Constructability:
A Design Philosophy to Build On

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The concept of constructability can help bring civil/structural engineering professionals back to their original roles of developer, designer, and builder.

Civil engineering (which incorporates structural engineering) is the profession in which a knowledge of the mathematical and physical sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the progressive well-being of humanity in creating, improving, and protecting the environment, in providing facilities for community living, industry and transportation, and in providing structures for the use of humanity.

—American Society of Civil Engineers, 1961

WHEN CIVIL ENGINEERING EMERGED FROM THE MILITARY ENGINEERING MODEL OF AGES PAST, THE PROFESSION SERVED AS DEVELOPER, DESIGNER, AND BUILDER—i.e., Eads's bridge, Roebling's Brooklyn Bridge, and Eiffel's tower. As time progressed, the civil/structural engineer as developer/designer/builder was displaced, and the engineer's role became primarily design, isolated from many aspects of concept development and construction. The impact of this displacement on the engineering profession has not been positive.

Increasingly, engineering has become a commodity without recognition of creative talents, creating pricing pressures and quality concerns. Even more alarming, the design profession now is threatened by automation, outsourcing, and digitization. Much of the current role of the civil/structural engineer is being replaced by a less experienced, less knowledgeable technician located abroad, or a computer program.

In his book *The World is Flat*, Thomas Friedman suggests that the key to thriving in today's (and tomorrow's) globalized world, where globalization reaches beyond countries and companies to individuals, is delivering "untouchable" services. He provides a "Help Wanted" list to define what service providers, including engineers, must become in order to survive and flourish. Below are some of the qualities that align most closely with what engineering professionals must become:

Great collaborators and orchestrators—able to operate in, mobilize, inspire, and manage a multi-dimensional and multicultural workforce.

Great synthesizers—able to bring together all of the parts from others and place them in front of the client.

Great explainers—able to see the complexity, but explain it with simplicity.

Great leveragers—able to combine the best of what computers can do with the best of what humans can do, and then constantly reintegrate the new best practices back into the system to make machines and people more productive

Great adapters—able to apply a depth of skill to a progressively widening scope of situations and experiences, gaining new competencies, building relationships, and assuming new roles.

Great localizers—able to understand the emerging global infrastructure, then adapt all the new tools it offers to local needs and demands.

Ironically, these qualities cry out for a re-kindling of the creative passion and talents that have been mothballed and long forgotten since the days of Eads, Roebling, and Eiffel.

Constructability

Here's where constructability comes in. Constructability enables the design professional to develop creative solutions and bring enhanced value to the client. Constructability is the path that will return the civil/structural engineering professional to his formal role, one that was integral in development, design, and construction of buildings and other structures. Constructability is a deliverable that cannot be automated, digitized, or outsourced.

It's a design philosophy that positions structural engineering professionals to become a relevant asset to their clients through the integration of design constraints and construction knowledge throughout the concept development, design process, and building information modeling process.

While this may be a long-term view, the positive impact of the



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constructability design philosophy can be immediate, improving delivery, reducing risk, and enhancing financial performance. Project benefits include:

- Enhances building information modeling and enables design success related to sustainability, security, design-build, risk management, hazard mitigation, and performance-based design.
- Promotes team building among client, designer and contractor, emphasizing the success of the project instead of the success of the individual, thereby minimizing the commoditization of engineering.
- Provides ongoing feedback from clients, users, and contractors to the design team, eliminating scope surprises.
- Reduces total project costs and engineering scope creep, improving profitability.
- Involves construction expertise in the design phase, identifying field issues and avoiding obstacles, unnecessary construction costs, and lawsuits.
- Improves the quality of construction documents, minimizing change orders and subsequent post-construction claims.
- Improves the quality of the next design, incorporating feedback from the field.

According to P. Douglas Folk, Esq., "Over half of *Engineering News-Record's* Top 500 Design Firms have formalized a corporate philosophy promoting constructability within their firms (25% throughout the entire design process; 51% as early as the conceptual planning stage)." By adopting a constructability design philosophy, structural engineers can seize the opportunity to position the profession for the future and improve performance on projects today.

What It Is

The Construction Industry Institute defines constructability as the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives. Those who advocate it as a concept claim that it will bring real benefits to all involved: clients, engineers, architects, contractors, and users.

Constructability involves the process of visualizing the construction of the project prior to beginning the actual design, and maintaining this vision throughout the design process. The focus is on maximizing the simplicity, economy, and speed of construction, while considering such project-specific factors as site conditions, code restrictions, and owner requirements. Constructability is a design philosophy that begins in the conceptual design stage and links project planning to design and construction.

Constructability is a challenge to achieve, because the traditional approach separates the individual functions involved in planning, design, procurement, and construction into specific tasks to be performed by the engineers. Procurement is managed by the construction manger, and construction is performed by the general contractor and appropriate trades.

The steel industry is no exception. The design process is typically separated from the detailing, fabrication, and erection processes. The design professional tends to place emphasis on the design program, budget, schedule, and liability, while the detailer, fabricator, and erector concentrate on meeting the project schedule and budget.

Why Does It Matter?

All projects will benefit from the right balance between production requirements and building constraints. Early involvement of constructability can reduce or eliminate the potential for problems, foster innovation, and help improve the basic structural design—all of which lead to efficiencies in the project budget and schedule.

Constructability impacts several key project areas:

Development of the project plan. Construction industry experience can assist in avoiding flaws such as a sequence and completion schedule that hinders delivery and installation, or construction durations that are not feasible, or overlooking local conditions that create opportunities for innovative solutions (or generate major production problems).

Site layout. While process and plant operations generally dictate the site layout for industrial projects—based on standard industry clearances and workstation layouts—these layouts are not always compatible with structural requirements. Constructability can identify potential conflicts and facilitate a balance between production requirements and building constraints.

Commercial buildings maximize the use of space within the governing code provisions. However, a poor layout may cause construction inefficiencies such as: inadequate lay-down area for subassembly, shakeout or project sequencing, limited access for personnel and material delivery, limitations on the availability of installation methods and or equipment, and inter-contractor coordination issues. Constructability reviews can reduce or eliminate these problems without compromising the basic structural design.

Basic structural design decisions. The selection of the basic structural system may require several iterations from initial concept to final design. Such iterations are a vital step in developing potential savings and reduced risk for the owner. The early involvement of constructability can greatly assist this process. Opportunities for cost or schedule savings can be identified, such as when high-strength steel should be considered, what materials are readily available and on what schedule, what connections might best serve the design and construction of the project, and how shop fabrication can be maximized. During the iterative design development stage, the determination of the structural concept should be based on proven structural systems, specific project constraints, known industry standards, and consideration of available fabrication and installation processes.

While constructability can deliver significant improvements in design and cost savings, it can also provide resolution of many quality assurance issues. By bringing the construction perspective into the design stage—where building information models and contract documents are created—the contractor's perspective is inherently incorporated into the documents, which improves their completeness and results in a level competitive playing field, where the most able and qualified contractor wins.

Constructability Isn't Value Engineering

While value engineering may provide some savings, it is by nature a process of fine-tuning only the individual parts. As such, it does not achieve a finely tuned project. Integration of the process with all the players engaged at the earliest possible stage is the best way to assemble a qualified, cooperative design and construction team and implement constructability.

Further, while some value engineering concepts are used in the typical constructability review, value engineering typically occurs too late in the process. Constructability maximizes the benefit to the owner by impacting the total project starting in the early planning and design phases when industry knowledge and experience can be used to make better design decisions. In contrast, value engineering is more commonly performed after substantial design decisions have been made. Not only is this too late to make changes that would maximize the benefit to the owner, it fosters a perception that the suggestions are

a criticism of the designer, self-serving for the fabricator or erector, and too little too late. Simply stated, value engineering normally occurs when there is little opportunity to impact the project cost or schedule.

Constructability is most beneficial when performed prior to establishment of a defined scope, during early planning and design phases. At this time, industry knowledge and experience is least restricted by design decisions and most capable of affecting the final project. Because value engineering is typically performed only during the final stages, it has limited opportunity to make a significant impact on the project's cost or schedule.

How Does Constructability Happen?

Constructability usually requires that owners go beyond conventional approaches to project execution by expanding front-end planning and investing additional money, time, and effort to enhance the final design and address any issues that may impact the successful completion of the project. In fact, the full benefits of constructability can only be achieved by a proactive design professional that takes a proactive approach to the concept and educates the owner on the benefits of engaging construction industry professionals in the design process.

While many design professionals have significant knowledge about what makes a project "constructable," benefit can almost always be derived from the early involvement of a steel contractor or other experienced construction personnel, such as:

Specialty structural engineer: specializes in steel design and construction.

Contractor engineer: a structural engineer, employed by a fabricator, erector, or other steel-savvy contractor, who has extensive experience in steel design and construction.

Connection designer: a structural engineer with extensive experience in structural steel who specializes in steel connection design.

Independent consultant: a structural engineer who has extensive experience in the structural steel industry.

Input in the planning and conceptual stages of a project provides for a more informed decision-making process based on accurate and up-to-date cost estimates and construction considerations. In addition, design document reviews, subcontractor qualifications, site constraints, weather impact, and schedule concerns can be evaluated sooner when the number of alternatives that can be considered is larger. MSC