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ABC109 Differential Movement and Expansion Joints in Brick Veneer

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FREE INFORMATION

The Brick Industry Association
BIA www.gobrick.com
BIA Tech Notes

ACME www.BRICK.com
Masonry Designer
NCMA TEK Briefs

BIA
Technical Notes on Brick Construction
Brick Industry Association 11490 Commerce Park Drive, Reston, Virginia 20191
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MOVEMENT
VOLUME CHANGES AND EFFECT OF MOVEMENT
PART I

Abstract: This Technical Notes describes the various movements that occur within buildings. Movement induced by changes in temperature, moisture, elastic deformations, creep, and other factors develop stresses if the brickwork is restrained. Restraint of these movements may result in cracking of the masonry. Typical crack patterns are shown and their causes identified.

Key Words: brick, corrosion, cracks, differential movement, expansion

INTRODUCTION

The various materials and elements that are used to construct a building are in a constant state of motion. All building materials change in volume due to internal or external stimuli. These stimuli may be changes in temperature, moisture, elastic deformation due to loads, creep, or other factors. Restraint of these movements may cause stresses within the building elements which in turn may result in cracks.

To avoid cracks, the design should minimize volume change, prevent movement or accommodate differential movement between materials and assemblies. A system of movement joints can eliminate cracks and the problems they cause. Movement joints can be designed by estimating the magnitude of the several types of movements which may occur in masonry and other building materials.

This Technical Notes describes the various volume changes in brick mas also describes the e rials are restrained. Other Technical Notes in this series address the design and detailing of move types of anchorage which permit movement.

MOVEMENTS OF CONSTRUCTION MATERIALS

The design and construction of most buildings does not allow precise prediction of movements of building elements. Volume changes are dependent on material properties and are highly variable. Age of material and temperature at installation also influence expected movement. When mean values of material properties are used in design, the actual movement may be underestimated or overestimated. The designer should use discretion when selecting the applicable values. The types of movement experienced by various building materials are indicated in Table 1.

Temperature Movements

All building materials expand and contract with variations in temperature. For unrestrained conditions, these movements are theoretically reversible. Table 2 indicates the coefficients of thermal expansion for various building materials.

Unrestrained thermal movement is the product of temperature change, the coefficient of thermal expansion, and the length of the element. The stresses developed by restrained thermal movements are equal to the change in temperature multiplied by the coefficient of thermal expansion and the modulus of elasticity of the material. The temperature change used for estimating thermal movements should be based on mean wall temperatures. For solid walls, temperatures at the center of the wall should be used. In cavity walls and veneers, the temperature at

TABLE 1
Types of Movement of Building Materials

Building Material	Thermal	Reversible Moisture	Irreversible Moisture	Elastic Deformation	Creep
Brick Masonry	x	--	x	x	x
C Masonry	x	x	--	x	x
C	x	x	--	x	x
Steel	x	--	--	x	--
Wood	x	x	--	x	x

Learning Objectives

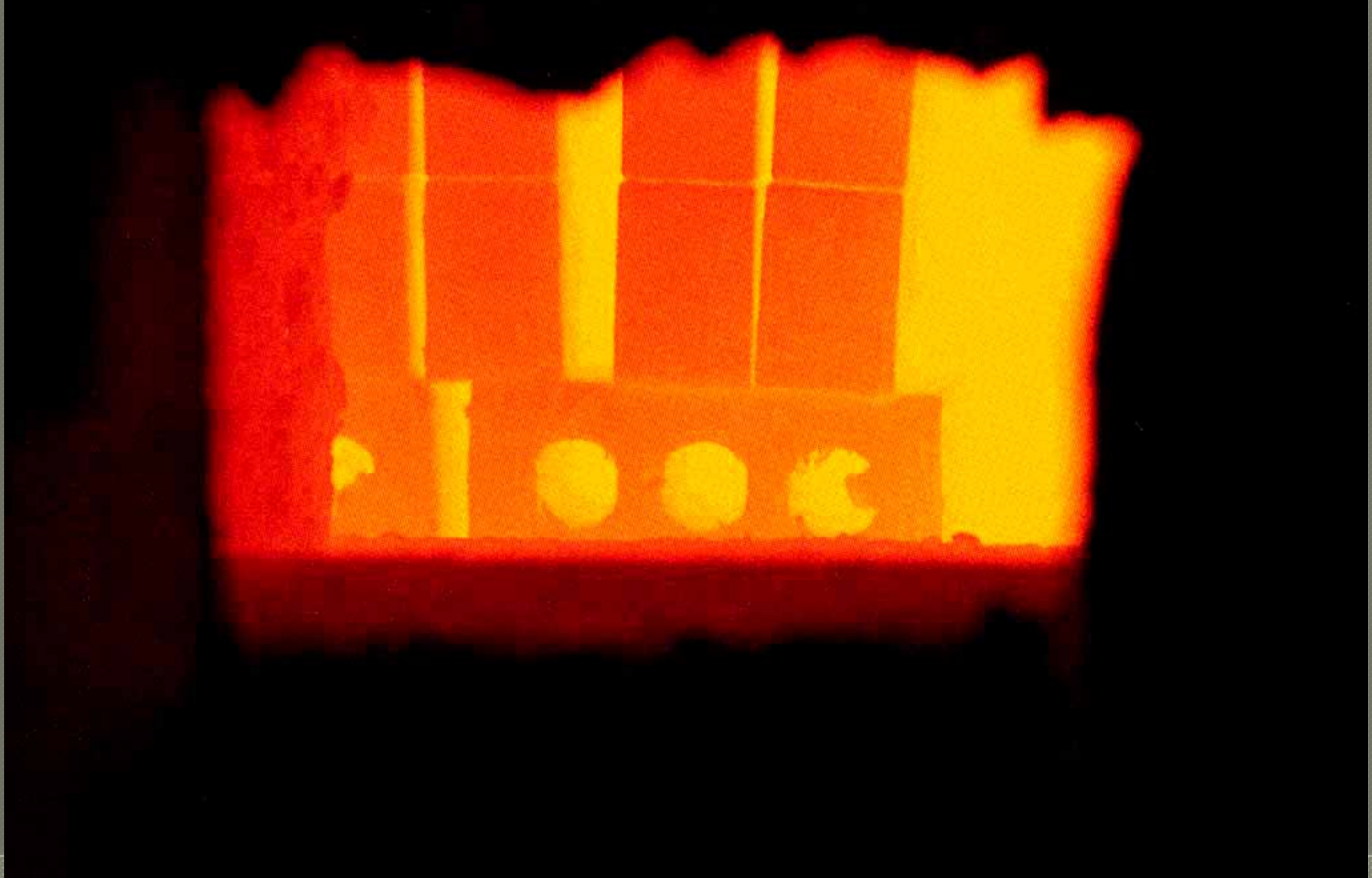
Clay brick has characteristic expansion and contraction movements that result from changes in temperature and moisture content. This presentation will explain those movements and suggest strategies to limit any cracking that results. We will discuss:

1. How do temperature and moisture changes cause brick and other materials to expand and contract at different rates?
2. Why do we need expansion joints in brick veneer?
3. Where should we place expansion joints for effective crack control, while retaining aesthetic symmetry?
4. Receive practical guidelines for placing expansion joints in brick veneer.

Who wants their building to look like this?

Brick are made from clay…

That is fired at 2000˚F



High temperature firing gives genuine clay brick many exceptional properties:

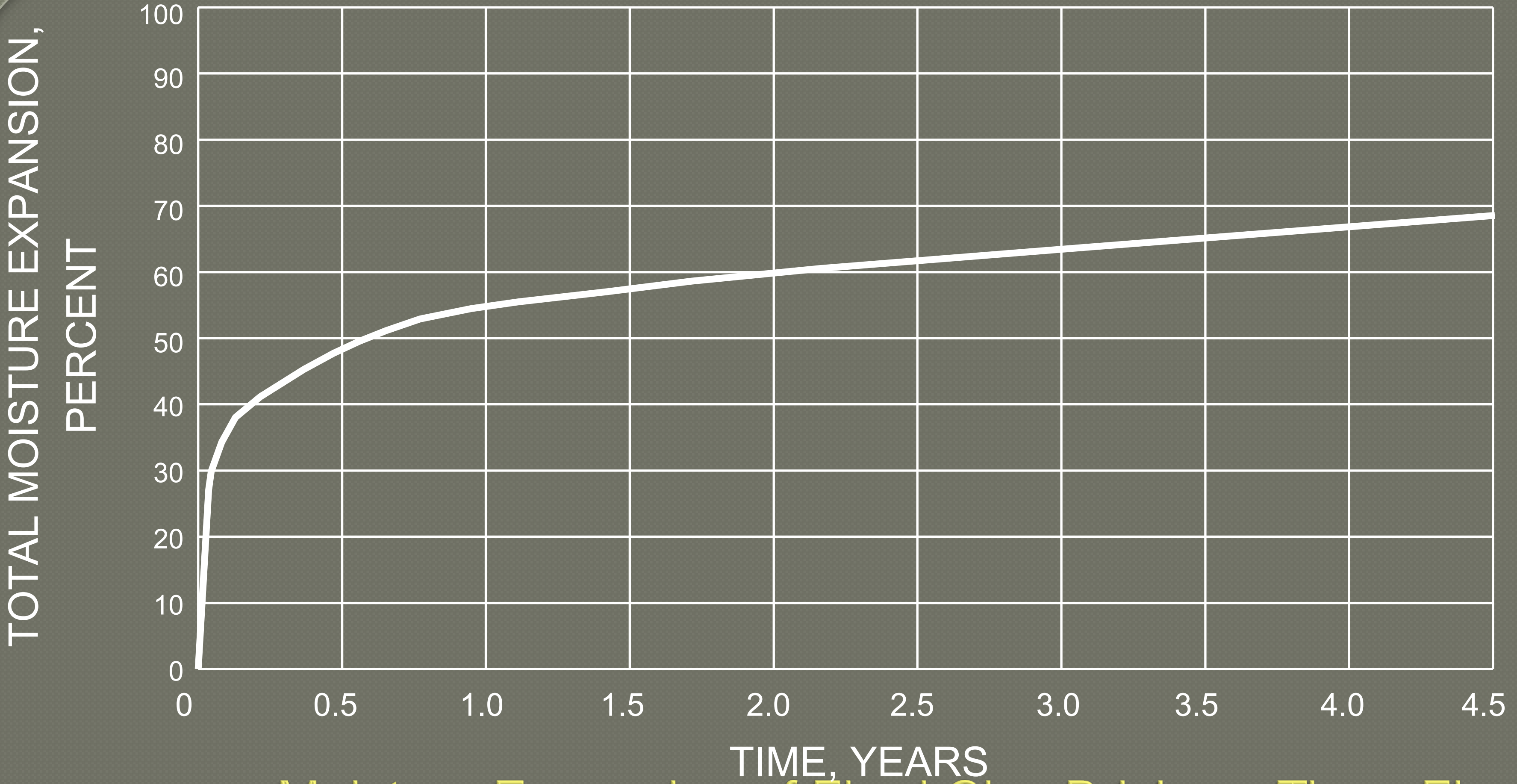
- Durable – lasts for centuries
- Color-fast – colors never fade
- Fire resistant – 1-hr fire rating over wood framing
- Dimensions stable – very low thermal expansion
- One-time moisture expansion
  - Which we will discuss

How does changes in temperature and moisture cause brick and other materials to expand and contract at different rates?

TABLE 1

Types of Movement of Building Materials

Building Material	Thermal Movement	Reversible Moisture	Irreversible Moisture	Elastic Deformation	Creep
Brick Masonry	X	–	**X**	X	X
Concrete Masonry	X	X	–	X	X
Concrete	X	X	–	X	X
Steel	X	–	–	X	–
Wood	X	X	–	X	X



Moisture Expansion of Fired Clay Brick vs. Time Fig. 1

Moisture Expansion of Certain Materials (inches in 25 ft)

Material	Expansion In/in dry to max moisture content	Inches in 25 feet
Clay brick (one-time expansion)	0.0003 – 0.0004	0.09 – 0.12
Clay and porcelain tile	0.0002 – 0.0003	0.06 – 0.09
Concrete Masonry (shrinkage)	0.0002 – 0.00045	0.06 – 0.135
Wet-cast concrete (shrinkage)	0.0006 – 0.0012	0.18 – 0.36
Wood parallel to grain	0.0001 or less	0.03 or less
Wood perpendicular to grain	0.03 – 0.06	9 – 18 inches

- Never embed wood in masonry work. Wood will expand from moisture and crack masonry work.
- Special precautions to allow for wood shrinkage for brick veneer on multi-story wood framing.
  - Wood can shrink 3/8” per floor
  - 1.5” in four-story building

TABLE 2 -- Thermal Expansion

Material	Thermal Expansion *10 ^-6 Inch/inch ^{0}F	Thermal Expansion Inch / 100 ft Per 100 ^{0}F	Material	Thermal Expansion *10 ^-6 Inch/inch ^{0}F	Thermal Expansion Inch / 100 ft Per 100 ^{0}F
Clay Masonry			**Metals**		
Clay or shale brick	3.6	0.43 (7/16)	Aluminum	12.8	1.54 (1 9/16)
Fired clay brick	2.5	0.30 (5/16)	Bronze	10.1	1.21 (1 3/16)
Clay or shale tile	3.3	0.40 (3/8)	Stainless steel	9.6	1.15 (1/ 1/8)
			Structural steel	6.7	0.80 (13/16)
Concrete Masonry			**Wood Parallel to Grain**		
Dense aggregate	5.2	0.62 (5/8)	Fir	2.1	0.25 (1/4)
Cinder Aggregate	3.1	0.37 (3/8)	Maple	3.6	0.43 (7/16)
Expanded shale aggreg	4.3	0.52 (1/2)	Oak	2.7	0.32 (5/16)
Expanded slag aggregate	4.6	0.55 (9/16)	Pine	3.6	0.43 (7/16)
Pumice or cinder aggreg	4.1	0.49 (1/2)			
Stone			**Wood Perp. to Grain**		
Granite	4.7	0.56 (9/16)	Fir	32.0	3.84 (3 13/16)
Limestone	4.4	0.53 (1/2)	Maple	27.0	3.24 (3 1/4)
Marble	7.3	0.88 (7/8)	Oak	30.0	3.60 (3 5/8)
			Pine	19.0	2.28 (2 ¼)
Concrete			**Plaster**		
Gravel Aggregate	6.0	0.72 (3/4)	Gypsum aggregate	7.6	0.91 (15/16)
Lightweight Structural	4.5	0.54 (9/16)	Perlite aggregate	5.3	0.62 (5/8)

Thermal Expansion (inches in 25 ft at 100^{0}F)

Material	Expansion	Difference From Brick	Material	Expansion	Difference From Brick
Clay brick	0.108	0	Fir Lumber With Grain	0.063"	-.045
Clay tile	0.075	-.033	Maple With Grain	0.108"	0
NW Concrete Masonry	0.156	0.048	Oak With Grain	0.081"	-.027
LW Concrete Masonry	0.129	0.021	Pine With Grain	0.108"	
Granite	0.141"	0.033	**Fir Lumber Across Grain**	0.960"	**0.852 ***
Limestone	0.132"	0.024	**Maple Across Grain**	0.810"	**0.702 ***
Marble	0.219"	0.111	**Oak Across Grain**	0.900"	**0.792 ***
			Pine Across Grain	0.570"	**0.462 ***
Normal Weight Concrete	0.180"		**Aluminum**	0.384"	**0.276 ****
Light Weight Concrete	0.135"		**Brass**	0.312"	**0.204 ****
Gypsum Plaster	0.228"		Stainless steel	0.288"	0.180 **
			Structural steel	0.201"	0.093 **

*Never embed wood in masonry work. Wood will expand from moisture and crack masonry work.

** Use great care where Aluminum, Brass, Stainless Steel, and Structural steel join brickwork. These common materials expand much faster than brick or other masonry products.

The total extent of movement can be estimated by this formula from BIA.

TE = L * .0009

Where:

TE = total expansion of a fixed brick wall

L = is the total length of the wall, in

.0009 is the expansion coefficient

How far between expansion joints?

$$S = (W*E)/(.09)$$

where:
S = spacing between expansion joints, in.

W = width of expansion joint, typically the mortar joint width, in.

E = percent extensibility of expansion joint material

The expansion joint is typically sized to resemble a mortar joint, usually 3/8 in. to 1/2 in.

The width of an expansion joint may be limited by the sealant capabilities.

Extensibility of sealants in the 25 percent to 50 percent range is typical for brickwork.

Compressibility of filler materials may be up to 75 percent.

Example.

Consider a typical brick veneer with a desired expansion joint size of 1/2 in. (13 mm) and a sealant with 50 percent extensibility.

Eq. 1 gives the following theoretical expansion joint spacing:

S = (0.5 in.) (50) / 0.09 = 278 in. or <u>23 ft - 2 in</u>.

Joint Size sealant coefficient

To make it easy expansion joints should be between 20 and 25 feet.

Special Precautions for Pre-stressed and Post-tensioned Concrete

Pre-stressed and post-tensioned concrete will shrink from creep in the direction of tensioning.

- This is in addition to drying shrinkage
- Occurs over several months to 1 year
- Have structural engineer and concrete producer estimate both drying and tensioning shrinkage for all slab floors.
- Allow for movements in framing design
- Allow for effects of movements on veneer design

Why do we need expansion joints in brick?

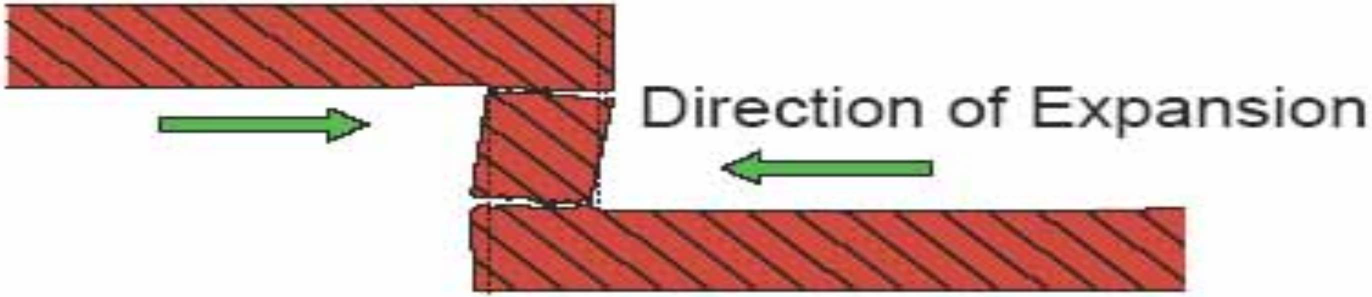
1. Because brick and all building materials expand and contract with changes in temperature, humidity and other environmental conditions.
2. Because those materials move at different rates.
3. Because nature will put them in if you forget.

Where should we put expansion joints in brick?

1. Periodically in long walls.
2. At offsets in walls.
3. Where short runs of masonry meet long runs.
4. At outside corners.
5. Where different materials meet.
6. At parapets and parapet wall caps.
7. Bond break at foundations, shelf angles, and lintels.
8. At junctions with different functions or different heights

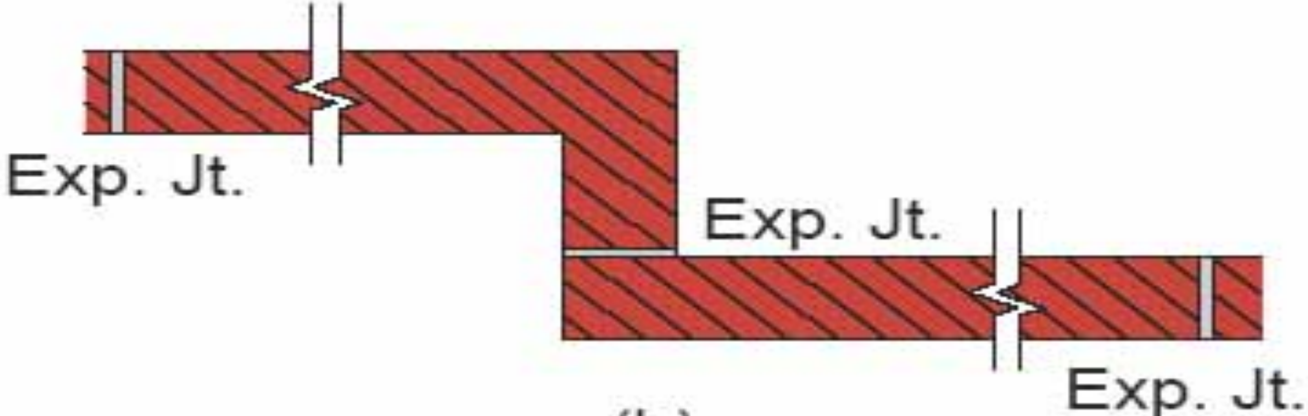
Periodically in long walls.

At offsets in walls.



(a)

Movement at Offset Without Expansion Joints



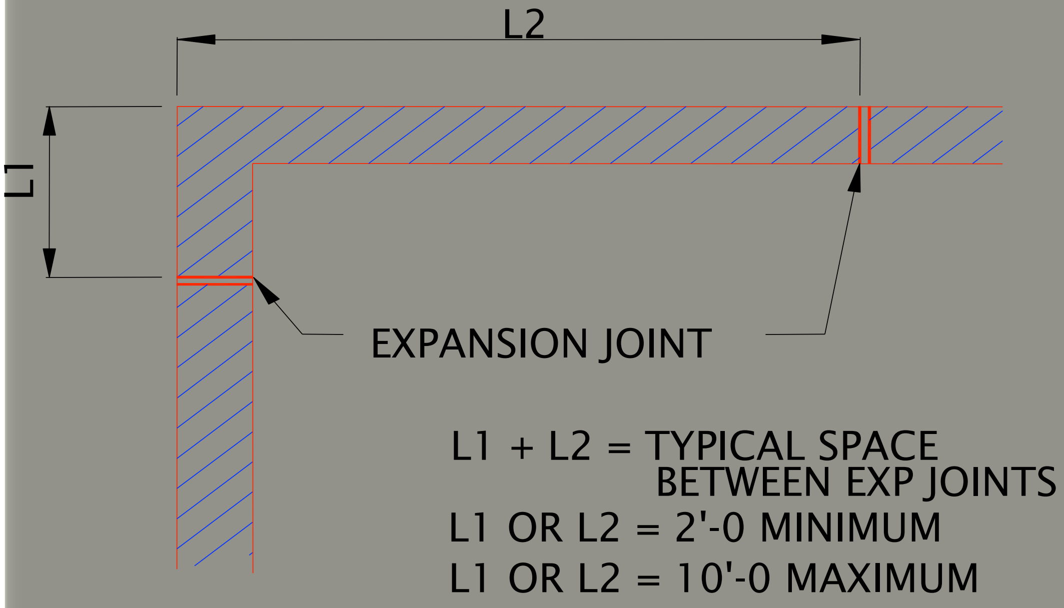
(b)

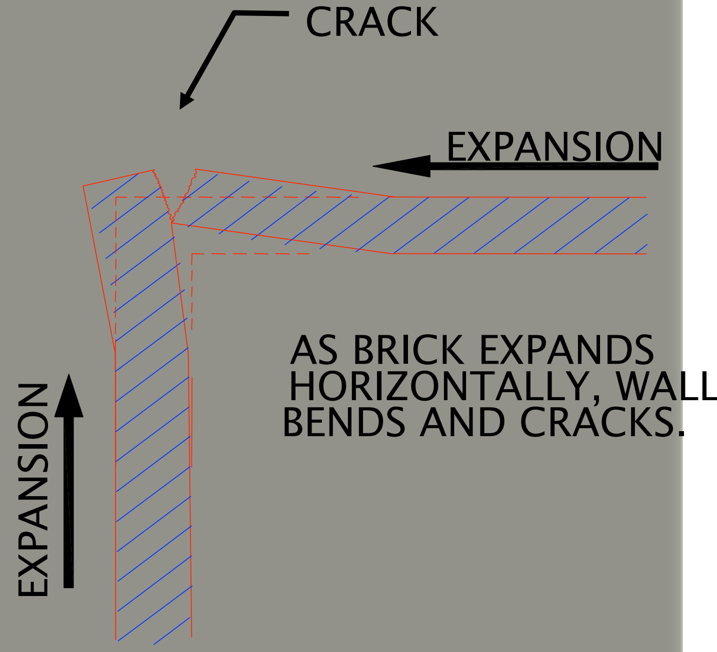
Proper Expansion Joint Locations at Offset

Where short runs of masonry join long runs.


T-Mobile
LAKEWOOD
CHIROPRACTIC
CLINIC
PHILLY
CONNECTION
CHEESESTEAKS • WINGS • SUBS

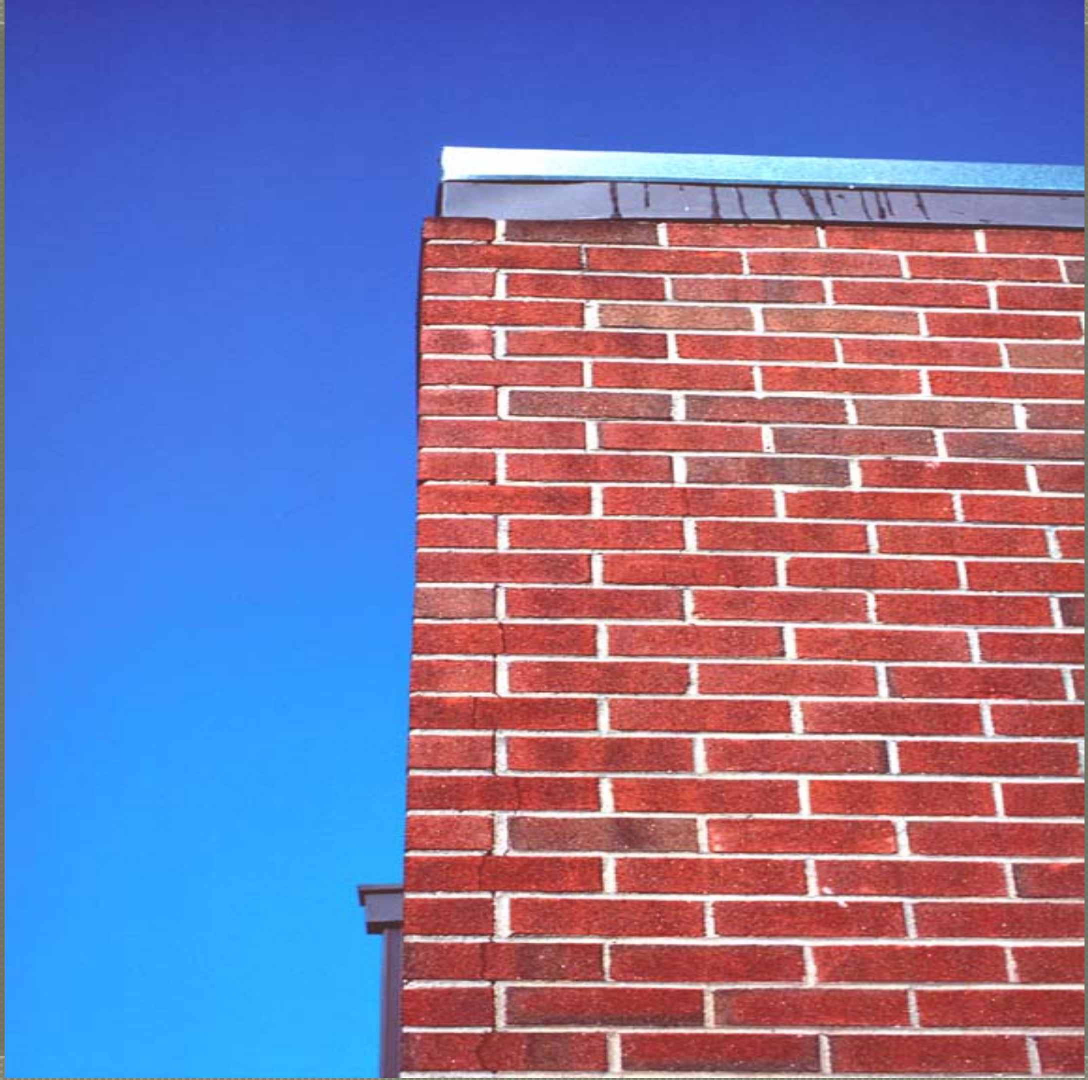
At outside corners.





EXPANSION JOINTS AT CORNERS

CORNERS WITHOUT EXPANSION JOINTS



Where different materials meet.

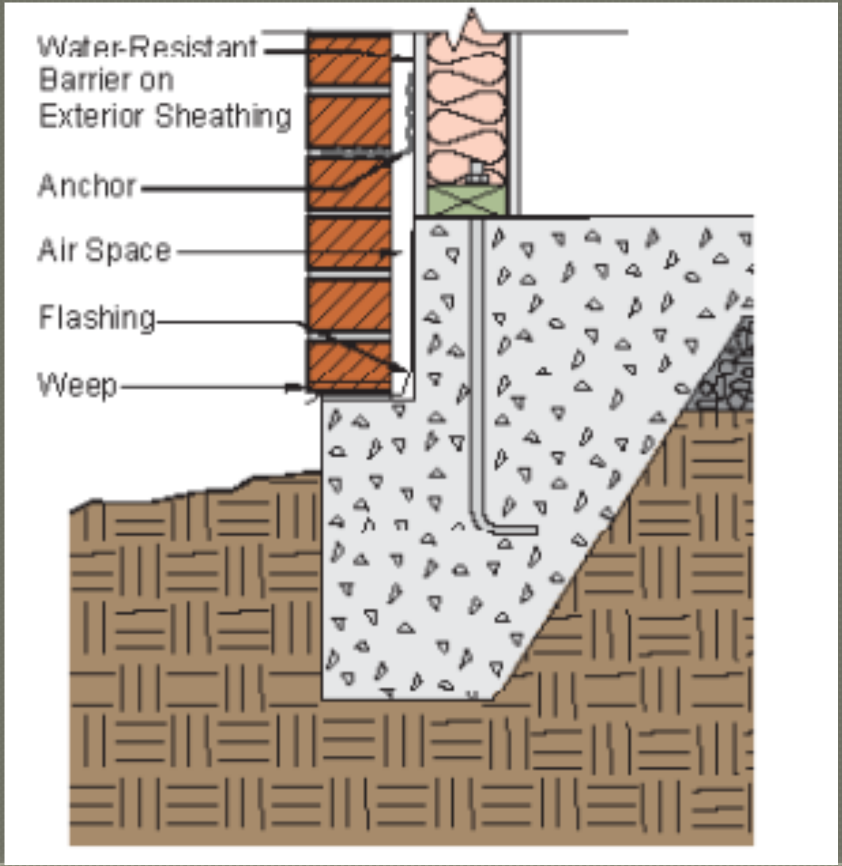
At parapets and parapet wall caps.

Row lock caps need additional exp joints 12-16 feet.
This also goes for brick pavers.

Expansion Joint and Bond Breaks

Foundations, Shelf Angles and Lintels

Foundations



Shelf Angles

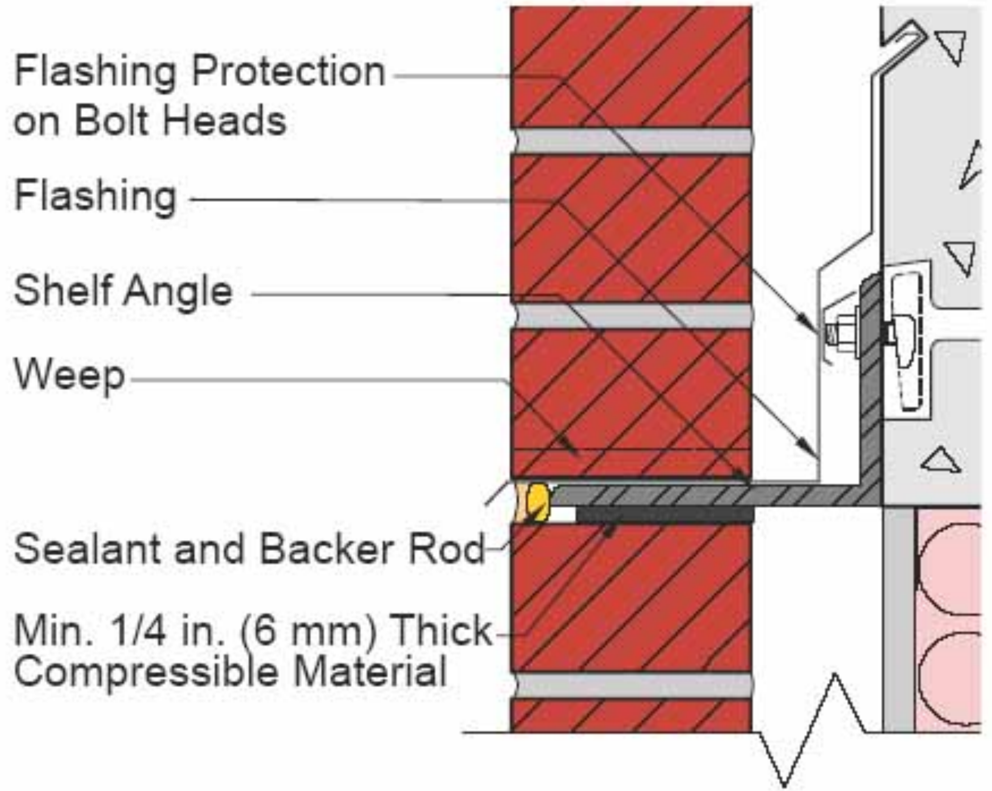
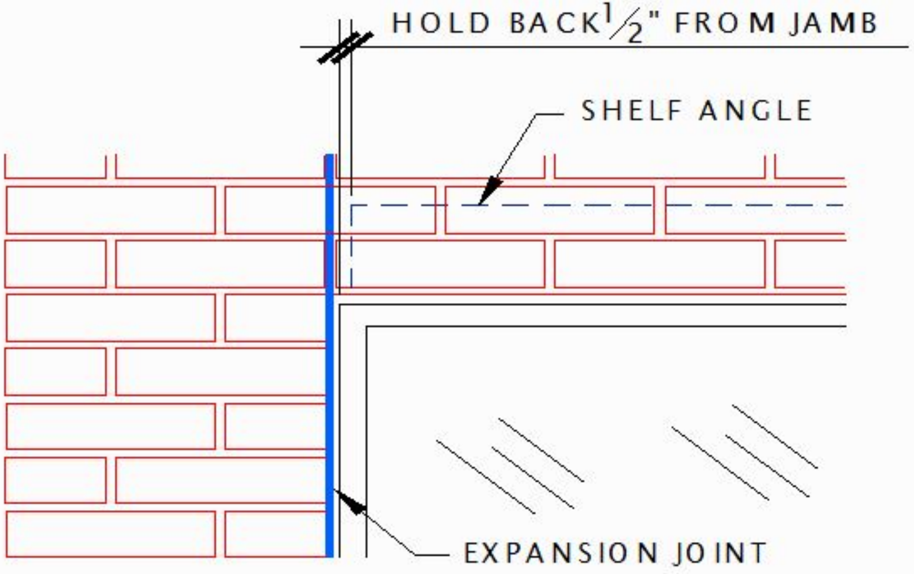


Figure 8

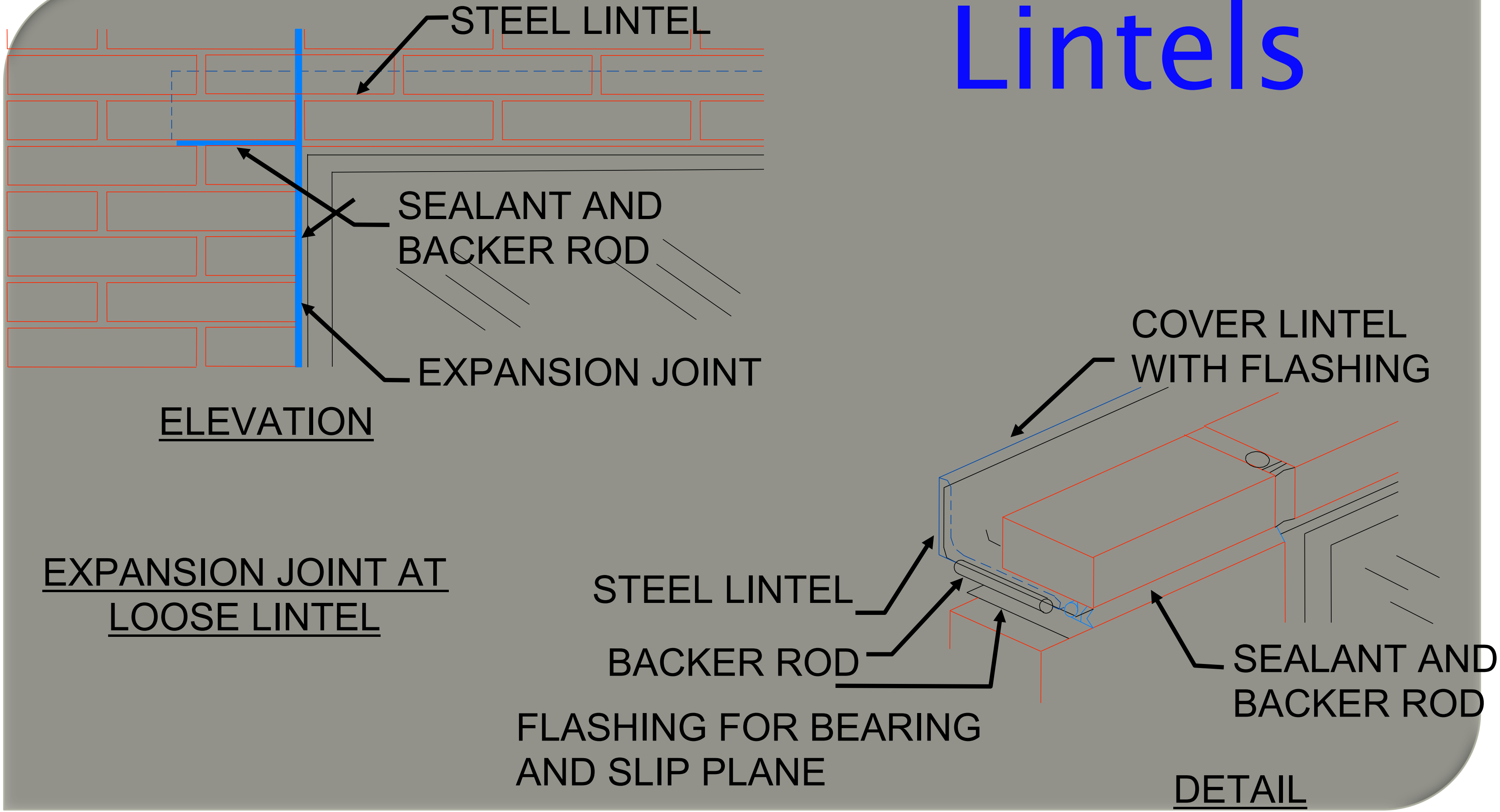
Expansion Joint at Shelf Angle



ELEVATION

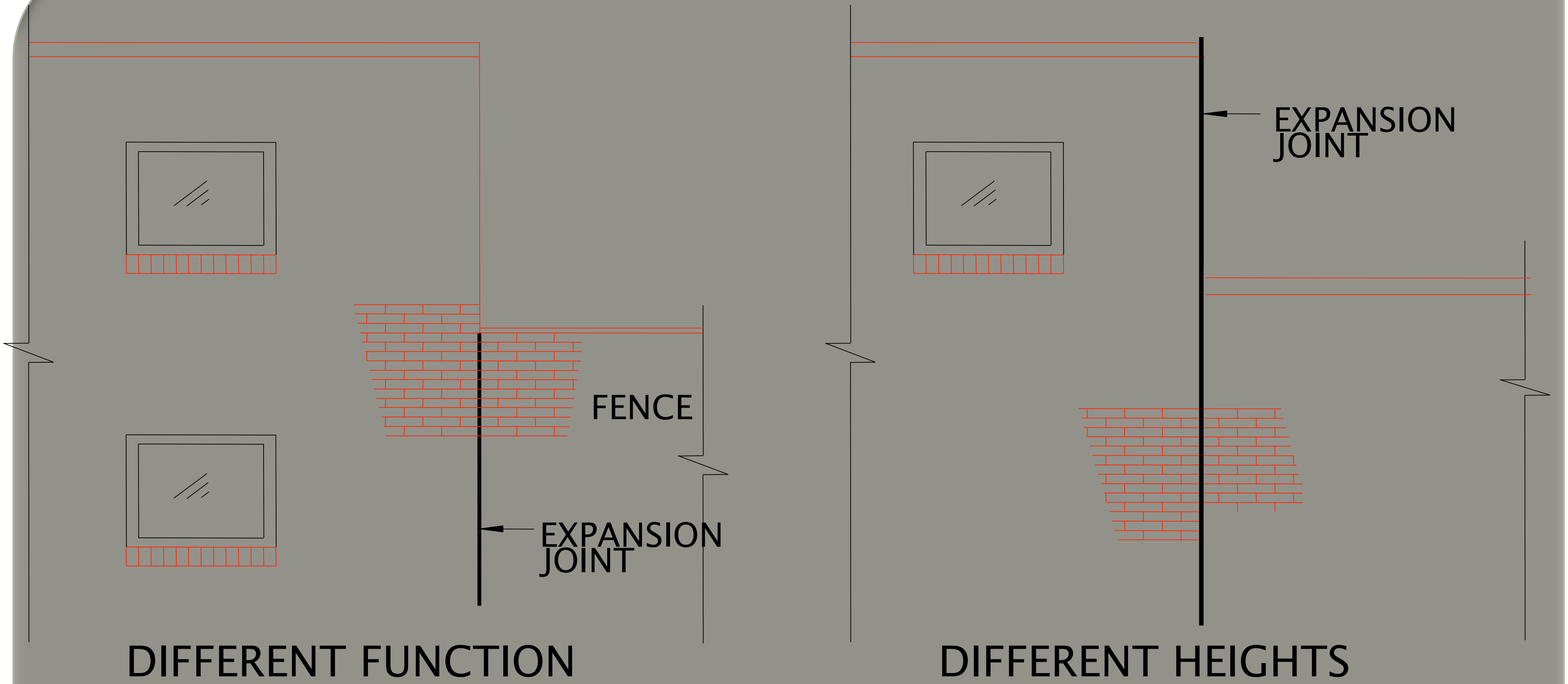
EXPANSION JOINT AT SHELF ANGLE

Lintels



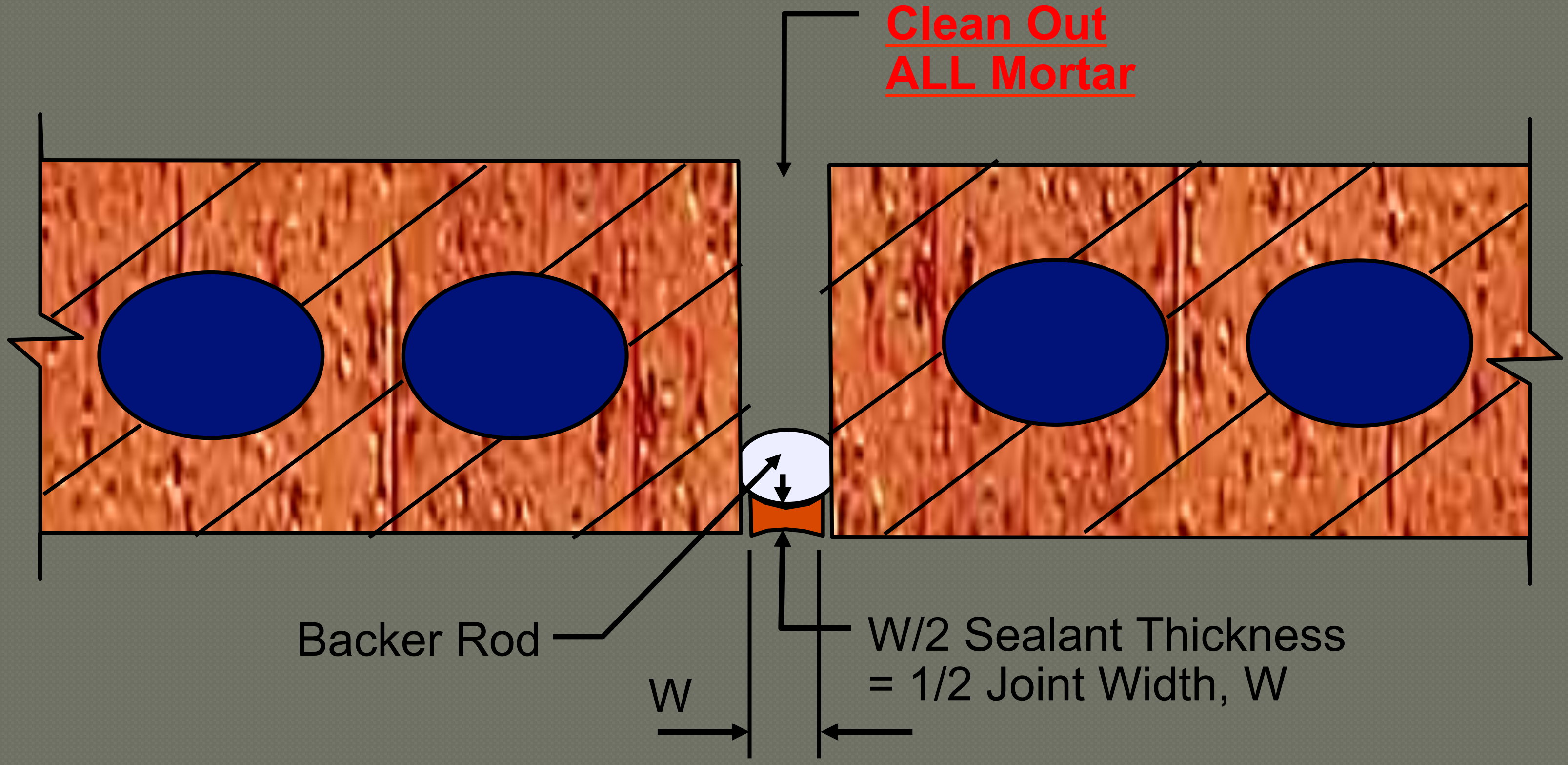
EXPANSION JOINT AT LOOSE LINTEL

EXPANSION JOINTS AT JUNCTIONS WITH DIFFERENT FUNCTIONS OR DIFFERENT HEIGHTS

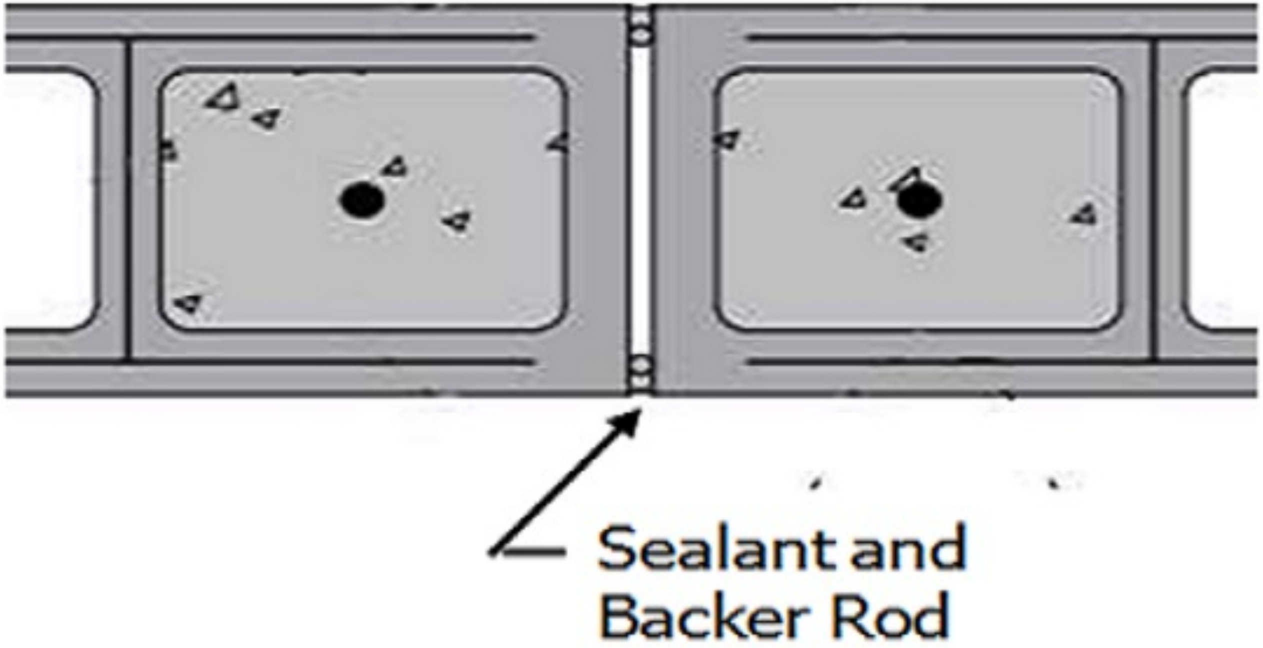


EXPANSION JOINTS AT JUNCTIONS

Let's Look a little close at the expansion joint.



BRICK EXPANSION JOINTS

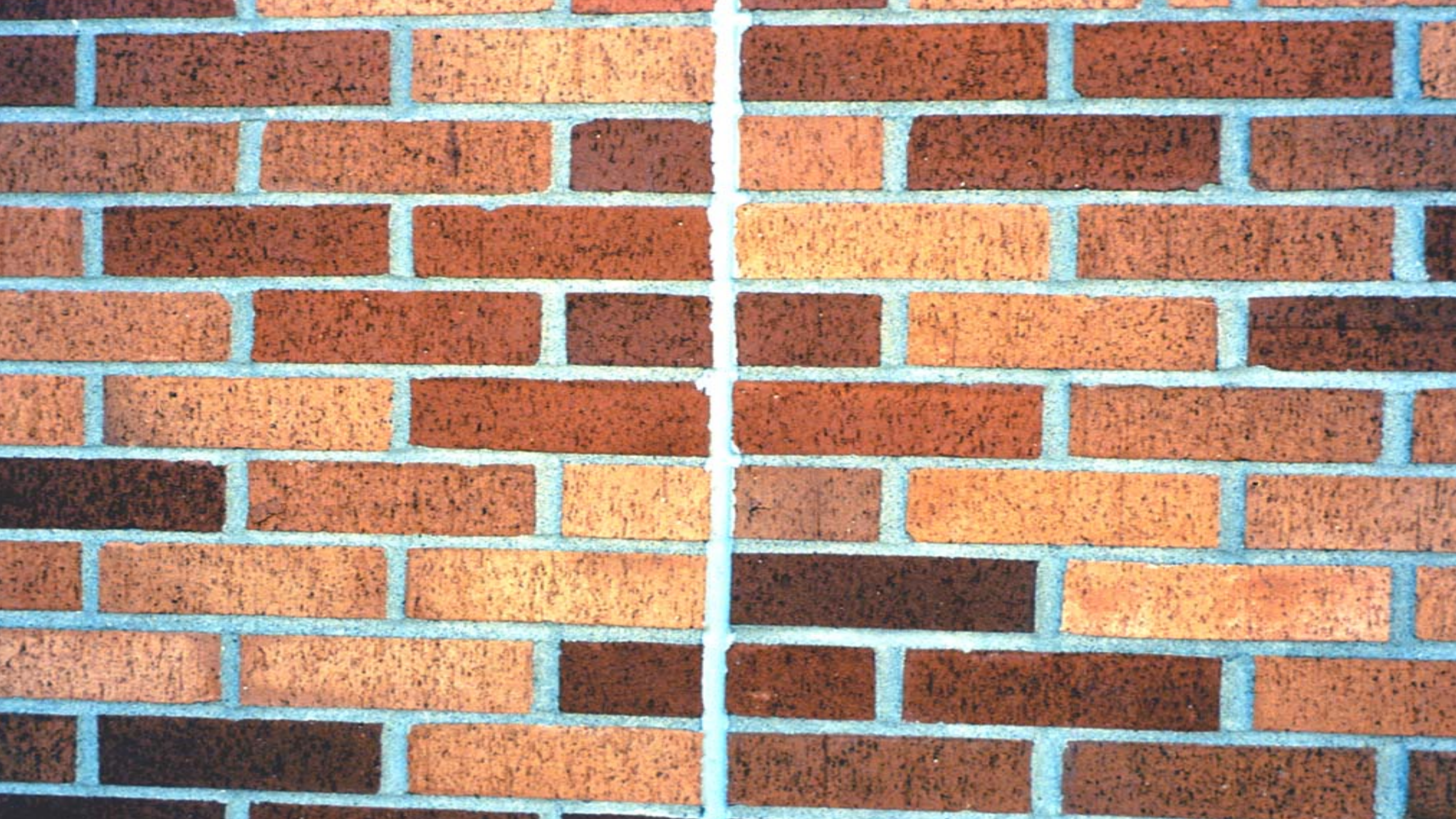


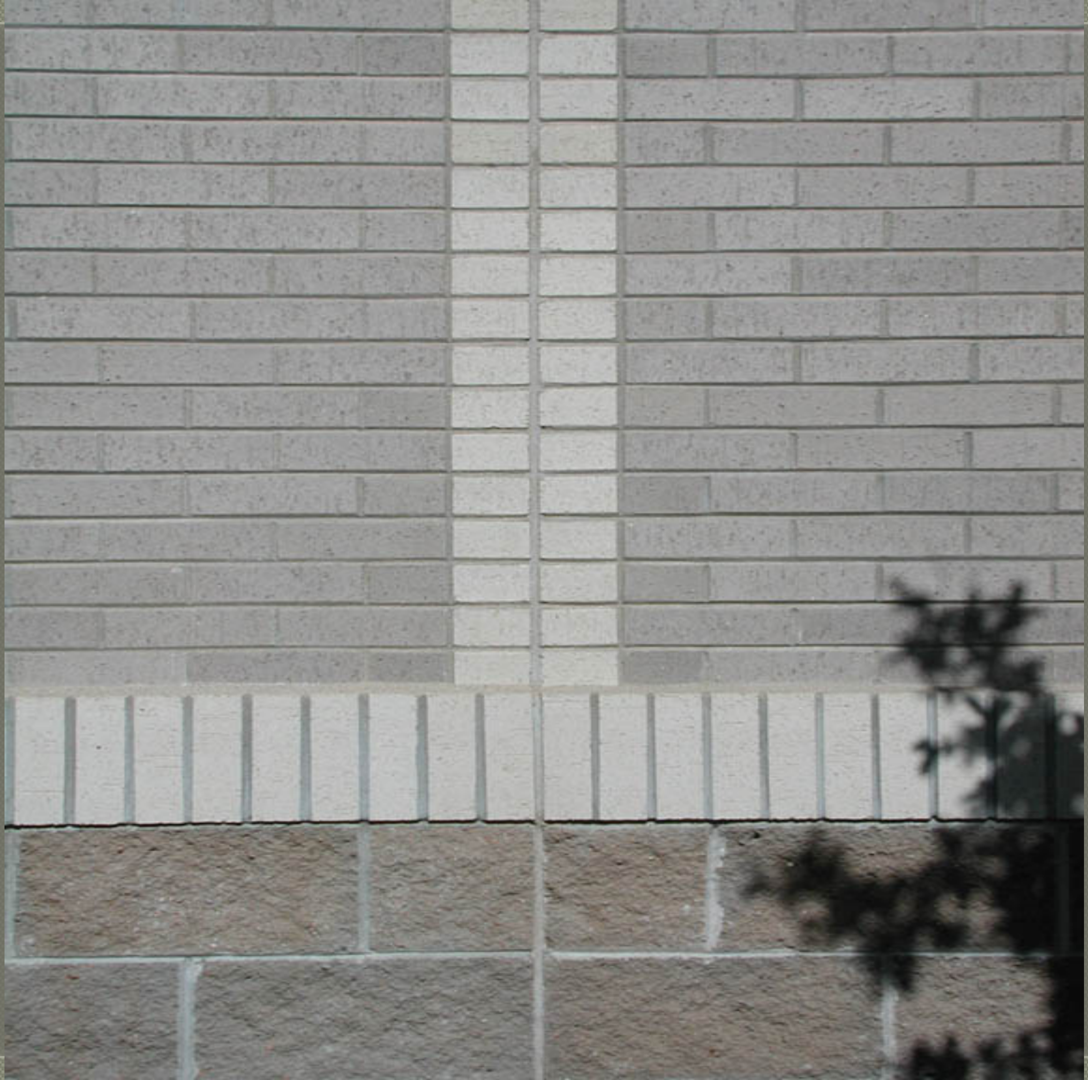
Concrete Masonry Control Joint

(May have mortar in joint)

Hiding Expansion Joints

Match sealant color to brick.
Dust wet sealant with sand.





Hide joints with brick details.
Use joint line as a feature.

Hide joints with brick details.

Use joint line as a feature.

Hiding in Plain Sight

Hide joints with brick details.

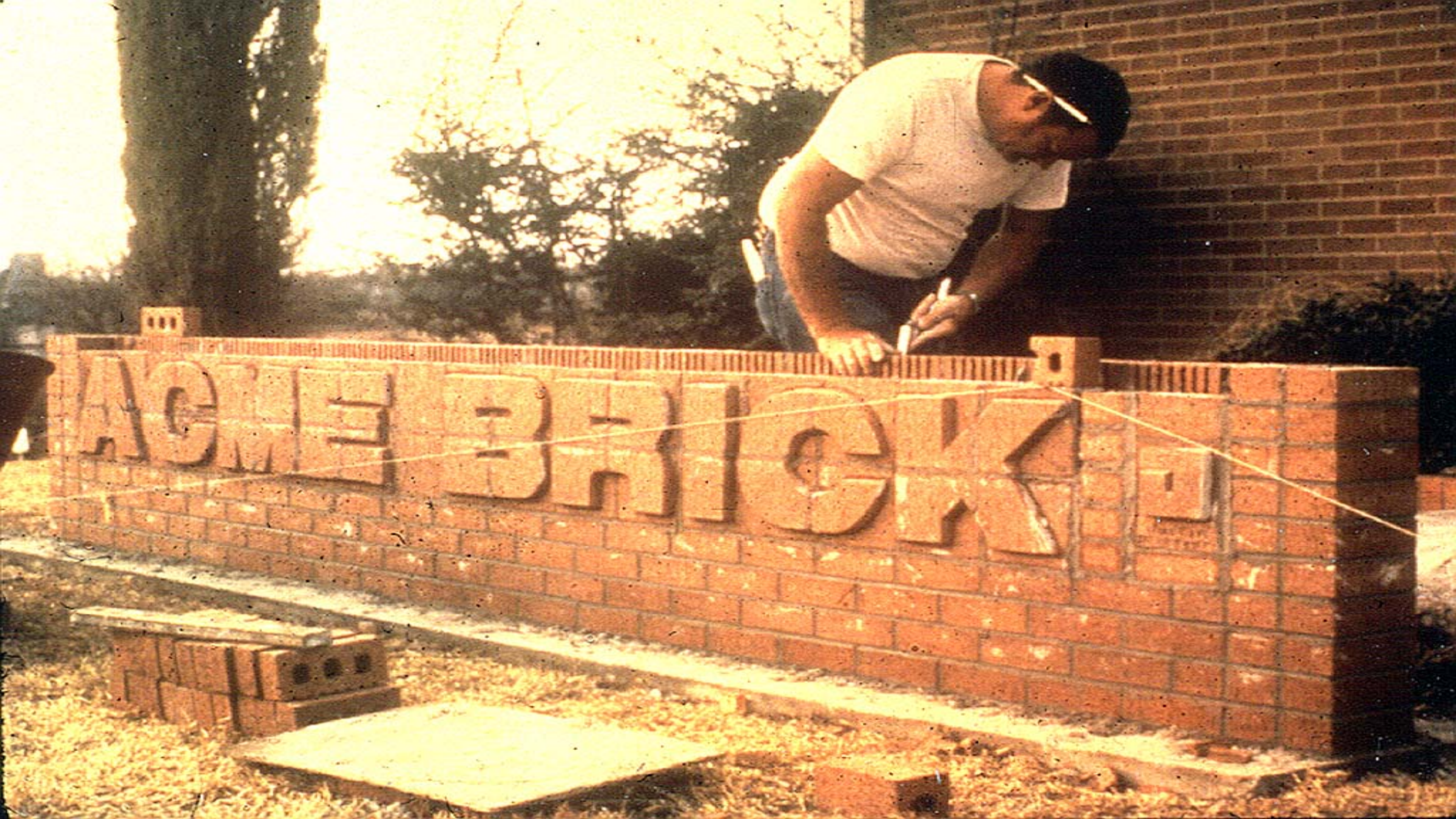
Put joints on inside corners.

Whatever you do,
keep it simple!

Beautiful Brick Work

Paris France

Art Complex 789, Beijing China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