

RESTRUCTURING THE REBAR SUPPLY SYSTEM

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ABSTRACT

The rebar supply system includes all the organizations involved in the manufacturing, design, procurement, fabrication, transport, installation, inspection and regulation of reinforcing steel. It also includes their relationships and their processes. That system is highly fragmented and sub-optimized; it needs to be restructured.

An industry task force, formed to support the authors' research, characterized the current state of the system in terms of adversarial relations, low pay, and failure to learn from project-to-project. No one is making an adequate profit, low fees constrain designers from full exercise of their professional capabilities, and drawing quality and design constructability are declining. The task force also proposed a vision of the future state, identified obstacles to its realization and generated basic strategies for overcoming those obstacles. This paper describes these task force outputs and develops its strategies into a plan for reforming the rebar supply system.

KEY WORDS

rebar, rebar supply system, reinforcing steel, system reform, supply chain management

INTRODUCTION

Specialists involved in the supply system for steel reinforcing bars used in concrete (rebar) include owners, architects; structural engineers, regulatory agencies, scrap metal processors, steel mills, concrete suppliers, fabricators, formwork suppliers and erectors, embeds- and accessories producers, general contractors, and specialist contractors for rebar and concrete placement. That they are numerous reflects the advanced technological understanding and capabilities that we exploit today to build structures to meet increasingly stringent owner and societal requirements. The need to specialize, however, has gone hand-in-hand with fragmentation of the industry resulting in a far-from-optimal process to deliver capital projects (e.g., Howard et al. 1989).

Performance metrics leave no doubt that current practice can be improved significantly: there are many unnecessary iterations and large amounts of rework in design and detailing, numerous requests for information from the fabricator and builder to the designer, long lead times to fabricate and deliver rebar, time consuming and costly constructability problems

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discovered during on-site placement, tons of paperwork cluttering the process, and huge legal issues challenging many a project.

As a step towards reforming the current rebar supply system, the authors recently completed the initial phase of research. This phase included one-on-one interviews with industry practitioners, the formation of an industry task force to provide steering and to participate in data collection and generation, as well as other tasks. Two task force workshops were held during the 1.5 year duration of the study. In those workshops, the task force produced a document describing the current state of the rebar supply system, the desired future state, obstacles to realizing that desired future state, and strategies for overcoming those obstacles. This paper develops that task force vision and strategy into a plan for reforming the rebar supply system.

TASK FORCE COMPOSITION

To explore opportunities and the feasibility of improving the delivery process of reinforced concrete, we organized workshops with industry practitioners at all levels in the rebar supply system. Our aim was to study the relationships between those who design the product and those who make it: mainly the structural engineer, the fabricator, and the rebar placer (the fabricator and placer may or may not be the same firm).

Table 1: Workshop Participants

Supply System Role	Company	Contact	Workshop 8/20/03	Workshop 10/27/03
Owner	UC Berkeley Capital Projects	Rob Gayle	X	
Struct. Engineer	Degenkolb Engineers	Janiele Maffei	X	X
Struct. Engineer	Tipping Mar & Associates	David Mar	X	X
Struct. Engineer	Kardon + Company	Josh Kardon		X
Fabricator/CRSI*	Far West Steel	Jim Soulé	X	X
Software/CRSI*	CADSUSA, Inc.	David Horton**	X	X
GC	Pankow	Jim Dick	X	X
GC	McCarty	Jeff Gleessen	X	
Labor Union	IW District Council of CA	Steve Rank	X	
Industry Assoc.	CRSI*	Tom Tietz		X
Industry Assoc.	CRSI*	Burt Purba		X
Academic	UCBerkeley – Professor	Iris Tommelein	X	X
Academic	UCBerkeley – Adj. Assoc. Prof.	Glenn Ballard	X	X
Academic	UCBerkeley – Assoc. Prof.	Boza Stoyadinovic	X	
Academic	Texas A&M – Asst. Prof.	David Trejo	X	

* CRSI = Concrete Reinforcing Steel Institute

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TASK FORCE STRATEGY

In the exploratory research, both structural engineering firms and rebar fabricators reported that profit margins were small and continuing to shrink, making it increasingly difficult to execute their project-specific tasks adequately and professionally, and largely eliminating the possibility of investment of time or money in the development of innovations. Furthermore, the sequential delivery process is reported to render collaboration across organizational boundaries almost impossible. This has diverted attention and energy of the participating organizations to solving their own problems, and away from ‘fixing’ the system in which they all operate. A worst-case scenario is that the system itself will progressively deteriorate, radically increasing the cost of construction, or rendering reinforced concrete more expensive than alternative materials.

As shown in Figure 1, the Task Force developed a strategy for restructuring the rebar supply system framed within descriptions of the current state and the desired future state, and taking into account obstacles that stand in the way of making the change from present to future.

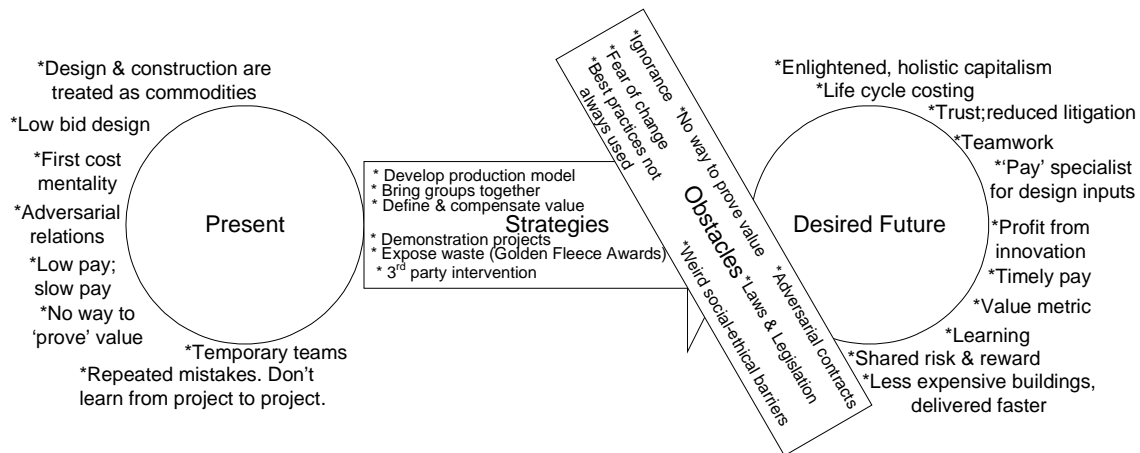


Figure 1: Task Force Strategy

PRESENT = CURRENT STATE OF THE SYSTEM

The characteristics of the current state of the system (shown as the Present on the left-hand side in Figure 1), “Design & construction are treated as commodities,” “Low bid design,” and “Low pay; slow pay” comment on the financial remuneration of participants, which was said to limit design development and the ability of fabricators and installers to invest and innovate. The characteristics “Adversarial relations,” “Repeated mistakes,” and “Temporary teams” reflect lack of teamwork. The characteristics “First cost mentality” and “No way to ‘prove’ value” point to the limited perspective encouraged by current thinking and practice. For example, there have been increasing complaints in the construction industry about the quality of design drawings. One driving factor may well be the reduction in design fees, which has led some structural engineering firms to minimize the detail provided in their

drawings to the point of omitting dimensions! Mar (2004) describes undesirable characteristics of current design practice in more detail and also provides recommendations to improve the design process.

DESIRED FUTURE

Not surprisingly, the Desired Future was mostly characterized in opposition to the Present. Thus, the future rebar supply system is to be one in which people and organizations cooperate, focus on total system performance, are rewarded for innovation and value generation, and learn together how to progressively deliver better buildings for less cost.

OBSTACLES

The Obstacles identified by the task force are mostly what one would expect to find confronting any attempt at social/organizational change. However, “No way to ‘prove’ value” may be an exception. The Task Force became convinced that the rebar supply system could generate greater value than it currently does, both for its customers and for its participants. However, inability to ‘prove’ that greater value will result from changes in current practice is one of the reasons why current practice persists.

STRATEGIES

The Strategies proposed by the task force require fuller explanation, as they are the basis for the system reform plan presented in this paper.

- *Develop production model:* One of the drivers for reform is adoption of the systems perspective. Currently, no one has visibility of the entire system and there are no governance mechanisms applicable to the rebar supply system as a whole. Providing that visibility and enabling such governance requires models of the system, especially a production model revealing how information and materials flow through the network of specialists.
- *Bring groups together:* Prior to formation of the task force, no participant had ever dealt with more than one other system participant at any one time. This by itself was/is a major deterrent to taking a systems perspective. An even more comprehensive coalition will be needed to go beyond visioning a future state to its creation.
- *Define and compensate value:* A persistent theme in the task force’s work was value generation. The opportunity and need to generate greater value for customers and producers—though evident—requires the ability to define and measure such value, which in turn will enable compensation for value delivered.
- *Demonstration projects:* No system as complex and resistant to change as the rebar supply system will change overnight. Change will inevitably be piecemeal and extended over time. Such changes will be promoted by demonstrations of their benefits, which can be provided through demonstration projects.

- *Expose waste*: The vision of generating greater value is paralleled by the perception of extensive waste in current practices. However, that waste may not be visible to all parties and so needs to be exposed, which can be done through measurement and documentation.
- *3rd party intervention*: Just as difficult, contentious meetings can benefit from a neutral facilitator, the task force recommended that the University play the role of a 3rd party outside the rebar supply system during its reform.

FINDINGS FROM PHASE I OF THE RESEARCH

In addition to the workshops, Phase I of the research also included:

- Visit to a steel mill and meetings with their production management personnel to understand the manufacturing process, and production system inputs and outputs,
- Visits to several rebar fabrication shops,
- Meetings with structural engineers to deepen our understanding of the structural design process, their use of CAD systems and drawings, and their means for communicating design intent,
- Meetings with detailers to deepen our understanding of how rebar designs get interpreted, which software is available on the market, and how it gets used for rebar detailing,
- Mapping of the rebar design, detailing and submittal processes,
- Hands-on exploration using different software packages to gain appreciation of the challenges associated with rebar detailing requirements and software capabilities,
- Review of the academic and trade literature.

These research efforts made it clear what value-adding contributions different participants in the rebar supply system can bring in each stage of project delivery. Professional expertise of different kinds is needed at each level and across levels, but practices vary significantly from person to person, company to company, and project to project. Practices on the east coast of the United States differ from those on the west coast, for reasons that are not obvious. Best practices do not appear to be documented, metrics and benefit/cost analyses do not exist, and a widely shared vision for the future well beyond today's best practices is sorely lacking.

The conversations we had revolved around the opportunities available but also those being missed, for reasons shown in Figure 1. Several expressed a fear for loss of long-term competitiveness of the rebar industry.

PLAN FOR RESTRUCTURING THE REBAR SUPPLY SYSTEM

Given the work of the Task Force and accepting the need to restructure the rebar supply system, what comes next? What needs to be changed and how to change it? We propose a three part change process:

1. Deploy lean project management as the governing philosophy for project delivery
2. Develop an agenda for further research

3. Form a coalition of supply system stakeholders to define and lead the change

DEVELOP UNDERSTANDING OF LEAN PROJECT MANAGEMENT AS AN ALTERNATIVE TO TRADITIONAL PROJECT MANAGEMENT

First of all, the rebar system in its present state can be understood as part and parcel of the way construction projects are normally delivered, an approach Howell and Koskela (2001) and others have argued is entirely consistent with and a consequence of attempting to apply the principles and techniques of project management presented in the Project Management Institute's Body of Knowledge (PMI 2004). None of the contractual systems used in the industry today, from design-bid-build to design-build, appear to be consistently superior with regards to performance in the rebar supply system (and the supply system of numerous other construction materials) because they more-often-than-not overlook organizational- and production-system design considerations. Comparing this traditional approach to a lean construction approach (Koskela et al. 2002, Ballard et al. 2002) reveals differences shown in Table 2.

We see a change in philosophy on how projects are delivered as essential to overcoming the limitations of current practices.

RESEARCH AGENDA

Second, we will develop an agenda for further research. This includes four steps:

1. Write a white paper to describe problems and possible improvements in the rebar delivery system. The white paper will propose the development of:
 - 1.1. Experiments to demonstrate the benefits of involving fabricators in design.
 - 1.2. Experiments to demonstrate the utility of 3D modeling in support of fabricator involvement in design.
 - 1.3. Guiding principles for design constructability of concrete reinforced structures akin to manufacturing's "design for manufacturing" (DFM) rules.
 - 1.4. A language to ease communication and collaboration, i.e., to enable those in the supply system to describe their professional decisions while also documenting intent, without unduly constraining the delivery process.
 - 1.5. Processes and guidelines for collaborative design of concrete reinforced structures by architects, structural engineers, and fabricator/placers.
2. Distribute that white paper to help organize a meeting of interested parties to develop a plan of action. Include such organizations as the American Concrete Institute (ACI), American Society of Civil Engineers (ASCE), Associated General Contractors (AGC), CRSI; key fabricators, structural engineering firms, and owners; the Ironworkers Union; as well as suppliers to and regulators of the industry.
3. Based on our research agenda and with a buy-in from stakeholders, agree and plan initiatives to improve the rebar delivery system.

Table 2: Traditional versus Lean Project Management
(used with the permission of the Lean Construction Institute)

Traditional Project Management	Lean Project Management
The primary focus of management is on transactions and contracts	The primary focus of management is on designing and making things
The goal is to deliver the project to contractual requirements	The goal is to deliver the project while maximizing value and minimizing waste
Decisions are made sequentially by specialists and “thrown over the wall”	Downstream players are involved in upstream decisions
Product design is completed, then process design begins	Product and process are designed together
Problems caused early in the process presumably can be fixed later	Problems are avoided or fixed as early as possible
Only selected product life cycle stages are considered in design	All product life cycle stages are considered in design
Activities are performed as soon as possible	Activities are performed at the last responsible moment
Separate organizations link together through the market and take what the market offers	Supply systems are structured for value generation and for flow, and systematic efforts are made to reduce lead times
Learning occurs sporadically	Learning takes place continuously and is incorporated into project, firm, and supply chain management
Stakeholder interests are not aligned	Stakeholder interests are aligned
Variability (in durations, deliveries, quality) are accepted as the way things are	Variability is reduced through production system design and control
Participants build up large inventories (materials, space, time, cash) to protect their own interests	Buffers are sized and located to perform their function of absorbing system variability that cannot (yet) be eliminated

4. Define specific research projects, involve key players, and secure needed funding.

4.1. Topics for supportive research include study of:

- Material availability, selection, and use, and impact of variability of characteristics (e.g., strength, ductility, chemical composition) on design and production of rebar
- ‘Standard of care’ in design and detailing
- Industry standards and regulatory requirements
- Steel mill production planning and coordination of distribution logistics
- Fabrication technologies (e.g., automated bending, welding, and cage-making)
- Organizational structures and industry business relationships
- Software capabilities and developments
- Definition of process and output metrics
- Knowledge creation and organizational learning

4.2. Topics for demonstration projects include:

- Collaborative design
- Production scheduling
- Modularization
- Prefabrication
- Assessment of value in the supply system
- Analysis of economics from a value perspective for all players in the supply system

COALITION OF INTERESTED PARTIES

Third, we recognize that reforming the rebar supply system will not occur instantaneously. Concerted effort involving all stakeholders will accelerate the reform process. Our efforts therefore will include:

- *Assembling a coalition of associations and influential participants, including (in alphabetical order):*
 - American Concrete Institute - ACI
 - American Institute of Architects – AIA
 - American Society of Civil Engineers - ASCE
 - Associated General Contractors – AGC
 - Concrete Reinforcing Steel Institute – CRSI

- Construction Industry Institute – CII
 - Construction Users Round Table – CURT
 - Design Build Institute of America – DBIA
 - Lean Construction Institute – LCI
 - Precast Concrete Institute – PCI
 - Steel Mills – e.g., Nucor, Cascade Steel, and Tamco on the West Coast, etc.
 - United Steel Workers of America – USWA
- *Defining the role(s) of industry practitioners:* they will have hands-on involvement in designing and carrying out experiments.
 - *Defining the role(s) of academics:* model the supply system across all stakeholders, provide input to the design of experiments, facilitate the initiative (form the coalition, facilitate meetings, assist in data collection), analyze data, synthesize findings, and generate knowledge through literature search and research.

We are keen on developing new collaborations and deepen those already established with colleagues at peer institutions, domestically and internationally, not only to conduct many more experiments than we can do on our own, but also to work with practitioners in different regions in order to capture geographic differences in industry practices. All involved will thus be able to leverage their research capacity and engage in comparative studies.

The problems that plague the rebar supply system are common to many trades, specialists, and supply chains in the construction industry. The characteristics of the Present and Desired Future, and the strategies for getting from one to the other may very well translate into systems solutions for other construction materials. Here too, collaboration is welcomed in order to explore the generality of the presented research approach and anticipated findings.

SUMMARY

This paper reported on findings from the first phase of research we conducted in order to understand opportunities for restructuring the rebar supply system. It included a plan and an agenda for future research. We look forward to pursuing our research agenda further and involve people from industry as well as academia to jointly implement radical change.

ACKNOWLEDGMENTS

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