Knowledge Mining: Experience Capture & Sharing

- Not important – Who cares??
- Coming Soon to a Project Near You??
- Utopian Dream??
- Distant Future??

The poster children here are one of the simplest things you might build – a steel railing set into concrete. Small failures are common among these, Often less durable than the presumed design intent. One reason is the hard time the industry has getting certain types of detailed knowledge into the structure they are building, especially where there is an interface between different materials, between different trades,.

Construction is manufacturing. More normal manufacturing invests more in design and in product development. Once we complete the prototype, we're done and ready to move onto the next one. For this and many other reasons the lessons learned in a single project are difficult to gather and utilize. Highways, plants,, buildings, etc. that look alike have subtle differences; overlooking any single one can be problematic or disastrous.

You know this drill - enter a movie title or just a lead actress in your phone and bammo you have a list of nearby theatres and times.

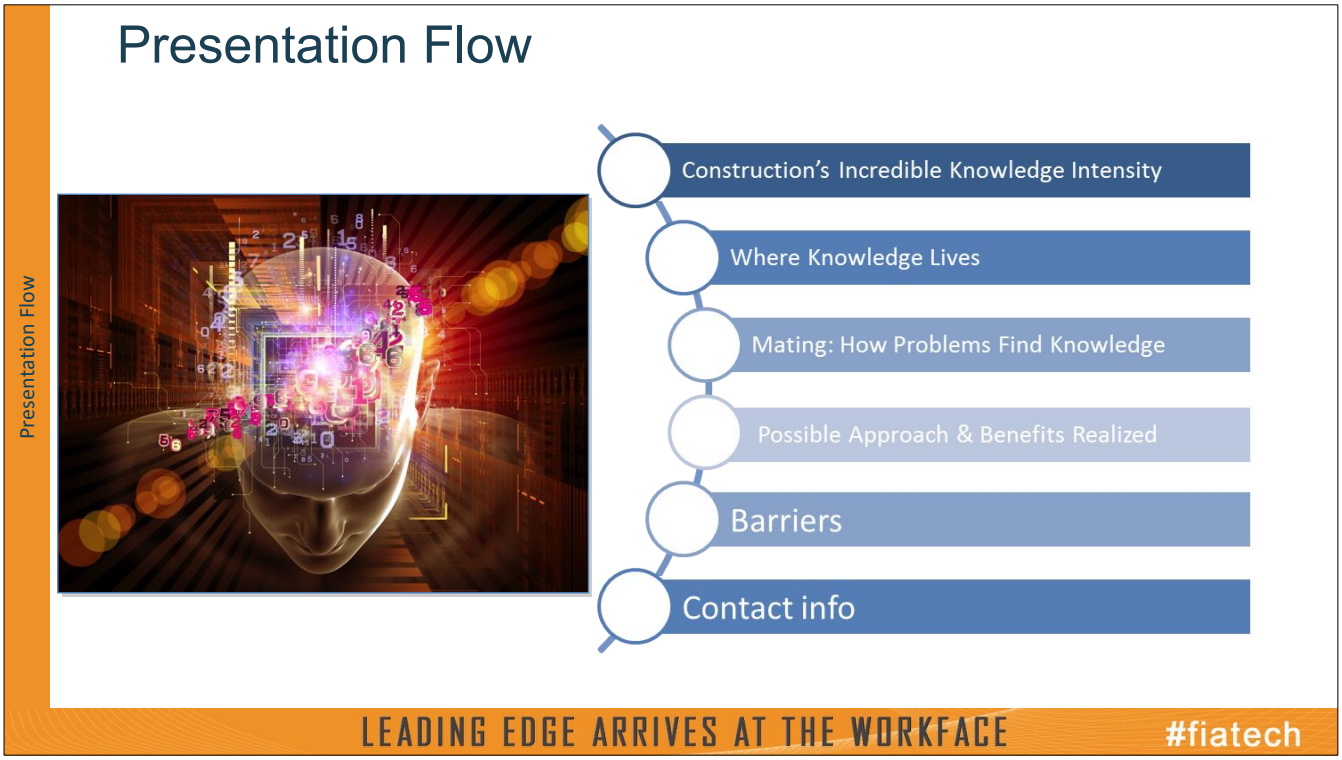
Now imagine you are constructing an office building and contemplating the caulk. You want to be sure the caulk sticks well to both the paint that's on the aluminum curtainwall and to the surrounding precast concrete spandrels, Oh, and be sure the caulk is compatible with the sealer on the concrete and if the sealer should be applied before or after the caulk. Just enter the materials and get your answer. Dream on, this is not on the near horizon. This talk is about how we might get closer to such a reality.

For starters, a few definitions:
DATA MINING – "Data" is a representation of reality that exist in a machine-readable form. Data mining is going through large databases looking for patterns or information. Not relevant here as there is hardly data available.
KNOWLEDGE – Experience-based understanding of the world that a human has. Often held in the form of stories, frequently tinged with pain.
KNOWLEDGE MINING – Getting access to knowledge derived from experiences of others. Do we all have to touch the hot stove to learn?
My answers to the questions I pose:
•Is it important? Current way in which knowledge and the many project-specific narrow problems come together is a huge cost, although typically hidden elsewhere. Master builders no longer exist. Changes make access to knowledge increasingly important.

- See supplemental slide address true cost of design in commercial construction.

•Coming soon? Not a chance!
•Utopian Dream? Might be. Involves lots and lots of cooperation among many players. Not easy.
•Is it possible? Yes. Real questions are: how soon and who will step up to the plate?

• Let me will sketch out some approaches and problems.



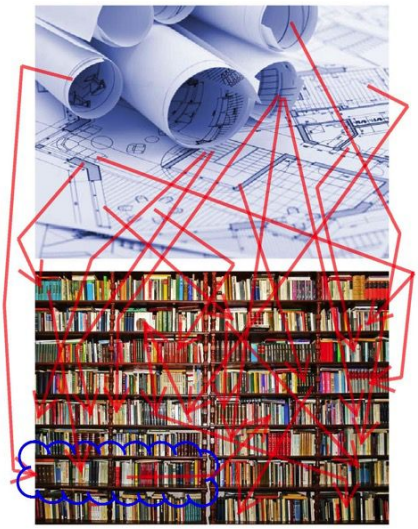
To build a capital project you bring together many diverse materials. Steel, concrete, plastic, coatings, sealants each has it's own history and embedded knowledge as a manufactured item. By themselves they are just a pile of materials. You need to gather a huge number of people-with-knowledge on an ad hoc basis in order to design and build a big prototype. We classify and identify the suppliers of materials better than we do the suppliers of knowledge – not general textbook knowledge, but highly specific knowledge, maybe how to join a coated pipe to a valve without diminishing the value of the coating, maybe even knowledge pspecific to the particular coating, or even to that coating and that valve). A single project has 1000's of low-frequency situations with variable importance and risk.

Googling that pipe coating–valve interface question is a waste of time or the start of a long hunt for one answer to one problem.

I will talk about what a technical solution might look like, and why technology alone is not a solution.

Presentation Takeaways/Deliverables

Extraordinary Density of Embedded Knowledge



- Not obvious to those at arm's length
- Complexity reduced in a well-defined system
- Each material has its own complexities
- Each interface between materials
  - Requires situation-specific knowledge
  - Small ignorance may = big problem
- Procedural vs. situational knowledge
- Bid system adds cost optimization to the knowledge embedded in a particular prototype

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People who build and interact with other specialists get the immense complexity. Most other folks do not. From afar, it looks simple. Music you are not into "all sounds the same"; in the genre you know and like, you appreciate the subtle differences between one piece of music and the next.

Mature closed systems develop interfaces are standardized and well-defined. Electricians don't think about how to connect a light fixture to a conduit. Street lights come with very clear and straightforward installation instructions. . Put a light in a fancy block of precast concrete, what could be simpler? It's an unregulated interface. You need to understand the fixture's particular configuration, back box details, bend radiuses (what works with ¾" conduit may not work with larger conduit) code issues, AND reinforcing, formwork, precast production methods, installation methods and sequences, etc. etc.). 3-5 people are involved; 10 project man hours fly by. The example is a microcosm – most projects have 100's or 1000's of such situations. High

The majority of failures, and of time consuming problems, are at unregulated interfaces. No one owns them at first. The coating guy, says " check with the substrate guy", the substrate guy says " talk to the coating manufacturer". Both agree: you test it. Someone, somewhere, has experience with the same material, same coating, in the same environment (temperature, atmosphere, surrounding materials, the list of minor but potentially significant variables goes on) but finding them is not always easy.

If cost were only a minor consideration, sub-optimal approaches, based on less situation-specific knowledge, would govern. It would still get the job done, but at a higher cost. Cost optimization requires extra knowledge.

Every standard and every procedure has a bunch of unstated assumptions about "normal". Many failures (minor and major) arise from not attending to small deviations from unstated assumptions.

Opportunities Being Addressed

How do problems meet up with knowledge?

- ***IF*** the problem is common & mastered
  - ***Then*** it's not a problem anymore
- ***IF*** the problem is highly specific ***Then***
  - Narrow specialists with knowledge or
  - Bungled task (partly or fully)
- To avoid problem (e.g. at left)
  - Find and read an academic paper?
  - Search online (and pay for info?)?
  - Use a deep specialist
- Informally transmit knowledge collegially
- How can more people learn from others?

LEADING EDGE ARRIVES AT THE WORKFACE #fiatech

Our poster child here is about welding to plates that are embedded in precast . I was bidding some repair work & I noticed the funny marks (circled here) but they were irrelevant to me. when the crew was on the lift and up close it became obvious that at each welded connection point the concrete had spalled from too much heat and then been patched. Typical of welding done by someone lacking experience with this exact weld (a "certified welder'' but not a deep and narrow specialist). For this presentation I spent some google time and found that in a similar situation in Kuwait, the owner was worried about a similar detail and so formal research was done and published in 2007 (see supplemental material - Weld cracks in concrete.pdf) and in 2008 the question was posed in an ACI journal (the answer is behind a paywall; I did not proceed) – webpage also in supplementals) . Experienced erectors knew the problem and solution back in the middle of the 20th century. When our poster child was built in 2011 the news had still not reached that jobsite. If you have never seen the problem,why would you go research it?

Someone with knowledge can go from expert to trainee in seconds by changing a small bit of context. Someone in metal fabrication used to working with mild steel will be dangerous if you shift to stainless. Move someone from Florida to Chicago and they may not understand how freeaze-thaw affects materials.

How do problems meet up with knowledge?: Often with great difficulty and at significant cost.

When "teams" try to figure out a problem, typically they are chatting until someone figures out who they might know that has encountered this before (ie, have the appropriate knowledge) or who might know someone who knows someone. The accumulated time of people who play a role in connecting each problem to people-with-relevant-knowledge is significant on many projects, but never explicitly accounted for.

Finding knowledge is part of design. [supplement material has my estimates of true cost of design in A/E/C. True cost is probably less in in E/P/C because of more upfront design efforts, more specific expertise involved initially, differing contractual relationships, and because the aesthetic and other complicating factors of architecture are absent]

IPD (Integrated Project Delivery) a relatively new initiative in the A/E/C world is essentially a way to get knowledge to meet the project and problems sooner than via traditional methods (in A/E/C the designer is not obligated to design something constructible). The "big room" puts a general contractor and a lot of subcontractors in one room and has them look at building models together and work together more closely. {Aside: classic case of technology (BIM in this instance) taking much of the credit for efficiencies that largely emanate from organizational change.}

Prototypers are constantly discovering new problems. Knowledge that is generated and retained and repeated is typically surrounded by pain. The pain (costly project, failure of some type, death, etc.) burns knowledge into the brain. Transmission often takes the form of people telling stories to other interested people. It's in-the-flesh social media, an old technology. Can we move beyond apprenticeship, beyond face-to-face?

Constraints & Barriers

Benefits and Possible Approach

- Effective sharing of knowledge => reduced project costs and risks.
- Software (non-trivial) + social change (very very large challenge) is required
- Must engage and incentivize knowledge holders (big challenge).
- Users must engage and love using it
- Involve many trade associations (are incumbent orgs. “owning” knowledge)
- Find various interested companies
- Create a committed eco-system

I think the benefits of sharing knowledge are obvious. Note that the knowledge problem defines the limits of ROI on BIM. An intelligent model needs knowledge in a form that is accessible to the model. At root, every player in construction needs something like this. OK, going from “why” to ‘how”.

Turn dispersed knowledge into networked knowledge. Network effects mean that value grows non-linearly as usage increases. Every company needs this. Let’s build one general tool – a knowledge sharing infrastructure for the industry that then grows as it proves more and more useful.

SOFTWARE – Must address in detail and with great ease of use – capturing, structuring, and retrieving or accessing knowledge. There are many other issues with the software, but populating the data base is a bigger challenge. People need a reason to share their experiences. The social component is critical -

Broad sponsorship is needed.. The highly specialized trade associations are a likely active participant – they all try doing this, albeit with limited success and typically with old technology. Active sponsors will include a broad swath of stakeholders -- owners and constructors, design professionals, specialty contractors and suppliers. STEP 1 – sufficiently large base of founding organizations. They provide financial capital and social capital. Must have enthusiastic users who participate in system design efforts. STEP 2 – use the early tools to solve problems that someone cares about. Grow it that way in small groups that are active participants. Spread to others among the sponsors.

This new entity would own the tool but not the knowledge. That would still be controlled by the contributor . Probably need a mixed system of usage fees (per use, subscriptions,) and credits for contributions. The tool must have the flexibility to support closed and open network of knowledge contributors and knowledge consumers and a few flavors of commenter .

I have more detailed ideas but time does not allow them here. They are available to those with serious interest.

Approach & Benefits Realized

Barriers

In ascending order of importance:

- Legal – fully indemnify contributors
- $ Cost to create software and participation
- Needs exquisitely usable software
- Maintenance of data
- Get a wide range of committed sponsors
- Vetting of contributions and contributors
- Getting contributors
- Getting users
- Getting Creating the virtuous circle of use and contribution (Wikipedia and eBay, sim.)

Empty shelves are the poster child here. In the dotcom boom, there were many auction sites, and “community sites” with forums. They used easy-to-build software. Most often the shelves were empty. Construction has a number of low activity, low value internet sites around. I see virtually nothing vibrant. Maybe I’ve missed it. No technology will address this knowledge transfer problem without getting those with knowledge to contribute, to adopt it. While a big challenge for the technology is how can its design facilitate contributions and usage, clunky software is not the main problem. Key questions: why should a professional (an engineer, a welder, etc.) bother to contribute knowledge? Social media has many failures and notable successes. The successes may provide guidance for the design of tools.

You need contributors to get users. Users will only generate contributors if the contributors are getting some form of reward, else why bother?

In general I find the level of industry participation in various existing internet places (Wikipedia foremost among them, but also other sites) to be surprisingly low. Why? How change it? The internet is full of forums with a very mixed bag of contributions (supplemental material includes a simple forum on a simple question about cabinet paints – Great example of how determining who is “right” is not easy). Many busy forums have the opposite problem to empty shelves – they are like an entire aisle of varied but minimally labeled mustards and sauces – and no guide to properties or ingredients. How pick the right one?

The tool must be very useful to the user in order to get used.

Thank You… Are There Any Questions?

Contact & More Information

Sharing knowledge

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An earlier and more detailed version of this presentation can be found at:
http://www.caryconcrete.com/writings/index.php?page=writings

There are a variety of supplemental materials at …..