Safety Performance through Operational Excellence, Phase II

Research Summary 317-1a

Construction Industry Institute

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Construction Industry Institute

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Executive Summary

Upon completing its four-year journey to understand and model Operational Excellence (OE) for safety in the delivery of capital projects, Research Team 317 (RT-317) has concluded that OE is simply "doing the right thing, the right way, every time – even when no one is watching." Developing a model to represent that concept during Phase I of the research led to outlining a holistic, professional, and rigorous safety program during Phase II. (Phase I is described in Research Summary 317-1 *Safety Performance through Operational Excellence – Phase I*, and Research Report 317-11, *Improving Site Safety Performance through Operational Excellence*.)

CII companies have found it challenging to reach the next level of safety performance. Some member organizations have spent significant resources developing programs and audits to improve safety. RT-317's research products assist this effort by offering a proven model and an approach to conduct a large-scale assessment of a project's commitment to safety. Users of the RT-317 findings will be able to identify gaps between what is stated at the corporate level and what is actually done in the field, identify areas that could yield the greatest opportunities for safety improvement up, down, and across their organizations, and ascertain the level of effort required for change.

RT-317's research approach for Phase II, outlined in this research summary, involved weighting components of the OE model, operationalizing the model's contents, creating an OE score, and collecting data against the model. The final data collection effort resulted in 77 responses across 25 projects. The average OE score for these projects was 42.9 out of a possible 66 points, corresponding to 65%. There is significant room for improvement for even the highest performing project (51.9, or 78%).

The RT-317 data collection effort generally shows that the higher the OE score achieved, the lower the safety incident rate (TRIR). Further, most projects saw a strong decline in awareness and implementation of safety programs from the corporate level to the site level. In other words,

people at the corporate level believe a certain program is in place and functioning; however, the craft professionals are either not aware of the program or do not believe it is well implemented on site.

Ultimately, the products from RT-317 gave CII member companies an opportunity to see whether they (and their employees from corporate down to the site) “do the right thing, the right way, every time – even when no one is watching.”

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Introduction

Safety is, and must be, a priority for Construction Industry Institute (CII) member companies. This is evident by the strong safety results realized year after year in the annual Safety Report produced by CII. Members' average Total Recordable Incidence Rates (TRIR) well below 1.0 demonstrate the emphasis that CII companies place on safety. However, this does not mean there is no room for improvement. The TRIR for CII member companies appears to have improved at a diminished rate in recent years (see Figure 1).

In line with its goal of continuous improvement, CII tasked Research Team 317 (RT-317) to investigate whether the concept of Operational Excellence (OE) could provide the next thrust forward in safety performance. CII posed an essential question to the team:

> "Can a sustainable step change in safety performance be achieved through an enhanced culture of rigorous operational discipline (later termed Operational Excellence), also known as performance excellence?"

To answer this essential question, the team envisioned research that would occur in two distinct projects:

1. Phase I of RT-317 developed a conceptual model for Operational Excellence for construction project safety and reported its findings in Research Summary 317-1 *Safety Performance through Operational Excellence – Phase I*, and Research Report 317-11, *Improving Site Safety Performance through Operational Excellence*. Once that model had been created, several critical steps remained to examine the relationship between Operational Excellence and safety performance.

2. Phase II of RT-317, described in this research summary, focused on the relationship between Operational Excellence and safety performance. The deliverables for this second effort also include a larger research report (RR317-12, *Improving Site Safety Performance through Operational Excellence, Phase II*).

Operational Excellence

Operational Excellence has been defined in numerous ways, since its formal existence is relatively new and vague. Its origins can be traced back to the chemical process industry's efforts to improve process safety. In its origins, OE refers to the desired execution of day-to-day activities that all organization personnel carry out. From upper management to the craft professionals, all employees must be fully committed to the process and take responsibility for adhering to procedures.

The underlying theme in the many definitions is that the result of Operational Excellence is the predictable and correct execution of tasks. The precursors required to reach this result combine behavioral and cultural elements:

- A strong safety culture must be established, in order to drive behaviors.
- For this safety culture to persist, consistent behaviors must be expected.

In that sense, the foundation for RT-317's model of OE is that culture drives behavior and behavior sustains culture. Subsequently, RT-317 synthesized the various definitions of OE into one: "doing the right thing, the right way, every time – even when no one is watching." (For more on the definition and origins of OE, see RS317-1 and RR317-11 from Phase I of the RT-317 research.)

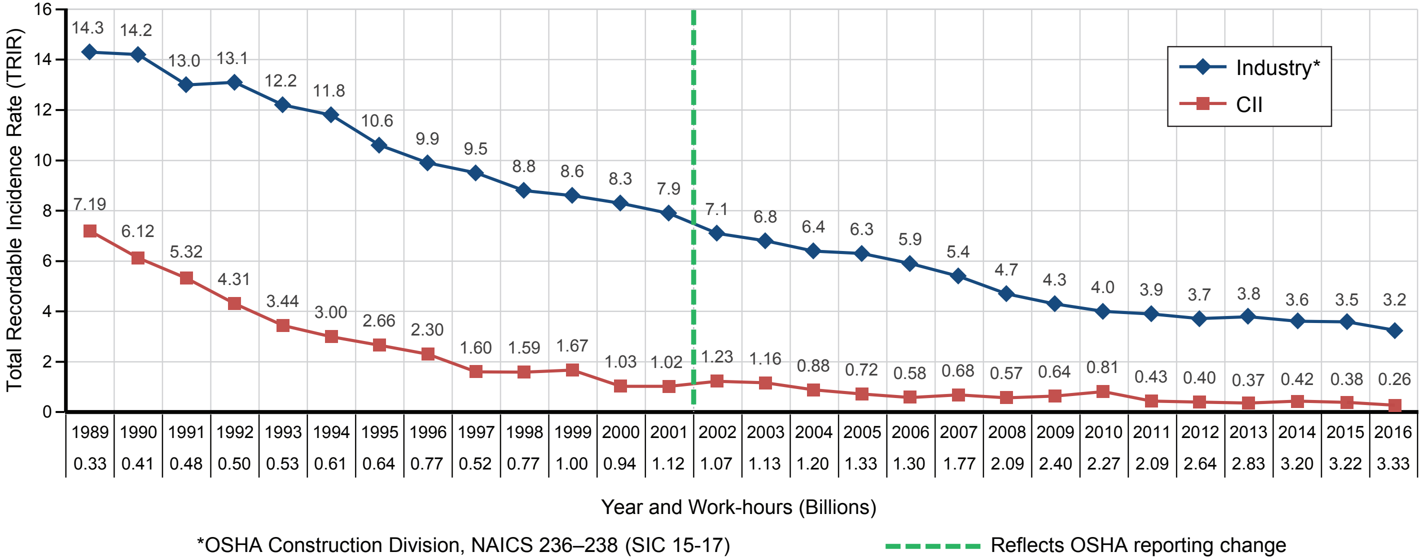

Figure 1. Total Recordable Incidence Rate, CII Members vs. Industry

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Methodology

The primary objective of the overall RT-317 research effort was to identify the impact that Operational Excellence has on safety performance. The Phase I research developed and conceptually validated an OE model. The primary objective of this Phase II research was to examine the impact that the developed OE model has on safety performance. To meet the primary objective of this phase, several secondary objectives needed to be accomplished. As outlined in Figure 2, these secondary objectives were to weight the safety drivers, operationalize the model, create the OE score, collect data, and analyze data.

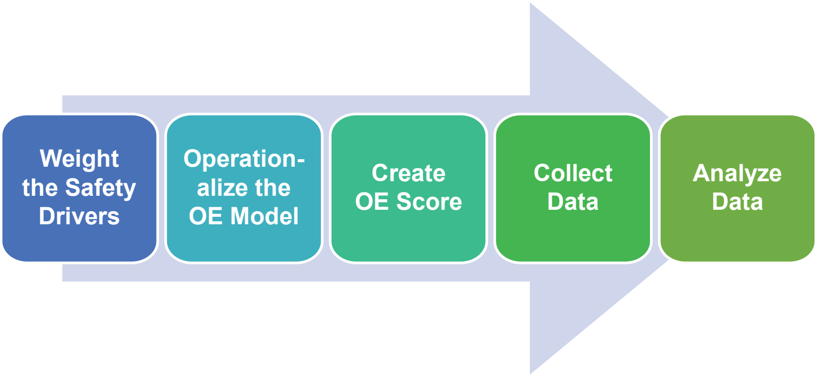

Figure 2. Phase II Research Methodology

Weight the Safety Drivers

The safety drivers in the model needed appropriate weights. Realizing the significant effort that would be required to collect data against the entire model, RT-317 sought to provide guidance on which drivers carry more weight (i.e., have a more significant impact on safety). Thus, if a CII member only wanted to use a portion of the OE model, it would be logical to start with the drivers that have a greater impact on safety. Looking to a larger audience, many contracting organizations need to formalize and professionalize a safety program. This guidance also offers those organizations a starting point.

RT-317 opted to use analytical hierarchy process (AHP), first proposed in 1980, as the weighting procedure for this model. As a management tool, AHP is designed to aid decision-making when addressing complex, unstructured, and multi-attribute problems. The primary approach of AHP is to decompose a “complex” objective into multiple “simple” elements, and then weight those simple elements through pairwise comparisons. To weight the safety drivers, RT-317 conducted five major steps based on the ASTM AHP standard (ASTM E1765-16):

1. Construction of Hierarchic Structure
2. Pairwise Comparison
3. Aggregation of Comparison Matrices
4. Relative Weight Computation
5. Consistency Ratio Computation

These steps were facilitated by a pairwise comparison survey conducted with CII and Construction Users Roundtable (CURT) member companies. Figure 3 shows the types of firms represented by the respondents to the AHP pairwise comparison survey, and Figure 4 shows the respondents’ construction sectors.

The RT-317 researchers validated the results of the AHP procedure, including reliable and relative weights, to allow a proper Operational Excellence score to be measured. Table 1 (on page 8) shows the results of the process. The tabulated score for each driver is modified by its relative weight for an appropriate analysis. (More details on the scoring mechanism follow later in this report. For additional details on the AHP procedure, please refer to RR317-12.)

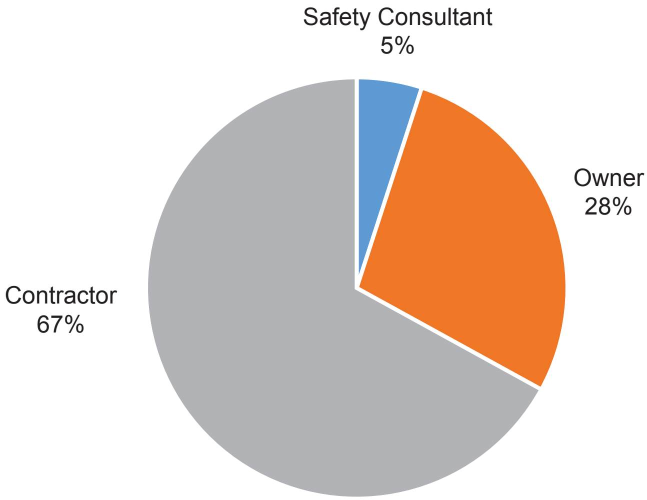

Figure 3. AHP Survey Respondents' Firm Types

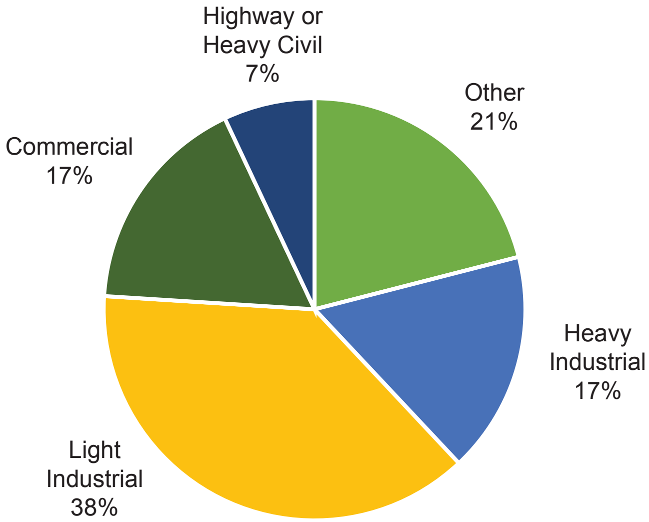

Figure 4. AHP Survey Respondents' Construction Sectors

Table 1. AHP Weighting Results

Safety Driver	Relative Weight
Owner's Role	4.20
Worksite Organization	3.35
Shared Values, Beliefs, and Assumptions	3.09
Transformational Leadership	3.08
Strategic Safety Communication	2.76
Training and Competence	2.54
Risk Awareness, Management, and Tolerance	2.49
Human Performance and Factors	2.30
Learning Organization	2.13
Employee Engagement	1.86
Subcontractor Management	1.69
Recognition and Rewards	1.00

Operationalize the OE Model

The next step in the Phase II research framework was to operationalize the conceptually validated OE model created during Phase I. Figure 5 shows a sample of this model, published in RR317-11, *Improving Site Safety Performance through Operational Excellence*. This framework was neither actionable nor measurable; therefore, it needed to be operationalized to allow projects to assess their adherence to it. In this sample, the blue box (left) is the Critical to Safety element (CTS) of "Sort" under the Safety Driver of "Worksite Organization," the green box (center) is the Critical to Expectation element (CTX), and the purple boxes (right) are the Specification/Measurements (S/Ms).

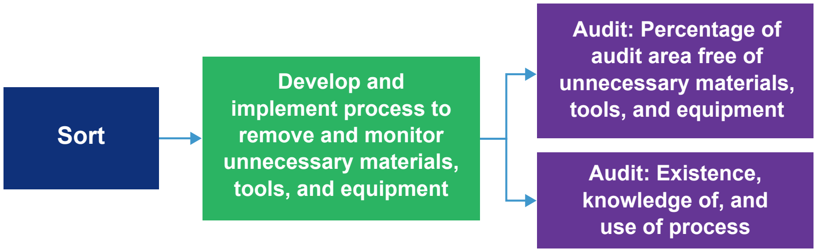

Figure 5. Sample Conceptual Segment of OE Model from Phase I

The output in Figure 6 details the operationalized version of the tree shown in Figure 5. It contains six specific questions that need to be answered for a given project. The first question, in the "Safety Driver" box at the top, asks whether a policy exists at the corporate level. The focus then flows down to the project level (on-site or off-site), to ask whether a procedure is written and exists at that level. The model then asks whether a written practice exists at the craft level. The craft employees are also asked whether there has been a formal implemented process, and if those responsible for executing the process have knowledge about it. Finally, the Specification/Measurements question asks for the results of the policy, procedure, and practice.

Safety Driver *(Corporate Level)*

Does a written policy for worksite organization exist at the corporate level?

Critical to Safety *(Project Level)*

Does a written procedure for the removal and monitoring of unnecessary material, tools, and equipment exist at the project level?

Critical to Expectations *(Site Level)*

Does a written practice for removing and monitoring unnecessary materials, tools, and equipment exist at the craft level?

Implementation *(Varies)*

Has a formal process been developed and executed to train appropriate personnel in the methods and procedures for staging materials in designated areas near their intended use?

Knowledge *(Varies)*

Do the individuals charged with executing this process have the necessary knowledge to do so?

Specifications/Measurements *(Varies)*

What percentage of the audit area has equipment, material, and tools staged in designated areas near the point of usage?

Figure 6. Operationalized Segment of the OE Model

This operationalization process was conducted for all elements of the model. It also breaks down into the fundamental definition of OE: "doing the right thing, the right way, every time – even when no one is watching." It queries several levels of the organization, from corporate down to craft professionals, and evaluates whether a policy is effectively implemented and reaches its intended audience. Too frequently, policies exist but are weakly implemented or are misplaced in a nice manual that no one knows about.

Create Operational Excellence Score

Next, the operationalized model was quantified by using a scoring paradigm to create a final OE score. RT-317 developed a standard scoring mechanism, based on a similar rating model system and internal testing and vetting. Figure 7 shows a sample of this scoring for the safety driver "Worksite Organization":

- Starting with the red box on the upper left, a positive response to the existence of a written policy at the corporate level for the safety driver would earn one point. (Conversely, if the policy had not existed, or if it were not written, no points would be earned.)
- Then, one of its Critical to Safety (CTS) elements, shown in blue, is explored in greater detail at the project level. The CTS in Figure 7 is "Sort." If a written procedure exists, one point is earned.
- Next, the Critical to Expectations (CTX) level, shown in green, asks whether a written practice exists the site level. Here, three points are earned for a positive response. The model offers additional points for the CTX, to reinforce how import it is that those responsible for executing the safety policies are aware of them. If the construction professionals are unaware of a policy, then likely it is either not practiced or not reinforced in a way that drives consistent practice.
- The light blue boxes in the middle of Figure 7 correspond to questions about implementation and knowledge. A policy must have a formal, written implementation plan in order to be regularly and consistently practiced. Further, a good proportion of the target population must be knowledgeable of the policy for its regular and consistent practice. Thus, the implementation of a policy can earn one point, and two more points can be earned if a representative sample of the target population is knowledgeable of the policy.

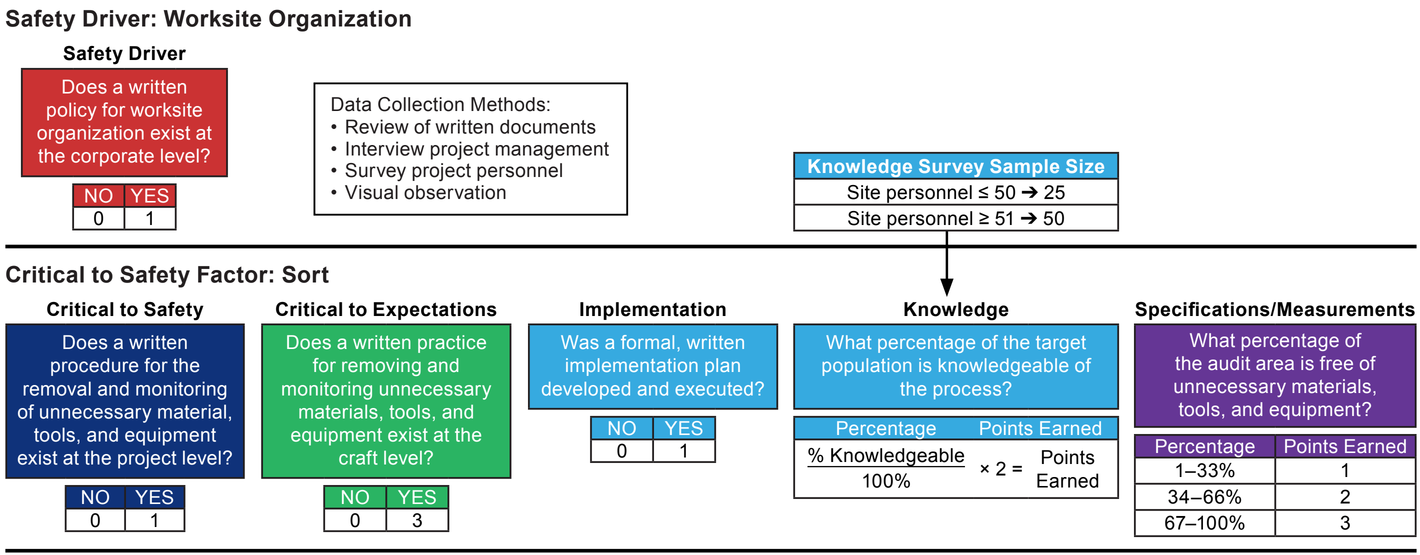

Figure 7. OE Model Scoring Paradigm

- Finally, the purple box on the far right of Figure 7 represents Specification/Measurements (S/M) elements that identify the outcome or results of the policy outlined in the CTS. Up to three points can be earned, with options for partial points depending on the specific S/M.

Figure 7 outlines how points are assigned in the model, but it lacks a methodology to aggregate an overall score. By drawing on the structure of the CTS tree shown in Figure 5, RT-317 developed the scoring calculation outlined in Figure 8. The final score is the Operational Excellence Index (OEI), which combines the scores for Safety or Operational Excellence Drivers (OED), Critical to Safety (CTS), Critical to Expectations (CTX), Implementation (IMP), Knowledge (KNW), and Specification/Measurements (S/Ms). In instances where multiple S/Ms correspond to a single CTX, those values are averaged. In an equal weighting scenario, the maximum possible OE score for a fully complete assessment is 132 points.

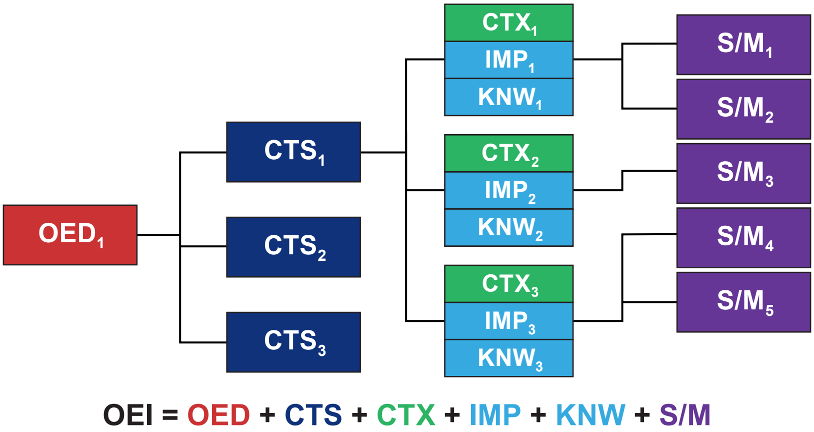

Figure 8. OE Score Calculation

Collect Data

To collect data to test the model, RT-317 converted the operationalized model into an online survey tool. This step allowed the team to solicit project participation to help assess the relationship between adherence to the model and safety performance. Prior to its final rollout, team members piloted the survey to identify and troubleshoot any areas of concern.

Dataset

Once it had completed converting the OE model into an online survey, the team decided initially to collect feedback on the questions. OED questions were deployed at the corporate level, CTS questions at the project level, and CTX questions at the site level. IMP questions were collected at various levels. This initial data collection strategy was deployed to maximize participation: the KNW and S/M questions would have required projects to survey a variety of project participants, while the surveyed questions only required a single individual to respond. The data collection results described in the subsequent discussion demonstrate the challenges to collecting a sufficient sample. Thus, data for the KNW and S/M were not included in the subsequent analysis.

After it finalized the online survey, the team solicited participation within its members' own organizations and from other CII member companies, CURT member companies, and other organizations in the construction industry. Seventy-seven people from 25 projects responded. Project characteristics from the respondents are reported in Table 2 (next page). The average participating project cost $63 million and required 533,000 work-hours at the time the survey was collected. Figure 9 outlines that 40% of the projects were in the industrial construction sector, 28% in commercial, 4% in heavy civil, and 28% other. Forty-six percent of the projects were union, 12% open shop, and 42% mixed. The construction manager delivery method was used on 46% of the surveyed projects; 38% used General Contractor, 8% used Design-Build, and 8% used Integrated Project Delivery.

Table 2. Survey Project Characteristics (25 Projects)

Metric	Average	Minimum	Maximum	Standard Deviation
Cost *(in Millions)*	$63.28	$1.64	$400	$92.76
Number of Hours	533,000	2,000	4,000,000	946,879
Maximum Number of Employees on Site	252	10	1500	361
Percentage of Project Completion	50.39	0	100	36.32
Expected Length of Project *(in Years)*	2	0.08	10	2.15

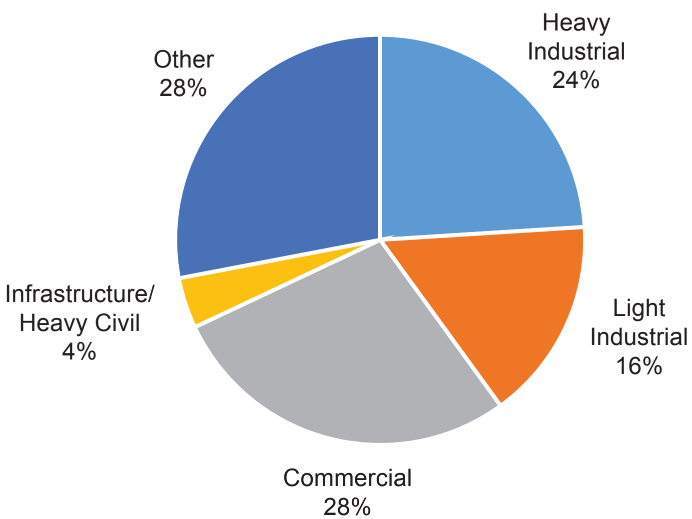

Figure 9. OE Survey Industry Sectors

Analyze Data

RT-317 collected and analyzed the project data from the survey to identify the relationship between Operational Excellence and safety performance. Figure 10 plots the OE Score versus the TRIR for the nine projects that completed all modules of the OE assessment. The maximum score for the modules assessed was 66 points. As Figure 11 shows, the highest OE score achieved was 51.9, indicating that there is still significant room for improvement.

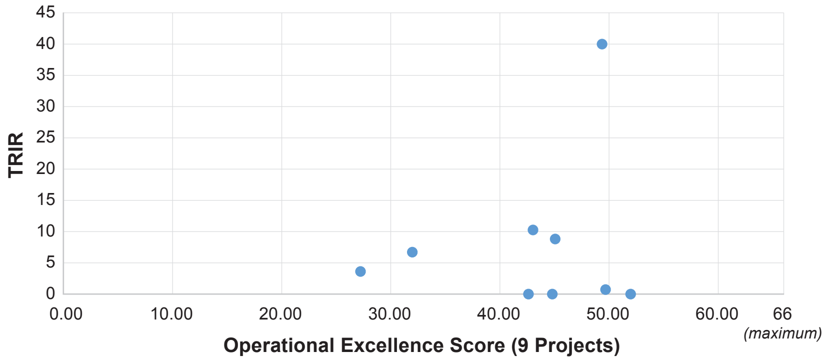

Figure 10. OE Score vs. TRIR for Projects Completing All Modules (Corporate, Project, and Site) in the OE Assessment, Including Both Ongoing and Completed Projects

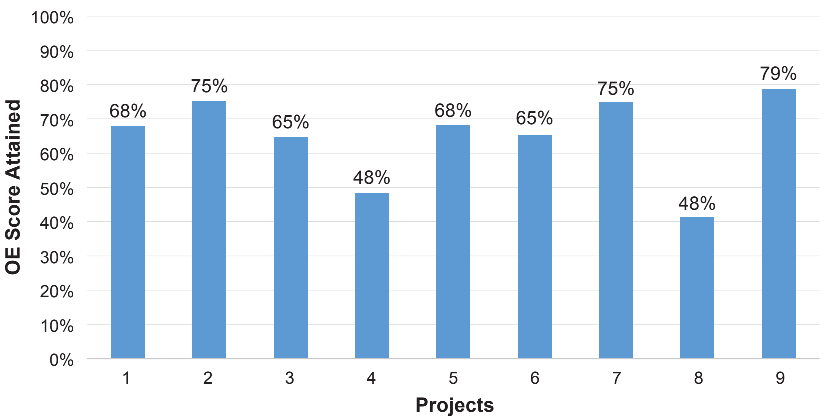

Figure 11. OE Score Percent Attained

There were insufficient data to support any statistically valid conclusions. Anecdotally, if you removed the one outlier with an extremely high TRIR (potentially it was early in that project), the projects with a zero TRIR tended to have a higher OE score.

Recognizing the limitations of the small sample size, Figure 12 displays the Project Level OE score against the TRIR for 38 individual project-level responses. The project-level assessment has a maximum score of 11, which was achieved by three projects. Figure 12 suggests that an inverse relationship may exist between OE score and TRIR. This result, although not statistically significant, provides preliminary support for the hypothesis that increased Operational Excellence tends to occur in projects with a lower safety incident rate. Further analysis will be necessary to obtain results that confirm this hypothesis.

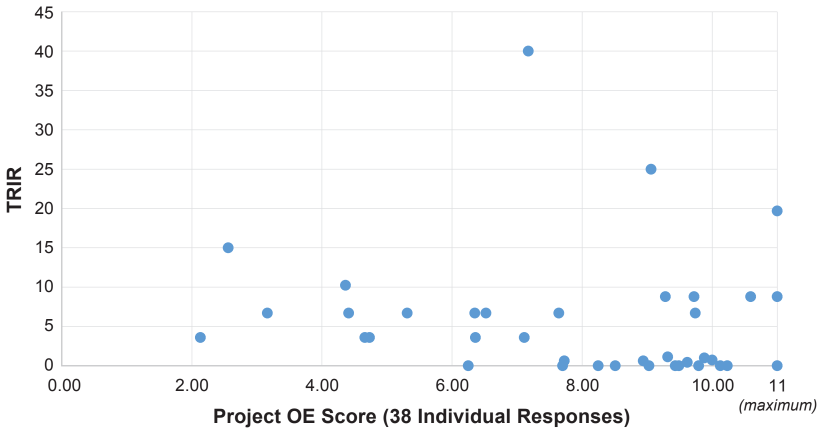

Figure 12. Project Level OE Score vs. TRIR

Another important aspect of the Phase II research was the ability to investigate the penetration of corporate policies through the project hierarchy structure down to the site. As previously noted, the assessment evaluates perceptions at the corporate, project, and site levels of the organization. Figure 13 displays radar plots for each safety driver's percent level of adherence to the model at each level. Immediately, it is evident that many of the policies that corporate-level employees believed to be in place were less understood at the site level, where these policies were supposedly being executed.

Figure 13. Safety Drivers' Adherence to the OE Model at the Corporate, Project, and Site Levels

To further investigate this dynamic, Figure 14 plots each safety driver with the average percentage difference between the corporate and site levels. Worksite organization and organizational learning were two concepts that appeared to be consistently applied throughout the organization (3% and 5% deviations, respectively). However, programs like leadership development, just and fair practices and procedures, employee engagement, strategic safety communication, subcontractor management, and training and competency all deviated more than 25% from the corporate level. The overall average deviation across all safety drivers was 23.2%.

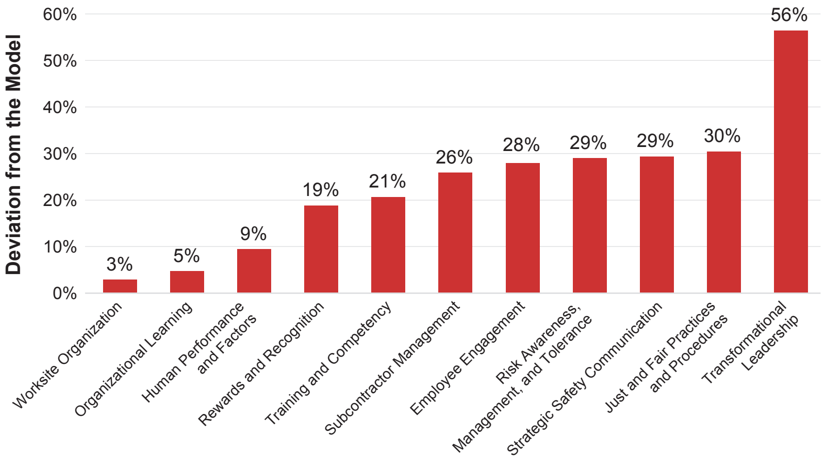

Figure 14. Average Percentage of Deviation from Adherence to the Model between Corporate and Site Levels

Figure 15 focuses on the craft professionals' awareness of OE safety programs. All drivers show that at least 19% of the craft professionals were unaware of any safety programs in these areas. Either these programs do not exist on these projects, or the safety policies are poorly communicated and implemented. CII companies, knowing their own policies, can use the RT-317 products to identify these dynamics.

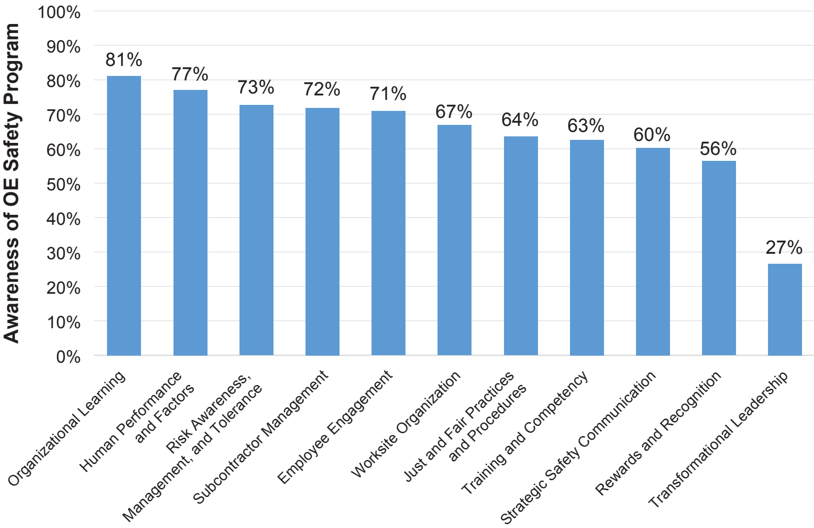

Figure 15. Average Percentage of Craft Professionals' Awareness of OE Safety Program

3

Findings

The primary objective of the Phase II research was to examine the impact that the developed OE model has on safety performance. This objective was met by weighting the safety drivers, operationalizing the model, creating the OE score, collecting data, and analyzing the data.

The findings of RT-317 suggested an inverse relationship between Operational Excellence and safety performance based on a model created by the team and a data collection effort described in Chapter 2. However, the small data sample did not make it possible for the team to confirm its hypothesis. In addition, many of the projects studied saw a decline in the awareness of policies as the focus moved from the corporate level of an organization down to the site level of a specific project. This is an important outcome of this study within the concept of Operational Excellence.

An organization can establish an ideal management system; however, if there is no assessment of the awareness, implementation, and formality with which individuals execute the daily business operations, that system may fail.

4

Conclusions and Recommendations

The Operational Excellence model created by RT-317 seeks to improve construction project safety using behavioral and cultural elements to assess a project's level of commitment to safety. The model outlines a rigorous, professional, and holistic model of safety for CII member companies. RT-317's final deliverables include a methodology for conducting focus groups on shared values, beliefs, and assumptions on projects. Preliminary results of the data collection suggest that projects with higher OE scores tend to have lower safety incident rates.

The assessment model provided in this report, if implemented, could allow an organization to evaluate a specific project's effectiveness at implementing safety policies across owner and contractor organizations, and across different levels within each organization. This assessment model could also be used to allow a single owner or contractor to compare different projects, and to test for consistency across the company portfolio. Such a model could also function as a planning tool for safety programs, similar to what the Project Definition Rating Index (PDRI) is for project execution performance.

The Phase II research identified a number of safety leading indicators, which is a current challenge in the industry. A significant benefit of the model would be to allow owners and contractors to plan, manage, and evaluate their safety programs. Addressing the identified areas for improvement can then help companies take the next significant step toward zero accidents. Future research may allow CII to partner with other organizations ready to commit to a widespread implementation of this model, measuring OE's effects on projects and improving efforts to evaluate its impacts on safety.

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