

**FEDERICO M. MAZZOLANI**

University of Naples “Federico II”, Italy



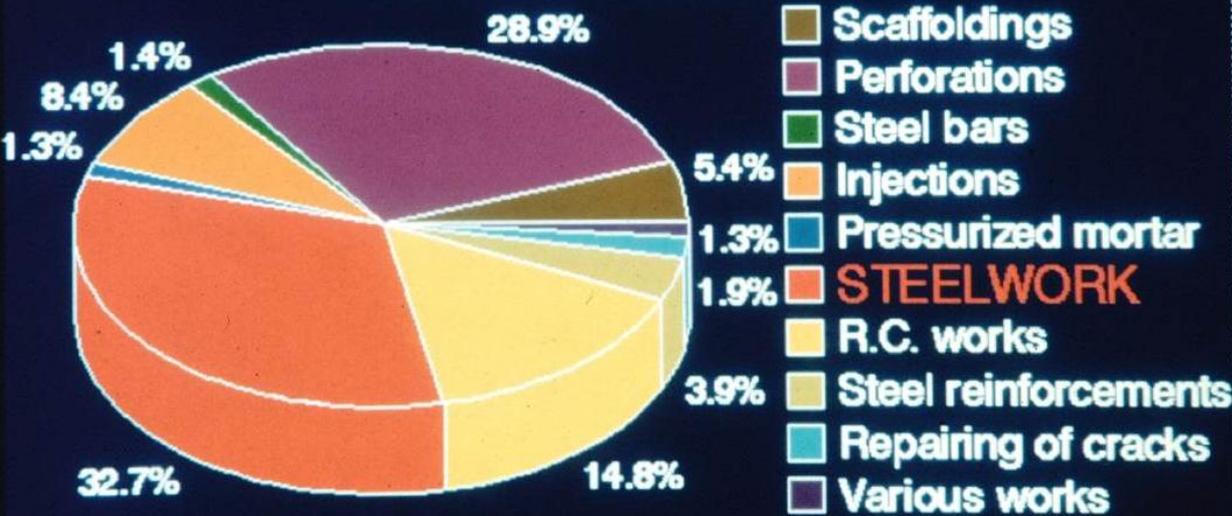
**THE USE OF STEELWORK IN CONSOLIDATION**

# **THE USE OF STEELWORK IN CONSOLIDATION FOR SEISMIC UPGRADING**

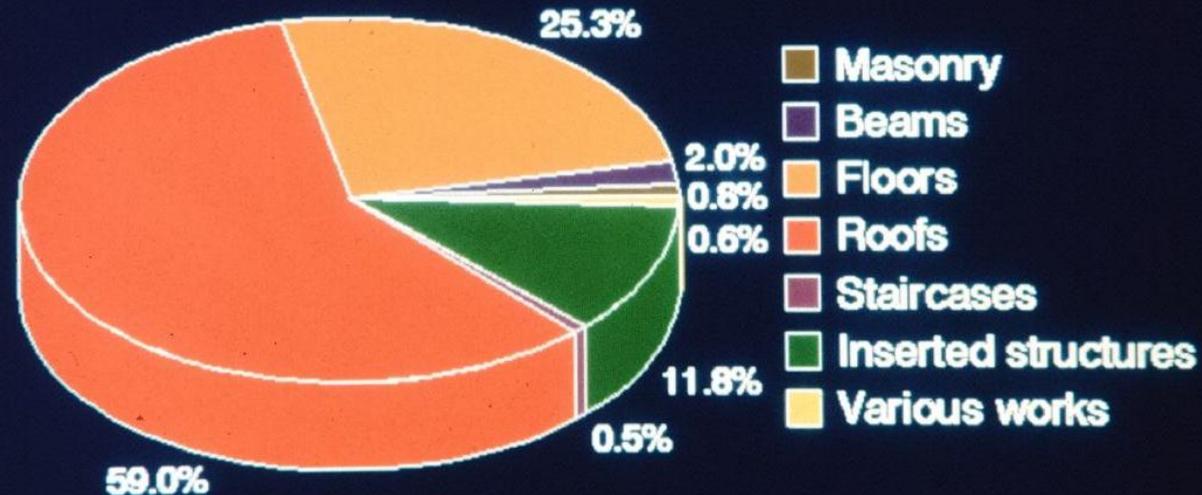
## **General Data**

# Historical Buildings

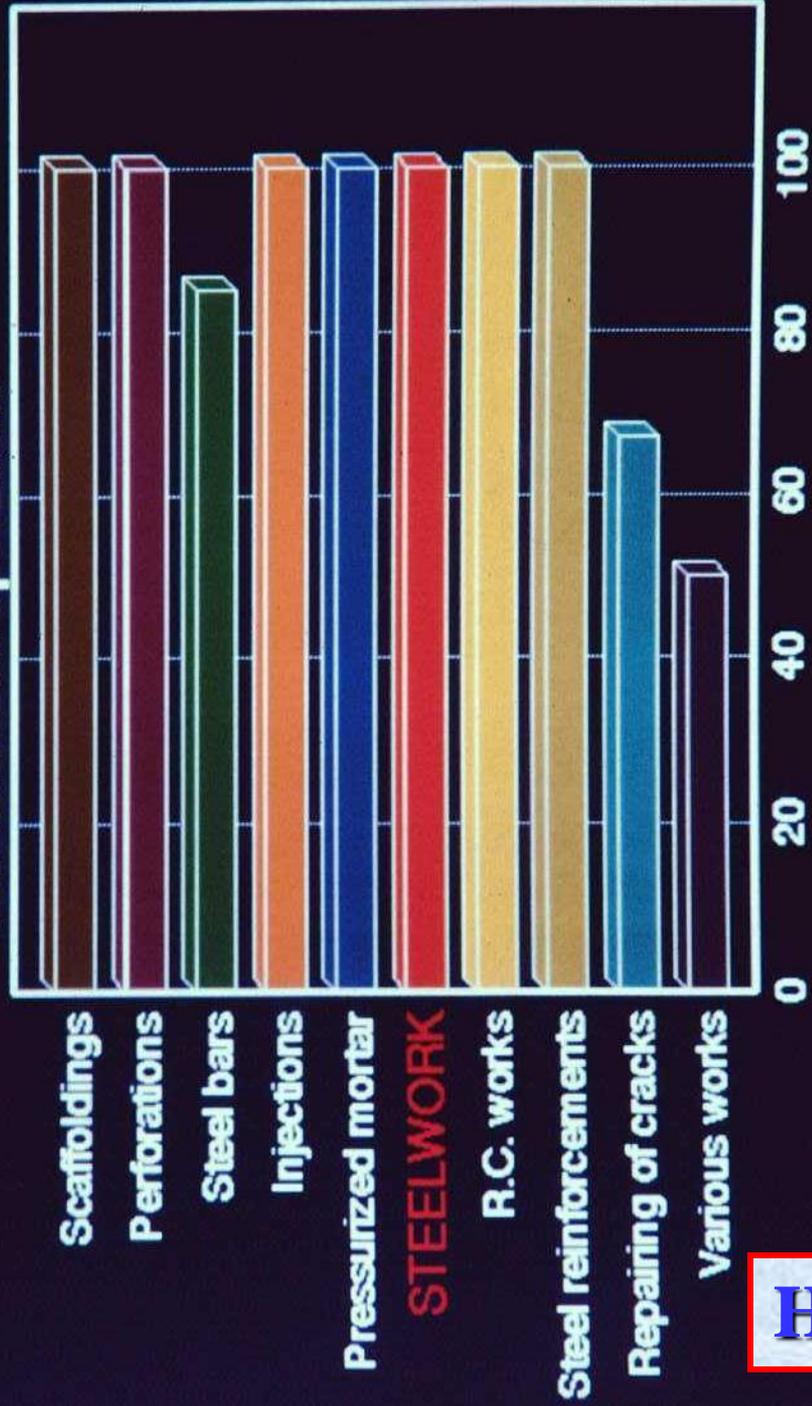
Percentage cost distribution of consolidation operations



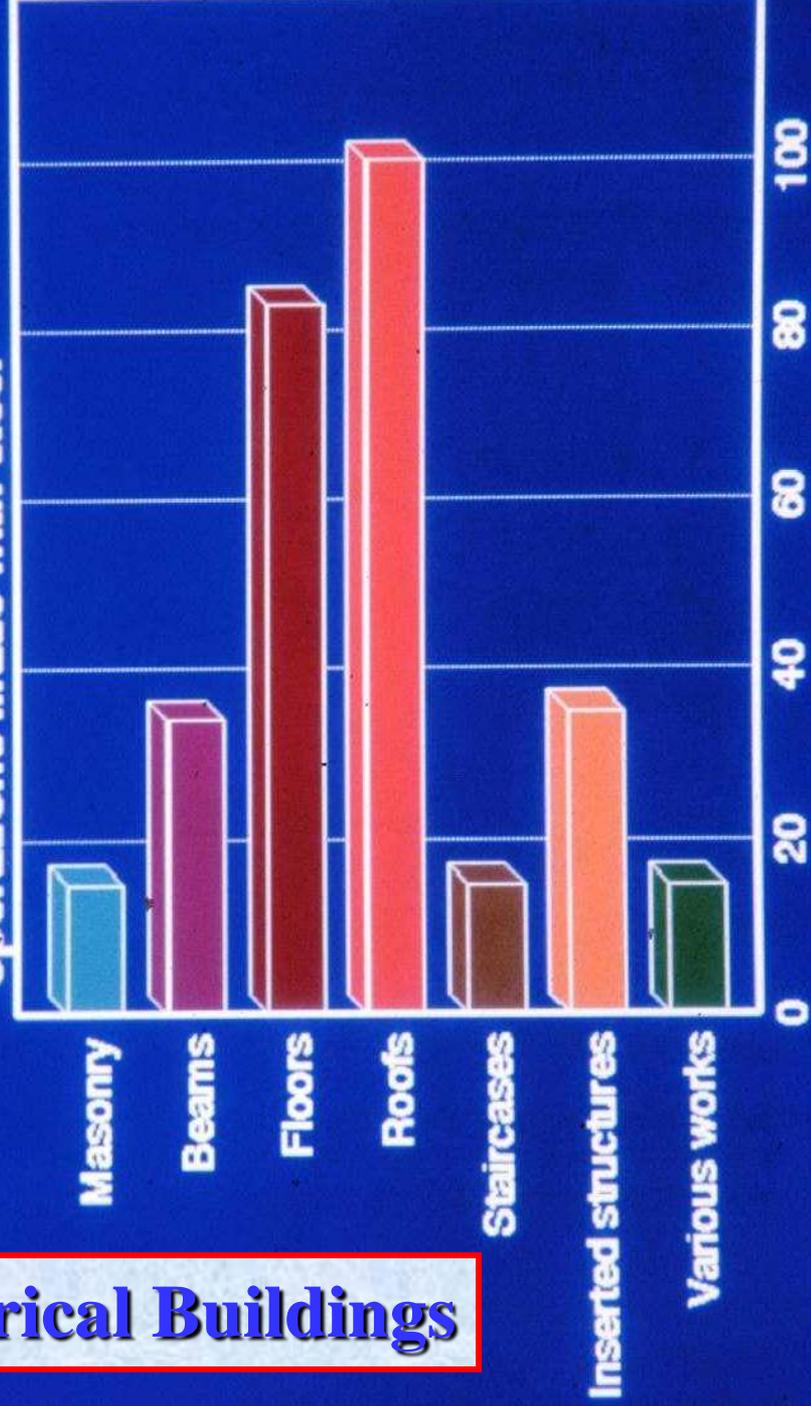
Percentage cost distribution of consolidation operations made with steel



Percentage distribution of consolidation operations



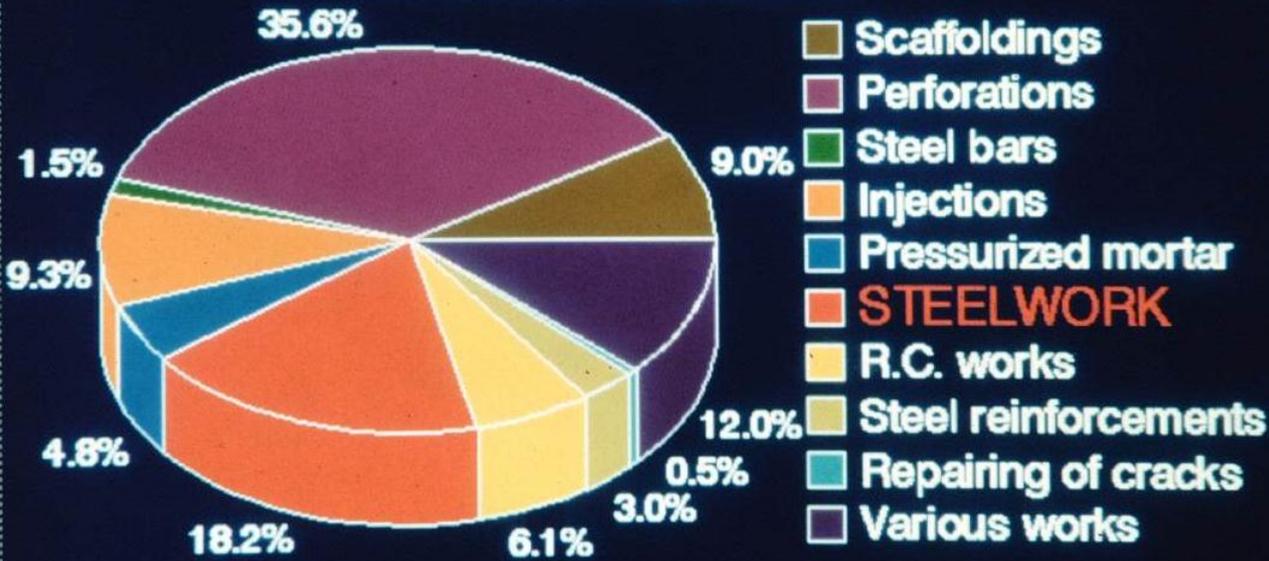
Percentage distribution of consolidation operations made with steel



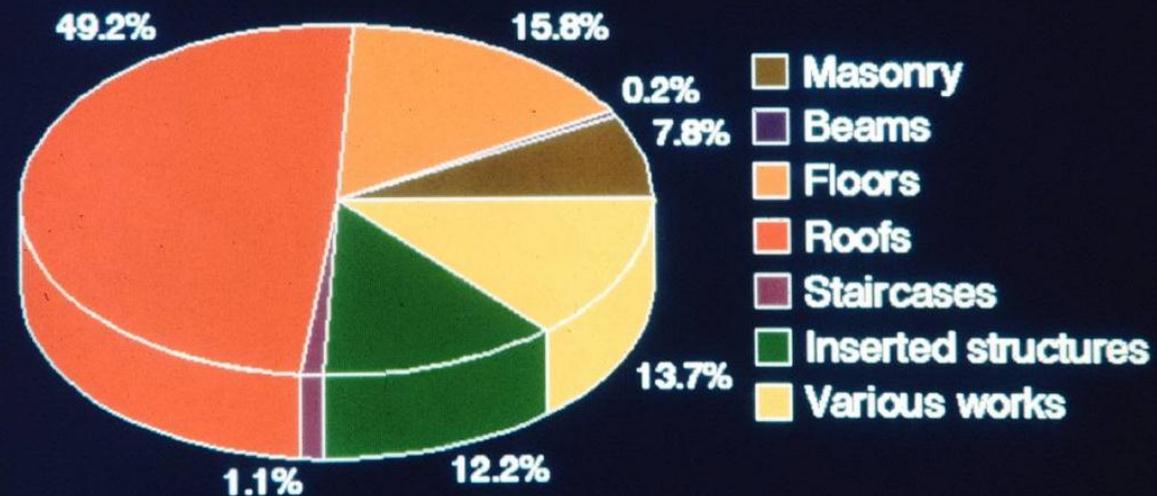
**Historical Buildings**

# Church Buildings

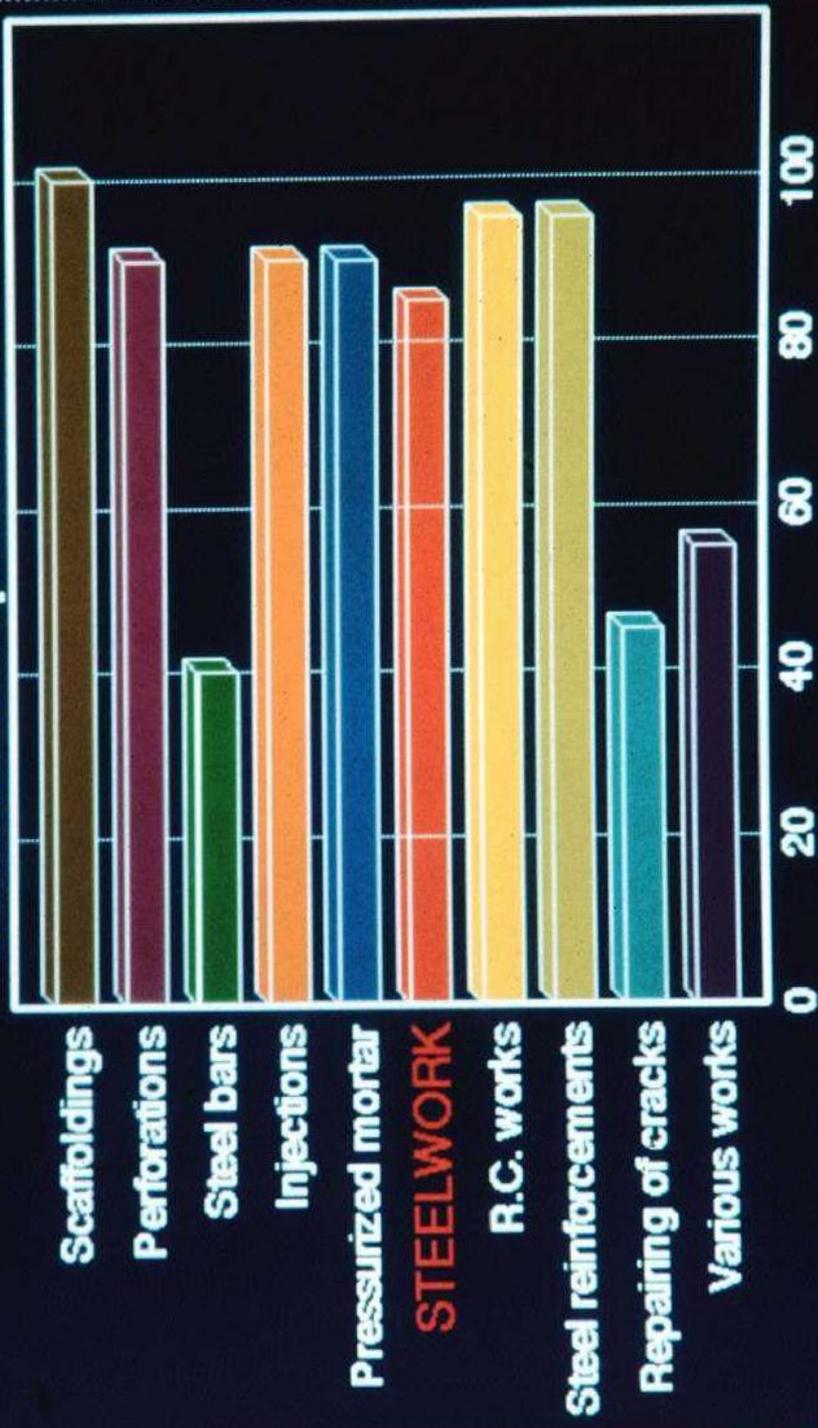
Percentage cost distribution of consolidation operations



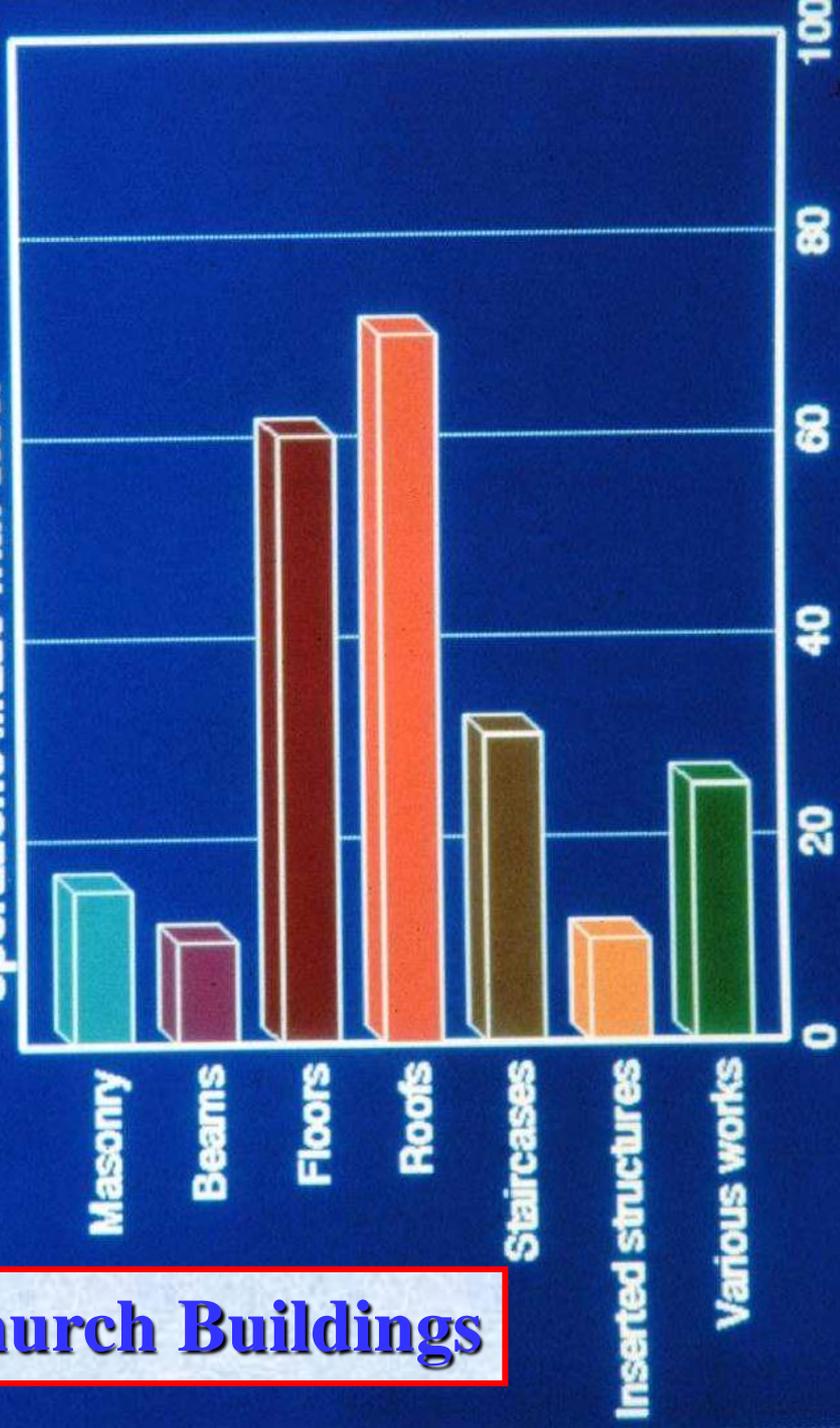
Percentage cost distribution of consolidation operations made with steel



Percentage distribution of consolidation operations



Percentage distribution of consolidation operations made with steel



**Church Buildings**

# Why steel in refurbishment

- resistance
- lightness
- easy erection
- reversibility
- “new material”





# Consolidation Levels

1. Safeguard
2. Repair
3. Reinforcing
4. Restructuring



## ■ **Safeguard**

action of temporary nature to achieve adequate safety for both the public and the site, prior to starting definitive operations.



# SCAFFOLDING SYSTEMS



**Guardia dei Lombardi  
(Avellino, Italy)**



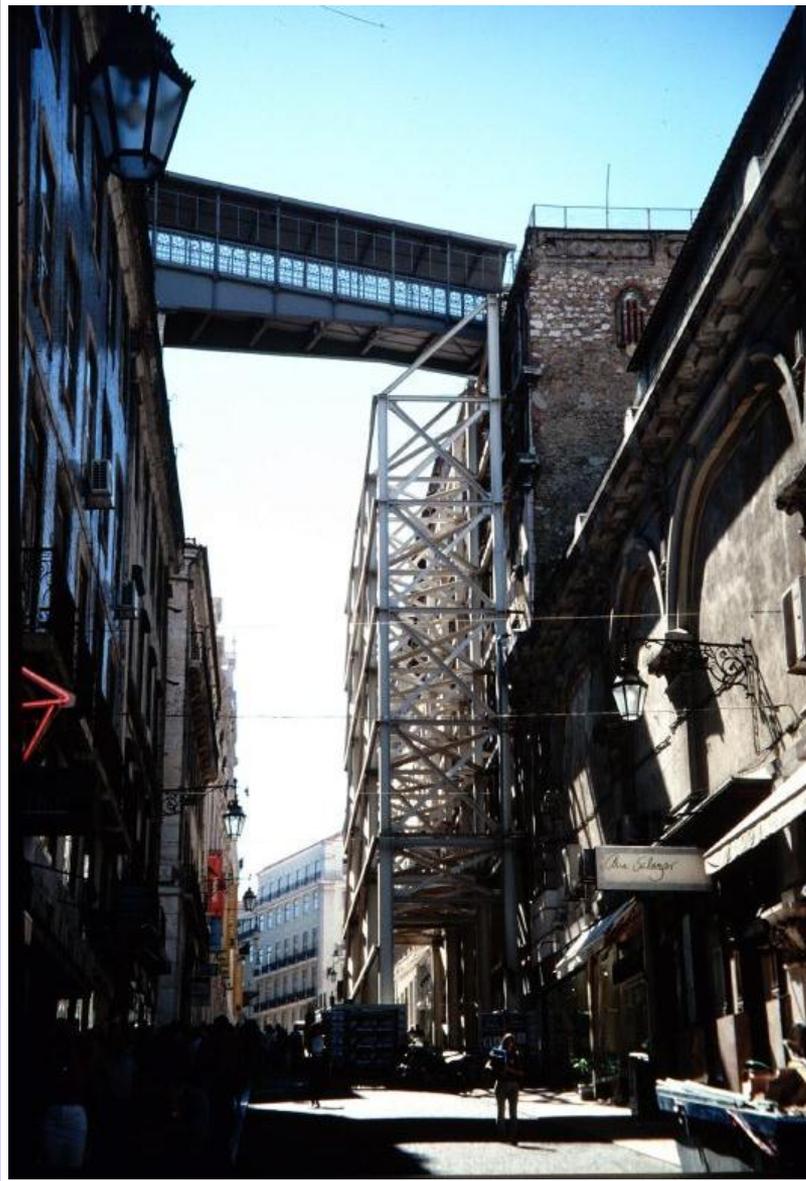
## Tortora (Cosenza, Italy)

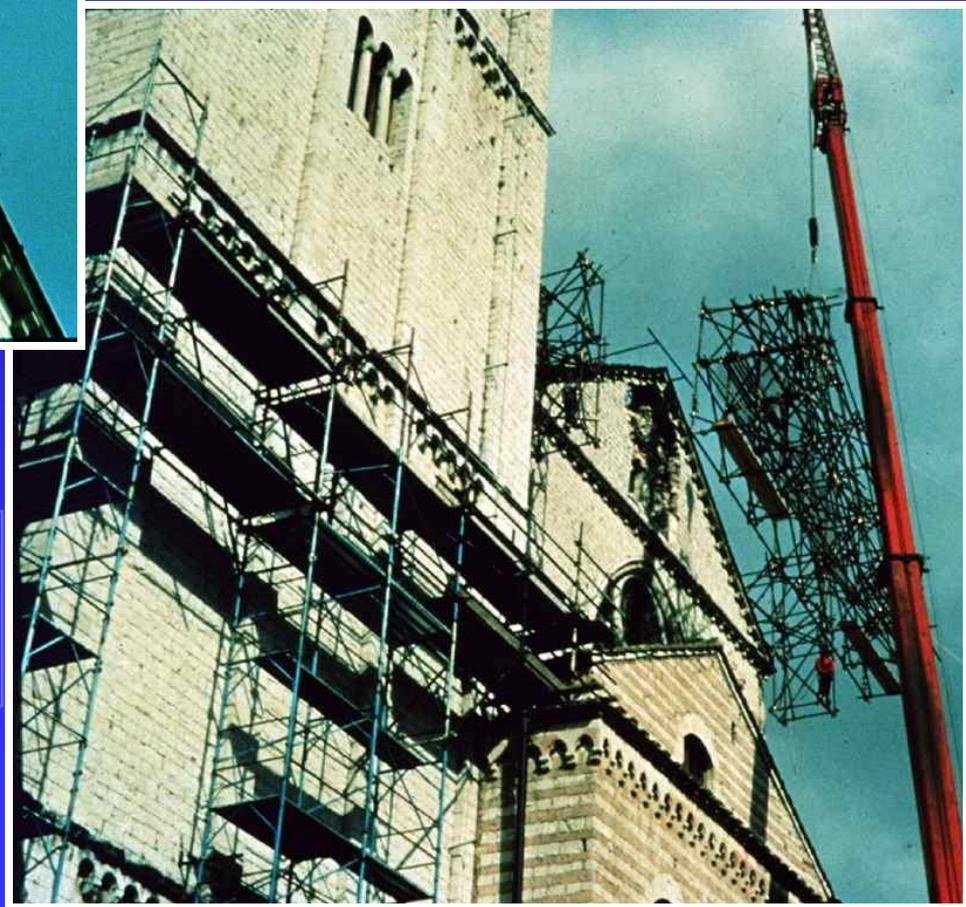
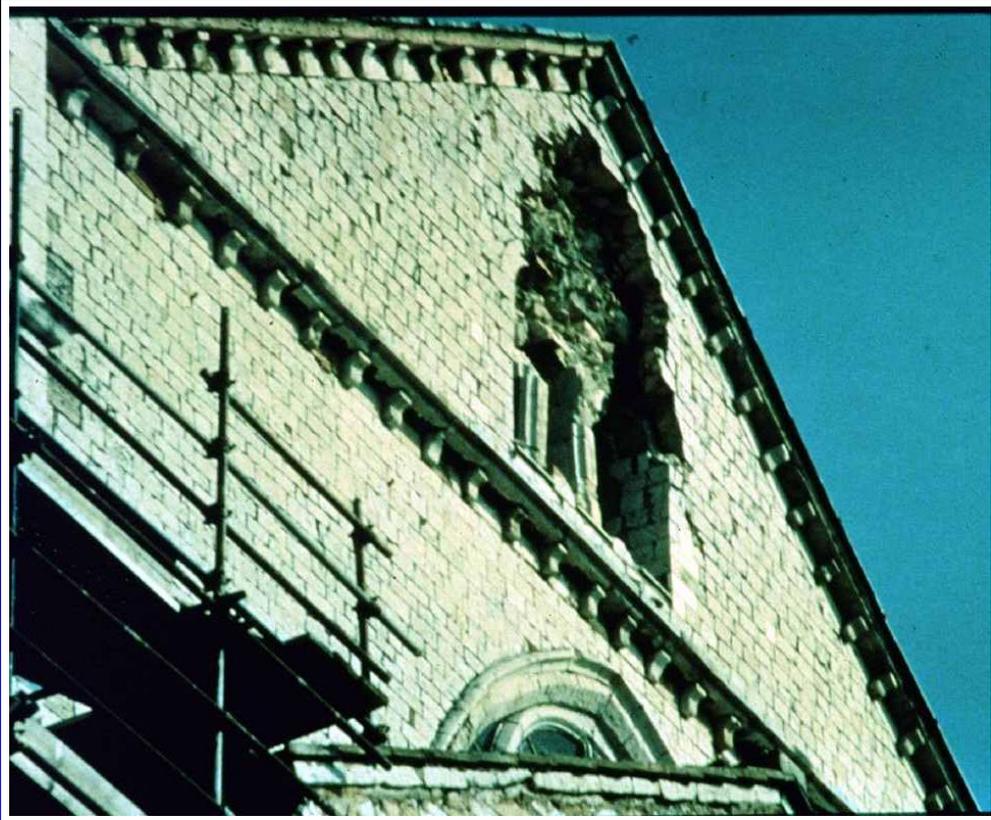




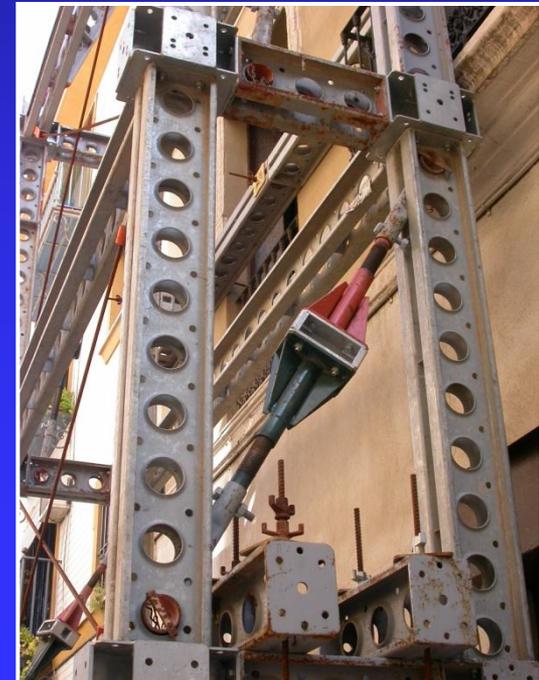
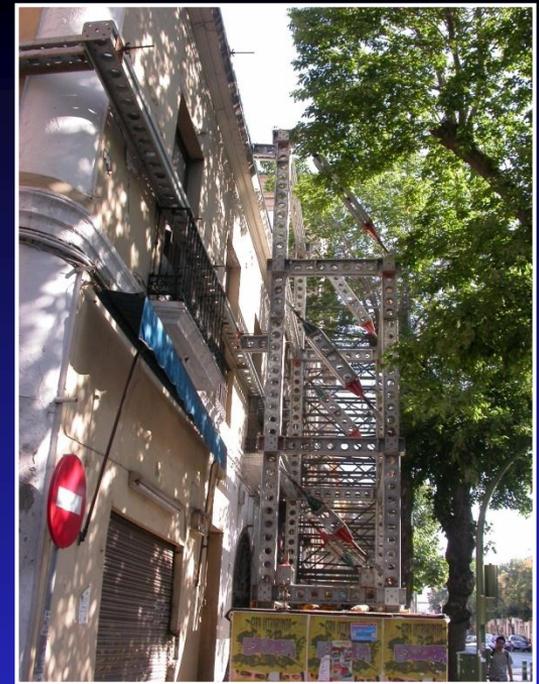
**Lisbon (Portugal)**

# Lisbon (Portugal)





**St. Francesco Church  
(Assisi, Italy)**

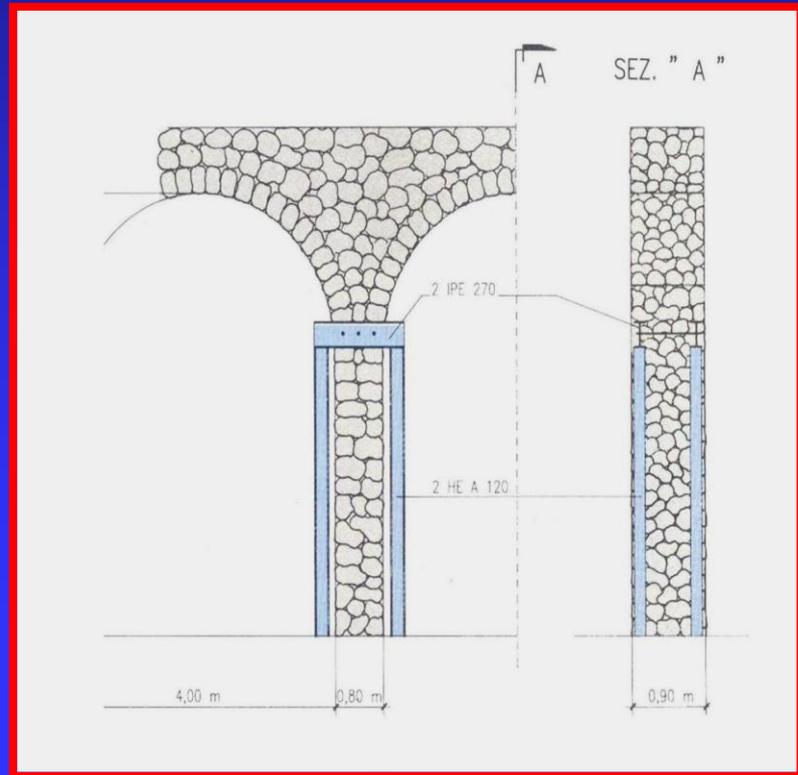
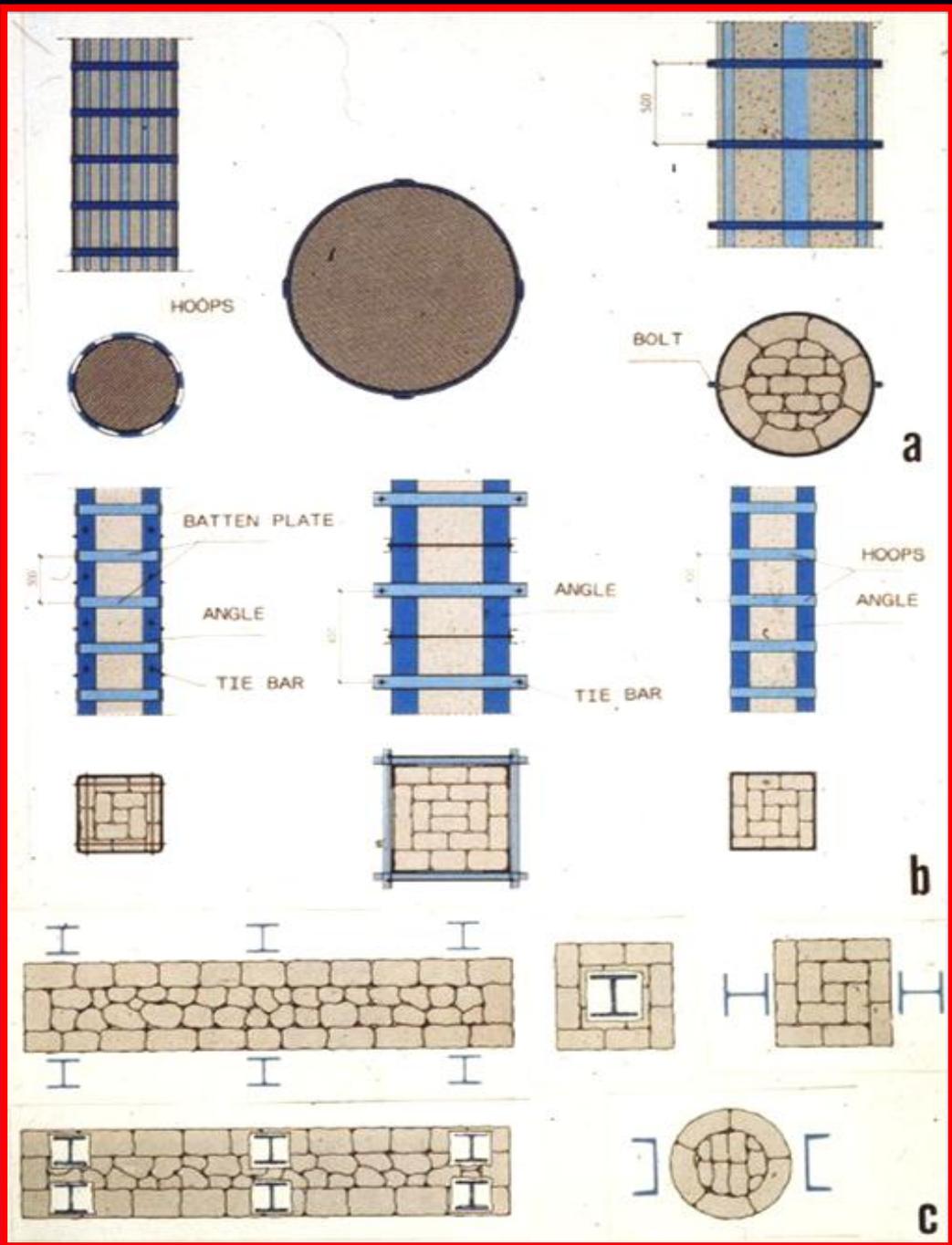


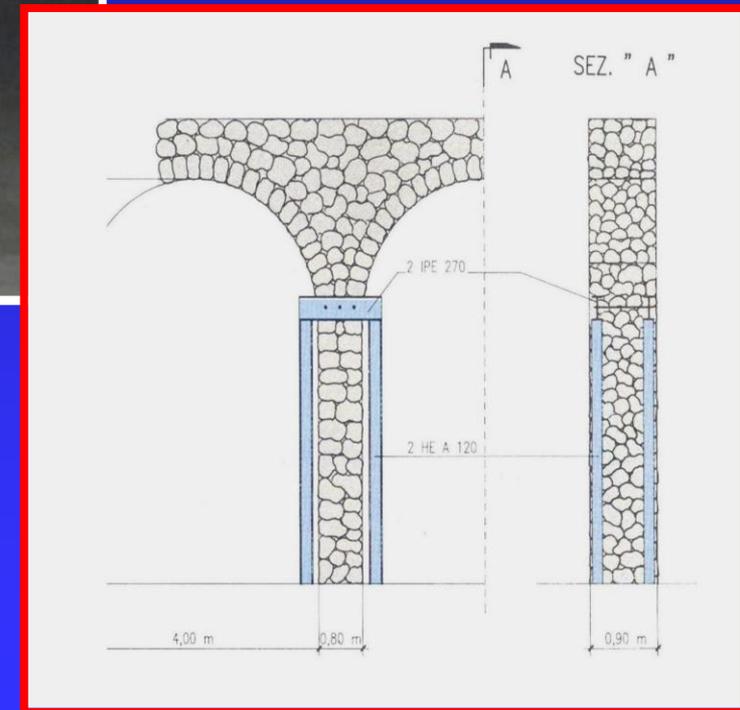
**Siviglia (Spain)**

- **Repair** = series of operations necessary to restore the former structural efficiency before the damage occurred

# **CONSOLIDATION OF MASONRY STRUCTURES**

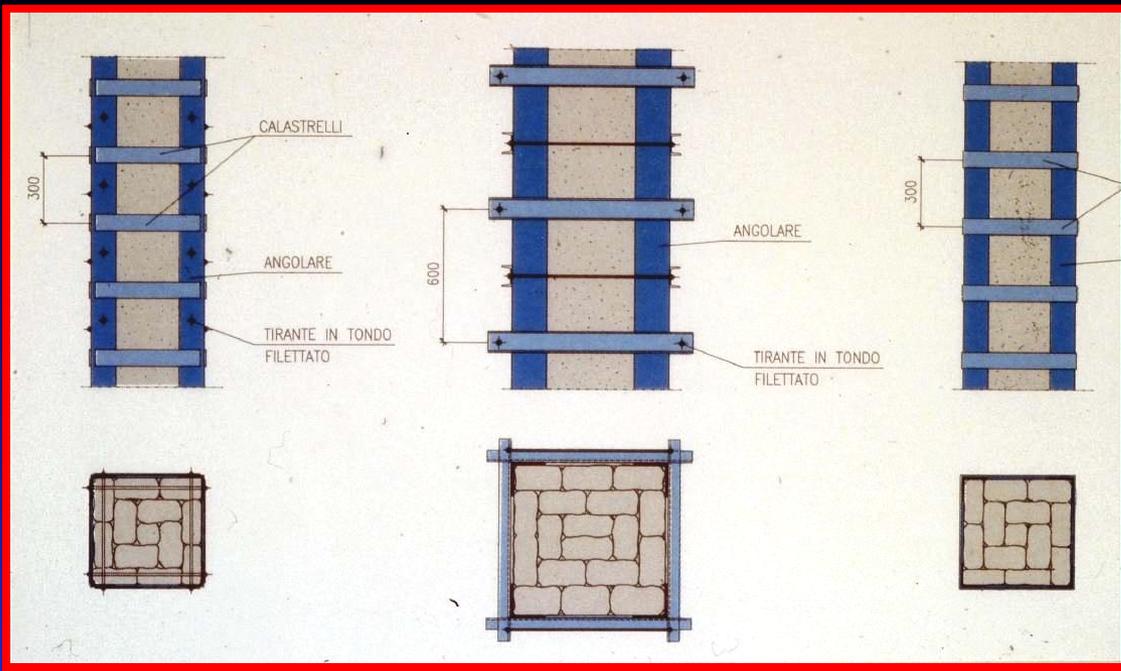


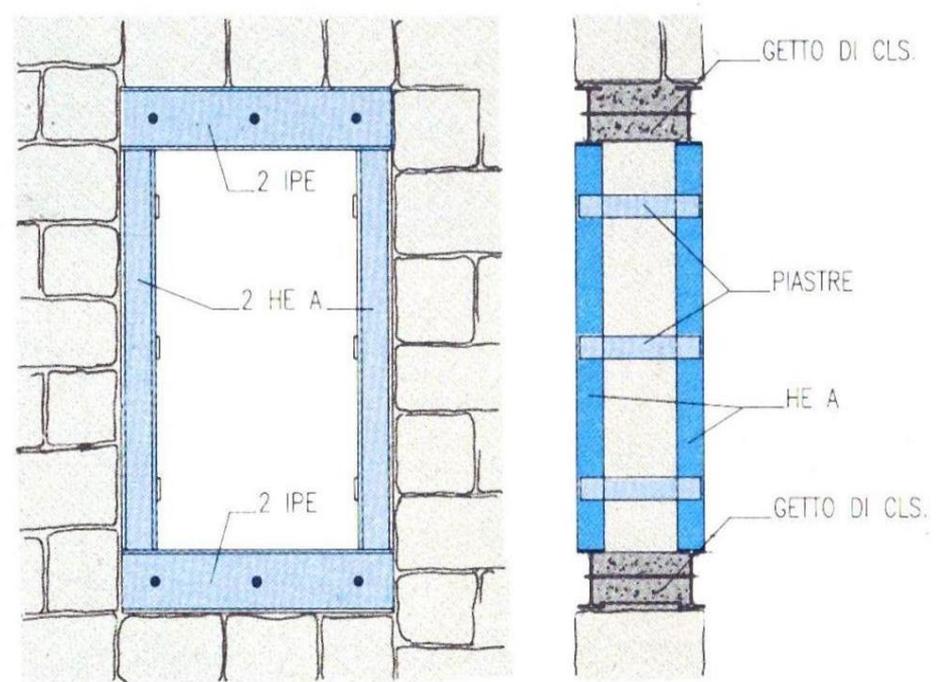
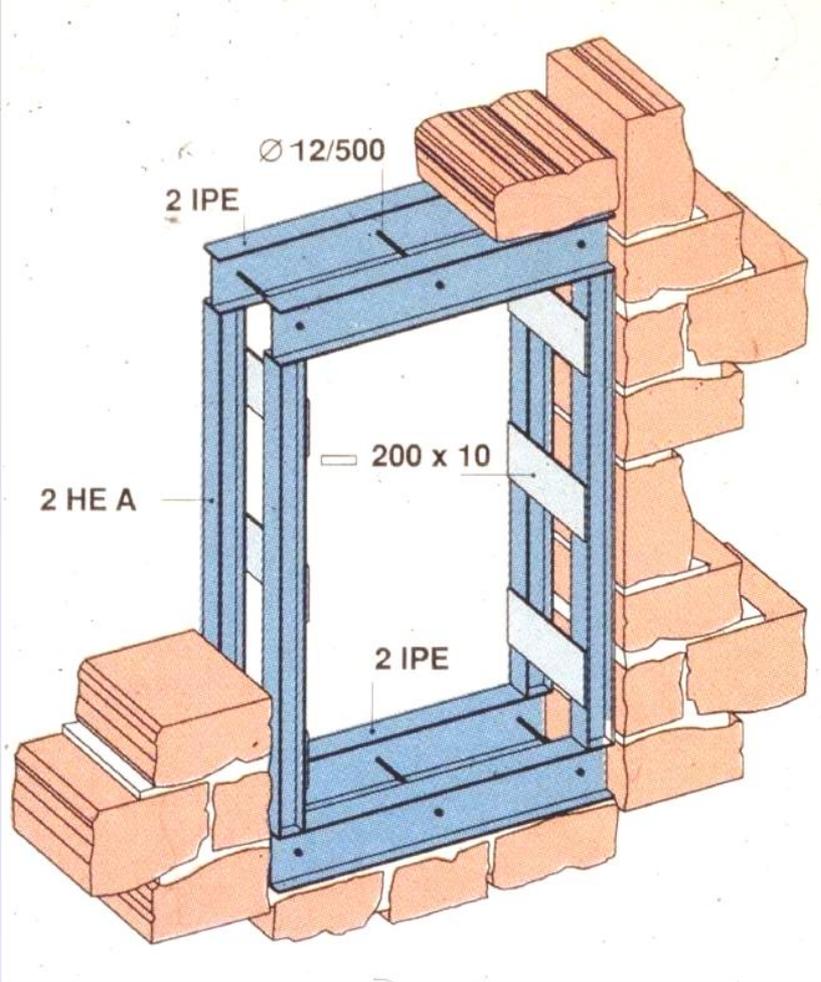


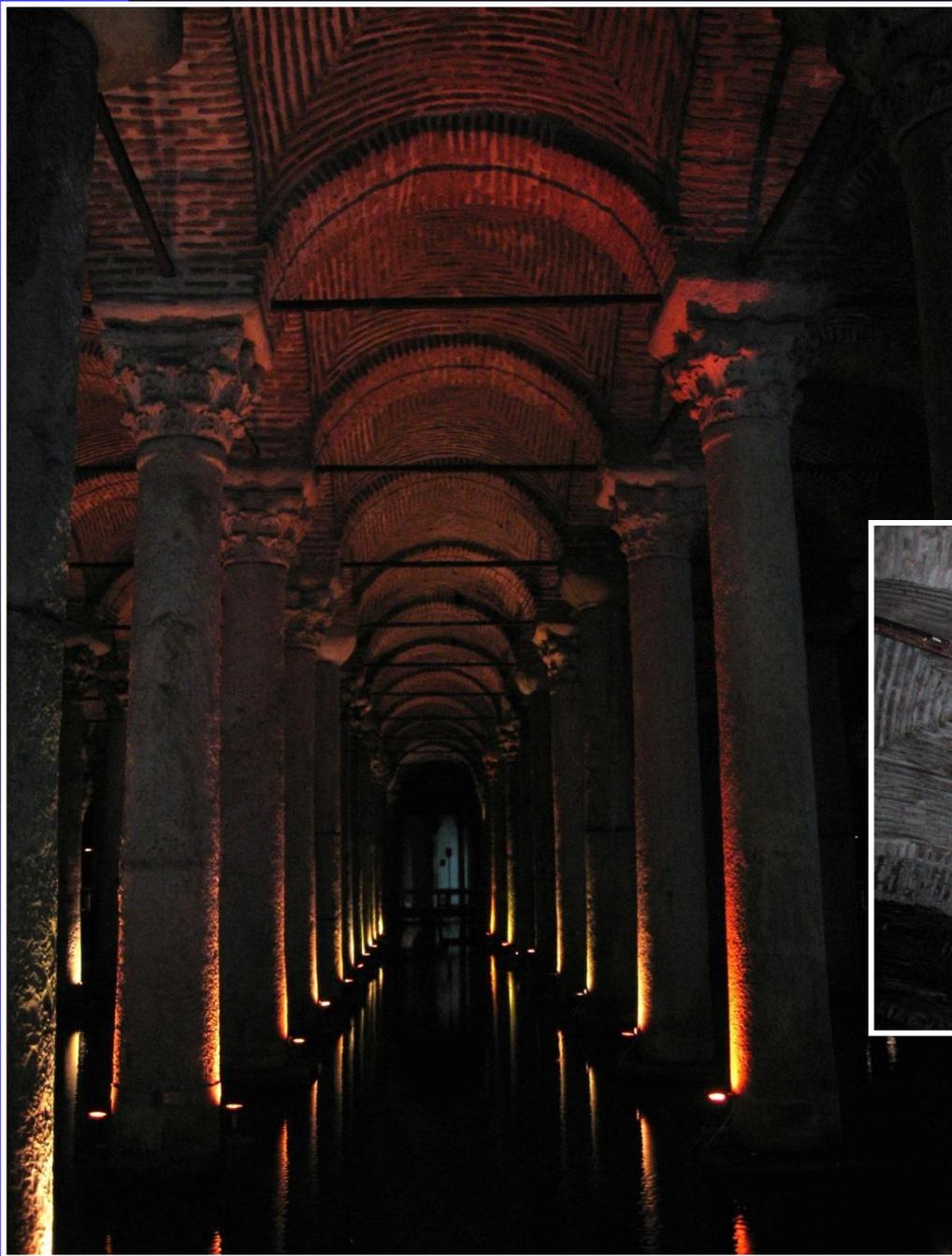










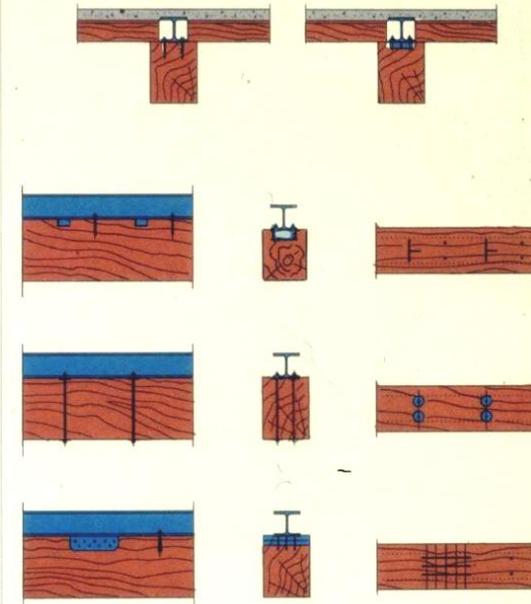
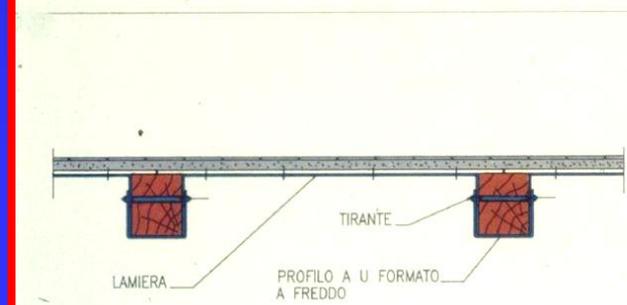
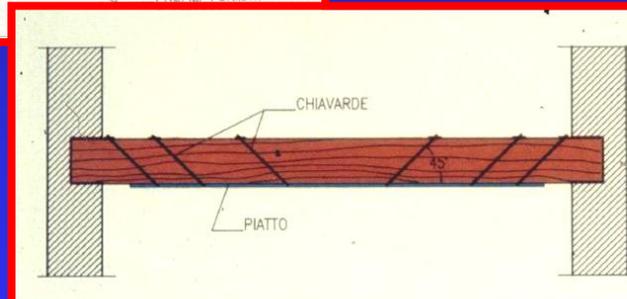
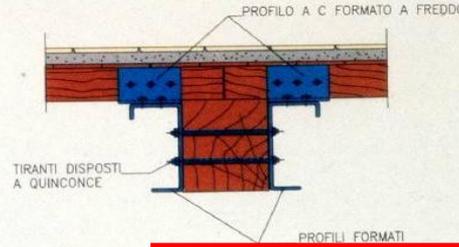
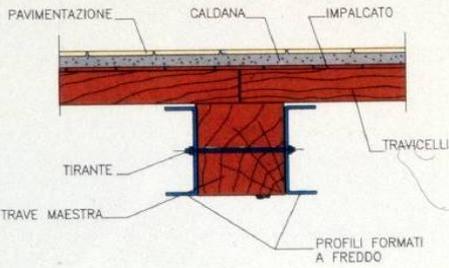
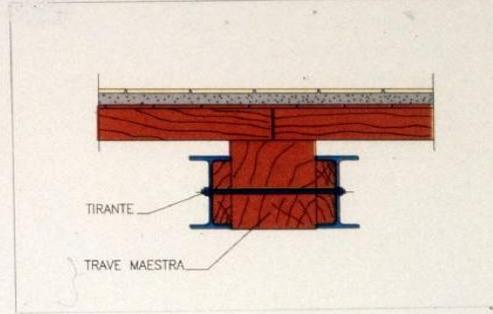
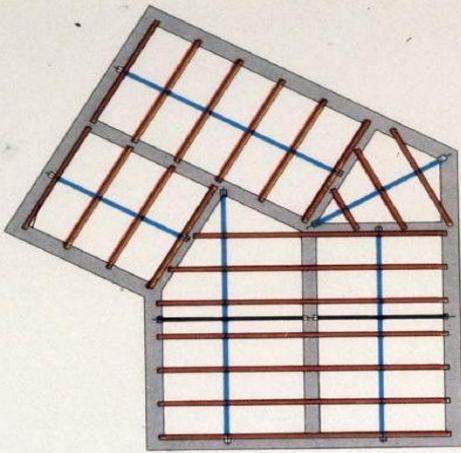


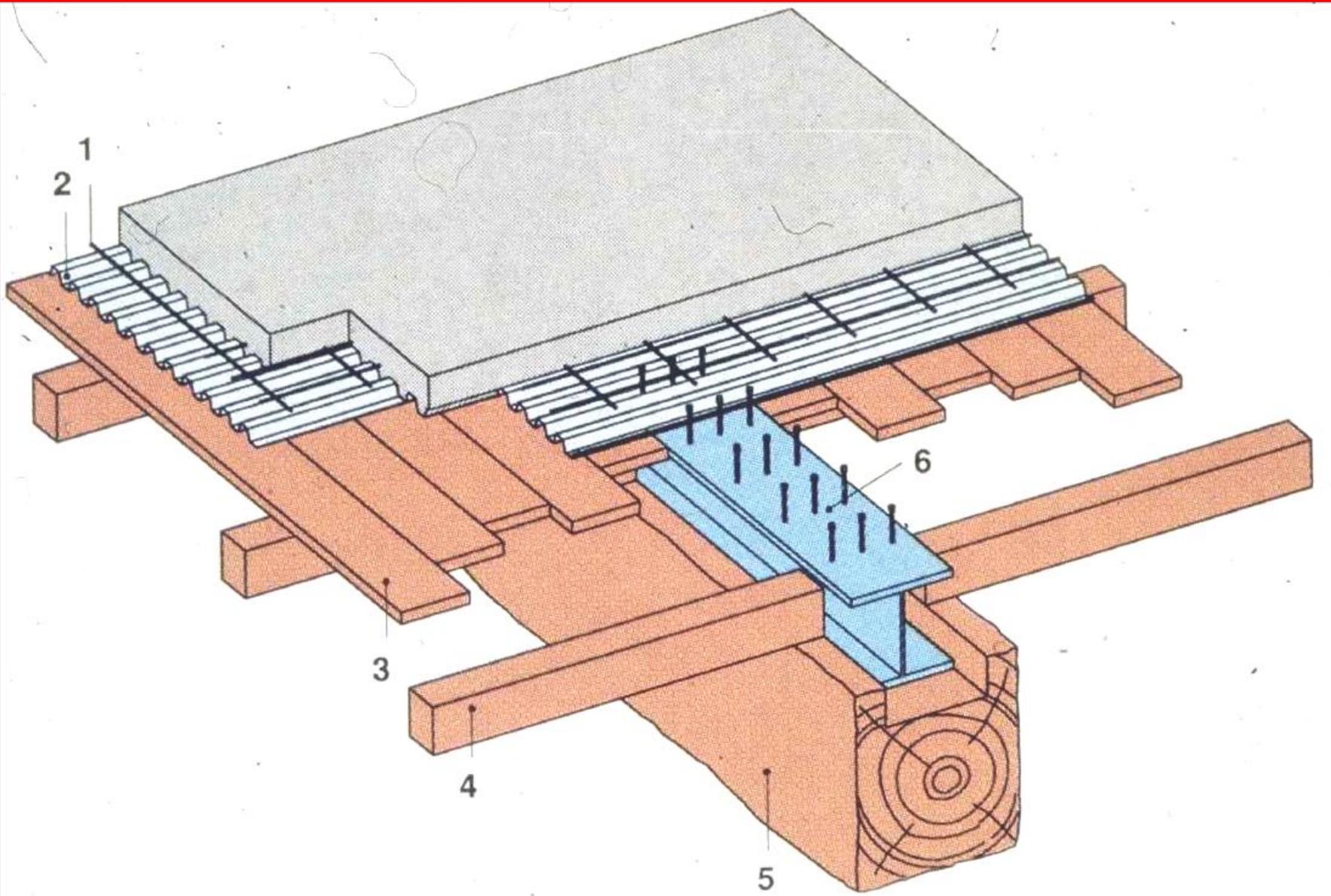
# **CONSOLIDATION OF WOODEN STRUCTURES**

# CONSOLIDATION OF WOODEN FLOORS

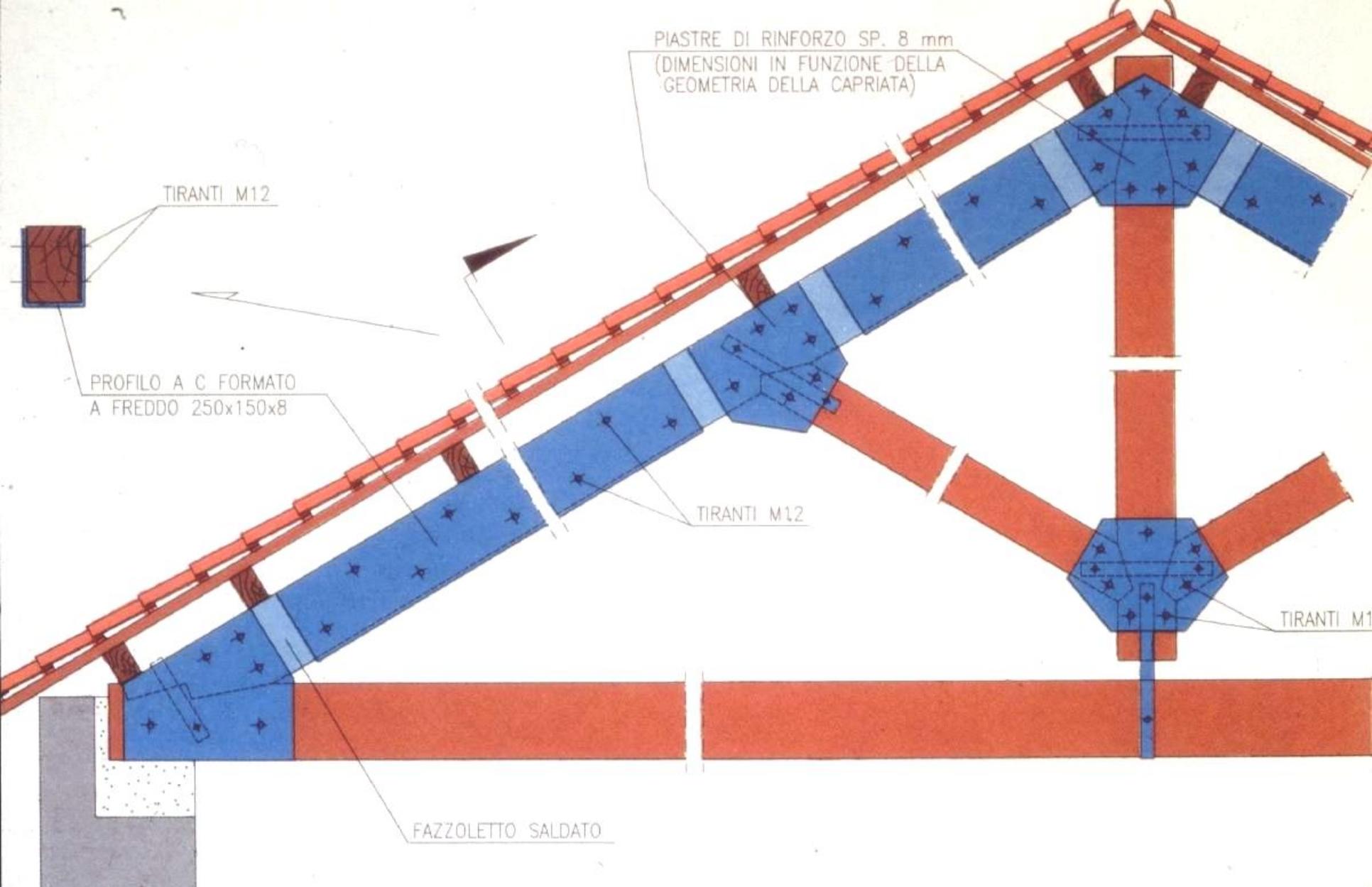


# CONSOLIDATION OF WOODEN BEAMS





**COMPOSITE SOLUTION :  
WOOD-STEEL-CONCRETE STRUCTURE**

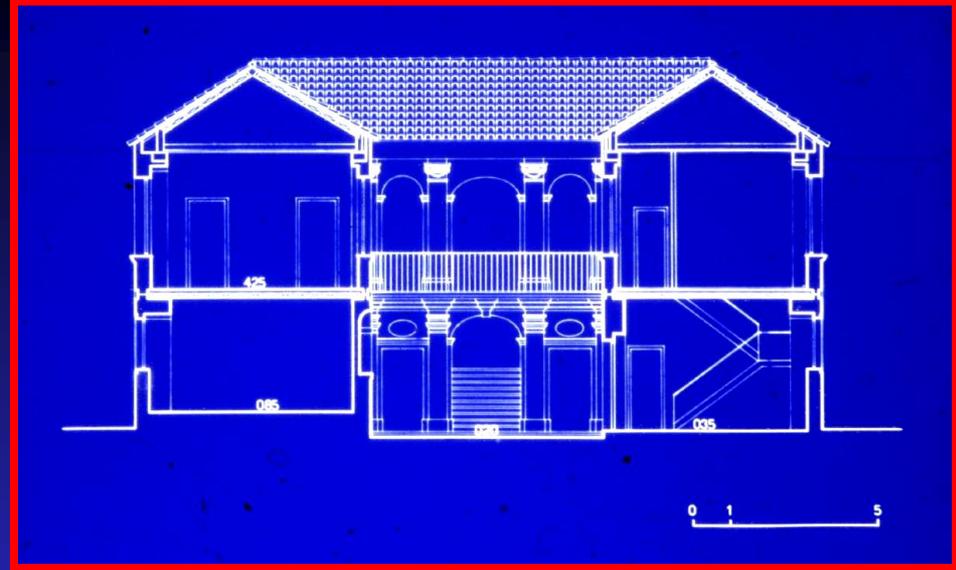
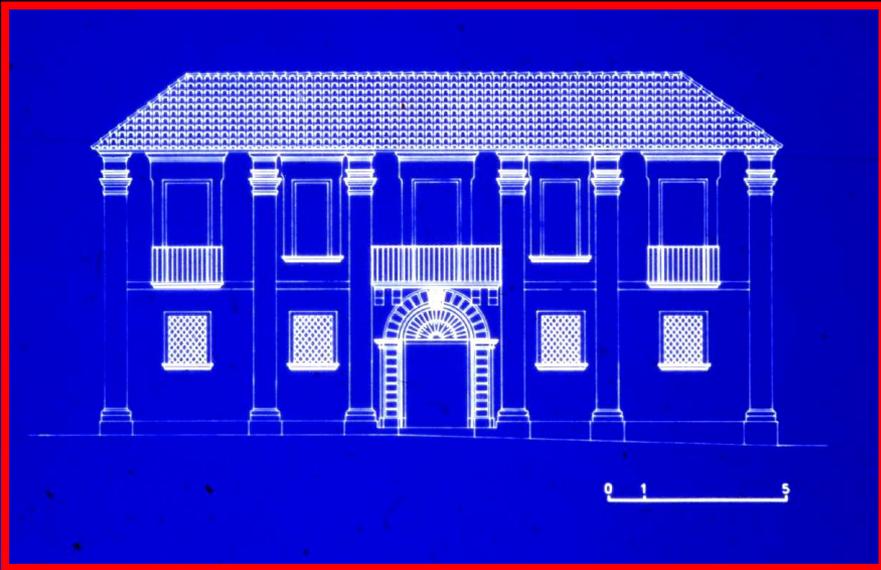


# CONSOLIDATION OF WOODEN TRUSSES

# **SUBSTITUTION OF WOODEN ROOFS WITH STEEL ROOFS**



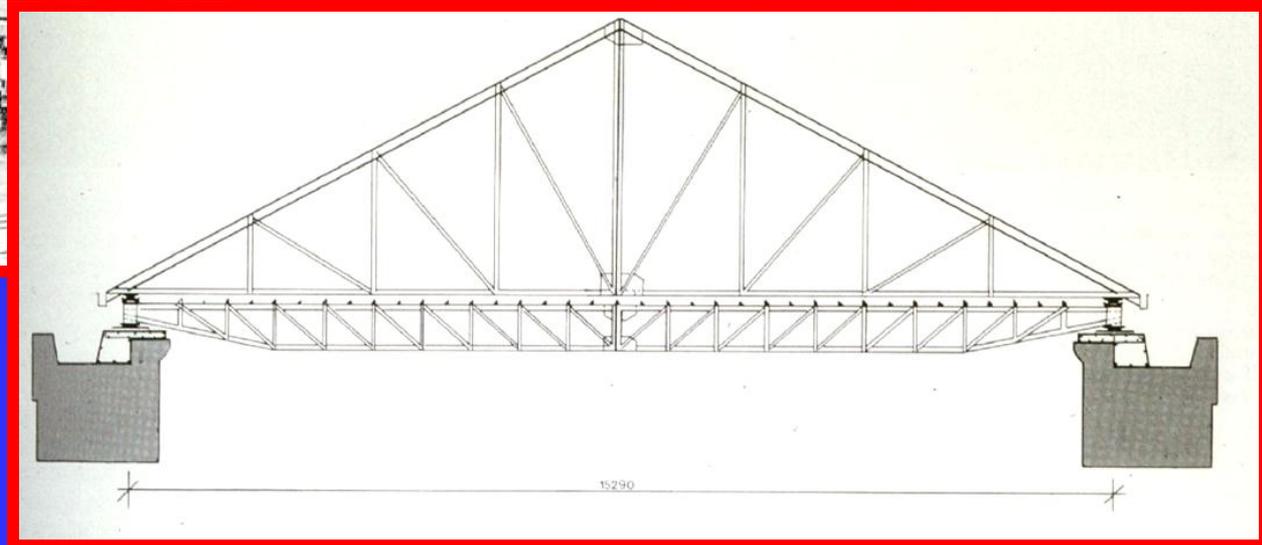
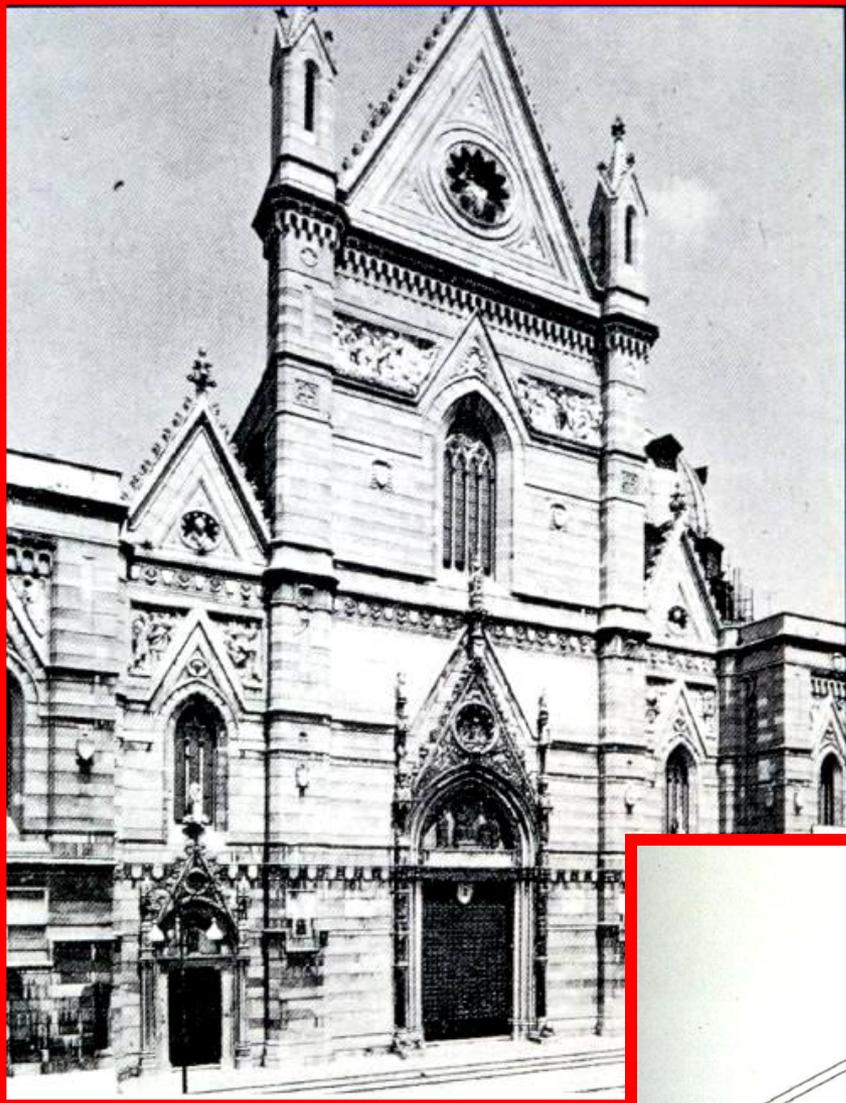
**NEW STEEL ROOF IN  
A CHURCH**



# NEW STEEL ROOF IN A MONUMENTAL BUILDING



# THE STEEL ROOF OF THE NAPLES CATHEDRAL



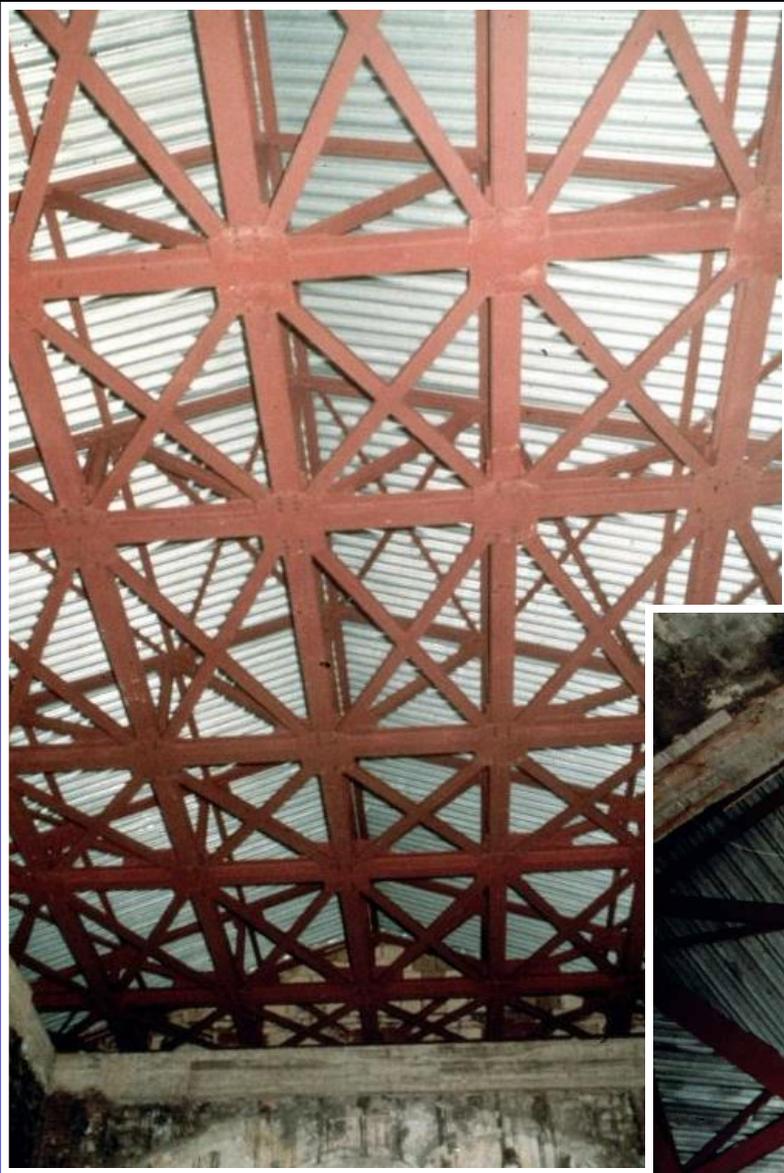
# SUCCIVO CASERTA (ITALY)



## A PENTHOUSE IN A MASONRY BUILDING



# STEEL DIAPHRAGM IN A MASONRY CHURCH



**SOLOFRA  
(AVELLINO)**



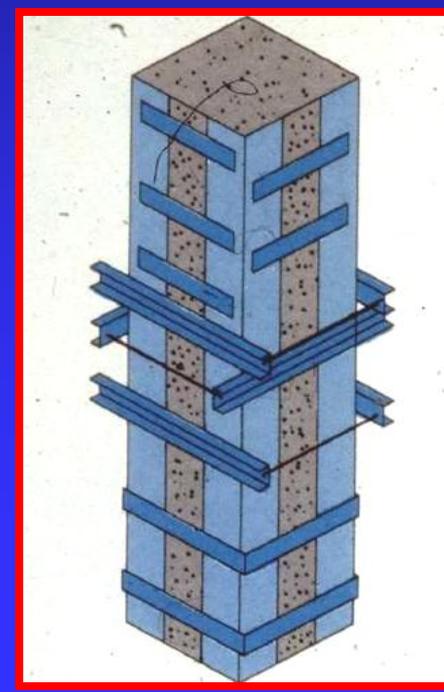
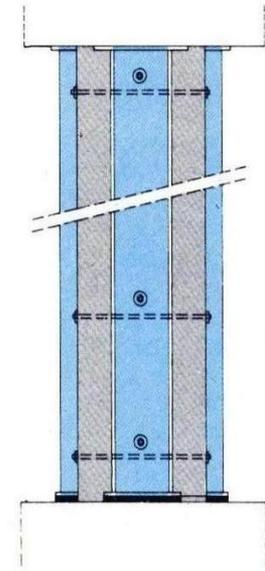
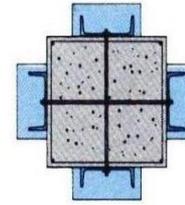
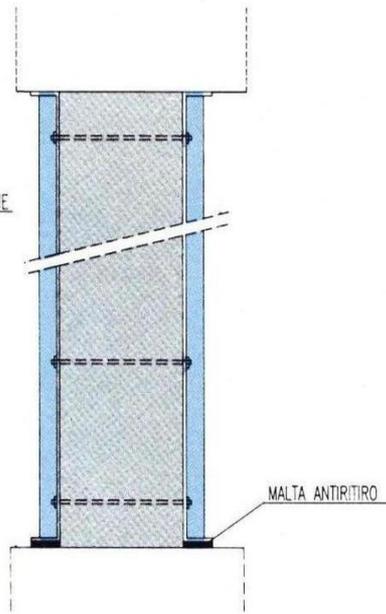
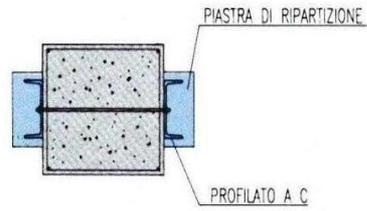
## **SPECIAL SEISMIC DEVICES**

**ST.GIOVANNI IN  
CARIFE (AVELLINO)**



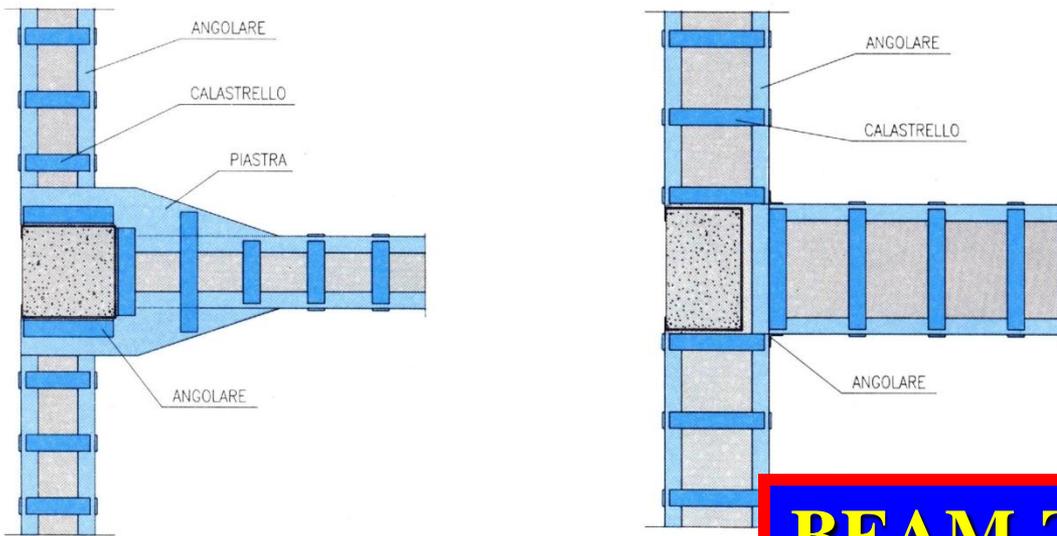
# **CONSOLIDATION OF R.C. STRUCTURES**

# COLUMNS

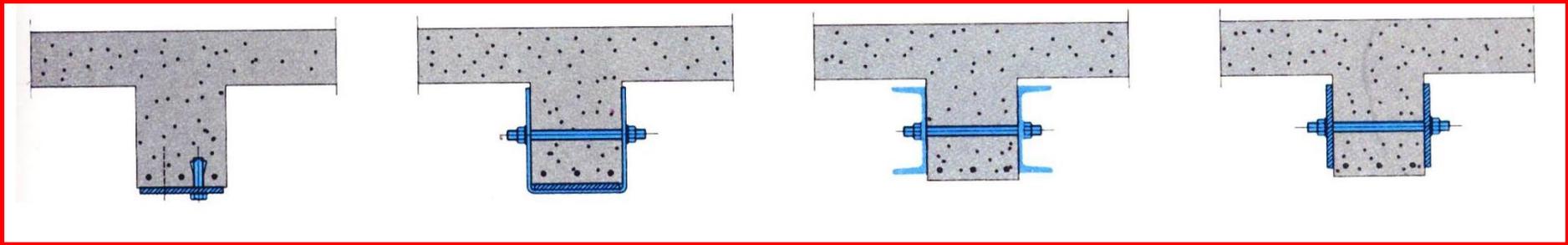


# Mexico City

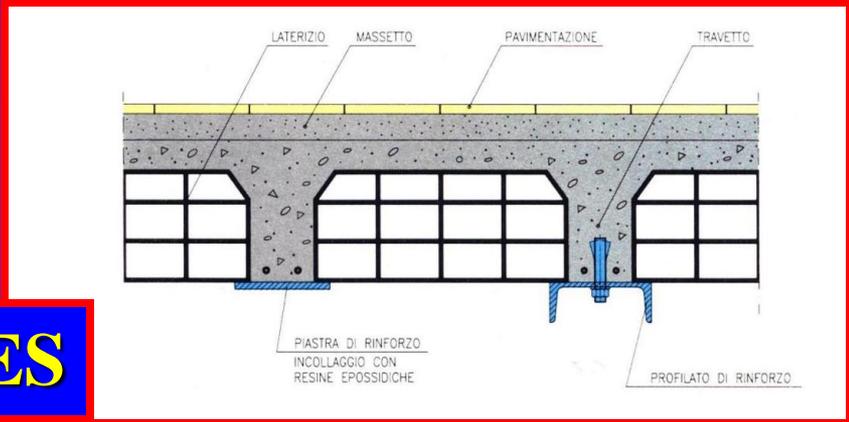




# BEAM-TO-COLUMN NODES



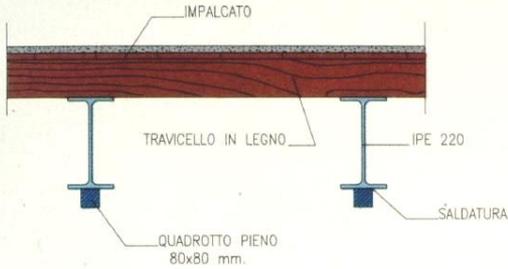
# BEAMS



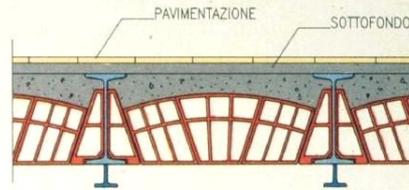
# FLOOR STRUCTURES

# **CONSOLIDATION OF STEEL STRUCTURES**

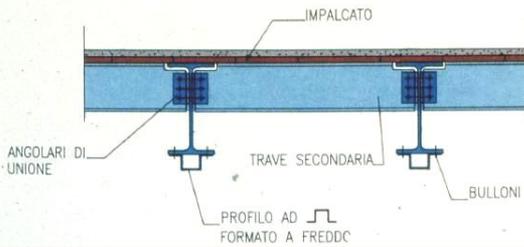
SOLAIO IN TRAVI METALLICHE E TRAVICELLI IN LEGNO



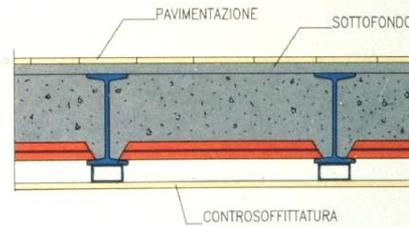
SOLAIO IN TRAVI METALLICHE E VOLTERRANE IN LATERIZIO



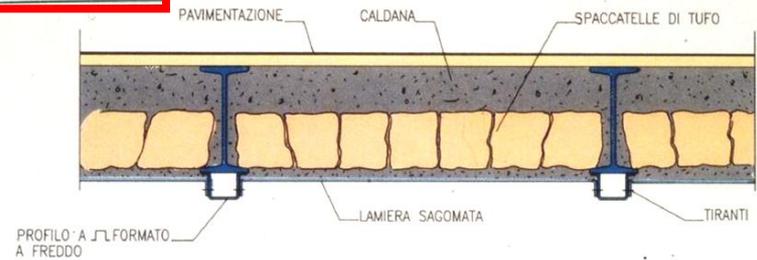
SOLAIO CON TRAVI PRINCIPALI E SECONDARIE IN METALLO



SOLAIO IN TRAVI METALLICHE E TAVELLONI IN LATERIZIO



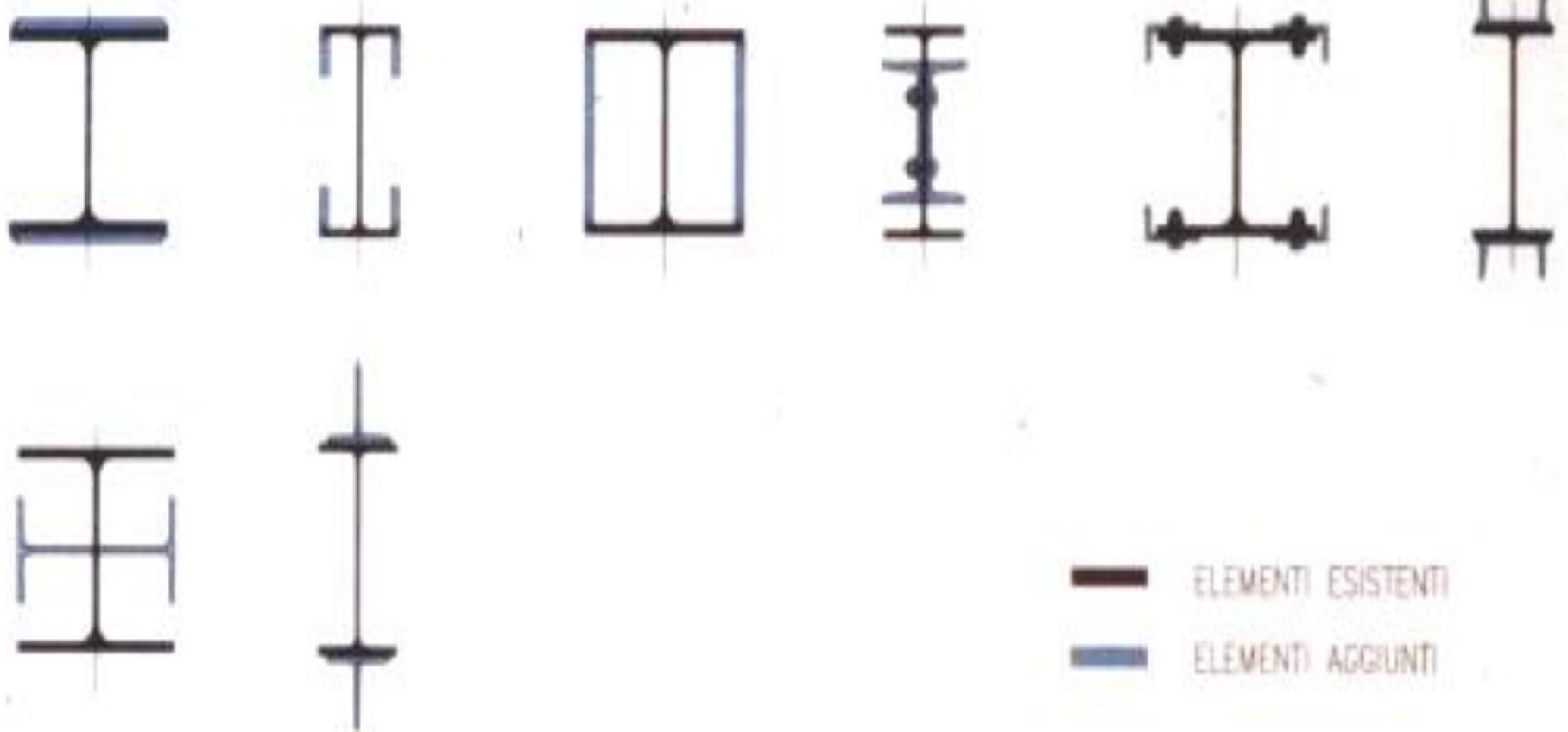
SOLAIO CON TRAVI METALLICHE E SPACCATELLE DI TUFO



# STEEL FLOORS



# STEEL SECTIONS

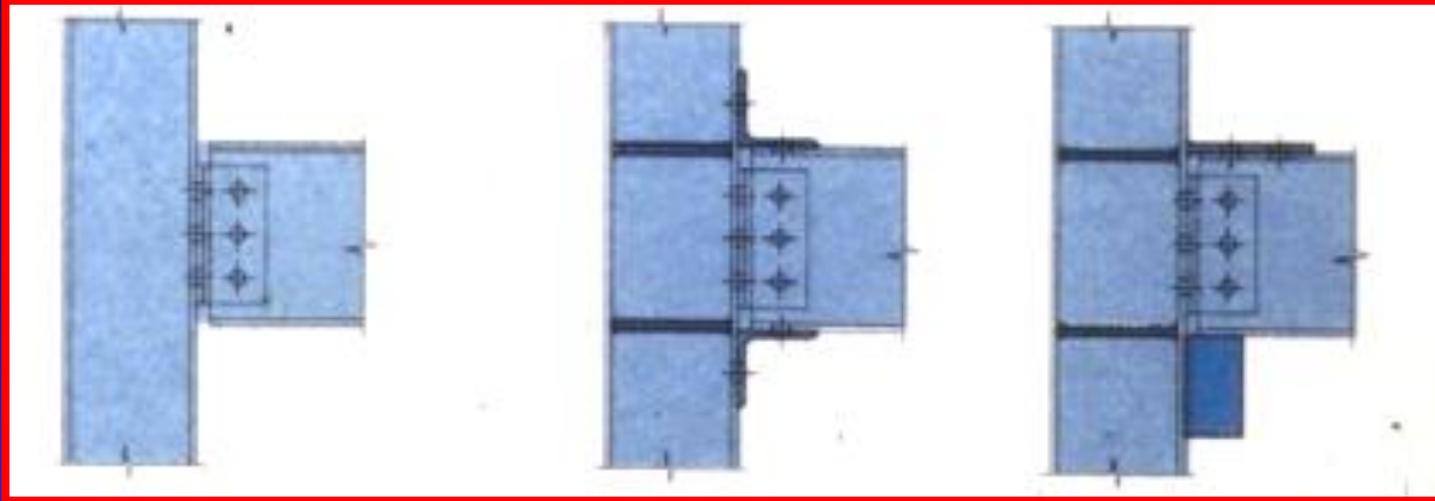


# STEEL NODES

pinned



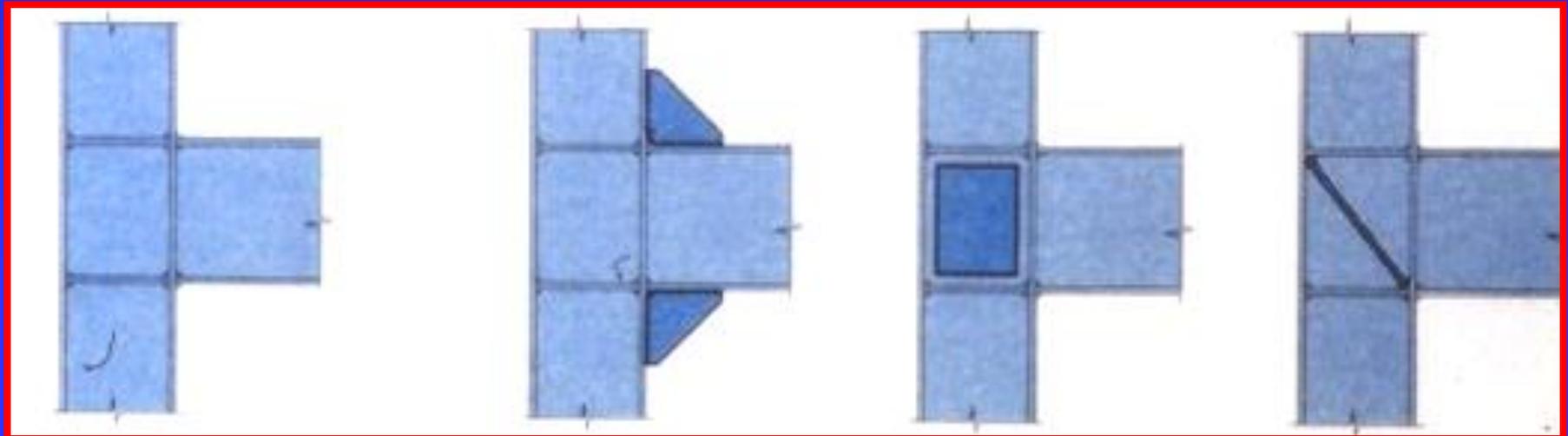
rigid



semi-rigid



rigid

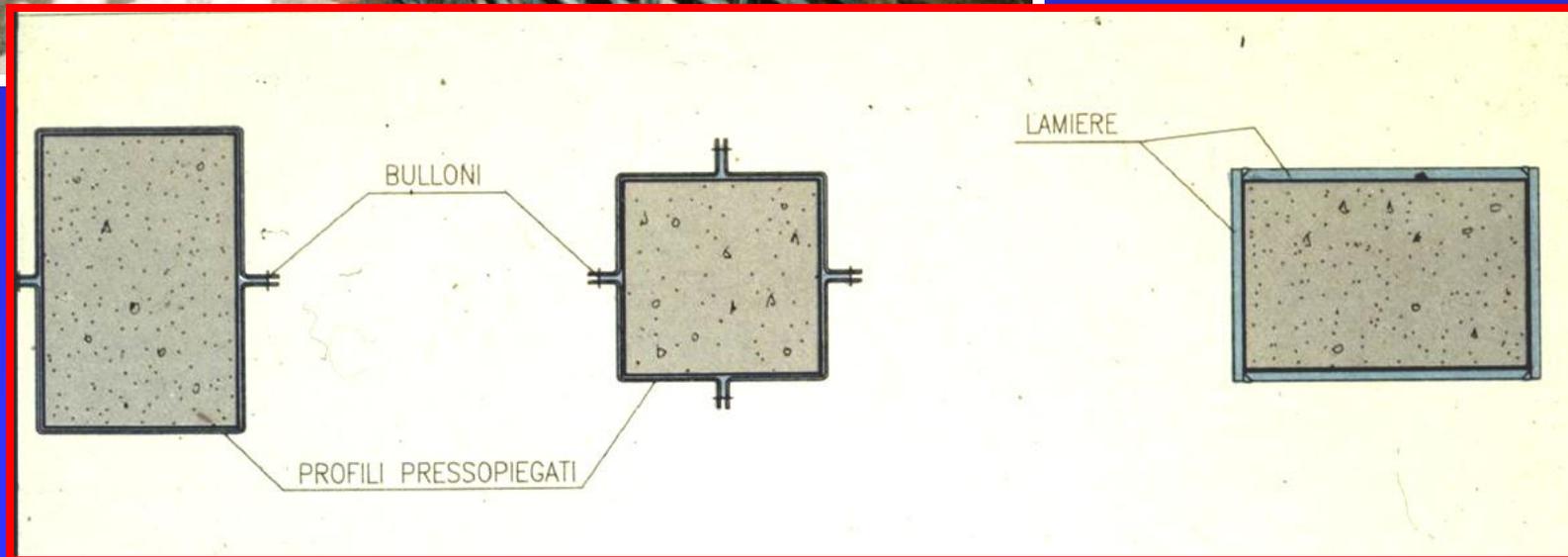


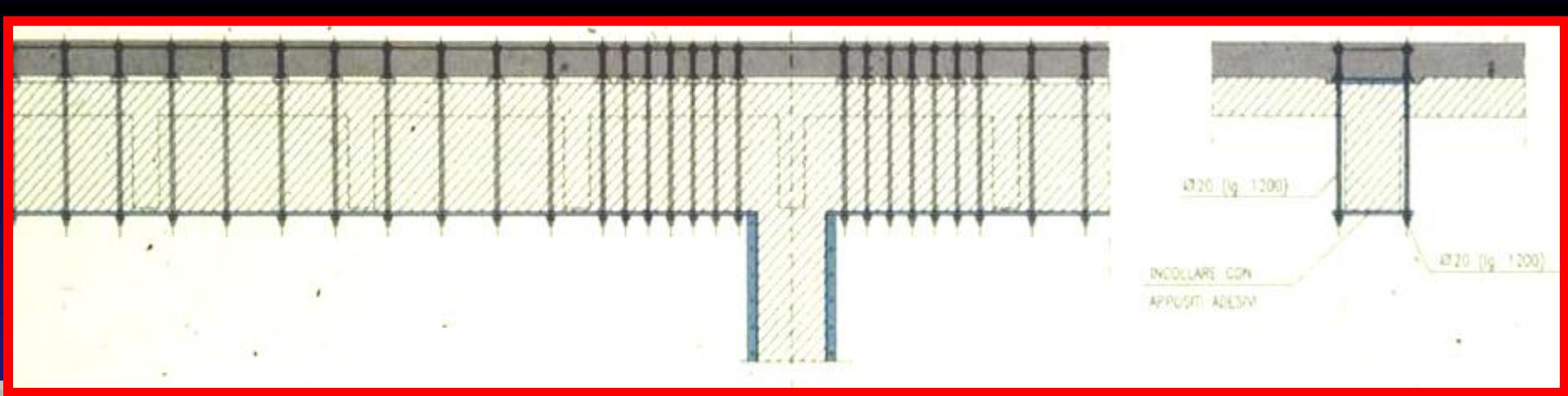


**ILVA steel mill  
(Bagnoli - Naples, Italy):  
seismic upgrading**

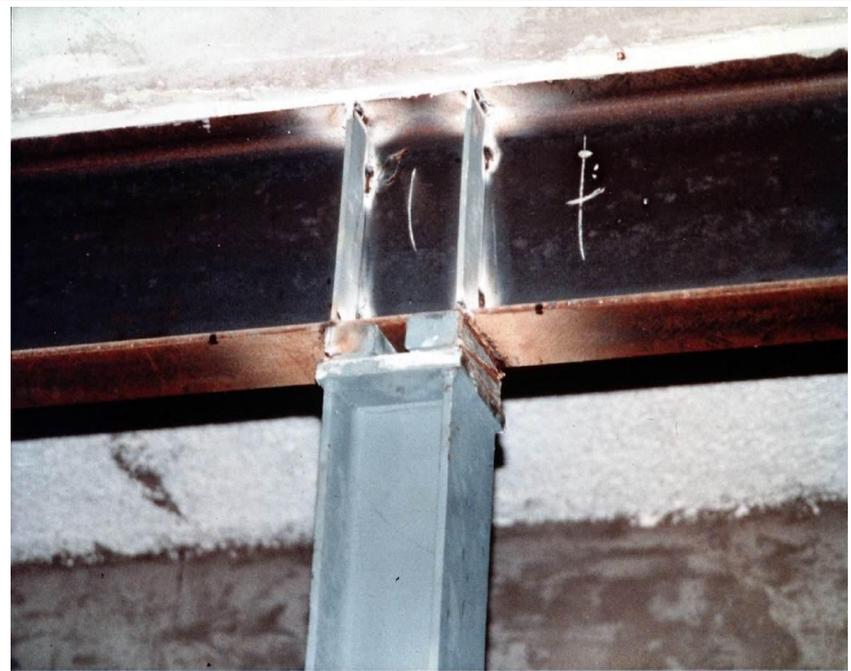
- **Reinforcing** = improving of the structural performance in order to make the building able to fulfil new functional requirements or enviromental conditions

# “Sigma coating” industrial building in Agnano (Naples, Italy)

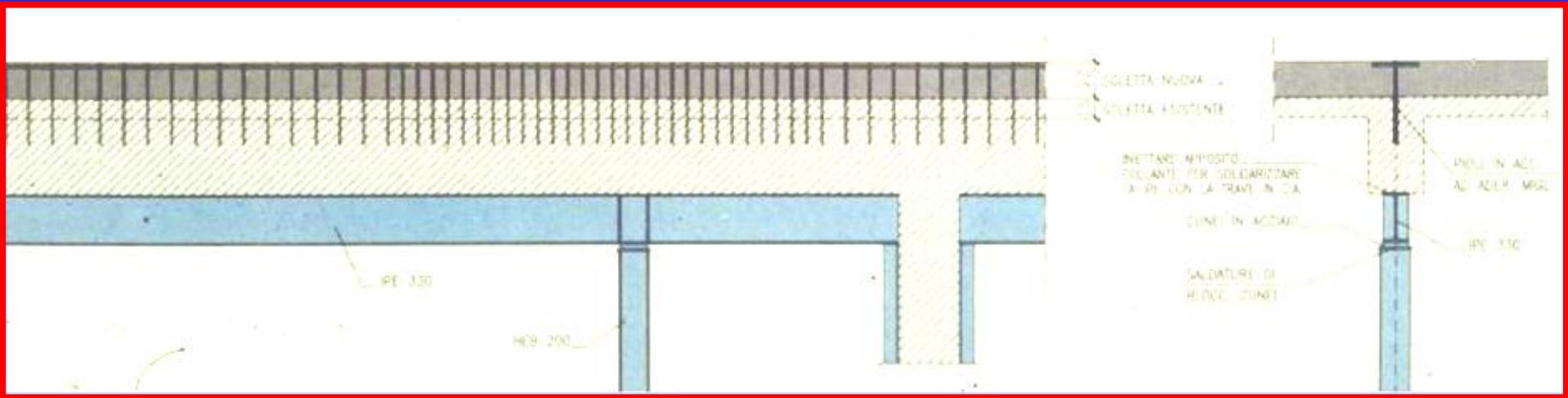




**“Sigma coating”  
industrial building  
in Agnano (Naples, Italy)**

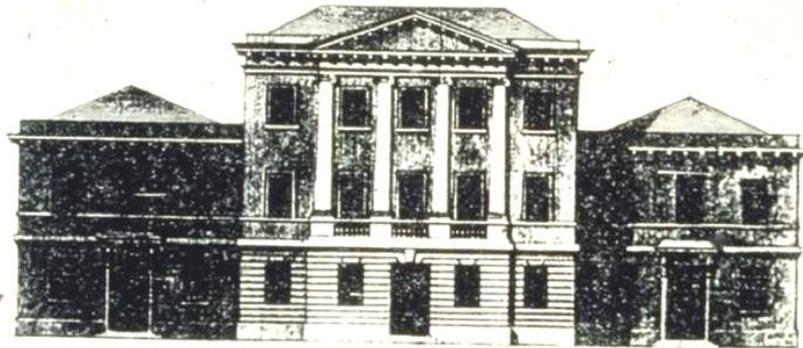
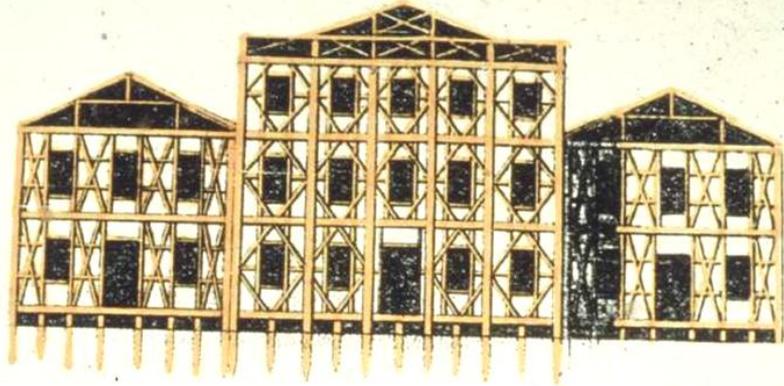


**“Sigma coating” industrial building in Agnano (Naples, Italy)**

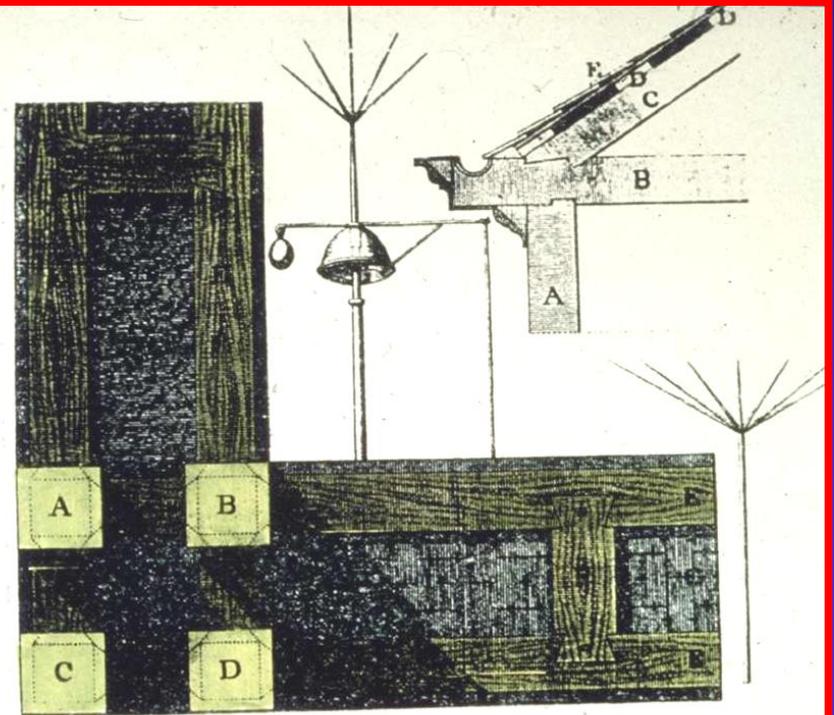


# SEISMIC UPGRADING WITH BRACING SYSTEMS

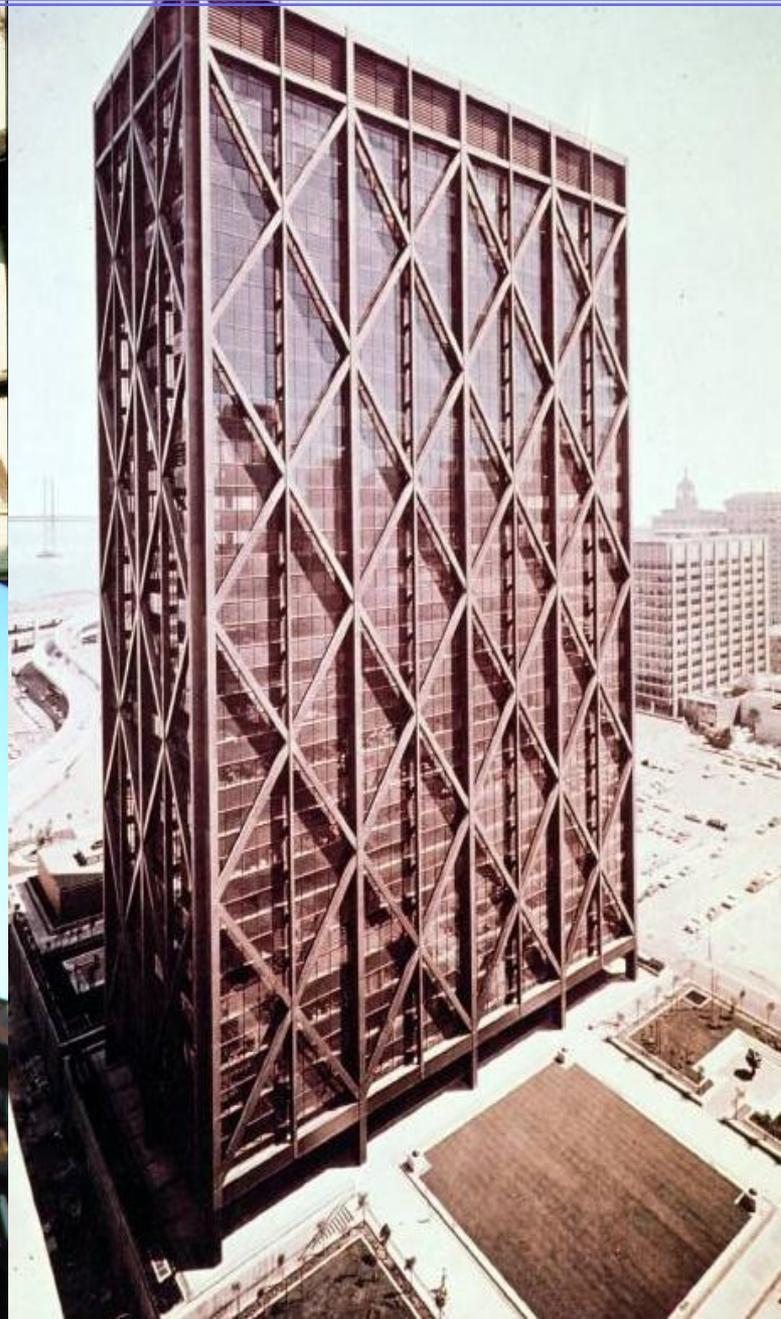




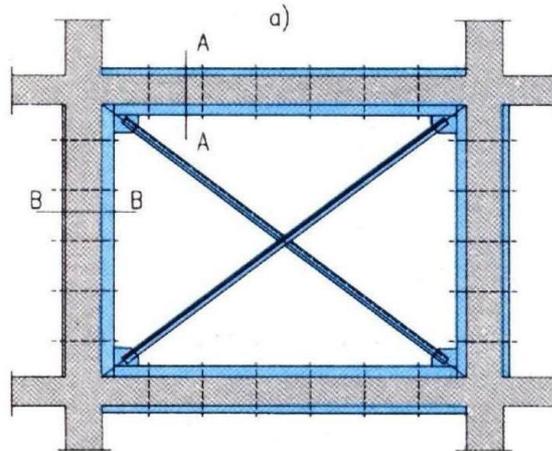
**“Case Baraccate”  
(Calabria, Italy)**



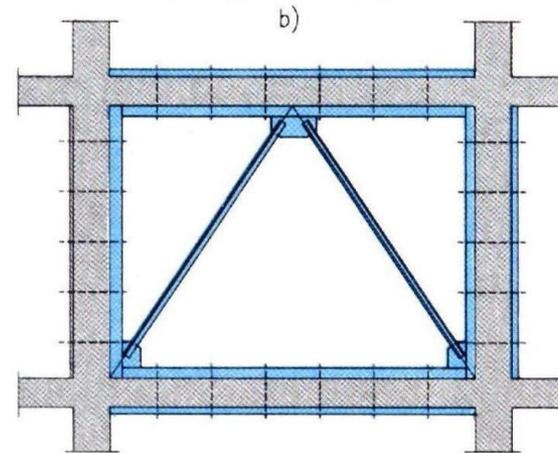
# Old and new bracing systems



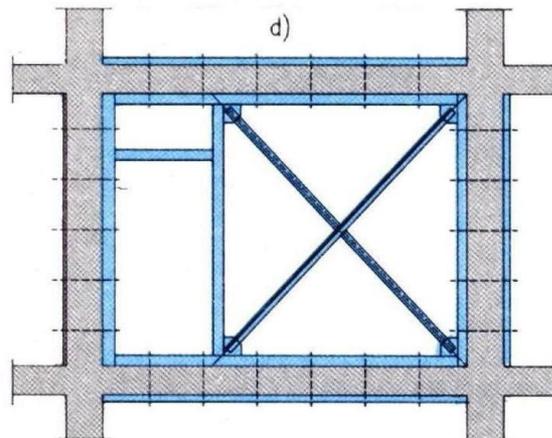
**Contr. a croce di S. Andrea**



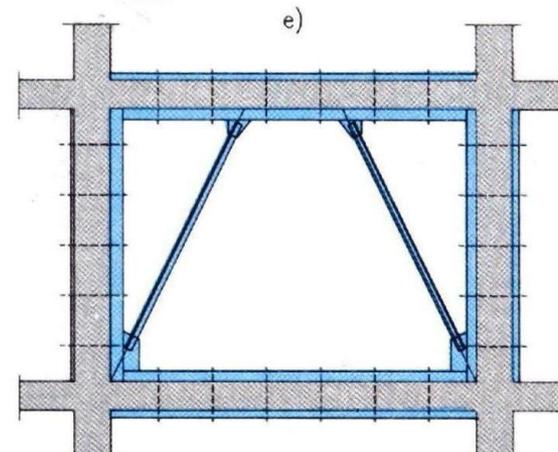
**Controvento a K**



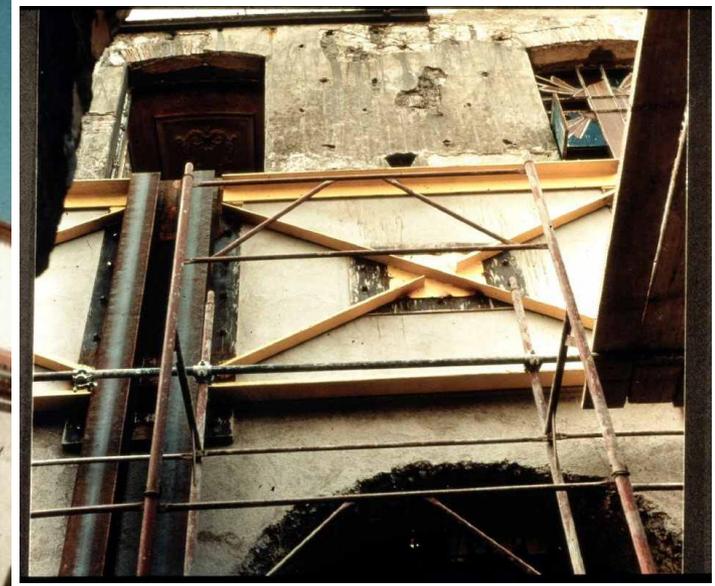
**Controventi con aperture**



**Controventi eccentrici**

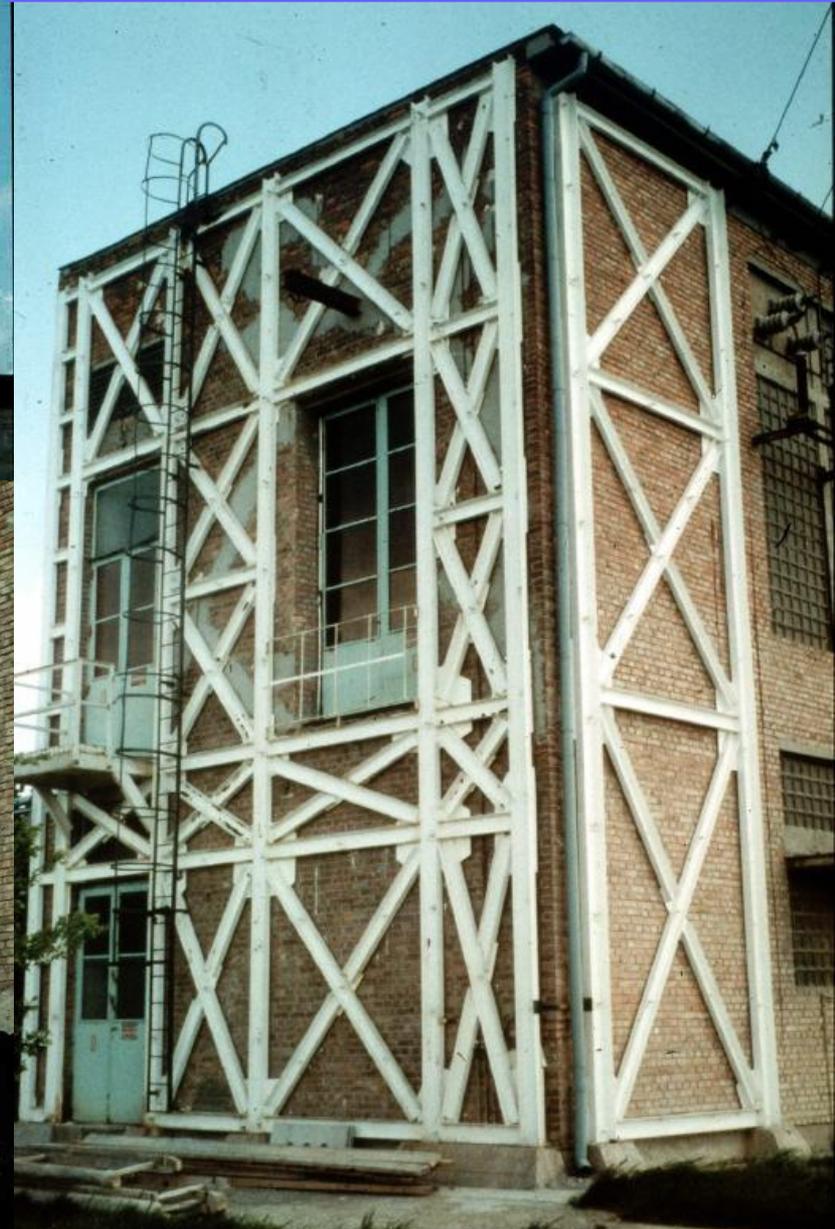
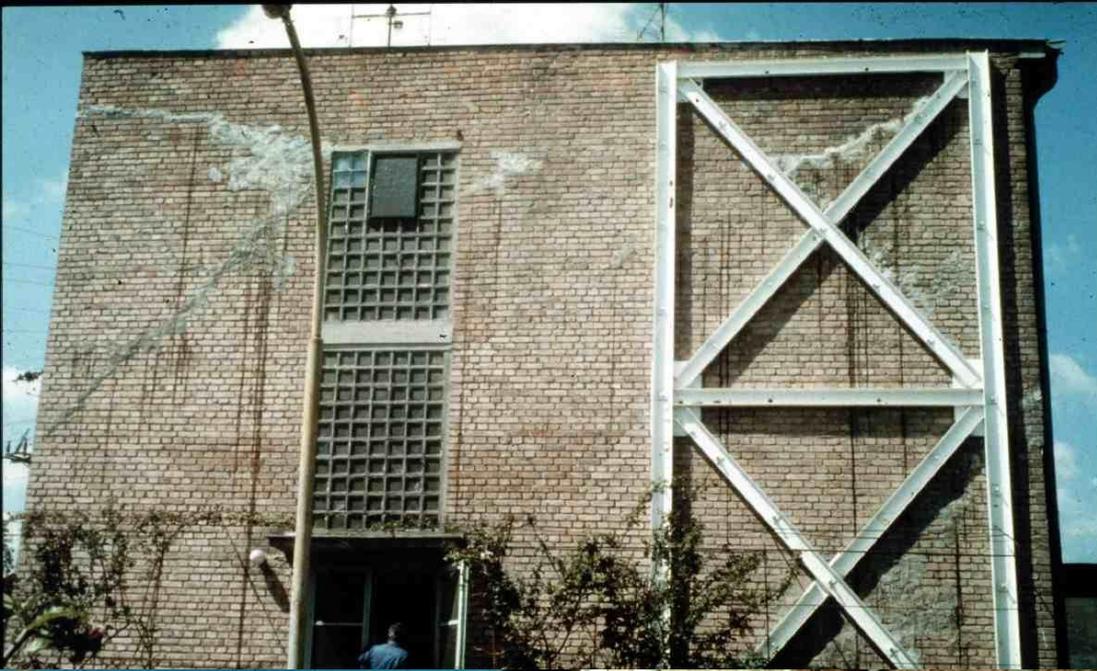


**Bracing systems for masonry structures**

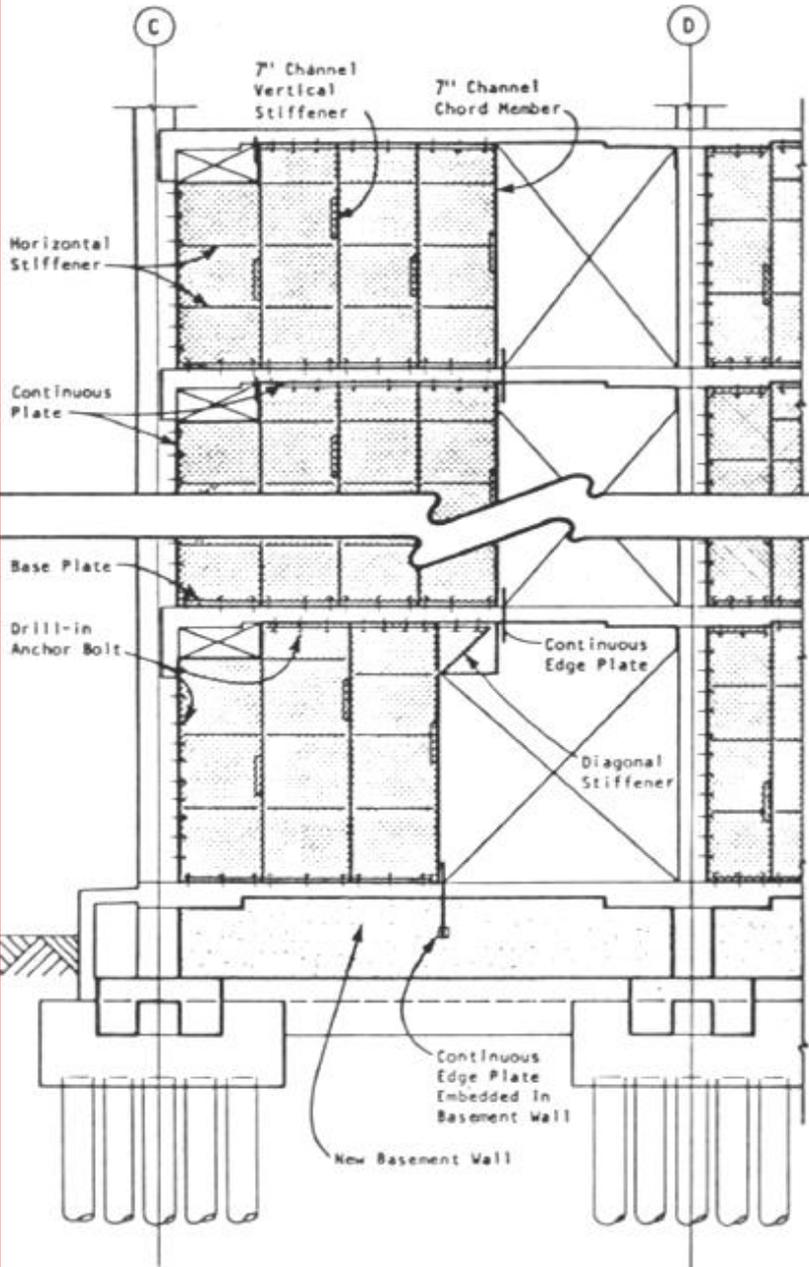


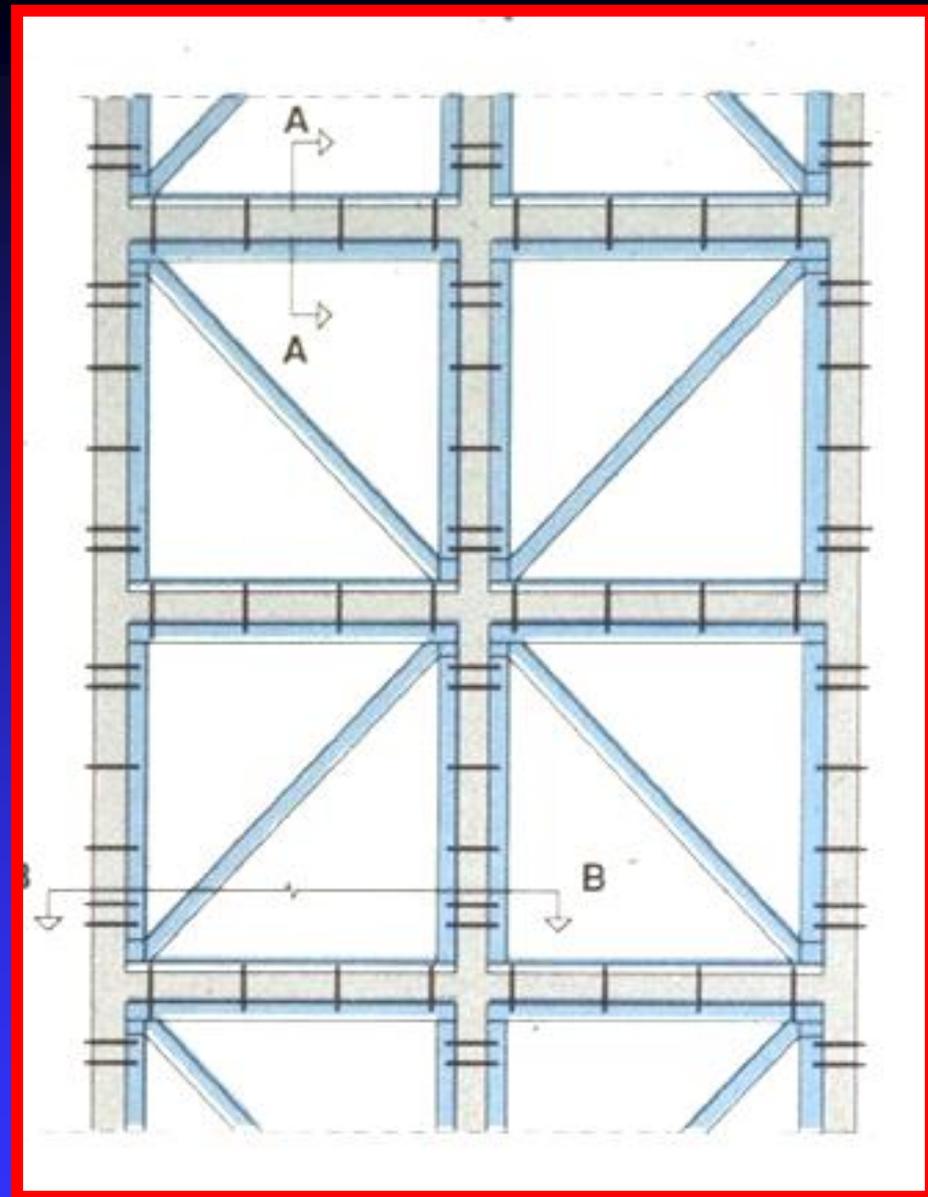
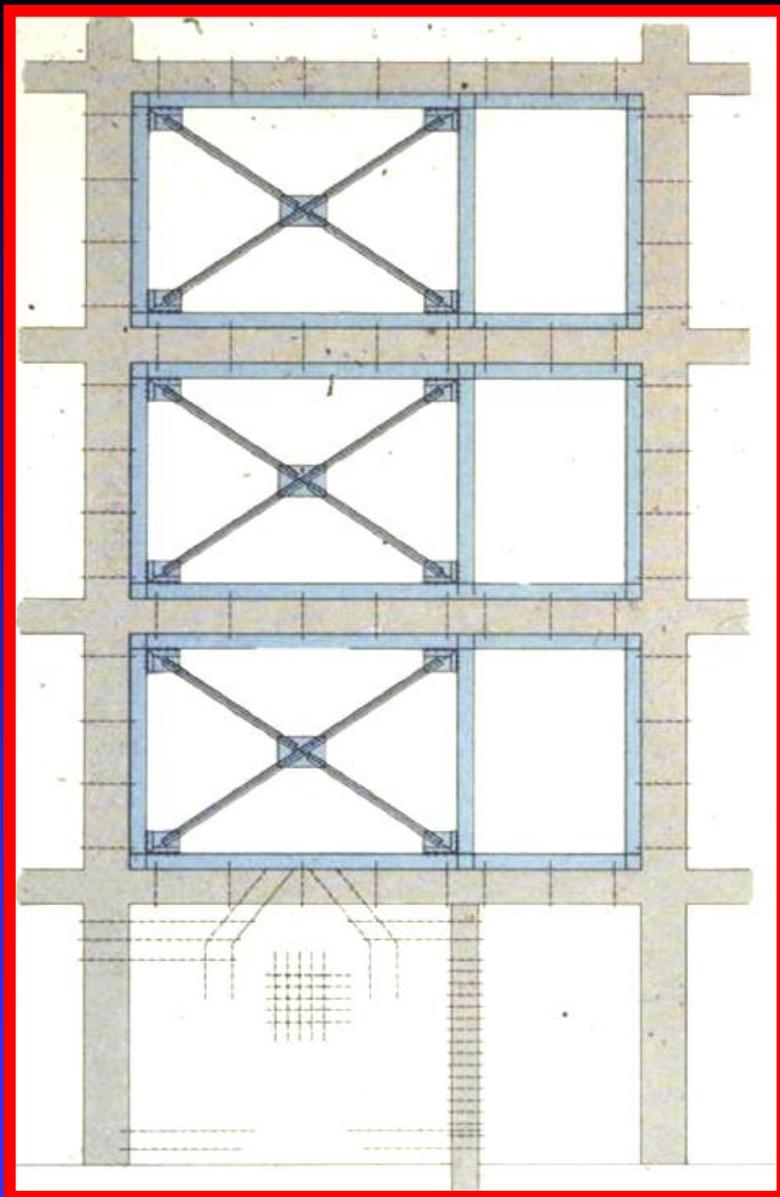
**Montemarano Church  
(Avellino, Italy)**

# Electrical power station (Hungary)



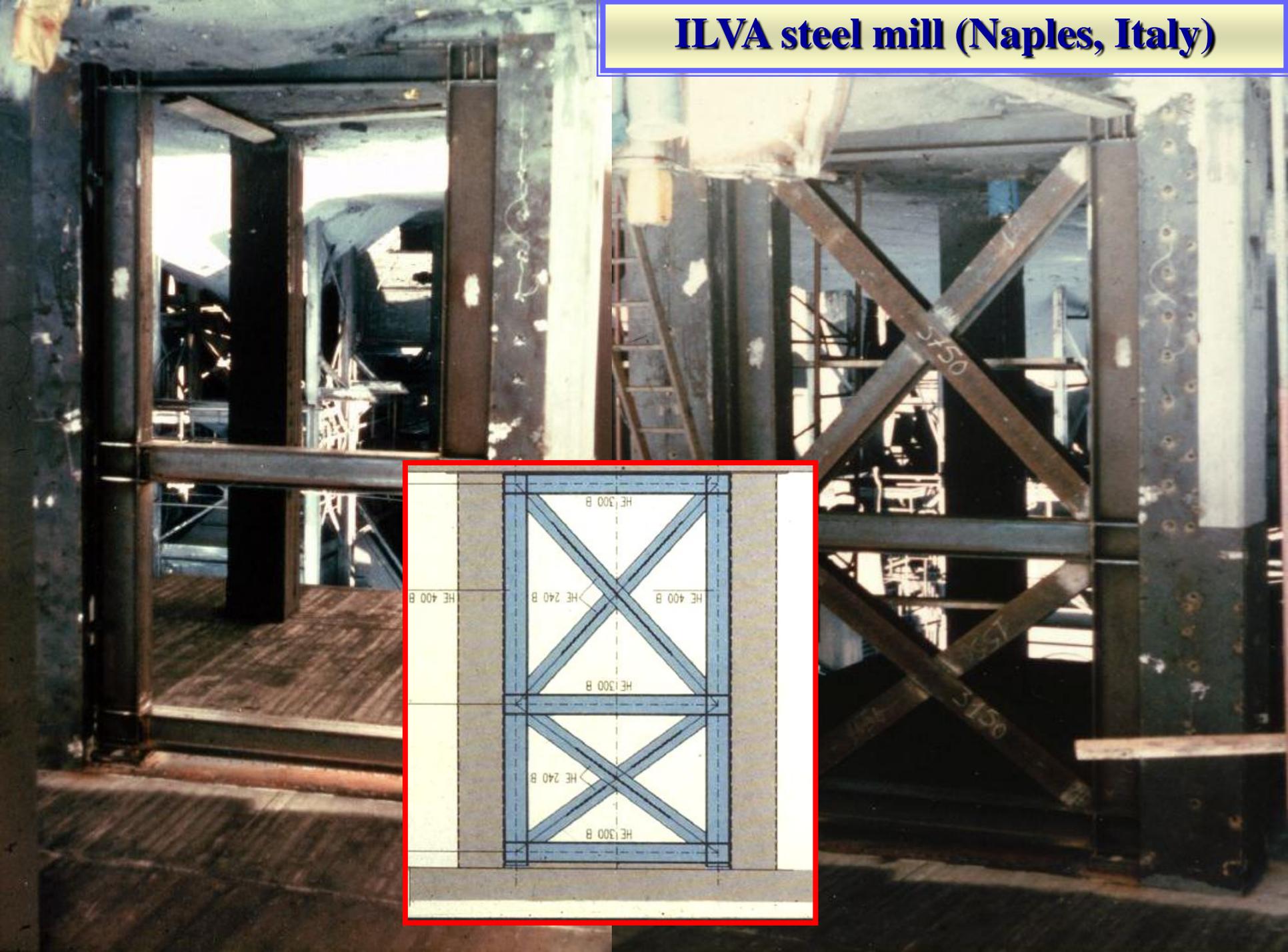
# Bracing panels

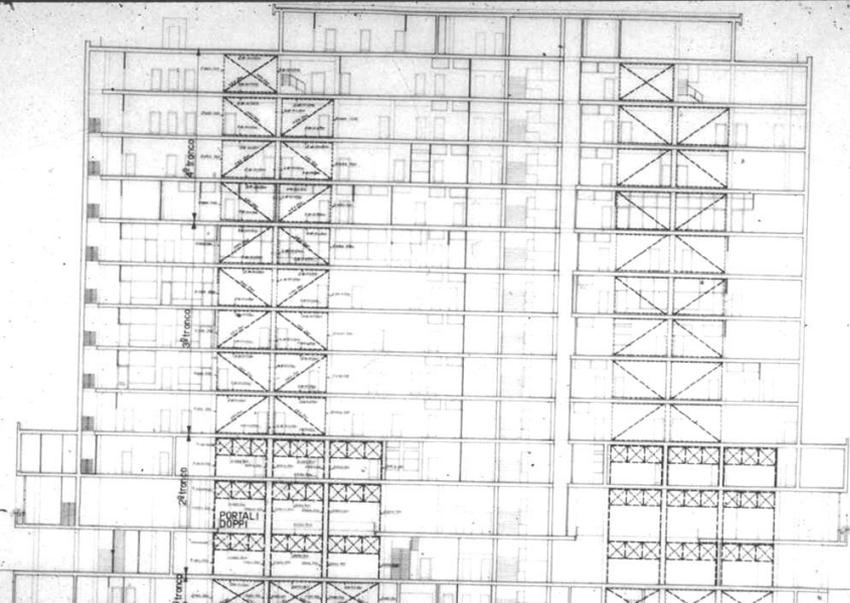
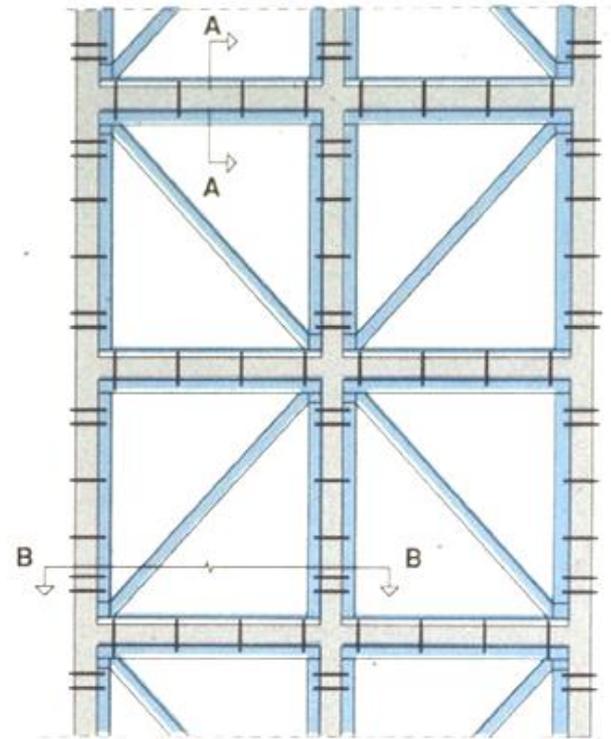




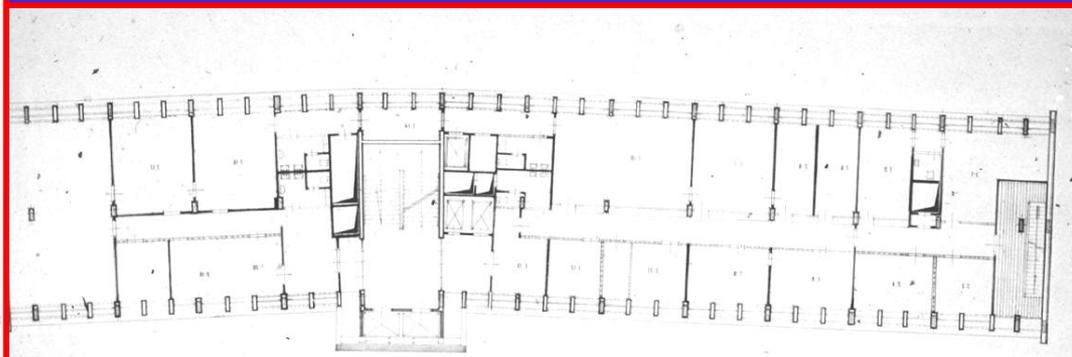
**Steel bracing schemes**

# ILVA steel mill (Naples, Italy)



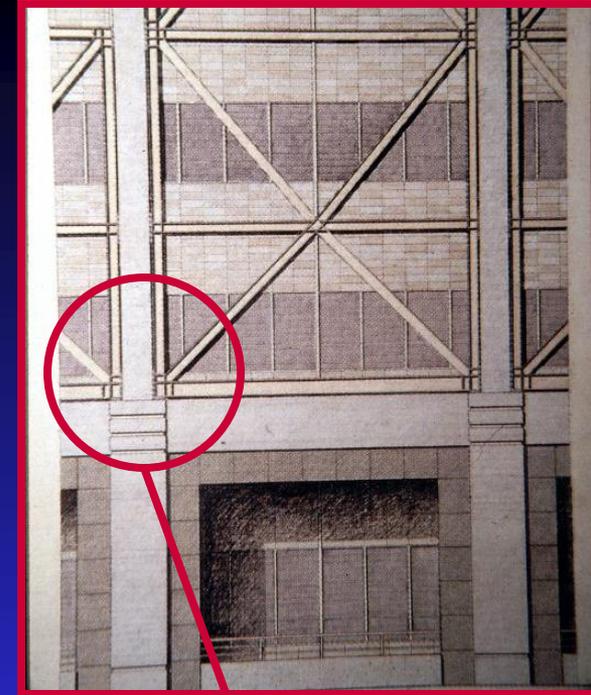


**Engineering Faculty (Naples, Italy)**

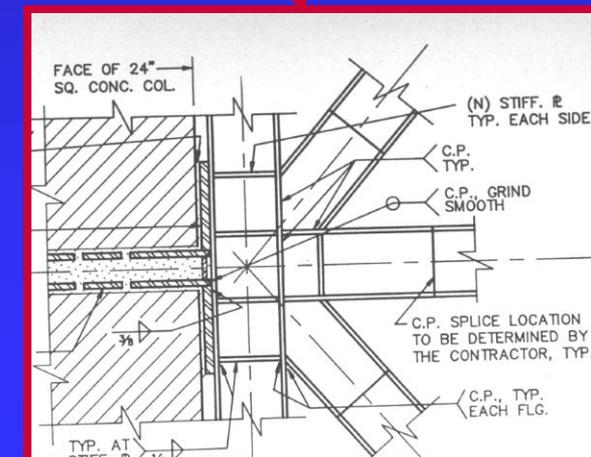


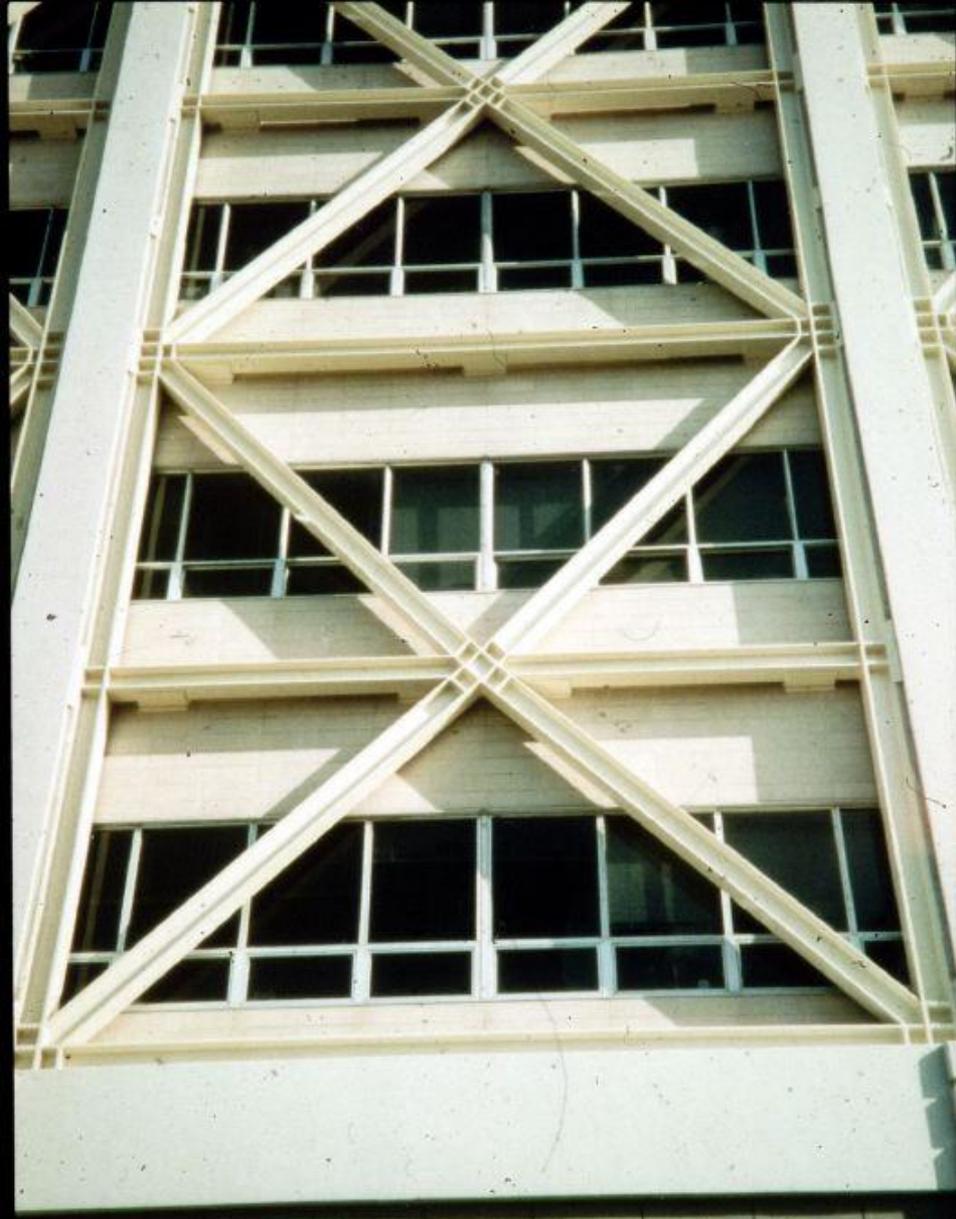
# Mexico City





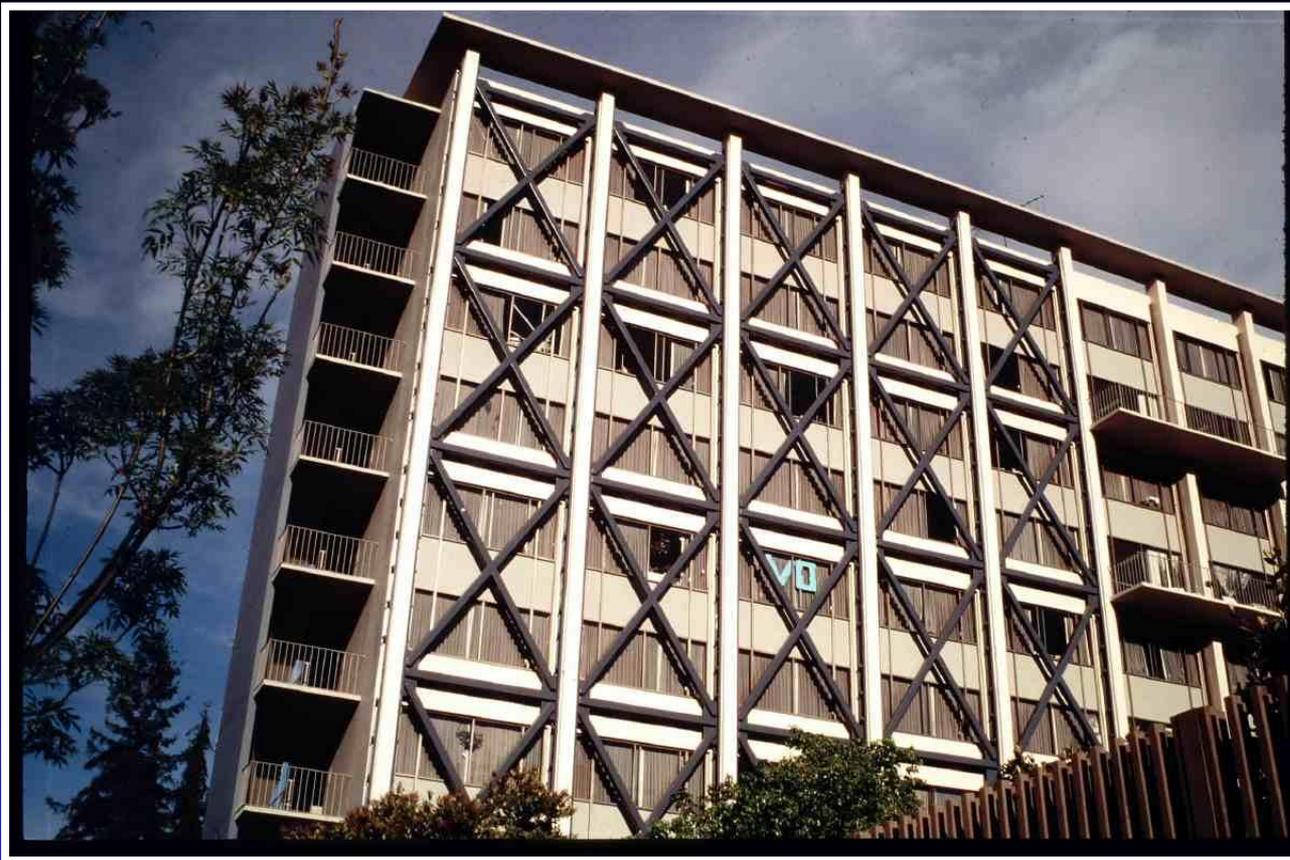
**University Hall  
(Berkeley, California)**



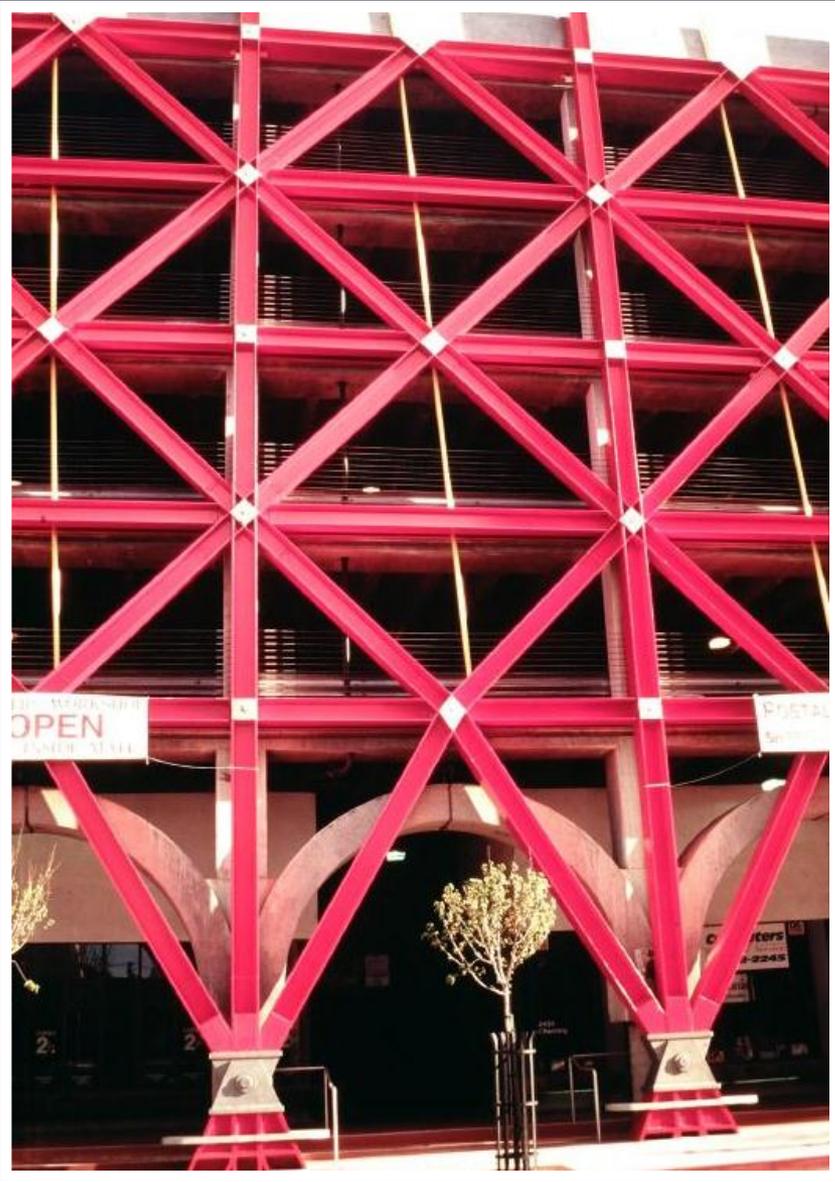


**University Hall  
(Berkeley, California)**

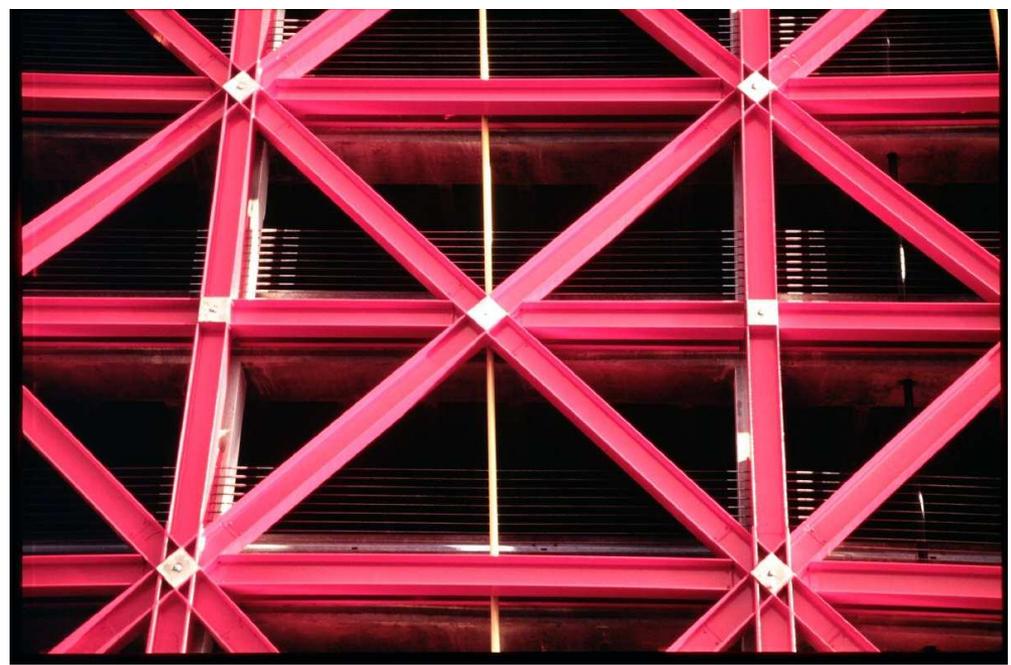


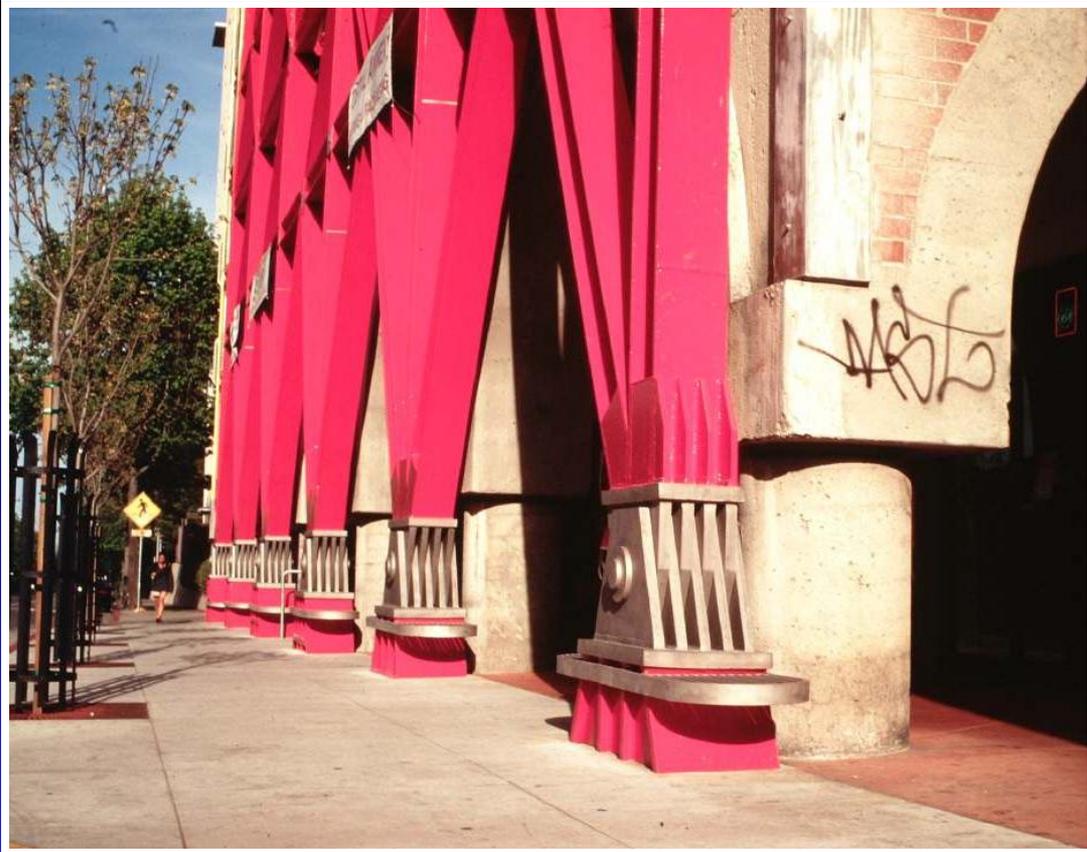


**Apartment building  
(Berkeley, California)**



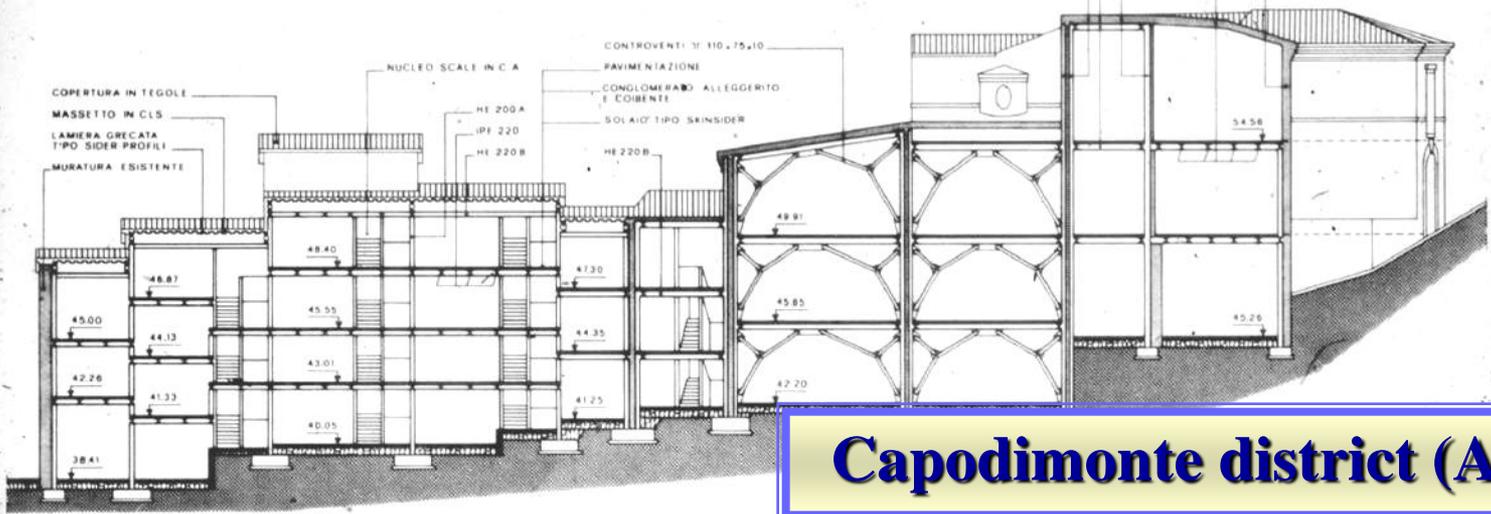
**Autolylos (Berkeley, California)**



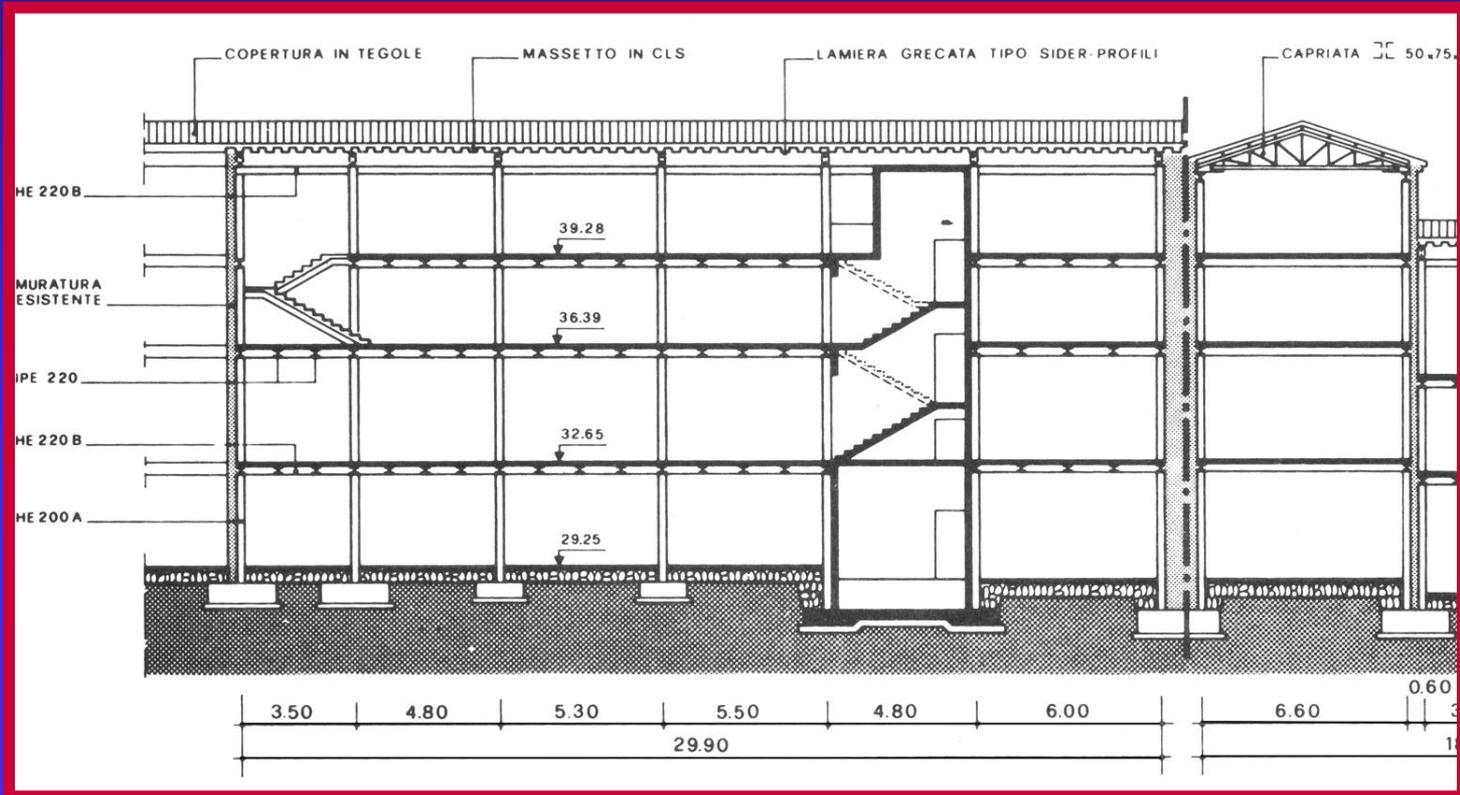


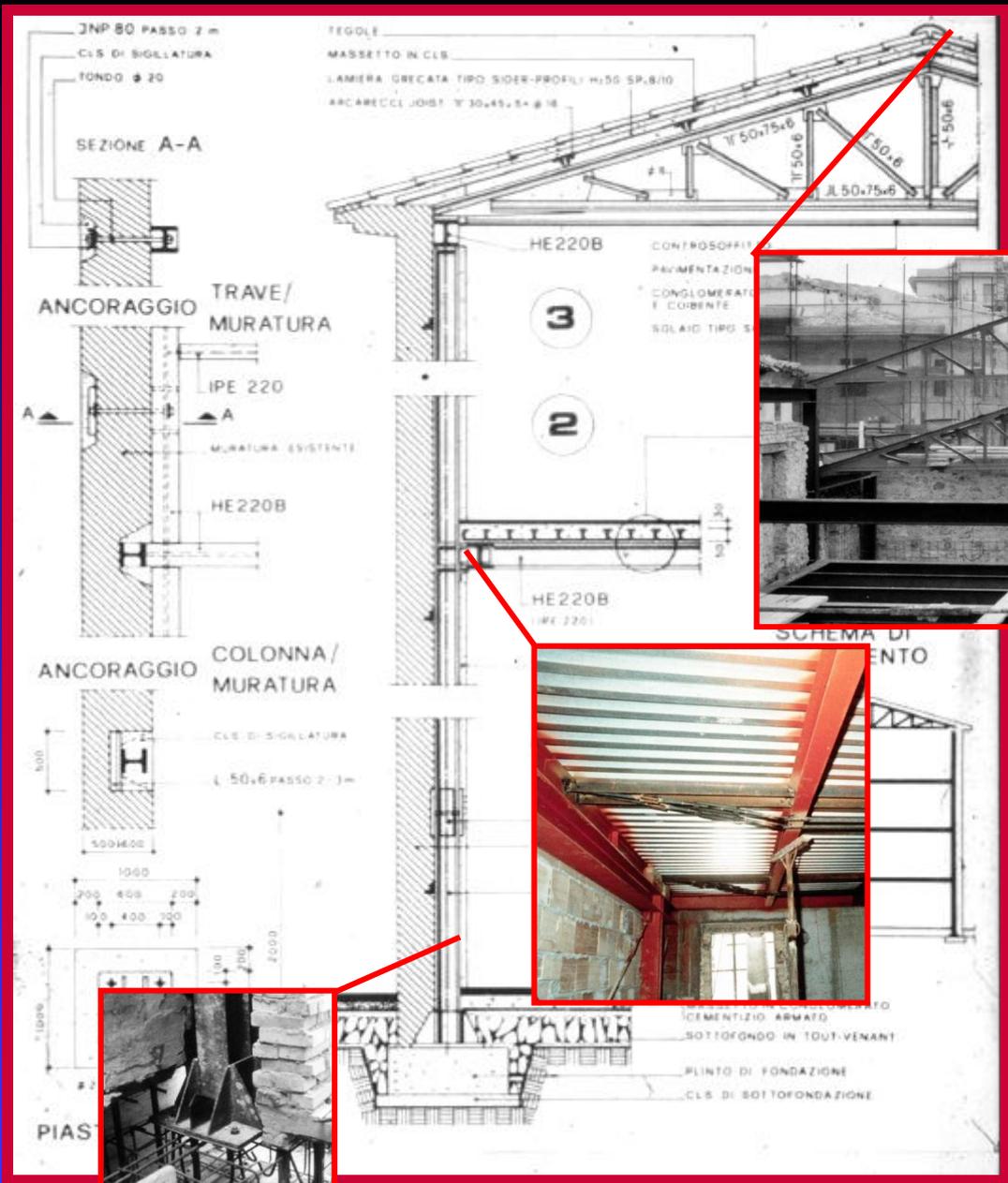
**Autosylos (Berkeley, California)**





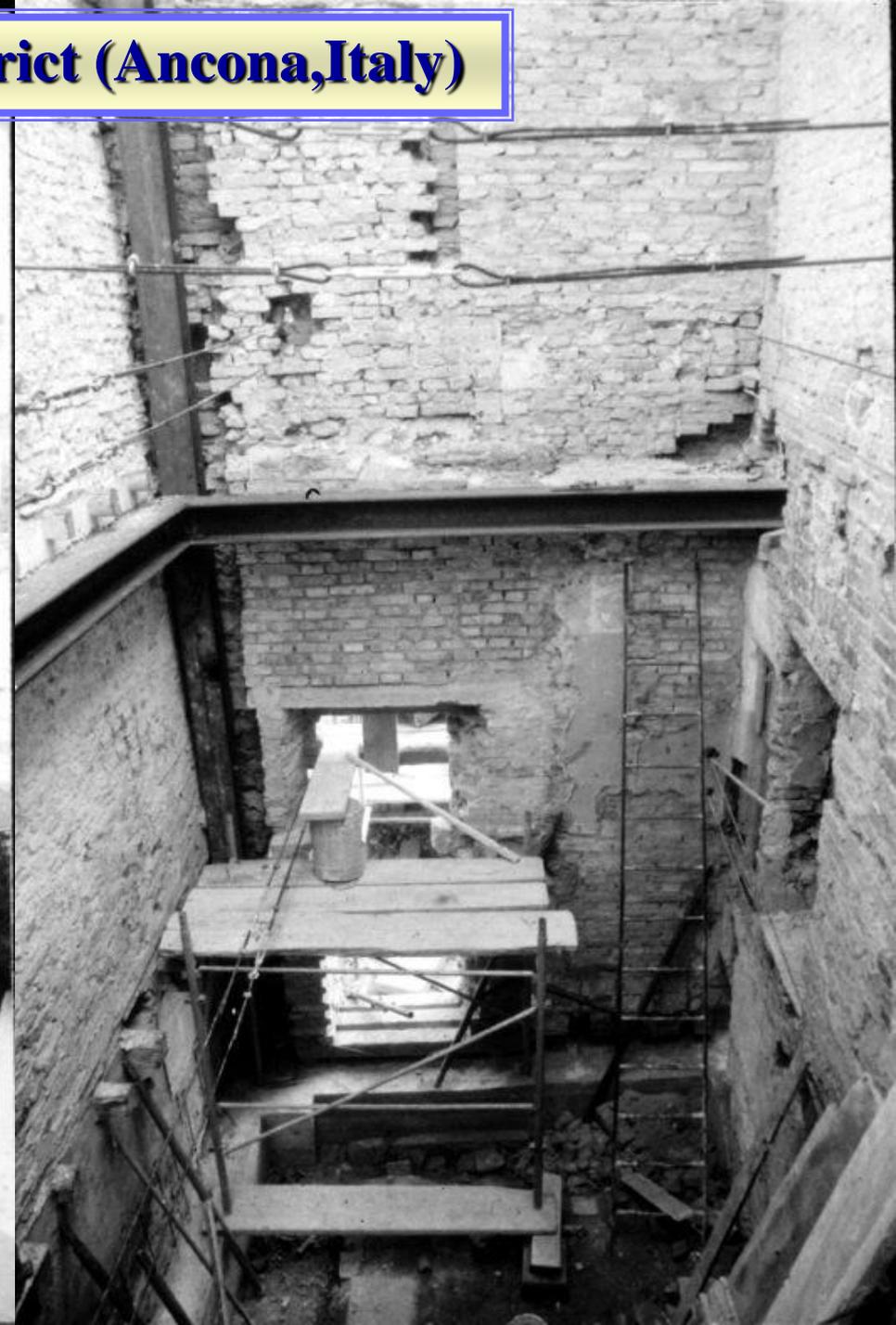
**Capodimonte district (Ancona, Italy)**



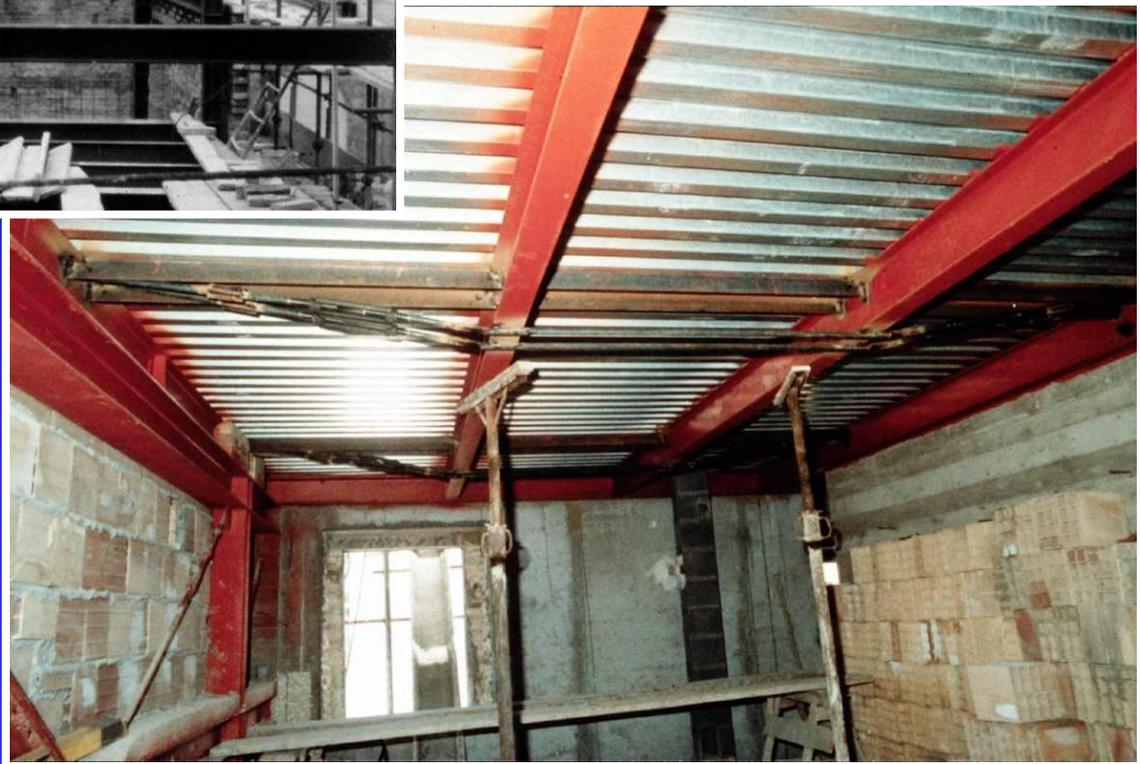


**Capodimonte district (Ancona, Italy)**

## Capodimonte district (Ancona, Italy)



# Capodimonte district (Ancona, Italy)





**Capodimonte district (Ancona, Italy)**

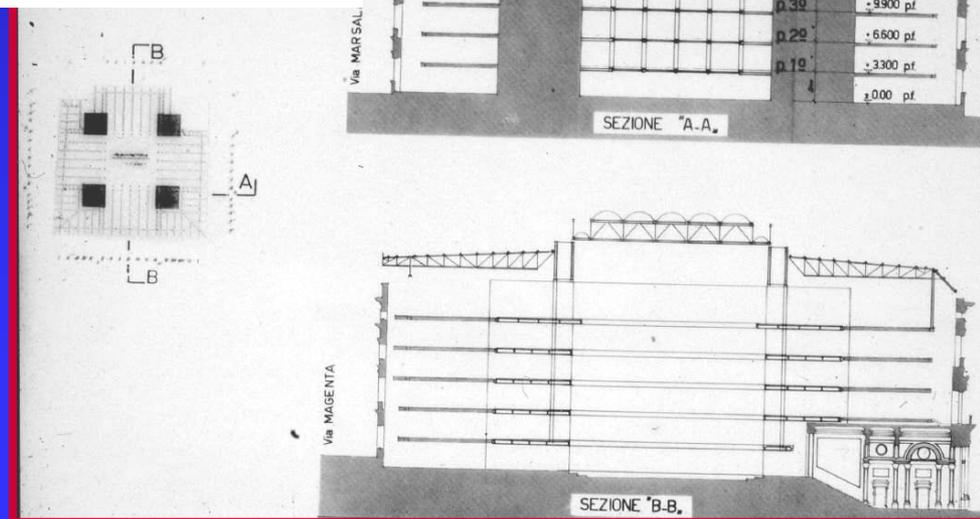
■ **Restructuring** = operation involving a drastic change of the original system due to the modification of the functional lay-out with new volumes and new areas



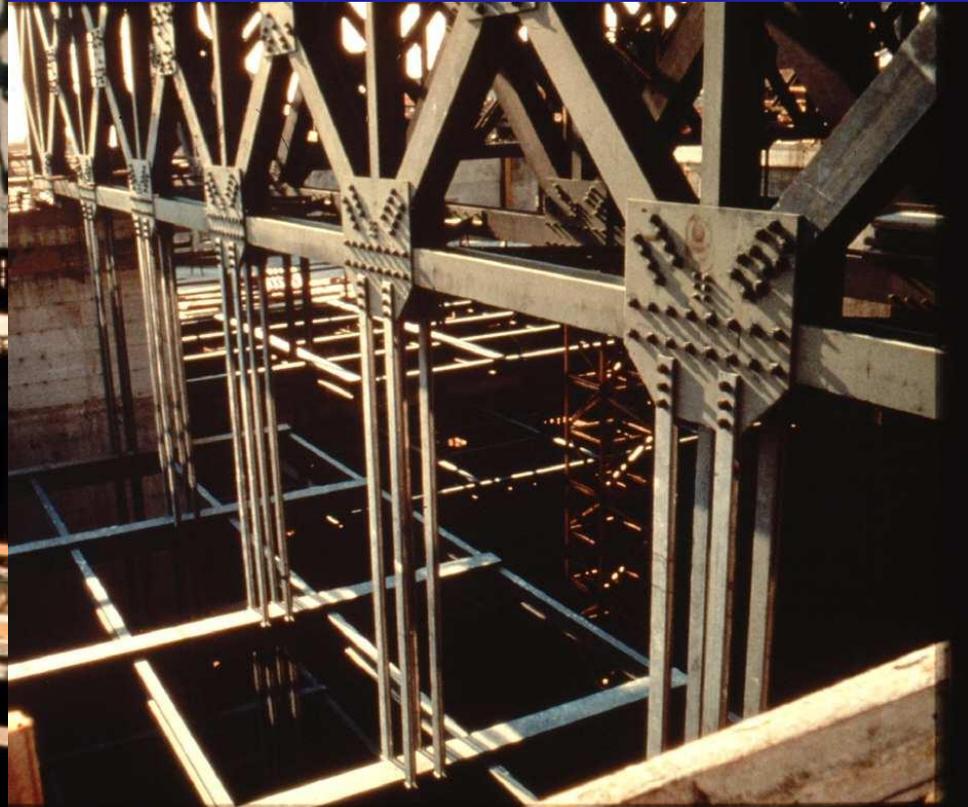
**Law Court Palace of Ancona (I)**

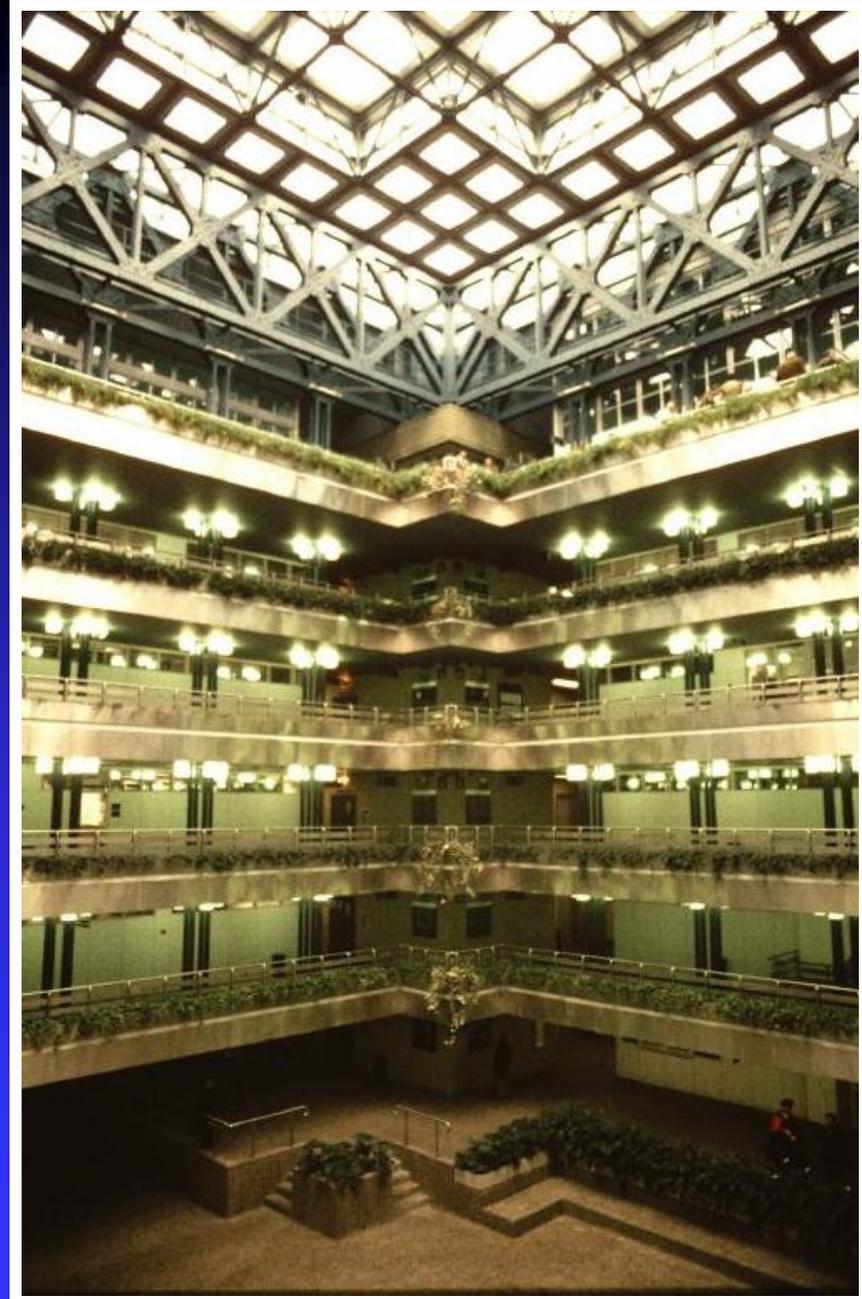


# Law Court Palace of Ancona (I)

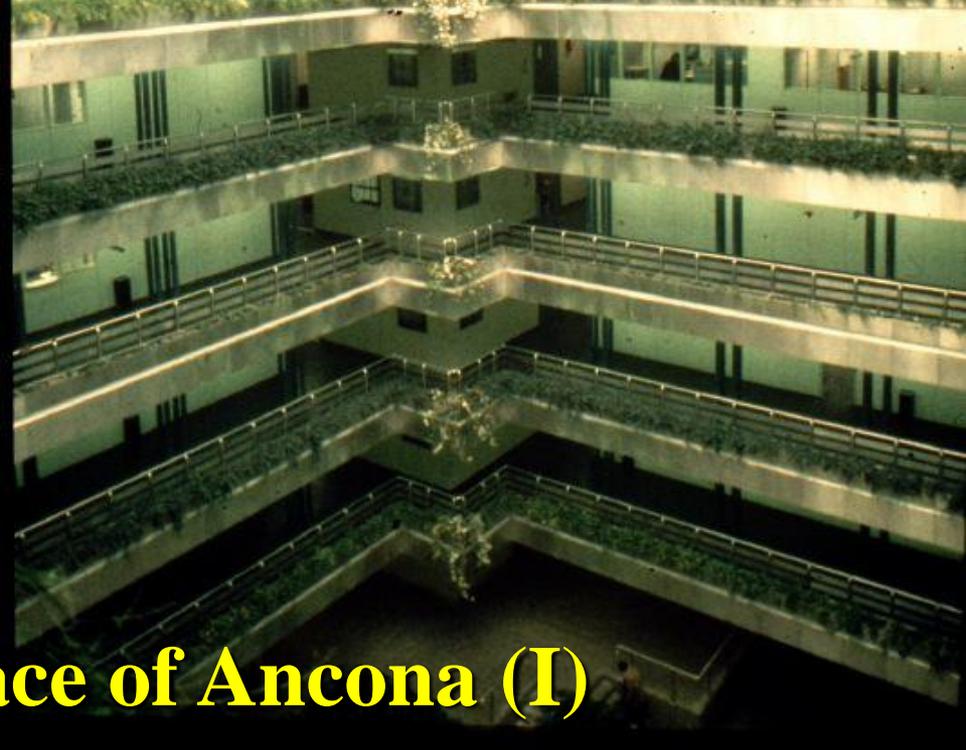
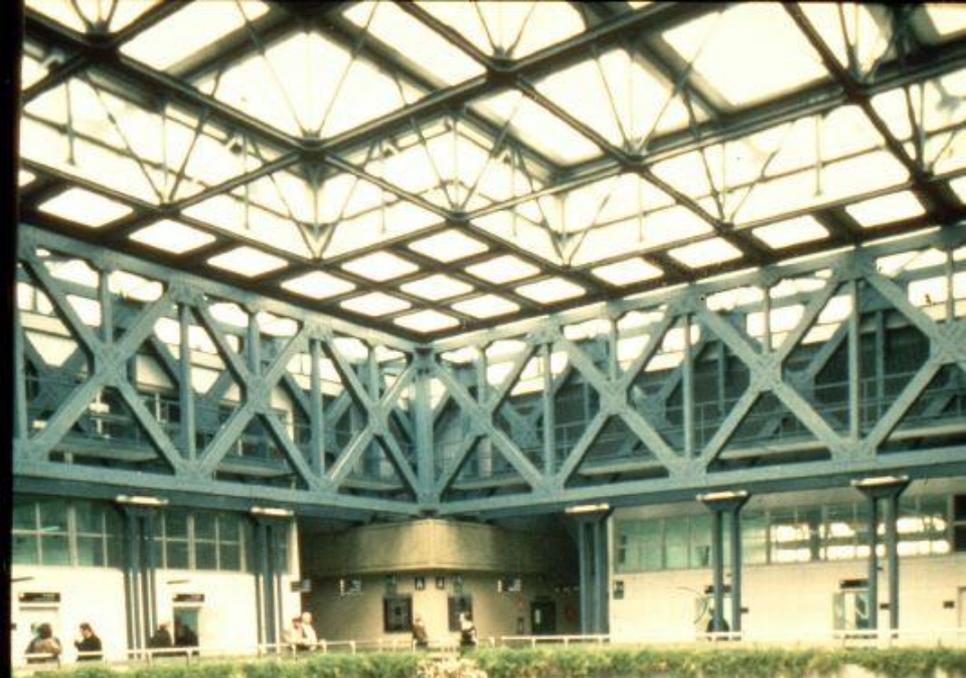


# Law Court Palace of Ancona (I)





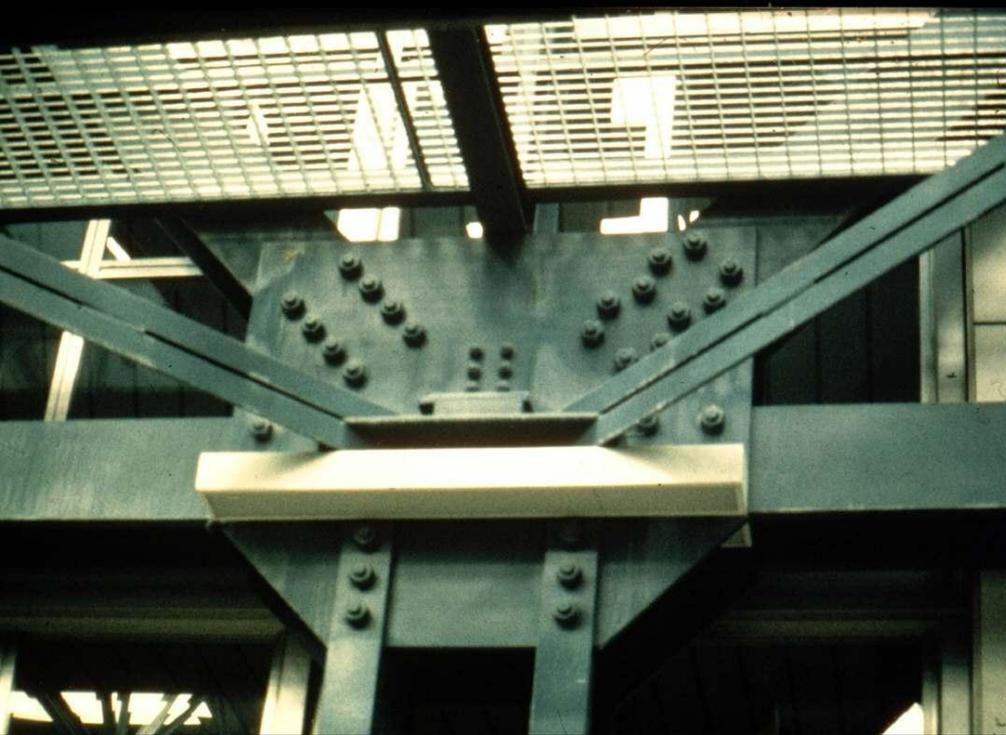
**Law Court Palace of Ancona (I)**



**Law Court Palace of Ancona (I)**



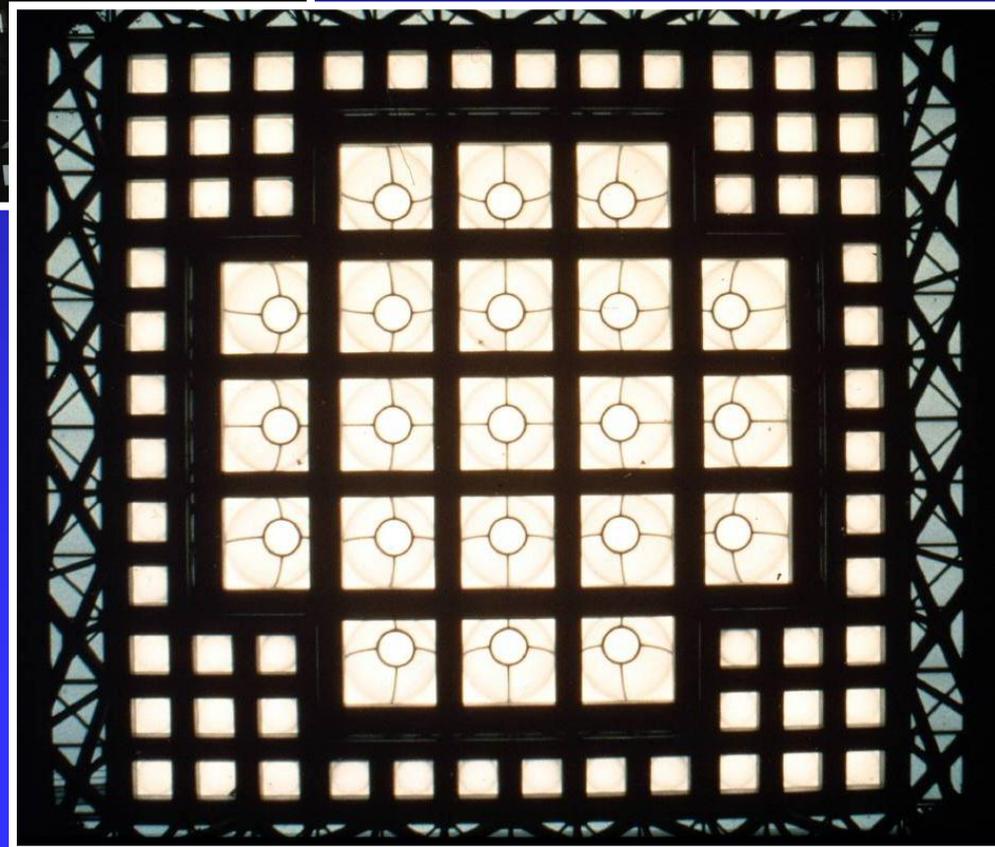
**Law Court Palace of Ancona (I)**



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# Law Court Palace of Ancona (I)



# Law Court Palace of Ancona (I)





**Law Court Palace of Ancona (I)**

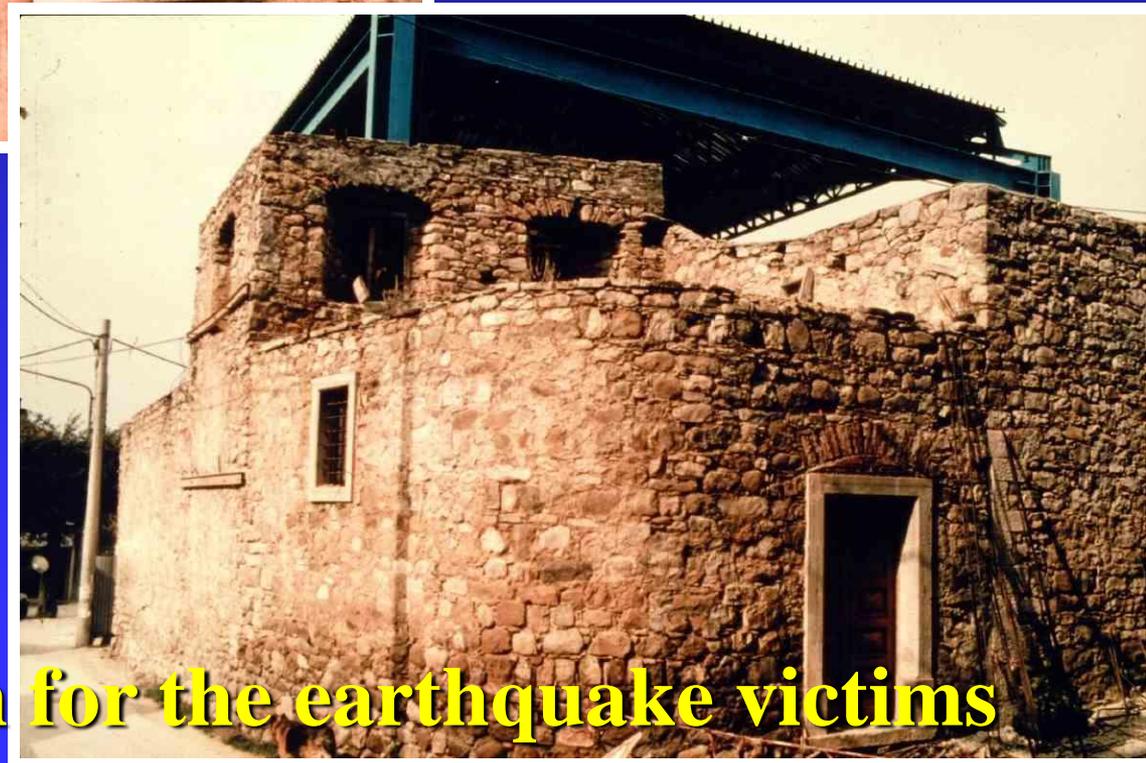


**San Rocco Church in Morra de Sanctis (I)**

# San Rocco Church in Morra de Sanctis



MINISTERO PER I BENI CULTURALI E AMBIENTALI  
SOPRINTENDENZA S.A.A.S. DI SALERNO E AVELLINO  
OPERE a CARICO del PROV. alla DD.PP. della CAMPANIA  
**LAVORI DI RICOSTRUZIONE DEL  
SACRARIO DI S. ROCCO**  
D.P.M. N. 26123 DEL 15-10-86  
SOPRINTENDENZA S.A.A.S. DI SA-UV.  
PROGETTO ARCH. G. RUSSO  
STRUTTURE PROF. ING. P. MALLAMORE  
DIR. LAVORI OFF. TECNICO SOPRINTENDENZA S.A.A.S. - SA-UV.  
IMPRESA S. L. E. S. - NAPOLI



**The Sacrarium for the earthquake victims**



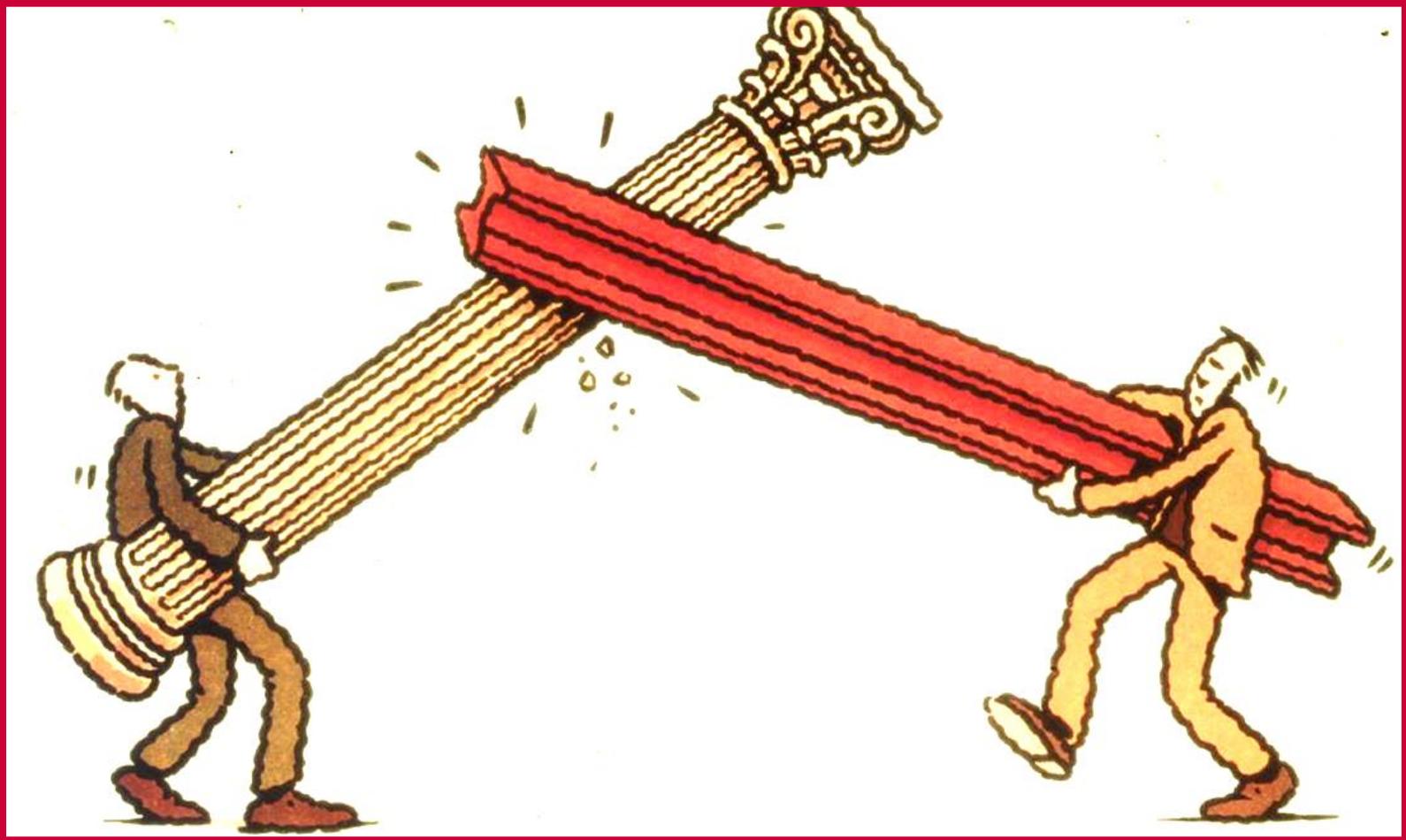
**San Rocco Church  
in Morra de Sanctis**

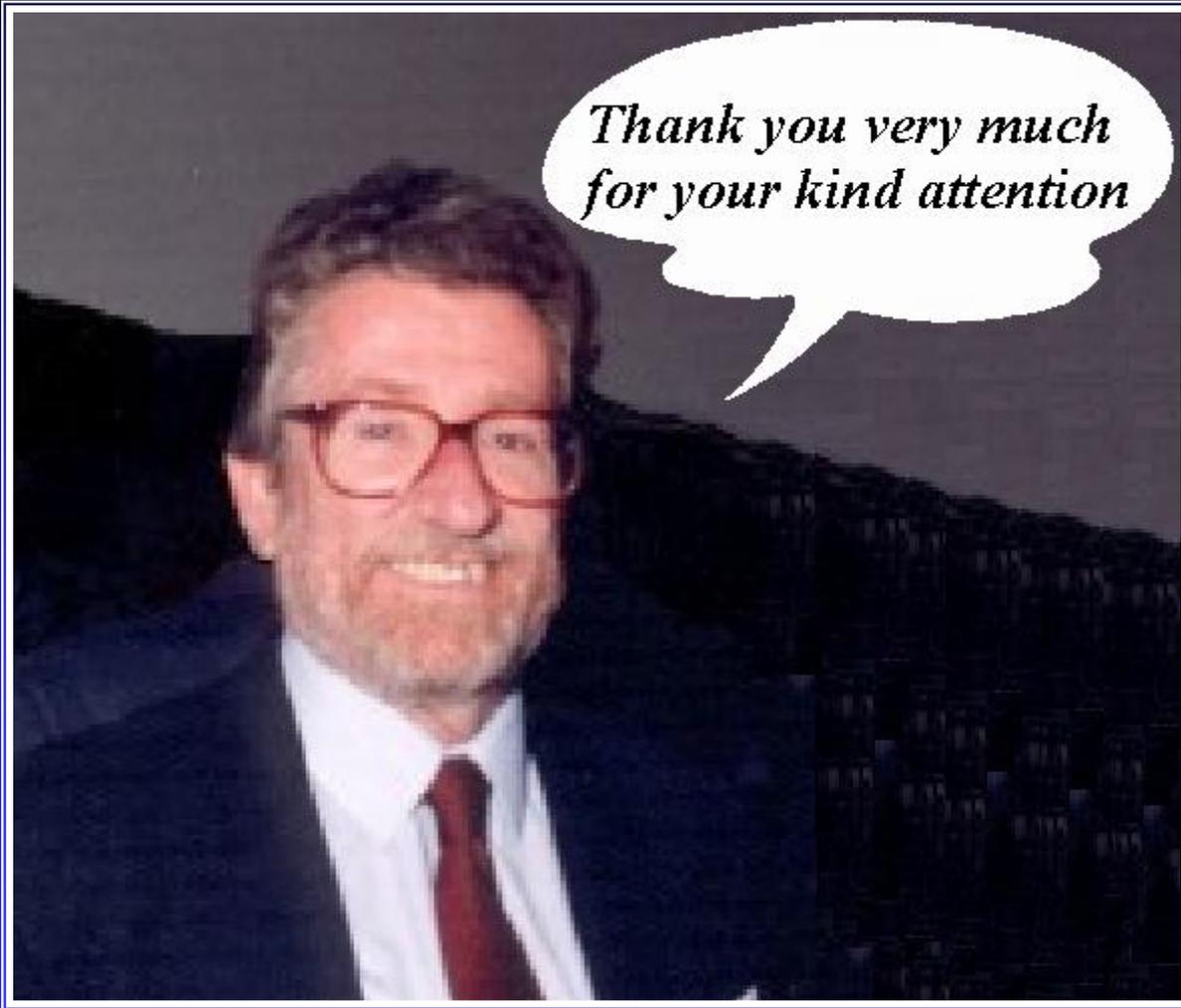
# Matrix for mutual co-operation among materials

## NEW COMPOSITE MATERIALS

		MATERIALS FOR CONSOLIDATION				
		STEEL	CONCRETE	MASONRY	WOOD	FRP
DAMAGED STRUCTURES	STEEL	★				★
	CONCRETE	★	★			★
	MASONRY	★	★	★	★	★
	WOOD	★			★	★

# COMPETITION AMONG MATERIALS





*Thank you very much  
for your kind attention*