SE INSIGHTS

FOR MASONRY DESIGN

Masonry Checklist: Reviewing Structural Plans

- ☐ f'_m (masonry assembly strength) for structural concrete or clay masonry is 2,000 psi or greater
  - ☐ Concrete masonry f'_m = commonly 2,500 psi or above
  - ☐ Clay masonry f'_m = commonly in the range of 3,000 psi to 4,000 psi
  - ☐ Masonry strengths up to 4,000 psi are permitted in current codes for strength design[1]
- ☐ Check that all components are specified - SE INSIGHT: HOW TO SPECIFY MASONRY[6]
  - ☐ Block strength: check masonry.forsei.com/masonry/cmudata/ to verify based on location
    - ☐ Commonly above 3250 psi for concrete masonry and 8250 psi for clay masonry
  - ☐ Mortar type (mortar strength need not be listed)
    - ☐ Recommend Type N for non-structural walls
      - ☐ Veneer walls commonly use this mortar
      - ☐ Can be used in some structural applications, but reduces capacity
        - ☐ Not to be used below grade
        - ☐ Not to be used in seismic SDC D, E, or F
    - ☐ Recommend Type S for structural walls
      - ☐ Can be used below grade
      - ☐ Can be used in all seismic areas, SDC A, B, C, D, E, and F
    - ☐ Type M is high strength, but more costly and reduced workability
      - ☐ Can be used below grade
      - ☐ Used in high load applications and extreme environmental conditions
  - ☐ Grout strength
    - ☐ Should be at least 2,000 psi, and equal to or greater than f'_m

- [ ] Consider masonry wall thickness and reinforcing
    - [ ] Reinforced masonry walls can be designed to have a height:thickness ratio up to 30:1 (common) or 50:1 (higher strength and heavily reinforced)
        - [ ] 4" hollow clay masonry walls can be 10 ft to 15 ft tall
        - [ ] 6" concrete or hollow clay masonry walls can be 15 ft to 25 ft tall
        - [ ] 8" concrete or hollow clay masonry walls can be 20 ft to 33 ft tall
        - [ ] 10" concrete or hollow clay masonry walls can be 25 ft to 42 ft tall
        - [ ] 12" concrete masonry walls can be 30 ft to 50 ft tall
        - [ ] 16" concrete masonry walls can be 40 ft to 67 ft tall
    - [ ] Consider the following for walls as well:
        - [ ] 4" is available for concrete and clay; only 4" hollow clay masonry can be reinforced
        - [ ] 6" - 8" - 10" are available for concrete and hollow clay masonry can be reinforced
        - [ ] 12" - 16" are available for concrete only and can be reinforced
    - ◆ Notes: Guidelines in TMS 402 code[1] recommend limiting reinforcement to:
        - ◆ Less than 1/8 of the overall wall thickness
        - ◆ Strength Design (SD): Less than 1/4 of the least clear dimension, less than 4% of the cell area, and maximum bar size of #9
        - ◆ Allowable Stress Design (ASD): Less than 1/2 of the least clear dimension, less than 6% of the cell area, and maximum bar size of #11
    - [ ] Reinforcement specified in schedule
        - [ ] Typical walls have reinforcement bars ranging from #4 (min) through #7 (max)
        - [ ] Reinforcement in columns/piers can be larger, but generally not more than #9
        - [ ] Lap lengths are specified for correct f'_m and based on current TMS 402 code[1]
    - [ ] Bond beam and joint reinforcement specified and coordinated with CJ locations
- [ ] Review masonry shear walls - masonry walls are effective to resist lateral loads
    - [ ] Verify masonry walls are considered and designed for lateral load
        - ◆ Note: Masonry walls connected to the structure diaphragms will resist substantial portion of lateral loads due to the stiffness and rigidity of masonry

- [ ] Wall groups (4 walls connected at corners, shaft walls) are more effective than 4 individual walls (separated by CJ) for lateral load resistance
- [ ] Masonry shear walls can be unreinforced, but that is uncommon for new construction
- [ ] Masonry reinforced shear wall designations:
    - [ ] Ordinary Reinforced Walls (summary)
        - [ ] Vertical reinforcement within 16" of opening edge and within 8" of wall ends
        - [ ] Minimum of 2-W1.7 horizontal joint reinforcement at 16" o.c.
            - [ ] Alternate: #4 @120" o.c. horizontal
        - [ ] Reinforcement above and below openings greater than 16" wide
            - [ ] Extend reinforcement 24" past opening, nor less than 40db
        - [ ] Reinforcement within 16" of top of walls
    - [ ] Intermediate Reinforced Walls, all requirements of Ordinary Reinforced
        - [ ] vertical reinforcement no further apart than 48" o.c.
    - [ ] Special Reinforced Walls, all req. of Ordinary and Intermediate Reinforced
        - [ ] Reinforcement no further than 48" o.c. vertically and horizontally
        - ◆ Note: see current TMS 402 code[1] for many additional requirements

- [ ] Review masonry partition wall designs and connections based on SE INSIGHT: MASONRY PARTITION WALLS[7]
    - ◆ Consider: the code prohibits partitions from serving a structural function for the building and therefore can have minimal reinforcement - see imiweb.org for partition wall program.
    - [ ] Partition walls can still be unreinforced in SDC A and B with minimal connections
    - [ ] For higher seismic areas, min. reinforcement:
        - [ ] SDC-C - #4@120"o.c.
        - [ ] SDC-D - #4@48"o.c.
        - [ ] SDC-E & F, see TMS 402 code

- [ ] Verify that movement joints (MJs) are located - control joints (CJs) are common for structural concrete masonry and expansion joints (EJs) are common for structural clay masonry. General nomenclature is to use either MJ for both, or CJ (concrete masonry) and EJ (clay masonry).
    - [ ] CJs or EJs for structural walls must be located on structural elevations or plans[1]
    - [ ] CJs or EJs in reinforced structural walls, locate:
        - [ ] At common wall locations [2]: generally at 25 ft spacing or less, change of wall height, building corners
        - [ ] At a distance (recommend 2 ft) away from opening edges[3], not at opening edges
    - [ ] CJs or MJs in unreinforced non-structural masonry walls, locate:
        - [ ] At common wall locations [2]
        - [ ] At openings edges [4]
    - [ ] CJs or MJs not needed when sufficient horizontal reinforcement [5] is provided
- [ ] Review lintels based on SE INSIGHT: EFFICIENT MASONRY LINTELS[8]; prefer masonry lintels.
    - [ ] Masonry lintels are considered for ALL openings, other materials as optional
        - [ ] Openings that do not need a lintel:
            - [ ] 8" in typical wall, 12" in partition wall[1]
        - [ ] Openings 6'-0" or less could be a single-course masonry lintel with minimal reinforcement, and jamb could be one cell with common wall reinforcement
        - [ ] Openings more than 6'-0" are likely multi-course masonry lintels
            - [ ] Bottom masonry course is lintel block
            - [ ] Top masonry course is bond beam block
            - [ ] If middle courses are necessary, standard wall block can be used
        - ◆ Note: only consider stirrups when deeper lintels are not possible
        - ◆ Consider: prefab masonry lintels (contractor option) to resolve shoring needs
    - [ ] Optional: Precast concrete lintels can be similar to masonry lintels
        - [ ] Prefer precast lintels shaped like lintel u-block, reinforced with tendons
        - [ ] Does precast lintel lintel allow for jamb reinforcement to be continuous?
        - [ ] Does lintel allow for bottom and top reinforcement that can be tied into the wall?

- [ ] Optional: Steel lintels- present many challenges
    - ◆ Consider: differential movement between steel and masonry, even after building is insulated and occupied, will cause very large forces unless steel is allowed to move relative to masonry. Slotted/slip connections are a must at one or both ends.
    - ◆ Note: one method for accommodating thermal movement is to use CJs at one or both ends, which reduces wall and lintel effectiveness, but is necessary for differentially moving material.
    - [ ] Vertical wall jamb reinforcement location- generally needs to be one or more cells away from opening
    - [ ] Torsional effects, especially with wide flanges with virtually no torsional capacity
    - [ ] For bearing plates, compatibility with block shapes used
    - [ ] Thermal bridging- architectural challenge with building insulation envelope
    - [ ] Thermal bridging- structural challenge with differential thermal movement between steel and masonry
    - [ ] Consider the thin masonry shells used to cover the steel
        - [ ] Are the masonry shells able to be cut to fit the steel section?
        - [ ] No connections are allowed on masonry soaps
- [ ] Review bearing plate details for steel joist and steel beams perpendicular to masonry walls
    - [ ] Detail must accommodate steel beam movement due to thermal loads during construction
    - [ ] Bearing plates should not bear upon upon masonry face shell in most cases
        - [ ] Consider confined bearing capacity
    - [ ] Masonry bearing plates should not be exposed (never extend to face of masonry)
- [ ] Conflicts between steel columns and masonry
    - [ ] Does steel column fit into masonry?
        - [ ] Consider a CJ at these locations of steel columns used within masonry
        - [ ] Consider the masonry remaining to cover the steel. Is it required to be cut to fit the steel section? Is remaining masonry durable to building use conditions?
    - [ ] Steel sections should not be encased in grout within masonry, gap should be provided
    - ◆ Consider: Using masonry piers instead of steel columns to avoid conflicts and support point loads. Often masonry piers have more potential capacity than the steel columns.

REFERENCES

[1] - Current masonry code is TMS 402/602-16

[2] - Based on NCMA TEK 10-2D (2019) or TEK 10-3

[3] - Based on NCMA TEK 10-2D (2019), Figure 2c or Figure 2d (page 3)

[4] - Based on NCMA TEK 10-2D (2019), Figure 2a or Figure 2b (page 3)

[5] - Based on NCMA TEK 10-3

[6] - SE INSIGHT: How to Specify Concrete Masonry

[7] - SE INSIGHT: Masonry Partition walls

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[8] - SE INSIGHT: Efficient Masonry Lintels

MASONRY RESOURCES

- **IMI** - International Masonry Institute - imiweb.org
- **NCMA** - National Concrete Masonry Association - ncma.org
  - NCMA TEK 10-2D (2019) Control Joints for Masonry Structures - Empirical Method
  - NCMA TEK 10-3 (2003) Control Joints for Masonry Structures - Alternative Engineered Method
- **BIA** - Brick Industry Association - gobrick.com
- **TMS** - The Masonry Society - masonrysociety.org
  - TMS 402-16 Building Code Requirements for Masonry Structures
  - TMS 602-16 Specification for Masonry Structures

FORSE - FOR Structural Engineering Masonry Resources - http://masonry.forsei.com/technical/se-insights/

- Visit the site to view the current, up to date Masonry Checklist
- SE INSIGHT: How to Specify Concrete Masonry
- SE INSIGHT: Masonry Partition walls
- SE INSIGHT: Efficient Masonry Lintels
- SE INSIGHT: Block Strength Map: masonry.forsei.com/masonry/cmudata/

