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CONSTRUCTABILITY GUIDELINES
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SECTION 1.0 - CONSTRUCTABILITY IMPLEMENTATION POLICY

The International Trade and Technology Building has endorsed the cost savings potential of constructability efforts, “the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives.”

In view of our continuing efforts to provide the highest degree of quality and cost effectiveness to our projects, it is our policy to implement constructability to the fullest degree possible. This applies to all phases of project planning, design, and construction. We will ensure that we take full advantage of high potential of constructability to achieve savings during the earliest phases of project planning and prior to the start of design.

_____________________________ is hereby designated as the Constructability Manager and will oversee the constructability program, ensure consistency with other continuous improvement processes, implement changes, and regularly report its effectiveness.

EXECUTIVE SPONSOR:

(OWNER) (SPONSOR)  

_____________________________  

Signature  Date

SPONSORS:

(Architect's Name):

_____________________________  

Signature  Date

(Contractor's Name):

_____________________________  

Signature  Date
SECTION 2.0 - PHILOSOPHY OF CONSTRUCTABILITY

The Message is: Be sure that construction considerations are incorporated into every phase of a project--Feasibility Studies, Conceptual Planning, Design, Procurement, as well as Construction.

- Constructability is the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives.

- Maximum benefits occur when people with construction knowledge and experience become involved at the very beginning of a project.

- Only through the effective and timely integration of construction input into planning, design, and procurement as well as field installation will the potential benefits of constructability be achieved.

- Industry in the past tended to separate the individual functions involved in capital projects by fine-tuning each individual function to minimize its costs. Fine-tuning the individual functions, however, does not yield the most successful project. Constructability integrates these functions and by so doing is the most powerful tool that can be used on projects.

- Traditional separation of engineering and construction early in the project must be bridged if constructability is to work. This bridging requires merging engineering and construction cultures which have both commonalties and distinct differences. This merger must be made easily, automatically, and permanently.

- The principle of continuous commitment is important. The front-end constructability participants are most effective when they know that they are the ones who will have to make it happen in the field. This focuses attention and builds true commitment within the constructability team.

- The size of a project is no barrier to constructability. It is equally valuable to both large and small projects. Smaller projects may warrant to combine some constructability functions. The important point is to include all the essential elements so that a team assembled for a project will have ample common ground for effective joint action by all constructability participants.

- Long-term or complex bureaucracies are not needed to make constructability happen. Constructability, like any other broad program, works best when it is simply an accepted way of doing business with self-evident benefits. Like productivity improvement programs, constructability is too important to be left to chance and must be reexamined periodically.
SECTION 3.0 - CONSTRUCTABILITY OBJECTIVES

- Zero accidents, incidents and injuries.
- Provide work quality that meets project needs and applicable regulatory requirements.
- Implement proven methods and techniques that maximize overall project performance.
- Provide a coordinated effort between engineering, procurement and construction that produces a schedule that meets the project's objectives.
- Continually improve project cost effectiveness through implementation of constructability concepts.
SECTION 4.0 - CONSTRUCTABILITY ORGANIZATION

• CONSTRUCTABILITY SPONSORS

OWNER - SPONSOR
ARCHITECT COMPANY - SPONSOR
CONSTRUCTION COMPANY - SPONSOR

The constructability sponsors' duties and responsibilities are to communicate to the companies' organizations and employees the high interest placed by top management on constructability and to remove any barriers encountered in implementing it.

• CONSTRUCTABILITY MANAGER

(NAME OF MANAGER):

The Constructability Manager's duties and responsibilities are as follows:

- Oversee the Constructability Program.
- Ensure consistency with other continuous improvement processes.
- Implement changes and regularly report its effectiveness.

• CONSTRUCTABILITY COORDINATOR

(NAME OF COORDINATOR):

The Constructability Coordinator's duties and responsibilities are as follows:

- Functionally report to Constructability Manager.
- Act as Chairman of the Constructability Committee.
  Call for and participate in all constructability reviews and concepts evaluations.
  - Report to the Constructability Committee any major feedback or development relevant to constructability.
  - Distribute notes of meetings and other documents to the Constructability Committee members.

• CONSTRUCTABILITY COMMITTEE MEMBERS

The Constructability Committee member's duties and responsibilities are to attend and participate in all Constructability reviews and concepts evaluations.

• DATABASE CUSTODIAN

The Database Custodian's duties and responsibilities are to be responsible for the documentation, tracking, and distribution of constructability concepts and lessons learned.
SECTION 5.0 - CONSTRUCTABILITY IMPLEMENTATION

Implementation of constructability concepts is essential to the success of the constructability process and shall provide a method to ensure all concepts are evaluated, that beneficial concepts are implemented and detrimental concepts are prevented from being implemented. Implementation shall also assure the means of documenting projected cost savings. Post auditing will generate lessons learned for future projects and determine the overall success of the program.

DEFINITIONS

• CONSTRUCTABILITY CONCEPT

Constructability concepts are ideas or suggestions that may improve the performance of a project. These ideas can be generated from any discipline by anyone for any aspect of the project.

• LESSON LEARNED

Lessons learned are observations generated from post auditing current project experiences. These lessons learned will be filed and may become concepts for future projects.

• EVALUATION OF CONCEPTS GENERATED FROM CONSTRUCTABILITY CONCEPTS FILES

The Constructability Committee shall evaluate every concept in the Constructability Concept Files and shall categorize as follows:

(A) Accept   The concept is agreed to by all committee members as a cost effective idea or method for executing the project. The concept is not standard practice but adds value to the project. Accepted concepts will not be cost-estimated but will be documented as project concepts guidelines.

(STD) Standard The concept represents the typical way the project would be executed and cost estimating is not required. The concept is documented in the project concepts guidelines.

(C) Consider The concept represents an idea whose merit requires analysis. The effect of the concept on all disciplines (i.e., Engineering, Procurement, and Construction) must be evaluated to determine its overall benefit to the project prior to acceptance and implementation. Once accepted, the concept is documented through constructability bulletins to be added to the project concepts guidelines.
(NA) Not Applicable for This Project

(R) Rejected The concept is documented as adding no value for this project.

- **CONSTRUCTABILITY CONCEPTS SUGGESTION FORM**

  The constructability concepts suggestion form, Attachment “A.” shall be used by all participants to submit constructability suggestions to the Constructability Committee through the Constructability Coordinator.

  The constructability process shall allow committee evaluation of all constructability concepts and individuals will be informed of results.

- **PROJECT CONSTRUCTABILITY CONCEPTS LOG**

  The project constructability concepts log, Attachment “B,” is used to track the status and record the cost savings of all constructability concepts. Concepts are generated from the “constructability concepts files” and from the “constructability concepts suggestion forms.” All suggested concepts are maintained and listed on the project constructability concepts log whether ultimately accepted or rejected.

- **LESSONS LEARNED REPORTING FORM**

  The lessons learned reporting form, Attachment “C,” shall be used by all participants to submit lessons learned on this project to the Constructability Coordinator.

- **PROJECT CONSTRUCTABILITY LESSONS LEARNED LOG**

  The Project Constructability Lessons Learned Log, Attachment “D,” is used to summarize lessons learned from this project to be used for future projects.

- **CONSTRUCTABILITY BULLETINS**

  When the Constructability Committee accepts a concept, the Constructability Coordinator notifies the various project disciplines via constructability bulletins.

- **CONCEPT ESTIMATING**

  Each constructability concept recorded on the project constructability concept log shall be reviewed by the committee for potential value added to the project. All concepts judged by the committee to be in excess of $25,000 savings shall be estimated [not to exceed eight (8) man-hours per concept] by the Project Control Manager with support from the various departments and will include the following documented savings or cost breakdown:

  - Engineering
  - Procurement
  - Construction
  - Total installed cost savings
Concepts judged by the Committee to be valued at less than $25,000 overall savings can be accepted in principle by the Committee without further estimating effort involved.

• REPORTING

The Constructability Coordinator shall formally report project constructability status monthly. The reports shall include the project constructability log and narratives as appropriate. The reports shall be part of the monthly project status review and distributed to committee members and sponsors as a minimum.
SECTION 6.0 - CONSTRUCTABILITY GUIDELINES

Because the ability to influence the overall optimization of schedule and cost is very high during the early phases of a project (i.e., feasibility study, conceptual planning, design, and procurement activities) and becomes very low at construction and start-up phases, there is the need to orient the engineering, purchasing, and subcontracting activities through constructability guidelines.

6.A CONSTRUCTABILITY DURING FEASIBILITY STUDY

Utilize construction input to help evaluate “do-ability” and cost effectiveness of alternatives during idea generation and elimination.

6.B CONSTRUCTABILITY DURING CONCEPTUAL PLANNING

An overall project management plan detailing the interactions of the various sub-plans (i.e., engineering, procurement, and construction execution plans) must be developed in the conceptual planning phase utilizing construction input.

6.C CONSTRUCTABILITY DURING DESIGN

Many of the conflicts between the extent of engineering's details and construction efficiency can be resolved at this time. An open and questioning mind is essential. Now is the time for the project team to quiz traditional approaches and consider different methods.

6.D CONSTRUCTABILITY DURING PROCUREMENT

Utilizing the overall project schedule and a list of major process equipment, construction must develop a set of field need dates for input to the procurement effort.

Procurement packages detailing vendor requirements must be reviewed to confirm that construction needs are met. Ongoing procurement activities, especially bulk material deliveries, must be aware of construction's field needs.

6.E CONSTRUCTABILITY DURING CONSTRUCTION

Labor-saving techniques resulting from new, modified, or enhanced tools or equipment or unique application of methods are to be reported to the constructability team members on the concepts suggestion form.

Lessons learned during the execution of the project are also to be reported to the constructability team members on the lessons learned reporting form for use on future projects.
SECTION 7.0 - RECOGNITION, INCENTIVES AND AWARENESS

• RECOGNITION

The Constructability Manager is responsible for recommending originators for recognition to be determined by the Constructability Committee.

Recognition may take any of the following forms:

- Certificate of merit
- Letter of commendation
- Incentive award

• INCENTIVES

The Constructability Committee shall determine the level of incentives to be awarded to individuals or groups. The level shall be funded based on constructability savings.

The savings/incentive progress is shown in Attachment “B.” Incentives will only be considered where reduced costs have been taken through reduction in budgets.

• AWARENESS

The Constructability Committee may elect to fund awareness campaigns designed to raise commitment to constructability. This may include but is not limited to:

- Outside presentations
- Team-building
SECTION 8.0 - CONSTRUCTABILITY CONCEPTS

CONCEPTUAL PLANNING CONCEPT 1

Details of the constructability program should be an integral part of project execution plan. If constructability is to be achieved on a project, it must be included in the project execution plan. In most cases, these plans are prepared by an owner project manager at a very early state of the owner’s project. The constructability program should become an integral part of the planning process. The constructability program can contribute to effective project execution in many ways, including:

- Helping to establish project goals and objectives
- Providing a logical and systematic manner for integrating design and construction
- Providing a mechanism for obtaining field construction experience as needed
- Improving the construction personnel understanding of the design intent

Notes

- The Project Execution Plan (PEP) is a formal approach to early comprehensive planning.
- The PEP should address the constructability program.
- The PEP facilitates new player buy-in and imposes a planning discipline.

Application

The A/E scope of services statement should outline in detail the owner’s expectations pertaining to constructability. The statement should cover such issues as level of effort, range of issues, interaction with other organizations, documentation, and results-tracking efforts.

CONCEPTUAL PLANNING CONCEPT 2

Project planning involves construction knowledge and experience. This concept addresses achieving cost and schedule benefits by including construction personnel in the early planning teams. These teams are responsible for determining how best to satisfy a business need—for example: manufacturing a new product, increasing existing capacity, reducing costs, or improving quality. Construction knowledge and experience can be actively involved in:

- Establishing project objectives
- Selecting major construction methods
- Selecting project site
- Analyzing schedule feasibility
- Creating productivity assumptions
• Preparing estimates and budgets
• Identifying sources of materials and equipment

Notes

• Many project planning issues would benefit from early construction input.
• One or more construction personnel should be involved in the early planning effort.

Application

Early planning issues that can benefit from early construction input include project siting, budget feasibility, schedule feasibility, relative priorities, conceptual sequencing of major activities, and feasibility of man-loading.

CONCEPTUAL PLANNING CONCEPT 3

Early construction involvement is considered in development of contracting strategy. The contracting strategy will have a major influence on the availability of qualified construction personnel to serve on constructability teams. Owners must be particularly cognizant of strategies limiting the role of the constructor during early phases of the project. For example, if the project delivery system uses the tradition strategy of separate contracts for the designer and general contractor, the owner will have primary responsibility for coordinating early construction input. Special arrangements, such as reviewing conceptual designs by prospective contractors or using a constructability consultant, may be required to obtain the necessary constructability input during the conceptual and early design phases. Regardless of which approach is selected, the appropriate construction personnel must be involved and their qualifications must be clearly specified in the contract documents.

Notes

• The contracting strategy often establishes the manner of acquiring construction input.
• It is critical to get the right kind of people.

Applications

• Early construction involvement or input can come from one or more of the following seven sources:

  - Owner construction staff
  - A/E construction staff
  - The project constructor hired early on
  - A project constructor hired early on
  - An EPC or design-build contractor
  - A CM (professional construction manager)
  - An independent constructability consultant (specialist)

• Equipment vendors or material suppliers may also be a good source of constructability input.
On large EPC contracts, many have found that specialty contractors are more effective for work such as stack construction, tanks, roofing, asbestos removal, piling, and site services, among others. Some suggest that piping, insulation, and heat-tracing activities be consolidated into a single contractor work package in order to facilitate efficient sequencing and coordination.

**CONCEPTUAL CONCEPT 4**

*Project schedules are construction-sensitive.* This concept establishes the principle that the project completion date and the requirements of the construction phase should be considered in optimizing the project cost and schedule. This concept addresses the overall project schedule, which balances and allocates durations of time among major project phases and activities. To reap the benefits of constructability, the “forward pass” technique of scheduling must be avoided by requiring a “backward pass” or construction-driven approach to overall scheduling. While using this approach, a proper balance must be maintained among the times allocated for planning, design, procurement, and construction.

**Notes**

- Base the conceptual design and procurement schedules on the conceptual construction schedule.
- The construction schedule should be totally integrated with the start-up schedule.
- Construction durations should be realistic; passive acceptance of an imposed schedule should be avoided.

**Applications**

- The allocation of project time among the major project phases must reflect a balance, based on iterative analysis.
- Considerations in allocating time include procurement lead time, contract negotiation period, mobilization and training activities, and construction seasons.

Projects with multiple power units should take advantage of the efficiencies of repetitive activities through judicious sequencing.

**CONCEPTUAL PLANNING CONCEPT 5**

*Basic design approaches consider major construction methods.* Major construction methods can be defined as the use of construction equipment, labor, and work sequencing in such a way that the methods become a major *design driver*. In this case, a *design driver* is a construction method, condition, or technique that design engineering must address, and which, if substituted later in the design or construction process, could significantly impact cost, time, or performance results. Major construction methods must be considered during conceptual planning. All members of the project team should interact and agree on the methodology that will quantitatively and qualitatively measure the output of the major construction methods as positive construction contribution to overall project objectives.
Notes

- The focus is on selection of high-impact construction methods:
  - Scope of modularization
  - Major structural and foundation systems
  - Concrete forming systems
  - Excavation planning
  - Heavy-lift planning

- Heavy-lift planning issues:
  - Identification of lifts
  - Lifting equipment selection
  - Location and scheduling of lifts
  - Crane support/foundation
  - Job-site accessibility

Applications

- Modularization applications include plant control rooms, pulverized coal delivery system, boiler boxes, boiler superheaters, boiler steam drums, turbine generators, exhaust stacks, scrubber additions, pipe racks, precast concrete manholes, and various skid-mounted equipment assemblies. Discussion of these matters should begin very early and involve vendors whenever appropriate.

- Equipment heavy-lift planning should be formalized and conducted early. Project schedulers, rigging consultants, and major vendors should play active roles in this planning.

CONCEPTUAL PLANNING CONCEPT 6

Site layouts promote efficient construction. This concept addresses the principle that construction efficiency is an important criterion in the layout of both permanent and temporary facilities. Permanent facility layout should be reflective of construction concerns and well-coordinated with temporary facility plans. Construction concerns include:

- Adequate space for lay-down and fabrication yards
- Access available for construction equipment, materials, and personnel
- Avoidance of costly and problematic types of construction, such as underground and elevated work when alternatives exist
- Temporary construction uses of existing facilities
- Planning for adequate drainage during construction

Notes

- The focus is on layout of both permanent and temporary facilities.
Considerations include:

- Accessibility
- Construction efficiency/minimize problematic types of construction
- Coordination of permanent facilities with temporary facilities

Applications

- Compact plant designs reduce cable and piping run lengths; however, corresponding construction and operations congestion should be avoided.
- Minimize structure and scaffolding by supporting pipe runs on sleepers at grade.
- A GIS-based system for automatic layout of temporary construction facilities has been developed.
- Construction uses of permanent facilities may require design modifications and changes in design and/or construction sequence.
- Temporary facility layout should fully incorporate a site drainage plan.

CONCEPTUAL PLANNING CONCEPT 7

Project team participants responsible for constructability are identified early on. This concept addresses the attributes of the key individuals on the project team who are responsible for constructability. These individuals should be identified as early as the contracting strategy allows and should continue throughout the project. Having prior involvement in a similar type of project, particularly during the construction phase, enhances the constructability. In addition to construction knowledge and experience, selection criteria should include:

- Teamwork skills
- Communication skills
- Ability to objectively evaluate design and construction trade-offs
- Receptiveness to new ideas

Notes

- Constructability is a team effort!
- Proper timing of involvement of key personnel is the secret to success—usually, the earlier, the better
- Needed skills of constructability coordinator include construction knowledge and experience, teamwork skills, communication skills, awareness of trade-offs, and receptiveness to new ideas.
Applications

- Include plant operations representatives on the project team from the start, but be aware that their influence may need “balancing.”

- Recognize the costly effects of not having continuity with key personnel; aggressively seek continuity in personnel.

- Conduct team-building sessions at the outset of every major project. Have the team collectively define constructability challenges, opportunities, and solutions.

- Another key to constructability success is having one or more team members with extensive start-up experience.

CONCEPTUAL PLANNING CONCEPT 8

*Advanced information technologies are applied throughout project.* Constructability is enhanced by exploiting the capabilities and benefits of advanced information technologies. The use of advanced information has the potential to revolutionize the methods used by the construction industry. Some of the information technologies being applied to projects include the use of three-dimensional computer modeling, relational database systems, expert systems, computer simulation, electronic data interchange, bar coding, and field notebook computers. The emerging technologies provide opportunities to better apply construction knowledge and experience by improving the interface of project engineering, construction, and maintenance personnel.

Applications

- Networked database of constructability ideas and lessons learned

- 3D solid modeling with physical interference detection and an integrated database for controls

- Bar-coding technology for materials management, tool control, document control, and worker training

- Electronic data interchange with suppliers to increase efficiency of the purchasing cycle

- Hand-held, user-friendly, durable pen-to-screen field notebook computers facilitate virtually all forms of field information management, including daily diary, materials management, progress tracking, and field inspections

- Graphical computer analysis and simulation of heavy lifts

- Expert systems as advisors on such issues as scoping of modularization/preassembly, selection of welding procedures, diagnosis of weld problems, diagnosis of pump problems, and diagnosis of rotating machinery vibration problems.
DESIGN AND PROCUREMENT CONCEPT 1

Design and procurement schedules are construction-sensitive. Construction normally is the largest cost segment of a project and thus exerts great cost leverage on a backward-pass schedule through both procurement and design. Procurement, other than for lead times, has a moderate ability to conform to the needs of the construction segment of the overall schedule. Design is a complex and demanding process, but frequently it is the most fruitful area in optimizing the entire project schedule. Owners and their project managers should be sensitive to cost and schedule trade-offs over the entire period of project activity. Needed skills of constructability coordinator include construction knowledge and experience, teamwork skills, communication skills, awareness of trade-offs, and receptiveness to new ideas.

Notes

- The focus is on definitive development of design and procurement schedules.
- The semi-detailed master construction schedule with major milestones must be established first.
- A non-conventional design sequence may be necessary.
- Details include:
  - Deliver plans and specs early enough to allow for job-site preplanning.
  - For large orders with multiple stages deliveries, specify the sequence of delivery.
  - Be aware of “area sterilization” effects (in which access to areas is limited for one reason or another).

DESIGN AND PROCUREMENT CONCEPT 2

Designs are configured to enable efficient construction. The desired result is to facilitate the exchange of ideas between construction and design professionals before pencil-and-paper design activities occur. The following factors should be kept up front in constructability deliberations.

Simplicity is a desirable element of any constructable design, as is flexibility for the field construction forces to select alternative methods of innovative approaches. Sequencing of installation is as much a design consideration as it is a procurement or construction consideration. And designs that require special skills should be minimized, along with ones that are highly labor-intensive.

Notes: The “Simplified Design” Litmus Test

- Could the design be accomplished with fewer components? [Value Engineering approach: Can the part be eliminated altogether?]
- Are the materials readily available? Have you used common sizes? Can the engineered equipment be purchased off the shelf?
- Have you minimized demands for extraordinarily skilled craftsmen?
- Can the task be accomplished without special environmental controls (shelter, HVAC, lighting, etc.)?
• Have you provided for a field capability for dimensional adjustment?
• Have you avoided making the task more sequential-dependent than necessary?
• Have you accommodated special handling, inspection, or testing requirements?
• Have you provided an incentive for the contractor to suggest a better design?

Applications: Lots!

• Reduce scope of work by maximizing use of existing site utilities such as water/wastewater treatment, emergency generator, auxiliary steam, and start-up transformer and storage facilities.
• Increase the amount of life-cycle, cost-benefit analysis to contain “scope growth” for automated control systems.
• Consider reducing the number of pile caps by enlarging pile cap size.
• Consider elimination of transformer oil retention pits by routing drains to the plant drainage system for oil removal.
• Consider replacing concrete duct banks with direct burial cable or sand-encased PVC.
• Substitute lightweight flexible steel mesh for formwork for underground duct banks.
• Consider replacing elbow-plus-fittings or welded elbows with induction pipe bending technology. Benefits can be significant.
• In lieu of total replacement of underground pipelines, consider the slip-lining approach.

DESIGN AND PROCUREMENT CONCEPT 3

Design elements are standardized. This concept addresses the achievement of cost and schedule benefits by using standardization—a process by which project elements are both regularly and widely used. Usually, the predominant trade-off is a cost reduction that results in time savings in construction and volume discounts in materials. Compare that to an increase in materials resulting from a more conservative design. Specific advantages of standardization include:

• Increased productivity from repetitive field operations
• Volume purchase discounts
• Simplified material procurement
• Reduced design time
• Greater interchangeability of spare parts during maintenance operations
• Reduced contingencies in estimates

Notes

• Standardization offers many benefits.
• Many aspects of design and equipment selection can be standardized.
• Questions to ask:
  - Where do you suffer from excessive variation?
  - How should the standard be determined?
  - How can standardization analysis be made part of the design process?

Applications

• Lack of standardization is often a problem for pipe valves, pumps, condensers, instrumentation (e.g., transmitters), switchgear, turbine accessory skids, and paints/coatings.

DESIGN AND PROCUREMENT CONCEPT 4

*Construction efficiency is considered in specification development.* Construction knowledge and experience can contribute significantly to the generation of specifications that promote efficiency in field construction operations. Constructability can be enhanced by recognizing the following:

• The underlying corporate guide specifications should offer clear-cut options.
• Specification development within a project should be done as a distinct project activity with full and early involvement of personnel with appropriate construction knowledge and experience.
• Sufficient time should be allowed to develop complete, consistent, and error-free specifications.
• Clarity is sought as one of the prime characteristics of a good specification.
• A single construction specification should cover all appropriate aspects of a single subject or component.
• The cost saving potential of “or equal” specifications often is balanced against the risk involved.
• Specifications should be maintained in order to include the most current cost-effective, state-of-the-practice techniques and materials.
• “Gold-plated” specs should be avoided.
• Specifications should be conducive to “global” procurement.
• Where appropriate, consider the use of a performance-type spec to increase contractor/vendor flexibility and cost-effectiveness.
Notes

- Both specification content and the manner of its communication can affect constructability.

- Why do such problems persist?
  - Spec development is often a rushed activity.
  - Constructability is often neglected in spec review.
  - Truly capable automated information systems are only now becoming available.

Applications

- Project close-out reports should address specification-related problems and lessons learned should be documented and reviewed periodically.

- Specifications should facilitate the use of recent low-cost technological developments, such as:
  - Geotextiles for troublesome soils or slopes
  - Flowable fill (or “fill-crete”) in lieu of normal compacted fill
  - Concrete superplasticizer admixtures
  - Fly-ash as a cement substitute (that improves workability and reduces heat of hydration)
  - Epoxy-set anchor bolts
  - Lightweight high-strength fiberglass beams and gratings

- Consider using 50 KSI steel rather than 36 KSI steel for building structures. The higher-strength steel is more costly per pound, but cross sections may be reduced, reducing both steel tonnage and foundation sizes.

DESIGN AND PROCUREMENT CONCEPT 5

Module/preassembly designs are prepared to facilitate fabrication, transportation, and installation. Once the decision has been made to use modularization, preassembly, and/or prefabrication, special factors must be addressed during design and procurement to ensure their successful implementation. Designers should first consider where the fabrication is to be performed. Module/preassembly designs add requirements for transporting and handling large assemblies. These activities form a revised scope for the project and introduce key physical or schedule restraints based on the availability of transportation and handling equipment. Finally, the installation method must be considered because it affects module design, overall plot layout, and design of underground services and foundations.

Notes

- Design considerations include:
  - Design/procurement organization restructuring
  - Engineering criteria/specifications
  - Work packaging/technical documentation
  - Module scoping/sizing/orientation
  - Module transport/handling methods
  - Module weight/c.g.
- Module-to-Module connections/QA-QC requirements
- Module structural support
- Module temporary support
- Module fabricator selection/component procurement
- Winterization/hazards minimization
- Fabrication yard layout, staffing, and management

Applications

- Each module should be treated as a mini-project unto itself for the purposes of scoping, engineering, drawing/specification production and work packaging, fabrication, and installation. Project organization and control systems should be modified accordingly.

- In general, modules should be designed as large as shipping constraints will allow.

- On-site boiler assembly will be facilitated with exceptionally tight control of boiler component fabrication tolerances.

- Precast concrete underground manholes and sumps often are subjected to settlement problems. Innovative foundation leveling and compaction methods are needed. Flowable fill (high-slump concrete) may offer an answer to this problem.

DESIGN AND PROCUREMENT CONCEPT 6

*Designs promote construction accessibility of personnel, material, and equipment.* Difficult access for personnel, material, and equipment on the project can have a negative impact on the project’s success. Difficult access for personnel can have a severe impact on productivity. In addition, difficult access routes frequently present unsafe working conditions. Similarly, difficult access routes for high volume commodity materials can adversely affect cost and schedule. Accessibility studies of major equipment pieces and temporary erection access openings are as important as those for personnel and commodities. Specific issues that should be considered include:

- Sequencing of work
- Delivery schedules for major pieces of equipment
- Laydown areas on congested sites
- Delivery routes
- Use of permanent elevators for personnel lifts
- Installation and location of underground work to be traversed later by heavy equipment
- Type, location, and required opening size for equipment

Notes

- Poor accessibility can be costly.
• Accessibility problem tell-tales:
  - Remote sites
  - Tight sites/CBD sites
  - Road restrictions/limitations
  - Large loads
  - Steep grades
  - Elevated work/overhead work
  - Weak soils/muddy sites
  - Congested areas/concurrent scheduling
  - Security restrictions
  - Operating plant restrictions
  - Overhead obstructions/power lines
  - Sites with adjacent construction power lines
  - Add-ons and modifications to existing plants
  - Extreme weather
  - Strikes

• How can accessibility be enhanced?
  - Use effective activity planning/sequencing.
  - Use effective plant layout.

Applications

• Accessibility is obviously critical for installation of large pieces of equipment and modules in general; this applies to the cranes needed for installation as well.

• Accessibility for modularization is greatly facilitated by having a port/shipping channel or a rail spur that allows for increased module sizes.

• Pipe rack designs should provide adequate space for insulation, coatings, and worker head room.

• Heavy haul roads should be designed such that their utilization is not diminished by cross-traffic, excessive rain, or inadequate bearing capacities.

• Enhance site accessibility by maintaining an effective site drainage system. Plan for ditch crossings with minibridges, temporary culverts, and cover plates. With a high water table, be prepared to use sump pumps.

DESIGN AND PROCUREMENT CONCEPT 7

Designs facilitate construction under adverse weather conditions. It should be recognized that adverse weather conditions can have a significant impact on construction cost and schedule. In many cases, however, the effects of adverse weather can be alleviated with proper consideration in the design of the project. Typical activities that may reduce the effects of adverse weather are:

• Planning site layout that is accessible
• Selecting construction materials
• Use of off-site pre-assembly

Scheduling of design

• Minimizing subsurface construction that involves de-watering
• Planning construction lighting
• Allowing for adequate site drainage

• Scheduling and controlling delivery of equipment and materials to avoid unnecessary protection requirements
• Providing adequate temporary protected storage areas.

Notes

• To what extent will weather affect your project?

• What can you do about it?
  - Effective sequencing of activity
  - Modularization/preassembly
  - Proper selection of materials
  - Judicious project layout/design

Applications

• Cut drainage ditches and place road bases as soon as possible to enable productive work during rainy weather.

• Minimize problems with dust or smoke by locating wind-borne material stockpiles down wind and away from easily affected construction activities.

• Hot weather concreting can be facilitated with the use of chilled water or ice.

DESIGN AND PROCUREMENT CONCEPT 8

Design and construction sequencing should facilitate system turnover and start-up. This concept establishes that the overall project schedule for complex projects shall integrate turnover and start-up sequencing with design and construction sequencing. Recognizing that high penalties are paid to change construction sequences (with a possible corresponding change in design sequence), it is important that the overall start-up planning process begin early in the facility-delivery process. The sooner planning begins, the fewer start-up problems crop up that result in increased costs and delays. The longer the overlap between the start-up phase and the construction phase, the more important becomes early integration of start-up into the overall project plan. Of equal importance to integrated project planning is the need to identify start-up requirements that
have a direct impact on design, such as special piping connections, environmental considerations, and electrical power requirements.

Notes/Applications

- Facilitate start-up by converting from an area-based schedule to a systems-based schedule when approximately 75% of construction is complete.

- Start-up planning is critical for several reasons:
  - There is a significant amount of concurrent activity.
  - Design/vendor support is often required.
  - Hazardous operations require more attention to safety.
  - As the work force is downsizing, staffing may be a problem.

- Check out digital control systems and major equipment in the factory prior to shipment (substituting simulators for external interfaces).

FIELD OPERATIONS CONCEPT

Constructability is enhanced when innovative construction methods are used. Obviously, there is also a need to apply construction knowledge and experience to improve the effectiveness of field operations. Construction method innovations are numerous and typically “small” advances. These should not be overlooked, however. Collectively, the potential benefit is substantial. Innovative construction methods may involve a variety of issues:

- Sequencing field tasks
- Use of temporary construction materials/systems
- Use of hand tools
- Use of construction equipment
- Constructor-optonial preassembly
- Post-bid constructor preferences relevant to the layout, design, and selection of permanent materials

Notes

- Some constructability benefits may still be available during field operations. To some extent, constructors can still reap constructability benefits from their actions alone.

- There is a need to share construction innovations within and across field organization boundaries.

- These innovations are often small in scope or scale, yet are numerous in quantity. Collectively, the effect can be very significant!
There are seven classes of innovative construction methods:

- Innovative, definitive sequencing of field tasks
- Innovative uses of temporary construction materials and systems
- Innovative development and uses of hand tools
- Innovative uses of construction equipment
- Constructor-optional preassembly
- Innovative temporary facilities
- Post-bid economical constructor preferences related to layout, design, and/or selection of permanent materials

- Two related topics:
  - Promotion of innovation; see *Tucker’s Tidbits*, a newsletter for the exchange of craftsman ideas.
  - Awareness and application of advanced construction technologies.

**Applications**

- Examples of innovative sequencing of field tasks:
  - Effective preplanning/sequencing of the setting of boiler boxes enhances crane usage and overall task productivity
  - Underground construction should be sequenced so as to minimize excavation (and compaction) efforts.
  - Install the permanent fire water system early for use in hydrotesting.

- Examples of innovative uses of temporary construction materials:
  - Flexible, easily erected, left-in-place, chicken-wire type mesh has been used in lieu of conventional formwork for underground duct banks and spread footings.
  - Demolition of large boulders and concrete structures (including foundations) is made easier and quieter with the use of expansive grouts placed within drilled holes.
  - Stack and large vessel fabricators should provide the foundation contractor with a template of the anchor bolt arrangement in order to facilitate proper alignment.

- Examples of innovative hand tools may be found in issues of *Tucker’s Tidbits*.

- Innovative construction equipment developments include the following:
  - Automatic wire feeders for casing work
  - Automatic shoring adjusters

- Common examples of constructor preassembly include pipe fabrication and reinforcing steel cages.
# Constructability Concepts Suggestion Form

**Project Title:**

________________________________________

**Discipline Group:**

________________________________________

**Concept Description:**

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**Originated By:** ________________________  **Date:** ___________

**Office Comments:**

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**Reply:** __________________________________

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## ATTACHMENT B
### PROJECT CONSTRUCTABILITY
### ACTION ITEM LIST

### COST ESTIMATE DATA

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**TOTAL**

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**STATUS KEY:**

- A = ACCEPTED
- C = UNDER CONSIDERATION
- NA = NOT APPLICABLE TO THIS PROJECT
- R = REJECTED

**TOTAL % COMPETITION**

- DESIGN:
- CONSTRUCTION:
- PROGRAM COST TO DATE:
# Constructability "Lessons Learned" Reporting Form

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ATTACHMENT D
PROJECT CONSTRUCTABILITY

“LESSONS LEARNED” LOG

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## CONSTRUCTABILITY REPORT FOR MONTHLY ENGINEERING SUMMARY

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### Constructability:

- Concepts: _____ (this month)
- Concepts accepted: _____ (this month)
- Total concepts accepted: ______

- Total Program Cost: ______
- Total Potentially Avoided Cost: ______
- Total Value Added Cost: ______

*Optional* Describe any concepts that had a major affect on the project.

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SECTION 10.0

MEETING NOTES
0.0 PROGRAM OBJECTIVES

- Implement a rigorous constructability program following The University of Texas System, Office of Facilities Planning and Construction Constructability Manual.

- Identify and document project cost and schedule savings (targeted costs are 5% of construction costs).

1.0 PROGRAM IMPLEMENTATION

1.1 Project Team Meeting with Constructability Consultant
(Initial meeting)

1.1.1 Constructability Implementation

- Review Constructability Manual for constructability program, implementation and documentation requirements.

- Establish constructability organization following the Constructability Manual.

- Identify preliminary constructability priorities and special challenges or concerns.

1.2 Schematic Design Phase
(On-going tasks during Schematic Design Phase and for final review of Schematic Design Documents)

1.2.1 Constructability Consultant

- Attend project team meetings, review documents, and develop constructability recommendations and documentation following the Constructability Manual.

- Provide construction cost estimates to coincide with the Project Architect’s submissions. The Project Architect and Constructability Consultant shall consult and resolve any differences in their respective construction cost estimates.

1.2.2 Project Team and Constructability Consultant

- Review constructability recommendations, documentation and construction cost estimates for acceptance.

1.3 Design Development Phase
(On-going tasks during Design Development Phase and for final review of Design Development Documents)

1.3.1 Constructability Consultant

- Attend project team meetings, review documents, and develop constructability recommendations and documentation following the Constructability Manual.
• Provide Cost Quantity Surveys to coincide with the Project Architect’s submissions. The Project Architect and Constructability Consultant shall consult and resolve any differences in their respective Cost Quantity Surveys.

1.3.2 Project Team and Constructability Consultant

• Review constructability recommendations, documentation and Cost Quantity Surveys for acceptance.

1.4 Construction Documents Phase
(On-going tasks during Construction Documents Phase and for final review of Construction Documents)

1.4.1 Constructability Consultant

• Attend project team meetings, review documents, and develop constructability recommendations and documentation following the Constructability Manual.

• Provide Cost Quantity Surveys to coincide with the Project Architect’s submissions. The Project Architect and Constructability Consultant shall consult and resolve any differences in their respective Cost Quantity Surveys.

1.4.2 Project Team and Constructability Consultant

• Review constructability recommendations, documentation and Cost Quantity Surveys for acceptance.

1.5 Close-out Documentation

1.5.1 Constructability Consultant

• Complete all documentation following the Constructability Manual.

1.5.2 Project Team and Constructability Consultant

• Review documentation for acceptance.