.mdb), which contains the required formulas and run queries to provide the required functionality. Following are the steps the use the MOTES software

1. The first thing to be done to start the procedure is to enter the project ID that must be a string of numbers. Note that all the cells but for the project ID cell are grey, they cannot be changed before the project ID is entered and the *Start* button is clicked.

!




2. Completing step 1 will create another spreadsheet that will be in a temporary drive, and will enable users to change the values of the other cells. At this stage the user will not see the new spreadsheet,




3. The user now can input the project characteristics that will be used to calculate the MOT bid item quantities. The related work mix code, transportation system definition and the project location will be selected from a drop down menu. The other variables; project days, project length (miles), letting date (MM/DD/YYY ), project expenditure (USD), cross street frequency (per mile), whether cones will be used as substitutes for barricades in resurfacing jobs, number of signalized intersections (EA) and whether there will be significant drop off situations throughout the construction process, are to be input by the user. Once all the values are inserted the user needs to click on *Submit* button to obtain the MOT bid item estimates and clear out the fields for different project quantity estimations.

4. The spreadsheet that was created in step 2 will now be visible with the MOT estimates on it. That spreadsheet will be named as the project ID entered-MOT, i.e. 1001-MOT. The output spreadsheet will include a complete list of MOT bid items, their predicted quantities, unit and total costs of these items and two legends providing extra information about the predictions.

The bid items and their quantities are as follows:

| Item Number | Item Description | Predicted Quantities | Unit Cost | Total Cost |
|---|---|---|---|---|
| 0102 76 | ADVANCE WARNING ARROW PANEL | 200 | 8.53 | 1705.60 |
| 0102 74 1 | BARRICADE, TEMPORARY, TYPES I, II, DI, VP & DRUM | 31375 | 0.19 | 5873.41 |
| 0102 71 11 | BARRIER WALL,TEMPORARY,F&I,CONCRETE | 1320 | 22.53 | 29745.50 |
| 0102 61 | BUSINESS SIGN | 79 | 38.92 | 3091.20 |
| 0102 99 | CHANGEABLE-VARIABLE MESSAGE SIGN,TEMPORARY | 250 | 19.96 | 4989.40 |
| 0102 3 | COMMERCIAL MATERIAL FOR DRIVEWAY MAINTENANCE | 613 | 28.02 | 17160.78 |
| 0102 89 7 | CRASH CUSHION | 9 | 1465.46 | 13311.79 |
| 0102 77 | HIGH INTENSITY FLASHING LIGHTS,TEMP,TYPE B | 3325 | 0.47 | 1556.10 |
| 0102 79 | LIGHTS,BARRIER WALL MOUNT,TEMP,TYPE C,STEADY BURN | 2487 | 0.17 | 413.80 |
| 0102911 3 | PAVEMENT MARKING REMOVABLE,WHITE-BLACK,OTHER | B | 4.35 | |
| 0102911 1 | PAVEMENT MARKING REMOVABLE,WHITE-BLACK,SKIP | B | 1.06 | |
| 0102911 2 | PAVEMENT MARKING REMOVABLE,WHITE-BLACK,SOLID | B | 1.58 | |
| 0102912 3 | PAVT MARKING REMOVABLE,YELLOW,OTHER | B | 1.56 | |
| 0102912 1 | PAVT MARKING REMOVABLE,YELLOW,SKIP | B | 2.08 | |
| 0102912 2 | PAVT MARKING REMOVABLE,YELLOW,SOLID | B | 1.45 | |
| 0102 78 | REFLECTIVE PAVEMENT MARKER,TEMPORARY | 3890 | 3.82 | 14846.57 |
| 0102104 2 | TEMPORARY TRAFFIC CONTROL,FIXED SIGNAL | 63 | 26.53 | 1658.15 |
| 0102 14 | TRAFFIC CONTROL OFFICER | 476 | 53.83 | 25613.93 |
| 0102 60 | WORK ZONE SIGN | 6175 | 0.30 | 1862.38 |
| 0102 1 | MAINTENANCE OF TRAFFIC | 1 | 44666.32 | 44666.32 |
| 0102104 1 | TEMPORARY TRAFFIC CONTROL,PORTABLE SIGNAL | B | 117.30 | |
| 102107 | TEMPORARY TRAFFIC DETECTION, INTERSECT | 50 | 15.64 | 782.08 |
| 0102 73 | TEMPORARY GUARDRAIL | A | 25.63 | |
| 0102 71 12 | BARRIER WALL,TEMPORARY,F&I,WATERFILLED | A | 41.98 | |
| 0102 71 13 | BARRIER WALL,TEMPORARY,F&I,LOW PROFILE,CONCRETE | A | 50.56 | |
| 0102 71 14 | BARRIER WALL,TEMPORARY,F&I,TYPE K | A | 53.97 | |
| 0102 71 21 | BARRIER WALL,TEMPORARY,RELOCATE,CONCRETE | B | 6.36 | |
| 0102 71 22 | BARRIER WALL,TEMPORARY,RELOCATE,WATERFILLED | B | 10.11 | |
| 0102 71 23 | BARRIER WALL,TEMPORARY,RELOCATE,LOW PROFILE | B | 6.04 | |
| 0102 71 24 | BARRIER WALL,TEMPORARY,RELOCATE,TYPE K | B | 14.30 | |
| 0102 94 1 | GLARE SCREEN,TEMPORARY,F&I,WALL MATERIAL-CONCRETE | B | B | |
| 0102 94 11 | GLARE SCREEN,TEMPORARY,RELOCATE,WALL MATERIAL | B | B | |
| 0102150 1 | PORTABLE REGULATORY, SIGN | A | 30.47 | |
| 0102150 2 | RADAR SPEED DISPLAY UNIT | A | 29.57 | |
| 0102 2 1-30 | SPECIAL DETOUR(s) | B | B | |
| 0102 74 2 | BARRICADE, TEMPORARY, TYPE III, 6' | B | 0.38 | |
| 0102 98 2 | BARRICADE, TYPE III, 6', TO REMAIN | B | 150.80 | |

A =>Insufficient data in data base to make prediction.

Must be determined by estimator.

B =>Must be determined by estimator based on project. specific criteria.

**DETAILS ENTERED BY THE USER**

| | |
|---|---|
| WMC | 0012 - RESURFACING |
| TS | 5 - Non-Intrastate State Highway |
| Days | 125 |
| Rur/Urb | Rural |
| Length | 2.45 miles |
| Budget | $3,546,023.14 |

**MOT RESULTS**

| | | |
|---|---|---|
| MOT Budget | $167,277.02 | |
| % of Budget | 4.72 | % |

1001-MOT | MOTES-Login

5. If more than one project prediction is required, the user can simply go to the MOTES-Login spreadsheet and redo the steps 1-4 to obtain new predictions. Different projects' MOT bid item predictions will be created on different spreadsheets within the same excel file provided they have different project IDs. If user inserts an already populated project ID to start the process, the existing spreadsheet will be replaced by the new one.

## Appendix C Results of Final Testing of Model

**A**

| | |
|---|---|
| Project ID: | 417643-1-52-01 |
| Project Description: | SR 8 (I-10) from East of SR261 (Capital Circle North East) to East of SR10 (US90) East |
| Total Expenditures: | $11,182,388.10 |
| Days Used: | 171 Days |
| Work Length: | 7.519 Miles |
| Project Length: | 7.60 Miles |
| Transportation System: | Intrastate Interstate TS 1 |
| Work Mix: | Resurfacing |
| Rural/Urban | Rural |
| Date | 10/10/2005 |
| Cross Street | 0 |
| signalized intersection | 0 |
| Dorp-off | NO |
| Cones | NO |

| Item Number | Item Description | Units | Actual Quantity | Predicted Quantity |
|---|---|---|---|---|
| 0102-76 | Advance Warning Arrow Panel | ED | 179 | 274 |
| 0102-74-1 | Barricade, Temporary, Type I, II, Drum | ED | 60,479 | 63441 |
| 0102-99 | Changeable-Variable Message, Tem | ED | 893 | 342 |
| 0102-77 | High Intensity Flashing Lights | ED | 1,548 | 684 |
| 102-1 | Maintenance of Traffic | LS | 1 | 1 |
| 0102-78 | Reflective Pavement Marking, Temp | ED | 2,338 | 8196 |
| 0102-60 | Work Zone Signs | ED | 4,672 | 6840 |

| | |
|---|---|
| Average MOT Quantity Variance (%) | 13.8% |
| Average MOT Cost Variance (% of Expenditures) | 0.11% |

**Comment Legend**
A = Insufficient data in data base to make prediction
B = Must be determined by estimator based on project specific criteria.

**B**

| | |
|---|---|
| Project ID: | 209596-1-52-01 |
| Project Description: | NA |
| Total Expenditures: | $17,430,221.39 |
| Days Used: | 716 |
| Work Length: | |
| Project Length: | 1.446 |
| Transportation System: | Non-Intrastate State Highway TS5 |
| Work Mix: | 0421 Replace Low Bridge |
| Rural/Urban | Rural |
| Date | 10/10/2005 |
| Cross Street | 1 |
| signalized intersection | 0 |
| Dorp-off | YES |
| Cones | Non-Intrastate State Highway TS5 |

| Item Number | Item Description | Units | Actual Quantity | Predicted Quantity |
|---|---|---|---|---|
| 0102-74-1 | Barricade, Temporary, Type I, II, Drum | ED | 71,008 | 68736 |
| 0102-71-11 | Barrier (Temporary) (F&I)(Standard)(Concrete) | LF | 7,918 | 3196 |
| 0102-77 | High Intensity Flashing Lights | ED | 2,816 | 9153 |
| 0102-79 | Lights, Barrier Wall Mount, Temp | ED | 33,728 | 25658 |
| 0102-1 | Maintenance of Traffic | LS | 1 | 1 |
| 0102-78 | Reflective Pavement Marking, Temp | ED | 797 | 1696 |
| 0102-60 | Work Zone Signs | ED | 20,218 | 20532 |

| | |
|---|---|
| Average MOT Quantity Variance (%) | -7.56% |
| Average MOT Cost Variance (% of Expenditures) | -0.60% |

**Comment Legend**
A = Insufficient data in data base to make prediction
B = Must be determined by estimator based on project specific criteria.

**C**

| | |
|---|---|
| Project ID: | 208363-1-52-01 |
| Project Description: | Add Lanes and Reconstruct |
| Total Expenditures: | $28,857,028.84 |
| Days Used: | 907 |
| Work Length: | |
| Project Length: | 3.733 |
| Transportation System: | Non-Intrastate State Highway TS5 |
| Work Mix: | |
| Rural Section | Rural Divided |
| Date | 10/10/2005 |
| Cross Street | 4 |
| signalized intersection | 2 |
| Dorp-off | YES |
| CONES | NO |

| Item Number | Item Description | Units | Actual Quantity | Predicted Quantity |
|---|---|---|---|---|
| 0102 76 | Advance Warning Arrow Panel | ED | 107 | 1451 |
| 0102-74-1 | Barricade, Temporary, Type I, II, Drum | ED | 377,360 | 336497 |
| 0102 71 11 | Barrier (Temporary) (F&I)(Concrete) | LF | 7,574 | 7472 |
| 0102-61 | Business Signs | EA | 127 | 54 |
| 0102 99 | Changeable-Variable Message Sign, Temp | ED | 4,073 | 1814 |
| 0102 3 | Commercial Material for Driveway Maint | CY | 972 | 933 |
| 0102-77 | High Intensity Flashing Lights | ED | 31,801 | 34265 |
| 0102-79 | Lights, Barrier Wall Mount, Temp | ED | 9,889 | 17997 |
| 0102-1 | Maintenance of Traffic | LS | 1 | 1 |
| 0102-78 | Reflective Pavement Marking, Temp | ED | 448 | 2817 |
| 0102-107 | Temp Traff Detection Intersect | DA | 891 | 726 |
| 010-104-2 | Temp Traffic Control Fixed Signal | ED | 691 | 907 |
| 0102-60 | Work Zone Signs | ED | 97,964 | 99400 |

| | |
|---|---|
| Average MOT Quantity Variance (%) | 7.7% |
| Average MOT Cost Variance (% of Expenditures) | -0.13% |

**Comment Legend**
A = Insufficient data in data base to make prediction
B = Must be determined by estimator based on project specific criteria.

## D

| | |
|---|---|
| Project ID: | 209513-8-52-01 |
| Project Description: | |
| Total Expenditures: | $27,405,057.18 |
| Days Used: | 1192 |
| Work Length: | |
| Project Length: | 3.076 |
| Transportation System: | T5 Non Intrastate State Highway |
| Work Mix: | 0213 Add Lanes and Reconstruct |
| Rural/Urban | Urban Divided |
| Date | 10/10/2005 |
| Cross Street | 5 |
| signalized intersection | 3 |
| Dorp-off | YES |
| Cones | NO |

| Item Number | Item Description | Units | Actual Quantity | Predicted Quantity |
|---|---|---|---|---|
| 0102 76 | Advance Warning Arrow Panel | ED | 635 | 1907 |
| 0102-74-1 | Barricade, Temporary, Type I, II, Drum | ED | 566,181 | 500640 |
| 0102 71 11 | Barrier (Temporary) (F&I)(Concrete) | LF | 10,195 | 7574 |
| 0102-61 | Business Signs | EA | 37 | 72 |
| 0102 99 | Changeable-Variable Message Sign, Te | ED | 593 | 2204 |
| 0102 3 | Commercial Material for Driveway Mai | CY | 11,285 | 1033 |
| 0102-77 | High Intensity Flashing Lights | ED | 33,721 | 42453 |
| 0102-79 | Lights, Barrier Wall Mount, Temp | ED | 53,433 | 17997 |
| 0102-1 | Maintenance of Traffic | LS | 1 | 1 |
| 0102-78 | Reflective Pavement Marking, Temp | ED | 4,517 | 3732 |
| 0102-104-2 | Temp Traffic Control Fixed Signal | ED | 1,624 | 1788 |
| 0102-14 | Traffic Control Officer | MH | 10,706 | A, B |
| 0102-60 | Work Zone Signs | ED | 127,639 | 133838 |

| | |
|---|---|
| Average MOT Quantity Variance (%) | -12.7% |
| Average MOT Cost Variance (% of Expenditures) | -1.14% |

**Comment Legend**
A = Insufficient data in data base to make prediction
B = Must be determined by estimator based on project specific criteria.

**E**

| | |
|---|---|
| Project ID: | 208085-3-52-01 |
| Total Expenditures: | $6,738,408.98 |
| Days Used: | 376 |
| Work Length: | |
| Project Length: | 5.324 |
| Transportation System: | T5 Non-Intrastate State Highway |
| Work Mix: | 012 Resurfacing |
| Rural/Urban | Rural Divided |
| Date | 10/10/2005 |
| Cross Street | 1.5 |
| signalized intersection | 0 |
| Dorp-off | YES |
| Cones | YES |

| Item Number | Item Description | Units | Actual Quantity | Predicted Quantity |
|---|---|---|---|---|
| 0102-76 | Advance Warning Arrow Panel | ED | 272 | 602 |
| 0102-74-1 | Barricade, Temporary, Type I, II, Drum | ED | 19,597 | 8151 |
| 0102-71-14 | Barrier, Temporary, F&I, Type K | LF | 2,463 | 3358 |
| 0102-61 | Business Signs | EA | 37 | 173 |
| 0102-99 | Changeable-Variable Message, Tem | ED | 322 | 555 |
| 0102-77 | High Intensity Flashing Lights | ED | 11,922 | 14364 |
| 0102-79 | Lights, Barrier Wall Mount, Temp | ED | 8,349 | 5026 |
| 0102-1 | Maintenance of Traffic | LS | 1 | 1 |
| 0102-78 | Reflective Pavement Marking, Temp | ED | 2,915 | 7208 |
| 0102-14 | Traffic Control Officer | MH | 299 | A, B |
| 0102-60 | Work Zone Signs | ED | 26,742 | 25536 |

| | |
|---|---|
| Average MOT Quantity Variance (%) | -11.0% |
| Average MOT Cost Variance (% of Expenditures) | 0.66% |

**Comment Legend**
A = Insufficient data in data base to make prediction
B = Must be determined by estimator based on project specific criteria.

**F**

| | |
|---|---|
| Project ID: | 210447-3-52-01 |
| Total Expenditures: | $1,705,539.63 |
| Days Used: | 124 |
| Work Length: | |
| Project Length: | 1.471 |
| Transportation System: | T5 Non Interstate State Highway |
| Work Mix: | 0012 Resurfacing |
| Rural/Urban | Urban |
| Date | 10/10/2005 |
| Cross Street | 2 |
| signalized intersection | 4 |
| Dorp-off | YES |
| Cones | YES |

| **Item Number** | **Item Description** | **Units** | **Actual Quantity** | **Predicted Quantity** |
|---|---|---|---|---|
| 0102-76 | Advance Warning Arrow Panel | ED | 71 | 198 |
| 0102-74-1 | Barricade, Temporary, Type I, II, Drum | ED | 168 | 2849 |
| 0102-71-11 | Barrier (Temporary) (F&I)(Concrete) | LF | 360 | 402 |
| 0102-99 | Changeable-Variable Message, Tem | ED | 31 | 248 |
| 0102-77 | High Intensity Flashing Lights | ED | 2,085 | 2327 |
| 0102-79 | Lights, Barrier Wall Mount, Temp | ED | 1,570 | 4743 |
| 0102-1 | Maintenance of Traffic | LS | 1 | 1 |
| 0102-78 | Reflective Pavement Marking, Temp | ED | 99 | 2424 |
| 0102-107 | Temp Traffic Detection Intersection | DA | 208 | 198 |
| 0102-60 | Work Zone Signs | ED | 5,314 | 4669 |

| | |
|---|---|
| Average MOT Quantity Variance (%) | 81.6% |
| Average MOT Cost Variance (% of Expenditures) | 0.88% |

**Comment Legend**
A = Insufficient data in data base to make prediction
B = Must be determined by estimator based on project specific criteria.

## G

| | |
|---|---|
| Project ID: | 210067-2-52-01 |
| Total Expenditures: | $4,232,694.86 |
| Days Used: | 112 |
| Work Length: | |
| Project Length: | 8.789 |
| Transportation System: | T5 Non Interstate State Highway |
| Work Mix: | 0012 Resurfacing |
| Rural/Urban | Rural Divided |
| Date | 10/10/2005 |
| Cross Street | 1.5 |
| signalized intersection | 0 |
| Dorp-off | NO |
| Cones | YES |

| Item Number | Item Description | Units | Actual Quantity | Predicted Quantity |
|---|---|---|---|---|
| 0102-99 | Changeable-Variable Message, Tem | ED | 310 | 222 |
| 0102-77 | High Intensity Flashing Lights | ED | 4,293 | 5776 |
| 0102-1 | Maintenance of Traffic | LS | 1 | 1 |
| 0102-78 | Reflective Pavement Marking, Temp | ED | 4,361 | 5164 |
| 0102-60 | Work Zone Signs | ED | 10,679 | 11099 |

| | |
|---|---|
| Average MOT Quantity Variance (%) | 14.0% |
| Average MOT Cost Variance (% of Expenditures) | 0.09% |

**Comment Legend**
A = Insufficient data in data base to make prediction
B = Must be determined by estimator based on project specific criteria.
C = Pay item not found in current Master Pay Item List

## H

| | |
|---|---|
| Project ID: | 208402-3-52-01 |
| Total Expenditures: | $2,225,736.08 |
| Days Used: | 96 |
| Work Length: | |
| Project Length: | 7.511 |
| Transportation System: | Non Intrastate State Highway T5 |
| Work Mix: | 0012 Resurfacing |
| Rural/Urban | Rural Undivided |
| Date | 10/10/2005 |
| Cross Street | 0.5 |
| signalized intersection | 0 |
| Dorp-off | NO |
| Cones | YES |

| Item Number | Item Description | Units | Actual Quantity | Predicted Quantity |
|---|---|---|---|---|
| 0102-74-1 | Barricade, Temporary, Type I, II, Drum | ED | 1,129 | 712 |
| 0102-99 | Changeable-Variable Message, Tem | ED | 186 | 176 |
| 0102-77 | High Intensity Flashing Lights | ED | 1,758 | 2114 |
| 0102-1 | Maintenance of Traffic | LS | 1 | 1 |
| 0102-78 | Reflective Pavement Marking, Temp | ED | 1,678 | 2766 |
| 0102-60 | Work Zone Signs | ED | 4,056 | 4083 |

| | |
|---|---|
| Average MOT Quantity Variance (%) | 19.0% |
| Average MOT Cost Variance (% of Expenditures) | 0.19% |

**Comment Legend**
A = Insufficient data in data base to make prediction
B = Must be determined by estimator based on project specific criteria.

I

| | |
|---|---|
| Project ID: | 209411-2-52-01 |
| Total Expenditures: | $7,194,273.34 |
| Days Used: | 360 |
| Work Length: | |
| Project Length: | 10.173 |
| Transportation System: | Non Intrastate State Highway T5 |
| Work Mix: | 0012 Resurfacing |
| Rural/Urban | Urban Divided |
| Date | 10/10/2005 |
| Cross Street | 1 |
| signalized intersection | 0 |
| Dorp-off | NO |
| Cones | YES |

| Item Number | Item Description | Units | Actual Quantity | Predicted Quantity |
|---|---|---|---|---|
| 0102-76 | Advance Warning Arrow Panel | ED | 103 | 576 |
| 0102-74-1 | Barricade, Temporary, Type I, II, Drum | ED | 1,890 | 7570 |
| 0102-99 | Changeable-Variable Message, Tem | ED | 139 | 548 |
| 0102-77 | High Intensity Flashing Lights | ED | 16,236 | 17169 |
| 0102-1 | Maintenance of Traffic | LS | 1 | 1 |
| 0102-78 | Reflective Pavement Marking, Temp | ED | 5,745 | 8866 |
| 0102-60 | Work Zone Signs | ED | 27,741 | 29174 |

| | |
|---|---|
| Average MOT Quantity Variance (%) | 22.4% |
| Average MOT Cost Variance (% of Expenditures) | 0.31% |

**Comment Legend**

A = Insufficient data in data base to make prediction

B = Must be determined by estimator based on project specific criteria.

**J**

| | |
|---|---|
| Project ID: | 209664-3-52-01 |
| Total Expenditures: | $3,118,423.18 |
| Days Used: | 237 |
| Work Length: | 3.273 |
| Project Length: | 3.273 |
| Transportation System: | Non Intrastate State Highway |
| Work Mix: | 0012 Resurfacing |
| Rural/Urban | Urban Divided |
| Date | 10/10/2005 |
| Cross Street | 3 |
| signalized intersection | 0 |
| Dorp-off | NO |
| Cones | NO |

| Item Number | Item Description | Units | Actual Quantity | Predicted Quantity |
|---|---|---|---|---|
| 0102-76 | Advance Warning Arrow Panel | ED | 601 | 379 |
| 0102-74-1 | Barricade, Temporary, Type I, II, Drum | ED | 23,008 | 48897 |
| 0102-77 | High Intensity Flashing Lights | ED | 5,828 | 10394 |
| 0102-1 | Maintenance of Traffic | LS | 1 | 1 |
| 0102-60 | Work Zone Signs | ED | 20,061 | 18703 |

| | |
|---|---|
| Average MOT Quantity Variance (%) | 59.5% |
| Average MOT Cost Variance (% of Expenditures) | 0.21% |

**Comment Legend**
A = Insufficient data in data base to make prediction
B = Must be determined by estimator based on project specific criteria.