COMPARING AND IMPLEMENTING ALTERNATIVE WORK STRUCTURES: INSTALLATION OF DOOR FRAMES

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ABSTRACT

For each new project, supply chain participants (SCPs) must decide whether to adopt a ‘tried and true’ past work structure or an alternative that involves designing and building perhaps using an unfamiliar approach. Significant risks but also rewards may be associated with using different work structures. Conservative SCPs therefore favor work structures that involve no change or only incremental change, as opposed to radical change. Often, a project’s tight budget and schedule induce SCPs to use only the ‘tried and true’ because the corresponding processes and outcomes are predictable. In addition, directions given to SCPs instruct them to design and build projects in a certain way, so it is difficult to consider building projects any differently, especially if the current method works. If one SCP sees an opportunity for improvement with an alternative work structure, others remain to be convinced that it is an opportunity before they will help obtain approvals and manage implementation. This paper describes such a case. It presents ways to characterize and compare work structure alternatives. SCPs might use similar comparisons to guide their selection of work structures on future projects.

KEY WORDS

Work structuring, process design, product design, supply chain management, door frame installation, precast concrete wall installation, caulking, grouting, design build, project management, change management, first-run study

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INTRODUCTION

WORK STRUCTURING

Work structuring is “the development of operation and process design in alignment with product design, the structure of supply chains, the allocation of resources, and design-for-assembly efforts” (Ballard 2000) (or DFX efforts, generally speaking). Product design is everything that helps define ‘what’ a project will be. Process design is ‘how’ supply chain participants (SCPs) will make the product design into a reality. (We use the term ‘supply chain participants’ as opposed to ‘project participants’ to stress a multi-project view of the production process. This keeps us vigilant in determining which lessons learned from past projects can be applied to future projects.)

When SCPs develop product and process designs, some stakeholder values will be maintained while others get compromised. Work structuring negotiates this balance to make work flow more reliable and quick in order to deliver greater value to the customer. In essence, “work structuring is the most fundamental level of process design,” making it a major component of the Lean Project Delivery System (Ballard 2000).

SCOPE OF PAPER

This paper discusses the ‘hollow metal doors case,’ which focused on the Redgranite Correctional Institution, built in Redgranite, Wisconsin. Tsao et al. (2000) detailed this project’s wall and door frame supply chain and installation procedure. They developed alternative work structures for this case by recommending different materials, equipment, and methods, and by shifting work between SCPs. Hollow metal door frames in precast walls is a simple system to study in comparison to other systems found in construction. This simplicity makes it possible to cogently present ways to describe, analyze, and compare work structures. Nevertheless, work structuring applies equally to systems of any complexity.

This paper expands upon Tsao et al.(2000) by rationalizing why SCPs may not pursue a range of alternative work structures. It examines how SCPs learn from past work structures and manage change to try alternative work structures.

PROJECT BACKGROUND

U.S. State and Federal governments build thousands of prison cells each year. Security concerns require that door frames be solid, i.e., hollow frames must be filled with grout or concrete. The door frame installation procedure used in Redgranite is commonly used.

The owner, the Wisconsin Department of Corrections, awarded the Redgranite design-build project to the Oscar J. Boldt Construction Company (Boldt) for a guaranteed maximum price of $48 million. Prior to this project, Boldt had already built 4 similar prisons. This project’s buildings are 2 stories tall, with walls made from precast concrete. The first-level floors are slab-on-grade while the second-level floors are precast concrete slabs. The contract documents required that 538 door frames be filled with a 14 MPa (2,000 psi) grout mix.

‘FIXING’ CURRENT PRACTICES

Work processes in current practice generally appear to be acceptable, not necessarily because they are optimal - often they are far from it - but rather because they have proven to work. In this case study also, the procedure for grouting hollow frames worked on past projects. Productivity improvement studies might have suggested incremental change (e.g., improving the grouting procedure itself by using different methods and ingredients) but it is doubtful they would have led to radical change (e.g., simplifying the process by getting rid of the grouting procedure altogether) because they are operation-centric and rarely if ever cut across organizational boundaries.

In this case study, we stress the need to consider not only changes of methods and ingredients-which are denoted by the term ‘fix’-but also of work flow, people, and the assignment of work to different SCPs. All these considerations combined are denoted by the term ‘work structure.’ ‘Fix’ and ‘work structure’ go hand in hand with one another, though it is often easier to focus on products than on processes. To illustrate this, the initial- and two alternative fixes with corresponding work structures developed by Tsao et al. (2000) are detailed and compared next.

INITIAL WORK STRUCTURE WITH PLYWOOD FIX

DESCRIPTION AND IMPLEMENTATION

As design-builder, Boldt took on construction management responsibilities and hired Venture Architects to be the project architect. Boldt selected Spancrete Industries, Inc. to supply the precast walls and LaForce to supply the doors and door frames. Boldt chose Central City Construction, Inc. to install the walls after Spancrete delivered them to the job site. Boldt then installed the door frames. Boldt hired R.J. Jacques to apply latex caulking and security sealant around the frames. With the caulking and sealant in place, Boldt pumped grout into the frames. Unfortunately, pump pressure combined with the hydrostatic pressure of the wet grout caused grout to blow out through the caulking and sealant.

As a remedy, and because the frames were installed before grouting so that any leak prevention system had to be applied to the frame exterior, Boldt created the Plywood Fix. This fix uses two large U-shaped pieces of plywood sized slightly larger than the frames, held snugly against the frames using plywood C-clamps. The workers shimmed between the C-clamps and the U-shaped pieces to tighten the fit. This prevented grout blowout. When they removed the Fix, they sometimes damaged the caulking, in which case Jacques had to re-caulk the frames. Figure 1 outlines the work sequence for this Fix.

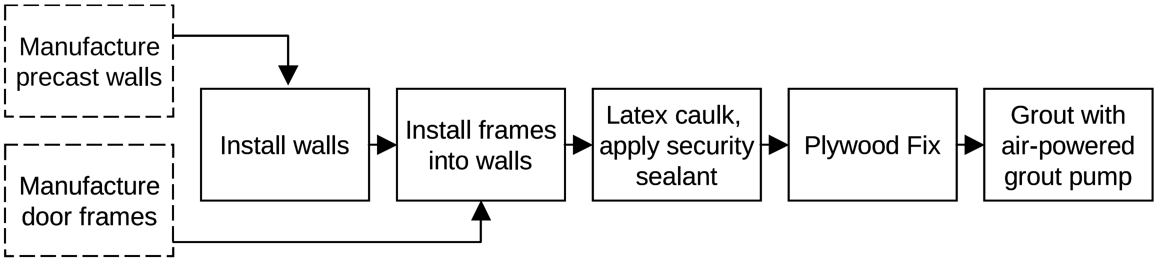

Figure 1: Work Sequence for Plywood Fix (dashed rectangles depict off-site work, solid rectangles depict on-site work)

Boldt workers built 25 sets of the Plywood Fix and used it on 284 frames. Eventually, one worker was able to install the Fix in 10 minutes and remove it in 10 minutes. Workers also learned to remove the Fix without damaging the caulking.

LESSONS LEARNED

Contractors as innovators: The Plywood Fix shows how construction workers apply their craftsmanship skillfully and creatively to solve problems encountered on site. Slaughter (1993) noted that innovations on site are needed because problems at the interfaces between products are less likely to be tackled by any one of the product suppliers. This lack of consideration of upstream SCPs for constructability issues forces contractors to employ highly skilled crafts that can build custom products. Not only is this expensive; the continued reliance on craft skills in future years is unrealistic as fewer people are entering the construction trades. It therefore makes sense to turn to work structuring. One must explicitly trade off SCPs abilities and product requirements. To capitalize on their ability to conceive and make things, increasing numbers of contractors are moving upstream in the supply chain to become involved in design.

Point speed vs. system performance: Boldt's Vice-President of Production Process Innovation, formerly a Manager of Project Controls, noticed the heavy labor requirements for the grouting procedure involving the Plywood Fix, so he initiated a performance improvement study. With support from upper management, he enlisted Boldt workers to help him understand the process. It became clear that the grouting procedure could be improved, but, better even, that work could be restructured and better meet the wall-and-door-frame system requirements. Working with Boldt, Tsao et al. (2000) developed 14 fixes and corresponding work structures, which fall in 5 categories. Table 1 lists 3 of those 14 fixes, the Plywood Fix and two alternatives, which are detailed next.

Table 1: Fixes and Responsibilities (excerpt from Table 1 in Tsao et al. 2000)

■ perform fix ▦ work affected by fix ▤ approve fix

FIXES	Venture Architects	Boldt Constr.	Spancrete Industries	LaForce Doors	Central City Panel Erection	Jacques Caulking
Category 1 - Prevent Caulking Blowout						
Grout Pump Fix plus Caulking Fix	▤	■				■
Category 2 - Prevent Grout Leakage						
Plywood Fix		■				▦
Category 3 - Eliminate Grouting						
Category 4 - Manage Cracks						
Category 5 - Combine Components						
Precast Fix	▤	▦	■	▦	▦	▦

ALTERNATIVE 1: WORK STRUCTURE WITH GROUT PUMP FIX PLUS CAULKING FIX

DESCRIPTION AND IMPLEMENTATION

Grout Pump Fix: On Redgranite, Boldt had been using an air-pressure powered grout pump operating at 30 MPa (4,350 psi). Instead, the Grout Pump Fix recommends using a hand-operated grout pump operating at 5 MPa (725 psi), e.g., as supplied by Kenrich (Rountree 2000). It is capable of up to 6.10 m (20') of horizontal push and 3.05 m (10') of vertical lift (Kenrich 2002). In particular, the resistance felt while operating a hand-powered grout pump provides a gauge of hydrostatic pressure build-up, so grouters can fill frames quickly without blowing out the grout.

Caulking Fix: This Fix uses security sealant on both sides of the door frame, as opposed to using it on only one side, with latex caulking on the other side. Sealant is more resilient than caulking because it is stronger and adheres to surfaces better.

The original Redgranite design had called for sealant on both sides, but initial attempts to apply it failed. Boldt then devised the Plywood Fix, based on which they submitted a change request to Venture to require sealant only on one side and allow caulking on the other side. Venture approved Boldt's request, so Boldt used caulking and sealant as well as the Plywood Fix on 284 door frames. The application of sealant takes longer and requires more skill and care than caulking does. This may be why the Caulking Fix did not work initially. However, Jacques eventually learned how to apply it. He used it on the remaining 254 door frames and thus put the Plywood Fix out of commission.

After completing Redgranite, Boldt successfully implemented both the Grout Pump Fix and the Caulking Fix at a project located in Taycheedah, Wisconsin. Figure 2 outlines the corresponding work sequence.

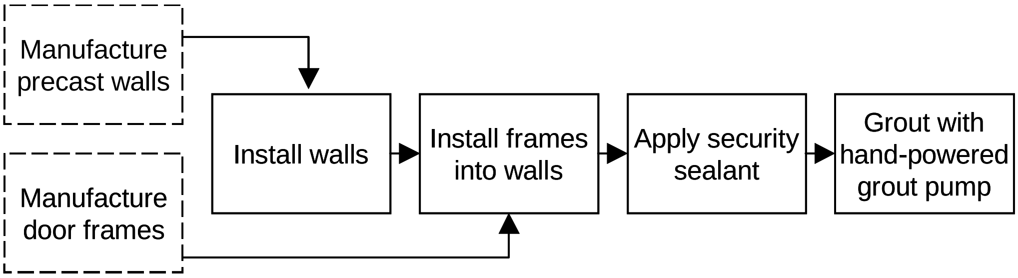

Figure 2: Work Sequence for Grout Pump Fix and Security Caulking Fix (dashed rectangles depict off-site work, solid rectangles depict on-site work)

LESSONS LEARNED

'Right-sizing' resources: The Grout Pump Fix argues for 'right-sizing' equipment, rather than assuming 'bigger is better.' Boldt may have introduced problems by using too powerful a pump, perhaps believing that it would enable workers to grout doors faster. However, grout blew out because the hydrostatic pressure overwhelmed the sealant and caulking barriers. Had Boldt used a low-pressure grout pump, the sealant might have held up better against the slowly increasing volume of grout. Clearly 'bigger is *not* better.' Boldt can reduce the waste of using inadequate equipment (Alarcon 1994 p. 371) by implementing the Grout Pump Fix.

Change does not necessarily cost more: Boldt owned the air-powered grout pump and charged the Redgranite project $1,200 per month for 5 months for its use. In contrast, a Kenrich Products hand-operated grout pump costs $475 to purchase (Rountree 2000). Kenrich customers usually purchase one new pump for each project that requires door frame grouting (Rountree 2000). By rightsizing to improve the operation, Boldt also saved money in this case.

ALTERNATIVE 2: WORK STRUCTURE WITH PRECAST FIX

DESCRIPTION AND IMPLEMENTATION

The Precast Fix is to cast door frames directly into concrete walls, which are made from a 35 MPa (5,000 psi) concrete. It requires LaForce to deliver frames to Spancrete's off-site facility, and Spancrete to cast the door frames into the walls and then ship the assembly to the site. In a meeting with Boldt, Spancrete expressed confidence that they could make this Fix work at a marginal incremental cost, if any. Their finished product would have to meet fabrication and field tolerances for the doors to operate correctly. In addition, Spancrete normally casts an angle iron strongback across the door frame opening to protect walls from warping during shipping. A worker has to cut it off with a blowtorch at the job site. With a door frame inside the opening, strongbacks would have to be attached in some other way. Figure 3 outlines the work sequence for the Precast Fix.

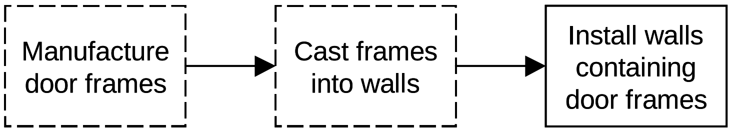

Figure 3: Work Sequence for Precast Fix
(dashed rectangles depict off-site work, solid rectangles depict on-site work)

Successful implementation of this Fix requires that (1) Venture specify door frames earlier, (2) Boldt procure door frames earlier and account for additional shipping and handling, assign liability for damaged frames, and compensate Spancrete for handling door frames, (3) Spancrete cast door frames consistently in the same plane as the walls, (4) Central City safely lift heavier walls, and, (5) Boldt control construction tolerances of the building structure (especially the camber in floor slabs) so that pre-cast door frames will function properly.

The State of Wisconsin is using design-build contracting and thus is open to innovative designs as long as they meet their performance criteria. Therefore, the real challenge in getting approval for the Precast Fix lies with Venture Architects, as they carry design liability. As the Fix replaces grout with stronger concrete, Venture may not object to this Fix (though note that stronger is not always better). Venture may require proof (e.g., through testing) that the Precast Fix, like the original design, meets project requirements. Regardless of the outcome, Boldt may have to absorb the costs associated with trying to get approval.

LESSONS LEARNED

Any or all SCPs (in this case fabricators) can help with innovation at different levels: During the meeting with Boldt to discuss the Precast Fix, Spancrete gladly worked out a solution. They developed different approaches for implementing the Fix while considering problems that might occur.

At one point, a Spancrete employee developed another idea to improve the existing system of grout, walls, and door frames. Normally, Boldt pumps grout through grout ports in the door frames, and spends time covering up the holes afterwards to match the frame's finish surface. The employee proposed instead that Spancrete block out grout ports near the top of the door openings for Boldt to pump grout through. Covering holes in concrete is easier than in metal. Thus, should the Precast Fix not be adopted, Boldt at least obtained an idea for improving its current production system by talking to Spancrete.

Change does not necessarily cost more: The Precast Fix appeared to be a more radical departure from the original design and assignment of work, so there was concern about the cost to implement it. In fact, Spancrete's work became simpler. They would not have to worry about the finish surface of the door openings in the walls, and the time spent blocking out door openings would be spent instead on positioning door frames. The Precast Fix might even speed up Spancrete's process of forming the walls. The time saved might be spent on receiving and handling frames. The Precast Fix eliminates the need to grout. This saves Boldt not only the cost of grouting, but also the cost of caulking and applying the Plywood Fix.

COMPARISON OF ALTERNATIVE FIXES AND WORK STRUCTURES

Table 2 compares the Grout Pump Fix plus Caulking Fix, and the Precast Fix to help SCPs select a work structure to use on future projects. The dimensions of comparison are by no means exhaustive nor prescriptive; they serve as a starting point for describing work structures.

Table 2: Comparison of Fixes

Grout Pump Fix plus Caulking Fix	Precast Fix
SCPs that directly implement the fix	
Boldt - Use hand-operated grout pump. **Jacques** - Apply security sealant to both sides of door frames.	**Spancrete** - Cast door frames into precast concrete walls.
Authority to approve the fix	
Venture - As this fix reverts to the original design, Venture approval is only a formality.	**Venture** - Approval required only if specs do not already allow precasting of door frames.
SCPs whose work is affected by the fix	
Kenrich - Supply the grout pump.	**Boldt -** No longer needs to grout door frames. **LaForce** - Deliver door frames to Spancrete. **Central City** - Precast walls are heavier due to attached door frames. **Jacques** - No longer needs to apply sealant.
Major handoffs required by SCPs so they can execute their work	
Central City – Workspace from Boldt and walls from Spancrete to erect walls into place. **Boldt** - Workspace from Central City and door frames from LaForce to install door frames. **Jacques** – Workspace from Boldt to apply sealant. **Boldt** - Workspace from Jacques and grout pump from Kenrich to grout door frames.	**Spancrete** - Door frames from LaForce to fabricate walls. **Central City** - Workspace from Boldt and walls from Spancrete to erect walls into place.

Materials handling	
LaForce - Deliver door and frames to job site. **Spancrete** - Deliver walls to job site. **Kenrich** - Deliver grout pump to job site.	**LaForce** - Deliver door frames to precaster earlier and doors to job site later. **Spancrete** - Deliver walls + frames to job site.
Interface tolerance management	
Jacques - Foam backer rods and sealant fill cracks between door frames and walls. **Boldt** - Grout fills in cavity between door frames and walls. Frame installer uses shims to get door frames plumb and square.	**Spancrete** - 3-piece formwork to hold door frame in place during concrete pour and cure and to control door frame square-ness. **Central City** - Installed walls must be plumb to ensure door frames can open properly.
Safety	
Boldt - Hand-operated grout pump does not require electric or air power source.	**Central City** - Lift heavier loads since precast walls contain door frames.
Influence of worker on product quality	
LaForce - Finish quality of doors and frames. **Spancrete** - Finish quality of walls. **Central City** – Plumbness of walls. **Boldt** - Plumbness and squareness of doors and door frames as well as grouting of frames without blowouts. **Jacques** - Finish quality of sealant.	**LaForce** - Finish quality of doors and frames. **Spancrete** - Finish quality of walls (including filling of all concrete voids) and initial plumbness and squareness of frames in relation to walls. **Central City** - Final plumbness of walls and frames.
Aesthetics	
Jacques - There is a visible line of sealant between the frame and wall. **Boldt** - Close up 2.5 cm (1.0”) grout ports to produce a clean finish along frames.	**Spancrete** - Wall runs flush against frames. Close up 6.4 mm (0.25”) weep holes to produce a clean finish along frames.
Performance	
Jacques, Boldt, and Spancrete - Provide a 55 MPa (8,000 psi) sealant barrier against inmate access to gaps that might exist between the 14 MPa (2,000 psi) grout and 34 MPa (5,000 psi) walls.	**Spancrete** - Provide a 34 MPa (5,000 psi) precast concrete barrier against inmate tampering.
Schedule	
Boldt - Eliminates time spent on installing Plywood Fix and rework when grout blows out of door frames. **Jacques** - Adds time spent on applying security sealant.	**Boldt** - Eliminates time spent on installing Plywood Fix, rework when grout blows out of door frames, and grouting. **Jacques** - Eliminates time spent on applying security sealant. **LaForce** - Door frames must be designed, fabricated, and delivered earlier than usual. **Spancrete** - Adds time spent on receiving, storing, and handling door frames.
Cost	
Boldt - Eliminates cost of air pump, Plywood Fix, and rework due to grout blowout. Adds cost of hand pump.	**Boldt** - Eliminates cost of Plywood Fix and grouting. Adds cost of design change approval, earlier delivery coordination of door frames to

Jacques - Adds labor cost associated with the application of sealant on both sides of door frames.	precaster. **Jacques** - Eliminates cost of security sealant. **Spancrete** - Adds cost to receive, store, and handle door frames. **Central City** - Adds cost to erect heavier walls.
Liability	
Venture and Boldt - Liability remains same since Fix preserves original design intent. **Jacques** - Liability increases because project relies upon security sealant to contain grout.	**Venture** and **Boldt** - Liability may shift since Boldt proposed the Fix. **Spancrete** - Liability increases since it must receive and cast door frames into walls. **Central City** - Liability increases since walls will be heavier due to door frames.
Achievement of SCP values	
Venture - Design cells that are resistant to inmate tampering. Also, use prison designs that have worked on past projects. **Jacques** - Maximize security sealant work.	**Venture** - Design cells that are resistant to inmate tampering. **Boldt** - Manage congestion on job site to reduce risk of accidents.
Supporters of the fix and why	
Jacques – Has to do work. **Kenrich** - They can sell pumps. **Venture** - Product design has proven to be effective on past projects.	**Boldt** - Fix eliminates risks, costs, and time associated with frame handling and installation, grouting, and applying sealant. **Spancrete** - Instead of managing finish surface of door penetrations, make forms that keep frames in place during concrete pour.
Opponents of the fix and why	
	Venture - They have not designed a project in this fashion before. **Jacques** - Loses work.
Execution predictability	
Boldt - Grout does not blow out of door frames as often, so grouting process will more reliably proceed as planned. There can still be a fitting problem for door frames and precast wall door openings.	**Boldt** - Fewer handoffs of work to manage between various SCPs due to simplified process. No more problems with fitting door frames into precast wall door openings. **Venture** - Door frames need to be specified earlier in the design development process.
Potential benefits	
Boldt - Removes need for Plywood Fix. Experimenting with this Fix is inexpensive. If Fix fails, it is easy to revert back to original design.	**Boldt** - Removes need for Plywood Fix, caulking, and grouting. **Wisconsin DOC** - Provides solid solution.
Potential risks	
Wisconsin DOC – Seam between door frame and precast wall can be tampered with by inmates.	**Boldt** - Testing may or may not convince Venture that this Fix meets performance requirements of existing design. **Central City** - Door frames might not be plumb after precast wall installation, so doors cannot open properly. Central City may not be blamed for this problem, but could be asked to fix it.

DEVELOPMENT AND SELECTION OF ALTERNATIVE WORK STRUCTURES

Tsao et al. (2000) developed alternative work structures by using the "Five WHYs" method for root cause analysis. These alternatives tackled both process- and product design of the current production system. Upon further investigation as to their practicality, several alternatives proved to already have been implemented by practitioners in other geographic regions. Why then was the Plywood Fix still being used? Consider the following reasons:

- **'Received Tradition'** (Schmenner 1993 p. 379)**:** Venture views grouted door frames as an acceptable way to design the interface between prison cell walls and door frames. The continued use of this design is encouraged by (1) the use of this design on past projects, (2) the acceptance of this design by the owner, and (3) the ability of the contractor to perform the grouting operation and their perception that the operation is not problematic in any way (note: Boldt suggested the operation for analysis because Greg Howell asked for an operation to be studied and they singled it out from others for its high labor content).
- **Minor design detail:** Grouting of door frames is a small activity compared to others on the construction schedule. It may not seem worthwhile to investigate and modify the design of minor details. However, the Precast Fix shows that improving details potentially can improve overall project performance.
- **Tight budget and schedule:** By hiring architecture, engineering, and construction professionals, owners may see no need to invest time and money to let SCPs explore radically different work structures. Instead, their contracting strategy probably defines key aspects of how work is to be structured. They may urge project planners to select a work structure immediately so that all SCPs can begin (and therefore presumably finish) their work sooner. In these situations, past work structures prevail and are commonly applied directly or adapted to suit the new project at hand.
- **Change champion:** A change champion is an individual who acts as a catalyst and a critic for the development and implementation of innovations (Schmenner 1993 p. 469). Championing an alternative work structure requires investing time and money, and many SCPs are in no position or are unwilling to take such a risk.
- **Project controls and cost accounting:** By using its own air-pressure pump on this project, Boldt could account for a higher utilization of this resource. Some companies consider resource utilization to be a performance indicator. However, operating ineffective equipment at full capacity is a form of waste.
- **Liability assignment:** If a work structure alternative involves many SCPs, it can be difficult to determine 'Who pays and who gains?' as needed to compensate SCPs fairly for their efforts. In addition, if the selected work structure fails, SCPs should know how to identify 'Who is responsible?' These points could be addressed in contractual agreements.

When SCPs develop the work structure for a project, they may chose from (1) work structures that they are familiar with from past projects, (2) anecdotal work structures that they have heard of being implemented on past projects or seen described in publications, or (3) experimental work structures that none of the SCPs have worked with or heard of before. To decide which work structure to use, SCPs may compare alternatives based on their execution predictability and potential risks vs. benefits, given the project's circumstances and incentives for SCPs to implement change.

SCPs tend to favor implementing past- over anecdotal work structures, and anecdotal- over experimental work structures because the first have significantly higher execution predictability than the latter. However, SCPs could-but do not always-study alternatives to increase their execution predictability, e.g., conduct tests and first run studies (Ballard and Howell 1994) and review the product literature. In addition, directions given to SCPs instruct them to design and build projects in a certain way, so it is difficult to consider building projects any differently, especially if the current method works. Consequently, the balance needs to tilt heavily in favor of using an anecdotal- or experimental work structure in order for it to be selected over a past work structure.

A majority of people naturally appear to favor stability; they are reluctant to change. Sometimes only a change champion can convince them to consider and select alternatives. Change is an effect of anxiety. Psychologist Edgar H. Schein (Coutu 2002) identifies two types of anxiety related to learning. 'Learning anxiety' is the basis for resistance to change. 'Survival anxiety' is the realization that in order to make it, change is necessary. Learning occurs only when survival anxiety exceeds learning anxiety. Perhaps industry competitiveness and ultimately business survival will be the key driver behind the pursuit of work structuring and learning associated with it.

CONCLUSIONS

This case study described a system with hollow metal door frames in precast walls, and specifically focused on the interface between those two products. It presented two alternative work structures to achieve this system's purpose; then explained how those could be implemented and what might be learned from doing so. The first alternative involves incremental change and it has since been successfully implemented on another project. The second alternative involves more radical change and it has yet to be implemented by the SCPs involved in this case study.

Alternative 1, the Grout Pump Fix plus Caulking Fix, yielded a work structure that is superior to the fix used in current practice, but it is limited in scope. Lean production advocates systemic process simplification (e.g, Koskela 1992). Alternative 2, the Precast Fix, has illustrated that taking a broader view on the supply chain and simplifying the chain can indeed yield greater gains in terms of systems performance. Added cost has always been a convincing argument against doing things differently, but cost was not an issue in either one of these two alternatives. In fact, by structuring work better, costs could be reduced.

The case showed that relying on craft skills on site to make systems work adds process variability; it is not a good idea. Product interfaces can be managed better by upstream SCPs. Moreover, the industry's rising labor shortage is likely to contribute to survival anxiety in many contractors, thereby forcing them as well as other SCPs to learn how to structure work differently, e.g., how to create better designs that match SCP capabilities and support reliable execution.

For each new project, SCPs must decide whether to adopt a 'tried and true' past work structure or an alternative that involves designing and building perhaps using an unfamiliar approach. Significant risks but also rewards may be associated with using different work structures. By blindly following the age-old adage 'Don't fix it if it ain't broke,' people lose an opportunity to think creatively about how and why work is done the way it is, and to learn how to develop better practices. Work structuring sets out to actively promote lateral thinking and question 'received tradition,' so that incremental as well as radical improvements may be recognized and implemented.

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