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NEW CONCEPTS TO BE INCLUDED IN STANDARDS ON ENCLOSURE WALLS

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ABSTRACT

Masonry work is characterised by the placing by hand of prismatic bricks or blocks side to side in successive horizontal courses or layers, taking care to avoid the vertical continuity of the joints between units and achieving a perfect bond between the same by means of a light intermediate material in the form of mortar.

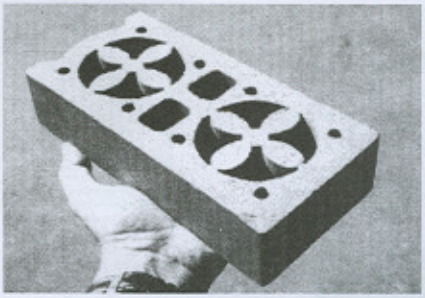
In order to solve the difficulty of vertically reinforcing the brickwork, due to the lack of vertical and continuous voids within the same, a new technology for vertically reinforcing masonry walls has been developed using redesigned masonry units and new prefabricated reinforcement in order to allow the reinforcement to be placed through lateral voids in the brick.

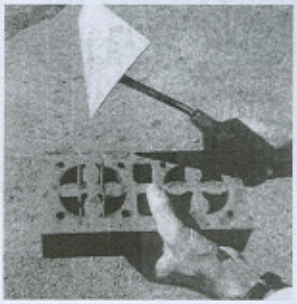
The combination of universal masonry, so-named as it permits vertical reinforcement, together with traditional prefabricated bed-joint reinforcement, and the new reinforcing ribs embedded in large perforations which are opened out from the universal masonry unit, all serve to broaden the scope of application of masonry.

The incorporation of this new method of reinforcement by lateral access of new universal masonry units, together with the latest types of prefabricated rib, all require new terminology and suitable inclusion within the building standards as they will account for substantial changes in building techniques and applications, and have a broad area of scope within Spanish enclosure walls.

Key words: *Masonry. Universal Unit; Rib Reinforcement; Enclosure Wall; Plate Wall.*

Figure 1. Unreinforced universal unit.
Figure 3. Opening of void and access channel.





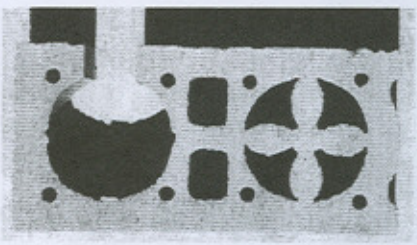
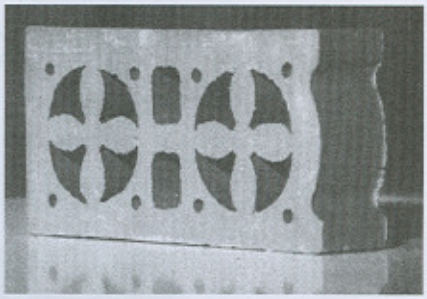
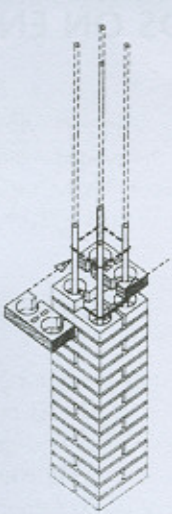
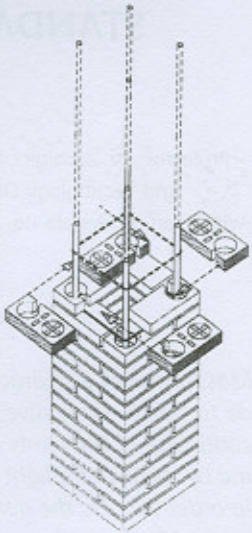


Figure 2. Universal clay brick and header-joint.
Figure 4. Vertical bar reinforcement (columns).







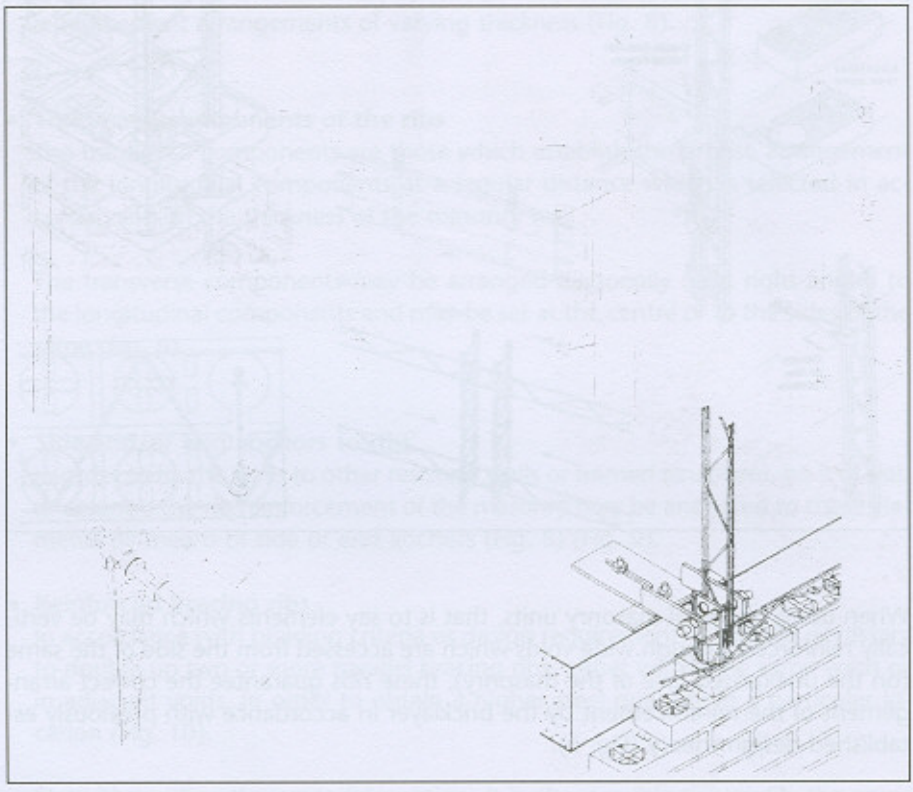
2. UNIVERSAL UNIT

A universal unit shall be one which will have the inherent qualities of a masonry unit of its kind, but one which allows the possibility of placing vertical reinforcement through lateral access channels in the same which lead to large interior voids, and which are simply opened by hand or machine.

The universal unit, regardless of its material, shall not alter the volume of void space of the original masonry unit in question and, therefore, shall remain within the same groupings in the Standards (Fig. 1).

The design and arrangement of the large opening voids shall be such as to allow the lateral placing of vertical reinforcement without altering the bond of the brickwork. As such the said opened voids have to vertically coincide with those of upper and lower units once these have been laid.

Figure 5. Rib reinforcement in position to vertically reinforce a masonry wall.
Figure 6. Longitudinal and transverse component of the bracing ribs.
Figure 7. Different types of Rib Reinforcement: wires, plates and bars.
Figure 8. End anchors of Rib Reinforcement.



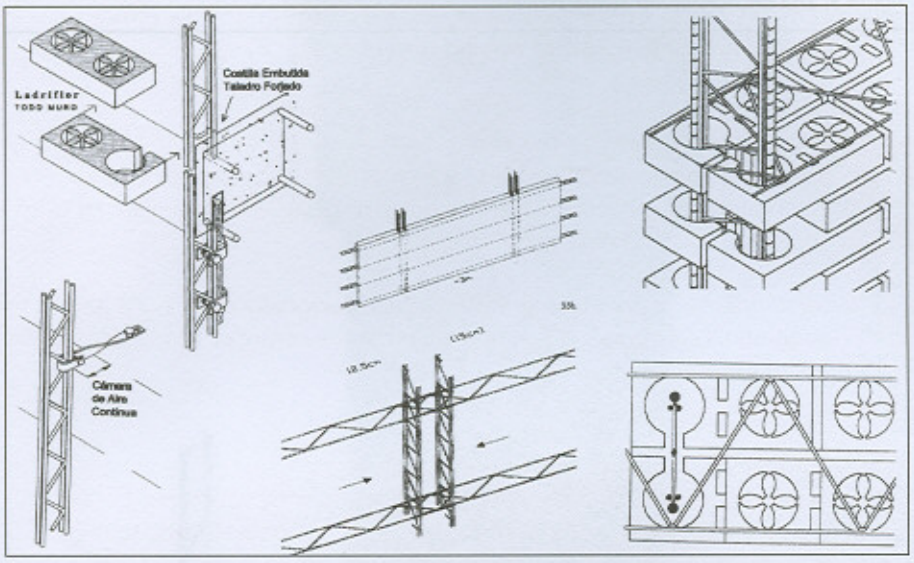
The lateral opening channel in the universal unit allows the housing of vertical reinforcement, which is previously set throughout the total height of the floor, without it being necessary to thread this reinforcement through the units or vice-versa (Fig. 4).

The universal units may be provided with a recessed or moulded header face in order to allow the housing of a reinforcement rib within a continuous vertical joint or, alternatively, to house the sealing for joints between prefabricated panels (Fig. 2).

3. RIB REINFORCEMENT

Prefabricated bracing ribs have been created in order to take advantage of the maximum inertia provided by the thickness of the masonry wall in question, these allowing the precise housing of vertical reinforcement within the wall and set close to the outer faces of the same.

Figure 9. Lateral anchors to ribs.
Figure 10. Double bracing ribs.
Figure 11. Reinforced bracing ribs.



When using universal masonry units, that is to say elements which may be vertically reinforced through wide voids which are accessed from the side of the same (on the unexposed face of the masonry), these ribs guarantee the correct arrangement of the reinforcement by the bricklayer in accordance with previously established design theory (Fig. 5).

These bracing ribs are characterised by the following elements (fig. 6):

- longitudinal components
- transverse components connecting the former

There are many types of rib reinforcement formed by wire, plate and bar, etc (Fig. 7).

These ribs may also have lateral anchors (set on the inner face of the wall) or end anchors (above or below the wall) (Fig. 8).

The quality of the steel employed in each case shall be selected in accordance with environmental conditions in order to prevent the subsequent corrosion of the steel with time.

- **Longitudinal components of the rib reinforcement**

  The longitudinal components of the ribs may be composed of wires, tubes, plates, profiles etc., in unit form or grouped in parallel.

In bed joint reinforcement the narrow thickness of the horizontal masonry joint does not allow the use of wires of 5mm thick in order to allow a suitable mortar joint covering of 1 cm thick (at least 2mm above and below the reinforcement). However, as the ribs are set in relatively large voids this allows vertical reinforcement arrangements of varying thickness (Fig. 8).

- **Transverse components of the ribs**
  The transverse components are those which establish the precise arrangement of the longitudinal components at a regular distance which is selected in accordance with the thickness of the masonry wall.

  The transverse components may be arranged diagonally or at right angles to the longitudinal components and may be set at the centre or to the sides of the same (Fig. 6).

- **Side and/or end anchors to ribs**
  In order to fix the walls to other resisting walls or framed structures, be it of slab or column, the rib reinforcement of the masonry may be anchored to these elements by means of side or end anchors (Fig. 8) (Fig. 9).

- **Reinforced bracing ribs**
  In accordance with building criteria or design requirements it may be necessary to double up two or more parallel bracing ribs, either within the same voids or in adjacent voids, in order to obtain a higher steel quantity in a particular location (Fig. 10).

  Notwithstanding the preceding option, it is also possible to simplify the construction process on site by employing prefabricated bracing ribs with added reinforcement (suitable bars) in the longitudinal components (single or double) (Fig. 11).

4. POSITIONING OF RIB REINFORCEMENT

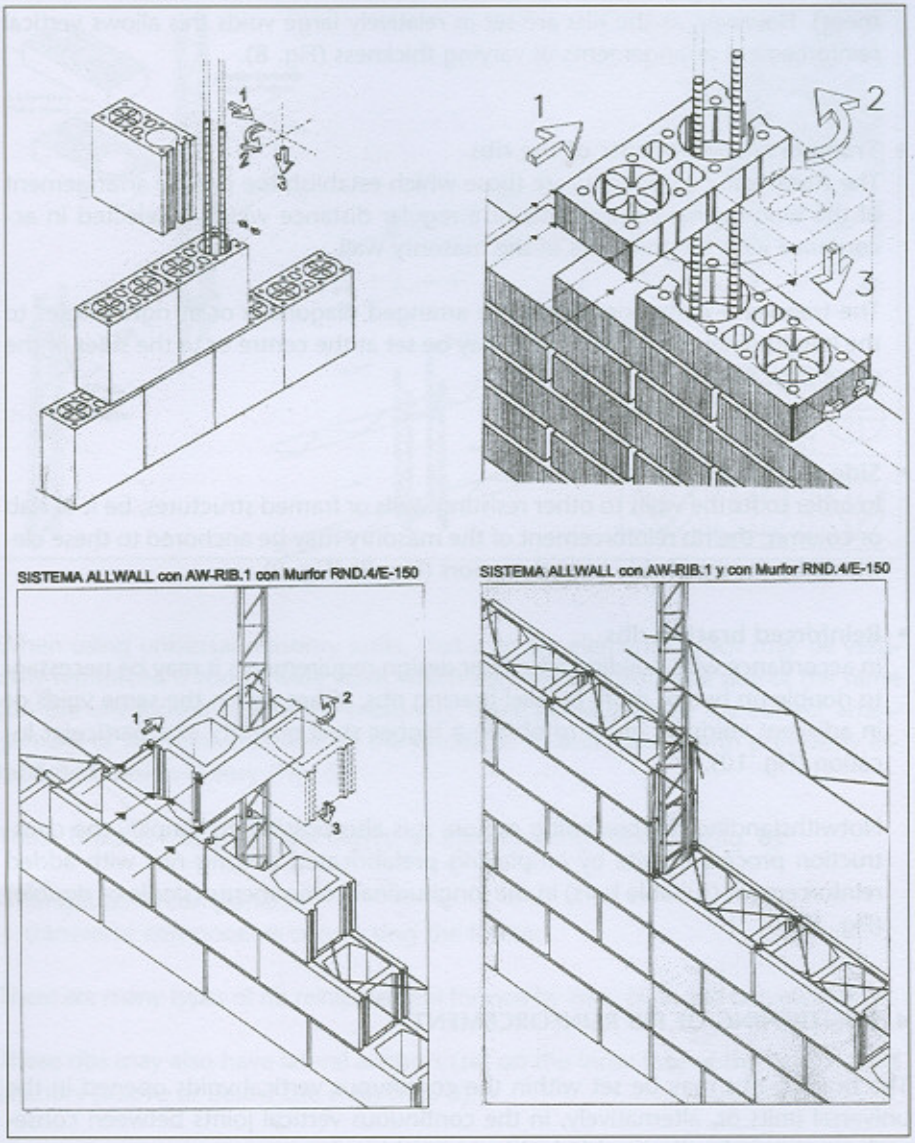
The bracing ribs may be set within the continuous vertical voids opened in the universal units or, alternatively, in the continuous vertical joints between consecutive courses of units provided with recessed headers.

The ribs may be totally housed in the voids of the unit or within the thickness of the wall or, alternatively, may be partially embedded in the same and protrude from the side of the wall.

If the ribs are of stainless steel they will only require a minimum covering of mortar or may even be exposed to view, or air, without being embedded in any type of mortar.

Figure 12. Positioning of two parallel reinforcing bars in Ladriflor brick/block: 1. Access 2. turn and 3. bedding.

Figure 13. Bracing rib set within concrete block in vertical continuous joint.



On occasions the ribs may be set between two adjacent masonry walls (set within the cavity of the same) and tied to the same by lateral anchors.

Normally the rib reinforcement will be incorporated within walls together with truss-type bed joint reinforcement which is threaded through the same. The ribs are usually placed at points where they will coincide with the overlaps of the bed joint reinforcement in order to aid vertical and horizontal connection.

- **Rib Reinforcement set within universal units**

The bracing ribs (or parallel bars) may be totally housed within the vertical continuous voids of universal units of brick or block without being exposed from the outer or inner side. (Fig 12).

In order to achieve this effect of bonded exposed brickwork vertically reinforced with ribs, it is necessary to select an appropriate breadth of rib, to set the same and then to place the universal units in three simple steps:

1. set the opened channel in the header end of the unit against the rib
2. turn the unit 90º
3. lower and lay the unit on the corresponding bed

On some occasions and when the small thickness of the wall or the stress calculations of the rib so require, it is possible to leave the access channel of the bracing rib in a continuous vertical line on the inner face of the exposed brickwork without this weakening the wall, as in this area the rib is threaded through bed joint reinforcement which provides it with three-dimensional reinforcement.

The fact that there is a continuous vertical channel running up the inner face of the masonry wall will not reduce the strength of the same providing this is fitted with void rib reinforcement. If this bracing rib is combined with bed joint reinforcement the channel will then be set at the point of the vertical and horizontal crossing of the steel and shall then form the most resistant part of the wall (Fig. 15).

- **Bracing ribs set in continuous vertical joints**

When the bracing ribs are set to the left and right of unbonded masonry panels this then creates continuous vertical joints which break the staggered bond of the wall. The said vertical joint may then house a bracing rib which, instead of being embedded within the voids of universal units, is set flush to the recessed header end of the unit (Fig. 13).

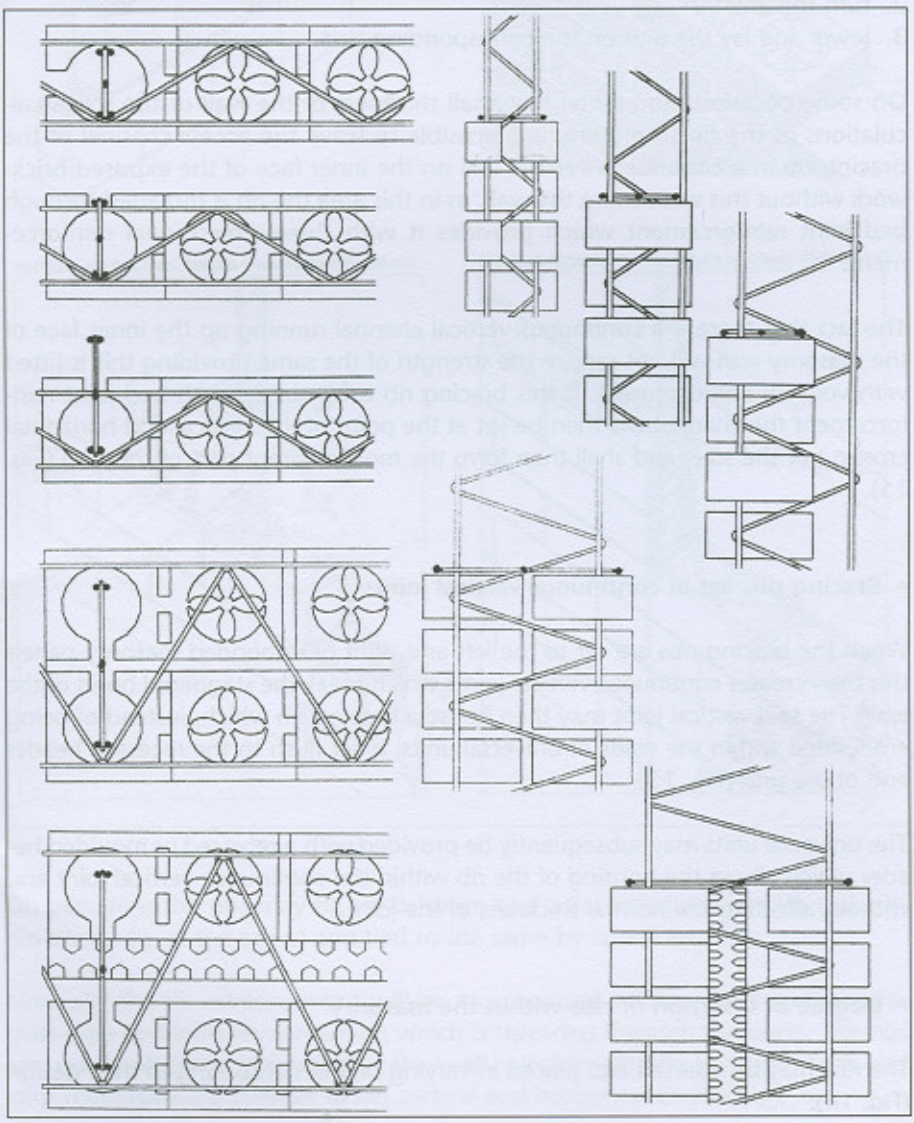
The universal units may subsequently be provided with a recessed or moulded header which allows the housing of the rib within the continuous vertical joint and without affecting the normal thickness of the joint.

- **Degree of insertion of ribs within the masonry**

The ribs may be inserted and placed in varying degrees according to their design (Fig. 14):

I. Totally housed within a single leaf
II. Totally housed between two leaves
III. Partially embedded between two leaves and exposed within the cavity
IV. Partially protruding from one leaf in order to fix internal panels
V. Set between two leaves and totally exposed within the central cavity
VI. Variations on the previous cases but placed within a continuous joint

Figure 14. Varying degrees of insertion of Ribs in different types of walls. Totally housed within a single leaf wall (ACW); Flush with channel void in single leaf wall (ACW); Laterally protruding from a single leaf wall (ACW); Totally housed between double leaf wall; Partially embedded between two leaves and exposed within the cavity (DCW); Set between two leaves and totally exposed within the central cavity



5. ENCLOSURE WALLS

Enclosure walls are those which separate the internal and external space of a habitable building. They are, therefore, masonry walls which comply with the hygrothermic requirements of a building within its specific environment.

These enclosure walls may then be formed by single leaf walls or by various leaves with or without internal cavities and insulation.

Enclosure walls also have to comply with requirements regarding their own inherent resisting functions such as the withstanding of wind action in the cased of framed structure buildings and suit the resisting capacity required by the masonry structure in the case of buildings with load bearing masonry walls.

Enclosure walls may be of single or multiple leaf, be of uniform and/or different materials, and be solid or provided with internal cavity.

6. REINFORCED MASONRY ENCLOSURE WALLS

A "reinforced masonry wall" shall be taken to be a masonry wall which, in order to control cracking, is provided with regular bed joint reinforcement vertically spaced at no more than 60 cm and containing a minimum quantity of steel of 0.03% of the section of the masonry.

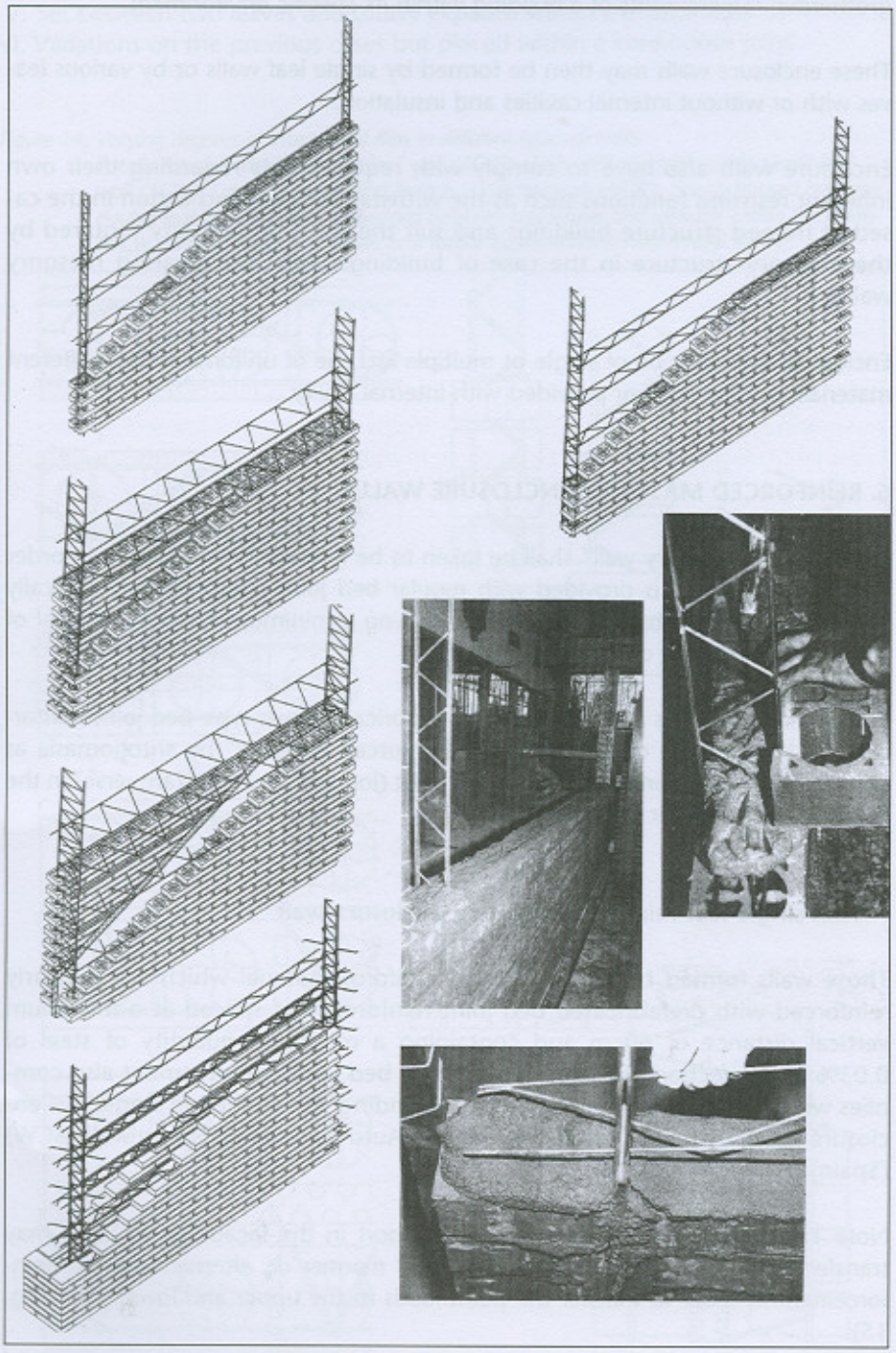
When a wall contains regularly placed prefabricated truss type bed joint reinforcement, this shall be denominated as "reinforced masonry" by antonomasia as this reinforces both directions of the bed joint (longitudinal and transverse) in the most efficient manner possible.

- **Thin single leaf reinforced masonry enclosure wall**

Those walls formed by a single leaf of uniform material which are regularly reinforced with prefabricated bed joint reinforcement spaced at a maximum vertical distance of 60cm and containing a minimum quantity of steel of 0.03% of the section of the masonry. If the bed joint reinforcement also complies with the structural function of withstanding wind action in single leaf enclosure walls, this shall be referred to as an Auto-supporting Cavity wall (ACW) (Spain).

Note 1: The ACW requires a structural support in the façade to which it may transfer wind action in a continuous vertical manner or, alternatively, Rib Reinforcement in order to transfer the point loads to the upper and lower slabs (fig. 15).

Figure. 15 Reinforced Masonry Walls with different positioning of Bracing Ribs: R.R totally housed within a single leaf wall (ACW); R.R flush with channel void in single leaf wall (ACW); R.R. laterally protruding from a single leaf wall (ACW); R.R. totally housed between double leaf wall; R.R. partially embedded between two leaves and exposed within the cavity (DCW); R.R. set between two leaves and totally exposed within the central cavity.



- **Thin double leaf reinforced masonry wall with central cavity, tied and reinforced with bed joint reinforcement set between both leaves which work in conjunction.'**

Those walls formed by two leaves of similar or different materials with a central cavity between the two (for air and/or insulation) which is regularly reinforced with truss-type bed joint reinforcement set between both leaves and spaced at a maximum vertical distance of 60cm and containing a minimum quantity of steel of 0.03% of the section of the masonry.

If the bed joint reinforcement also complies with the structural function of withstanding wind action in double leaf enclosure walls, this shall be referred to as a Duplex Cavity wall (DCW) (Spain) (Fig. 15).

Note 2: This type of wall (DCW) with bed joint reinforcement is only valid with truss-type bed joint reinforcement set between both leaves of masonry, and which due to its triangular arrangement serves both to reinforce the masonry leaves and tie the two together, thereby transferring shear stresses via the 45º diagonals in the same manner as a thick homogeneous resisting wall (see note 1).

7. ENCLOSURE PLATES WITH REINFORCED MASONRY AND RIB REINFORCEMENT

In order to withstand wind action in single leaf brick walls which are not provided with structural columns or external struts, it is possible to use rib reinforcement housed within the universal units of the wall.

On constructing a reinforced masonry wall, that is to say, one with regular truss type bed joint reinforcement, and when employing regularly spaced vertical bracing ribs, we thereby obtain a wall which is capable of acting as a plate against the wind (Fig. 15).

The reinforcement arrangement in the plate wall, with greater or lesser uniformity of vertical or horizontal reinforcement, shall be established by design requirements. However, it is easier and more economic to place horizontal truss type reinforcement than the vertical ribs and, therefore, plate walls shall be designed to employ the minimum number of ribs possible.

The rib reinforcement may have different widths, or spacing between longitudinal components, according to the prefabrication employed in the transverse components.

The degree of insertion of the ribs within the masonry or universal units offers different construction solutions in both ACW and DCW walls.

8. BIBLIOGRAPHY

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