Design by Phases

Part 1

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Most engineers use a six-phase project methodology. In chronological order, the six project phases are pre-design, schematic design, design development, construction documents, bidding and negotiations, and construction administration. It's important to proceed in the proper order as the project develops. Completing a task during the wrong phase can create a domino effect that will cause extensive rework, time, money, and even embarrassment.

A checklist that defines the tasks assigned to each phase can assist in the process. Entry-level engineers should use this index until they know it by heart. Seasoned engineers should use it as tool simply to ensure they are on schedule. It also can be used as an instrument to inform the owner-client of what you've produced at each phase and what you'll need for the next phase.

Here is a phase-by-phase summary of the purpose of and tasks to be completed during the first three phases of a project. The last three phases are the subject of the next column, in the November/December issue of *Plumbing Systems & Design*.

Phase 1. Pre-Design

This phase of the project requires meeting with the owner to define the exact scope of work. Then the engineer prepares a written summary of the anticipated work. Preparation of a project budget and project schedule also are part of this phase. The engineer works jointly with the owner to establish the timeline for the project and the available funds.

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✔ Pre-Design Actions

Initial Meeting

1. Discuss the client's objectives.
2. Discuss the client's wish list.
3. Discuss the project scope and program.
4. Discuss the project budget.
5. Review the existing drawings and surveys.

Architect's and Engineers' Responsibilities

1. Write the basic services agreement.
2. Perform a zoning and code analysis to determine local codes, building department requirements, and restrictions.
3. Complete a field survey (for a remodeling project).

Phase 2. Schematic Design

The American Institute of Architects' owner-architect agreement states, "The Architect [or Engineer] shall provide those services necessary to prepare drawings and other documents illustrating the general scope, scale and relationship of project components for approval by the Owner." An ancillary purpose of the schematic design phase documents is to prepare an estimate of the probable construction cost so it can be compared with the owner's budget. To develop a cost estimate with reasonable accuracy and gain the owner's approval, the engineer must develop documentation sufficient to communicate the design intent to the owner and whoever is responsible for preparing the cost estimate (the architect, an independent cost estimator, or a construction manager). Those in the industry commonly understand two important aspects of the schematic design phase:

✔ Schematic Design Actions

Plumbing

1. Assess the adequacy of existing toilet fixtures.
2. Assess the adequacy of existing drinking fountains.
3. Review the existing drawings and buildings to identify all code deficiencies and possible approaches.
4. Establish the quantity and locations of roof drains.
5. Identify new spaces requiring floor drains.
6. Suggest locations for drinking fountains or water coolers.
7. Establish space requirements for water heaters and special equipment.
8. Establish locations of primary vertical and horizontal pipe runs.
9. Indicate all of the above on schematic architectural floor plans.
10. Prepare an outline of major materials and systems.
11. Support preparation of the cost estimate.

Fire Protection

1. Review the existing drawings and buildings to identify all code deficiencies and possible approaches.
2. Determine fire pump, engine type, gallons per minute, and head requirements.
3. Establish the preliminary size and location of fire standpipes or other primary sprinkler risers.
4. Establish the size and location of special equipment.
5. Indicate all of the above on schematic architectural floor plans.
6. Prepare an outline of major materials and systems.
7. Support preparation of the cost estimate.

- The most far-reaching decisions—those have the most profound effect on the eventual design and cost of the project—are made during the schematic design phase.
- The later in a project the schematic design information is generated, the more likely it is that the team's efficiency during the later phase, will be adversely affected. Consequently, shortcuts during this phase can have a disproportionately large adverse impact on the project's success.

The schematic design phase tasks and deliverables are even more necessary when, by virtue of the project's complexity or schedule, the game plan calls for the team to proceed directly into the construction documents phase. Without a design development phase, adequate time and effort must be allocated so this phase's tasks and deliverables can be fully accomplished.

Phase 3. Design Development

According to the standard American Institute of Architects' owner-architect agreement, the objective of the design development phase is "to establish and describe the size and character of the project as to architectural, structural, mechanical, and electrical systems, materials and such other elements as may be appropriate…for the construction manager's review [when there is one] and for the owner's approval."

Much of the design development phase is spent considering design options for various portions of the project. The final design evolves from this process. The results of the design analysis and development must be adequately documented to communicate the design intent to both the owner and the construction manager, even though the documents will fill different needs for each of them:

- For the owner, documentation should demonstrate that the design was developed in accordance with the owner's objectives and expectations; and that the specific materials and systems selected for the project, along with the ways in which they will be assembled, are acceptable to the owner.

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✔ Design Development Actions

Components of a Well-Developed Set of Documents

1. Project title
2. Drawing title
3. Scale
4. North arrow, as required
5. Project number
6. Drawing number
7. Date
8. Names: Drawn, checked, and approved by__________

Plumbing Engineering Services

Required by the plumbing group at the start of design development

1. Approved schematic floor plans and site plan
2. Schematic building sections
3. Schematic building elevations or perspective
4. Building construction type occupancy and use group
5. Fire resistance requirements
6. Special areas requiring plumbing

Required from the plumbing group to the architectural group at the start of design development

1. Plumbing design concept developed and indicated on schematic architectural plans
   a. Preliminary sizes and locations of vertical stacks, risers, leaders
   b. Preliminary size, number, and locations of roof and floor drains
   c. Suggested locations for drinking fountains and water coolers
   d. Special space requirements for water heaters and special equipment
   e. All other primary vertical and horizontal pipe runs
2. Floor plans
   a. Vertical stacks, risers, leaders, floor drains
   b. Horizontal piping runs
   c. Water heaters and other equipment
3. Site utilities plan
   a. Water and gas service, pump houses or pumping stations, as required
   b. Sanitary sewer or sewage disposal system
   c. Storm drainage piping and catch basins
4. Catalogue cuts of all equipment exposed to view (e.g., plumbing fixtures, faucets, water coolers, hose cabinets)
5. Outline specification
6. Cost estimate of plumbing work (if required)

Final review and coordination with all disciplines: Incorporate final revisions

Fire Protection Engineering Services

Required by the fire protection group at the start of design development

1. Approved schematic floor plans and site plan
2. Schematic building sections
3. Schematic building elevations or perspective
4. Building construction type, occupancy, and use group
5. Fire resistance requirements
6. Special requirements

Required from the plumbing group to the architectural group at the start of design development

1. Fire protection design concept developed and indicated on schematic architectural plans
   a. Preliminary size and location of fire standpipe or other sprinkler risers
   b. Preliminary location of hose racks and cabinets
   c. Size and location of space for special equipment
2. Floor Plans
   a. Head and piping layout
   b. Fire hose cabinets
3. Outline specifications
4. Cost estimate of fire protection work (if required)

Final review and coordination with all disciplines: Incorporate final revisions

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constructed in a pipe form, usually using lead. Lead was expensive, but it was strong and could handle the water pressure. The pipe went down one side of a valley and up the other side. On the outlet side of the pipe, water pressure forced the water back up to the same height as the origination point.

- **Wall:** A wall was used for shallow or medium-depth depressions. It was simple to construct the aqueduct along the top of a solid wall. However, a wall, unlike an arch, prevents traffic from moving underneath from one side to the other.
- **Arcade:** An arcade is a bridge built from a series of arches. Roman arches were constructions of beauty and they were engineering marvels, as no mortar was used. The arched design was used because it required less material than a solid wall and allowed for freedom of movement under the aqueduct. Arcades were used to traverse deep depressions and valleys.
- **Cascade:** Most cascades were simple angled chutes or stepped chutes used for mild to steep sections of an aqueduct system. They continued the overall principle of using the force of gravity to move the water.
- **Drop shaft:** A drop shaft is a form of cascade having a vertical shaft connecting horizontal or sloping conduits. The drop shaft is constructed at different vertical elevations. The Roman engineers constructed both rectangular and circular drop shafts. On occasion, the outlet conduit would be at 90º from the inlet conduit direction, resulting in a very efficient design for energy dissipation.

- **Regulation basins:** As the sophistication of the aqueducts evolved, a regulation basin was incorporated into the design. This basin had a system of gates and overflow dams. The gates were used to control the overall flow of the water through the system, while the overflow dams allowed for overflow discharge.

Whatever the Name

It's clear that the Roman Empire engineers had a unique understanding of hydrology, and it's no wonder they are considered pioneers in hydraulic engineering. Using solid hydraulic design experience, these engineers were able to design aqueducts that incorporated trenches, culverts, cascades, drop shafts, arches, and regulation basins.

It isn't much of a stretch to imagine there must have been an organization of hydraulic engineers back in the Roman Empire—perhaps the precursor to the American Society of Plumbing Engineers. Perhaps their motto was *Aquarius Engineerusadunare*. ■

PLUMBING DESIGN BY THE NUMBERS

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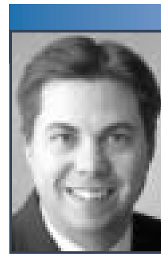
- For the construction manager, documentation should allow assessment of whether the specific materials and systems proposed for the project are appropriate to achieve the owner's objectives and should set forth the scope of the work with sufficient clarity to facilitate development of an accurate cost estimate.

Some projects require the team to proceed from the schematic design phase directly into the construction document phase. This streamlining of the design process is really a false efficiency, because all of the services required in the design development phase must be performed to properly complete the project. They simply are being deferred and combined with the construction document effort.

Combining these inherently different services (design attention and production efficiency) more often than not leads to reduced efficiency. Failure to study design issues thoughtfully during the design development phase will have an adverse impact on the efficient production of construction documents. ■

Look for Phases 4, 5, 6 in the November/December issue of *Plumbing Systems & Design*.



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This article is meant to provide some basic guidelines. Always check all relevant codes and resources for a particular project.