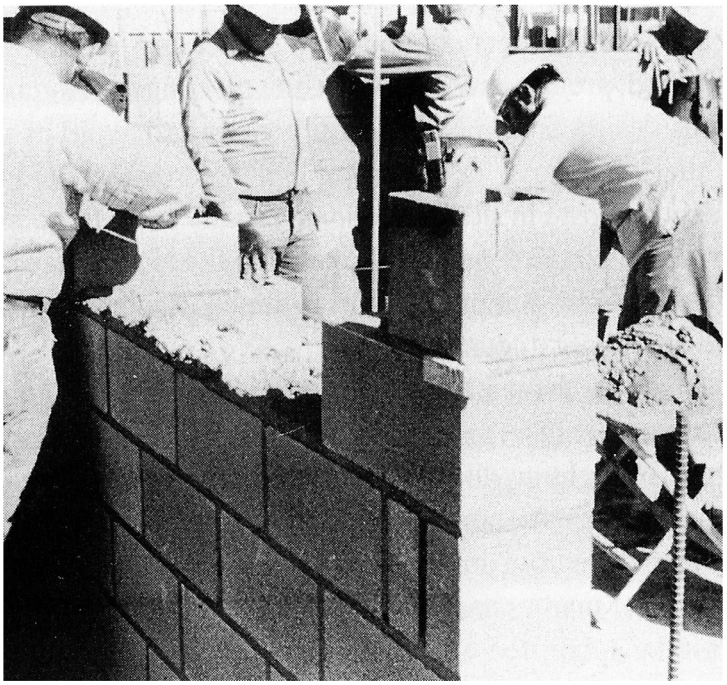
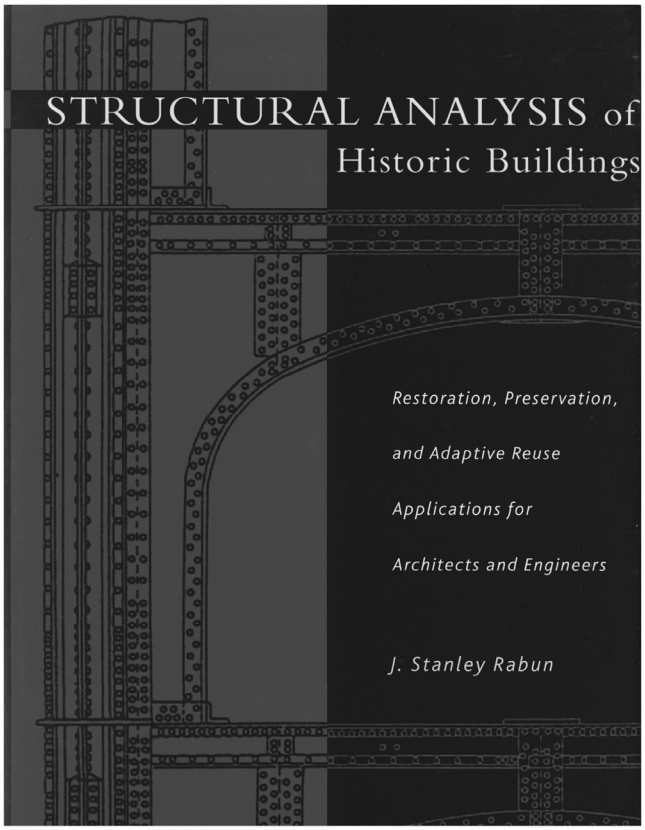
Construction Details



Construction considerations
Workmanship
Specifications

Structural Analysis of Historic Buildings

By Stanley Rabun



Structural Analysis of Historic Buildings
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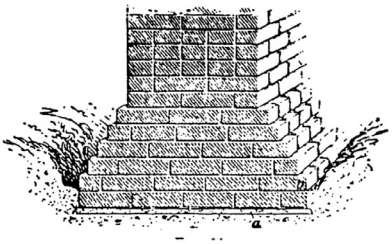
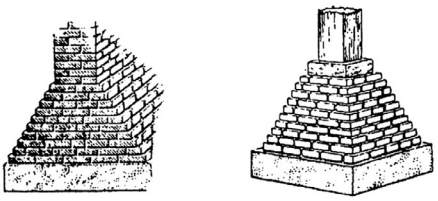
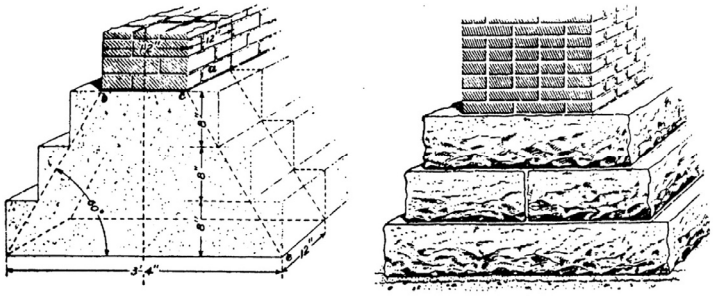
Foundations
- Spread “belled out”
  - Stone
  - brick





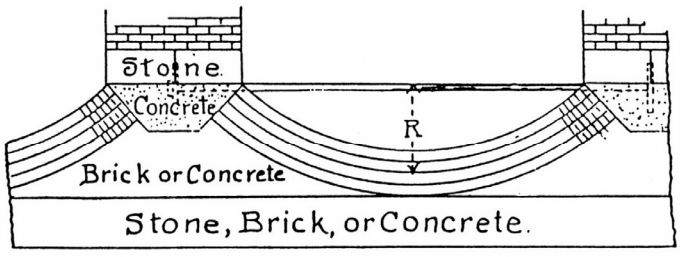
Belling out for bearing width.



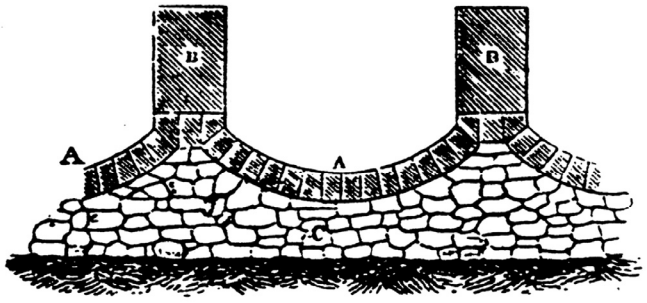
Belled out footings of stone.

Structural Analysis of Historic Buildings
By Stanley Rabun

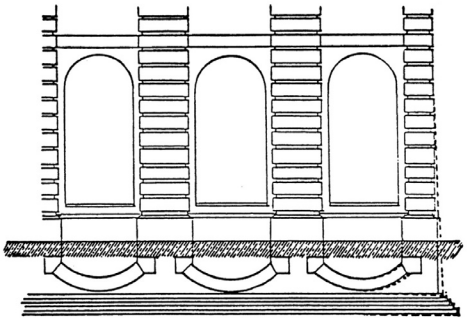
Foundations
- Inverted arch



Inverted arch foundations. (*From Kidder 1905, 68.*)



Inverted arch foundations. (*From Mahan 1885, 254.*)



Inverted arch foundations. (*From Kidder 1905, 67.*)

Structural Analysis of Historic Buildings

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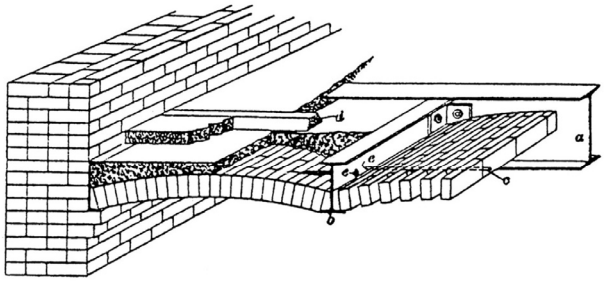
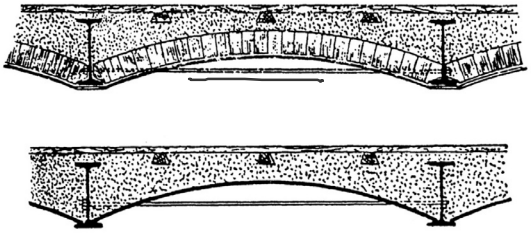
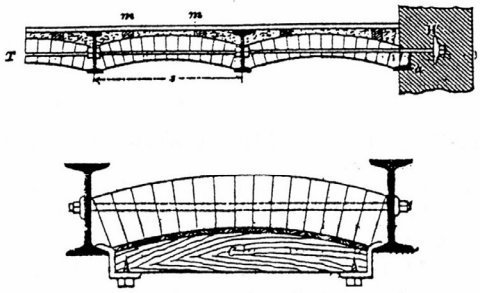
Floor arches



Details of brick arch fireproof floor.



Brick arch and corrugated iron arch.

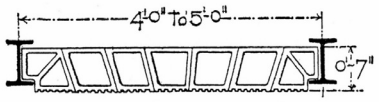


Fireproof floor systems. *From Trautwine 1888*

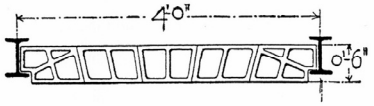
Structural Analysis of Historic Buildings

By Stanley Rabun

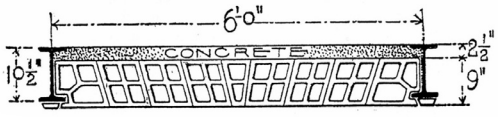
Masonry Flat Jack Arches



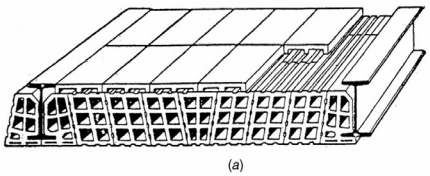
Terra cotta flat arch: Equitable Building, Chicago, 1872.



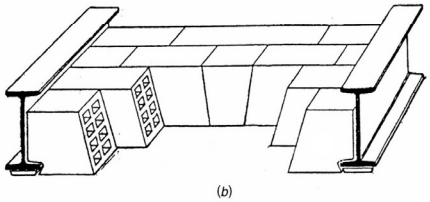
Flat arches: Montauk Building, Chicago, 1881.



Terra cotta arch: Home insurance Building, Chicago, 1884.



(*a*)



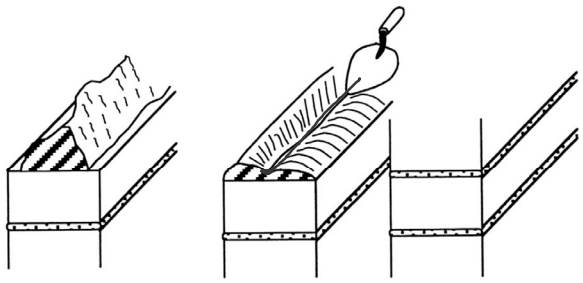
(*b*)

Types of terra cotta elements: (*a*) side construction terra cotta arch; (*b*) end construction terra cotta arch.

Construction Details

Quality of Construction:

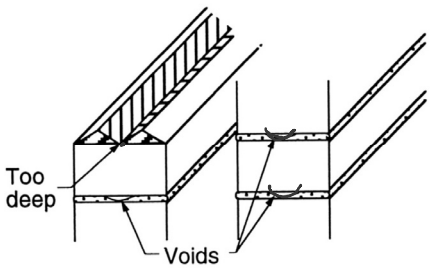
- Materials
- Workmanship
- Proper detailing
- Clear specifications
- Inspection requirements



Light furrowing

Defects

- Unfilled mortar joints
  - Gaps in mortar reduce strength
  - Lower resistance to rain penentration
- Thick bed joints
  - 5/8" to ¾" joints have 20-30% less strength than 3/8"
- Misalignment: deviation from vertical
  - ½" off in 10ft, 8" block wall loses 15% capacity

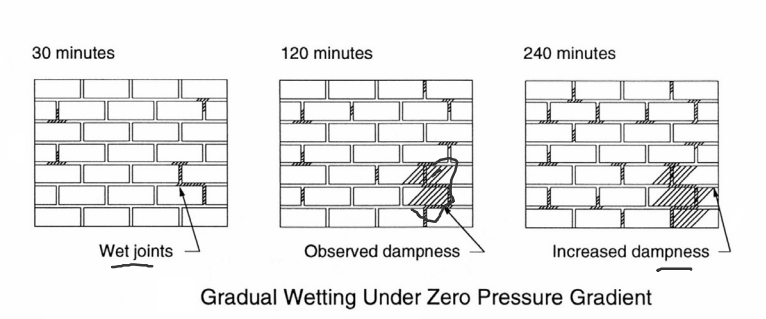


Deep furrowing

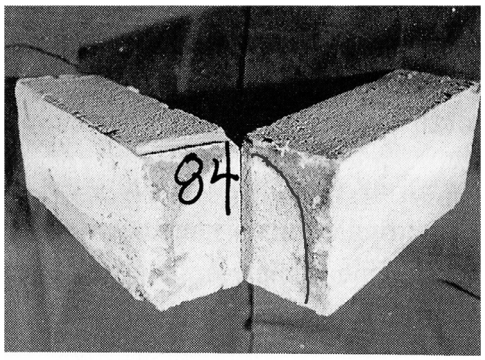
Construction Details

Water penetration:

- Leakage through mortar joints
- Quality of the joints is crucial
  - Workmanship
  - Materials – chipped unts
  - Laying
  - Tooling and filling joints
  - Quality of mortar
  - Shrinkage
  - Bond
  - Permeability



Gradual Wetting Under Zero Pressure Gradient

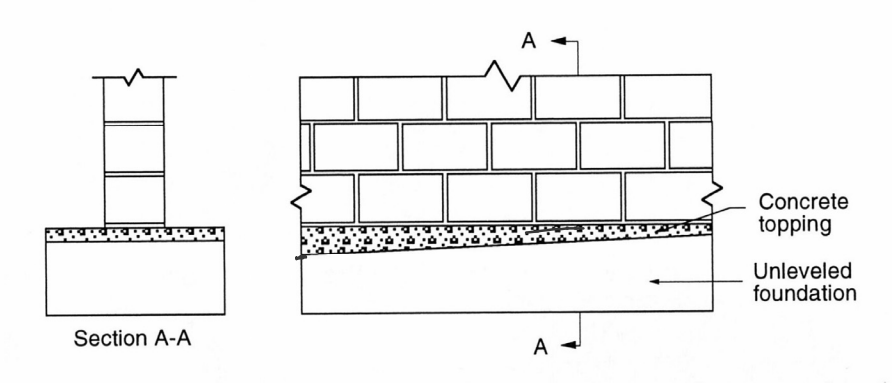


Leakage Through Head Joint

Construction Details

Preparation:

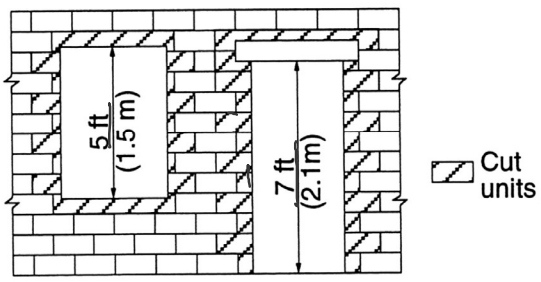
- Level alignment
  - Foundation
  - Floor slab
  - Shelf angle
- Tolerances
  - Floor: ¼" in 10 ft
  - Mortar at wall base
    - Can vary between ¼" and ¾"
  - Otherwise use slab topping to level



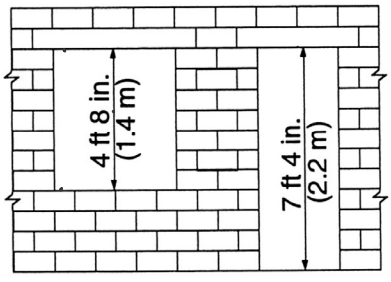
Construction Details

Preparation:

- Alignment of dimensions
  - Align openings with masonry
  - Corner details



(a) Improper Layout Ignoring Modular Dimensions

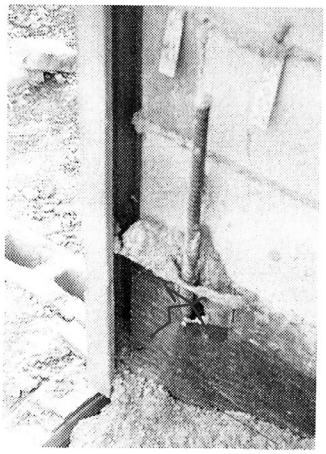


(b) Proper Layout Taking Advantage of Modular Dimensions

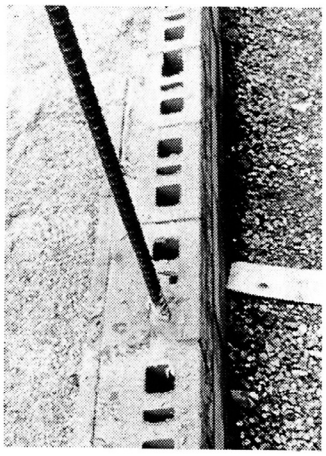
Construction Details

Preparation:

- Alignment of reinforcement
  - Can be bent to fit
  - Slope not to exceed 6:1
  - Otherwise, cut off and replace



(a) Improperly Placed



(b) Correct Location

Construction Details

Preparation:

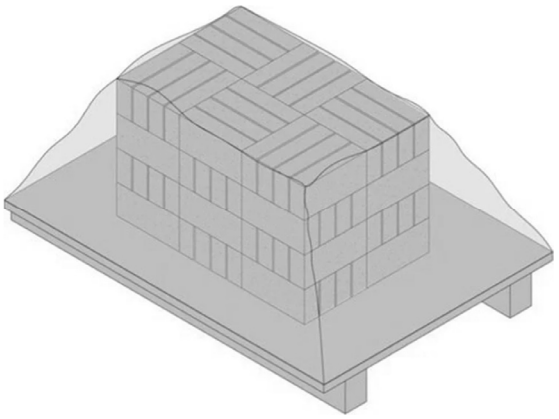
- Mortar mixes
- Materials
  - Kept dry – prevent hydration
  - Proportioning
    - Better NOT by shovel
    - Use gage box or hopper
    - If using shovel – calibrate with box
- Protect sand from rain

- Too little sand
  - Mortar sticks - "fatty"
- Higher cement past
  - bond breaks and cracks due to shrinkage
- Too much sand
  - "lean" difficult to spread
- Stiff mortar
  - Difficult to spread
  - Hard to align units
- Too fluid
  - Units move after placing

Construction Details

Preparation:

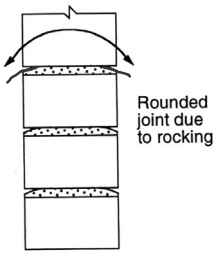
- Mortar admixtures
  - Accelerators – high early strength
  - Retarders – longer workability
- Compatibility of Mortar w/ units
  - If too dry – can wetten
  - CMUs should not be wetted
  - Can cause shrinkage of units



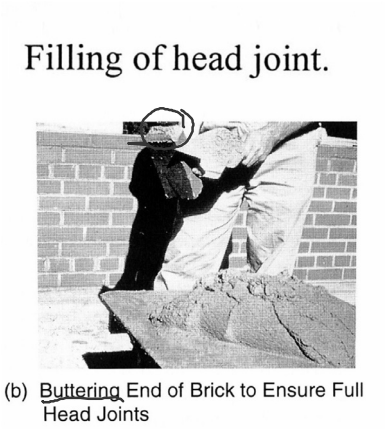
Construction Details

Preparation:

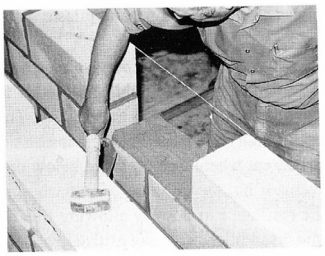
- Layup of masonry
  - Clean foundation – base course
  - Foundation fully mortared
  - Vertical webs fully mortared in piers, columns and pilasters
- Fill head joints
  - Prevent water penetration
  - Avoid rocking while placing



(b) Rocking Effect on Mortar Joints



(b) Buttering End of Brick to Ensure Full Head Joints



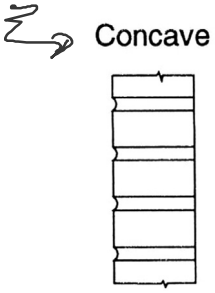
(a) Full Bed Joint of Mortar for Solid Units

(c) Shoving Units into Fully Mortared Collar Joint

Construction Details

Rate of construction:

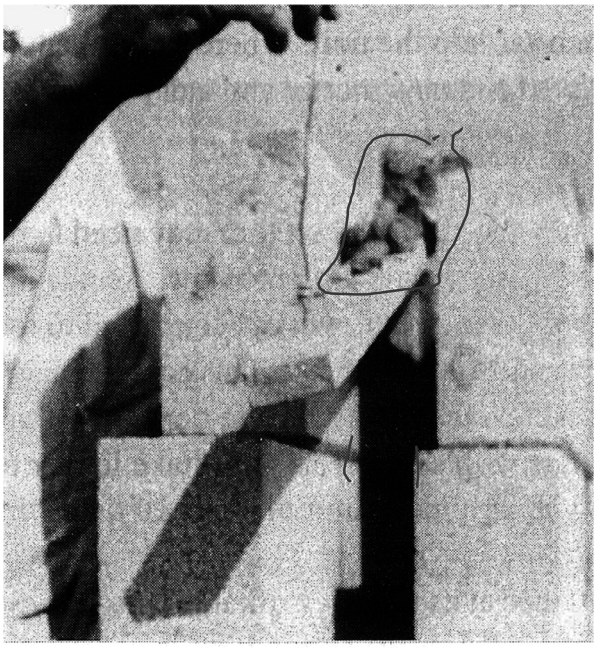
- Limit vertical rate to prevent deforming mortar below
- Height limit of 15-20 times the thickness of the wythe / day
- Wet mortar is better as moisture is absorbed by the units
- Lay units within 1 min. of placing mortar.
- Do not place mortar more than 4 ft ahead of units
- Tool mortar when "thumbprint hard" – press a thumbprint and mortar does not stick to thumb.
- Tool concave joints
- Ties and anchors should be placed as mortar is layed



Construction Details

Excess Mortar

- Protrudes from joint or falls into cavity
- Should be struck off cleanly
- Keep cavity clear of droppings
  - Wood strip – pulled out before next row of ties
  - Clean-out at base of wall
- Keep movement joints clear



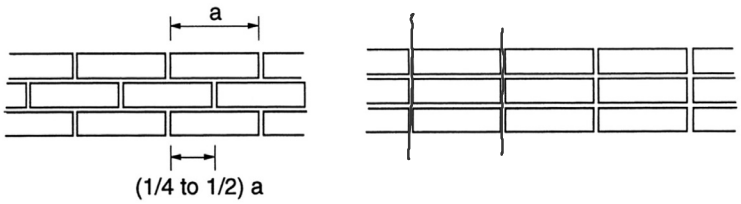
Removal of a Wood Strip Used to Catch Mortar Droppings.

Construction Details

Laying of units:

- Units should be dry
- Units should absorb water from mortar
- But highly absorptive units dry out the mortar – weakens it
- If the Initial Rate of Absorption (IRA) is more than 1 gramm/in^2/min. units should be pre-wetted

- Stack bond is more likely to crack on vertical joint
- Stack bond requires joint reinforcement

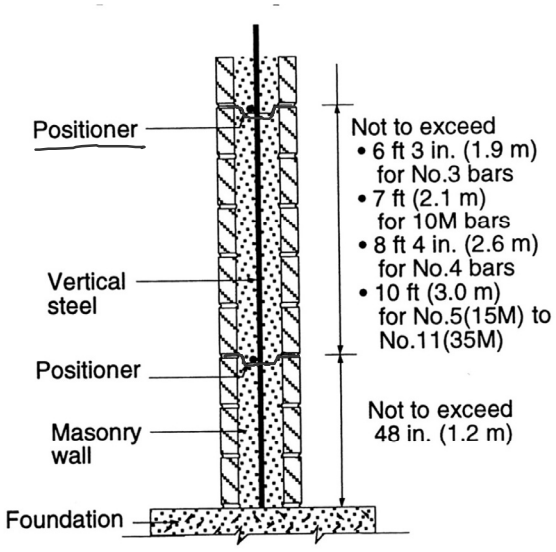


(a) Running Bond (b) Stack Pattern

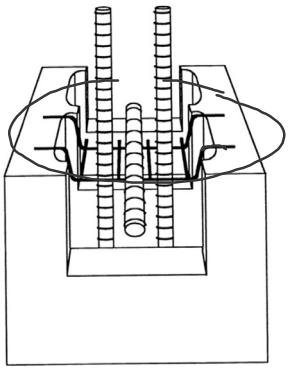
Construction Details

Reinforcing and Grouting

- Like with reinforced concrete
- Must be clean, deformed, etc.
- Accurately located in wall
- Held in place by positioners
- Minimum cover of reif. is ¾"
- Min. cover when exposed to weather is 1 ½"
- Min. cover when exposed to soil is 2"



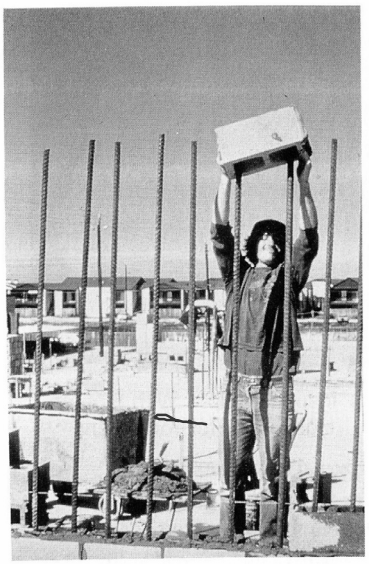
(a) Securing Vertical Steel



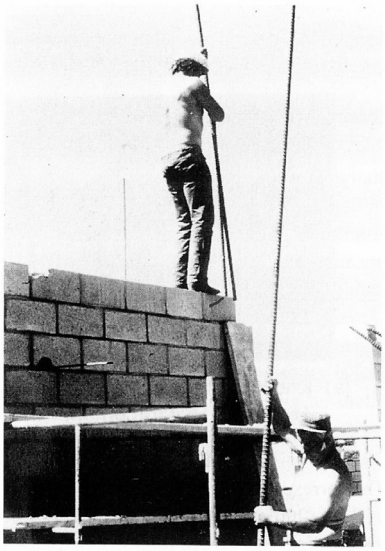
(b) Positioners for Holding Reinforcement

Construction Details

Reinforcing and Grouting



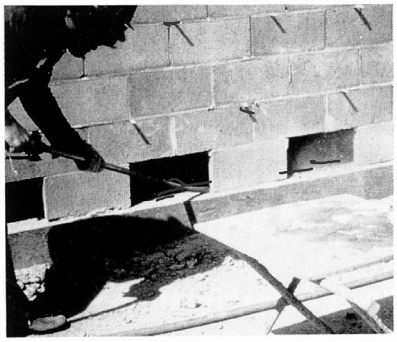
(a) Difficult Placement of Standard Stretchers After the Reinforcement is in Place



(b) Placing Vertical Steel after Wall has been Built. (Courtesy of National Concrete Masonry Association.)

Construction Details

Preparation for Grouting
- Clean off any mortar fins
- Use cleanout holes to remove debris
- Sand at base prevents sticking but must be removed before pour
- Pour continuously – without delays
- Stop about 1 ½" below top course



(a) Face Shells Removed to Permit Clean Out

Low lift grouting
- Max height of 5 ft
- Cleanout holes not needed

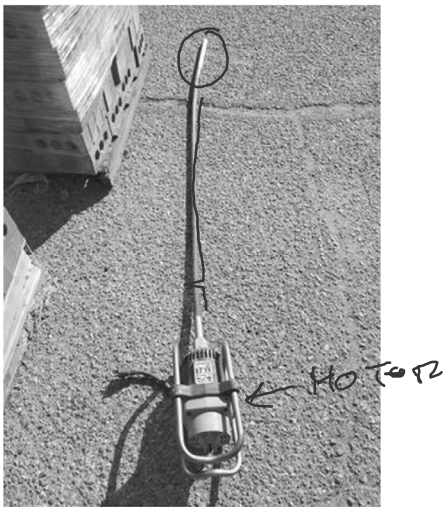
High lift grouting
- Over 5 ft
- Need cleanout holes on bottom course
- Min. size of 3"
- Replace unit or cap before pouring

(b) Face Shells Replaced (Usually Only for Exposed Faces)

Construction Details

Grouting
- Concrete should not be used
- Min. slump is 8” to 10”
- Masonry absorbs the water
- Strength tests of grout should be formed in blocks

Consolidating
- 12” or less can use rod
- Above 12” use vibrator
- Do not move horizontally with vibrator



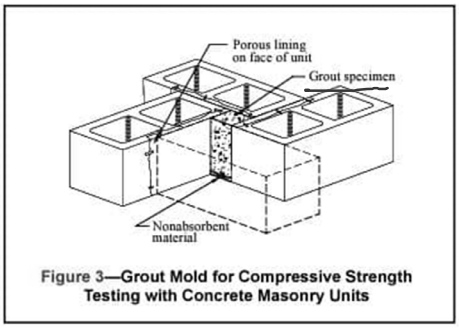
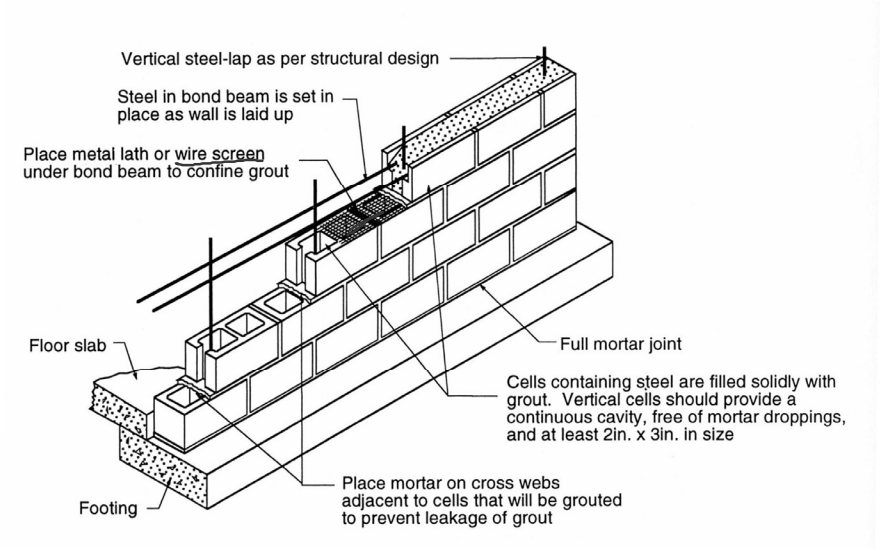


Figure 3—Grout Mold for Compressive Strength Testing with Concrete Masonry Units

Construction Details

Grouting
- 1 to 3 days after wall layup
- Large jobs are pumped
- Minimizes segregation
- Mortar dams are used to limit pour
- Screen is used to contain vertically



Construction Details

Grouting

- Dimensions of cavity

Table 15.1 Grout Space Requirements (from Ref. 15.1)

Grout Type*	Grout Pour Maximum Height, ft (m)		Minimum Width of Grout Space, in. (mm)**†		Minimum Grout†‡ Space Dimensions for Grouting Cells of Hollow Units, in.×in. (mm×mm)
Fine	1	(0.3)	¾	(19)	1½ × 2 (38 × 51)
Fine	5	(1.5)	2	(51)	2 × 3 (51 × 76)
Fine	12	(3.7)	2½	(64)	2½ × 3 (64 × 76)
Fine	24	(7.3)	3	(76)	3 × 3 (76 × 76)
Coarse	1	(0.3)	1½	(38)	1½ × 3 (38 × 76)
Coarse	5	(1.5)	2	(51)	2½ × 3 (64 × 76)
Coarse	12	(3.7)	2½	(64)	3 × 3 (76 × 76)
Coarse	24	(7.3)	3	(76)	3 × 4 (76 × 102)

* Fine and coarse grouts are defined in ASTM C 476. Grout should attain a minimum compressive strength at 28 days of 2,000 psi (13.8 MPa).

** For grouting between masonry wythes.

† Grout space dimension is the clear dimension between any masonry protrusion and shall be increased by the horizontal projection of the diameters of the horizontal bars within the cross-section of the grout space.

‡ Area of vertical reinforcement should not exceed 6% of the area of the grout space.

Construction Details

Tolerances

- More critical for structural walls
  - Prevent eccentricity
  - Placement of reinforcement
- Less critical in non-loadbearing walls
  - Visual appearance

Table 15.2 Construction Tolerances (from Ref. 15.1)

Measurement	Location	Tolerances*
Dimension of element	1. In cross-section or elevation	−¼ in., +½ in.
	2. Mortar joint thickness	
	bed joint	±⅛ in.
	head	−¼ in., +⅜ in.
	collar	−¼ in., +⅜ in.
	3. Grout space or cavity width	−¼ in., +⅜ in.
Element	1. Variation from level:	
	bed joints	±¼ in. in 10 ft ±½ in. maximum
	top surface of bearing walls	±¼ in. in 10 ft. ±½ in, maximum
	2. Variation from plumb	±¼ in. in 10 ft. ±⅜ in. in 20 ft.
	3. True to a line	±¼ in. in 10 ft. ±⅜ in. in 20 ft. ±½ in. maximum
	4. Alignment of columns and walls (bottom versus top)	±½ in. for bearing walls ±¾ in for nonbearing walls
Location of element	1. Indicated in plane	±½ in. in 20 ft ±¾ in. in maximum
	2. Indicated in elevation	±¼ in. in story height ±¾ in. maximum
Placement of reinforcement	1. Flexural elements:	
	d** ≤ 8 in.	±½ in.
	d** ≤ 24 in.	±1 in.
	d** > 24 in.	±1¼ in.
	2. Shear walls†	±2 in.

* 1 in. = 25.4 mm

** Distance from centerline of steel to the opposite face of masonry.

† From the specified location along the wall length as indicated in the project drawings.