



AIA Best Practices: Less rework equals more productivity and quality

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Summary

We can improve the quality of construction documents and increase productivity of the project team at the same time in part by the approach and order of decisions made. The aim is to reduce the amount of time spent redrawing during the development of construction documents.

By way of illustration, we are going to look at three approaches to the development of a typical floor plan of a high-rise condominium project. The approaches taken have both productivity and quality implications. In some sense, they are variations in degree, differing primarily by upfront organization and the order in which decisions are made, and how that plays into the time it takes to draw the plan.

Approach 1: Continual rework

Continual rework is a fairly common approach, as shown in this example. The project team tackles what is considered the important problem of the day and gives little attention to problems yet to be worked out. For example, the architect developing the plan is working on the arrangement of the various units within a somewhat loosely defined building envelope. There is also some development of the core elements and some regard to the structural requirements. However, there is no requirement that the structural gridlines, column locations, column and shear wall sizes be determined in the schematic design phase. At the end of schematic design, the architect has what he considers to be a floor plan of the typical floor, complete with core unit layout and building envelope. However, little in the plan can be considered accurate in the sense that it could be dimensionally fixed.

Then, in design development, the structural gridlines are defined, the column schedule is complete, and the perimeter envelope including curtain wall modules are fixed. The architect then reworks the plan, fixing the structural grid, the column sizes and the building envelope.

Continuing in design development, the partition types are fixed. This requires addressing acoustical isolation, limiting heights, construction cost issues and coordination requirements. The architectural team then reworks the plans, adjusting the nominal widths of the partitions and hatch types.

At such time that attention is placed on the kitchen and bathroom design, the plans are reworked to address the development of the cabinets, appliances and plumbing fixtures in the plans. Later, an analysis of accessibility requirements reveals that changes are required to the kitchen and bathroom layouts. This latest

rework has a domino effect requiring adjustments to the unit layouts, the structural gridlines and even to the overall building envelope.

This process continues, with working and reworking of the plan as each subsequent decision is made.

Approach 2: A uniform development of all of the plans

"The Plan is the generator. Without a plan, you have lack of order and willfulness. The Plan holds in itself the essence of sensation." – Le Corbusier.

"The Plan proceeds from within to without; the exterior is the result of an interior." – Le Corbusier

In this approach, the project team takes a more structured method, recognizing the importance of developing the plans in schematic design, and that the development of one plan has implications for other plans because to some extent the plans have common extruded elements. The team also recognizes that programmatically it's important by the end of schematic design to have each of the plans somewhat developed so that the overall size and organization of the building is determined.

The team also recognizes that it is important to dimensionally fix a few items that serve as references between the plans. These items could include the principal structural gridlines, elevator hoistways and the overall building envelope.

The architectural design team in schematic design focuses on unit development on the residential floors and in fixing the partition layout of each of the floor plans. This task requires some level of design layout coordination with the developing structural design. There is also a simultaneous coordination of the plans with the building elevations and envelope development.

One of the planning tasks requires developing the building core elements consisting of the elevators, stairs, electrical closet and duct risers for make-up air. The focus is on simultaneously solving all the various stair plans, electrical closet and duct riser configurations. The architectural team should coordinate with the structural engineer, the electrical consultant, and the mechanical consultant so as to have a general idea of the core impacts of consultant work on each plan. Each of these team members has a daunting task, with their focus primarily quantitative rather than qualitative. Refinement and adjustments will come later.

This methodology is more structured than the continual rework approach; however, it is still the case that few elements of the drawings are graphically fixed and dimensional at the end of schematic design.

Approach 3: A typical residential floor plan should be graphically complete at the end of schematic design

For this approach, the project team sets out at the beginning of the conceptual design phase to clearly articulate general objectives, tasks, and deliverables for each design phase as a part of the team's quality management procedures. A work plan is devised for each member of the design team that sets specific tasks to be completed at each phase point.

One objective of such a work plan is to examine the development of the project from a productivity standpoint. For our hypothetical high-rise condominium project, one of the tasks states that at the end of

schematic design “a typical residential floor plan should be graphically complete.” Graphically complete means with little exception there will not be further rework of the plan, and it is accurately drawn and dimensioned.

This task recognizes that since the drawings have become computer generated, the demarcations between schematic design, design development and construction documents have become more blurred than they were in days gone by, and that the schematic design drawings are to some extent developing construction documents. Even so, each phase retains some specific purpose, and there should be specific expectations for these phase points.

Graphically fixing a typical residential floor plan is just one of the tasks slated for schematic design, and this task needs to be coordinated with other tasks. These include that all plans are required to be developed to the extent that general layouts are determined, the floor-to-floor dimensions be fixed and small scale full building elevations be graphically complete. Some of the concerns expressed in Approach 2 are equally applicable in this approach.

There is no conceivable scenario where a design team can correctly and accurately draw each element in the drawings without rework. What a design team can do, however, is to create a work plan that defines at the various phase points (or issue dates) specific objectives that would include defining fixed elements requiring limited rework. This differs from Approach 2 when we look at the project team’s objectives and work flow. It is no longer an objective to uniformly develop the various floor plans, but rather to graphically fix a representative plan and develop the other plans sufficiently so that other schematic design task objectives can be met.

How might this work in practice? The same manpower as in Approach 2 is utilized, but there is a shift in focus. Team members recognize that they need to perform their respective tasks with two focuses; one addressing the typical residential unit floor plan and the other addressing the balance of the floors. The goal is still to develop all the plans to a schematic design level, but with a special emphasis on the typical residential floor plan.

There is a balance between the quantitative and qualitative. This approach requires planning and cooperation between the architecture team members, consultants and the client. Let’s examine more closely how this process could work.

Structure

The structural design needs to develop overall focusing on the principal framing design and the lateral design so that a framing model for the entire project can be advanced at the conclusion of schematic design. At the same time, those portions of the structural design that impact the typical residential floor plan are refined to the point where sizes of the columns and shearwalls are fixed in size and location. For our high-rise condominium project, in order to accomplish these objectives the architectural design team, the structural engineer, the pre-construction phase contractor and the owner have to work together in the design and decision process. In order to graphically fix the structural elements on the typical floor, the impact that the column layout of the typical floor has on all other floor plans needs to be studied.

In our hypothetical case, there is a parking structure occupying floors below the typical tower residential floor plate. Early in schematic design two structural schemes emerge, both flat-plate concrete designs; one with column centers of 27 feet, which permits three parking stalls between columns, and the other 20 feet, which permits two stalls. The structural analysis concludes that the 27-foot span design is a post-tensioned slab design whereas the 20-foot span design is a conventionally reinforced mild steel design.

Besides the planning impact of each scheme to the floor plans, including the typical residential floor, there are issues of construction cost, construction scheduling and adequacy of sufficient skilled manpower in the case of the post-tensioned slab design. Given that these two schemes have substantially different column layouts, the impact to the development of the plans is significant.

Halfway through schematic design phase, a decision was made to proceed with the post-tensioned layout. Then the structural and architectural team focused on refining the gridlines, column sizes, shearwall layouts and principal slab edges and openings, so that at the end of schematic design the structural layout of the typical residential floor plate was graphically fixed.

MEP/FP

Simultaneously, the MEP/FP design needs to develop such that the principal systems are defined, the major mechanical spaces are located, and major risers through the residential tower are located and sized. At the same time, those elements of the MEP/FP system that affect the typical residential floor plate are designed and refined to the extent that the typical residential floor can be graphically correct at the end of schematic design. This means:

- Ductwork risers are sized and located and shafts are fixed
- The electrical closets in the various equipment configurations are laid out to a large scale, confirming space requirements
- Fan coil units are laid out within the units
- Plumbing fixtures are selected
- The sprinkler main, branch piping and sprinkler heads are located

Core/unit plans/exterior envelope geometry

The paragraphs above address some of the tasks required of the structural and MEP/FP engineers in schematic design in order to increase productivity in line with Approach 3. Likewise, each task primarily driven by the architectural design team in schematic design needs to be developed knowing which elements of the drawings are scheduled to be graphically fixed when.

By committing to drawing a graphically accurate typical residential floor core plan at the end of schematic design, common aspects of other core plans are inherently correct. At the beginning of design development, the typical residential floor core is a known and reliable quantity.

Commonalities on the other floor cores are known and reliable quantities. The emphasis in design development would be on designing, and fixing in a graphically accurate manner, those elements on the

other core plans that are not common. This does mean, however, when developing the typical floor core in schematic design any aspect of another floor core that could impact the graphic layout of the typical floor core needs to be considered.

In laying out the kitchens and bathrooms, the architect needs to simultaneously address the programmatic design intent of each, how they fit within the unit plans, specific fixtures and appliances, accessibility requirements and any finish material patterns. It's actually not that difficult, and mostly a function of the order of decisions made. Address specific toilet room fixtures, kitchen appliances and tile patterns early in schematic design rather than in design development. If such selections are made later, that increases the rework.

And so it goes; with each aspect of the plan, the level of accuracy expectation by phase needs to be in the project work plan, and the development of the documents proceed accordingly. Graphically fixing the exterior envelope of the typical residential floor plan coordinates with the requirement for the small scale building elevations to be mostly graphically complete at the end of schematic design.

With the objective of a graphically accurate typical residential floor plan achieved at the end of schematic design, it's achievable to set a task requiring each floor plan to be graphically complete at the end of design development.

And, likewise, expectations for other aspects of the drawings follow. The fact that the design team knows that some subset of the documents is fixed at one phase point increases reliability and allows the focus to shift to other tasks in the next phase.

Less rework brings efficiency and quality

"Why is it that productivity increases as quality improves? Less rework. There is no better answer." – W. Edwards Deming, Out of Crisis

It seems an easy argument that with more upfront organization and less rework the more efficient the design team. No proof required. As more elements of the plan become fixed those aspects of the plan become reliable. The team can move ahead with confidence and address other issues.

The argument that the resulting drawings including our illustrative typical condominium floor plan are of higher quality follows. Reasons for resulting higher quality drawings include:

- the fee can only tolerate so much rework
- the schedule can only tolerate so much rework
- the continual coordination process within the architectural team produced drawings qualitatively diminishes each time the same aspects of the work requires rework
- continual rework required of consultants work qualitatively diminishes at an even faster rate
- working in a less organized and structured process diminishes pride of workmanship

- a corollary to the previous is that the team enthusiasm diminishes after each iteration of rework

The key is to develop clear work plans to be more productive, therefore becoming more profitable with higher quality documents.

About the contributor

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