



Temporary Structures

Key Points

- Temporary structures are critical to the success of project execution and must be planned and priced early.
- Temporary structure plans must be coordinated with those of the permanent facility and the site logistics plan.
- It is important to plan for the removal, reuse, or disposal of the temporary work.
- It is important to ensure clarity between the owner and contractor on who is responsible for temporary structures.
- A key function for temporary structures is to ensure safety for all personnel on the project site and members of the public nearby.

Introduction

This Executive Insight focuses on temporary structures. The importance of temporary structures for the success of a construction project is discussed and recommendations are offered for contractors, designers, and owners.

Temporary structures represent a subset of all the temporary facilities required to support construction projects. Plans should be made early regarding schedule, cost, and removal, reuse, or disposal of these temporary structures. Many dependencies exist in planning and executing temporary structures in coordination with permanent facility construction and site logistics operations.

Examples of Temporary Structures

Temporary structures are structural components that are not required for the function of the permanent facility but are required in the construction process. Examples include:

- Formwork to support concrete during placement and curing.
- Cofferdams to exclude soil and water during the installation of a bridge pier in a river.
- Trench shields to mitigate trench collapse and protect workers during underground utility installation.
- Scaffolds to provide safe access for workers.
- Concrete bases for tower cranes.

- Bridges to take construction equipment or public traffic across excavations temporarily during a construction process.
- Temporary marine trestles for construction equipment access as well as temporary marine bridges for maintaining public traffic during construction.

Importance of Temporary Structures to Project Success

- Temporary structures are often critical activities in a construction process and must be well-planned to facilitate an efficient and safe project.
- Many temporary structures primarily provide worker safety.
- Many temporary structures enhance the flow of workers and materials therefore enhancing logistics.
- Many temporary structures are constructed at the beginning of a project and their success or failure can set the tone for subsequent phases of the project.

Challenges of Temporary Structures Planning and Execution

- For design-bid-build projects, the bidding period may not be long enough to develop a well-planned design and construction process for temporary structures.
- The permanent facility may have been designed without regard to the possible difficulties in providing necessary temporary structures. Making appropriate changes to the permanent facility may be prudent in some situations.
- Temporary structures are normally considered as contractor means and methods. The temporary structure may be more influenced by the means and methods that are finally selected by the contractor after the scope of the permanent work is defined by the design team.
- There may be opportunities to increase cost and schedule efficiencies by modifying the permanent structure design to accommodate cost- and schedule-efficient temporary structures.
- Design criteria for temporary structures are often not as developed or detailed as those for permanent facilities.
- In some cases, materials and machinery for temporary structures will be second hand. The design for temporary structures will then need to accommodate such materials and machinery.

Successful Planning for Temporary Structures

Temporary structures must always support the construction of the permanent facility. In some cases, reasonable modifications to the permanent facility can enhance temporary structure construction to such an extent that the entire project execution is enhanced. Since the movement of materials and workers is critical to the efficiency of construction execution, temporary structure plans must be coordinated with site logistics plans. The selection of an effective process for planning temporary

structures depends on the routineness or novelty of the situation, the project delivery method chosen, the risk environment, and the stakeholders who are impacted.

Site logistics plans lay out a vision for how construction facilities, including temporary structures, will support construction of the permanent facility. For complicated projects, a series of such plans will be required that shows each phase of work as construction progresses. Facilities shown will include:

- access points
- temporary offices
- testing labs
- material production equipment
- parking locations
- laydown areas
- hoisting equipment
- material
- personnel movement corridors
- temporary structures

Thorough planning will often uncover situations where investments in temporary structures will substantially improve material and personnel movement and safety. Including planners with temporary construction experience will aid in uncovering such opportunities. Construction supervisory staff such as superintendents and general supervisors can be insightful. For projects with heavy requirements for temporary structures, investments in planning at the conceptual design phase can pay handsome dividends by harnessing contractor creativity.

In some cases, the use of temporary structures can be routine in the context of the project. A construction crew may repeatedly build formwork for a particular type of concrete structure and be well-practiced in using that system. A utility installation crew working in an area with consistent soil conditions making similar installations may regularly use a particular type of trench shield. In such cases, the planning effort required for such temporary structures may be quite modest if there is not an undetected change in relevant conditions. Cost and schedule requirements will also likely be predictable with considerable confidence. Planners should be on the lookout, however, for situations that are beyond the routine and could cause disruptions.

In routine situations, several different temporary structures solutions may be equally successful after construction crews become familiar with their use. Also, several competing contractors may be equally effective in using different solutions. In cases where contractors are expected to compete, the designer and owner should avoid making decisions that unnecessarily limit the types of temporary structures that construction crews can use so as not to limit competition and creativity.

For professionals who are managing construction crews, changes in routinely used temporary structures should be carefully considered. In some cases, a surprising loss of productivity and even crew morale comes with such a change. A switch from one proprietary forming system to another is an example. Properly involving the crew or crew leaders in such decisions can ease the change.

Design-Build Considerations with Early Contractor Involvement

Project delivery methods such as design-build that engage contractors as early as possible in planning and design have the potential to create the most harmony between temporary structures and the permanent facility. Examples include design-build, turnkey, construction manager at risk, construction manager-general contractor (CMGC), and others. For brevity, they are referenced herein as “design-build” with the understanding that several different contact arrangements are possible. Depending on the needs of the project and the details of the delivery method, the most responsibility for this harmonization might lie with either the owner or the contractor.

For some projects, the owner must take a strong lead in coordinating all aspects. Often the owner will use a design-build approach to provide construction expertise for early planning. Owner leadership is often necessary for facilities that include proprietary processes that require confidentiality regarding trade secrets. Certain military and governmental projects can also have confidential aspects that require considerable owner control and therefore leadership in many aspects, including the use of temporary structures. Making modifications to operating industrial plants can also have similar requirements. If an owner can develop a trusting relationship with a designer or contractor, it may be possible to transfer some leadership and coordination activities, along with temporary structure planning and execution, to those entities. Under any circumstances in such projects, excellent communication and coordination will be required among stakeholders.

For real estate development projects in urban areas that require an extensive number of temporary structures, it is possible for the owner to enter into a preconstruction or consulting agreement with the contractor. This could result in considerable planning leadership and control for the contractor. This can facilitate early planning and design for temporary features such as soil retention systems, tower crane placement, delivery routes, and temporary horizontal supports so they can be included in the schematic design. Since financing cannot usually be arranged without a schematic design, there is considerable risk to the investment in developing this design in case the project is not successfully financed. In exchange for the opportunity to build the project, the contractor may provide planning and coordination services for the owner at modest rates on a cost-reimbursable basis. Since the contractor is leading the early planning process and reviewing temporary structure designs along with permanent facility designs, it is likely that the relationship amongst the temporary structures, the construction process, and the permanent facility will be harmonized. When financing is obtained and the risk lessens, the expectation is that the contractor will be retained for the balance of the project with a guaranteed maximum price based on an estimate using their regular labor and mark-up rates.

Owners can employ other means to encourage early construction input for temporary structures. For example, some owners will use a two-step process to engage a design-build contractor. First, an initial review of proposals or qualifications takes place. Second, a limited number of contractors (possibly

three or four) will be invited to submit a second proposal. Often the requirements for the first submission will be set to limit the effort to make this submission, while the second submission is expected to be more extensive. In some cases, the owner will provide a stipend for the invitees of the second submission. If temporary structure requirements are extensive and the stipend is generous, it is expected that the submitters will be motivated to invest additional effort in planning temporary structures, resulting in better proposals that will ultimately benefit the owner.

Design-Bid-Build Considerations

For projects with routine uses of temporary structures, contractors often develop adequate plans for temporary structures within a typical bidding period. For projects involving non-routine temporary structures, however, expecting a contractor to carefully plan such structures within typical bidding periods may present challenges. Since contractors bid several projects unsuccessfully for each successful bid, they usually cannot afford to develop a final design in such cases. Several work-around approaches exist to meet this challenge.

One approach is for the contractor to develop a conceptual temporary structure design along with a conceptual schedule and estimate on which to base the bid. This cost estimate must be adjusted appropriately (almost always to a higher cost) to recognize the risk of bidding with a conceptual design. If the bid is successful, the contractor will convert the estimate to a budget and attempt to complete the final design and execute within the budget. Both the conceptual and final design may be developed in-house or with a consultant. It is more likely, however, that the final design will be developed by a consultant.

If the material for the temporary structure comes from a supplier, the supplier may provide both a conceptual and final design for the temporary structure that is included in a purchase or rental. The material will usually be proprietary. Formwork and scaffolding are examples of temporary structures where this approach is common. This can be advantageous because the supplier may have considerable expertise for the temporary structures in question. Also, the supplier might offer the same opportunity to several bidders, thus spreading development costs over several bids. In addition, competition among multiple suppliers may exist to provide the same scope for temporary structures. Some of these advantages, however, can be lost if the supplied system is more expensive compared to an in-house or consultant design or if the contractor's crews are unfamiliar with assembling and removing the supplied materials.

Seeking subcontractors to take responsibility for temporary structures is another approach that may be advantageous because subcontractor personnel will likely have greater expertise with a particular temporary structure. A few specialty subcontractors may offer quotations to all or most competing prime contractor bidders on a project. Concrete formwork is an example and is most likely to be a successful approach for large projects with repetitive formwork. Subcontracting is also successful for more complicated and less repetitive projects in certain situations. In considering this approach, planners should be cautious to avoid coordination problems that might occur amongst reinforcing

installation, concrete placement, and hoisting activities. The scope of the subcontract must be thoughtfully developed to address these concerns. In some cases, complex steel erection activities require temporary structures, which can also be included in the scope of a steel erection subcontract.

If a design-bid-build project requires a considerable amount of complex temporary structures, an owner might lengthen the bidding period as much as possible to allow more time for bidders to plan for temporary structures. If the temporary structures involve geotechnical designs, an owner can facilitate contractor designs by commissioning a geotechnical investigation and making the results available to bidders. In some cases, the project will benefit if the owner provides a design for certain temporary structures. Such an action might add risk for the owner in case the design is unsatisfactory or may sacrifice efficiency for situations where contractors would prefer to custom design the structures to their specific preferences.

For large marine or riverine projects where a cofferdam is required, the owner could arrange for separate prime contracts for the construction of a cofferdam, the construction of the facility within the cofferdam, and the removal of the cofferdam.

Sometimes construction execution can be improved if the contractor can propose changes to the permanent facility or the owner-designed temporary structure after the contractor is selected. In such cases, the contractor is often expected to pay for the cost of design modifications and share savings with the owner.

Obtaining contractor input can be helpful in making the decisions implied in the previous paragraph. For the design-bid-build contract delivery system, opportunities to obtain such input are usually limited to avoid situations where one competitor would gain an advantage over others by making suggestions that benefit its construction execution approach. Despite this difficulty, it is possible to obtain at least a modest amount of input in a manner that does not materially favor one contractor. Sometimes it is possible to invite all relevant contractors and specialty subcontractors to a workshop early in the design phase and seek input in an open, public meeting. The amount of useful input, however, may be limited because contractors are reluctant to reveal an efficient approach that will benefit competitors. Another possibility is developing a consulting engagement with a person or an organization with relevant experience that will not be competing as a contractor on the project. In a best case scenario, such a consultant would need to have sufficiently broad experience to give advice on how contract documents can be arranged to facilitate construction of temporary structures for a variety of potential bidders.

Owner/Designer Interest in Temporary Structures for Design-Bid-Build Projects

For design-bid-build projects, contractor means and methods usually cover temporary structures, for which the contractor has considerable freedom to select and execute without owner or designer restrictions or input. Regardless, the owners and designers often require some level of review for temporary structures to ensure the safety of their employees who must enter the job site during construction as well as the neighboring public. Additionally, it is important to understand how

temporary structures will impact owner communication and coordination responsibilities and how temporary structures will affect risk management regarding adjacent properties and activities.

Sometimes an owner will require the involvement of licensed design professionals. Permitting processes may require additional review if the temporary structures potentially affect streets, railroads, or buildings. Given the preceding, the owner has interests in reviewing plans for temporary structures even though they are included in contractor means and methods.

Design-Build Considerations: Contractor Involvement After Schematic Design

Some owners choose to develop a schematic design and then select a design-builder to complete the design and execute construction. The version of design-build is mentioned here because an owner may benefit from some of the techniques mentioned in the design-bid-build section to obtain construction expert input on temporary structures while developing the schematic design. Having workshops with relevant contractors, specialty subcontractors, and suppliers and engaging experienced construction professionals in consulting relationships can enhance the schematic design and result in better proposals to complete the design and construction of a facility.

Removal, Reuse, Recycling and/or Disposal of Temporary Structures

At the end of the construction project, the disposition of temporary structures must be determined. Several possibilities exist. In some cases, the responsible party will determine disposition in the early planning or bid stage.

For routinely used temporary structures, reuse is a desirable disposition, especially if items are in usable condition. Items that are in temporary service for shorter periods of time are more likely to be reusable or require less repair than those in use for a longer time. If the item is owned by the contractor, a storage location is necessary—in a warehouse or outdoor laydown yard. A contractor will most likely consider repairing the items before storage so they will be ready for use when needed. If the item requires custom modification before its next use, it may be desirable to delay repairs if it is more efficient to repair and modify at the same time. Delays to repairs are also warranted if such efforts can be used to keep crews employed during slack times. Some temporary structures such as formwork and scaffolding require numerous, small, costly components and a system for tracking and storing them is beneficial. If temporary structures are to be used soon after project completion on another project, the effort of storing is eliminated or mitigated. At some point most temporary structures will be beyond repair and reuse. Plans should be developed to pay for replacement.

One advantage to renting or subcontracting temporary structures is reducing the need to store and inventory items. This is especially attractive for items that are not in constant use. Contractors sometimes use a mixture of owned and rented items for projects that require a surge of that item. Note that rental providers will charge for lost or damaged items, including smaller and sometimes costly components. Whether temporary structures are owned or rented, cost estimates and schedules must reflect the time and effort required to transport, handle, and store temporary structures.

Non-routine temporary structures are more challenging to reuse. Such structures are large structures that are difficult to remove, transport, and store. If transport and storage is possible, consider retaining the items with the expectation of future use in a modified configuration. Such reuse may involve a sale to another contractor. Consider also breaking a large structure down into smaller components that are easier to transport, store, and reuse. Except for large and costly temporary structures, possible proceeds of sales may not be considered when developing a cost estimate, leaving the project to bear the total cost of acquisition. On the other hand, material that can be obtained from previous temporary structures is often provided at no cost to a new project. If no possible reuse is contemplated or storage is not possible, the items are often recycled as scrap material.

Some temporary structures may be incorporated into the permanent facility, so they are left behind. Examples are tower crane bases that will not impede future facility uses or are strengthened portions of the foundation or excavation supports that cannot be retrieved after construction concludes. In making such plans, the contractor should check with designers and owners that such items left behind will not be problematic in the future. As-built drawings should document temporary structure materials that are left behind on the project.

Summary

Even though temporary structures are transient, they are important to the success of certain permanent facilities. For non-routine temporary structures, it is important to give proper consideration in planning both the temporary structures and the permanent facility; both owner and contractors should make efforts to harmonize the two. During site logistics planning, special consideration should be given to how an investment in temporary structures might enhance material movement and personnel safety, thereby benefiting project execution. The approach to the design and planning of temporary structures is different from that for the permanent facility. Construction experts with relevant experience should be engaged in the development process. Carefully planning for temporary structures as early as possible can greatly enhance the success of projects by developing processes that efficiently and safely build the permanent facility.

About the Author

Charles (Chuck) Jahren was elected to the National Academy of Construction in 2018. Chuck retired from Iowa State University after more than 30 years in education and research and six years of industry experience. He is known nationally for his innovative approaches in construction engineering education. He holds a bachelor's degree in civil engineering and an MBA from the University of Minnesota and a PhD in civil engineering with a specialization in construction engineering and management from Purdue University.

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