



NAC Executive Insights

Management of Engineering in Design/Build

Key Points

- Design/build changes the nature of the relationship between the constructor and engineer.
- Effective management of engineering activities by the contractor is essential for successful delivery of design/build projects.
- Design/build changes the nature of the design process.
- The basis of design is one of the most important set of documents in a project, but often does not get the time and attention it deserves.

Design/build project delivery changes the nature of the relationship between the project's constructor (design/build contractor) and the engineer. This changed relationship has a myriad of legal, commercial, and risk implications. Importantly, it changes the very nature, sequencing, and emphasis of the design process. Many of these changes must begin at the bid stage, making crucial that period immediately after project award regarding the overall project outcome.

This Executive Insight is not designed as a "how to" guide, but rather brings attention to some recurring challenges in key activities of design/build engineering. It concludes with some common issues experienced in engineering's support of the overall project.

Scope

With design/build delivery, the design/build contractor is undertaking many of the risks traditionally retained by the project's owner. Completeness of scope is extremely important, first at the bid stage, when the design/build contractor is developing a fix-priced cost for undertaking the project. Completeness of scope is also important to ensure the clarity of the work to be undertaken by the engineer on the contractor's behalf. Third, a well-defined scope helps to assess the engineering durations required to deliver the outputs the contractor requires for efficient construction.

Some issues commonly encountered with respect to completeness of scope include:

- Poor/incomplete scope definition at bid stage.

- Allowances for design growth included in the construction estimate are inadequate.
- Underground utilities are not well characterized; also, the extent of utility relocations may be significantly underestimated.
- Geotechnical conditions assumed are not supported by an adequate, comprehensive geotechnical design report.
- Engineering deliverables, including building information modeling (BIM) content, format, and capability.
- Extensive/extended design review comments by owner/regulator:
 - contain conflicting comments.
 - contain comments that go beyond the agreed-to scope.
- Signage requirements and responsibility for transition zones are underestimated.

Basis of Design

The basis of design guides the engineer in his/her undertakings. It may be one of the most important set of documents on the project, but often does not get the time and attention it deserves. Therefore, assumptions made in developing the basis of design must be clearly spelled out and tracked.

The common challenges in this regard (noted below) are primarily related to the construction basis of design (CBOD). The CBOD compliments the more traditional “engineering” basis of design by specifically addressing construction considerations, including principle means and methods before design is begun. In public/private partnerships as well as in significant undertakings economically driven by life-cycle costs, an operations & maintenance (O&M) basis of design (O&MBOD) is also considered at this stage.

The following are some common issues in the management of engineering on a design/build project:

- Inadequate incorporation of construction requirements in the basis of design. Constructability reviews, held later in the design process, often do not produce the desired improvements.
- Inadequate consideration of O&M requirements in the basis of design that may lead to ongoing changes that have not been adequately compensated for and that may impact the schedule.
- Errors or incomplete identification of all applicable standards, including revisions, and associated quality or acceptance testing, including revisions.
- An inability to demonstrate any life-cycle performance requirements.
- Unforeseen aesthetics issues.

- Accidents on a similar system impact the basis of design with cost and schedule consequences that may not represent a change.

Configuration Management/Interface Management

When using design/build, configuration management and interface management require the contractor to ensure the various interfaces have been considered and identified by the engineer. These include interfaces with third-party providers, any separate O&M contractor, the owner, and various stakeholders, especially regulatory and permitting agencies.

The constructor needs to keep the engineer's focus on who the current client is, thus avoiding any tendency to satisfy any owner requests or preferences that go beyond the strict interpretation of the contract.

Items warranting special attention include:

- Owner-driven changes that are not adequately compensated for (that is, disruption costs may be inadequate).
- Design team is focused on improving/optimizing design rather than meeting "fit for purpose" requirements in the contract.
- Design changes that are not recognized by the design team as such.
- Vehicle interfaces (i.e., transit projects) that are not tightly managed, which may lead to impact on interface and commissioning.
- Interface management with the O&M contractor that starts too late and does not "freeze" early enough.
- A civils/systems interface responsibility matrix that is incomplete at an early enough stage and leads to rework.

Design Sequence and Productivity

One of the recurring mistakes witnessed in engineering execution in design/build is inadequate recognition of the timing, extent, and sequencing of construction's need for various engineering outputs, including permits and approvals derived from engineering deliverables. In simple terms, the constructor is building from the ground up while the engineer may be sequentially designing the project element by element.

At the bid stage, the engineering activities to be undertaken in the first 30-60-90 days should be absolutely clear along with clarity on the critical elements of construction that those activities are supporting. Challenges often arise because the constructor has not sufficiently communicated his/her

plan of construction to the engineer. Thus, the role of managing engineering, or more specifically its *support of construction*, lies squarely with the contractor and is often a new role.

Management of engineering in design/build requires attention to the following situations, should they occur:

- Design sequence/package does not adequately support construction.
 - Overall project schedule is construction-driven.
 - Seasonal requirements for utility relocations are not taken into account.
 - Inadequate granularity of permit and right of way (ROW) packages that are linked to construction work packages.
- Targeted levels of design productivity are not achieved.
- A high level of design rework occurs due to incomplete scope or changes; subsequently, inadequate change control delays construction.

Quality of Design/Request for Information (RFIs)

“Do it right once” is an old saying. Unfortunately, a major challenge on many design/build projects results from inadequate and/or incomplete design deliverables and the subsequent large number of requests for information (RFIs) and amount of rework that these trigger. All too often in an effort to get physical construction underway (frequently driven by early yet inadequate communication of the construction plan), drawings that are not ready for execution, often with extensive “holds” noted, are rushed to the field.

The resultant RFIs not only negatively impact the efficiency of the overall engineering process, but also create a predictable inefficient sequence of construction.

High quality, complete (for intended purposes) designs, with a minimum of RFIs, require that engineering management be cognizant of the following common issues:

- All utilities are not reflected on drawings.
- Delays in the design process result in poor quality drawings being issued to the field.
- RFIs are not addressed in a timely manner.
- Engineering management and the design process are inadequate to meet project schedule.
- Quality system is not in place or subject to regular audit.
- Failing to confirm the validity of licenses of engineers of record.
- Lack of a detailed pre-operational testing and quality assurance plan.

- The start-up plan is inadequate.
- Design submittal rejection rates are not adequately monitored and timely corrective actions are not taken.

Common Issues

The following common issues come from the author's observations and experiences across a multitude of design/build projects, many seen more than once, and focus on the unique role required of engineering management:

- Lack of a start-up team and plan.
- Inadequate availability of design resources that results from these resources not being identified at bid stage:
 - Required subcontractors are brought on late.
- Tight coupling between design deliverables, procurement processes, and start of construction requires special attention.
- Incomplete designs delivered on time drive unplanned cycling of procurement processes:
 - Start of construction is delayed.
 - Construction productivity is negatively impacted by high levels of RFIs.
 - Not enough attention on "white space" between sections.
- Resourcing has rearview mirror view vs forward looking outlook.
- Delays, even off the critical path, may impact overall project schedule through constraint coupling.
- Delays in the earliest stages of engineering are a leading indicator of future project difficulties.
- Unrecognized coupled constraints – design productivity or quality issues; inadequate recognition of precedents.
- Failure to consider physical complexity of a project – footprint/limited laydown; degree of temporary construction.
- Work packaging artificially constrained by a joint venture agreement.
- Work packaging and unnecessary phasing or grouping of approvals, thus delaying start on initial work elements.
- Inadequate document management system and data integrity.

- Inadequate management of owner-driven changes/interpretations of agreed-to scope.
- Matrix organization does not provide dedicated, adequate core resources for management of each section.
- Design and construction staff not sufficiently co-located:
 - Need multiple, strong, dedicated construction interface/resident engineers.
- Inadequate due diligence on hazardous material disposal sites and vendors.
- Inadequate identification of all required approvals (including confirmation of authority to approve).
- Incomplete or outdated permitting documentation delays approvals.
- ROW datasheet is incomplete or underestimated.
- Failing to consider need for “permits to enter.”
- Inadequate coordination of utility work across sections results in out-of-sequence relocations.
- Division of labor between designer and constructor needs close look, especially for certain field tests.
- Inadequate engineering oversight.
- Failure to conduct a process audit of the engineering process and quality program allows a systemic problem to occur.

Conclusion

The engineering management role in design/build is essential to a successful estimate, project launch, and efficient execution of a plan of construction. Effective engineering management can support innovative approaches through upfront consideration of a construction basis of design (CBOD) and reductions in rework and RFIs. This engineering management function in design/build differs from that found in traditional engineering organizations that work directly for the owner. It also is beyond the construction engineering work undertaken by many contractors.

About the Author

Bob Prieto was elected to the National Academy of Construction in 2011. He is a senior executive who is effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering, and construction industries.