A Labor Cost Analysis of the Design Review Process at the U.S. Army Corps of Engineers, Wilmington District Design

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Abstract
The U.S. Army Corps of Engineers (USACE) mission is crucial to the nation's security and resilience of our infrastructure. As steward of public trust and funding, it is fundamental to design and construct with the highest standards and tradition of quality. The Wilmington District adheres closely and invests significant man-power to comply with a clearly defined guidance for design products quality reviews. Historical project data was analyzed on this research paper with the primary objective of measuring the level of effort invested on design reviews and create a numeric relationship or proportion to the cost increase during construction. This proportion is defined as the Efficiency Ratio (ER); the ratio between the costs of Change Orders per every hour of labor invested in review. The ER is expressed as a decimal number that gives us a graphical representation and attempts to illustrate the level of effectiveness from one perspective. In times of funding challenges and limitations, it is imperative that the distribution of human resources is capitalized and not challenged by it. The conclusions of this analysis provide project teams and management with a tool to prioritize or reallocate resources where the cost benefits and construction cost savings are maximized. Conclusions suggest that resources currently invested in reviewing a certain type of project may be shifted to provide additional review for other type of projects that are resulting in higher changes during construction.

Keywords
Design review, construction labor, USACE.

1. Introduction

The U.S. Army Corps of Engineers (USACE) was founded just a year before the Declaration of Independence and has served our country since 1775. During the early 19th century, Congress and presidents assigned military engineers to such duties as surveying, mapping, locating routes for superintending the construction of roads, canals, and coastal defensive works (http://www.saw.usace.army.mil, 2017). This unique organization is cemented on sound engineering design, construction, and the quality of all its professionals.

In present days, the USACE Wilmington District is tasked with providing design and construction services to the Special Operations Command (SOCOM) residing within the Fort Bragg Army facility in Fayetteville, North Carolina. With approximately 57,000 military personnel, 11,000 civilian employees and 23,000

family members, Fort Bragg is one of the largest military complexes in the world (www.bragg.army.mil, 2017), continuously growing, and requiring the design and construction of new facilities, buildings, and infrastructure upgrades on a continuous basis.

Tasked with such a demanding mission and protective of such tradition and the preservation of its quality principles, the District invests a significant effort, resources, and funding in the quality assurance of design and engineering products. Army guidelines mandate that all design and construction activities intended for contract award follow the process of quality management executed within the District (US Army Corps of Engineers, 2006). The quality management process consists of a series of progressive technical reviews of the design packages performed by internal USACE resources throughout the design stages and at major design milestones and deliverables. The review process is intended to verify the technical completeness and accuracy of the design products and reduce risks of cost, time growth, and unnecessary changes and claims during construction.

The review process is formally documented through comments written by each reviewer at each phase of design. A normal project will produce hundreds or even thousands of comments that must be addressed, discussed, and resolved between the reviewer originating the comments and the designers. The number of comments submitted by each reviewer can be a general indication of the project complexity, but it is also in great part an indication of the level of effort invested by each reviewer to accomplish the review task. The level of effort is translated into labor hours or man-power cost for the District.

There is easily obtainable and accurate data to compare the number of review comments generated per project versus the dollar cost of change orders executed during the construction phase. This data is available for dozens of projects in recent years and for projects of different levels of complexity and construction cost. This comparison will provide a relationship between the labor efforts invested during design phases and the resulting cost of change orders during construction and can illustrate the level of effectiveness from this perspective.

This analysis is based on the reasonable assumption that more review effort and labor time invested on a project during its design phase would result in minimizing the costs of change orders during construction. However, I could not identify a tangible or readily available tool for statistically determining that relationship and if there is a proportional relationship between more labor invested resulting in less change orders.

The objective of this research paper is to sample a significant number of projects to determine the relationship between the number of review comments and the dollar amount of Change Orders. A numeric value designated as the Effectiveness Ratio will be calculated and evaluated for each project type.

2. Background

The review process for USACE is fundamentally based on a regulation defined as BCOES. The purpose of this regulation is to "*establish policy and systematic procedures for conducting effective reviews of a project's Biddability, Constructability, Operability, Environmental, and Sustainability (BCOES) characteristics. These reviews are done during design for a project using the design-bid-build (D-B-B) method or during development of the request for proposal (RFP) for a design-build (D-B) project. The BCOES review results are to be incorporated into the procurement documents for all construction projects."* (US Army Corps of Engineers, 2013)

In compliance with the BCOES regulation, the series of technical reviews performed at the District consists of Design Quality Control (DQC) at every major design milestone and a final BCOES review performed just before the projects are issued for solicitation. This process is performed for all design products that are

developed by both USACE internal resources ("In-house") or by contracted A/E firms and that exceed the minimum threshold of $ 150,000 of construction cost. The review process is documented through comments written by each reviewer at each phase of design.

2.1 Design Quality Control Reviews (DQC)

District Quality Control / Quality Assurance (DQC) is the backbone of USACE's quality process. (US Army Corps of Engineers, 2016). Internal technical resources, typically professional engineers and architects, perform this review. For a typical Design-Bid-Build (D-B-B) project where the design is developed on its entirety and of significant complexity, a total of three DQC review efforts are performed. An initial review is performed at the Conceptual/Schematic Phase (35%), a second review at the Design Development Phase (65%) and a third and final at the Construction Documents Phase (95%).

On a Design-Build (D-B) delivery project the District partially develops a design that will be finalized by the awarded D-B Contractor. Two to four DQC reviews will be performed to the design submittals and the Release for Proposal (RFP) documentation depending on the project's complexity. The design contained on a typical D-B RFP package fluctuates between 35% and 65% development.

2.2 BCOES Reviews

In addition to the DQC series of technical reviews, a final review is performed right before projects are solicited for construction. BCOES is defined as Biddability, Constructability, Operability, Environmental and Sustainability. The main objective of this review policy is to *"minimize problems during the construction phase through the effective checks performed by knowledgeable experienced personnel prior to advertising for a contract" and "help to ensure that the government's contract requirements are clear, executable, and readily understandable by private sector bidders or proposers."* (US Army Corps of Engineers, 2013). A fundamental difference between the DQC and the BCOES is that the contract General and Supplementary Conditions (USACE, Contracting Front End) are included in the BCOES package and reviewed by the office of counsel within the District.

2.3 Review Comments Documentation

The USACE utilizes the "Design Review and Checking System" (Dr Checks), a secure, internet-based system to document all review comments originated throughout the process. (East, Kirby, & Kelly, 2001). All comments are entered by the reviewer into the software platform, followed by an analysis and response from the design team and when the comment is clarified and resolved, it is closed by its originator.

The District adheres to this tool for comments documentation. During the design phase, design submittal packages are received by the various teams within the District. Technical resources within those teams evaluate the content of the packages and enter their review comments into Dr Checks. A typical DQC and BCOES review period is open for 1-2 weeks to allow time to the reviewers to evaluate the package and enter comments. After this time window, the review phase is closed and no further comments can be entered until the next design phase review.

Once all the BCOES and DQC comments have been addressed and incorporated by the responsible designer and final resolution agreed with the reviewer, a BCOES Certification, containing a report of all review comments closed, will be signed by the District's Chief of Engineering prior to issue for bid.

3. Data & Analysis

The focus of this research paper is centered in the military mission projects by the USACE at the Wilmington District. All projects analyzed are related to new building construction and maintenance of facilities within that installation and constructed during the past seven years. A total of 40 projects were analyzed and the list was broken down into three types (Type A, B, and C) based on their construction contract amount therefore grouping them into similar scope and complexity, as shown in Table-1.

Table 1: Cost Range of the Construction Project Analyzed in This Research

Projects Type	Construction Cost Range	
TYPE A	$0	$1,000,000
TYPE B	$1,000,000	$5,000,000
TYPE C	$5,000,000	$60,000,000

Three sources of data are gathered, tabulated, and analyzed with the objective of finding relationships and counterbalances between them. This data can be studied by the District's management to better understand the net results and efforts required for the design review process as it is currently executed. The data sources are the following:

3.1 Design Review Comments

The first data obtained was a detailed report from the Dr Checks (https://www.projnet.org, 2017) database containing the number of comments originated for all individual projects identified. Although the comments are broken down by design phase (35%, 65%, 95%, and BCOES), the total number of comments per project was analyzed as one overall figure. The nature and/or technical complexity of the comments are not part of the analysis of this research paper but it is suggested as future research. An overall number of almost 30,000 comments were originated for the 40 projects analyzed, yielding an average of 745 comments per project.

3.2 Change Order Costs

The second data set to compare is the Change Order Costs. The construction contract cost and executed change orders costs for each contract have been obtained for all the projects. Scrutiny was performed to determine that the change orders analyzed are only for changes or modifications during construction and do not include change orders related to previously negotiated alternate items or Bid Options.

The USACE utilizes the Corps of Engineers Financial Management System (CEFMS) (http://www.usace.army.mil/Finance-Center/, 2017) and the Resident Management System (RMS) (http://rms.usace.army.mil/, 2017) which maintain documentation and formalize the financial commitments for every construction contract including all change orders. Data from these two databases was obtained and tabulated to correlate with the design review comments data obtained from Dr Checks. The overall construction cost for the 40 projects analyzed exceeds the $ 500,000,000 with an average of 5-6% cost net increase resulting from change orders.

Table 2 illustrates a tabulation of all the gathered raw data and determines: (A) Average Change Orders / Project and (B) Average Number of Comments / Project

Table 2: Average Change Orders / Average Number of Comments per project

	N	E	F	G	H	A	I	B
					E / N	F / N		I / N
	Number of Projects Analyzed	Total Construction Cost Analyzed	Total Change Orders Analyzed	Increase Cost Percent.	Average Cost / Project	Average Change Orders / Project (rounded $10k)	Total Number of Comments	Average Number of Comments / Project (rounded 10)
TYPE A: $ 1M	10	$5,000,000	$250,000	5%	$500,000	$25,000	1200	120
TYPE B: $ 5M	9	$20,000,000	$1,000,000	5%	$2,222,222	$110,000	1600	180
TYPE C: $ 60M	21	$479,000,000	$29,000,000	6%	$1,380,952	$1,380,000	27,000	1,290
						A		B

3.3 Labor Effort

Lastly, the labor effort for the review tasks was estimated to create a numerical relationship between the costs of labor review and the costs of change orders. The design review process is labor intensive requiring project managers, technical reviewers, managers, customers, and many other stakeholders to invest a considerable effort. Major tasks include not only the actual technical review, but also, management and documentation of the process. Although the labor time invested is directly related to the complexity, how voluminous and familiarity of the reviewers with the type of project, there are administrative tasks and steps that need to be performed for every project creating a baseline labor effort.

Table 3: Estimated Labor Hours per Comment

	Task	Employees	Number of Reviews	Hours per Review	Number of Persons	Sub-Total (rounded)	
TYPE A: $ 1M	Review	Reviewers	2.2	4	4	35	
	Back checks	Reviewers		4	4	35	
	Management	PM		8	1	18	
	Design review meetings	PM + Reviewers		4	5	44	
			Total Number of Hours			132	D
			Average Number of Comments			120	
			Labor Hours per Comment			1.1	C
TYPE B: $ 5M	Review	Reviewers	2.4	8	6	117	
	Back checks	Reviewers		8	6	117	
	Management	PM		12	1	29	
	Design review meetings	PM + Reviewers		8	7	137	
			Total Number of Hours			401	D
			Average Number of Comments			180	
			Labor Hours per Comment			2.2	C
TYPE C: $ 60M	Review	Reviewers	3.4	12	10	411	
	Back checks	Reviewers		12	10	411	
	Management	PM		16	1	55	
	Design review meetings	PM + Reviewers		8	11	302	
			Total Number of Hours			1179	D
			Average Number of Comments			1290	
			Labor Hours per Comment			0.9	C

An average labor effort has been estimated for the design review of each project type (Type A, B, and C) utilizing factors such as: Number of Reviews (35%, 65%, 95% and BCOES), Number of Persons involved in the reviews and Labor Hours per review. Table 3 illustrates the method utilized for the labor estimate and determines: (C) Estimated Labor Hours per Comment.

4. Rationale

The objective of this analysis is to integrate and correlate these three parameters to estimate an Effectiveness Ratio (ER). The ER is formulated as the ratio of how much change order cost is related to one hour of labor invested in the review phase and helps us understand how much review time and labor is currently being invested on a project and what is the return on the investment of that time.

A. Average Change Orders / Project
B. Average Number of Comments / Project
C. Estimated Labor Hours per Comment

EFFECTIVENESS RATIO
= 1*hr of Review Labor: Cost of Change Orders*
= Average Reviewer Salary ($100) / Dollar amount in Change Orders

Table 4: Effectiveness Ratio

	A	B	C	D	E	A / D			E / (A/D)
	Average Change Orders / Project (rounded $10k)	Average Number of Comments / Project (rounded 10)	Labor Hours per Comment	Labor Hours for Review / Project	Average Reviewer Hourly Salary	1 hour of Review		Gvt Pays this $ in Change Orders	
TYPE A: $ 1M	$25,000	120	1.1	132	$100	1	:	$189	0.53
TYPE B: $ 5M	$110,000	180	2.2	401		1	:	$274	0.36
TYPE C: $ 60M	$1,380,000	1,290	0.9	1179		1	:	$1,170	0.09
AVERAGES	$756,250	745	1.4	1053	$100	1	:	$718	0.14

5. Conclusions

5.1 Projects Type A, Construction Cost up to $ 1M

The level of complexity, both in design and construction for this type of projects is limited with a maximum construction cost of $ 1M. The average Change Order per project is $25,000 equivalent to a base contract increase of 5%. An average of 120 review comments are originated and the overall review effort requires 132 labor hours.

The ER for projects Type A is 1: $189, meaning that per every hour invested in review, the District pays 1.89 times this cost in Change Orders resulting on an **ER = 0.53**.

5.2 Projects Type B, Construction Cost up to $ 5M

The level of complexity for this type of projects increases to moderate with a maximum construction cost of $ 5M. The average Change Order per project is $ 110,000 equivalent to a base contract increase of 5%, consistent with Projects Type A.

An average of 180 review comments are originated as compared to 120 for Type A, nevertheless the overall review effort increases from 132 to 401 hours. This is a significant 300% increase in labor hours required for this type of projects. It is acknowledged that this projects type may include more complex features such as complex site work, new primary infrastructure connections, secured facilities/SCIF, more specialized telecommunication requirements, and others that may result in an increase in review effort.

The ER for projects Type B increases from Type A to 1: $274, resulting on a **BR = 0.36**.

5.3 Projects Type C, Construction Cost up to $ 60M

These types of projects are of the highest complexity and number of features. Some of these projects will likely include multiple buildings or facilities therefore a much more elaborate design and construction. The average Change Order per project is $ 1,380,000 increasing to 6% when compared to Types A and B at 5% increase from the base contract.

A staggering increase of 700% in review comments is found when compared to Type B. An average of 1,290 review comments are originated for this Type, illustrating the significant increase in project complexity. The labor hours for review increase to 1179 hours, a 300% increase when compared to Type B.

The ER for projects Type C increase astronomically to 1: $1,170. This proportion is expected to be higher due to the higher costs of construction and for the higher risks of Change Orders due to the size and complexity of these projects.

The ER for these types of projects drops accordingly to just **ER= 0.09**.

- The average ER for all projects combined is 0.14, nevertheless this average is highly influenced by a very low ER for projects Type C and may not be indicative. The average between Types A and B is ER=0.44 and may be more indicative of the true effectiveness.

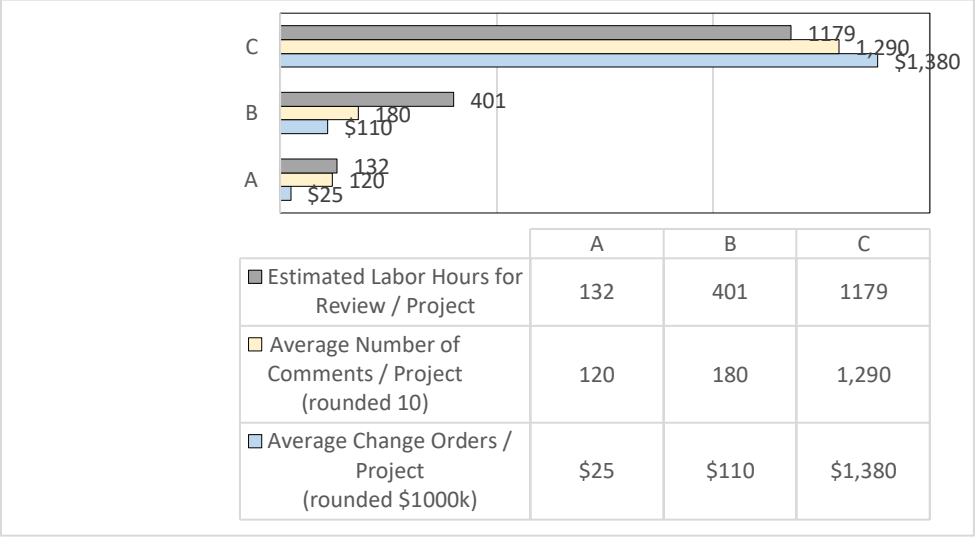
- ER for Type A = 0.53 and Type B = 0.36 reflect a uniform trend reflected as a constant construction cost increase (Change Orders) of 5% for both types of projects.

- The labor effort for projects Type B increases by 300% nevertheless the ER remains reasonably uniform. This is indicative that a substantially higher effort is required to account for the increase complexity in order to maintain the same level of Effectiveness Ratio.

- ER for Type C = 0.09 is below acceptable range and this is reflected as a level in construction cost increase (Change Orders) 6%.

- Analysis may suggest that resources currently invested in reviewing project Types A and B may be shifted to provide additional review for projects Type C where the ER is significantly lower and where there is enormous opportunity for costs savings and Change Order avoidance.

In times of funding challenges and resources limitations within the USACE, the conclusions of this analysis provide project delivery teams and management with a tool to prioritize or reallocate resources where they result in higher cost benefits, or in this case is higher construction cost savings.



	A	B	C
Estimated Labor Hours for Review / Project	132	401	1179
Average Number of Comments / Project (rounded 10)	120	180	1,290
Average Change Orders / Project (rounded $1000k)	$25	$110	$1,380

Figure 1: Labor Hours, Number of Comments and Change Orders Comparison

6. Future Research and Analysis

The topic of this research paper can benefit from future research and analysis efforts. The following areas could be explored:

- Investigate the specific causes or circumstances for change orders and identify by topic. By tabulating the causes of change orders, a trend, recurrence, and vulnerable areas can be identified. The identification of these vulnerable areas can benefit the design and reviewing team as follows:
    - Provide specific and direct attention to those areas during design review
    - Promote labor cost savings by assigning review to less experienced resources (such as recent graduates) that will have a very specific guidelines to follow and not rely entirely on their experience. This will guarantee that these areas are reviewed and provide developmental experience

- A tangible tool can be developed in the form of checklist or a simple computerized application to facilitate the work of reviewers and guarantee that those vulnerable areas are reviewed

In final conclusion, the analysis performed on this Research Paper is not intended to pass judgement on the review process or how it is being implemented at the Wilmington District, but rather provide project teams with a graphical representation of what the review process entails in terms of effort versus value. Also the future research identified could be a potential positive impact to the Districts continuous process of quality improvement.

7. References

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