# LCI Design Forum

The purpose of the LCI Design Forum is to bring together designers, builders and owners to explore ways of improving the design and construction process. The basic premise is that investing in design and the collaborative design process is a cost effective way to add value to a project and benefit all parties involved in its construction. The following outline lays out many limiting characteristics found in current practice: upward creeping budgets, poor coordination and suboptimal design solutions. In response, we ask what we would change if we ran the zoo and could implement a series of recommendations. Listed below is a brief outline of possible improvements to conventional practice. They are intended to be a starting point and template for a rich discussion. Each topic for improved practice will be introduced with a short presentation or case study. This will be followed by discussion aimed at generating practical recommendations.

## Undesirable Characteristics of Current Design Practice

### *Difficulty with Defining or Measuring Values*

If a team were to design to target characteristics (values) then the difficulty of defining and measuring values quickly becomes apparent. Let us consider values as being either quantifiable or unquantifiable and subtle or obvious. One observation is that outside of the architect, the rest of the design team and construction team does not have a complete understanding of the client’s values because most of the team has little direct contact with the client. What information the greater team has is usually filtered through the values of the architect. Faced with little information, the team will naturally make choices reflecting their own values. It is not uncommon to hear complaints of designers about contractors who only care about reducing first cost and minimizing risks. Nor is it uncommon to hear complaints about architects who only care about aesthetics to the detriment of all other values. What is missing is the complete value matrix that is known and held by the entire team. Such a matrix would express a weighting of various values to capture their relative importance. The team also needs to know of any minimum threshold limits of any values. The building code is one form of minimum limits. For this outline, the following categories of values are defined:

1) Quantifiable and Obvious Values: These are the easiest to handle. Examples include construction cost, schedule, a LEED rating, etc. One can imagine design-build delivery having a bias toward designs which satisfy quantifiable and obvious metrics.

2) Quantifiable and Subtle Values: These are performance characteristics that can be determined with enough effort and modeling by a sophisticated and highly skilled design team. Because of the time and expense needed to perform complex analysis, such work is not typically done on most projects. Examples include operating costs, maintenance costs, indoor air quality, ecological footprint, acoustic performance, seismic performance, etc. In the case of seismic performance, the models used to quantify performance are quite complex, because they are based on probabilities. For instance, to help clients understand the coupling between design and performance, computer models of seismic structural performance need to be linked to financial models to evaluate repair and business interruption costs.

3) Non-quantifiable and Obvious Values: These consist of beauty, curb appeal, quality of thermal comfort, natural light, natural ventilation, connection to outdoors, etc. These values can prove tricky because everyone can have different experiences of them, such as beauty. One can imagine that architect led teams with traditional delivery methods have a bias toward designs that satisfy non-quantifiable and obvious values.

4) Non-quantifiable and Subtle Values: These consist of quality, design risk, reliability, durability, adaptability, site context (urban and rural), cultural context, fung shui, etc.

The client's awareness may be limited with regard to many of the potential project characteristics and expressions of value. Consequently, clients are often unable to impart their value matrix to the team.

A second difficulty is that the client may not consider the relative weighting that he/she/they have for their values. For example, many clients want both top quality and low cost. This is little help to the design team, because the relative weight of potentially conflicting values is left undefined.

### *Poor Integration*

Complexity of modern construction projects has led to great specialization within the design community and thus creating many potential integration problems.  A full team can consist of the architect, urban planner, interior designer, consultants for color, day-lighting, waterproofing, elevator design and acoustics and structural, civil, mechanical, electrical, plumbing and geotechnical engineers.  The construction teams are similarly complex with many subcontractors. Many general contractors seem to act as subcontractor brokers with little to add to the design quality.

1) Often the designs are developed somewhat independently.  Usually, with the exception of the architect, team members have little understanding of each other's work.  Coordination can be expensive and inefficient. There are strong pressures to meet schedule that act to squeeze out coordination.  Unfortunately, the alternative of incomplete coordination is worse.

2) The design team is often fractured, with little interdisciplinary contact. This condition discourages innovation and synergy between systems and disciplines.  When fees are offered by sub-consultants, a common practice is to define the scope of work as narrowly as possible based on a preconceived design.  From a sub-consultant's view, the work of integration is often shifted to the architect in the design phase and to the contractor during construction.

3) The current system rewards ordinary and safe systems while discouraging innovation or systems needing lots of integration between consultants.

4) It is difficult for anyone to fully grasp the complete set of possible interactions between the systems.

5) Design conflicts can remain obscured until construction, when they are very difficult and expensive to correct.

6) Often systems can work against each other: thermal mass vs. seismic mass, windows vs. strength, good solar orientation vs. good urban design, efficiency vs. adaptability, day lighting vs. acoustics, etc.

7) Potential system synergies are often missed.

8) Individual system goals may be met at the expense of the overall project goals.

### *Inability to Design to Set Budgets*

Cost feedback for a design team often comes too late in the process to make the best use of the information. It comes in large batches after major design milestones. The information tells the designers where they have been; a snap shot taken from the rear view mirror. Unfortunately, the information is usually not packaged and processed to give the design team guidance to understand where they are going or how they can correct course.

1) Pricing is based on cost templates. This is necessary because the design information is only complete at the end of Construction Documents. However, early estimates (by General Contractors) are usually low for complex designs because the cost related to the complexity is difficult to anticipate when templates are inadequate. It is very common to have costs creep throughout a design (sometimes even with value engineering revisions) because information keeps getting added as the design matures.

2) The design team simply adds stuff to the design as it progresses. Much of this added stuff may be essential to make the project work. Unfortunately, the designers often can not anticipate or convey everything that will be needed for the final working design early in the process.

3) The design team has little access to specialty information from subcontractors. Anecdotal observations are that the information is not very reliable. This is not surprising because the information was not paid for. One should naturally expect that very little time or effort would be put into developing it.

4) When cost cutting is triggered, the core parts of the design are usually protected because there is not enough time to go back and re-think the early fundamental relationships. The basic architectural form and structural system will be preserved, even if they are inefficient and expensive. For example, if a structure needs expensive transfer beams to solve the problem of vertical discontinuities, these will remain in the design. There is no time, or design budget available to go back and avoid the problems that are

embedded in the basic form and layout of the building. Consequently, only the discrete and non-essential parts of the project are available for cost cutting such as finishes, ornamentation, landscaping, sunshades etc. Visible areas of project get stripped down and degraded, while core inefficiencies remain.

5) There is subtle pressure on the design and construction team to make the numbers work, and keep the project alive as long as possible. If an owner has committed lots of resources to design, then it is difficult for him/her/them to back out. The hope is that they will simply find more money, or simply raise more money in the case of a non-profit organization.

### *Missed Opportunities for Adding and Capitalizing on Value*

The premise is that because there is often no connection between the party that pays for a benefit and the party who stands to gain, many opportunities to add value are missed. For example, if gas heating is more efficient and less expensive than electric heating based on life cycle costs, then why is electric heating often installed in housing projects? The most common reason is that the developer has no way of benefiting from the higher investment of gas heat. The tenant who pays the bills loses the opportunity for cheaper heat. The missed opportunities for investing in added value are a natural outcome of any system with first cost and life cycle cost differences involving separate parties and no way for mutual benefit.

1) Any shortsighted decision favoring quantifiable benefits over unquantifiable can result in missed opportunities. An example would be the opportunity to commercially develop more architecturally significant buildings which potentially secure higher rents.

2) Developers often keep first costs and risks down by minimizing expenditures for design in the very early phases of a project. If they delay in assembling a core design team, it can result in discovery of hidden costs. A real life example is a company that suffered a large loss due to skimping on adequate pre-design investigation. The company purchased a building to renovate and use. The condition of the foundation was investigated relatively late in the design process rather than prior to purchase. The project was stopped when the investigation discovered rotten wood piles which triggered an unanticipated cost to replace the foundation. Since the project

economics no longer balanced, the company sold the building to cut their loss. A subsequent developer purchased the building and demolished it to construct a new structure.

### *Typical Fee Structures Do Not Have Incentives for Adding Value*

Design fees are generally fixed. When designers are forced to compete on the basis of fee, doing less for less makes good business sense. The less work a designer does means the more money his/her firm can make. If typical details are adequate, then it is considered good practice to use them. Unfortunately, context, graphical tests for fit, integration, and constructability checks are lost with typical details. The burden of integration is shifted to the architect and the contractor.

1) There is the incentive to define very tight scopes of work based on an anticipated design solution. Changes in scope, redesign, special studies, and the like are additional service. Consequently, there is no incentive for doing something extra or unusual for the benefit of the project.

2) There are few opportunities, outside of reputation, for rewarding adding value to projects. Most clients do not understand the connection between clarity of documents, coordination between disciplines, and constructability reviews with fewer change orders and fewer field errors.

3) Producing documents quickly for low fees is rewarded. This usually comes with a tradeoff of incompleteness and inefficiency in the design which is initially difficult to detect. There is no incentive to produce better quality documents.

4) Good aesthetic design is an important architectural characteristic which is obvious and rewarded. However, there is no incentive to produce more durable and adaptable designs. These are subtle values that may not be understood or valued by the client.

### *Other Problems…*

1) Since various consulting firms may come together for only the life of the project, there is little chance to refine and streamline the working coordination process. Even when firms work together over multiple

projects, the individual team members can change. There is little opportunity for organizational learning among offices.

2) Technical complexity, the demand for speed, thin margins, and impermanent teams make coordinating design work difficult at best, but the difficult becomes impossible when the team does not have a culture of making and keeping *reliable promises*. If I am unreliable and you depend on me for something you need to do your work, you are robbed of the ability to plan.

3) Drawing protocol, CAD platforms, and other compatibility issues can be problematic. A lot of time is wasted fussing with drawings between team members. This problem can get much more complicated with the promise of shared 3D object based models.

4) Builders are not necessarily well trained in design. They may not know how to effectively contribute to the design process.

5) Engineers are trained as "problem solvers", not designers. However design asks to first create the problem to be solved out of many possibilities, in the context of the overall value structure of the project.

6) University researchers are "thinkers" and consequently it is difficult to get immediately useful information from original research.

7) Some architects have lost their connection to building science and the construction process.

8) Architects and engineers have different design rhythms. Architects work primarily graphically. Engineers are trained to work primarily analytically with little emphasis on graphical construction. Many engineers believe that the design follows calculations rather than calculations confirming design.

9) Geotechnical engineers are often not integrated into the design team. The recommendations are often given in a vacuum neglecting the opportunity to collaborate with the structural engineer and builders on the design the foundation.

10) Special Inspection adds cost but it does not necessarily add value. The potential for added value exists when inspectors are working as part of the team. It does little good to document a construction

problem that has occurred. However, if problems could be prevented, then the inspection would be highly valuable.

## Recommendations to Improve the Design Process

### *Assemble Teams Early in Pre-Design*

The core design team will include the architect, structural and mechanical engineers, the cost estimator (cost modeler) and the general contractor. (In commercial developments, a realtor/market specialist is often in the core team). The team can expand to include the geotechnical engineer, specialty sub-consultants and specialty sub-contractors as needed in the early design process. For this discussion, pre-design is at the start of the planning phase.

The team members who participate in the early collaborative design need to be especially skilled in their own particular discipline. They also must be articulate in expressing the workings and interplay of their design with other systems. It is essential that they each be able to understand multiple systems, understand their complex interactions and do system thinking. Each member needs to be capable of embracing and synthesizing whole project values rather than their particular discipline's values.

Assembling teams early does not mean that they are necessarily off and charging lots of fee. Rather, the client has access to advice and early strategic input from all the core members. The early work may simply be to participate in meetings.

### *Get the Client to Develop and Commit to a Set of Design Values*

The developing of a working set of design values is critically important for an integrated collaborative design. The design team needs to learn the relative importance and relative weighting of all the client's values. The team also needs to know if there are any inviolate limits, like a budget that can not grow, or minimum program requirements. This step may take a lot of work and bring to light many unresolved issues with the client, especially if there are many stakeholders.

The design team may need to extensively educate the clients with regards to a large range of potential values or outcomes, especially with regards to subtle values. The team will also need to teach the client the interaction and interplay of the systems and values. For example, if a client wants a cost effective design with power from photovoltaic panels, this will prompt a larger discussion about solar orientation, thermal mass, natural ventilation and natural day-lightning. Similarly, is the client aware on correlations between day-lighting and lower rates of absenteeism? How does this correlation relate to the client's potential business model, etc?

A good team will also need to challenge the client when there is a lack of discipline or clarity with regards value definition or if there are contradictions between values.

### *Determine the Decision Making Structure of the Ownership Group*

At issue is how decisions are to be made by the client group. Ultimately, the design team needs to be able to navigate through the political terrain in order to expeditiously get design decisions approved. It is essential that those participating in the design process on behalf of the client actually have the authority to make durable decisions. A few possibilities include:

1. Consensus (democracy) – where all parties have equal voice and must reach agreement to progress. A dysfunctional version of consensus is like a "multi-headed dragon".

2. Modified Consensus (representative democracy or oligarchy) – where some stake holders are more important than others or where some stake holders speak for others.

3. Central Authority (dictatorship, benevolent or otherwise) – where a single person can make decisions on behalf of all the stakeholders.

### *Perform Planning Using the Charrette Process*

Despite appearances, conducting a series of planning charrettes is the most effective means of collaborating and reaching consensus to produce an integrated design. In the charrette process, the design team can guide the client in defining their goals, needs, values, etc. The planning process should reconcile program, quality, and schedule. The outcome of the planning process will be a consensus design in which all the stake holders participate and sign-off on the plan. Integral cost modeling will be required to bring discipline to the design process. Although this sounds simple, it may require a complex negotiation between the stakeholders to reconcile and accept a workable and balanced solution.

### *Perform Design Using the Charrette Process*

The best cost effective design solutions are integrated and they often achieve synergies between systems. For an example showing the potential of integrated design, let us return to the question of using photovoltaic panels for power. With out a common conversation, the design can just cycle through, iteration after iteration with the architect acting as a negotiator between his/her consultants. What typically will happen is that the design will devolve into safe solutions. Any designer could simply "muscle it" by buying lots of expensive PV panels and cover up the fact that the building is inherently inefficient from a solar orientation and mass perspective. The structural engineer will simply "solve" the problem of large expansive windows by adding expensive moment frames. The electrical engineer can simply size a larger transformer to "solve" the problem of high lighting loads. Unfortunately, each reactive design solution is unnecessarily expensive and wasteful.

An alternative strategy would be a design charrette, in which the mechanical engineer could express the need to start with good solar orientation, adequate thermal mass, good thermal envelope, a buy-in from the users as to their acceptable range of thermal comfort, and an effective day lighting design. The building's orientation, day lighting, thermal mass and thermal envelope involves the architect. The day lighting design and modeling is carried out by a specialty sub consultant. The configuration and thermal mass involves the structural engineer. The designers need to come together and achieve a harmony of systems in order to achieve a balanced design capable of making cost effective use of PVs. Finding the synergies between systems is the most effective (and often the only) means of meeting the design goals and cost goals. In this example, five parties are directly involved in this design, along with the cost modeler and the client. To find the system synergies, the team can discover the balance between wall and window to avoid frames and have adequate thermal gain. Or the balance between building width and space planning to reduce lighting loads through better day lighting and have a smaller transformer. Throughout this process is initial and life cycle cost feedback. Since the interplay of system performance and cost is so complex, the most direct and efficient way to integrate this design is to bring everyone together and collaborate in group design sessions.

### *Design to Target Cost and Other Defined Characteristics*

Reacting to cost estimates at discrete phases in the design process is a limited and inefficient means of achieving cost objectives. In the traditional design method, the design team looks at costs in aggregate after the selection and initial design of the primary systems have taken place. The more direct and insightful approach is to explicitly use cost modeling as a design tool. By designing to target costs, a team can take the overall project cost and break it to down to determine discrete system cost. The designers can then process fine grained cost information as an integral characteristic of their design. The discrete cost assigned to each system ensures that a sensible cost balance is maintained throughout the entire design between the systems.

### *Design with Awareness of the Construction Process*

In order to achieve the most reliable cost effective design, the team needs to design-in the construction process. The shortcoming with traditional design is that the team usually chooses components limited by the designer's particular familiarity and experience, independent of various construction issues such as access and production rate. There is also a natural hesitancy of a team to specify sole source systems because of potential price gouging. Multiple options can be presented to the contractor, but this is extra work for a design team. Consequently, traditional designs will tend to be conservative with regards to using new construction techniques and unresponsive to the builder's process.

In contrast, by designing with the contractor and specialty sub-contractors, the team can realize efficiencies based on specialized equipment and construction techniques. For example, in order for a structural engineer to design an efficient foundation on poor soils, he/she needs to create a system team with input from the cost modeler, the geotechnical engineer, the general contractor and specialty contractors. The design may consider options using steel piles, pre-cast concrete piles, micro-piles, fundex piles or a mat slab while accounting for costs, construction access, disturbance, production rates, etc. In this case the team needs to know specific costs from four specialty sub-contractors in the contexts of at least five potential designs, to find the value "sweet spot" where all the constraints are balanced and optimized to make the best fit and meet the target cost. The efficiencies of any particular system will become apparent through the review of overall system cost and fit.

### *Set Fees for Pre-Design to Schematic Design on an Hourly Basis*

Except for simple projects, design is rarely a linear and predictable process. Rather, it appears chaotic and expansive in the early stages. To account for the unpredictability of the early design stages, the team members (including the contractor) should be paid on an hourly basis. Doing this allows the design team to use the client's value matrix to completely focus on exploring design possibilities in the best interest of the project, rather than having to shepherd their fee while waiting for the "real" work to start.

With regards to the contractor and specialty sub-contractors, they need to be paid for their time to discourage skimping or simply giving "lip service" to the design efforts.

### *Set Aside a Portion of Remaining Design Fees and Make them Subject to Meeting Performance Targets*

Once the schematics are completed, the core design team has enough information to reasonably estimate the remaining design effort and fee. To encourage and build in incentives for collaboration and good performance, the team should consider setting aside a portion of fees based on achieving specific design goals. These could be schedule, costs, a specific LEED rating, etc. A formal system of shared pains and gains should include bonuses for exceptional performances as well as reduced compensation for poor performance.

### *Coordinate Design Work through Reliable Promising*

Activities on complex projects have been successfully coordinated using techniques developed by LCI, especially the practice of reliable promising. Schedules are inadequate coordinating devices and must be supplemented by weekly (sometimes even daily) discussions and agreements by the design team as to who will do what by when.

Schedules themselves are best produced as a group product showing key handoffs between specialists. Building a schedule on the wall with cards, working backwards from target milestones, inevitably reveals questions not asked and assumptions unquestioned. Quick calculations can reveal if a target completion date can be achieved within the available time, and replanning launched if needed. Using this 'pull planning' technique, teams create their own work plans, handoffs are identified as key objectives to be achieved, everyone understands why decisions were made, and adjusting in flight becomes feasible.

### *Design Using Shared 3D Object Based Modeling*

As integrating the design and building processes hold potential for improvement, a shared object based model of the design product offers great promise. Like most new tools, a committed design team may need to go through a lot of shared growing pains before payoffs are realized. For extremely complex systems, shared models are probably the most effective means of design delivery. However, no matter how advanced the modeling tools become, the shared model may be useful in only the later stages of design. In the early stages, a model may overly burden the team and cut off design potential too soon. In contrast consider the skills needed to effectively contribute to a design charrette; good listening, open mindedness, imagination and the ability to sketch and express design ideas through dialog.