Stone and Brick Masonry

A preparatory course assembled for the
Architectural Record Examinations

Data accumulated from Kent Ballast's "Architecture Exam Review," and various sources of the Internet

(This is only for educational purposes)

AVANT-GARDE ENGINEERING LLC
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FROM MESOPOTAMIA TO THE WEST

- Simple, very reliable construction method that relies on two basic principles:
  - Availability of raw materials, and
  - Elements of manageable size, assembled in a way that they can resist compression forces.
- Bonds may be mechanical or chemical (mortar cement) but the principles remain the same.

ADVANCING TO CONTEMPORARY TECHNOLOGY

- Through the use of reinforcing materials that can assume tensile stresses, the limits of compressive configuration are broken.
- Is this Masonry however or is it something else?
  - Louis Kahn presented the argument that if a brick would aspire to be part of something, that would have been an arch.

Oregon Hall, The University of Oregon
Source: http://baowww.uoregon.edu/staff.htm March 2008

MORTAR

- Components of Mortar:
  - Mixture of cement, sand and water. Lime is incorporated to add to the plasticity and the resilience of the final mixture. It withholds humidity and it aids toward the proper hydration of the cement incorporated in the mixture.
  - Masonry cement is available commercially as a mixture of portland cement and pulverized limestone. It is suitable for veneers and interiors
  - There are four types of cement:
    - M, N, S, & O.

MORTAR

- Types M, S, N, and O are the four basic types.
  - See ASTM C 270

  Source:
  www.cement.org

  March 2008

  O type should not be exposed to lateral loads or frost when wet.
- Generally, one should consider not using any mortar that is stronger than required.
- High lime content mortar is best for bricks with high initial absorption rate.

Rule of Thumb: Use a Type N mortar for all masonry work unless there is a compelling reason to choose another mortar. C 270 provides recommendations for mortars choices in a concise tabular format as shown here. Note that alternative mortar types are also suggested, whether for availability considerations or for minimizing the number of different mortar types on the job site. Consult the appendix of C 270 for tuckpointing mortar guidance.

Location	Building Segment	Recommended Mortar	Alternative Mortar
Exterior, above grade	Load-bearing walls Non-load bearing walls Parapet walls	N O N	Sor M N or S S
Exterior, at or below grade	Foundation walls, retaining walls, manholes, sewers, pavements, walks and pations	S	M or N
Interior	Load-bearing walls Non-load bearing walls	N O	S or M N

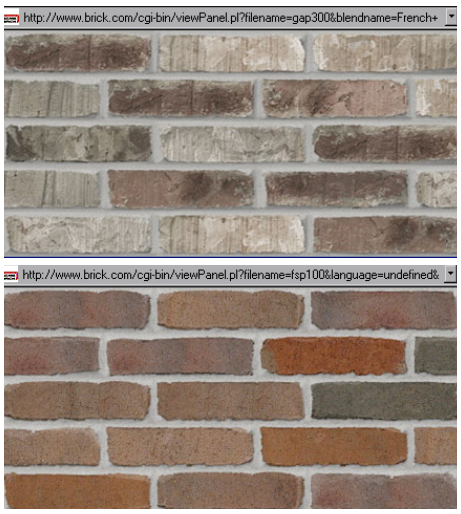
From ASTM C 270

MORTAR

- Grout is a mixture similar to mortar but incorporates more water to keep it to a pouring consistency to fill cavities on wall, hollow masonry units or to bond masonry to reinforcement.
- It can be fine or coarse, the latter including #4 aggregates (pea gravel). Fine grout is applied when fillings smaller than 2 inches are to take place.

BRICK

- Bricks are small units of masonry fabricated of burned clay, shale or a mixture of these materials. The mixture should be at least 75% solid.
- The two basic types of Brick are:
  - The *building brick* or *common brick*, used when it may be covered by other material.
  - The *facing brick* that is used when appearance and uniformity are prime.

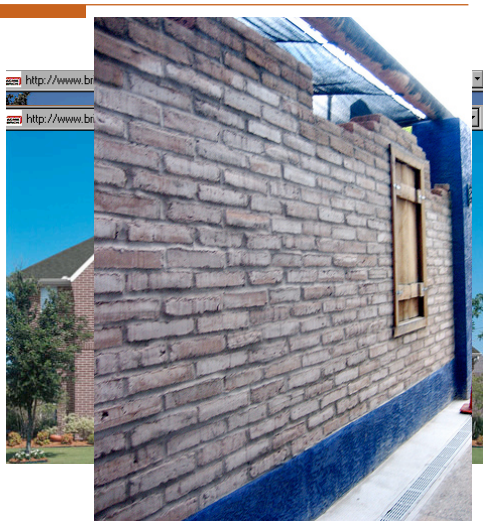


BRICK

- Types of Brick cont.:
  - Building brick is set on specified grades according to its resistance to exposure.
  - SW stands for severe weathering,
  - MW stands for moderate and
  - NW for negligible weathering.
  - Also, these grades represent the capacity of the different types of brick to resist freezing / thawing.

BRICK

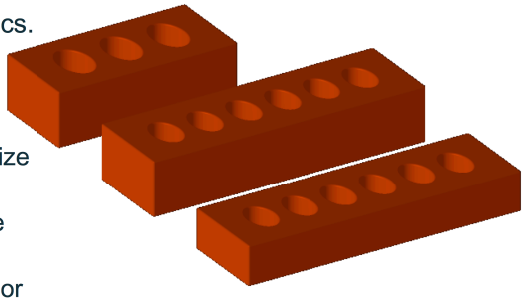
- Types of Brick cont.:
  - Facing Brick is also categorized in the SW and MW, but it is also classified further into the following types:
    - FBS: General use with a variety of colors and sizes is desired,
    - FBX: Used when dimensional and color range need to be limited,
    - FBA: Used when non uniformity in color or dimension is desired



Adobe Brick Wall –
Source: http://www.flickr.com/photos/mollyeh11/206823779/, March 2008

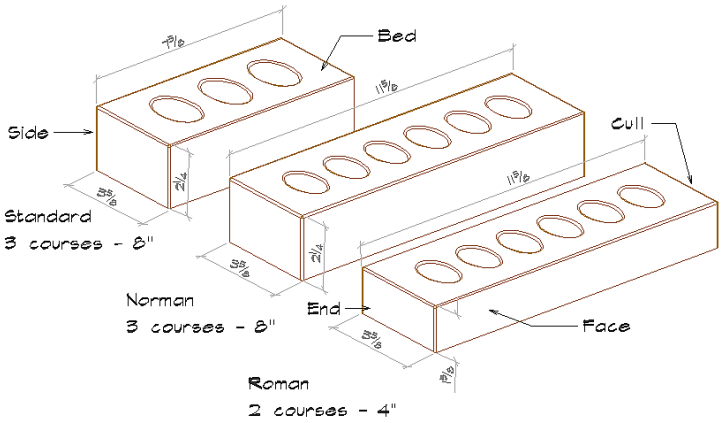
BRICK

- Types of Brick cont.:
  - Hollow Brick is also categorized in SW and MW grades. Just like the facing brick it is also categorized according to its characteristics. The "F" character for facing brick is replaced by an "H". Thus:
    - HBS – general use with size and color variation
    - HBX – narrow color range and precise dimensions
    - HBA – Non uniform color or size



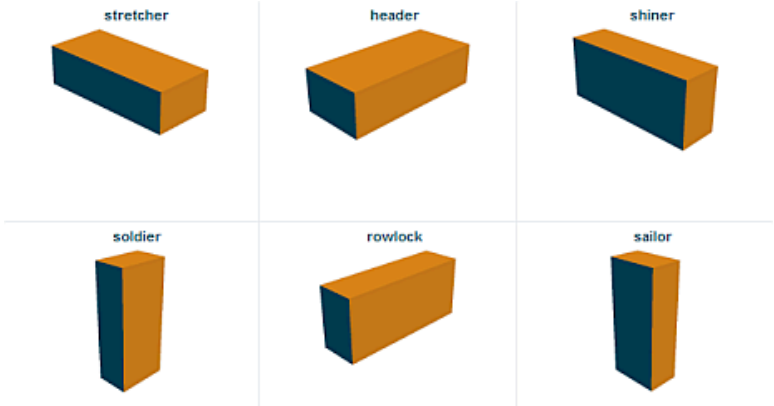
BRICK

- Sizes and faces of brick:
  - There are many types but here are some standard types:



BRICK

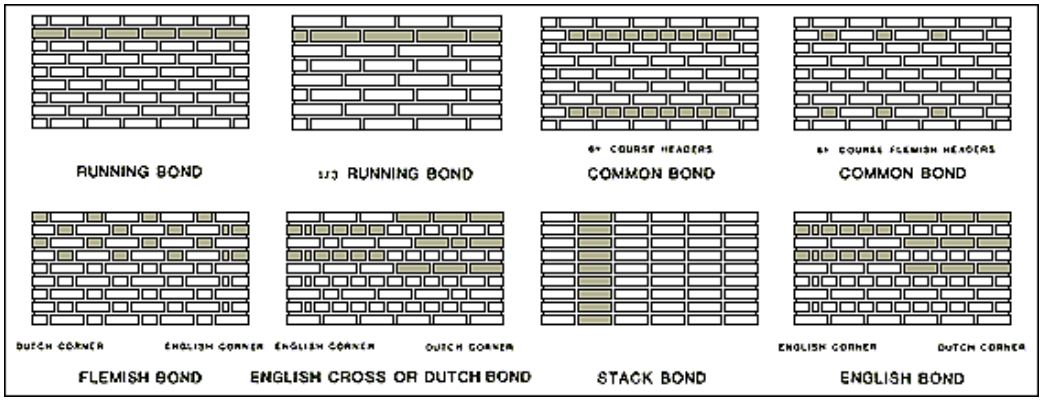
- Coursing:
  - Depending on the side of the brick that is facing on the outside, and it's positioning, a typology is established.



Methods of brick laying –
Source: http://na.hansonbrick.com/builder/positions.php, March 2008

BRICK

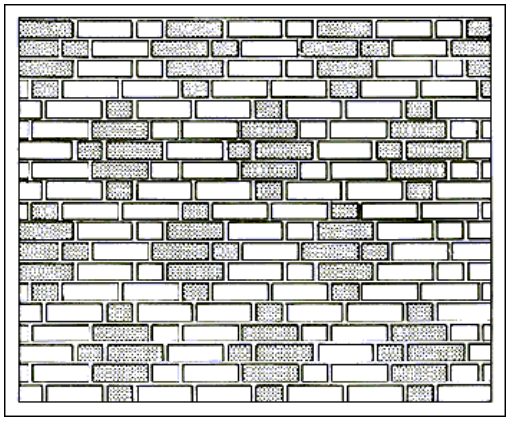
- A traditional set of courses is represented in the diagram. The bonding patterns used to be more structurally sound. However, given the contemporary means applied, with metal wall ties and joint reinforcement, brick veneer walls, bonding patterns are not as critical.

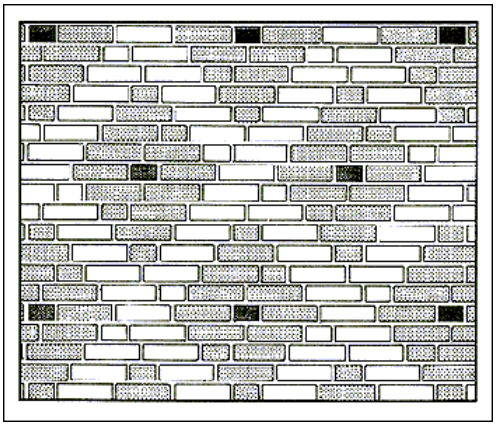


Traditional pattern bonds –
Source: http://www.bia.org/BIA/technotes/t30.htm, March 2008

BRICK

- More Coursing varieties:

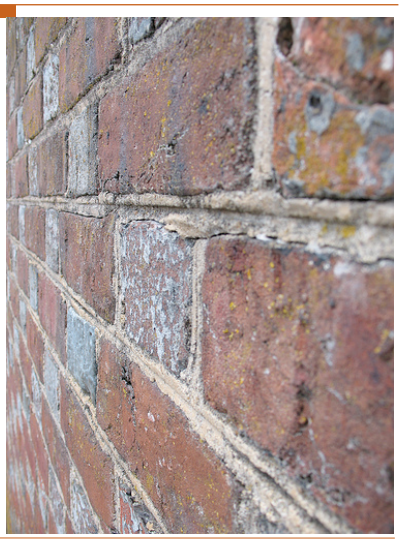




Double Stretcher Garden Wall Bond with Units in Diagonal Lines and Garden Wall Bond with Units in Dovetail Fashion –
Source: http://www.bia.org/BIA/technotes/t30.htm, March 2008

BRICK

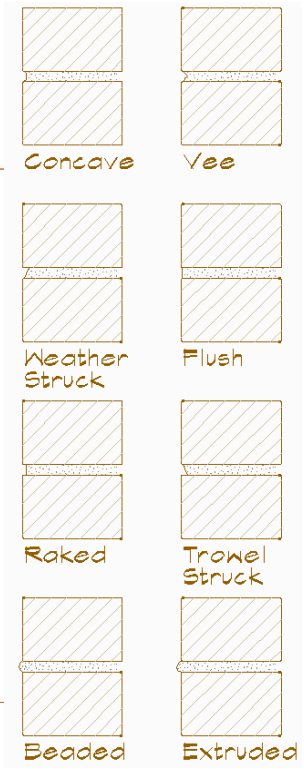
- Brick Joints are very critical as they hold the bricks together but they also keep the humidity out of the building. Mortar should be laid in the entire area of the bed and the end faces.
- Once the brick is laid, the joints are *tooled* to compress the mortar on the exterior side, making it more impermeable.
- There is also a decorative effect to address in the form the mortar takes.



Flemish bond with glazed headers and struck joints. Stratford Hall, Westmoreland County, Virginia. Birthplace of R. E. Lee – Source: http://www.flickr.com/photos/3tuxedocats/2275792944/, March 2008

BRICK

- Brick Joints:
  - There are various types of joints that can be specified by the architect. However, for reasons of practicality and effectiveness, the Concave, Flush, and Vee joints are preferable for exterior surfaces as they shed water more effectively.
  - The geometric forms of some of the joints may allow adhesion forces by the water to act, instead of shedding, and then capillary action to keep the humidity in the wall.



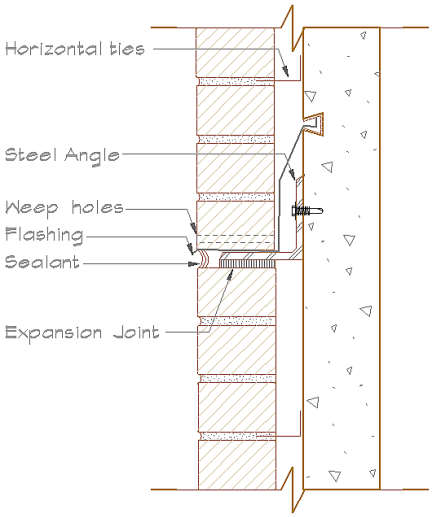
BRICK

- Differential Movement Joints:
  - Brick expands
  - Concrete Shrinks
  - Do you think there may be an issue?
- Joints need to be placed to accommodate this type of movement. If not, either the mortar joints or sometimes the bricks will crack and fall off. The joints that serve this purpose are actually called *Expansion joints*.

The ECJ Civil Engineering Building and the RLM Math building of the University of Texas – Source: http://www.lib.utexas.edu/engin/history/index.html, March 2008

BRICK

- Other Brick Joints:
  - *Construction joints* isolate masonry from openings (windows, doors, etc.).
  - *Control joints* allow the movement due to thermal expansion and contraction, like the Expansion joints.
  - Horizontal Expansion Joints are placed below steel angles that support the exterior masonry (see figure). As there may be deflections from structural elements (including the steel angle shown in figure) these joints assume the stress that would have transferred to the brick wall



BRICK

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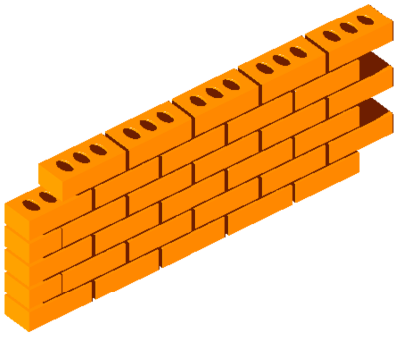
Fake brick on top of stone veneer used on exterior walls of Dog House Grill, Fresno CA – Image used only for application of expansion joint – **NOT real Masonry**

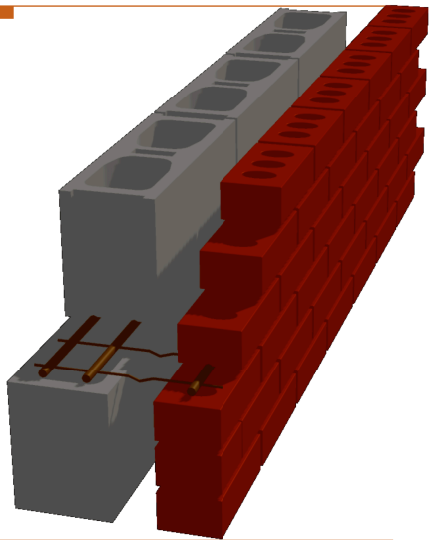
BRICK

- Brick Construction:
  - Though simple in concept, brick masonry involves a series of steps that need to be taken, following a process for the construction of types of walls that will function in specific ways. There is a variety of brick walls and the most common are the following:
  - Single-wythe wall is the simplest, with only one layer of bricks that can – but non necessarily – act as load bearing. Due to lack of reinforcement, the maximum ratio of unsupported height to thickness may only reach 20/1 for solid or 18/1 on hollow brick wall.



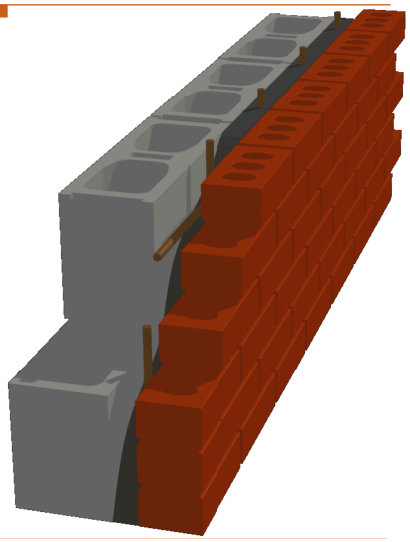
BRICK

- Brick Construction cont.:
  - The Cavity wall consists of two wythes of masonry, usually the exterior being brick and the interior some type of block masonry unit. The cavity is empty and the two wythes are tied together with galvanized metal ties or continuous horizontal reinforcement, placed 16" O.C. vertically.
  - Cavity walls are very effective in providing possibilities for thermal and noise insulation, besides being structurally more sound than single wythe walls.



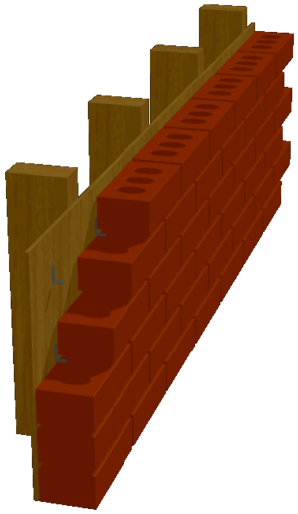
BRICK

- Brick Construction cont.:
  - The reinforced grouted wall consists of two wythes of masonry, usually the exterior being brick and the interior some type of block masonry unit. The cavity is completely filled with mortar and reinforcement.
  - Reinforced grouted walls are stronger than empty cavity walls and thus can resist more vertical and lateral loads. They also can be designed to greater unsupported heights.



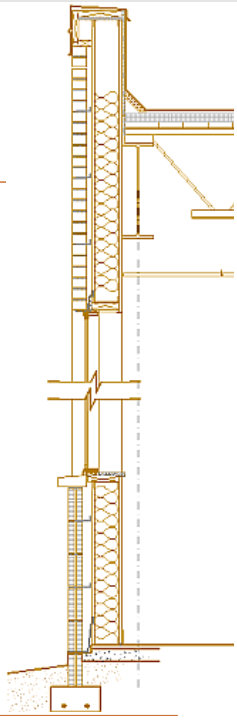
BRICK

- Brick Construction cont.:
  - The veneer wall is a single wythe masonry attached to the a wall that supports it. Most of the times the support is just an assembly like a wood-frame wall. However that can be much more structurally sound like a concrete block (CMU) wall like the cases seen previously.
  - The exterior masonry is applied for decorative purposes mainly, although it also serves in waterproofing and it definitely works for thermal and noise insulation.



BRICK

- The most important aspect of masonry wall design is the waterproofing of the building. It is necessary to take the following steps:
- Select the appropriate brick type for the applied stresses and the weather conditions and tool the joints appropriately.
- Expansion and control joints need to be implemented correctly.
- The wall needs to be flushed and finished.
- Tops of walls should be capped with coping extending beyond the wall face, and incorporate drains.
- Use base flashing at 8” - 10” set in a reglet on the interior wythe, and apply weep holes at 24” O.C. This should also be applied over window and shelf angles



BRICK

- Masonry Construction Detailing:

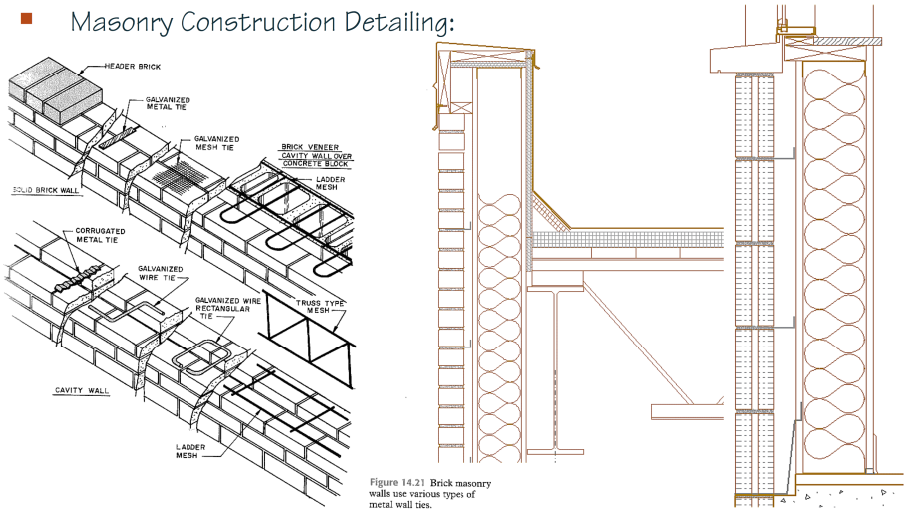


Figure 14.21 Brick masonry walls use various types of metal wall ties.

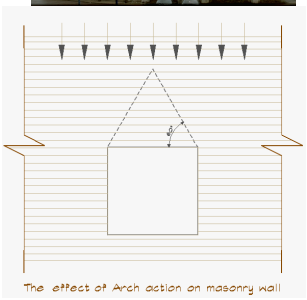
BRICK

- Openings:
  - In contemporary construction, for openings in Masonry, steel lintels prevail because of their ease of application and low cost. The most important concern presented is the minimum of 6" of bearing length.
  - However, there are alternatives to that, including the most graceful of the options, the well engineered arch.
  - The option of straight horizontal concrete lintels or masonry lintels, or even chiseled stone lintels is also available,like the post and lintel system.

Use of double angles in T formation for steel lintel –
Source: http://www.free-ed.net, March 2008

BRICK

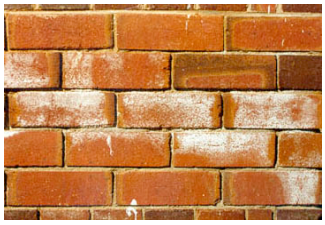
- Openings:
  - Regardless of the type of lintel that the designer specifies, there is always an arch action acting upon the opening. A 60º triangle is what can be assumed for the transfer of forces unless there are other point loads acting upon the lintel that supports the masonry.
  - Compare this effect to the pointed arch!



The effect of Arch action on masonry wall

BRICK

- Efflorescence:
  - The effect of salts contained in the mixtures of clay brick, mortar, or any other part of the masonry that dilute to moisture and come to the surface of the wall. As the humidity evaporates, the salts remain deposited on the surface of the masonry.
  - It is harmless unless if there is excessive amount of salt like cases where contractors use sand from the beach. Other than that, it is only a cosmetic issue and it can be avoided by the use of materials not rich in soluble salts, or by good detailing that will prevent penetration of humidity.
  - It can be resolved through brushing, mild sand blasting, or through the use of 5% muratic acid.
  - In warm dry weather, water wash can also be effective.



Efflorescence – concentration of water soluble salts on the surface of brick – Source: http://www.diydoctor.org.uk/projects/efflorescence.htm, March 2008

BRICK

- Restoration:
  - Restoration of old bricks or mortar may be particularly difficult. Overtime brick or mortar can be physically damaged. Damaged units should probably be replaced.
  - Mortar can be replaced through the process of *tuck pointing*. Mortar is removed to 2.5 times the width of the joint. The area is cleaned and moisturized and high-lime mortar is applied in layers – each applied after the previous starts to solidify – with a special tool.

Process of Tuck pointing masonry and tooling new mortar, Tuck pointing tool –
Sources: http://www.buildingrestoration.com/tuckpointing.html, http://hand-tools.hardwarestore.com, March 2008

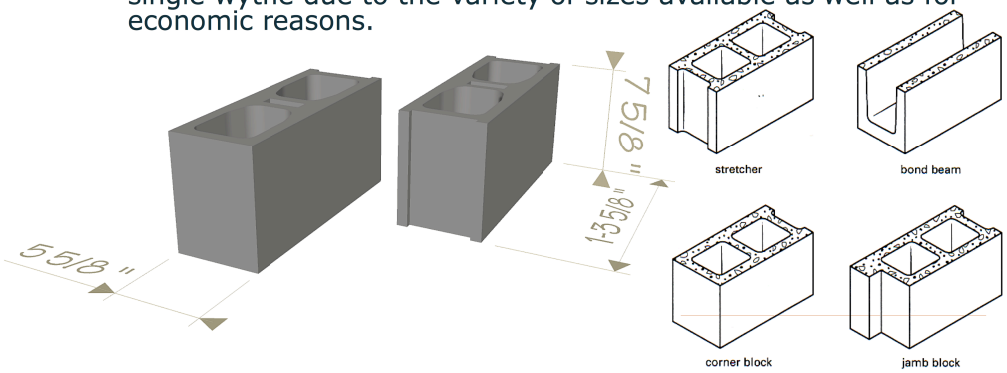
CONCRETE MASONRY UNIT

- The CMU is a prefabricated block that is fabricated with cement, water, gravel, shale or slate, expanded slag or pumice, and limestone cinders.
- The classifications are as follows:
  - Hollow load bearing
  - Hollow non load bearing
  - Solid load bearing, and
  - Solid non load bearing
- Solid signifies a cross sectional area of 75% or more that is solid material. Vice versa applies for the hollow unit.

Assembly of various Concrete Masonry Units –
Source: http://www.block-lite.com/products.htm, March 2008

CONCRETE MASONRY UNIT

- The dimensions of concrete blocks are, like those of bricks, based on a module of minimum 4", keeping it 3/8" less for mortar margin. Unit sizes are referred by width x height x length. Common thicknesses are 4", 6", 8", 10" and 12". Common lengths are 8", 12", and 16". The example indicated below is a 6" x 8" x 16".
- Concrete block walls can be double wythe but usually we see single wythe due to the variety of sizes available as well as for economic reasons.



CONCRETE MASONRY UNIT

- Special Characteristics:
  - Walls can be grouted if fire or noise resistance is required. Bond beams can also be used as lintels over openings or to provide strength against vertical or lateral loads.
  - Due to the fact that concrete blocks are usually hollow, there is a method of calculating the *Equivalent thickness,* which would be the thickness had it been solid. The value is calculated by the percentage of solids and the actual thickness, e.g. an 8" @60% would be 7 5/8" x 0.6 = 4.58"

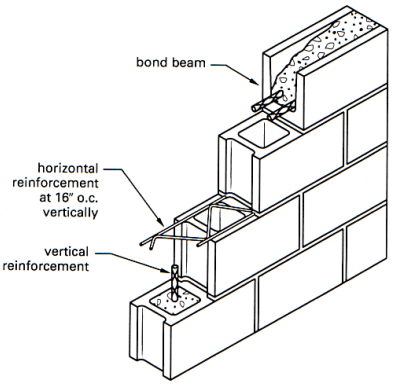
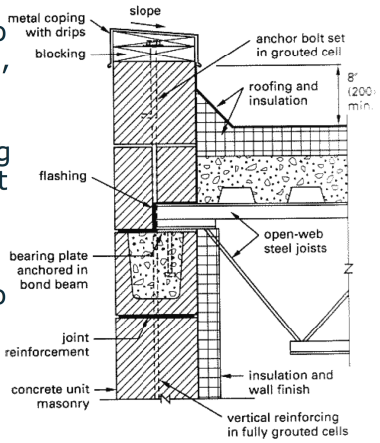


Figure 16.11 Reinforced, Grouted Concrete Masonry Wall

Reinforced Grouted Concrete Masonry Wall –
Source: Ballast, David, K.: *Architecture Exam Review, Volume II: Nonstructural Topics,* 4th Edition, Belmont, CA, 1998, pg16-10.

CONCRETE MASONRY UNIT

- Detailing:
  - Detailing of CMU is important in order to prevent cracking, leaking, and of course, structural issues.
  - In the example: a fully grouted design with a bond beam to provide the bearing capacity and a steel plate used as a seat to the owsj. Generally the height of the parapet should be up to three times the thickness. Here the vertical reinforcing extends into the parapet, anchoring it to the rest of the structure
  - Note the use of metal coping sloping inside not allowing water to drip on the outside of the wall. Flushing could be used if the parapet was higher, with one edge embedded in a mortar joint.



Reinforced Grouted Concrete Masonry Wall –

Source: Ballast, David, K.: *Architecture Exam Review, Volume II: Nonstructural Topics,* 4th Edition, Belmont, CA, 1998, pg16-11.