KTC

Implementation of KYTC Contract Time Determination System

A Supplement to KYSPR 11-411

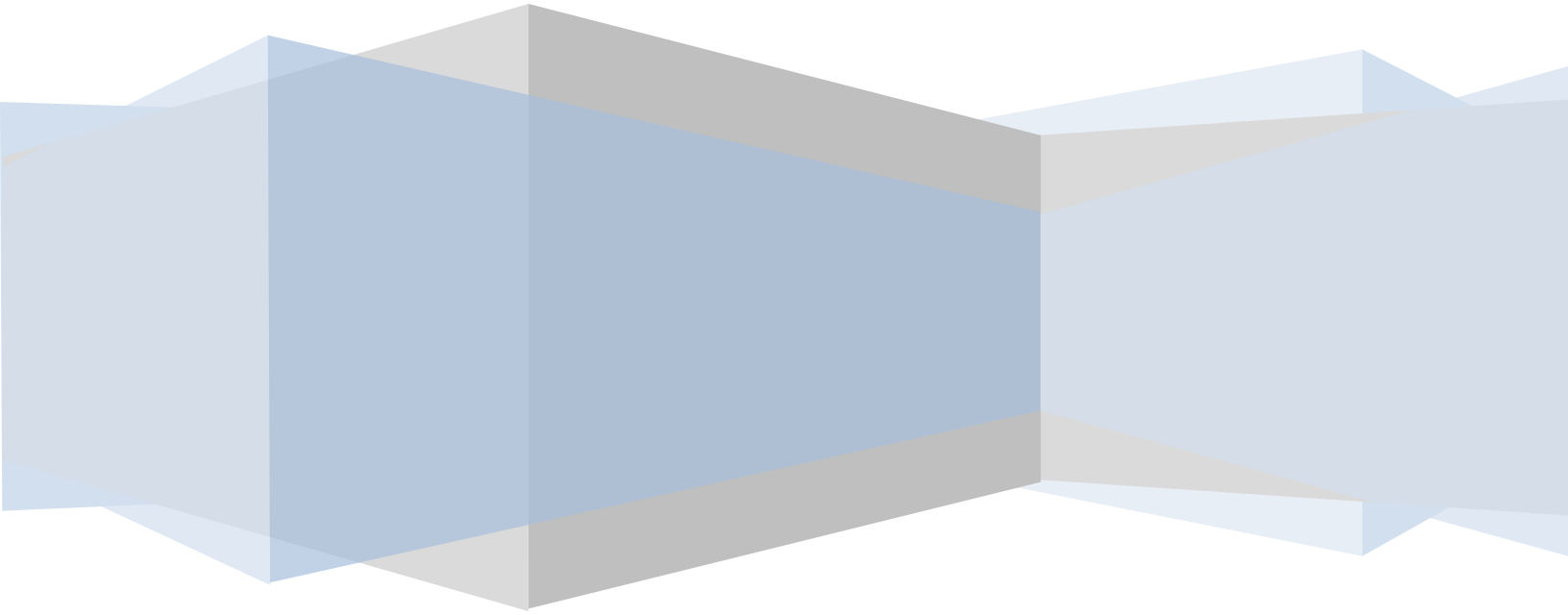


Table of Contents

Introduction

This guide is a supplement to the report for KY SPR 11-411, Updating the Kentucky Contract Time Determination System, completed by Paul M. Goodrum, Timothy R.B. Taylor, Michael Brockman, Kevin Hout, Yongwei Shan , Roy Sturgill and Barry Bishop.

The original Kentucky Contract Time Determination System (KY-CTDS) was implemented on February 9, 2000 with the intention of providing a tool to assist the Cabinet in estimating contract time for Kentucky Transportation Cabinet (KYTC) projects. Estimating contract time accurately can create a significant benefit to all parties involved. By completing work in a timely manner, both the agency and the traveling public are beneficiaries. The state agency does not incur additional administrative or inspection costs typically seen on over length projects. Also, the public does not incur the added road user costs associated with delayed projects. Road users could be affected by extended travel distance, additional travel time, and potentially a decrease in safety. Contract time is important to all aspects of a project. An unreasonably short contract time will raise bid prices, restrict qualified bidders from submitting bids, potentially reduce quality of the work, and increase the possibility of legal disputes. On the other hand, contract times that are too long are a general inconvenience for the traveling public and encourage less qualified contractors to submit bids.

KY SPR 11-411, Updating the Kentucky Contract Time Determination System, developed in-depth analyses on the most efficient and accurate methods to predict future construction durations. Details on those analyses are found in the KY SPR 11-411 Final Project Report though some alterations have occurred with the system to facilitate improved implementation. Meanwhile, this implementation resource directly addresses how to implement the results of those efforts to better estimate future construction durations.

This implementation resource is designed for project managers and project team members who are responsible for estimating a project's construction duration during the planning and design stages of a project's development.

Overview of the Models

The central approach to estimating contract time within this system is through regression based modeling. Regression is a statistical modeling approach wherein historical data is used to develop mathematical equations that closely aligns with the historical data based on significant variables. This project initially found that regression modelling was useful for projects on a larger scale with construction estimated over $1million. It was believed that higher accuracy was achievable with smaller projects through a more intensive process using activities, production rates, and activity logic. Upon instituting some trials it was discovered that this approach was not desirable for KYTC staff. A separate set of regression models was developed for use for projects with construction estimates of less than $1 million. While these models for smaller projects provide contract time estimates, counterintuitively, there are many more factors to consider (closure desires, contractor scheduling needs, etc.) with smaller projects than larger projects.

The first step for estimating a project's contract time begins with determining its classification according to the project's construction estimate. Upon opening the Kentucky Contract Time Determination System, a MS Excel based tool, the user is asked which side of the $1 million threshold their project lies on as seen in Figure 1. The tool then directs them to the appropriate location in the tool to begin their estimate. Projects of less than $1 million are here on referred to as small projects while those over the threshold are referred to as large projects.

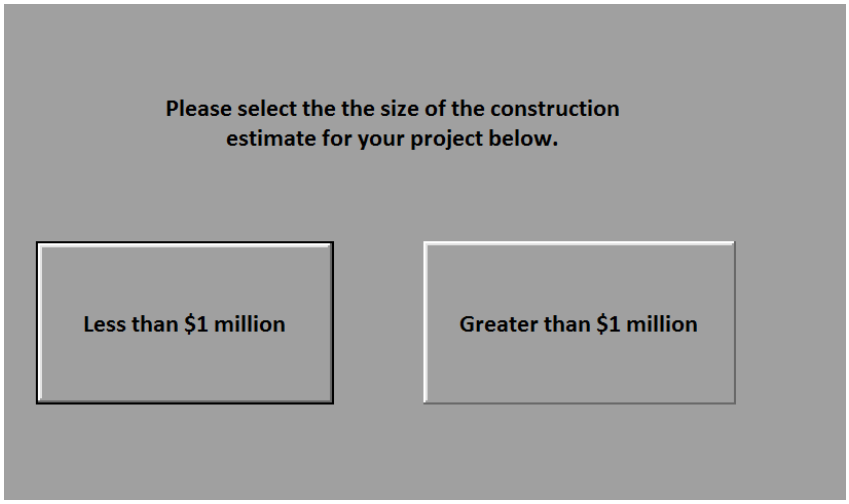


Figure 1: Opening Screen

The processes from this initial step are detailed in the following sections but it should be noted that there are many considerations in estimating contract time. Some of these considerations will be covered but in all cases experienced staff (design and/or construction personnel) should check these contract time estimates.

Considerations in Contract Time Estimates

Estimating contract time and creating a schedule for work is a very complex task with many factors to consider. Many believe this type of effort is more of an art than a science and an individual's experience level drastically affects the ease with which an estimate can be produced as well as the accuracy of that estimate. There are additionally varying levels of detail in relation to scheduling documents. The tools and guidance here are meant to inform a most basic level of estimate. This level is considered appropriate for estimating contract time.

When using this guidance these estimates produced should always be validated by individuals having experiences around construction and being knowledgeable of topics including production rates, construction means and methods, maintenance of traffic, weather and seasonal impacts, and the like. Before going further into the two methods presented under this project, it is important to consider variables and project needs that may impact a schedule or contract time for a project.

Several are listed here but this is not an all-inclusive list:

- First, public constraints and inconvenience; is work going to impact daily commutes and if so to what degree. Are there special events which will be drastically impacted by work? Can work be scheduled to minimize those impacts? Is there access that needs maintained or maintained by a certain date for school traffic or other reasons? The answers to these questions may impact the proposed letting for a project or may incur constricting the schedule or the use of milestones.

- There also needs to be a clear understanding of the goal of the project. Is it intended to be in place and open for a particular reason?
- The answers to the previously considered questions can also affect cost. If there can be flexibility given to the schedule, it is likely project bids will reflect that flexibility. On the other hand, if by necessity the schedule is not flexible, it is likely construction cost will result.
- Milestones are a scheduling tool that can be used to have different aspects of the project completed by times varying from the total project completion date. These may be considered with the contract time estimates produced from the tools provided here but the system is not sophisticated enough to automatically make adjustments from adding these milestones.
- Another area of consideration concerns seasons and weather. Adverse weather in the months from December through March can drastically affect the ability to do work (by specification, working days are not even charged within these months). These items need to be considered and the risk associated with these delays can vary depending on the type of scheduling contract conditions used.
    - Calendar days as produced from the large schedule tools attempts to account for weather from a historical viewpoint. This contract approach charges contract days regardless of weather.
    - To use working days a conversion is required to manipulate the calendar days to working days by estimating adverse weather days. This type of contracting charges a contractor only when weather

conditions allow work on controlling operations. This allows the contract to shed some risk associated with weather but is problematic for construction staff to monitor and document.

- Completion date contracts use calendar days and the anticipated letting date to determine a completion date. Both calendar day and completion date contracts place weather risk on the contractor.

While the contract time system attempts to provide information to inform any of these three scheduling types, understanding the differences, how they are determined or converted, and their uses are important. For further information related to project scheduling contract requirements refer to the current Kentucky Standard Specification for Road and Bridge Construction.

Small Project Duration Determination

Historically, over 90% of all projects costing less than $1 million are completed in less than 6 months, or a single construction season. Ideally, the first approach to schedule projects of this size would be to determine if there was flexibility to allow the project to occur within a given construction season giving a completion date at the end of the season, such as October 1st. Next, validate this single season approach with review by the contract time tool and more importantly by construction personnel. If restrictions or desires are such that this is not possible, the contract time estimate tool may provide more information.

The contract time tool for small projects is essentially one regression equation using design project type and the construction estimate for estimating contract time. The design project types should already be determined by the project team. The project types for possible use within this system include:

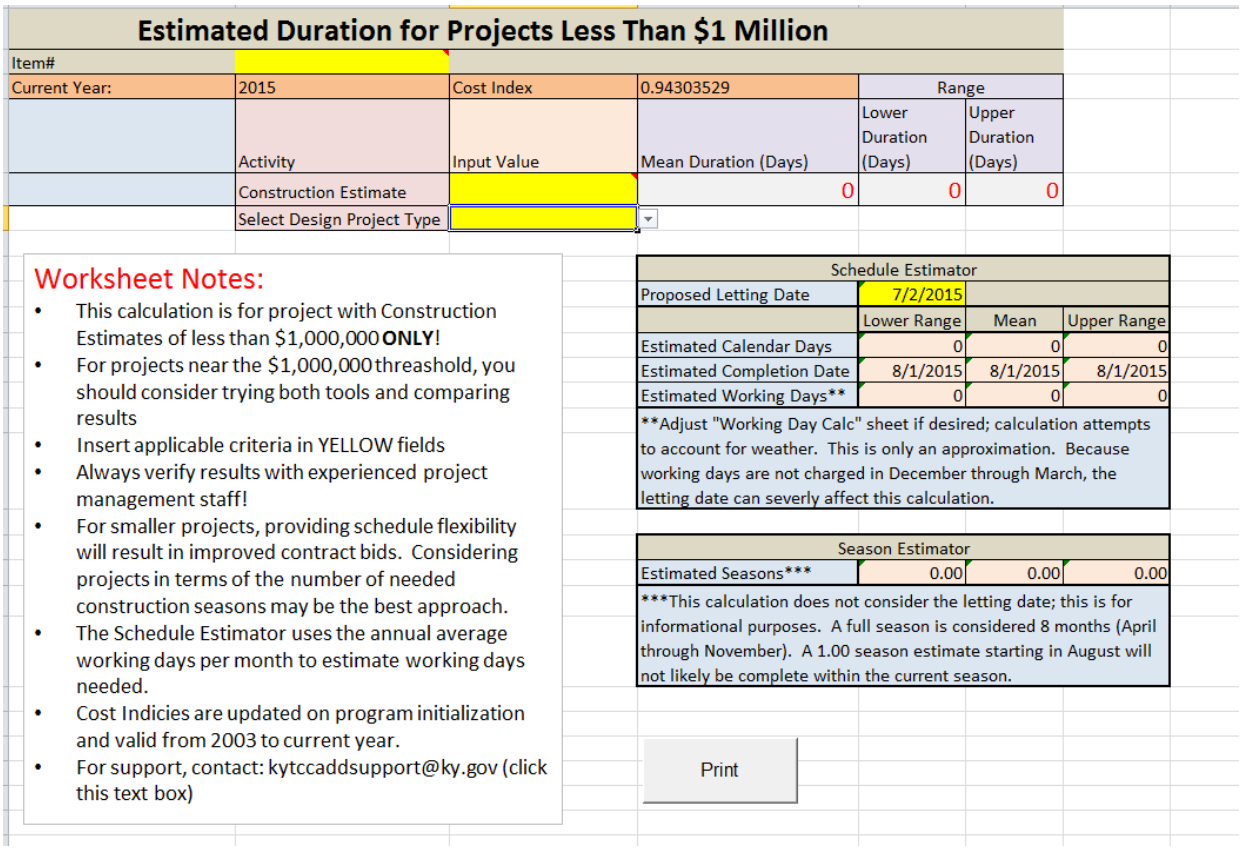
- Bridge Rehabilitation
- Bridge Replacement
- Congestion Mitigation
- Guardrail Replacement
- Minor Widening
- New Route
- Pavement Rehabilitation
- Reconstruction
- Resurfacing
- Safety/Hazard Elimination

The project type should be considered holistically for the project and the closest project type used. Again, these should already be assigned to the project upon estimating the contract time. The parameters for estimating the mean and upper and lower 95% confidence interval of the contract time estimate are found in Table 1.

Table 1: Small Project Parameters

Design Desc Range	Mean	Lower 95% CI	Upper 95% CI
BRIDGE REHAB	-28.012	-73.84893	17.824936
BRIDGE REPLACEMENT	50.771987	30.465602	71.078372
CONGESTION MITIGTN	3.5490812	-49.44283	56.540988
GUARDRAIL REPLCMNT	-12.70174	-41.51222	16.108746
MINOR WIDENING	-3.312152	-56.08908	49.464777
NEW ROUTE	2.5356311	-78.59201	83.663274
PAVEMENT REHAB	-11.46744	-45.50797	22.573093
RECONSTRUCTION	55.440977	16.420342	94.461612
RESURFACING	-71.53783	-138.4699	-4.605795
SAFETY/SAFETY-HAZARD ELIM	0	0	0
Intercept	28.741366	7.6043166	49.878415
Construction Est.(2005 $)	0.0001325	0.0000978	0.0001672

With this information in mind, the next section presents the user steps to completing a small project time estimate using the tool displayed in Figure 2. These steps are presented in the following list.



Estimated Duration for Projects Less Than $1 Million

Item#					
Current Year:	2015	Cost Index	0.94303529	Range	
	Activity	Input Value	Mean Duration (Days)	Lower Duration (Days)	Upper Duration (Days)
	Construction Estimate		0	0	0
	Select Design Project Type				

Worksheet Notes:

- This calculation is for project with Construction Estimates of less than $1,000,000 **ONLY**!
- For projects near the $1,000,000 threashold, you should consider trying both tools and comparing results
- Insert applicable criteria in YELLOW fields
- Always verify results with experienced project management staff!
- For smaller projects, providing schedule flexibility will result in improved contract bids. Considering projects in terms of the number of needed construction seasons may be the best approach.
- The Schedule Estimator uses the annual average working days per month to estimate working days needed.
- Cost Indicies are updated on program initialization and valid from 2003 to current year.
- For support, contact: kytccaddsupport@ky.gov (click this text box)

Schedule Estimator			
Proposed Letting Date	7/2/2015		
	Lower Range	Mean	Upper Range
Estimated Calendar Days	0	0	0
Estimated Completion Date	8/1/2015	8/1/2015	8/1/2015
Estimated Working Days**	0	0	0

**Adjust "Working Day Calc" sheet if desired; calculation attempts to account for weather. This is only an approximation. Because working days are not charged in December through March, the letting date can severly affect this calculation.

Season Estimator			
Estimated Seasons***	0.00	0.00	0.00

***This calculation does not consider the letting date; this is for informational purposes. A full season is considered 8 months (April through November). A 1.00 season estimate starting in August will not likely be complete within the current season.

Print

Figure 2: Small Project Contract Time Tool

1. Step 1: Open the MS Excel based tool and enable Macros if you have not previously done so. Then select the button indicating your project has a construction estimate of less than $1 million. At this point, the system must be online and must update a cost indices table. This is necessary to adjust the construction estimate for inflation according to the equation using 2005 dollars.
2. Step 2: Enter the Item number for the project in the upper most yellow field. **The only fields a user should manipulate in this tool are highlighted yellow**.
3. Step 3: Read through the "Worksheet Notes" for additional guidance as seen in the tool and Figure 2.
4. Step 4: Input the construction estimate for the project in the applicable field. It must be less than $1 million.
5. Step 5: From the drop down arrow for project type select the most application or the assigned Design Project Type. The list of possible types was previously discussed.

At this point, the system will have estimated the mean and upper and lower ranges for the number of calendar days for the applicable project. This may be all the information you need but some additional tools are included. Additionally, please reference the final section of this document regarding some added considerations before finalizing the contract estimate. Make sure to name and save your file.

The Schedule Estimator & Season Estimator

The system will automatically use the current date as the "Proposed Letting Date" but this can easily be changed by keying in a different date. The schedule estimator uses this information and the calendar days calculated by the tool to project estimated of the completion date and working days. The season estimator attempts to provide an estimate of the number of seasons a project might take and **does not consider letting date** in the calculation. The following will discuss these items in further detail.

The "Estimated Completion Date" is calculated by adding the calendar days determined by the system to the "Proposed Letting Date." Additionally, approximately one month is added to this duration to account for the time transpiring between the Letting Date and the awarded contractor's Notice to Proceed. This date should offer similar accuracy as the estimation tool itself but with dependence on the Letting Date accuracy and the time required for Notice to Proceed.

The "Estimated Working Days" are calculated using anticipated working days in the months of April through November according to historical temperatures, rainfall, and typical contractor schedules. This can be adjusted as discussed in the section entitled, *Advanced Uses of the Working Day Calculations*. The "Proposed Letting Date" and the "Estimated Completion Date" are used to estimate the required working days. Approximately one month is added to the "Proposed Letting Date" to account for time until the Notice to Proceed. Next, specifications do not allow for charging working days until the 31st day after Notice to proceed so those days are also added. The range between this date (approximately two months after the letting date) and the estimated completion is used to determine the number of working days within that window. This

calculation becomes slightly more complex the specifications do not allow working day charges in the months of December through March. Figure 3 shows an excerpt of the working days table that helps with this estimate.

Calendar (Eqn)			Starting Month (First Month After NTP--Approx 2 months after letting)											
Year	Months	# WD/Mo	1	2	3	4	5	6	7	8	9	10	11	12
1	1	0												
1	2	0	0											
1	3	0	0	0										
1	4	15	0	0	0									
1	5	19	15	15	15	15								
1	6	19	34	34	34	34	19							
1	7	20	53	53	53	53	38	19						
1	8	20	73	73	73	73	58	39	20					
1	9	19	93	93	93	93	78	59	40	20				
1	10	17	112	112	112	112	97	78	59	39	19			
1	11	15	129	129	129	129	114	95	76	56	36	17		
1	12	0	144	144	144	144	129	110	91	71	51	32	15	
2	1	0	144	144	144	144	129	110	91	71	51	32	15	0
2	2	0	144	144	144	144	129	110	91	71	51	32	15	0
2	3	0	144	144	144	144	129	110	91	71	51	32	15	0
2	4	15	144	144	144	144	129	110	91	71	51	32	15	0
2	5	19	159	159	159	159	144	125	106	86	66	47	30	15

Figure 3: Working Day Table

As an example, if the time tool estimated a completion date of February and the letting date was the previous May, the table would estimate 91 working days. This would be determined by going to column seven (May plus two months) and the row corresponding to year two and month two (the following February).

The working day estimate is highly dependent on the letting date due to charges not occurring December through March. Additionally, as seen in the table example, days are accrued in one month block and not on a continuous scale allowing for some loss of accuracy.

Large Project Duration Determination

The regression models helped predict, with some variability, the accuracy of estimated project durations for certain transportation projects. These estimated durations are products of the equations derived from the regression analysis using model variables and project durations. Each equation used is project specific and should only be used for their project type category. These equations have shown moderate to great accuracy and should help users estimate project durations in an efficient manner. Determination of the large project is a much more strait forward approach, with less room for human error than that of the small project. The process is as follows:

1. Upon opening the MS Excel contract time system, enabling macros, and selecting the button indication the project has a construction estimate of more than $1 million, the user will be taken to the Title Page for the large project tool. This tool is further categorized into subcategories (Table 2: Description of Large Project Subcategories, Table 3: Large Project Regression Equations). At this point, the system must be online and must update a cost indices table. This is necessary to adjust the construction estimate for inflation according to the equation using 2005 dollars.
2. Once you select a subcategory, the duration equation for that subcategory is identified
3. The quantities for the activities specific to that equation are entered
4. Durations are calculated

Also an excel tool has been provided to make this process easier (See Figure 4: Screenshot of KYTC Title Page).

1. First the tool is opened the user inputs the contract number and saves the document as the contract number
2. The user then simply selects the type of project being analyzed
3. The year of the project is entered
4. The input variables are then entered
5. The output will be an estimation of the duration, along with a range of slow, expected, and efficient times

It is important to remember that this tool is only accurate for projects that are greater than one million dollars and 100 days.

Table 2: Description of Large Project Subcategories

Project Template	Project Description
Limited Access	This is a project that utilizes the existing alignment but may revise the profile grade for an overlay.
Open Access	This is a project where a road is being rebuilt that has either "Access by Permit" or "Parital Control" while utilizing the existing right-of-way.
New Route	This is a project being built from point "A" to point "B".
Bridge Rehabilitation	This is a project that a lane on a bridge would be closed for reconstructing or widening the deck part width.
Bridge Replacement	This project's main focus would be to build a new bridge.

Table 3: Large Project Regression Equations

Project Type	Regression Equation
Limited Access (>$1 million)	145.821 + 9.493E-6* Engineer's Estimate (2005 Dollars) + 3.552E-4* DirtWork_Roadway Excv. (CY) + .023*Storm Sewer (LF)
Open Access (>$1 million)	173.642 + 1.188E-5* Engineer's Estimate (2005 Dollars) + 2.92E-4* DirtWork_Roadway Excv. (CY) + 0.048* PVC Pipe (LF) + .006*Stone Based_Crushed Stone (Ton) + 0.036* Storm Sewer (LF) + 0.075* Culvert Pipe (LF) -0.001* Striping (LF)
New Route (>$1 million)	39.289 + 6.894E-5* Engineer's Estimate (2005 Dollars) – 0.001* Steel Reinf. (LB) – 0.018* DirtWork_Granular Emb (CU. YD.) – 0.010* Perforated Pipe (LF) – 4.51E-4* Striping (LF)
Bridge Rehabilitation	26.933 + 5.602E-5* Engineer's Estimate (2005 Dollars)
Bridge Replacement-Engineers' Estimate (>$1 million)	97.155 + 0.447* Class AA Concrete (CU YD) + 0.043* DirtWork_Granular Emb + 1.909E-5* Engineer's Estimate (2005 Dollars)

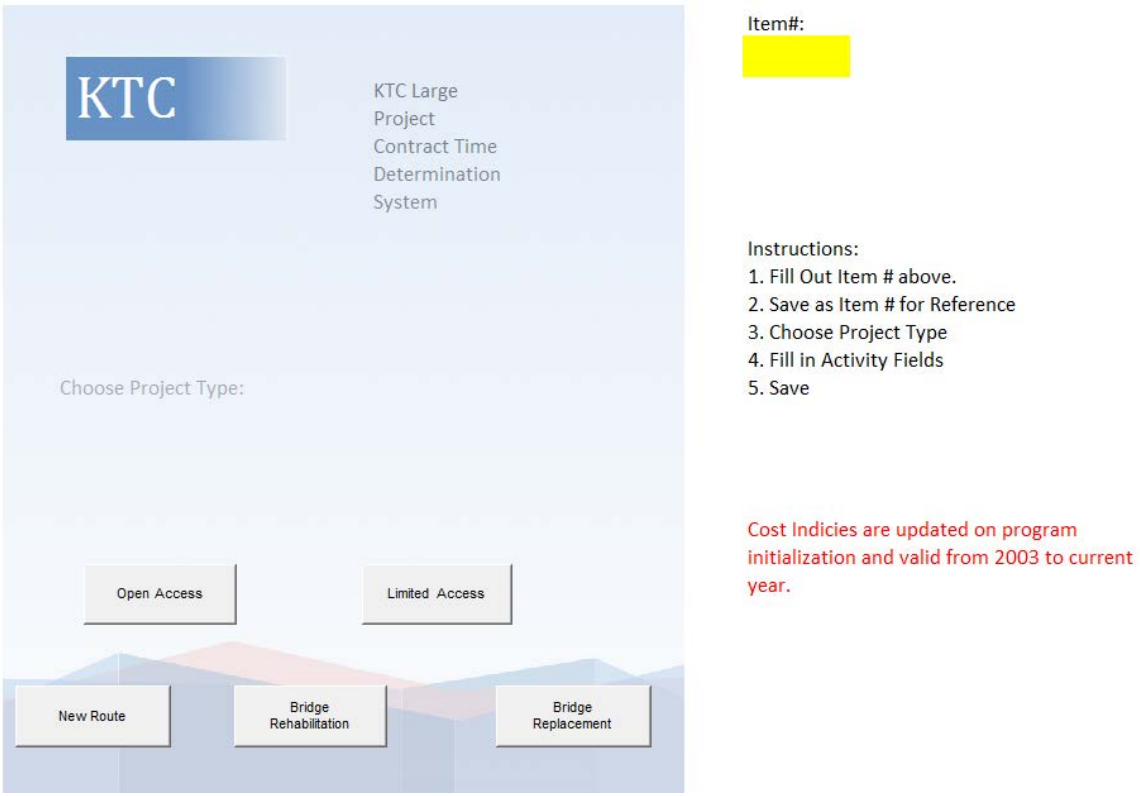


Figure 4: Screenshot of KYTC Title Page

Examples for each type of project are as follows:

Limited Access

See Figure 5: Screenshot for Excel Limited Access Calculation

- Quantities
    - Construction Estimate (2005 Dollars)- 49453199
    - DirtWork_Roadway Excv. (CY)- 0
    - Storm Sewer (LF)- 0
- Actual Duration- 544 Days

Duration= 145.821 + 9.493E-6* Construction Estimate (2005 Dollars) + 3.552E-4* DirtWork_Roadway Excv. (CY) + .023*Storm Sewer (LF)

Duration= 145.821 + 9.493E-6* 49453199 + 3.552E-4* 0 + .023*0

= 615.28

= 616 Days

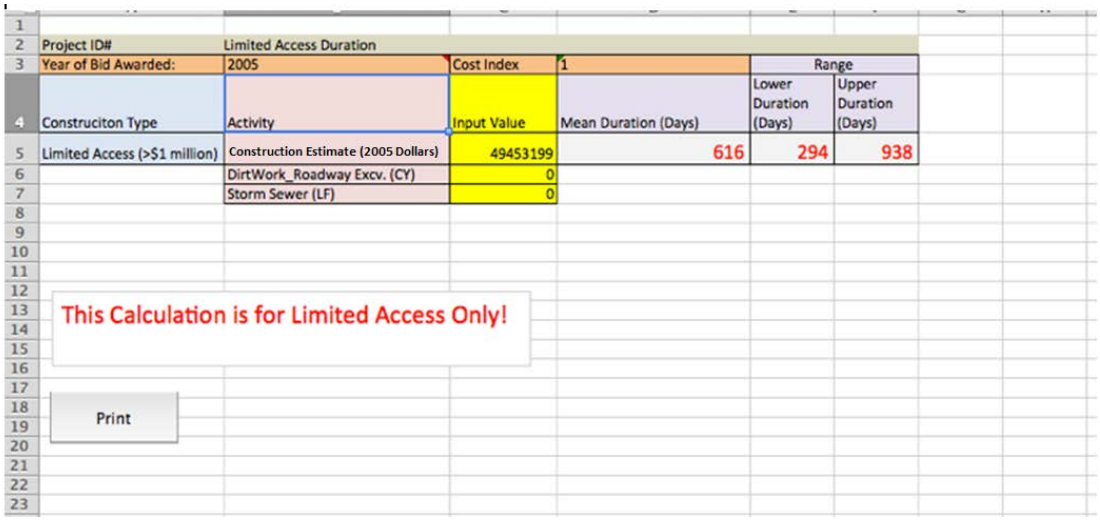


Figure 5: Screenshot for Excel Limited Access Calculation

Open Access

See Figure 6: Screenshot for Excel Open Access Calculation

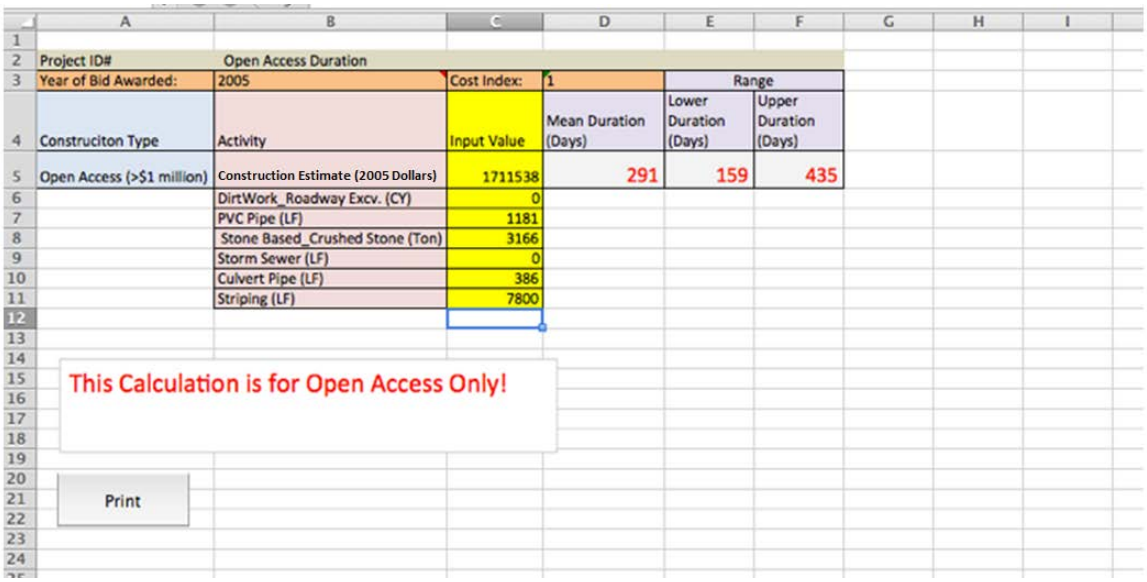
- Quantities
    - Construction Estimate (2005 Dollars)- 1711538
    - DirtWork_Roadway Excv. (CY)- 0
    - PVC Pipe (LF)- 1181
    - Stone Based_Crushed Stone (Ton)- 3166
    - Storm Sewer (LF)- 0
    - Culvert Pipe (LF)- 386
    - Striping (LF)- 7800
- Actual Duration- 332 Days

Duration= 173.642 + 1.188E-5* Construction Estimate (2005 Dollars) + 2.92E-4* DirtWork_Roadway Excv. (CY) + 0.048*PVC Pipe (LF) + .006*Stone Based_Crushed Stone (Ton) + 0.036* Storm Sewer (LF) + 0.075* Culvert Pipe (LF) -0.001* Striping (LF)

Duration= 173.642 + 1.188E-5* 1711538) + 2.92E-4* 0 + 0.048*1181 + .006*3166 + 0.0360 + 0.075* 386 -0.001* 7800

= 290.81

= 291 Days



	A	B	C	D	E	F	G	H	I
1									
2	Project ID#	Open Access Duration							
3	Year of Bid Awarded:	2005	Cost Index:	1	Range				
4	Construciton Type	Activity	Input Value	Mean Duration (Days)	Lower Duration (Days)	Upper Duration (Days)			
5	Open Access (>$1 million)	Construction Estimate (2005 Dollars)	1711538	291	159	435			
6		DirtWork_Roadway Excv. (CY)	0						
7		PVC Pipe (LF)	1181						
8		Stone Based_Crushed Stone (Ton)	3166						
9		Storm Sewer (LF)	0						
10		Culvert Pipe (LF)	386						
11		Striping (LF)	7800						
12									
13									
14									
15	This Calculation is for Open Access Only!								
16									
17									
18									
19									
20									
21	Print								
22									
23									
24									

Figure 6: Screenshot for Excel Open Access Calculation

New Route

See Figure 7: Screenshot for Excel New Route Calculation

- Quantities
    - Construction Estimate (2005 Dollars)- 1649942
    - Steel Reinf. (LF)- 700
    - DirtWork_Grancular Emb. (CY)- 0
    - Perforated Pipe (LF)- 264
    - Striping (LF)- 317
- Actual Duration- 132 Days

Duration= 39.289 + 6.894E-5* Construction Estimate (2005 Dollars) – 0.001* Steel Reinf. (LB) – 0.018* DirtWork_Granular Emb (CU. YD.) – 0.010* Perforated Pipe (LF) – 4.51E-4* Striping (LF)

Duration= 39.289 + 6.894E-5* 1649942 – 0.001* 700 – 0.018* 0 – 0.010* 264 – 4.51E-4* 317

= 149.55

= 150 Days

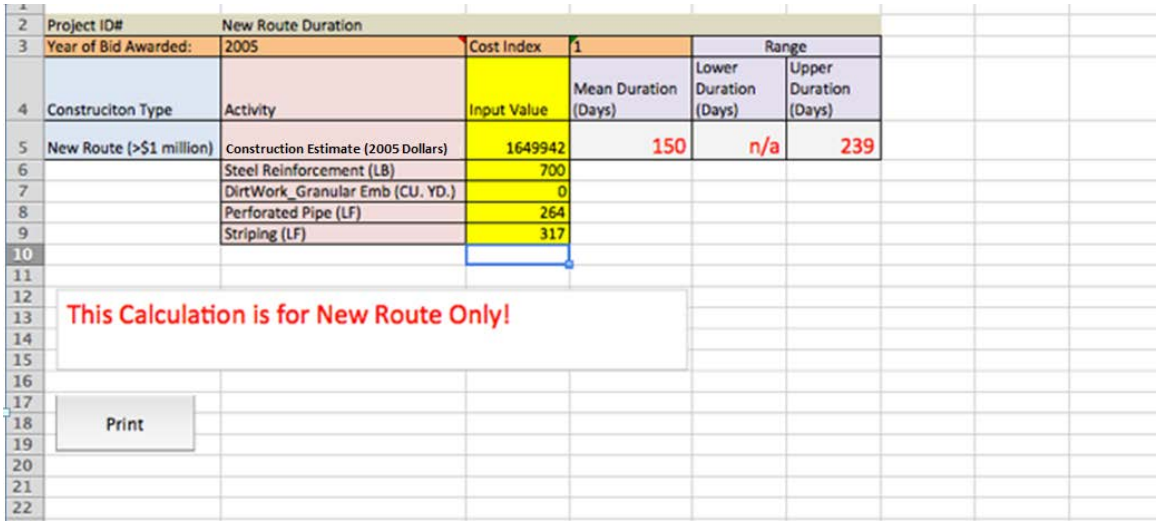


Figure 7: Screenshot for Excel New Route Calculation

Bridge Rehabilitation

See Figure 8: Screenshot for Excel Bridge Rehabilitation Calculation

- Quantities
    - Construction Estimate (2005 Dollars)- 1219384
- Actual Duration- 84 Days

Duration= 26.933 + 5.602E-5* Construction Estimate (2005 Dollars)

Duration= 26.933 + 5.602E-5* 1219384

= 95.24

= 96 Days

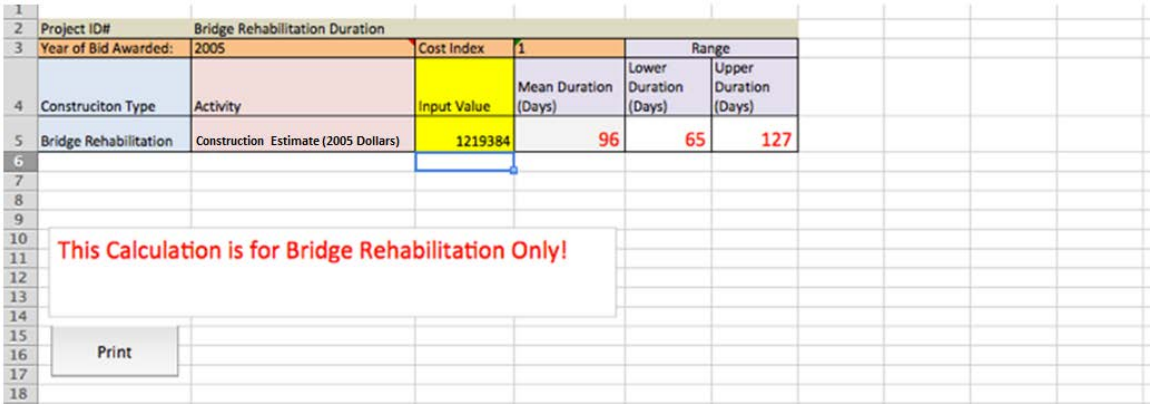


Figure 8: Screenshot for Excel Bridge Rehabilitation Calculation

Bridge Replacement

See Figure 9: Screenshot for Excel Bridge Replacement Calculation

- Quantities

- Class AA Concrete- 254.2
- DirtWork_Granular Emb- 0
- Construction Estimate (2005 Dollars)- 1910198

- Actual Duration- 298 Days

Duration= 97.155 + 0.447* Class AA Concrete (CU YD) + 0.043* DirtWork_Granular Emb + 1.909E-5* Construction Estimate (2005 Dollars)

Duration= 97.155 + 0.447* 254.2 + 0.043* 0 + 1.909E-5* 1910198

= 247.248

= 248 Days

2	Project ID#	Bridge Rehabilitation Duration				
3	Year of Bid Awarded:	2005	Cost Index	1	Range	
4	Construciton Type	Activity	Input Value	Mean Duration (Days)	Lower Duration (Days)	Upper Duration (Days)
5	Bridge Replacement-Engineers' Estimate (>$1 million)	Class AA Concrete (CU YD)	254.2	248	89	407
6		DirtWork_Granular Emb	0			
7		Engineer's Estimate (2005 Dollars)	1910198			
8						
9						
10	This Calculation is for Bridge Replacement Only!					
11						
12						
13						
14						
15						
16	Print					
17						
18						

Figure 9: Screenshot for Excel Bridge Replacement Calculation

Each equation does have a certain error inherent to that particular equation, so when taken into consideration, there should be duration with plus or minus the error. The engineer should take into account the range and use engineering judgment to produce a single duration. Once the duration of the project is produced a schedule then can be made and then sent to the project engineer for review.

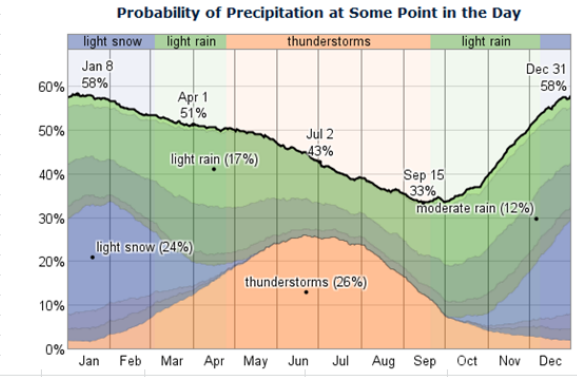
Advanced Uses of the Working Day Calculations

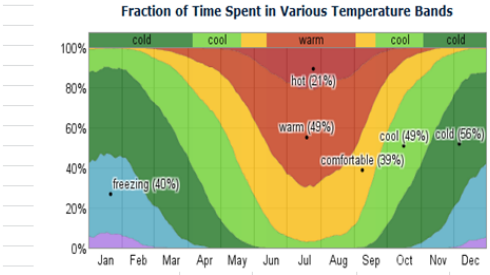
The table and information for working day calculations can be seen in Figure 10. Adjusting the figures in the beige fields will adjust the number of working days in the months from April through November. This information also updates the table seen in Figure 3. Adjustments should only be made here if absolutely necessary. Possible changes include working days per week or the percentage of days with rainfall or temperature related issues. Currently settings approximately follow the heavy rainfall curve and the freezing band of the associated figures from weatherspark.com.

Kentucky Adjusted Working Days

Month	Calendar Days	Working Days Per Week	Start Working Days	Adjusted Working Days (AWD)	Spec & Weather Adjusted Working Days		Rainfall Issues	Temp Issues	Adverse Days
January	31	5	22	11	0		20%	30%	11
February	28	5	20	10	0		25%	23%	9.6
March	31	5	22	13	0		33%	8%	9.02
April	30	5	21	15	15		30%	0%	6.3
May	31	6	27	19	19		28%	0%	7.56
June	30	6	26	19	19		25%	0%	6.5
July	31	6	27	20	20		23%	0%	6.21
August	31	6	27	20	20		23%	0%	6.21
September	30	6	26	19	19		25%	0%	6.5
October	31	5	22	17	17		25%	0%	5.5
November	30	5	21	15	15		25%	5%	6.3
December	31	5	22	12	0		23%	25%	10.56

**Criteria: Moderate or greater rainfall/snow, temperatures less than 32 degrees (Source: weatherspark.com)





Finalizing the Contract Time Estimate

Once a contract time estimate is determined, careful consideration should be given to its significance. It should be also noted whether it is essential for the project be completed in the scheduled time calculated or if there is flexibility to build in float. For example, if a project would realistically take 15 days to complete, but KYTC did not need the job complete for 90 days, then the project should not be scheduled for 15 days.

Before the estimate is applied to the project design and specifically construction personnel should be given the opportunity to review the project and time estimate. If the letting date of the project changes or it is re-let, reevaluate the contract time estimate.