Heritage Problems, Causes and Solutions

Calogero Bellanca and Susana Mora Alonso-Muñoyerro

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This material is didactic, to be used in education. The graphic material although fundamentally is made by the authors, includes photographs and drawings compiled from material used by the authors in their lessons in ETSAM (UPM) (*Construction and Heritage Courses*), Sapienza University of Rome (*Course of Theory and Practice of Conservation* and *Laboratorio di Restauro*) and other european university.

In this volume have collaborated specially these architects:
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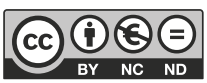

In copertina | *Cover image*: *Colosseum*, detail. Photo by Susana Mora and Calogero Bellanca.

Dedicated to our parents

Maria and Antonino
Consuelo and Justo

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CHAPTER 10. FLOORS: CONSTRUCTIVE SYSTEMS, PROBLEMS, CAUSES AND SOLUTIONS

Floors wear down to receive the loads of the building and transfer them to the vertical structural elements.

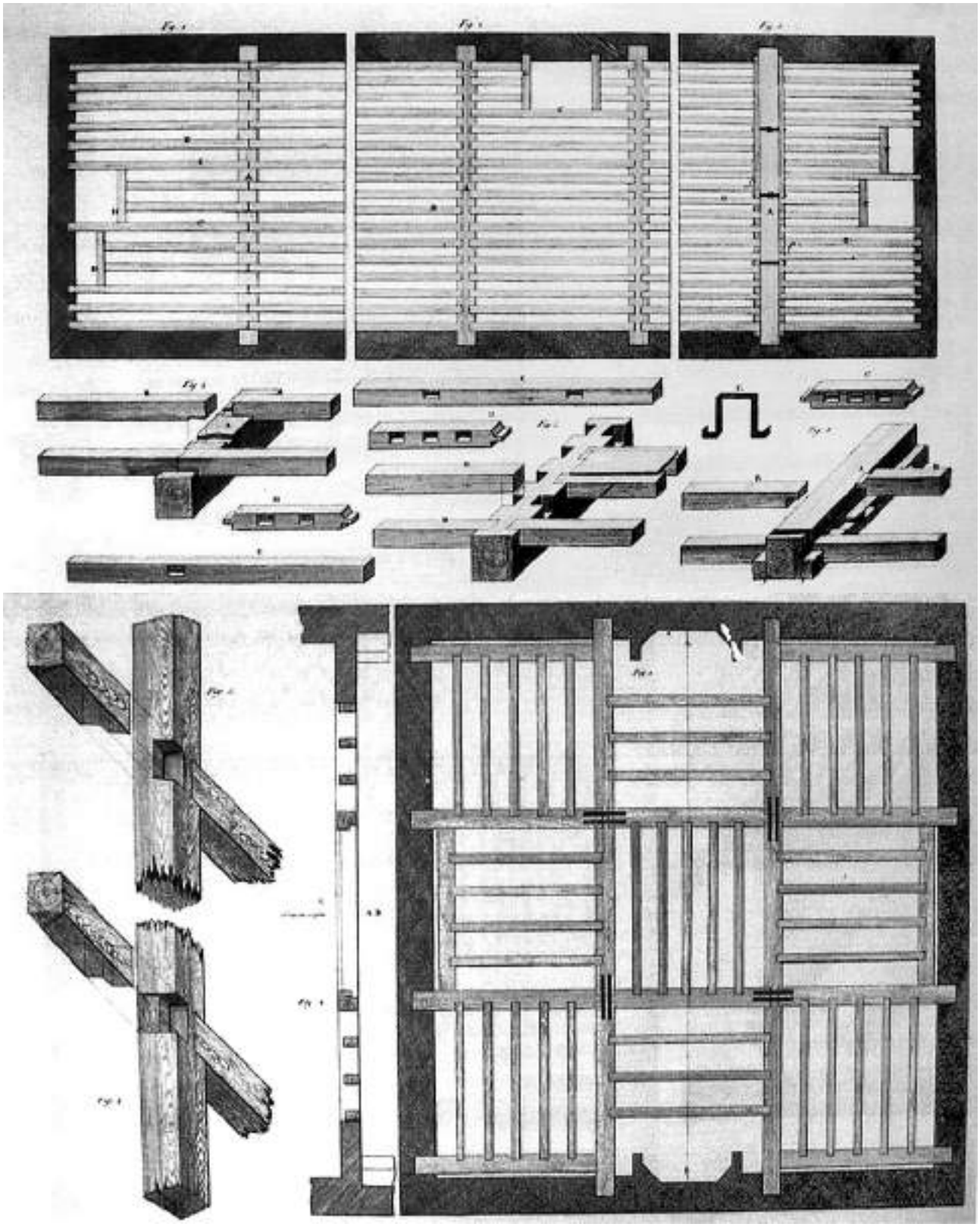


Fig. 1. Beam filling with layers of differentiated function. From G. Rondelet, *Trattato teorico e pratico dell'arte di edificare*, Mantova 1832, Vol. I, Tab. LXXXVIII.

HISTORIC EVOLUTION

Historic floors were made in wood but they changed:

BEAM FILLING

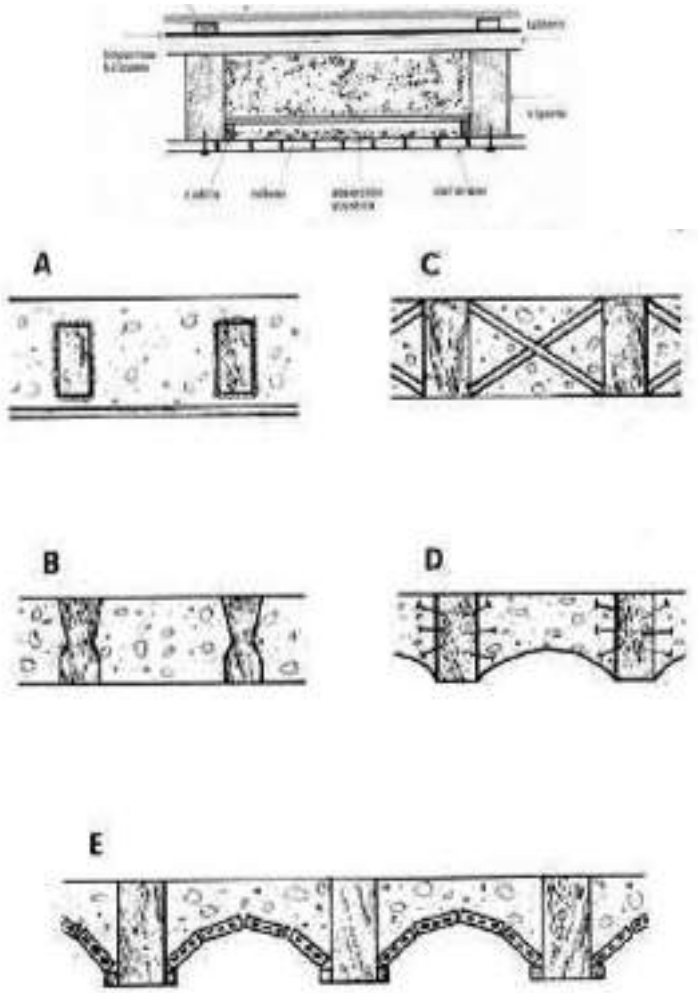


Fig. 2. Redesigned by Susana Mora.

CEILING

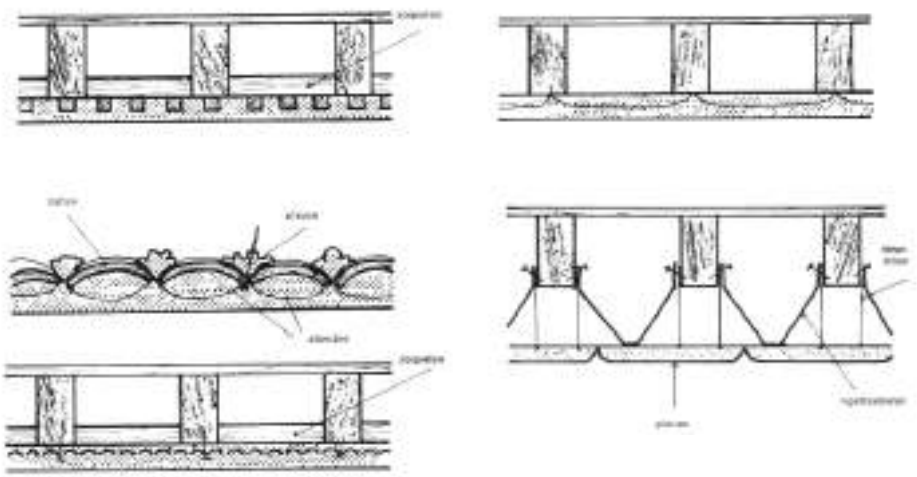
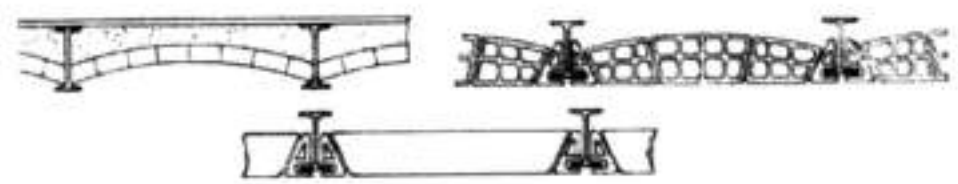


Fig. 3. Redesigned by Susana Mora.

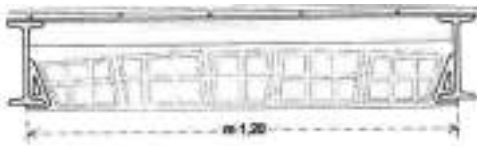
STEEL BEAMS



(1)

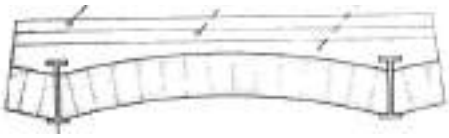
Fig. 4. From A. Ciappi, *Manuale dell'architetto*, Torino 1946.

Fig. 5. From A. Ciappi, *Manuale dell'architetto*, Torino 1946.



Flooring with ceramic vaults.

Flooring with arched planks.



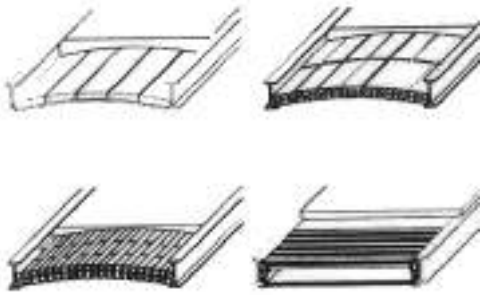


Fig. 6. From C. Blasi, *Manuale del restauro architettonico*, Mancosu, Roma 2001, "Anatomia degli organismi edilizi moderni", Section B1.2., B36.

Example of steel flooring.

REINFORCED CONCRETE FLOORS

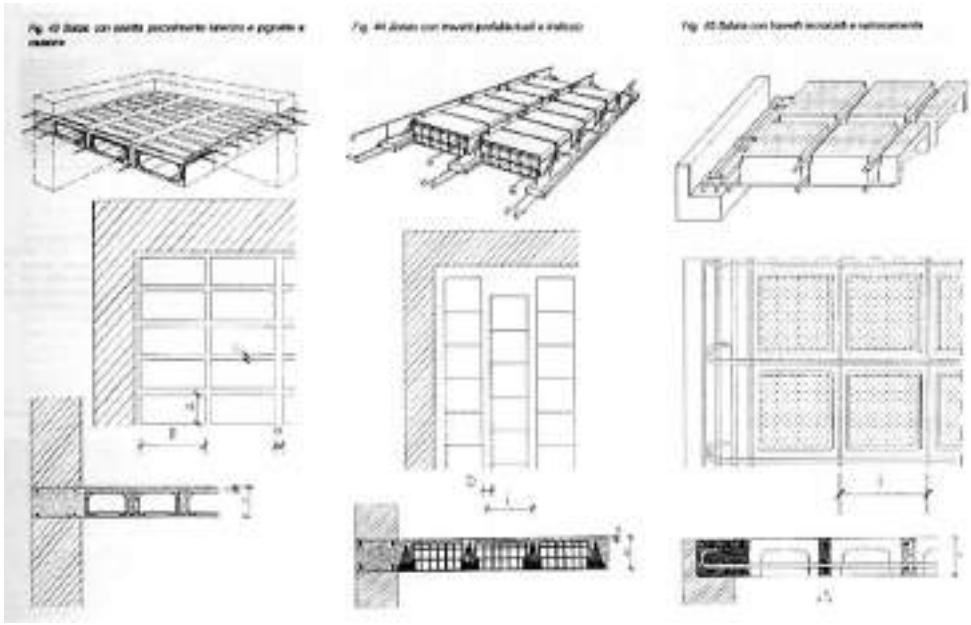
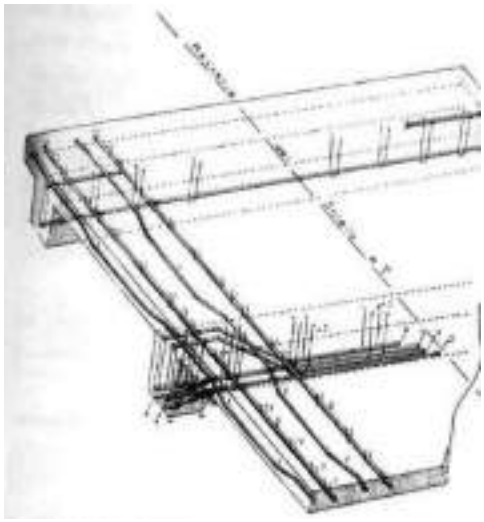


Fig. 7. Hennebique System. From C. Blasi, *Manuale del restauro architettonico*, Mancosu, Roma 2001, "Anatomia degli organismi edilizi moderni", cemento armato, B1.1., B4.

T Floor System



Ceiling

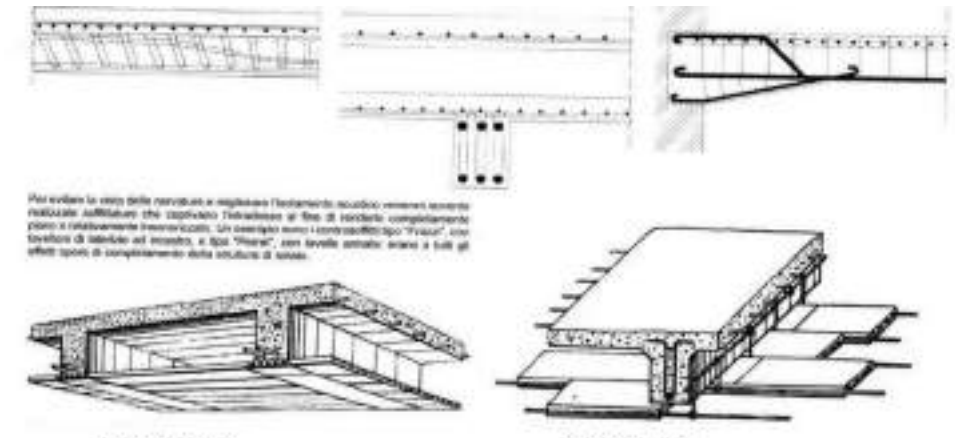
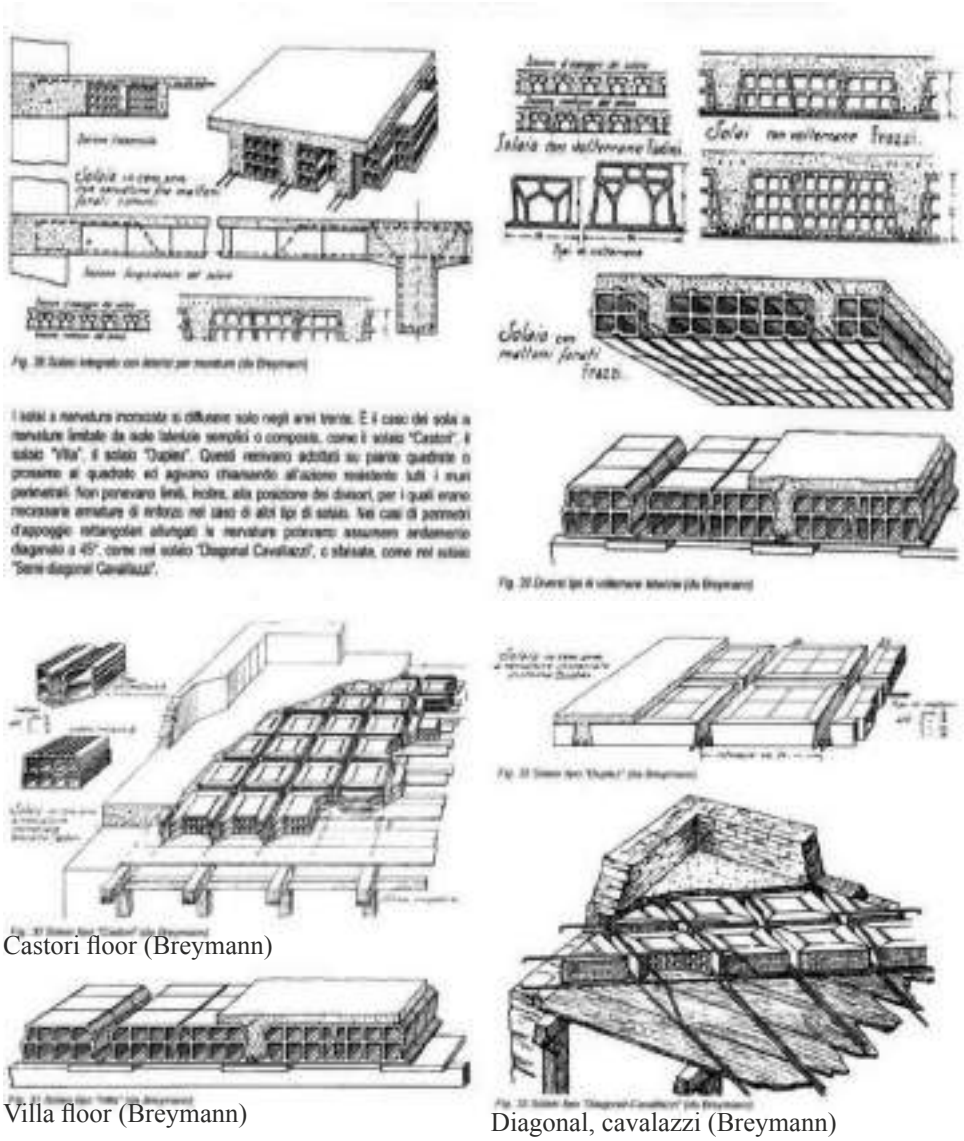


Fig. 8. Hennebique System. From C. Blasi, *Manuale del restauro architettonico*, Mancosu, Roma 2001, "Anatomia degli organismi edilizi moderni", cemento armato, B10, B1.1.

Structural Hollow Clay Block



Frazzi floor

Frazzi floor

Different types of floors (Breymann)

Duplex floor (Breymann)

Castori floor (Breymann)

Villa floor (Breymann)

Diagonal, cavalazzi (Breymann)

Fig. 9. Hennebique System. From C. Blasi, *Manuale del restauro architettonico*, Mancosu, Roma 2001, "Anatomia degli organismi edilizi moderni", cemento armato, B11.

Other Types of Floors

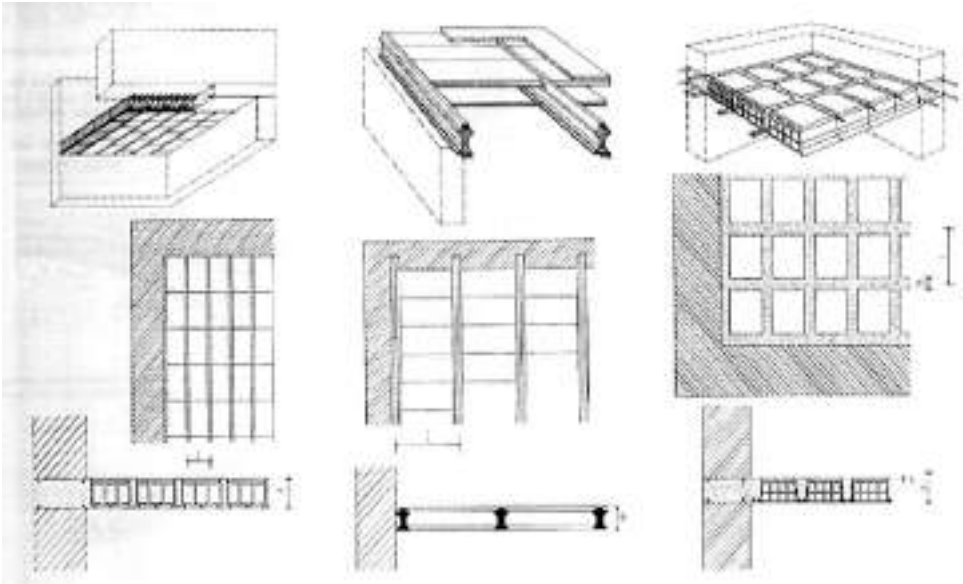


Fig. 10. Hennebique System. From C. Blasi, *Manuale del restauro architettonico*, Mancosu, Roma 2001, "Anatomia degli organismi edilizi moderni", cemento armato, B14.

CAUSES

FOUNDATION AND GROUND DAMAGES
Internal Damages

Wall is uniformly pushed and displaced with vertical shear cracks.

SOLUTIONS

CONSOLIDATION OF FLOORS

- Shorten distance from a beam
- Shear connectors
- Overlay:
  - · Reinforcement
  - · Suspended structure
- Anchoring

SHORTEN DISTANCE FROM A BEAM

Fig. 12. Almudín, Valencia. Photo by Susana Mora, 2010.

SHEAR CONNECTORS

The use of connectors can allow for a significant reduction of the beam whilst ensuring the same load-bearing capacity.

- Wooden Beams.

(2)

Fig. 13. Tecnaria, Bassano del Grappa, Italy.

- Steel Beams.

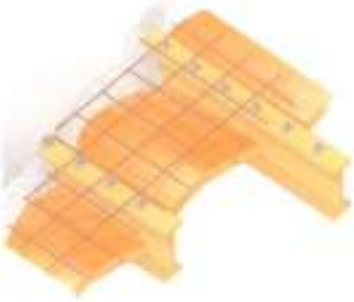


Fig. 14. Tecnaria, Bassano del Grappa, Italy.

Fig. 15. Tecnaria, Bassano del Grappa, Italy.

OVERLAY

- Reinforcement with concrete.

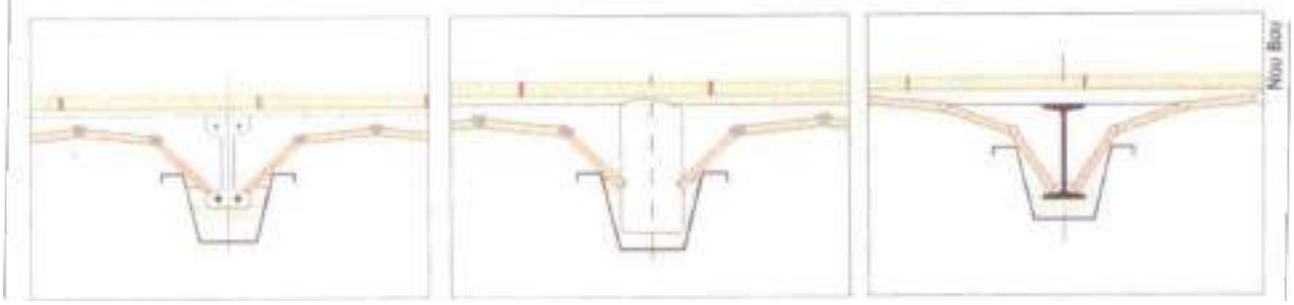


Fig. 16. Avis Technique CSTB.

- Reinforcement. Steel Auxiliary Structure. Axial effort increased.

Fig. 17. Palazzo Altemps, Roma. Photo by Calogero Bellanca, 2020.

- Reinforcement. Fibers:
Many new products composed of FRP (fiber reinforced polymers) are now used to consolidate traditional structures for the reinforcement of concrete and sustitution of iron elements: glass, carbon, aramide, basalt, PBO, metallic and natural fibers.

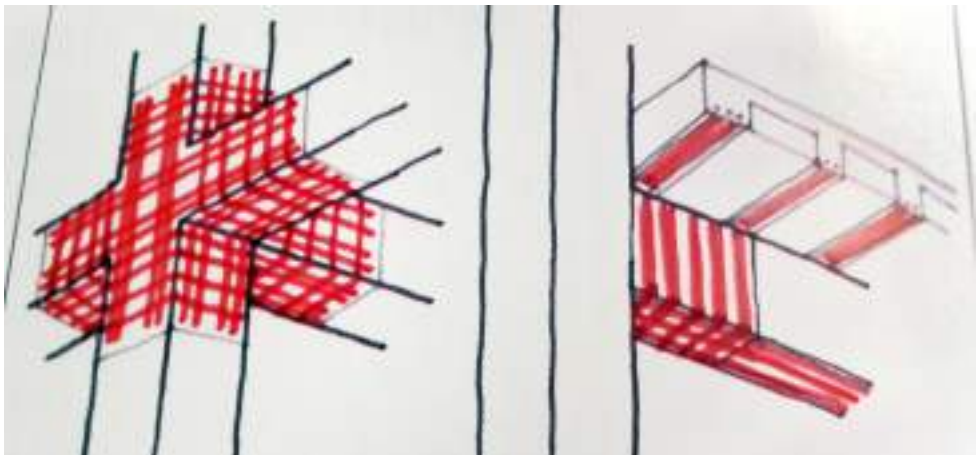


Fig. 18. From F. De Cesaris, "Materiali e strutture", n. 12, 2017, p. 78.

ANCHORING
Anchoring of the floor to the masonry consolidation.

Fig. 19. Refectory and new roof of San Pedro de Arlanza, Hortigüela, Burgos. Salvador Pérez Arroyo and Susana Mora. Photo by Susana Mora, 2012.

Fig. 20. New beams anchors in the vaults of the Refectory, San Pedro de Arlanza, Salvador Pérez Arroyo and Susana Mora. Photo by Susana Mora, Burgos, 2012.

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