Chapter 2
Integrated Design

2.1 Conventional Design and Construction Strategies and Players

The main players in a conventional (traditional) method of designing and constructing a building are the building owner, architect, engineers, commissioning team, and general and subcontractors. Code reviewers and authorities having jurisdiction that review the design documents and upon approval of the design issue building construction permits are the secondary group of the players. Finally last group of the players are the firm's attorneys that handle the firm's lawsuits and prepare educational presentations for the firm managers and employees, in order to familiarize them with the basics of defensive and protective architectural, engineering, and construction practices.

In a typical traditional design and construction process owner's needs and expectations are primarily communicated to the architect. Architect then designs a preliminary building and depending on the size and type of the building, employs a group of engineers including structural, civil, HVAC, plumbing, electrical, fire protection, fire alarm, audio-visual, and acoustical engineers to design the building engineering aspects. A close communication among all these players is essential for delivering a successful design product.

Design process in a typical consulting engineering firm usually starts with reception of the architectural preliminary plans and guidelines. These preliminary plans as a minimum show the orientation, function, and sizes of each space in the building as it is intended by the building owner and as it is envisioned by the architect. Usually at this time there is only sufficient information for a preliminary engineering design. Different design engineers always need considerably more information to be capable of performing their expected designs meaningfully. This additional information includes items such as building sections and elevations, number of

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occupancy, lighting, equipment, reflected ceiling plans, fire-rated walls and partitions, and the characteristics of walls and glasses. At the same time, design engineers have to provide feedbacks to the architect which based on this data the architect would be able to complete his design. Samples of this data are duct and pipe chase requirement, mechanical, electrical, plumbing and fire protection space requirement, etc. Based on the quality and effectiveness of the architect and engineers this information exchange could take place either quickly or consumes some considerable time. In some unfortunate situations, when one or more of the involved parties are not well experienced, building design could be performed without complete and accurate exchange of some important information. This most likely would lead to a problematic and troublesome construction process.

After all the coordinations took place and was included in the building design, the final design product will be presented to the code reviewers and authorities having jurisdiction for their approval before being handed to the general contractor for construction. General contractor is usually selected through a competitive bidding process.

The selected general contractor then hires different subcontractors to construct different parts of the building. One more time a very close communication among the architect, engineers, general and subcontractors is needed to make delivering a successful final product to the owner possible. As the general contractor and his subcontractors become involved in the construction process, their first task is to provide construction shop drawings. These shop drawings are produced based on the information available in the construction documents, and later will be used for constructing the actual building. Shop drawings are a set of coordinated drawings that contractors provide from over laying all the architectural and engineering drawings at each building part. Contractors send these shop drawings along with selected equipment data back to the design team for their final review and approval of its exact equivalency with the design intents, and after receiving an approval from the design team use it to start the actual construction phase. During the construction process, design team in pre-approved time intervals performs a few site visits, and informs the general contractor if there is any construction deviation from the design contract documents. When construction finishes the design team performs the final site visit and approves the building for occupancy. Again at this stage and based on the quality and accuracy of the contractors and design team site visit performances, construction process could be completed either smoothly with a high quality, or poorly with unchecked and uncorrected mistakes.

Architects and engineers usually prefer this method of design and construction because they get to perform a design with much higher than what is set as the minimum quality required by the codes and standards. After contractors got the project based on becoming the lowest bidder, they may rely on collecting more money through issuing request for information (RFI). This would require a successful demonstration that design has not been clear and complete when they bid the project, and they have calculated their estimated cost based on uncompleted design document.

Due to the structure of the market another processing method has been received more attention in the industry in the recent years. In a design-build process only the general contractor is selected directly by the owner, and architect, engineers and subcontractors are then added to the team by the general contractor. In this process from the start of design the general contractor and his subcontractors have interaction with the architect and the engineers to provide a design that has all the minimum code compliance acceptable quality with a pre-negotiated guarantied cost. Owners that do not plan to keep the building ownership to themselves after completing the building construction may prefer this method, because in this case spending minimum first cost may be more important for them than a building with higher quality and better future performance. Throughout this process generally most of the upgraded designs proposed by the architect and engineers that could add to the value of the building and therefore total cost of the project is ruled out by the general contractor in order to keep the total project cost within the pre-agreed upon budget.

2.2 Integrated Design

A building is made of multiple components and systems, which each one is designed and installed by a different professional. A small change in characteristics of any one of these components or systems can have a considerable effect on the other components and systems performances. For example a small change in the heating characteristics of a typical building glazing system has a dramatic effect on HVAC system cooling and heating equipment sizes, ductwork and piping network size, power requirements, consumed energy, day-lighting strategies and lighting design, mechanical space requirement, and noise level in the building. Also selecting how to orient the building on a site has a lucid effect on where to locate the mechanical rooms and fresh air intakes in the building, and building ventilation, lighting, day-lighting, noise, and air quality control strategies. This not only implies a close co-operation among the architect and engineers, but also requires their vast cross-discipline knowledge.

It has become obvious that the traditional way of design in which each individual (trade) player was working in a vacuum for most of the design and construction time and everybody was relying on either architect or general contractor project manager to coordinate and solve all the conflicts is not an efficient method of design and construction to be pursued any more. In an integrated method every individual should not only be in continuous contact with the architect or construction team leader, but also shall be in continuous information exchange with all the other players. This communication is most critical specifically in the early stages of the design. Experience has shown the earlier the need for changing design or construction is discovered, the less burdensome the financial effects of the design change will be on the project itself, and also on all the involved parties as well.

Usually the best way to manage a successful integrated design effort is to get all the lead design players together at the beginning of the project and establish brainstorming sessions to study the building and collect all the player's inputs, requirements and concerns on cross-related issues and use that to make the initial design based on an overall agreement among all the involved parties. Such efforts promise a correct initial design direction along with eliminating possible multiple designs of the same system due to discovering its conflict with other team member's design approaches later and along the way. Such actions should not be limited just to the initial sessions, but they should continue throughout the rest of the design process regularly. Such collaborative efforts will help the team to find and solve the probable conflicts throughout the design and construction process much faster and with much less financial and environmental burdens.

An example of an integrated design emerging out of the integrated design brainstorming sessions can be integration of building skin design by the architect, daylight illumination by the electrical engineer's and HVAC system by the mechanical engineer. In this approach the architect optimizes the design of the building envelope system in such way that maximizes the use of day-lighting in the building, by specifying high-quality glazing system. This technique helps the electrical engineer to reduce the use of artificial lighting during the hours of the day that it is possible to replace design lighting with natural light in the building. At the same time the HVAC engineer gets the benefit of lower artificial lighting load and higher quality glazing system in the form of smaller HVAC equipment size requirement. As the result of smaller HVAC equipment the architect gets the benefit of additional usable spaces and higher ceilings heights in the building that obviously adds to the beauty of the architectural design. Electrical engineer also gets the benefit of smaller generators due to smaller size HVAC systems and of course lighting system that would collectively helps the team to bring the project cost and its environmental negative effects lower. Such benefits cannot be realized without engagement of all the team players in early interactions and their collective efforts.

In summary the integrated project design and construction should be looked at as a method of working on and completing a project by maximizing the project outcome for the owner and minimizing undesired effects on the environment. Most important element of this process should be managing the waste (specifically energy waste) and increasing the design and construction efficiency. This cannot be achieved other than by utilizing the maximum skills, knowledge, and resources of the involved players. An important step in performing a well-executed integrated project delivery is proper cost, schedule, quality, performance, sustainability goal settings, and developing procedures to measure and verify the success of each outcome. For a detail discussion on the principles, procedures and benefits of an integrated project delivery refer to "Integrated Project Delivery: A Guide; version 1; 2007; AIA National/AIA California Council; The American Institute of Architects."

A typical integrated design process and the proposed required steps along with a sample design charrette matrix has been presented in Appendix "H" of ASHRAE standard 189.1, 2011 (ASHRAE 2011). In this specific charrette each factor which is believed to be dedicating to the high performance of the building is graded between 1 and 10 in order to create an overall advantage of one system over the competitive solutions. Of course this is not the only way of utilizing integrated design and many other grading methods depending on the specifics of the projects also can be utilized.

2.3 Energy Conscious-Integrated Design Approach

Delivering a successful energy conscious building construction project also should start with an integrated effort from the early stages of conceptual design and continue throughout the whole process of delivery and even beyond it. A well-planned scheduling and outcome targeting should be utilized in order to specify, monitor, and verify each parties responsibilities at each step along the project life to guarantee a successful outcome. The desired sustainability goals and energy saving measures should be known as early as possible, since adding a new sustainability characteristic to the building in the middle of the design could be very costly. As an example, energy consumption monitoring for different energy users in the building is always a very good sustainability measures to have in the building specifically in order to monitor the real energy consumption of the building sections after the building is occupied by different tenants. From the point of view of an electrical engineer wiring the electrical power in the building should be designed in a specific manner to comply with this requirement. If from day one the owner and the team agree upon achieving this desirable measure, the cost of the design and construction would not be affected considerably. But if the building power wiring is designed or even worse is installed without expectation of achieving this measure, and sometimes down the road a decision is made to add this function to the building sustainability system, then the cost of design or constructing the change into the under construction building would be dramatically higher.

As I have mentioned earlier in a successful integrated design all parties including the owner, the design team, the construction team and the commissioning team should be actively involved in all stages of the project. Different stages of a project delivery are usually referred to as conceptualization stage, design development stage, design stage, construction stage, and post-occupancy stage.

Conceptualization stage is the earliest stage that the design and construction team meet the owner and get familiar with his expectations of the building and also the project budget. There are many examples of the building designs that were started with a very high level of energy saving factors conceptualized in the early stages of the project implementation, just to be removed from the scope of the project due to lack of harmony between the design team imagination and the owner's budget. The design and construction team should in detail study the level of sustainability and energy saving that the owner desires to include into his building. Design team then should propose the possible systems, designs, material availability, and more important the cost associated with these factors to make sure that enough budget is available for designing and implementing these measures.

In design development stage, design and construction team should finalize the sustainability factors and level of expected performance from the building with a realistic input from all parties. A simple but complete design of major building systems and an early stage energy model should be presented that clarifies all the outcomes and associated cost for the expected performance of the building. Agreement of the owner of the project on selected systems and expected performances among the other possible options presented by the design team, and preliminary input from manufacturer's regarding their capability of delivering equipment that can provide the expected performance within the project assigned budget are other major milestones in this stage.

In design and construction stages all the building systems including its sustainable characteristics should be incorporated in design and construction of the building, and compliance of the building with all the expectations, performances, and codes should be verified. Performance of the building should be calculated and finalized via completion of the energy modeling exercises.

The post-occupancy stage which is as important as the other stages in realizing the performance of the building should include continuous engagement of the owner of the building in educating of the occupants and building management crew to make sure the building performs as the design intended to. The building owner shall oversee to make sure a proper service execution, and stay in continuous engagement with the design and construction team regarding monitoring and reporting the real performance of the building, and comparing it with the design intentions. If corrective measures are required it should be coordinated between the owner and the design and construction team to bring back the building to the proper operation and performance level.

2.4 Other Tools

Building Information Modeling (BIM) which is a digital shared knowledge resource for support of the decision making and designing a facility has taken a significant step in improving parts of the processes that was discussed in this chapter, but until all individual players think and act in-line with integrated design spirit, a real efficient design and construction procedure would be very hard to be performed even with advance software.

Creating design and quality control check lists by the firms are among other successful strategies that can be used as part of an integrated design and construction effort also. Some firms gather, update and complete their check lists as time goes by, which helps the individuals to refer to these lists for their designated responsibilities and required coordination with all other parties during the life of the project. Such checklist could be carried on to the brainstorm sessions in order to help even higher levels of success in integrated design approach.

In the next chapter of this book I will discuss the concept of organizing knowledge that if it is implemented correctly can have significant positive consequences on the improvement of a collaborative design processes.

Reference

ASHRAE (2011). ANSI/ASHRAE/USGBC/IES Standard 189.1-2011. Standard for the design of high-performance green buildings, except low-rise residential buildings. Atlanta, GA: American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., and U.S. Green Building Council

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