Cast-in-Place Concrete Industry

Adoption of Information Technology

Chang-sun Chin
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Existing Processes

• Architects and engineers produce their drawings using computer generated design format (AutoCAD…) or paper format.
• The reinf. bar fabricators receive drawings in these formats and reproduce them on paper for reinf. bar fabrication (Bar bending Schedule)
• To date, process of reinf. bar fabrication (cutting & bending) has been automated in part.
• Needs to utilize and manipulate this information more efficiently and effectively: enhance the integrated process from engineering/design to fabrication / assembling.
Existing Processes

- Earth Work
- Dewatering
- Scaffold & Support
- Concrete Work
- Reinf. Work
- Form Work
- Mix Design
- Order Conco
- Bar Bending Schedule
- Cutting & Bending
- Fixing & Supporting
- Form Plate Installation
- Reinf. Bar
- Form Plate & Timber
- QA/QC
- Schedule
- Cost Control
- Curing
- Deliver to Site
- Concrete Pouring
- Pre-Pouring Inspection
- Yes

Ingredients:
- Cement
- Gravel
- Sand
Existing Processes (Bar Bending Schedule)
Existing Processes
(Reinf. bar fabrication & Fixing)

Bar Cutting M/C   Bar Bending M/C

View of Reinf. bar fixing
Existing business environment

- Concrete Industry comprises establishments primarily engaged in the use of concrete and asphalt to produce parking areas, building foundations, structures, and retaining walls, and in the use of all materials to produce patios, private driveways, and private walks. Activities performed by these establishments include grout and shotcrete work. The concrete work performed includes new work, additions, alterations, and maintenance and repairs.

The Standard Industrial Classification (SIC) system
Existing business environment

- Concrete contractor (in the U.S.)
  - Number of Establishment = 30,417 nos.
  - Value of Construction work
    \[= \$25,848,848,000\]
    - New construction = $18,737,938
    - Additions, alterations, or reconst. = $3,558,605
    - Maintenance & repair = $3,217,936

"1997 Economic Census (U.S. Census Bureau)"
## Existing business environment

### U.S. Apparent Consumption of Rebar

<table>
<thead>
<tr>
<th>Year</th>
<th>1996</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
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</thead>
<tbody>
<tr>
<td>Domestic Shipments (000 Tons)</td>
<td>5,762</td>
<td>6,188</td>
<td>5,909</td>
<td>6,546</td>
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<tr>
<td>U.S. Rebar Imports (000 Tons)</td>
<td>582</td>
<td>701</td>
<td>1,229</td>
<td>1,833</td>
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<tr>
<td>Annual % Increase</td>
<td>20.6%</td>
<td>75.3%</td>
<td>49.1%</td>
<td></td>
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<tr>
<td>Exports (000 Tons)</td>
<td>(107)</td>
<td>(179)</td>
<td>(142)</td>
<td>(128)</td>
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<tr>
<td>U.S. Apparent Consumption of Rebar (000 Tons)</td>
<td>6,237</td>
<td>6,710</td>
<td>6,996</td>
<td>8,251</td>
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<tr>
<td>Rebar Imports as % of U.S. Consumption</td>
<td>9.3%</td>
<td>10.5%</td>
<td>17.5%</td>
<td>22.2%</td>
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</tbody>
</table>

“Steel Manufacturers Association (2000)”
Available and suitable information technologies

• Improving the flow of information between all parties involved in the rebar design, supply and construction chain

• **RebarCAD System & CADS RC** (Bar bending Schedule)

• CAD-Integrated Rebar Placement Planning (CRPP system (increasing the productivity of rebar design, detailing, fabrication, delivery, and placement)

• **Bamtec** system (Alternative reinforcement)

• The rebar bending operation ≠ labor intensive, hazardous work any more.
Available and suitable information technologies (RebarCAD System-bar bending schedule)

* RebarCAD

* CADS RC
RebarCAD System-Key Benefits

• Productivity
• Accuracy - virtually eliminates errors and reduces inconsistencies in detailing and scheduling (take-off).
• Flexibility - detail any arrangement of bars in any type of structure and is not a restrictive modular system that can only detail standard units such as footings, etc.
• Efficiency - Links with fabrication management / production systems reduces data re-entry to provide a total solution.
CADS RC-Key Benefits

• Fast Accurate Detailing
• Automatic Bar Lists / Schedules
• Automatic Detailing Macros
• Links to RC Design Software
• Links to Fabrication Systems
• Powerful Editing Systems
• Reduced Checking/Errors
CAD-Integrated Rebar Placement Planning System
(Information Link between CRPP and a Rebar Fabrication Shop)
CAD-Integrated Rebar Placement Planning System Adaptation of FMS Framework to Rebar Fabrication
CAD-Integrated Rebar Placement Planning System (Schematic of Adaptive Control Structure for Automated Rebar Bending)
CAD-Integrated Rebar Placement Planning System (Integrated Adaptive Control System)
CAD-Integrated Rebar Placement Planning System (Integrated Adaptive Control System)

• The impact of automating control of the entire rebar fabrication operation on safety and productivity should also be investigated.

• A human-machine control interface should be analyzed for its effect on the fabrication operation as well as the product quality.

• The model proposed for full integration of adaptive control in the rebar fabrication environment may also be modifiable for application to other construction material fabrication or prefabrication operations.
Available and suitable information technologies (* Bamtec System)

- Concrete slab reinforcement which is rolled out on site just like a carpet.
- Rolls can be delivered to site in lengths up to 15m wide and 30m long.
- *Bamtec* can be used instead of both standard mesh and cut and bent bar.
Available and suitable information technologies (* Bamtec System)

- Design
- Manufacture
- Delivery to Site
- Installation
Available and suitable information technologies (* Bamtec System)

- **Benefits for Contractors:**
  1. Savings in fixing costs of up to 90%.
  2. Material savings of between 20-40%.
  4. Increased quality management.
  5. Reinforcement fixing in computer controlled factory environment.
Available and suitable information technologies (* Bamtec System)

• Benefits for Consulting Engineers:
  1. Shorter and more automated design time.
  2. Shorter and more automated detailing time.
  3. Reduced opportunity for human error.
  4. Consultants drawings are reproduced exactly on site, not to a steel fixer's interpretation of the drawings.
  5. Reduced requirement for resident engineering.
A framework target plan

A generic diagram showing rebar process information flow
A framework target plan

Modeling tool applied to rebar processes
The expected costs of achieving the plan

Improving the flow of information between all parties involved in the rebar design, supply and construction chain will:

- Speed up the design process, and reduce the amount of re-working.
- Reduce duplication and the scope for errors in re-keying information.
- Reduce lead times with increased flexibility for change.
- Reduce waste from bending machines
Analysis of the readiness of the Cast-in-Place Concrete sector

The reinforced concrete industry should:

• Use electronic exchange and sharing of rebar information. Initially this should take the form of standard formatted bending schedules

• Adopt reinforcement detailing by contractors using integrated rebar detailing and manufacturing information.
Analysis of the readiness of the Cast-in-Place Concrete sector (Cont’d)

• Use bar-coding and text files as an automatic identification technique for the exchange of bills of quantities, test certificates, delivery notes and invoices.

• Use electronic transfer of information for the control of rebar bending and cutting machines.
A detailed plan for
the next incremental step