

Cost Estimation procedure for highway design projects

Purpose

To maintain consistency within the Engineering Division regarding cost estimates; to get cost estimates that more accurately reflect the final construction costs.

Background

The Tentative Construction Program (TCP or Red Book) is MDT's best estimate of when projects will be let and what the final, constructed costs will be. The TCP is a balanced program, which means that the outgoing cash cannot exceed the incoming funds. The Engineering Division uses the TCP to prioritize project design. Accurate cost estimates ensure that designers are working on the appropriate projects. If cost estimates are too low, the TCP will over-estimate the number of projects for a given fiscal year and there won't be enough money to fund all of the designed projects: designers will be focusing on projects that can't be let until the next fiscal year. If cost estimates are too high, the TCP will under-estimate the number of projects and we will not have enough projects designed for the fiscal year. This could result in designers scrambling to fill the void or the loss of federal funding.

Procedure: Use the methods described in the Cost Estimation Guidelines

1. Designer or consultant puts together preliminary cost estimate using as much detail as is available
2. Crew specialist (PDM, Design Supervisor or Lead Worker, CE Specialist) reviews and revises estimate using tools, training, and judgment
3. Traffic control, mobilization, contingencies/risk, inflation added as appropriate to scope of project and design stage
4. Update cost estimate at all key stages of design using current price information, and discuss the cost estimate with the design team and Construction at the plan review meetings; be aware of project budget constraints
5. Document all steps and assumptions used in determining cost estimates
6. For projects with construction estimates over \$15 Million, convene a Cost Estimate Review team to further refine the cost estimate at key stages
7. District Prices will no longer be required from District personnel – regional prices will be determined by the design team and the Project Design Manager

Tools:

AASHTOWare Project Estimation
Bid History
Bid Data
Cost Estimates

- Road surface cost per square yard (Regional, Pavement Management System (PvMS) guidance)
- Bridge cost per area
- Cost estimate training
- Traffic Control History Tool

Reporting Cost Estimates

Use this format as a beginning point for Preliminary Field Review (PFR), Alignment and Grade (AGR), Scope of Work (SOW), Plan-In-Hand (PIH), and Final Plan Review (FPR) reports. Omit items that are not applicable to the project, and add any major contributor not usually included in a highway project. The purpose of this format is to clarify what has/has not been included in the estimate. Indirect costs (IDC) are only applied to the CN and CE totals.

	w/o IDC	w/IDC (10.91%)
New Structure		
Remove Structure		
Road Work		
Detour		
Traffic Control		
Subtotal		
Mobilization (___%)		
Subtotal		
Contingencies (___%)		
Subtotal		
Inflation (3% per year x ___ years)		
Total CN	\$ _____	\$ _____
CE (___%)	\$ _____	\$ _____

Also include the cost estimate from the previous key report, along with an explanation for significant change in the cost estimate. For the PFR report, give the nomination cost estimate. The purpose of showing the changes along with an explanation is to track our estimate history and trends. By giving accurate accounts of our estimates, we will be able to improve our estimating abilities.

Large Project Estimate Review

For projects over \$15 million, the PDM will convene a Cost Estimate Review team to review the bid prices used, and to evaluate the known and unknown issues as well as the potential for significant risk issues. The Cost Estimate Review team is a subset of the design team and should include the PDM, District Engineering Services, Construction representatives, designer and/or design supervisor, FHWA, and any functional managers whose technical area is involved in a high cost item or contingency issue (Table 2) for the specific project. The review team is responsible for checking the cost estimate by considering constructability issues, traffic control, anticipated work conditions, etc. Costs for individual bid items should be adjusted based on past bid history and individual item

contingency or risk. If appropriate, the team should consider individual bid item cost escalation. The PDM will document all decisions and keep the cost estimate work sheets.

Mobilization Rates

The following suggested rates are a starting point for determining mobilization.

PROJECT TYPE	CONTRACT AMOUNT	% MOBILIZATION
Chip Seal	\$0 - \$1,000,000	13.0%
	\$1,000,000 +	10.5%
Overlay or Mill/Fill	\$0 - \$1,000,000	12.0%
	\$1,000,000 - \$4,000,000	12.0%
	\$4,000,000 +	8.5%
Bridge Rehab	\$0 - \$2,000,000	15.0%
	\$2,000,000 +	13.5%
Bridge Replacement	\$0 - \$1,000,000	12.0%
	\$1,000,000 - \$4,000,000	15.0%
	\$4,000,000 +	13.5%
Reconstruction (Excluding Bridges)	\$0 - \$1,000,000	13.0%
	\$1,000,000 - \$4,000,000	11.0%
	\$4,000,000 - \$8,000,000	10.0%
	\$8,000,000 +	9.0%

Compare the percentage mobilization for similar projects in the area and adjust the mobilization as needed.

Construction Engineering

The following suggested rates are a starting point for determining mobilization and construction engineering (CE). These rates can and should be adjusted as necessary for specific projects.

Project Type	CE Rate %
New Construction	10
Reconstruction	10
Major Rehab	8
Minor Rehab	7
Asphalt Resurfacing	6
Seal & Cover	6
Bridge Reconstruction	12
Bridge Rehab	8
Safety Improvements	14
Traffic & Signing	18
Environmental	24
Bike/Ped	13

Traffic Control

The following are average daily rates for traffic control devices dependent on the project type. Determine a rough contract time based on similar projects and use those charged days to determine the quantity of traffic control units.

PROJECT TYPE	AVERAGE UNIT PER DAY	AVERAGE UNIT PRICE
Bridge	700	0.61
Reconstruction	2240	0.70
Overlay or Mill/Fill	2050	0.72
Interstate (Crossover/2way)	1100	0.75
Interstate (One Way)	2500	0.65
Safety	1550	0.63

Traffic Control History Tool

The Traffic Control History tool is a useful tool to estimate traffic control units and unit prices, as well as project durations for projects. The tool is accessed via the Oracle system.

Contingency

Contingency and risk account for the unknown and depend on the scope of project and the potential for known/unknown conditions. Also consider risk to the project design schedule. Typical issues that can drive up contingencies and risk include the following:

Schedule time (extra cost for expedited work, timing restrictions, time of year, A+B bids)	Traffic control issues
Project setting – remoteness, urban setting, tight constraints, Reservation	Railroad, utility issues
Availability of materials	Environmental issues and/or mitigation needs
Availability of contractors	Geotechnical issues
Project size	Potential for poor soil conditions
	Unknown risks/potential change orders

Table 2. Contingency and Risk Factors

Contingency means an event that may occur but is not likely or intended. It is a possibility, condition of chance, for which there must be a plan of action (or additional money). Risk is a possibility of suffering harm or loss. Think of contingency and risk in terms of quantifiable and non-quantifiable outcomes.¹ Contingency is an amount added to the project cost to account for the effects of incorrect quantities or unit costs, the possibility of unknown conditions or events, unforeseen project requirements, and other project risk. Contingency also applies to project scope creep and project additions throughout the design phase. Examples are a weather monitoring system added on a bridge project or noise walls on an urban interstate project.

Phase	Low Risk	Medium Risk	High Risk
Planning\Nom\OT	20-45	30-80	40-110
PFR	15-40	25-60	40-100
AGR		20-40	35-80
SOW	10-30	15-35	30-70
PIH	5-20	10-25	20-55
FPR	0-5	3-10	5-20

Issue	Cost	Coverage in the Estimate
Identified issue	Known	Direct cost
Identified issue that will occur	Unquantified	Approximate cost
Identified issue that may occur	Unknown	Contingency/Risk
Issue that has not been identified	Unknown	Risk

Table 3. Contingency and Risk Coverage

¹ Project Cost Estimating, A Synthesis of Highway Practice, Schexnayder, et. al.

NOTE: Until the MDT research project on Cost Estimating is complete and MDT has a procedure in place for handling risk, risk will be included in the contingency. The type of project and level of risk will determine the amount of contingency.

Inflation

Inflation is calculated up to the estimated midpoint of construction and is currently set at 3% per year, compounded annually and rounded to the nearest year. Discuss the anticipated contract time (number of construction seasons) during the PFR. Typical project development time for the different project types:

Pavement preservation – 1 year (2 years for urban settings with ADA work)

Minor rehabilitation – 2 years

Major rehabilitation – 3-4 years

Reconstruction – 5-6 years

Bridge replacement – 4-5 years

Turn bay or spot improvement – 2-4 years

Inflation represents the decreased buying power of money due to the general increase in prices. Annual compounding assumes that inflation will be steady over the design life of a project. Currently, MDT has set inflation at 3% per year. To calculate the future cost of a project:

$$F = P(1+i)^n$$

Where:

- F = Future cost, in dollars
- P = Present cost, in dollars
- i* = annual inflation rate, expressed as a decimal amount
- n* = number of years until the midpoint of construction (rounded to full year)

Design Phase Guidance

NOMINATION/ PRELIMINARY FIELD REVIEW

There are different methods for estimating costs before quantities are available. Some common methods are listed below. For more confidence in a cost estimate, compare the estimates from more than one method. Use the highest level of estimating accuracy possible given the amount of information available, document all assumptions, and provide a written estimate. Include a list of the items considered in the estimate. Nomination estimate documentation must be provided to the Project Design Manager (PDM) at the Preliminary Field Review (PFR) so that assumptions can be discussed and the estimate can be refined during the field review using input from all the technical areas.

Appropriate Cost Estimate Methods

1. Cost per yd² from the current Pavement Condition and Treatment report published by the MDT Pavement Analysis Section (PvMS report). Determine the project area (yd²) and multiply by the appropriate cost/yd² taken from the cost trend table. Consider additional items from Table 1.
2. AASHTOWare Estimation typical sections- Utilize the typical section that represents the project type and define the variables for the typical. If variables aren't known, such as pavement and CAC thicknesses, use engineering judgement from similar projects to estimate. Add additional typical sections to define other items from Table 1 below.
3. Similar project comparison – generally for small, specialized projects. Compare to similar projects that were let recently and adjust for differences in project scope, regional cost variations, constructability issues, etc.

Guardrail	Traffic signals, lighting, ITS items
Large culverts, irrigation facilities	Turn bays, other isolated widening
Storm drain	Pavement markings, signing
ADA ramps, curb and gutter, sidewalk work	Wetland mitigation, wildlife crossings, wildlife fencing, etc.
Bridge work	Unique or unusual fencing needs
Bridge survey	Constructability issues
Bridge adoption	Public relations (especially urban jobs)
Retaining structures	Training program
Contaminated soil removal/disposal	Noxious weed control
Railroad involvement	Extensive utility work-arounds (urban)

Table 1. Additional Items

Example 1: A field review is held for a pulverize, overlay, and widening project, 5 miles long. Some grading will be included to correct two sag vertical curves to improve sight distance. The current roadway is 28' wide, and the route segment plan calls for a 32' roadway width. There are two named drainage

crossings with 60” corrugated metal pipes in place. Slope flattening will be included as necessary to minimize the need for guardrail. The project is entirely rural.

The project type will be major rehabilitation project, expected to have a 4 year design life. The field review concluded that culvert extensions will be needed, and that about 2000’ of guardrail will be necessary to avoid impacts to wetlands. No other items from Table 1 were identified. The review team determined that contingency and risk factors would be relatively low based on Table 2, and they agreed upon a 15% contingency.

The following costs have been determined for this district for 2016:

<u>Method</u>	<u>Cost factor</u>	<u>Quantity</u>	<u>Total Cost</u>
Cost/mile	\$250,000/mi	5 miles	\$1,250,000
Cost/yd ²	\$46/ yd ²	93,900 yd ² (1.)	\$4,320,000
Estimation	\$1,937,827		\$1,900,000

Typical

(1.) $(32 \text{ ft} \times 5 \text{ mi} \times 5280 \text{ ft/mi}) \div (9 \text{ ft}^2/\text{yd}^2)$

Using engineering judgment and adding costs for guardrail and culvert extensions, the designer determines that a total cost of \$2,200,000 is appropriate.

Add contingencies: $\$4,320,000 \times 1.40 = \$6,050,000$.

Add inflation for 4 years: $6,050,000 \times (1.03)^4 = \$2,847,537$

Round for the construction cost estimate: \$6,800,000

ALIGNMENT AND GRADE

Once alignment and grade are set, the major items including grading, surfacing, and large drainage facilities can be estimated more accurately. There are still a lot of unknown quantities, but the need for many of the additional items listed in Table 1 can be better estimated than at PFR. Cost estimates at alignment and grade (AGR) stage are based on more known factors.

Appropriate Cost Estimate Methods

1. Cost estimate spreadsheet – estimate quantities for the major bid items. Major bid items are those items that together make up 65% to 85% of the total project cost. Add costs for the items from Table 1 that haven’t yet been designed. Get estimates from the other technical sections for non-roadwork items (Geotech, Hydraulics, Traffic). Consider the proportion of the project that the major items comprise and increase the cost to account for the additional items.

Example 2: A designer determines that the grading and paving items, which have been calculated, make up about 80% of the costs for an overlay/widen project. The remaining 20% of the cost will be for the striping, signing, guardrail upgrades, and other miscellaneous work, for which quantities have not yet been

calculated, and are extrapolated. There may be some rock netting included to eliminate rock fall. The cost estimate should be shown as follows:

	w/o IDC	w/IDC (10.91%)
Road work (grading, gravel, surfacing)	\$80,000	
Other items (striping, signing, guardrail)	\$20,000	
Rock netting	\$35,000	
Traffic control	\$50,000	
Subtotal	\$185,000	
Mobilization (15%)	\$27,800	
Subtotal	\$212,800	
Contingencies (20%)*	\$42,600	
Subtotal	\$255,400	
Inflation (3% per year x 2 years)	\$15,500	
Total CN	\$271,000	\$300,566
CE (8%)	\$22,000	\$24,400

*Contingencies are set at 20% to account for the potential for additional geotechnical work at the rock fall site.

2. Cost per mile or similar project comparison to be used as a check in addition to the cost estimate spreadsheet. Cases that may require this method as a first choice would include projects with alternate alignments where quantities are not known.
3. Cost/yd² should be used as a check.

Contingencies depend on scope of project and known/unknown conditions: 20% - 80% Remember to consider potential constructability issues, and the potential for unknown factors to arise. Include an explanation for the contingency used. If contingencies outside this range are indicated based on the potential for risk, provide justification with the cost estimate.

Inflation should be based on the project schedule from the project schedule (OPX2) and TCP: determine the realistic amount of time remaining to complete the project design and add time for letting. Take to the midpoint of construction.

Traffic Control should be based on similar projects in the district. Nationwide studies have found no correlation between traffic control costs and total project costs; therefore, percentage based traffic control should not be used. Discuss traffic control methods and get input from Construction for the traffic control estimate during the review meeting. District personnel have access to Traffic Control database reports that can provide additional information on project-by-project basis, including total costs, average costs, and per mile or kilometer costs.

SCOPE OF WORK

All of the major items should be known at the Scope of Work (SOW) stage, although quantities are not yet finalized. The Scope of Work report documents the inclusion or elimination of big items that were options up through Alignment and Grade, which should improve the level of confidence for the cost estimate.

Costs for individual bid items should be adjusted based on past bid history and individual item contingency or risk.

Appropriate Cost Estimate Methods

1. Cost estimate spreadsheet – estimate quantities for the major bid items and add costs for additional items. Include cost estimates from other design areas, including Bridge, Traffic (striping and signing), and Geotech.
2. DSS bid history – use the bid history and refine bid prices for regional and availability cost factors.

Contingencies depend on scope of project and known/unknown conditions: 10% – 70% Remember to consider potential constructability issues, and the potential for unknown factors to arise. Include an explanation for the contingency used. If contingencies outside this range are indicated based on the potential for risk, provide justification with the cost estimate.

Inflation should be based on the project schedule from OPX2 and TCP: determine the realistic amount of time remaining to complete the project design and add time to get to the midpoint of construction.

Traffic Control should be based on similar projects in the district. Discuss with District personnel as needed to get the best estimate.

PLAN-IN-HAND

Almost all of the bid items should be known for Plan-In-Hand (PIH). The PDM is responsible for ensuring that the plan package is close to the letting package at this stage. If the project cost is over \$15 million, the Cost Estimate Review team should reconvene to review the estimate and the contingency factors. This is the time to start to focus on the final, constructed costs rather than just the bid letting costs.

Individual item costs for the big items should be adjusted for regional factors and for the effect related to quantities.

Appropriate Cost Estimate Methods

1. Cost estimate spreadsheet – estimate quantities for the all bid items. Include cost estimates from other design areas. Bridge costs, structural walls, landscaping and associated irrigation, signing and pavement markings, electrical items, and traffic control should be included. Discuss the cost estimate at the PIH review, spending time on the critical items and the impact of constructability issues on costs.
2. DSS bid history – use the bid history and refine bid prices for regional and availability cost factors.
3. Estimator can be used with discretion as a check on the cost estimate, especially for the larger cost items.

Contingencies should be low, based on the level of known conditions: 5% - 55% Consider potential constructability issues, and the potential for unknown factors to arise. These should all be discussed in depth at the PIH review. Include an explanation for the contingency used. If contingencies outside this range are indicated based on the potential for risk, provide justification with the cost estimate.

Inflation should be based on the project schedule from OPX2 and TCP: determine the realistic amount of time remaining to complete the project design and take to the midpoint of construction.

Traffic Control should be discussed thoroughly at the PIH review. Costs can be assigned using input from Construction during the review meeting.

FINAL PLAN REVIEW/CONTRACT PLANS

All bid items are quantified and known. Reconvene the Cost Estimate Review team if there has been a significant time lag or if major issues have developed. Issues can include scope adjustments, discovery of previously unknown site problems, or construction issues that arise on other projects that may impact this project. Also think about the potential for change orders that could increase the final, constructed costs.

Individual item costs for the big items should be adjusted for regional factors and for the effect related to quantities. For unusual, large dollar amount items (such as unique retaining walls, very large culverts or arch structures, wildlife overpasses, etc.), think about constructability and the effect on costs. Also consider contacting contractors or suppliers to determine prices for items without much recent bid history. Get prices on similar items with reliable bid history to determine the added costs for installation.

Appropriate Cost Estimate Methods

1. Cost estimate spreadsheet – include costs from all design areas.
2. DSS bid history – use the bid history to refine bid prices for regional and availability factors. Also use cost index information if appropriate.
3. Estimator can be used with discretion as a check on the cost estimate.

Contingencies are not expected at this stage: 0% – 20%. Include an explanation for the contingency used. If contingencies outside this range are indicated based on the potential for risk, provide justification with the cost estimate. If there is a potential for change orders for unexpected events during construction, increase the contingencies accordingly.

Inflation should be based on the time remaining to the anticipated construction midpoint.

Traffic Control costs should be based on the traffic control method to be used. The District Construction Engineer and District Traffic Engineer should be consulted to determine the traffic control costs.

Summary

Engineering judgment will be needed to determine the best estimate after comparing different methods. Document all assumptions and list the major items included in the "roadwork" portion of the estimates. Include explanations for contingencies outside the given ranges. Give the previous cost estimate and provide an explanation for significant increases or decreases. Remember that the Project Design Manager is going to be held accountable for the cost estimates, and that it takes a team to develop the most reliable estimates.

RESOURCES

MDT Cost Estimating Webpage

Intranet: <http://mdtinfo.mdt.mt.gov/highways/cost.shtml>

Internet: <http://www.mdt.mt.gov/business/contracting/cost.shtml>

MDT Pavement Analysis Section, Annual Pavement Condition and Treatment Report:

<http://app.mt.gov/pvms/>

MDT Construction Bureau website: <http://www.mdt.mt.gov/business/contracting/>

See: Bid History, Archived Reports (award sheets, bid tabulations)

Trns*port Decision Support System bid history available on the Oracle Menu (on line applications on the Intranet), under Trns*port, DSS forms. Access must be granted through Contract Plans; <http://mdtinfo.mdt.state.mt.us/trnsport/> under Requests, request access.

Project Cost Estimating – A Synthesis of Highway Practice prepared for AASHTO SCOH by Cliff J. Schexnayder, Ph.D., P.E., Sandra L. Wever, Ph.D., P.E., Christine Fiori, Ph.D., P.E., Arizona State University, June 2003.

<http://cms.transportation.org/sites/design/docs/Project%20Cost%20Estimating%20Report.pdf>

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