

# PROCEEDINGS

10334

of the

## 10<sup>th</sup> INTERNATIONAL BRICK AND BLOCK MASONRY CONFERENCE

Calgary, Alberta, Canada

5-7 July, 1994

Masonry Council of Canada

The University of Calgary

Vol. 2



**MCC**

Masonry Council  
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## NINETEENTH CENTURY BRICK ARCHITECTURE: RATIONALITY AND MODERNITY

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### 1. ABSTRACT

The analysis of clay brick architectural works in Europe between the middle of the 19th century and the beginning of the 20th century shows that they exploited the material's technical and formal potential, and followed the trends in construction that prevailed at the beginning of the industrial era.

The works reveal sufficient common characteristics, beyond nuances of style found in each region or country, to enable the term **Nineteenth Century Brick Architecture** to be used.

This paper analyses the most significant characteristics of this **Brick Architecture** so that it may be understood within the development of architectural history.

### 2. INTRODUCTION

During the closing decades of the 19th century there developed in Europe an interesting architecture based on a full understanding and exploitation of clay brick masonry.

In Spain historians named the style "neo-mudéjar"<sup>2</sup>, associating it with a medieval architecture that featured decorative exposed brickwork. The name seemed to satisfy theoretical concepts related to style, form and period.

However, if the new architecture is analyzed, taking into account technological, construction and design aspects, we see that much wider issues are involved and the label "neo-mudéjar" is too limited as it only refers to similarities in the visual

**Keywords:** Clay Brickworks; Brick Architecture; Bonds; Arches.

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2. "Mudéjar" is the architecture carried out by Christians in the Moorish regions of Middle Age Spain. "Neo-mudéjar" is the modern architecture that recreates the ancient "mudéjar" themes (eg. facing brickwork, horse-shoe arches, etc.).

characteristics of some of the significant works that appeared in the period between the construction of the bullfighting Plaza of Rodríguez Ayuso & Alvarez Capra in 1874 (now demolished) and 1932 when the bullfighting Plaza Monumental de las Ventas was built (see Figure 1).

If we set aside the restricted view that divides architecture according to superficial similarities of style, we are able to identify in the buildings of this period characteristics of a way of building which is more accurately referred to as NINETEENTH CENTURY BRICK ARCHITECTURE.

### 3. THE BRICK: A MODULAR ELEMENT

Brick has been used as a building material from very ancient times, but in the 19th century it begins to have a special importance of its own because it is central to a whole industrialized manufacturing and construction process characteristic of that century.

During the 19th century great technological breakthroughs were accomplished in brick manufacturing. The ancient techniques of burning were developed by the introduction of circular and straight continuous burning kilns. Roller mills, pug mills, etc. and extrusion and pressing machinery improved productivity enormously. The result was a manufactured building element with defined and controlled physical characteristics.

Even though individual bricks do not always have precisely the same dimensions, a modular system exists with brickwork. The ancient proportions (more-or-less square) were slowly abandoned and there was a move in standardization of form and dimensions until the proportion of 2:1 (length equals twice width) was eventually established.

Also it is significant that new types of bricks appeared as a direct result of developments in the industrialized manufacturing processes-hollow bricks, perforated bricks, pressed bricks. Towards the end of the century concrete and calcium silicate materials, which do not require burning in processing begin to be introduced as a cheaper alternative to clay bricks.

It is also important to understand that during this period traditional measuring systems were being subjected to a standardization process. The ancient measuring units of each region ("sogas" = cords, "varas" = yards, "pies" = feet and "palmos" = palms), were eventually superseded by the Metric System: the new, unique and universal measuring system.

The result of all this transformation was that brick came to be reconsidered as a "new material" with the characteristic of being modular. It began to be accepted as the basic element of a whole conceptual structure that allowed a rationalization of architectural features and composition in accordance with construction principles. The architecture of this period demonstrates this new understanding of brick, using it in widely varying details. Architects wanted to create modern buildings by the use of a traditional material that had been transformed by the Industrial Revolution.



Figure 1  
Monumental Bullfighting Plaza, Madrid

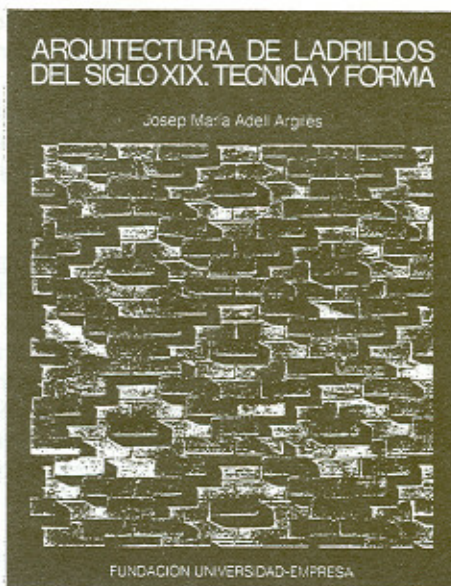


Figure 2  
19th century Bricks Architecture:  
Technique and Form, by J.M. Adell

#### 4. RATIONALITY: FROM LINKING TO BONDING

In order to understand the evolution in masonry construction from "trabazón" (linking) to "aparejo" (bonding) let us study a real case:

In the Madrid 1857 Ordinances (which were also applied in Valencia and Sevilla), quoted by Fornes & Gurrea in their "Art of Building" (2), it was established that the bricks to be used in any construction works should be a foot long, a quarter wide and two inches thick. These measurements related to the subdivisions of a "vara" (yard) - a third of a yard equalled one "foot", a fourth of a yard equalled one "quarter"- and these measurements defined the proportions of the bed face of the brick. The length was not twice the width. In Castilla the metric value of the yard was 864mm.

The size of unit imposed by the Ordinances made it impossible, due to the 3:4 proportion of the bed face, to alternate the disposition of bricks lengthwise (stretchers) and widthwise (headers) in the brickwork in an orderly manner. For good execution of the wall it was considered enough to accept "trabazón" (linking), both in the wall surface and in its thickness. That is, vertical continuity of joints was avoided when laying the bricks.

It is surprising that in the book "Art of Bricklaying" by Juan de Villanueva, published in Madrid in 1827 (based on the book "Art and Uses in Architecture" by Fray Lorenzo de San Nicolás, in 1667) the term "aparejo" (bond) is not found, but only the term "trabazón" (link). The diagrams of this book confirm the use of the 3:4 proportioned brick established by the Ordinance, and the impossibility of orderly alternation of stretchers and headers within the same brickwork.

During the restoration of ancient buildings, bricks one foot long and a quarter wide have been found and these facts confirmed.

Even when bricks were later standardized and the new 2:1 proportion adopted (length equals twice width) the "aparejo" used in Madrid was the "aparejo a tizón" (header bond) following the tradition formerly adopted when using the old 3:4 proportioned units (see Figure 2).

Observing the architecture of preceding periods it can be seen that in Madrid there was no tradition of decorative fancy brickwork.

In older buildings brick is used in a cumulative construction in which structural integration was achieved by the linking arrangement ("trabazón"). What then is the difference between this and the later 19th century work? In the later work emphasis is placed on the material as a controlling and defining feature of the construction and brick is used in such a rational manner that it gives a special character to the structure, form and appearance of the architecture.

During the 19th century, because the brick acquired fixed 2:1 proportions the construction process of linking totally gave way to bonding.

Bonding is a technique of assembly that supplements the building process by the application of rules which, if followed, result in enhanced formal characteristics in the masonry, including improved load bearing potential. Towards the end of the 19th century when bonding in brickwork, meaning "adequate disposition of the brickwork units", becomes universally recognized specific values were adopted for each of the different bonding arrangements.

As a result of this wide acceptance books appeared all over Europe establishing rules for bonding. At first these bondings were defined simply with numbers, as in the case of the french book "La brique ordinaire au point de vue decoratif" (3) where the bond patterns named 1, 2, ... 6 are depicted.

In particular places -countries or regions- it was sometimes common to build brickwork by always assembling the bricks in the same way and this led to an association of the name of the bond with the place name, eg. English, Flemish, Belgian, Dutch and American bonds.

In Madrid, as research published in the book "NINETEENTH CENTURY BRICK ARCHITECTURE: TECHNIQUE AND FORM" (4) proves, every building constructed during this period had the explained above. This circumstance, together with nationalistic reasons, led to the establishment of "aparejo a tizón" (header bond) and "aparejo a la española" (Spanish bond) as synonymous.

The Madrid brick architecture exposes headers and consequently the maximum number of joints. It follows that the surface is subdivided into the greatest possible number of modular units. This characteristic of header bond means that it allows more ornamental possibilities than any other bond arrangement, including those that combine stretchers and headers.

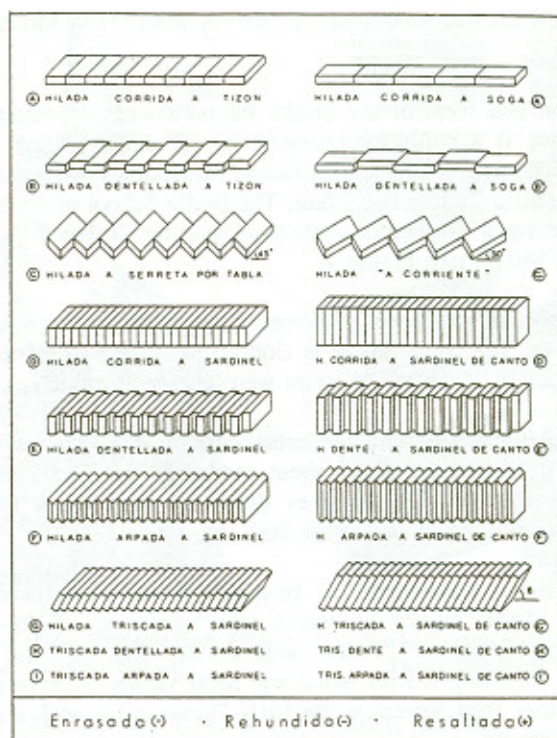


Figure 3 - Types of brick courses

Thus it is that the richness of form displayed in brick architecture "a la española" is outstanding when compared with other 19th century brick architecture for which bond patterns other than header bond were generally used.

If we analyze, from a geometric and construction viewpoint, the bonding arrangements possible with the basic prism shape, following simple rules of assembly, we see that they are almost infinite (see Figure 3).

Beside the usual ways of placing bricks in the masonry horizontally in courses "a tizón" (as headers) or "a soga" (as stretchers) the bricks can be laid "a sardinel" (on edge) or "a sardinel de canto" (on end as "soldiers"). There also exists the possibility of placing the bricks at a slant, "triscada", to form a herringbone course of bricks on edge or on end.

As further variation the bricks in such courses can be laid "corridas" (with their faces in line), "dentellada" (toothed or notched) or "arpada" (in a saw tooth).

The three-dimensional character of the brickwork surface can also be enhanced by recessing, flushing or projecting courses relative to the general wall surface, thereby creating attractive nuances of light and shade.

Striking polychromatic effects can be achieved using bricks of different colours in combination with bond patterns.

## 5. EUROPEAN BRICK ARCHITECTURE: A WAY TOWARDS MODERNITY

The decoration and form of the brickwork built with the materials and techniques described above is a definitive characteristic of the so called 19th Century Brick Architecture. The term covers a great variety of buildings -works as different from each other as the Madrid Bullfighting Plaza, The Berlin School of Architecture by Schinkel and the design for a gardener's house published by Chabat in "La brique et la terre cuite"- Paris 1880-89 (see Figure 4).

There are important ideological differences between the design of the buildings. For some the chosen figurative model is Gothic, for others Romanesque and for others Moorish. A variety of mediaeval styles were chosen as models.

However, the designs reflect the intellectual currents that were prevalent during the 19th century in response to questions about modernity raised in the previous century. Perhaps even more importantly, they direct the way to an understanding of the architecture that was developed in the 20th century.

19th Century Brick Architecture can be considered as a popular challenge to the cult of classicism. In it master craftsmen and bricklayers display their freedom of expression; respecting the material and simple rules of bond they create "their architecture", enriching it with moral and local values. Referring to the sincerity of their construction John Ruskin wrote (6) - "Leave your walls flat and bare, do not plaster them with lies...".

The style is even associated in a literary way with socialist theories (William Morris), and it reflects the genuine traditions of every place in Europe at a time when nationalist feelings were very strong.

Architecture of this period with facing brickwork built with the same rational approach to construction is found throughout Europe - London, Milan, Berlin, Madrid, etc...

If we consider American architecture we see that it also crossed the Atlantic and became a popular style in the USA, as typified for example in Chicago and Memphis. The Bullfighting Plaza on Bogota, Colombia is an example in South America.

The illustrated publications produced in this period were very important vehicles for the dissemination of an understanding of this architecture. Among the most significant was "Brick Architecture" by Fleischinger, published first in Berlin in 1864 and again in 1875 in Barcelona (see Figure 5).

This kind of book typically consisted of a collection of plates that illustrated the grammar of brick language, ordered according to the elements of construction. They described in a simple way the construction technique of each example and, in conclusion, offered models that builders could copy. The plates illustrating the works, most of them printed in colour, stimulated the imagination of the craftsman-bricklayer because he found in them sound guidance that would allow him to incorporate the particular features into his own work.

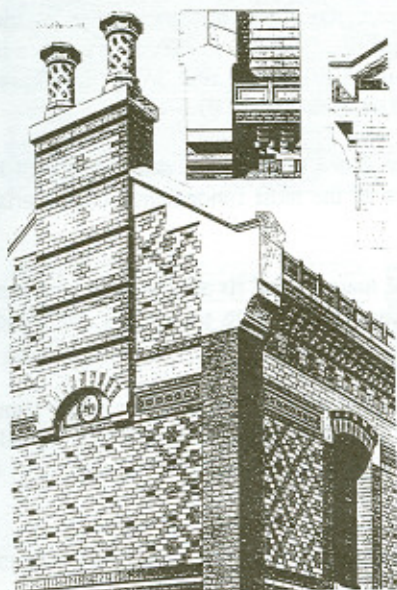


Figure 4  
 La Brique et la Terre Cuite, 1880 and 1889, Paris  
 P. Chabat. Gardener House.

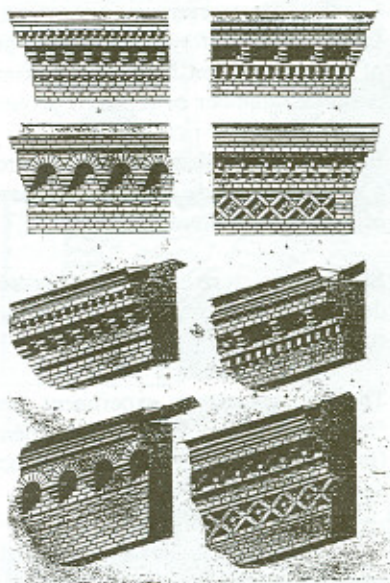


Figure 5  
 Bricks Architecture, 1875, Barcelona  
 Fleischinger/Bececker. Cornices

## 6. THE LOAD-BEARING WALL AND THE BRICK ARCH

As well as recognizing the rational nature of bonding, together with the bricklayer's freedom to express his feelings against the academic rigidity of classicism, we should also take notice of the other factors that cause an architecture of such variety of detail to display common technical and visual characteristics.

There are two important influences: the load-bearing nature of brick masonry and the way in which openings are formed in walls.

True brick architecture is conceived as load-bearing. This applies to any kind of building be it a church, a museum or the most humble house. 19th Century Brick Architecture features solid, load-bearing masonry that, due to the beneficial effects of bonding and the regularization of its bricks and the joints, achieves maximum compressive strength and can be designed with lesser wall thickness than would be possible with the less rationalized brickwork of former times.

During the closing decades of the 19th century cast-iron structure was combined with load-bearing masonry for many large buildings, but as time progressed the two systems became increasingly independent, specially for industrial buildings.

The structural character of the 19th century load-bearing wall affected the general design of the building and had a direct influence on the architectural composition of its facade - wall thickness, solid/void rhythm, visual indication of floors, cornices as a protection of the facade from a roof overhang, all become important as potential ornamental features confirming again the rational nature, consistency and versatility of this architecture.



Cornice construction severely tests the bending, or flexural, strength of masonry. Unless steel reinforcement is used projection of the overhang is very restricted, a limit of barely two feet being the maximum permitted projection and 35 is the maximum permitted number of repeated projecting courses (see Figure 6).

It is significant that in guidance literature there are many detail descriptions of how openings are made in brickwork as this is one of the most fundamental characteristics of brick architecture.

Brick architecture exploits the versatility of the material and its assembly arrangements, developing a vocabulary of decorative form based on laying techniques and bonding rules.

The bricklayer may experiment creatively and freely, combining one after another "modillones" (bracket courses), "dentellados" (dentil or toothed courses) and "arpados" (sawtooth courses) of different projection and rhythm, giving singularity, originality and personality to each construction.

However, when arches are required less freedom is appropriate as a precise form of construction is important for the structural function of an arch.

The structural solution to closing the wall at the head of an opening in masonry and supporting the walling above it is traditionally an arch. An arch supports the masonry above the opening ensuring that it remains subjected only to compression stress. Arches may be of several forms and the builder is able to choose one most suited to the span of the opening and the style of the building.

An arch is built using a refined bricklaying technique and construction may become an ornamentation process in which each element - "rocas" (rings), "dovelas" (voussoirs), "salmores" (springers), "claves" (key bricks),... - is a very important feature of the construction and visual character of the arch.

There are many forms of arch that are both visually and structurally satisfying - flat or cambered, semi-circular, segmental, multi-centred curved types, and forms in which curves are mixed with straight lines. These basic shapes can be built in different ways - "de roscas" (as ring arches), "de hojas" (as multi-ring arches) or as "aparejados" (with bonded voussoirs) - and in addition the construction can be enriched by the use of ornamental brick mouldings.

The potential for decoration is increased by the possibility of applying decorative features in different planes related to the build-up of the rings of the arch, from the "guardapolvos volados" (projecting arch rings) at its outer extent in to the "arquivoltas" (sunken arch rings) within. Such decoration can give the opening a horn like depth through which space passes from the front of the arch on the surface of the wall (Fig. 7)

The springing of an arch deserves special attention as do the buttresses which give it support. Also the key closer may be a special feature comprising a single voussoir unit or an assembly of several units bonded for example "fishbone-like", "indented" or "purse-like".

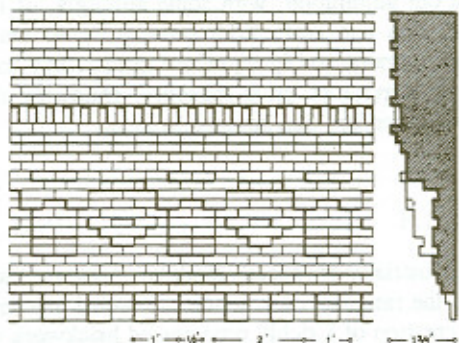
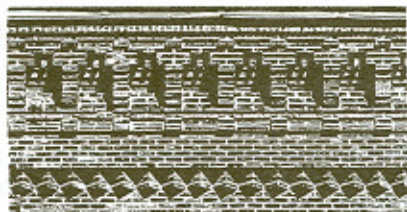


Figure 6

- a) Cornice with brackets and sawtooth courses  
 b) Three-part overhanging cornice. 33 courses

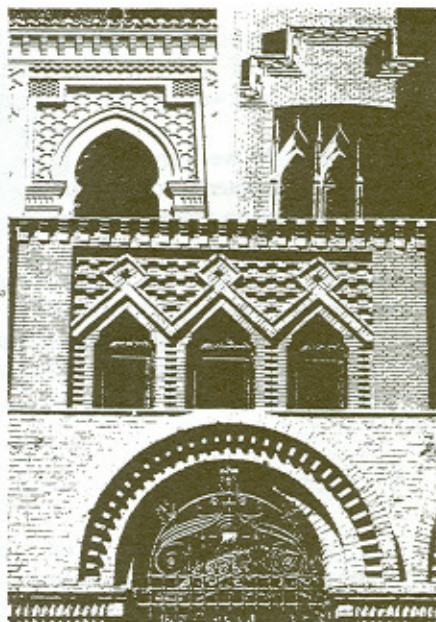


Figure 7

- a) Moorish arch  
 b) Ring-leaves arch  
 c) Straight 45 arch  
 d) Bonded arch with projecting and sunken arch rings

Voussiors are made with care to suit the geometry of the arch. Generally they are tapered and laid with parallel joints, but for large radius arches the voussoir units may be parallel sided and the joints slightly tapered.

It is common to create a framing panel around an arch, the "alfiz", and this is usually of richly ornamental brickwork.

19th Century Brick Architecture shows a masterful exploitation of brick masonry for the efficient construction of attractive buildings of many different types, but by the early decades of the 20th century the potential of brick masonry was neglected in favour of other newer materials and building techniques.

In the 20th century steel has revolutionized construction. Rolled steel and steel reinforced concrete are extensively used for the structural frames of buildings. Their external walls may still be built of brickwork but it no longer has to support the loads from floors and roofs and the rational influence imposed on the facade of a masonry structure by the necessary disposition of solids and voids is no longer justified. Steel and reinforced concrete lintels were also introduced as a substitute for arches to span openings.

These changes of structural system led to corresponding changes in the appearance of buildings. Vertical loads were carried down to the ground by relatively slender columns independent of the enclosing walls that therefore did not need to maintain vertical continuity of structure. The characteristic vertical composition appropriate to load-bearing masonry construction with arches was replaced by a horizontal emphasis in the composition of masonry facades no longer required to provide structural support and with openings spanned by lintels instead of arches.

Relieved of its structural role the brick enclosing wall could be thinner and lighter, this has benefits of economy but greatly restricts the opportunity for the creation of decorative brickwork by the manipulation of the brick bonding.

Only now, as we were about to enter the 21st century, is there reawakening to the considerable potential of structural masonry, particularly when it is combined with steel reinforcement to dramatically improve its flexural strength.

However, these changes do not diminish our admiration, with some nostalgia, of the wonderful brickwork carried out in the 19th and early 20th century by so many architects and master craftsmen. Often anonymous and little valued in their day they searched for and achieved maximum expressivity of brick masonry, following the scheme of its modular discipline. This paper renders due homage to them.

## 7. CONCLUSIONS

- \* In the 19th century brick becomes an industrially produced, modular, masonry unit.
- \* The modular character of the brick and the rational construction of bonded masonry provide extensive opportunities for the creation of a richly ornamented brickwork by the skillful manipulation of bricks during their assembly.
- \* 19th century brick architecture is characterized by thick walls, arched openings, cornices, corbels, friezes, etc., all of which are features derived from the rational application of load-bearing masonry construction.
- \* Occasionally the form, detail and decoration of the elements of construction follows eclectic historical models and this obscures the essential modernity of the architecture.
- \* Madrid's 19th century brick architecture is outstanding because the exclusive use of header bond "aparejo a la española" provides for an exceptional richness of decoration
- \* 19th century brick architecture fell into disuse when the lintel was introduced as a substitute for the arch in spanning openings. During the same period steel and reinforced concrete frames became popular and brick external walls became cladding for framed structures.

Publication of the book **19th Century Brick Architecture: Technique and Form** that formed the basis of this paper, was made possible thanks to the help of HISPALYT- Spanish Federation of Clay Brick Manufacturers. Translation from Spanish edited by M. Hammett, Dip Arch ARIBA. The Brick Development Association UK.

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