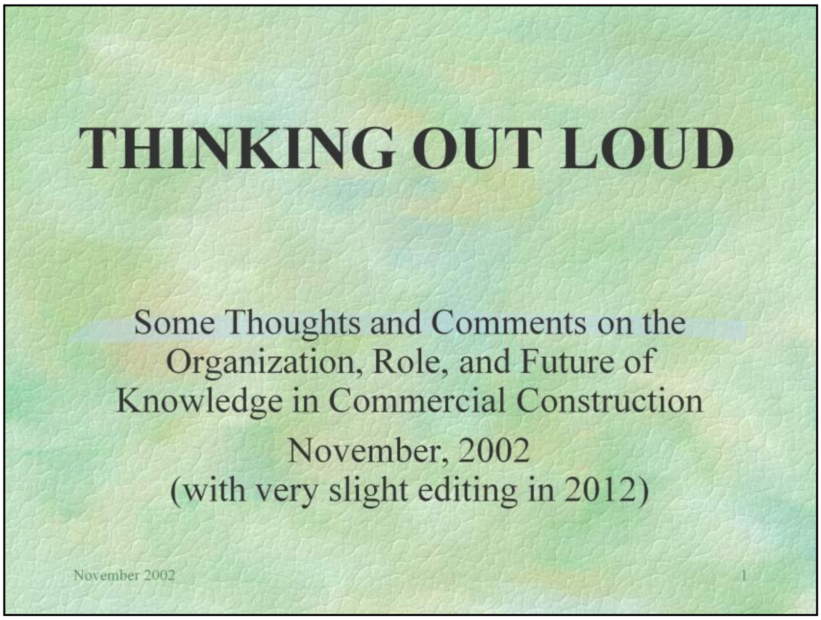
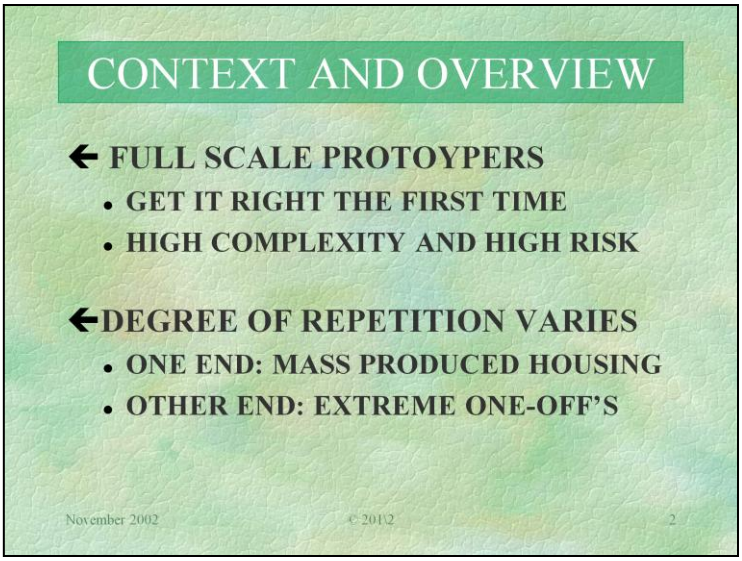


I learned quite a bit in the course of three distinct careers. The first involved technical abstracting and literature searching using print-based tools. The increased availability of online tools in the early 1970's led to an involvement with minicomputers. The second career involved building software and integrating data, and was focused initially on "office automation" (in this century a rough translation might be "paperless:") and later on complex data flows in a large insurance company. The third career was in commercial construction. I jumped to being a fabricator of architectural precast concrete and then spent the last decade founding and building two specialty companies. One focused entirely on the information flows surrounding plans and specs fabrication (precast concrete, cast stone, GFRC, terra cotta, etc) for commercial construction projects (in electronics today this is a "fabless manufacturer"). The other focused on standardizing and cataloging products that were created as a byproduct of the first process, utilizing leftover molds and other tooling. Reading, listening, and observing in a wide range of roles and situations, and thinking about it all during that period led to some insights into how we design and construct the built environment. I write this for people with interest in the future of construction, and particularly for people interested in the role of information in design and construction.

This very preliminary draft is distilled and abstract, and is not intended for a wide audience.

My perspective is skewed from years of involvement with the fine details that impact specialty fabricators. But buildings are mostly built by subs and by lower tier contractors and suppliers. It may be that I am too sensitive to the problems of exquisite fine points, but I think not. I well understand order, regularity and the analysis that underlies automation and systematization in any realm. Imposing standardization and explicit structure where it was not is almost second nature to me. Nothing in my previous experiences in IT equipped me for the chaos and complexity I found on entering commercial construction back in 1987. After a few years of study, I considered "writing the book" on the detailed design of something as (apparently) ridiculously simple as window sills and coping. It was much more complex than I could ever have imagined. The complexity involves plans, specs, contracts, optimizing for efficient installation and other cost factors, as well as durability (this is a non-exhaustive list of factors). I look up from the bottom of the supply chain, but as we all know, sometimes a reflected ceiling plan is useful.



As an unusual manufacturing industry, commercial construction delivers highly complex, customized, very large ticket items to its customers. Buildings are essentially prototypes - “one-offs” - designed and then manufactured on land typically owned by the customer. The core challenge for a typical commodity manufacturer, for example a company making nails or bricks, is to be efficient or low-cost in repeatedly making the same item. Since the item is being manufactured on an on-going basis in a relatively stable environment, cost of production is well known and accounted for in pricing, and quality and consistency challenges are reasonably stable. Continuous improvement can be readily incorporated into the organizational structure.

The core technical challenge in construction is to <u>get it right the first time</u>. This is difficult to accomplish. The complexity is enormous, and often not fully appreciated. People deeply involved in the process may appreciate their own complexities without appreciating those of other players or specialists. All parties recognize that the risk of error of one sort or another is large and that they can be very costly. Shifting of these risks is the main thrust of the great attention paid to contracts (which includes explicit contracts as well as the large body of incorporated items such as plans, specifications, and externally referenced requirements such as codes and standards).

Of course, the degree of novelty varies among projects. One end of the construction continuumis extreme new structures, such as a showcase Gehry or Jahn project. The other end includes repetitive structures, such as certain highway overpasses and mass-produced housing, as done by Centex or Pulte. These latter products are configurable manufactured items rather than prototypes. The former are the relatively rare structures where the ordered quantity of identical items exceeds one.

Most of commercial construction falls in the middle. And most of commercial construction is riddled with apparent inefficiency from its incoherent approach to a design that must have as its endpoint a set of instructions for purchasers, manufacturers and installers of tens of thousands of products, each with their own internal complexity and set of interface considerations with the other products.

The core business challenge in commercial construction is to make money in the face of all the possibilities for fatal errors. There are two main responses to this challenge:

1) learn how to get it right the first time

2) learn how to shift the risks to another party.

The past decades have seen GC's and architects be more focused on risk shifting. Elements of this trend include the emergence of construction management as a discipline separate from construction and the increased delegation of detailed design to contractors, particularly to subcontractors and specialty suppliers.

My interest here is in how we organize and access the knowledge necessary to get it right the first time. Issues of risk-shifting are totally outside my scope. There is plenty of written material on the topic. It is an interesting reflection of the state of the industry, that there is so much more time and money invested, so much more of a literature, so many more conferences addressing how an organization shifts risk of error to other entities than there is comparable effort addressing how an organization avoids errors.

GOES ELSEWHERE********

Economic reward or a price that was established without is very difficultThe extent of the challenge and difficulty for each person involved in trying to efficiently design and construct structures is in large part a function of how closely the project resembles prior projects performed <u>by that human participant</u>. Low end mass produced housing is essentially a complex case of configurable manufacturing, a complex assembly of standard components. The parameters are well known and the relevant knowledge is widely diffused. It is a different case than our focus here.

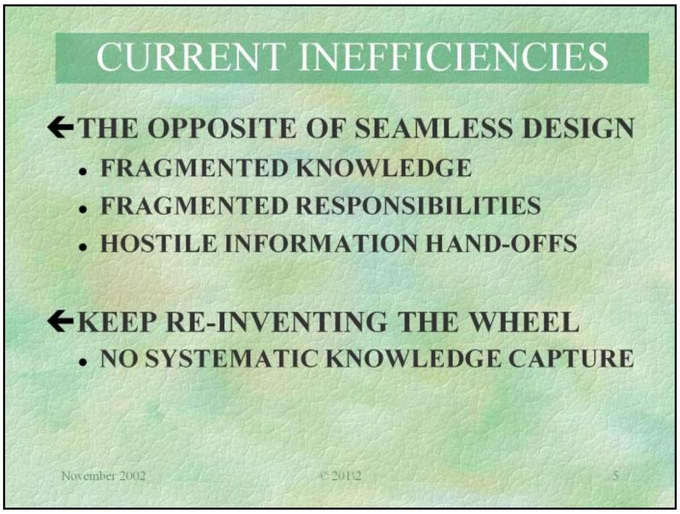
The process of designing and constructing buildings has not kept up with these changes. Architects today, even after decades of working and learning, have no realistic hope of having the knowledge that some architects had in the past. Craft knowledge (both among designers and the trades) is vanishing in relevance and depth.

Systems that are new or vastly more complex include mechanical systems, power, signal and main structural and glazing systems. Growth in complexity of engineered materials (steel, concrete, organic composites) as well as the systems has been explosive. External requirements such as OSHA, EPA, ADA are tremendously complex and rapidly changing. Staying abreast of changes in design tools (CAD, etc.) consumes resources and competes for attention with all the other changes.

Whenever I think of all the knowledge and detail that is encapsulated in a modern physical structure, I am in awe that it stands. The depth and breadth of knowledge necessary for a specialist to be effective in this industry amazes me; coordinating and putting it together within constraints of time and money is a miraculous process to me. It is not well understood because of all the autonomous activity and checking that occurs at multiple levels and at multiple moments.

The repetitive design and manufacture of incrementally evolving complex items such as automobiles and airplanes is challenging, but much better controlled, because the prototype is not delivered to the customer and because continuous improvement is possible during the product life.

An aside: because the product life of structures exceeds that of most other manufactured items and because modeling and accelerated aging tests cannot fully predict the time-dependent behavior of materials and systems, we can realistically expect the next decades to bring a succession of unanticipated failures, ranging from mild to spectacular, of modern components and structures.



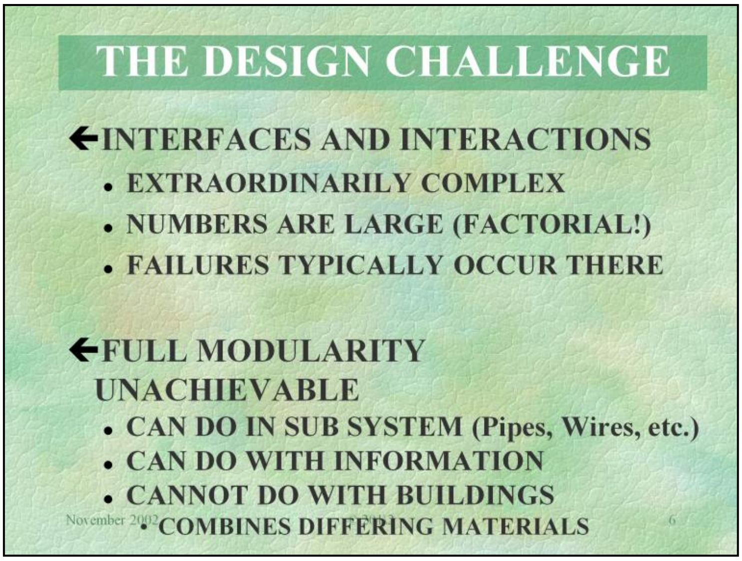
Those who believe in the power of technology to enforce coordination and to integrate design efforts should try to measure the changes over the past decades. My experience and knowledge are anecdotal and primarily concerned with coordination between architectural and structural drawings. **Every** experienced specialty subcontractor or supplier I have spoken with believes that coordination has gotten **worse**! A simple skeptical observer might conclude, in fact, that the advent of CAD has resulted in less coordinated drawings rather than more.

The believers in solving problems with software without concomitant discipline and management control should be reminded that GIGO is not an obsolete phrase.

Despite persisting legacy-based references to "approval" of shop drawings, the actual language stamped on submitted drawings has migrated to "reviewed only for conformance with general design intent…[you check everything I tell you and proceed at your own risk]". The diffuse responsibility for getting it right guarantees inefficiency.

I have spent over a decade observing the extreme job shops that provide plans and specs fabricated material to the construction industry. The most common repository for "lessons learned" is in the head of single individuals. I have not seen a design firm, construction company, or fabricator with even a slightly effective means for capturing and re-using the lessons learned in the last prototype. The amount of learning that occurs during design and construction of each prototype is astonishing, as new people get to solve a problem or learn a factoid that many others in the world have already solved or know. The major exception is individuals and organizations that are narrowly focused, and repeat similar projects. Often, of course, even in these situations, many of the players (both organizationally and individually) are not doing a repeat performance and they must re-learn and re-invent. Engineers still serve apprenticeships, and learn on a craft model.

An aside: My experience is that most large GC/CM's (Turner, Bovis, Gilbane, etc.) tend to be the least concerned with technical construction knowledge. Their core competency is neither in how to design nor how to construct, but in how to shift the risks.

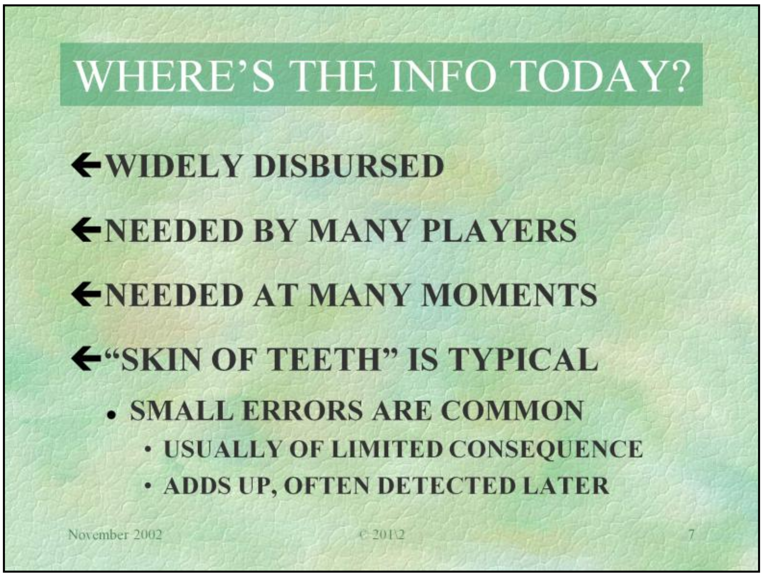


Most failures occur at the interface between differing materials or systems. Highly reliable information related to suitability for use in a particular circumstance and other interface issues is often hard to come by. There are insufficient constraints on the interface and interaction problem for it be manageable. A single product may be used in so many different situations, each with its own particular circumstances.

Responsibility is diffuse and often unclear. Who is responsible for knowing the compatibility of caulk with two different materials? Each material manufacturer should know about their own material and the caulk, and the caulk manufacturer should know about both materials (if there is shared language describing the material; often there is not). But who is likely to know how BOTH materials move and whether the caulk is fully suitable for use in that particular situation?

The organization of such knowledge within a single company is difficult, and typically involves perspective, classification, and format that are company specific. Unless it is considered marketing material, the requirements of any such system, be it paper-based or computerized, may not even include that it be intelligible to outsiders. We are a long way from it being intelligible to a piece of computer software. Try spending a day looking at ten different product binders attempting to get answers to situation-specific questions.

Both plumbing and software utilize well-defined and constrained internal interfaces and a high degree of modularity. Few building products, however, come with a clear API for surrounding materials. Intelligent software objects present the same challenge as the physical design. Which software object in a pair whose interface concerns us has information about the interface between the physical material or object it represents and the other material in the pair? Only if the physical object (and the software object) and its possible interfaces are highly constrained is it doable today or in the near future. And since the world keeps changing, who is responsible for maintaining interface information in an intelligent object? Not designers. Not software vendors. Manufacturers? Suppliers? I am not talking about general design, but about detailed design with real life products. Of course, the less common, the less standard the product, the bigger the issue is.



Today the info is all over. Everyone from designer to tradesperson at the job site may be unaware of some small detail, and will guess or follow their accustomed practices.

I well understand that in many cases the structures that put me in awe are standing only because of very conservative design practices that favor overdesign.

Missing information is a hidden cause of many small problems and failures. Minor ones will often not manifest themselves until well after the warranty period. As builders assume more operating responsibility and have to bear the full cost of correction they will be more concerned about the diseconomies associated with these minor problems and more interested in buying ounces of prevention.

The existence of large numbers of product reps whose prime functions include providing technical information to designers and builders is testimony to the importance of such information. The cost of their service is embedded in every structure. They are not particularly cheap or effective. Nor will they readily disappear.

Basically I am saying, let's take not only the binders, but also the phone calls and faxes, and capture them and throw them into a single location, where format is not manufacturer-dependent, contributions come from many sources, and access is available to all players.

Turn dispersed knowledge into networked knowledge.

This is not simple, either from a business perspective or from a technical software perspective. The former problem has to do with capture; the latter with retrieval. Given how crudely the industry handles these problems today, almost anything will be an improvement.

It is a big undertaking, but if designed to evolve at a rational pace, it can be created efficiently and provide large payoffs to those who use it. There is no rush; the industry has gotten along without so far.

In essence I am proposing a hub, or switch, for the technical conversations (actual and metaphoric) that take place around construction products.

When implemented it would provide benefits to every entity in the design/build or a/e/c and e/p/c supply chains. A major questions is: how to get there?

The prior question is: who will sponsor the initial work? The interest of the sponsor(s) will inevitably shape the path.

POSSIBLE SPONSOR(S)

- **INFORMATION COMPANIES**
  - **McGraw or CMD**
- **NIBS (Natl. Inst. Of Building Sciences)**
- **TRADE ASSOCIATIONS**
- **LARGE MANUFACTURERS**

Create a framework (organization, standards, software) that will be iterated and grown. Use the framework to solve specific problems of stakeholders; those problems become test cases, and the needs of stakeholders become the requirements. The system (software and discipline) will grow organically.

ON THEIR OWN, EVERY COMPANY IN THE INDUSTRY NEEDS A KNOWLEDGE BASE.

EVERY TRADE ASSOCIATION (SUCH AS PCI, SHOULD HAVE ONE FOR ITS MEMBERS)

VERY FEW CAN AFFORD TO BUILD THEIR OWN.

THE VALUE OF THE KNOWLEDGE BASE IS MULTIPLIED EXPONENTIALLY BY THE NUMBER OF PARTICIPANTS.

WHY NOT BUILD A SINGLE SUCH INDUSTRY BASE?

WHO IS ENTITLED TO SEE WHAT CAN BE CONTROLLED.

Let the progressive players select in. Don't worry about the rest.

There should be no exit of capital for a minimum of 10-15 years, as this cannot be grown quickly. (Dotcoms have had enormous capital and made little progress over past two years.)

Unlike typical consortia, which are buy-side driven, this must be neutral and have participation from many different players. Start with existing trade partners. Look for buy/sell and other pairs who already want to share information. (For example, the proposed knowledge base can be a mechanism for a manufacturer to communicate with reps and customers.)

An enterprise such as the proposed one may end up generating fabulous income, since it is presumed that it will "own" the knowledge. It is unlikely, however, to ever generate a story so compelling that it can be sold and re-sold to investors (the business of VC's is selling a story to subsequent investors). And unlikely to generate early exit options. Restricting investors to those with a long-term perspective would allow such an endeavor to grow in a sensible and efficient manner. In any event, the risk/reward ratios will not likely be appealing to speculative investors. Investors should be participants, and view their investment as similar to one they might make in an internal project. There are investment firms and venture funds that are tied to companies that operate within a/e/c. Their investment would be welcomed to the extent they saw it as a long-term investment.

Commitment from participating entities, in the form of contributed capital and/or time, is critical to success. Lip service will get it nowhere. Companies in this industry vary widely in size, revenue, and ability to invest. A size-related minimum investment for all initial participants would raise seed capital and assure active usage.

The revenue model attempts to match revenue with costs, which would be a mix of fixed, developmental, and operational. Modest subscription fees will be a barrier to use, but once paid, they become an incentive for use. And they draw attention to the commitment issues. Low usage fees make sense, for there is clearly value in the accessed information. If it does not have perceived value, then the enterprise should be stopped. Since the model asks all relevant stakeholders to contribute to the knowledge base, it will be worth considering incentives, such as rebates or credits for adding to the base.

Manufacturers, trade associations, and others should have the ability to create private areas. For example, purchase of a product might entitle a customer to access to certain otherwise restricted areas of records related to the specific product. Usage of such areas would likely have a separate fee structure.

NOTES

- SELECTIVE USE ON PER KNUGGET BASIS
- COMBOS OF SPONSORS
- EXAMPLE WITHIN CONCRETE (full slide w SPONSORS AND NOTES)
  - WHY (BASIC MATERIAL AND I KNOW IT)
- NOT TECHNO DRIVEN

MORE NOTES

- DEEP EXAMPLE IN CONCRETE
- CLARIFY THE LEVELS OF ISSUE
  - OVERALL APPROACH
  - TECHNICAL STUFF
  - ORGANIZATION STUFF
- MANY WAYS TO DO, THIS IS TO STIMULATE DISCUSSION, FIND SPONSORS

