

Advanced Methodology to Determine Highway Construction Cost Index (HCCI)

by

David Jeong, PhD

Associate Professor of Construction Engineering

and

Doug Gransberg, PhD

Professor of Construction Engineering

Iowa State University

Institute for Transportation Research

Construction Management and Technology Program

2711 South Loop Drive, Suite 4700

Ames, IA 50010-8664

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Montana Department of Transportation

2701 Prospect Avenue

P.O. Box 201001

Helena, MT 59620-1001

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PROBLEM STATEMENT

Highway Construction Cost Index (HCCI) is an indicator of cost fluctuation in current market condition and hence the purchasing power of a highway agency. It allows the agencies to make early financial decisions based on the changing amount of financial resources and changing market conditions. It also helps determine the return on investment value of a new project. Higher budget and lower spending results in waste of remaining budget while lower budget and higher spending results in the cancellation or delay of projects. In addition, there is an inconsistency in the amount of federal funding available over years. Thus, quick and reliable conceptual cost estimation is very important for maximum utilization of available budget.

Montana Department of Transportation (MDT) currently uses eight groups of bid items – earthwork, aggregate, plant mix, asphalt, reinforcing steel, structural steel, concrete, and structural concrete – to calculate the Highway Construction Cost Index (HCCI) (Alavi and Tavares 2009). The items are selected based on the availability of unit prices for a predetermined number of time periods. Items with same units within each group are then used to calculate the weighted average unit prices and are combined to generate HCCI. However, a single composite HCCI has serious limitations. Specifically, the effects of item quantities, project size, project type, and spatial distribution of the project are neglected and it is in many cases difficult to estimate cost changes and differences for a wide range of construction projects. This can be specifically problematic when state DOTs shift their strategic focus from letting fewer larger projects to many smaller maintenance and rehabilitation projects. Thus, the high level of budget allocation decisions driven by current indexes can be significantly misleading in current environment because of those limitations and unreliable analysis techniques used. As a result, many state DOTs are looking forward to updating their HCCIs (Walters and Yeh 2012). There is a strong need to develop an advanced methodology to determine realistic and practical HCCIs and tools that MDT can use.

This proposed project will develop a Montana specific Highway Construction Cost Index (HCCI) system and a process to update when needed. The new methodology developed in this study is expected to significantly improve the accuracy and reliability of HCCI for planning and budgeting for future fiscal years. The advanced HCCI system that will be developed from this study is expected to play a key role in maximizing the utilization of available budget.

BACKGROUND SUMMARY

The advancement of information technologies has enabled the storage and processing of a large amount of data that was not possible a few years back. State DOTs have been collecting more data than ever and these data have potential to help DOTs make reliable data-driven decisions throughout the project life cycle. The project information systems including the bid tabulation data are one of the examples of digital data that are growing rapidly. The bid tabulation data of MDT, for example, is estimated to have grown by about thousand times since the first recorded bid letting. More importantly, the MDT bid data have been stored digitally in a structured table since 1990s. In addition, the introduction of a digital project information system has resulted in the collection of various project data attributes including project location coordinates, project types, engineering hours used, etc. This high growth of digital data in MDT gives a great opportunity to perform analyses using data analytics that can be used for data-driven decision makings during budgeting, project planning, and bidding stages.

Yet, the current use of the various project related data has been very limited because of the lack of the proper methodologies to extract information and knowledge from the data. For example, the project bid data has been used to generate HCCIs but the use of HCCI has been limited because of the unreliable traditional methodologies used to calculate the HCCI. The details of key limitations are described in the following paragraphs.

Most DOTs have developed a methodology to calculate a HCCI for their state in late 1980s – same time as the development of FHWA’s Bid Price Index (BPI) (Walters and Yeh 2012). The methodology developed by MDT is fundamentally the same as the FHWA’s BPI. In MDT, the major items are grouped into eight categories of the items – earthwork, aggregate, plant mix, asphalt, reinforcing steel, structural steel, concrete, and structural concrete (Alavi and Tavares 2009). Then the items with same units within each group are used to calculate the weighted average unit prices. Finally, the weighted average unit rate of each category of item and its corresponding quantities are used to calculate the HCCI using the chained fisher ideal index. The chained Fisher ideal index is considered to represent the cost growth experience more accurately compared to other indexes (e.g. Laspeyres and Paasche) and can be presented mathematically as shown in Equation 1. (OECD et al. 2010):

$$\text{Fisher Ideal index, } F = \sqrt{\frac{\sum_{j=1}^N p_{j,t} q_{j,0}}{\sum_{j=1}^N p_{j,0} q_{j,0}}} \times \frac{\sum_{j=1}^N p_{j,t} q_{j,t}}{\sum_{j=1}^N p_{j,0} q_{j,t}} \quad (1)$$

In the equation above, j is the pay-item number, p is the average unit price, and q is the quantities. Index 0 and t represent price and quantities in base year and current year respectively. The bid data contains a large number of unit prices and corresponding quantities that are used to calculate the average unit price.

The average unit price, p in equation (1), is calculated as a quantity weighted unit price, i.e. the sum of multiplications of unit prices and corresponding quantities divided by the sum of the quantities:

$$\text{Average unit price of bid item } j, p_j = \frac{\sum_{i=1}^M p_{j,i} q_{j,i}}{\sum_{i=1}^M q_{j,i}} \quad (2)$$

where, index M represents the instances of projects using the same bid item in a given period of time. However, this method of averaging the unit price essentially creates a biased average unit price due to the effect of larger projects with larger quantities. For instance, Rueda Benavides (2013) found that there is an inverse exponential relationship between the unit price and the quantity as shown in Figure 1.

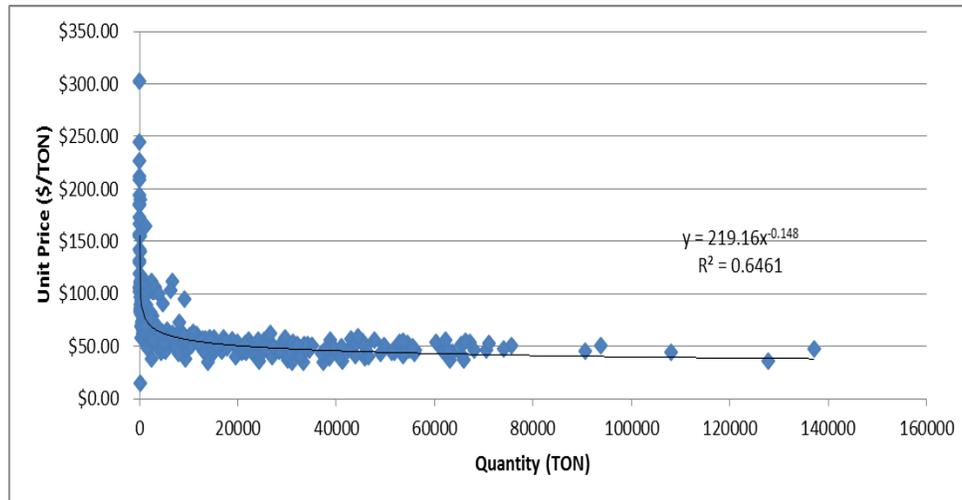


Figure 1 Unit Price Variation with the Quantity

(Minnesota DOT wearing course) (Rueda Benavides 2013)

This inherent bias exists irrespective of the indexing formula (Fisher, Laspeyres, Paasche, etc.) used. As a result, the overall cost estimation based on such index becomes overly optimistic for most projects which are smaller in size. This essentially leads to the cost growth of the project over time from planning stage to bidding stage. This bias is also noted in a recent Colorado DOT report (Mills 2013). Such quantity effect is not currently considered in the MDT HCCI index system.

Many state DOTs have limited their HCCI calculation to the use of bid item code, unit price, and total quantity in the bid tabulation data. There are multiple databases within state DOTs with information such as project information, project location, highway density, highway routes, and locations of construction companies eligible to bid. Most HCCI calculation methodologies do not have a documented process for taking account of such project characteristics stored in those databases (Anderson et al. 2009). Consideration of such databases for more detailed cost estimates have the potential to give more accurate cost estimates (Paulsen et al. 2008). Those databases should be selected, preprocessed and transformed before any data analytics is applied. The spatial aspect is the most important, yet the most neglected aspect of all. MDT's Geographic Information System (GIS) based Highway Economic Analysis Tool (HEAT) only considers rural and urban locations (Wornum et al. 2005) due to the lack of a proper methodology to take account of the spatial factor. It is apparent that construction costs in Helena are likely to be different from the construction costs in Plentywood area. The notion behind using the spatial factor is, as Campbell (2010) stated, "everything is related to everything else, but near things are more related than distant things." In case of highway construction, the location not only considers rural/urban settings but can also account for differences in construction methods, design variations, and environmental issues specific to a particular location.

The technique has been actively used in other industries like Dow Jones Industrial Average (stock market index) (“Dow Jones Industrial Average” 2014). In the construction industry, efforts have been made to develop time-series models for forecasting input cost indexes (see for example (Ashuri and Lu 2010; Shahandashti and Ashuri 2013)) – however such forecasting models have not been developed and implemented for highway projects yet. The current forecasting methods used were found to be highly unreliable. The better the forecasts are, the better the business plans of the MDT can be.

Some of the major limitations discussed above have resulted in the use of HCCI as a very rough indicator of the market conditions. By applying advanced data analytics, we can significantly improve the accuracy of the HCCI and its predictions so that it can be used to make early cost estimates for reliable project budgeting, as a better replacement for the constant inflation rate currently used in MDT and to visually and effectively communicate current market condition variations across the state of Montana.

BENEFITS AND BUSINESS CASE

Accurate cost estimation has been a challenging job because of multiple factors such as material cost volatility, lack of methodologies to take account of project characteristics, spatial and temporal aspects, inadequate project scope, and traffic control requirements (Anderson et al. 2007). In addition, the planning level budgeting of future projects is challenging because of uncertainty in the federal as well as state level budget for highway projects. The HCCI is an indicator of current market conditions and hence the purchasing power of a highway agency. The trend of current market conditions can then be used to reasonably predict future market conditions. Thus, HCCI serves as an early warning system for possible cost fluctuations. The HCCI can be used to convert highway construction costs from current-dollar expenditure to constant-dollar expenditures. As a result, HCCI can be used by the agencies to make early project decisions based on changing amount of financial resources and changing market conditions.

This study will develop a noble and innovative method of calculating the HCCI that can meet MDT's needs by reflecting regional and national trends. The new methodology developed in this study is expected to significantly improve the accuracy and reliability of HCCI for planning and budgeting future projects. The study will also make active use of the investment made by MDT in the GIS. A GIS tool that will be developed in this study can be used to visualize cost zones that are experiencing higher cost growth. In addition, the tool will also allow the utilization of the spatiotemporal map to generate clusters of cost zones with varying degrees of cost growth over time. Such cost zones can be used to estimate project costs for various locations taking account of the spatial effect. It will also help in identifying possible reasons of the cost growth across different locations. Also, the HCCI calculation methodology and tool developed in this study will also take account of other factors such as temporal effect, quantity effect, and the effects of other project characteristics that can be used for the cost estimation during the planning, budgeting, as well as bid level cost estimation.

The result of all improvements in the current systems of planning and budgeting is expected to increase the ratio of the executed to planned projects and the ratio of completed to executed projects by making the optimal use of the available budget. In other words, the study will aid in making the optimal use of the available budget so that the MDT TCP will have just the right number of projects which can be executed in the given fiscal year. This will ensure that the designers are spending sufficient time for the projects that will be executed in the fiscal year and not distracted by the projects that will not be executed soon. The study will also ease the decision making process for the project planning and budgeting by presenting the required data not only numerically but also visually. The results of the study are expected to be a major enhancement for early project cost estimating. The tools developed from this study can be added to the list of the tools in MDT's cost estimation procedure guideline (MDT 2007).

OBJECTIVES

The overall goal of this study is to assist MDT in improving their current estimation practices by developing a Montana specific HCCI methodology that can improve the accuracy and precision of project estimates. The specific objectives to accomplish this goal are listed below.

- Determine the current state-of-the-practice in using construction cost index (CCI) data to develop project estimates, pinpointing gaps in the current knowledge base, and identify successful practices that may exist
- Develop a Montana specific HCCI methodology by identifying and using factors applicable and available to MDT and develop a Microsoft Excel based tool to determine HCCI
- Develop a method for using HCCI data to improve the accuracy and precision of project cost estimates and validate that method using historical data to determine its effectiveness
- Develop a GIS tool to visually show construction market conditions in Montana. This GIS tool will be developed in accordance with MDT IT standards and working with MDT Mapping staff
- Develop an HCCI update process and schedule
- Develop web-based interactive training modules

RESEARCH PLAN

The research plan has been developed to accomplish the research objectives effectively. Figure 3 shows the overall research plan. The research plan is divided into six phases and ten different work tasks. The specific descriptions of each phase and task are provided in the following section.

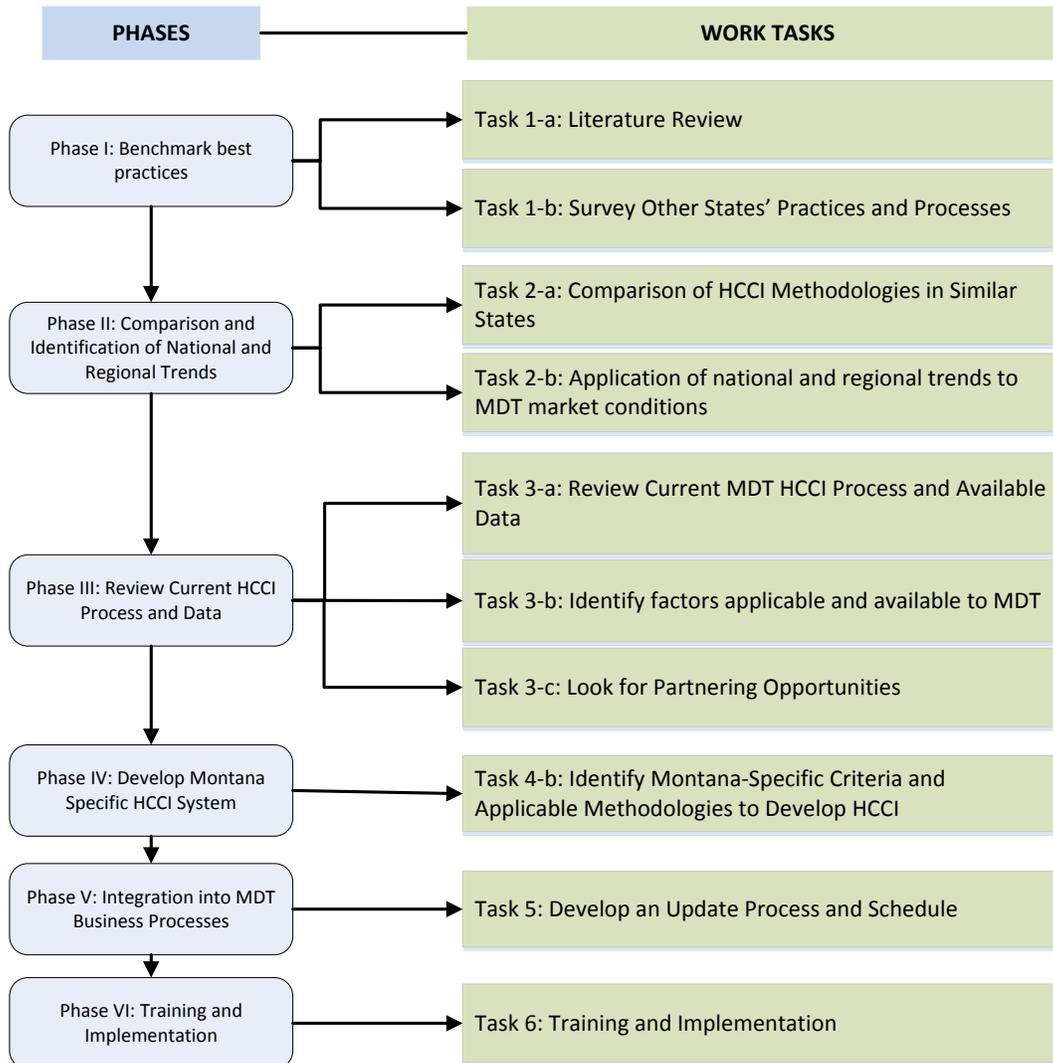


Figure 3 Overall Research Plan

Phase I: Benchmark best practices

The first phase will consist of a kick-off meeting, review of existing literature, and survey of other state DOTs to document their methods and practices and benchmark the best practices.

Task 1-a: Literature Review

The research will begin with a kick off meeting between the research team and the MDT technical panel members. This will give a clear understanding of expectations from the MDT as well as tasks to be completed by the research team. After that, the research team will review the

existing literature on the use of bid tabulation data, HCCI calculation methodologies, applications of HCCI, planning and budgeting procedure, and other cost index models such as ENR CCI, RS Means Cost Index, Eurostat CCI, Global Insight, UCLA Cost Index, CPI, PPI etc. During this task, the documented practices in state DOTs will be extensively reviewed. Some of the relevant studies include a study by United Nations (United Nations 2008) on various types of indexing formulas like Fisher, Laspeyres, Paasche, Divisia, Yong, Tornqvists, and chained indexes; use of HCCIS (Duval 2013); studies to forecast the HCCIs (Ashuri and Lu 2010; Shahandashti and Ashuri 2013; Wilmot and Mei 2005; Xu and Moon 2013), and use of input cost indexes (Pinkasovitch 2013). Iowa State University subscribes to the major construction engineering journals that will be used to obtain the relevant and recent studies.

Task 1-b: Survey Other DOTs' Practices and Processes

A quick review of some state DOT websites shows that some DOTs publish their HCCIs on their websites while most of them do not publish a detailed methodology of calculating the HCCI. After collecting some information about the procedures employed by different DOTs in task 1-a, a survey questionnaire will be developed to learn detailed and specific information about their existing procedures (such as the process of selecting bid items, current bid items that are used, a mathematical formula to determine HCCI, sub-indexes if any, and a procedure used to forecast HCCI if any) and the current usage of HCCIs within the DOTs and by external parties. FHWA's current research project entitled *Index Based Cost Estimation with Accuracy and Precision Analysis* includes survey results of DOTs regarding their indexing practices. This result will be used to effectively design the questionnaire in this study. The survey will specifically focus on identifying innovative ideas that have been applied or in the development phase in other state DOTs. The survey will also identify external cost indexes tracked by state DOTs, methodologies used to compare their HCCIs with external indexes and methodologies to monitor the current and future construction market fluctuations in their state. The list of personnel to be surveyed and the survey questionnaire will be provided to the MDT technical panel before conducting the survey as per MDT requirement. The tailored design method for survey developed by Dillman (2011) will be used to develop a questionnaire survey for this research. A Web-based platform – Qualtrics – will be used for the survey which will reduce time and effort required by survey participants to complete the survey. ISU has a university-wide license for Qualtrics and it can be used at no additional costs. The web-based method allows for collecting partially completed questionnaires and it also makes use of skip logics to present only relevant questions to the survey participants. The readability of the questionnaire will be checked using Flesch-Kincaid readability index before sending it to survey participants to ensure that the questionnaire will be clearly understood. The research team will also seek feedback from MDT technical panel for the questionnaire developed in this task. Follow-up communications with survey participants via emails and telephone calls will be made to collect additional and necessary information to better understand their practices and processes. The survey results will be statistically analyzed and systematically documented for further analysis in the next work tasks.

Phase I activities will be able to determine the current state-of-the-practice in using CCI data to develop project estimates, pinpoint gaps in the current knowledge base, and identify successful practices that may exist.

Phase II: Comparison and Identification of National and Regional Trends

The main goal of the second phase is to compare HCCI methodologies in similar states to Montana, and identify and document national and regional trends in developing HCCI.

Task 2-a: Comparison of HCCI Methodologies in Similar States

After conducting the nationwide survey, the responses from the survey as well as the information collected from the literature review will be used to compare different processes of determining HCCI in different DOTs using SWOT analysis. SWOT is an acronym for Strength, Weakness, Opportunity, and Threat which is traditionally used to identify and evaluate internal and external factors affecting the strategic planning and decision-making in an organization (Renault 2014). It is equally applicable to comparing the benefits and limitations of various processes used to determine HCCI. While analyzing and comparing the methodologies used in other state DOTs, DOTs which are similar to MDT in terms of lane mile density, weather, geographical conditions, design criteria, etc. will be identified and their HCCI systems will be extensively studied for possible adaption of their methodologies in this study.

Task 2-b: Application of national and regional trends to MDT market conditions

Recent national and regional trends in developing and utilizing HCCI will be captured and documented. The relevance of those trends to MDT market conditions will be evaluated and possible application areas will be identified.

Phase III: Review Current MDT HCCI Process and Data

In this phase, the research team will comprehensively review the current MDT HCCI processes and identify data available to develop an advanced HCCI system. The research team will also look for partnering opportunities with surrounding states on data sharing and methodology.

Task 3-a: Review Current MDT HCCI Process and Available Data

The research team will comprehensively review the current process to develop MDT HCCI and current practices in using HCCI data. This includes mathematical models used to calculate the HCCI, bid items that are used in calculating HCCI, and any other databases used in the HCCI process. The researchers will communicate with the MDT personnel to get relevant documents as well as interview the personnel for additional undocumented information. A structured interview guideline will be prepared and sent to the MDT personnel before the interview. The interview will also be used as an opportunity to brainstorm new ideas for HCCI. During the interview, the availability of bid data and other relevant data such as project information including project location, project type, project size, as-planned and as-built cost, as-planned and as-built duration/schedule, special contracting terms, and project duration will also be evaluated. The accuracy of these data points (for example, project location accuracy at 1 mile or 1 meter level) will be discussed with the technical panel members and the appropriate accuracy will be determined for this study. The past five to seven years of data will be considered in this study with the approval of the technical panel. Also, as part of bid item data, fuel price components will be obtained and studied in this study.

Task 3-b: Identify factors applicable and available to MDT

With the results from Task 3-a, the applicability of those databases and data attributes will be studied. The research team will collect databases and data attributes identified as potentially useful for this study. The preferred format of the data is MS Access – a relational database – as it can be queried to generate customized results. Most of the data are likely to be stored in the AASHTOWare software products currently used in MDT. The quality and completeness of the data will be tested and preliminary analysis of the data will be performed. In addition, access to the MDT GIS database will also be required for spatial analysis. The early collection of data would allow researchers to conduct preliminary analysis.

Task 3-c: Look for Partnering Opportunities

The contact points obtained for the survey will further be utilized to look for the opportunities of partnering for sharing the unit price data with other neighboring states in a single repository. Such data sharing has been practiced among the Western Federal Lands Highway member states for certain type of projects (FHWA 2011). Their experience will be useful for developing a GIS based data sharing platform in the future. This can be useful for not only MDT but also for the neighboring state DOTs. It will also open doors for neighboring DOTs to further utilize the tools and methodologies developed from this study. It can be used to study the correlation between the HCCIs for neighboring locations of different states.

Phase IV: Develop Montana Specific HCCI System

Phase IV is the most important stage of the project. The research team will identify MDT specific criteria and develop an advanced HCCI system.

Task 4: Identify Montana-Specific Criteria and Applicable Methodologies to Develop HCCI

The research team will use the results from previous phases to identify Montana-specific criteria and applicable methodologies to develop an advanced MDT HCCI system. The use of MDT specific data will ensure that the criteria are relevant to MDT's business environments and needs. Some preliminary tasks to be performed are:

- Determination of base year
- Identifying major items for market basket and corresponding weights
- Selection of indexing formula
- Frequency determination of calculating and updating the HCCI.

To develop Montana-specific criteria, MDT datasets will be first cleaned to remove non-relevant data attributes. For example, the data will be analyzed to eliminate lump sum items and infrequent items which may not be useful and relevant to HCCI. The current data cleaning procedure is considered very labor-intensive. The research team will study the feasibility of developing a semi-automated tool to clean data in Microsoft excel using macros.

As of now, the outlier detection of unit price data is done with arbitrary parameters. In the National Highway Construction Cost Index (NHCCI) system, for example, outliers are identified as any unit prices with at least two standard deviations from the mean. Unit prices can vary largely because of the effect of the location and quantity among others. As a result, such method can falsely mark some items as outliers and remove them from further calculations. Those

arbitrary criteria should not be used and a proper statistical tool should be used to justify such criteria.

Figure 4 show the concept of multiple highway construction cost indexes for major bid items that are specific to location, project size, and project type. For major bid items that are to be included in developing HCCI, this concept will be applied and HCCI cubes will be developed. The research team will utilize GIS tools to determine the unit price distribution across the state as shown in Figure 2. As a result, the state of Montana will be divided into several different cost zones (e.g. low, medium, and high). In addition, an analysis will be performed to identify the movement of the zones over time. This temporal variation of spatial cost zones will help to identify another level of insights. For instance, the movement of the cost zones can indicate the population growth in the region or a newly established contractor in the region.

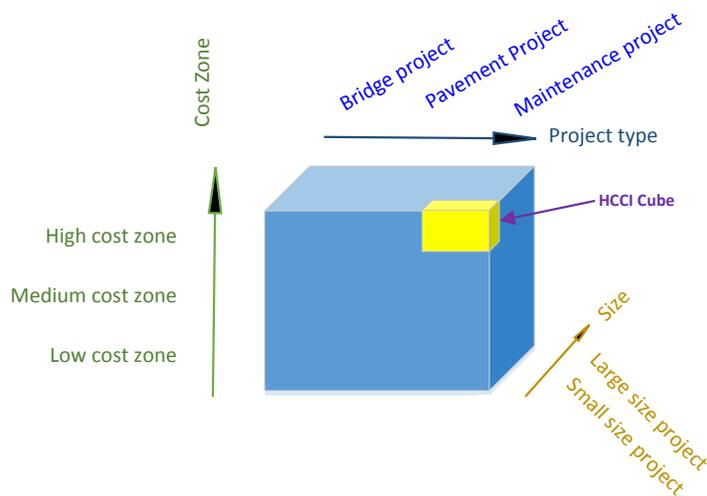


Figure 4 Highway Construction Cost Index Cubes

Major bid items in terms of their impact on total costs and volatility would be analyzed to develop a market basket. The feasibility of utilizing a dynamic market basket approach will be studied where the market basket will change over time. In a dynamic market basket, the bid items will also have a dynamic weighting. It is necessary to ensure that the HCCI would be consistent even after utilizing the dynamic market basket.

Sub-indexes can be generated for each different location category which would provide valuable information during the planning and budgeting phase if the location of a project is known. It will give a visual clue to the decision makers about the different level of cost growth in different areas of the state. In addition, sub-indexes will be developed for different project types and sizes.

A methodology to forecast the MDT HCCI will also be developed to be used as a potential inflation rate to estimate the cost growth of a specific type of future projects. The forecast methodology will be based on time-series analysis. The forecasts based on the historical HCCIs will further aid decision makers to plan ahead of time using the existing data. Finally, a complete

Microsoft Excel based tool will be developed for MDT personnel to use in determining sub-indexes and overall indexes as well.

Phase IV activities will also be able to develop a method for using CCI data to improve the accuracy and precision of project cost estimates and validate that method using historical data to determine its effectiveness.

Phase V: Integration into MDT business Processes

In phase V, the methodology and tools developed in phase IV will be integrated into the existing MDT business processes.

Task 5: Develop an Update Process and Schedule

Under this task, an update process and schedule will be developed and documented. The update process will provide sufficient details on how to update the HCCI system and how frequently the system needs to be updated with input from the technical panel members. If there is rapid change in prices and market conditions, more frequent analysis and updating would be deemed necessary. This HCCI updating process should appropriately reflect the MDT current business operating processes.

Phase VI: Training and Implementation

This is the final phase of the study. In this phase, a workshop style training session will be provided to the MDT personnel for rapid dissemination of the research findings. Also, internet based interactive training materials will be developed for autonomous learning.

Task 6: Training and Implementation

The tools and the methodology developed in this project will be quickly disseminated to the potential group of users in MDT through a workshop style training session. In addition to the training session, web-based interactive online training materials will be developed and provided for continuous use in the future. The Department of Civil, Construction, and Environmental Engineering at Iowa State University has an experienced online learning material development team that can provide technical support in developing highly professional interactive training modules for this project.

MDT INVOLVEMENT

The proposed study will require involvement of MDT personnel and resources. The research team will need assistance from MDT personnel who have knowledge in the current practices of HCCI and its use throughout the project development process. The research team will also need feedback from the technical panel members on a questionnaire that will be developed for a nationwide survey. MDT personnel will also need to review the list of the contacts who will be surveyed for the study. In addition, the MDT personnel is expected to be available for meetings regarding the research tasks and issues identified during the research. The team may also need help from MDT librarian to access some of the internal reports and documents.

The bid databases and project information databases will be required from MDT. In addition, the research team will work with MDT Mapping staff in accordance with MDT IT standards to obtain and use the MDT GIS database for spatial analysis. In addition to the databases, any tools (such as spreadsheets, AASHTOWare software) that are currently used to calculate the HCCI and preliminary project cost estimation will also be required for the study.

PRODUCTS

Following are the list of products to be developed from this research:

- ★ Best Practices to determine HCCI
- ★ Methodology to determine MDT specific HCCIs
- ★ MS Excel based tool to determine MDT specific HCCIs
- ★ GIS based tool/methodology for visualizing the HCCI data
- ★ Quarterly progress reports
- ★ Task reports (One report for tasks 1a & 1b, one report for tasks 2a & 2b, and one report for tasks 3a through 3c. Tasks 4 – 6 will be part of the final report)
- ★ Final report with recommendations
- ★ Project summary report
- ★ Implementation meeting and report
- ★ Onsite training for MDT staff involved with HCCI process
- ★ Web-based Interactive training materials for future use

All products will be prepared using the latest MDT guidelines and requirements to meet MDT quality standards. The Institute for Transportation (InTrans) at ISU has a full time technical writing and publications staff. All products will be reviewed and edited by the technical writer at Institute of Transportation (Intrans) to ensure professional quality.

IMPLEMENTATION

The Highway and Engineering Division will be responsible for implementation of the research results. The implementation plan for the project is as follows:

- ★ Delivery of the research products to MDT
- ★ On-site workshop style training for MDT staff in Phase VI.
- ★ Delivery of Web based interactive training materials to MDT and uploaded to MDT website. – Month 1
- ★ Train key personnel – month 3
- ★ Train other personnel by the key personnel and using the web based materials – month 5
- ★ Evaluation of the performance of new HCCI system – month 6
- ★ Update the methodology as required – month 9
- ★ Implement new system state-wide – Month 9.

The implementation of the results will affect the process of planning and budgeting highway projects, and possibly other cost estimating related activities throughout the project delivery process. The tools developed in this study will be based on Microsoft Excel and GIS. MDT already uses GIS for other tasks, thus, there will be no additional costs associated with the implementation from IT aspects. There will be additional costs to MDT for training the personnel, which is a necessary activity for successful implementation.

SCHEDULE

The proposed schedule for the project is presented in Table 1

Table 1: Project Time Schedule (updated)

Work Tasks	2015												2016												17
	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1
Task 1-a: Literature Review	█	█	█	█																					
Task 1-b: Survey Other States' Practices and Processes			█	█	█	█																			
Task 2-a: Comparison of HCCI Methodologies in Similar States					█	█	█	█																	
Task 2-b: Application of national and regional trends to MDT market conditions							█	█	█																
Task 3-a: Review Current MDT HCCI Process and Available Data							█	█	█	█															
Task 3-b: Identify factors applicable and available to MDT							█	█	█	█															
Task 3-c: Look for Partnering Opportunities								█	█																
Task 4: Develop Montana Specific HCCI system												█	█	█	█	█									
Task 5: Develop an Update Process and Schedule																			█	█					
Task 6: Training and Implementation																				█	█				
Review																							█	█	
Final report submission																								█	
Major Milestones																									
- Kickoff meeting	★																								
-Data Collection trip to MDT							★																		
- MDT Training																						★			
- Draft Report submission																						★			
- Final Report Submission																								★	
- Quarterly reports		★			★			★			★			★			★			★			★		

BUDGET

Required fiscal year and summary budget breakdown are shown in Table 2, 3, and 4. Table of Key personnel with hourly pay rates and benefits are itemized in Table 5.

Table 2: Budget broken down by Federal and State Fiscal Year

Table 3: Proposed Budget Broken Down by Task

Table 4. Proposed Budget Summary

Table 5. Pay and Benefit Rates for Key Personnel

Itemized IN-Country Travel Costs

Travel Costs are based on the information contained in Table 6.

Table 6. In-Country Travel Costs

Face-to-face TAP meeting	Unit Cost	Quantity	Total Cost
Airfare (3 people)	\$800	3	\$2,400
Lodging (3 rooms/night)	\$70	6	\$420
Per Diem (2 days)/person	\$56	6	\$336
Rental Car/Day	\$70	2	\$140
Fuel	\$40	1	\$40
Parking in DSM airport	\$40	2	\$80
Total			\$3,416

Data Collection Trip	Unit Cost	Quantity	Total Cost
Airfare (2 people)	\$800	2	\$1,600
Lodging (2 rooms/night)	\$70	6	\$420
Per Diem (3 days)/person	\$56	6	\$336
Rental Car/Day	\$70	4	\$280
Fuel	\$70	1	\$70
Parking in DSM airport	\$55	2	\$110
Total			\$2,816

Training and Final Presentation	Unit Cost	Quantity	Total Cost
Airfare (3 people)	\$800	3	\$2,400
Lodging (3 rooms/night)	\$70	6	\$420
Per Diem (2 days)/person	\$56	6	\$336
Rental Car/Day	\$70	2	\$140
Fuel	\$40	1	\$40
Parking in DSM airport	\$40	2	\$80
Total			\$3,416

Total in-country travel costs: \$9,648

STAFFING

A Highly qualified research team has been assembled for this research project. Both PIs have sufficient experience and knowledge in cost estimating, risk management, project delivery process and project management which are a required set of expertise for successful completion of the proposed project. Dr. David Jeong will be the PI for this project overseeing the entire progress of the project. Dr. Doug Gransberg will participate in this project as Co-PI and one PhD level graduate student from ISU's department of Civil, Construction, and Environmental Engineering will be hired throughout the project.

Dr. Jeong has conducted several research projects on the active use of construction data to support data-driven decisions. Most of his previous and current research projects are highly related to project estimating, cost engineering, highway project management, infrastructure asset management and data analytics for project management. He has published more than 50 technical journal and conference papers in this area for the past 10 years. He also has 6 years of industry experience in bridge and highway construction projects as project engineer and cost engineer. He has won the 2010 Construction Industry Institute (CII) outstanding researcher of the year award and he is the recipient of the 2008 Institute of Industrial Engineers (IIE) Transactions Award for Best application paper in Operations Engineering. Several of Dr. Jeong's past funded research projects that are directly related to this work are listed below:

- Co-Principal Investigator, "Preconstruction Services Estimating Guidebook," 2013-2015, NCHRP Project 15-51,
- Principal Investigator, "Data and Information Integration Framework for Highway Project Decision Makings", Oklahoma Transportation Center, 2012-2013
- Principal Investigator, "Procedures and Models for Estimating Preconstruction Engineering Costs of Highway Projects", Oklahoma Transportation Cener, 2010-2012
- Principal Investigator, "Estimating as a Competency in Capital Projects", Construction Industry Institute, 2007-2009

Dr. Doug Gransberg holds the Greenwood Endowed Chair in Construction Engineering at the ISU CCEE Department and brings over 20 years of research experience and 20 years of industry experience to the project. He is currently PI on the NCHRP 15-51 "Preconstruction Service Cost Estimating Guide." He has also served as PI/Co-PI on 53 funded research projects worth a total value of \$12.0 million sponsored by National Cooperative Highway Research Program, the National Science Foundation (NSF), the Departments of Transportation in California, Minnesota, North Carolina, Oklahoma, Oregon, Texas, and Washington State, as well as, several privately funded research institutes. Several of Dr. Gransberg's past funded research projects that directly relate to this work are listed below:

- Principal Investigator, "Develop Parametric Cost Estimating System," 2010-2011, San Antonio Water System
- Co-Principal Investigator, "Project Management Strategies for Complex Projects," 2009-2014, SHRP2 Project R-10, Transportation Research Board.
- Principal Investigator, "Preconstruction Services Estimating Guidebook," 2013-2015, NCHRP Project 15-51,

- Co-Principal Investigator, “Quantification of Cost, Benefits and Risk Associated with Alternative Contracting Methods and Accelerated Performance Specifications,” Federal Highway Administration, 2013-2015.
- Co-Principal Investigator, “Construction Manager General Contractor Risk Assessment,” MnDOT Project 2010-077, 2010-2011

A PhD level graduate student will get involved in this project. The student has been working on a Mid-American Transportation Center funded project that aims to make data-driven decisions using the daily work report data collected by state DOTs. Since January 2014, he has also been working on Iowa DOT bid tabulation data to develop unit price distribution across the state. Thus, the student has good knowledge and experience on project cost estimating issues.

Table 7 provides detailed breakdown of staff hours allocated for each work task.

Table 7. Project Staffing

Name of Principal, Professional, Employee, or Support	Role in Study	Tasks											Percent of Time vs. Total Project Hours	Percent of Time - Annual Basis (total)
		1-a	1-b	2-a	2-b	3-a	3-b	3-c	4	5	6	Total		
Dr. Jeong	PI	15	15	25	25	40	40	10	50	10	10	240	11%	12%
Dr. Gransberg	Co-PI	5	10	10	10	15	15	10	25	10	10	120	6%	6%
Grad Student	Data collection, analysis, and evaluation	80	100	100	100	140	140	30	800	150	100	1740	81%	84%
Editor*	Report Preparation, editing, and review	0	0	0	0	0	0	0	0	20	30	50	2%	2%
TOTAL		100	125	135	135	195	195	50	875	190	150	2150	N/A	N/A

*Editor hours included in the \$2,500 lump sum for communications services per Intrans policy.

FACILITIES

The scope of work outlined in the Research Plan has very little equipment or facility needs associated with any of the tasks. For this research, the level of support services within the institutions will be more important than physical equipment and facilities, although ISU has exceptional facilities for high quality research.

The ISU research team is affiliated with the Institute for Transportation (InTrans). Resources at InTrans include access to staff specializing in publications work, computer facilities, student resources, and professional staff. InTrans is an ISU research institute administered by the Office of the Provost for Research and Advanced Studies.

The proximity of InTrans to the university campus and the state transportation agency offers tremendous opportunities to share resources and provides an integrated knowledge community environment. Resources at InTrans also allow researchers to maintain websites for information exchange and provide access to e-mail lists, conference programs, and training calendars for federal and state highway administrations. Such access will be critical in both gathering and disseminating information, including feedback on the research products and planning and delivering the research findings.

ISU also supports a world-class library with collections totaling more than 2.2 million volumes and close to 22,000 currently-received journals and serial publications. The Iowa Department of Transportation (Iowa DOT) maintains a synergistic working relationship with the university, providing programmatic support for InTrans, while InTrans conducts significant research and development work for the Iowa DOT. The Iowa DOT also manages an excellent transportation library with many specialty publications and access to TRIS, which InTrans students and staff use regularly.

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