

# **BRICK** IN ARCHITECTURE

From the Brick Industry Association



## The 2013 Brick in Architecture Award Winners



### BEST IN CLASS WINNERS

#### IN THIS ISSUE – DECEMBER 2013

Since 1989, the Brick in Architecture Awards have been one of the most prestigious national architectural award programs featuring clay brick. Architecture firms from around North America enter their best projects to be judged by a jury of their peers.

This year, architects from around the United States independently reviewed and scored each of the entries. Based on the technical and creative use of brick in meeting the aesthetic and functional design challenges, the Brick Industry Association is pleased to showcase the following projects which were chosen as the Best in Class in their respective categories.

## COMMERCIAL DESIGN

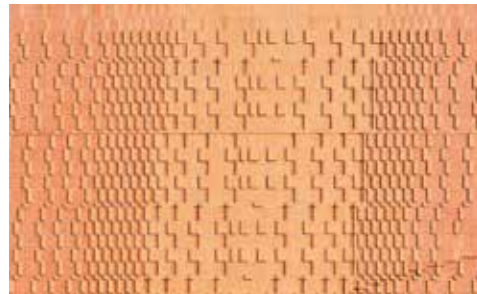
### Farm Credit Services of America Corporate Office North Building Omaha, Nebraska

#### Agricultural Motifs Come to Life With Creative Brick Patterning

When Farm Credit Services of America decided to expand their corporate offices with a 77,000-square-foot second building, their main design goal was to reinforce the agriculture-inspired concepts seen in the original building that continues to reflect the mission and culture of the organization.

On the new building's west façade, the architects used brick patterning to create an abstract representation of wind blowing through a wheat field. They achieved this striking visual effect by setting two different brick colors at varying depths and orientations.

The different depths of brick provide an ever-changing pattern of shadows throughout the day. At times, the shadows create large circles whose forms pay homage to irrigation system pivot tracks, the unique circles seen from an aerial view of the agricultural landscape. To create the superimposed circular shadow lines, the façade is separated into three fields, each with its own unique combination of brick pattern relief.



Brick is the predominant building material in the area and was a natural choice. It allowed the design team to at once express the client's abstract agricultural concepts while simultaneously conveying their long-standing connection and commitment to the region. The solidity of brick also conveys a sense of permanence that is characteristic of the client's agricultural heritage.

Brick proved to be a functional choice as well. Because of its durability, brick helps the building withstand the severe weather patterns of the area and reduce maintenance costs over its lifespan.

Finally, the architects designed the building for LEED Certification, although the official certification process has not been pursued. Nonetheless, many

green building concepts were incorporated, including the use of locally sourced brick and other materials.

In the end, brick continued to be the material of choice for the architects and client to best bring them value, function, and aesthetic benefits. ■



On the building's west façade, the architects used brick patterning to create an abstract representation of wind blowing through a wheat field.

**Architect:**

The Clark Enersen Partners

**Builder:**

Sampson Construction

**Brick Mason:**

D C Masonry Inc.

**Photographer:**

Scholzimages

Credits appear as submitted in entry form

## Golkin Hall at University of Pennsylvania Law School Philadelphia, Pennsylvania

### Brick Integrates Nineteenth Century Georgian Hall With State-of-the-Art Law Center

The new Golkin Hall completes the University of Pennsylvania Law School's architectural vision for a unified and interdisciplinary urban law campus. For the first time, the building connects the larger University with Penn Law's campus and establishes a civic-scaled public entry into the central courtyard.

The site is adjacent to the monumental nineteenth-century Georgian-style brick Silverman Hall, the Law School's former main entry and existing public face. Golkin Hall is designed as both building and bridge, as it links three existing law buildings at several levels through new bridges, roof terraces, and a 2,000-square-foot renovated student lounge.

To help unify the new building with existing structures, the architects made sure to incorporate a sand-molded brick and a distinctive Flemish Bond pattern, which can be seen throughout the campus. Golkin Hall's adjacency to Silverman Hall provided an opportunity to establish a relationship between the two buildings: one built upon multiple wythes of brick supporting robust limestone ornamentation

and the other built with a contemporary veneer skin designed to meet both energy code and exterior envelope engineering demands.



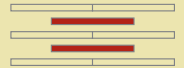
Brick is often thought of as a hard material and, when coupled with the demands of rigid programs, can appear unrelenting. However, a primary function of Golkin Hall was to provide flexibility and a diversity of spaces. Through the use of parametric modeling and scripting software, the brick wall undulates inward and carves out deep window recesses that protect interior offices from southern sun exposure.

In addition, the site's unique north-facing courtyard and south-facing urban streetscape provided just the opportunity to exploit the inherent "softness" in brick. The design team created a south street elevation that is ephemeral in character, reflecting its urban condition. On the north side facing the courtyard, the architects designed offices of varying sizes, resulting in a non-repetitive rhythm of brick piers. The transition from the urban street character to the softer, garden-like courtyard is created through the masonry skin's ability to separate and form stepped-back terraces that bring in needed light.

While still in process, Golkin Hall anticipates LEED Gold Certification. ■



To integrate the new building with existing structures, the architects incorporated a sand-molded brick and a distinctive Flemish Bond pattern, which can be seen throughout the campus.



**Architect:**

Kennedy & Violich Architecture, Ltd.

**Builder:**

Hunter Roberts Construction Group

**Manufacturers:**

The Belden Brick Company

Glen-Gery Corporation

**Distributor:**

Diener Brick Company

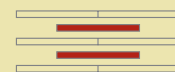
**Brick Mason:**

Dan LePore and Sons

**Photographer:**

Halkin Architectural Photography

Credits appear as submitted in entry form



# New Settlement Community Campus Bronx, New York

## Intricate Brickwork Brings Contemporary Spirit to Traditional Design

The 172,000-square-foot New Settlement Community Campus occupies a busy urban block in Bronx, New York, and houses three schools with nearly 1,100 Pre-K to 12th-grade students. Architecturally, the school blends in with its urban environment. Its solid brick façade echoes the adjacent buildings and marks the school as an enduring community asset.

Two interlocking brick volumes define the campus. The first wing is a two-story red brick commons that runs parallel to an elevated subway line. It intersects a four-story buff brick classroom wing that bends away from the street. The contrasting brick colors and course patterns distinguish each wing. A graduated vertical pattern of darker projecting brick articulates the classroom wing's façade, which is perpendicular to the elevated train to minimize noise. Each of these volumes pivots on each other to reveal the school's entrance, which is sheltered by a dramatic cantilever from the library above. This interplay of massing, materials, and patterning creates scale and interest for the block-long building.

The brickwork distinguishes the primary program spaces housed within and the volumes contrast in color,

coursing, texture, fenestration, and massing. For example, the interplay of a cream-colored face brick and a graduated vertical pattern of darker brown projecting accent brick articulates and visually reduces the massing of the four-story classroom wing. Recessing every other course of the red brick skin creates a distinct striated corrugated texture. In doing so, the design team highlights the commons wing, home to the community center, gym, auditorium, and library. In addition, openings slice and cut through the solid masonry, punctuating the more transparent elements including entries, windows, and glass-enclosed stairwells.

With a nod to the surrounding Bronx neighborhood and typical school construction in the city, the intricate brickwork lends a contemporary spirit to the exterior envelope and creates a true twenty-first-century building.



The interplay of massing, materials, and patterning creates scale and interest for the block-long building.

### Architects:

Dattner Architects and Edelman Sultan Knox Wood / Architects

### Builder:

Turner Construction Company

### Manufacturer:

The Belden Brick Company

### Brick Mason:

Mastercraft Masonry I, Inc.

### Photographer:

David Sundberg / Esto

Credits appear as submitted in entry form

## Hendricks Regional Health YMCA Avon, Indiana

### Two-Tone Brick Design Symbolizes Unity of Joint Health Care Facility

Traditionally, a hospital center, physician's office, and fitness facility would build as individual, stand-alone facilities, but the community of Avon, Indiana, has created a forward-thinking solution for these like-minded organizations. By housing all three together in the Hendricks Regional Health YMCA, residents have discovered the benefits of a seamless transition in health care. This one-stop concept lets residents conveniently access everything they need for the prevention, treatment, and maintenance of a healthy lifestyle in the same 115,000-square-foot facility.

Architecturally, the facility's primary charge was to celebrate the symbiotic relationship of health and wellness through integral use of brick and organic forms. Aesthetically, the goal was to create an iconic structure and set the architectural character for the development. The design team chose brick for its versatility in color, shape, and form, which easily conformed to the straight, angled, and curved walls used throughout the facility.

The deep brown brick color serves a dual purpose: the dark brick anchors the façade and holds up the lighter buff-colored brick while, at the same time, it creates a sense of place and familiarity consistent with the hospital brand. The two-tone scheme was easily achieved with brick, and symbolically it represents the partnership between the organizations and the promotion of both health and wellness. Brick also bestowed upon the building a monumental



character that promotes a sense of permanence, representative of the lifetime of health and wellness found inside the walls.

As a functional tool, brick was used in areas where noise and privacy were primary concerns, while glass was used in public areas. This mix of material provides visitors an intuitive understanding of the building to assist in wayfinding. Brick is also extremely versatile, durable, easy to clean, and requires little to no maintenance. As a regional and natural material, brick further reflects the "healthy" environment desired by both partners.

So far the building has exceeded the owners' expectations for usage and membership. ■



Brick bestowed upon the building a monumental character that promotes a sense of permanence, symbolic of the lifetime of health and wellness found inside the walls.



**Architect:**

American Structurepoint, Inc.

**Builder:**

Skillman Corporation

**Distributor:**

Edgewood Building Supply

**Brick Mason:**

Purdy Masonry, Inc.

**Photographers:**

Susan Fleck Photography

Tony Frederick Photography

Credits appear as submitted in entry form



# Kent R. Hance Chapel Lubbock, Texas

## Brick Brings Value and Aesthetics to a University Chapel

With a growing need for a space capable of supporting a broad range of religious services and events for students and alumni alike, administrators at Texas Tech University called for the creation of the Kent R. Hance Chapel. The non-denominational chapel is approximately 7,000 square feet and has the capacity to seat 250 guests.

Because its operation would be supported in part by gifts and donations, it was imperative that the architects select a material that was not only aesthetically pleasing but also one that was high quality, high value, and energy efficient to minimize operating costs. The team selected clay brick to fulfill all these needs.

While designed in the Spanish Renaissance style and true to the historic sections of the campus, the chapel explores the load-bearing architectural possibilities of brick in order to introduce new elements to the formal vocabulary of the University. The clearly articulated planning and bold massing of the Hance Chapel are inspired in equal parts by the sculptural qualities of the nearby historic construction and by classical ideals of proportion.

The chapel's bell tower, the curved articulation of the gabled parapet walls, and the ermine patterning of the principal façade are all instances where brick played a decisive role in the introduction of new architectural motifs. By providing exemplary

materiality and quality aesthetics, the use of brick allowed the judicious allocation of ornamentation to celebrate only the most important architectural elements.

In the case of the principal façade, the subtle inflection and patterning of the brick bond adds a heightened sense of occasion as visitors pass through the main entry.

In the end, clay brick proved to be a key element in the creation of this simple, but elegant, multifunctional chapel. ■



The chapel explores the load-bearing architectural possibilities of brick in order to introduce new elements to the formal vocabulary of the University.



**Architect:**  
McKinney York Architects  
**Manufacturer:**  
Acme Brick  
**Brick Mason:**  
Western Builders  
**Photographer:**  
Dror Baldinger

Credits appear as submitted in entry form



# Fountaindale Public Library District Bolingbrook, Illinois

## Brick Adds a Natural and Rustic Feel to a New Suburban Library

As public libraries strive for relevance in today's world, the Fountaindale Public Library designed its new building as a welcoming hub for the community. The new LEED Gold-Certified library creates a meaningful narrative about place and community and advances the state of the art in public library design.

The library is located in a suburban environment at the confluence of the village's municipal campus, tract housing developments, and a recreational park. The community envisioned a library in the park despite the library's location in a treeless landscape. The design, therefore, fulfills the community's wishes through several unique strategies.

First, with an organic shape, the building's perimeter walls mediate a pragmatic stack-driven structural grid and an imagined park environment. A single modular, hinge-shaped face brick created twenty-eight different inside and outside corner conditions.

Next, the design team employed a molded brick face to create a rustic feeling. With a rough texture, the brick gives off a more organic, tactile impression to those passing by. The brick



also represents the natural world as the units themselves are made completely from materials that occur abundantly in nature.

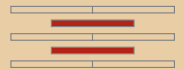
The library's landscaped outdoor terraces further create a park-like setting, but nature is also ingeniously brought inside through the glass forest. To compensate for the lack of mature trees, a shadow cast by a tree was photographed, digitally traced, and formed into custom patterned glass that encloses the upper floor. As sunlight passes through the glass, forest-like shadows move around library interiors.

Finally, the practice of sustainable design and application of LEED Gold standards were achieved not for an aesthetic benefit, but to follow in the spirit of the project's nature-oriented goals. Prior to construction, the concept of sustainable design was unknown to the client, so the project team agreed to a sustainable design goal of LEED Gold Certification because it represented a known quantity and an understandable standard for an owner being introduced to sustainable design practices.

With the goal met, the new library has been warmly embraced by the public. ■



With an organic shape, the building's perimeter walls mediate a pragmatic stack-driven structural grid and an imagined park environment.



**Architect:**  
Nagle Hartray Architecture  
**Builder:**  
Power Construction  
**Manufacturer:**  
The Belden Brick Company  
**Distributor:**  
Illinois Brick Corporation  
**Brick Mason:**  
Ramcorp  
**Photographer:**  
Ballogg Photography

Credits appear as submitted in entry form



## Pierce's Park Baltimore, Maryland

### Meandering Clay Paver Path Guides Visitors Through Downtown Park



The unexpected death of prominent Baltimore, Maryland, businessman Pierce Flanigan was the inspiration for the creation of Pierce's Park, a one-acre open space at Pier V that honors his memory. Drawing from the things he loved, the design combines art, language, music, and nature into a much-needed green space in the Inner Harbor area. Today, this area provides the growing numbers of families who have relocated to downtown Baltimore with a space to play and a sanctuary from the urban hustle and bustle.

The meandering path—made with clay brick pavers—is the primary organizing element and dominant design feature of the park. Its geometry was inspired by the flowing water and wind of the adjacent Chesapeake Bay. The curving brick path establishes the form of the park, creating two open areas where children of all ages can play. Many of the brick pavers were also engraved with homonyms such as “hear” and “here,” and were scattered throughout the park to be discovered by strolling visitors.



By focusing on non-traditional, sculptural elements, the landscape architect brought a unique and welcoming character to the park that allows visitors to interact with the park's playful elements as they wander down the modern, boardwalk-like brick pathway. A testament to Pierce Flanigan's legacy, the park has become a new model for creative open spaces in the city of Baltimore. ■



The meandering path—made with clay brick pavers—is the organizing element and dominant design feature of the park.

**Architect:**

Mahan Rykiel Associates, Inc.

**Builder:**

P. Flanigan & Sons

**Manufacturer:**

Whitacre Greer Co.

**Brick Mason:**

Priority Construction Corp.

**Photographer:**

Mahan Rykiel Associates, Inc.

Credits appear as submitted in entry form



## Warren Cultural Center Greenfield, Iowa

### Brick Plays a Key Role in Reviving Timeless Grandeur of Landmark

From the moment its doors opened in December 1896, the Opera House reigned supreme as the “grand lady” of the Greenfield, Iowa town square. With its expansive windows, oxidized copper accents, and distinctive turret, the three-story brick structure served as a landmark for culture and commerce. Though the ground floor continued to house retail businesses into the 1990s, by the late 1940s the theater space fell into complete disuse.

The building was placed on the National Register of Historic Places in 1979. Efforts to restore it, however, did not begin in earnest until 1994, when it was given to Main Street Greenfield. As part of the rehabilitation, the new owners completed an addition to house new code-required components. The materials selected for the addition replicate those used on the primary elevation facing the

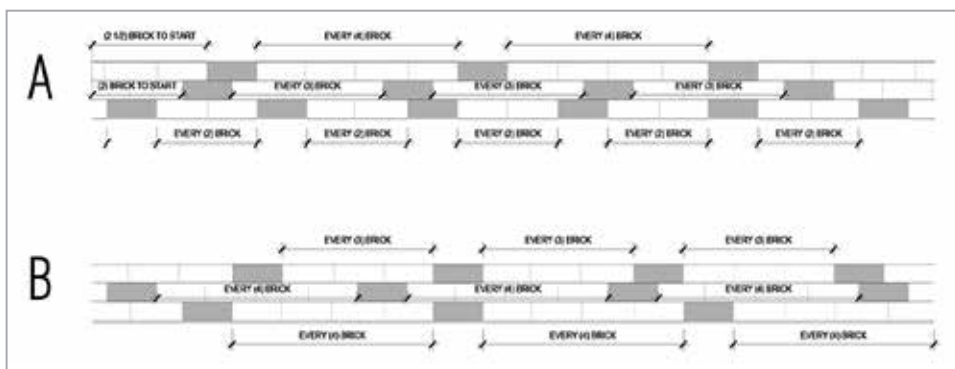
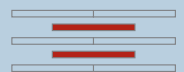
courthouse square: clay brick, glass, and metal. The design team assembled these components to recall the proportions and the organization of the historical façade.

Brick defines the service and restroom areas, and the primary historical façade is delineated as a storefront glazing base, a body of brick with punched openings, and a decorative copper cornice and pediment. This traditional composition relied heavily on the interaction and coordination of the individual craftsmen to properly tie the various materials together. The addition’s division of materials occurs vertically in a single location. This composition sped construction time and reduced the potential for the envelope to fail.

Through the work of restoration experts, the auditorium and other rooms have been returned to their original grandeur following the Secretary of the Interior’s Standards for Historic Preservation. The Warren Opera House and Hetherington Blocks of Greenfield opened its doors in the spring of 2012 and now stand as well-preserved examples of Iowa’s commercial architecture from the late nineteenth century.



Brick defines the service and restroom areas while the primary façade is delineated as a storefront glazing base, a body of brick with punched openings, and a decorative copper cornice and pediment.



**Architect:**  
INVISION Planning Architecture Interiors

**Builder:**  
Lang Construction Group, Inc.

**Manufacturer:**  
Glen-Gery Corporation

**Brick Mason:**  
Seedorf Masonry

**Photographers:**  
Integrated Studio  
INVISION Planning Architecture Interiors

Credits appear as submitted in entry form



# Gables 12 Twenty-One Arlington, Virginia

## Brick Brings a Modern Edge to an Often-Overlooked Neighborhood

Located in the city of Arlington, Virginia and overlooking the grounds of the Arlington National Cemetery, Gables 12 Twenty-One is comprised of two boutique residential buildings that each bring a modern edge to residents in this often-overlooked residential area of town.

The buildings contain forty-one units in a smaller west building and ninety units in the east building that are separated by a forthcoming pocket park. The size and scale of Gables 12 Twenty-One was thoughtfully designed to blend into the mix of building scales of single family homes on one side and the seven- to eight-story apartment towers on the other.

The project uses traditional design elements, materials, and colors but in a forward-looking composition. The façades were developed to reinforce the building's well-proportioned massing and rhythms. It was the intent of the architects to not overwhelm the surrounding context, but rather to interweave an interesting building within a neighborhood rich with details and diversity. Even the sophisticated color palette and subtle detailing of the buildings bring a unique vision to the site.

The design team used a variety of brick masonry openings to add an element of interest to the



buildings. Some openings are wide and tall—in some cases spanning over several stories. Other openings are crafted for individual windows. In all cases, a rock-faced block header accents the top and serves to add texture to the brickwork.

As an award-winning and nationally recognized vertically integrated real estate company, Gables Residential views the resulting buildings as a continued achievement that further reflects their high service standards, extensive knowledge of their markets, and expertise in development and management. ■



It was the intent of the architects to not overwhelm the surrounding context but rather to interweave an interesting building within a neighborhood rich with details and diversity.



### Architect:

The Preston Partnership

### Builder:

Gables Residential

### Manufacturer:

Glen-Gery Corporation

### Distributor:

Capital Brick & Tile, Inc.

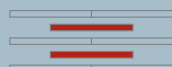
### Brick Mason:

Diverse Masonry

### Photographer:

Donna H Chiarelli Studio

Credits appear as submitted in entry form



## French Normandy Guest House Greenwich, Connecticut

### With Modern Techniques, Brick Plays a Pivotal Role in Grand Guest House

When construction began on this French Normandy guest house, it marked the culmination of nearly 18 years of collaboration between the architect and the owner. Much research had been done over that span of time, and part of the findings revealed that the architect of the site's original structures was known for his "French farmhouse style." Therefore, it seemed an appropriate style to use given the architecture of the existing accessory structures and formal Georgian main house.



The client wanted this new guest house to take inspiration from the Normandy region in France. The architect wanted an individual identity for this new parcel and not to simply repeat the extensively used Georgian aesthetic found on the property. Taking both ideas into account, the structure that emerged was an old post and beam French Normandy manor with brick nogging—long, thin Roman brick set randomly in between an authentic timber frame.

Brick provided a durable material capable of great texture and subtle color variations. Though the final layout appeared to be laid randomly, each section was meticulously planned. After studying a variety

of stylistic brick infill patterns, each bay on every elevation was hand-rendered and given to the mason as a template for construction. The mason provided mock-ups of these layouts; in turn, they allowed for the review of the mortar joint spacing and grout finish, as well as determining how the overall placement of the brick was to be modulated to create the desired effect. The skillful combination of these techniques gives the building the distinctive character that the architect desired.

Although original examples of this architectural style had true post and beam frames with masonry infill, the need for today's weather-tight construction, moisture mitigation, and compliance with energy codes demanded cavity wall construction instead. Therefore, this home has a traditional wood frame covered with plywood and breathable waterproofing. The post and beam frame was then overlaid to the outside, flashed, drained, and infilled with brick veneer inside the frame.

The end result is a modern home that embodies the rich character found in a historic style of European architecture. ■



The structure that emerged was an old post and beam French Normandy manor with brick nogging, or long, thin Roman brick set randomly in between an authentic timber frame.



**Architect:**

Charles Hilton Architects

**Builder:**

Home Construction, LLC

**Brick Mason:**

Mauro Fidaleo Construction, LLC

**Photographers:**

Nicholas Rotondi Photography

Woodruff-Brown Photography

Scott Francis, Ltd.

Credits appear as submitted in entry form



## GOLD WINNERS

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### COMMERCIAL

#### Triangle Brick Company Corporate Office and Design Center

Location: Durham, North Carolina  
Architect: Clark Nexsen / Pearce Brinkley Cease + Lee  
Builder: Barnhill Contracting Company  
Manufacturer: Triangle Brick Company  
Mason Contractor: Whitman Masonry

### EDUCATIONAL (Higher Education)

#### Molecular Plant Sciences Building

Location: East Lansing, Michigan  
Architect: SmithGroupJJR  
Builder: The Christman Company  
Mason Contractor: Schiffer Mason Contractors, Inc.

### EDUCATIONAL (K-12)

#### Sarah E. Goode STEM Academy

Location: Chicago, Illinois  
Architect: STR Partners  
Builder: FH Paschen  
Manufacturers: Glen-Gery Corporation  
Endicott Clay Products Company  
Distributor: Illinois Brick Company  
Mason Contractor: A.L.L. Masonry Construction Company

### HOUSES OF WORSHIP

#### St. John the Apostle Catholic Church

Location: Leesburg, Virginia  
Architect: Franck & Lohsen Architects  
Associate Architect: Hord Architects  
Builder: The Whiting-Turner Contracting Company  
Manufacturer: Bowerston Shale Company  
Distributor: Capital Brick & Tile, Inc.  
Mason Contractor: United Masonry Incorporated of Virginia

### MUNICIPAL / GOVERNMENT / CIVIC

#### Multipurpose Building - WV Army National Guard

Location: Kingwood, West Virginia  
Architect: Assemblage Architects  
Builder: Rycon Construction  
Manufacturer: The Belden Brick Company  
Mason Contractor: Cost Company

#### Lon Evans Corrections Center

Location: Fort Worth, Texas  
Architect: David M. Schwarz Architects  
Builder: Gilbane  
Associate Architect: Bennett Benner Pettit  
Manufacturer: Acme Brick  
Mason Contractor: Gay & Son Masonry, Inc.

### PAVING & LANDSCAPE ARCHITECTURE

#### Sutton Park

Location: Palmetto, Florida  
Architect: Moore2Design, LLC  
Landscape Architect: Allison-Gause, Inc.  
Builder: Stellar Development  
Manufacturer: Pine Hall Brick Company, Inc.  
Distributor: Ruck Brick / Oldcastle  
Mason Contractor: Timo Brothers Paving

### RENOVATION / RESTORATION

#### NSO Bell Building

Location: Detroit, Michigan  
Architect: Fusco, Shaffer & Pappas, Inc.  
Builder: O'Brien Edwards Construction  
Manufacturer: Endicott Clay Products Company  
Distributor: Brick Tech Architectural  
Mason Contractor: RAM Construction Services, Inc.

### RESIDENTIAL – MULTI-FAMILY

#### 1225 Old Town

Location: Chicago, Illinois  
Architect: Hartshorne Plunkard Architecture  
Builder: Lend Lease  
Distributor: Illinois Brick Company  
Mason Contractor: Illinois Masonry Corp.

### RESIDENTIAL – SINGLE FAMILY

#### Main Street House

Location: New Albany, Mississippi  
Architect: Ryall Porter Sheridan Architects  
Manufacturer: Columbus Brick Company  
Mason Contractor: Steven Willard

## SILVER WINNERS

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### COMMERCIAL

#### Cuyahoga Community College and The Collection Auto Group Center

Location: Cleveland, Ohio  
Architect: Richard Fleischman + Partners Architects, Inc.  
Builder: Thomarios  
Manufacturer: Endicott Clay Products Company  
Distributor: The Thomas Brick Company  
Mason Contractor: Sidley Precast Group

### EDUCATIONAL (Higher Education)

#### Weyerhaeuser Center for Health Sciences

Location: Tacoma, Washington  
Architect: Bohlin Cywinski Jackson  
Builder: GLY Construction  
Mason Contractor: Keystone Masonry Inc.

### EDUCATIONAL (K-12)

#### Cresthaven Elementary School

Location: Silver Spring, Maryland  
Architect: Sorg Architects  
Manufacturer: The Belden Brick Company  
Mason Contractor: George Moehrle Masonry

# The 2013 Brick in Architecture Award Winners

## MUNICIPAL / GOVERNMENT / CIVIC

### Riverdale Town Center

Location: Riverdale, Georgia  
Architect: Sizemore Group  
Builder: New South Construction  
Manufacturer: General Shale, Inc.  
Mason Contractor: C & M Masonry Contractors, Inc.

## PAVING & LANDSCAPE ARCHITECTURE

### Hawthorne Park

Location: Philadelphia, Pennsylvania  
Architect: LRSLA Studio, Inc.  
Landscape Architect: LRSLA Studio, Inc.  
Builder: Miniscalco Construction  
Manufacturer: Whitacre Greer Co.  
Distributor: Church Brick Company  
Mason Contractor: Eastern States Paving

## RENOVATION / RESTORATION

### Building 13

Location: Great Lakes, Illinois  
Architect: Johnson Lasky Architects  
Builder: VCO Vennen Company  
Associate Architect: EME, LLC  
Mason Contractor: Ramirez Construction Co.

### The End of the Road

Location: Bethesda, Maryland  
Architect: Muse Architects  
Builder: Horizon Builders, Inc.  
Mason Contractor: B&B Masonry

## RESIDENTIAL – MULTI-FAMILY

### Wormley School Rowhouses

Location: Washington, District of Columbia  
Architect: Cunningham I Quill Architects  
Builder: Encore Development  
Manufacturer: Glen-Gery Corporation  
Distributor: Capital Brick & Tile, Inc.  
Mason Contractor: Wells & Associates, Inc.

## RESIDENTIAL – SINGLE FAMILY

### Ravenswood Residence

Location: Chicago, Illinois  
Architect: Burns + Beyerl Architects  
Builder: Eriksen Armstrong Corporation  
Manufacturer: Redland Brick Inc.  
Mason Contractor: Robert Niemiec / Professional Masonry

## BRONZE WINNERS

## EDUCATIONAL (Higher Education)

### Cougar Woods Dining Hall

Location: Houston, Texas  
Architect: PageSoutherlandPage  
Builder: SpawGlass  
Manufacturer: Acme Brick  
Distributor: Upchurch Kimbrough Company  
Mason Contractor: City Masonry

### University of Delaware Campus Bookstore & Development Office

Location: Newark, Delaware  
Architect: DIGSAU  
Builder: BPGS Construction, LLC  
Manufacturer: The Belden Brick Company  
Mason Contractor: Rizzo, Joseph & Sons Construction Co., Inc.

### University of Wisconsin Oshkosh Horizon Village (New Residence Hall)

Location: Oshkosh, Wisconsin  
Architect: VOA Associates Incorporated in association with  
Berners-Schober  
Manufacturer: Endicott Clay Products Company  
Mason Contractor: Miron Construction Company, Inc.

## MUNICIPAL / GOVERNMENT / CIVIC

### Arlington County Fire Station No. 3

Location: Arlington, Virginia  
Architect: Hughes Group Architects  
Builder: The Whiting-Turner Contracting Company  
Manufacturer: Glen-Gery Corporation  
Distributor: Capital Brick & Tile, Inc.  
Mason Contractor: United Masonry

## PAVING & LANDSCAPE ARCHITECTURE

### Salvation Army College for Officer Training Playground

Location: Chicago, Illinois  
Architect: Harding Partners  
Landscape Architect: CYLA Design Associates  
Builder: W.B. Olson, Inc.  
Manufacturer: The Belden Brick Company  
Mason Contractor: Crouch-Seranko Masonry, LLC

## RENOVATION / RESTORATION

### Gertrude Ederle Recreation Center

Location: New York, New York  
Architect: Belmont Freeman Architects  
Associate Architect: Bargmann Hendrie + Archetype  
Manufacturer: The Belden Brick Company  
Mason Contractor: Padilla Construction Services, Inc.

### Milan Readiness Center

Location: Milan, Illinois  
Architect: Bailey Edward Design  
Builder: Swanson Construction  
Manufacturer: Glen-Gery Corporation  
Mason Contractor: Seedorff Masonry

All credit information appears as it was provided in the entry by the architect or BIA member company.

*BIA would like to thank this year's judges for their efforts and expertise.*

Allison Anderson – Unabridged Architecture

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Preston Gumberich – Robert A.M. Stern Architects LLP

Jeff Knopp – Behnke Associates

Marvin Malecha – College of Design, NC State University

Dave Otte – Holst Architecture

Eric Penney – Nagle Hartray Architecture

Bruce Schenk – Mark B. Thompson Associates

Vanessa Schutte – DLR Group

Donald Selander – Pedcor Design Group

Bruce Wood – Kallmann McKinnell & Wood Architects

Read the following learning objectives to focus your study while reading this article. To receive credit, follow the instructions found at the end of the article which direct you to complete the AIA questionnaire.

## Learning Objectives

After reading this article you should be able to:

1. Recognize the implications of a brick arch's shape on its load capacity and required strength as chronicled through the development of arch construction.
2. Select correct arch type and utilize correct arch terminology to ensure the form and stability of a brick arch.
3. Examine how to detail self-supporting brick veneer arches properly in construction documents to ensure satisfactory arch performance.
4. Design self-supporting brick veneer arches with spans up to 6 feet using prescriptive criteria and simple formulas.

Louis Kahn used to tell his students: if you are ever stuck for inspiration, ask your materials for advice. “You say to a brick, ‘What do you want, brick?’ And brick says to you, ‘I like an arch.’”

Louis Kahn's oft-quoted dialogue with brick characterized his relationship with brick masonry. He understood well that untainted, simple brick masonry—unencumbered by reinforcing, steel lintels or shelf angles—could gracefully support itself through the use of arches. He knew that brick masonry was strong in compression, that the size of the mortar joint could be tapered and varied to create a curve, and that the individual brick between the mortar joints was small enough to result in an elegant arch.

Tracing the history of the arch requires that we go back in time to consider the first openings in masonry walls—with the use of lintels and corbels in stone masonry. Masonry lintels typically consisted of longer, taller masonry units. These units were located in the masonry course immediately above the opening and were supported by the segment of masonry wall on each side of the opening. Masonry lintels can also be supported by posts or columns as was the case at the Ggantija temple complex on the Mediterranean island of Gozo in Malta. This temple complex was constructed of stone during the Neolithic Age (3600-2500 BC), which makes its structures older than the pyramids of Egypt.

Corbeling involves making each course of masonry extend beyond the course below it. Only masonry that had sufficient overlap of masonry units from one course to the next can be corbelled and remain stable. For an opening to be spanned by corbeling, each successive course of masonry in the segment of wall on each side of the opening is extended slightly toward the center until the opening is spanned. Sometimes the corbelled masonry units were cut on a slant in such a way that the opening created by the corbeling was shaped like a triangle.

The earliest use of corbeling is found in the Tomb at Newgrange located

in Boyne Valley, Ireland, and dates from about 3000 BC. This site contains a vault constructed of corbelled stones that were set without mortar to support the earthwork above. The stone corbeling of these vaults was so well constructed that they have survived to this day virtually as they were placed on the day they were built.

No one really knows when the first brick arch was constructed. One of the oldest-known brick arches is found at the Edublalmahr temple in ancient Ur in Mesopotamia and dates to between 2000 and 1400 BC. This arch is made of mud brick and is in the shape of a semicircle. Another brick arch in the Bronze Age city of Ashkelon, a Mediterranean port located in the current nation of Israel, dates to around 1850 BC. This was also an arch constructed from mud brick but it was shaped like a parabola—with its height longer than its span of 8 feet.

Until the seventeenth century, the design of brick masonry arches was determined entirely by rules of proportion that had evolved over time by trial and error. It was not until 1675, when Robert Hooke wrote that he had discovered “a true mathematical and mechanical form of all manner of arches for building,” that designers began to gain



©Bill Alexander  
Architect: Earl Swenson Associates, Inc.  
Manufacturer: The Belden Brick Company

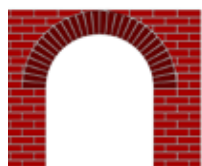
an understanding of the mechanics behind arches. But only in 1705, after Hooke's death, did the executor to his estate reveal that such an arch was, in fact, an inverted catenary curve—the shape assumed by a chain under its own weight when held at each end. Hooke realized that the hanging chain and the arch both must be in equilibrium. Just as a chain can support only tension, a true masonry arch must support only compression.

In 1743, Giovanni Poleni applied Hooke's hanging chain principle when assessing the cracked dome of St. Peter's Basilica in Rome. To do this, he built a model of the dome and divided it into 50 slices. For each opposing pair of slices, he hung 32 unequal weights which were proportional to the weight of its corresponding section of the dome. He then showed that when these weights were applied to a chain, the resulting shape of the chain could be inverted and fit within the depth of the masonry section of the dome it represented. Thus, knowing that the chain must assume the shape of the line of force within it, and that the tensile stress within the chain would be equivalent to the compressive stress if it could be inverted, he demonstrated that the depth of the masonry section of the dome was safe to carry those loads.

Many applied their focus to more formal methods of analyzing arches. Most built upon the line of thrust method, which defines the primary load path that forces take as they make their way down through each element of the arch. The next major advancement in arch theory occurred in 1858 when William Rankine proposed that if the line of thrust of an arch was within the middle third of its cross-section (e.g., the middle third of its depth and of its thickness), then the stability of the arch was guaranteed. This theory is still applied in arch design today.

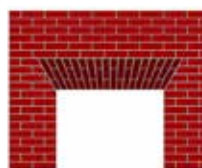
**Arch Types**

Arch forms have evolved over many centuries. An arch is normally classified by the curve of its intrados (lower edge) and by its function, shape or architectural style. The four most common types of arches used in contemporary brickwork are shown as follows:



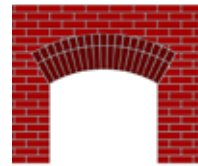
Semicircular

**Semicircular Arch** – An arch whose intrados is a semicircle (half circle).



Jack

**Jack Arch** – A flat arch with zero or little rise.



Segmental

**Segmental Arch** – An arch whose intrados is circular but less than a semicircle.



Multicentered

**Multicentered Arch** – An arch whose curve consists of several arcs of circles which are normally tangent at their intersections.

Arches not as common today were more prominent in antiquity. Some were more favored in certain regions of the world. These are shown below:



Bullseye

**Bullseye Arch** – An arch whose intrados is a full circle. Also known as a Circular arch.



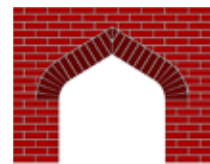
Horseshoe

**Horseshoe Arch** – An arch whose intrados is greater than a semicircle and less than a full circle. Also known as an Arabic or Moorish arch.



Gothic

**Gothic Arch** – An arch with relatively large rise-to-span ratio, whose sides consist of arcs of circles, the centers of which are at the level of the spring line. Also referred to as a Drop, Equilateral or Lancet arch, depending upon whether the spacings of the centers are respectively less than, equal to or more than the clear span.



Tudor

**Tudor Arch** – A pointed, four-centered arch of medium rise-to-span ratio whose four centers are all beneath the extrados of the arch.



Triangular

**Triangular Arch** – An arch formed by two straight, inclined sides.



Venetian

**Venetian Arch** – An arch formed by a combination of jack arch at the ends and semicircular arch at the middle. Also known as a Queen Anne arch.

## Arch Terminology

A unique vocabulary to describe a variety of arch components and elements has developed. Figure 3 illustrates many of the terms used. Below is a glossary defining arch terminology used throughout the remainder of this article.

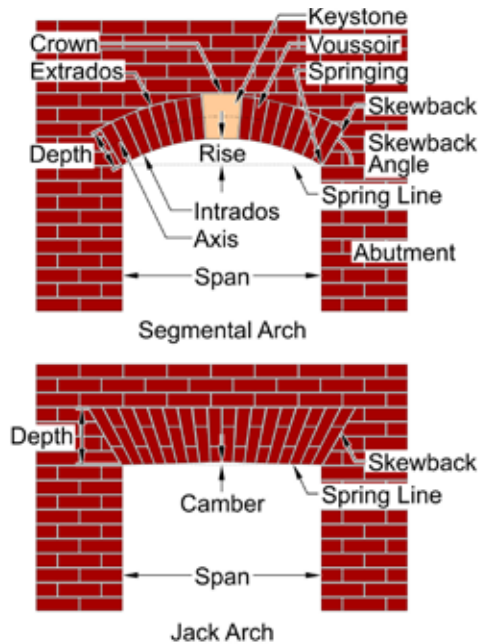


Figure 3. Arch Terminology

**Abutment:** The masonry or combination of masonry and other structural members which support one end of the arch at the skewback.

**Camber:** The relatively small rise of a jack arch.

**Centering:** Temporary shoring used to support an arch until the arch becomes self-supporting.

**Crown:** The apex of the arch's extrados. In symmetrical arches, the crown is at the midspan.

**Depth:** The dimension of the arch at the skewback which is perpendicular to the arch axis, except that the depth of a jack arch is taken to be the vertical dimension of the arch at the springing.

**Extradados:** The curve which bounds the upper edge of the arch.

**Intrados:** The curve which bounds the lower edge of the arch. The distinction between soffit and intrados is that the intrados is a line, while the soffit is a surface.

**Keystone:** The voussoir located at the crown of the arch. Also called the key.

**Label Course:** A ring of projecting brickwork that forms the extrados of the arch.

**Rise:** The maximum height of the arch soffit above the level of its spring line.

**Skewback:** The surface on which the arch joins the supporting abutment.

**Skewback Angle:** The angle made by the skewback from horizontal.

**Soffit:** The surface of an arch or vault at the intrados.

**Span:** The horizontal clear dimension between abutments.

**Spandrel:** The masonry contained between a horizontal line drawn through the crown and a vertical line drawn through the upper most point of the skewback.

**Springing:** The point where the skewback intersects the intrados.

**Springer:** The first voussoir from a skewback.

**Spring Line:** A horizontal line which intersects the springing.

**Voussoir:** One masonry unit of an arch.

## DETAILING CONSIDERATIONS

A brick masonry arch should serve its structural purpose and provide water resistance as well as provide an attractive architectural element to complement its surrounding structure. Careful consideration should be given to the options available for the arch, soffit and skewback. Proper configuration of the abutments and location of expansion joints should be considered for any arch design.

### Flashing and Weeps

Preventing water entry at an arch in an exterior building wall is just as important as at any other wall opening. Water penetration resistance can be provided by using a drainage wall system or a barrier wall system. Refer to *Technical Note 7* for definitions and discussion of barrier and drainage wall systems. A drainage wall system, such as a brick veneer or cavity wall, is the most common brick masonry wall system used today. For either wall system, the arch should be flashed, with weeps provided above all flashing locations.

Installation of flashing and weeps around an arch can be difficult. Installation of flashing is easiest with jack arches because they are flat or nearly flat. Tray flashing that extends a minimum of 4 in. (102 mm) past the wall opening at each end and is turned up to form end dams should be installed below the arch and above the window framing or steel angle lintel. Weeps should be provided at both ends of the flashing and along the arch span. A maximum spacing of 24 in. (610 mm) is recommended for open head joint weeps, or 16 in. (406 mm) if rope wicks or tubes are used. An example of flashing a jack arch in this manner is shown in Figure 4. Attachment of the flashing to the backing and formation of end dams should follow standard procedures. If the arch is constructed with reinforced brick masonry, place flashing and weeps in the first masonry course above the arch.



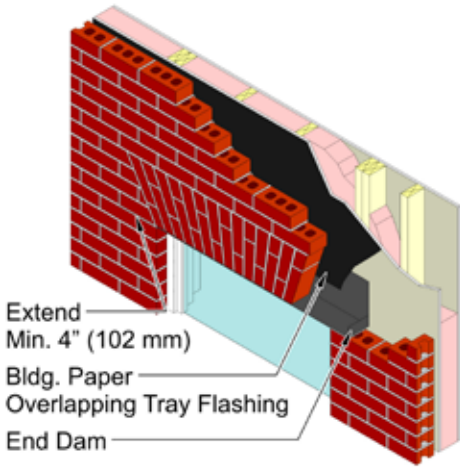


Figure 4. Flashing at Jack Arch

Installation of flashing with other arch types, such as segmental and semicircular arches, can be more difficult. This is because most rigid flashing materials are hard to bend around an arch with tight curvature. If the arch span is less than about 3 ft. (0.91 m), one section of tray flashing can be placed in the first horizontal mortar joint above the keystone, as illustrated in Figure 5. For arch spans greater than 3 ft. (0.91 m), flashing can be bent along the curve of the arch with overlapping sections or a combination of stepped and tray flashing can be used, as shown in Figure 6. To form a step, the end nearest the arch is turned up to form an end dam, while the opposite end is laid flat. A minimum of No. 15 building paper or equivalent moisture resistant protection is installed on the exterior face of the backing over the full height of the arch and abutments. The building paper or equivalent should overlap the pieces of arch flashing.

The design of a structural masonry arch should include consideration of the effect of flashing on the strength of the arch. Flashing acts as a bond break. If flashing is installed above the arch, the loading on the arch will likely be increased, and the structural resistance of the arch will be

reduced. Installation of flashing at the abutments will affect their structural resistance and should also be considered. Refer to BIA *Technical Note 31A* for a more extensive discussion of arch loads and structural resistance of brick masonry arches.

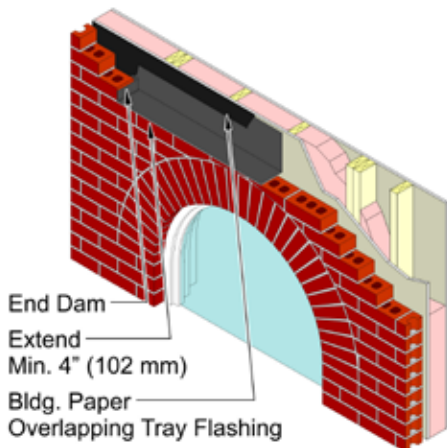


Figure 5. Tray Flashing at Short Span Semi-Circular Arch

**Arch Configuration**

Arches can be configured in a variety of depths, brick sizes, shapes and bonding patterns. The arch is normally composed of an odd number of units for aesthetic purposes. Some of the more common arch

configurations are illustrated in Figure 7. Arch voussoirs are typically laid in radial orientation and are most often of similar size and color to the surrounding brickwork. However, the arch can be formed with brick which are thinner or wider than the surrounding brickwork and of a different color for contrast. Another variation is to project or recess rings of multiple-ring arches to provide shadow lines or a label course.

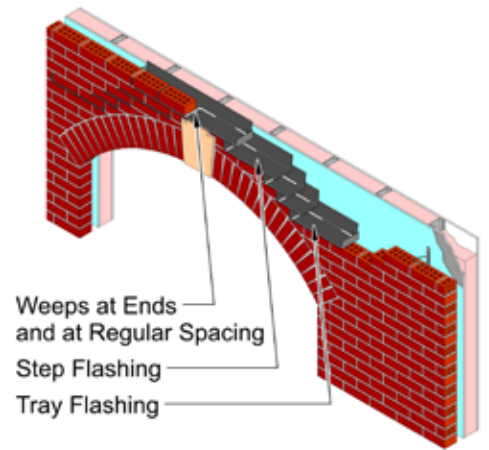


Figure 6. Stepped Flashing at Long Span Arch

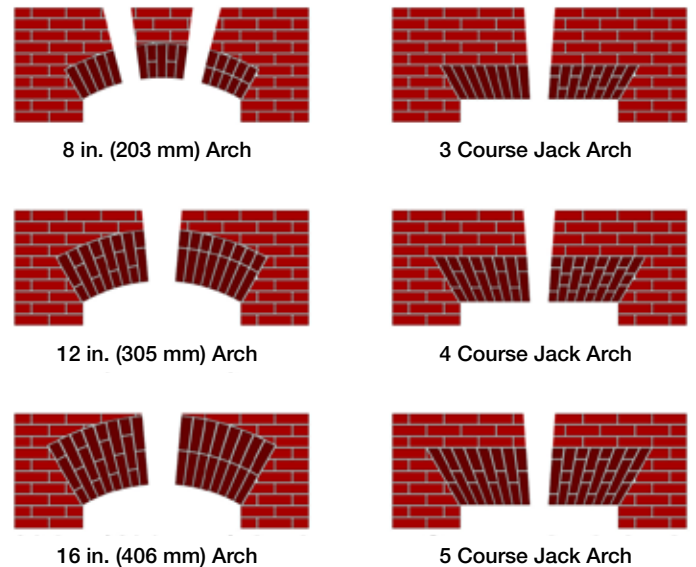


Figure 7. Typical Arch Configurations

Brick masonry arches are constructed with either wedge-shaped or rectangular brick. Wedge-shaped brick are tapered in the appropriate manner to obtain mortar joints of uniform thickness along the arch depth. When rectangular brick are used, the mortar joints are tapered to obtain the desired arch curvature. In some cases, a combination of these is used. For example, a slanted arch is formed with a tapered keystone

and rectangular voussoirs. This arch is similar to a jack arch, but can be more economical because it requires only one special-shaped brick.

Selection of tapered or rectangular brick can be determined by the arch type, arch dimensions and by the appearance desired. Some arch types require more unique shapes and sizes of brick if uniform mortar joint thickness is desired. For example, the brick in a traditional jack arch or elliptical arch are all different sizes and shapes from the abutment to the keystone. Conversely, the voussoirs of a semicircular arch are all the same size and shape. Arch types with many different brick shapes and sizes should be ordered pre-cut from the brick manufacturer rather than cut in the field.

The arch span should also be considered when selecting the arch brick. For short arch spans, use of tapered brick is recommended to avoid excessively wide mortar joints at the extrados. Larger span arches require less taper of the voussoirs and, consequently, can be formed with rectangular brick and tapered mortar joints. The thickness of mortar joints between arch brick should be a maximum of 3/4 in. (19 mm) and a minimum of 1/8 in. (3 mm). When using mortar joints thinner than 1/4 in. (6 mm), consideration should be given to the use of very uniform brick that meet the dimensional tolerance limits of ASTM C216, Type FBX, or the use of gauged brickwork. Refer to Table 1 for determination of the minimum segmental and semicircular arch radii permitted for rectangular brick and tapered mortar joints. Typically, the use of tapered brick and uniform thickness mortar joints will be more aesthetically appealing.

Nominal Brick Dimensions		Minimum Arch Radius at Intrados	
Depth of Arch	Width of Voussoir	1/2" (12.7 mm) Joint Width at Extrados	3/4" (19.1 mm) Joint Width at Extrados
4 in. (102 mm)	2 2/3 in. (68 mm)	1'-10 7/8" (0.58 m)	1'-1 5/8" (0.35 m)
	3 1/5 in. (81 mm)	2'-3 5/8" (0.70 m)	1'-4 5/8" (0.42 m)
	4 in. (102 mm)	3'-0" (0.91 m)	1'-9 5/8" (0.55 m)
8 in. (203 mm)	2 2/3 in. (68 mm)	4'-0 1/4" (1.23 m)	2'-5" (0.74 m)
	3 1/5 in. (81 mm)	4'-10 3/8" (1.48 m)	2'-11" (0.89 m)
	4 in. (102 mm)	6'-4 1/8" (1.93 m)	3'-9 3/4" (1.16 m)
12 in. (305 mm)	2 2/3 in. (68 mm)	6'-1 5/8" (1.87 m)	3'-8 1/8" (1.12 m)
	3 1/5 in. (81 mm)	7'-5 1/8" (2.26 m)	4'-5 1/2" (1.36 m)
	4 in. (102 mm)	9'-8 1/4" (2.95 m)	5'-9 3/4" (1.77 m)
16 in. (406 mm)	2 2/3 in. (68 mm)	8'-2 3/4" (2.51 m)	4'-11 3/8" (1.51 m)
	3 1/5 in. (81 mm)	9'-11 3/4" (3.04 m)	5'-11 7/8" (1.83 m)
	4 in. (102 mm)	13'-0 1/4" (3.97 m)	7'-9 3/4" (2.38 m)

Table 1  
Minimum Radius for Arches using Uncut Rectangular Brick

**Depth.** The arch depth will depend upon the size and orientation of the brick used to form the arch. Typically, the arch depth is a multiple of the brick's width. For structural arches, a minimum arch depth is determined from the structural requirements. If the arch is supported by a lintel, any arch depth may be used.

The depth of the arch should also be detailed based on the scale of the arch in relation to the scale of the building and surrounding brickwork. To provide proper visual balance and scale, the arch depth should increase with increasing arch span. Because aesthetics of an arch are subjective, there are no hard rules for this. However, the following rules of thumb provide guidance on determining the proper scale of an arch. For segmental and semicircular arches, the arch depth should equal or exceed 1 in. (25 mm) for every foot (305 mm) of arch span or 4 in. (102 mm), whichever is greater. For jack arches, the arch depth should equal or exceed 4 in. (102 mm) plus 1 in. (25 mm) for every foot (305 mm) of arch span or 8 in. (203 mm), whichever is greater. For example, the minimum arch depth for an 8 ft. (2.44 m) span is 8 in. (203 mm) for segmental arches and 12 in. (305 mm) for jack arches.

The depth of jack arches is also a function of the coursing of the surrounding brick masonry. The spring line and the extrados of the jack arch should coincide with horizontal mortar joints in the surrounding brick masonry. Typically, the depth of a jack arch will equal the height of 3, 4 or 5 courses of the surrounding brickwork, depending upon the course height.

**Keystone.** The keystone may be a single brick, multiple brick, stone, precast concrete or terra cotta. Avoid using a keystone which is much taller than the adjacent voussoirs. A rule of thumb is that the keystone should not extend above adjacent arch brick by more than one third the arch depth. When a keystone is used that is larger than adjacent arch brick or formed with different material, one option is to use springers that match the keystone.

If the keystone is formed with more than one masonry unit, avoid placing the smaller unit at the bottom. Such units are more likely to slip when the arch settles under load. Also, it is preferred to have the arch crown (the top of the keystone) coincident with a horizontal mortar joint in the surrounding brickwork to give the arch a neater appearance.

The use of a large keystone has its basis in both purpose and visual effect. With most arch types, the likely location of the first crack when the arch fails is at the mortar joint nearest to the midspan of the arch. Use of a large keystone at this point moves the first mortar joint further

from the midspan and increases the resistance to cracking at this point. Aesthetically, a large keystone adds variation of scale and can introduce other masonry materials in the facade for additional color and texture.

**Soffit**

A brick masonry soffit is one attractive feature of a structural brick masonry arch. Many bonding patterns and arrangements can be used to form the arch soffit. Deep soffits are common on building arcades or arched entranceways. In this case, it is common to form a U-shaped wall section, as illustrated in Figure 8. The arches on each wall face should be bonded to the brick masonry forming the soffit. Bonding pattern or metal ties are used to tie the brick masonry forming the soffit together structurally and to tie the arches on each wall face to the soffit. If metal ties are used to bond the masonry, corrosion resistant box or

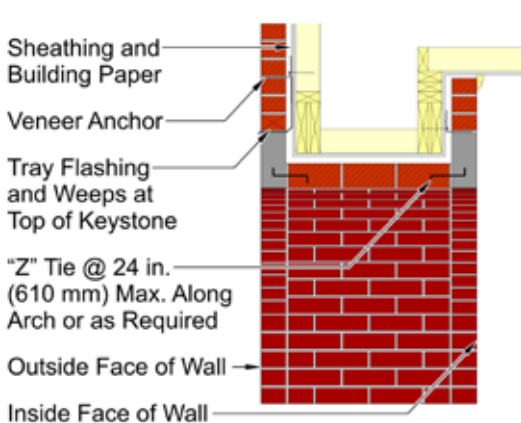


Figure 8. Stepped Flashing at Long Span Arch

Z metal wire ties should be placed along the arch span at a maximum spacing of 24 in. (610 mm) on center.

Structural resistance of the arch should be

evaluated at sections through the soffit, the exterior wall face and the interior wall face. Deeper soffits may require an increase in arch depth. If the arch is structural, connection of the brick masonry forming the soffit to interior framing members with veneer anchors or connectors may not be required.

**Skewback**

For jack arches and arch types that have horizontal skewbacks, such as semicircular arches, the most desirable spring line location is coincident with a bed joint in the abutment. For other arch types, it is preferred to have the spring line pass about midway through a brick course in the abutment, as illustrated in Figure 9, to avoid a thick mortar joint at the springing. The brick in the abutment at the springing should be cut or be a special cant-shaped brick. This allows vertical alignment with the brick beneath, producing more accurate alignment of the arch.

When two arches are adjacent, such as with a two-bay garage or building arcades, intersection of the arches may occur at the skewback.

Attention should be given to proper bonding of the arches for both visual appeal and structural bonding. Creation of a vertical line between arches should be avoided. Rather, special shape brick should be used at the intersection of the two arches. One example is illustrated in Figure 10.

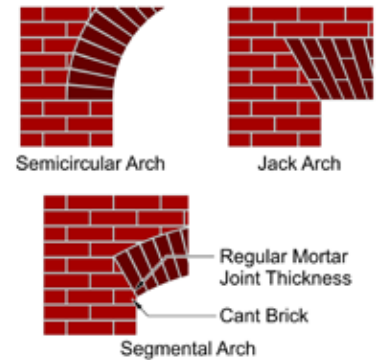


Figure 9. Arch Skewbacks

**Abutments**

An arch abutment can be a column, wall or combination of wall and shelf angle. Failure of an abutment occurs from excessive lateral movement or exceeding the flexural, compressive or shear strength

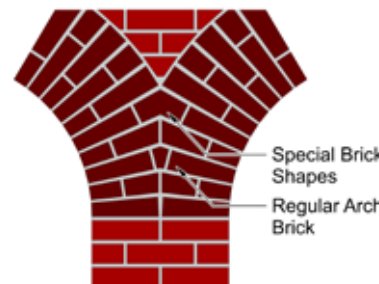


Figure 10. Intersecting Arches

of the abutment. Lateral movement of the abutment is due to the horizontal thrust of the arch. Thrust develops in all arches with the thrust force greater in flatter arches. The thrust must be resisted so that lateral movement of the abutment does not cause failure of the arch. If the abutment is formed by a combination of brickwork and a non-masonry structural member, rigidity of the non-masonry structural member and rigidity of the ties are very important. Adjustable anchors or single or double wire ties are recommended. Corrugated anchors should not be used in this application because they do not provide adequate axial stiffness. Consult BIA *Technical Note 31A* for further discussion of abutment and tie stiffness requirements.

**Lateral Bracing**

In addition to gravity loads, out-of-plane loads should be considered when designing a masonry arch. The arch should have adequate resistance to out-of-plane loads or lateral bracing should be provided. In veneer construction, lateral bracing is provided by the backing through the use of veneer anchors. Arches which are not laterally braced may require increased masonry thickness or reinforcement to carry loads perpendicular to the arch plane in addition to vertical loads.

**Expansion Joints**

Thermal and moisture movements of brick masonry are controlled by expansion joints. Expansion joints prevent cracking of the brickwork by reducing the size of wall sections. Reduction of wall size has

a very important effect upon the performance of structural brick masonry arches. The state of stress in a structural brick arch and the surrounding masonry is very sensitive to the relative movements of the abutments. If an inadequate number of expansion joints are provided, the differential movement of abutments can cause cracking and downward displacement of brick in the masonry arch and surrounding masonry. Proper size and spacing of expansion joints is discussed in BIA *Technical Note 18A*.

If an arch is structural, care should be taken not to affect the integrity of the arch by detailing expansion joints too close to the arch and its abutments. Vertical expansion joints should not be placed in the masonry directly above a structural arch. Because this region of masonry is in compression, movement occurring at an expansion joint will result in displacement when centering is removed and possible collapse of the arch and surrounding brickwork. Placing vertical expansion joints in close proximity to the springing should also be avoided. An expansion joint near the springing reduces the effective width of the abutment and its ability to resist horizontal thrust from the arch. If an arch is not structural, placement of expansion joints may be at the arch crown and also at a sufficient distance away from the springing to avoid sliding. While permitted, placement of an expansion joint at the arch crown is not preferred because it disrupts one's traditional view of the arch as a structural element. Refer to

Figure 11 for suggested expansion joint locations for structural and non-structural arches.

Detailing of expansion joints can be difficult with very long span arches or runs of multiple arches along an arcade. Structural analysis of the arch should consider the location of expansion joints. Where multiple arches are spaced closely to each other, vertical expansion joints should be detailed at a sufficient distance away from the end arches so that horizontal arch thrusts are adequately resisted by the abutments to avoid overturning of the abutments. For long arcades, expansion joints should also be placed along the centerline of abutments between arches when necessary. In this case, horizontal thrusts from adjacent arches will not be counteracting, so the effective abutment length is halved and overturning of each half of the abutment needs to be checked. Refer to *Technical Note 31A* for further discussion of abutment design for adequate stiffness.

## MATERIAL SELECTION

To provide a weather resistant barrier and maintain its structural resistance, the arch must be constructed with durable materials. The strength of an arch depends upon the compressive strength and the flexural tensile strength of the masonry. Selection of brick and mortar should consider these properties.

### Brick

Solid or hollow clay brick may be used to form the arch and the surrounding brickwork. Brick most commonly used comply with the requirements of ASTM C216, *Specification for Facing Brick* or ASTM C652, *Specification for Hollow Brick*. However, brick meeting the minimum physical property requirements of other standards, such as glazed brick complying with ASTM C126 or ASTM C1405 may be selected as appropriate. Refer to BIA *Technical Note 9 Series* for a discussion of brick selection and classification. The compressive strength of masonry is related to the compressive strength of the brick, the mortar type and for reinforced masonry, the grout strength. For structural arches, brick should be selected with consideration of the required compressive strength of masonry. Typically, compressive strength of the brick masonry will not limit the design of the arch.

Tapered voussoirs can be ordered from the brick manufacturer or cut from rectangular units at the job site. Before specifying manufactured special arch shapes, the designer should determine the availability of special shapes for the arch type, brick color and texture desired.

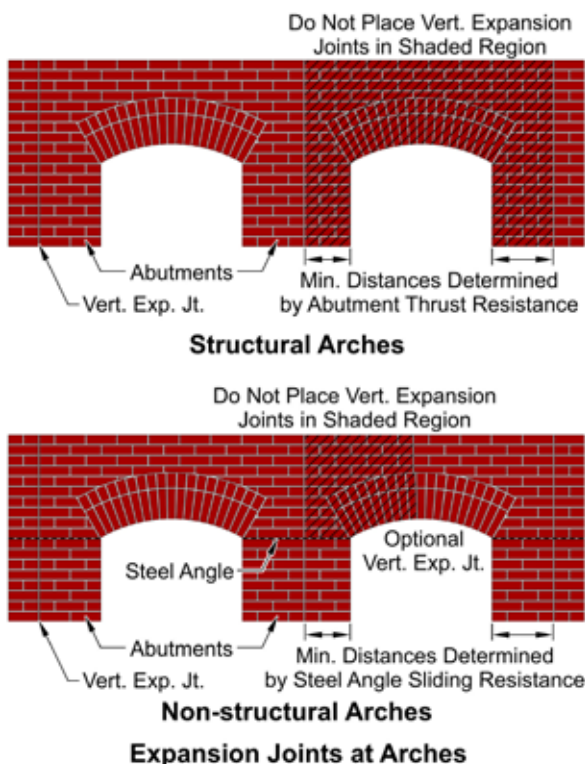


Figure 11. Expansion Joints at Arches

Many brick manufacturers produce tapered arch brick for common arch types as part of their regular stock of special shapes. Contact the manufacturer as early as possible to provide the maximum lead time for the production of special shapes. Special shapes often experience a slightly different exposure during firing than rectangular units which may result in minor color variation.

### Mortar

Mortar used to construct brick masonry arches should meet the requirements of ASTM C270, *Standard Specification for Masonry Mortar*. Consult the *Technical Notes 8 Series* for a discussion of mortar types and kinds for brick masonry. For structural arches, the flexural tensile strength of the masonry should be considered when selecting the mortar. The flexural tensile strength of the masonry will affect the load resistance of the arch and the abutments.

## CONSTRUCTION AND WORKMANSHIP

The proper performance of a brick masonry arch depends upon proper methods of construction and attention to workmanship. Layout of the arch prior to construction will help avoid poor spacing of voussoirs, which results in thicker mortar joints and asymmetrical arches. Some arch applications, such as barrel vaults and domes, can be entirely self-supporting, even during construction. However, most applications of the masonry arch used today require proper shoring and bracing.

### Centering

Both structural and non-structural arches should be properly supported throughout construction. Brick masonry arches are typically constructed with the aid of temporary shoring, termed centering, or permanent supports, such as a structural steel angle.

Centering is used to carry the weight of the brick masonry arch and the loads being supported by the arch until it has gained sufficient strength. The term "centering" is used because the shoring is marked for proper positioning of the voussoirs forming the arch. Centering is typically provided by wood construction. Careful construction of the centering will ensure better arch appearance and avoid layout problems, such as an uneven number of brick to either side of the keystone.

Immediately after placement of the keystone, moving the centering very slightly downward, referred to as easing, can cause the arch voussoirs to press against one another and compress the mortar joints between them. Easing helps to avoid separation cracks in the arch. Though easing involves a slight loosening, in no case should centering be removed



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until it is certain that the masonry is capable of carrying all imposed loads. Premature removal of the centering may result in collapse of the arch.

Centering should remain in place for at least seven days after construction of the arch. Longer curing periods may be required when the arch is constructed in cold weather conditions or and when necessary for structural reasons. The arch loading and the structural resistance of the arch will depend upon the amount of brickwork surrounding the arch, particularly the brick masonry within spandrel areas. Appropriate time of removal of centering for a structural arch should be determined with consideration of the assumptions made in the structural analysis of the arch. It may be necessary to wait until the brickwork above the arch has also cured before removing the centering.

### Workmanship

All mortar joints should be completely filled, especially in a structural member such as an arch. If hollow brick are used to form the arch, it is very important that all face shells and end webs are completely filled with mortar. Brick masonry arches are sometimes constructed with the units laid in a soldier orientation. It may be difficult to lay units in a soldier position and also obtain completely filled mortar joints. This is especially true for an arch with tapered mortar joints. In such cases, the use of two or more rings of arch brick laid in rowlock orientation can help ensure full mortar joints.

## RULES OF THUMB FOR DESIGNING SHORT ARCHES IN BRICK VENEER

The following is a list of rules of thumb which may be used when designing structural arches in brick veneer. For in depth analysis or for longer spans, refer to BIA *Technical Note* 31A.

### Jack Arches

- Six-foot maximum span without a lintel
- Larger skewback angle with longer span
- Skewback = 1/2 in. per ft. (4 mm per 100 mm) of span for each 4-in. (102 mm) arch depth
- Camber of 1/8 in. per ft. (1 mm per 100 mm) of span
- Minimum arch depth of one unit length, not rowlock only
- Abutment length equal to: span length for one surface, 1/2 span length for two surfaces (see Figure 12)

### Segmental Arches

- Rise/span ratio between 0.15 and 0.5
- Make skewback angle as small as possible
- Increase arch depth for better performance
- Wall height above spring line at least 1.3 times arch radius
- Abutment length equal to:
  - 0.66 times span length for one surface
  - 0.33 times span length for two surfaces (see Figure 12)

### Semi-Circular Arches

- Arch depth as small as 1/2 brick length
- Wall above should be at least (0.9) (span) from spring line
- Abutment length equal to:
  - 0.4 times span length for one surface
  - 0.2 times span length for two surfaces (see Figure 12)

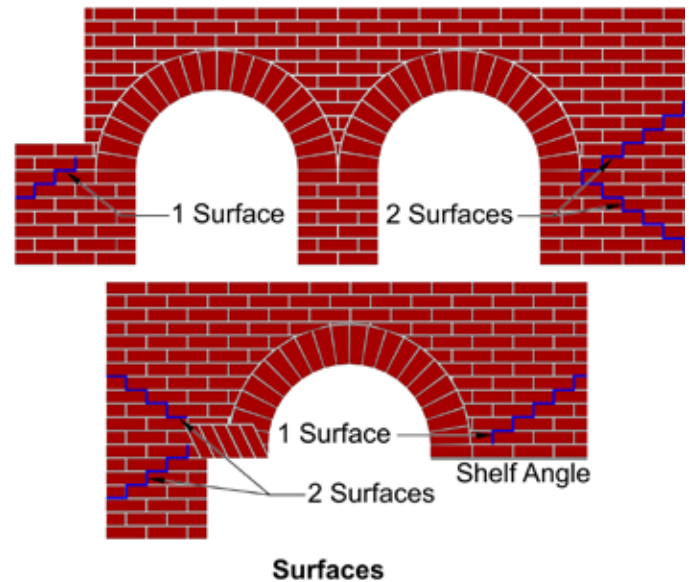


Figure 12. Surfaces for Determining Abutment Length

Note: In order to qualify as two surfaces, the abutment must extend up to the crown of the arch. Also, combination wall and steel angle abutments have only one surface.

### Summary

The article gives an overview of the historic development of brick arch design, explains the terms typically used in brick arches, and shows examples of common brick arch types. The proper construction and detailing for brick veneer arches is discussed including the specification of materials. Rules of thumb for designing short arches in brick veneer are presented.

## BIA *Technical Notes on Brick Construction*

The Brick Industry Association's (BIA) *Technical Notes on Brick*

*Construction* have long provided guidance on brickwork to the design and construction professions. The information provided in the preceding technical discussion and in all issues of *Technical Notes on Brick Construction* is based on the available data and the combined experience of BIA engineering staff and members. The information must be used in conjunction with good technical judgment and a basic understanding of the properties of brick masonry. For further recommendations on brick arch construction, refer to the *Technical Notes* 31 Series at [www.gobrick.com](http://www.gobrick.com).



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