What is Rebar Detailing?

- The art of placing reinforcing in a concrete member to follow the design intent

- Thou shall follow the design & placing rules of ACI, AASHTO, and CRSI...
Why is Detailing Important?

- It is how the project gets built
- Not everything gets caught
- It makes the SE think
- When problems occur . . .
  » Delays in the project
  » Cost implications
  » Possible finger pointing

U.S. Detailing Practice

Structural Design – A/E
- Building
  » Drawings / Specs
  » Placing Drawings
- Bridge
  » Structural – Placing Drawings

Detailing of Rebar in Concrete

- Buildings
- Bridges
- Role of SE & Detailer
- Two Case Studies
- What can we (SEs) do?
Buildings

Building Deliverables

- Drawings
  - Structural
  - Architectural
- Project Specifications
  - Section 03200 - Reinforcing
- General Notes

ACI 318 – Building Code

- Dawn of time
- Current version is 2008
- Governs building design
- Contains info on reinforcing
ACI 318, Section 1.2.1 – Drawings, Details & Specs

- Specified strength / grade of reinforcement
- Size and location of all
  » Structural elements
  » Reinforcement
  » Anchors

ACI 318, Section 1.2.1 – Drawings, Details & Specs

- Reinforcement anchorage lengths
- Lap splices
  » Location
  » Length
- Mechanical & welded splices
  » Type
  » Location

Building Drawings

- Beams / girders
- Columns
- Walls
- Foundations
- Plans, sections, & details
Building Drawings

Many elements are shown TYPICAL

- Beam / girder table
- Column schedule

Typical Beam Detail

Typical Column Details
**Building Drawings**

- **Structural (& arch) drawings**
- **Many typical details**
  - Schedules, tables
  - Bar size & spacing (#5 @ 12” o.c.)
- **Detailer’s role**
  - Placing plans development
  - Bill of material for fabrication

**Bridges**

**Bridge Deliverables**

- **Drawings**
  - Structural – rebar placing
  - Rebar schedules
  - Civil
- **General / structural notes**
- **Project special provisions**
  - Rebar covered in Std Specs.
**Plans – Bar Schedule**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar ID (unique)</td>
<td>Quantity (or #)</td>
<td>Rebar size</td>
<td>Total length (including bends)</td>
<td>Depiction of shape</td>
</tr>
</tbody>
</table>

(E) = Epoxy coated

**Plans – Bend Diagrams**

- Stirrups
- L-bars
- Straight with 180° hook

Bar ID from schedule

**Rebar Markings for Deck**

DECK SLAB REINFORCEMENT
**Plans – splices**

- Bridge deck plan
- Splice locations & length

**Bridge Drawings**

- Structural & placing drawings
- Very prescriptive by DOT
  - a, b, c bars ~ deck
  - h(E) & v(E) bars ~ wall
- Detailer’s role
  - Check engineers layout
  - Bill of materials

**Buildings vs. Bridges**

**Buildings - Private**
- Bidding package
  - Lump sum
- Furnish and install
- Rebar lumped in
- Change orders
- RFIs
- Unique nature - not cookie cutter

**Bridges - Public**
- Bidding package
  - Unit prices
  - Itemized
- Rebar
  - Weight ~ plain & (E)
  - Placing unit
- Not many COs / RFIs
- Bridges are more typical
Admittedly, this is more focused on the building side

- What are the issues / concerns?
- Why worry?
  - Costs
  - Project delays
  - Structural issues

Meet Mr. Detailer . . .

- **Detailer**
  - Technically trained individual
  - Interprets contract documents
- **Responsible for**
  - Placing plans development
  - Bill of material for fabrication

*They are not design professionals*
Meet Mr. SE . . .

- **Structural Engineer**
  - BSCE, MSCE, or PhD
  - FE (EIT), PE, or SE
- **Responsible for**
  - Design of concrete
  - Preparing design plans & specifications
  - Placing/shop drawing review
  - Anything else to ensure our designs get built properly

*We are licensed design professionals.*

SE Point of View . . .

- What are the perceived “normal” relationships between SE and detailer?
- How can this relationship be improved?
- How do we solve the problems?
- Who takes the lead to avoid problems?

SE Relationship Perception

- **Detailer prepares placing drawings**
  - SE and architectural drawings
  - CRSI “Manual of Standard Practice”
- **SE provides background drawings to detailer to “assist” in starting plans**
  - Detailer verifies their scale & redraws if necessary
- **SE expectations:**
  - Detailer to be properly trained or
  - Working under the supervision of an experienced detailer
SE Relationship Perception

- SE expects interpretation questions during the preparation stage & prior to reviewing placing drawings
  » SE will provide quick response to questions
- Placing drawings to be complete with unanswered issues clouded
- SE will review promptly and clearly mark comments

SE Relationship Perception

- SE will not transmit design changes during the placing drawing preparation
  » During mark-ups
- Detailer addresses mark-ups prior to fabricating & issuing final drawings

How Can SEs Get Better? Part 1

- Recognize the tools available
  » Publications
- Get familiar with rebar detailing
  » Make buildable designs
  » Aids in placing drawing review
- Field issues cannot always be solved with a BFH
CRSI – Manual of Std. Practice

- First published by CRSI in 1927
- Industry “Standard Practices” for all activities related to steel reinforcing bars
- Essential reference for the A/E

ACI Committee 315 Report

- Details and Designing of Concrete Reinforcement (ACI 315-02)
- Reported by ACI Committee 315

ACI Detailing Manual

- Current Edition ~ 2004
- Contains ACI 315 report
- Illustrative standards
- Example drawings
  - Slabs
  - Walls
  - Footings
  - Bridges
  - Etc.
Two “What Went Wrongs”

- Continuous beams
- Slab folds

Continuous Beam

SE Typical “Screw Ups”

- Conflicting reinforcing over support
  » Different sizes called on adj. beams
- Too many bars for beam width
  » Specify layers
- No direction on rebar location at intersecting beams
- Full length bars not taken into account
- Congestion over columns
  » Take column reinforcing into consideration
Slab Folds

- Two Way Slabs
- Difficult for detailers
- Slab elevation differences and the complexity of a two-way slab

Slab Folds Again

- SE Typical “Screw Ups”
  - Detail is not cut on plan
  - Extent of fold not clearly shown
  - Fold not coordinated with architectural
  - No instructions are provided when fold depth exceeds “maximum fold allowed”
  - Fold location – many bar lengths
    - Framing bars
    - Fill bars spliced to longer bars
Typ. Detailer “Screw-Ups”

- Slab reinforcing is “replaced” by fold reinforcing
  - Two-way reinf. not considered
- Other structural components in vicinity are effected
- Incorrect laps
  - Location, length

Problem Resolution

- Identify issues ASAP & communicate to all parties
- Share possible solutions
- Document, but “do not point fingers”
- Implement best solution ASAP
  - Keeps job moving
- Learn from problems & don’t repeat
  - At least not on the same job

Improving the Relationship

- Allow communication between parties
- Provide Detailer with latest set of contract documents
  - Including architectural drawings
- Encourage detailer to contact SE during placing drawing preparation
- Share “lesson learned” experience from previous projects
Improving the Relationship

- Identify potential problems ahead of time
- Simplify and standardize details
- Follow latest codes & practices
- Keep Detailers trained and current

Meetings !!

- If needed, call early project meeting
  - Detailer, Subs, & GC
  - Discuss project “misunderstandings”
- Sub / Detailer may request meeting
  - Details confusing or not clear
  - He/she proposes alternate detail
  - Without changing intent, if these have worked previously

Stretch Time . . . .

2 minutes
How Can SEs Get Better?  

- **Take the lead!!**
- **Identify potential issues in design phase**
  - Draw details to scale to visualize
  - Detail / think out the “tuffys”
  - Go beyond dots & lines
  - Recognize congestion issues

SE Takes the Lead . . .

- **Design process begins with EOR / SE**
- **In-house training of young engineers**
  - Starts ASAP upon hiring from college
  - Mentoring from experienced engineers
  - In-house seminars, site visits, lessons learned
- **Clarify intent at pre-constr. meeting**
- **Contact detailer early**
  - Initial placing drawings indicate a lack of understanding of design intent

U.S. Bar Sizes

<table>
<thead>
<tr>
<th>Bar Size</th>
<th>Nominal Weight, lb/ft</th>
<th>Diameter, in.</th>
<th>Cross-Sectional Area, mm²</th>
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<tbody>
<tr>
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<td>0.375 [9.5]</td>
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**U.S. Bar Sizes**

<table>
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<th>Bar Size</th>
<th>Nominal Diameter (in.)</th>
<th>Outside Diameter (in.)</th>
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<td>2 1/2</td>
</tr>
</tbody>
</table>

Figure 6-1 from CRSI's *Manual of Standard Practice*

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**Common Problem Areas**

- Beam – column joints
- Brackets / haunches / ledges
- Integrity steel
- T-Joints
- Top of columns

*Avoid Congestion*

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**Beam-Column Joints**
Beam-Column Joints

- Congestion is a given
- Consider making beams wider
  - B, 4 in, 2 in each side
  - Corner beam bars don’t interfere
- Consider ⊥ beams
  - Different depths or elevations
  - Top & bottom bar interferences
Column Brackets

- Where located on column?
- What is the size?
- Bar spacing?
- How does this effect the strut-and-tie model?

Bottom Integrity Rebar

- Lap outside column to avoid congestion

Retaining Wall T-Joints

Easier for contractor
Final Configuration

Shear Wall Ends – L to M

Shear Wall Ends – L to M
Column Ends – Headed Bars

Punching Shear Studs

SE Need to Knows - Rebar

- **Standard rebar stock length**
  - (40 to) 60 ft
  - Special lengths possible coordinate with mill or fabricator
- **Try to use same steel grade throughout project**
- **#14 & #18 may require lead time**
**SE Need to Knows - Rebar**

- Use largest bar size possible
- Repeat bar sizes & lengths
- Provide minimum 4 - 6 in. gap between top bars
- Follow ACI 315 for bending details
- Minimize bar bends & hooks
- Keep bars in one plane

**SE Need to Knows - Columns**

- Multi-story construction, usual practice
  - Limit column bar lengths to one story
- For larger bars & couplers
  - Two and three story heights possible
  - Bar sizes of #9 & > have sufficient stiffness to use free standing two story heights.

**SE Need to Knows - Columns**

- Use same column size, vary
  - Bar size
  - Concrete strength
- Lap splices permitted up to #11
- #14 & #18 bars have to be mechanically spliced or welded, if tension splice
Rebar Splicing - Coupler

- Couplers are:
  - Grouted
  - Threaded
  - Screw type
- Manufacturer's literature

Rebar Splicing - Couplers

- Couplers take up space
  - Greater diameter than rebar
- Stagger couplers
- Can they be installed?
  - Grouting
  - Set screws

Better SEs - Review

- Identify potential issues
  - Draw details to scale to visualize
  - Detail / think out the “tuffys”
  - Go beyond dots & lines
  - Recognize congestion issues
- Get familiar with rebar detailing
What Can Mr. CRSI Do?

- Manuals of Standard Practice
  - Keep current / up to date
  - Reflect latest Code changes
- Encourage & promote detailer training
- Promote field experience importance
  - Young engineers
- Work with college professors
  - Discuss importance of detailing
  - Properly expressing design in contract docs

Questions?