

# Heritage Problems, Causes and Solutions

Calogero Bellanca and Susana Mora Alonso-Muñoyerro





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Causes and Solutions

3



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*Calogero Bellanca and Susana Mora Alonso-Muñoyerro*



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In this volume have collaborated specially these architects:

IGNACIO MORA MORENO, ALEJANDRO INIESTA MUNOZ, MAGDALENA PRIETO DE LA LASTRA

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In copertina | *Cover image: Colosseum, detail. Photo by Susana Mora and Calogero Bellanca.*

*Dedicated to our parents*

*MARIA and ANTONINO*

*CONSUELO and JUSTO*





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## CHAPTER 7. FOUNDATIONS: CONSTRUCTIVE SYSTEMS, PROBLEMS, CAUSES AND SOLUTIONS. SOIL MOISTURE

### INTRODUCTION

Reminder of what we have written in Part I: Methodological Approach to Conservation.

First of all, we must study, to know the “monument” and its problems, after the “libraries and archives survey”.

### SURVEY

1. Geometrical Survey
2. Constructive Systems Survey
3. Stratigraphy. Phases
4. Constructive Survey
5. Map of Damages
6. Damage Monitoring



Fig. 1. Geometrical Survey.  
From F. Vella, E. Viganò,  
“Final Degree Project”,  
*Manuale del restauro  
architettonico*, Mancosu,  
Roma 2001, Section H.  
Approcci metodologici,  
rilievo geometrico, 12.



Fig. 2. Architectural  
Survey. Elevation by P. F.  
Cueto.



Fig. 3. Mechanical and  
Constructive Survey.  
From Carlo Blasi, *Manuale  
del restauro architettonico*,  
Mancosu, Roma 2001.

## CONSTRUCTIVE SYSTEMS

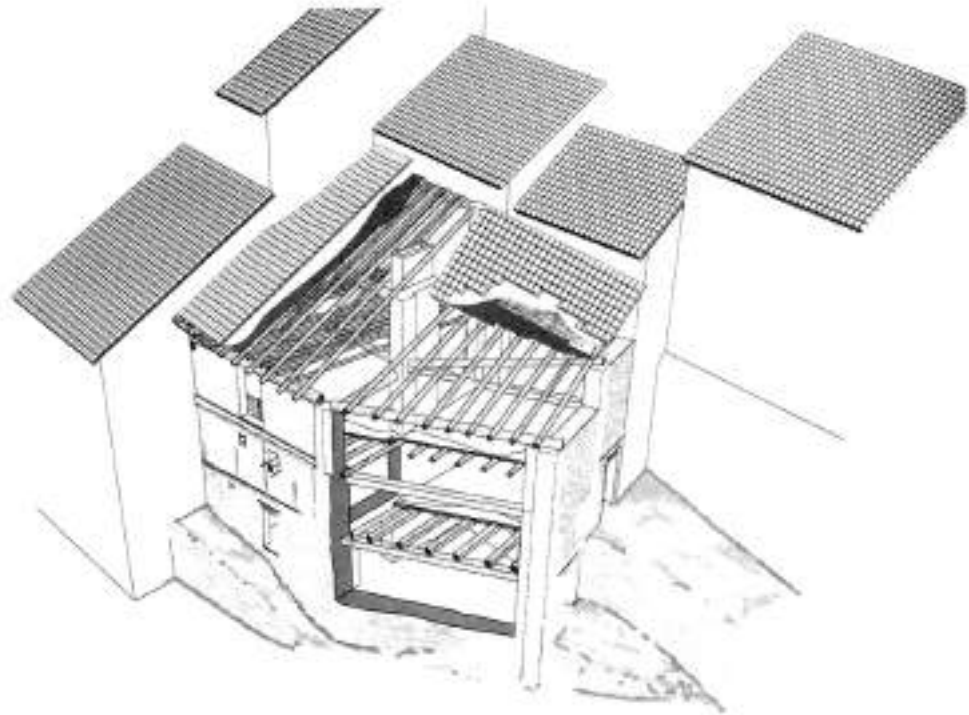


Fig. 4. Constructive Systems Survey.  
From F. Vegas, C. Mileto,  
*Aprendiendo a restaurar*,  
in *PH: Boletín del Instituto  
Andaluz del Patrimonio  
Histórico*, year n. 26,  
n. 93, 2018.

## MAP OF DAMAGES

Using as a basis a cartographic architectural survey on which is portrayed the perimeter of the areas subject to some typical aspects of degradation, such as surface deposit, cracking, fracturing, scaling, alveolization, black crusts, pitting, corrosion, spotting, efflorescence, detachment, etc.

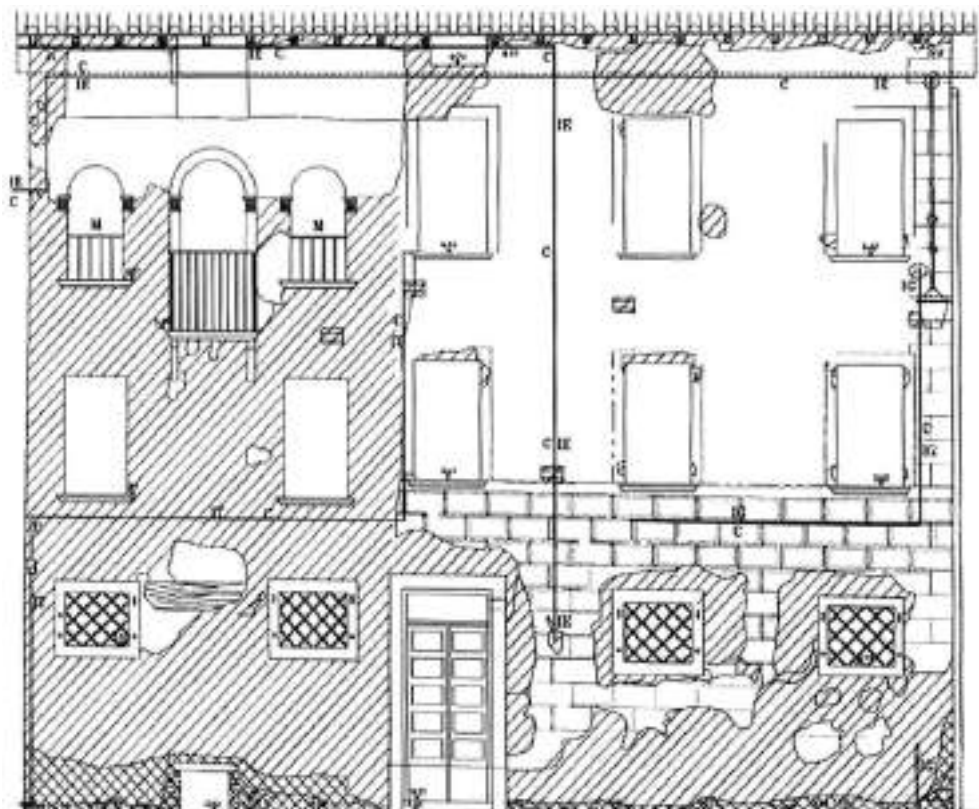


Fig. 5. Map of Damages.  
From F. Doglioni,  
*Nel restauro. Progetti  
per la architettura  
del passato*, (IUAU  
Documenti), Marsilio,  
Venezia 2008, p. 228.

First of all, we must know the principal “historic” constructive systems.

## CONSTRUCTIVE SYSTEM

### *ELEMENTS*

- Vault
- Lintel
- Foundations
- Walls
- Floors
- Roofs
- Other Traditional Structures

### *CRITERIA*

- Compatibility
- Minimal Intervention
- Reversibility

The interventions on the “structures” must be decided after having identified their values, degradation, and the causes, the current conditions and the type of material and constructive system that constitutes the construction.



Fig. 6. Santa Maria di Collemaggio, L’Aquila.  
Photo by Susana Mora, 2012.

GENERAL CAUSES OF PROBLEMS: GROUND

Soil settlements belong to the category of indirect actions that induce movement at the boundaries. Soil deformation is one of the major causes of damage to buildings and therefore it is essential to understand the main concepts with a general view of the various problems and solutions.

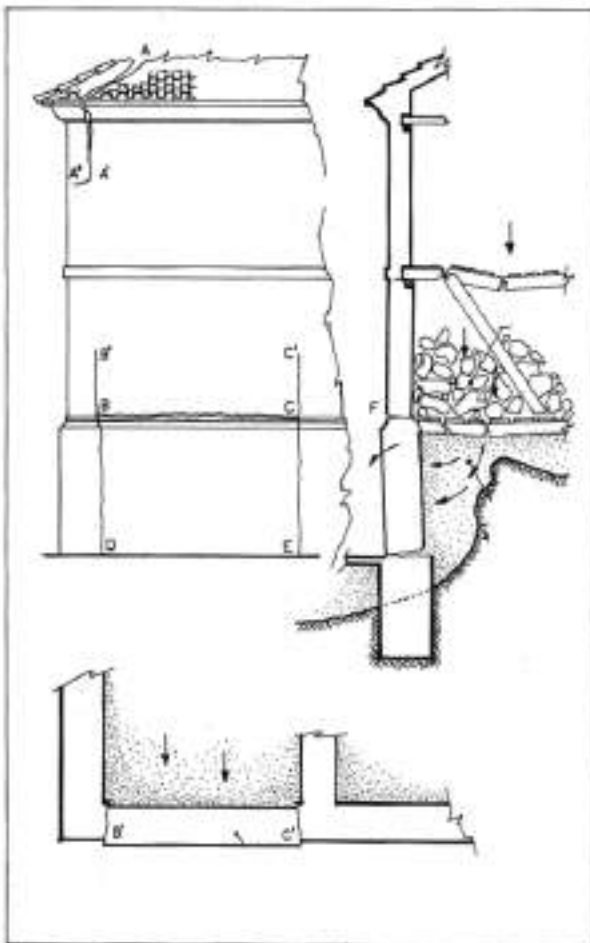


Fig. 7. From G. López Collado, *Las Ruinas en Construcciones Antiguas*, Miján, Artes, Gráficas, Ávila 1985.

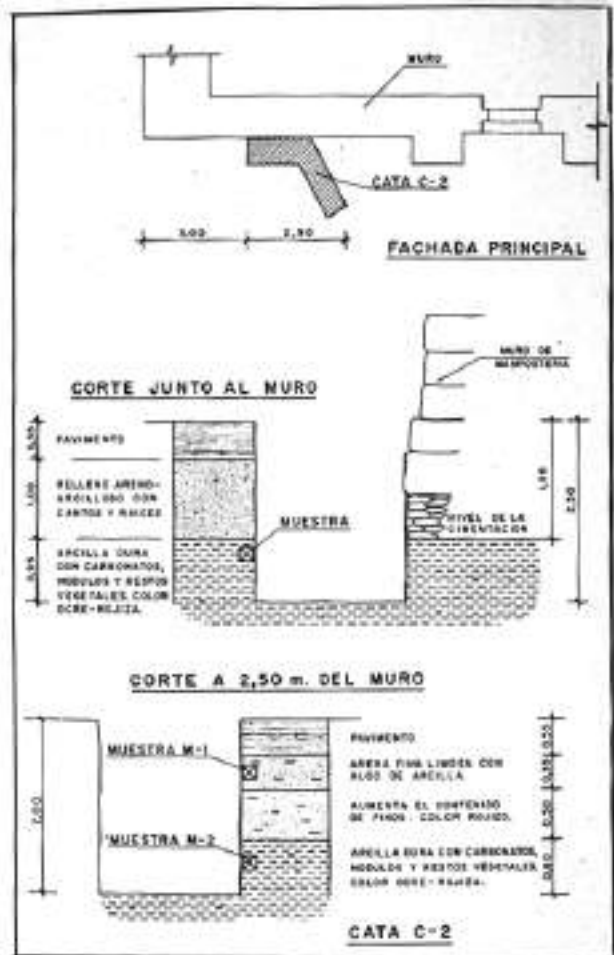


Fig. 8. Geological study. San Bartolomé, Tarazona de la Mancha. Project by Susana Mora.

GENERAL CAUSES OF PROBLEMS: WATER

The penetration of moisture into the walls is one of the main causes of deterioration in the structures. This humidity can come from:

- A. Condensation of water vapor
- B. Rainwater that penetrates through the roof or external surface
- C. Soil moisture that rises through the foundation and the walls by capillarity

## FOUNDATIONS

“Foundations are that part of a building that distributes the loads from roofs and walls on to the earth below. This is generally done by a widening of the wall into a footing which bears on the soil under the building; however, in many early buildings no such widening was practised. The main factor in the permanence of architecture is the sufficiency of its foundations and, when this is lacking, there is no sense in spending large sums of money elsewhere on superficial restoration work. Ground movement is not at all uncommon. Geologically, it occurs continuously and, when extreme, causes earthquakes. It can be induced by manmade activities such as mining and underdrainage. Heavy rain can also induce landslides, while underground streams, especially in chalk and gravel, can cause potholes and caves under buildings. Conversely, blocked underground watercourses may cause the water table to rise. The absolute movements of a building -with the exception of earthquakes-are of less concern than differential or relative movements which may be caused by different types of ground under the building or uneven loading of different parts of the preexistence”.

From FEILDEN B. M., *Structural elements IV: Foundations in Conservation of Historic Buildings*, Oxford 1982, revised edition 1994, third edition 2003, p. 79.

### 1. DAMAGES AND BACKGROUND

- Historical Preferences:
  - Photographs, documents, testimonies
- Existence of previous buildings
- Structural or architectural modifications
- Damages: earthquakes, flooding...
- Water table
- Modifications of the environment:
  - Excavations, paving, sanitation, wells, cellars...

#### CAUSES:

Excavations, paving, sanitations, wells, cellars...

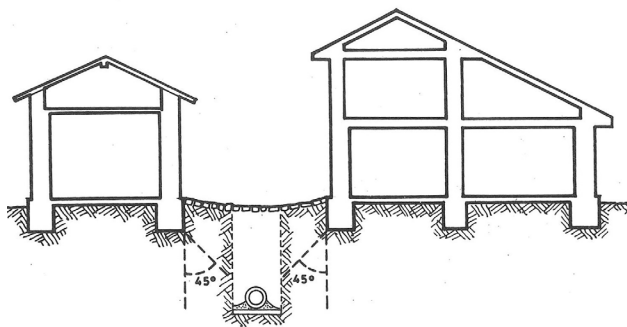


Fig. 9. From G. López Collado, *Las Ruinas en Construcciones Antiguas*, Miján, Artes, Gráficas, Madrid 1985, p. 144.

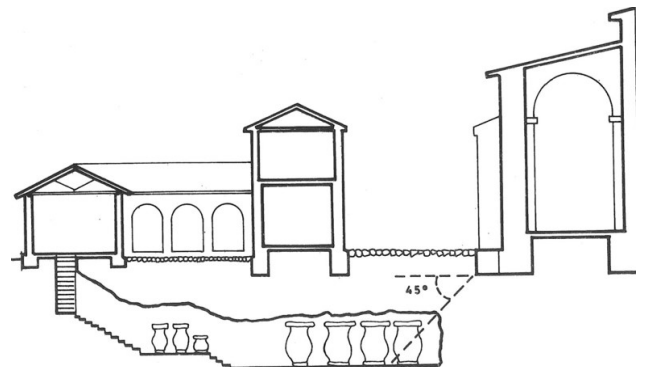


Fig. 10. From G. López Collado, *Las Ruinas en Construcciones Antiguas*, Miján, Artes, Gráficas, Ávila 1985, p. 151.

**2. ANALYSIS OF OBSERVED PATHOLOGY**

- VERIFY THE ORIGIN OF DAMAGES
- TYPOLOGY OF FOUNDATION AND GROUND DAMAGES:
  - EDGE MOVEMENTS
  - INTERNAL MOVEMENTS
  - GENERALIZED MOVEMENTS
  - TWIST
  - COLLAPSE

**PROBLEMS**

- Damages and deformations in a masonry structure:

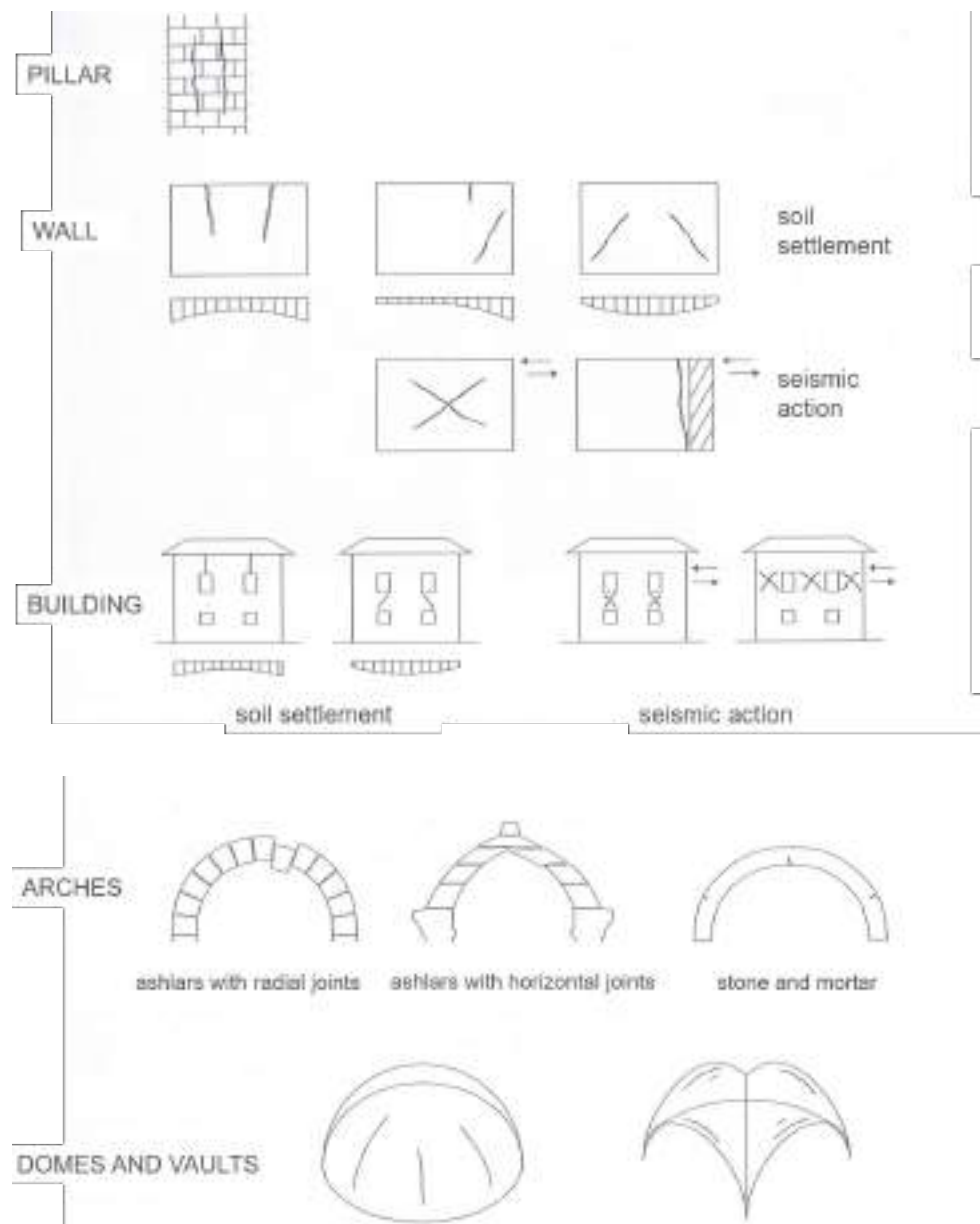


Fig. 11. From G. Croci, *Conservazione e restauro strutturale dei beni architettonici*, Utet, Torino 2001, p. 121.



- Foundation and ground damages: Edge movements.

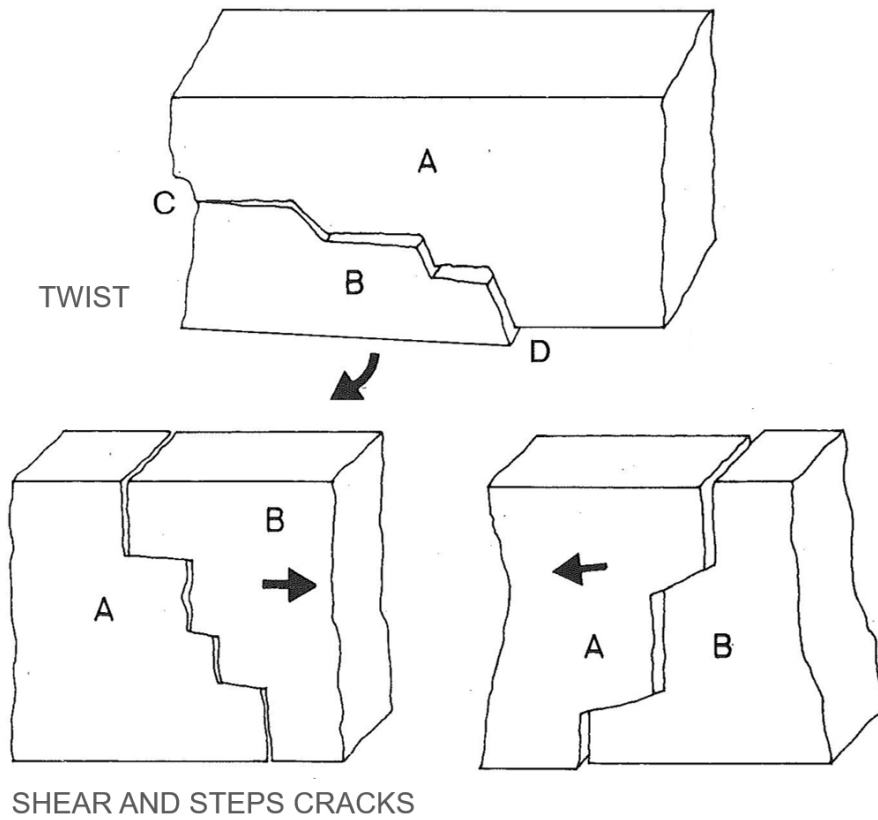


Fig. 12. From G. López Collado, *Las Ruinas en Construcciones Antiguas*, Miján, Artes, Gráficas, Ávila 1985, p. 54.

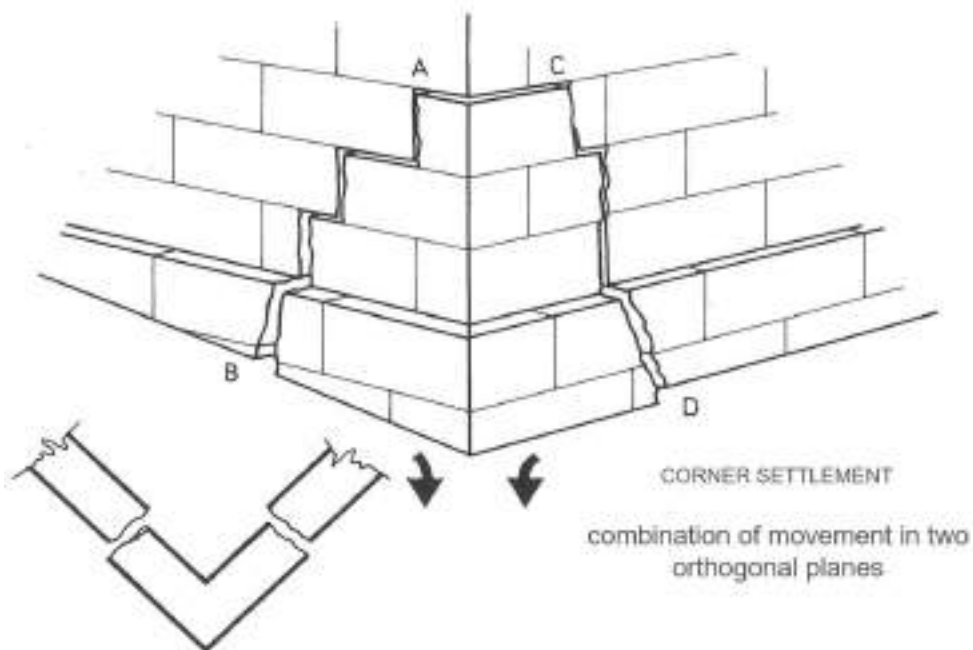


Fig. 13. From G. López Collado, *Las Ruinas en Construcciones Antiguas*, Miján, Artes, Gráficas, Ávila 1985, p. 63.

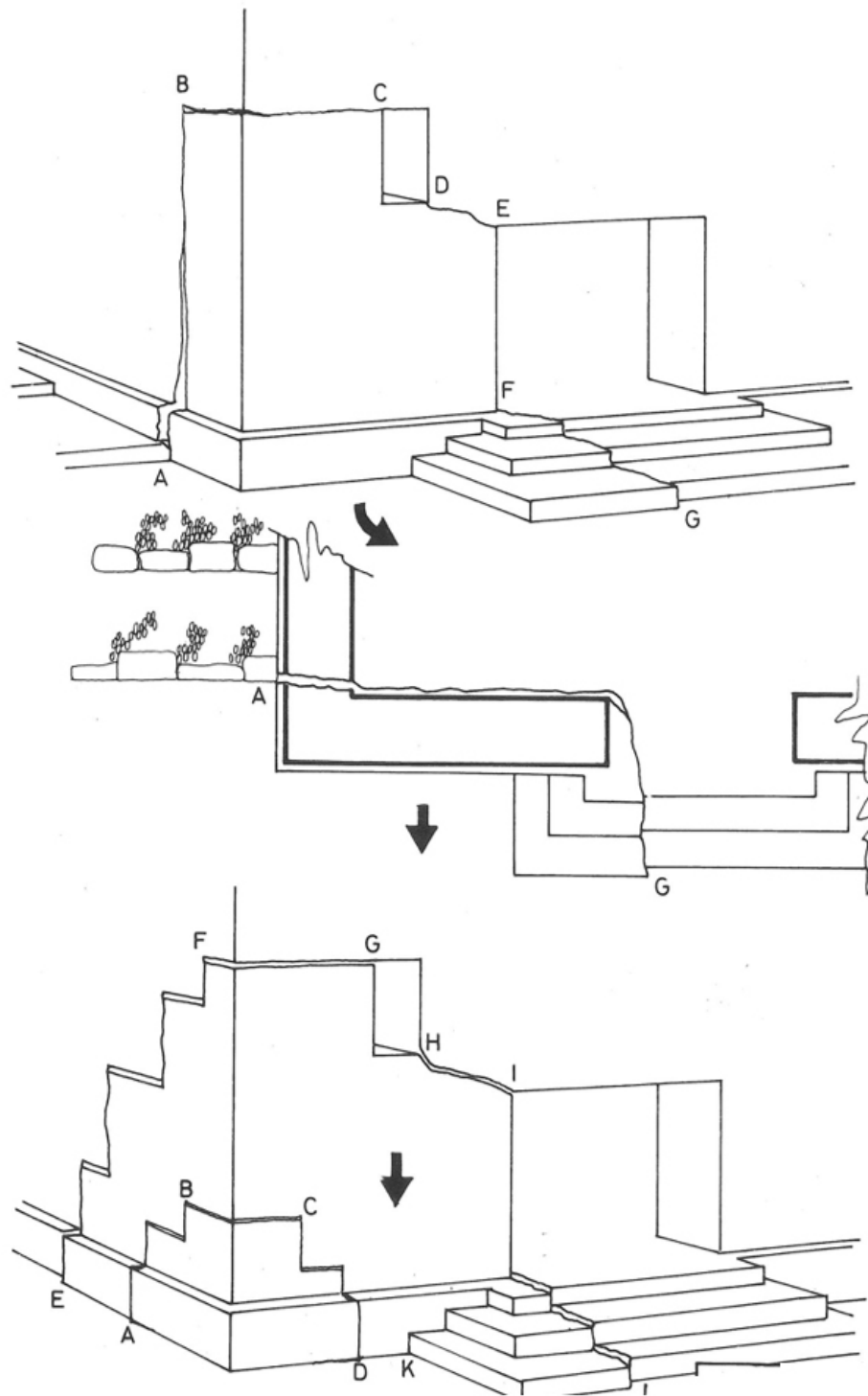


Fig. 14. From G. López Collado, *Las Ruinas en Construcciones Antiguas*, Miján, Artes, Gráficas, Ávila 1985, p. 66.

FOOTING SETTLES AND  
LEANS  
combination of movement in two  
orthogonal planes with shear and  
steps cracks

- Foundation and ground damages: Internal movements.

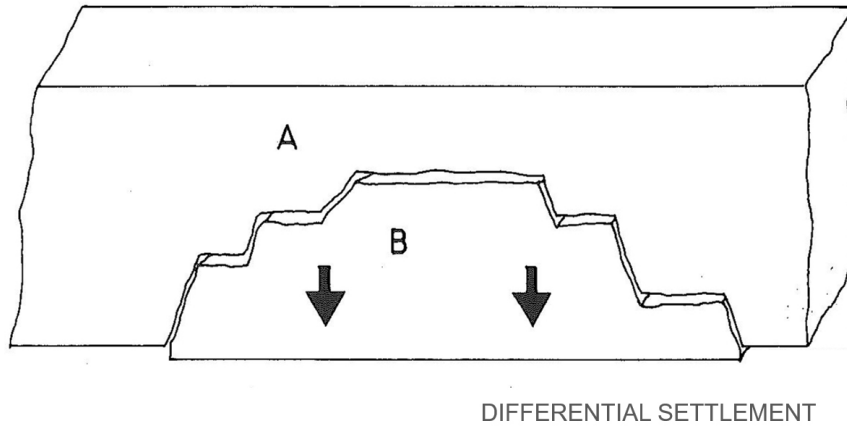


Fig. 15. From G. López Collado, *Las Ruinas en Construcciones Antiguas*, Miján, Artes, Gráficas, Ávila 1985, p. 54.

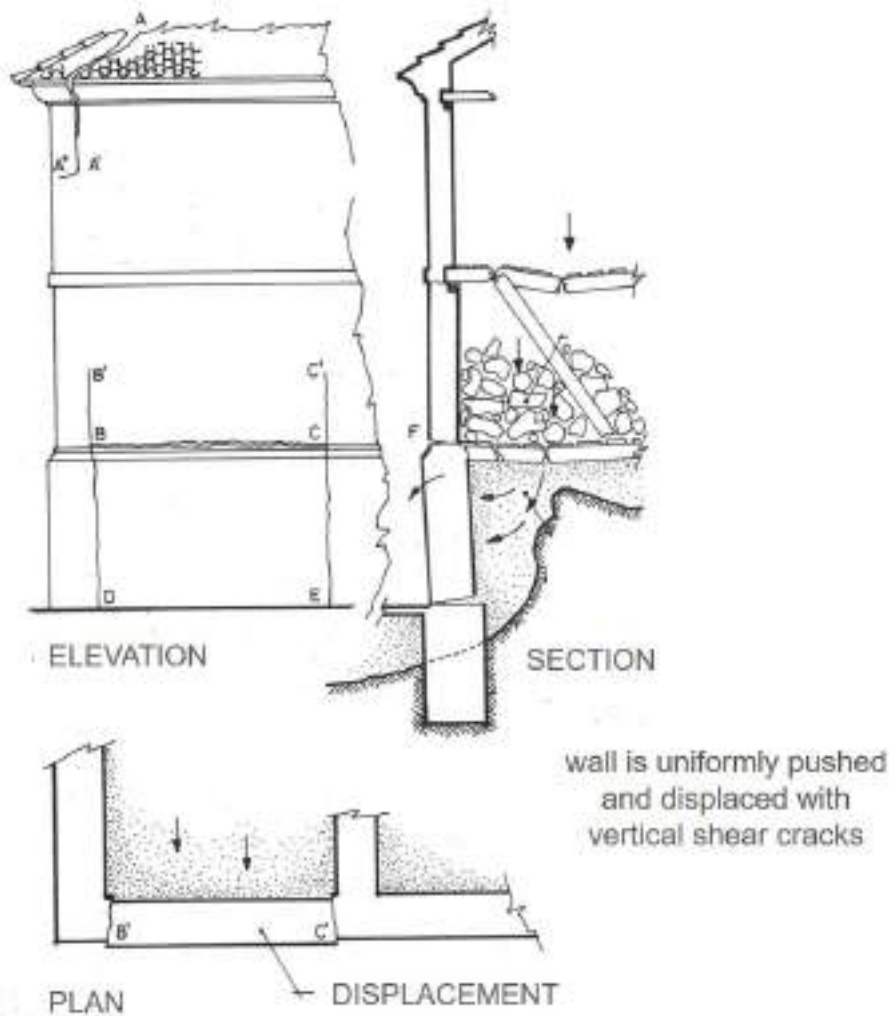


Fig. 16. From G. López Collado, *Las Ruinas en Construcciones Antiguas*, Miján, Artes, Gráficas, Ávila 1985, p. 56.

### 3. VERIFICATION OF THE HYPOTHESES

- STRUCTURAL ANALYSIS
- SURVEYS AND PROSPECTIONS
- GEOTECHNICAL INTERPRETATION

**4. SELECTION OF REPAIR SOLUTIONS**

1. REINFORCEMENT
2. BRIDGING AND ENLARGE FOOTINGS
3. NEW FOUNDATION OVER THE PREVIOUS
4. MICROPILES
5. REPLACEMENT
6. INJECTIONS
7. EXTERIOR REINFORCEMENT
8. JET GROUTING

(1) Work of consolidation, repair or reconstruction that is made to the foundations of a wall or a building, without damaging the superstructure.

**1. REINFORCEMENT**

**Wider footings solutions**

1. Original foundation
2. Grout
3. Perimeter ring or concrete tie beam
4. Anchor bar
5. Drill
6. Cable-stayed perimeter ring
7. Wedge cutout
8. Pyramidal ring
9. Toothed joint

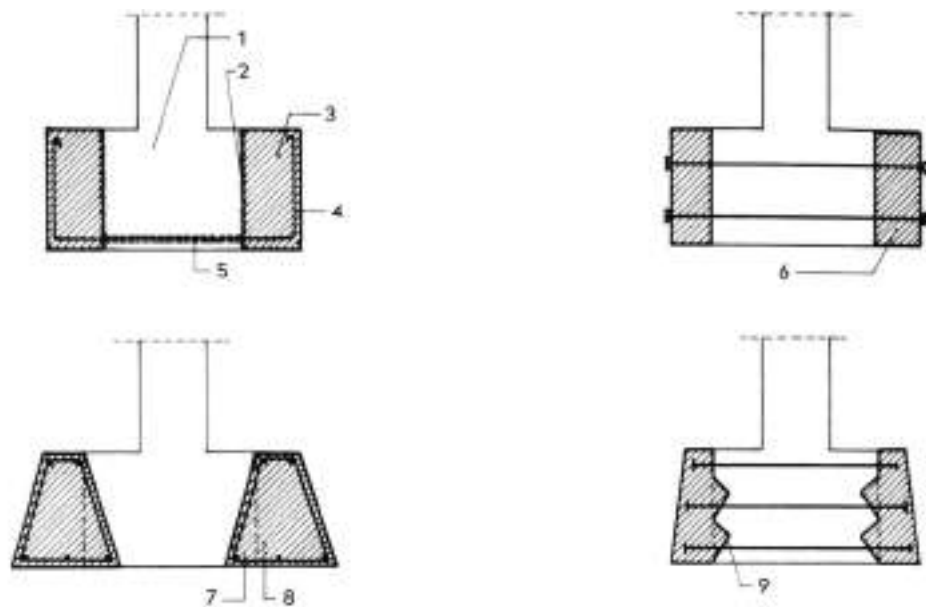


Fig. 17. From J.M. Rodríguez Ortíz, *La cimentación*, Curso COAM, Madrid 1984, p. 32.

**2. BRIDGING AND ENLARGE FOOTINGS SOLUTIONS**

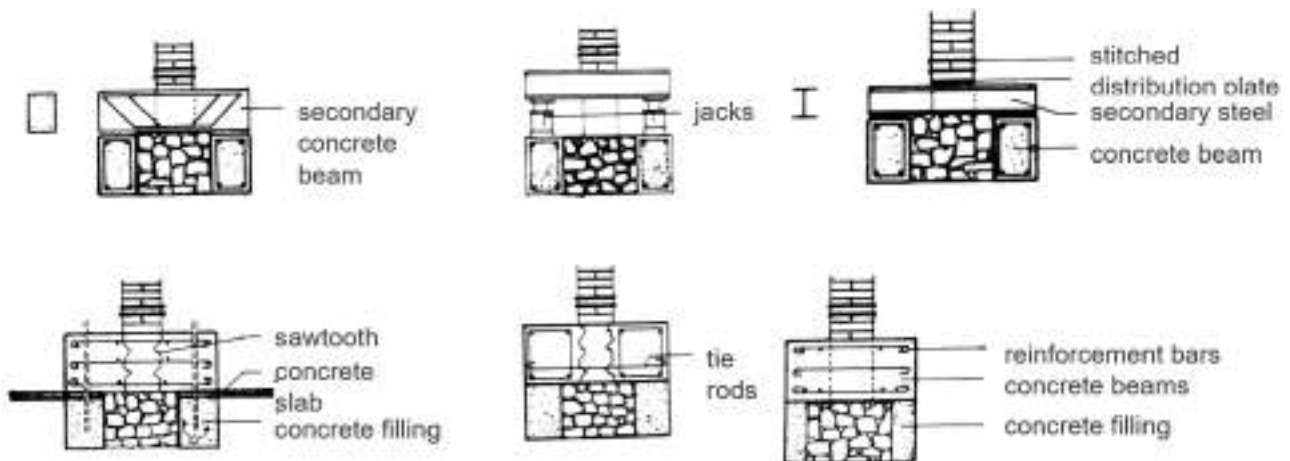
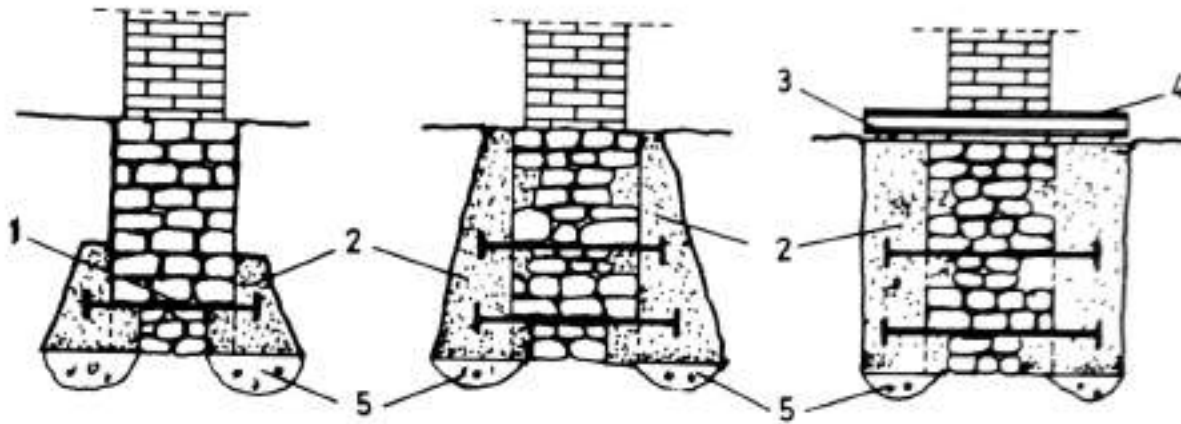


Fig. 18. From J.M. Rodríguez Ortíz, *La cimentación*, Curso COAM, Madrid 1984, p. 32.

Enlarge footings solutions with local ground improvement.



1. Tie rods; 2. Concrete; 3. Wedges; 4. Secondary beam; 5. Compacted or injected soil.

Fig. 19. From J.M. Rodríguez Ortiz, *La cimentación*, Curso COAM, Madrid 1984, p. 33.

### 3. NEW FOUNDATION PLACED OVER THE PREVIOUS

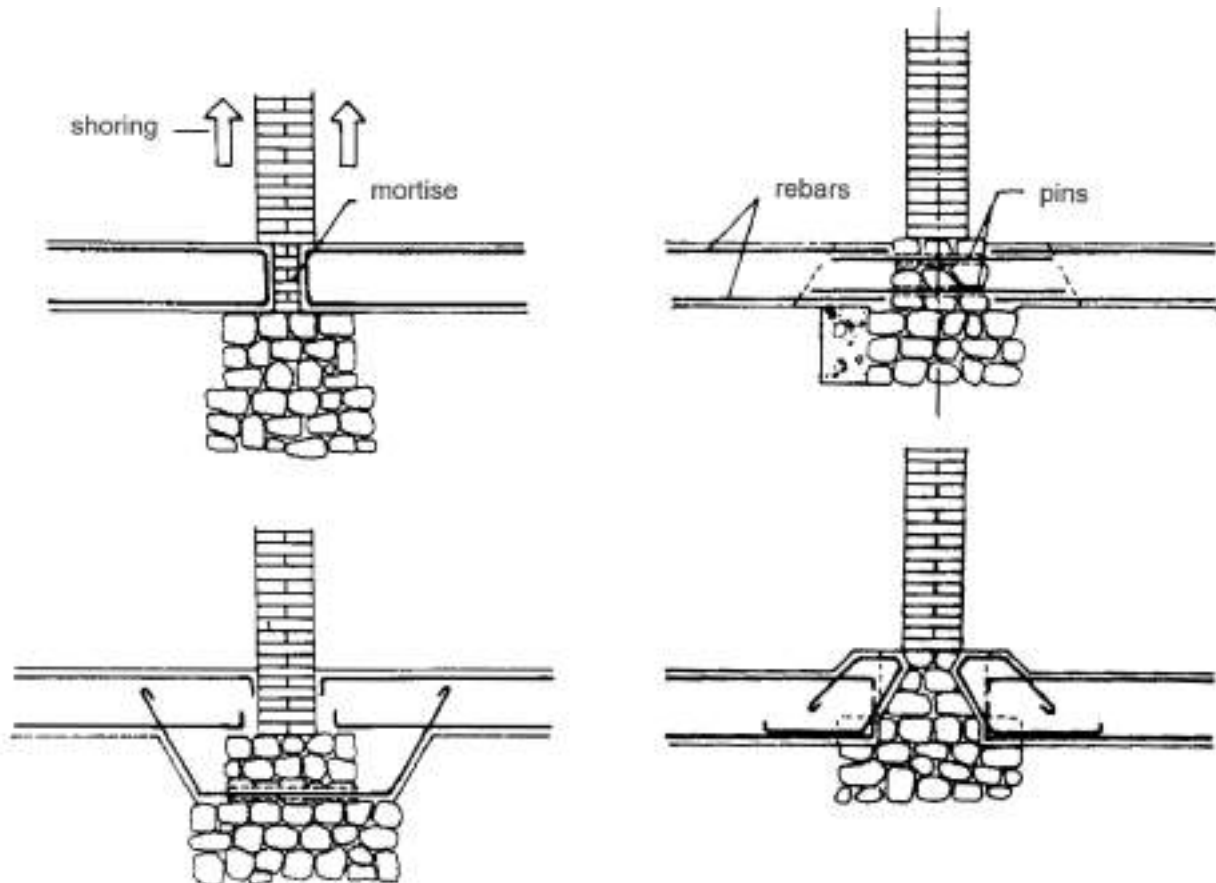


Fig. 20. From J.M. Rodríguez Ortiz, *La cimentación*, Curso COAM, Madrid 1984, p. 35.

4. MICROPILES

- (2) Micropiles are a deep foundation element constructed using high-strength, small-diameter steel casing and/or threaded bar.

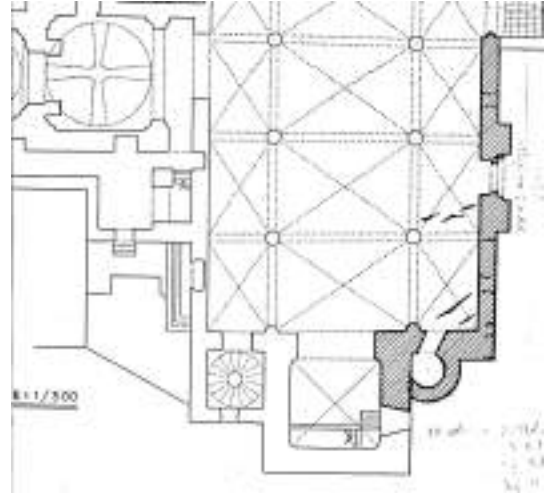
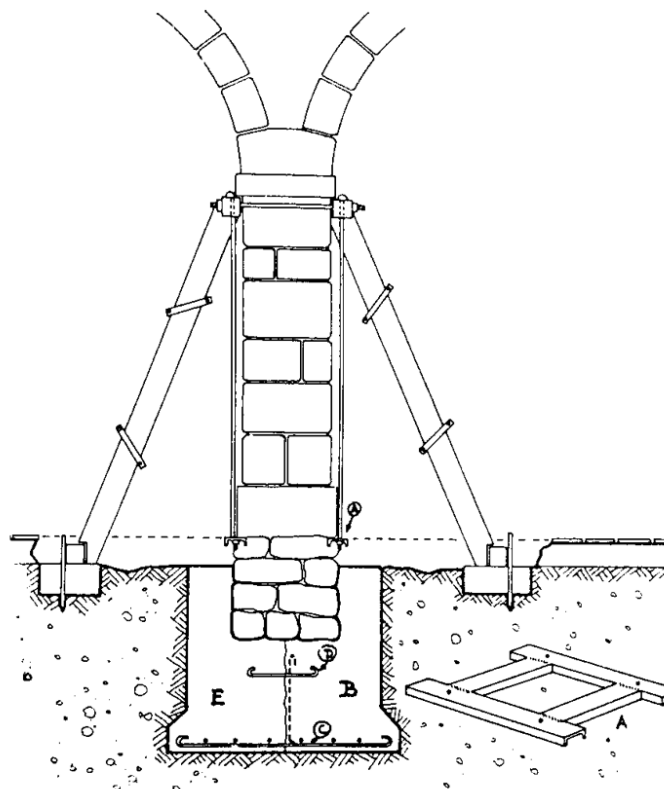


Fig. 21. Above left. San Bartolomé, Tarazona de la Mancha. Photo by Susana Mora.

5. REPLACEMENT

Complete shoring of the pillar for replacement of the foundation with shoring and hanging of the pillar.

Fig. 22. Above right. Floor plan by Susana Mora.



- A. Metallic frame
- B. Half the foundation trench
- C. Footing reinforcement
- D. Rebar nailed on the ground

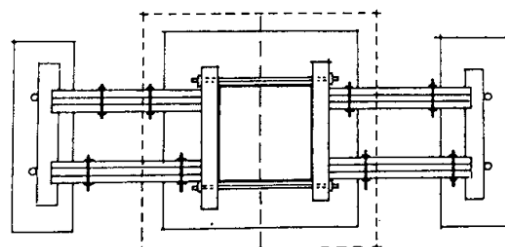


Fig. 23. From J.M. Rodríguez Ortiz, *La cimentación*, Curso COAM, Madrid 1984, p. 37.

Complete shoring of the pillar for replacement of the foundation with shoring frames on hydraulic jacks.

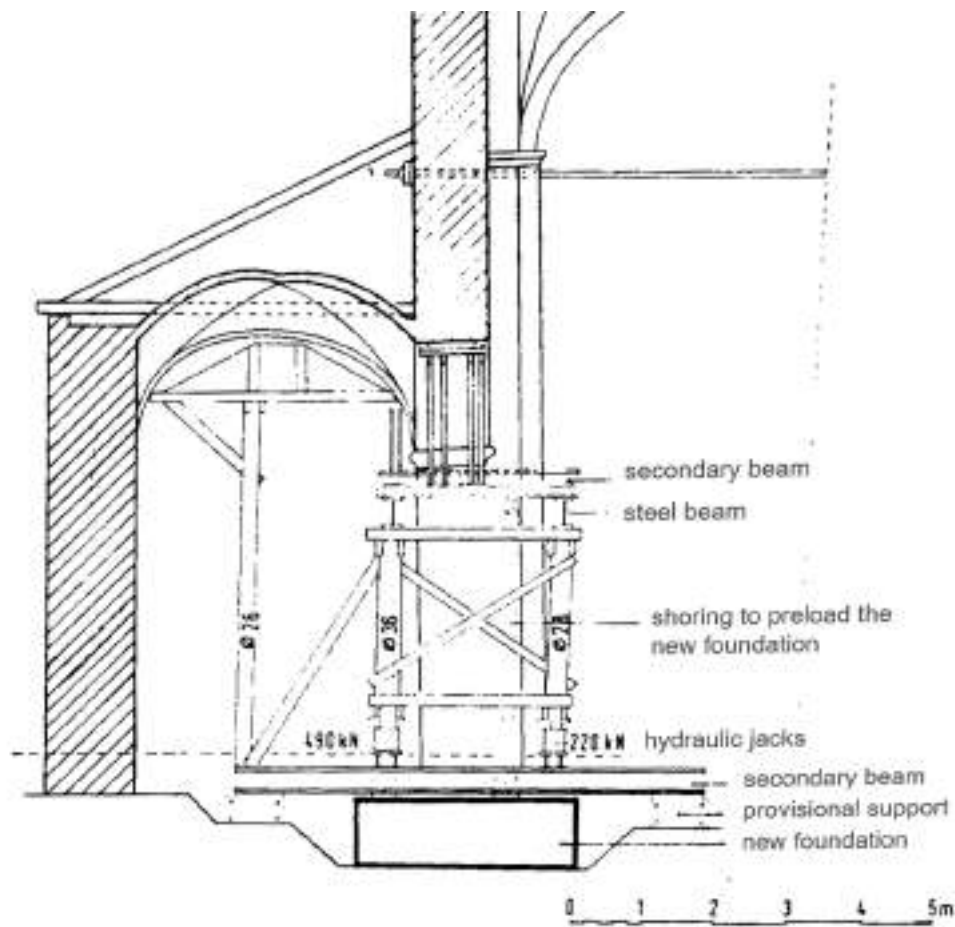


Fig. 24. From J.M. Rodríguez Ortíz, *La cimentación*, Curso COAM, Madrid 1984, p. 37.

## 6. INJECTIONS

The objective is to improve the properties in terms of continuity and resistance. The technique consists in the injection of a liquid consistency mortar, in order to fill gaps and fissures, returning the mechanical capacity to the foundation.

### *INJECTIONS BY GRAVITY*

- Injection control
- Grout density
- Washing inner leaf

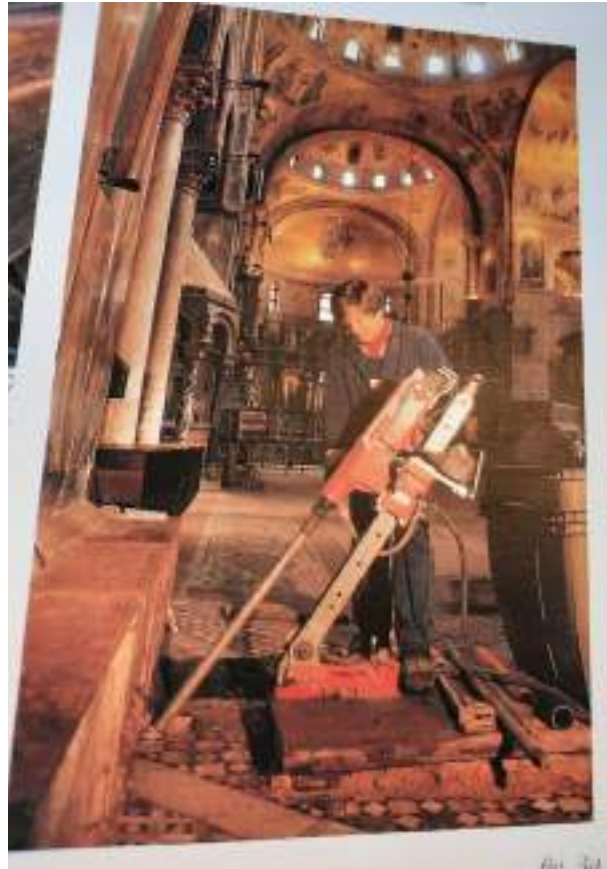


Fig. 25. Restoration of the crypt of San Marco, Venezia. From *San Marco la cripta e il restauro*, CM Vallardi & Associati, 1993, p. 83.

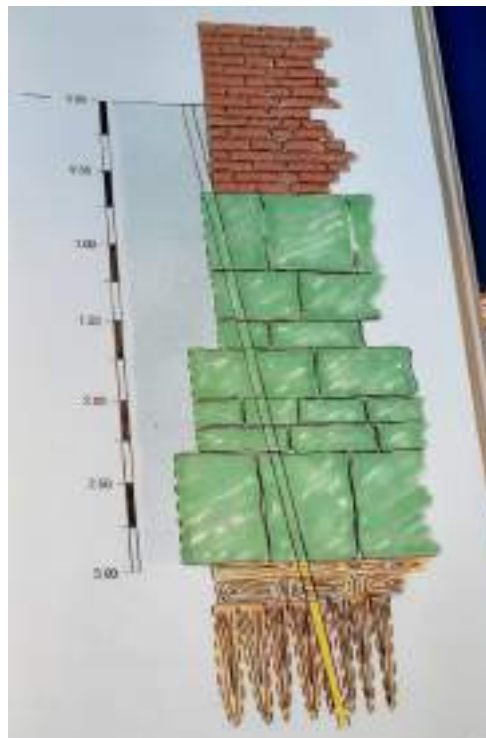


Fig. 26. Restoration of the crypt of San Marco, Venezia. From *San Marco la cripta e il restauro*, CM Vallardi & Associati, 1993, p. 83.

#### *INJECTIONS BY PRESSURE*

- Injection control
- Grout density
- Washing inner leaf



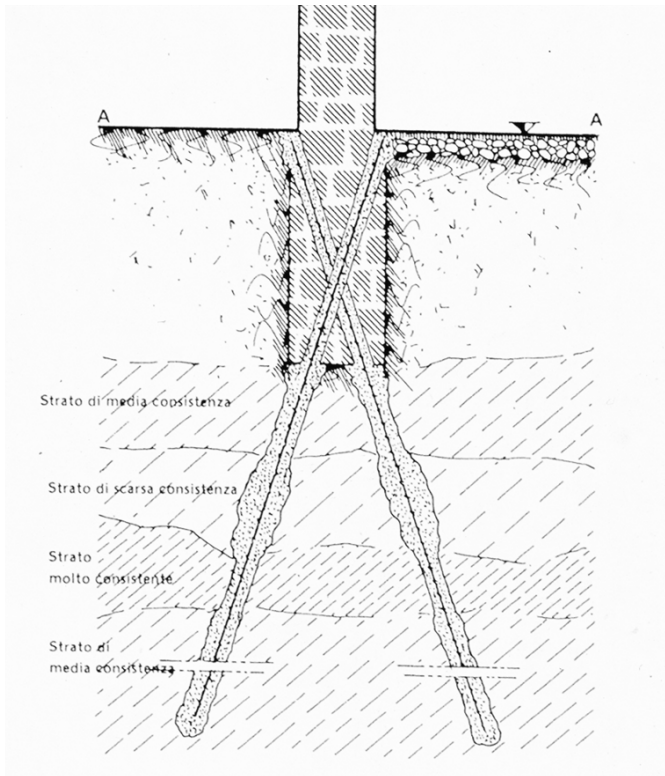


Fig. 27. From F. Lizzi, *The static restoration of monuments*, Sagep Publisher, Genova 1982, p. 29.

### PROBLEMS

- Compatibility
- Constructive system changes
- Static / Hyperstatic
- Expulsion of the bars
- Homogeneous systems

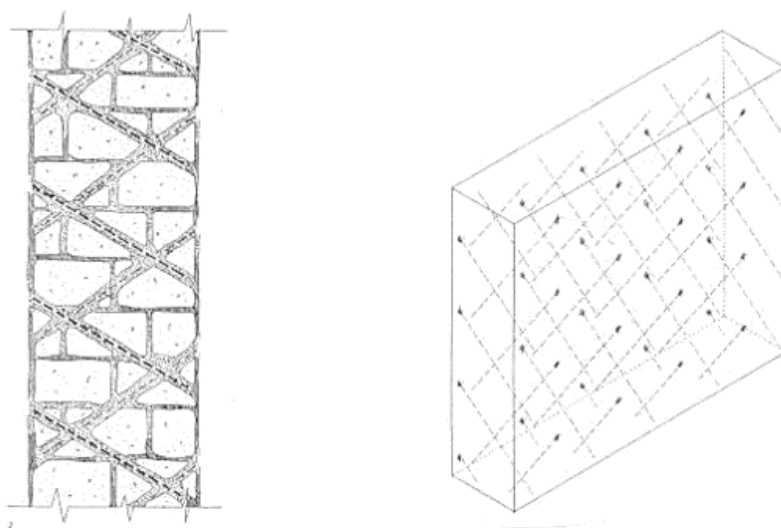


Fig. 28. From F. Lizzi, *The static restoration of monuments*, Sagep Publisher, Genova 1982, p. 18.

## 7. EXTERIOR REINFORCES



Fig. 29. Parish Church, Villalba del Rey (Cuenca). Restoration by Susana Mora. (3)

## 8. JET GROUTING

Jet grouting involves inserting a cement bond material (usually cement grout) using one or more high-speed jet pumps. The energy from the jets break up the ground and restructure it, mixing it with the injected material to produce an improved ground. Any surplus material rises to the surface as spoil return



Fig. 30. Photo by F. Ripollés.

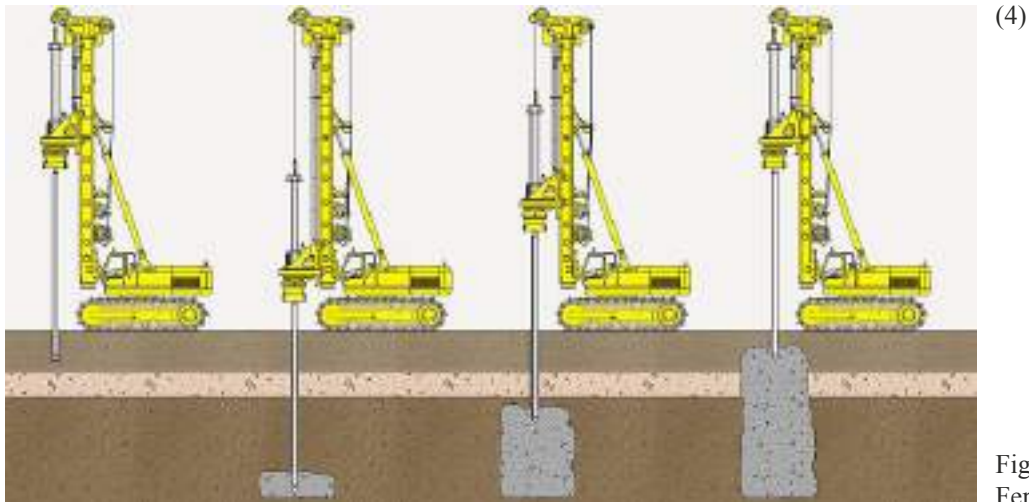
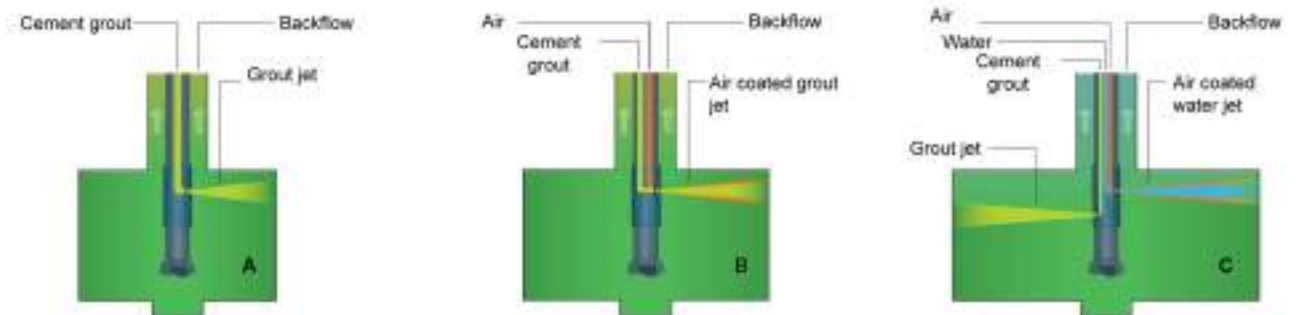


Fig. 31. Design by Fernando Ripollés.



Fig. 32. Design by Fernando Ripollés.



- A. Single Fluid Jet Grouting
- B. Double Fluid Jet Grouting
- C. Triple Fluid Jet Grouting

Fig. 33. Design by Fernando Ripollés.

Application in restoration:

- Strengthening the foundation of existing buildings
- Treatment of the foundation of buildings near excavations
- Improving the ground foundation under increased loads or settlement
- Strengthening and consolidation of the bottom of excavations
- Strengthening of the soil

**SOIL MOISTURE**

(5) The objective is ensuring good ventilation and allowing for permeability in the wall surfaces.

1. CAVITY WALL / VENTILATION GALLERIES
2. WALL SECTIONS
3. SIPHONS
- WATERPROOFING
4. ELECTROOSMOSIS

1. VENTILATION GALLERIES

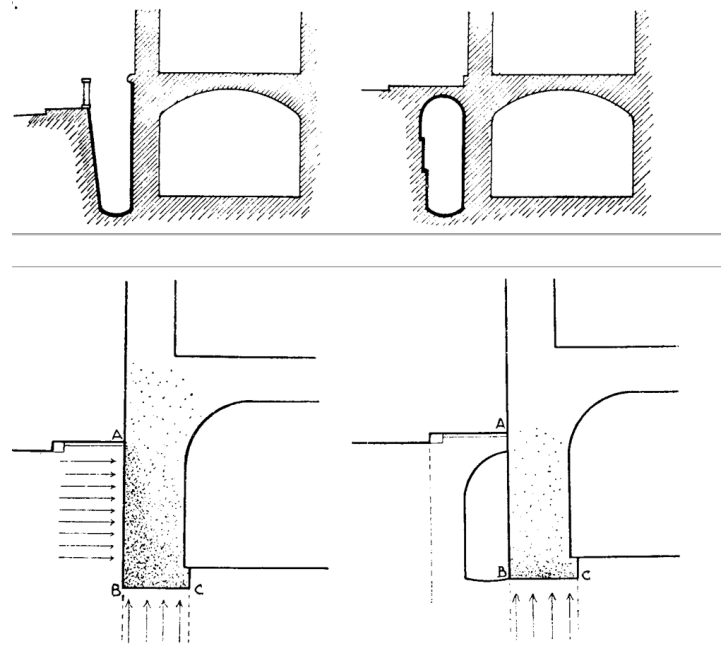
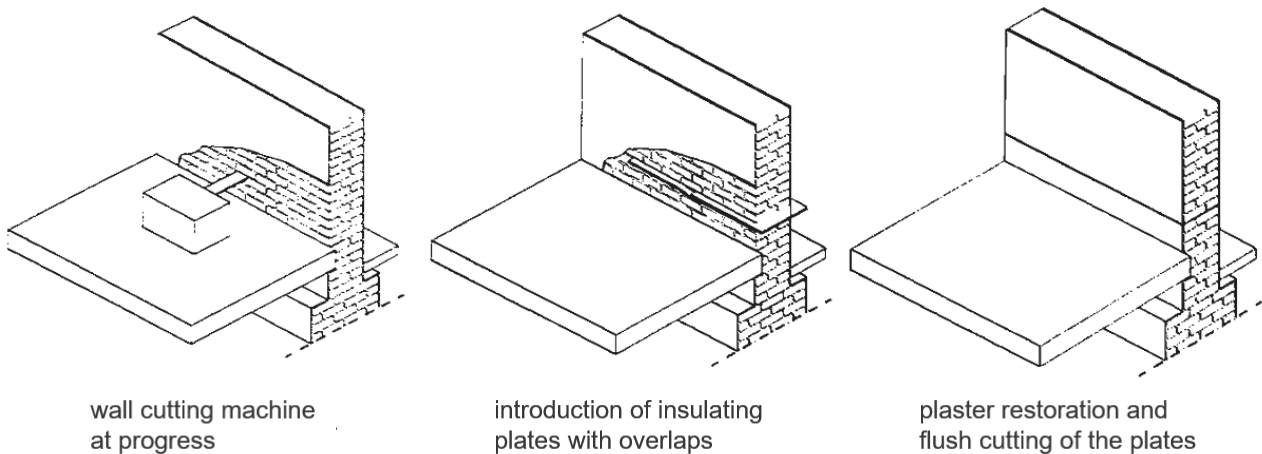


Fig. 34. From G. e I. Massari, *Risanamento igienico dei locali umidi*, Hoepli, Milano 1981, p. 111

2. WALL SECTIONS

*INSULATING PLATES*

Mechanical cutting of the wall for the insertion of insulating plates



wall cutting machine at progress

introduction of insulating plates with overlaps

plaster restoration and flush cutting of the plates

Fig. 35.

Method against the capillary rising of water: execution of a double series of partially overlapping holes for the insertion of insulating material.

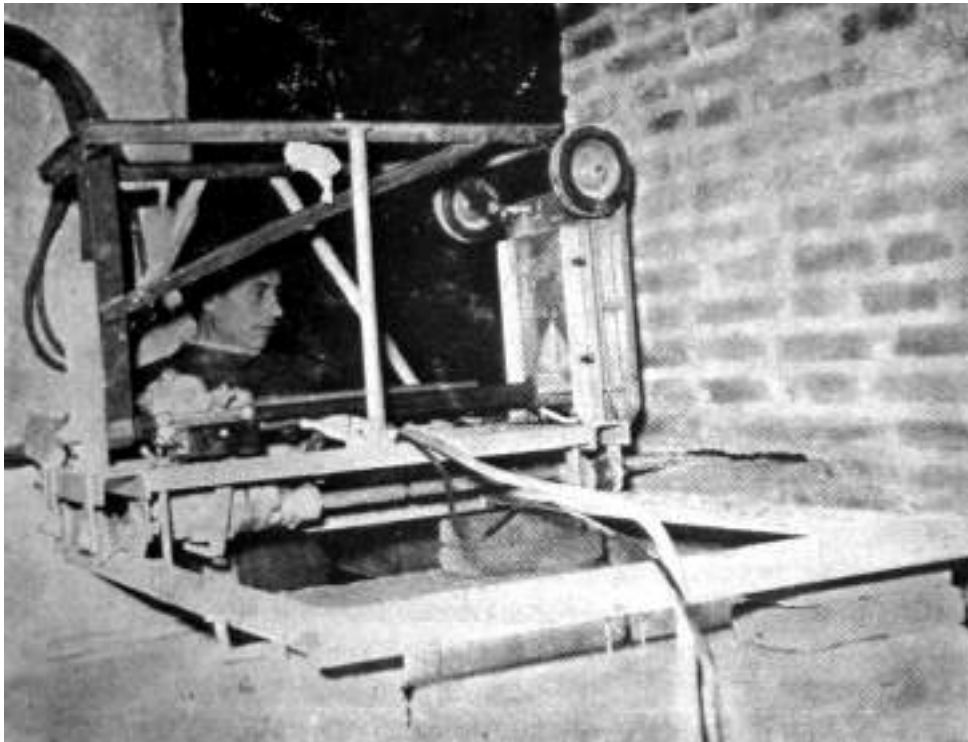


Fig. 36. Core drill in operation on a brick wall. From G. e I. Massari, *Risanamento igienico dei locali umidi*, Hoepli, Milano 1981, p. 107.

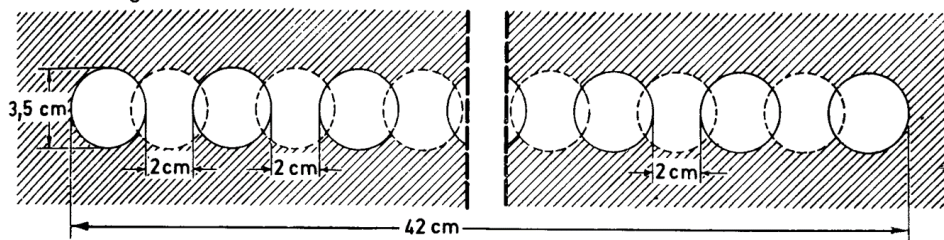
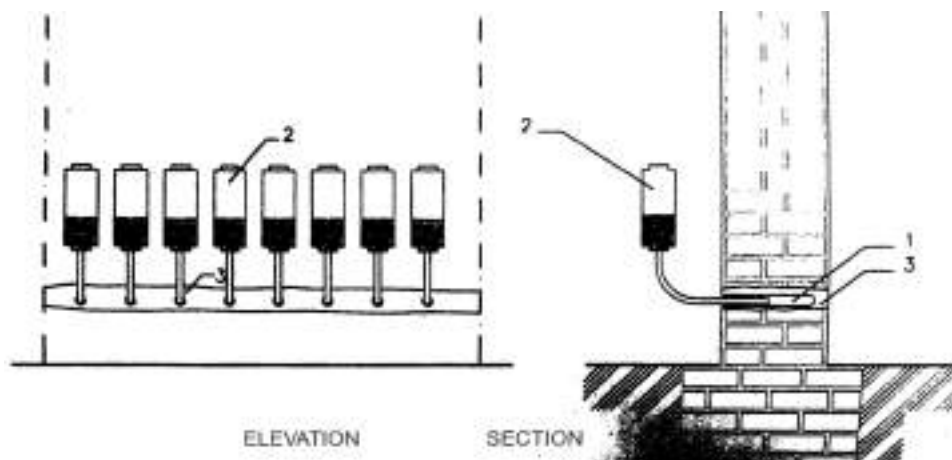


Fig. 37. Front view of the cut. From G. e I. Massari, *Risanamento igienico dei locali umidi*, Hoepli, Milano 1981, p. 107.

Horizontal barrier of slow diffusion waterproofing product



1. Hole
2. Containers of fluid resin
3. Spread of the waterproofing

Fig. 38. From G. e I. Massari, *Risanamento igienico dei locali umidi*, Hoepli, Milano 1981, p. 107.

### 3. KNAPEN ATMOSPHERIC SIPHON

The atmospheric knapen siphons, placed in the walls to be treated, attract humidity and evacuate it outside by an air circuit ensuring a permanent and effective functioning.

Each siphon, in its radius of action, attracts moisture, and this, impregnating its porous wall, saturates the drier outside air that enters the siphon channel.

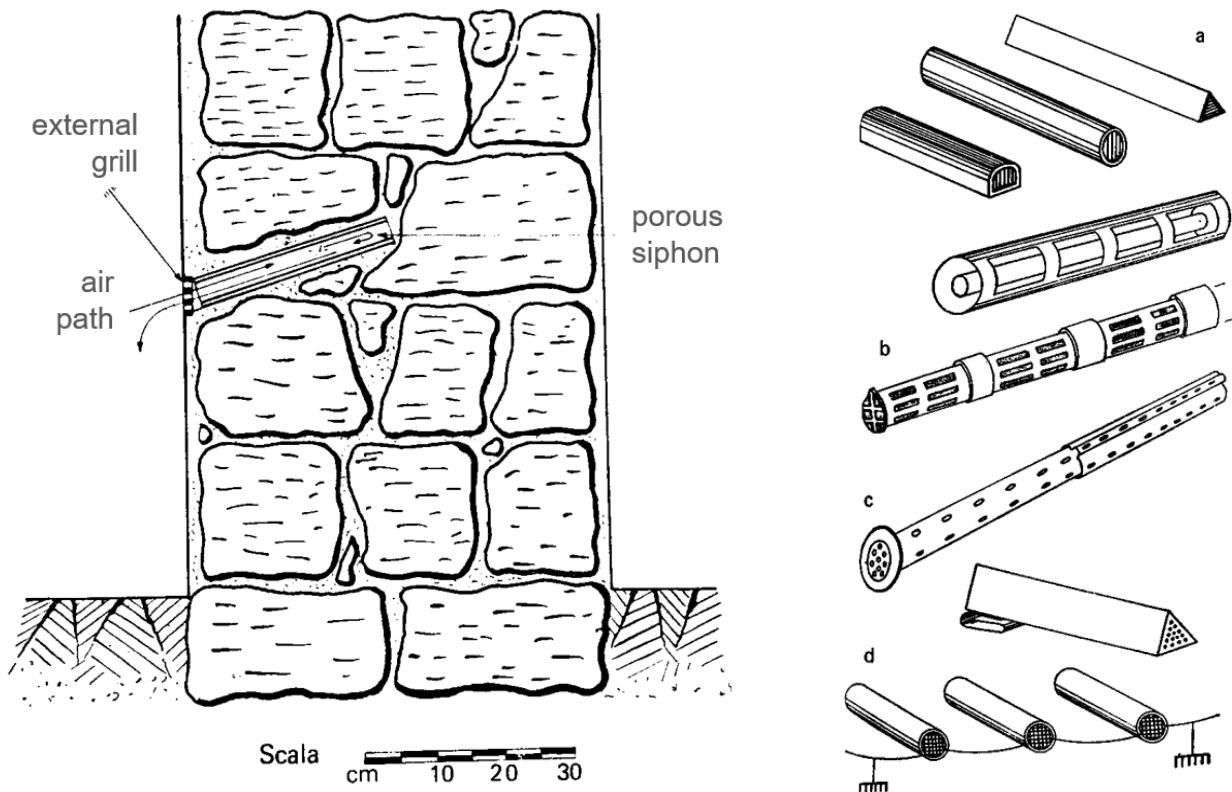


Fig. 39. Above left. From G. e I. Massari, *Risanamento igienico dei locali umidi*, Hoepli, Milano 1981, p. 113.

### 4. ACTIVE ELECTROOSMOSIS

The device emits small pulses from electrodes inserted in the wall to the ground. In this way the polarity between the soil and the wall is inverted, causing the ionized water to descend through the wall to the ground.

Fig. 40. Above right. From G. e I. Massari, *Risanamento igienico dei locali umidi*, Hoepli, Milano 1981, p. 115.

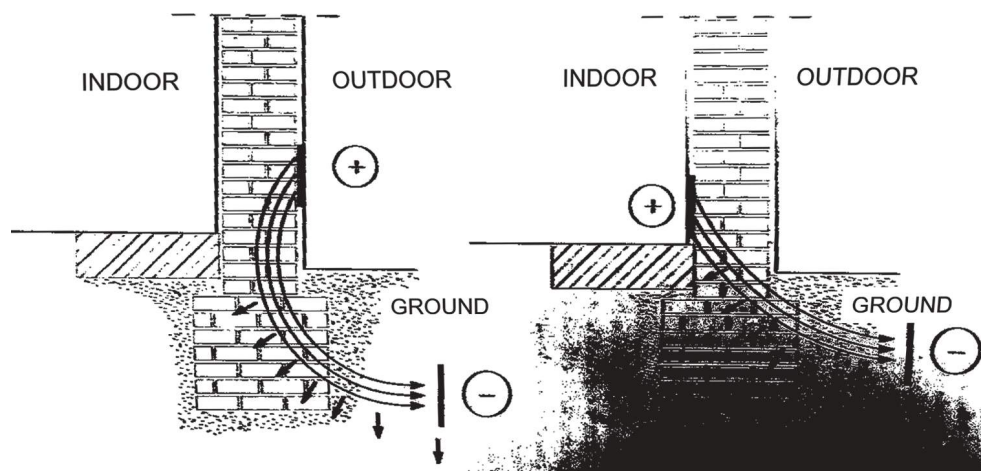


Fig. 41. From G. e I. Massari, *Risanamento igienico dei locali umidi*, Hoepli, Milano 1981, p. 119.

## NOTES

For the study and restoration of architectural preexistence, it is necessary the knowledge of history of processuality of architecture.

For this is natural to remember some basilar books:

- ALBERTI L., *De re Aedificatoria*, Firenze 1485, rist. anas. München 1976,  
 Francesco di Giorgio Martini, *Trattato di Architettura civile e militare (1456)*, I ed. a stampa  
 C. Promis e C. Saluzzo 1841;  
 SERLIO S., *Trattato di Architettura*, i vari libri, da Venezia 1537, a 1584;  
 BARBARO D., *I dieci libri di Architettura di M. Vitruvio tradotti e commentati da mon.  
 Barbaro*, Venezia 1556;  
 PALLADIO A., *I quattro libri di Architettura*, Venezia 1556-1570, numerose ristampe;  
 BORROMEO C., *Instructiones Fabricae et Supellectilis Ecclesiasticae*, liber. II Milano  
 1577;  
 SCAMOZZI V., *L'idea dell'Architettura Universale*, Venezia 1615;  
 BLONDEL F., *Cours d'Architecture enseigné dans L'Académie Royale d'Architecture,  
 parte I*, Paris 1675;  
 CAPRA A., *La nuova Architettura civile e militare*, Bologna 1678;  
 DESGODETS A., *Les édifices antiques de Rome*, Paris 1682;  
 D'AVILER A.C., *Cours d'Architecture, qui comprend les ordres de Vignole*, Paris 1691;  
 BELIDOR B.F., *Architecture Hydraulique, ou l'art de conduire, d'élever, et de menager les  
 eaux*, 4 voll, Paris 1737-1753;  
 VITTONI B., *Istruzioni elementari per indirizzo de' giovani allo studio dell'architettura  
 civile divise in libri tre*, Lugano 1760;  
 MASI G., *Teoria e pratica di Architettura, per istruzione della gioventù specialmente romana*,  
 Roma 1788;  
 CHOISY A., *L'art de batir chez le romains*, Paris 1873;  
 CURIONI G., *Materiali da Costruzioni*, Torino 1872;  
 ANDREANI I., *Costruzioni lesionate, cause e rimedi*, Milano 1912;  
 DONGHI D., *Manuale dell'architetto, vol. I, la costruzione architettonica*, Torino 1925;  
 BREYMANN G. A., *Costruzioni in Pietra, e strutture murali*, Milano 1926;  
 RUSSO C., *Le lesioni dei fabbricati, sintomi, cause, effetti, rimedi*, Torino 1930;  
 MASTRODICASA S., *Dissesti Statici delle strutture edilizie*, Milano 1978, e successive  
 edizioni;  
 GIANGRECO E., *Considerazioni ed esempi di restauro statico*, Milano 1971;  
 CROCI G., *Intuizioni e calcolo nella progettazione delle strutture*, Milano 1977;  
 DEFEZ A., *Il consolidamento degli edifici*, Napoli 1978, e successive, edizioni;  
 LIZZI F., *Restauro statico dei monumenti*, Genova 1981;  
 CARBONARA G., *Restauro e cemento in Architettura*, Associazione Italiana Tecnico  
 Economica del Cemento, Roma 1981, vol. II, Roma 1984;  
 CROCI G., *L'origine dei dissesti, convegno di studio sul consolidamento delle costruzioni*,  
 Udine 1982;  
 BINDA L., *Indagini per la valutazione dell'efficienza statica di strutture murarie*, in Ibidem,  
 ADAM J.P., *L'arte di costruire presso i romani, materiali e tecniche*, Milano 1988.

On foundations:

- DAVEY N., *A history of building materials*, London 1961;  
 TORROJA E., *Rajon ser de los tipos estructurales*, ed it. *La concezione strutturale*, Torino  
 1966;  
 CESTELLI GUIDI C., *Geotecnica e tecnica delle fondazioni*, Milano 1980;  
 AA.VV., *San Marco, Basilica Patriarcale in Venezia, la cripta, il restauro*, Milano 1993;  
 DI PASQUALE S., *L'arte del Costruire, tra conoscenza e scienza*, Venezia 1996;  
*Structural studies, repairs and maintenance of historical buildings*, edited by S.Sanchez-  
 Beitia, C. A. Brebbia, vol. 3, Boston, Southampton, 1997.

IENILE R., *Per un consolidamento consapevole dei beni architettonici*, Torino 2001.

- 1) To study historic types of foundations, problems and solutions dont forget Cap. V, LA REGINA F., *Sicurezza e conservazione del patrimonio Architettonico*, Liguori editore, Napoli 1995. See also, DI STEFANO R.C. *Il consolidamento strutturale nel restauro architettonico*, Edizioni Scientifiche Italiane, Napoli 1990, pp. 156 e sgg; CARTAPATI E., *Fondazioni*, in sezione c1, in *Atlante del Restauro*, vol. VIII, tomo II, diretto da Carbonara G., Torino 2004, pp. 159-175; ID., *Interventi sulle Fondazioni*, sezione G1, *Atlante del restauro*, vol. VIII, tomo II, diretto da Carbonara G., Torino 2004, pp. 487-507;
- 2) Micropiles used in the consolidation of the foundations of the church of San Bartolomé in Tarazona de la Mancha, Albacete, Spain. Project and direction of Restoration by Susana Mora, architect, for the Junta de Comunidades de Castilla La Mancha (1990-95).
- 3) Exterior reinforces for the parish church of Villalba del Rey, Cuenca, Spain. Project and direction of restoration by Susana Mora, architect, (2000-) for Junta de Comunidades de Castilla La Mancha.
- 4) For jet grouting, see DI STEFANO R.C., *Il consolidamento*, Napoli 1990, pp. 176-186; LA REGINA F., *Sicurezza e conservazione*, Napoli 1995, pp. 132,146;
- 5) See also CIGNI G., *Murature degradate*, 1977, pp. 48-76; MASSARI G., I. *Risanamento*, in particolare, cap. VII, Milano 1981, pp. 101-124; VITIELLO V., CASTELLUCCIO R., *Il risanamento delle murature affette da umidità da risalita capillare, il metodo CNT*, Napoli 2019; AGLIATA R., MOLLO L., *Sulle tecnologie per il monitoraggio non invasivo dell'umidità nelle murature*, in *Technologies for the recovery of built heritage*, 4-5 aprile, Matera 2019, Napoli 2019.

But for the thematic relative to the study of disturbances and the remedies for structures see some texts that are classic in the structural sector: from the volumes of Carlo CESTELLI GUIDI. To the studies by Giorgio MACCHI, and Giorgio CROCI.

ASHURST D.N., *Practical Building Conservation*, Vol. 2, Brick Terracotta e Earth, Hampshire, Gower Technical Press, 1988.

LOURENZO P.B., ROCA P., *International Journal of Architectural Heritage. Conservation, Analysis and Restoration*, Vol. 15, Philadelphia P1, 2021.

STANLEY RABUN J., *Structural analysis of Historic Buildings Restoration, Preservation, and Adaptive Reuse Applications for Architects and Engineers*, edit by John Wiley and sons, York (UK), 2000.

VAN GEMERT D., *The use of grouting for the consolidation of historic masonry constructions. Advantages and limitations of the method*, in *Stable – Unstable?*, pp. 265-276.