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DEVELOPMENT AND UTILIZATION OF THE PROJECT DEFINITION RATING INDEX FOR SMALL INDUSTRIAL PROJECTS

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Abstract: Front end planning is arguably the most impactful activity in the management of construction projects. Organizations expend substantial effort in planning large projects, intending to minimize risk and promote project success. Small projects –typically classified as such based on their lower costs – often have minimal planning completed prior to the start of design and construction. To date, little research has been performed regarding the planning and management of small construction projects, especially those in the industrial sector. In 2013, the Construction Industry Institute (CII) set out to develop a Project Definition Rating Index (a front end planning tool) specifically for small industrial projects. CII Research Team 314 identified forty-one specific elements as most pertinent in assessing a small industrial project. Sixty-five industry practitioners reviewed and prioritized these elements through a series of focus group "weighting workshops." The tool has been used to assess 12 separate small industrial projects to date, with positive results. This paper summarizes how the PDRI-Small Industrial Projects was developed, how the tool differs from the previously-developed PDRI-Industrial Projects tool, and how it has been utilized to date to assess small industrial projects. Future research opportunities are proposed, including use of the PDRI-Small Industrial Projects research methodology to develop similar tools for the infrastructure and building construction sectors.

1 INTRODUCTION

Poor scope definition has been shown to be one of the major factors leading to poor project performance (Gibson et al 2006). Many construction experts believe that planning efforts conducted during the early stages of a project (e.g., preproject planning or front end planning) have a significantly greater effect on project success that those undertaken after a project has begun. Since 1991, the Construction Industry Institute (CII) has created a suite of tools to be used to define project scope and assess the level of planning readiness during front end planning. These Project Definition Rating Index (PDRI) tools offer a method to measure project scope definition for completeness at any point prior to the start of detailed design and construction. These tools identify and precisely describe each critical element in a scope definition package, and allow project teams to quickly identify project risk factors related to desired outcomes for cost, schedule, and operating performance.

Prior to 2013, separate PDRI tools were developed for industrial, building, and infrastructure project types (CII 1995, 1999, 2011). Though effective in the planning of large construction projects, the PDRI tools were not developed or validated on small projects. Small projects were deemed by CII to be a significant portion of completed work across the industrial sector, including projects in oil/gas production facilities and refineries, chemical plants, manufacturing facilities, and electrical generation facilities to name a few. CII tasked Research Team 314 with developing a PDRI tool specifically for small industrial projects in the

summer of 2013. This paper summarizes how the PDRI-Small Industrial Projects was developed, how the tool differs from the previously developed PDRI-Industrial projects, and how the tool has been utilized to date to assess small industrial projects.

2 DEVELOPMENT OF THE PDRI-SMALL INDUSTRIAL PROJECTS

PDRI tools consist of two main documents that are used to assess a project: a set of elements (with comprehensive descriptions) that detail specific items that should be addressed during the front end planning phase of a project, and a score sheet that provides a hierarchy to the importance of each element relative to the total set of elements. The thorough analysis of planning tasks recommended for industrial projects completed by CII Research Team 113 led to the development of the PDRI-Industrial Projects in 1995. The tool has successfully been used to assess the level of scope definition on thousands of industrial construction projects across the globe since its initial publication. Research Team 314 felt it prudent to use this document as the baseline for developing the PDRI-Small Industrial Projects.

Research Team 314 was initially broken down into three sub-teams, each separately focusing on one of the three PDRI sections (Basis of Decision, Basis of Design, Execution Approach) to develop the element descriptions for the small industrial projects tool. The element descriptions in each section were reviewed and scrutinized by the sub-teams for applicability to small projects over the course of 10 months and 4 separate team meetings. Brainstorming sessions during team meetings, web-based conference calls, and individual reviews were all methods utilized to complete this review. Non-pertinent elements and "items to-be considered" bullets were removed, re-written, or combined with other elements. New elements were developed as necessary. All elements were then thoroughly reviewed by the entire research team during three separate team meetings. The team agreed upon a final set of element descriptions after rigorous discussion and debate. Figure 1 provides an example of one PDRI element description, specifically Element E.3, Electric Single Line Diagrams. Each PDRI element description is provided in this manner, starting with a description of the element. Additional items to be considered while assessing the project at hand follow the description. Pertinent renovation and revamp and program considerations are also listed.

E.3 Electric Single Line Diagrams

Electric single line diagrams document the components, devices, or parts of an electrical power distribution system. These diagrams portray the system layout from the public utility's incoming supply to the internal electrical power distribution system. Depending on the size of the electrical system, the single line diagrams may include several levels of distribution. Items to consider should include:

- ☐ Incoming utility with owner substation/distribution to high and medium voltage motors and substations
- ☐ Electrical load list
- ☐ Unit substations and switch gear
- ☐ Motor control centers with distribution to motors, lighting panels
- ☐ Other user defined

**** Additional items to consider for Renovation & Revamp projects****

- ☐ Field verify existing single line diagrams to ensure they are correct and have been maintained to reflect the actual site conditions.
- ☐ Verify locations and availability of power for new or relocated equipment.

Figure 1: Sample PDRI-Small Industrial Projects Element Description

The 41 elements created by the Research Team were broken into three sections, and further broken down into eight categories (Note: the PDRI-Industrial Projects has 70 elements). This structure was used

to keep the same “look and feel” as the previously developed PDRIs. Table 1 provides a breakdown of the PDRI-Small Industrial Projects sections, categories, and elements.

Table 1: PDRI-Small Industrial Projects **SECTIONS**, **Categories**, and Elements

SECTION I. BASIS OF PROJECT DECISION			
A.	**Project Alignment**	**B.**	**Project Performance Requirements**
A.1	Project Objectives Statement	B.1	Products
A.2	Project Strategy and Scope of Work	B.2	Capacities
A.3	Project Philosophies	B.3	Processes
A.4	Location	B.4	Technology
		B.5	Physical Site
SECTION II. BASIS OF DESIGN			
C.	**Design Guidance**	**D.**	**Process/Product Design Basis**
C.1	Lead/Discipline Scope of Work	D.1	Process Safety Management (PSM)
C.2	Project Design Criteria	D.2	Process Flow Diagrams along with Heat and Material Balance
C.3	Project Site Assessment	D.3	Piping and Instrumentation Diagrams (P&ID's)
C.4	Specifications	D.4	Piping System Stress Analysis
C.5	Construction Input	D.5	Equipment Location Drawings
		D.6	Critical Process/Product Items Lists
E.	**Electrical and Instrumentation Systems**	**F.**	**General Facility Requirements**
E.1	Control Philosophy	F.1	Site Plan
E.2	Functional Descriptions and Control Narratives	F.2	Loading/Unloading/Storage Requirements
E.3	Electrical Single Line Diagrams	F.3	Transportation Requirements
E.4	Critical Electrical Items Lists	F.4	Additional Project Requirements
SECTION III. EXECUTION APPROACH			
G.	**Execution Requirements**	**H.**	**Engineering/Construction Plan and Approach**
G.1	Procurement Plan	H.1	Engineering/Construction Methodology
G.2	Owner Approval Requirements	H.2	Project Cost Estimate
G.3	Distribution Matrix	H.3	Project Accounting and Cost Control
G.4	Risk Management Plan	H.4	Project Schedule and Schedule Control
G.5	Shutdown/Turnaround Requirements	H.5	Project Change Control
G.6	Precommissioning, Startup, & Turnover Sequence Requirements	H.6	Deliverables for Design and Construction
		H.7	Deliverables for Project Commissioning/Closeout

A basic tenet of front end planning is that not all items to be assessed are equally critical to project success. Certain elements are higher in the hierarchical order than others with respect to their relative importance. An analysis was necessary to “weight” the elements accordingly. Focus groups were utilized to gain prioritization data from a subset of the total industrial construction stakeholder population. Focus groups are simply a group of subjects interviewed together, prompting a discussion (Babbie 2011). This method was successfully utilized by each of the previous PDRI research teams (Gibson and Whittington 2010). Five such focus groups, or “weighting workshops,” were convened to weight the PDRI elements. The weighting workshops were held in multiple locations in an effort to gain a variety of industry

perspectives related to typical small industrial projects. Workshop locations, dates, and number of participants are shown in Table 2.

Table 2: PDRI-Small Industrial Projects Weighting Workshops

Location	Date	Number of Participants
Baton Rouge, Louisiana	4/10/14	19
Houston, Texas	5/9/14	12
Greenville, South Carolina	6/4/14	12
Indianapolis, Indiana	7/21/14	12
Houston, Texas	7/30/14	10

Purposive sampling, also referred to as judgmental sampling, is a method in which individuals are selected to be part of the sample based on the researcher's judgment as to which individuals would be the most useful or representative of the entire population (Babbie 2011). Industry experts with substantial experience in the management and/or design of small industrial projects were targeted to participate. Snowball sampling, or asking targeted individuals to suggest other individuals with similar expertise (Babbie 2011) was used to increase workshop attendance. Figure 2 provides some demographical background information about the workshop participants.

- 65 Workshop Participants
- 65 Weighted PDRI forms completed
- 1,299 Collective years of experience
- 20 years (on average) estimating/project management experience
- 64% of experience (on average) related to small projects
- 85% of experience (on average) related to industrial construction projects
- 29 Organizations represented

Figure 2: Workshop Participant Demographics

During the workshop sessions, participants were asked to assign a contingency amount (i.e., weight) to each of the PDRI elements, indicating the relative importance of each element as compared to the balance of elements in the PDRI. The weights provided by the participants were compiled and analyzed to develop the weighted PDRI score sheet. An excerpt of the weighted score sheet is provided in Figure 3. The workshop participants were also asked to provide feedback relating to any concerns they had regarding the element descriptions. Items brought up during workshop discussions were noted by the workshop facilitators. Each participant was also provided a "Suggestions for Improvement" sheet where additional thoughts could be recorded. The research team reviewed all comments collected during the workshops, and revised the element descriptions as appropriate. For more detail on the data analysis procedures utilized, please see CII (2015).

SECTION I - BASIS OF PROJECT DECISION							
CATEGORY Element	Definition Level 0	1	2	3	4	5	Score
A. PROJECT ALIGNMENT (Maximum Score = 153)							
A.1 Project Objectives Statement	0	2	13	24	35	47	
A.2 Project Strategy and Scope of Work	0	3	13	24	34	45	
A.3 Project Philosophies	0	2	8	14	19	25	
A.4 Location	0	2	11	19	28	36	

Definition Levels
0 = Not Applicable 1 = Complete Definition 2 = Minor Deficiencies 3 = Some Deficiencies
4 = Major Deficiencies 5 = Incomplete or Poor Definition

Figure 3: Weighted Score Sheet for Category A Project Alignment

Previously developed PDRI's use a scale of 70 (i.e., sum of all Level 1 definitions) to 1000 (i.e., sum of all Level 5 definitions). A project with low definition would receive a higher score (i.e., closer to 1000) than a project with higher definition that would receive a lower score (i.e., closer to 70). Any elements deemed not applicable would lower the potential Level 1 and Level 5 scores on a pro-rata basis depending on the weighting of the element. Research Team 314 chose to use this same scale for the PDRI-Small Industrial Projects to keep constancy with the previously developed PDRI tools.

3 COMPARISON OF INDUSTRIAL PROJECT PDRI'S

3.1 Characterization of Small Industrial Projects

Industrial projects with substantial scope, complexity, schedule duration, and cost are typically considered "large". Considerable effort is expended to ensure success on large projects, as they are viewed to be critical to an organization's overall financial prosperity. "Small" projects - projects typically differentiated from large projects due to having lower costs – oftentimes have minimal emphasis placed on detailed front end planning. Small projects tend to be seen as having low risk, and thus not warranting a structured planning approach. Younger or inexperienced project managers and engineers are assigned small projects as training tools in preparation for work on larger future projects (CII 1991).

In reality, assuming that a small project inherently carries lower risk or is less critical to an organization is short-sighted. Based on an industry survey conducted by Research Team 314, seventy to ninety percent of all projects completed in the industrial sector (on a count basis) are considered small, making up a vast majority of completed work each year. While additional project cost or schedule overrun on one small project could possibly have a minimal impact on an organization, the cumulative effect of poorly planned small projects can have a major impact on an organization's bottom line. The PDRI-Small Industrial Projects was developed to specifically address this important and prevalent project type.

Small projects should not be differentiated from large projects based on solely on static levels of project costs within an organization or the industry at large. Project complexity is the true differentiator between small and large projects. Complex is defined as "a group of obviously related units of which the degree and nature of the relationship is imperfectly known" (Merriam-Webster 2014). Complexity is the quality or state of being complex. Industrial construction projects can fall anywhere along the spectrum of complexity, from projects with little to no complexity (i.e., pure maintenance projects) to highly complex projects (i.e., mega-projects). The rigor of planning efforts expended on a project should match its level of complexity. The PDRI-Small Industrial Projects focuses on lower-complexity projects.

Table 3 below provides data from a study of ninety industrial projects with varying levels of complexity completed by Research Team 314. The averages of nine separate project attributes for typical small and

large industrial projects are given. Table 3 also provides direction in selecting the appropriate PDRI tool for use on an industrial project, but PDRI users are urged to not see the matrix as a strict guideline. For example, in some organizations projects with total installed cost of US$10 million may be very small, while in other organizations projects of this caliber may be considered very large. In choosing a suitable tool for a specific project, project teams assessing industrial projects are urged to consider these factors and choose the appropriate tool based on their organization's internal project planning specifications.

Table 3: Industrial PDRI Selection Guide

Project Complexity Indicator	PDRI- Small Industrial Projects	PDRI-Industrial Projects
Total Installed Cost	Less than $10 Million (US Dollars)	More than $10 Million (US Dollars)
Construction Duration	3 to 6 months	9 to 15 months
Level of Funding	Between regional and corporate	Between corporate and Board of Directors
Project Visibility	Moderate	Significant
Number of Core Team Members	7 to 9 individuals	10 and 15 individuals
Availability of Core Team Members	Part-time availability	Combination of part-time and full-time to completely full time
Extent of Permitting	None to minimal permitting	Minimal to significant permitting
Types of Permits	None to local/state permits	Locals/state to national permits
Number of Trade Contractors	3-4 separate trade contractors	7-8 separate trade contractors

3.2 Process vs. Non-Process Industrial Projects

The PDRI-Small Industrial Projects was developed to assess both process and non-process related projects. Research Team 314 defines a "process" related project as any project in an industrial facility related to constructing or refurbishing the systems, equipment, utilities, piping, and/or controls that directly affect the production rate, efficiency, quantity, or quality of the product being produced. These projects typically have a stated Return on Investment (ROI) expectation directly related to improved production factors, and may affect how the product is marketed to consumers (e.g., higher quality than before, increase in quantities available). In most cases, documents pertaining to the ongoing operations of the facility (e.g., piping and instrumentation diagrams, process safety management plans) need to be created, or existing documents updated. A "non-process" related project is defined as any project in an industrial facility that is ancillary to production processes, but does not directly affect the quantity or quality of the product being produced. Examples of these types of projects include additions to or expansion of the infrastructure that supports a facility, facility updates necessary for environmental or safety compliance, replacement-in-kind of facility components (e.g., equipment, structural, piping) that do not directly affect the nature of the product being produced. If an ROI is required on these projects, it is typically attributed to improving the operating efficiencies of the facility that are not directly related to production, such as increased energy efficiency related to installing Variable Frequency Drives (VFD's) on HVAC equipment, or installing solar panels to lessen the amount of power needed from a public utility provider. Documents pertaining to the ongoing operations of the facility (e.g., piping and instrumentation diagrams, process safety management plans) may or may not need to be created or updated.

Examples of small industrial projects can include:

Process

- Oil/gas Refining Facilities
  - Stack monitoring and flare line replacement
  - Replacement of desalter effluent cooler fin fans
  - Installation of gasoline cooler in pipeline
  - Addition of hydrogen plant within existing refinery
  - Replacement-in-kind of process piping
- Pulp/Paper Mills
  - Replacement of entangling section
  - Replacement of internal screens in digester vessel
  - Replacement of headbox section
  - Replacement of components associated with wood yard log chipping line
- Manufacturing Facilities
  - Installation of a new packaging line
  - Modifications to existing packaging line
  - Addition of a motor control center
- Breweries
  - Replacement of cooker coils
  - Upgrade coders on can line
- Chemical Plants
  - Installation of new technology nylon compounding extruder and pack-out
  - Replacement of injection molder

Non-Process

- Plant Upgrade/Retrofit
  - Replacement of existing elevators
  - Replacement of existing HVAC equipment
  - Repointing of existing masonry structures
  - Replacement or upgrades to existing power supply
  - Installation of raw material railcar offload station
  - Water conservation projects
  - Replacement of constant speed electric-feed-water pumps with variable frequency driven pumps
  - Addition of waste water clarifier to storm sewer system
  - Installation of new dust collection equipment and ducting
  - Installation of environmental monitoring or noise abatement equipment
  - Installation of new security cage and associated security system within an existing operating warehouse facility

3.3 Industrial PDRI Application Points

Previous PDRI research (CII 2008, 2008(b), 2010) has found that assessing a large project (from any of the construction sectors) is best performed four separate times during the front end planning process, as shown in Figure 4. This iterative “stage gate” approach allows project teams to assess how well planning activities have progressed prior to formally moving the project forward to the next phase.

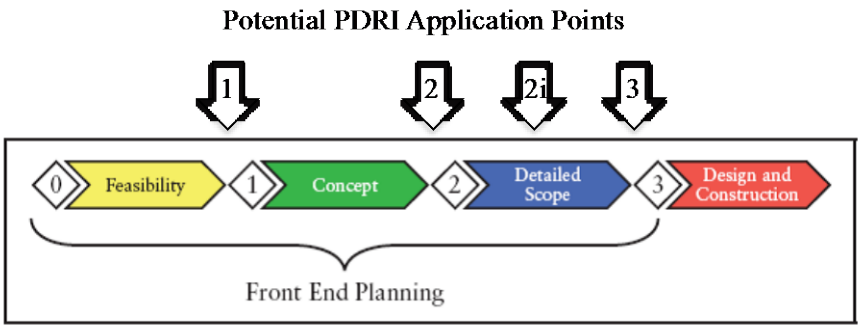

Figure 4: Typical PDRI Application Points

The speed and concurrent phasing of small projects makes it more difficult to provide guidance on the best time to conduct a PDRI review. In many small projects, the entire project may be charged against a funding budget; hence the users will want to perform an assessment to "get on track". In other situations, there may be a funding point after the initial decision to proceed with the development, and just prior to that funding decision may be the optimal time to use the tool. A small project may be phased such that Feasibility, Concept, Detailed Scope, and Design, Procurement and Construction are all overlapping. This may not be the optimum way to proceed with a project, but may reflect the reality of typical small industrial projects.

The PDRI-Small Industrial Projects was designed with the intent that it could be used multiple times throughout the FEP process, or as a one-time use tool. Project size, complexity and duration will help determine the optimum time (or times) that the PDRI tool should be used. To aide in the expanded use of this tool, Figure 5 illustrates suggested application points for the PDRI-Small Industrial Projects. By utilizing the tool multiple times, project teams can capture the benefits of an iterative review process in a timeframe consistent with a shorter project schedule. However, if used only once in the FEP process, the project team may find the tool comparably effective if deployed properly. Proper review-team development, effective capture, and follow up on action items, and open and honest discussion aimed at revealing project scope concerns best support using the tool only once. If a project is assessed only once, the earlier in the project life cycle this occurs the better.

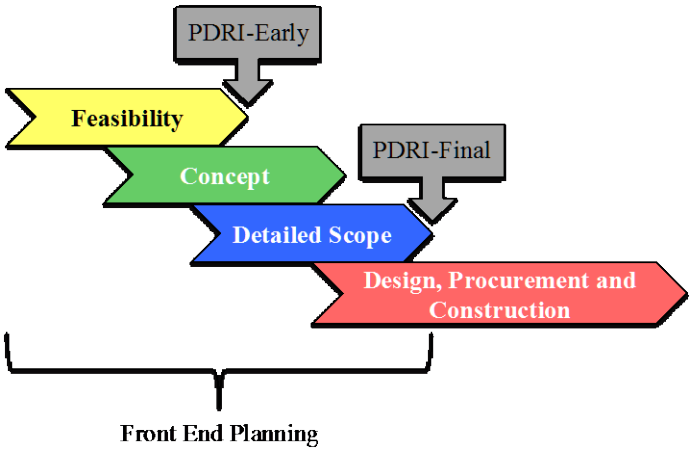

Figure 5: PDRI-Small Industrial Projects – Suggested Application Points

4 PDRI- SMALL INDUSTRIAL PROJECTS USAGE TO DATE

The PDRI-Small Industrial Projects has been used on 12 projects during real-time planning exercises. Nine of the projects were process related, including a stand-alone manufacturing facility, additions to

existing manufacturing lines, structural replacement of an existing cooling tower support system, a natural gas pipeline meter station, replacement of a reverse-osmosis water treatment system, and a clean-room manufacturing suite. The three non-process related projects included a new stand-alone QC lab, a petroleum pipeline measurement skid, and a natural gas pipeline meter station. The average budgeted total installed cost was US $4.0 million, and the average construction schedule duration was 5 months. Each assessment was completed at the PDRI-Final application point detailed in Figure 5. The average time to complete the PDRI assessment was approximately 1.5 hours.

In general, the feedback from users was extremely positive. The tool performed very well in identifying critical risk issues during the front end planning process, and spurred important conversations about elements not yet considered by the project team. As one user stated, “Utilization of the PDRI-Small Industrial Projects tool not only provided for a structured process to assess the status of project scope definition and execution readiness, it also assisted the team in bringing newly assigned individuals on the project up to speed on the project scope and status, as well as gaining alignment within the team on the project plan.” As another user stated, “My first reaction was – this is going to take a long time… I picked it up and realized it wasn’t complicated at all. I like (the tool) because it’s easy and straight forward.”

5 CONCLUSION

Effective front end planning practices can substantially improve project performance if implemented consistently and correctly. The PDRI tools developed by CII are meant to assess how well a project team has planned for an upcoming project, providing guidance to specific elements that should be considered during front end planning to quickly identify project risk factors related to desired outcomes for project cost, schedule, and operating performance. The PDRI elements are weighted to highlight their relative importance to project success. This paper has summarized the development of the newest PDRI tool, which was developed specifically to address small industrial projects, a project type the makes up a substantial portion of industrial projects completed each year. The tool has been used on 12 projects to date, with extremely positive feedback regarding the tool’s effectiveness and ease of use.

Empirical evidence would suggest that small projects are just as prevalent in the building and infrastructure sectors as they are in the industrial sector. The methodology described in this paper along with the Research Report (CII 2015) developed by Research Team 314 could be used in future research to develop PDRI tools specifically for small infrastructure and building projects.

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References

Babbie, E. 2011. *The Basics of Social Research (5th ed.).* Wadsworth, Belmont, CA, USA

Construction Industry Institute (CII) 1991. *Manual for Special Project Management.* University of Texas at Austin, Austin, TX, USA

Construction Industry Institute (CII) 1995. *Project Definition Rating Index (PDRI) for Industrial Projects.* University of Texas at Austin, Austin, TX, USA

Construction Industry Institute (CII) 1999. *Development of the Project Definition Rating Index (PDRI) for Building Projects.* University of Texas at Austin, Austin, TX, USA

Construction Industry Institute 2008. *PDRI: Project Definition Rating Index for Industrial Projects* (3rd ed.). University of Texas at Austin, Austin, TX, USA

Construction Industry Institute (CII) 2008(b). PDRI: *Project Definition Rating Index for Building Projects* (3rd ed.). University of Texas at Austin, Austin, TX, USA

Construction Industry Institute (CII) 2010. PDRI: *Project Definition Rating Index for Infrastructure Projects*. University of Texas at Austin, Austin, TX, USA
Construction Industry Institute (CII) 2011. *Development of the Project Definition Rating Index (PDRI) for Infrastructure Projects.* University of Texas at Austin, Austin, TX, USA
Construction Industry Institute (CII) 2015. *Development of the Project Definition Rating Index (PDRI) for Small Industrial Projects.* University of Texas at Austin, Austin, TX, USA
Complex [Def. 1]. (n.d.) In *Merriam-Webster Online*. In Merriam-Webster. Retrieved August 23rd, 2014 from http://www.merriam-webster.com/dictionary/complex
Gibson, G., Wang, Y., Cho, C., & Pappas, M. 2006. What Is Preproject Planning, Anyway? *Journal of Management in Engineering*, 22(1), 35-42.
Gibson, G., Whittington, D. 2010. Charettes as a Method for Engaging Industry in Best Practices Research. Journal of Construction Engineering and Management. 136(1), 66-75.