

Construction Document Changes to Improve Constructability

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Overview

- Target background
- Why we looked at CD constructability
- Research process
- Progress to date
- Recommendations for owners, designers, contractors, and commissioning agents

Target Background



- Minneapolis headquarters
- Property Development
 - Real Estate
 - Construction
 - Building Services
 - Store Planning
 - Architecture
 - Engineering
- Architecture/Engineering staff of 150

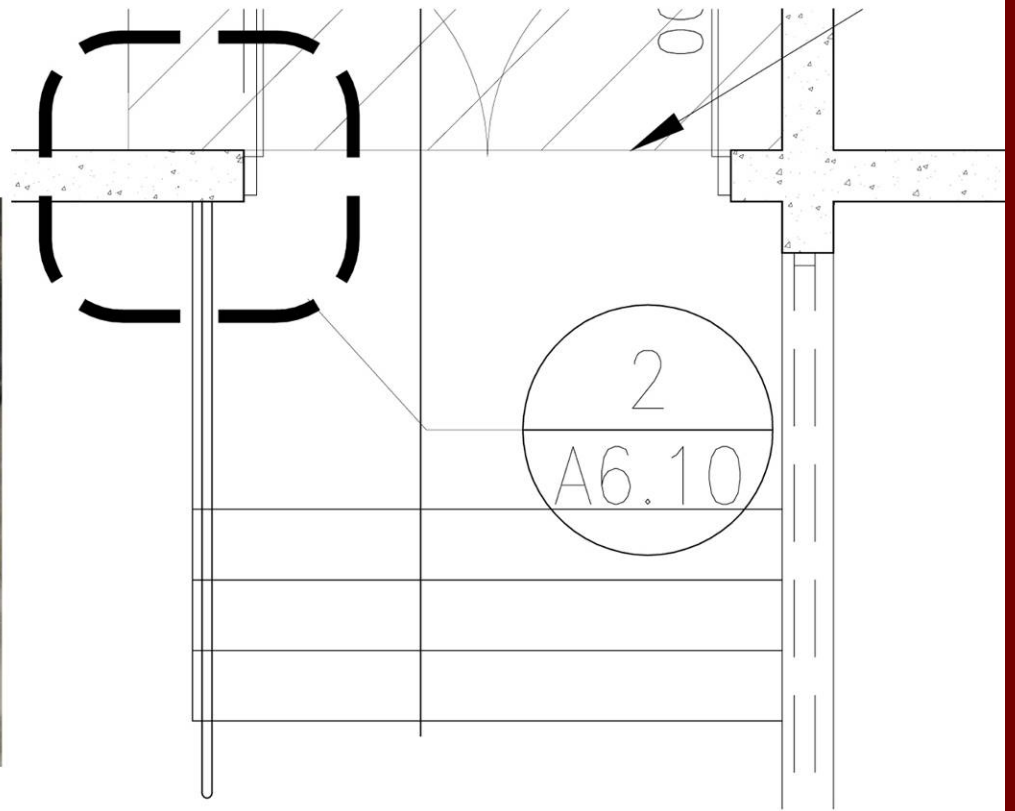
- Prototype process
- Prototype documents updated twice per year
- Prototype documents up to 80% complete
- Site specific document modifications
 - Weather related (heat gain/heat loss)
 - Code requirements

- Internal commissioning team
- Combination of internal and external new store commissioning and existing store commissioning
- Incorporating Cx findings into prototype

Construction Process

- Design, bid, build
- GC typically negotiated
- Subs typically bid
- Direct purchase
 - Rooftop units
 - Building Automation Systems
 - Lights
 - VAV boxes
 - Refrigeration systems and cases
- Direct vendors
 - Testing, Adjusting, Balancing
 - Controls installation

Why CD Constructability?



Why CD Constructability?

- Full prototype building update
- Research teams – Building systems and costs
- CD production
 - Documents produced for ease of design rather than constructability
- Example
 - A/E design services \$2,000/sheet
 - Construction \$40,000/sheet

Initial Work Plan

- Does current prototype process work for increasingly complex unique stores?
- Use CAD as building modeling tool rather than just a drawing tool
- Is there a more efficient way for the field (const) to receive and use CDs?
 - Bigger size
 - Smaller size
 - Color plots
 - Electronic files
- Use CD documents for additional electronic equipment and material take-off
- How could CDs be better developed and utilized by Building Services for the life of the building?
- What CAD and design tools would cut the time required for site specific CD production?
- How to enhance ability of construction teams to understand design intent?

- Study group
 - GCs (included sub-contractors)
 - Architect consultant
 - M/E consultant
 - Structural consultant
 - Target construction site representative
 - Internal teams

Research Process

■ Questionnaire

- Are there variations to traditional drawings and specifications that would aid constructability? (Consider drawing size, scale, color, shading, etc.). Are there areas where more detailing or drawing would help field interpretation?
- What are the trades-offs of providing information on drawings versus in the specifications?
- What specific information could be included in the CDs to aid the permitting process?
- Is there a preference of plan key notes versus notes directly on the plans?
- Could plan details be presented in a way to improve understanding? Would photos be valuable? Would a separate detail book be easier to work with in the field? Would details on the plan sheet where referenced be preferred to a separate detail sheet?
- What processes could be provided to design teams to reduce the time required to create site specific plans from prototypical plans?
- What impact will Building Information Modeling (BIM) have on the design and construction teams? BIM uses modeling tools and standards to create a 3-D model with attributes on components rather than 2-D line drawing.
- Will construction firms use and benefit from BIM for items such as electronic material take-off? Will construction firms trust the information they receive from CD material take-off?
- Will design firms accept responsibilities for CD accuracy if electronic material and equipment take-offs are used?
- What is the best process to feedback as-built field conditions to allow accurate record documents turned over to operations teams?
- Open for any and all other ideas and comments.

Research Process

- Benchmarking
- Independent Building information Modeling study group
- Six Sigma
 - Determine problem and what you want to fix
 - Focused on reduced cycle time
 - Separate opinion from fact
 - Use data to make decisions
- Review electronic certification
 - Improve document flow
 - Reduce risk to certifiers
- Document layout for expedited code review

- 200 individual comments and suggestions
 - "...additional screening and/or slightly heavier line types would enhance the readability of the drawings."
 - "A colored elevation would be nice to have when bidding to subs estimating the exterior façade."
 - "More detailing is not as necessary as accurate detailing"
 - "...use photographs of materials and equipment in lieu of creating and inserting line drawing details."
 - "I know that I can say with confidence that I have NEVER seen a sub-contractor carrying a set of specs around the projects."

1. Plan layout

- Issues
 - Inconsistent layout between disciplines
 - Information on single area spread throughout documents

- Action
 - Two options
 - A. Follow National CAD Standards (NCS)
 - Distinct sheets for plans, blow up, details, etc.
 - B. Consolidate information on single sheet
 - Single sheet includes plans, blow up, details, etc.

2. Drawing numbering
(A1,A2...M1,M2...E1,E2...etc.)
 - Issues
 - Numbering of sheets has no format
 - No consistency between disciplines
 - Action
 - Review NCS

3. Key notes

- Issues
 - Key notes sometimes overly used and not consistent between plans

- Action
 - Review use of key notes versus plan notes and use of CAD tools

4. Appropriate plan scale

- Issues
 - Areas of the plan are difficult to read at small scale
 - Different scales are used by different disciplines

- Action
 - Utilize more blow ups of complex areas
 - Attempt to use consistent blow ups between disciplines

5. Alternate drawing size

– Issues

- Smaller size sheets can require splitting building to two sheets
- Larger size sheets difficult to handle in field, plotting may also be issue

– Action

- Review alternate sizes as part of implementation

6. Color plots

- Issues
 - Complex systems are often difficult to differentiate on black line prints

- Action
 - Use color plots for store elevations
 - Consider color plots for engineering systems to enhance presentation

7. Graphic layout

– Issues

- Line weights and screening may cause issues in plans reaching field
- Fonts are not consistent and some are difficult to read

– Action

- Review line weight, screening, fonts, cells, cross-discipline drawing consistency
- Aid drawing modification by design team and readability of documents

8. Plotting process

- Issues
 - Drawings reaching field lower quality
 - Line weights variable

- Action
 - Determine process used by field
 - Review pen tables between design teams

9. Building Information Modeling (BIM)

– Issues

- BIM may transform CAD from drawing tool to actual modeling tool

– Action

- Review available BIM packages
- Partner with construction and procurement groups

10. Move appropriate information from drawing to specification

- Issues
 - Drawings are more available on construction site and more likely to be used than specifications

- Action
 - Show appropriate information on drawings to avoid references to specification
 - Example: Hanger spacing
 - Update specification to CSI standards

11. Electronic certification

- Issues
 - Scanning of signed prints reduces graphic quality
 - Signing multiple copies can lead to missing sheets, etc

- Action
 - Investigate state certification laws

Plan Layout

- Consolidate information on single sheet for a given area of building
- Provide similar plan enlargements for each discipline
- Place appropriate details, enlargements, equipment schedules, etc. on single plan sheet
- Break up drawing sheets by discipline, separate HVAC from plumbing
- Same detail on multiple sheets

Appropriate Plan Scale

- Increase scale in complex areas
- Use consistent scale between disciplines
- Added one sheet in mechanical set

Graphic Layout

- Look at plans reaching field
- Scanning reduces quality
- Graphics reviewed in all plan layout
- Line weight
 - Too light fades out
 - Too heavy blends together

Drawing Notes

- Key note consistency between plans
 - Example Key Note: “3 inch vent through roof” remains key note 2 on multiple plans
- Combination of key notes and plan notes
 - Eliminate need to reference key note
 - Cut and paste with CAD
- Plan note tools

Drawing Numbering

- National CAD Standard
 - Good organization
 - Splits information related to common area
- Target numbering
 - Split drawings into division specific
 - Ex: HVAC and plumbing
 - Primary floor plan
 - A111, E111, S111, M111, P111, R111
 - Enlarged sheet coordination
 - Food Service A301, M301, P301
 - Enhanced cross-discipline design coordination
 - Ease construction coordination between subcontractors

Figure B: Example of Drawing Numbering System

ARCH		MECH		PLUMBING		FIRE PROTECT		REFRIG		ELECTRICAL		STRUCTURAL	
General Project Info	G001												
Site Plan	G002												
General Arch Info	A001	Plumbing & Mechanical Index	PM01							Electrical symbol list and Site Plan	E001	General Structural Notes	S001
										<i>Electrical Site Plan</i>	<i>E002</i>		
<i>Supplemental Architectural Information</i>	<i>A011</i>												
<i>Architectural Demolition Plans & Details</i>	<i>AD11</i>												
Exit Diagram	A021												
				<u>Underfloor Plumbing</u>	P100								
<i>Parking (1st Lvl)</i>	<i>A101</i>									<i>Parking Ramp Lighting - 1st Floor</i>	<i>E101</i>		
<i>Subgrade, or 1st Flr Plan for Elevated</i>	<i>A110</i>											<i>Ground/Lower Lvl Plan</i>	<i>S110</i>
Floor Plan	A111	Building HVAC	M111	Building Plumbing	P111	Fire Protection	F111	Refrig System Plan, Sched	R111	Lighting Plan - 1st floor	E111	Foundation Plan	S111
<i>Ground Lvl Floor Finish, Blocking</i>	<i>A120</i>												
Floor Finish, Blocking, Insulation	A121									Specialty Lighting Plan - 1st floor	E121		
<i>Ground Lvl Floor Reflected Ceiling ...</i>	<i>A130</i>												
Reflected Ceiling Plan	A131									Food & Guest Services Ltg Plan	E131		
Roof Plan	A141	Roof HVAC	M141	Roof Plumbing	P141					Office & Pharmacy Lighting Plans	E141	Roof Framing Plan	S141

Specification Numbering

- Total revision to CSI master format
- More consistent with industry practices
- Better contractor understanding and compliance
- Specific sections expanded for Target
 - Example: Refrigeration

BIM

(Building Information Modeling)

- Reviewed major BIM packages
- Architectural and Structural somewhat ahead of Mechanical and Electrical
- Productivity tools in addition to modeling
- Example: Coordinated HVAC calculations
 - Clash detection
- Benefits of providing electronic documentation?

Alternate Drawing Size

- Larger sheets still under review
- Plotting of large sheets a concern

Design Intent Information

- Design intent document for Mechanical
- Edited by design team for each project
- Design intent for other disciplines in development
- Valuable for design team, construction teams, building service personnel, commissioning agents, future remodeling teams

Color Plots

- Contractors currently highlighting own plans
- Designers use color in CAD to differentiate systems
- Plotting/pen table variables
- Cost to plot
- Testing

Plotting Process

- Mylar/blueprints
 - Provided reasonably consistent quality
- Electronic transfer
 - Scanning conversion, inconsistent quality
- Review plans contractors have in field
- CAD to tiff and plotting quality still under review

Move Information from Specifications to Drawings

- Ease of design team placing information in specification vs. drawings
- How often is specification seen in field project site?
- Specific installation practices, such as hanger spacing
- More design time, better results



Specification spotted in field!

BIM

- Opportunity for biggest improvement since CAD
- Modeling versus drafting
 - Place ductwork versus drawing lines
- Clash and interference
- 3-D visual
- BIM tools
 - Organize details
 - Organize key notes
 - Automated equipment schedules

BIM (continued)

- Material take-offs
 - Sq. ft. sheet rock
 - Pounds of sheet metal
 - Refrigeration charge capacity
- Increased design team responsibility/risks
- More accurate construction take-offs
- Reduced change orders (?)

Field Feedback

- First sets of documents just hitting streets
- Generally positive feedback
- Review construction phasing
 - Underground piping
 - Above ceiling coordination
- Design improvements to help test processes
 - Group underground piping to allow isolation for pressure testing
 - Review ductwork and damper locations for ease of balancing

Conclusions

- Document change easier for owner to drive
- Prototypical document process helps implement
- Commissioning team push to focus CDs on contractor needs
- Goal to meet owner's project requirements
- Costs and changes will be tracked

Owners

- Ask design teams how their documents improve constructability
- Be willing to spend more on fees for improved documents
- Pay back
 - Improved construction
 - Reduced work orders
 - Likely construction cost savings

Designers

- Review your documents in eyes of installing contractor
- Spend time in field.....discuss constructability of documents
- Differentiate your services by highlighting better documents

Contractors

- Inform designers and owners where documentation can be improved
- Challenge design teams that do not provide good documentation

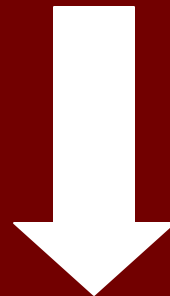
Commissioning Teams

- Provide constructability suggestions/guidelines to design team
- Add constructability of documents to your early design review
- Discuss constructability of documents with contractors

Improved Construction Documents



Improved Constructability



Project Meets Owner's Project Requirements



Comments

Suggestions

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