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INTEGRAL MASONRY SYSTEM AND THE CONTEMPORARY FAÇADE

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ABSTRACT

On investigating the symptomatic problems of Spanish enclosure walls which had appeared in recent years, it was decided that a new building technology should be designed for these walls in order to confront these problems of cracking and collapse.
This circumstance gave rise to the employment of reinforced masonry as the first step in the solution to the problem. This was subsequently supplemented by the Integral Masonry System which allowed the vertical reinforcement of brick enclosure walls when necessary, in view of the need to leave horizontal movement joints below the slabs of framed structures.
When applying the Integral Masonry System to the components which were recently designed for the same it is possible to construct buildings of reinforced or unreinforced masonry, by using universal units, bricks or blocks of any material, which may be vertically reinforced by rib reinforcement as and when necessary.
As such, the Integral Masonry System may solve any situation where it is necessary to place specific reinforcement and always respecting both the vertical modulation of the bed joints and the horizontal modulation of the masonry in question.
The three-dimensional reinforcement of the Integral Masonry System makes it possible to build prefabricated walls on site or at the workshop. The said prefabricated walls may be built in a horizontal, vertical or sloping directions which substantially simplifies bricklaying technique and reduces labour costs.
The Integral Masonry system may be applied to all types of constructions and buildings.

Key words: *Integral Masonry system; Universal Unit; Bed Joint Reinforcement; Rib Reinforcement.*

THE CONTEMPORARY FAÇADE AS A SOLUTION TO SPANISH CONSTRUCTION PROBLEMS.

The author of this article was entrusted by ASEMAS (The Architects' Mutual Insurance Association) with the study and preparation of a report on "Exposed brick leaf enclosure walls" in an attempt to prevent the damages which were currently appearing in enclosure walls.

The report, FFC001, considered the following items:

1. Causes of damage in enclosure walls,

   - The materials employed
   - Aspects related to Building Codes
   - Lack of calculation
   - Design faults
   - Problems arising from VPO regulations
   - Problems arising from execution
   - Problems arising with passage of time
   - Seismic problems

2. Analysis of enclosure types

   - Enclosure 1. Supported/Exposed flush support
   - Enclosure 2. Overhanging 1/3. Hidden flush support
   - Enclosure 3. Overhanging _. Recessed support
   - Enclosure 4. Exterior set on continuous angle iron/without support
   - Enclosure 5. Exterior set in frame/unsupported area

3. Recommendations for better building practice

In order to avoid the symptomatic problems of these walls, the Report gave new enclosure solutions under the generic heading of "The Contemporary Façade" (Fig. 1).

4. Design criteria of the contemporary facing wall

   - Vertical/horizontal movement joints between slab/support
   - Crack control and increased contribution of reinforced masonry
   - Suitable anchorage with suitable freedom of movement – slab/support
   - Hygrothermic and acoustic performance of brickwork and joints
   - Vertical rib reinforcement when there are no supports on the façade

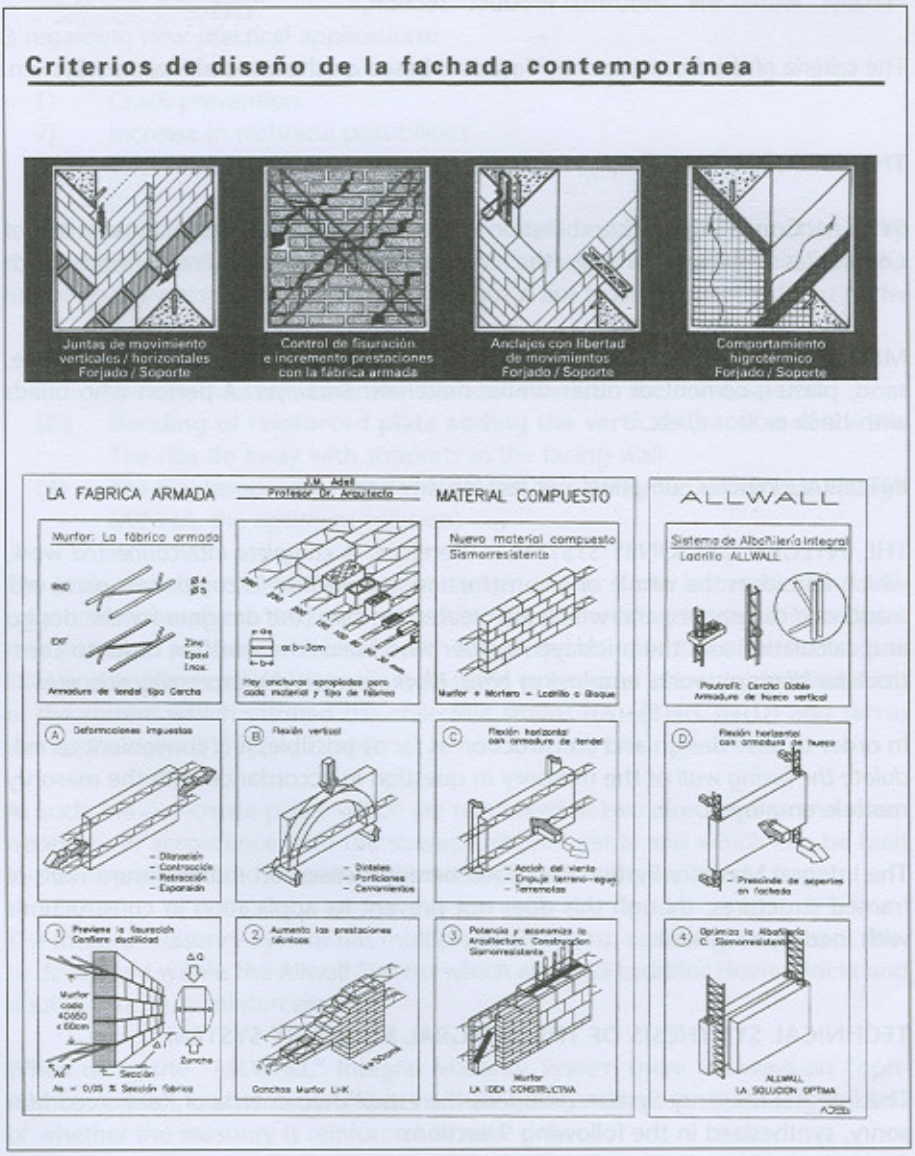
5. Self-supporting enclosure wall of reinforced brickwork

6. Semi-supported enclosure wall of reinforced brickwork

7. Curtain enclosure wall of reinforced brickwork

The publication of the said report coincided with the CONSTRUMAT '97 Building Trade Fair and where the BEKAERT stand exhibited prototypes of the enclosure walls which had been developed to avoid the defects commonly seen in Spanish buildings. These new enclosure walls were indicated as: Alpha, Beta and Omega "in situ" and prefabricated enclosure walls.

Figure 1. Design criteria of the contemporary facing wall.
Figure 2. Synthesis of the Integral Masonry System.



The Bekaert stand presented 4 different types of enclosure walls within the Integral Masonry System and 1 prefabricated variation.

* 2 Self-Supported Enclosure Walls
  - Alpha
  - Beta
* 2 + 1 Curtain Walls
  - Omega "in situ" enclosure wall
  - Omega prefabricated enclosure wall

The CONSTRUMAT'97 jury selected the ALLWALL Integral Masonry system as a "finalist" within the "Industrial Product" section.

The criteria of the Contemporary Façade is based on the Integral Masonry System.

THE INTEGRAL MASONRY SYSTEM

SYSTEM: Consisting of a combination of *Elements* formed by a specific number of *Composites* obtained through the combination of various *Components* which when suitably *Interconnected* suit a specific *Objective.*

MASONRY: *The art or work of constructing buildings* or works in *brick,* stone, lime, sand, plaster, cement or other similar materials. *Bricklayer:* A person who builds with brick or stone, etc.

INTEGRAL: Whole, complete, not lacking any part

THE INTEGRAL MASONRY SYSTEM is therefore: A *complete interconnected work,* which considers the whole of a construction and *each of its component parts, elements and composites,* and which are created by man (the designer for the design and calculation and the bricklayer/builder who builds the work) in order to construct *buildings* or works employing *brick, block, mortar, reinforcement, ribs, etc.*

In order to ease design and construction as far as possible, it is convenient to *modulate the facing wall* or the masonry in question in accordance with the masonry module employed.

The Integral Masonry System described here is focused on the enclosure walls of framed structures, though this does not prevent its application in constructions with load bearing walls.

TECHNICAL SYNTHESIS OF THE INTEGRAL MASONRY SYSTEM

The Integral Masonry System broadens the established criteria of Reinforced Masonry, synthesized in the following 9 sections:

3 regarding the form of the composite material (*) (**) (***)

* Truss-type reinforcement
** Ratio of widths between truss reinforcement and units
*** New regularly reinforced Composite Material

3 regarding the new technical qualities (A) (B) (C)

A) Imposed strain: expansion, contraction, shrinkage
B) Vertical bending: lintels, partitions, facing walls
C) Horizontal bending: wind action, earth/water thrust, earthquake

3 regarding new practical applications:

1) Crack prevention.
2) Increase in technical possibilities
3) Cost reduction and increased architectural possibilities

In the Integral Masonry system the said synthesis is substantially broadened by the use of rib reinforcement placed within the universal units, and which add the following 3 aspects:

(****) **Configuration of the Integral Masonry System**
Double truss reinforcement embedded within the universal unit
(D) Bending of reinforced plate adding the vertical direction of the rib
The ribs do away with supports in the facing wall
(4) The Contemporary Façade. ACW / DCW. Alpha, Beta, Gamma, Omega
(AllWall, the optimum solution)

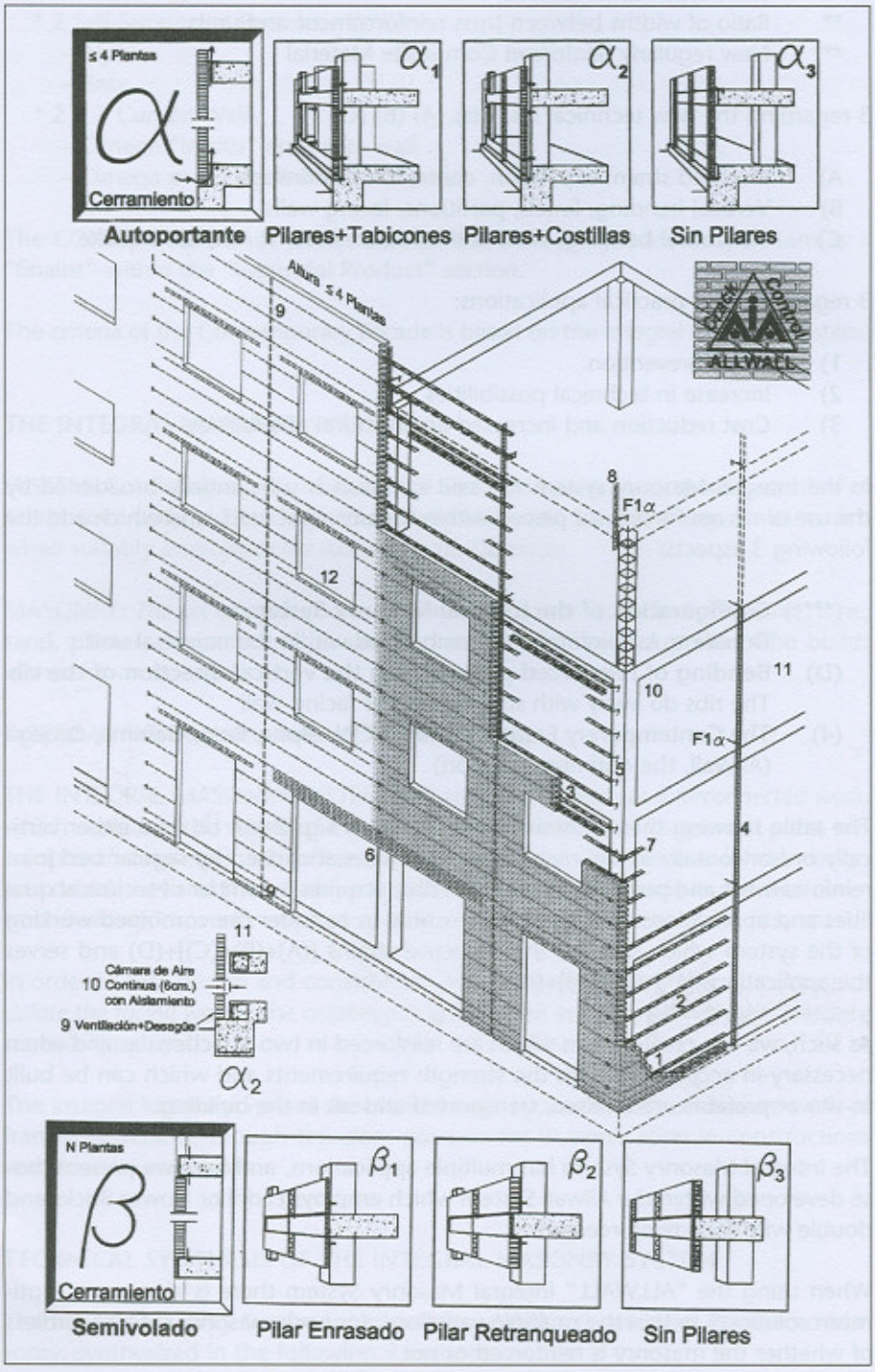
The table showing the synthesis of the system in Fig. 2 can be read either vertically or horizontally as the new composite material created by regular bed joint reinforcement and point reinforced with ribs, acquires a number of technical qualities and applications which make it possible to consider the combined working of the system which satisfied the collective strains [(A)+(B)+(C)]+(D) and serves the applications [(1)+(2)+(3)]+(4).

As such, we can create plates which are reinforced in two directions as and when necessary in accordance with the strength requirements and which can be built in-situ or prefabricated, raised, transported and set in the building.

The Integral Masonry System has multiple applications, and here we present those developed within the Allwall System which employs Ladriflor Flower Bricks and double wire truss reinforcement.

When using the "ALLWALL" Integral Masonry System there is always an "optimum solution", within the multiple variations, for each masonry case, regardless of whether the masonry is reinforced or not.

Figure 3. Self-supporting Enclosure Wall Alpha. Variations 1, 2, 3.
Figure 4. Self-supporting Enclosure Wall Alpha 2.
Figure 5. Semi-supported Enclosure Wall Beta, Variations 1, 2, 3.



The prevention of corrosion should be taken into account when selecting the type of reinforcement, in accordance with the mortar employed and the specific location of the rib reinforcement.

SUPPORTED ENCLOSURE WALLS OF THE INTEGRAL MASONRY SYSTEM

The Alpha and Beta supported enclosure walls, these being Self-bearing and Semi-supported respectively, have been developed for their use in Spanish building.

All the relevant details of the Alpha enclosure walls (Alpha 1, Alpha 2, Alpha 3) and the Beta walls (Beta 1, Beta 2, Beta 3) have already been developed. These have been developed on the basis of a standard façade (plan 0) which include plans of the following masonry forms (M):

I. BM Blind Masonry
II. WM Window Masonry
III. VBM Venetian Blind Housing
IV. CM Corner Masonry
V. AM Elevated/Hanging/Balcony Apron Masonry

For each of these masonry forms (I, II, III, IV, V) in both Alpha (1, 2 and 3) and Beta (1, 2 and 3) walls the following construction details have been developed:

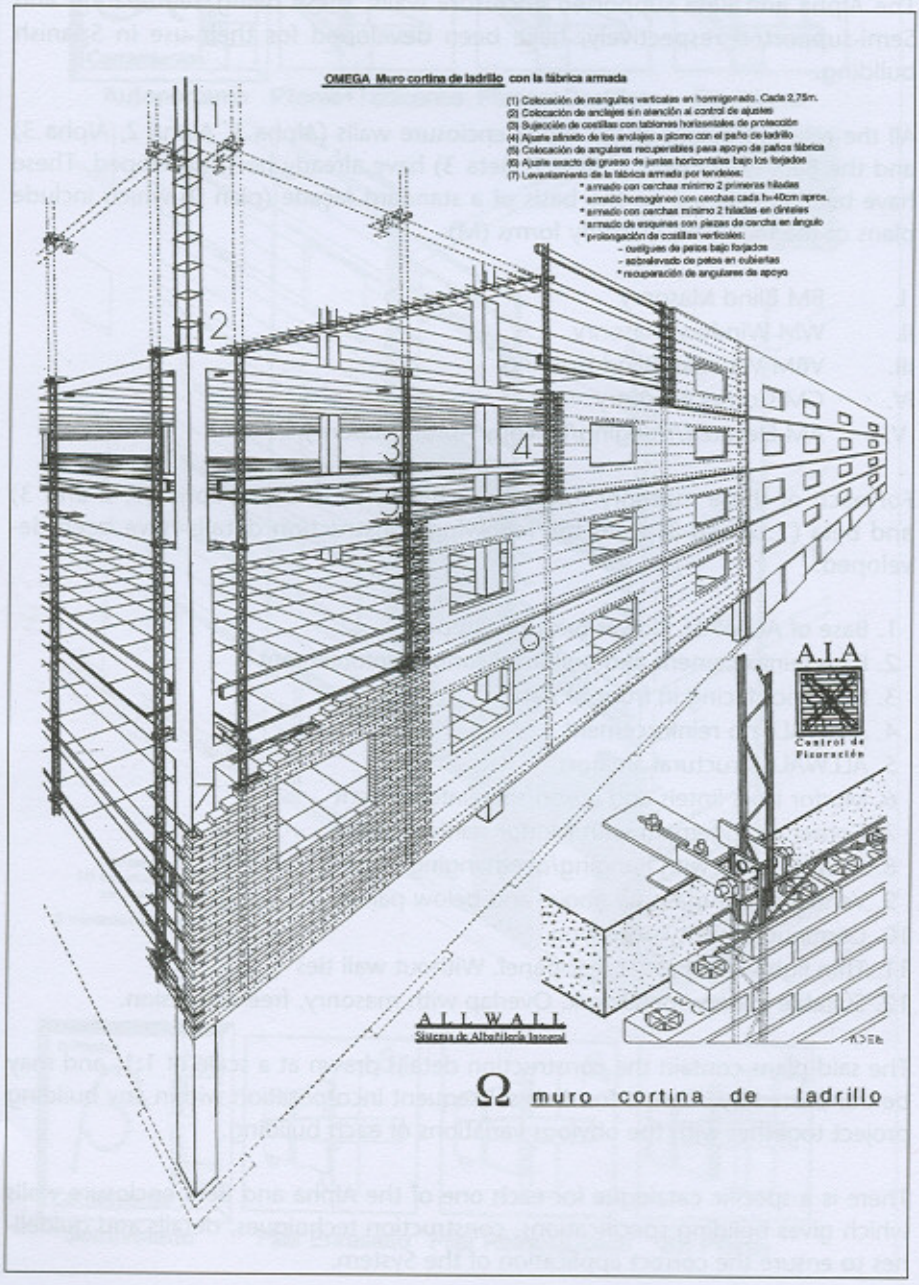
1. Base of ALLWALL Flower Brick on support
2. Base reinforcement and uniform Murfor reinforcement
3. Half brick facing in front of slab
4. ALLWALL rib reinforcement
5. ALLWALL structural anchors
6. Murfor truss lintels and apron/sill reinforcement
7. Corner arrangement with Murfor reinforcement
8. ALLWALL ribs with hanging/overhanging aprons
9. Ventilation of masonry above and below panels
10. Continuous cavity insulation
11. Thin lightweight inner leaf/panel. Without wall ties
12. Suitable joinery/metalwork. Overlap with masonry, free expansion.

The said plans contain the construction details drawn at a scale of 1:1, and may be transferred by internet for their subsequent incorporation within any building project together with the obvious variations of each building.

There is a specific catalogue for each one of the Alpha and Beta enclosure walls which gives building specifications, construction techniques, details and guidelines to ensure the correct application of the System.

Together with the above documents there is an itemization of *individual components* which allow the precise evaluation of the characteristics of the components to be used in each case and allows the calculation of the cost of each composite item and the overall cost of the façade

Figure 6. Omega Enclosure Wall. Brick curtain wall built in-situ.



ALPHA Self-supporting Enclosure Wall

Enclosure wall with self-supporting outer leaf in reinforced masonry, passing in front of the structure, without horizontal joints at the slabs.

Ventilated air cavity with continuous insulation and lower damp proof course, without connections to the inner leaf.

Leaf built in vertical continuation until 12m or four floors, uniformly reinforced with truss type reinforcement every 40 cm height.

Wind supporting vertical ribs spaced 2.75m with special anchors at slab level.

Base with low porosity bricks (one brick thick) on damp proofed foundation.

This is a ventilated facing wall without thermal bridges and with freedom of movement with regards to the structure (Fig. 4).

The system allows the adjustment of tolerances between the slabs and the plumb line of the facing wall, with overturning control

It is possible to construct the outer wall before the inner wall and vice-versa.

There are 3 variations to the Alpha Self-Supporting Enclosure Wall (Fig. 3):

- Alpha 1: With columns and/or partitions in façades (without ribs)
- Alpha 2: With spaced columns on façade and ribs
- Alpha 3. Without columns on façade and double quantity of ribs.

BETA Semi-supporting Enclosure Wall

Enclosure wall with semi-supported masonry outer leaf, supported and anchored on slabs and unconnected to the inner leaf.

Horizontal joints at the level of each slab.

Ventilated air cavity with continuous insulation and breaking of thermal bridge at the face of slabs and columns. Damp proofed support.

Leaf constructed between each floor and suitable for high buildings. Uniformly reinforced with truss type reinforcement every 40 cm height.

Wind supporting vertical ribs spaced 2.75m which prevent overturning of the semi-supported leaf and allow the fixing of the apron to brackets set in the insulated slab.

This is a discontinuous ventilated façade without thermal bridges with freedom of movement with regards to the structure.

The system allows the adjustment of tolerances between the slabs and the plumb line of the facing wall, with overturning control

It is possible to construct the outer wall before the inner wall and vice-versa.

There are 3 variations to the Beta Semi-Supporting Enclosure Wall (Fig. 3):
Beta1: With columns and/or partitions in façades (without ribs)
Beta 2: With spaced recessed columns on façade and ribs
Beta 3. Without columns on façade and double quantity of ribs.

HANGING ENCLOSURE WALLS WITH THE INTEGRAL MASONRY SYSTEM

OMEGA Brick curtain wall built in-situ (fig. 6)

External facing and ventilated wall detached from the inner leaf and with totally continuous insulation, built in-situ or prefabricated on site.

Construction process:

1. Placing of vertical sleeves in the concrete. Every 2.75m
2. Placing of anchors with adjustment control
3. Fixing of ribs with horizontal protection boards
4. Fine adjustment of anchors flush with the brickwork
5. Placing of retrievable angles to support the masonry
6. Precise adjustment of thickness of horizontal joints below slabs
7. Raising of reinforced masonry by courses:

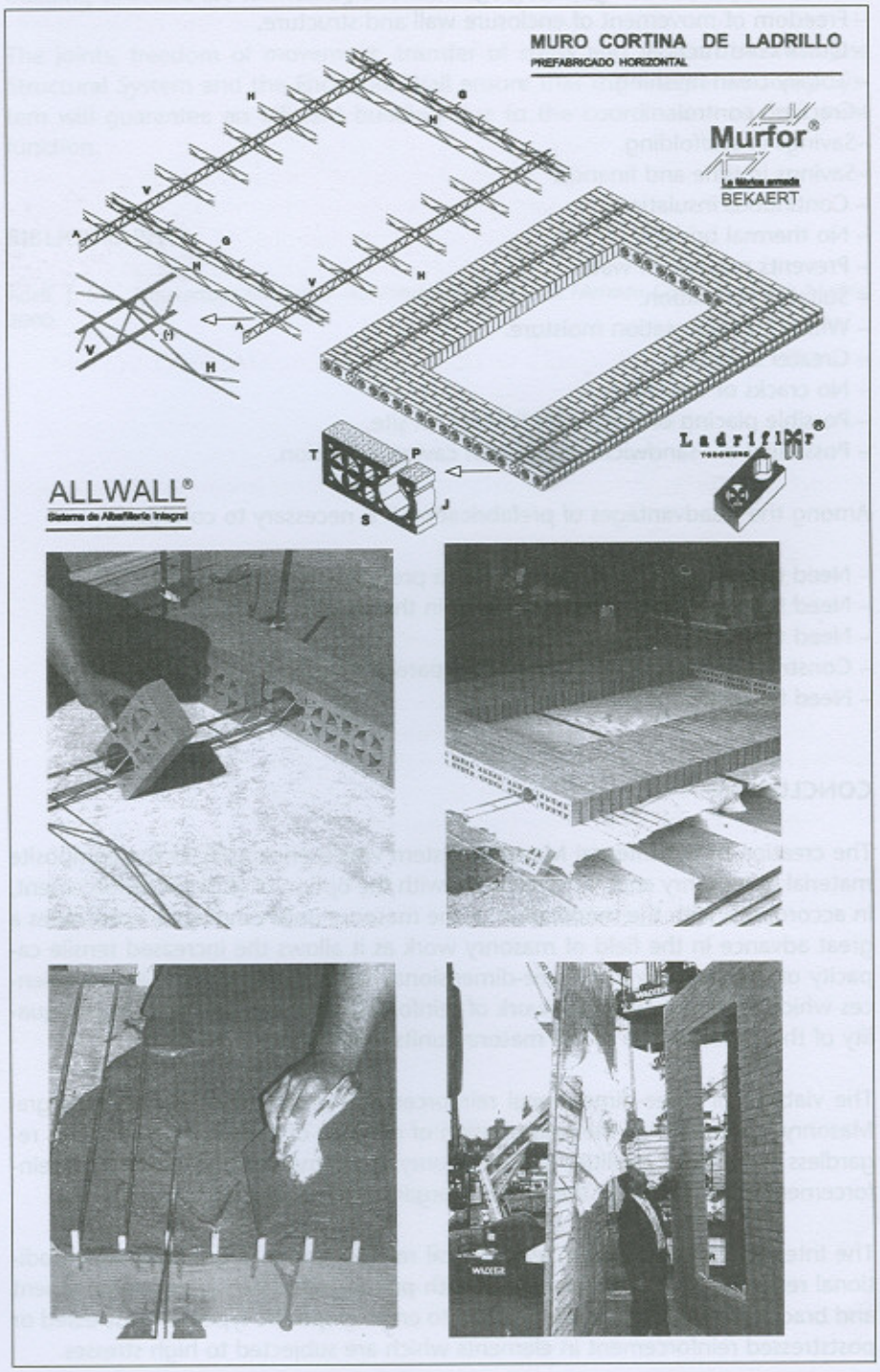
* truss reinforcement minimum first 2 courses; uniform reinforcement trusses every h = 40cm.
* truss reinforcement minimum 2 courses at lintels; *angled truss piece corner reinforcement.
* extension of vertical ribs; –apron hangers below slabs; –overhanging aprons at roofs.
* recovery of support angles after 8 days.

OMEGA PW: Prefabricated Curtain Wall

As an example of the building possibilities of the curtain wall, a prefabricated panel was exhibited at the Bekaert Stand at the CONSTRUMAT'99 Trade Fair (Figs. 7, 8 and 9).

The horizontal prefabrication considered here as many advantages which include:

Figure 7. Omega Prefabricated Wall. Construction layout.
Figure 8. Horizontal construction of prefabricated panel.
Figure 9. Transport and hoisting of prefabricated panel.



– Freedom of design and composition of panels.
– Economic and unskilled labour
– No bricklayers, levelling, plumbing or lines required.
– Freedom of movement of enclosure wall and structure.
– Quick construction.
– Totally clean finishing.
–Cracking control.
–Savings in scaffolding.
–Savings in time and finance.
– Continuous insulation.
– No thermal bridges.
– Prevents passage of water.
– Suitable ventilation.
– Without condensation moisture.
– Greater durability.
– No cracks or corrosion.
– Possible placing of metalwork/joinery on site.
– Possibility of "sandwich" panel with cavity+insulation.

Among the disadvantages of prefabrication it is necessary to consider:

– Need to organize the construction in a premeditated manner.
– Need for area of free space on site or in the vicinity.
– Need to employ reusable formwork.
– Construction control according to prepared plans.
– Need for vertical and horizontal joints.

CONCLUSION

The creation of the Integral Masonry System which encompasses the composite material of masonry and reinforcement, with the option of vertical reinforcement, in accordance with the modulation of the masonry units employed, constitutes a great advance in the field of masonry work as it allows the increased tensile capacity of the masonry in a three-dimensional manner, without the inconveniences which arise from the formwork of reinforced concrete, and with all the quality of the exposed face of the masonry units employed.

The viability of three-dimensional reinforcement which arises with the Integral Masonry System allows the optimization of all types of construction solutions regardless of the basic qualities of the masonry units employed, as the internal reinforcement does not affect the order or organization of the masonry.

The Integral Masonry System allows local reinforcement to be made with traditional rebars or in a uniform manner with prefabricated bed joint reinforcement and bracing ribs, it even being possible to employ specific types of prestressed or poststressed reinforcement in elements which are subjected to high stresses.

The fact that this is a system implies a suitable relation with other building systems and, particularly with the Structural System when the enclosure wall and the building structure are formed by two different systems.

The joints, freedom of movement, transfer of stress and relation between the Structural System and the Enclosure Wall ensure that the Integral Masonry System will guarantee an efficient building due to the coordination of their joint function.

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