Overview

Topics:

• History of Direct Design
• Direct Design Software today
• Demo: Simple building, start to finish demo
• Demo: Complex building design/review
• BIM integration
• Questions
History of Direct Design
Engineering Complexity

**Codes**

- More codes
- More editions
- More pages
- More research
- More events
- More feedback
Masonry is no exception...

1953 .......... 1983 ............ 2013

40 pgs .......... 40 pgs .......... 400 pgs
What About Masonry?

Design Practices Committee
What About Masonry?

TMS 403

The Direct Design Handbook
Tabulated Designs

Table 3.2-5(2a): Maximum Vertical Spans for Walls without Openings (ft) if 20 psf < $p_g$ ≤ 40 psf for $V$ up to 110 mph

<table>
<thead>
<tr>
<th>Wind Category</th>
<th>Occupancy Category</th>
<th>Exposure Category</th>
<th>Maximum $L_{joist}$ (ft)</th>
<th>Unreinforced PCL Mortar</th>
<th>Unreinforced Masonry Cement Mortar</th>
<th>Vertical No. 5 at 120&quot; oc</th>
<th>Vertical No. 5 at 96&quot; oc</th>
<th>Vertical No. 5 at 72&quot; oc</th>
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<tbody>
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<tr>
<td>up to 90</td>
<td>I or II</td>
<td>B</td>
<td>9'-4&quot;</td>
<td>15'-4&quot;</td>
<td>18'-0&quot;</td>
<td>10'-0&quot;</td>
<td>10'-0&quot;</td>
<td>10'-0&quot;</td>
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<tr>
<td></td>
<td></td>
<td>C</td>
<td>7'-4&quot;</td>
<td>13'-4&quot;</td>
<td>15'-4&quot;</td>
<td>9'-4&quot;</td>
<td>10'-0&quot;</td>
<td>10'-0&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>III or IV</td>
<td>B</td>
<td>8'-8&quot;</td>
<td>15'-4&quot;</td>
<td>10'-0&quot;</td>
<td>10'-0&quot;</td>
<td>10'-0&quot;</td>
</tr>
</tbody>
</table>

Reinforcement for walls and lintels
Code compliance

• Load calculations based on ASCE 7
• Masonry design checks based on TMS 402
• Referenced by IBC
Limitations

• Single-Story Construction
• 8 inch Concrete Masonry ($f'_m = 1,500$ psi)
• No. 5 Reinforcement, Grade 60
• Parapets ≤ 4ft in height and ≤ 1/3 height of wall below
• Wind Exposure Category B or C
• Flexible Diaphragms only
• $0.25/12 \leq$ Roof Slope $\leq 12/12$
Direct Design Software - V1

Software to:

- Automate procedure
- Perform table lookups
Direct Design Software - V1

...and produce drawings
Minor Updates

2013

Version 2.0
Feedback

Upon further review.....

Limitations  =
“Keep the approach simple, but go beyond simple buildings.”
**Table approach abandoned**

**Software does everything**
Scenario: +X, +Z Wind

Note that this is not considering wind to act in both of these directions at the same time; they are just illustrated together for convenience and conciseness.

Roof Level

The design pressures calculated above are applied to the various surfaces at this level as appropriate, over a tributary height of 18.00 ft.
Direct Design Software is:

- Software for designing reinforced concrete masonry structures using Strength Design
- Code compliant per the following:
  - Software Ver. 1 ➔ TMS 403-10 ➔ 2012 IBC/IRC
  - Software Ver. 2 ➔ TMS 403-13 ➔ 2015 IBC/IRC
  - Software Ver. 3 ➔ TMS 403-17 ➔ 2018 IBC/IRC
- Performs load calculations, analysis, & design checks
- Produces detailed drawings
Capabilities

Improved flexibility vs. versions 1.0/2.0:

- Any $f'_m$
- 6, 8, 10, 12, and 14 inch CMU
- Rigid or flexible diaphrams
- Multi-story construction
- Any permitted mortar type
- No. 4 through No. 9 bars
Limitations

Model Geometry
- 60’ maximum height
- No curved or diagonal walls
- Walls must form part of rectangular sections in plan
- Same basic plan layout at each story
- Limited structural irregularities
- Joist spacing of 10 feet or less
Limitations

Model Geometry

• No funky roofs
Limitations

Model Geometry

• Architectural features.
Limitations

Loading Types

Considers
- Dead Loads
- Live Loads
- Snow Loads
- Wind Loads
- Seismic Loads

Not covered
- Blast loads
- Dynamic loads
- Flood loads
- Ice loads
Limitations

Loading Constraints

• Mapped wind speed $\leq 250$ mph
• Seismic site class A, B, C, or D
• Cladding weight $\leq 50$ psf
• Axial load eccentricity t/2 plus 3 inches
Limitations

Materials

• Units must comply with ASTM C90
  • (concrete masonry only)
• Standard mortar and grout

• Rebar: No. 4 thru No. 9, Grade 60
Limitations

Walls only: No option for pilaster

(but have loads for manual design)
Usability

Usage beyond formal/final engineering design

- Early concept
- Consideration of masonry as alternative
- Preliminary designs & estimating
- Trial design iterations (block size, bar size, etc.)
Ease of Use

1. Create Model
2. Enter Criteria
3. Review Output
Ease of Use

Modeling

Story 1 (Rigid diaphragm)

Plan Geometry
- Start X Coord: 0 ft
- End X Coord: 20 ft
- Start Z Coord: 0 ft
- End Z Coord: 30 ft

Column Lines
- [ ] Has Column Line(s)
Ease of Use

Entering Criteria

Topographic Factor (K20)
Ground Snow Load (pg)
Thermal Factor (Ct)

20 psf

Minimum Design Loads and Associated Criteria for Buildings and Other Structures
Ease of Use

Entering Criteria

Web Links

Tool Tips
Ease of Use

Review Output

Sample CMU Masonry Structure
This structure has a flat roof with 2 ft. parapet. Joist direction as indicated in criteria.

\[ E_s = \frac{29,000,000.00 \text{ psi}}{1,800,000.00 \text{ psi}} = 16.11 \]

\[ I_{cd} = n \left( A_t + A_b \right) \left( \frac{P}{f_y} \right) \left( d - c \right) + \frac{bc^3}{3} = (16.11) \left( (0.93 \text{ in}^2) + \left( \frac{3.17 \text{ kips}}{60,000.00 \text{ psi}} \right) \left( \frac{7.63 \text{ in}}{2(3.81 \text{ in})} \right) \right) \left( 3.81 \text{ in} \right) \left( 1.05 \text{ in} \right) + \left( \frac{44.00 \text{ in}}{3} \right)^3 = 137.93 \text{ in}^4 \]

P-delta analysis:

\[ M_{udf} = 0.00 \text{ ft.k} \]

\[ 5M_{udf}h^2 = \left( \frac{5(0.00 \text{ ft.k})(18.00 \text{ ft})^2}{48(1,800,000.00 \text{ psi})(1,625.51 \text{ in}^4)} \right) = 0.00000 \text{ in} \]

2 iterations were required to converge to these values.
Ease of Use

Review Output

Beta Test Engineer
Beta Test Company

Story 1, Wall along grid line 1 from grid lines A to B
Demo:
Simple Structure
Demo: Multi-Story Structure
BIM: Connecting with Revit
Final Thoughts
Release

When can we get it?

- Beta test starting soon
- Release shortly after
- Free trial version
Future

An ongoing effort

Future Activities

• Continue enhancements past version 3.0
• Further reduce limitations
• Further integrate with Revit & possibly other platforms
Free Trial

NCMA.org

www.DirectDesignSoftware.com
Thank You

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