



**Ordine degli Ingegneri
della Provincia di Macerata**
Commissione Strutture e Geotecnica

Evento organizzato con il contributo incondizionato di:

Leca
soluzioni leggere e isolanti
Laterlite

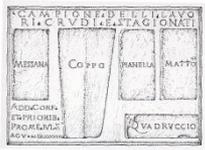

RUREGOLD
INNOVATION & SAFETY FOR BUILDINGS

SEMINARIO DI AGGIORNAMENTO PROFESSIONALE

CONSOLIDAMENTO DI EDIFICI ESISTENTI

- Elementi di meccanica delle murature e di archi e volte per la valutazione del comportamento statico e della risposta sismica degli edifici storici in riferimento al quadro normativo*
- Rilievo critico e restituzione grafica dell'organismo edilizio*
- Lettura e interpretazione dei quadri fessurativi*
- Meccanismi locali e comportamento globale per la valutazione della vulnerabilità sismica ai sensi delle NTC2018*

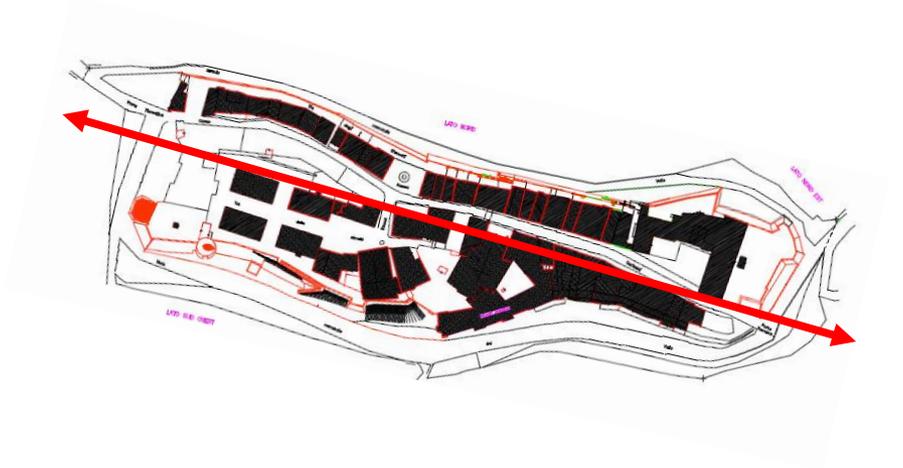
Ing. Giovanni Cangì – libero professionista



Terremoto di Citerna-Monterchi (26 aprile 1917)



Monterchi (AR)

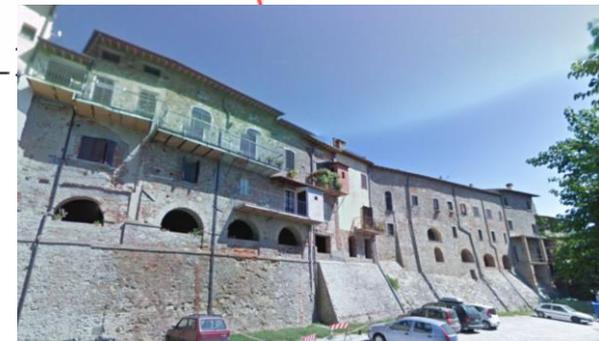
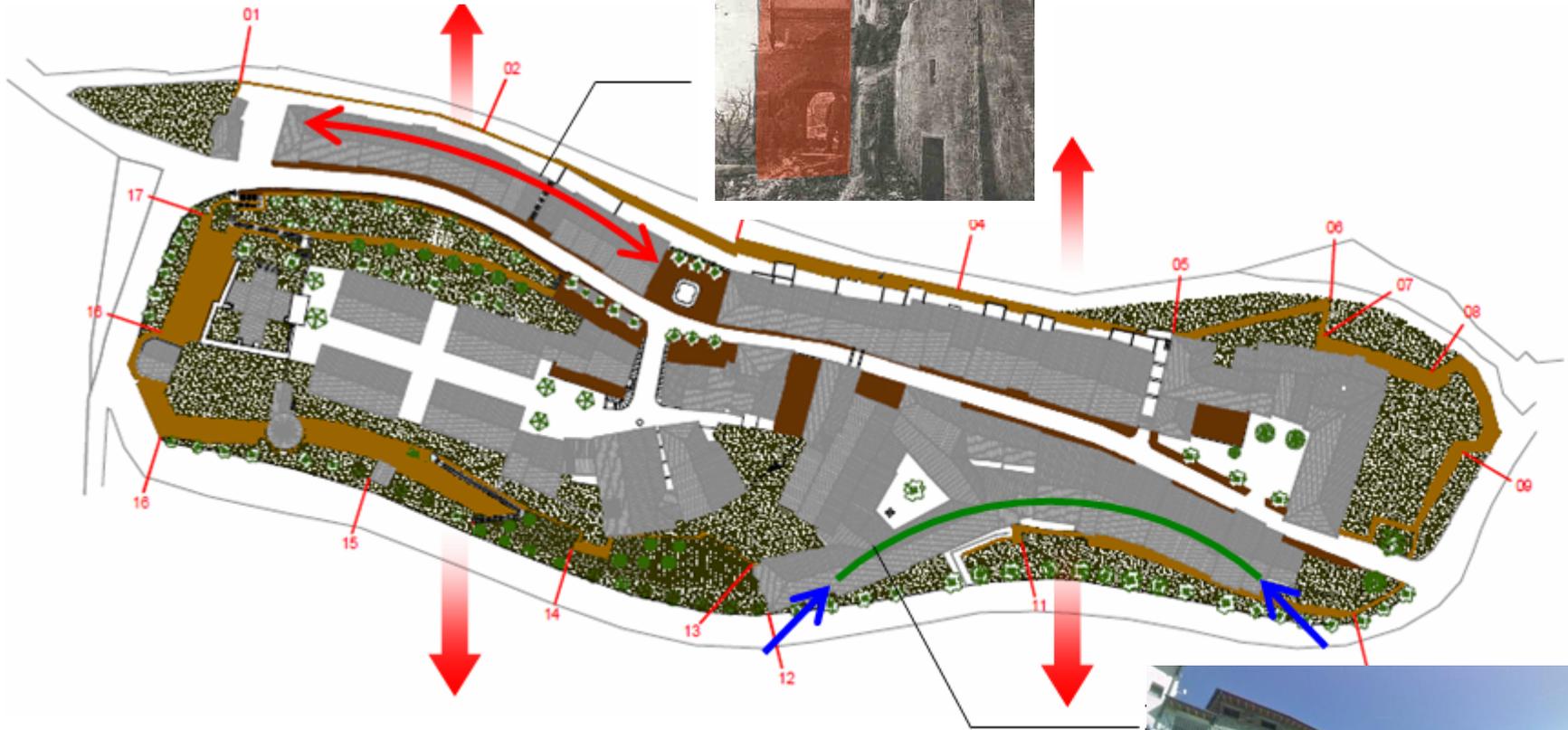


Citerna (PG)

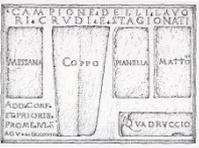
Borghi collinari a sviluppo circolare e lineare

Vulnerabilità sismica alla scala urbana

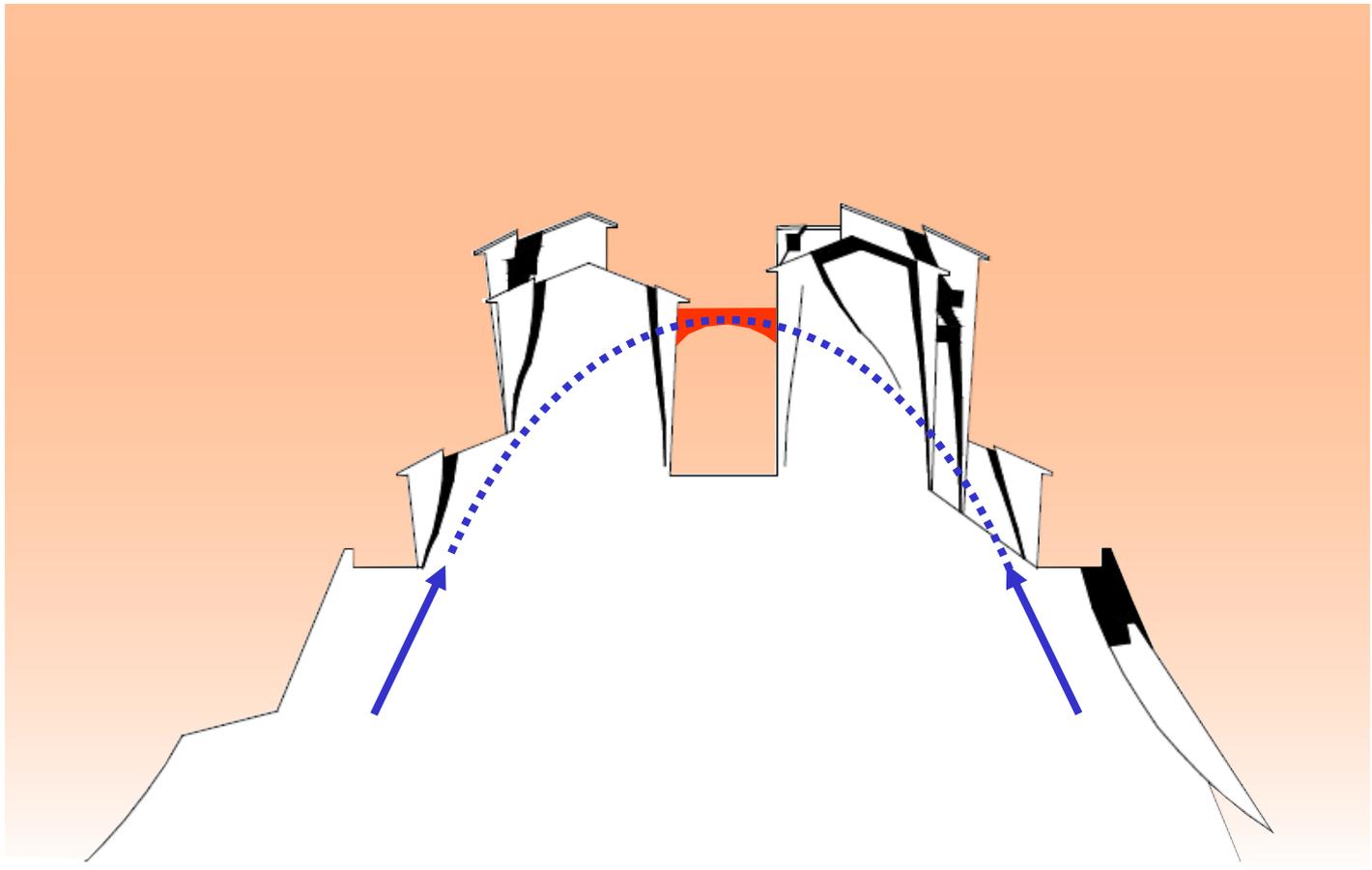
Citerna (PG), 26 aprile 1917

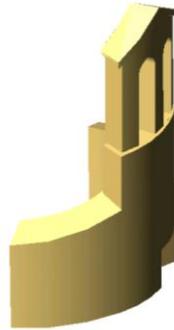
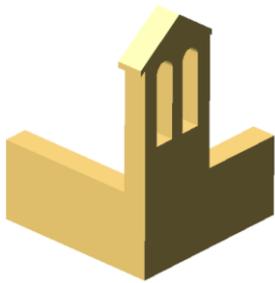
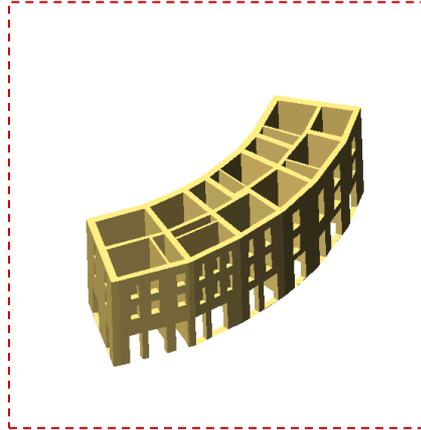
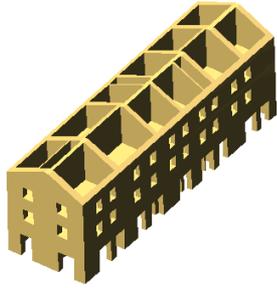
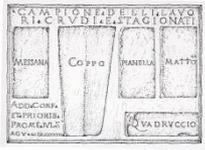


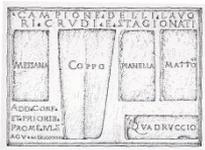




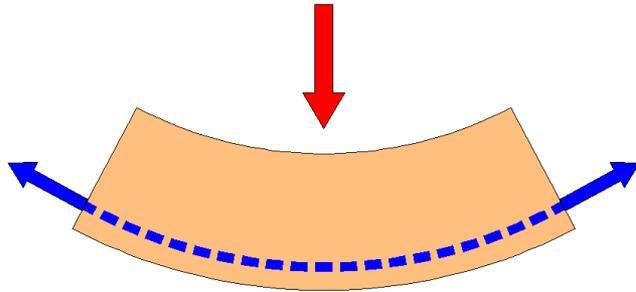
Meccanismi resistenti alla scala urbana



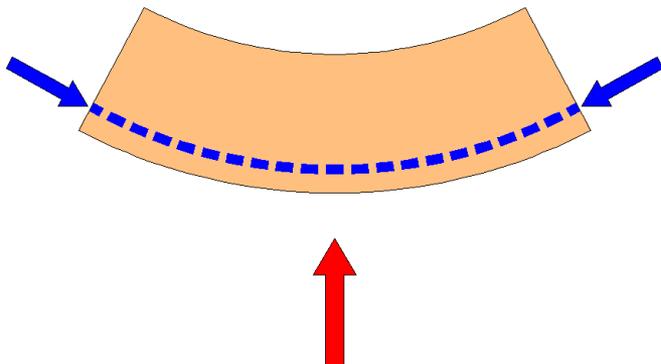




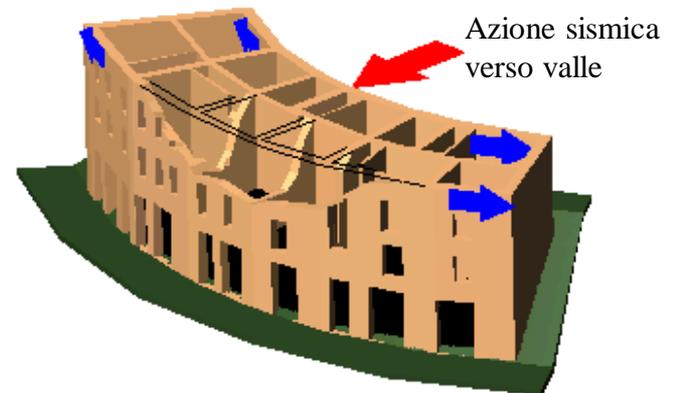
Effetti del sisma ortogonale negli isolati ad impianto curvilineo



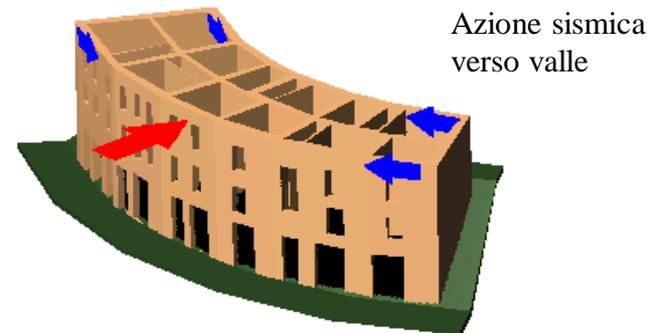
L'azione sismica verso valle mette in trazione la parete di facciata ((Allentamento parete di valle)



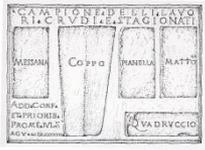
L'azione sismica verso monte comprime le pareti di facciata (Effetto arco)



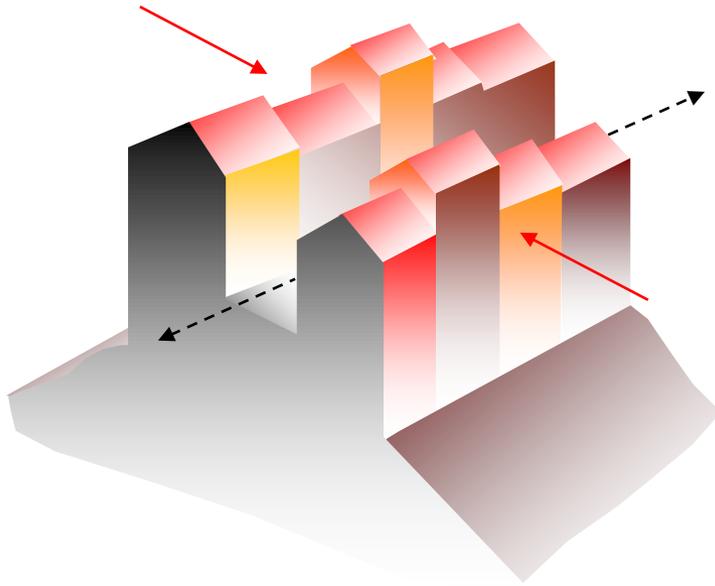
Azione sismica verso valle

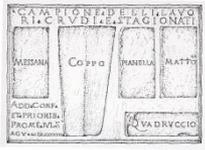


Azione sismica verso monte

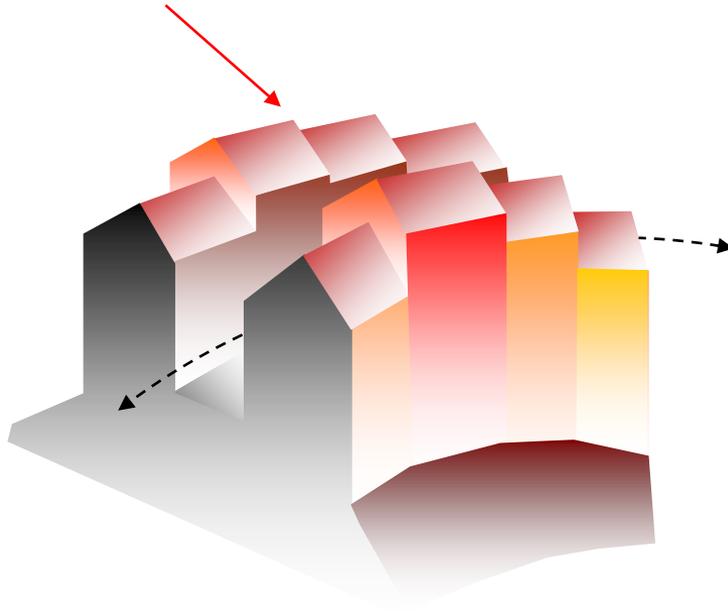


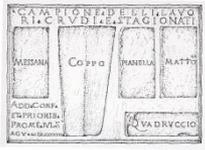
Valutazione del rischio sismico alla scala urbana



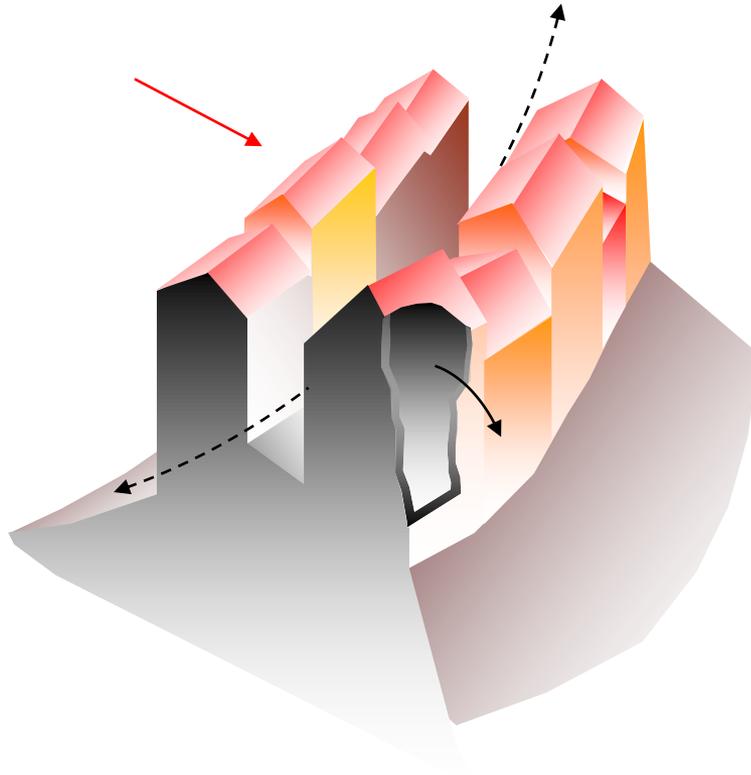


Valutazione del rischio sismico alla scala urbana





Valutazione del rischio sismico alla scala urbana

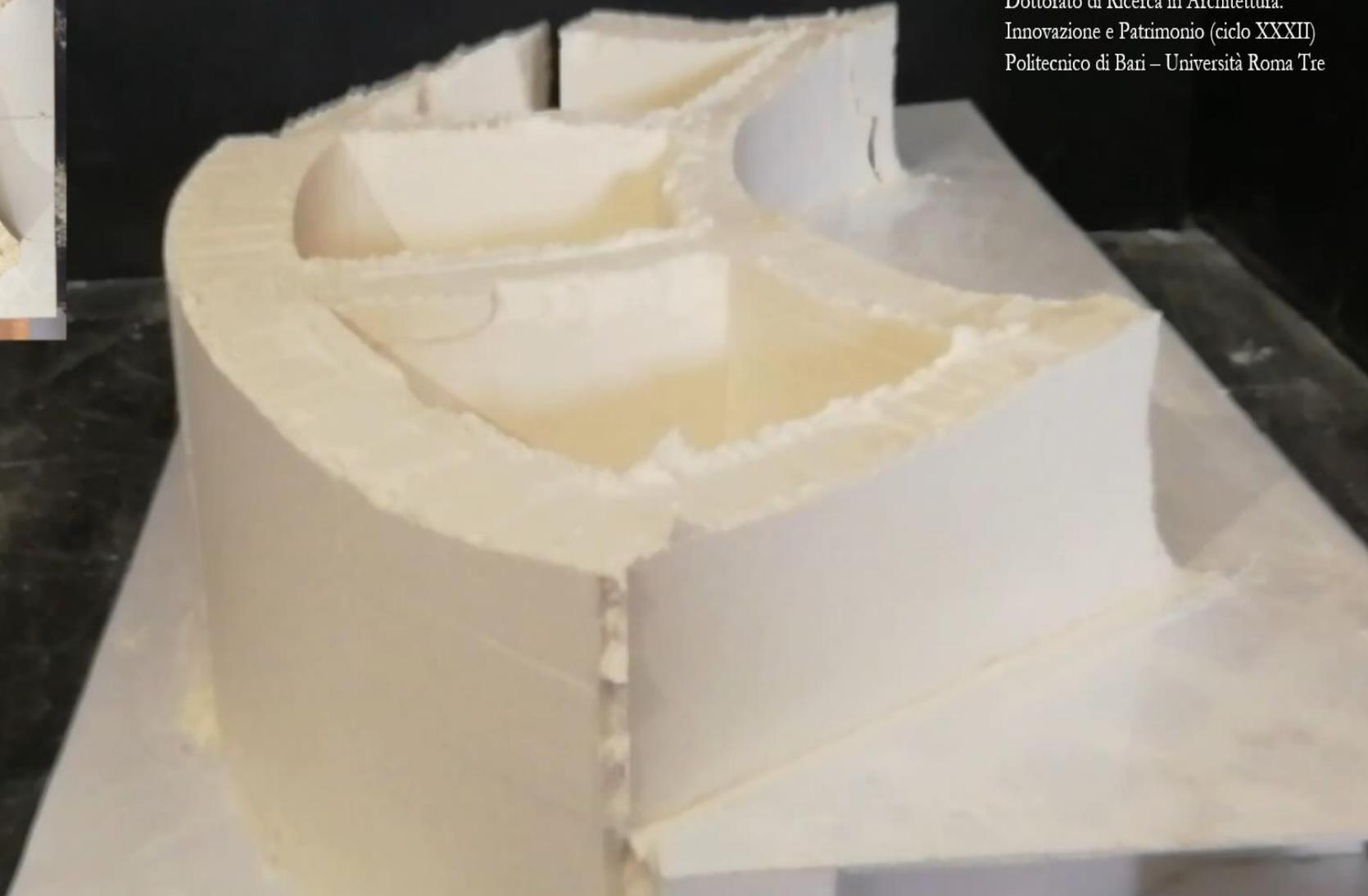




Gabriele Ajò con Giovanni Cangi

presso Polo Tecnico 'Franchetti Salviani' -
Città di Castello

Dottorato di Ricerca in Architettura:
Innovazione e Patrimonio (ciclo XXXII)
Politecnico di Bari – Università Roma Tre



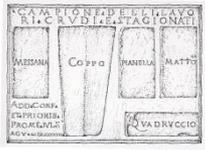


Gabriele Ajò con Giovanni Cangi

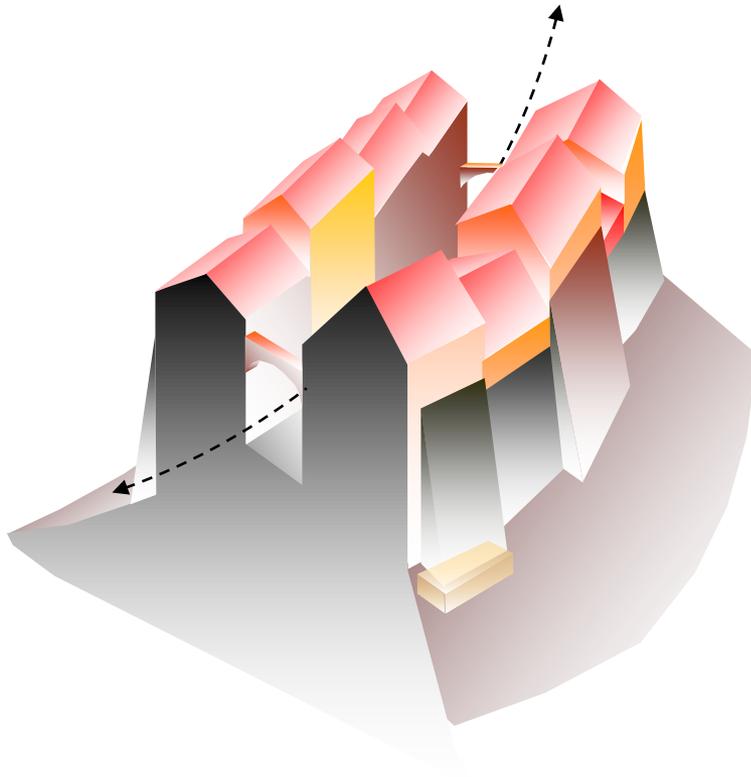
presso Polo Tecnico 'Franchetti Salviani' -
Città di Castello

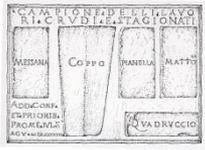
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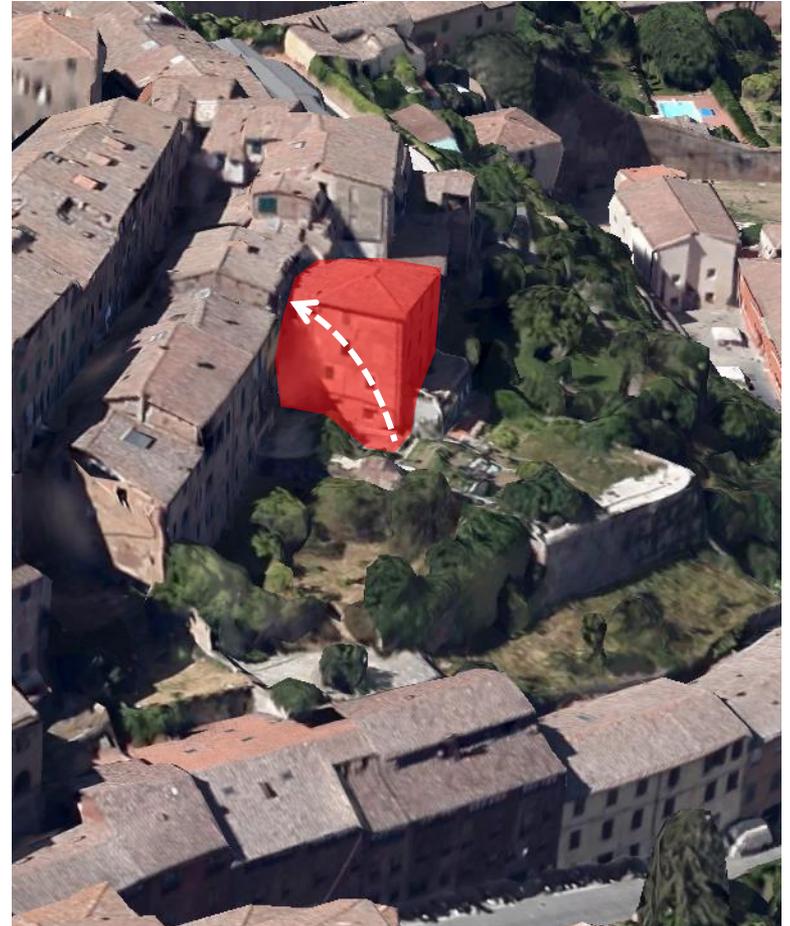
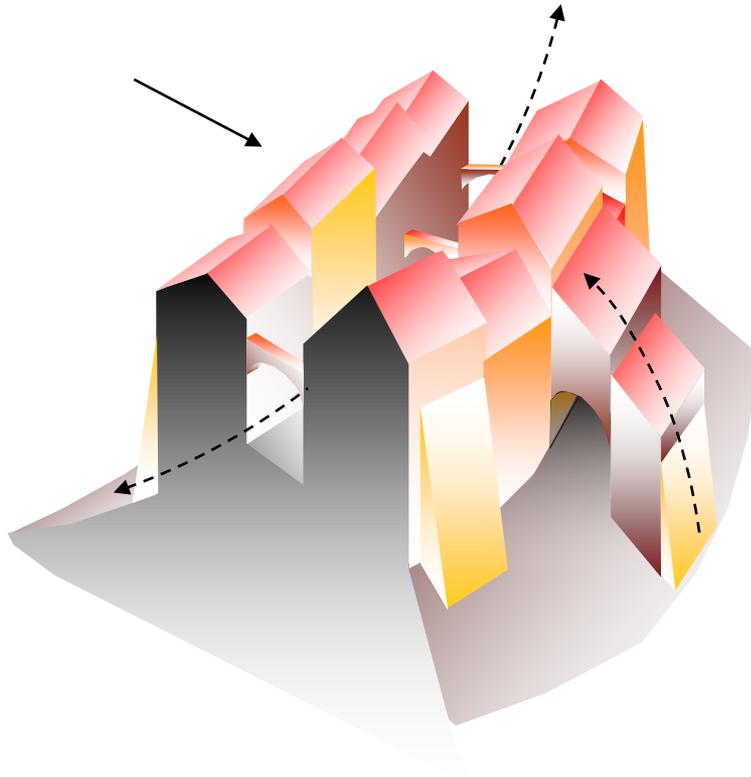


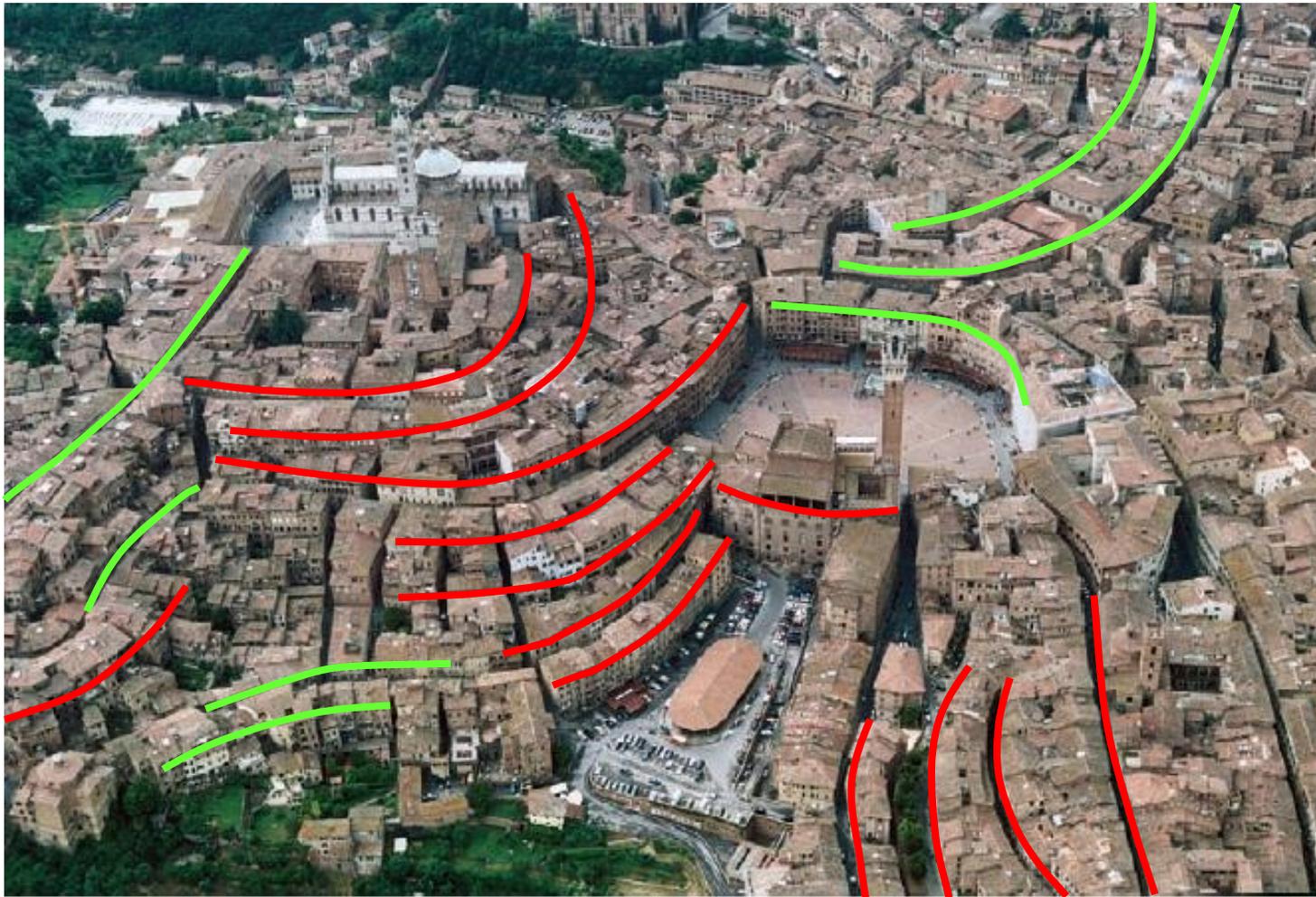
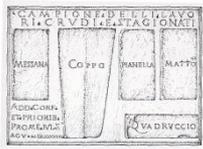
Valutazione del rischio sismico alla scala urbana



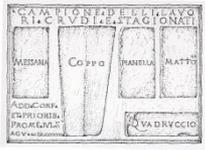


Valutazione del rischio sismico alla scala urbana

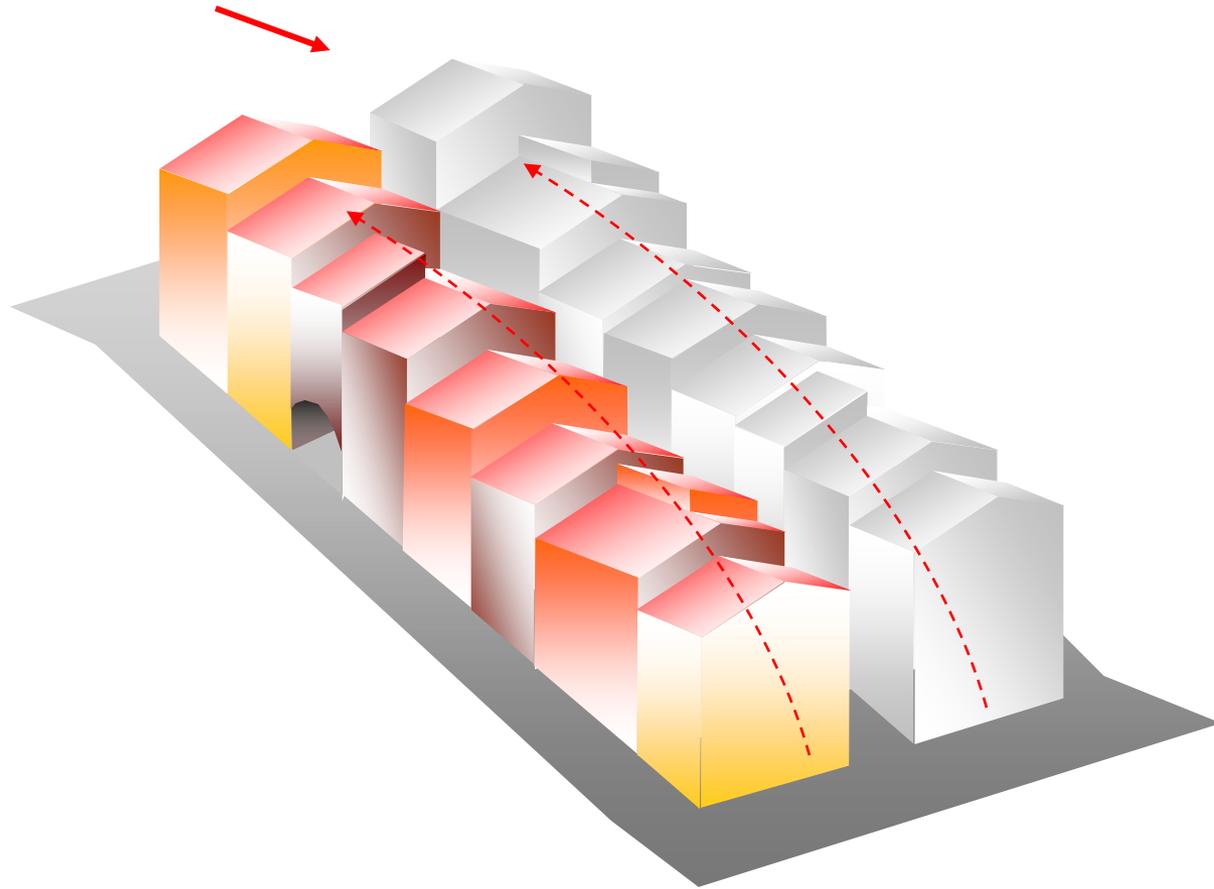


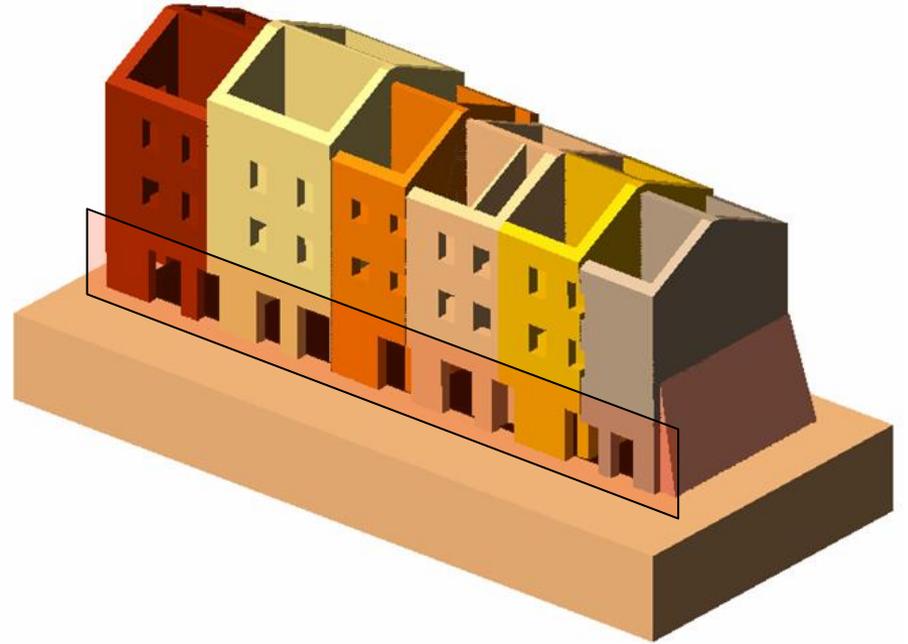
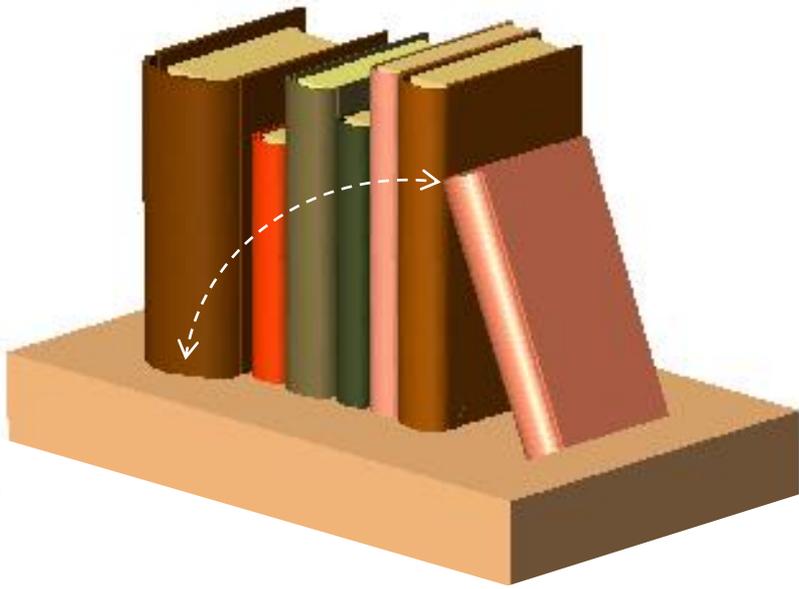
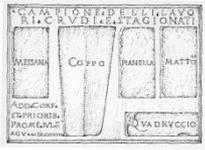


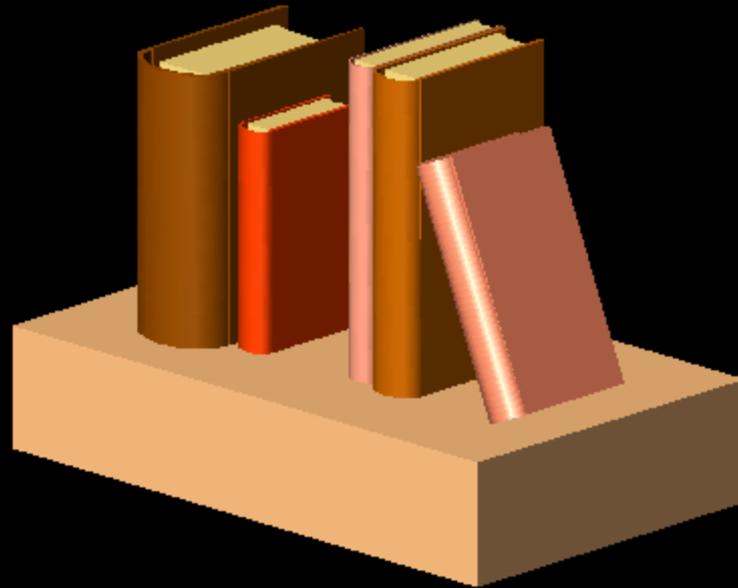
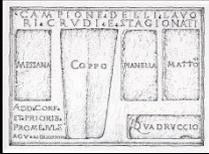
Siena: criticità determinate dalla conformazione planimetrica degli aggregati edilizi in relazione alla configurazione di pendio (concavità e convessità del lato a valle)

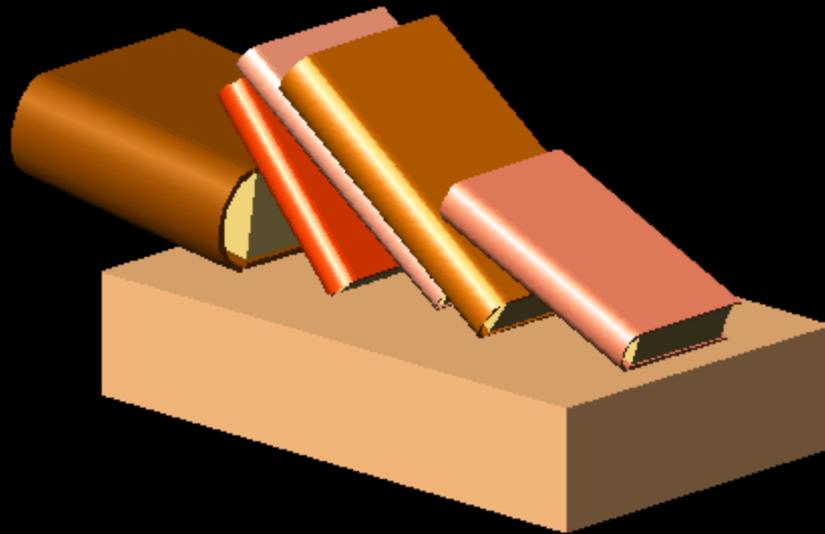
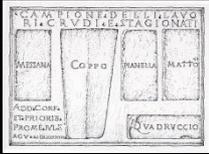


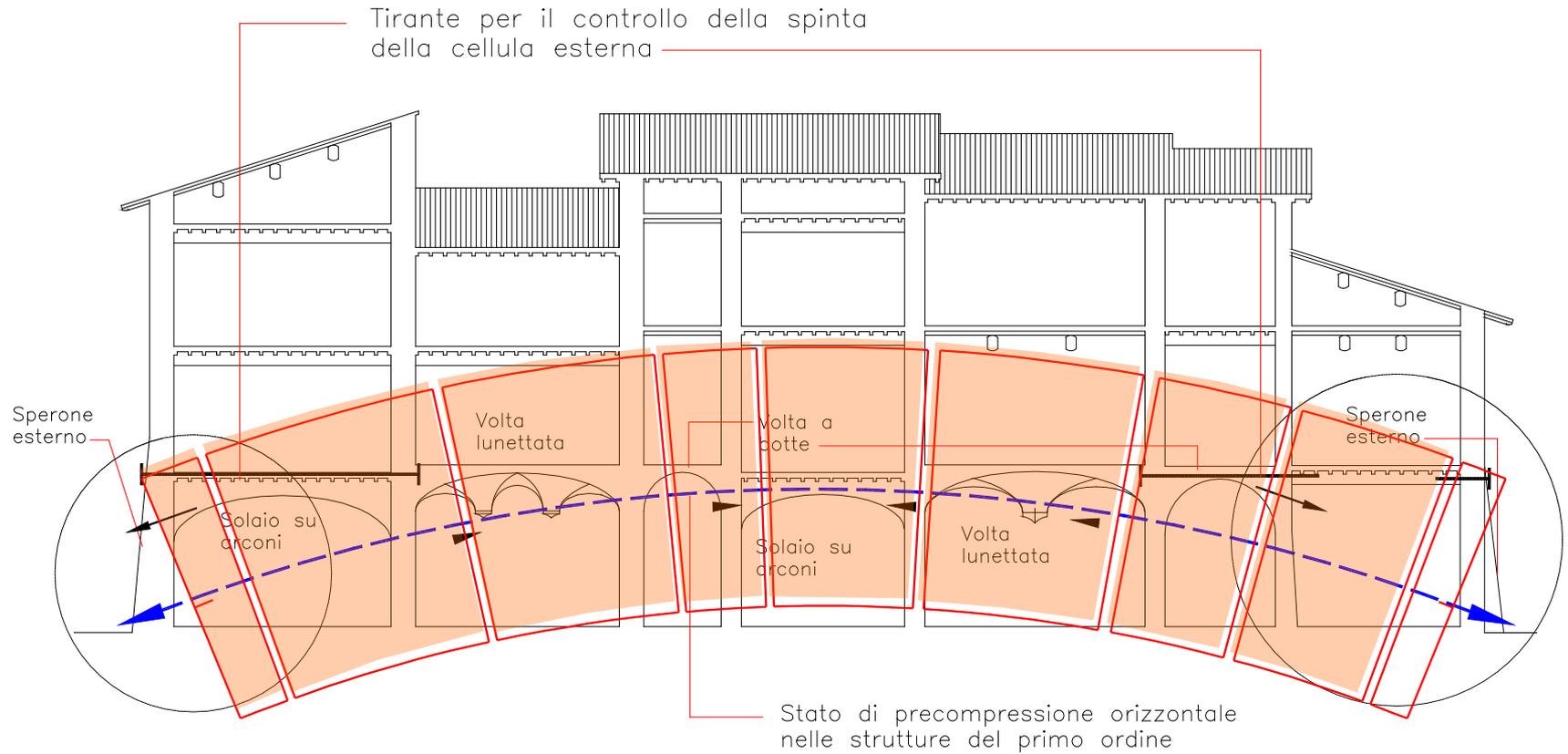
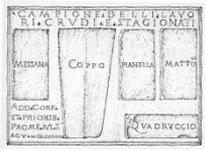
Valutazione del rischio sismico alla scala urbana

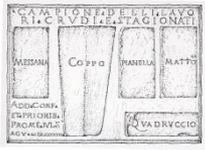




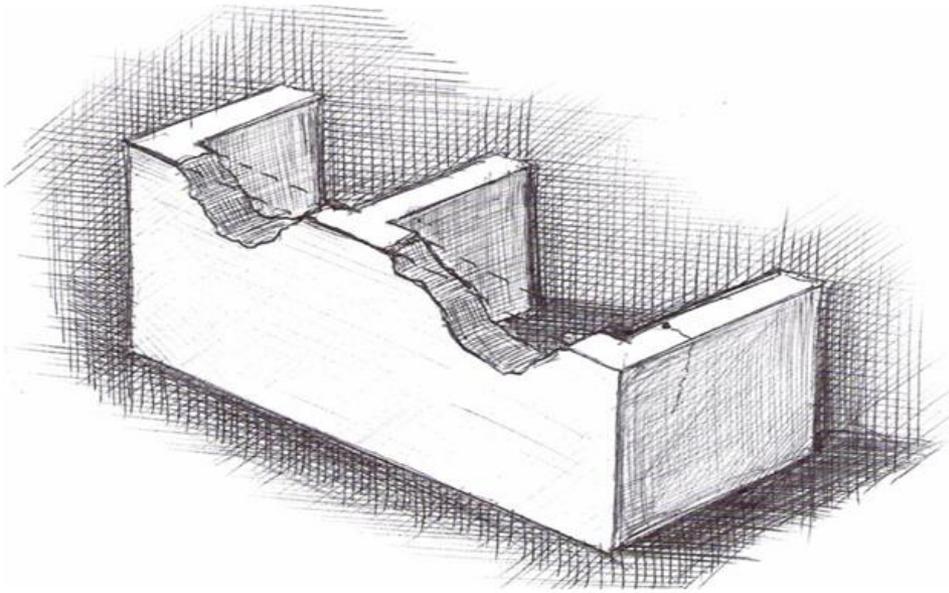
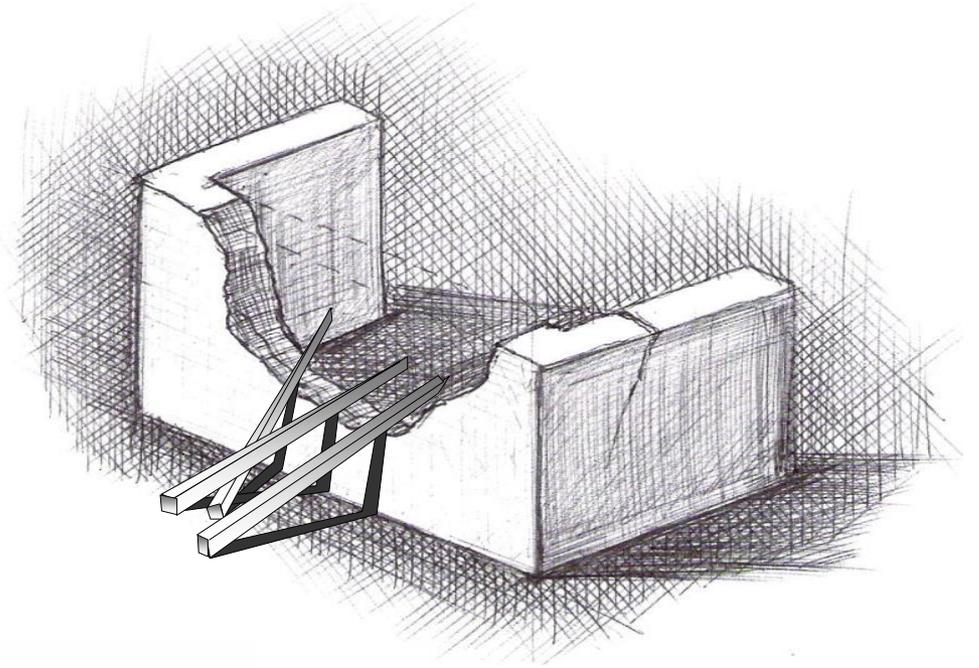
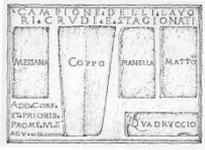


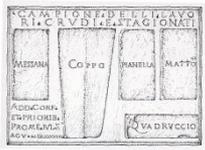




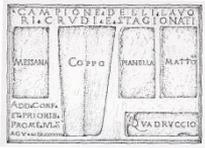


L'Aquila – 6 aprile 2009





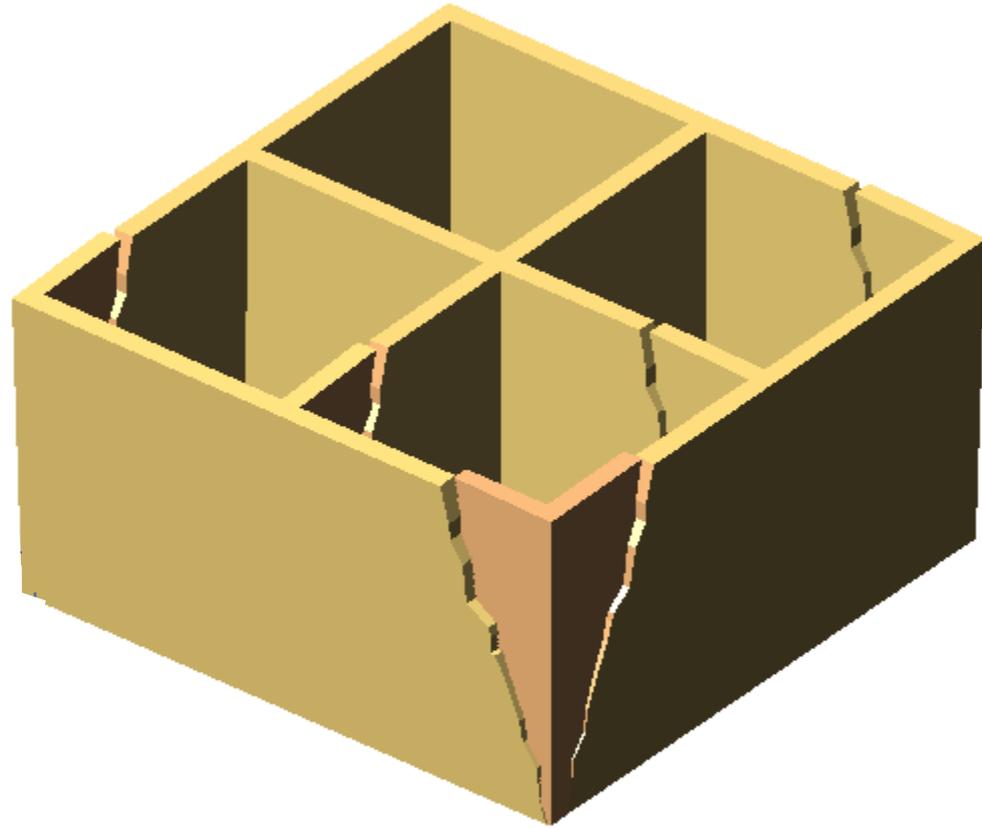
Terremoto dell'Emilia (maggio 2012):
ribaltamento di pareti sollecitate da azioni ortogonali

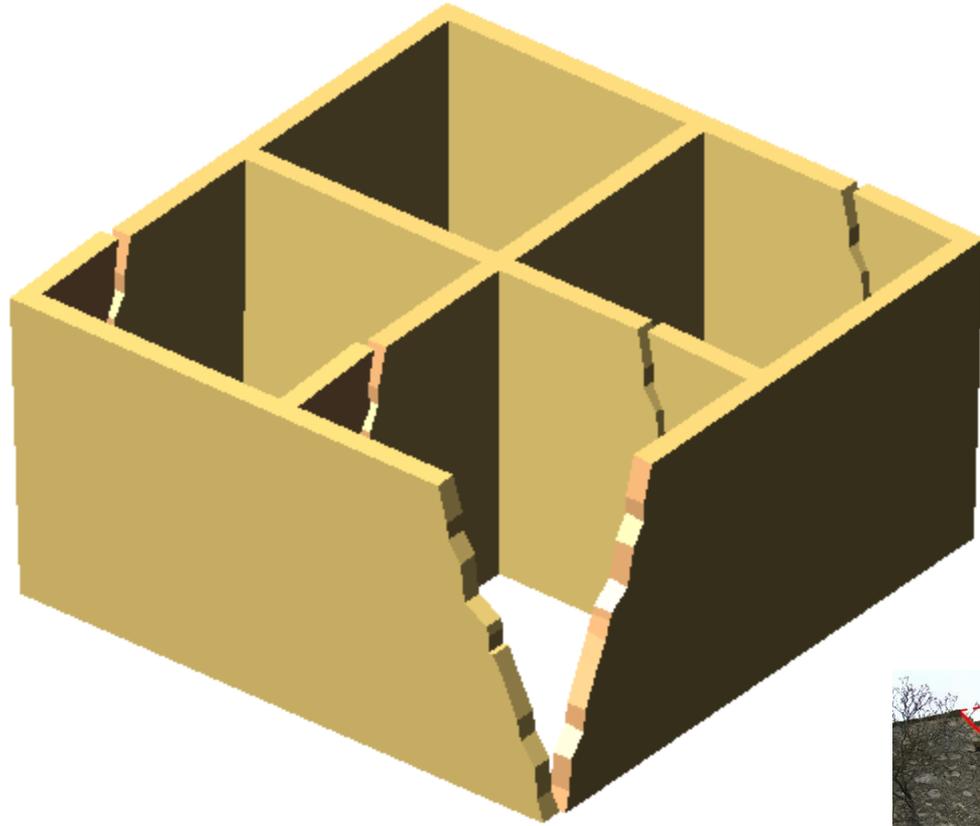


Umm al Jimal (Giordania), 749 dC



Chiesa di San Francesco - Avezzano (1915)







Torre di Babele



Ziqqurat (Persia)



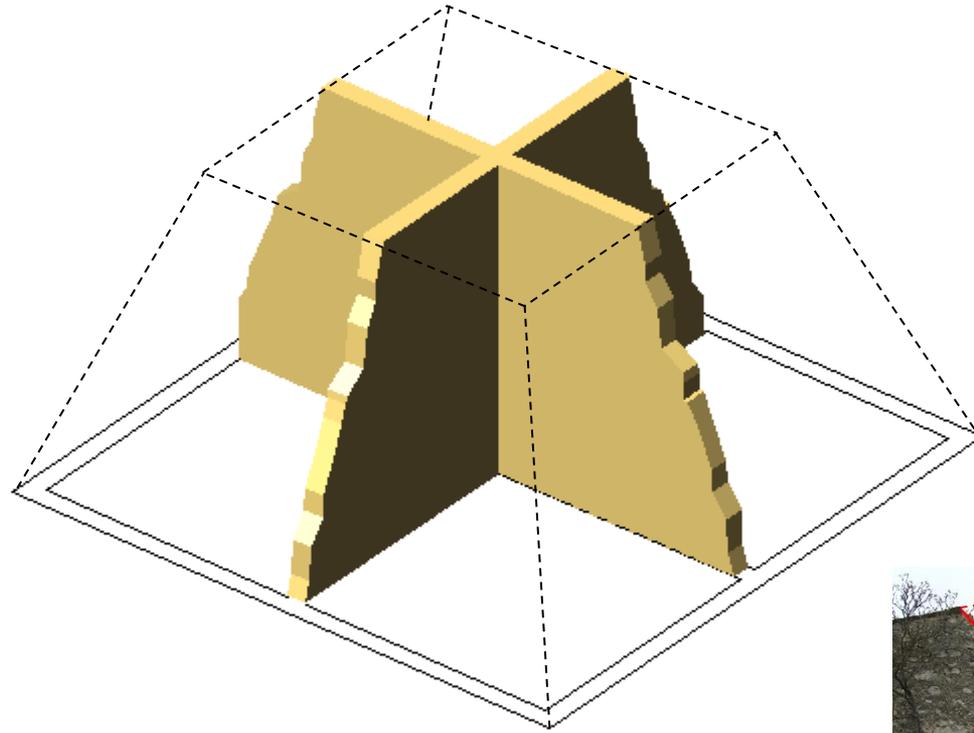
Piramidi egizie



Piramidi Maia



Castelli giapponesi





Torre di Babele



Ziqqurat (Persia)



Piramidi egizie

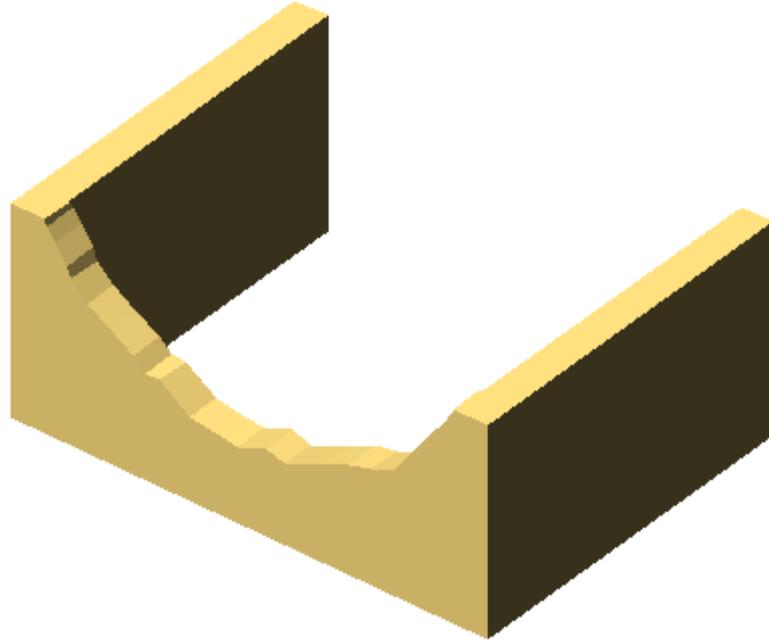
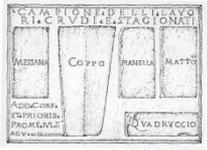


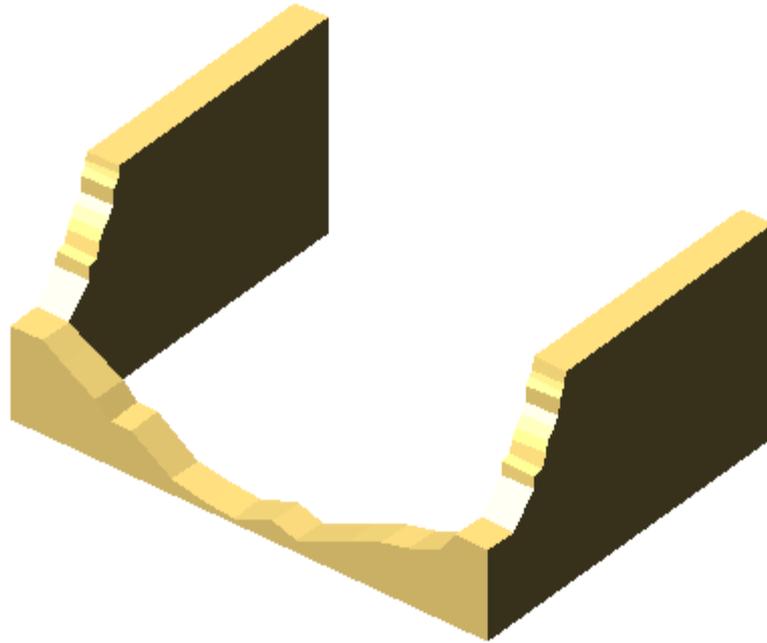
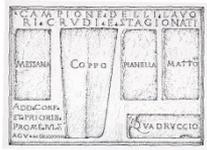
Piramidi Maia

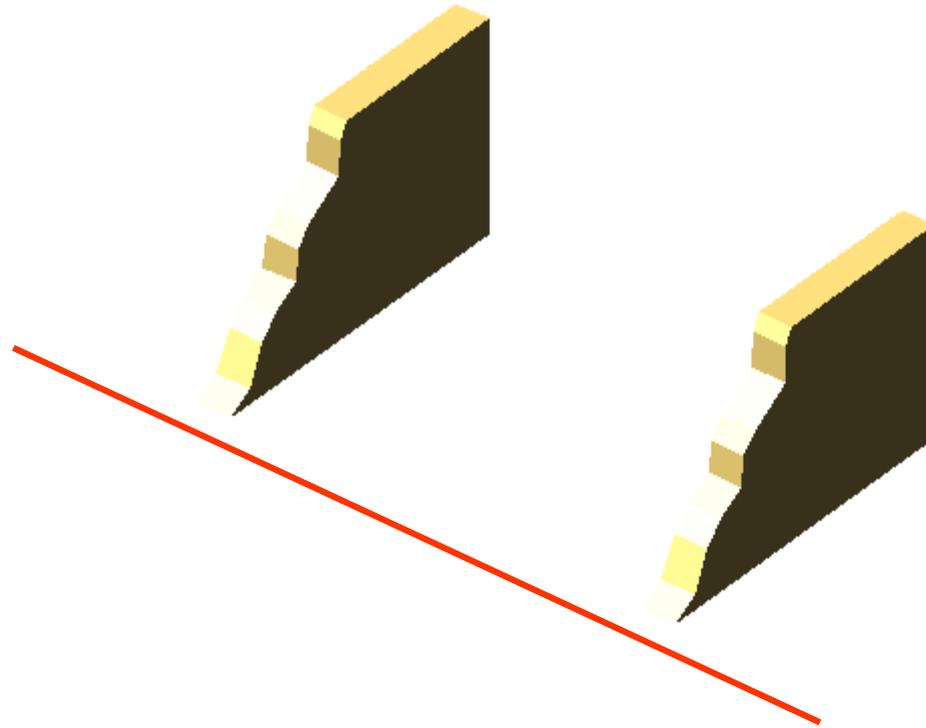
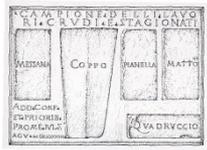


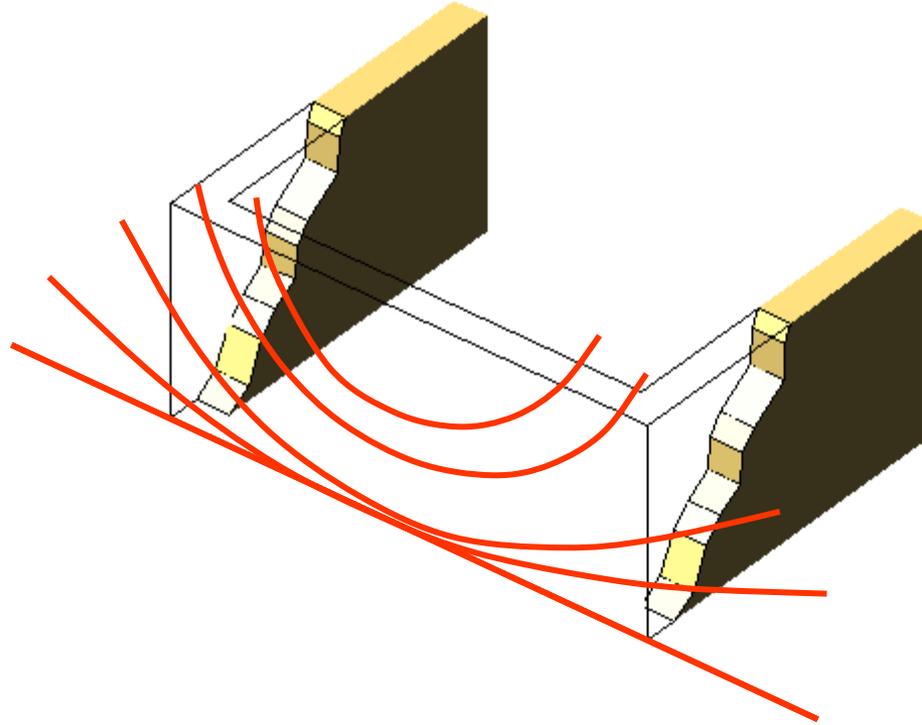
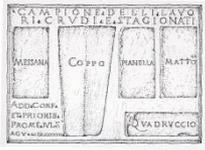
Castelli giapponesi

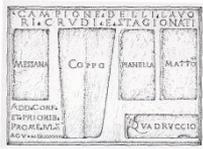




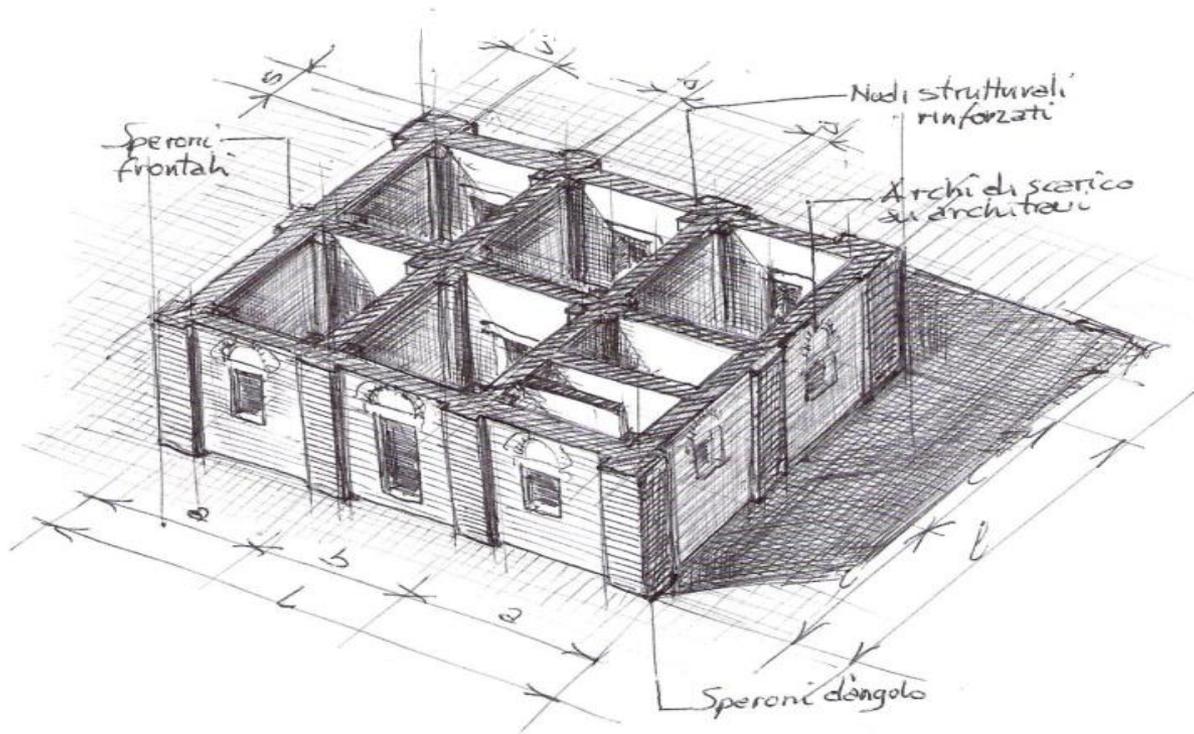






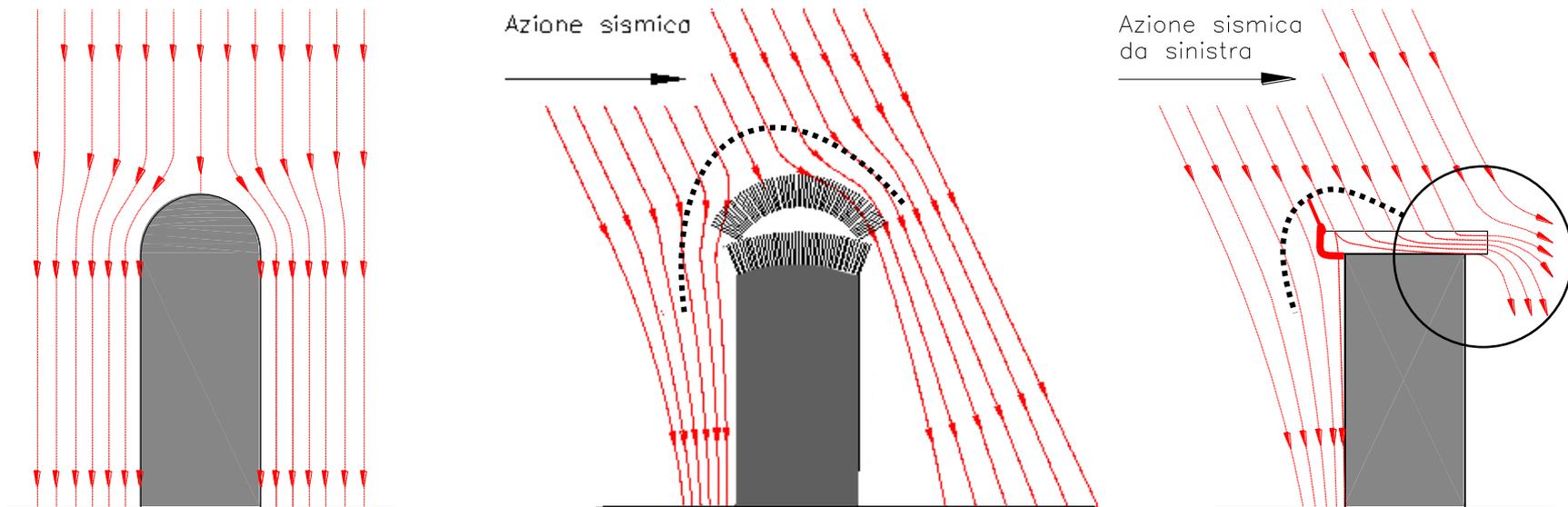


Progetto di “casa antisismica” elaborato dopo il terremoto del 1570 a Ferrara dall’architetto Pirro Ligorio, succeduto a Michelangelo presso la Fabbrica di San Pietro e trasferitosi alla corte degli Estensi nel 1568.



Punti fondamentali della “casa antisismica”:

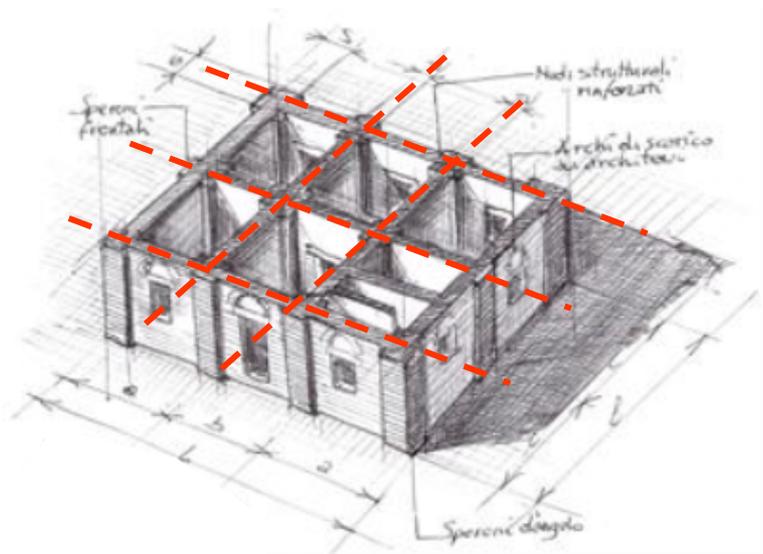
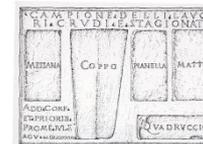
- *regolarità in pianta;*
- *interassi contenuti fra i muri portanti;*
- *spessori consistenti delle murature;*
- *cantionali rinforzati;*
- *rinforzo degli incroci murari;*
- *ordinata disposizione delle aperture;*
- *presenza di archi di scarico sopra gli architravi.*



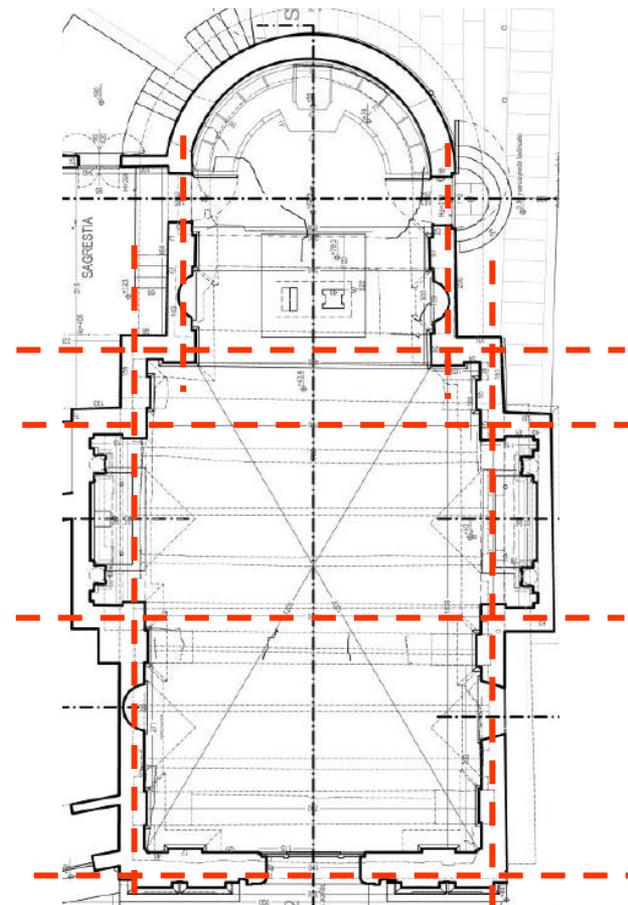
Archi di parete predisposti per diffondere i flussi di compressione in condizioni statiche e sismiche in presenza di archi e anomalie prodotte dagli architravi

Pirro Ligorio
di una casa antisismica

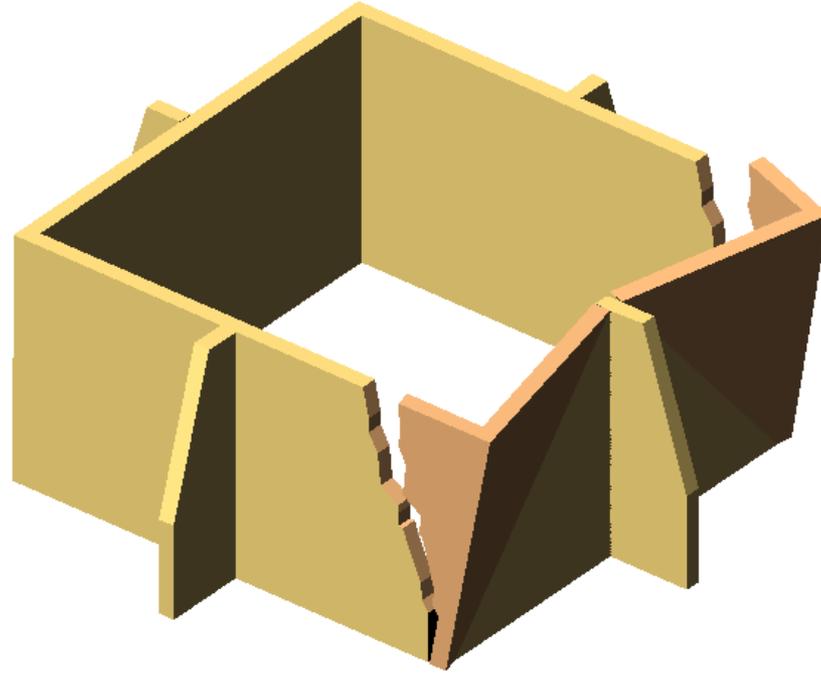
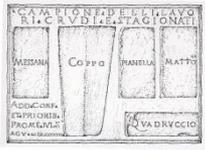
Progetto
Ferrara - 1574



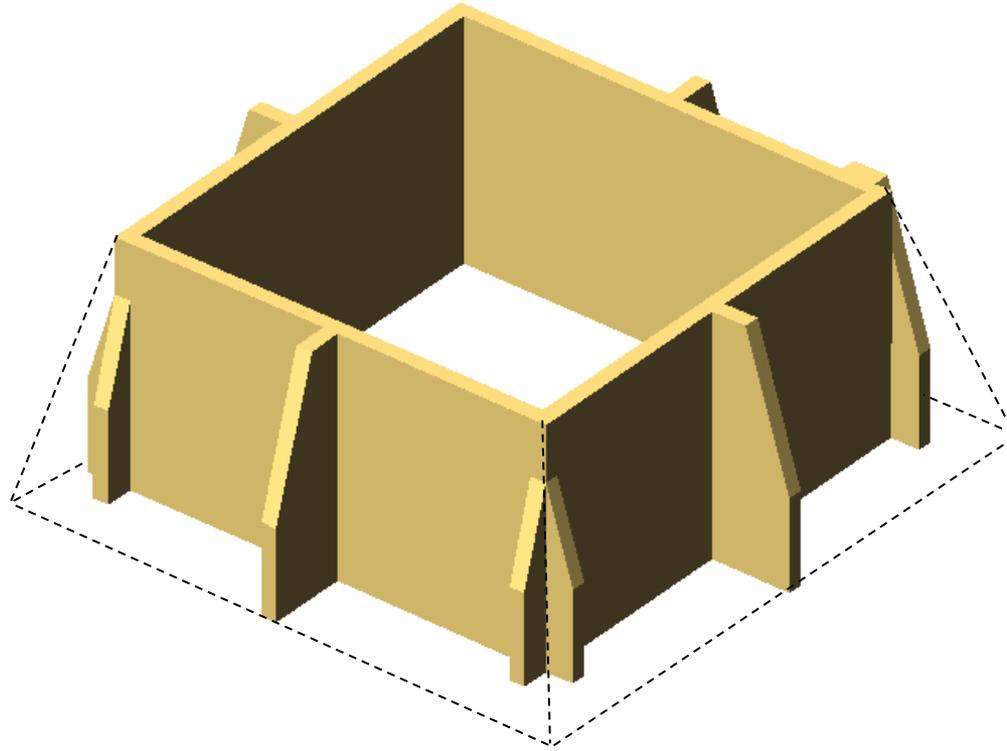
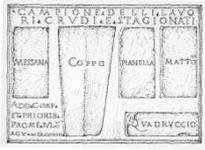
VALENTINA BARONCINI architetto
via Giuseppe Martucci 10
40136 BOLOGNA
Tel.-fax: 051/580817 cell. 338/9211687
valentina.baroncini@iscoll.it
valentina.baroncini@archiworldpec.it
CF. BRNVNT70P64A944K
P. IVA 03105041200



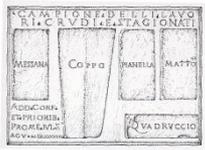
ORATORIO DI SANTA CROCE
SAN FELICE SUL PANARO (MO)

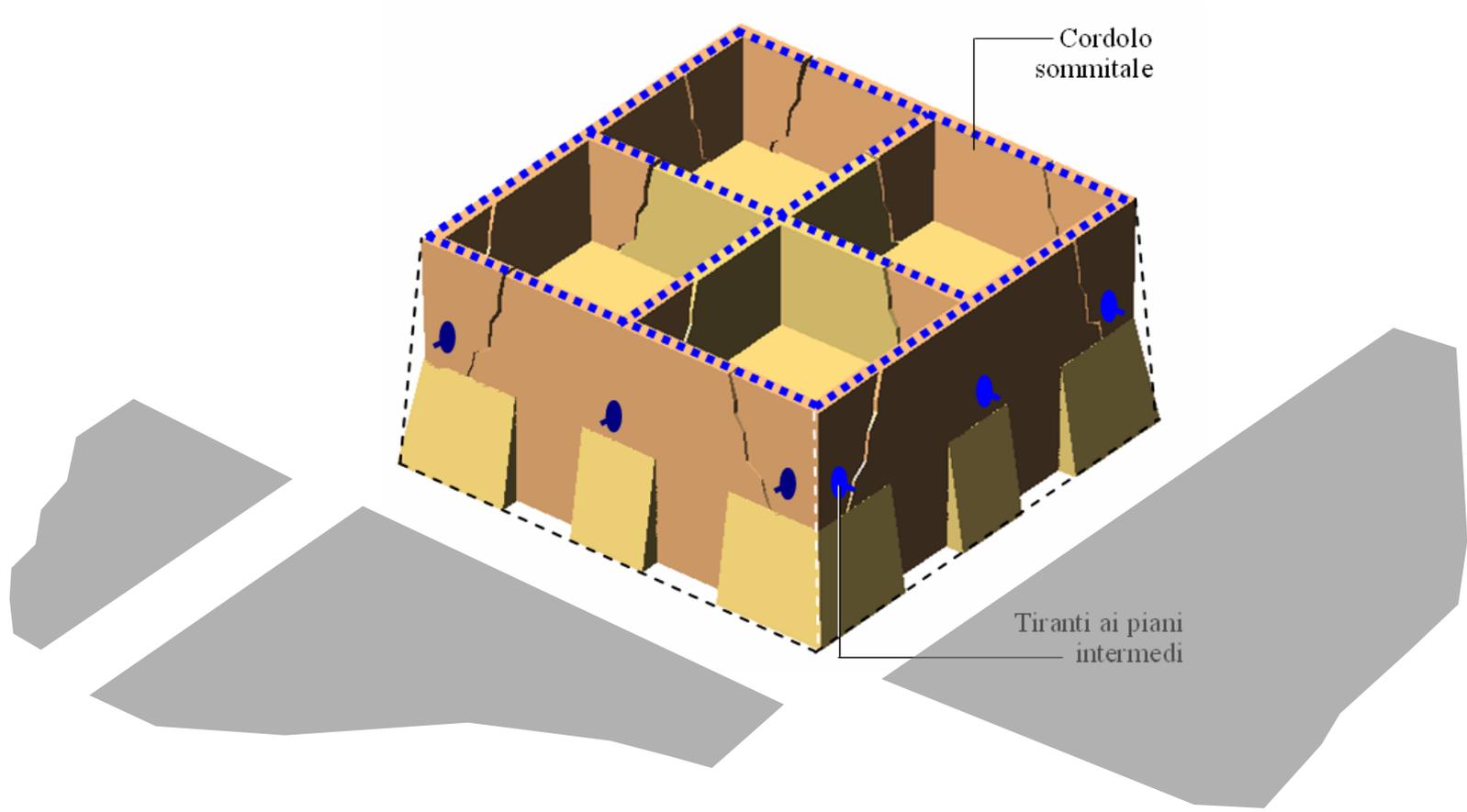
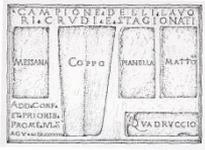


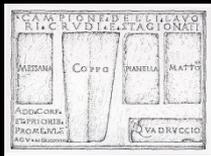
Lo stesso principio!



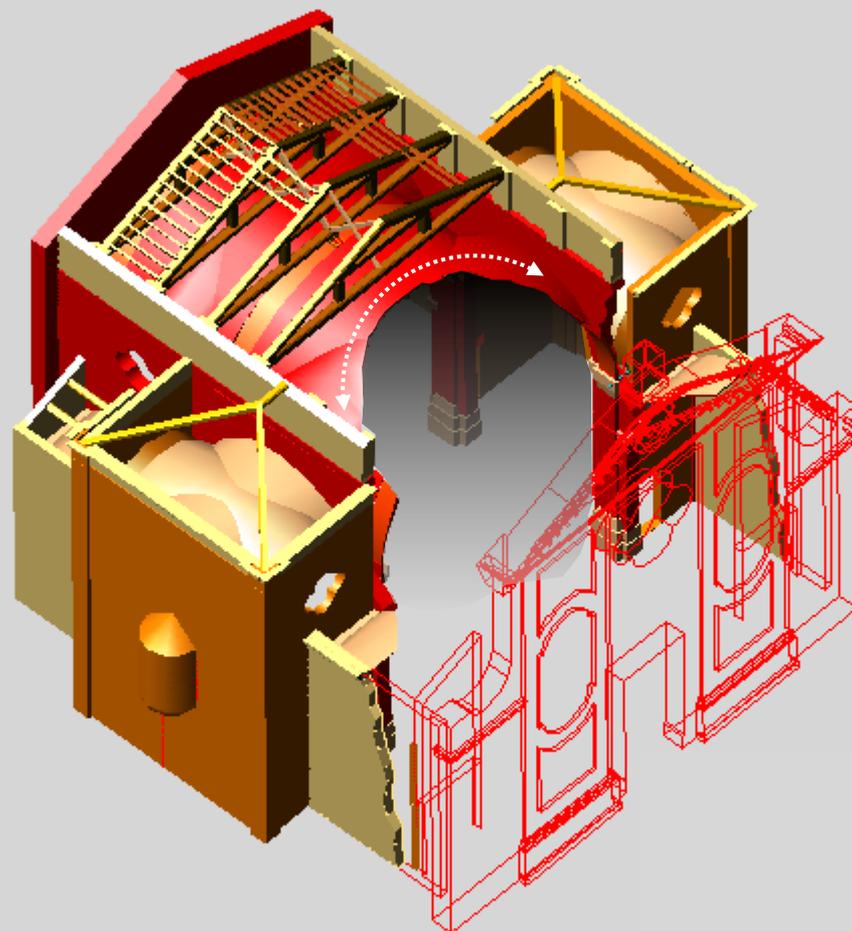
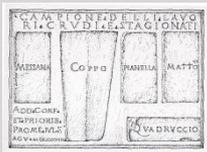
Lo stesso principio!







Cinematismi di danno tipici
delle chiese a navata unica

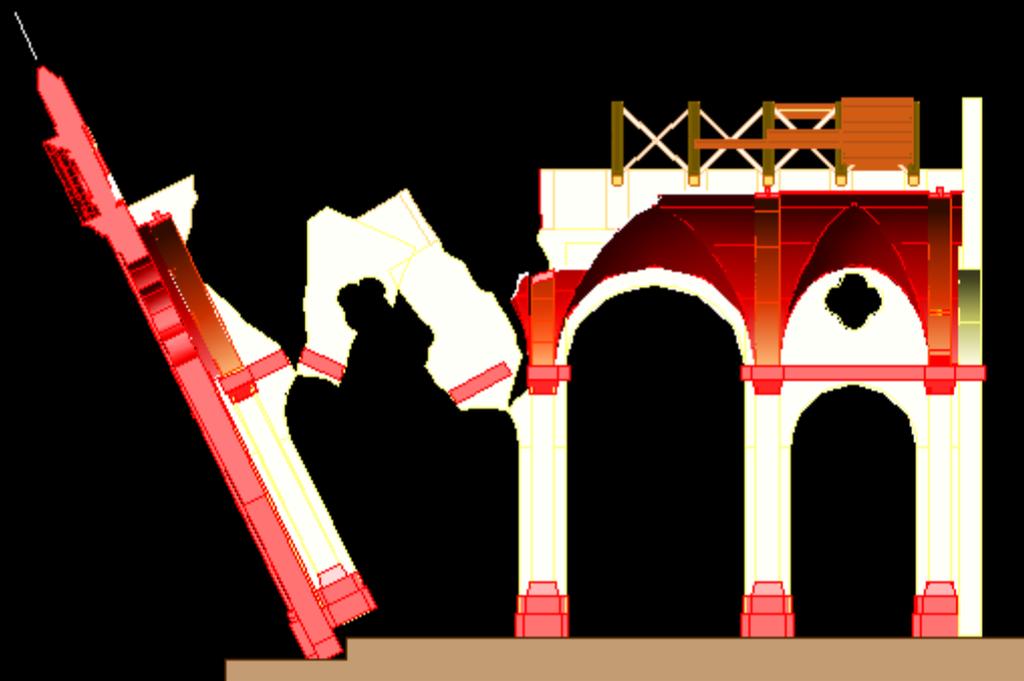


Chiesa di San Francesco
(Finale Emilia - MO)

C.Manenti - G.Cangi - L.Venturi - A.Petrani



Chiesa di San Francesco
(Finale Emilia - MO)

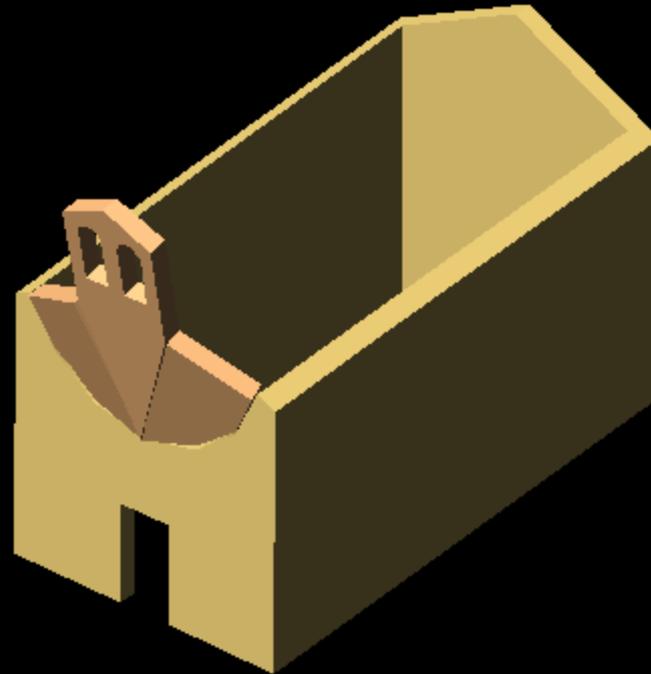
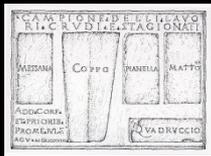


Chiesa di San Francesco
(Finale Emilia - MO)

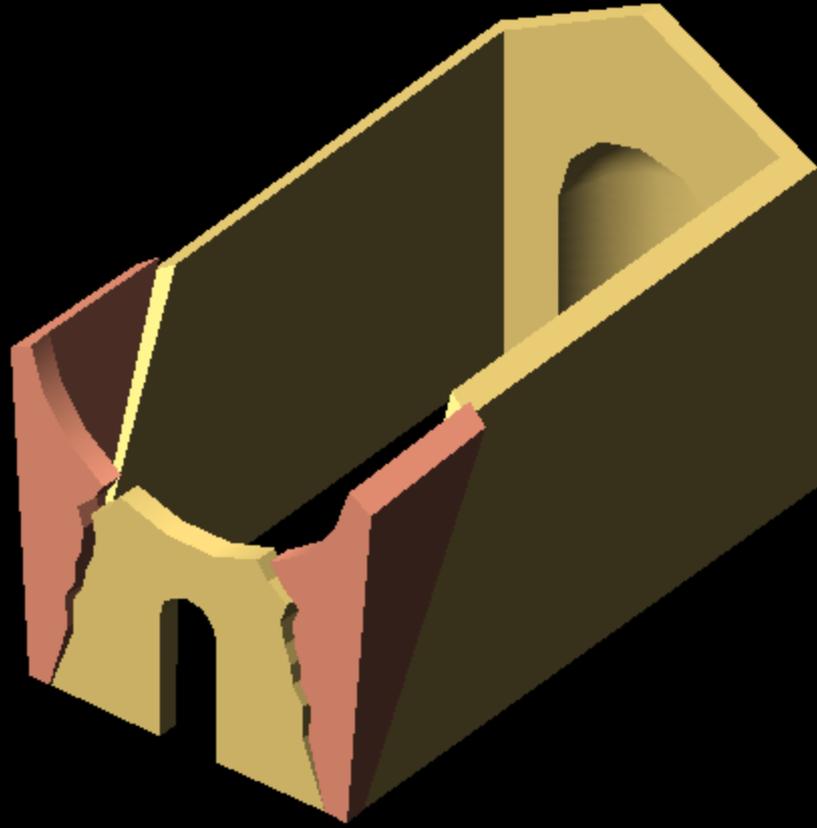
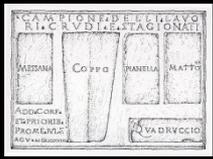
C.Manenti - G.Cangi - L.Venturi - A.Petrani

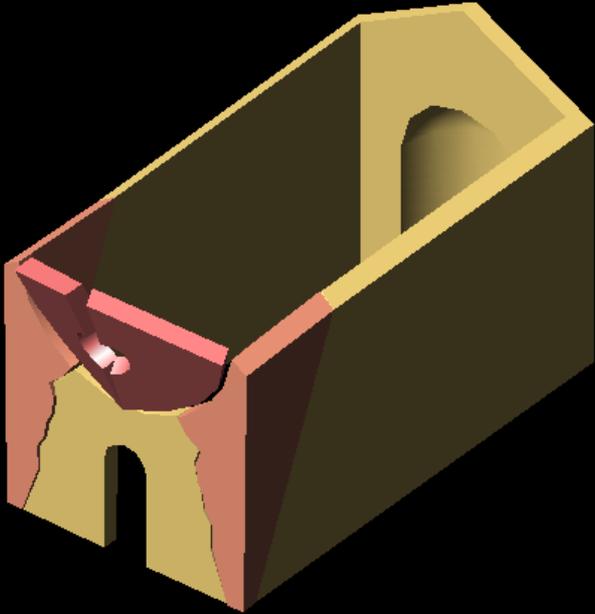
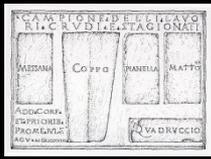


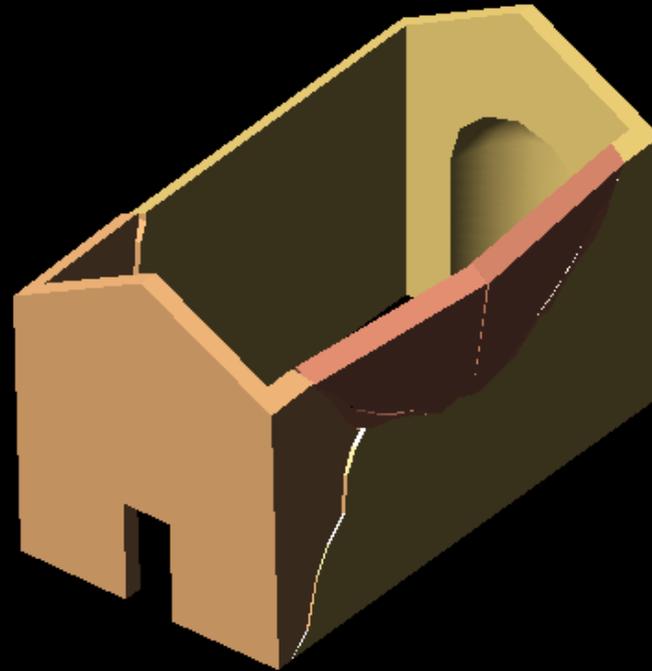
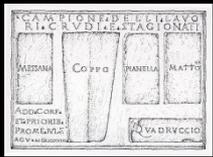
Chiesa di San Francesco
(Finale Emilia - MO)



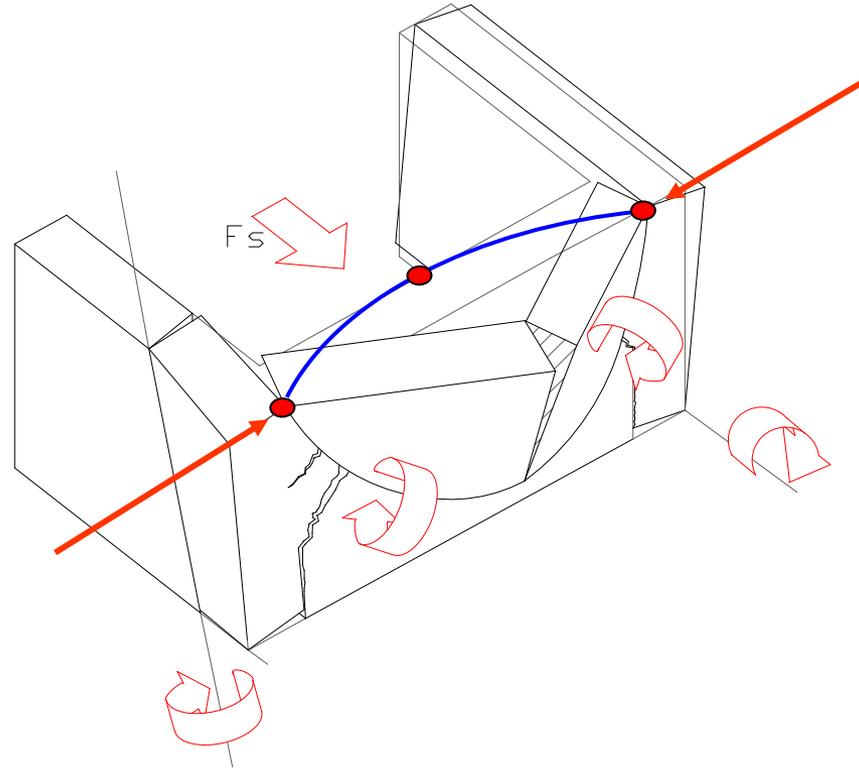
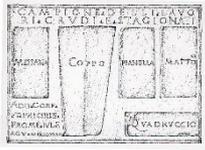
Cinematismi di danno tipici
delle chiese a navata unica



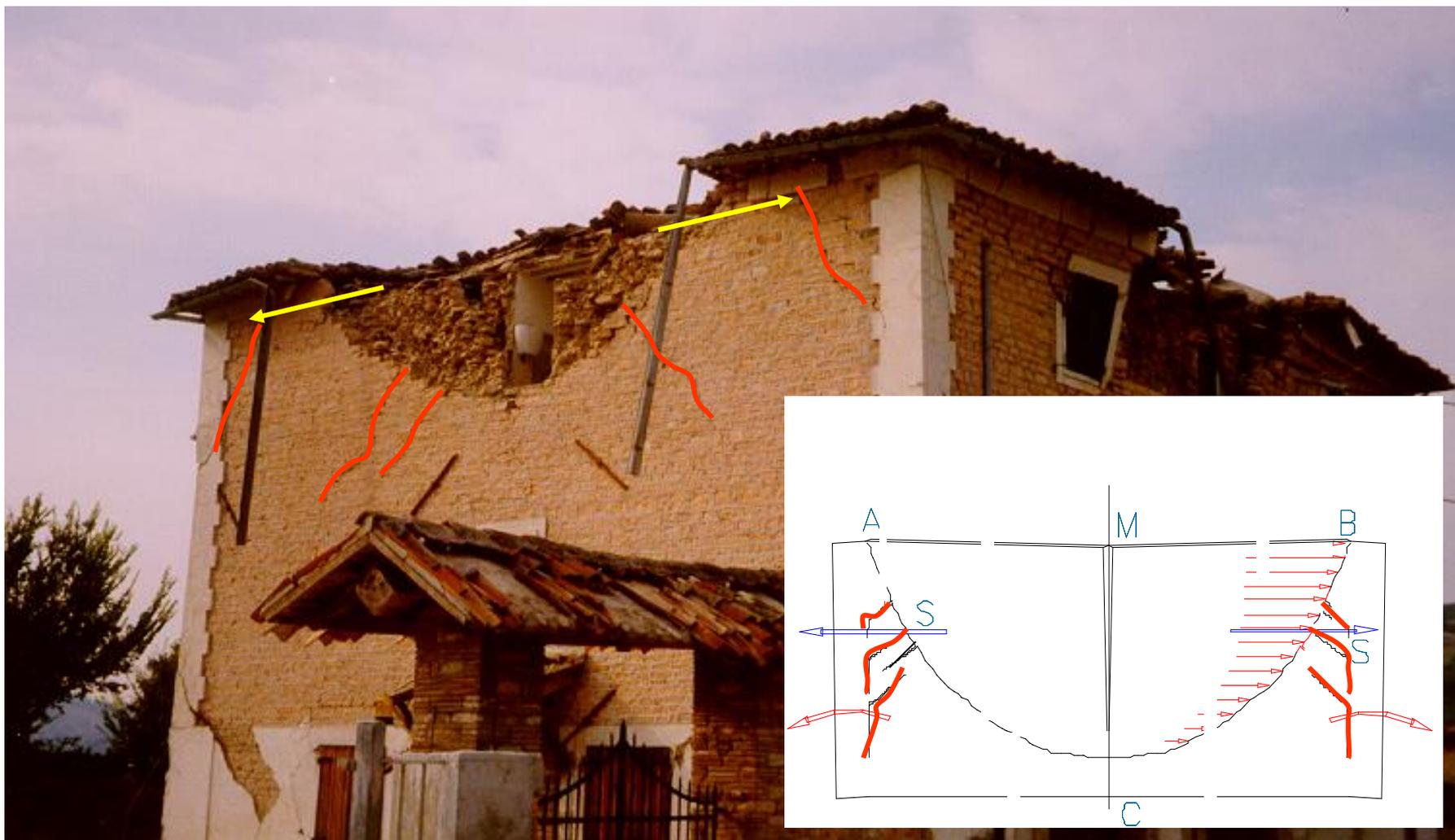




Cinematismi di danno tipici
delle chiese a navata unica

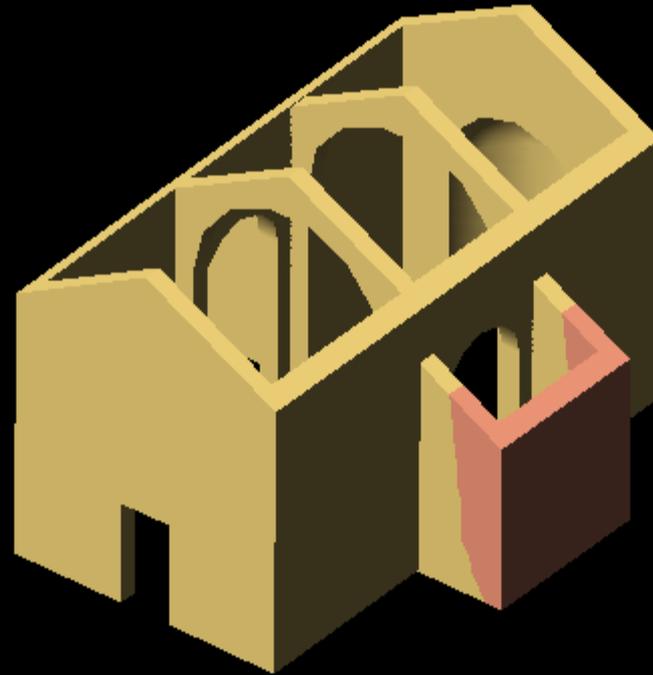
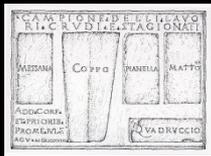


Ribaltamento pareti sollecitate da azioni ortogonali



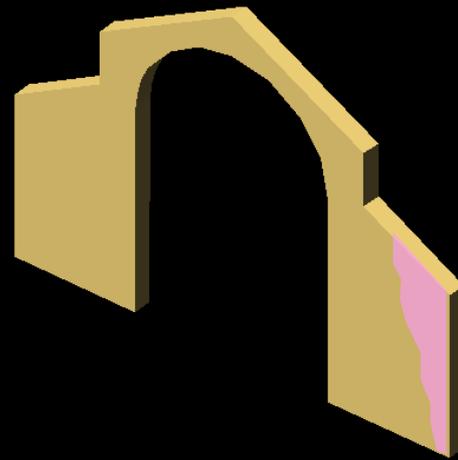
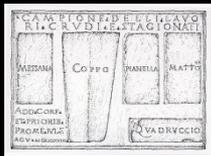
Edificio di Sellano (PG) danneggiato dal sisma del 1997

Foto Ing. Antonello Anastasi



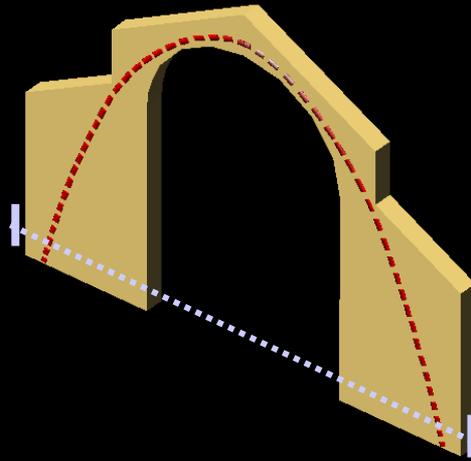
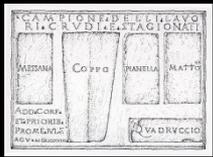
San Francesco d'Assisi
(Finale Emilia - MO)

Cinematismi di danno tipici
delle chiese a navata unica

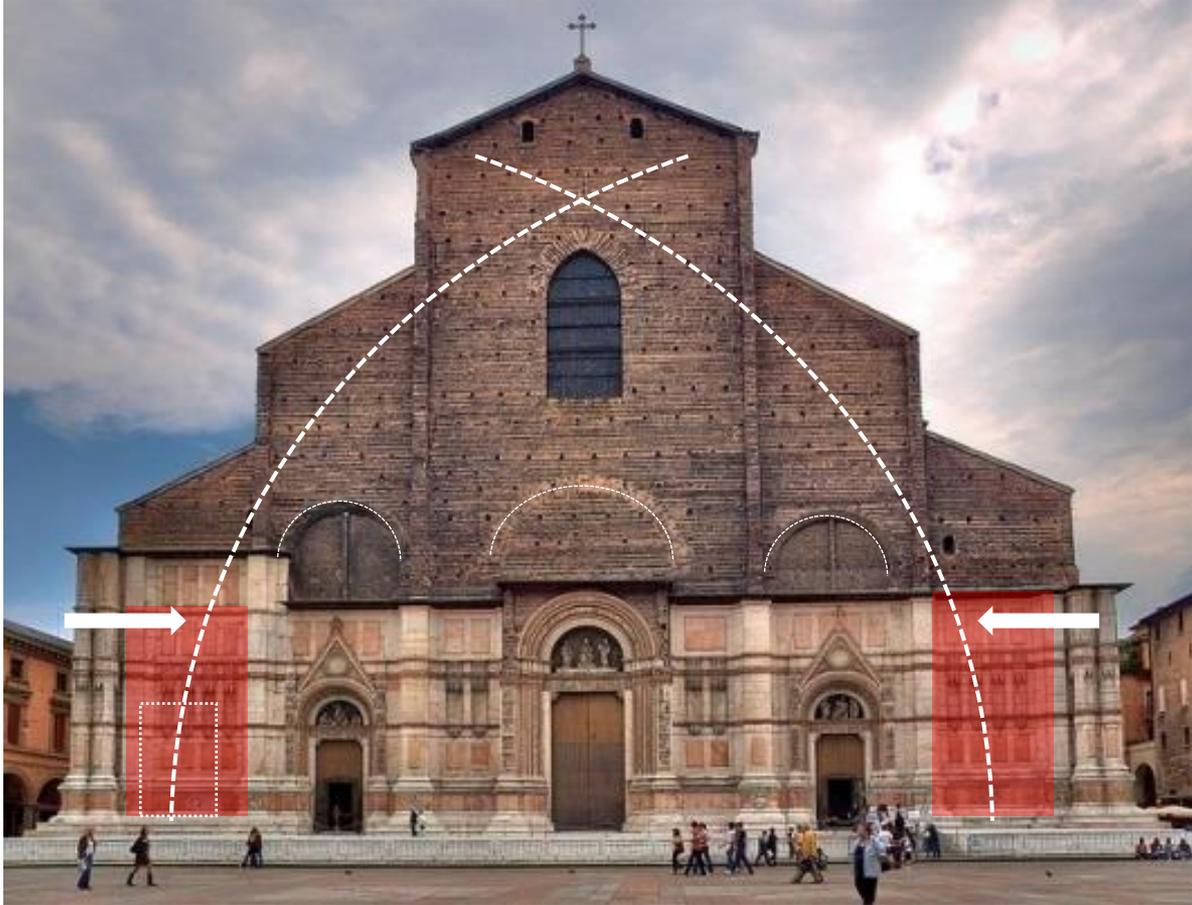
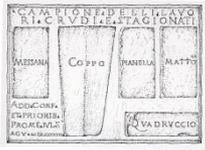


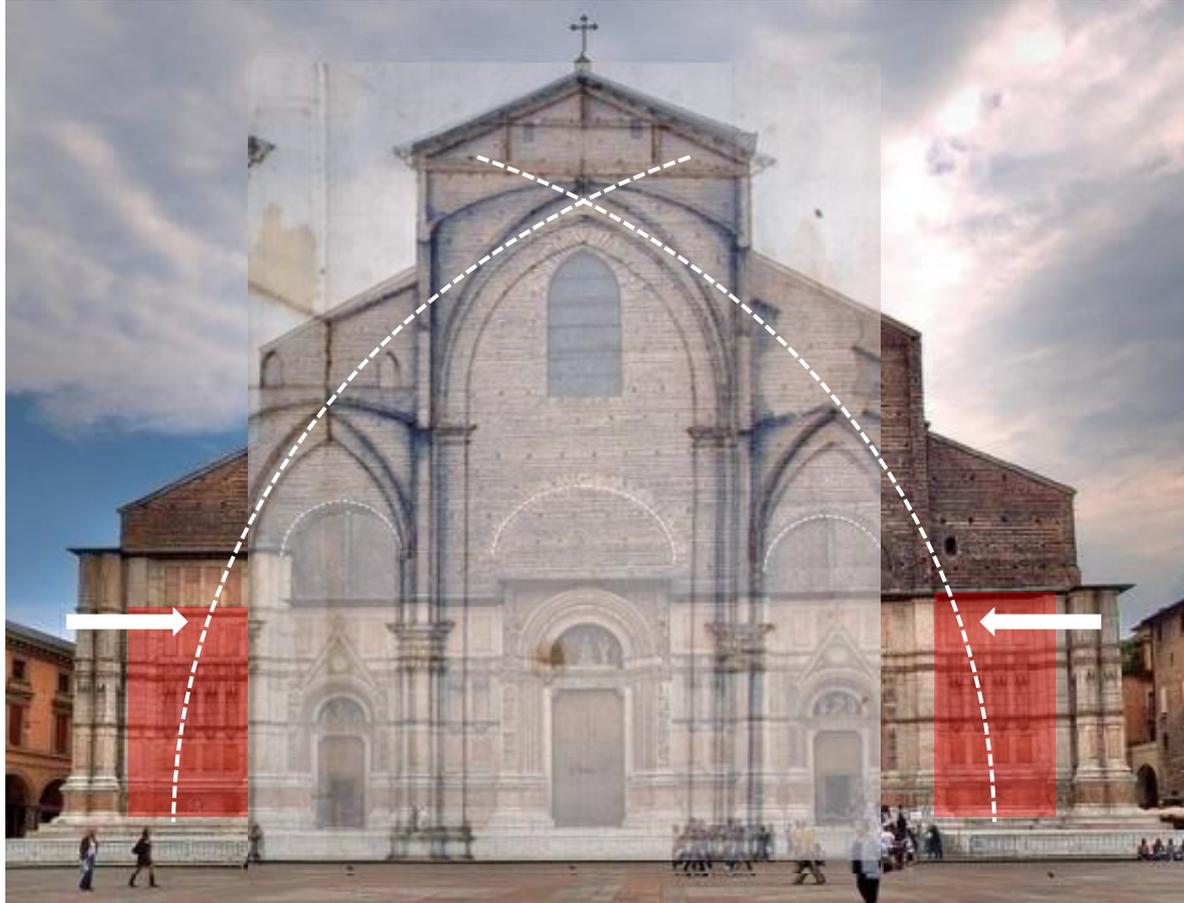
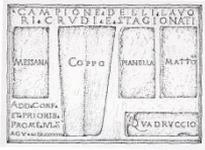
San Francesco d'Assisi
(Finale Emilia - MO)

Cinematismi di danno tipici
delle chiese a navata unica



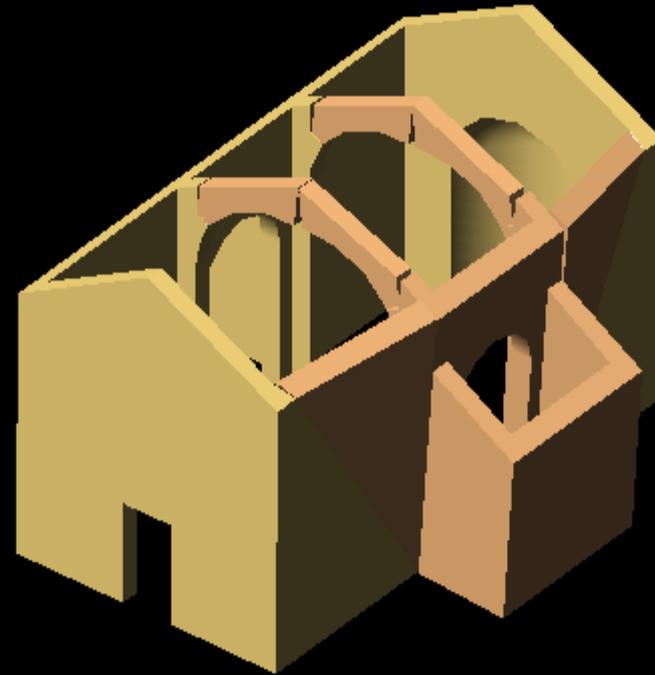
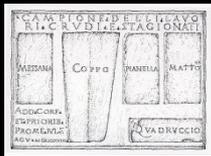
Cinematismi di danno tipici
delle chiese a navata unica



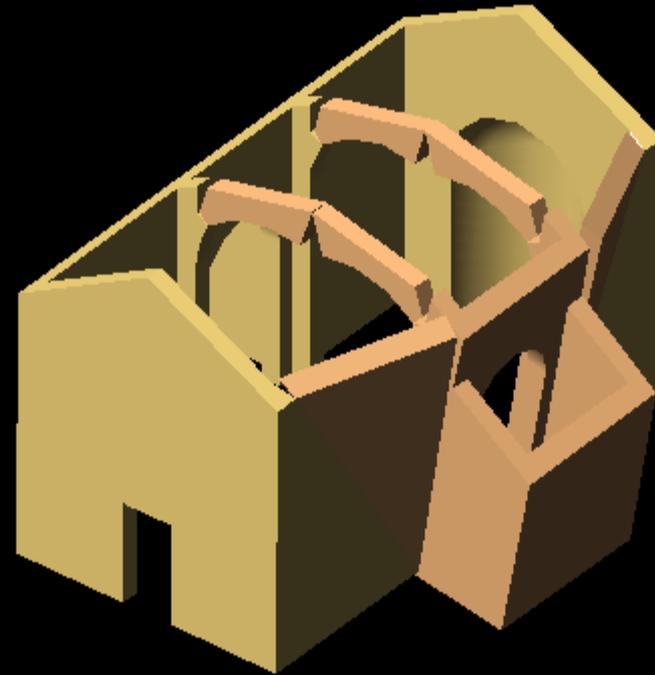
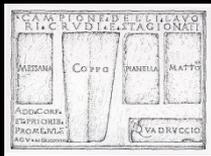




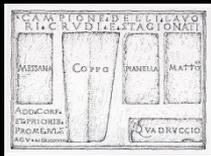
Cinematismi di danno tipici
delle chiese a navata unica



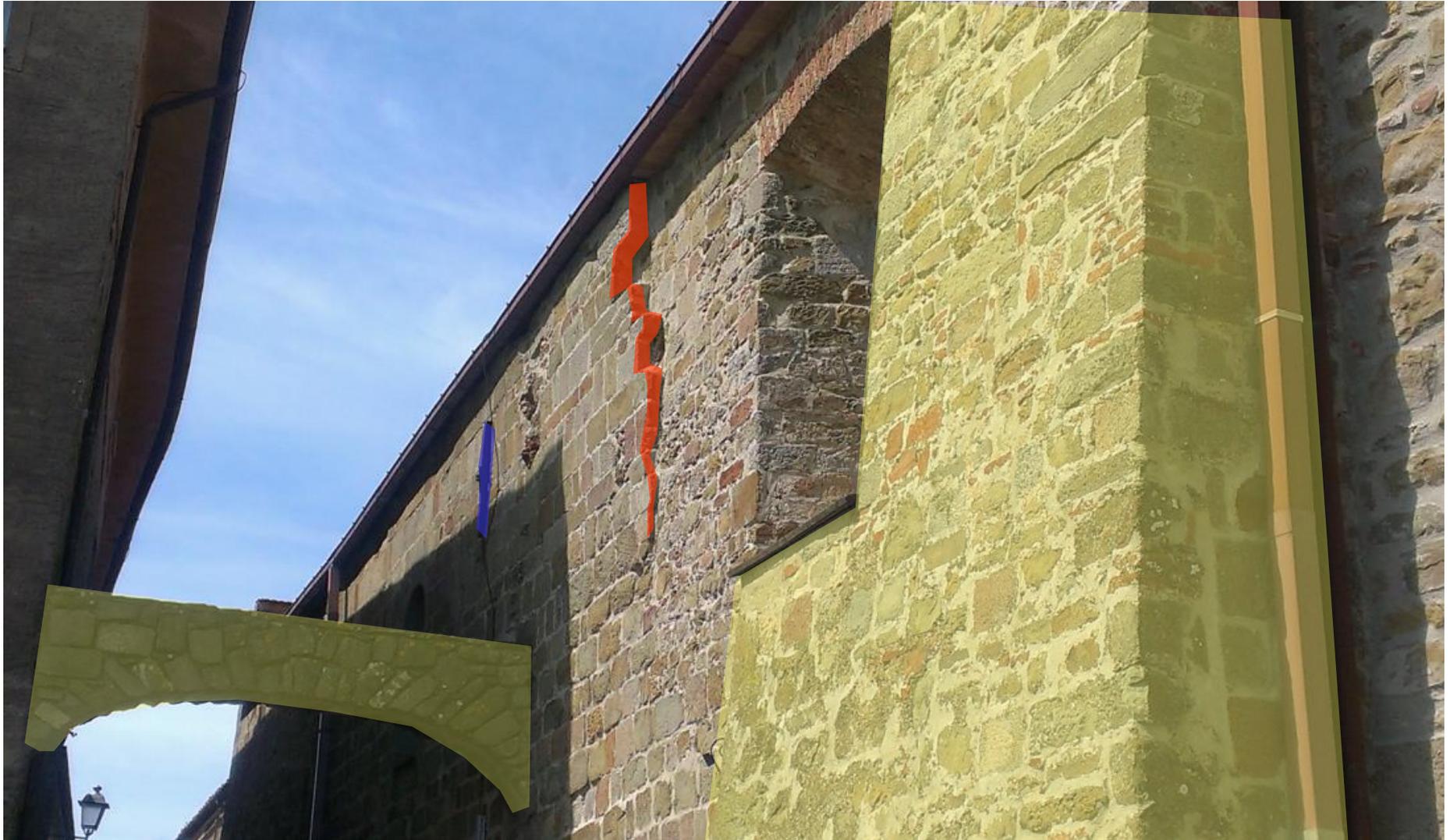
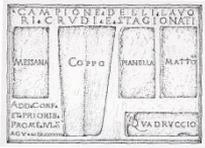
Cinematismi di danno tipici
delle chiese a navata unica



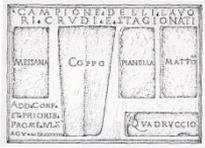
Cinematismi di danno tipici
delle chiese a navata unica



Cinematismi di danno tipici
delle chiese a navata unica



Vetulonia



Rilievo critico

Ministero delle Infrastrutture
Ministero dell'Interno
Dipartimento di Protezione Civile

PROCEDURE PER LA VALUTAZIONE DELLA
SICUREZZA E LA REDAZIONE DEI PROGETTI

NUOVE NORME TECNICHE PER LE COSTRUZIONI

DM Infrastrutture 17 gennaio 2018

CAP. 8 - COSTRUZIONI ESISTENTI

8.5 – DEFINIZIONE DEL MODELLO DI RIFERIMENTO PER LE ANALISI

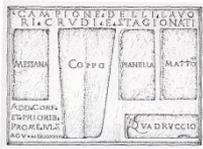
..... è impossibile prevedere regole specifiche per tutti i casi. Di conseguenza, **il modello per la valutazione della sicurezza dovrà essere definito e giustificato dal Progettista caso per caso**
.....tenendo conto:

- dell'analisi storico-critica;

- del rilievo geometrico-strutturale;

- della caratterizzazione meccanica dei materiali

- del livello di conoscenza e fattori di confidenza

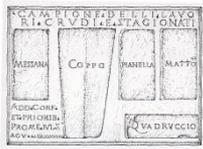


Tecniche costruttive e materiali da costruzione

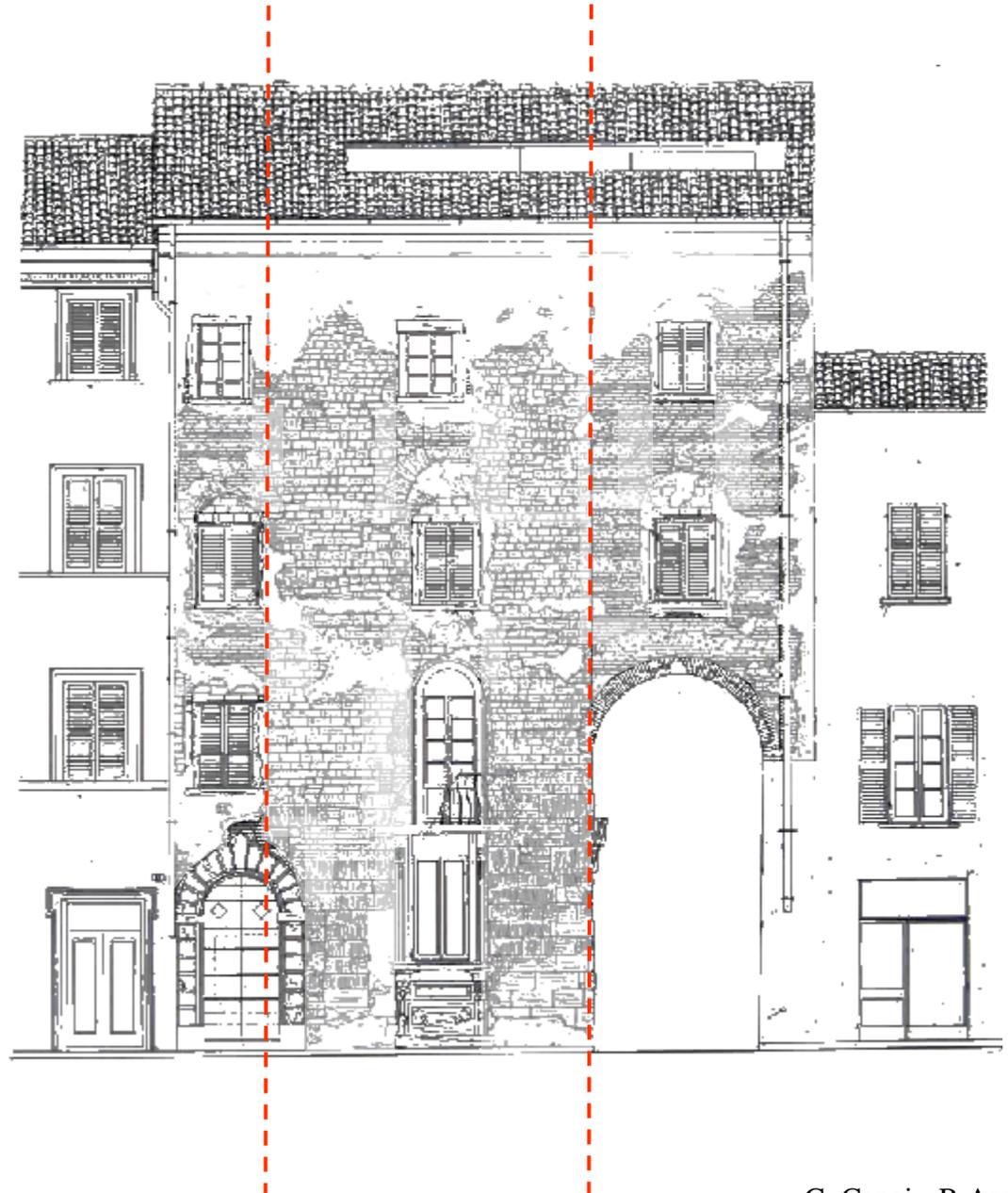


Città di Castello (PG)

Evoluzione di una casa torre in
Corso V.Emanuele

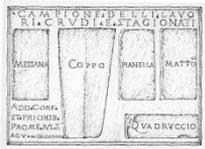


Tecniche costruttive e materiali da costruzione

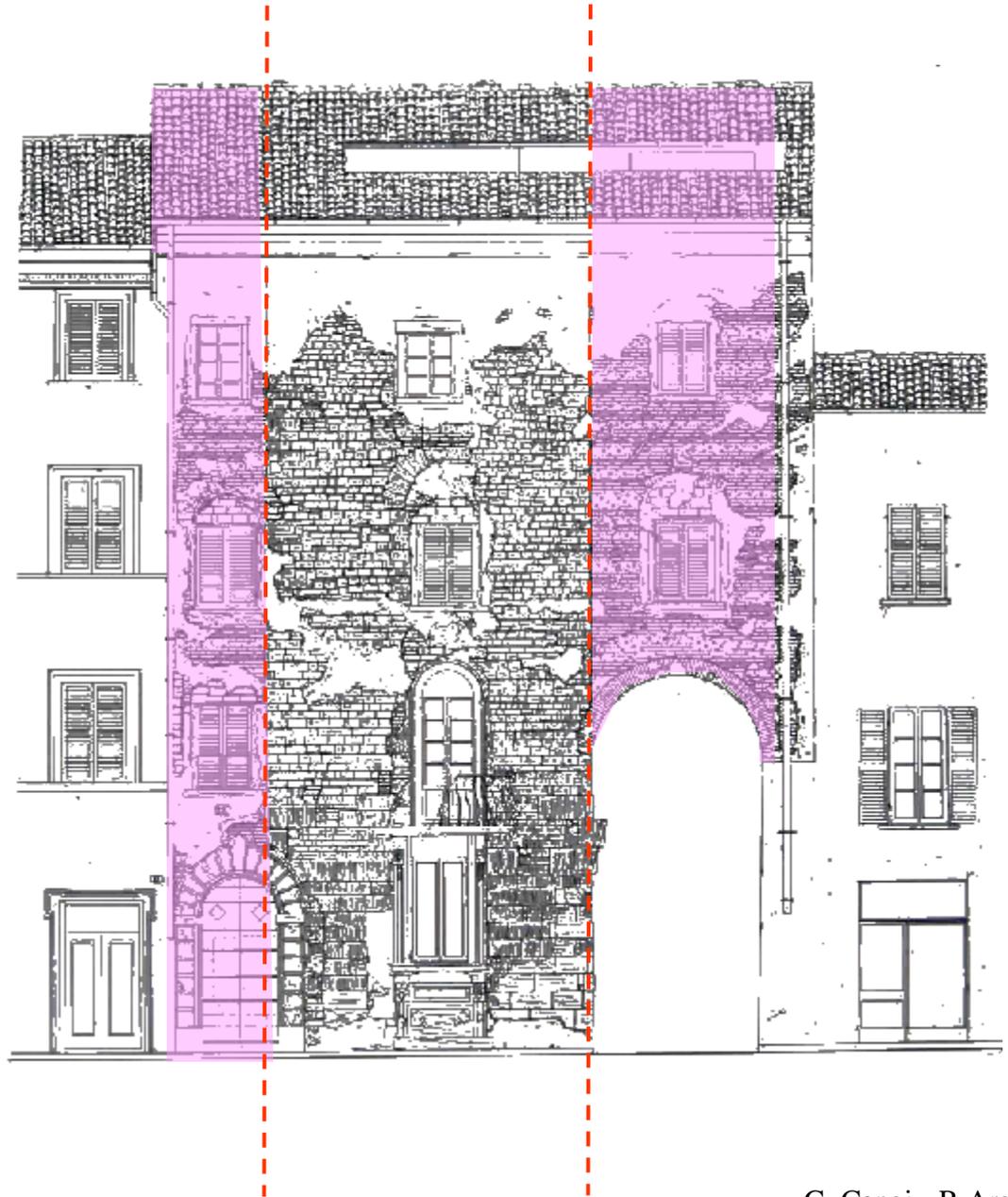


Città di Castello (PG)

Evoluzione di una casa torre in
Corso V.Emanuele

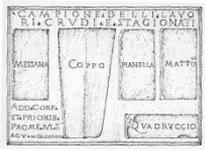


Tecniche costruttive e materiali da costruzione

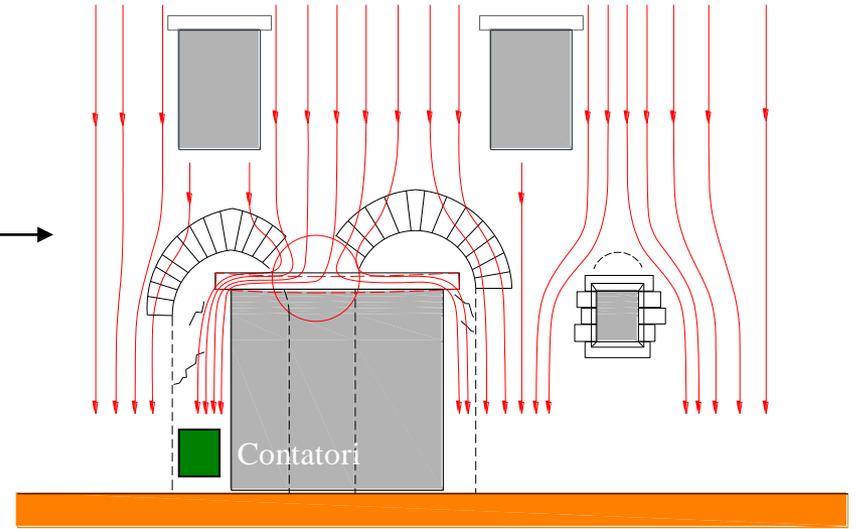
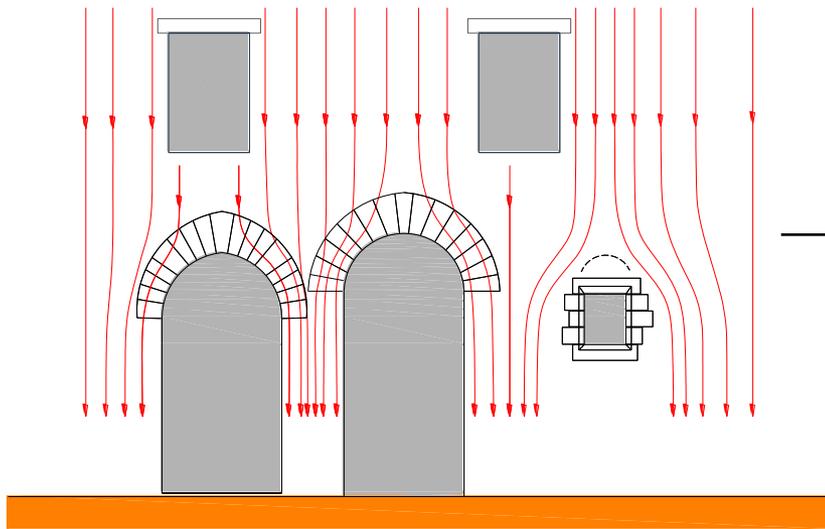
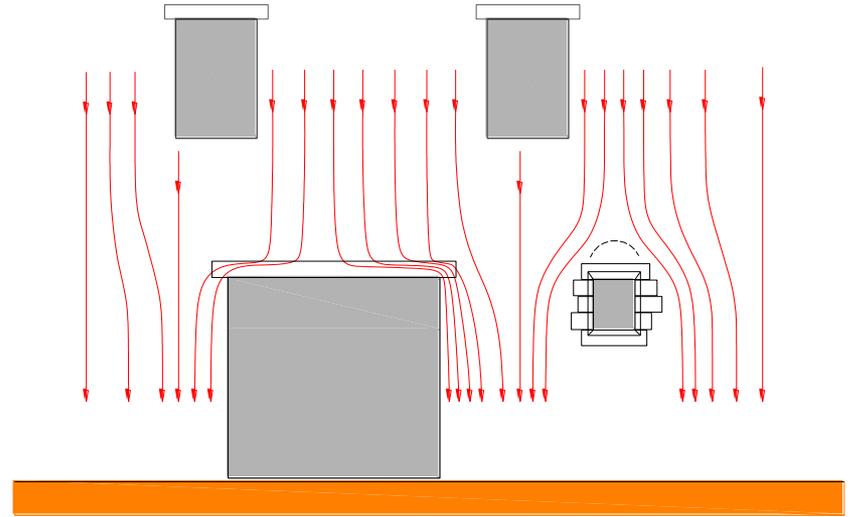


Città di Castello (PG)

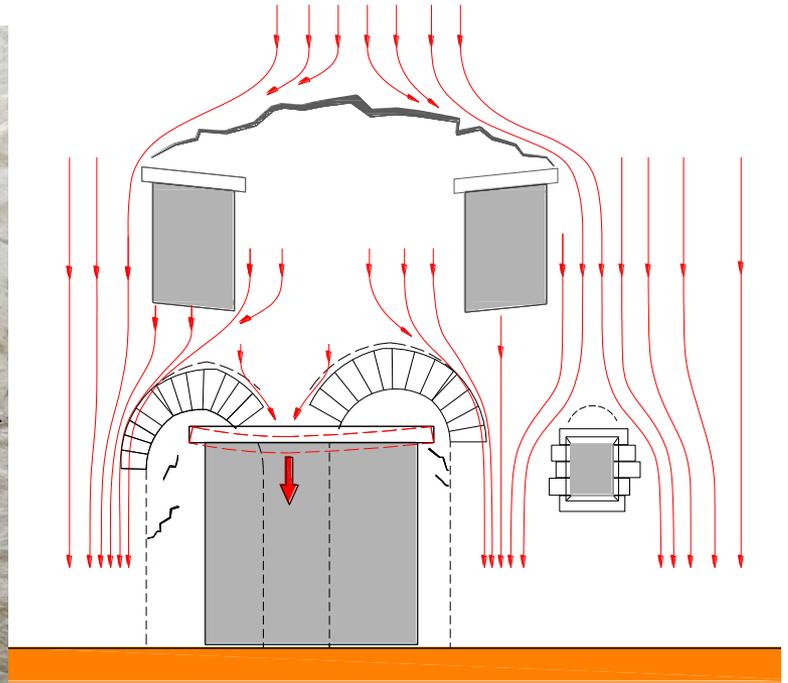
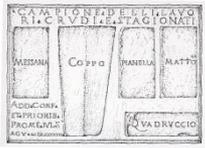
Evoluzione di una casa torre in
Corso V.Emanuele



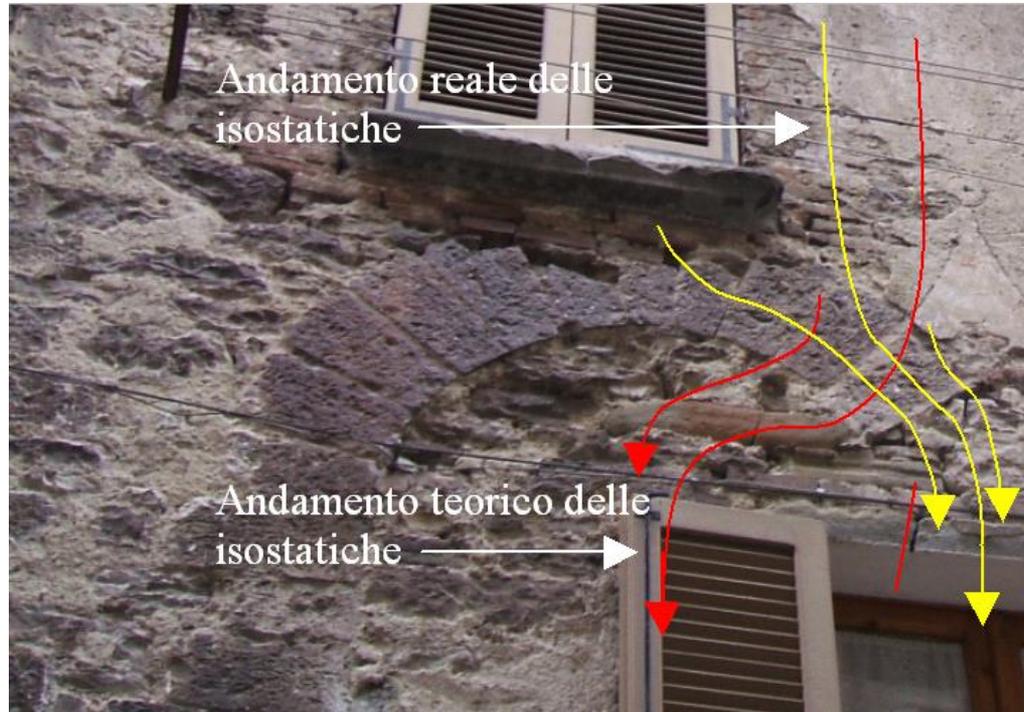
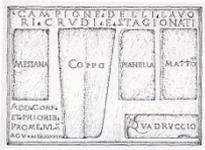
Andamento qualitativo dei flussi di compressione in una parete con aperture non allineate verticalmente



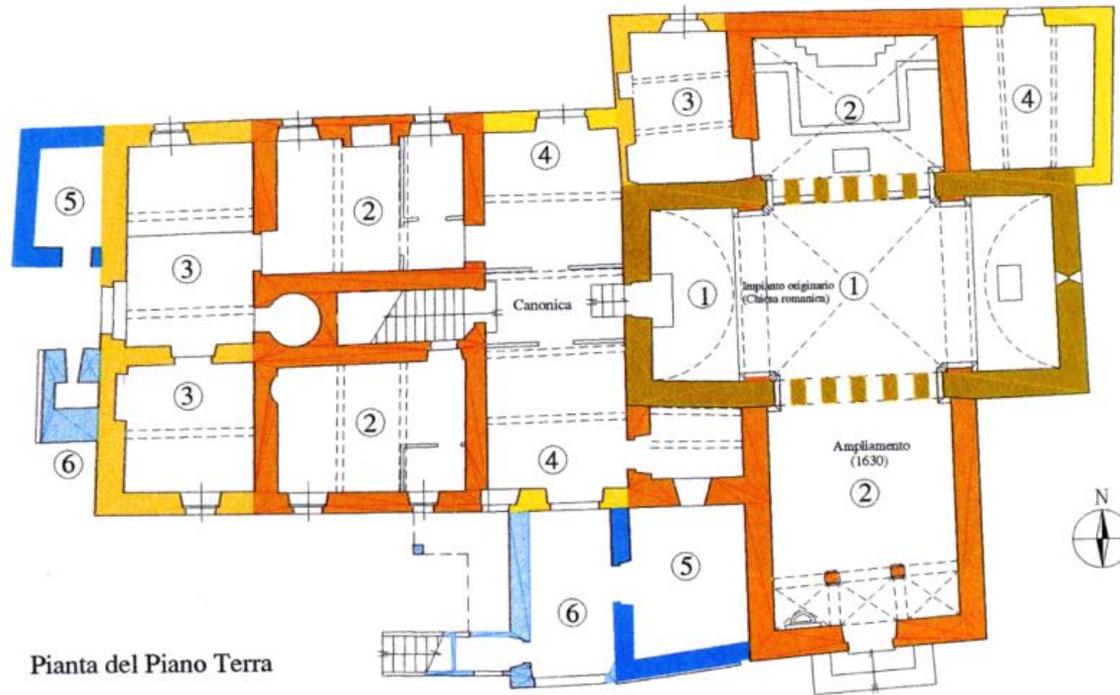
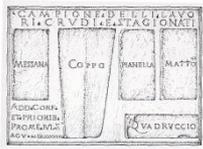
Reale andamento dei flussi di compressione nella stessa parete in funzione delle modifiche apportate al sistema di aperture originario.



Evoluzione dello stato di danno determinato dalla concentrazione degli sforzi sull'architrave, dall'eventuale cedimento flessionale e dall'assestamento della muratura agli appoggi

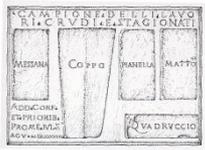


Fessurazione dell'architrave di pietra spiegabile con la presenza dell'arco "zoppo" superiore che produce la deviazione dei flussi di compressione.

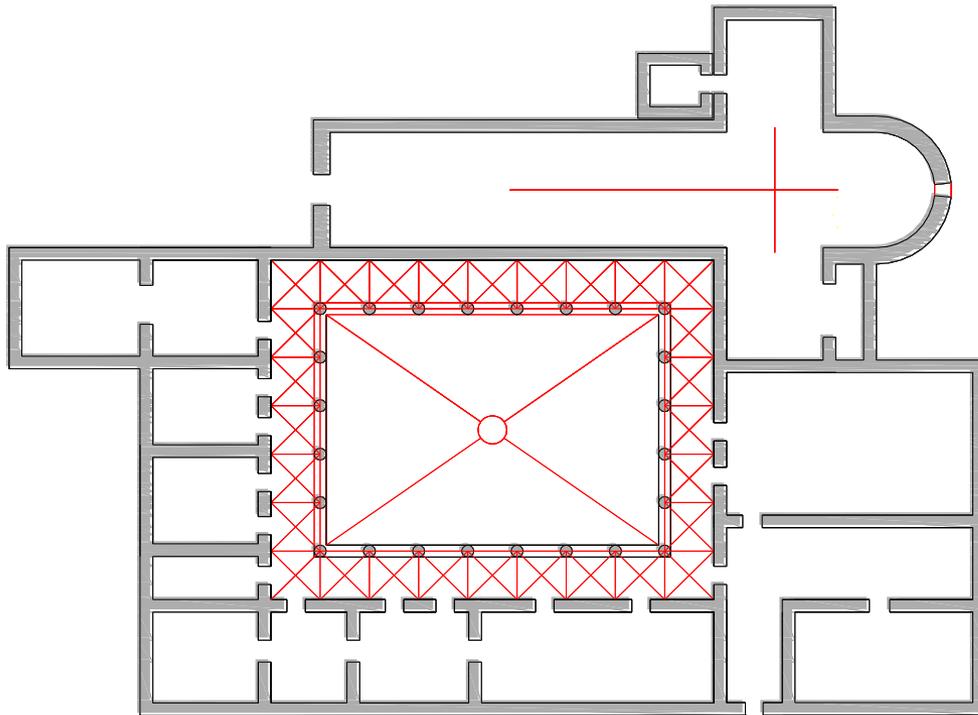


Pianta del Piano Terra

- | | | |
|-------------|-----------------|----------------|
| ① | ③ | ⑤ |
| XI-XII Sec. | XVII-XVIII Sec. | XVIII-XIX Sec. |
| ② | ④ | ⑥ |
| XVII Sec. | XVIII Sec. | XIX-XX Sec. |

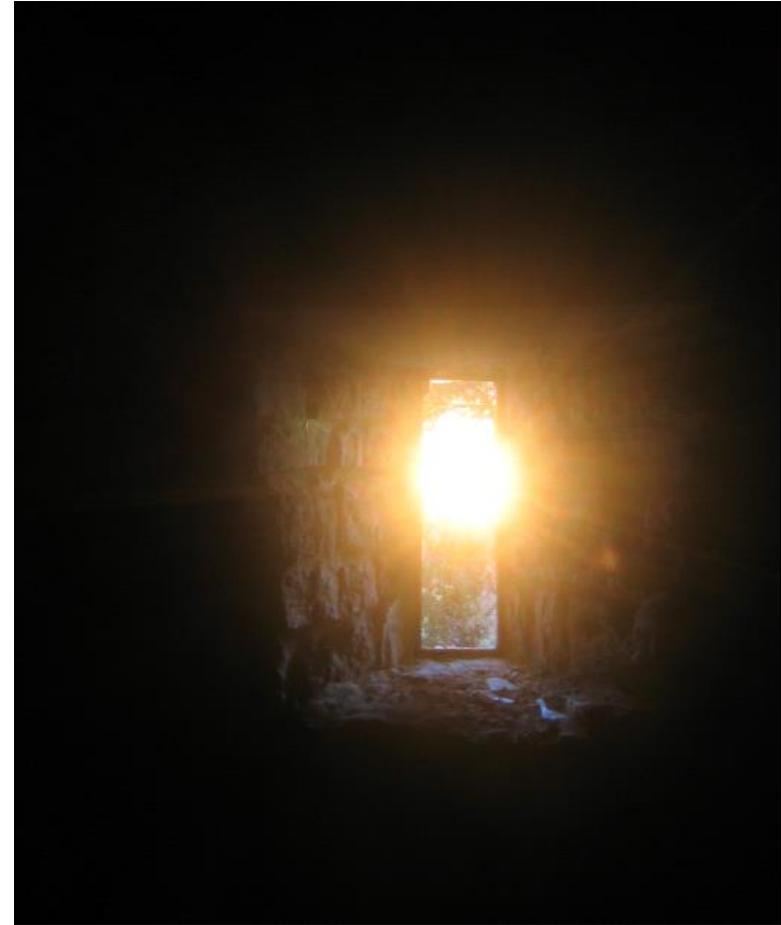


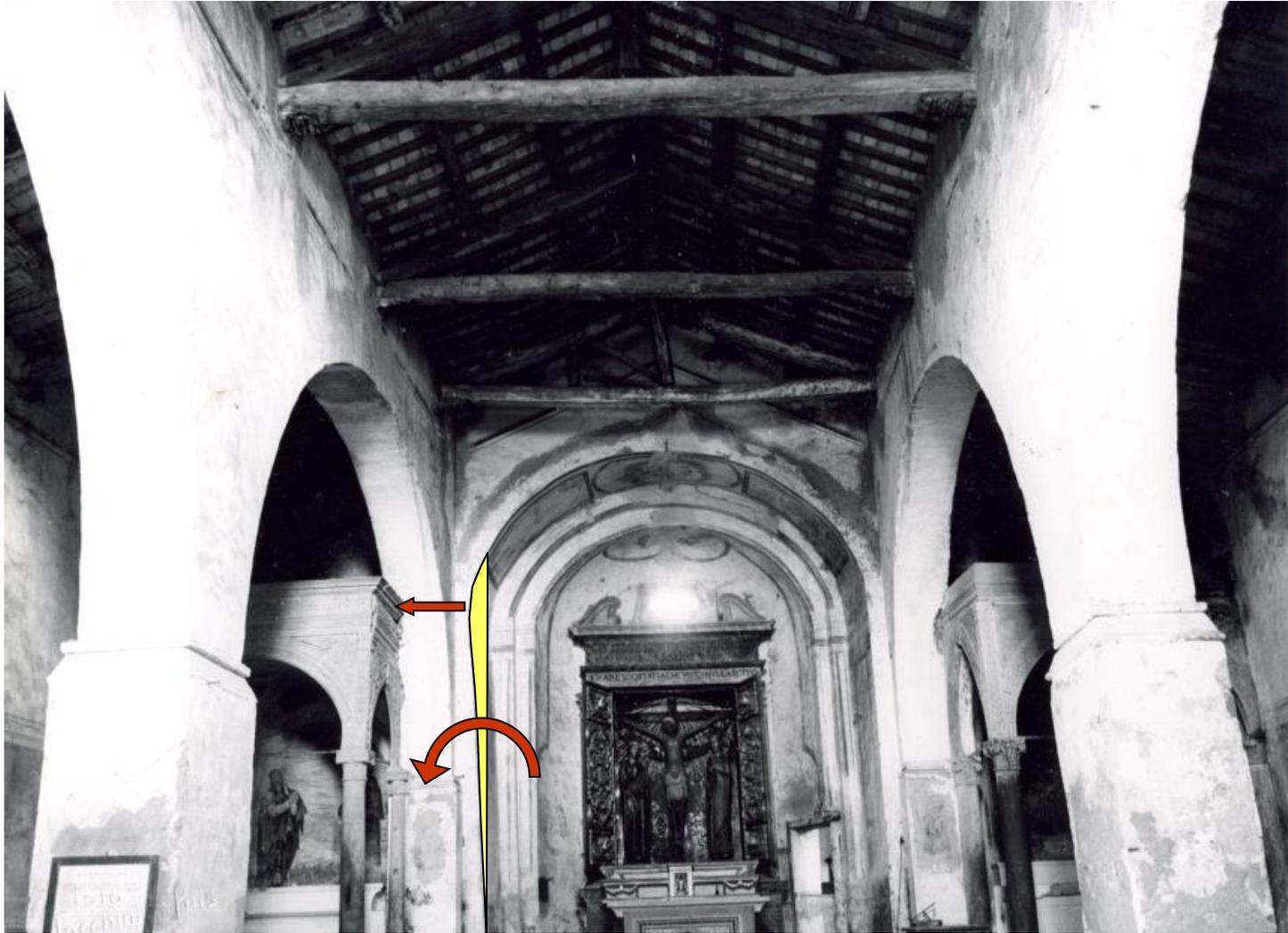
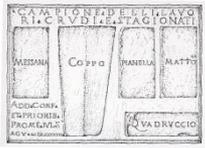
ASPETTI TIPOLOGICI STRUTTURALI



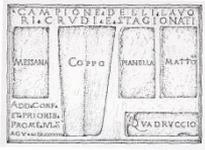
Relazione diretta fra tipologia edilizia e tipo di danno:

l'esempio delle chiese romaniche





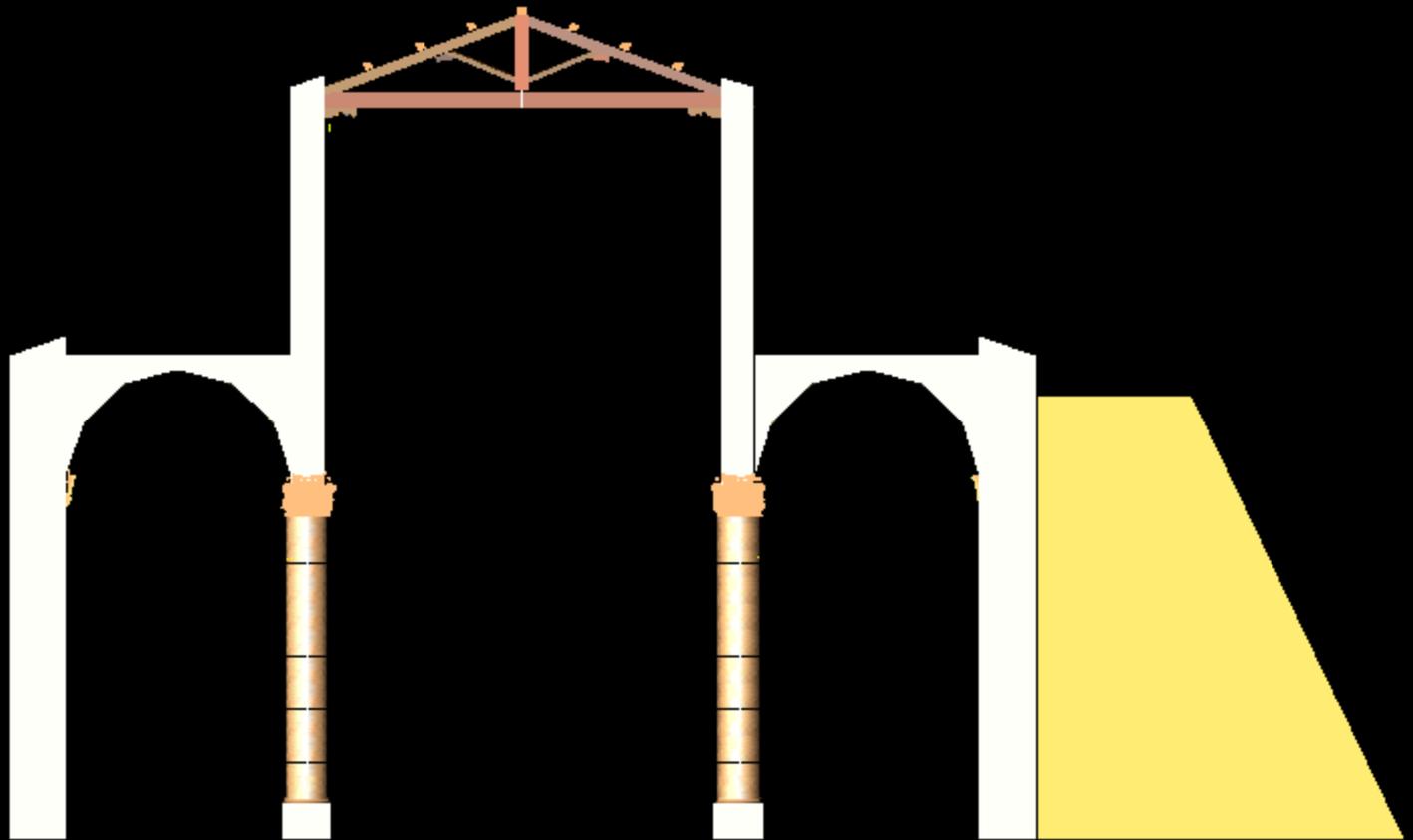
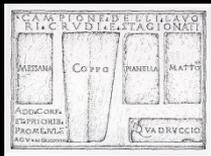
Pieve romanica di San Gregorio Montone (PG)



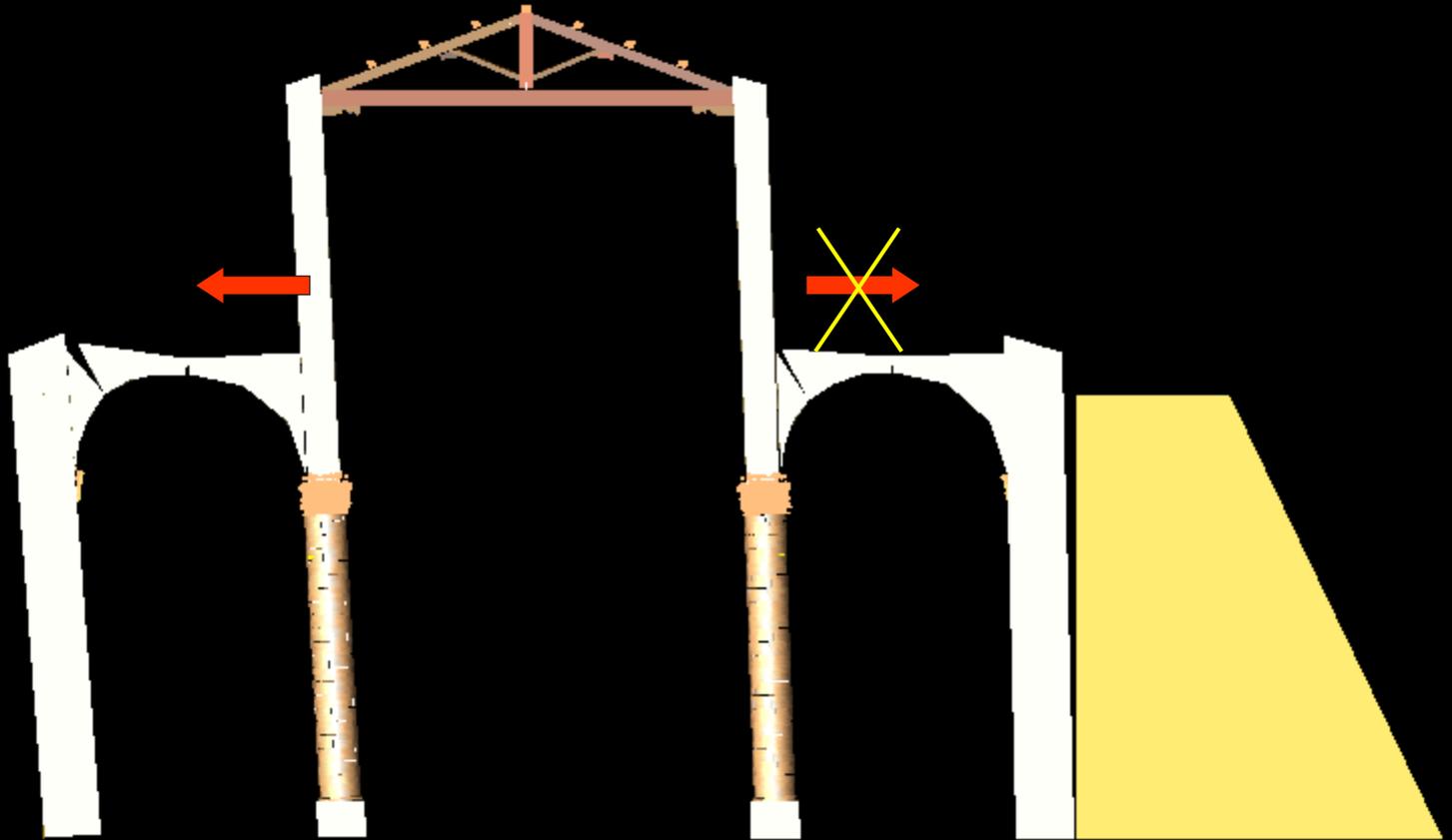
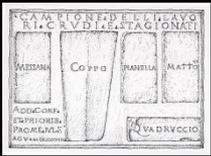
San Donato di Scoiano – Anghiari (AR)



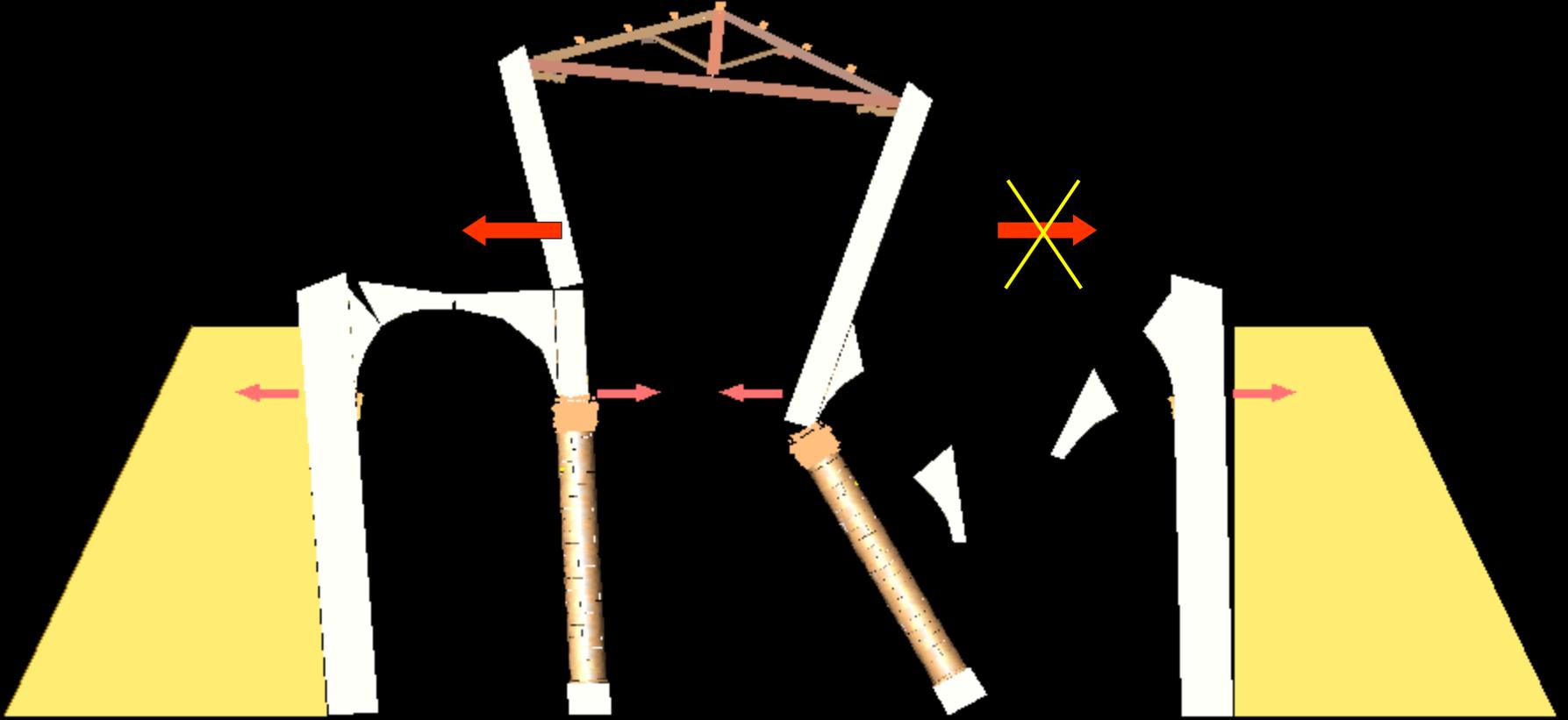
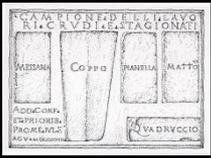
Santa Croce di Citerna (PG)



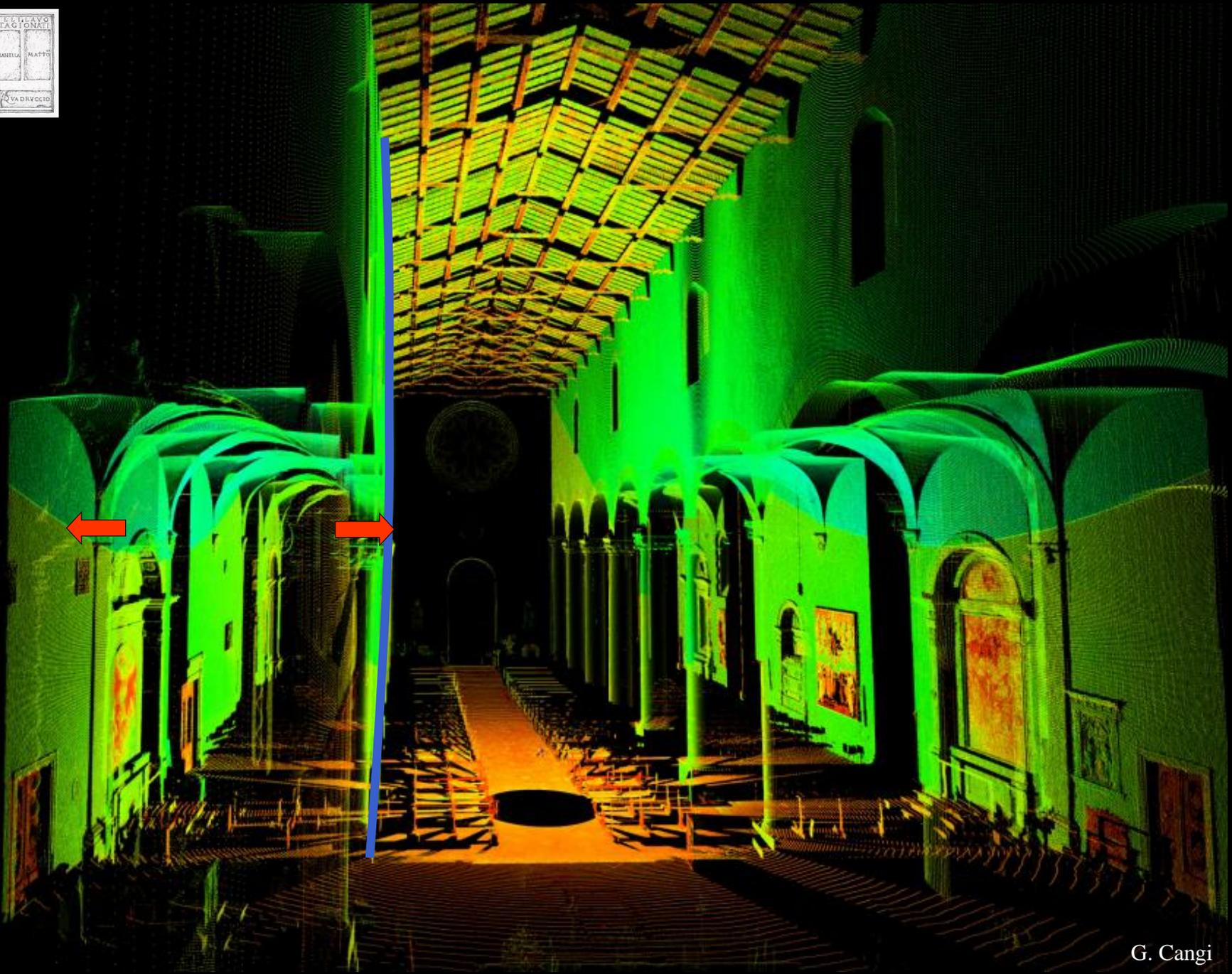
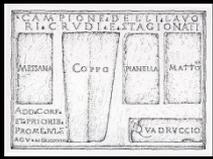
Duomo di Sansepolcro (AR)

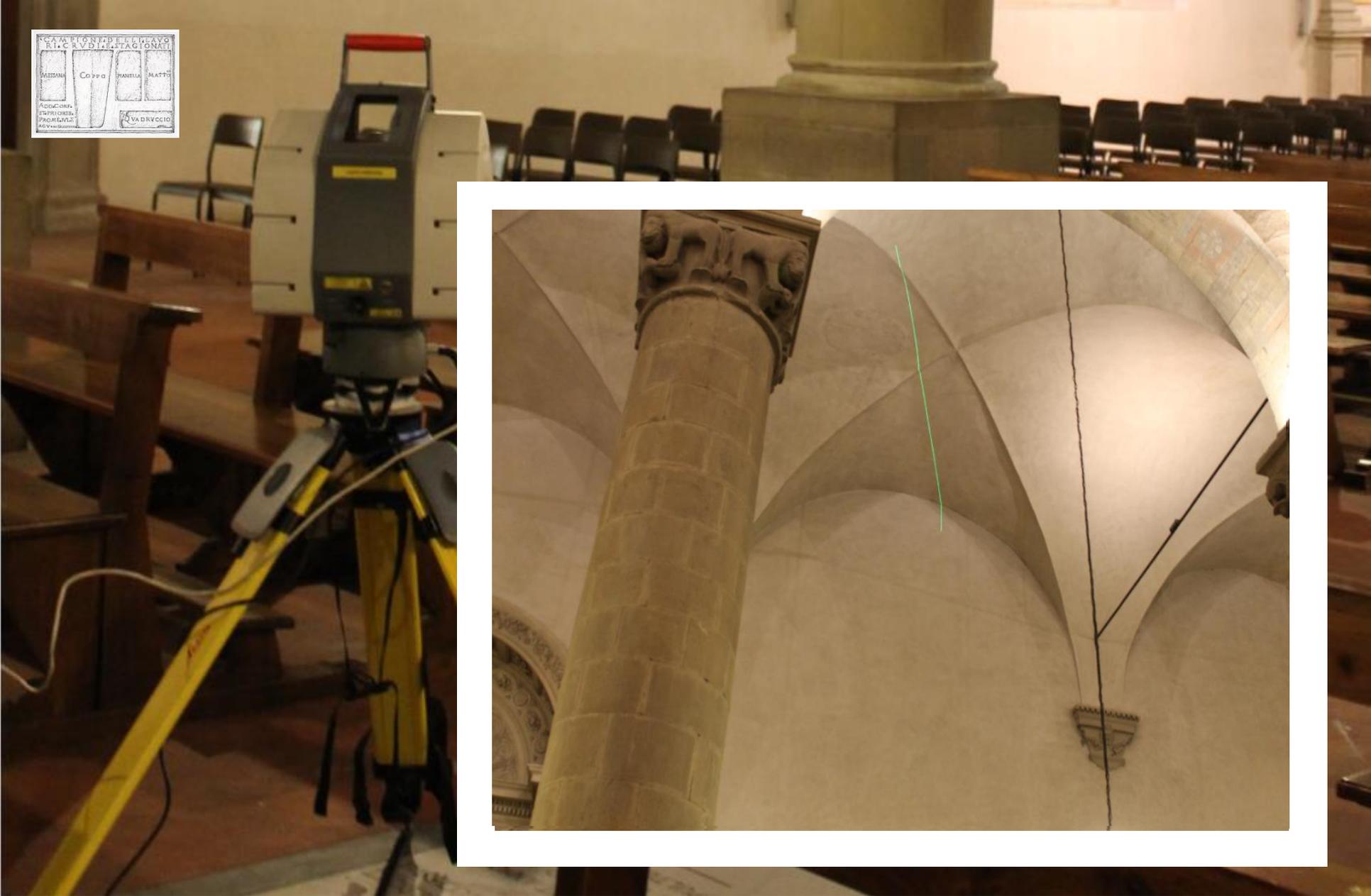


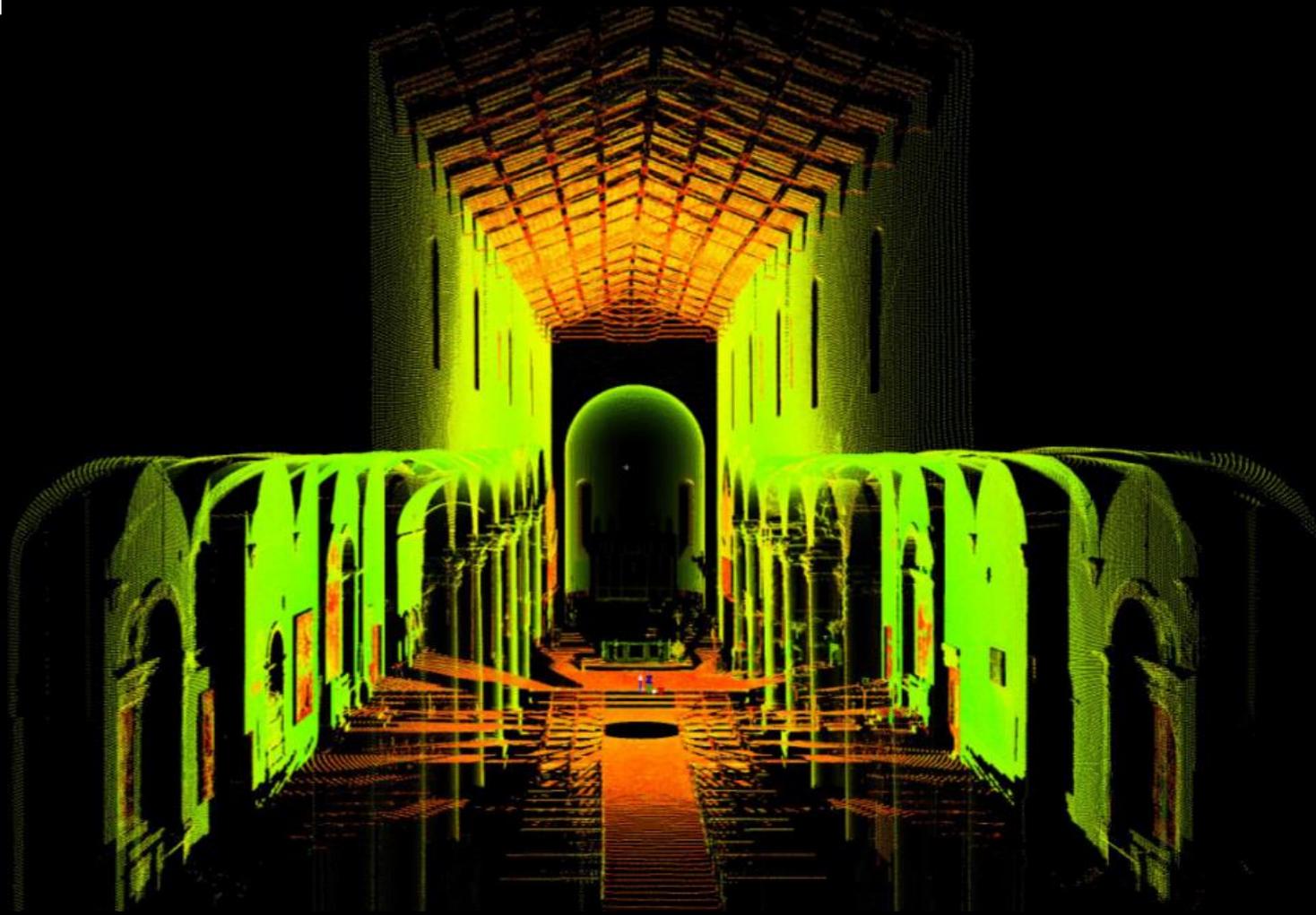
Duomo di Sansepolcro (AR)



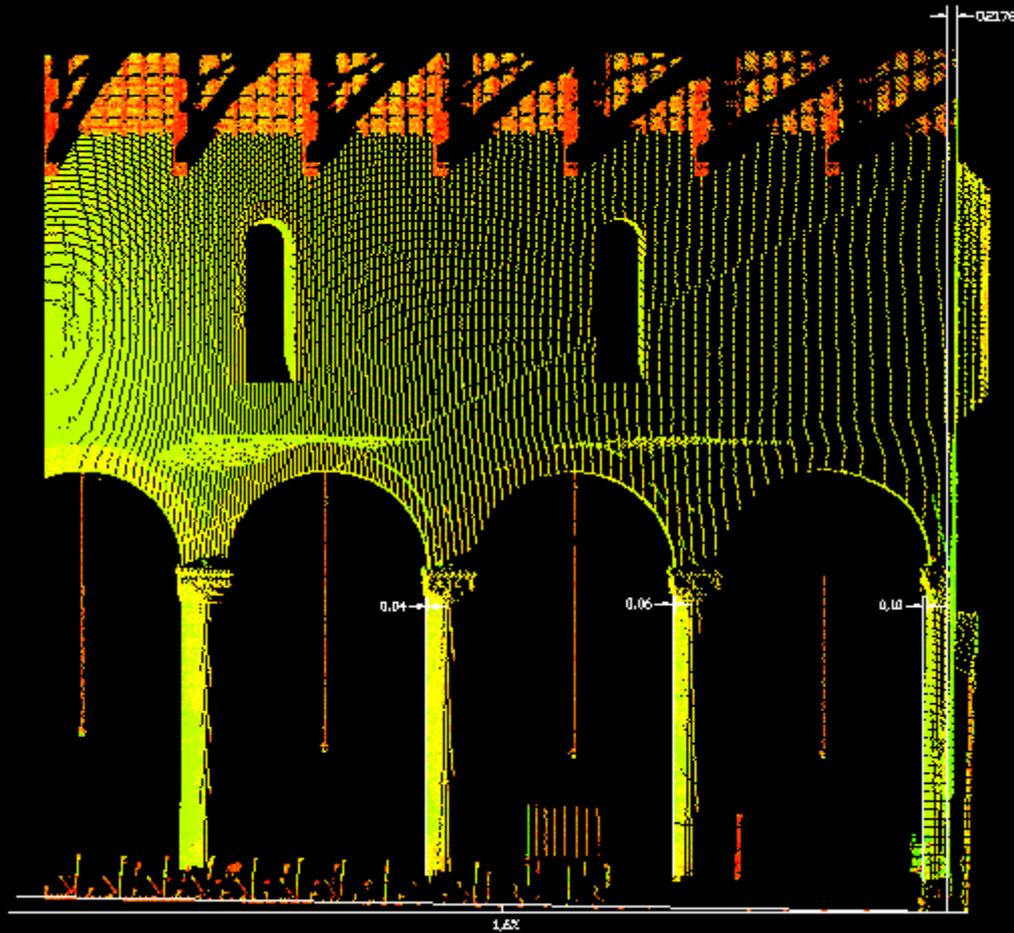
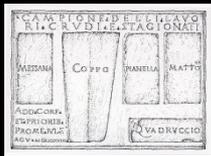
Duomo di Sansepolcro (AR)





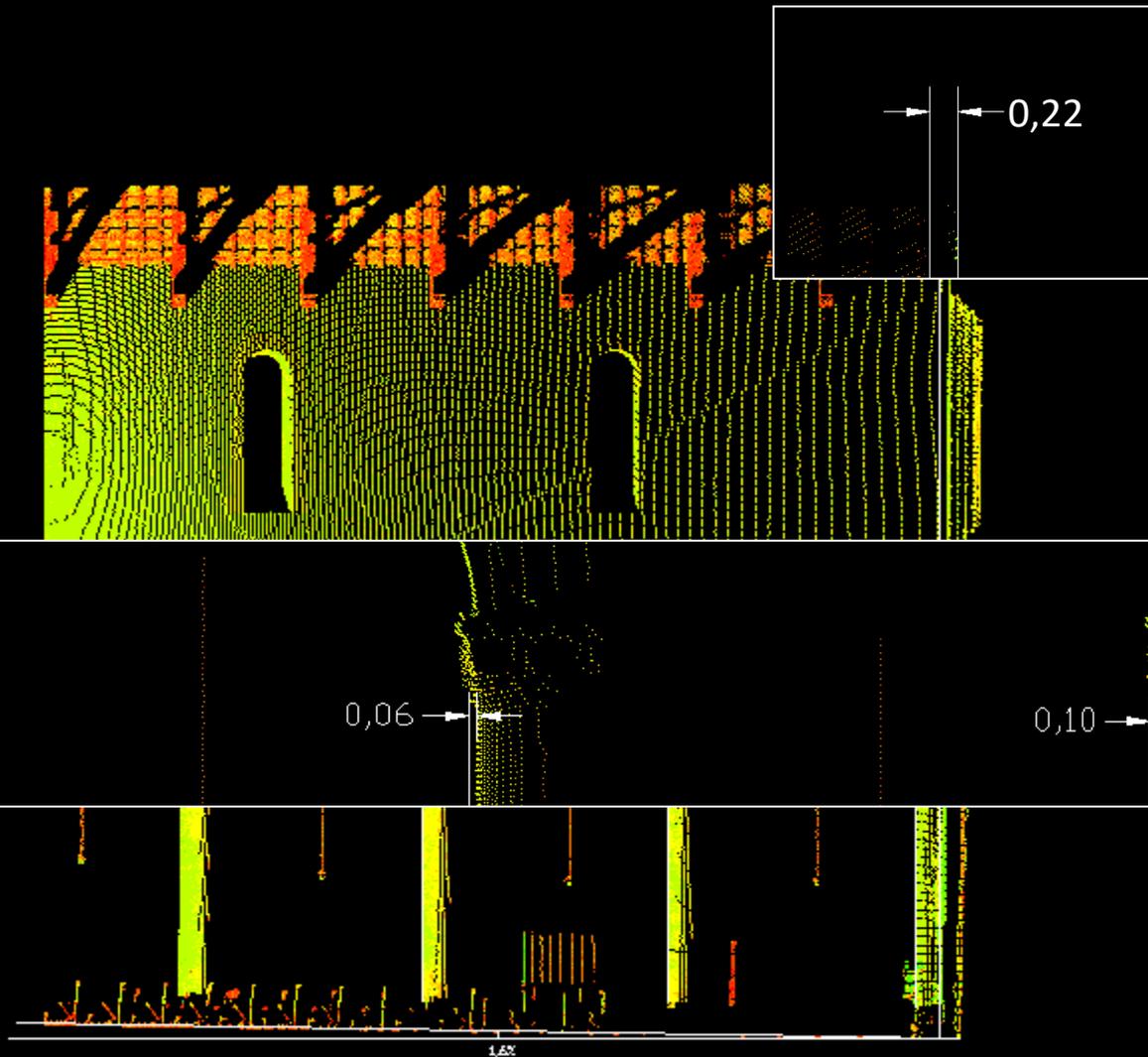
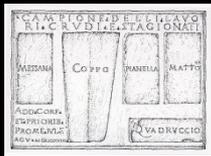


Duomo di Sansepolcro (AR)



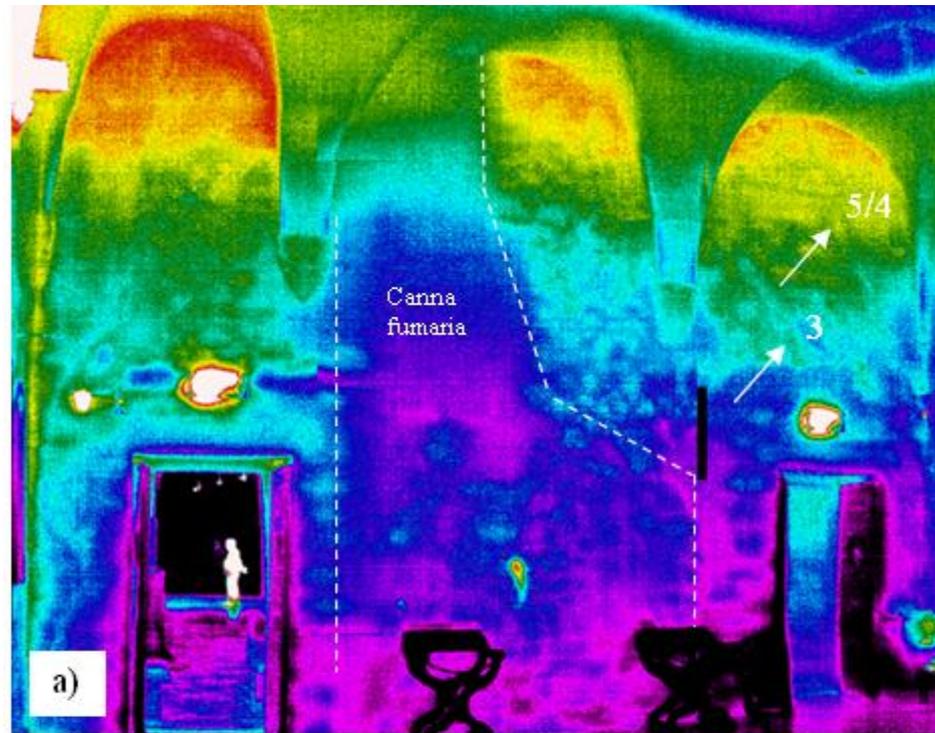
1917 Terremoto di Citerna-Monterchi
Atterrato il timpano della chiesa e scosse due ultime arcate della navata centrale sopra l'organo

Duomo di Sansepolcro (AR)



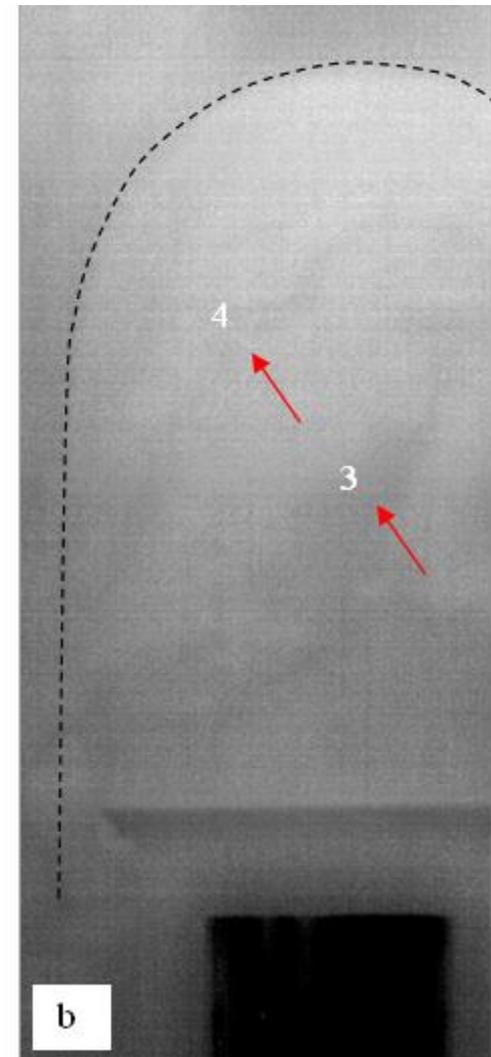
1917 Terremoto di Citerna-Monterchi
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Duomo di Sansepolcro (AR)

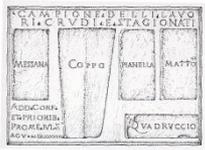


Immagini termografiche della parete affrescata:

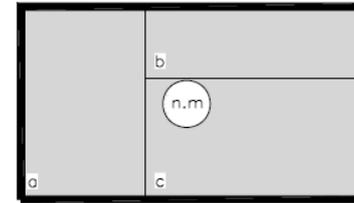
- lato a): sala Matteo di Giovanni;
In evidenza il profilo della canna fumaria e del vano del camino.
In vano della canna fumaria, sebbene posto dietro l'affresco, risulta spostato nettamente sul lato della sala retrostante.
- lato b): sala Piero Della Francesca (particolare sopra la porta sinistra)
I due aloni scuri corrispondono alle lesioni n. 3 e n. 4 riconoscibili anche nell'inquadratura lato a).



Rilievo termografico condotto dal Laboratorio Las.E.R. dell'Università degli Studi dell'Aquila – Facoltà di Ingegneria Dipartimento di Ingegneria Meccanica, Energetica e Gestionale, per conto dell'Opificio delle Pietre Dure di Firenze.



Maglia tipo

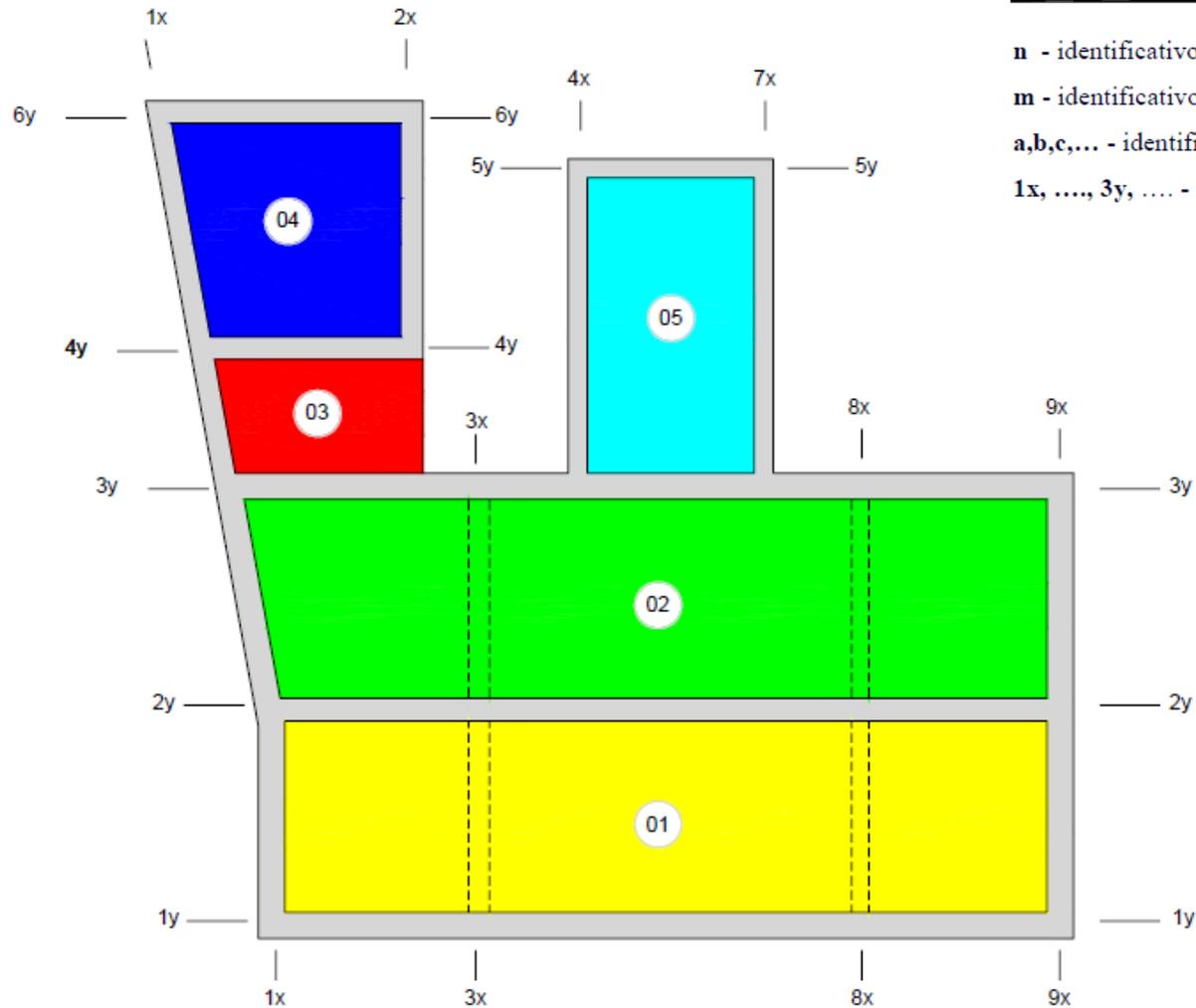


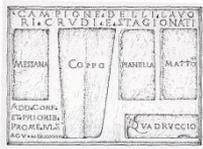
n - identificativo della maglia muraria

m - identificativo del piano (T, 1, 2, 3)

a,b,c,... - identificativo ambiente

1x, ..., 3y, ... - identificazione delle pareti portanti





STRUTTURE VOLTATE

PIANTA	ORTOGONALE PROSPETTO		PARALLELO PROSPETTO		
	fronte	retro	fronte	retro	
					volta a botte
					volta a crociera
					volta a padiglione

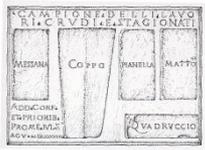
SOLAI

fronte	retro	
		solaio in legno
		solaio a voltine



DISSESTI

PIANTA	PROSPETTO	DESCRIZIONE SIMBOLO	PIANTA	PROSPETTO	DESCRIZIONE SIMBOLO
		crollo			lesione isolata associata a cinematismo di rotazione
		fuori piombo - spianciamento			scorrimento di facciata
		sfilamento testate travi			depressione della volta
		lesioni diffuse			inflessione solaio
		lesione isolata associata a traslazione orizzontale			architrave
		lesione isolata associata a traslazione verticale			infiltrazioni o umidità

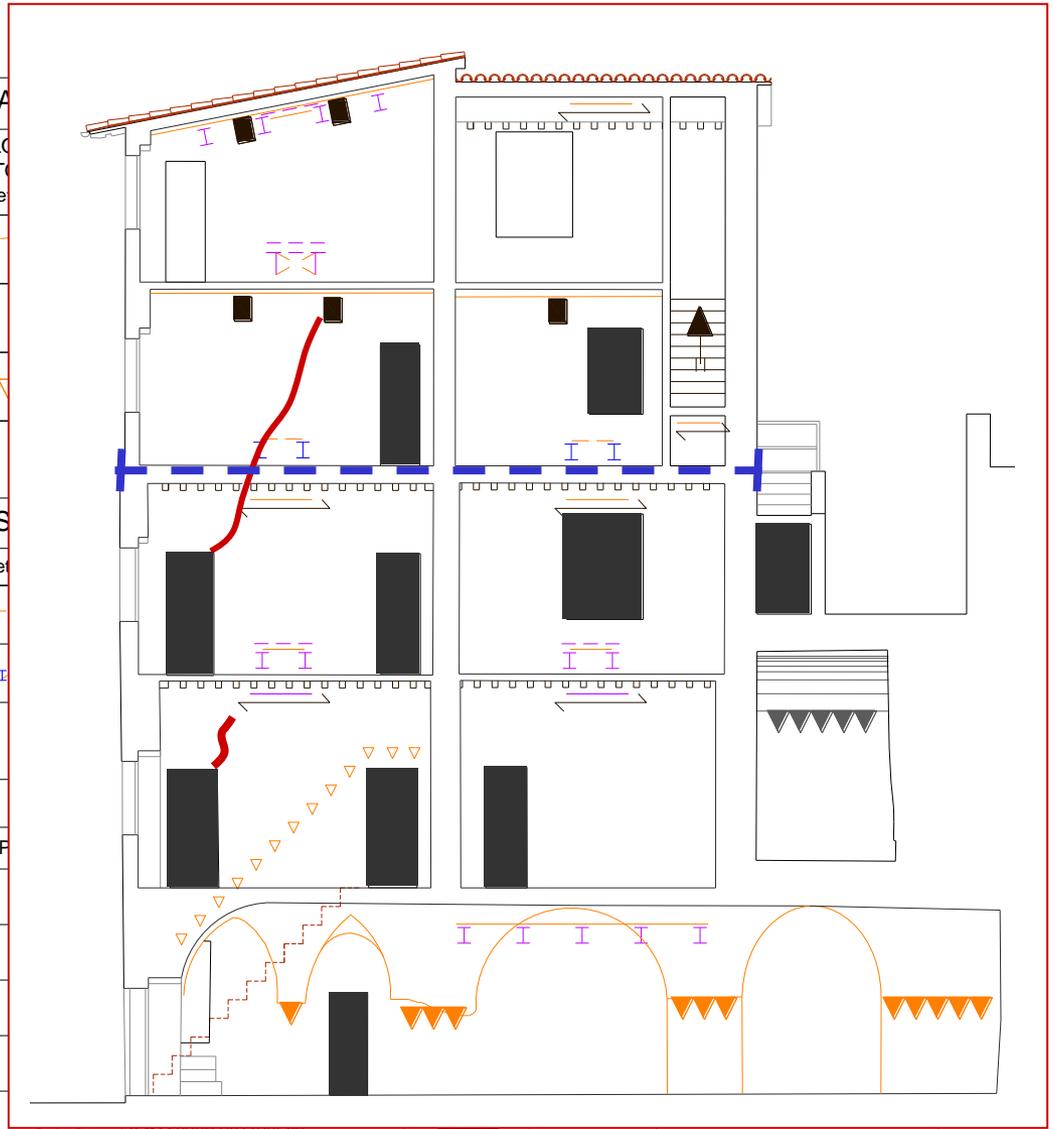


STRUTTURE VOLTA

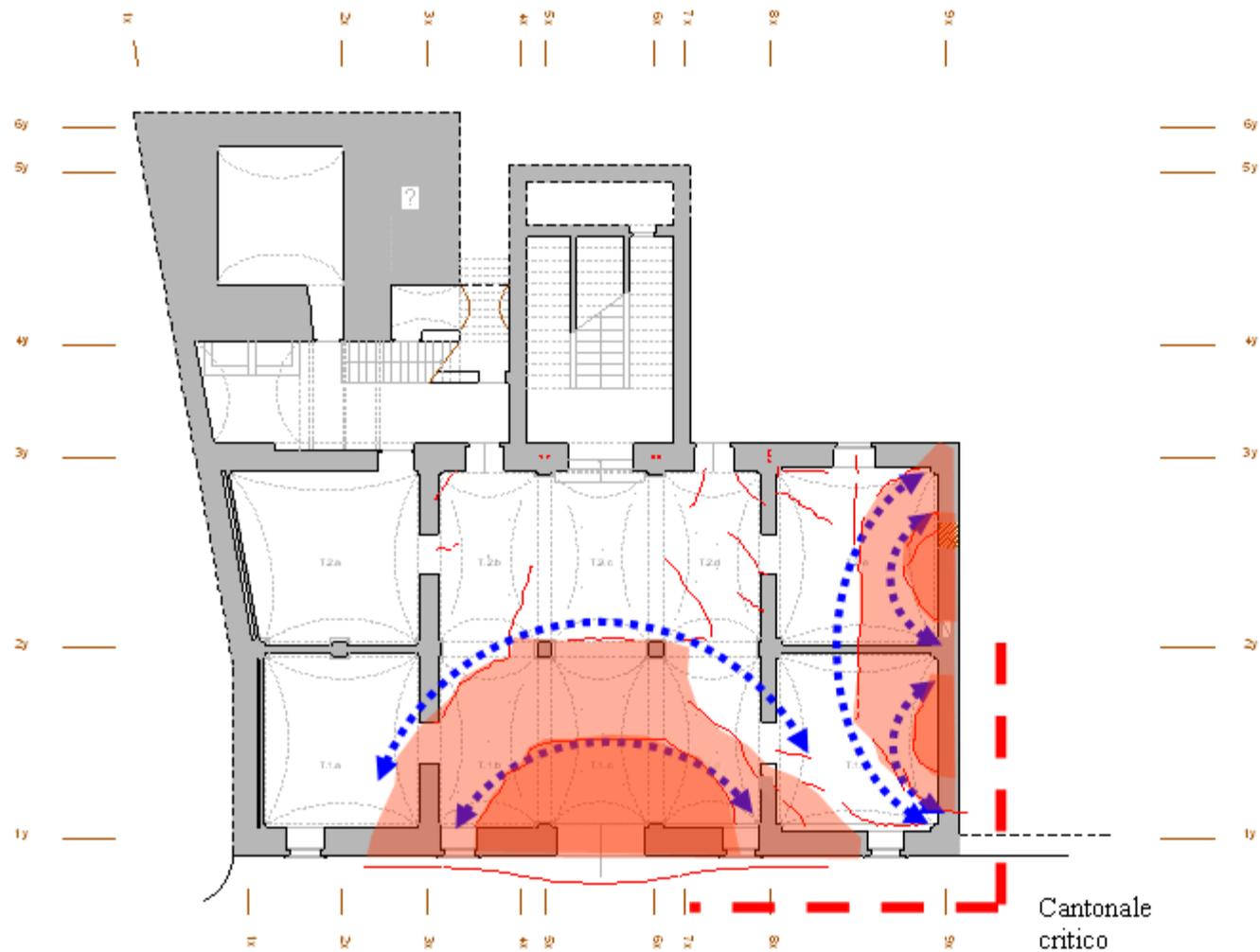
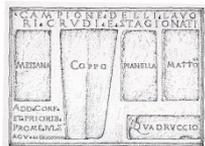
PIANTA	ORTOGONALE PROSPETTO		PARALLELO PROSPETTO	
	fronte	retro	fronte	retro

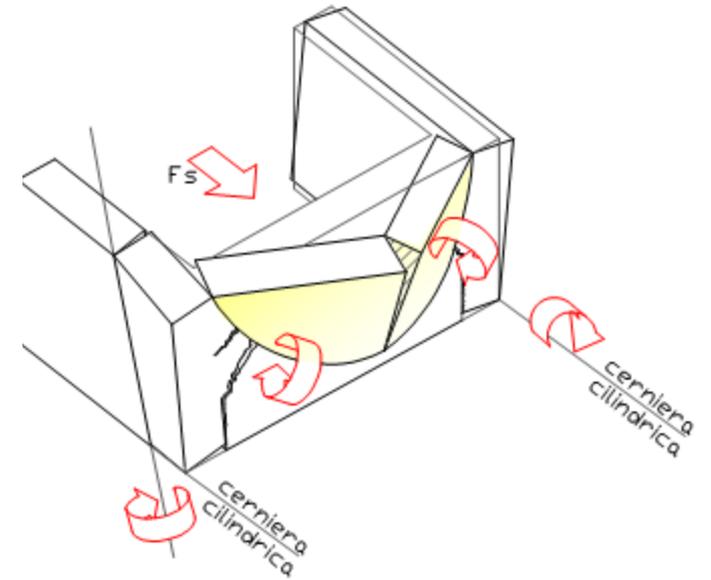
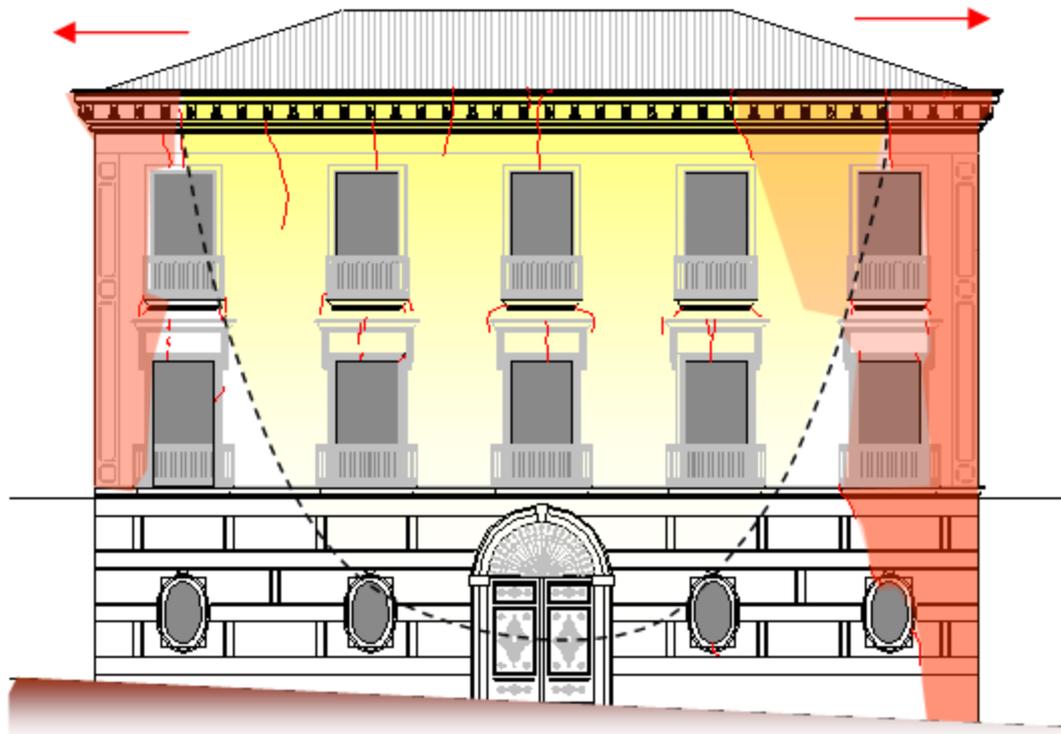
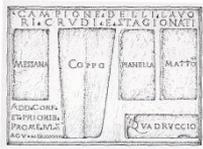
S	
fronte	retro

PIANTA	

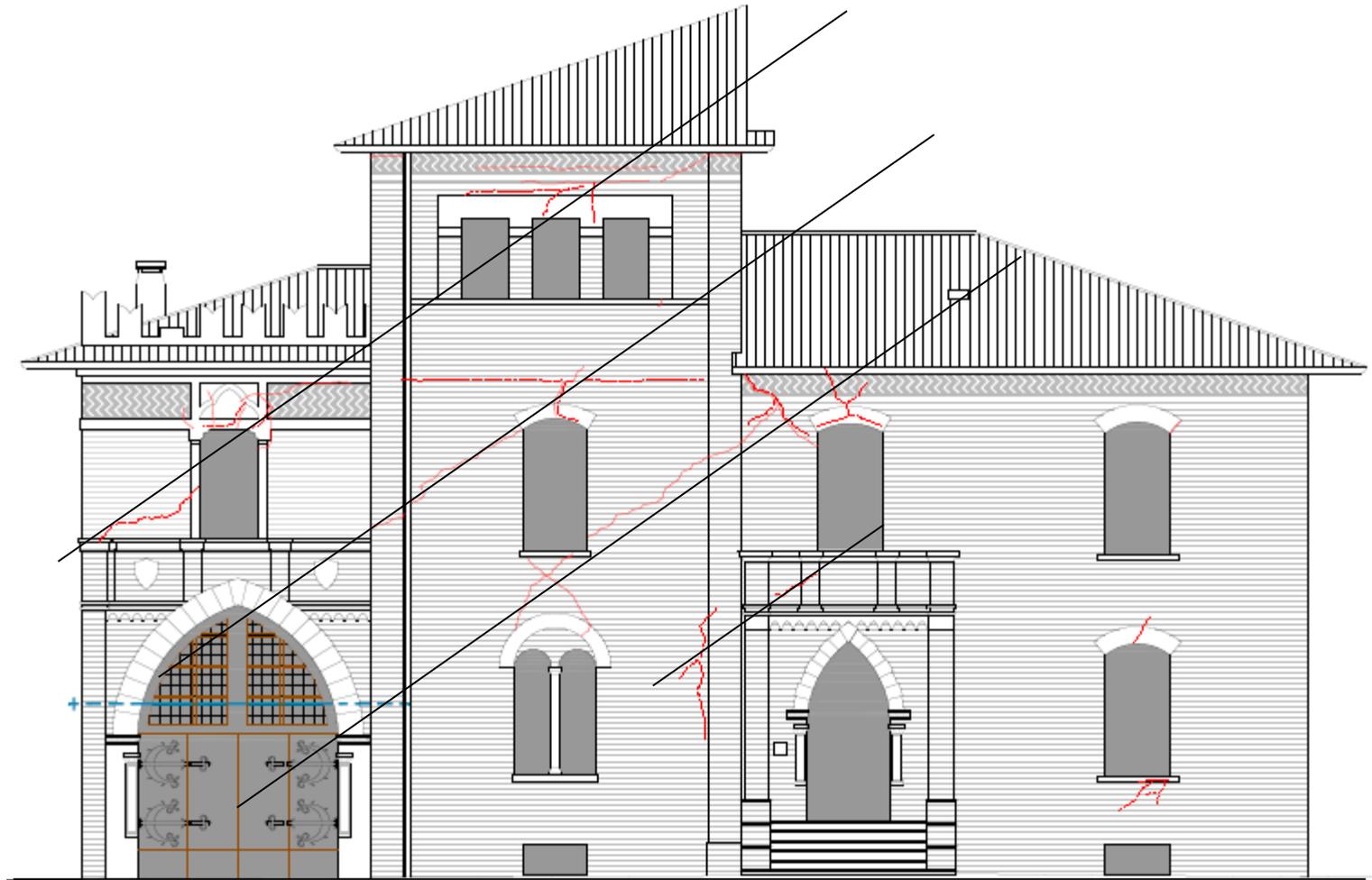
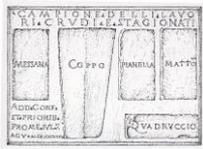


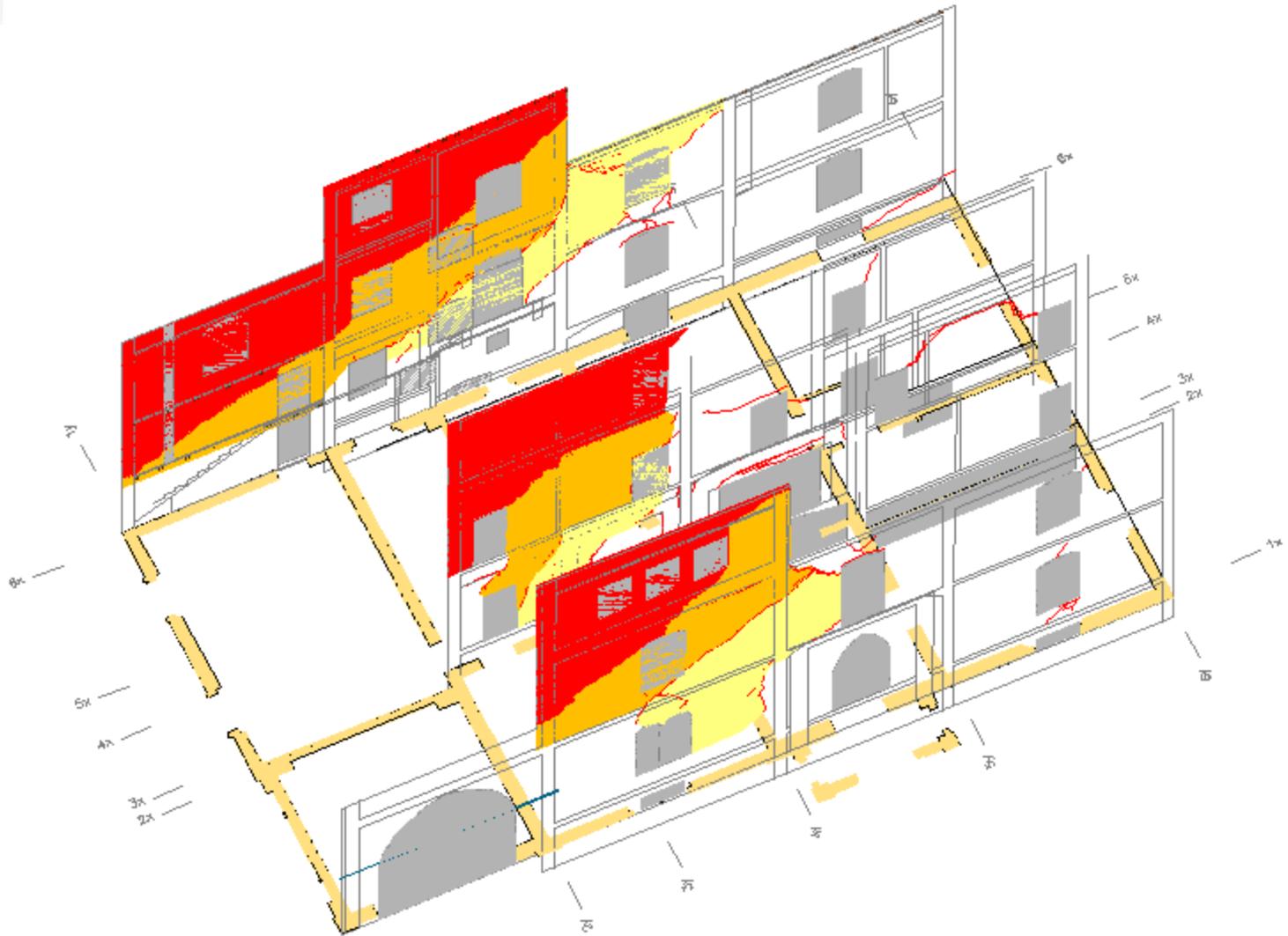
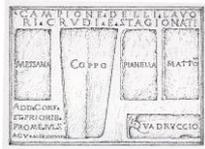
	traslazione orizzontale			infiltrazioni o umidità
	lesione isolata associata a traslazione verticale			

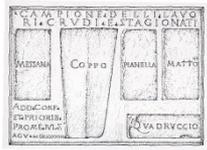




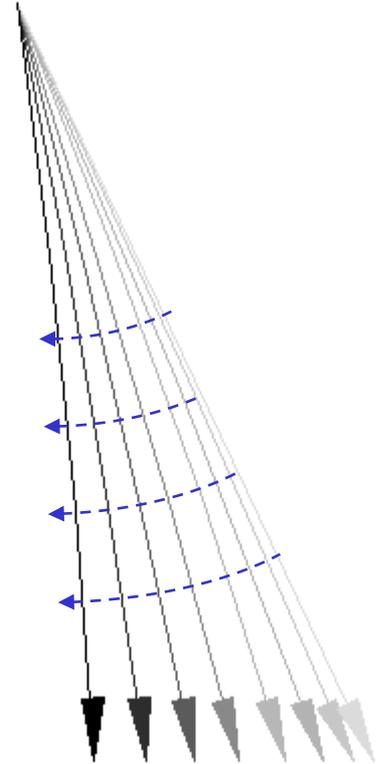
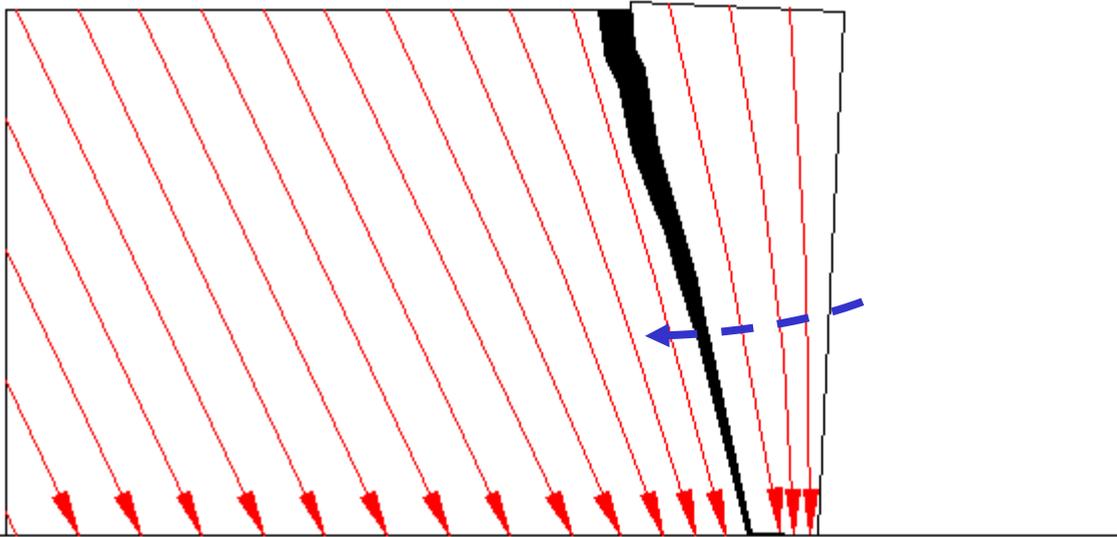
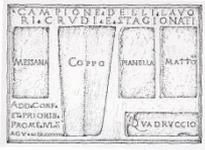
Schema di dissesto della parete di facciata per effetto di azioni sismiche complanari e ortogonali

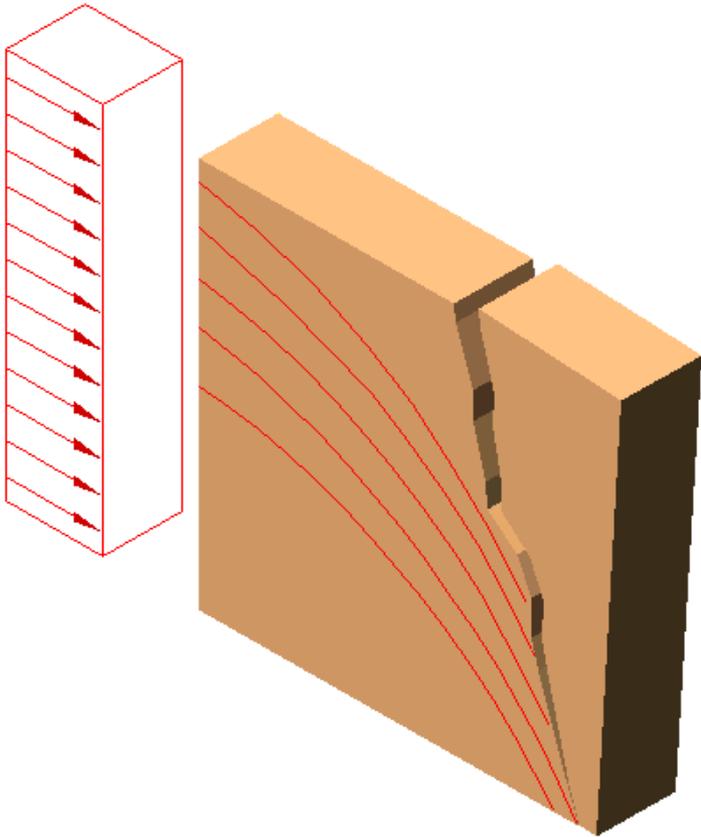
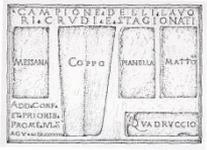


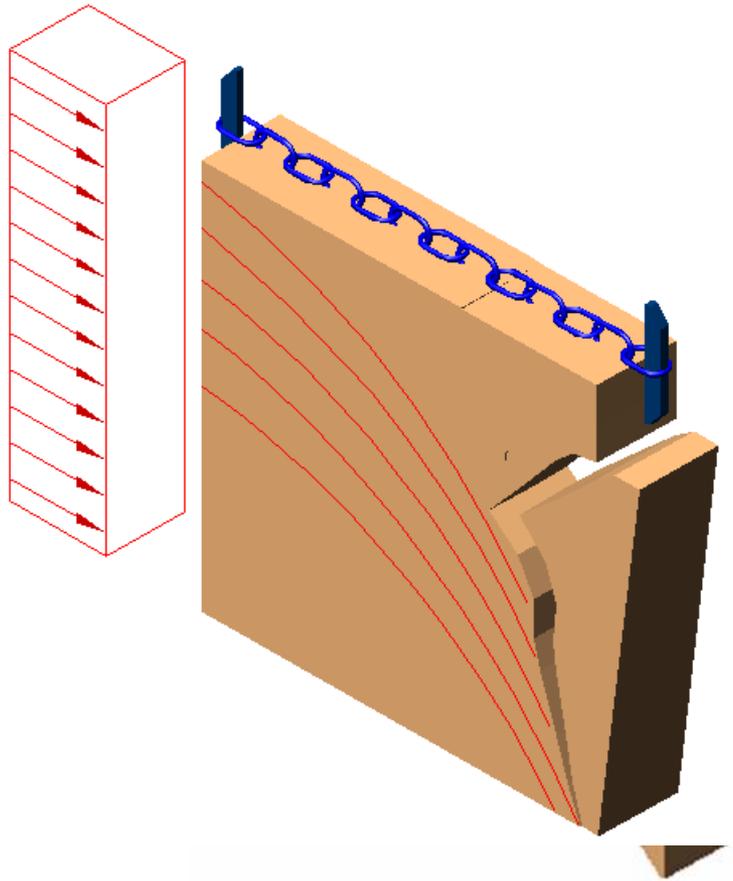
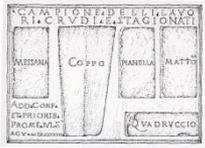


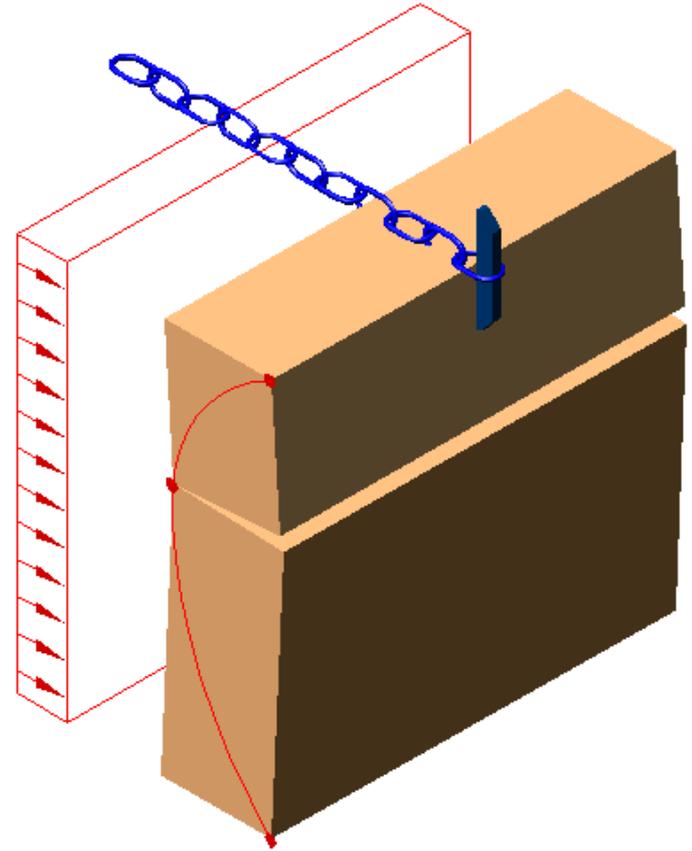
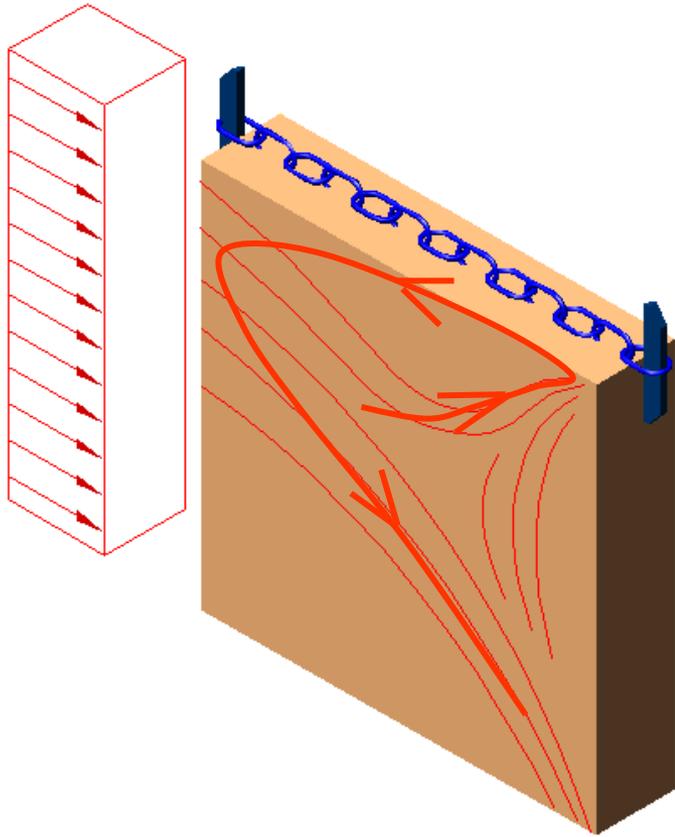
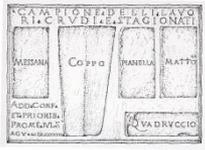


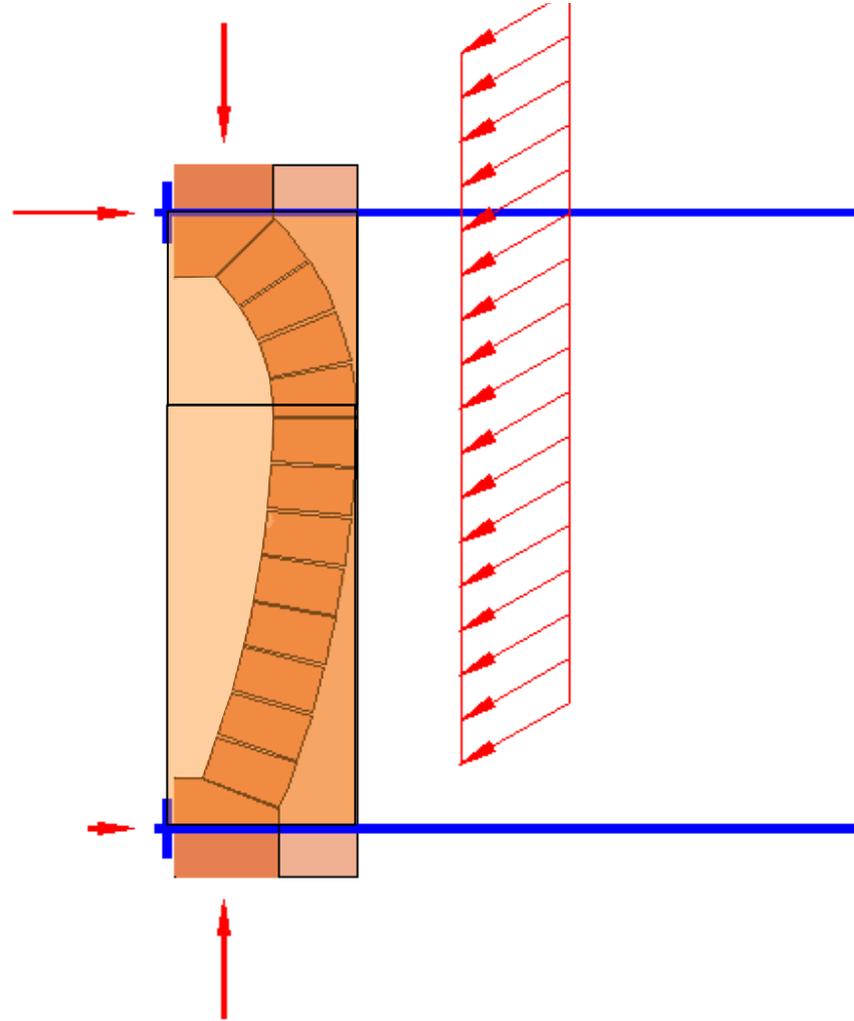
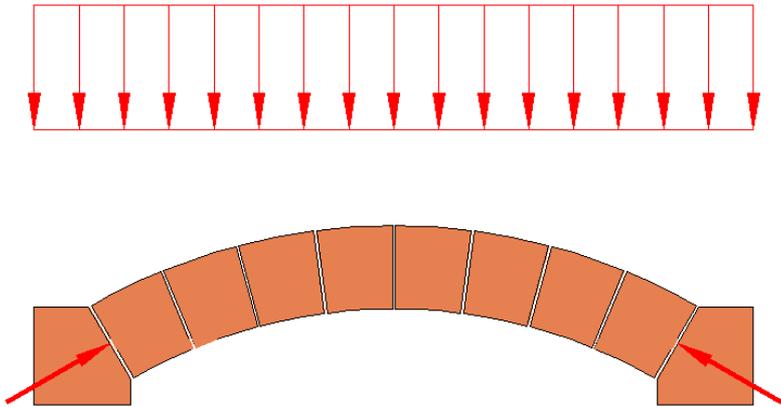
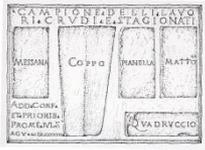
Cinematismi elementari

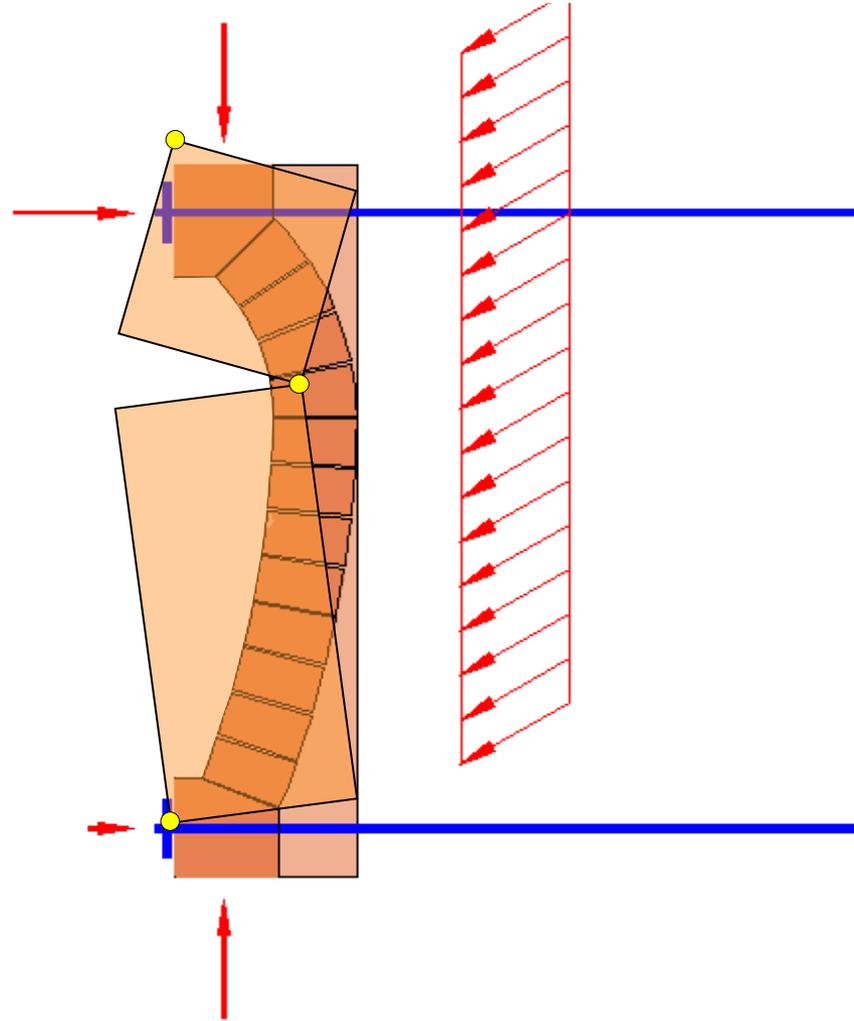
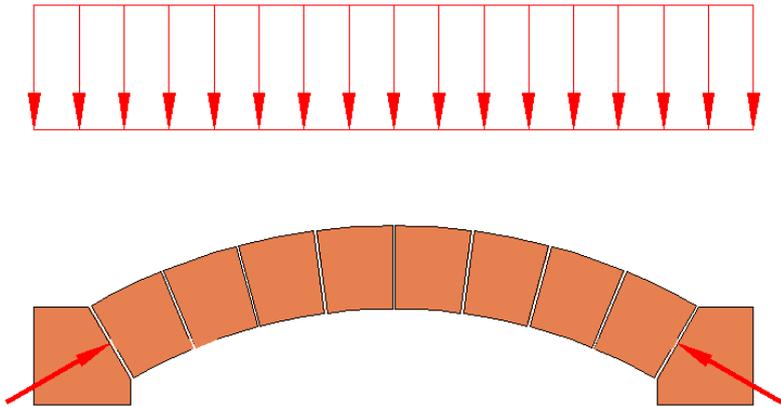
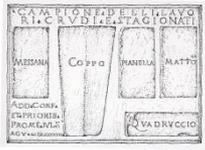


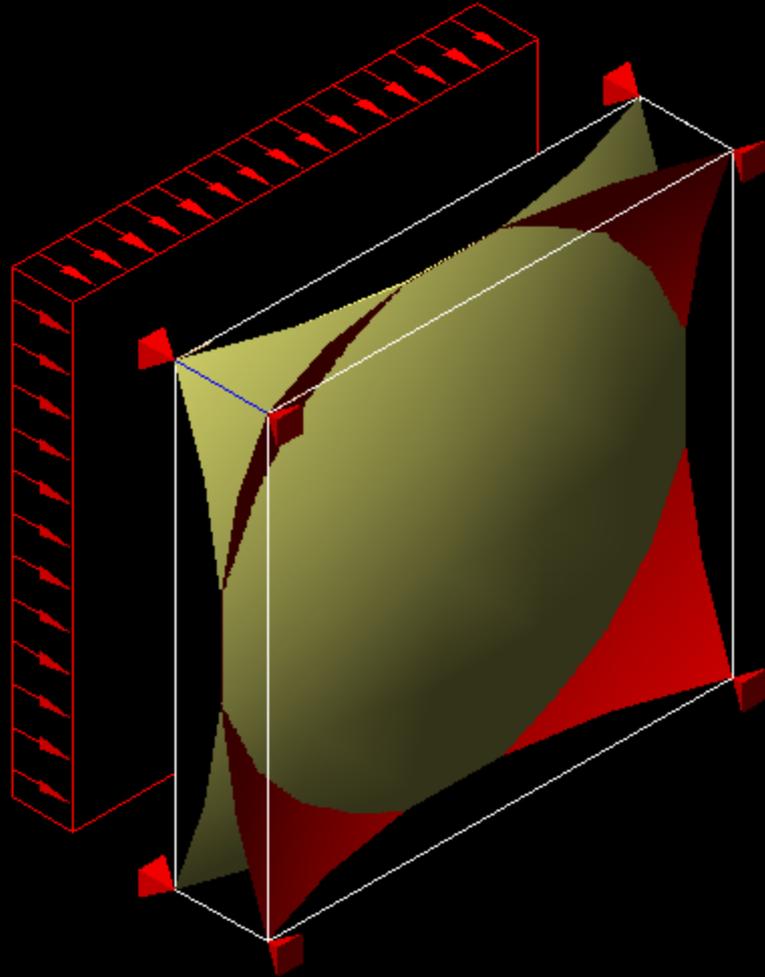
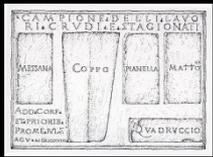


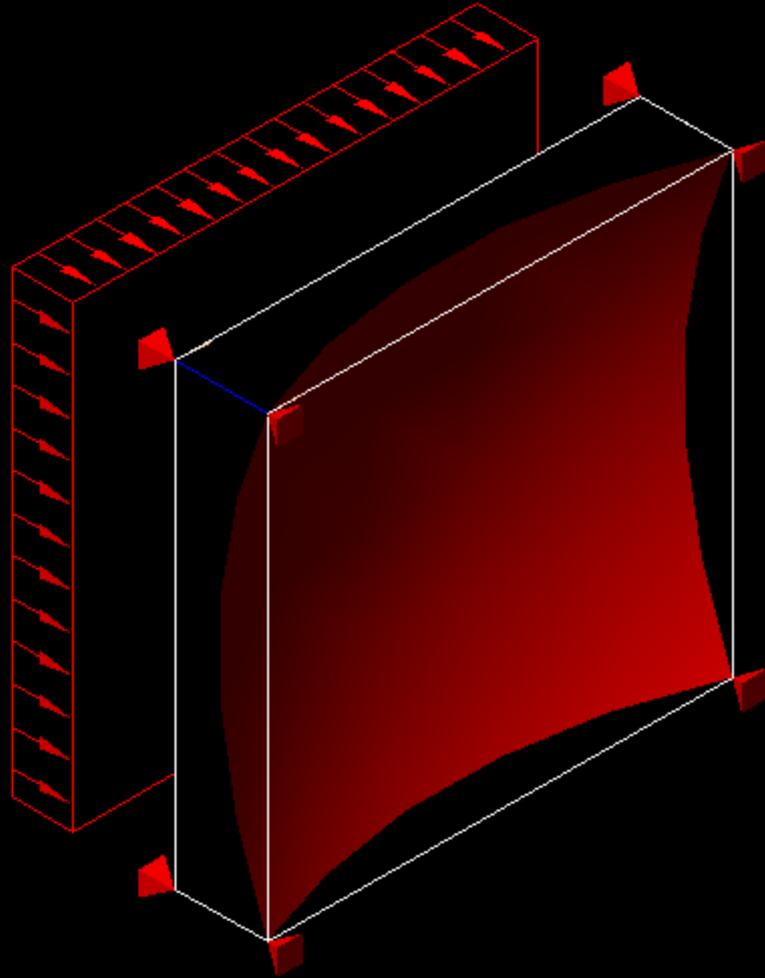
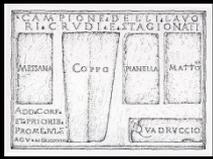


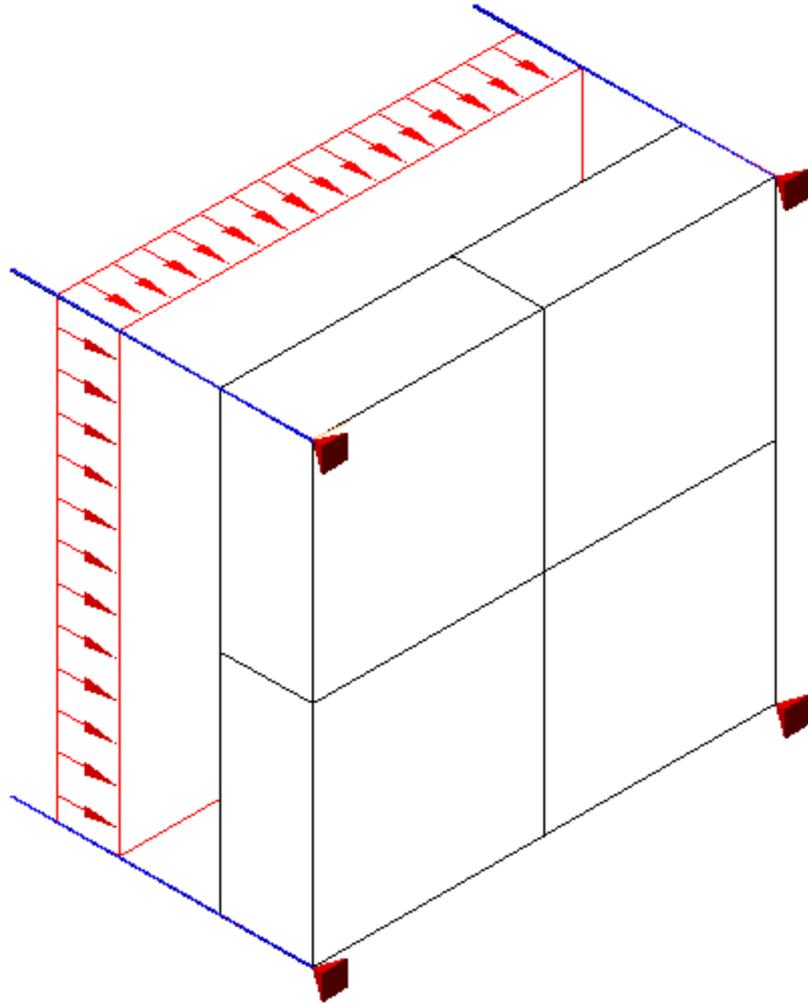
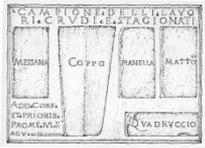


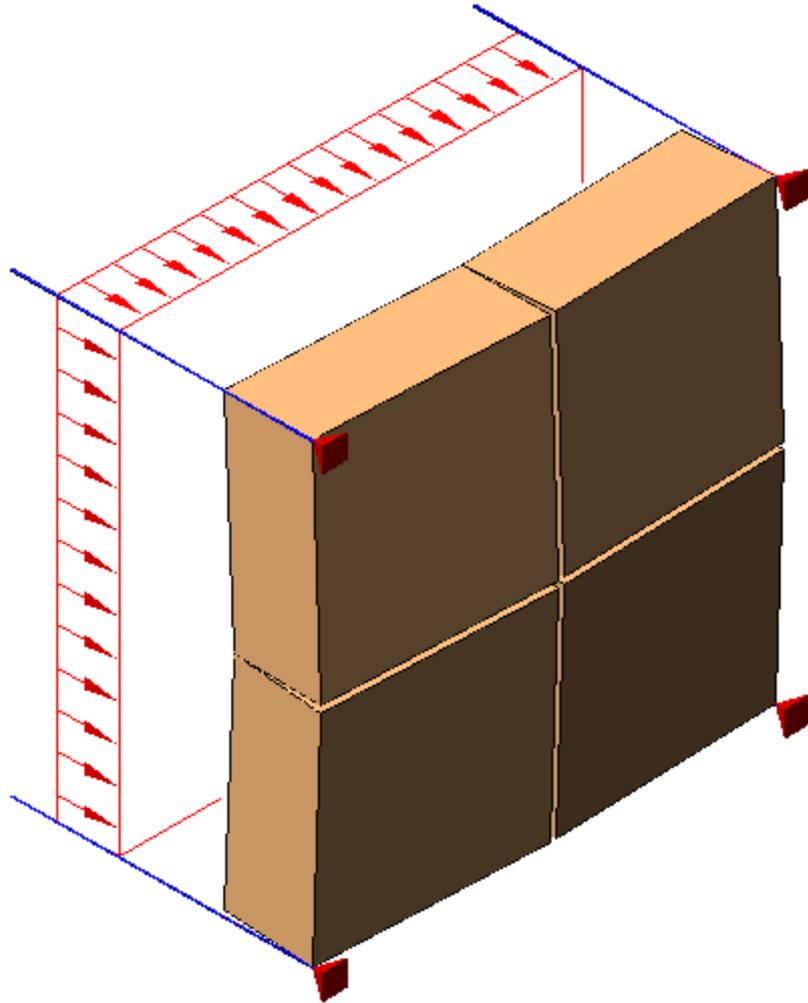
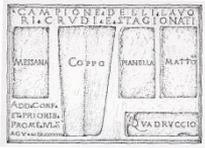


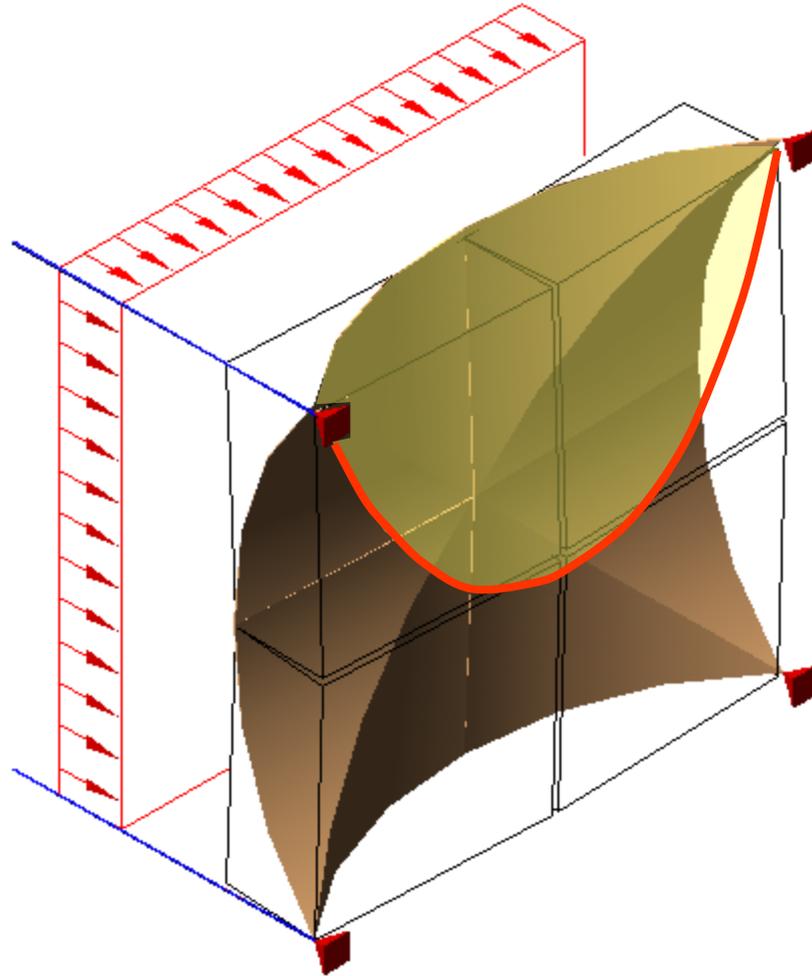
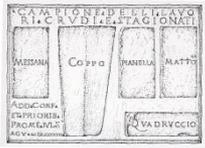


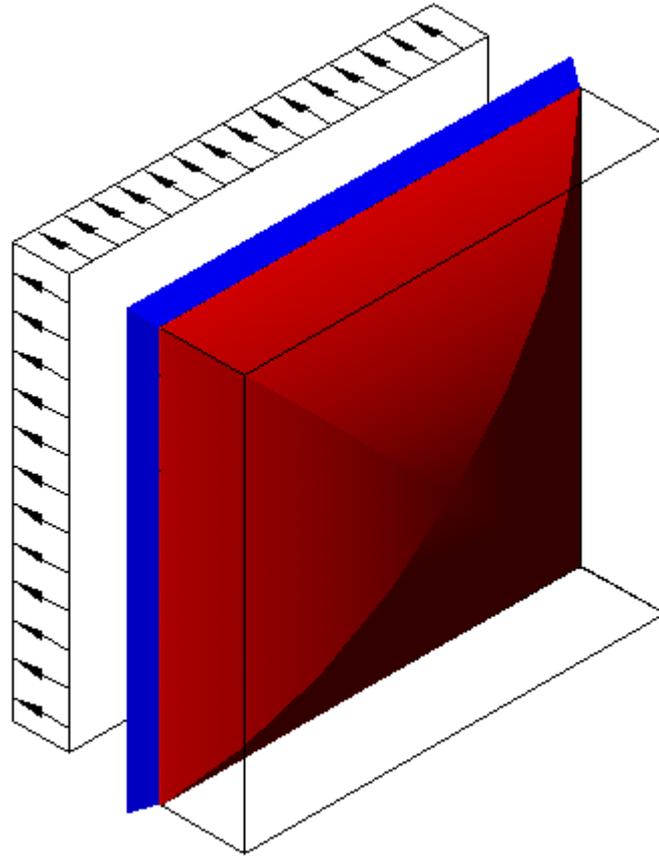
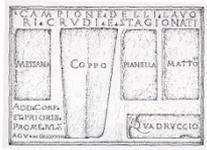


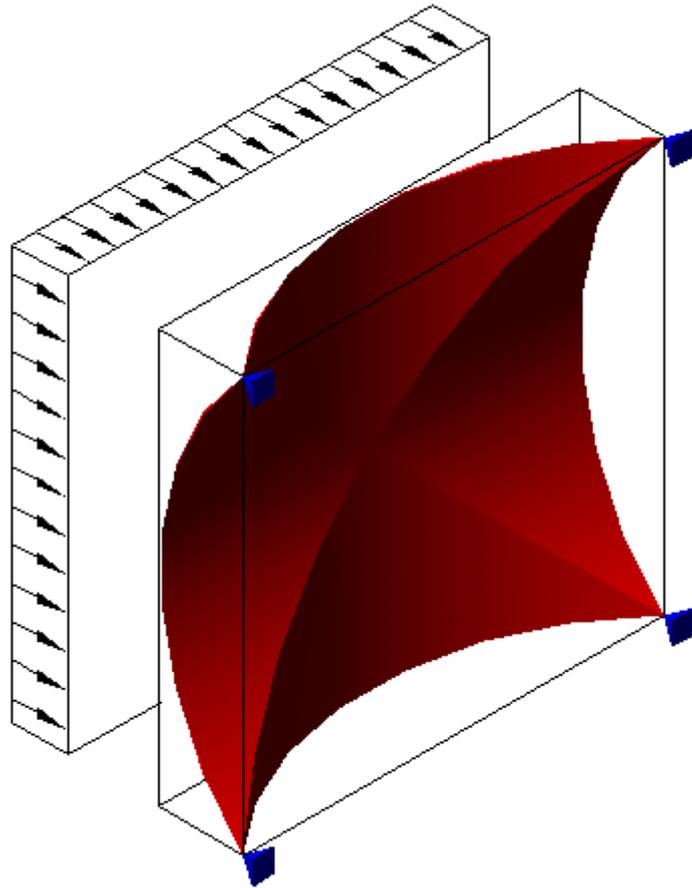
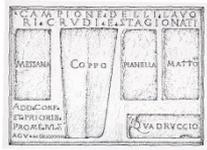


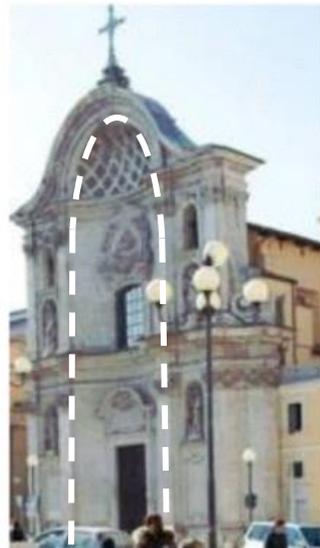
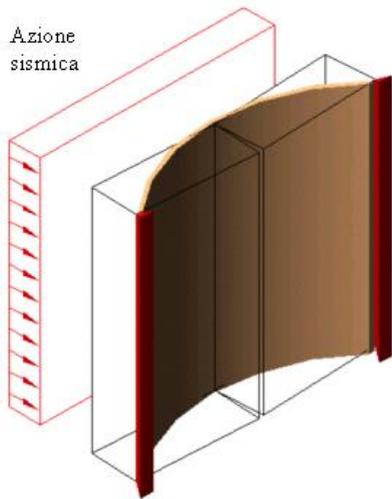




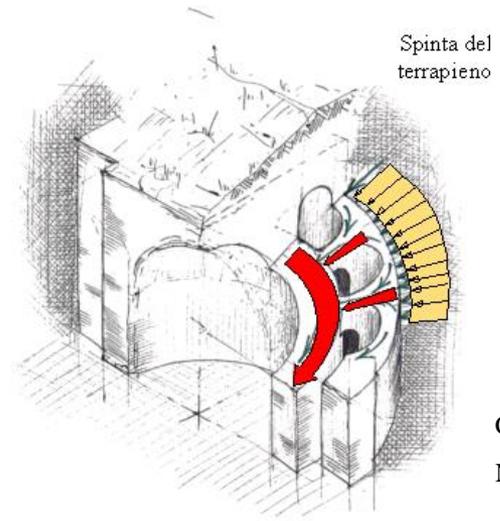




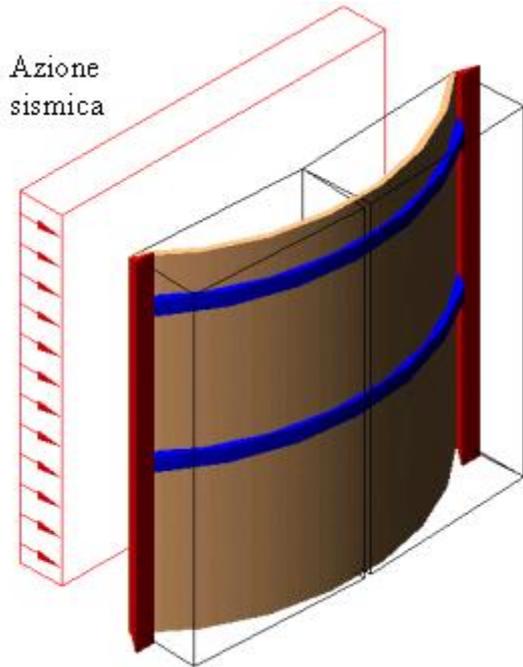




L'Aquila - Chiesa delle Anime Sante

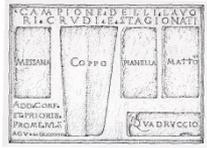


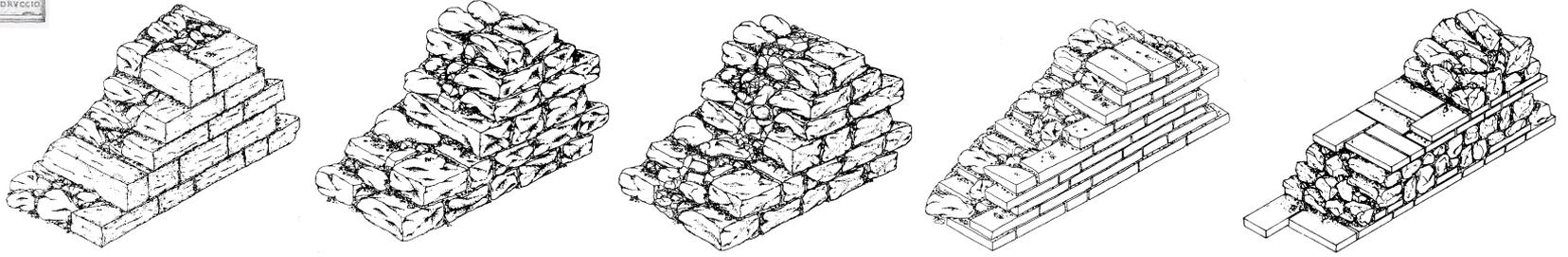
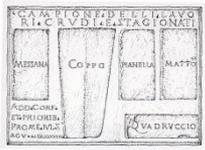
Roma – Podio
del Tempio di
Claudio al Celio
Nicchioni lungo
Via Claudia



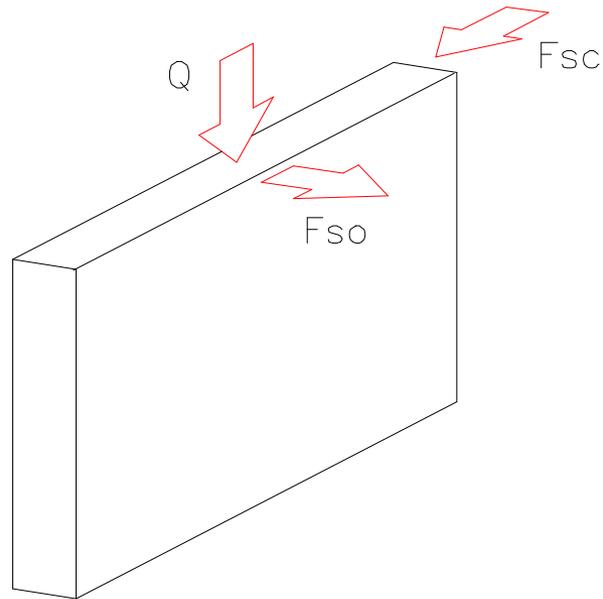
Chiesa dell'Immacolata a Paganica



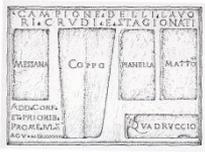




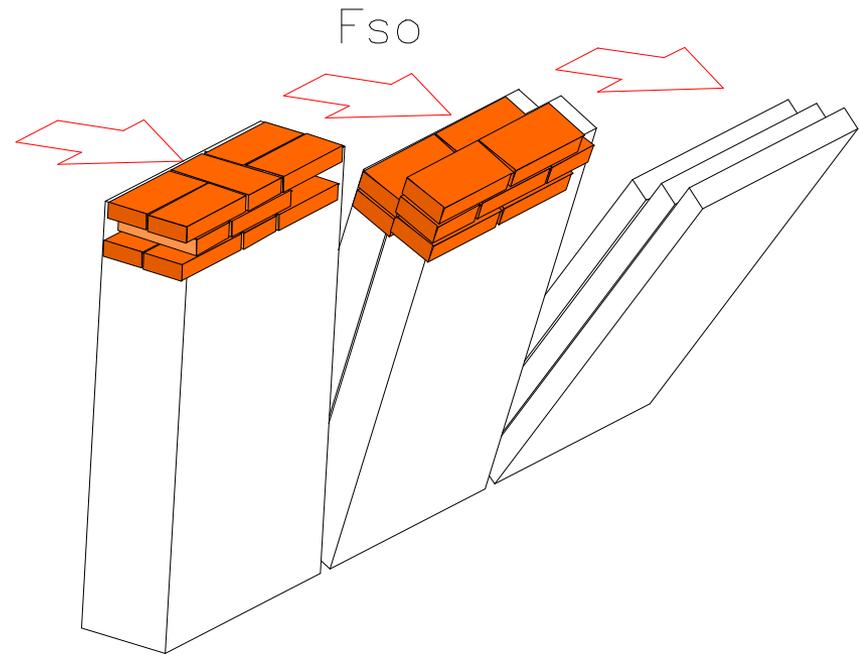
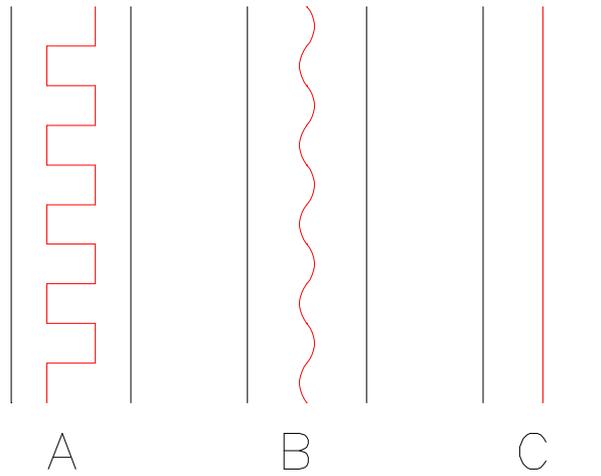
Esempi di murature tradizionali in pietrame e laterizio

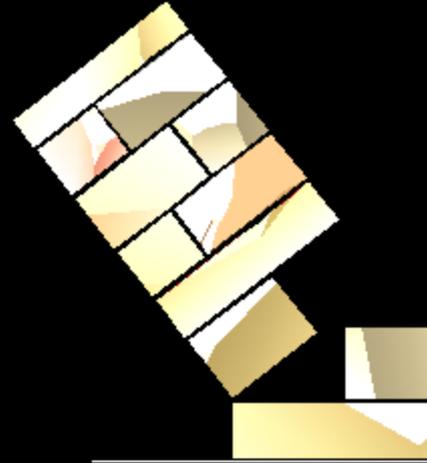
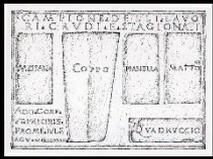


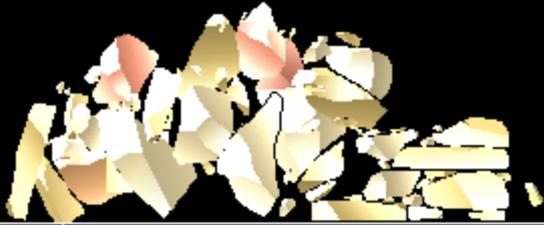
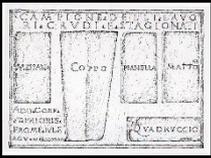
- Q – Carichi statici verticali
- Fsc – Forza sismica complanare
- Fso – Forza sismica ortogonale



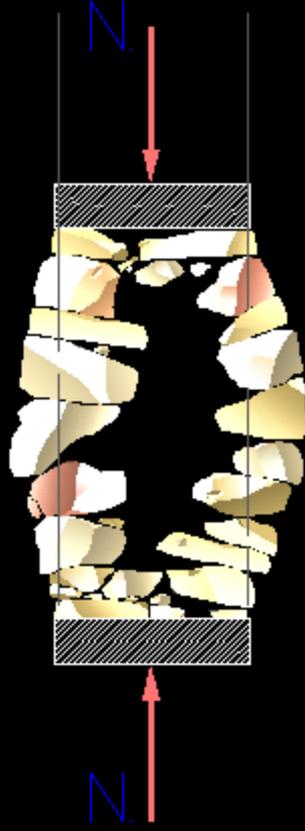
Livello d'ingranamento dei paramenti murari e risposta alle azioni ortogonali

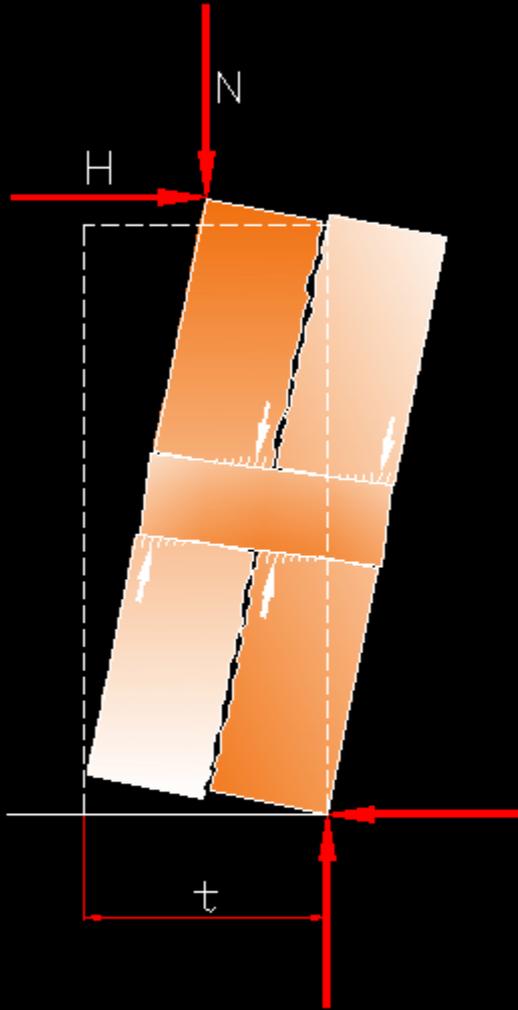
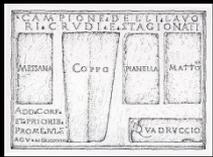


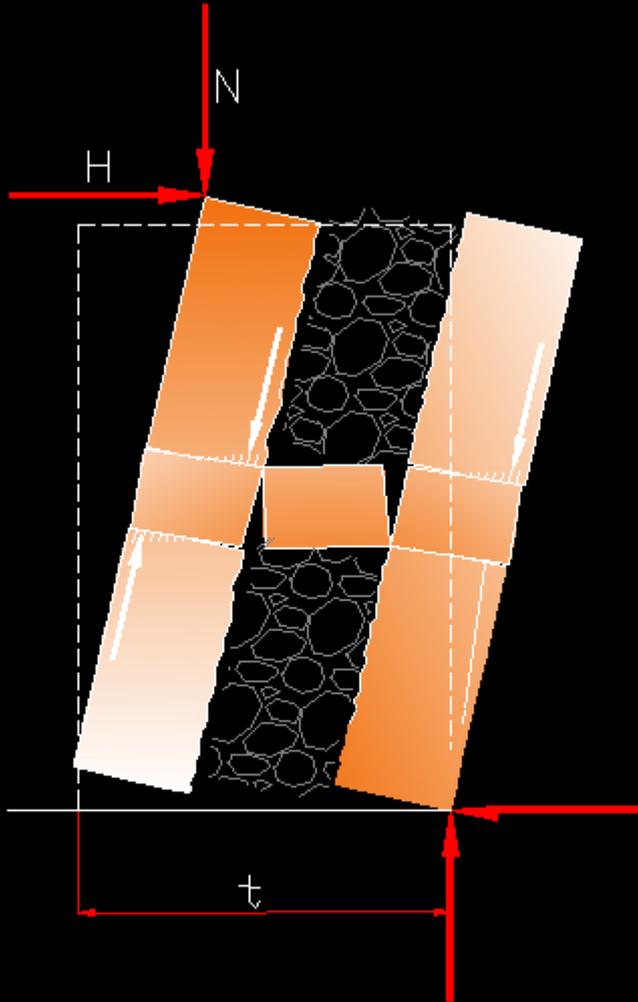
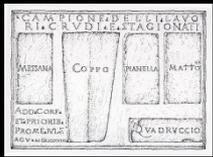


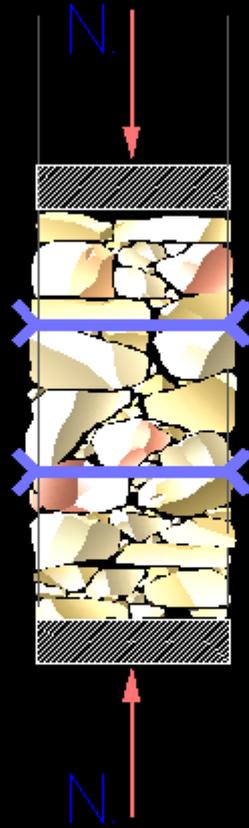
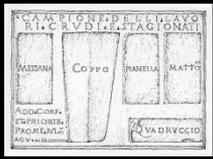


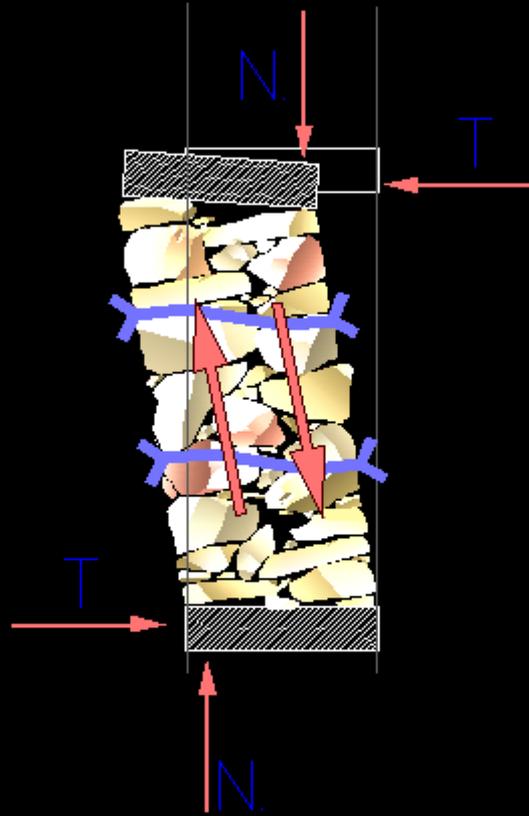
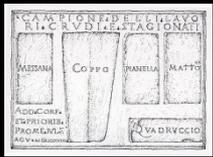


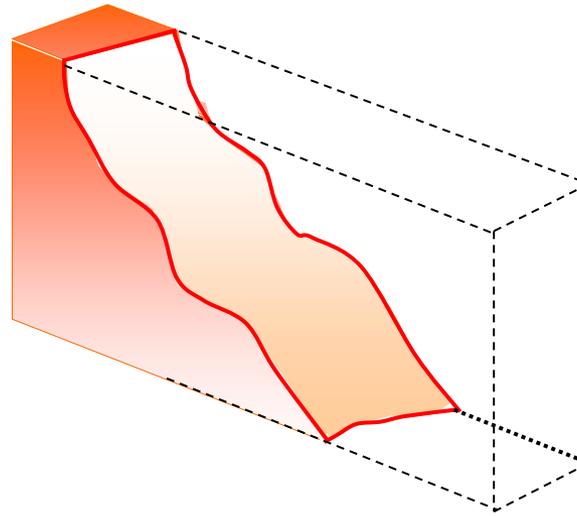
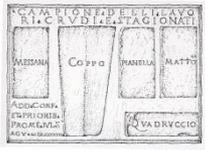






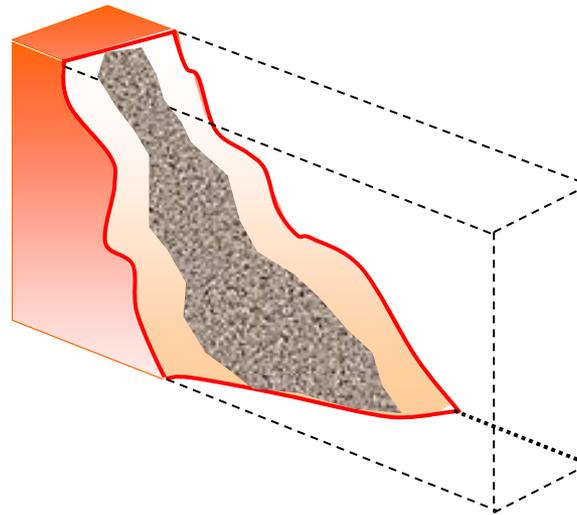
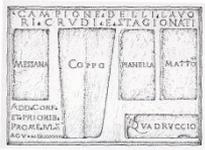






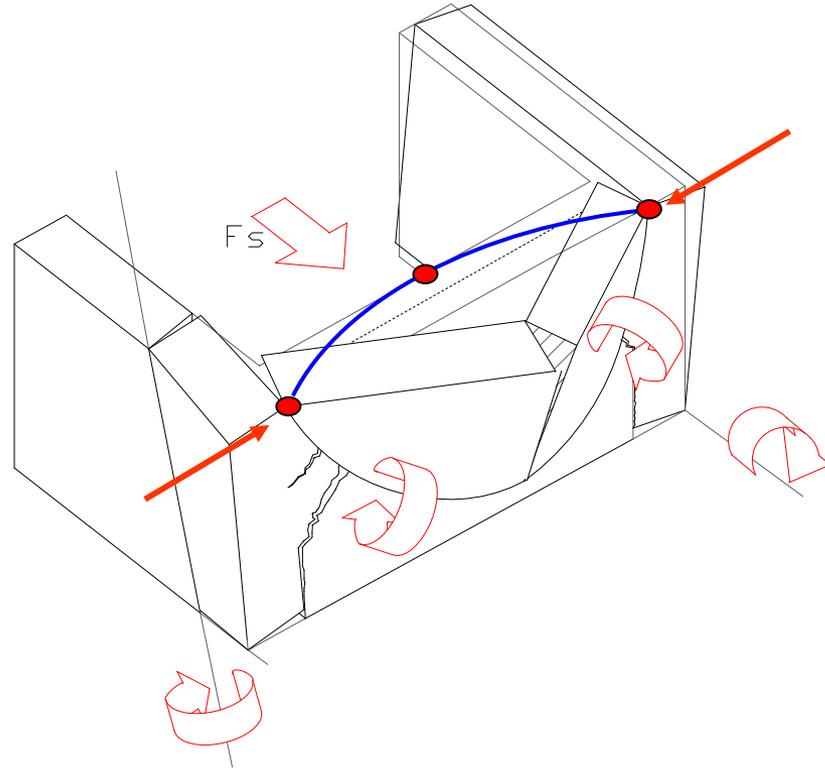
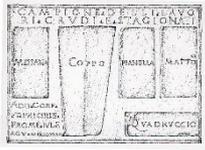
Andamento delle lesioni passanti

Indicatore della qualità muraria

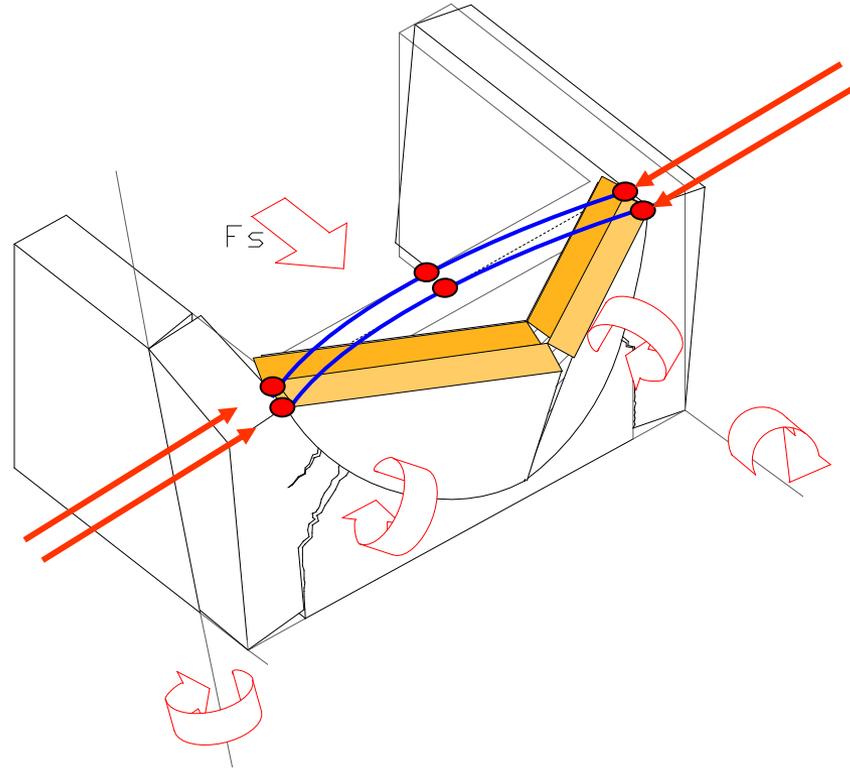
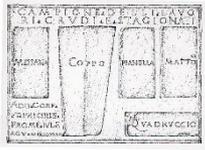


Andamento delle lesioni passanti

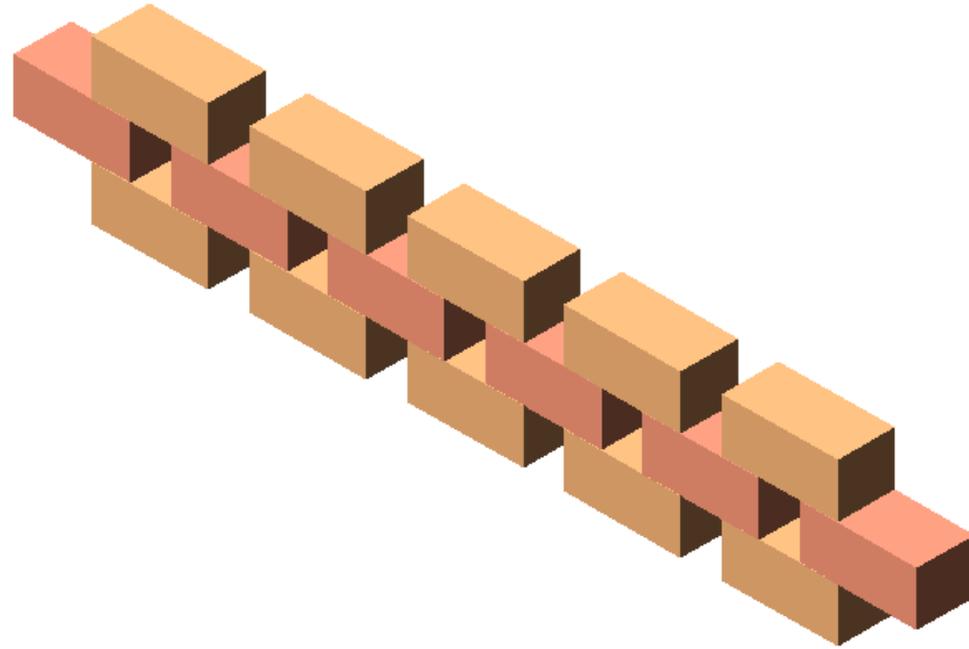
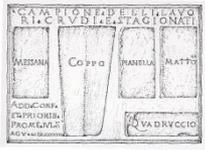
Indicatore della qualità muraria



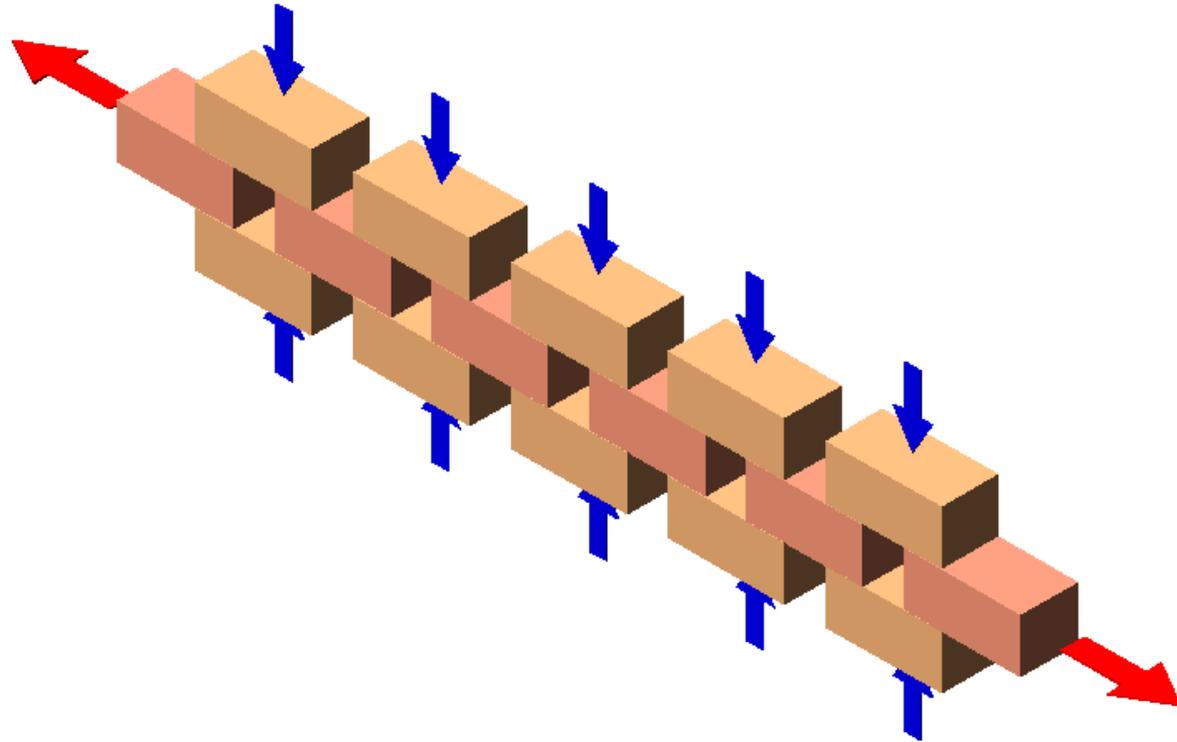
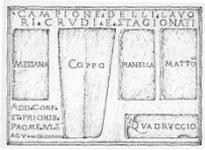
Ribaltamento di pareti a doppio paramento sollecitate da azioni ortogonali



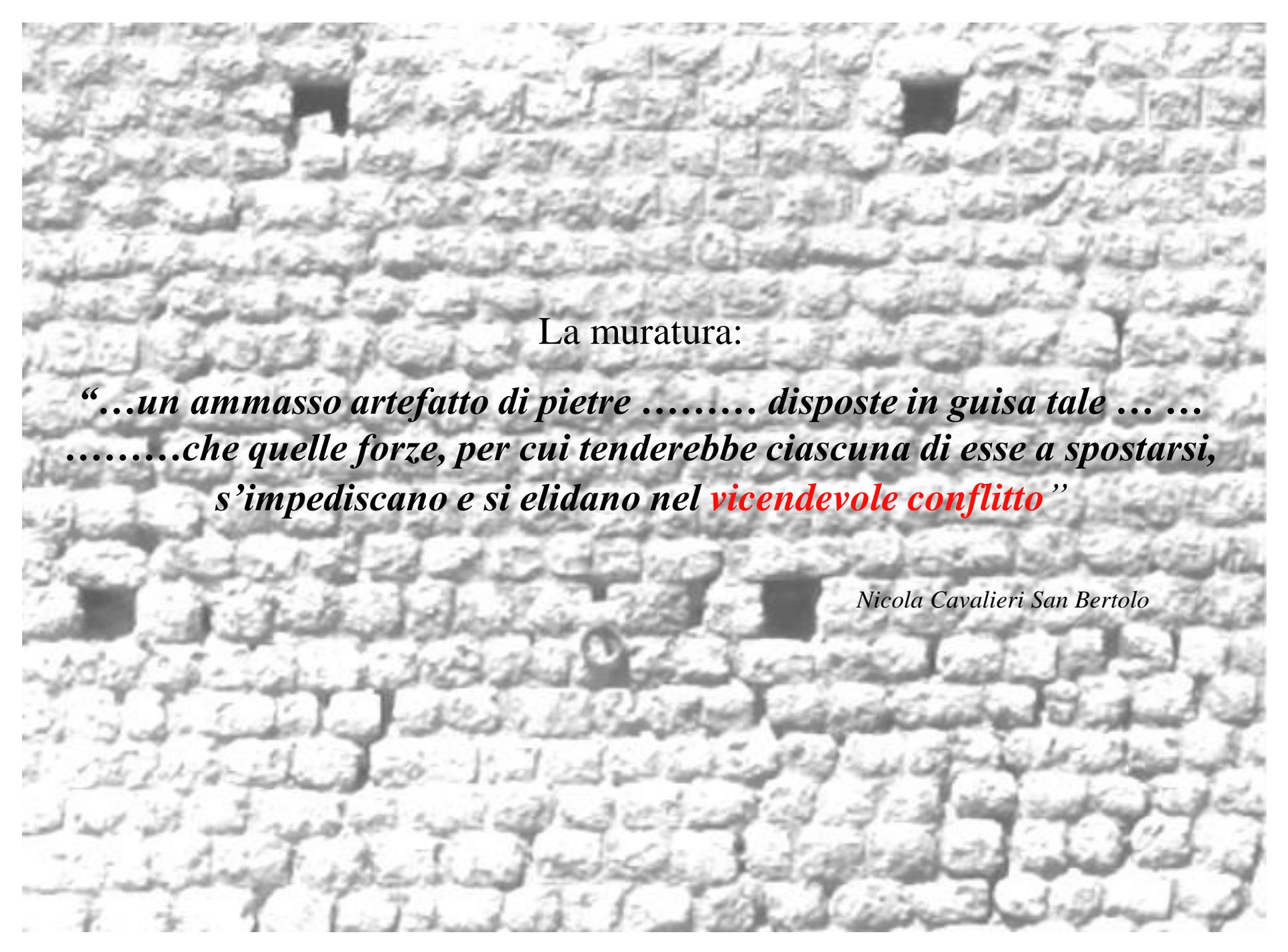
Ribaltamento di pareti a doppio paramento sollecitate da azioni ortogonali



Effetto catena nelle murature incatenate, garantito dall'attrito sulle superfici di contatto fra gli elementi e dalla coesione della malta



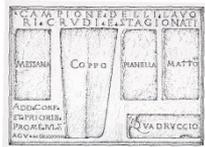
Effetto catena nelle murature incatenate, garantito dall'attrito sulle superfici di contatto fra gli elementi e dalla coesione della malta



La muratura:

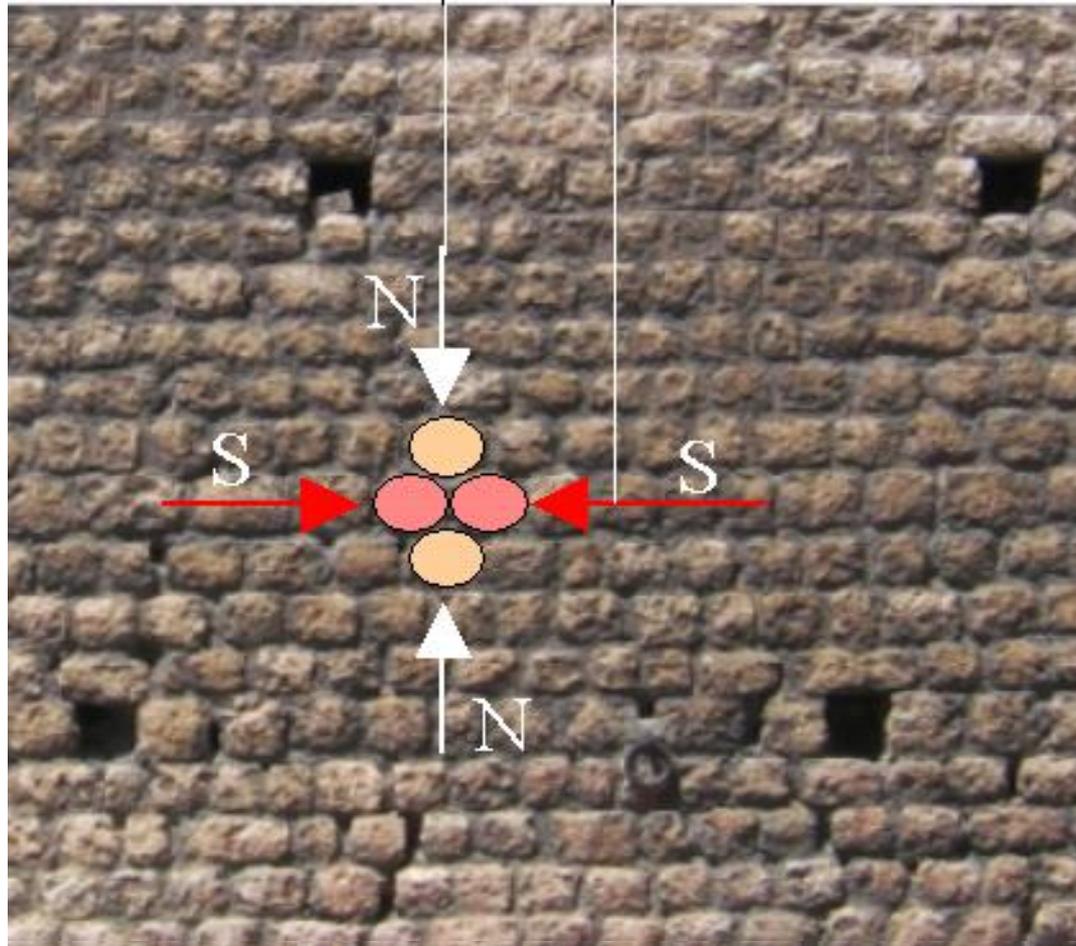
*“...un ammasso artefatto di pietre disposte in guisa tale
.....che quelle forze, per cui tenderebbe ciascuna di esse a spostarsi,
s’impediscono e si elidano nel **vicendevole conflitto**”*

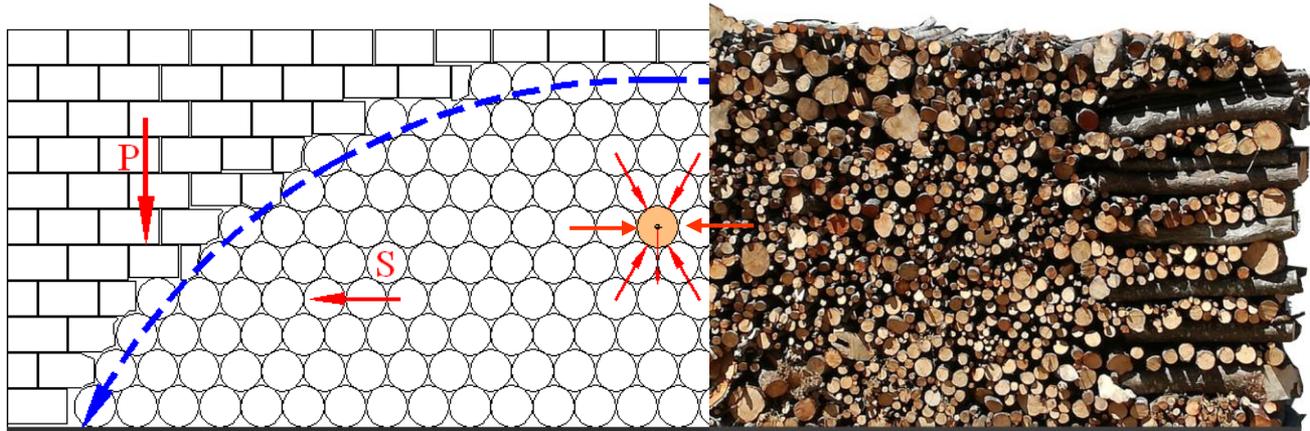
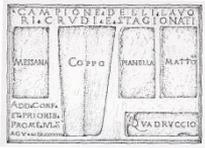
Nicola Cavalieri San Bertolo



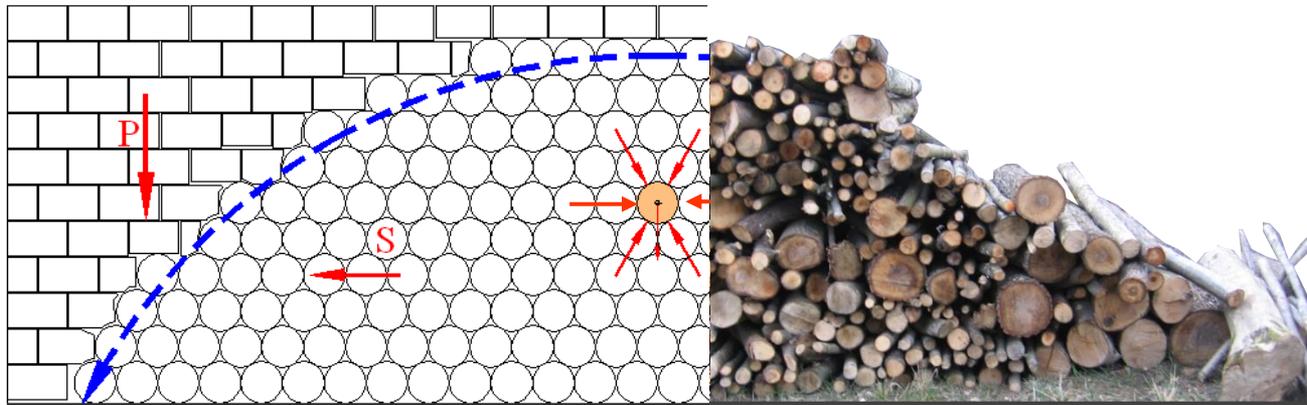
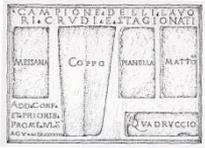
Sforzo di
compressione

Spinta di
contrasto

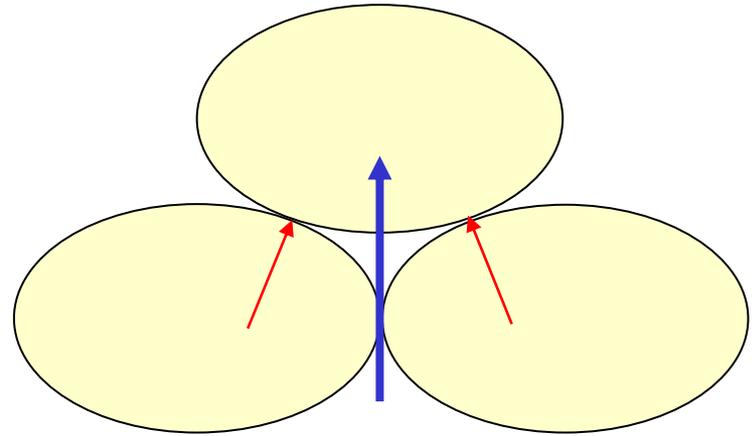
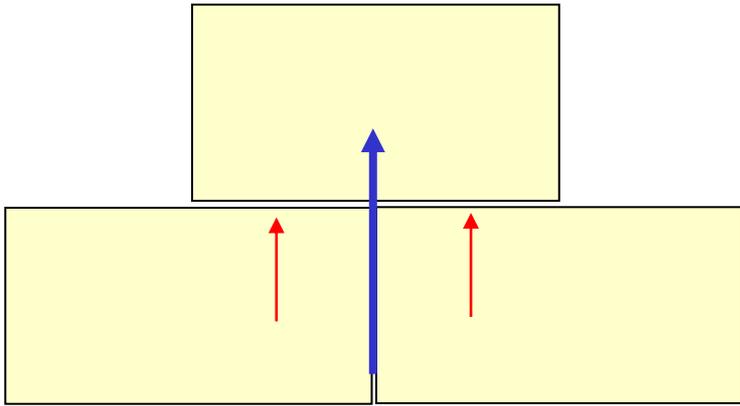
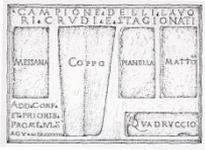




Modello di parete muraria con stato di “precompressione orizzontale” e testate di contrasto in blocchi squadrati

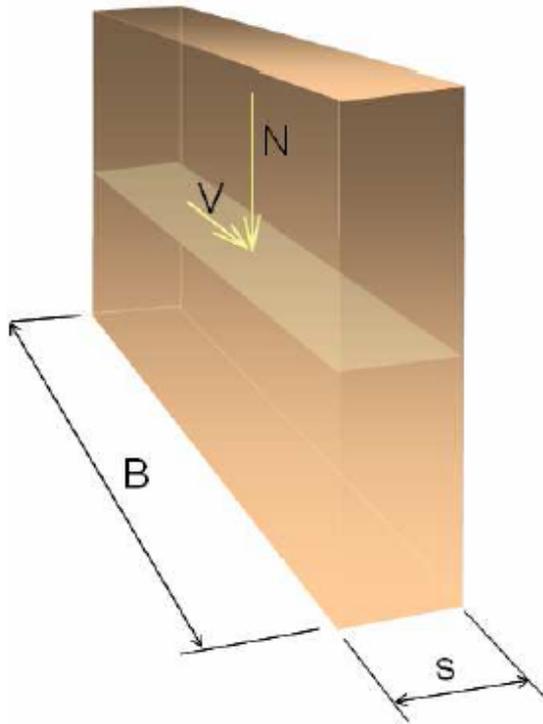
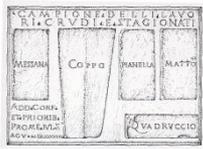


Modello di parete muraria con stato di “precompressione orizzontale” e testate di contrasto in blocchi squadrati





Palmira (Siria) – Rovine del tempio di Bel, con paramento costituito da rocchi di colonne riusate.
Foto: F.Giovanetti



Caratteristiche geometriche:

s = 0,40 ml

B = 1,80 ml

Sollecitazioni:

N = 30000 daN

$\sigma_v = 4,17$ daN/cm²

$\alpha = \sigma_h / \sigma_v = 0,20$

$\sigma_h = 0,83$ daN/cm²

Resistenza a taglio:

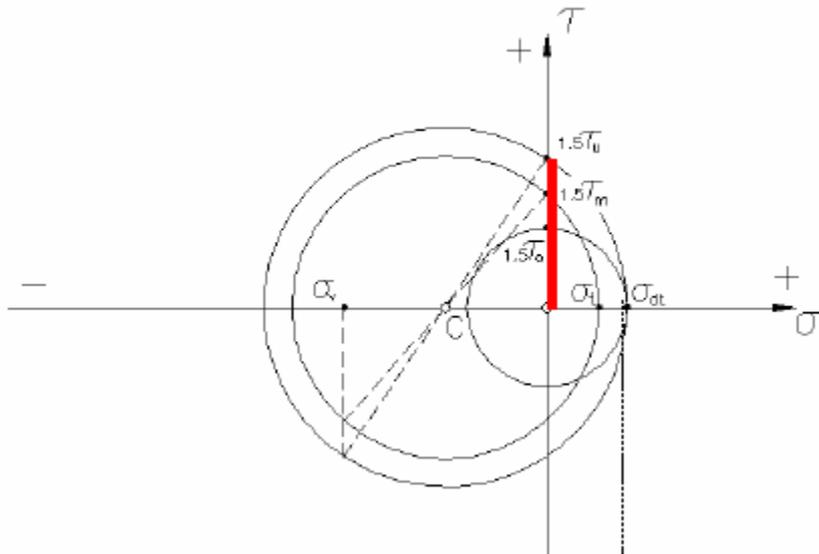
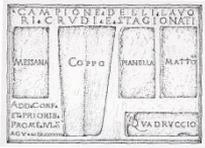
$\tau_0 = 0,40$ daN/cm²

α	τ_u (daN/cm ²)	rapporto +	Taglio ultimo $V_u = B * s * \tau_u$
0	1,13	1,00	8.118 daN
0,1	1,47	1,30	10.567 daN
0,2	1,74	1,55	12.546 daN
0,3	1,98	1,76	14.254 daN
0,4	2,19	1,94	15.778 daN
0,5	2,38	2,11	17.167 daN
0,6	2,56	2,27	18.451 daN
0,7	2,73	2,42	19.652 daN
0,8	2,89	2,56	20.784 daN
0,9	3,04	2,69	21.857 daN
1	3,18	2,82	22.880 daN

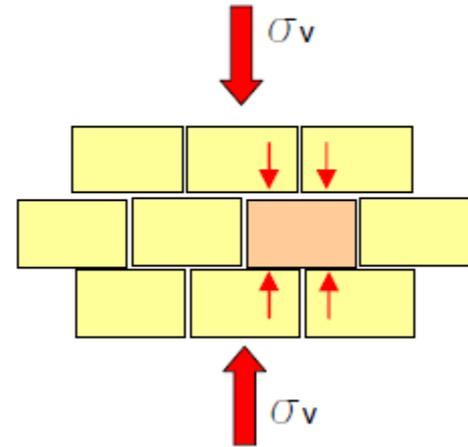
se $\alpha=0$ Formula di Turnsek - Cacovic

$$\tau_u = \tau_0 \sqrt{1 + \frac{\sigma_v}{1,5\tau_0}} = 1,13 \text{ daN/cm}^2$$

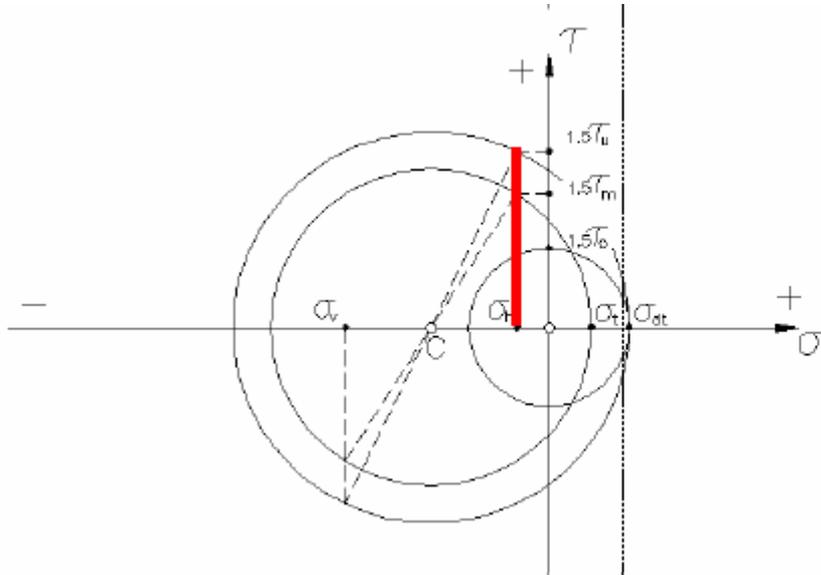
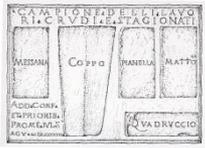
$$\tau_u = \frac{2}{3} \sqrt{[(\sigma_v + \sigma_h)/2 + 1,5\tau_0]^2 - ((\sigma_v - \sigma_h)/2)^2} = 1,74 \text{ daN/cm}^2$$



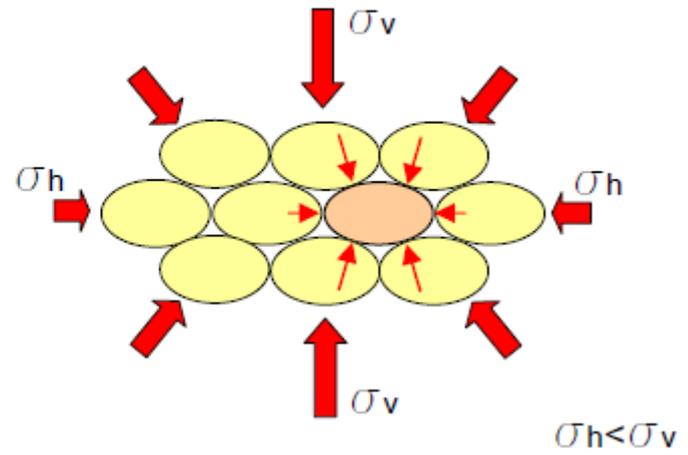
A)

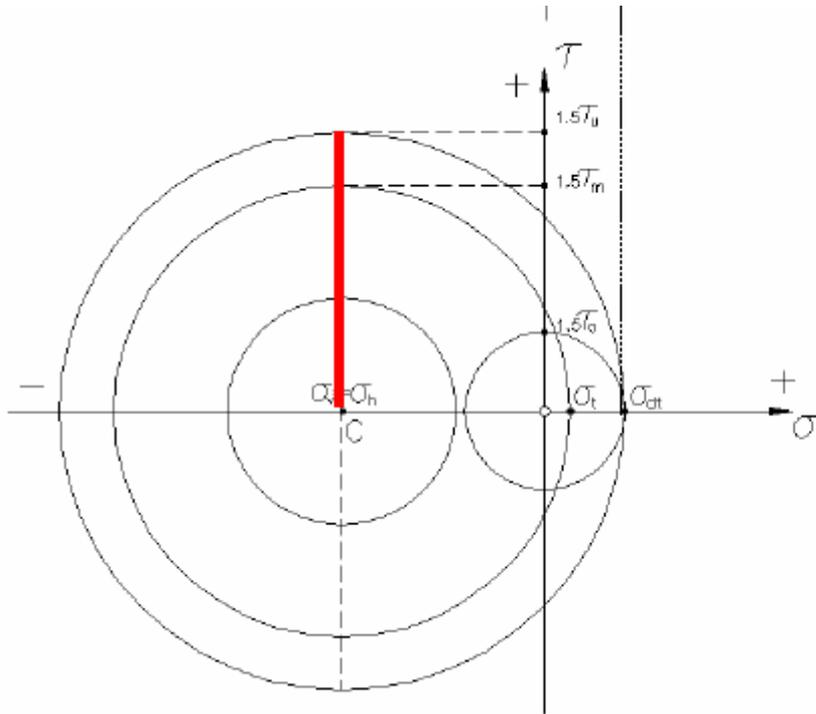
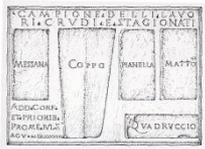


$$\sigma_h=0$$

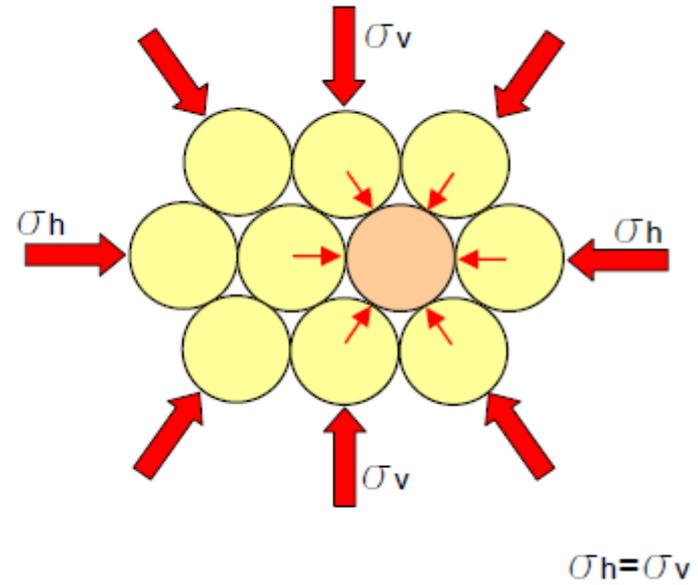


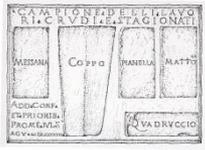
B)



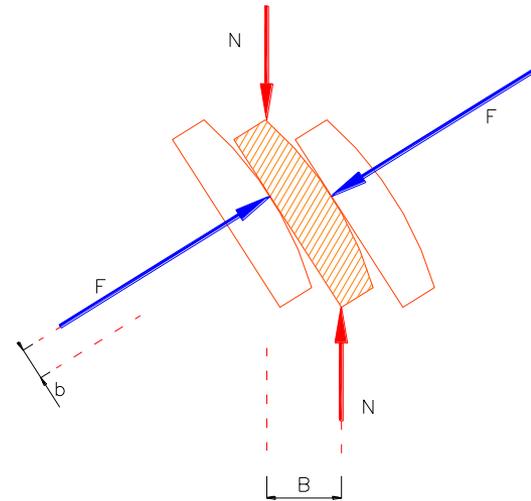
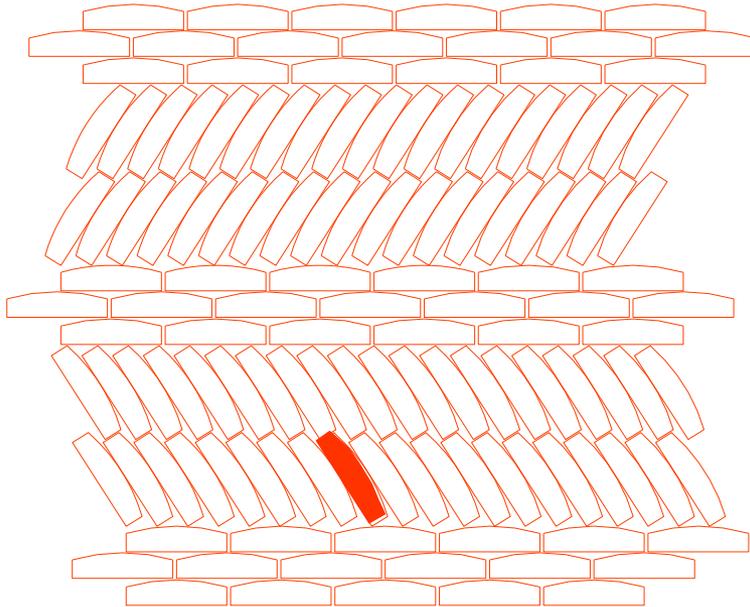


c)



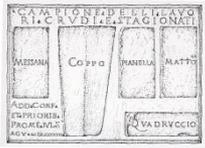


Esempi di murature autostringenti

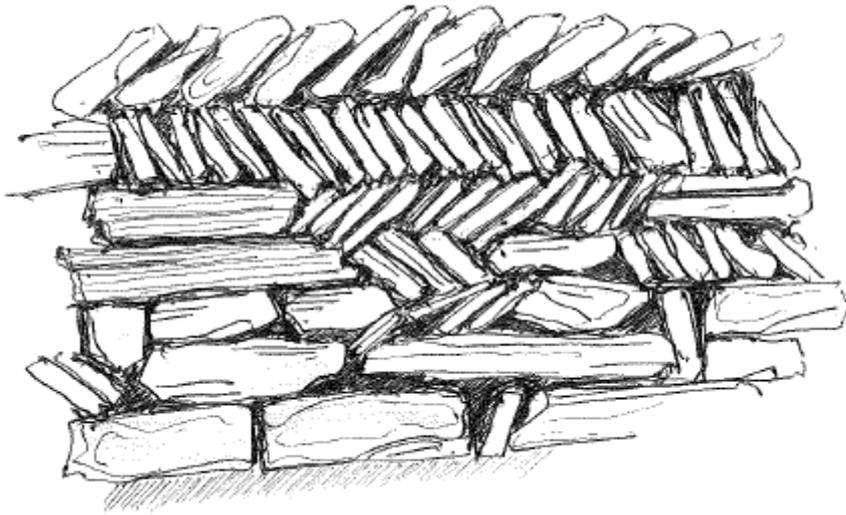


Condizioni di equilibrio
del singolo elemento

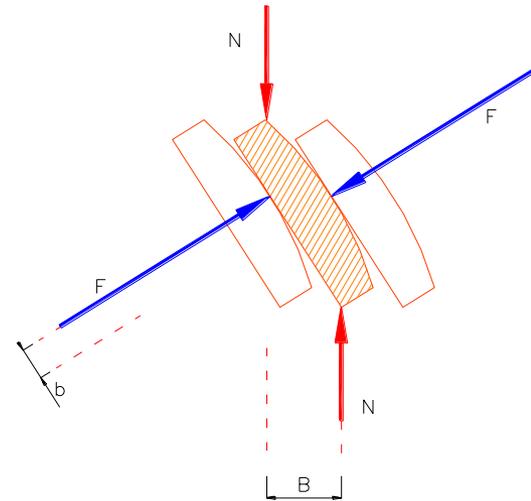
(con peso proprio trascurabile)



Esempi di murature autostringenti

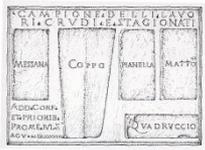


Cuandixia (Cina)



Condizioni di equilibrio
del singolo elemento

(con peso proprio trascurabile)



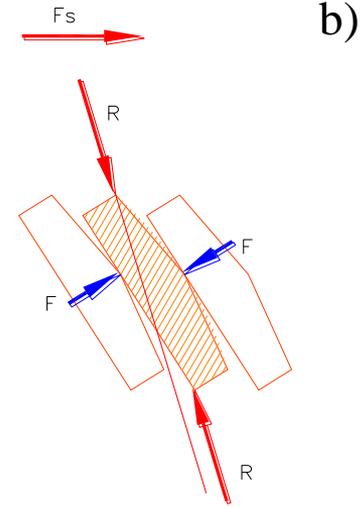
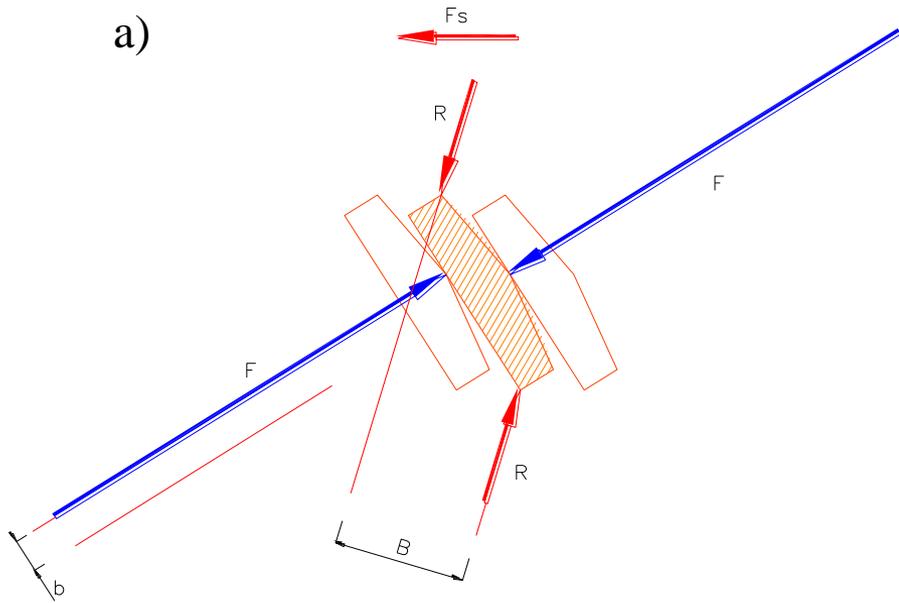
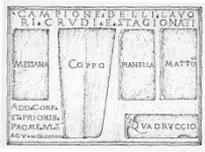
Esempi di murature autostringenti



Carsulae (Terni)



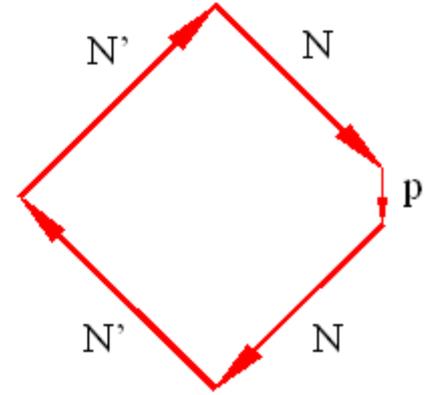
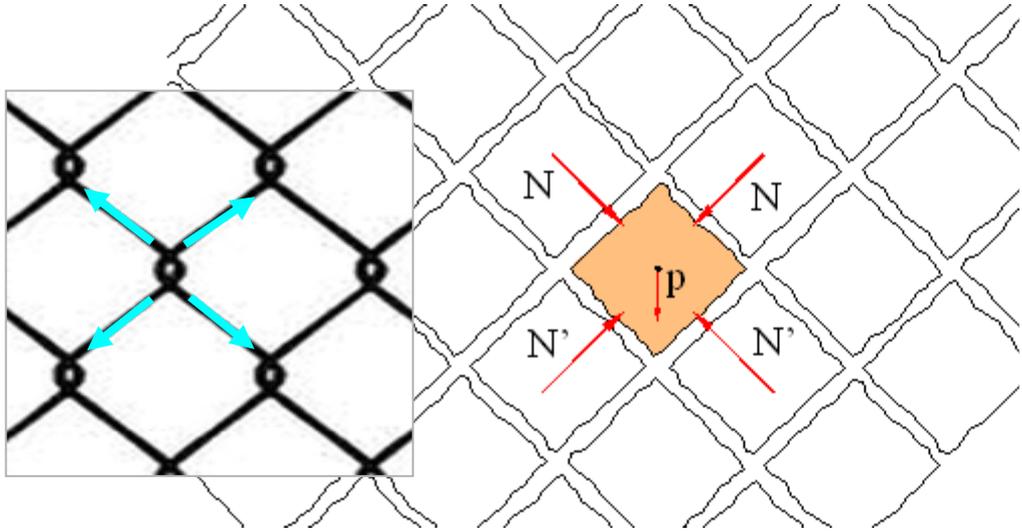
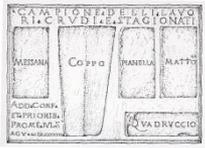
Norba (Latina)



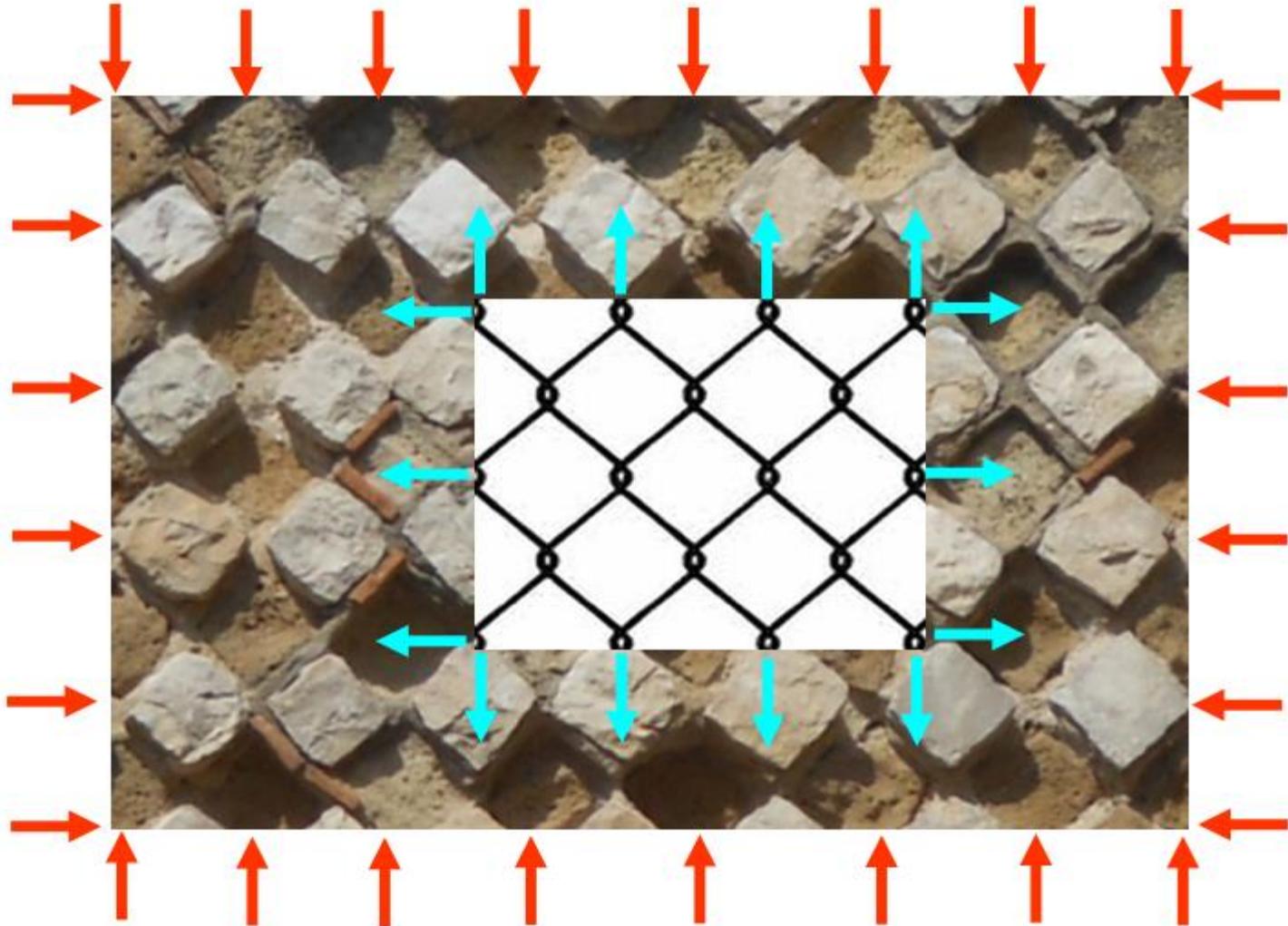
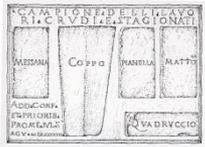
Variazioni dello stato di compressione con:

a) forza sismica da destra

b) forza sismica da sinistra



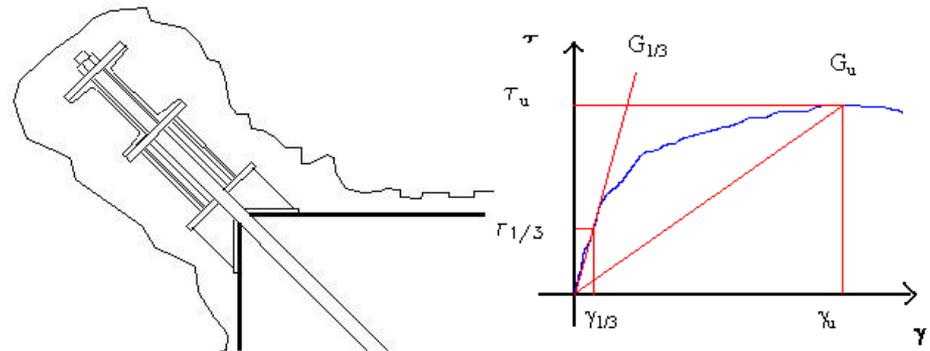
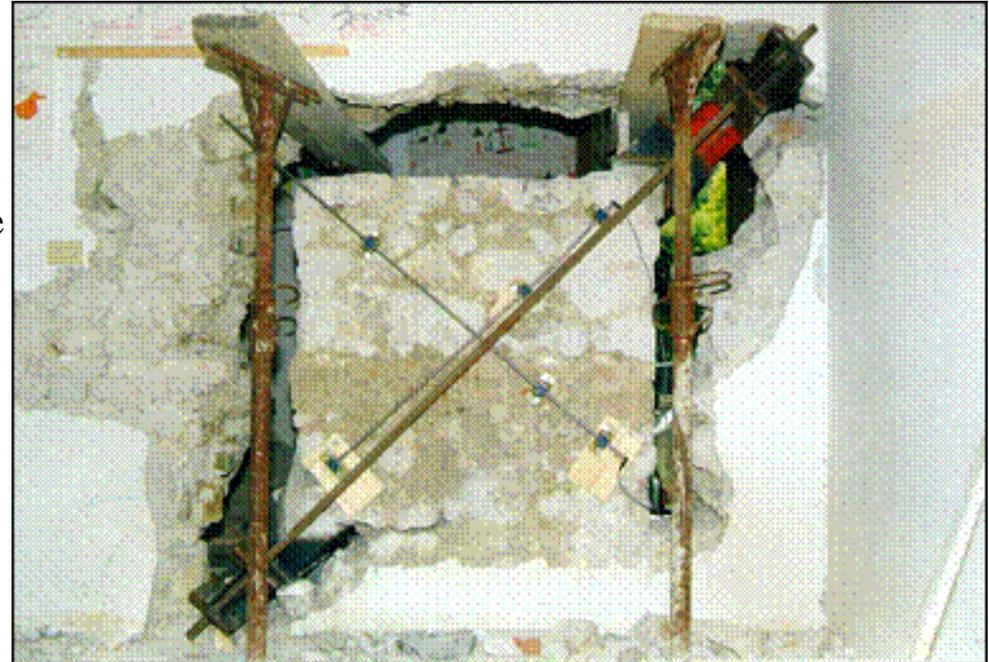
Stato tensionale interno nell'opus reticulatum con diagramma di equilibrio



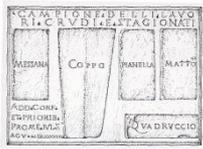
Caratterizzazione meccanica dei materiali

Prove diagonali

- Pannelli di dimensione di progetto 120x120 cm (secondo le specifiche ASTM E 519 81) con sezioni di spessore variabile in funzione delle diverse strutture su cui si è intervenuti.
- Scopo: determinazione della resistenza a taglio τ_k , τ_u e del modulo di elasticità tangenziale $G_{1/3}$, G_u , di $\gamma_{1/3}$, γ_u della muratura.
- Il pannello viene isolato dalla restante parte della muratura tramite fili diamantati in modo da non arrecare disturbo al pannello.



(Ing. A. De Maria, 2010)



Caratterizzazione meccanica dei materiali

- Valutazione delle caratteristiche meccaniche e livello di degrado dei materiali tramite:

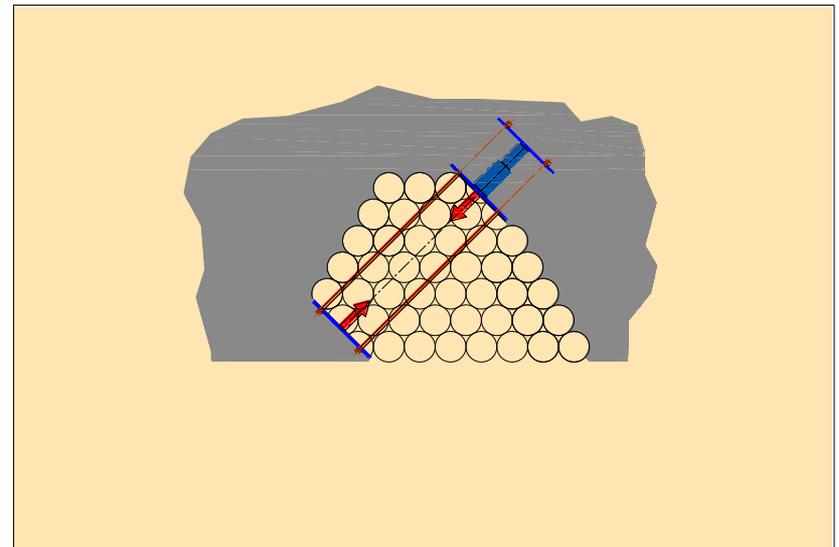
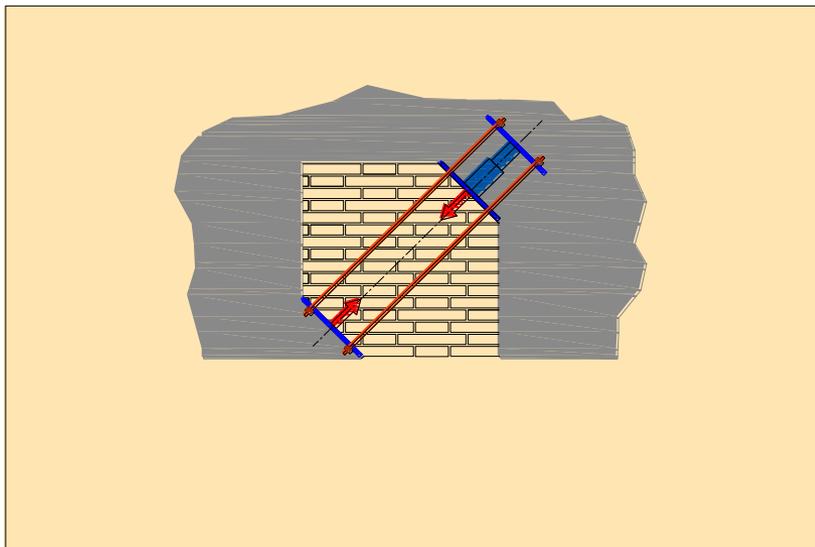
- . verifiche visive in situ
- . analisi dati già disponibili
- . prove sperimentali

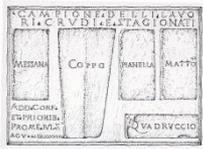
Livelli di conoscenza

(LC1, LC2 e LC3)



Indagini limitate, estese, esaustive





Caratterizzazione meccanica dei materiali

- Valutazione delle caratteristiche meccaniche e livello di degrado dei materiali tramite:

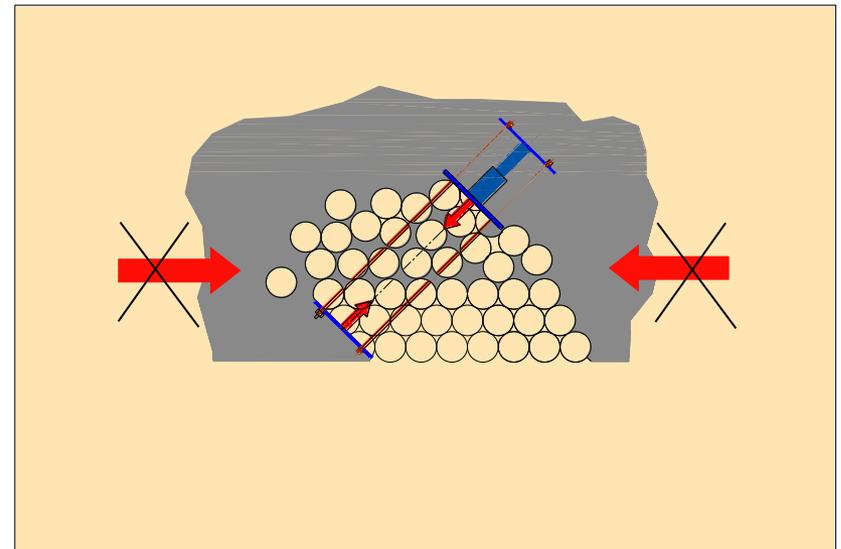
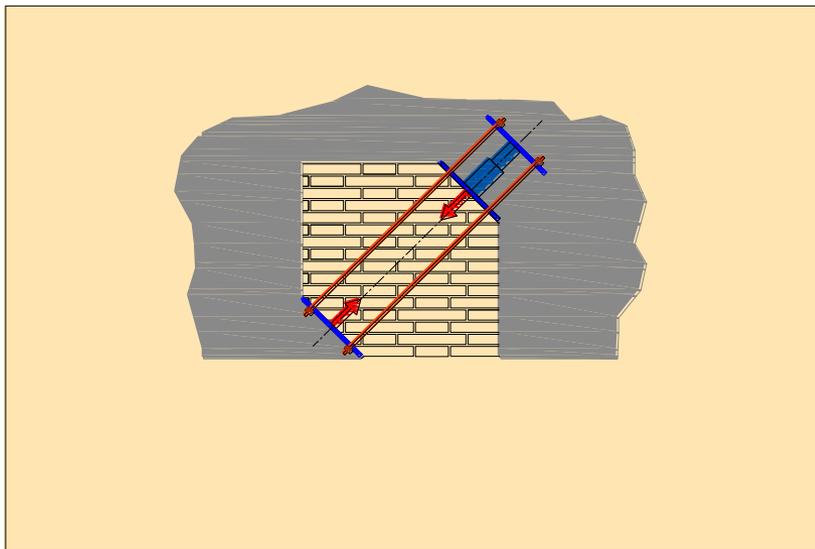
- . verifiche visive in situ
- . analisi dati già disponibili
- . prove sperimentali

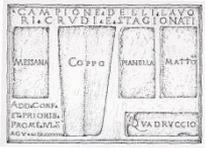
Livelli di conoscenza

(LC1, LC2 e LC3)

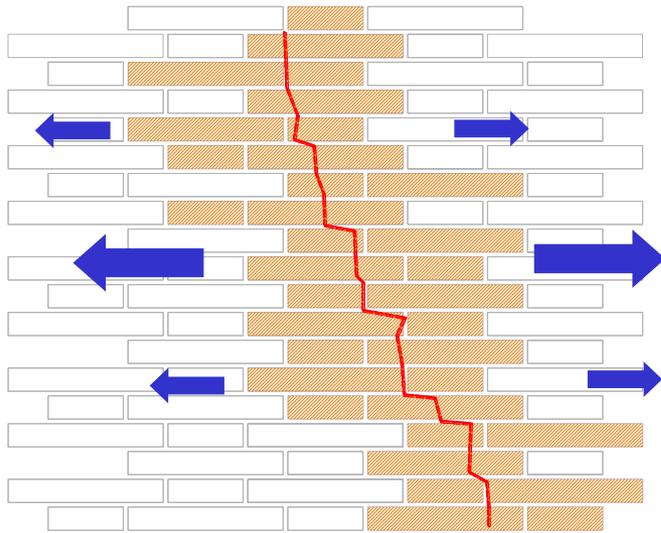


Indagini limitate, estese, esaustive

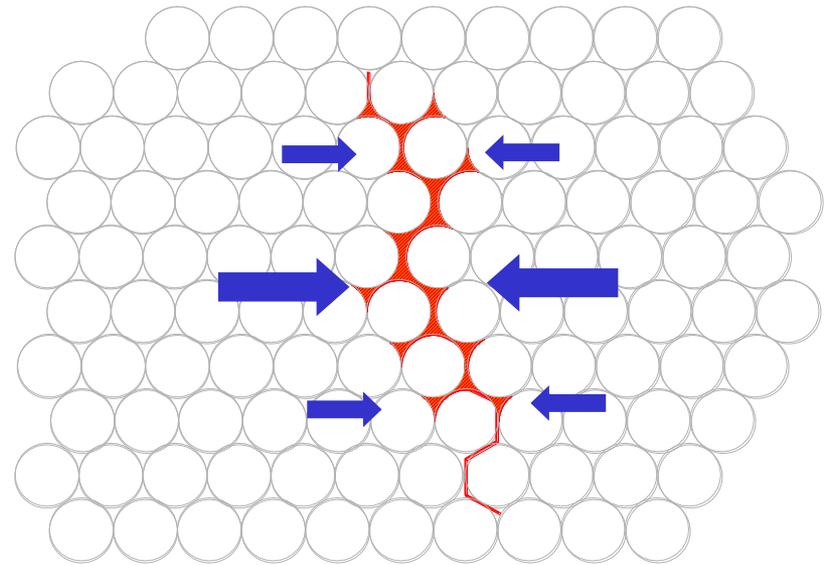




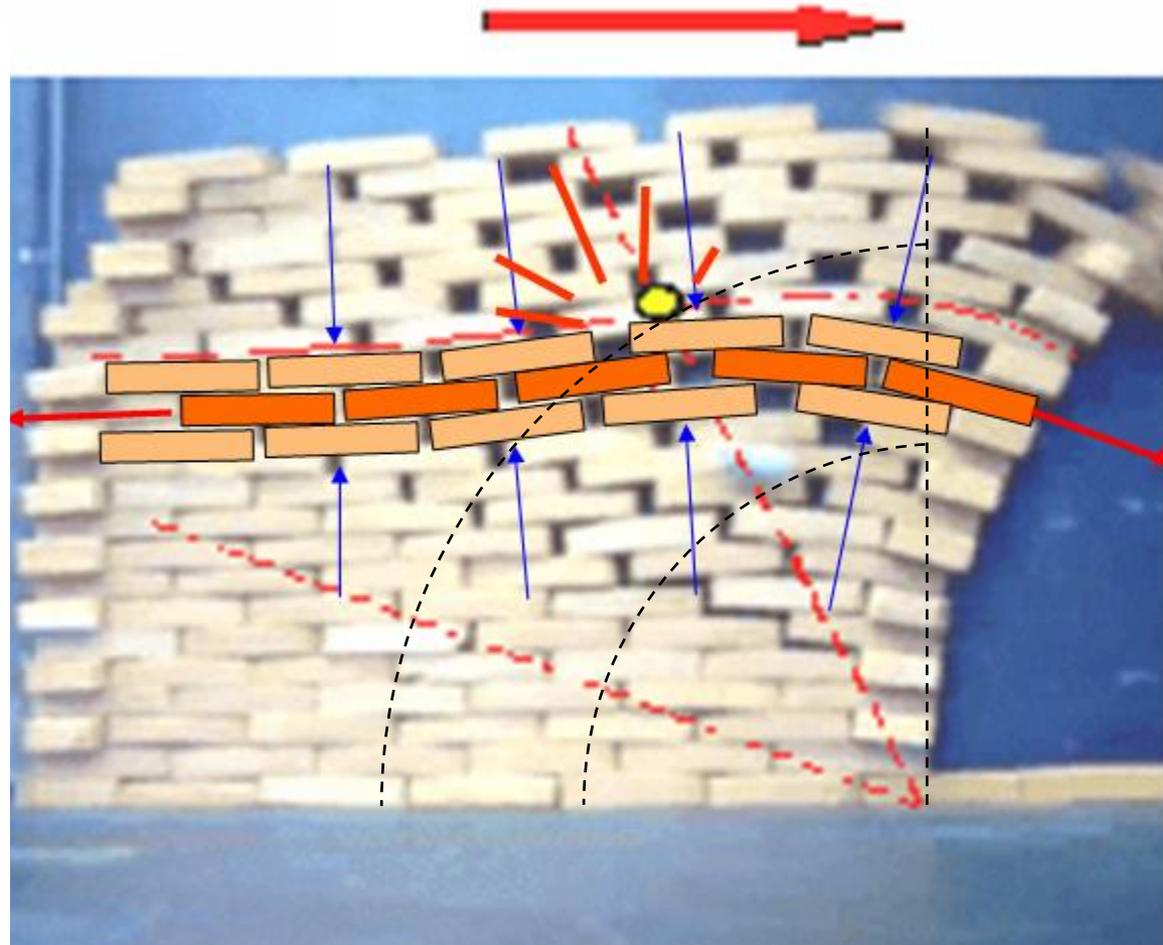
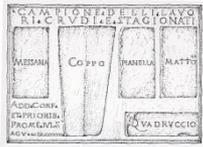
Interventi di cuci-scuci



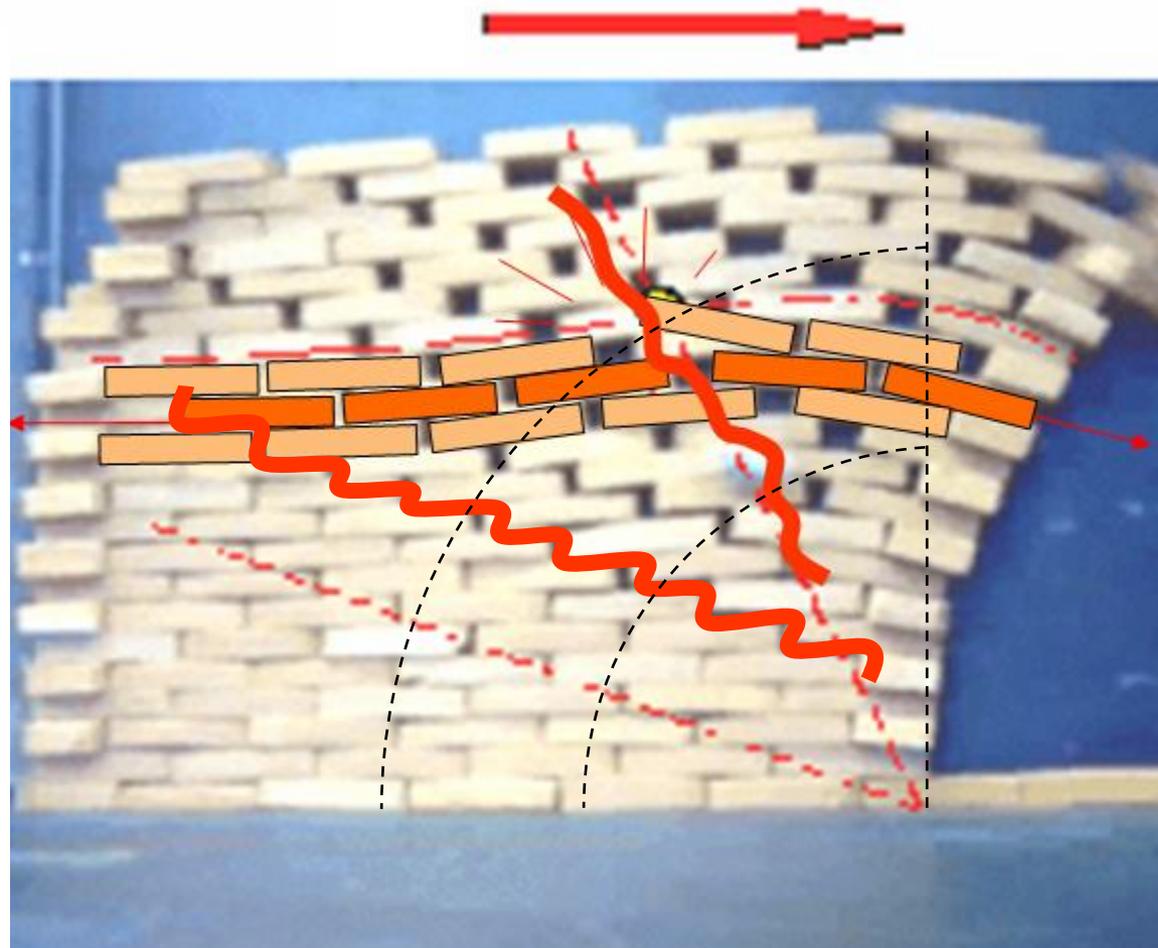
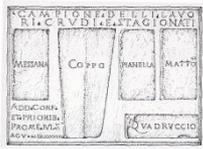
Ripristino dell'ingranamento e della resistenza a trazione equivalente per attrito e coesione



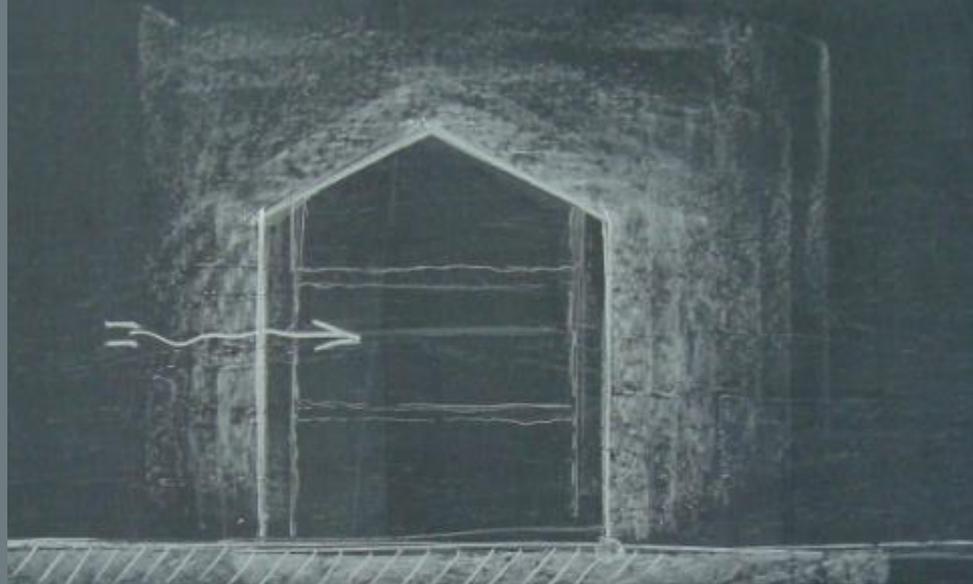
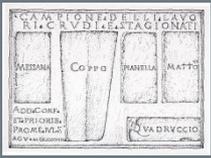
Ripristino dell'azione di contrasto e dello stato di precompressione

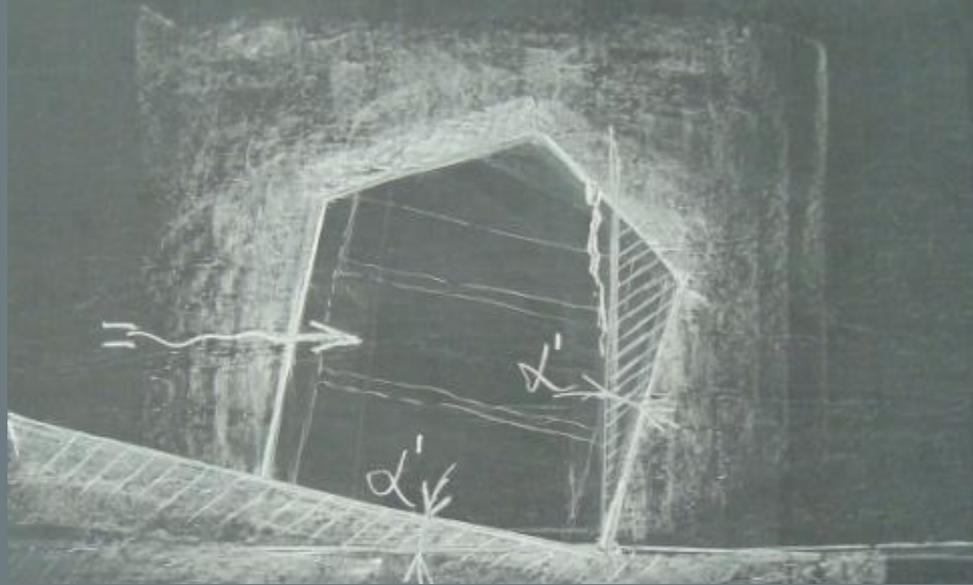
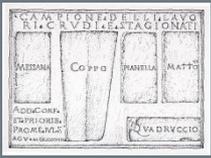


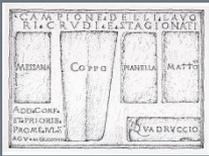
Schema dell'effetto catena in una parete di mattoni pieni ad una testa, evidenziato dalla dinamica di collasso di una parete sollecitata nel piano.

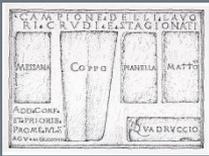


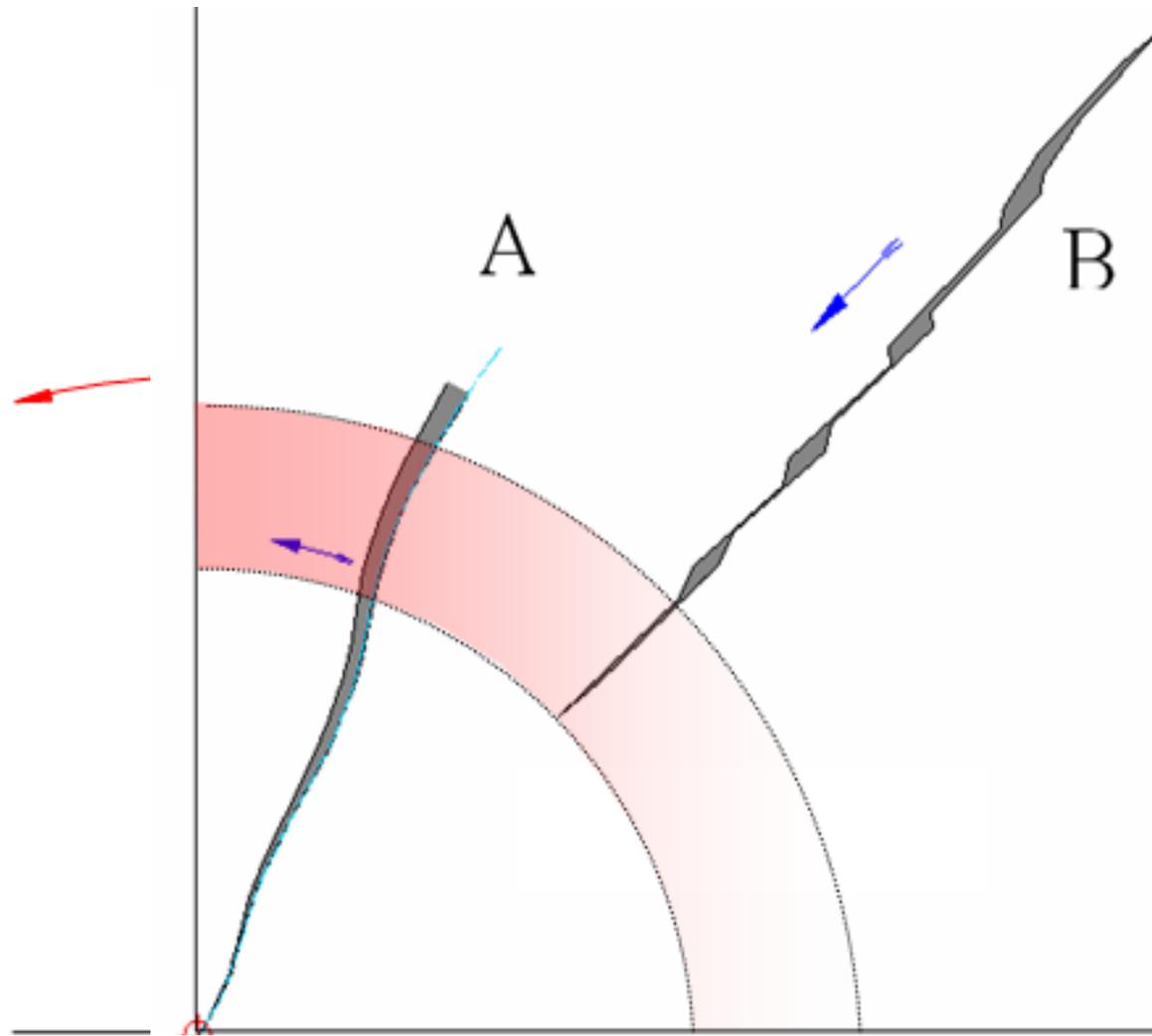
Schema dell'effetto catena in una parete di mattoni pieni ad una testa, evidenziato dalla dinamica di collasso di una parete sollecitata nel piano.

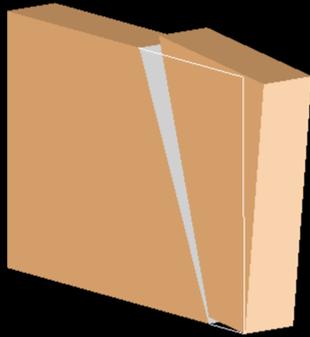
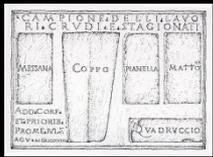




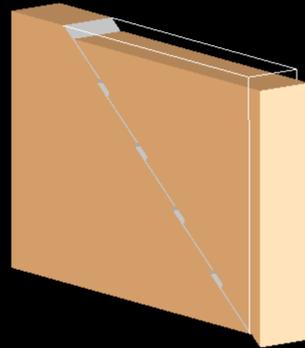




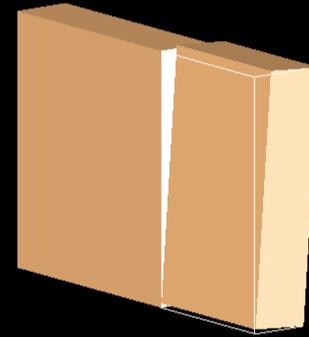




A)



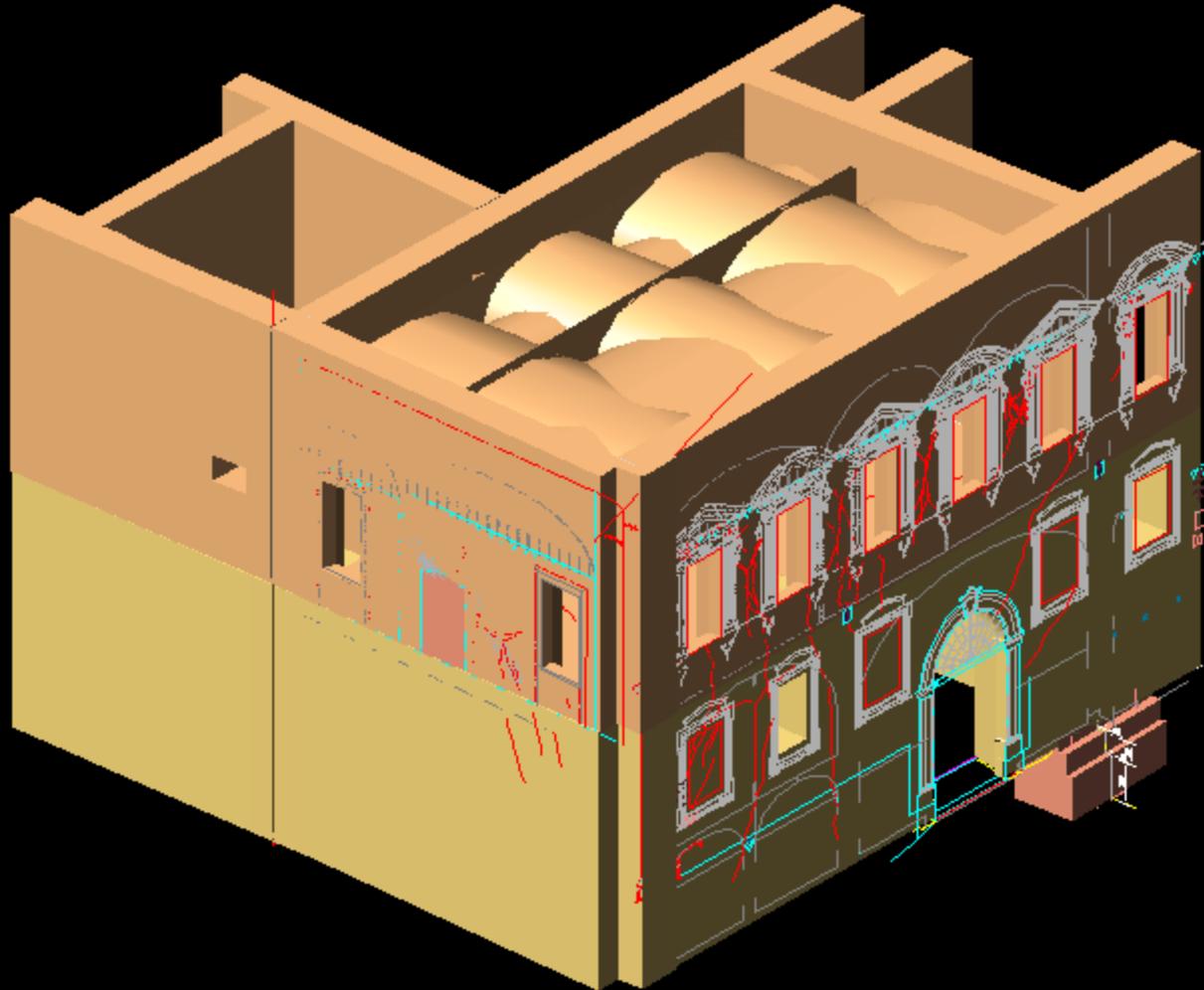
B)

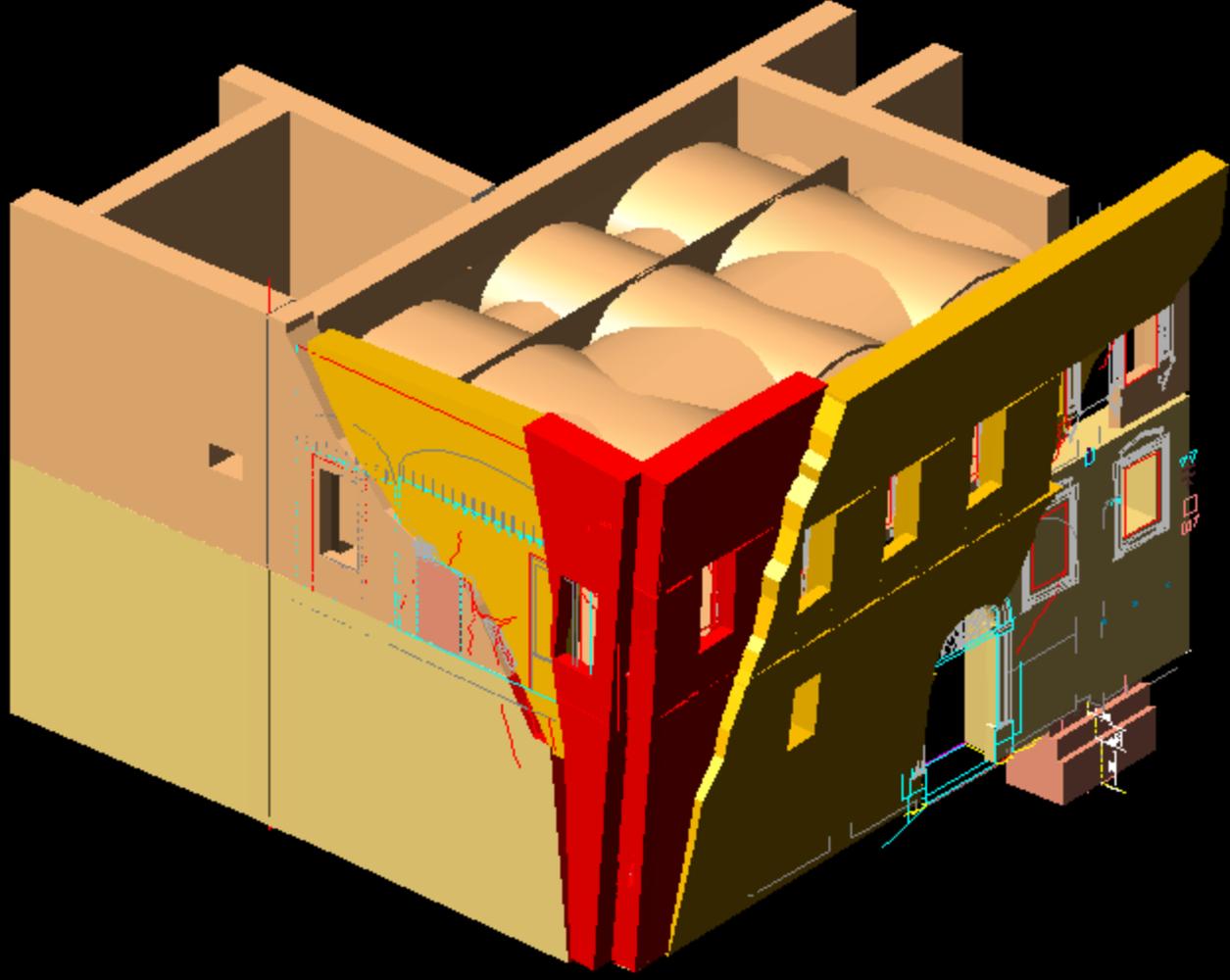


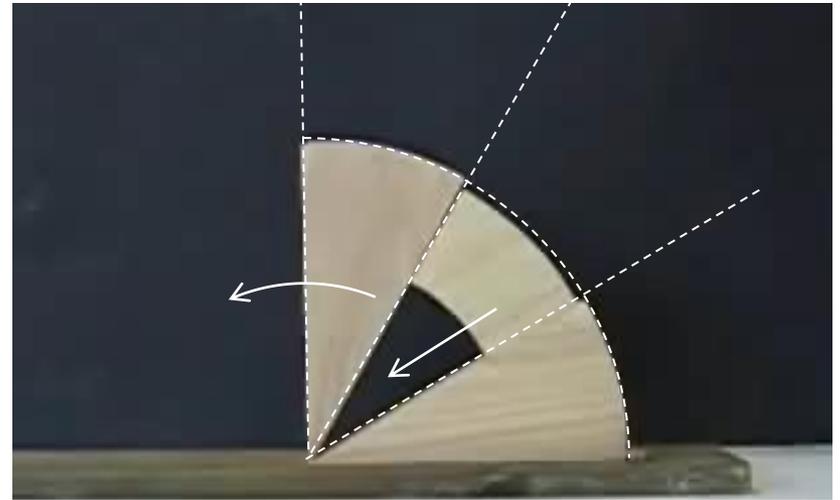
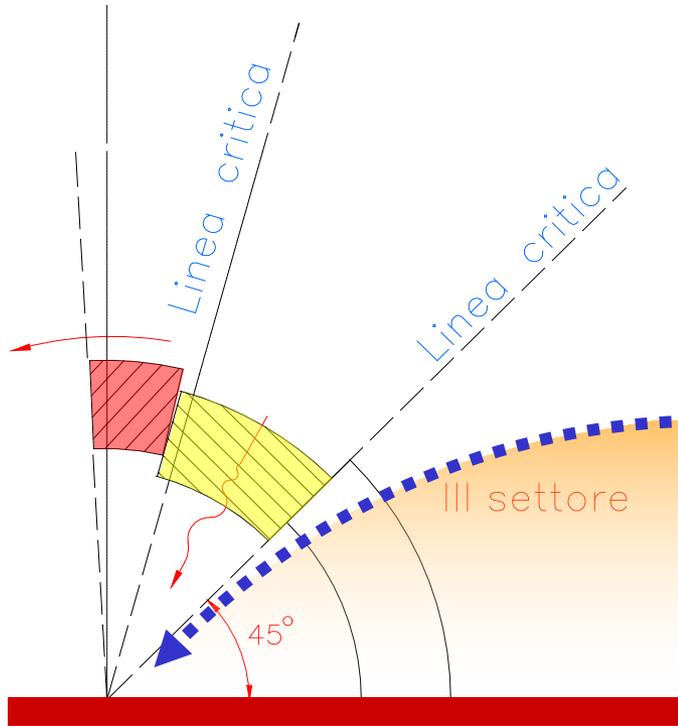
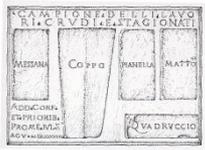
C)

Classificazione tipologica delle lesioni:

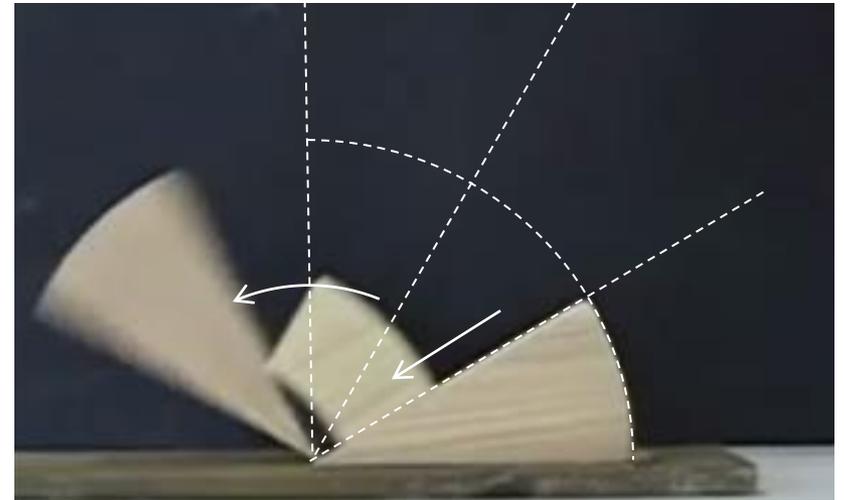
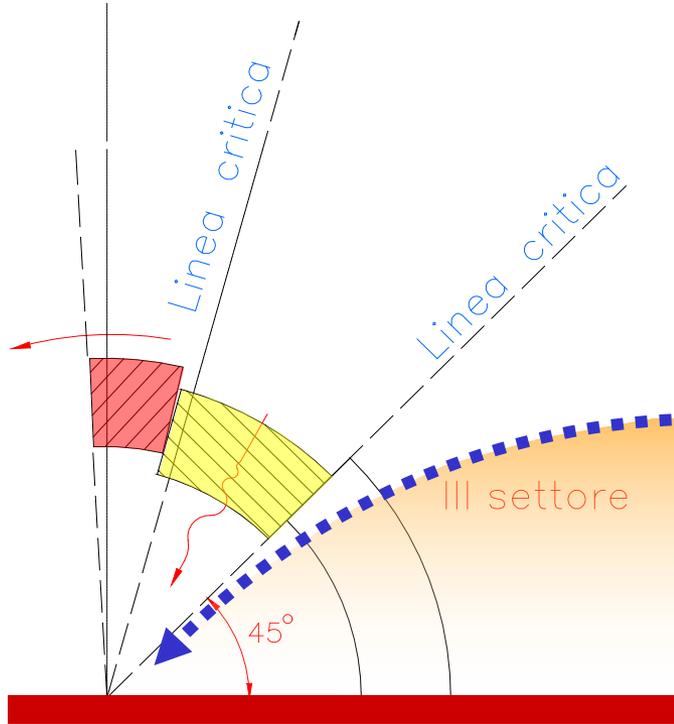
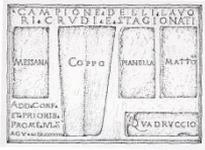
A) di strappo; B) di scorrimento nel piano; C) scorrimento fuori del piano



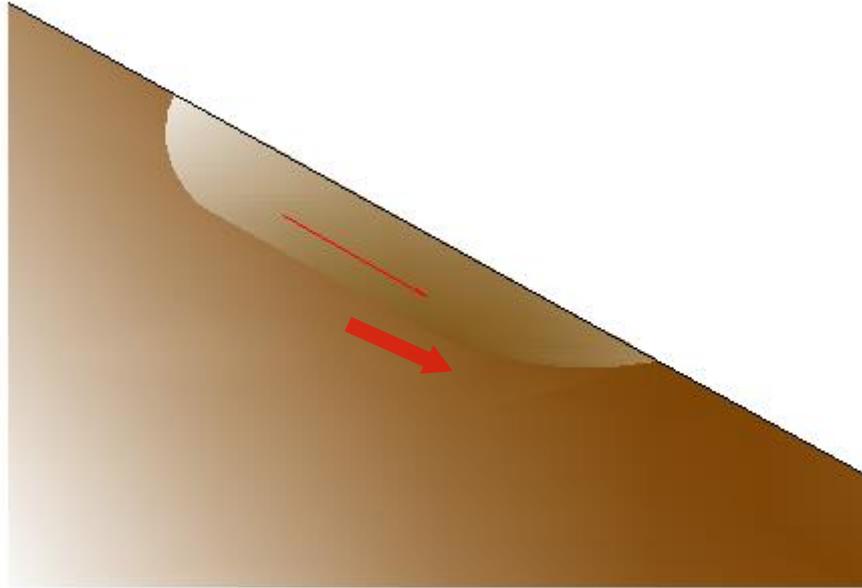
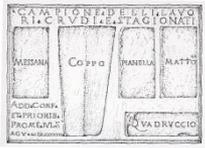




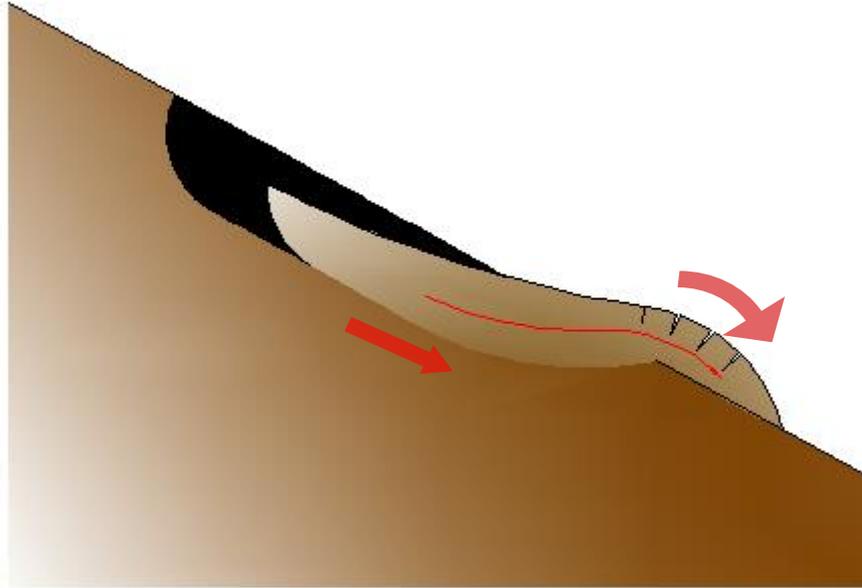
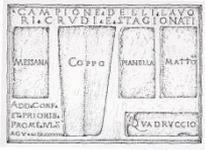
Configurazione della parete secondo il modello ad archi virtuali



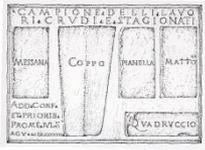
Configurazione della parete secondo il modello ad archi virtuali



Analogia della spinta delle terre (Movimenti franosi)

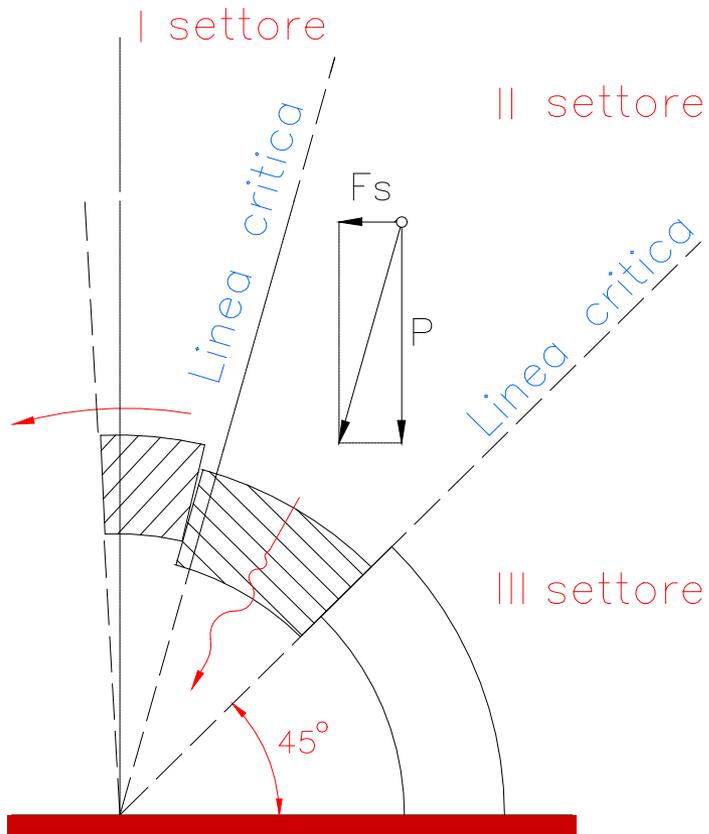


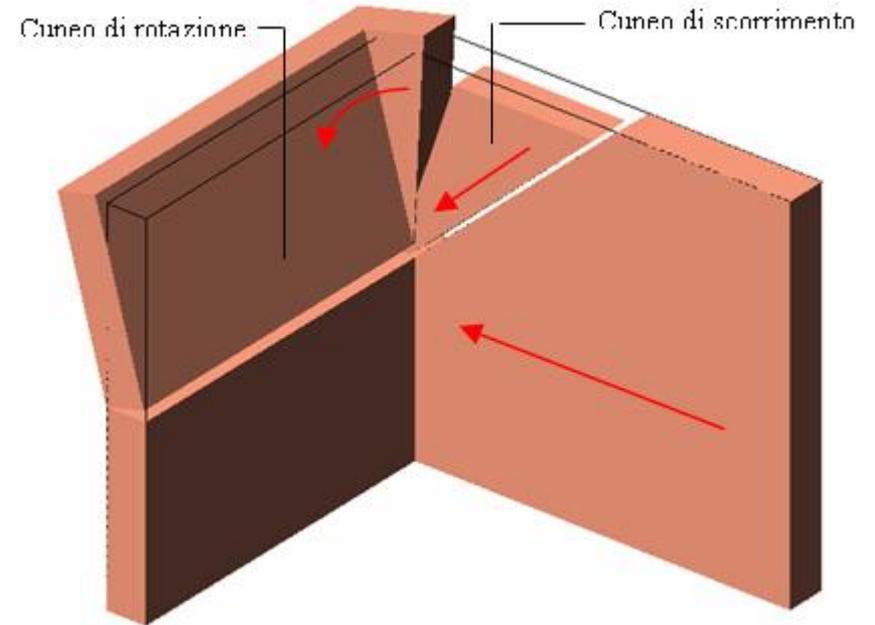
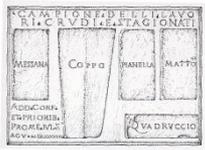
Analogia della spinta delle terre (Movimenti franosi)



Meccanismi di danno delle pareti per azioni complanari

Analogia dell'arco e sistema di consolidamento





Pompei – Regio I (Casa del Menandro)
Terremoto del 62 d.C.

Meccanismi di danno delle pareti per azioni complanari

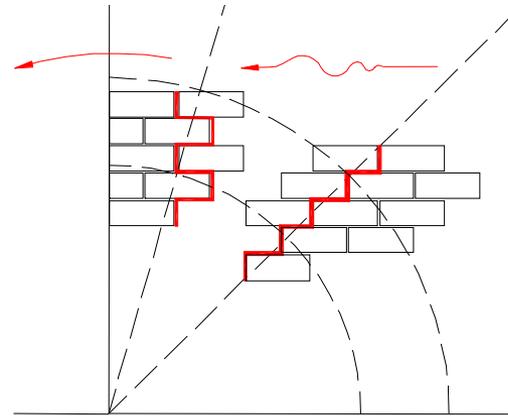
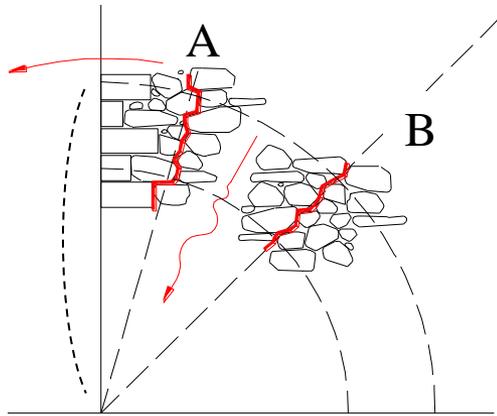
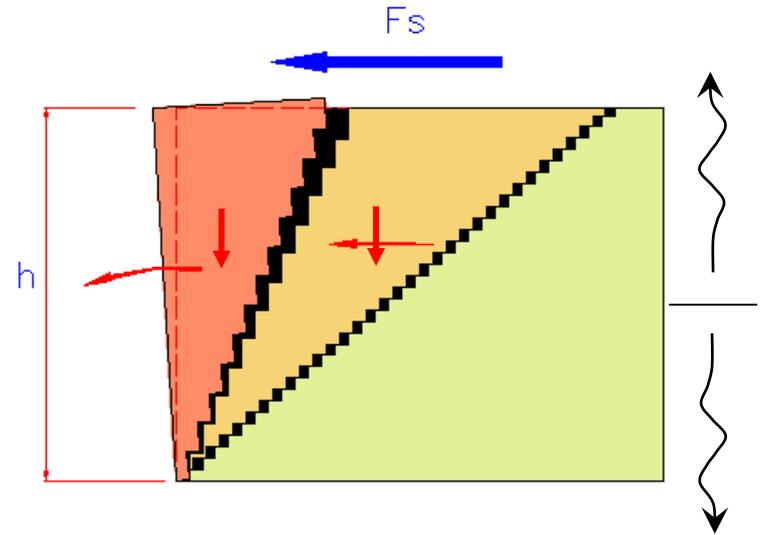
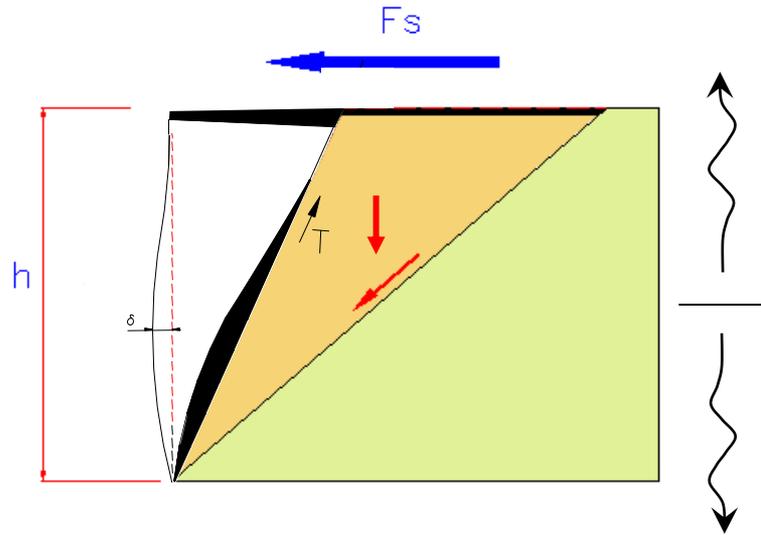
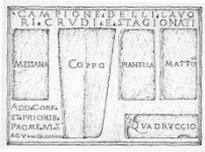
Analogia dell'arco e sistema di consolidamento

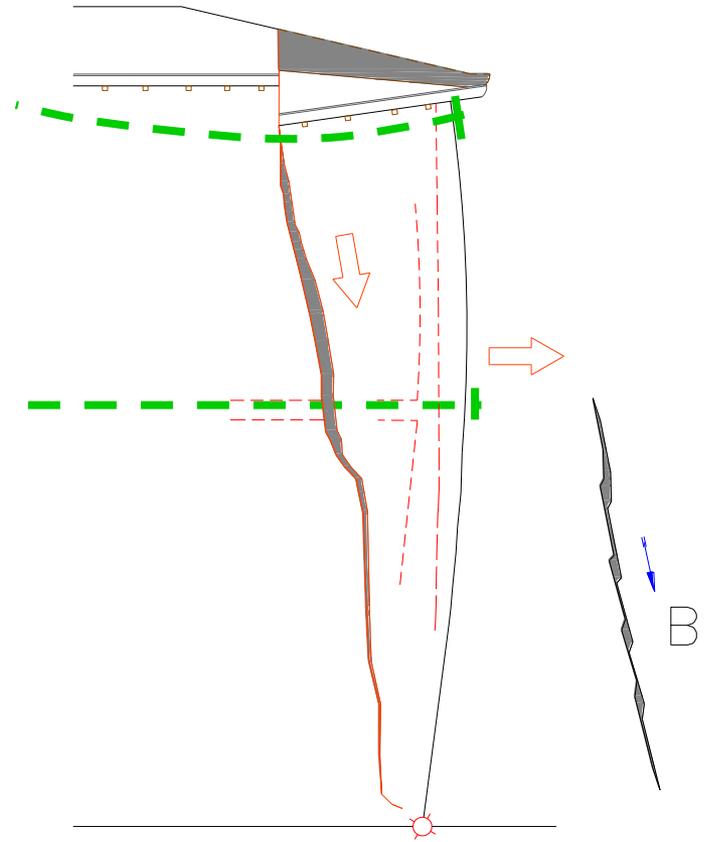
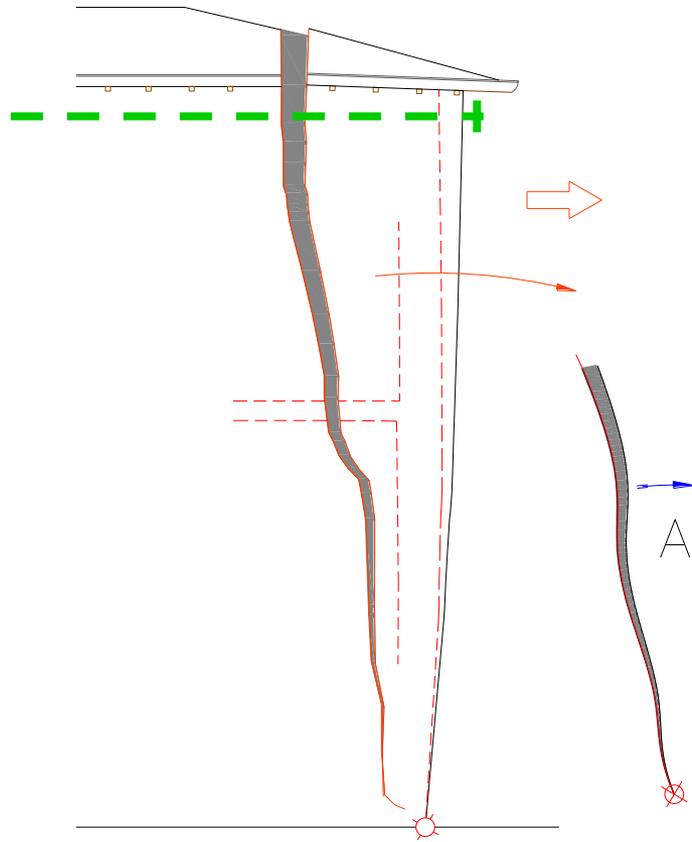
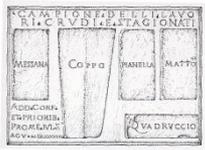


Meccanismi di danno delle pareti per azioni complanari

Analogia dell'arco e sistema di consolidamento

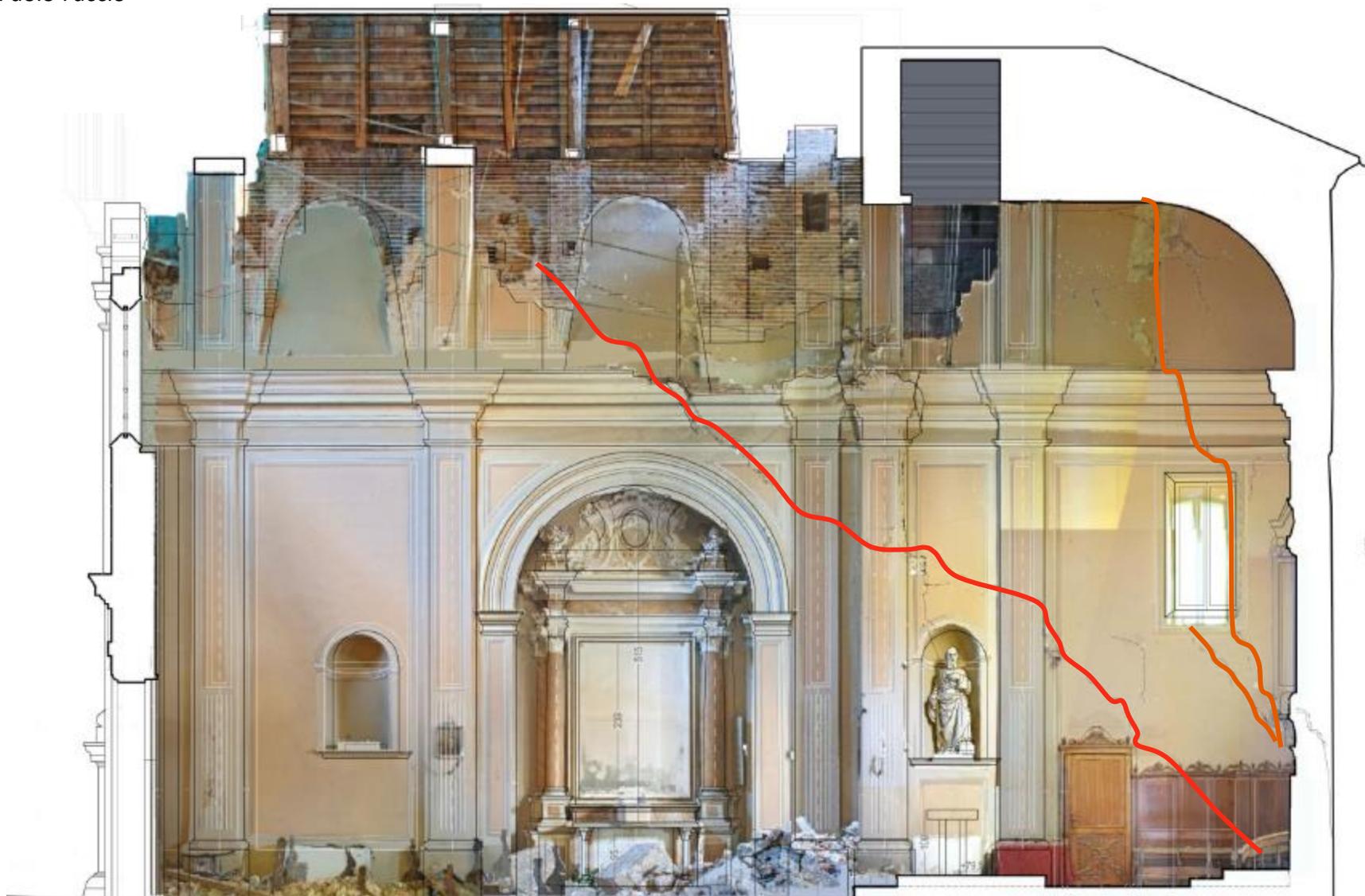






Rilievo:
Arch. Valentina Baroncini

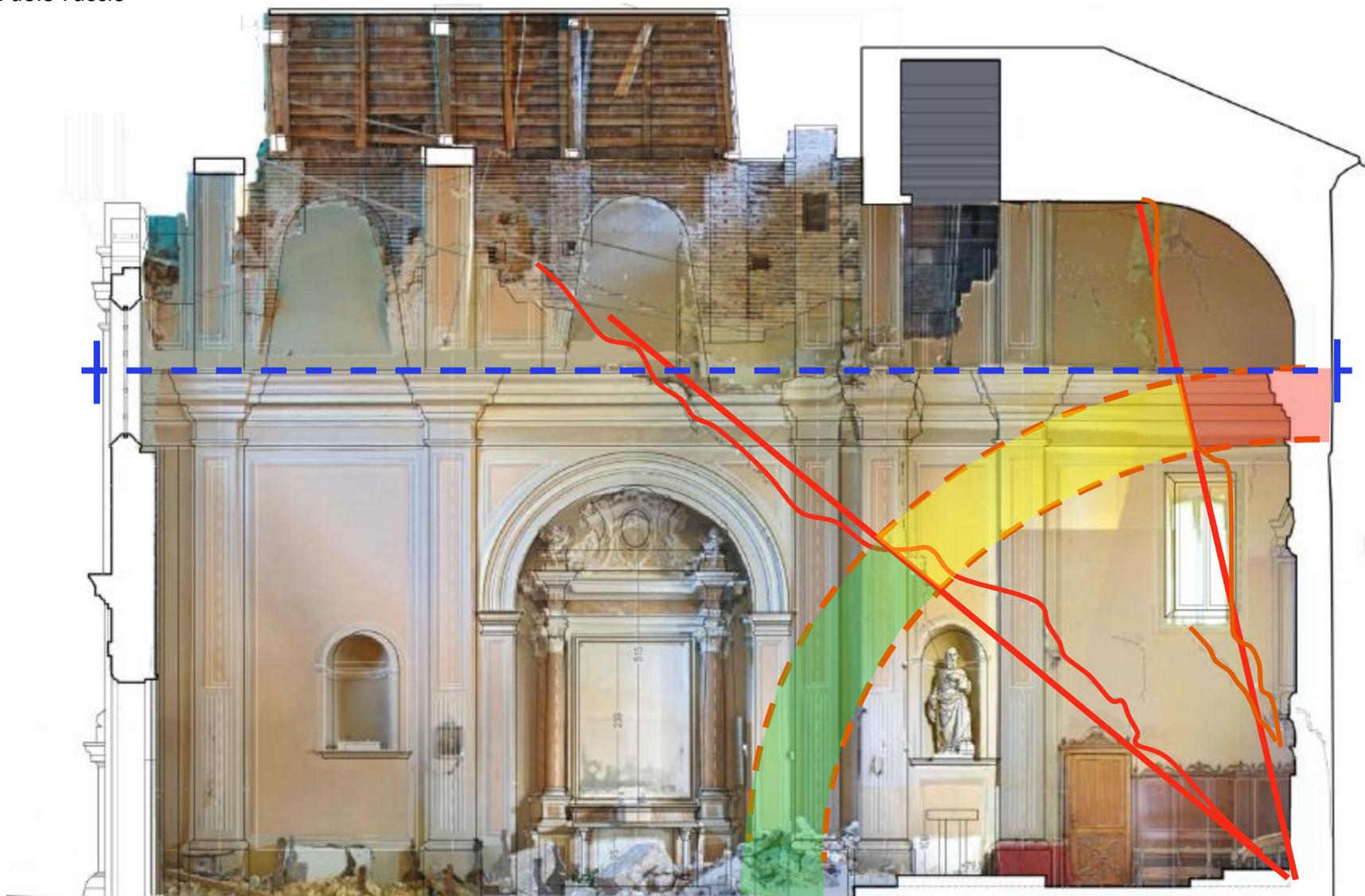
Progetto di recupero:
Ing. Paolo Faccio



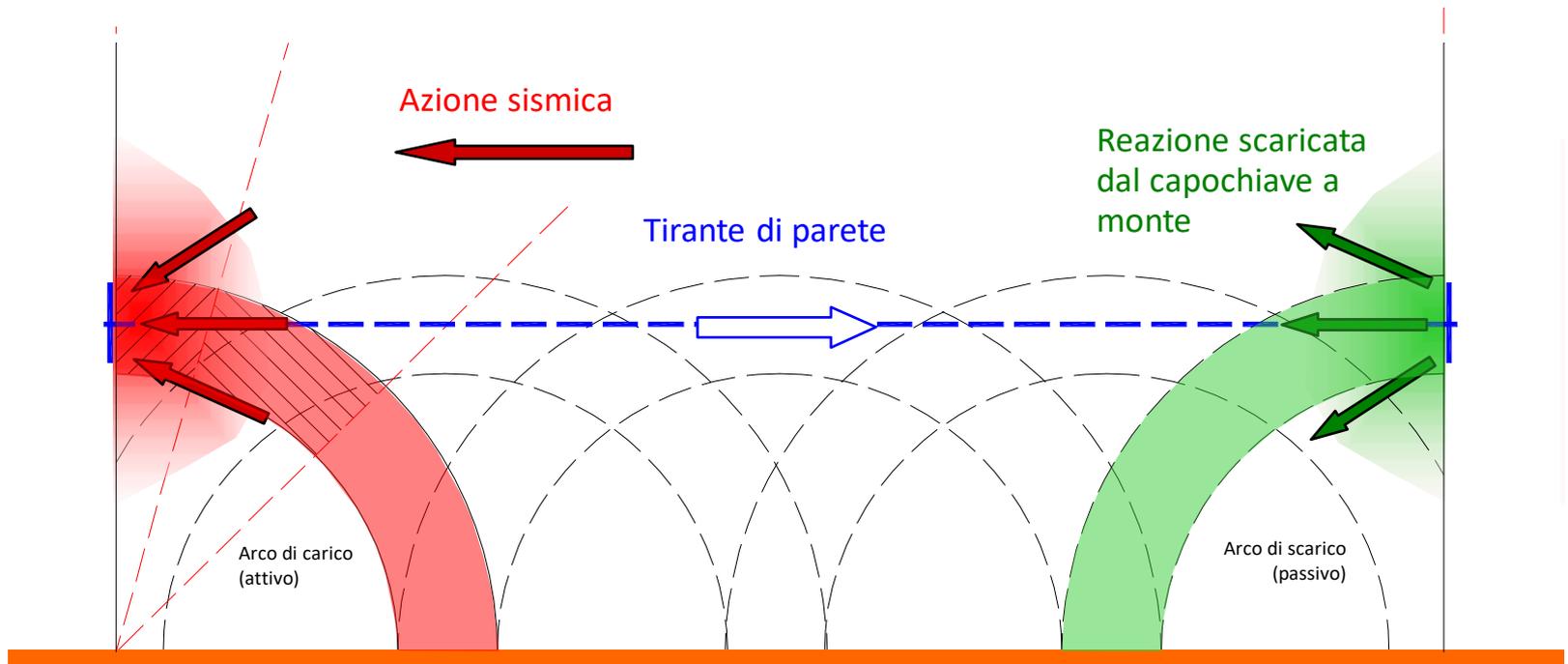
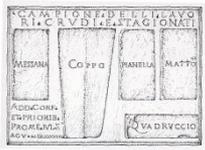
ORATORIO DI SANTA CROCE – SAN FELICE SUL PANARO (MO)

Rilievo:
Arch. Valentina Baroncini

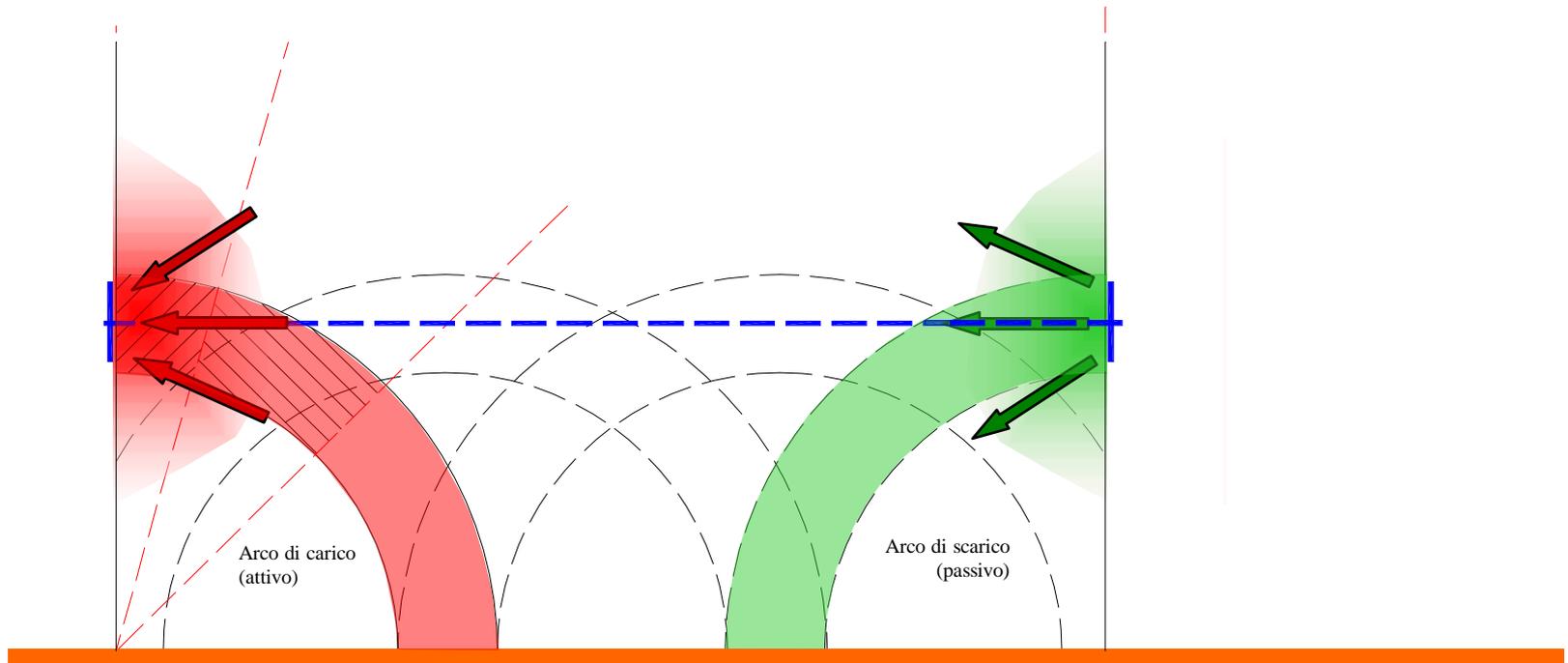
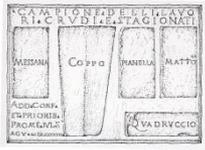
Progetto di recupero:
Ing. Paolo Faccio



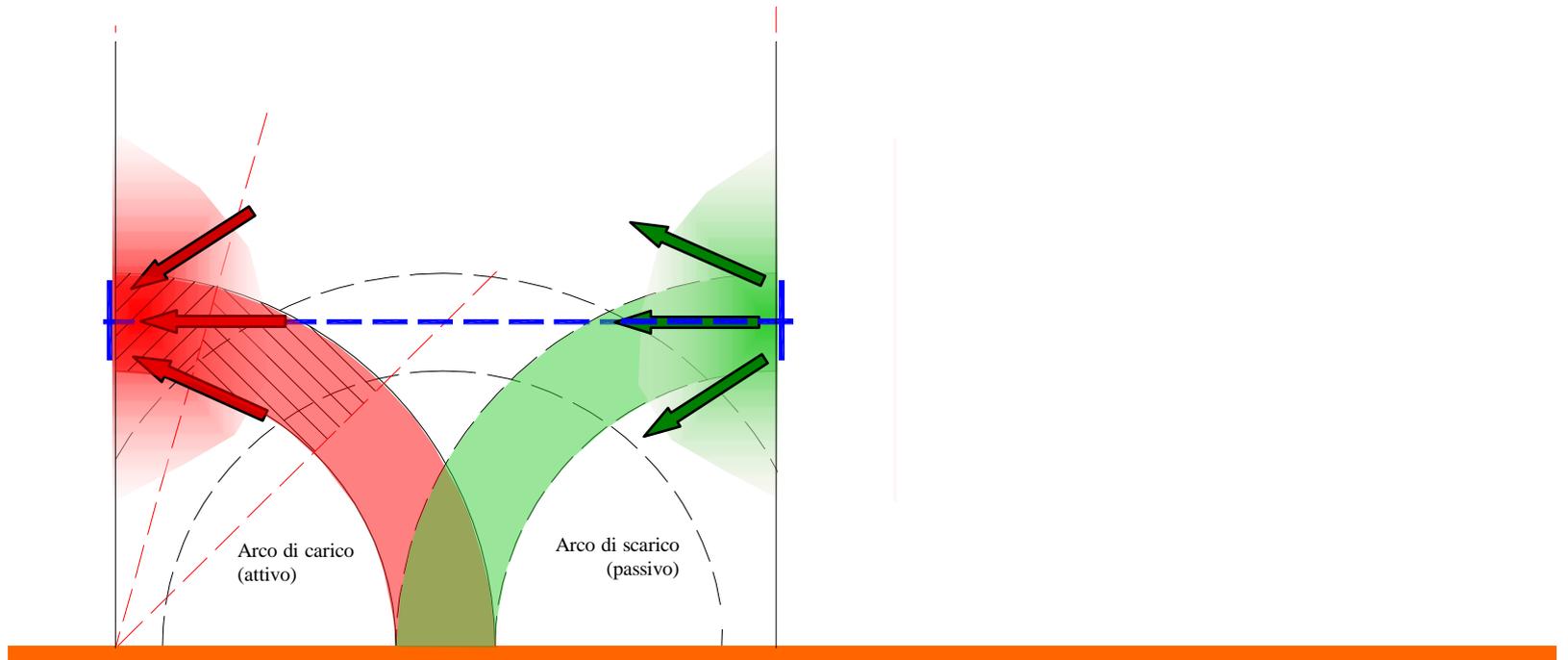
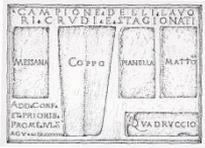
ORATORIO DI SANTA CROCE – SAN FELICE SUL PANARO (MO)



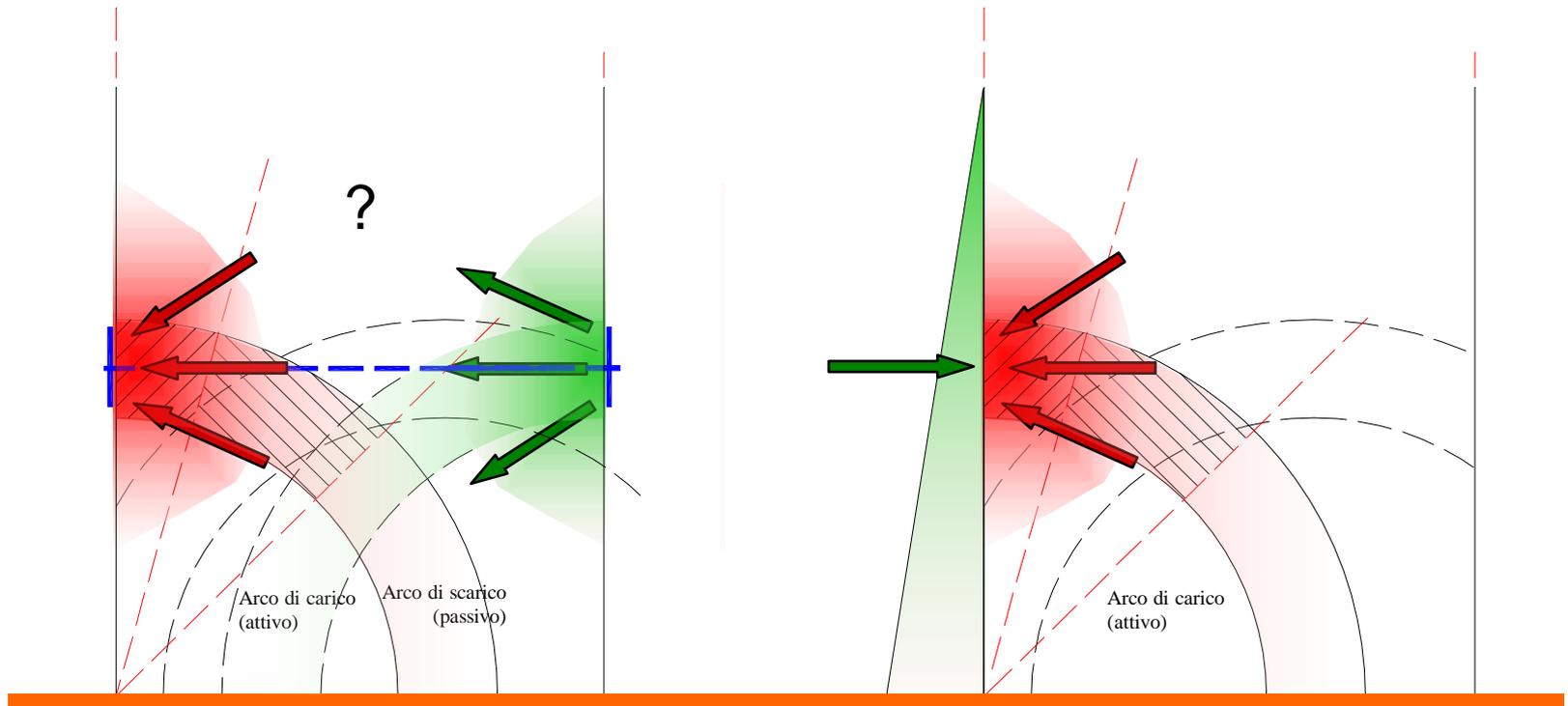
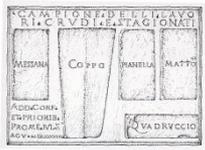
Schema di funzionamento dei tiranti di parete secondo il modello ad archi virtuali



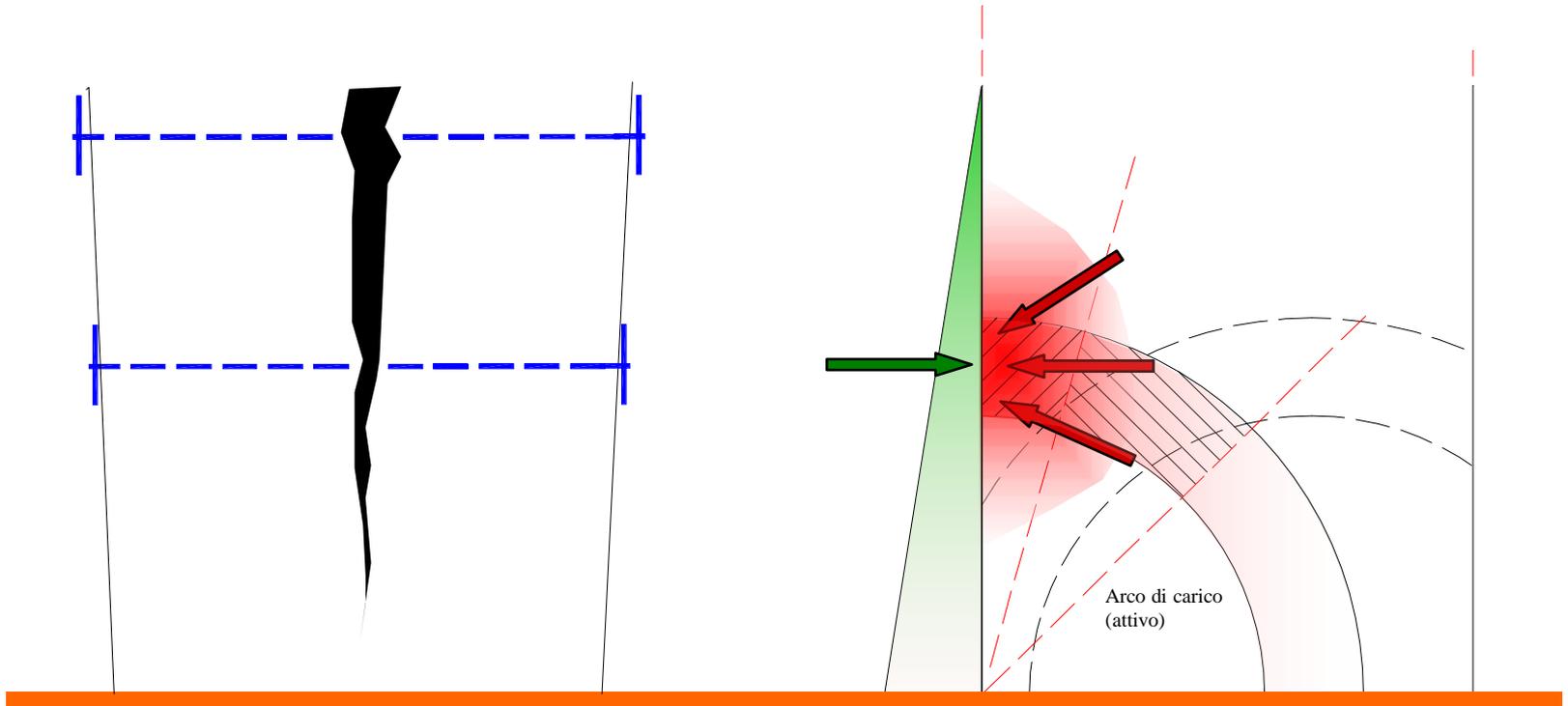
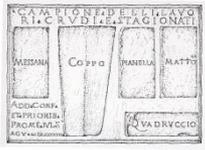
Schema di funzionamento dei tiranti di parete secondo il modello ad archi virtuali



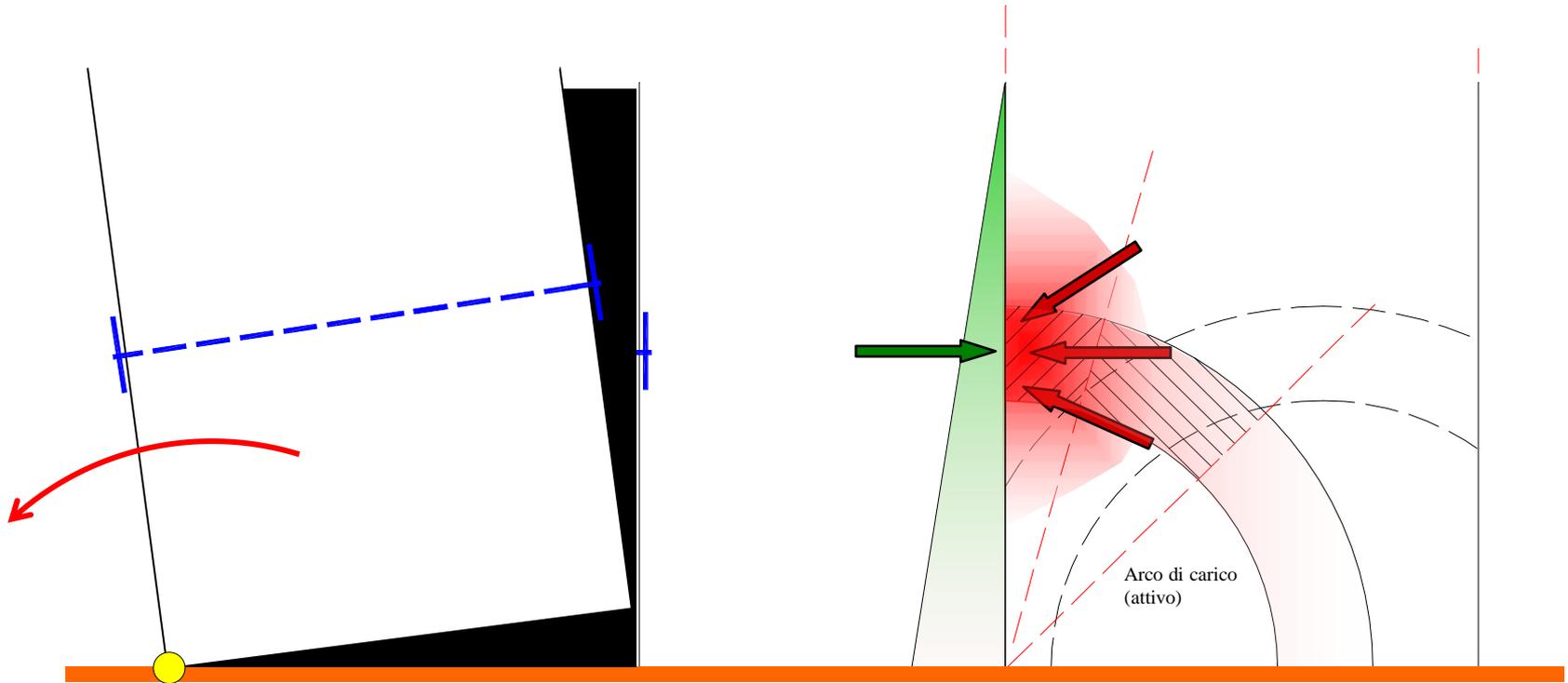
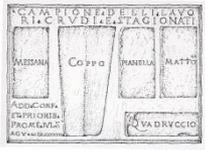
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Limite di funzionamento



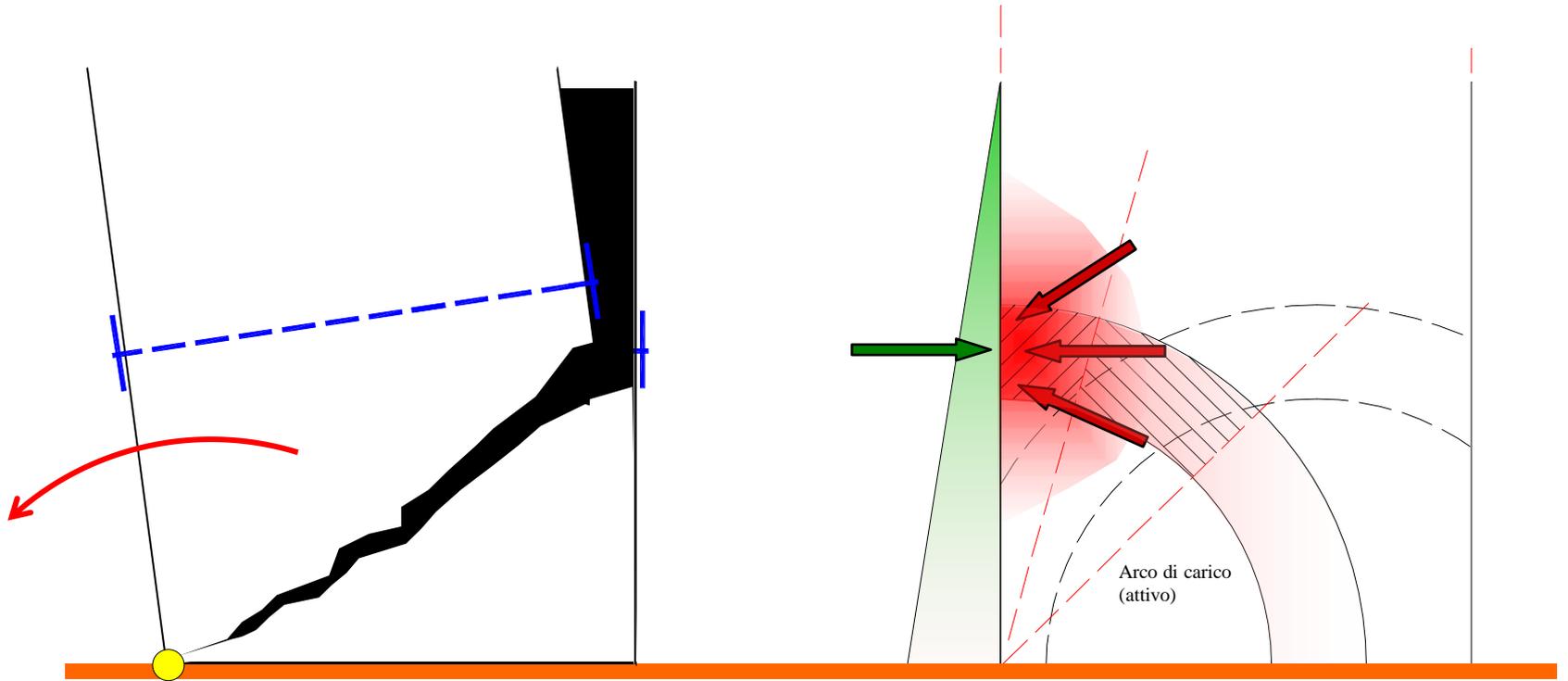
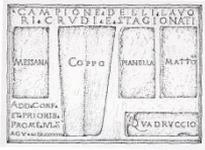
Schema di funzionamento dei tiranti di parete secondo il modello ad archi virtuali
Limite di funzionamento – Intreccio fra l'arco di carico e l'arco di scarico



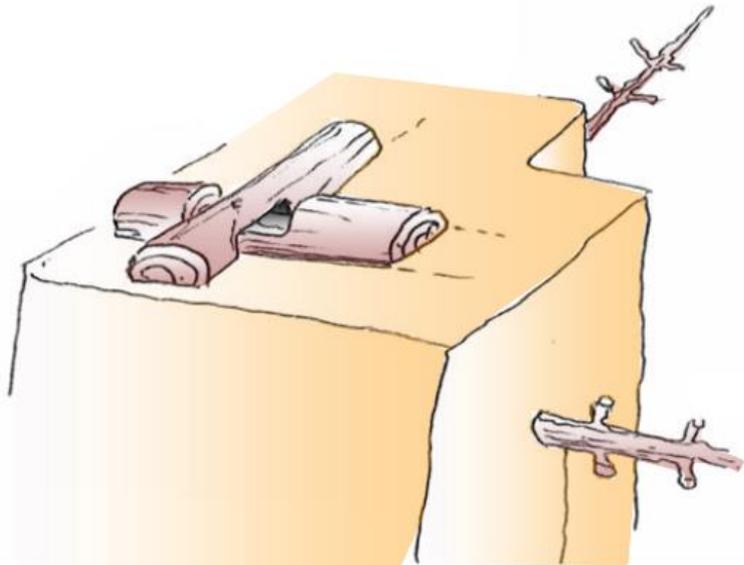
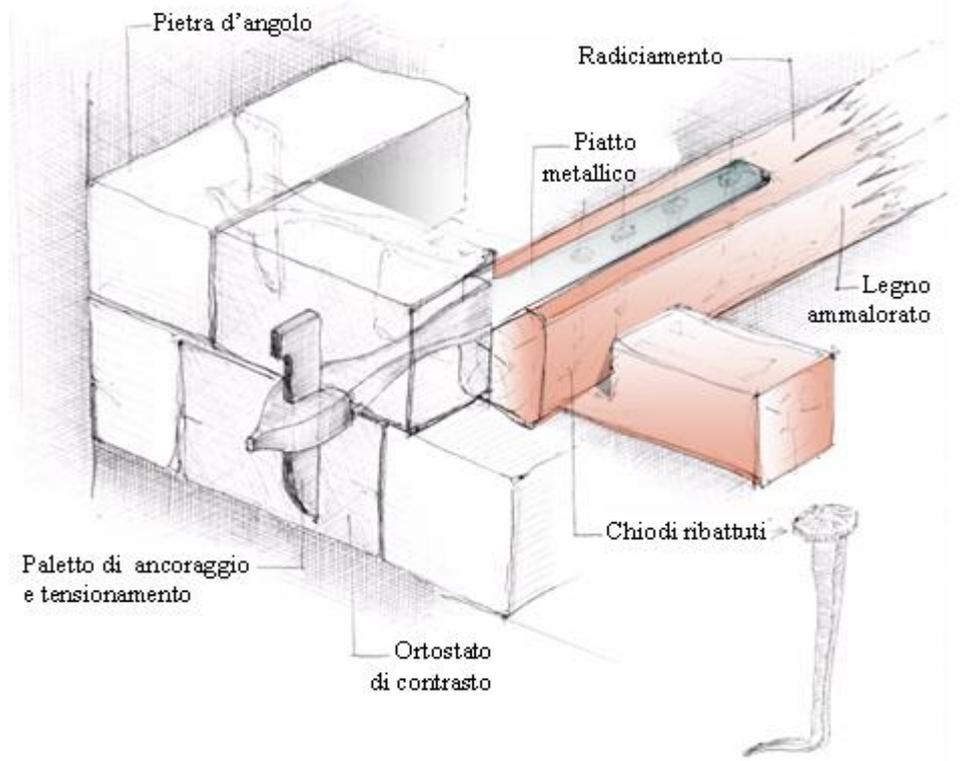
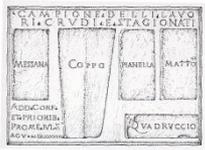
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Limite di funzionamento – Intreccio fra l'arco di carico e l'arco di scarico

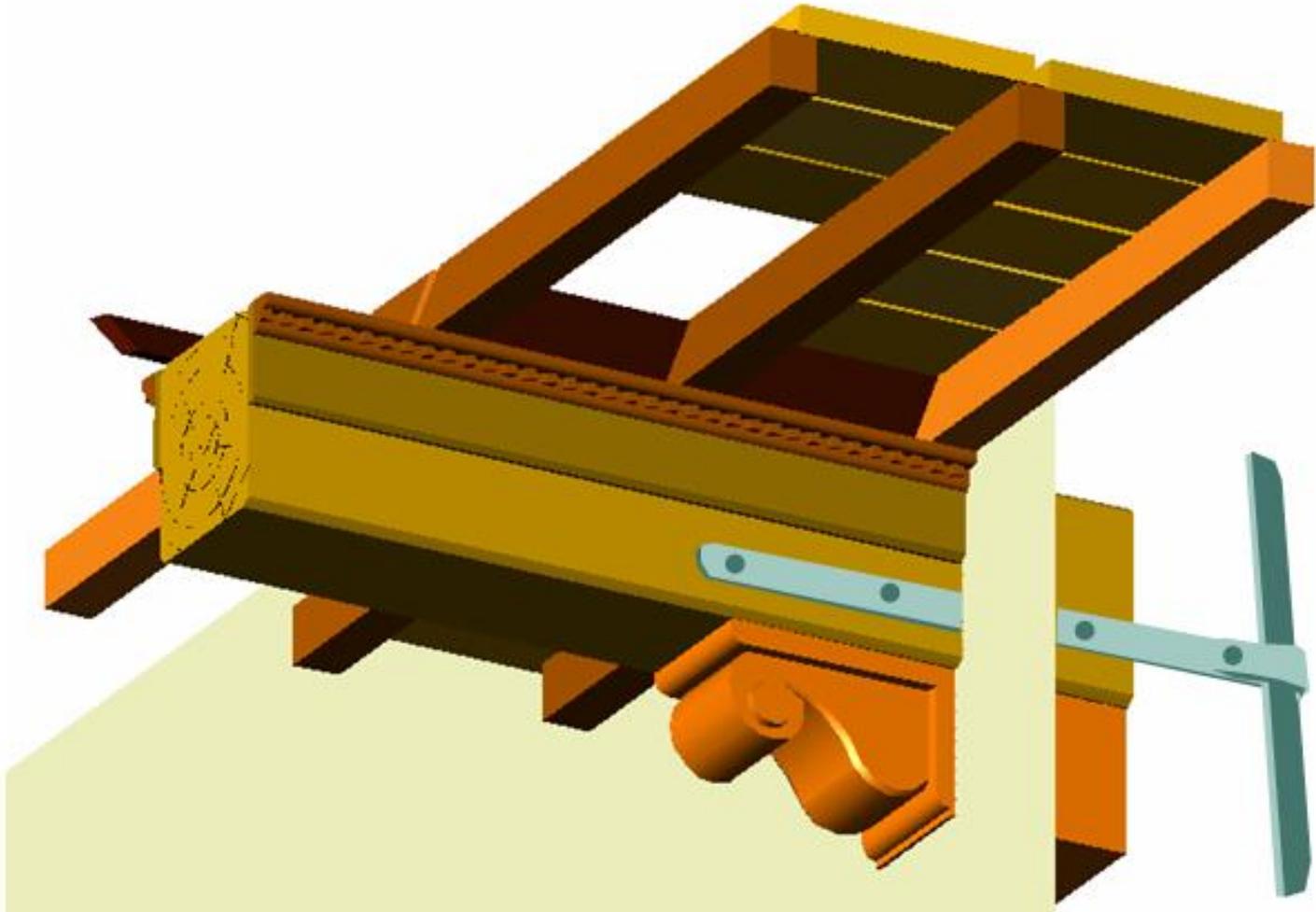
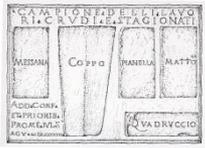


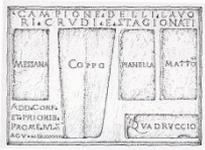
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Limite di funzionamento – Intreccio fra l'arco di carico e l'arco di scarico



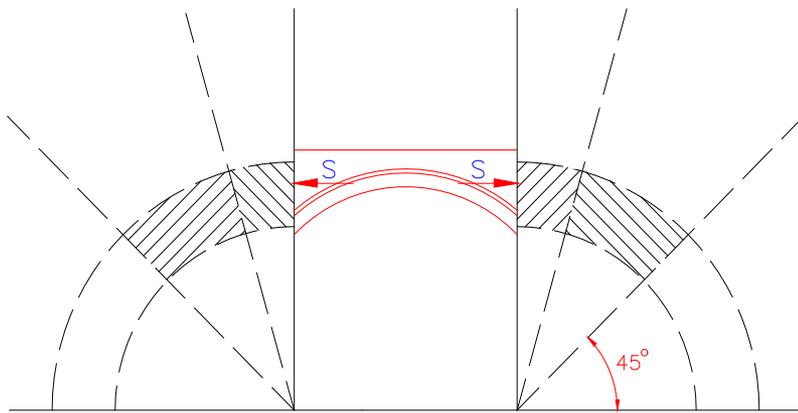
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Limite di funzionamento – Intreccio fra l'arco di carico e l'arco di scarico







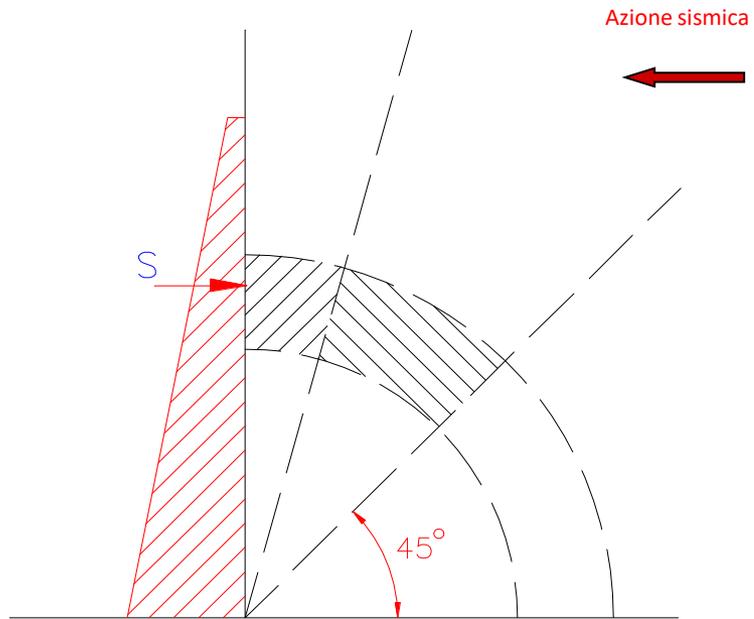
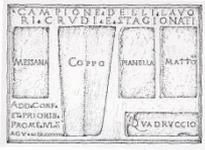
Archi di sbatacchio

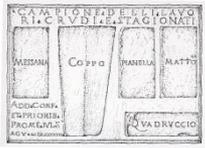


Lugnano, 1917

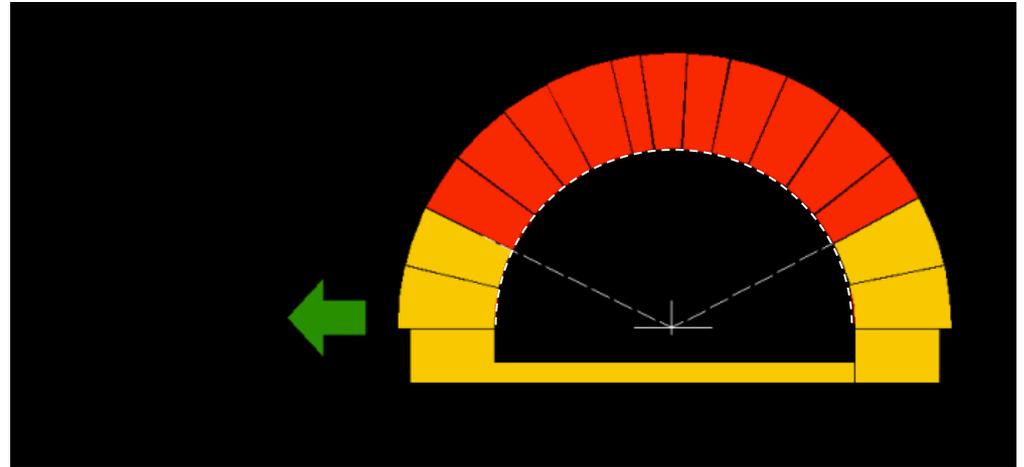
Archi di sbatacchio



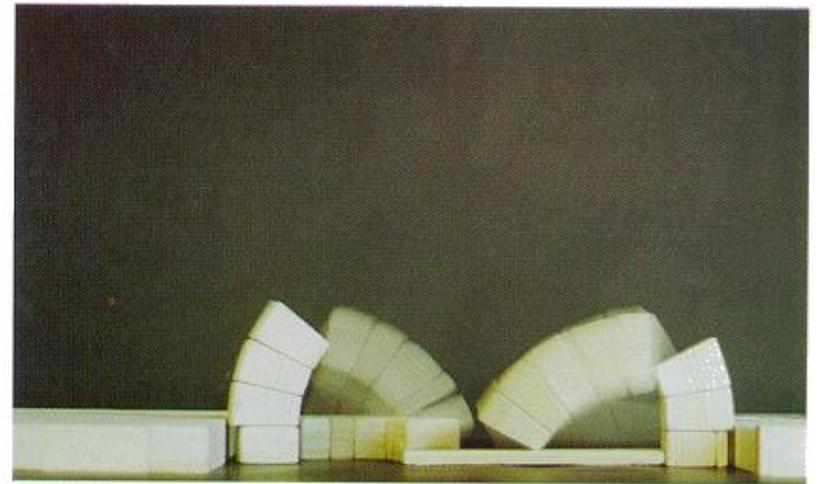
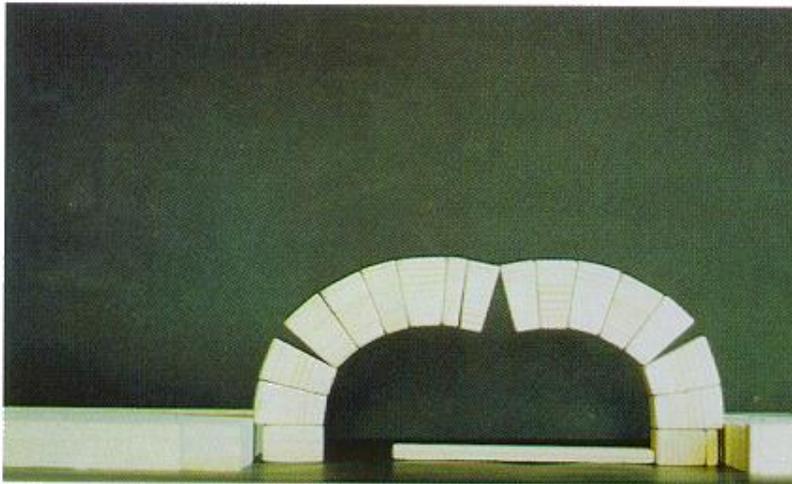


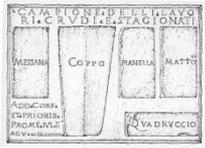


Dissesti di archi e volte Meccanismo di rottura a flessione

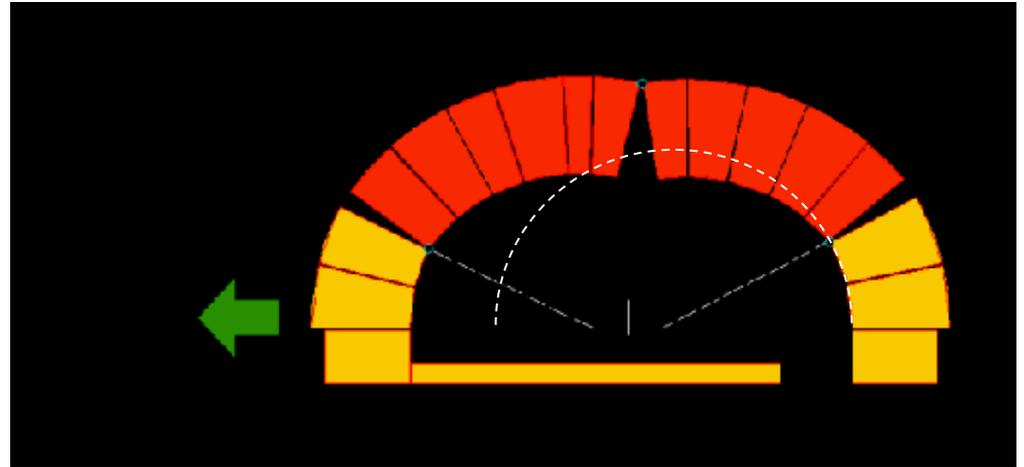


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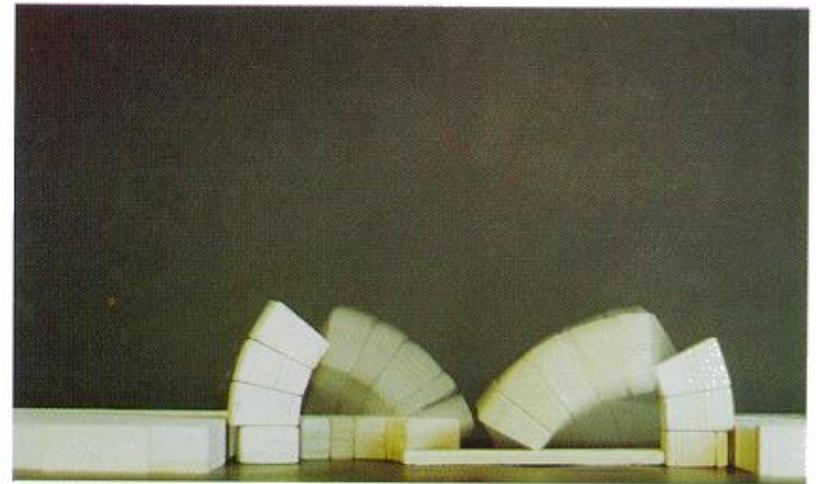
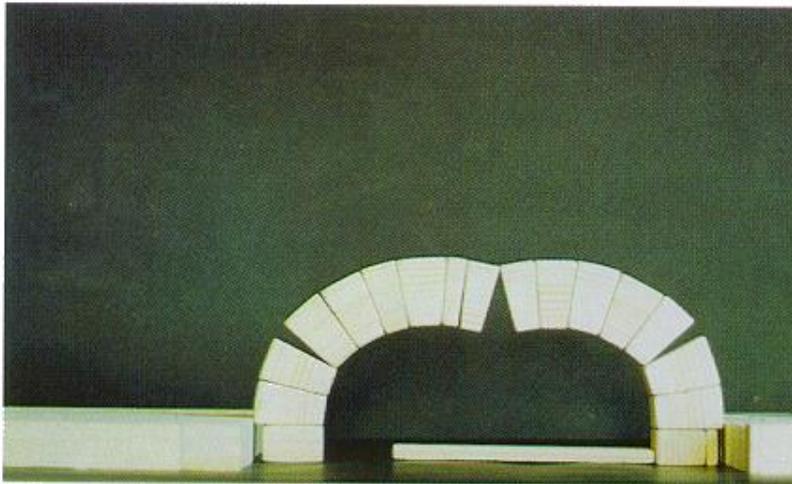


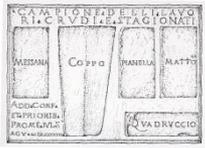


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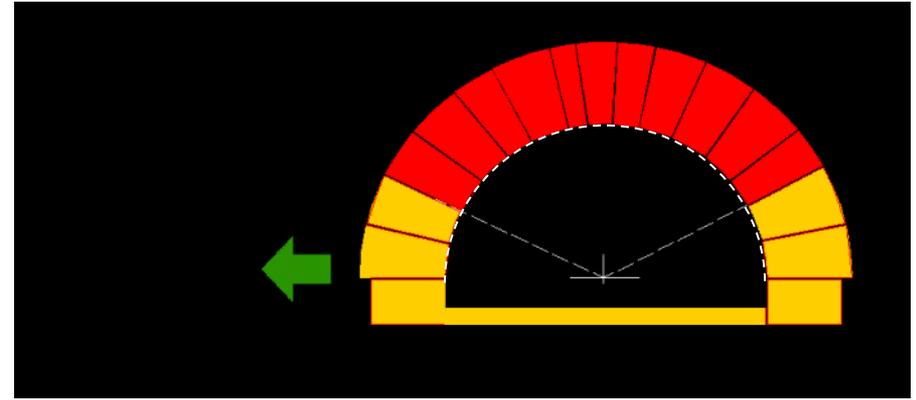


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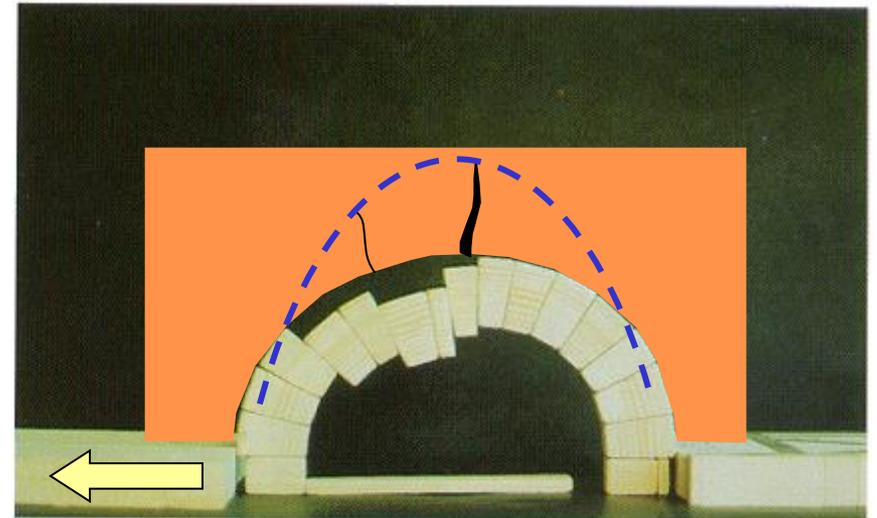
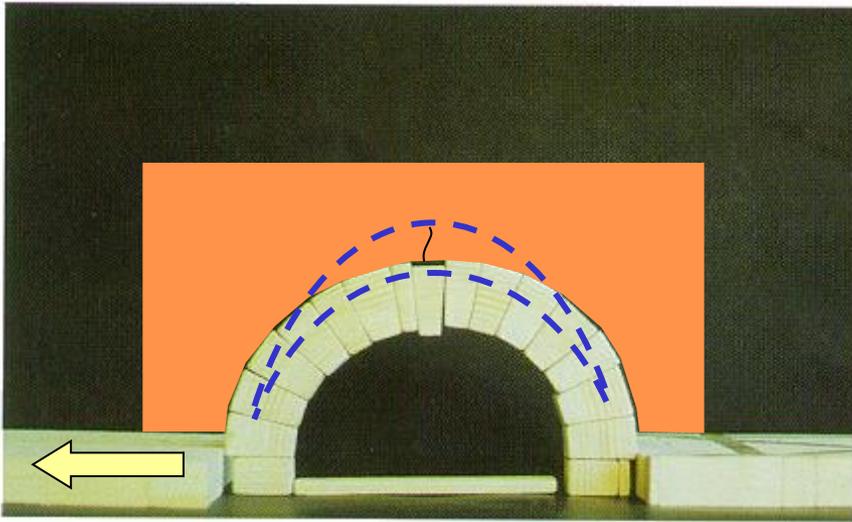


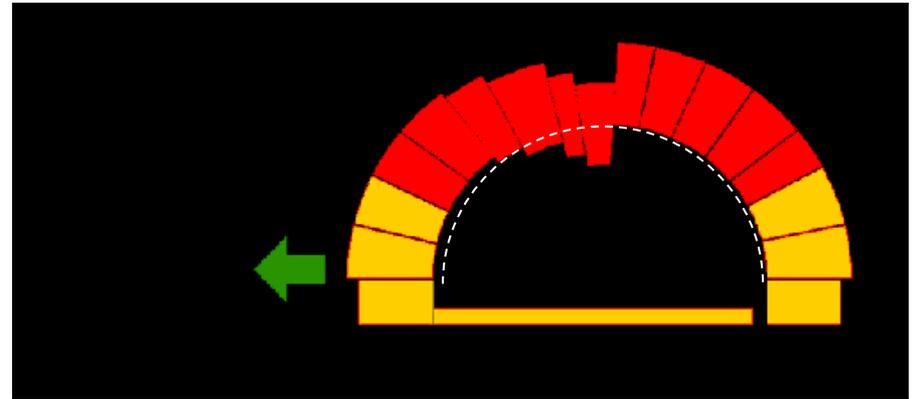


Dissesti di archi e volte Meccanismo di rottura a taglio

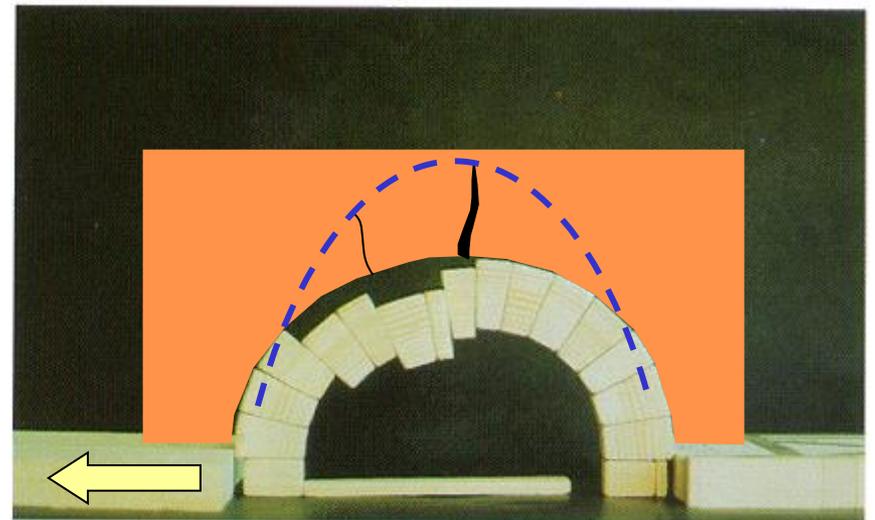
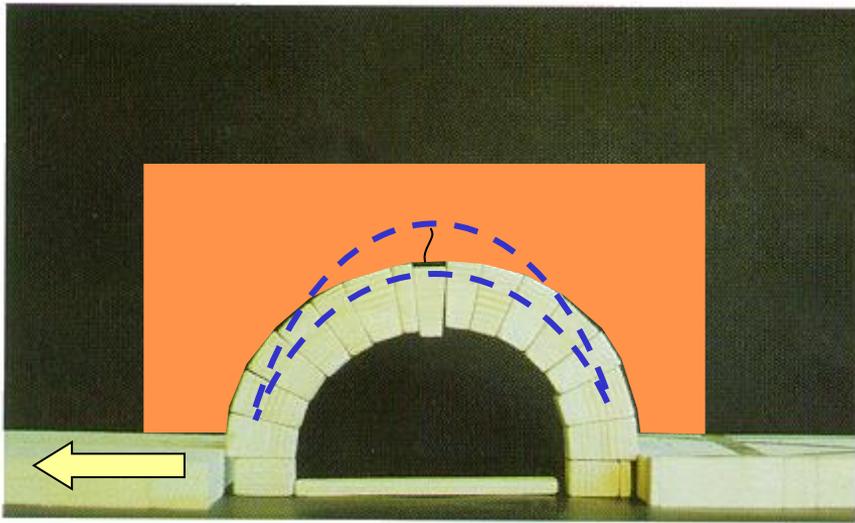


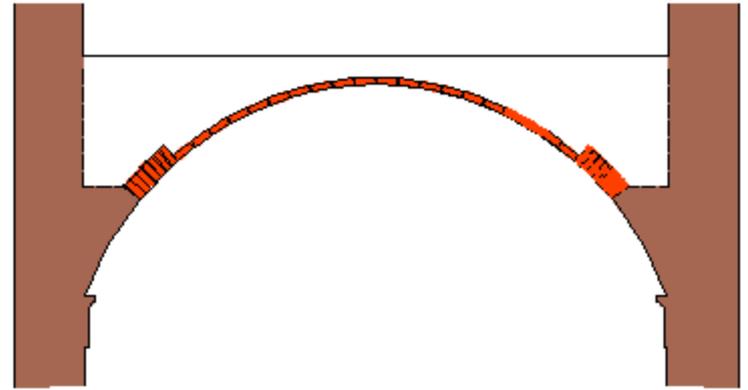
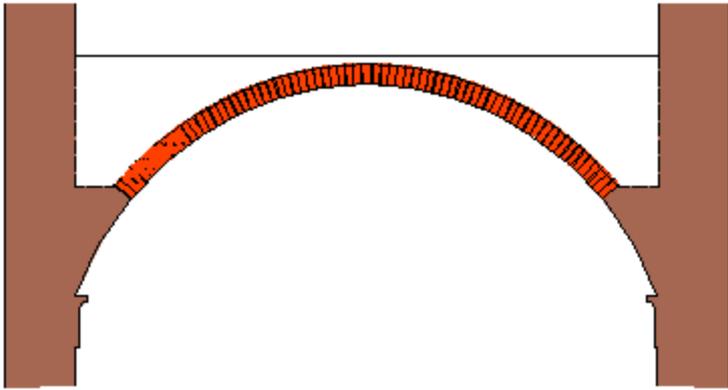
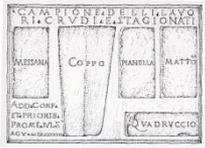
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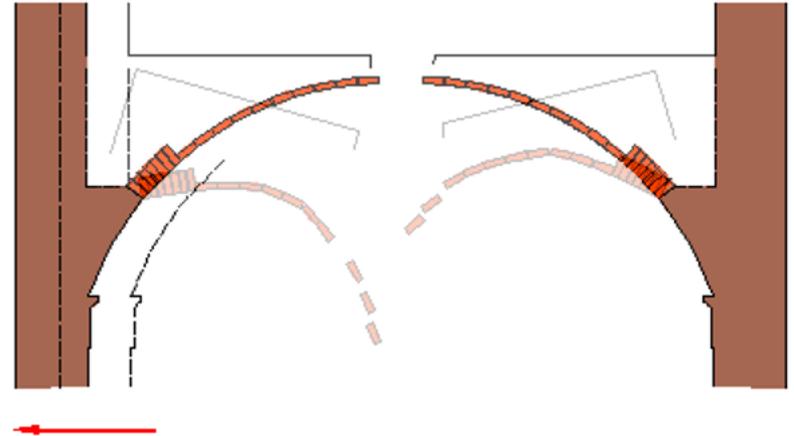
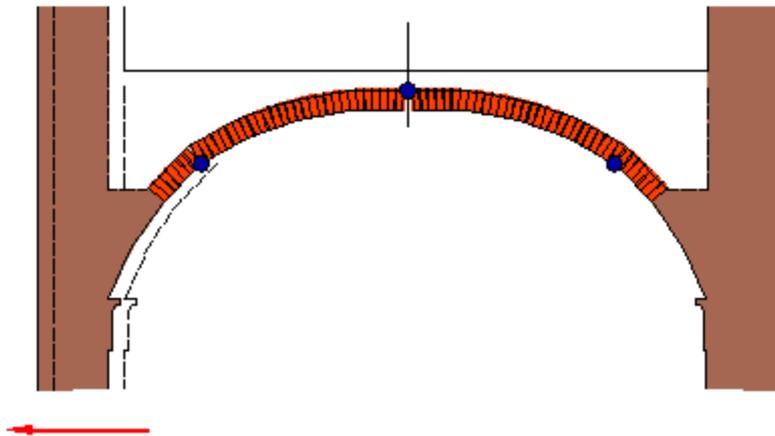
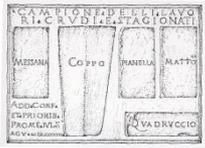




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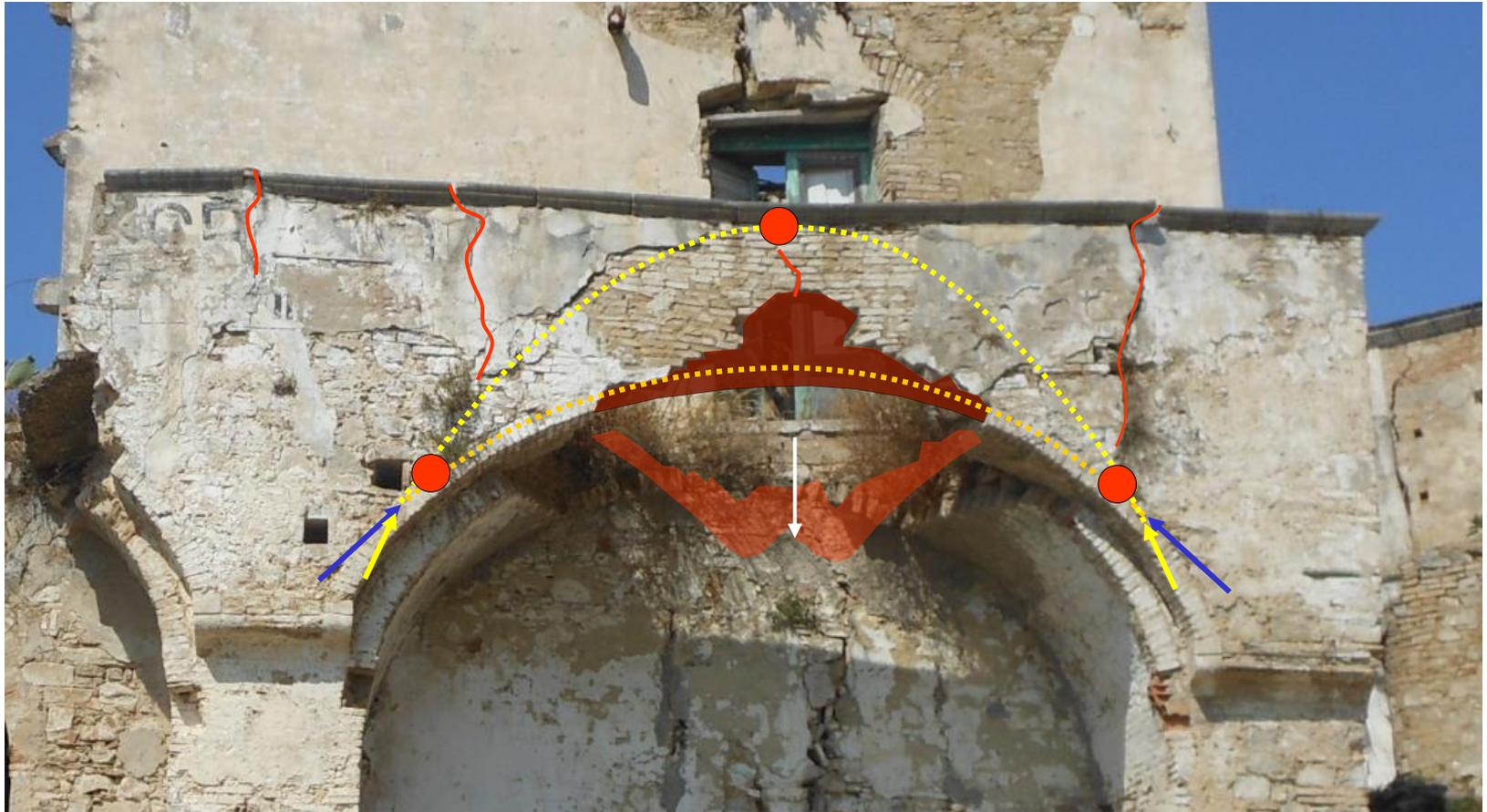






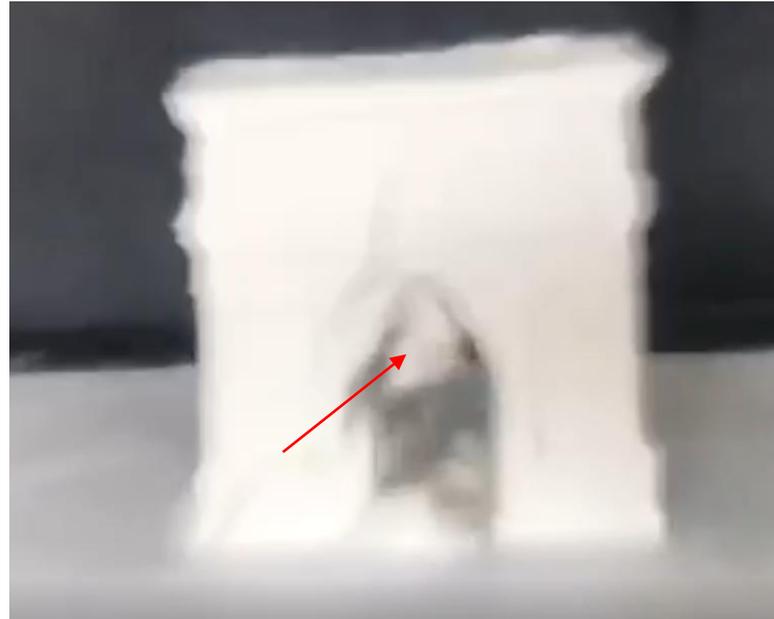
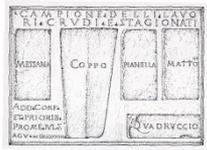
Cinematismi elementari:
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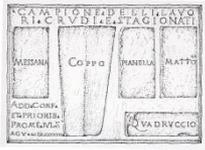
evoluzione
con migrazione

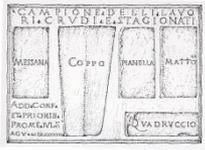


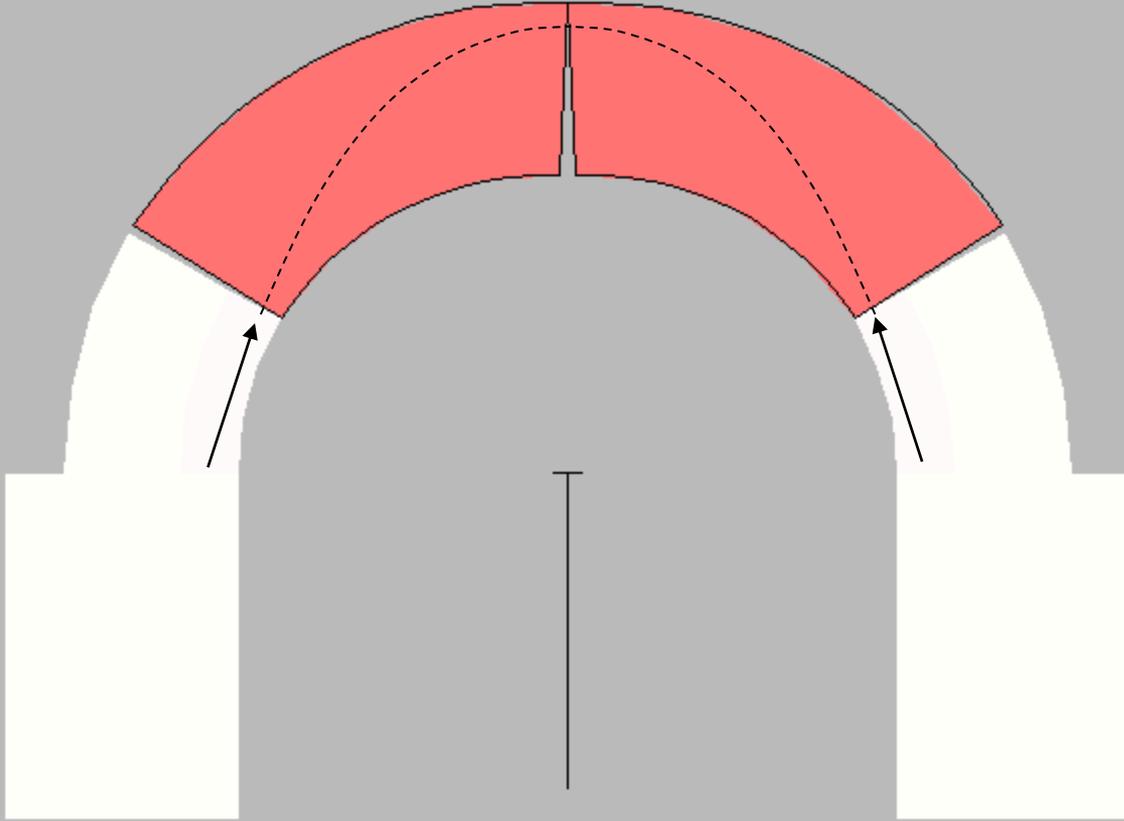
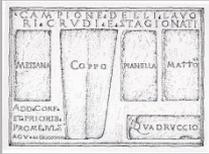
Cinematismi elementari:
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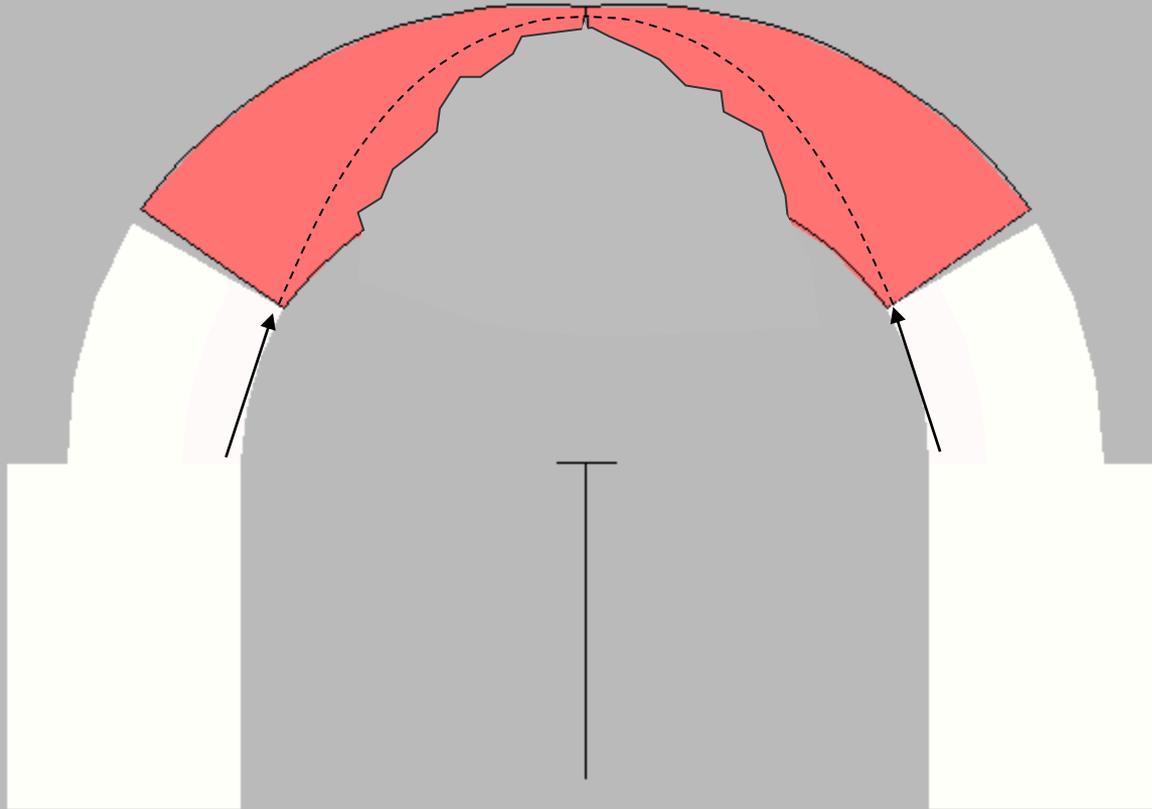
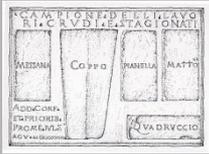
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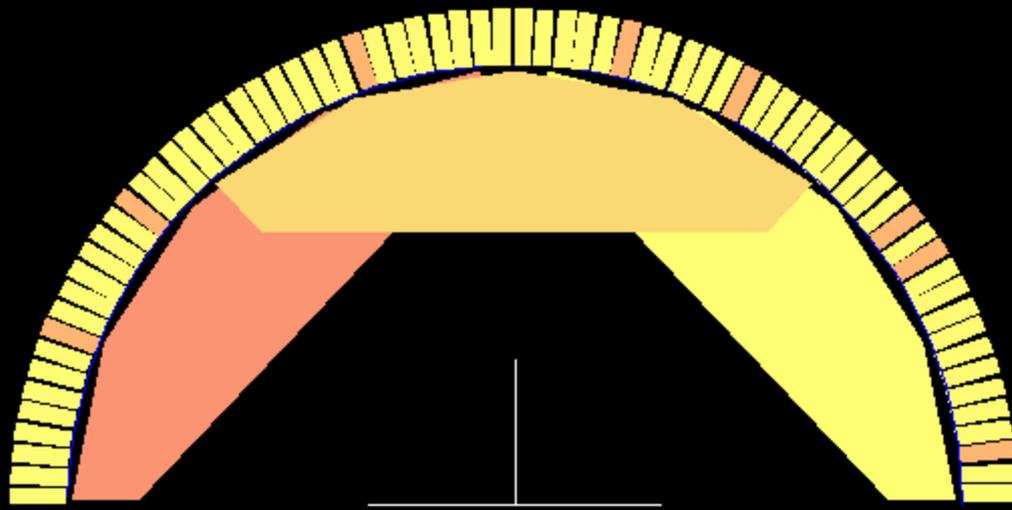
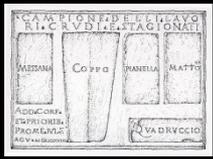


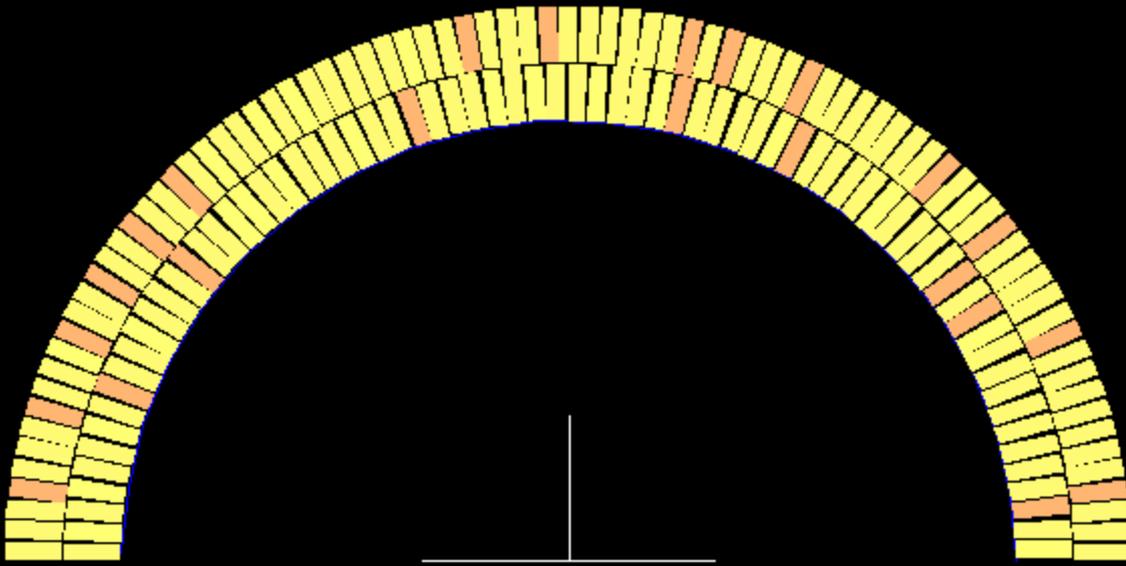


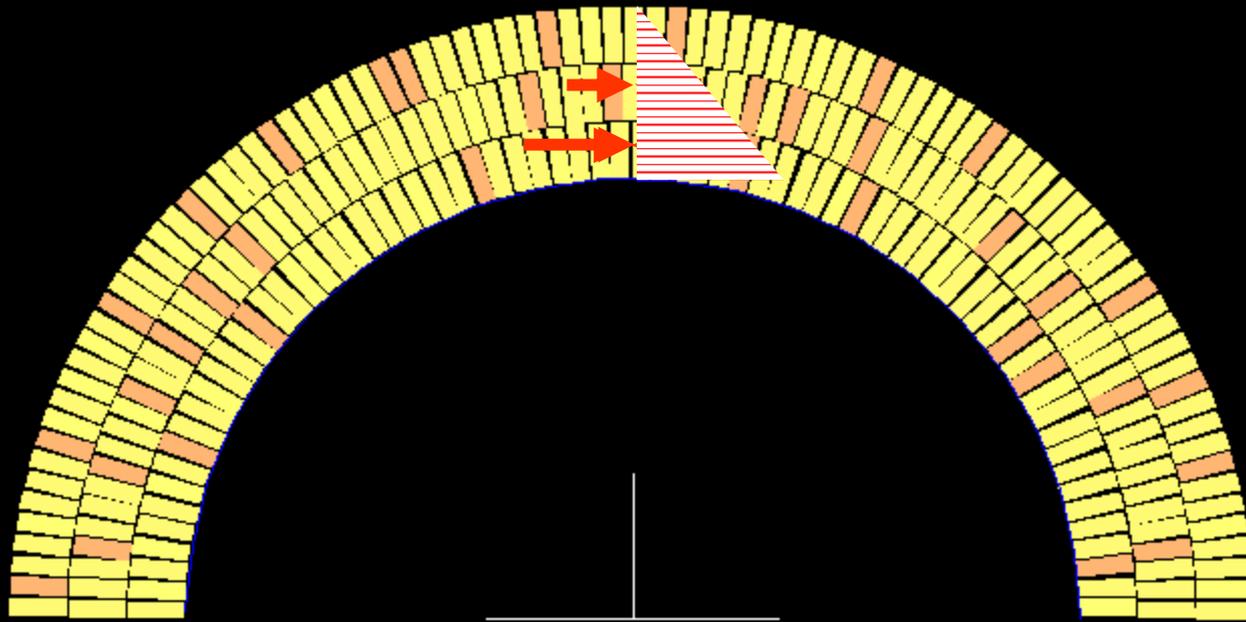


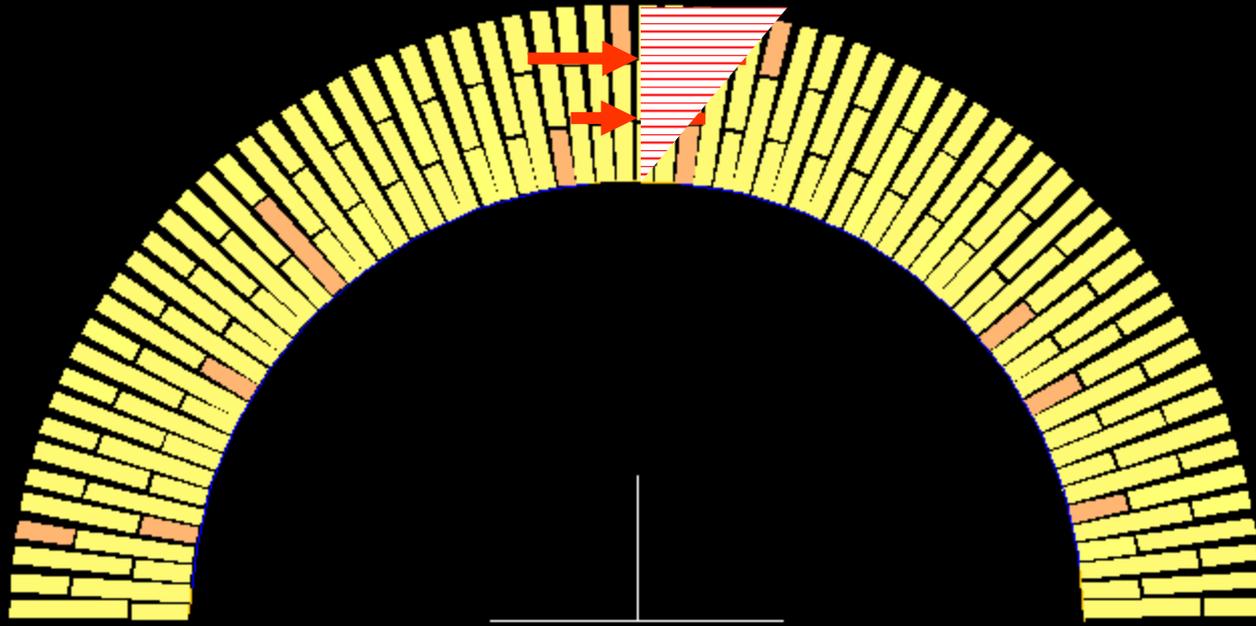
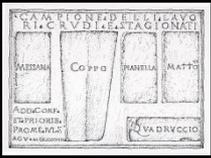


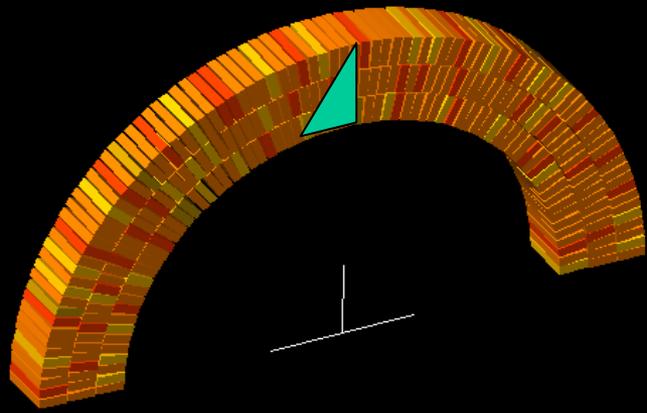
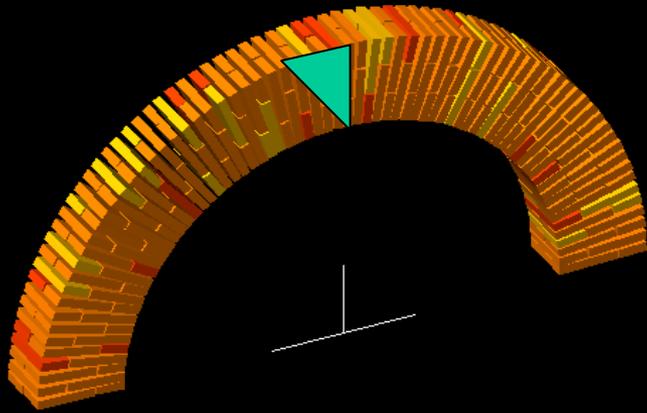
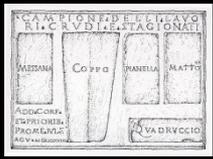


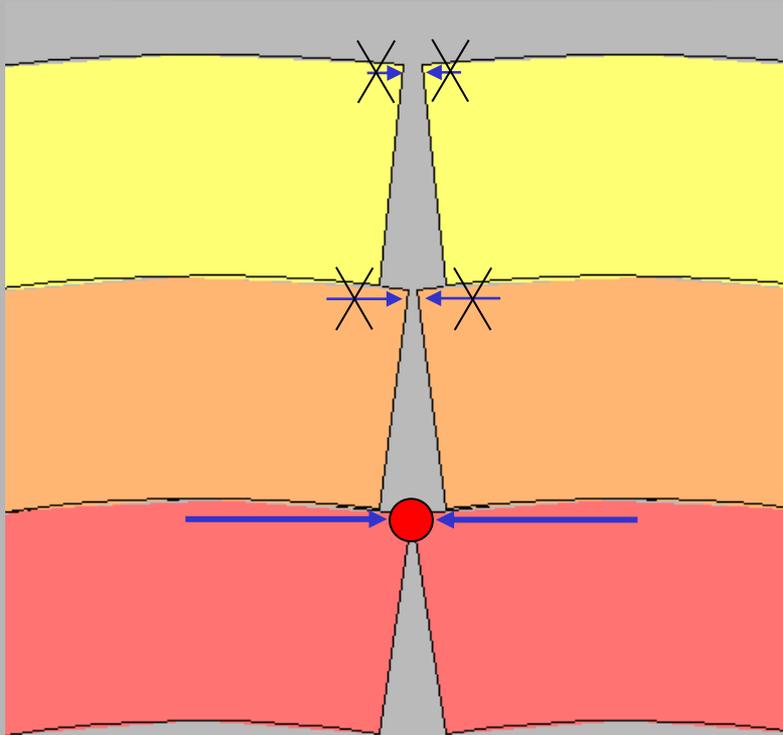
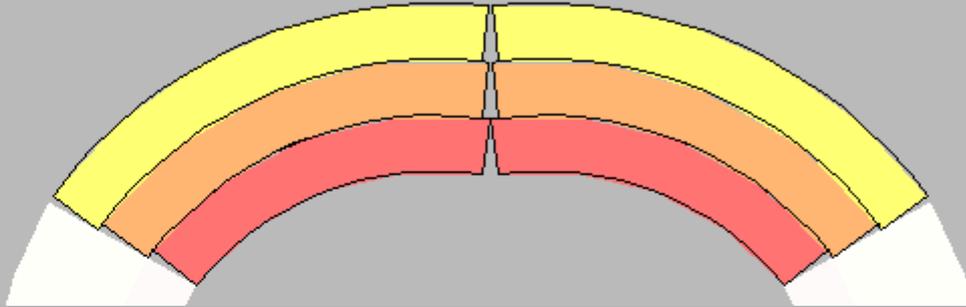
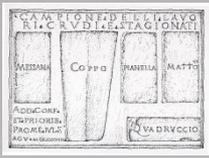


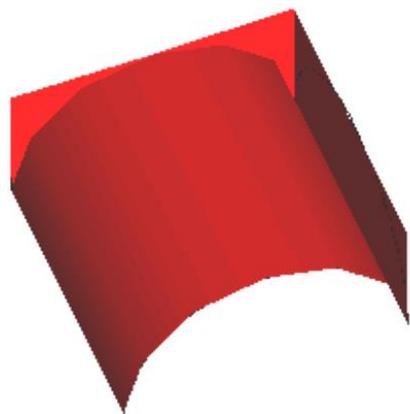








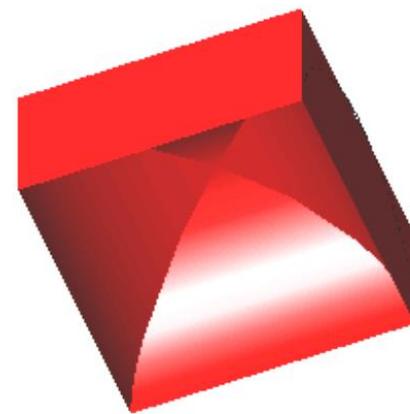




a) Volta a botte
 $V_b = 13,41 \text{ mc}$

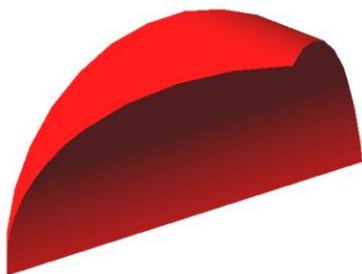


b) Volta a crociera
 $V_c = 5,99 \text{ mc}$



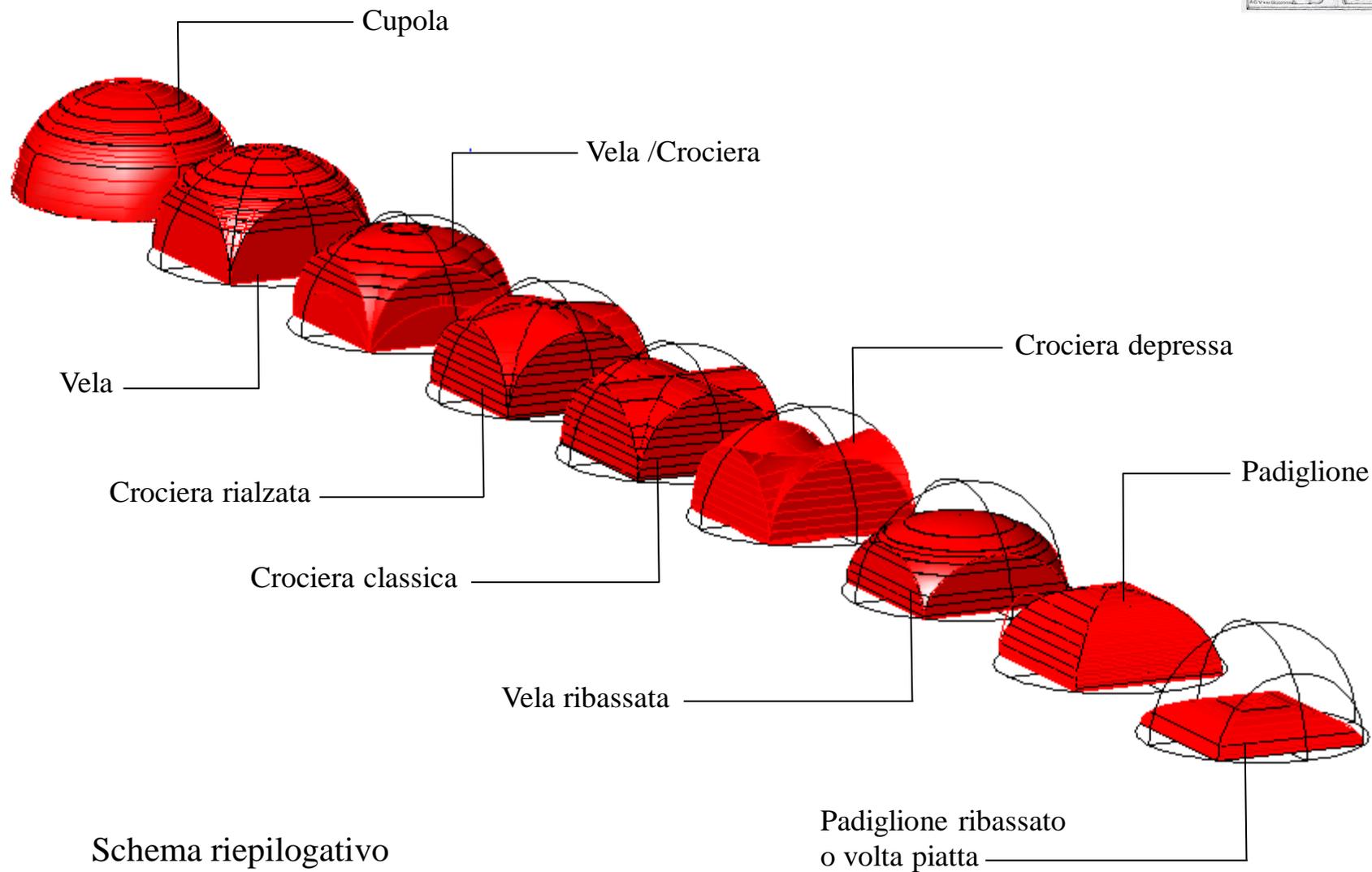
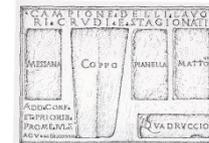
c) Volta a padiglione
 $V_p = 20,83 \text{ mc}$

Caratteristiche geometriche e dimensionali di alcuni tipi di volte – I volumi strutturali si riferiscono a volte a tutto sesto impostate su ambienti a pianta quadrata con lato di ml 5



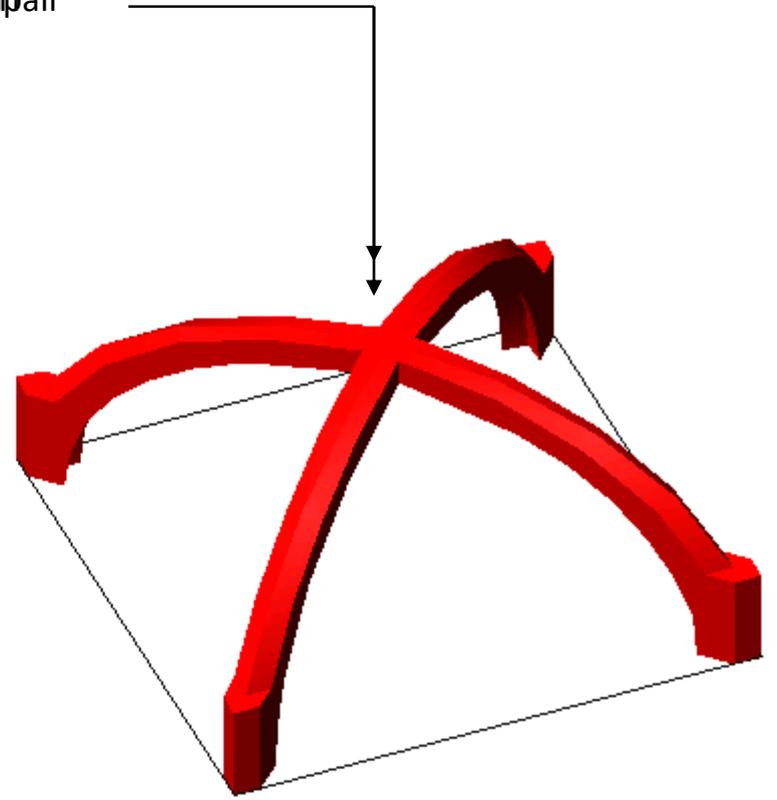
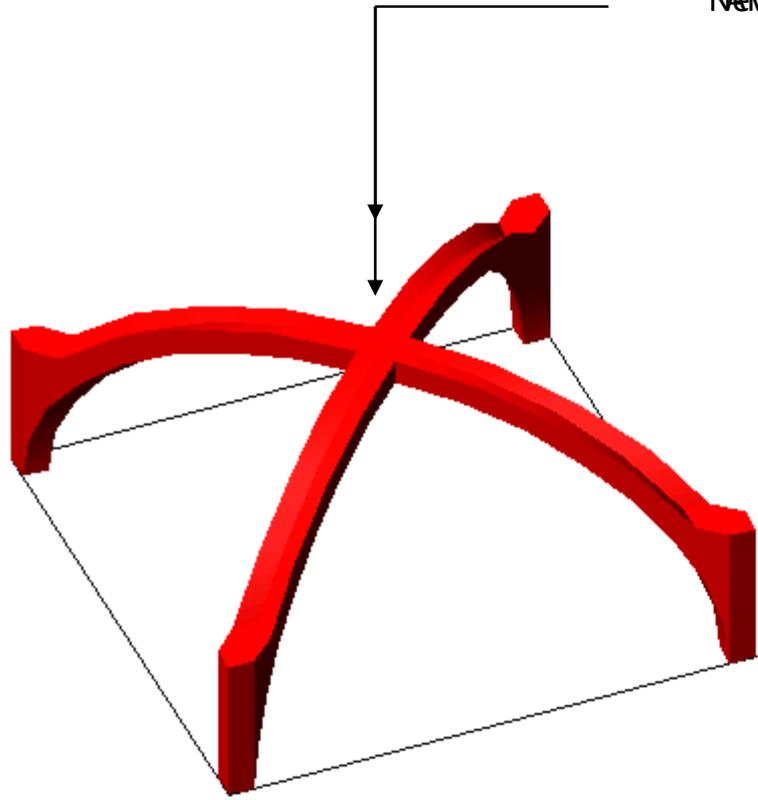
Unghia o lunetta
 $V_l = 3,71 \text{ mc}$

$$V_c = V_b - 2V_l; \quad V_p = V_b + 2V_l$$

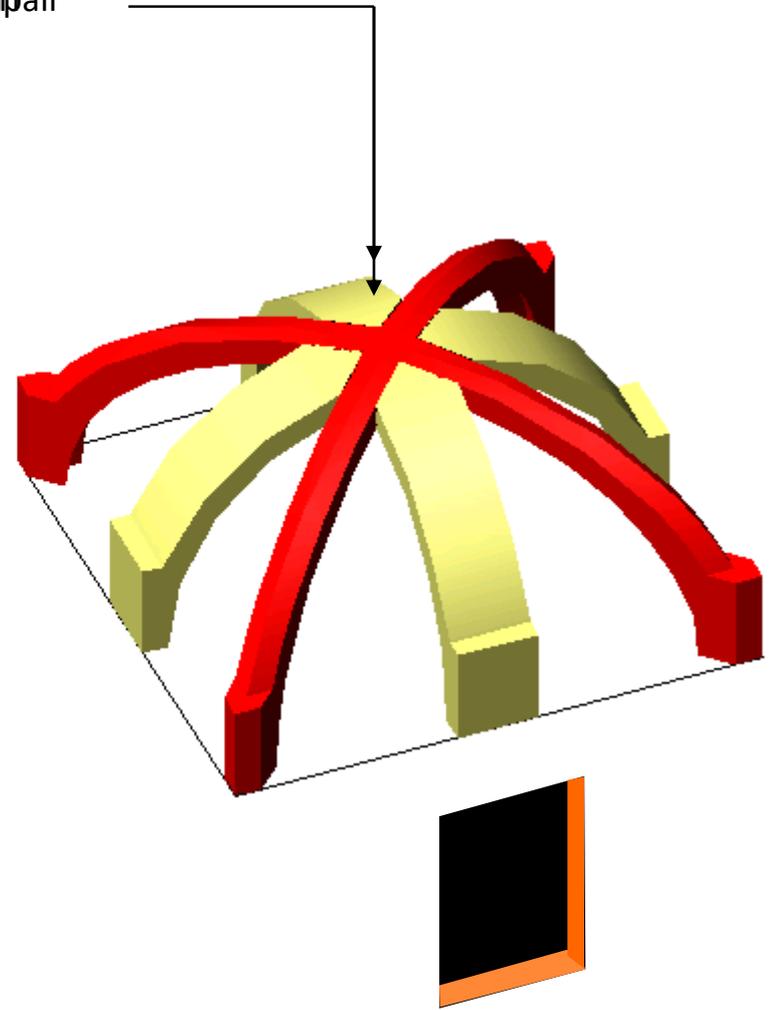
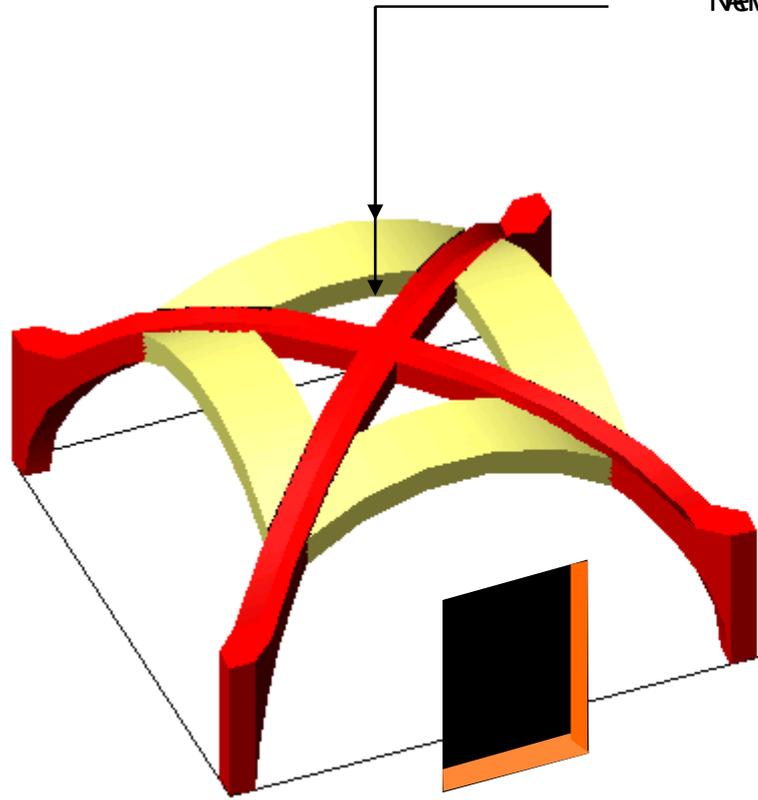


Schema riepilogativo

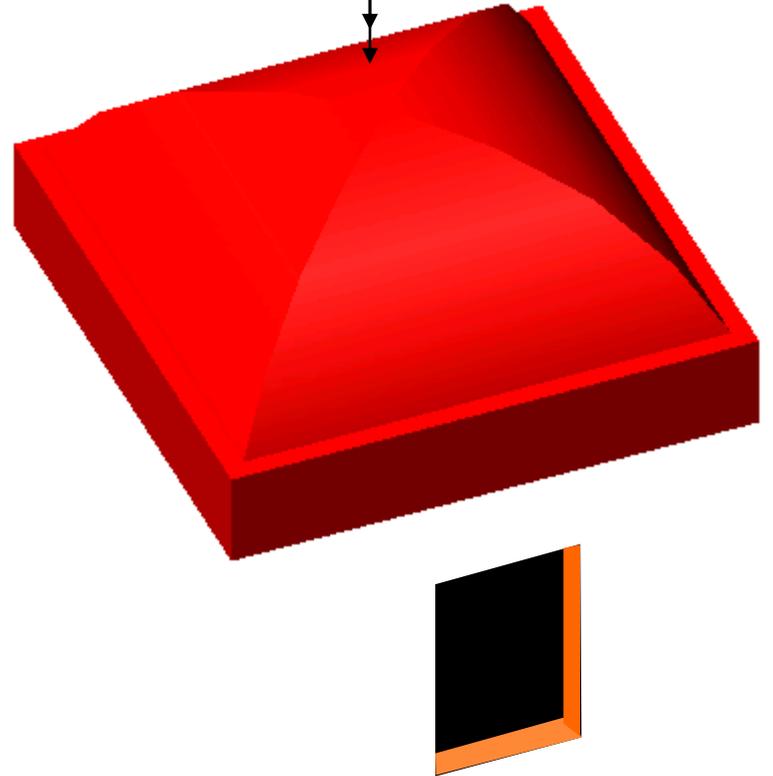
Nervature principali

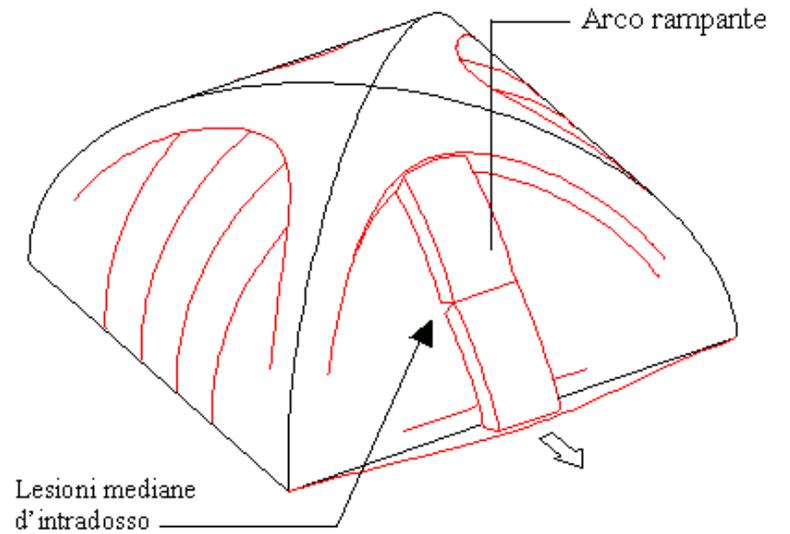
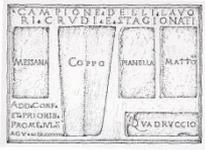


Nervature principali

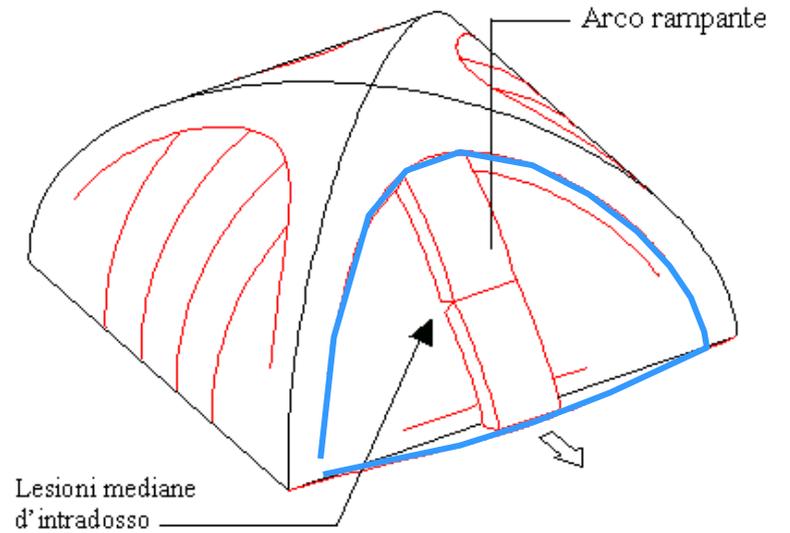
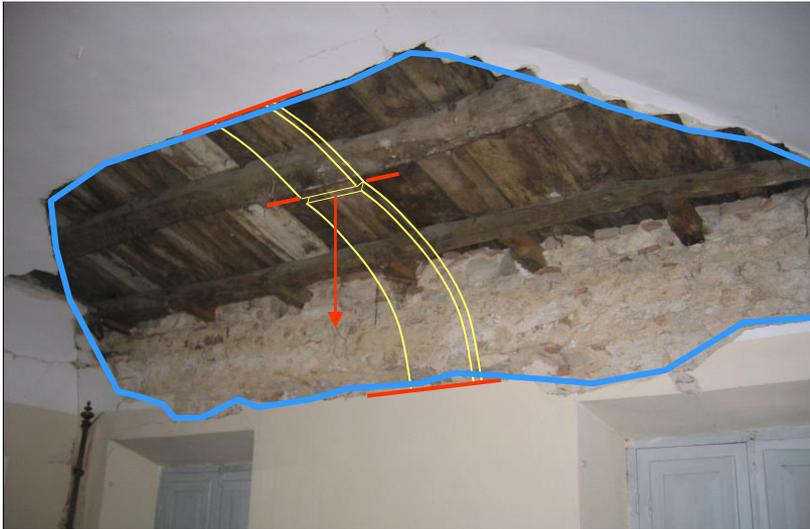
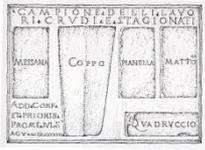


Nezatti secpri d'ipali





Tipologie di dissesto: volte a Padiglione



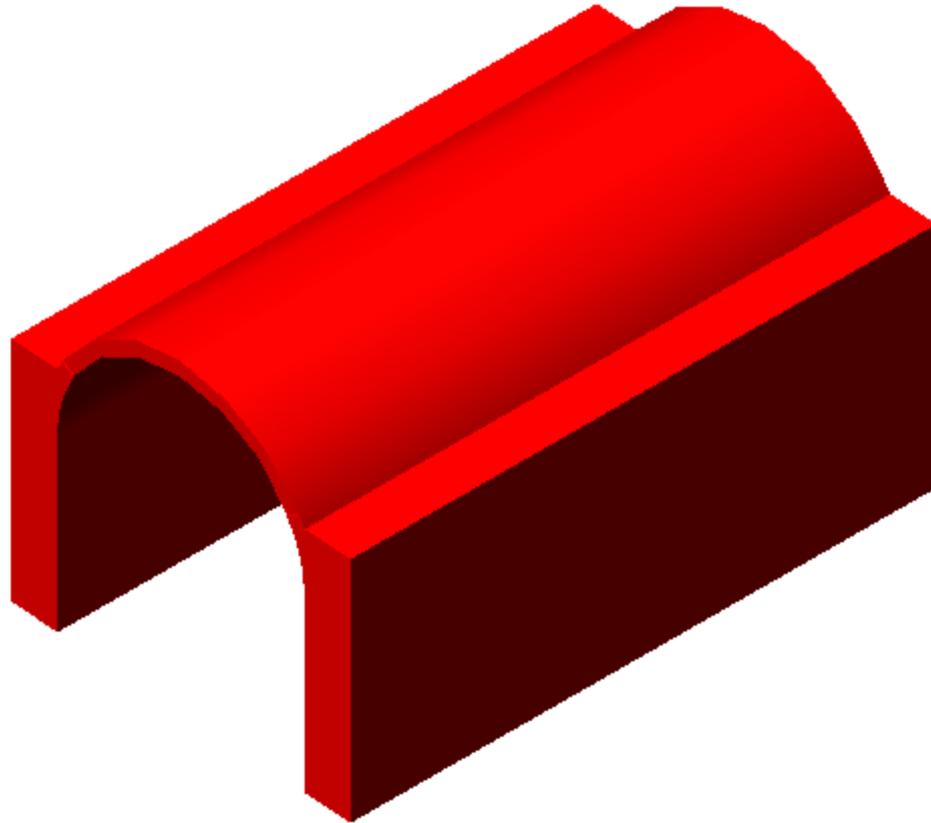
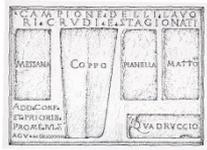
Tipologie di dissesto: volte a Padiglione

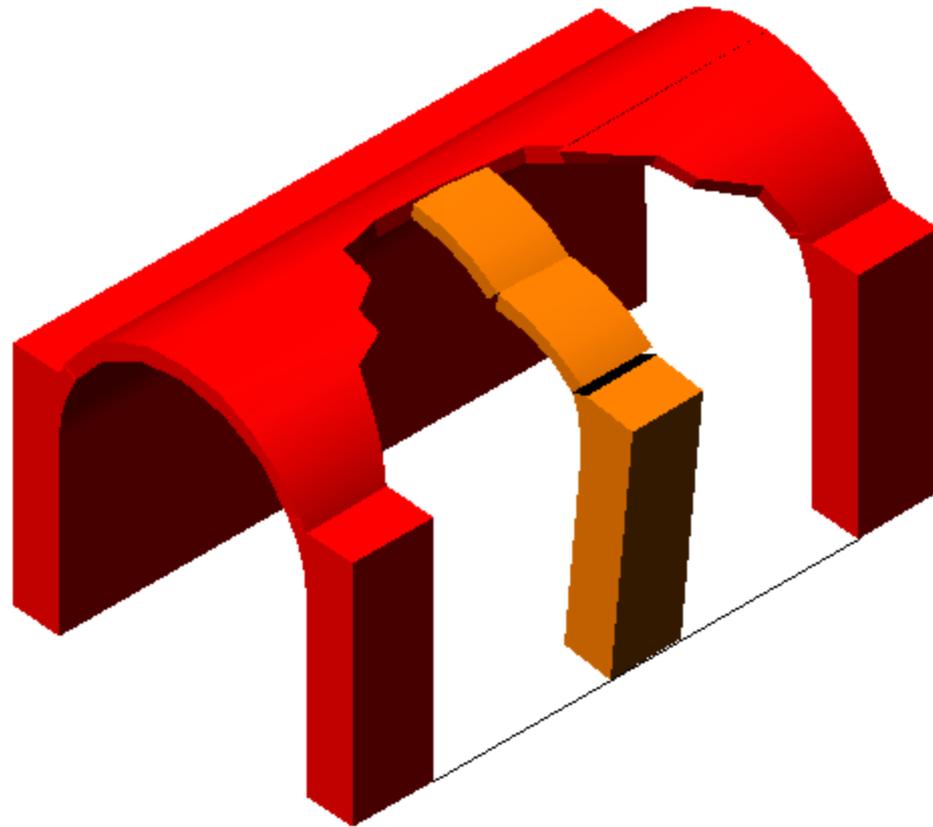
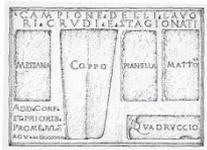


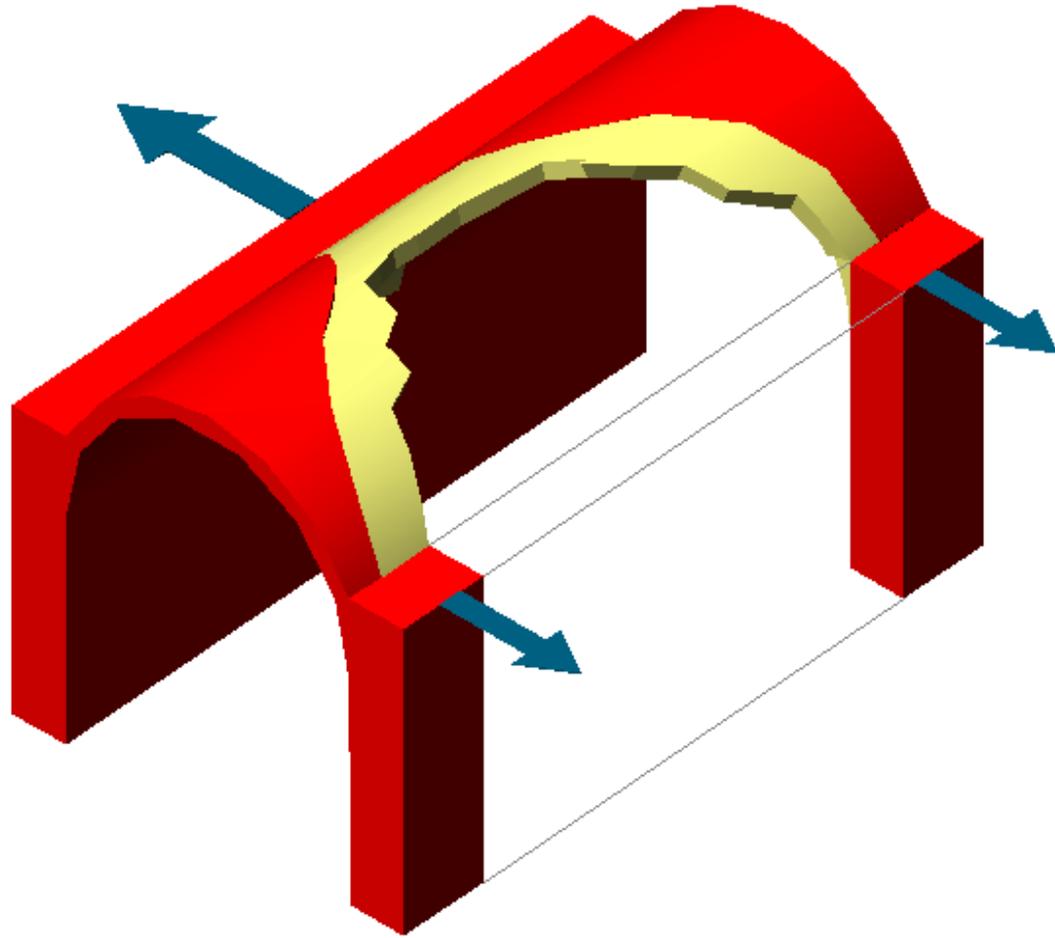
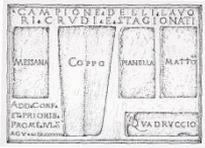
Foto: A. Borri

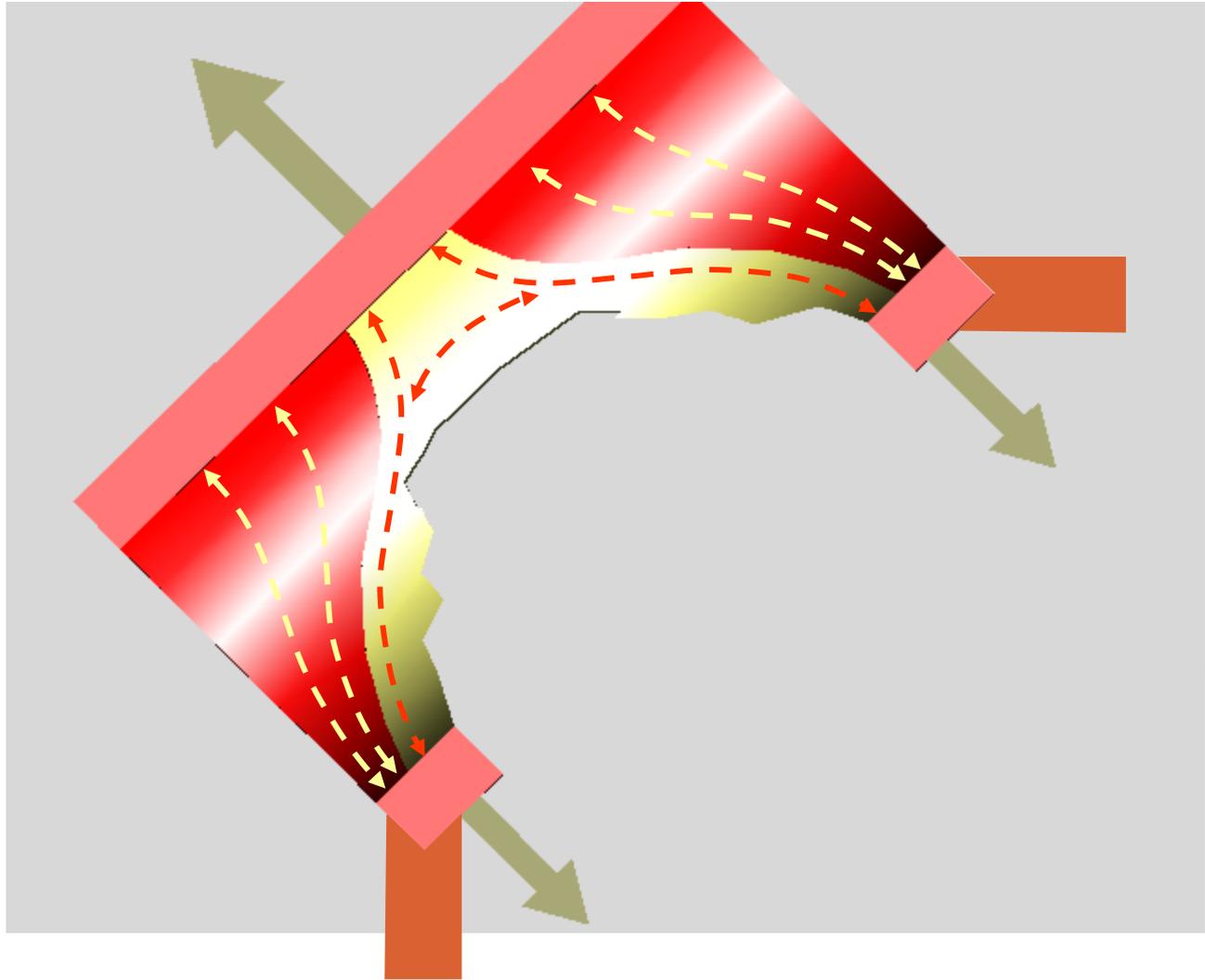
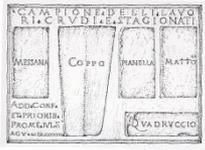


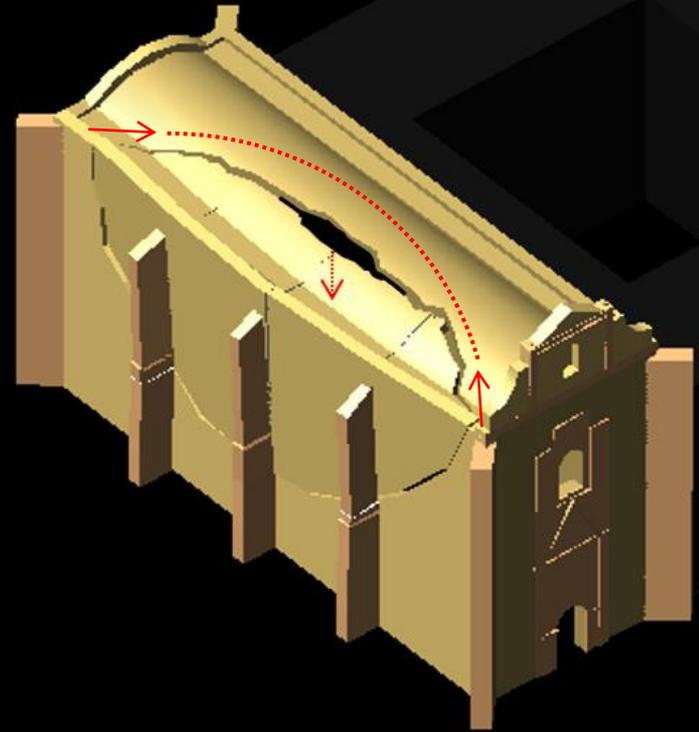
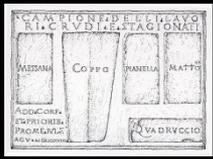
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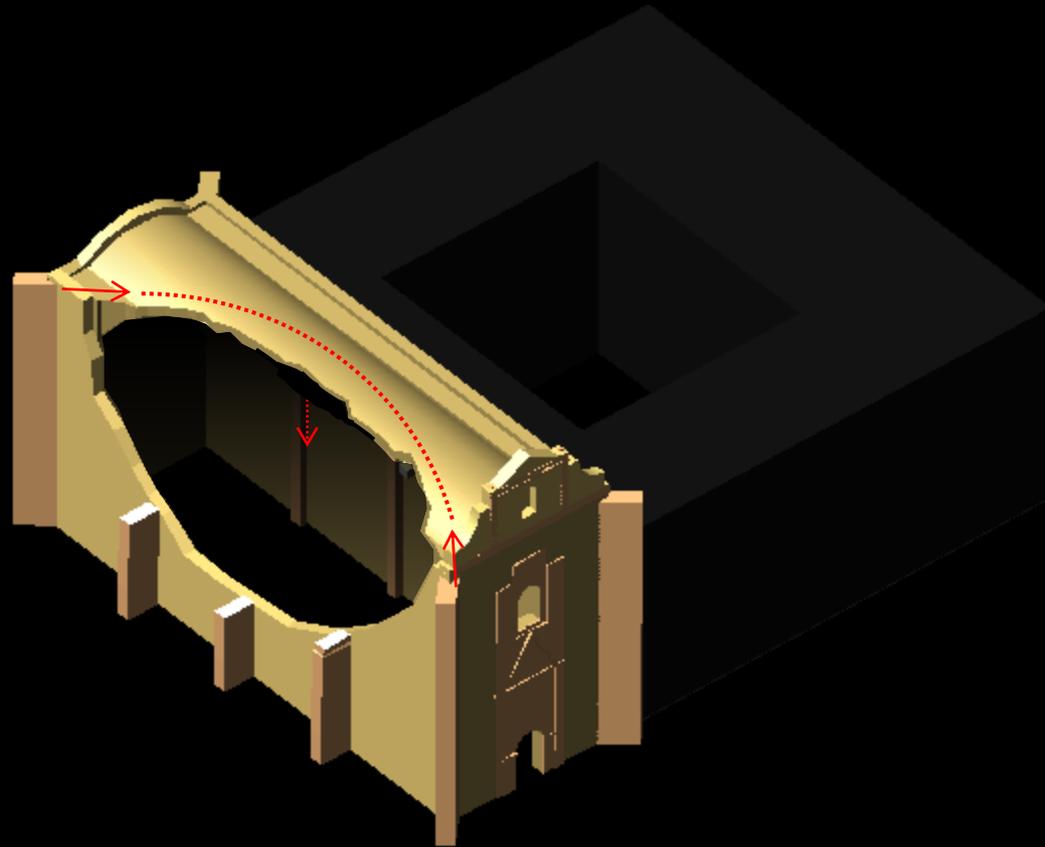
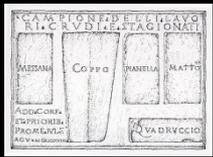


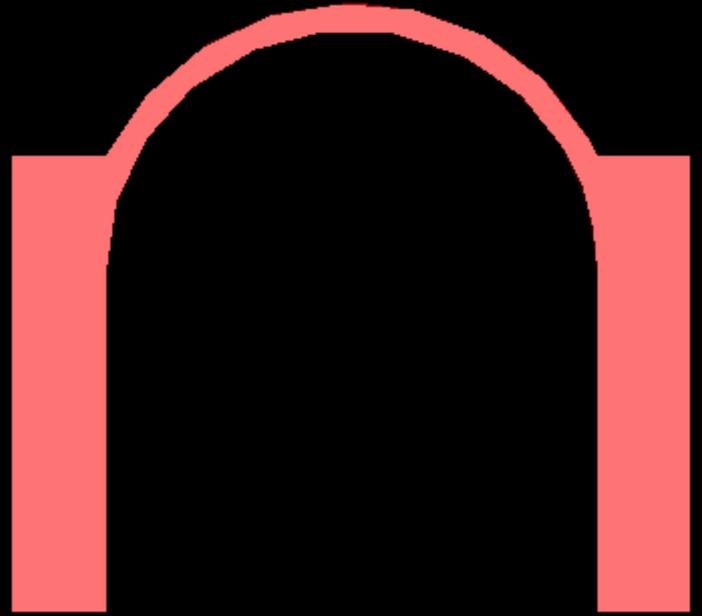
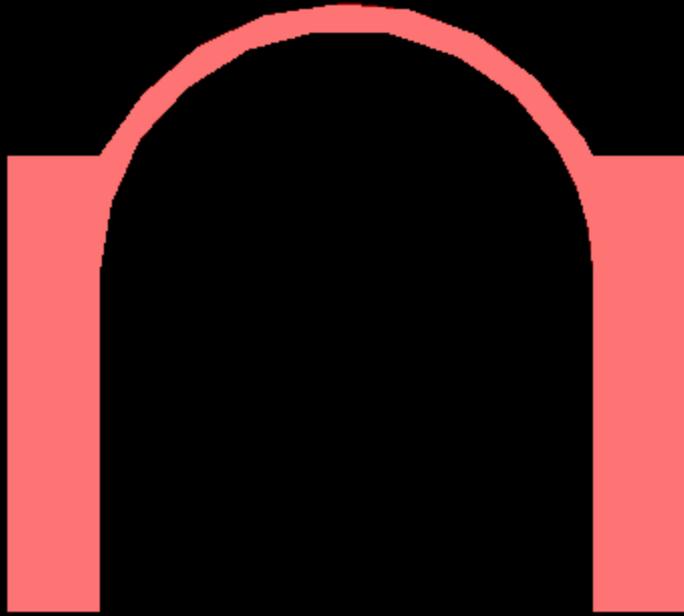
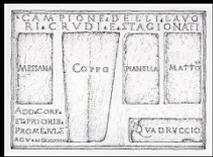


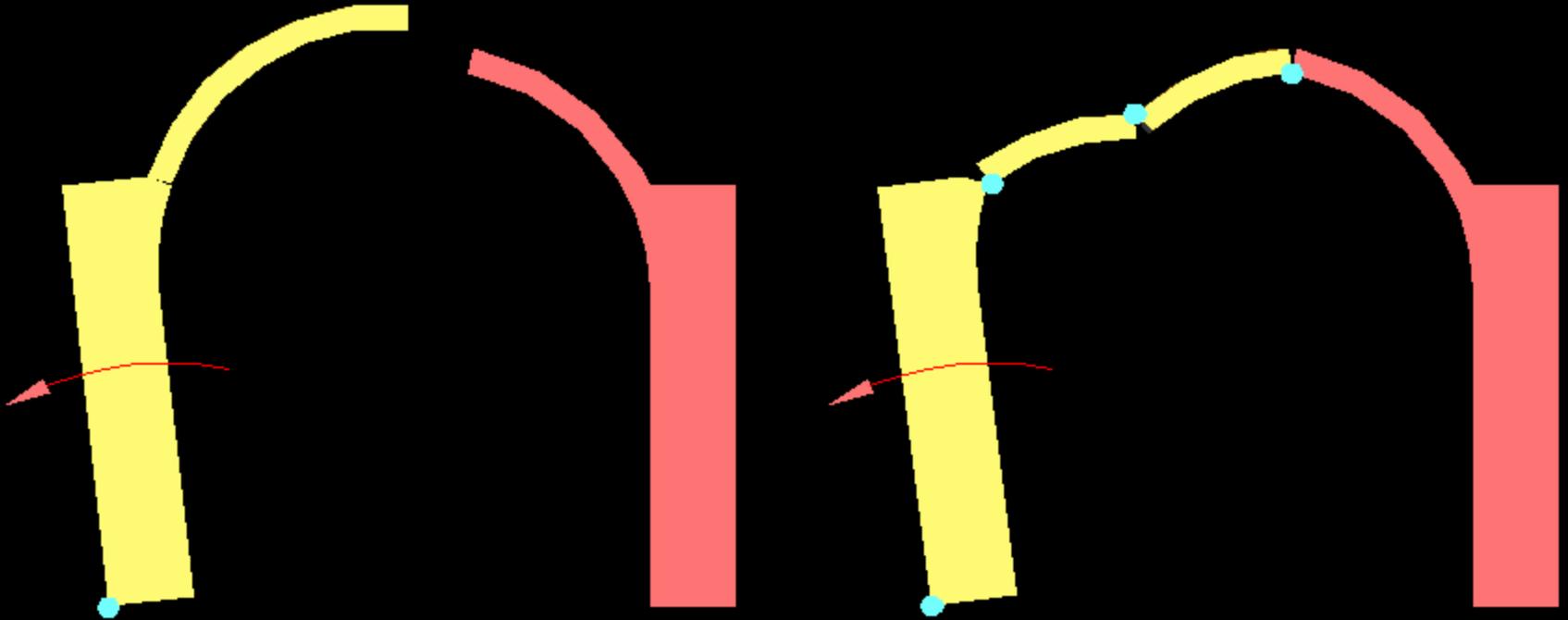
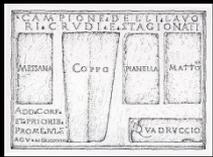


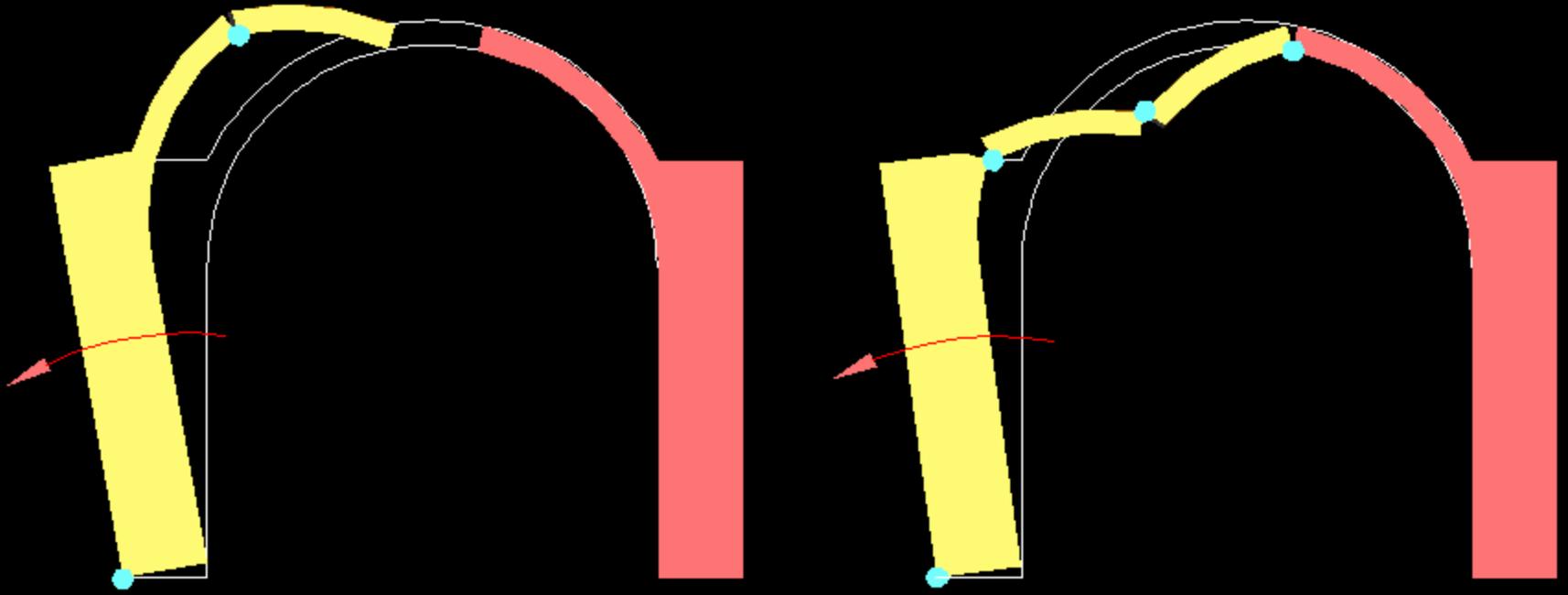
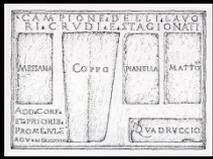


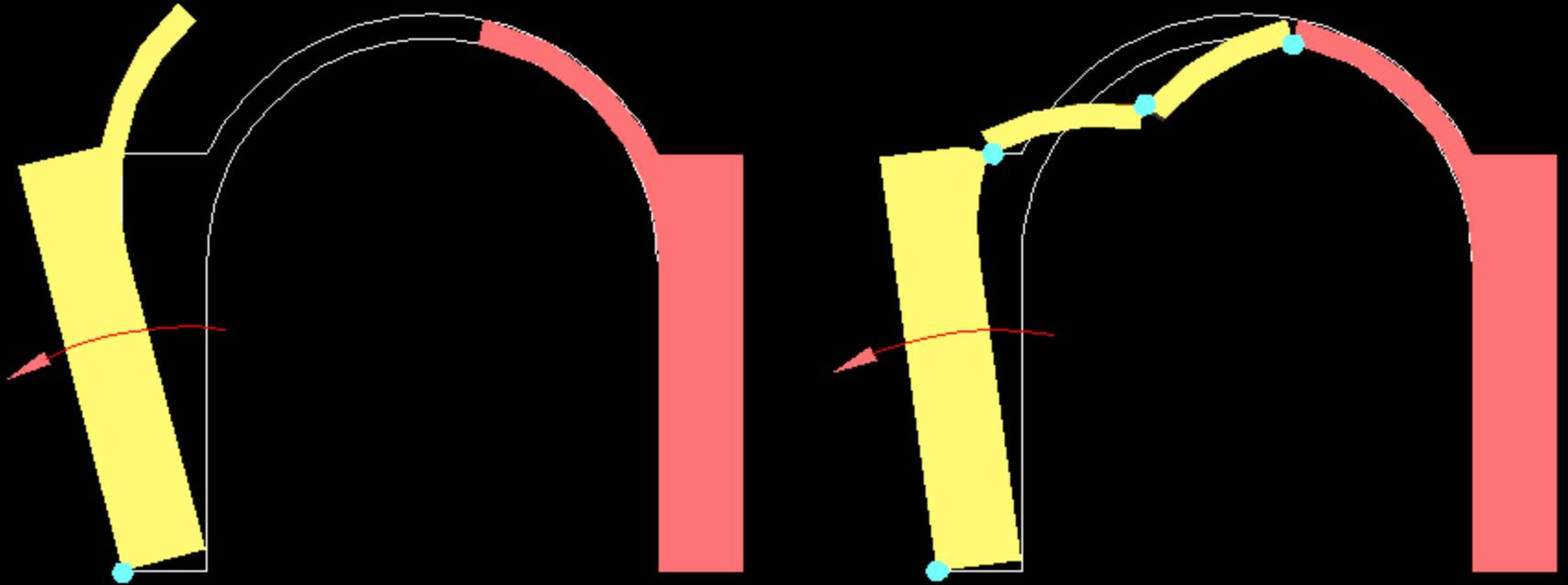
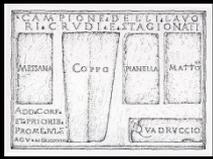






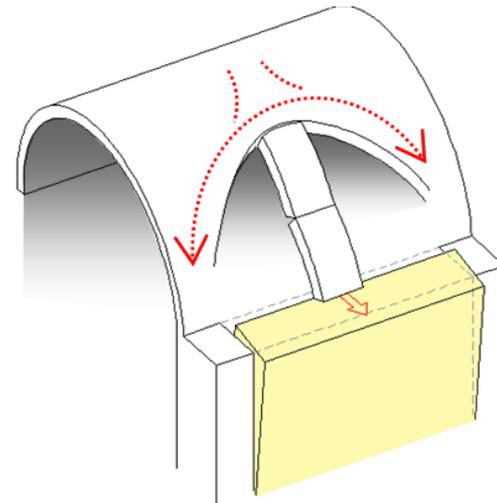
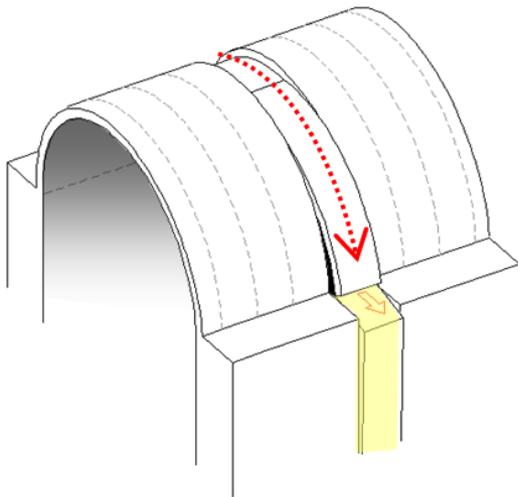




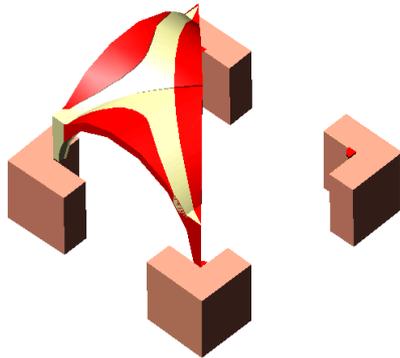
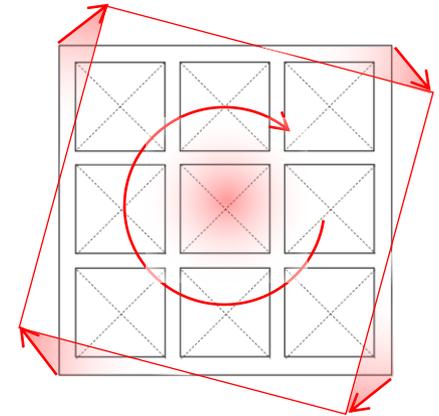
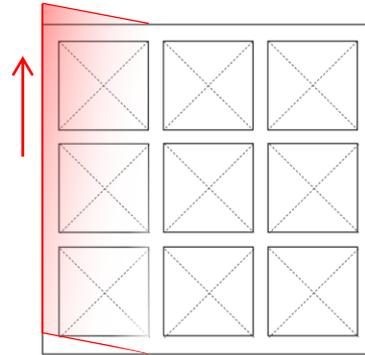
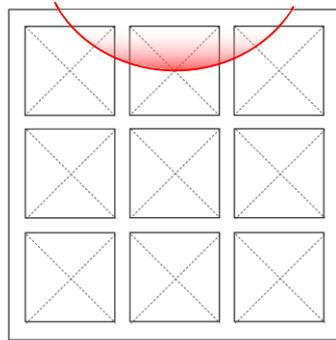
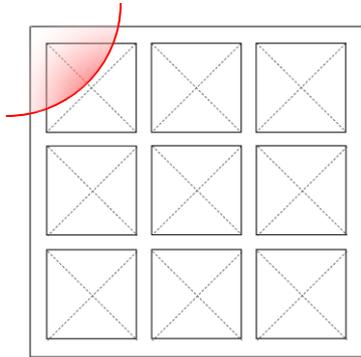
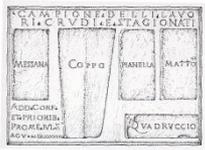






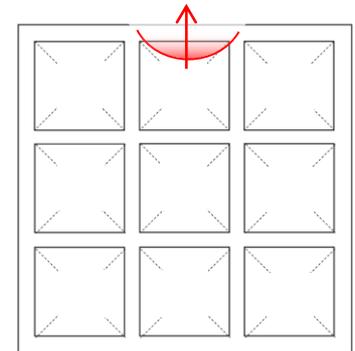


Passaggio dal meccanismo ad arco trasversale
al meccanismo di difesa ad arco longitudinale

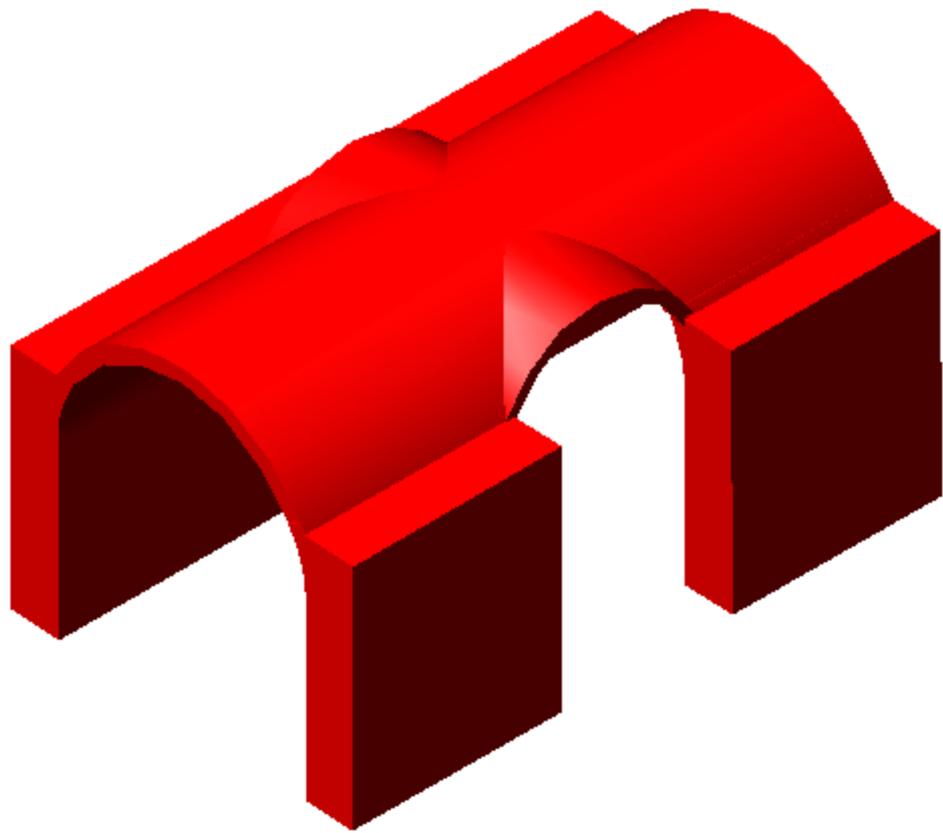


Schema d'impianto con volte a crociera

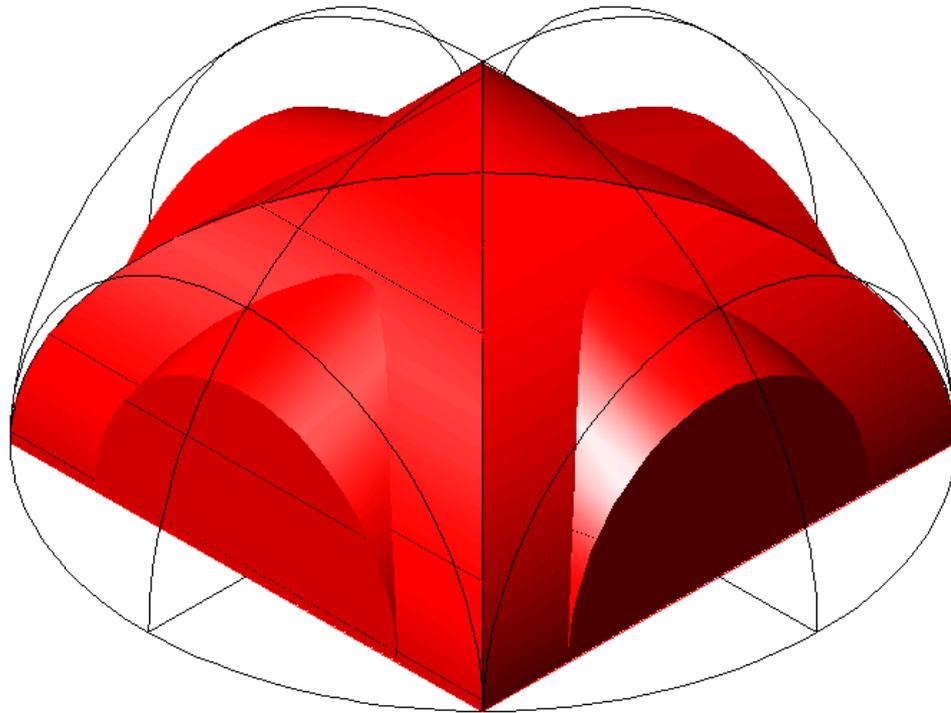
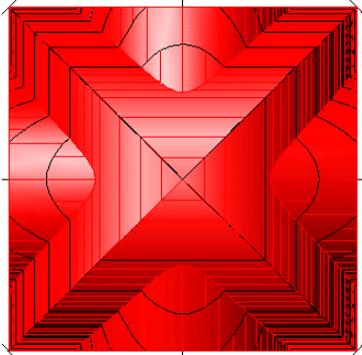
Tipo di danno in funzione della geometria strutturale e della posizione



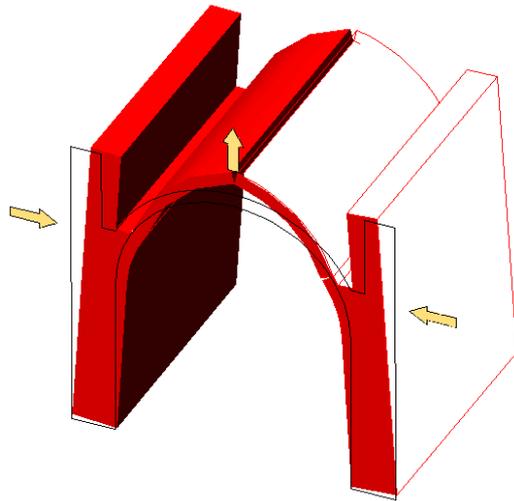
Volte a padiglione

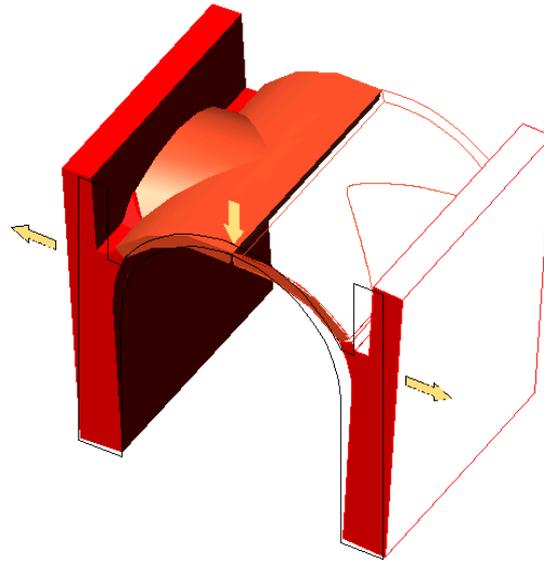


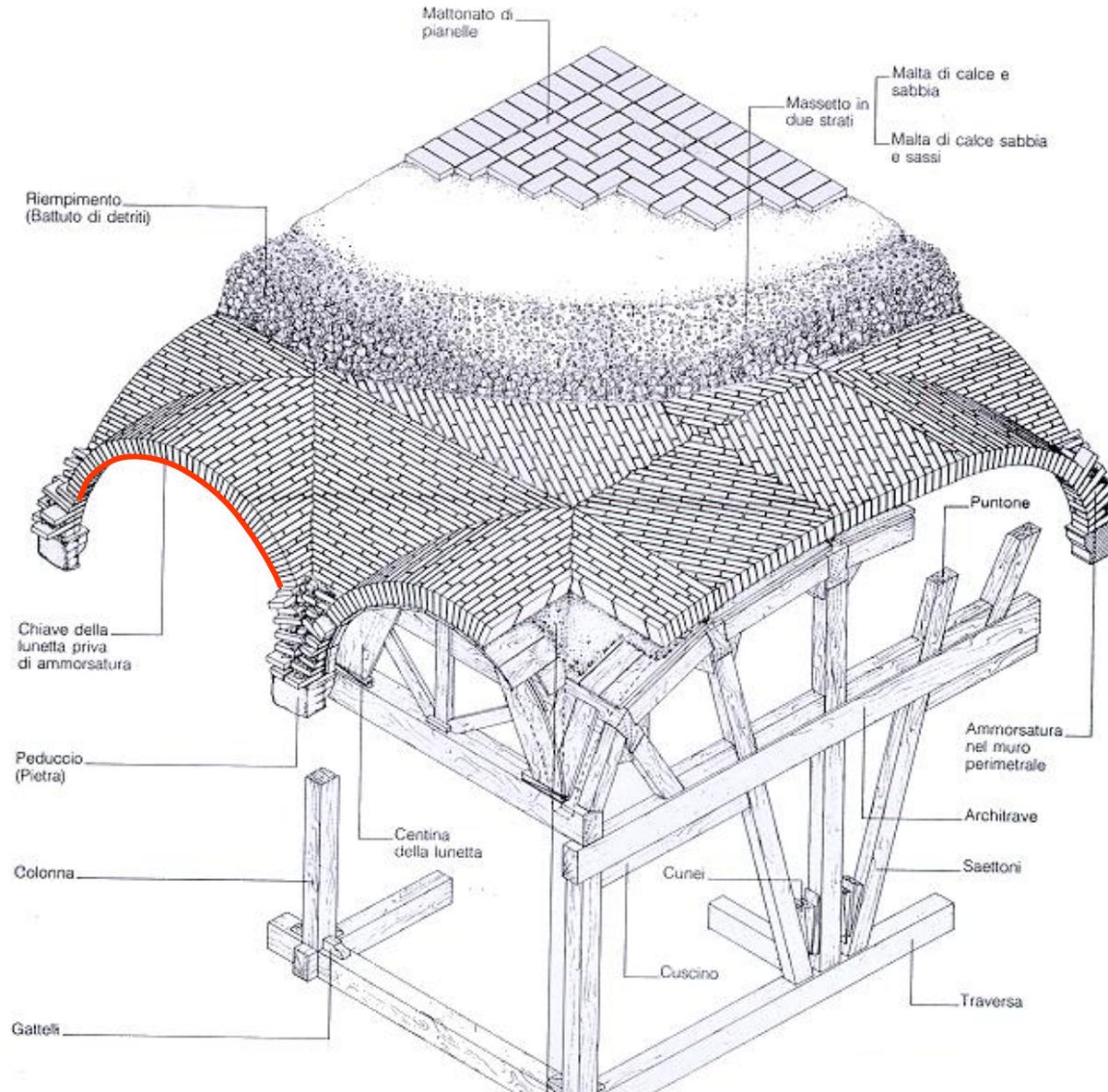
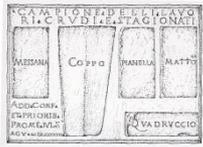
Volta a padiglione con lunette

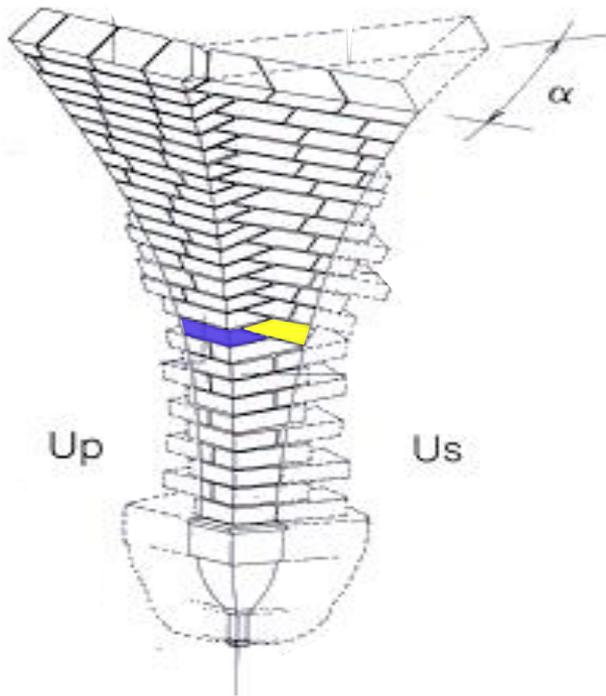
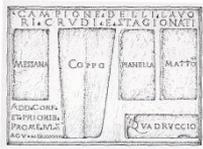


Classificazione delle volte in base alla configurazione geometrica





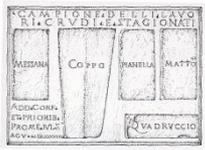




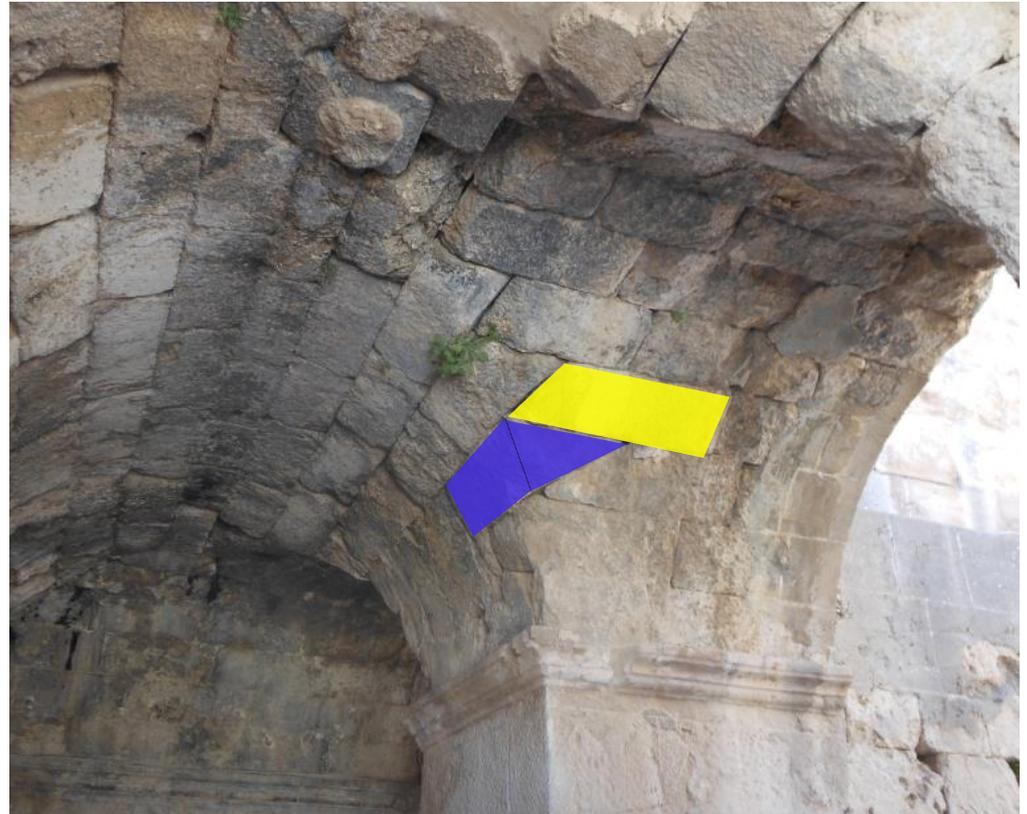
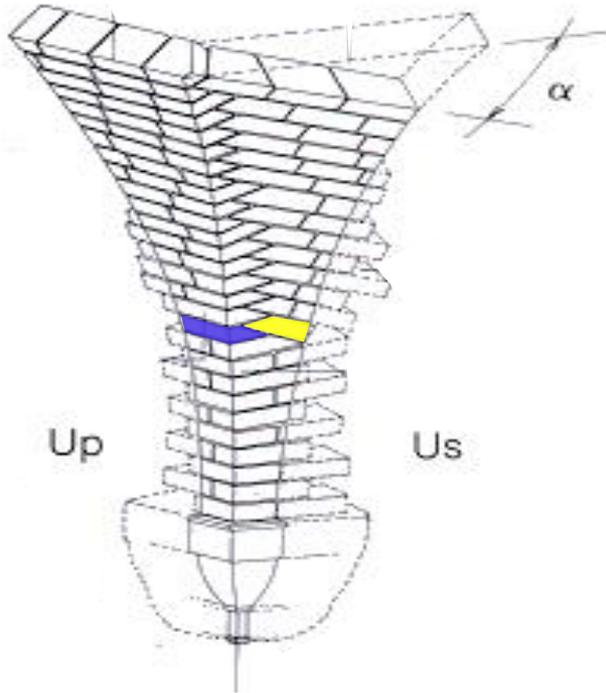
Pennacchio di volta laterizia a crociera con taglio dei mattoni lungo la nervatura (1991).

Scuola Operaia "G.O. Bufalini" – Città di Castello, 1997.





Jerash, Giordania (Teatro romano)

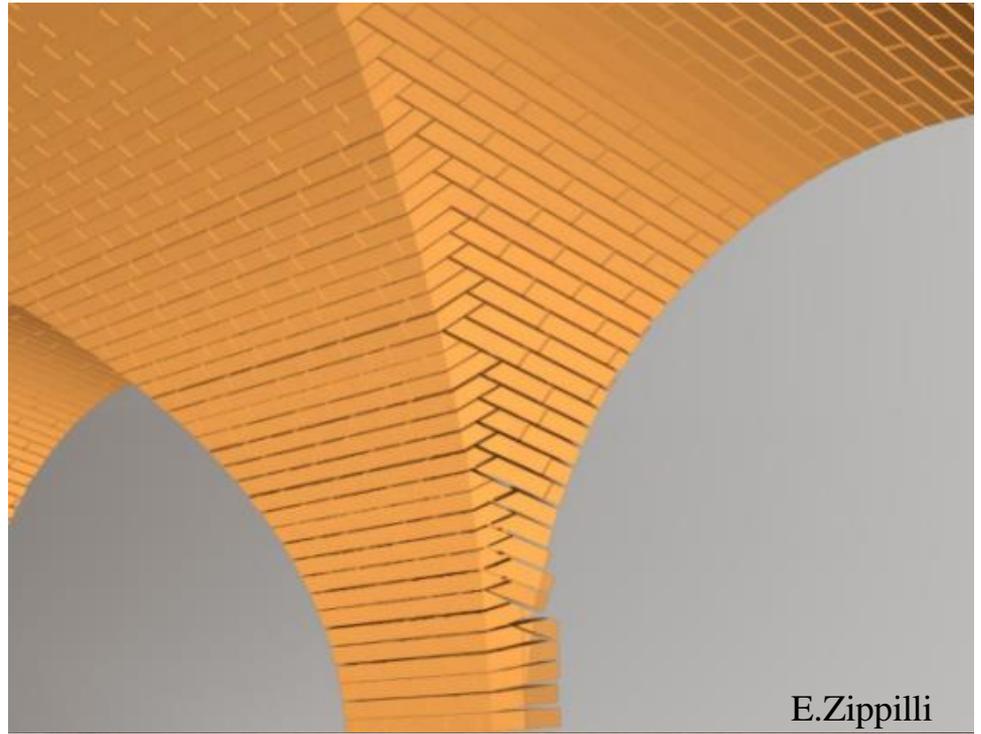


Pennacchio di volta laterizia a crociera con taglio dei mattoni lungo la nervatura (1991).

Scuola Operaia "G.O. Bufalini" – Città di Castello, 1997.



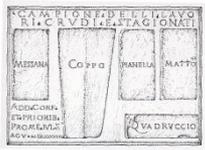
Prove per la disposizione
dei mattoni lungo gli archi
mediani e le nervature
diagonali.



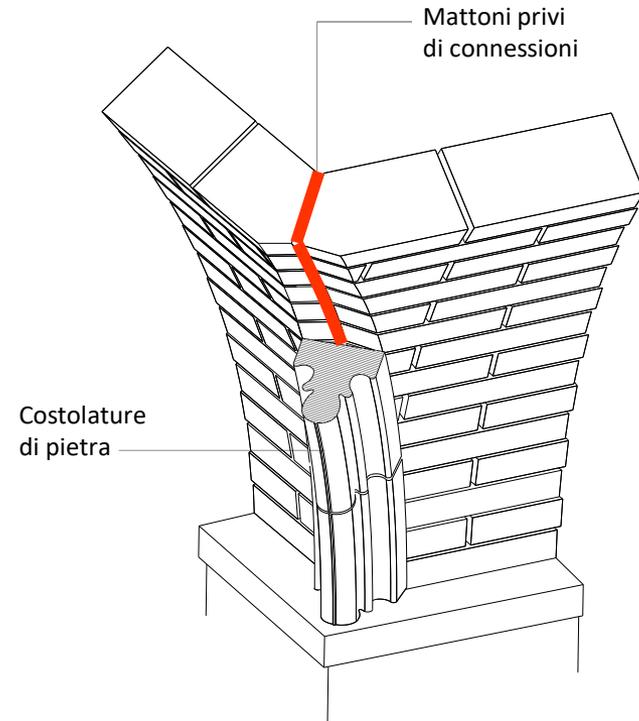
E.Zippilli

Intradosso della struttura subito dopo il disarmo.

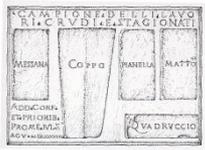




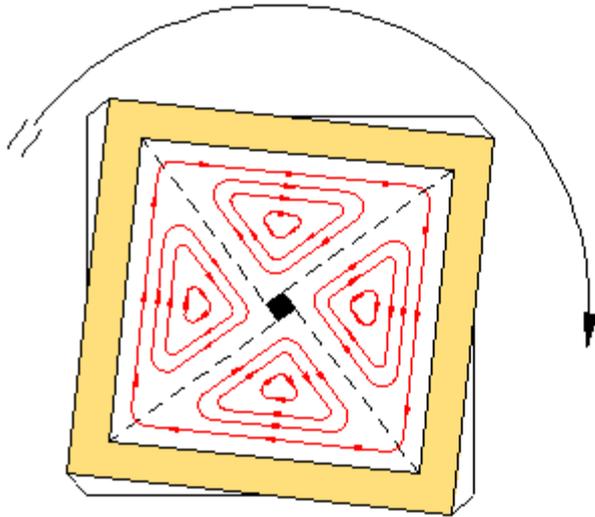
Costolature laterizie diagonali nelle volte laterizie a crociera della chiesa di San Galgano (Siena) (Foto F.Masseti)



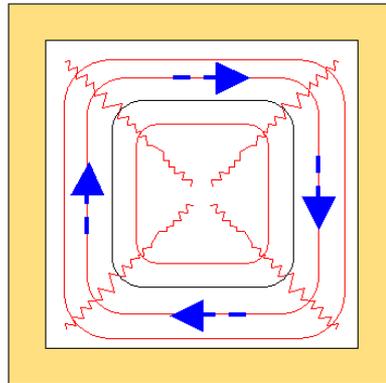
Costolatura di pietra destinato a ricoprire la nervatura all'intradosso priva di ammortature.



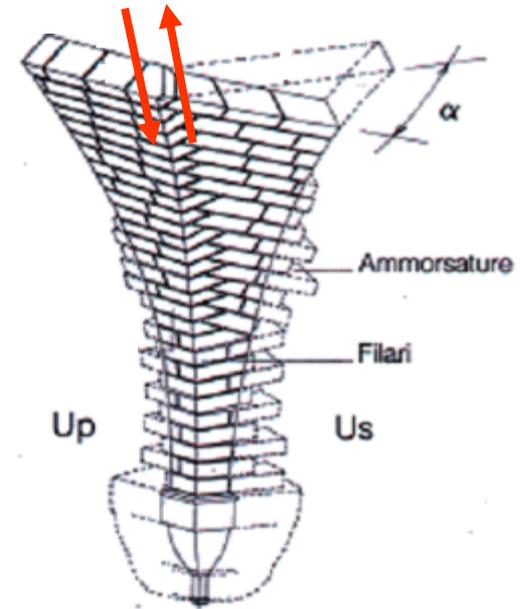
Torsione



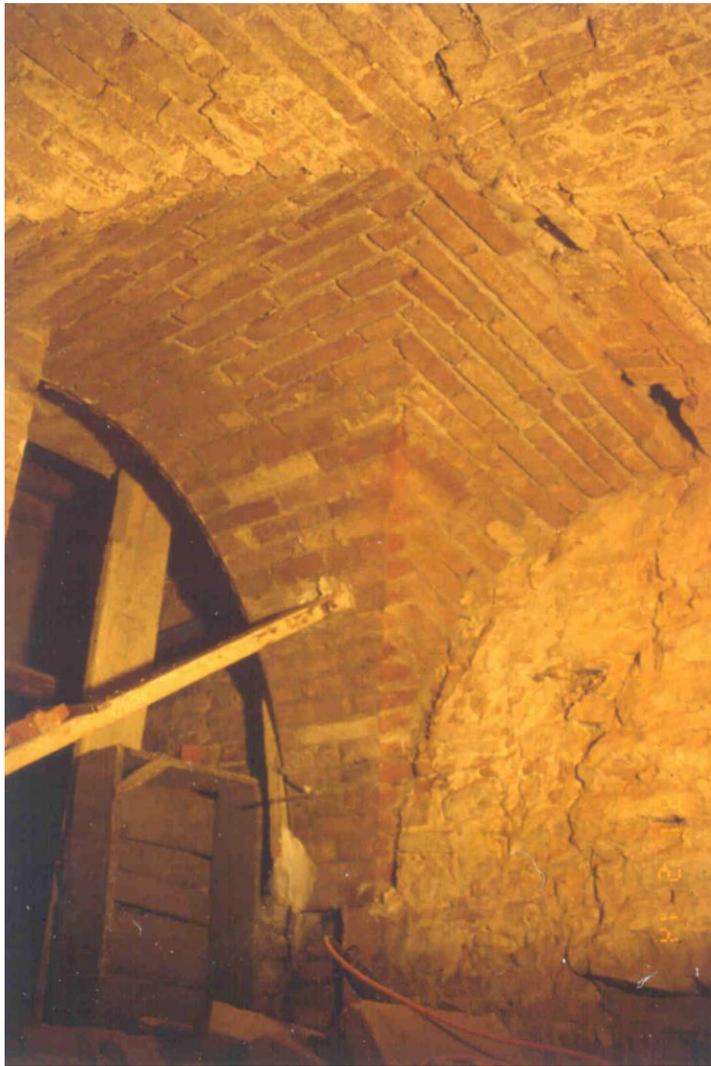
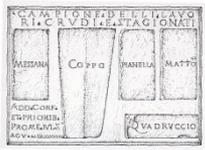
Stati tensionali e deformativi indotti dalla sollecitazione torsionale.



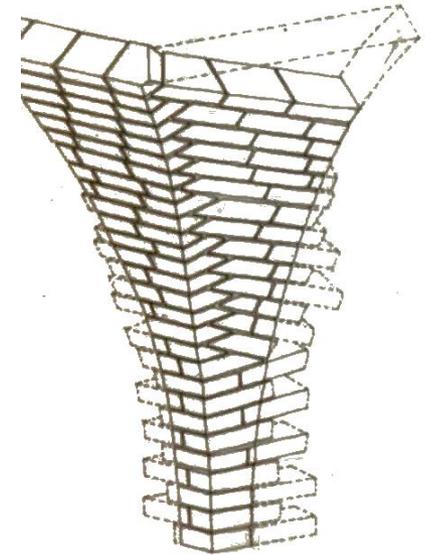
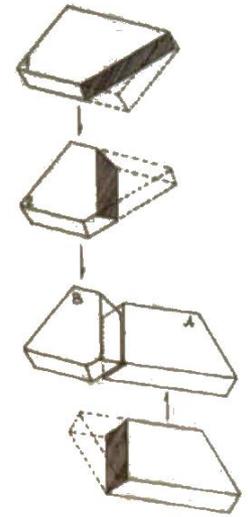
L'ingranamento delle nervature garantisce la resistenza a taglio lungo le diagonali

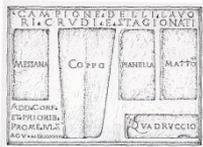


Tipo di nervatura con mattoni bene ingranati



Ricostruzione da sotto

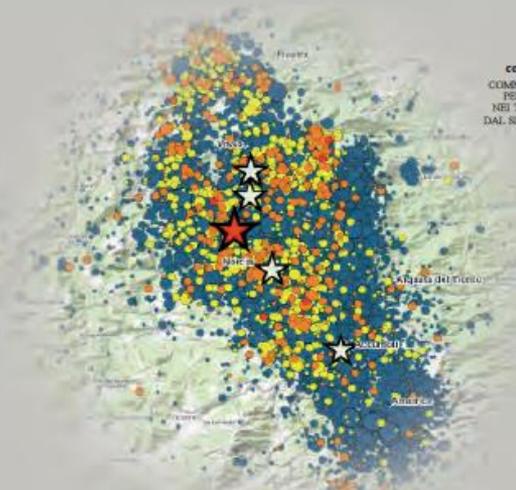




PREZZARIO UNICO DEL CRATERE DEL CENTRO ITALIA

ai sensi dell'art. 6, comma 7, del DL 189/2016, approvato con
**Ordinanza n. 7 del Commissario del Governo per la
Ricostruzione del 14/12/2016**

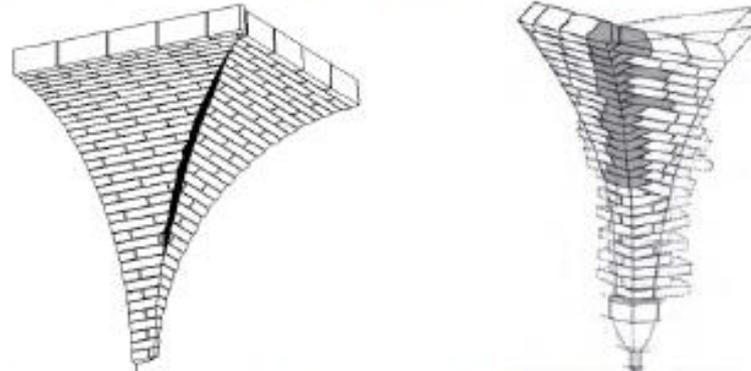

Presidenza del
consiglio dei ministri
COMMISSARIO DEL GOVERNO
PER LA RICOSTRUZIONE
NEI TERRITORI INTERESSATI
DAL SISMA DEL 24 AGOSTO 2016



 **Aedei** Sistema Qualità Aziendale
certificato ISO 9001:2008
INGEGNERI DEL CINQUE CIVILE

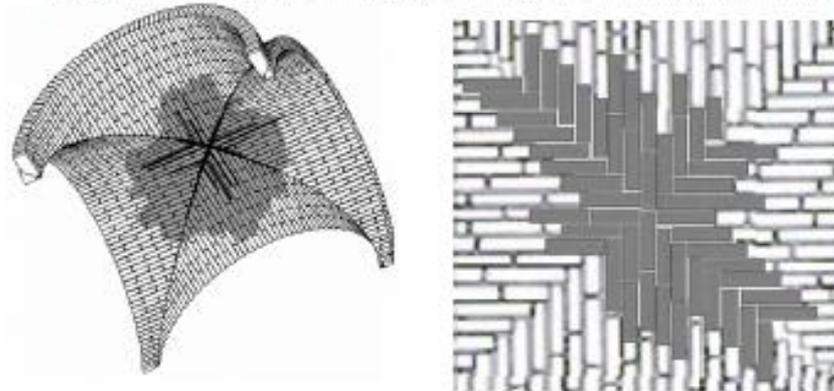
A05060 Ricostruzione con metodo souci-cuci di nervature di volte laterizie di mattoni posti a coltello, con geometria a crociera o botte lunettata, eseguito dal basso, senza l'ausilio di centine. Computato a m di nervatura trattata m

210,00



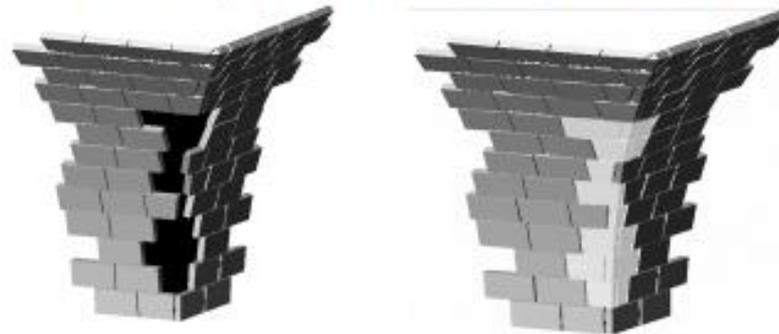
A05061 Ricostruzione con metodo souci-cuci del campo centrale di volte laterizie di mattoni posti a coltello, con geometria a crociera o botte lunettata, eseguito dal basso, senza l'ausilio di centine. Computato a m² di superficie trattata m²

415,00



A05062 Ricostruzione con metodo souci-cuci di spigoli di volte laterizie di mattoni posti in foglio, con geometria a crociera o botte lunettata, eseguito dal basso, senza l'ausilio di centine. Computato a m di nervatura trattata m

150,00



Ministero LL.PP.

Circolare 30 Luglio 1981 n. 21745

3.4 ARCHI E VOLTE

Una prima possibilità di risanamento e rinforzo è fornita dalla tecnica delle perforazioni armate.

.... Un valido sistema di rafforzamento consiste nel costruire in aderenza un guscio portante, generalmente estradosato, realizzato da una rete metallica elettrosaldata chiodata alla struttura da rinforzare e da uno strato sottile di malta antiritiro.

Un'altra possibilità che può risultare conveniente soprattutto in casi di maggiori luci è quella di sospendere la volta a un graticcio metallico.

Ministero delle Infrastrutture e dei Trasporti

Circ. 2 febb. 2009 n. 617

Consiglio Superiore dei LL.PP.

La realizzazione di contro-volte in calcestruzzo o simili, armate o no, è da evitarsi per quanto possibile, se ne viene dimostrata la necessità, va eseguita con conglomerato alleggerito e di limitato spessore.

Direttiva del Presidente del Consiglio dei Ministri per la valutazione e la riduzione del rischio sismico del patrimonio culturale con riferimento alle NTC.

26 febbraio 2011

6.3.3 INTERVENTI VOLTI A RIDURRE LE SPINTE DI ARCHI E VOLTE E AL LORO CONSOLIDAMENTO

La realizzazione sull'estradosso di controvolte in calcestruzzo armate o no, è da evitarsi, per la riduzione dello stato di compressione nella volta e per l'aumento delle masse sismiche, oltre che per l'impovertimento che induce in termini di valori culturali e testimoniali nel manufatto storico.

Ministero LL.PP.

Circolare 30 Luglio 1981 n. 21745

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Una prima possibilità di risanamento e rinforzo è fornita dalla tecnica delle perforazioni armate.

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[NTC2018 - Circolare](#)

Ministero delle Infrastrutture e dei Trasporti

Consiglio Superiore dei Lavori Pubblici

Servizio Tecnico Centrale

Contenimento delle spinte e consolidamento di archi e volte

L'assorbimento delle spinte può essere ottenuto con ***tiranti e cerchiature***.

Presidi estradosali possono essere realizzati con elementi anche dotati di rigidità flessionale (di limitata sezione) e aggiungendo tiranti inclinati a questi connessi e ancorati a livello delle imposte (**catene a braga**).

La realizzazione di contrafforti (o ringrossi murari) è utile nei confronti delle sollecitazioni non sismiche, **ma il loro effetto in caso di azioni sismiche deve essere adeguatamente valutato**, a causa dei potenziali effetti locali connessi al significativo irrigidimento.

Per il consolidamento di archi e volte è possibile anche il ricorso a tecniche di rinforzo estradosali basate sull'utilizzo di compositi fibrorinforzati. Soluzioni alternative o integrative possono essere ottenute con frenelli o riempimenti coesivi leggeri

Presidenza del Consiglio dei Ministri del 12/10/2007

Direttiva del Presidente del Consiglio dei Ministri per la valutazione la riduzione del rischio sismico del patrimonio culturale con riferimento alle norme tecniche per le costruzioni
(Gazzetta ufficiale 29/01/2008 n. 24)

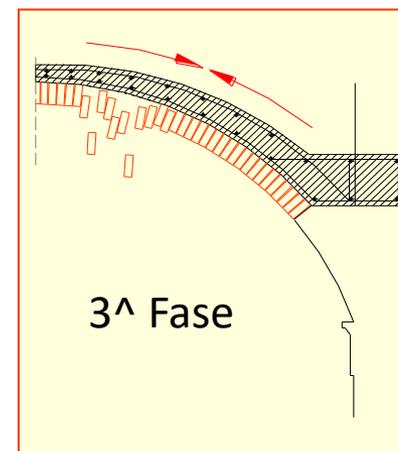
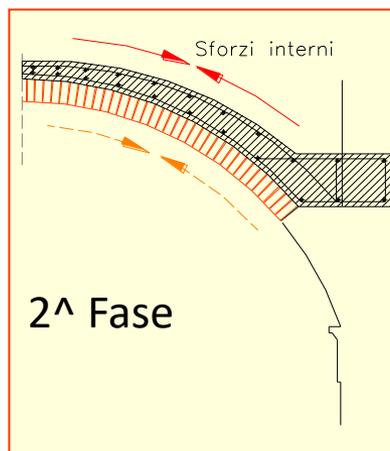
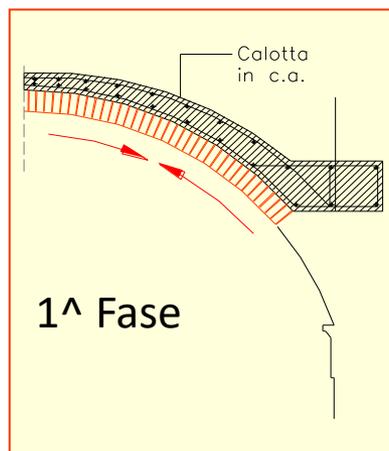
29-1-2008

Supplemento ordinario alla GAZZETTA UFFICIALE

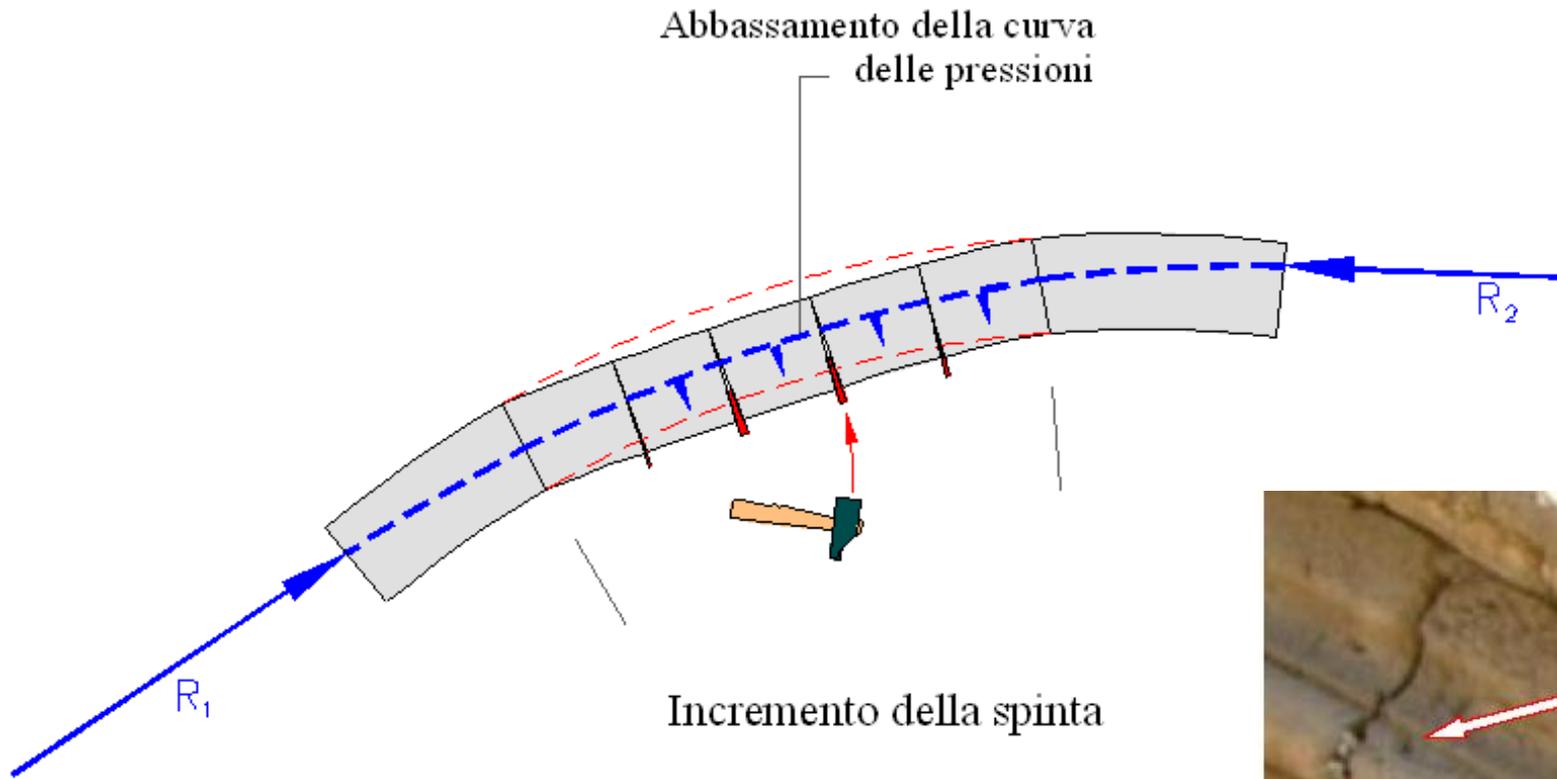
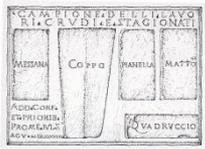
Serie generale - n. 24

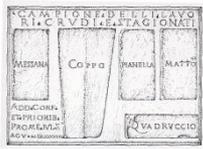
6.3.3 Interventi volti a ridurre la spinta di archi e volte ed al loro consolidamento

La realizzazione all'estradosso di controvolte in calcestruzzo, armate o no, è da evitarsi, per la riduzione dello stato di compressione nella volta in muratura e l'aumento delle masse sismiche, oltre che per l'impoverimento che induce, in termini di valori culturali e testimoniali, nel manufatto storico.

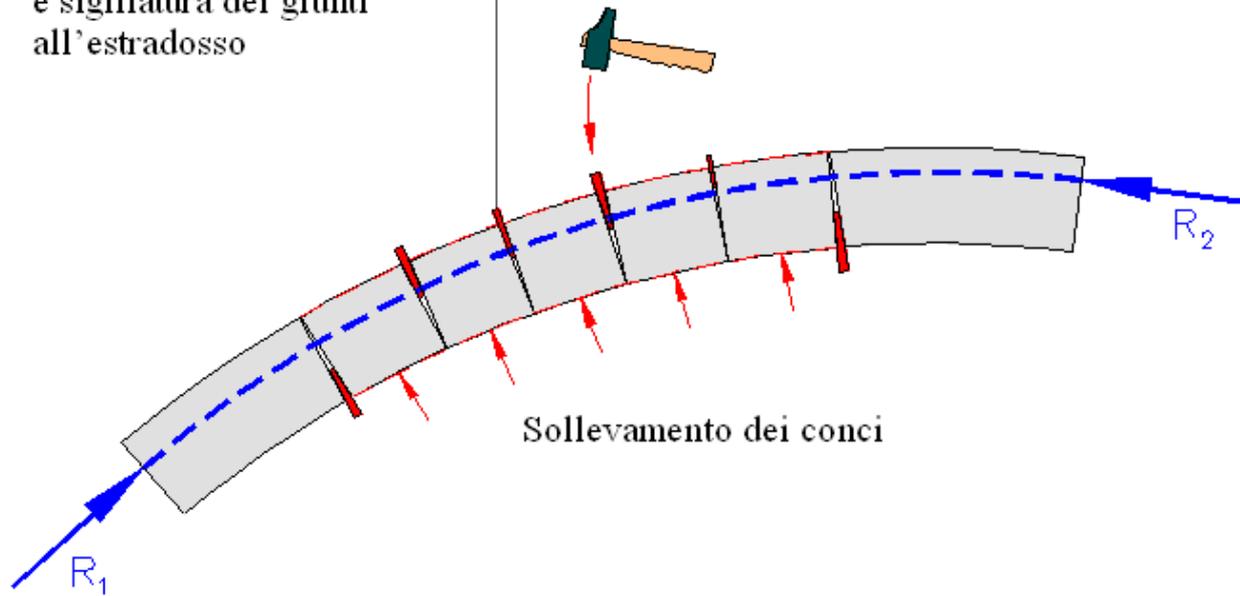


Conseguenze del consolidamento della volta con soletta in cemento armato d'estradosso



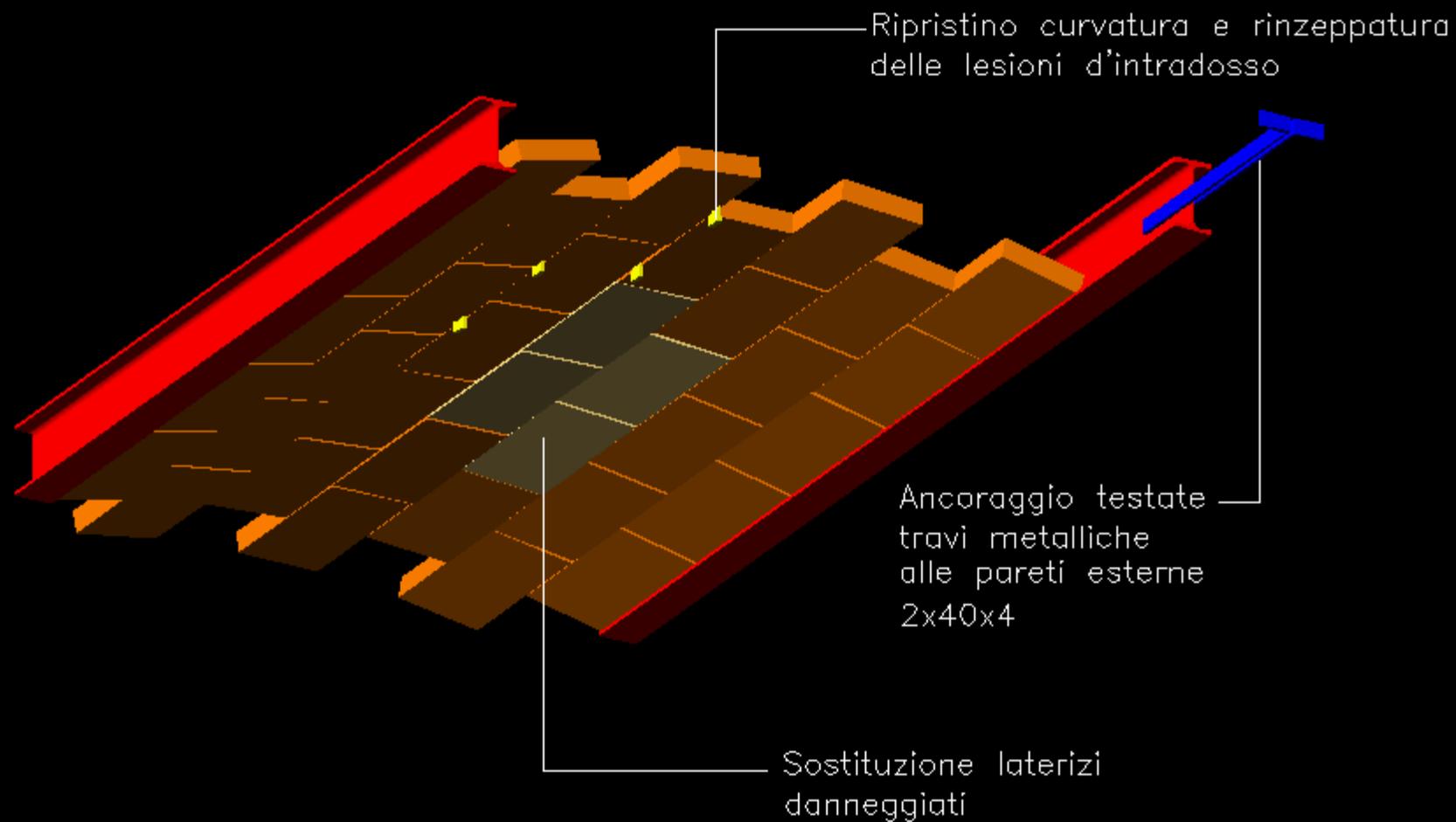
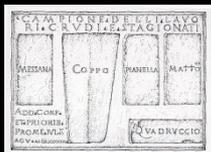


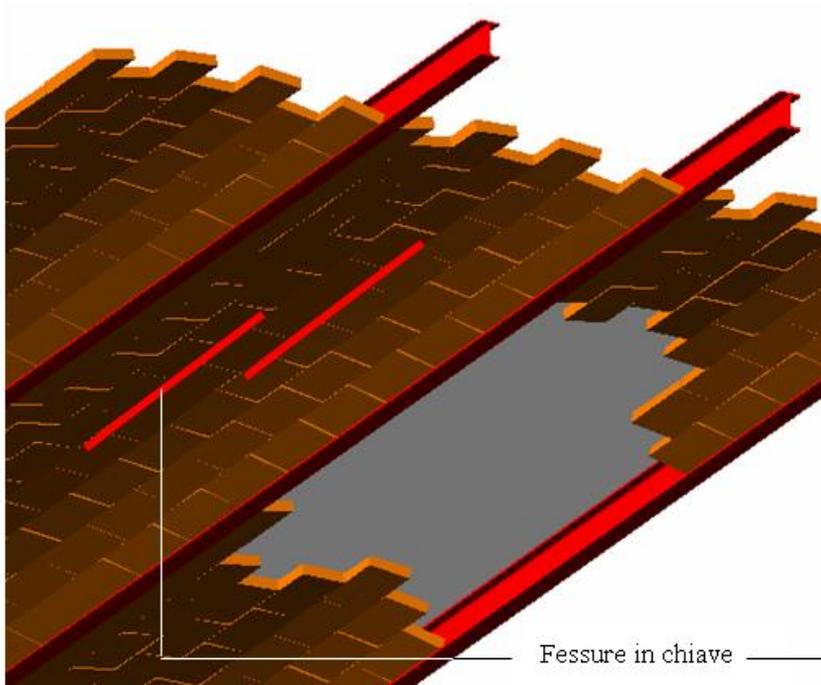
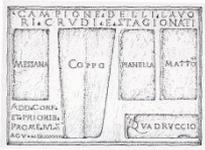
Inserimento cunei
e sigillatura dei giunti
all'estradosso



Sollevamento dei conci

Riduzione della spinta

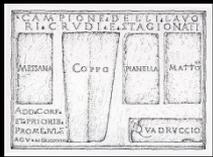




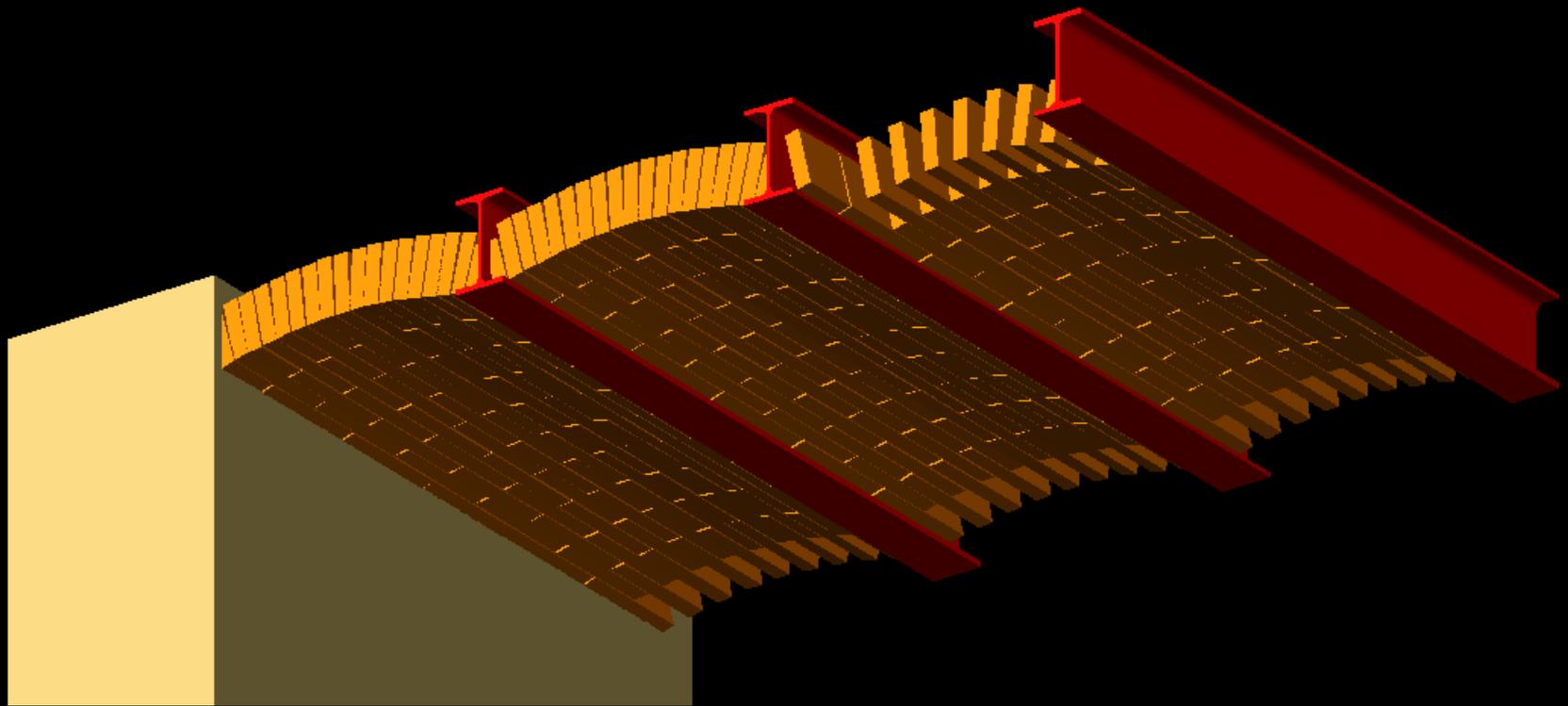
Fessure in chiave



Tipica configurazione di dissesto di solai a voltine laterizie su travi di acciaio, con quadro fessurativo e collassi parziali.

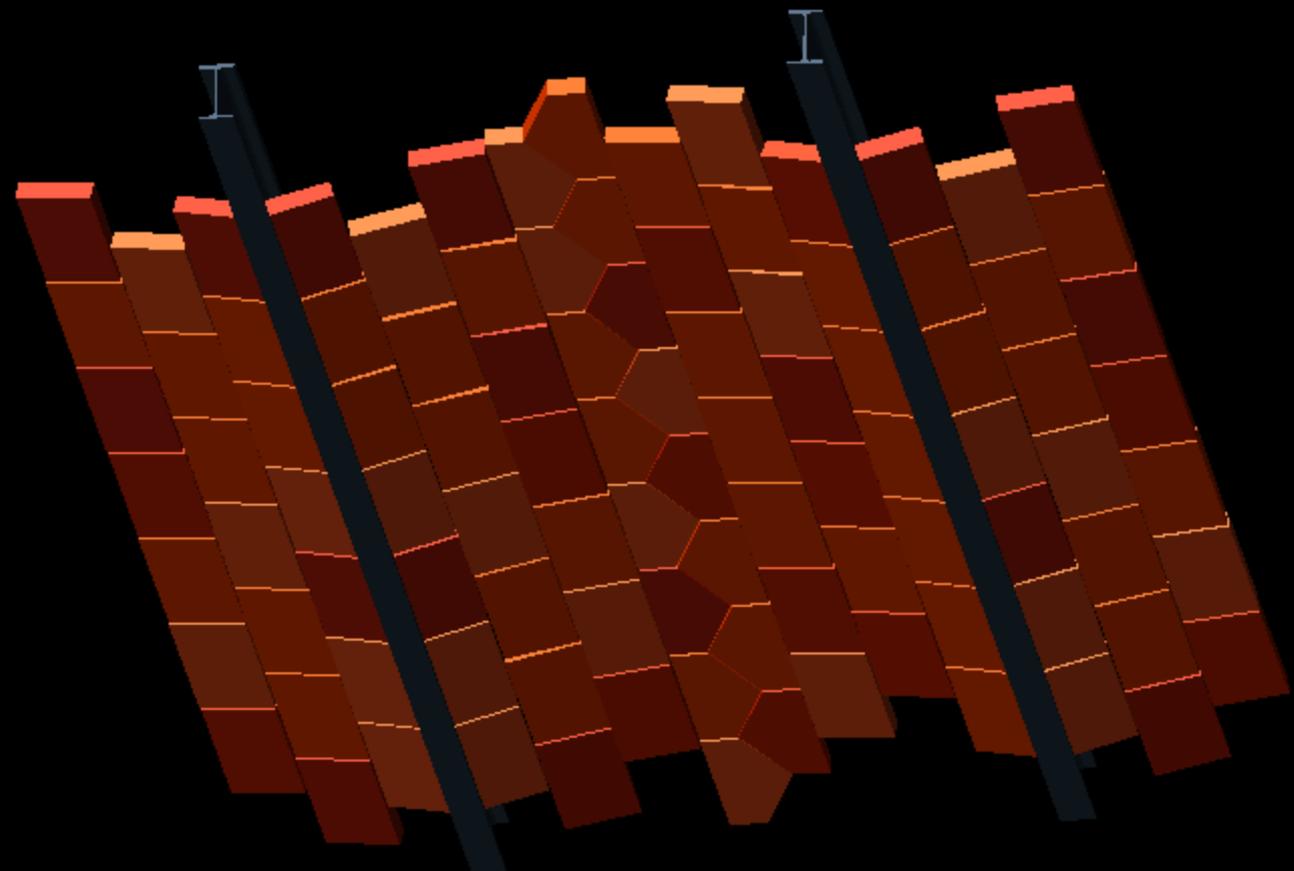


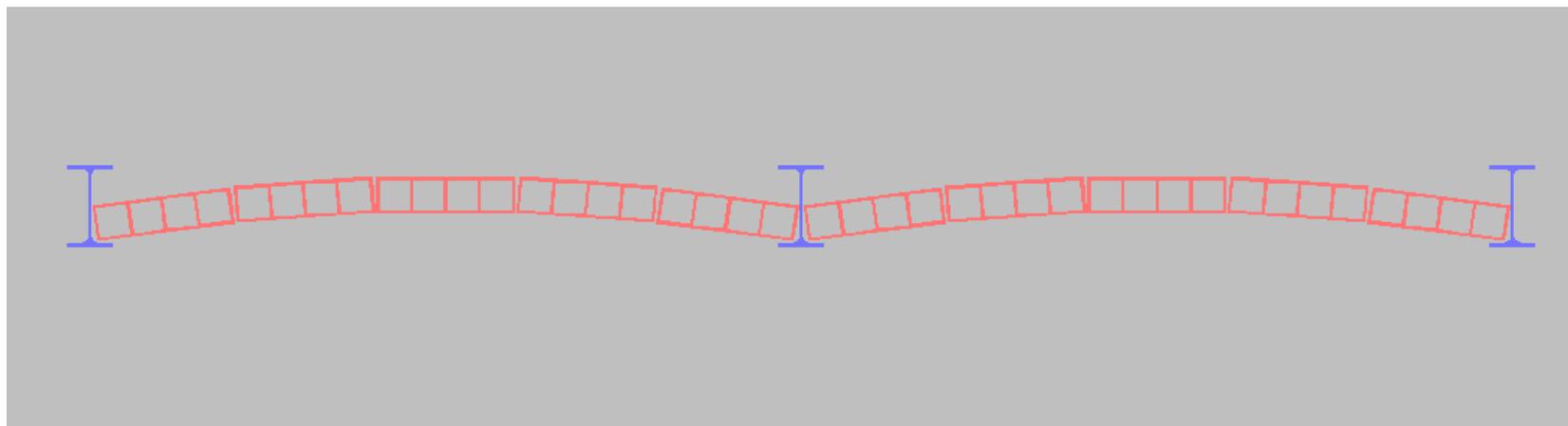
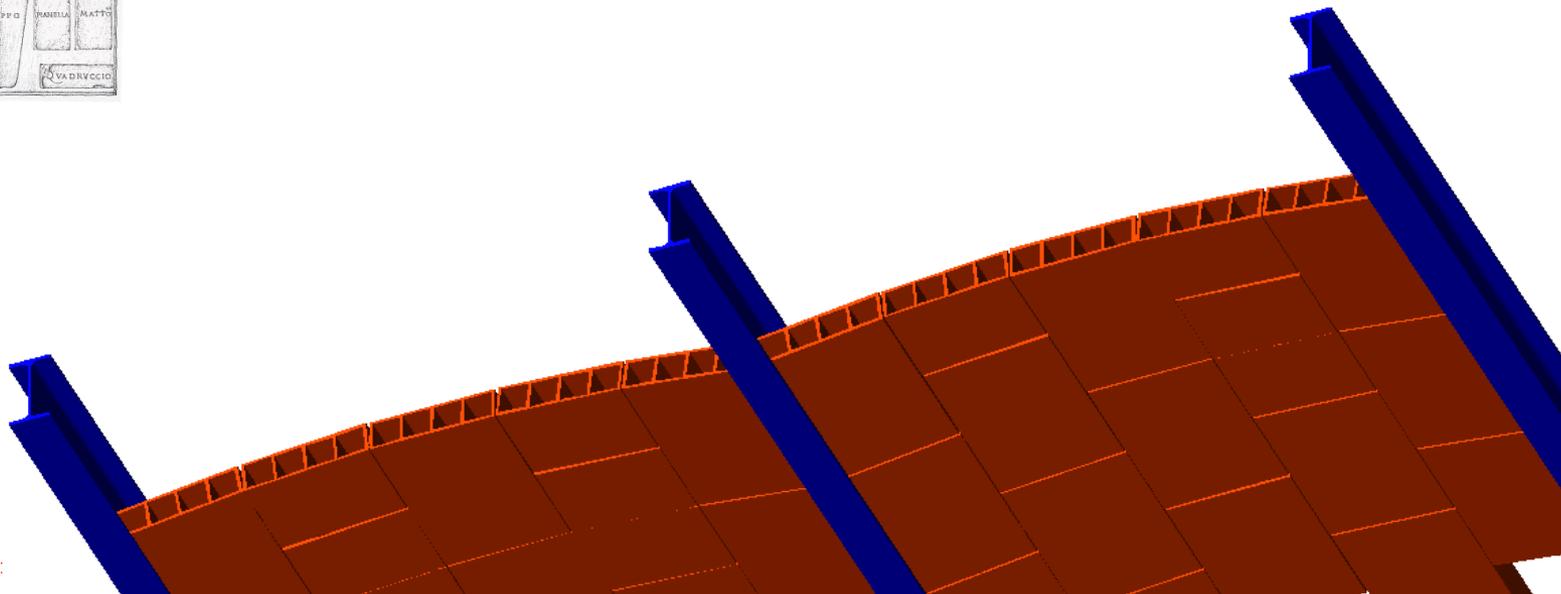
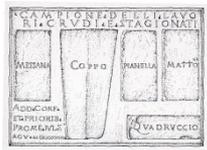
Solaio di voltine in laterizio di mattoni a coltello

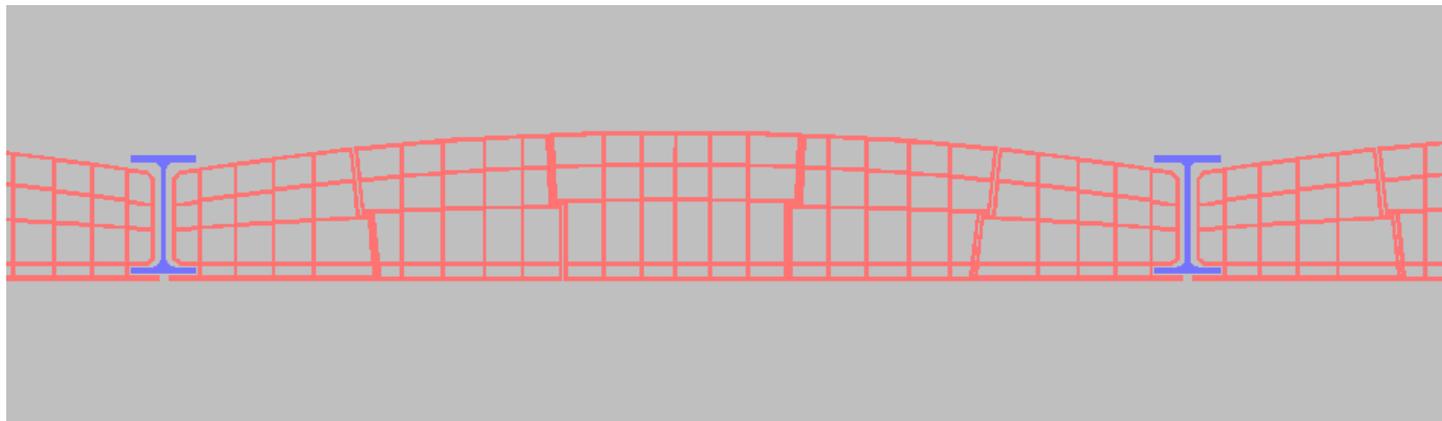
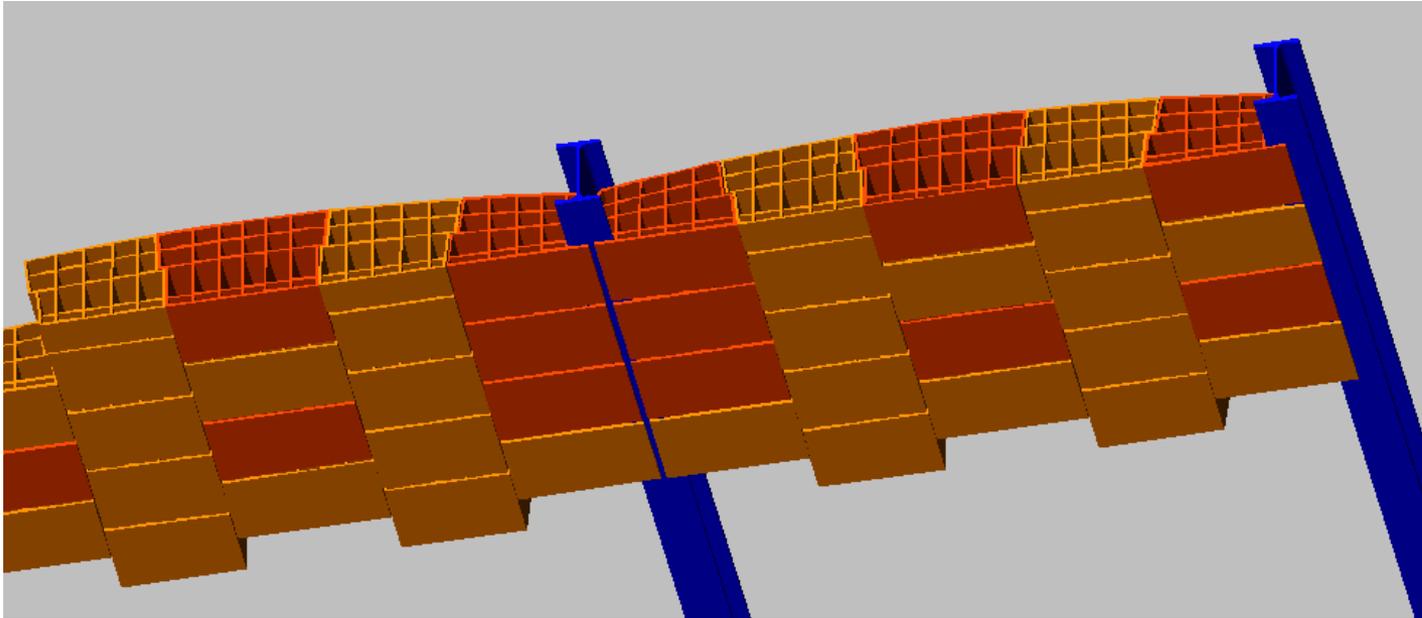
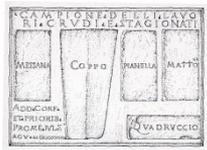


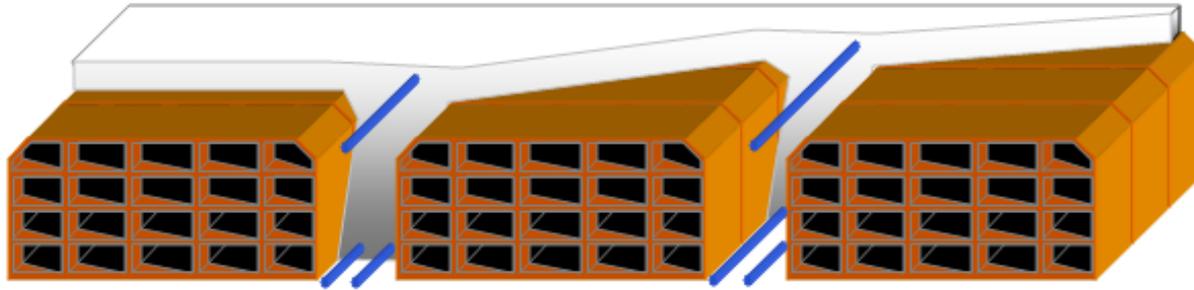
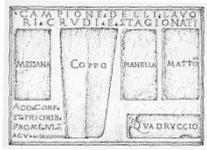


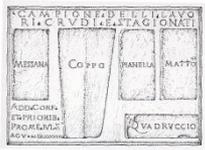
Solaio di voltine in laterizio di mattoni in foglio



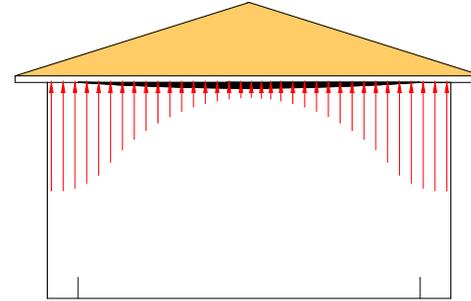








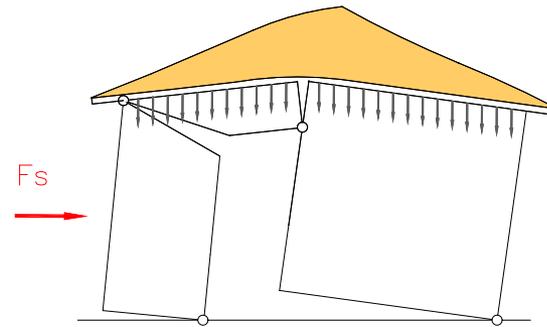
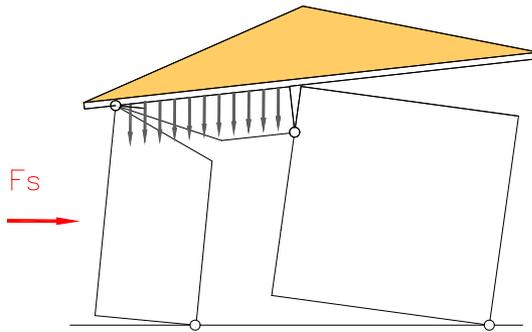
Comportamento anomalo delle coperture rigide



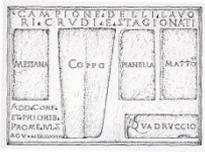
Effetto
trave

Umbria: terremoto 1997

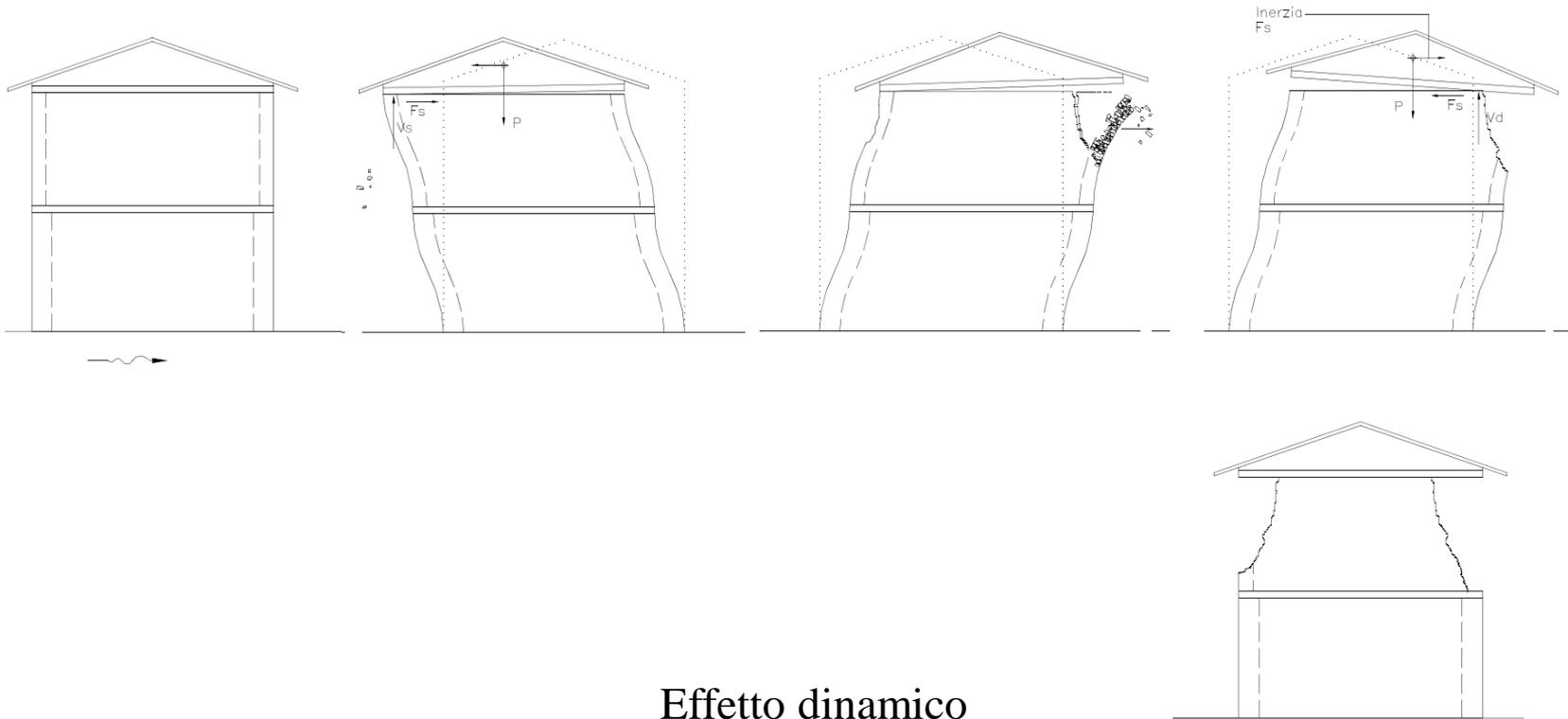
Comportamento statico delle coperture rigide

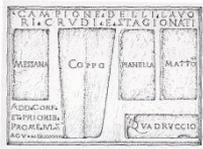


Comportamento cinematico in presenza di coperture rigide o deformabili

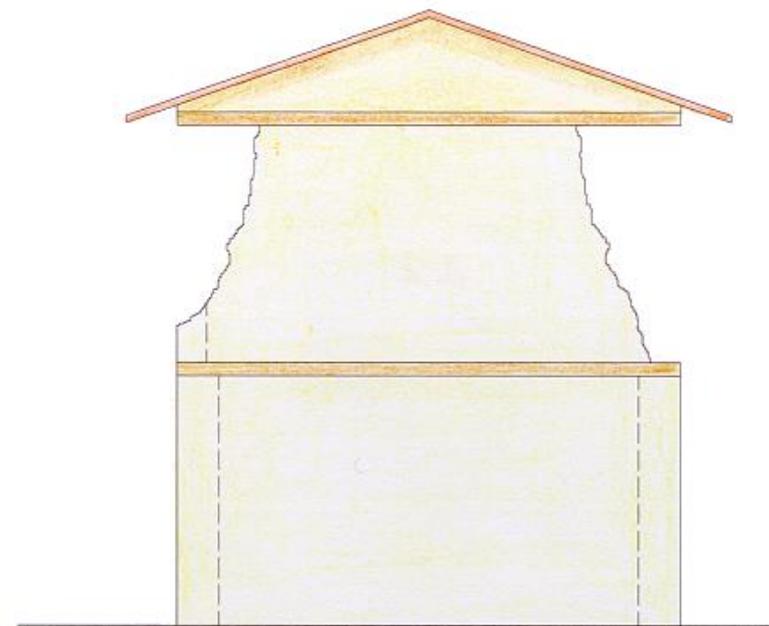
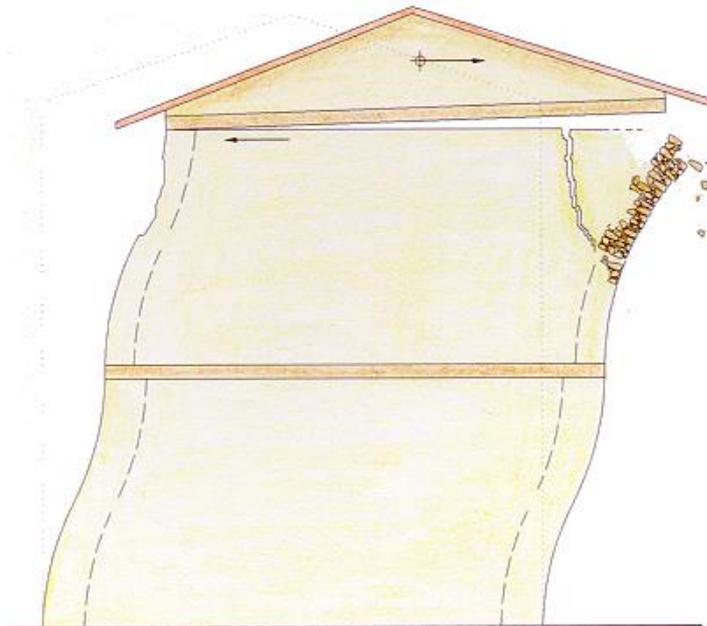


Effetti sull'irrigidimento delle coperture con cordoli in cemento armato



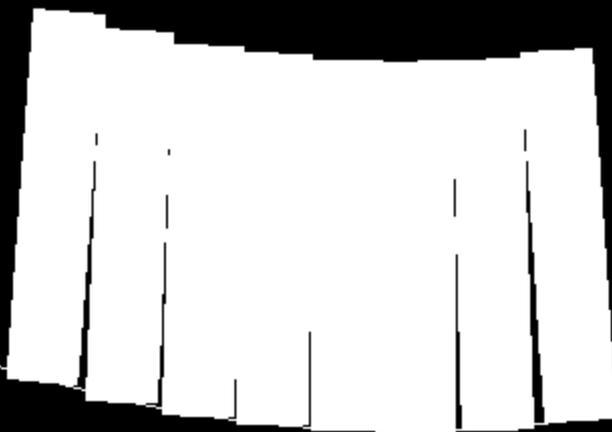


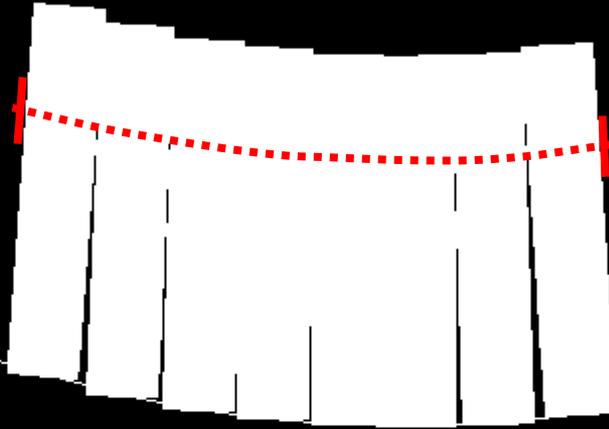
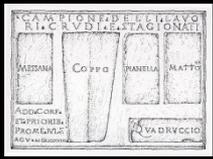
Effetti sull'irrigidimento delle coperture con cordoli in cemento armato

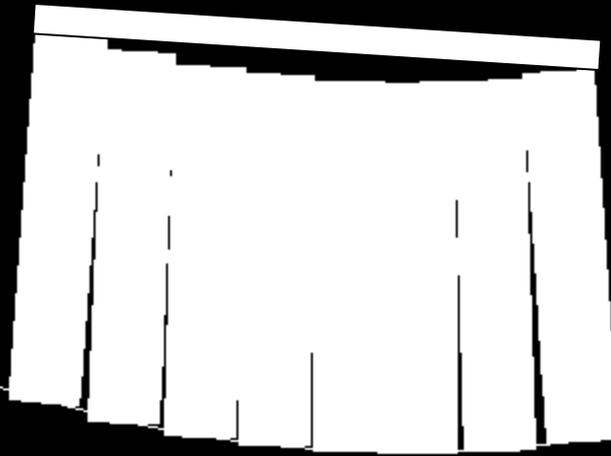
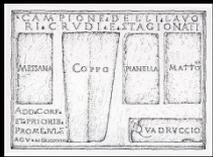


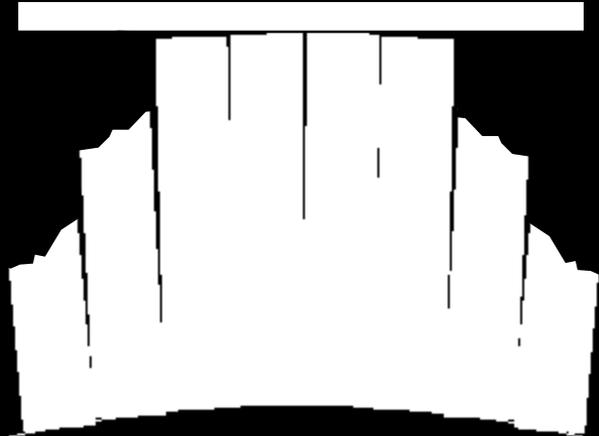
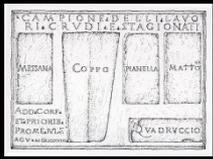
CONFIGURAZIONE FINALE

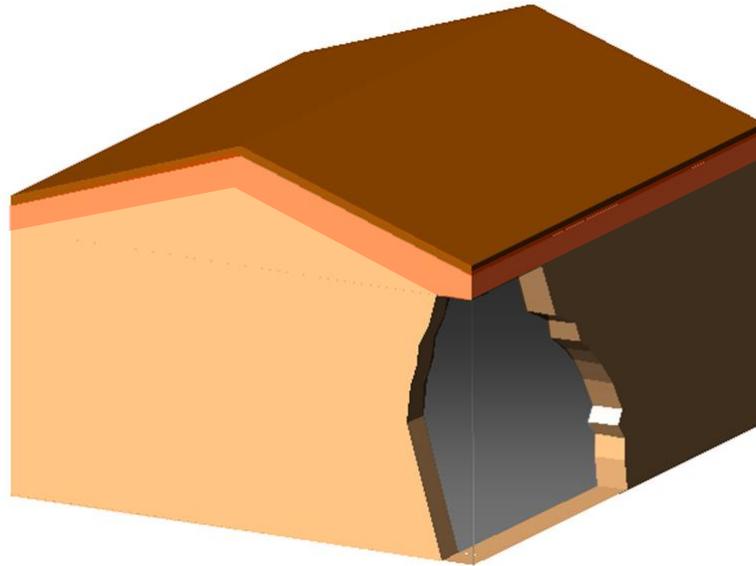
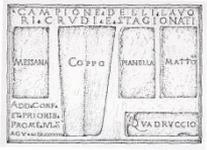


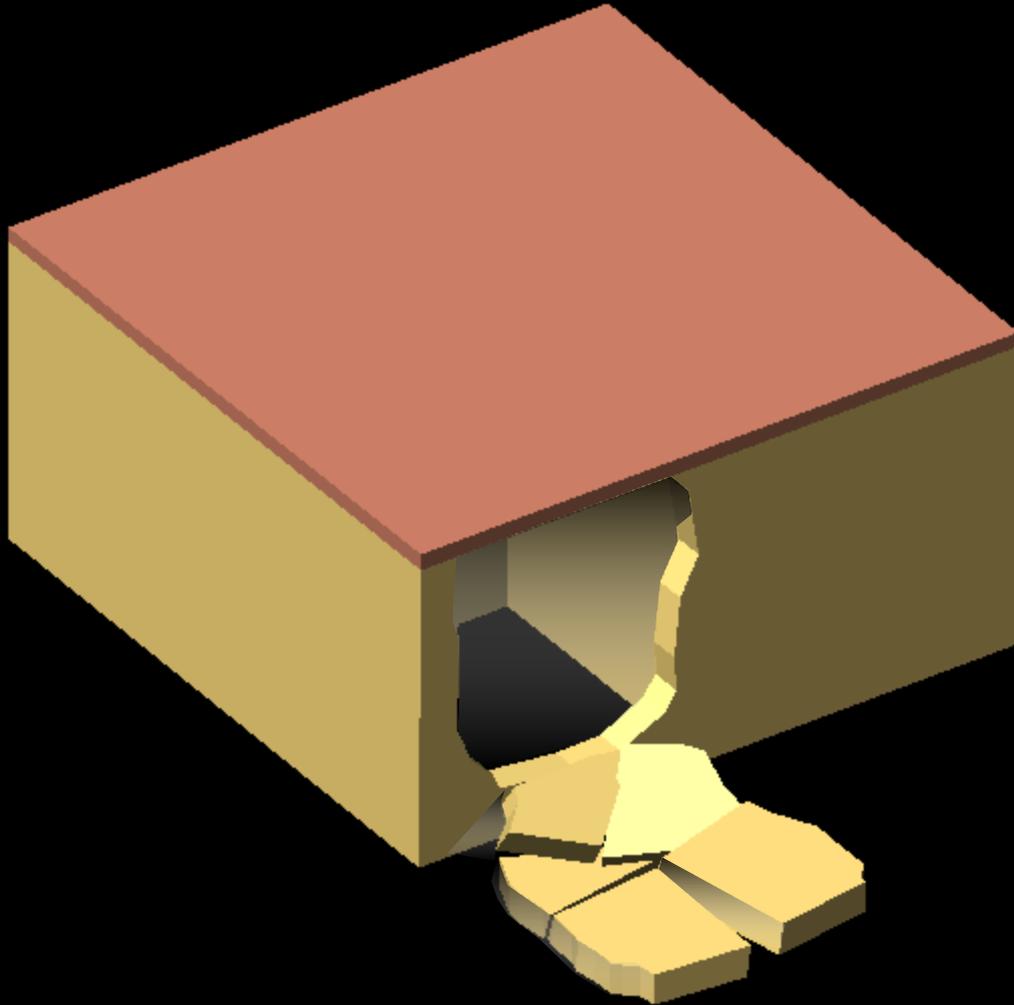


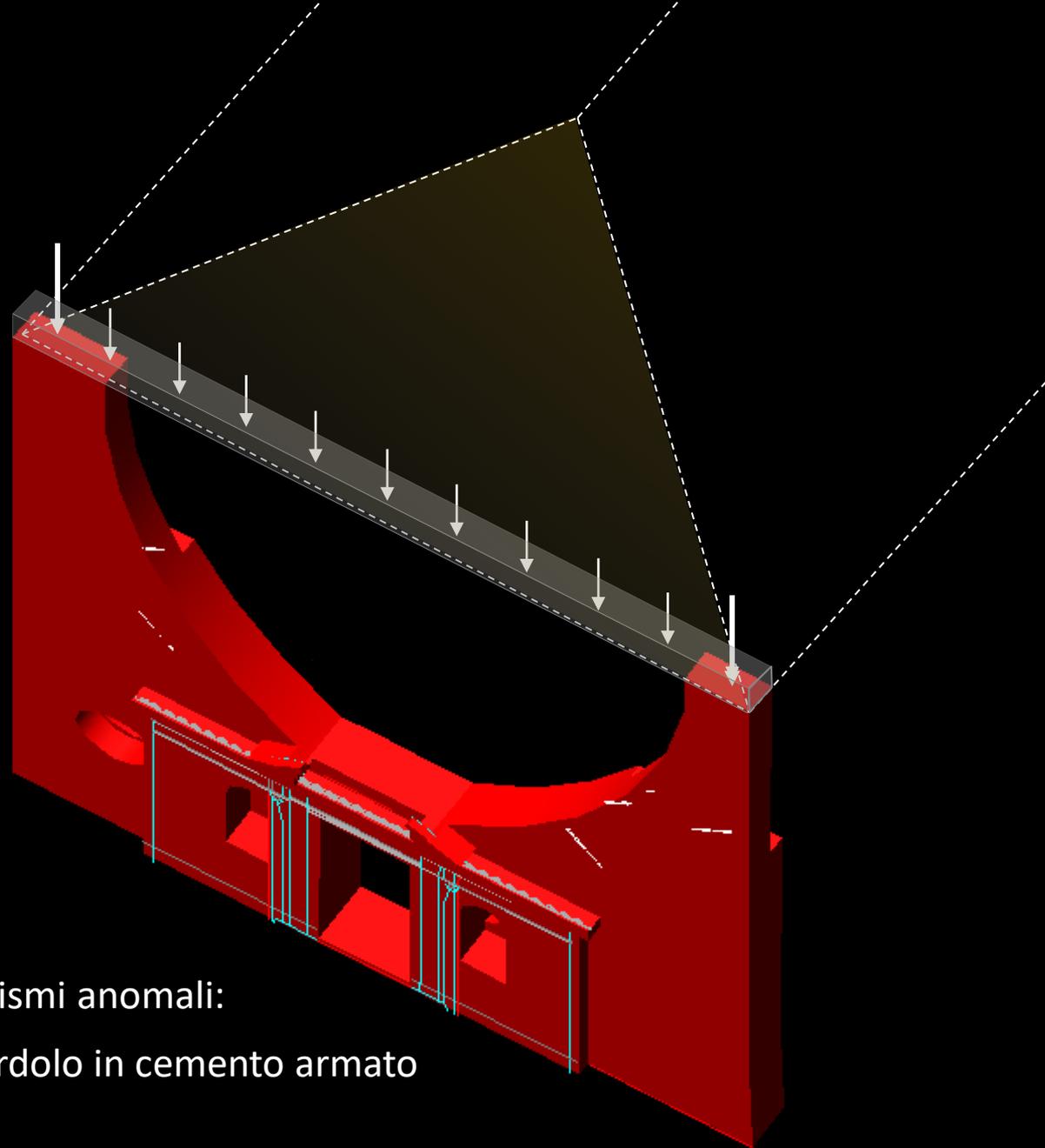












Meccanismi anomali:

«effetto trave» del cordolo in cemento armato



Ministero delle Infrastrutture e dei Trasporti
Consiglio Superiore dei Lavori Pubblici
Servizio Tecnico Centrale

C8.7.4.1 CRITERI PER GLI INTERVENTI DI CONSOLIDAMENTO DEGLI EDIFICI IN MURATURA

Formazione dei diaframmi di piano

Per *le coperture*, nelle costruzioni in muratura è in linea generale opportuno operare mediante il mantenimento dei tetti in legno per non incrementare le masse nella parte più alta dell'edificio, o con soluzioni più pesanti di acciaio o di calcestruzzo armato, previa verifica.

Ove i tetti presentino orditure spingenti, come nel caso di puntoni inclinati o cantonali privi di elementi di ritegno, la spinta deve essere contenuta, integrando in modo opportuno lo schema strutturale. E' inoltre opportuno intervenire sui collegamenti tra elementi lignei per evitare locali situazioni spingenti o di labilità.



Ministero delle Infrastrutture e dei Trasporti
Consiglio Superiore dei Lavori Pubblici
Servizio Tecnico Centrale

C8.7.4.1 CRITERI PER GLI INTERVENTI DI CONSOLIDAMENTO DEGLI EDIFICI IN MURATURA

I cordoli in sommità

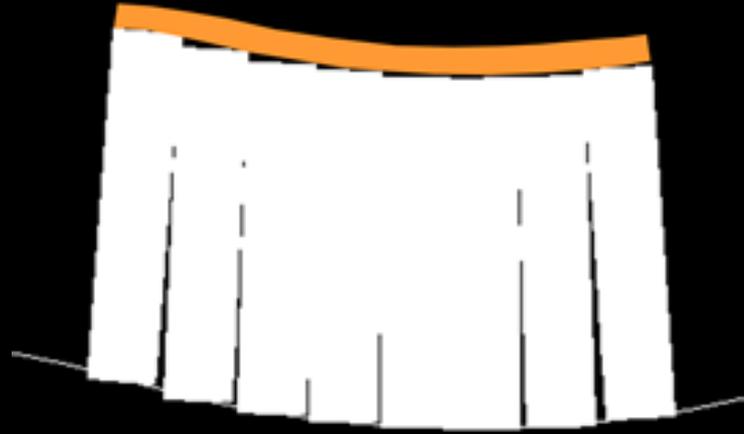
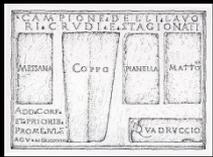
I cordoli in sommità possono costituire una soluzione efficace sia per collegare le pareti in una zona dove la muratura è meno resistente a taglio a causa del basso livello di compressione, sia per contenere eventuali azioni spingenti della copertura, sia anche per favorire l'appoggio delle singole membrature dell'orditura.

Il collegamento del cordolo con la muratura esistente può essere realizzato, in assenza di soluzioni più efficaci e meno invasive, attraverso perforazioni armate con barre metalliche, protette o di tipo inossidabile, oppure di altro materiale resistente a trazione, efficacemente ancorate alla muratura.

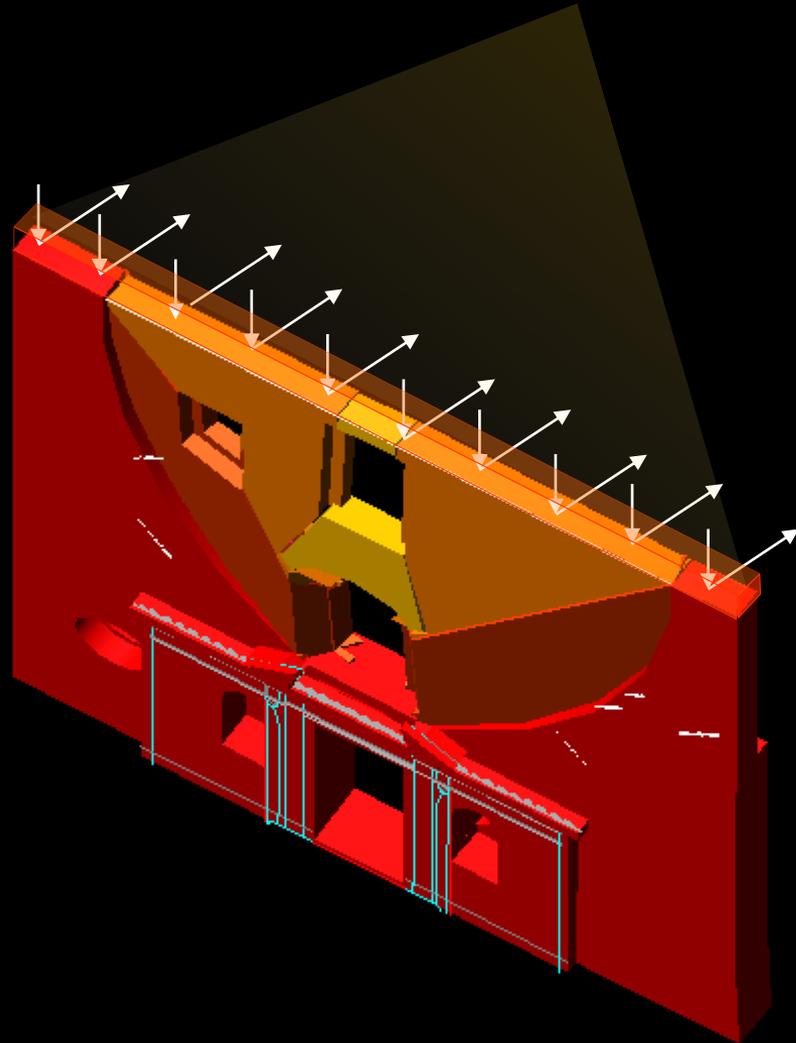
I cordoli in sommità possono essere realizzati nei seguenti modi:

- **Cordoli realizzati con elementi lignei, adeguatamente protetti;**
- **Cordoli realizzati con muratura armata;**
- **Cordoli realizzati con elementi d'acciaio;**
- **Cordoli in calcestruzzo armato.**

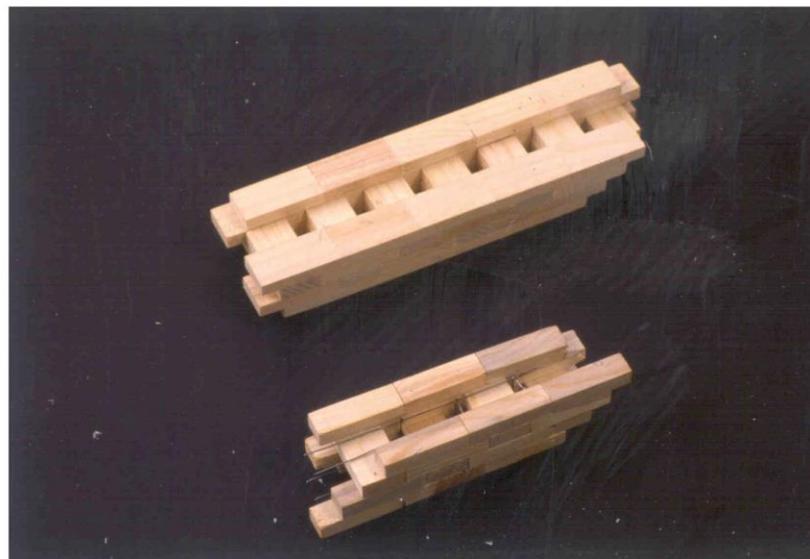
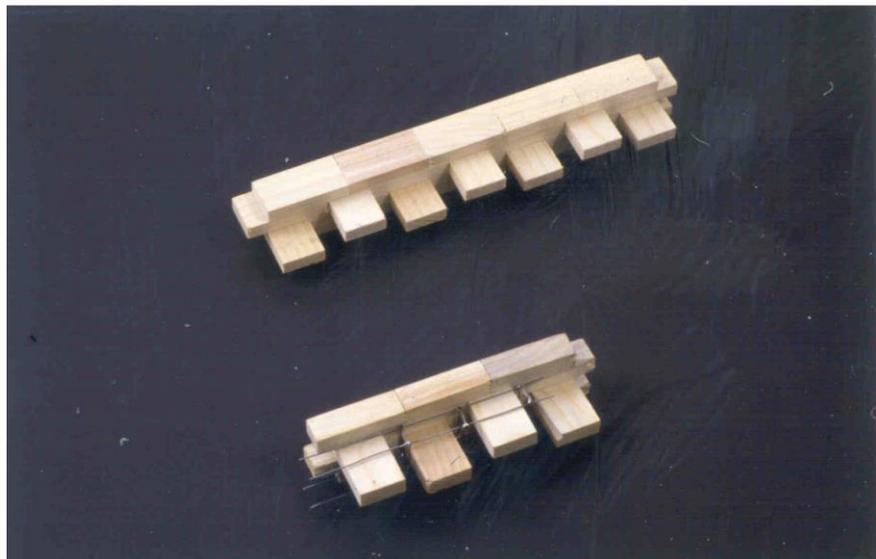
L'esecuzione di cordolature a livelli intermedi risulta necessaria solo in determinati casi, che devono essere motivati. L'uso di cordoli eseguiti a scasso nello spessore della parete deve generalmente essere evitato per gli eventuali effetti negativi legati all'alterazione dello stato di sollecitazioni della parete per effetto della formazione delle aperture in breccia. La soluzione più efficace per la realizzazione di cordoli a livello intermedio è quella della trave in muratura armata, ottenuta applicando piatti metallici sui due lati della muratura e collegandoli tramite barre passanti o mediante soluzioni di tipo analogo.



Copertura deformabile



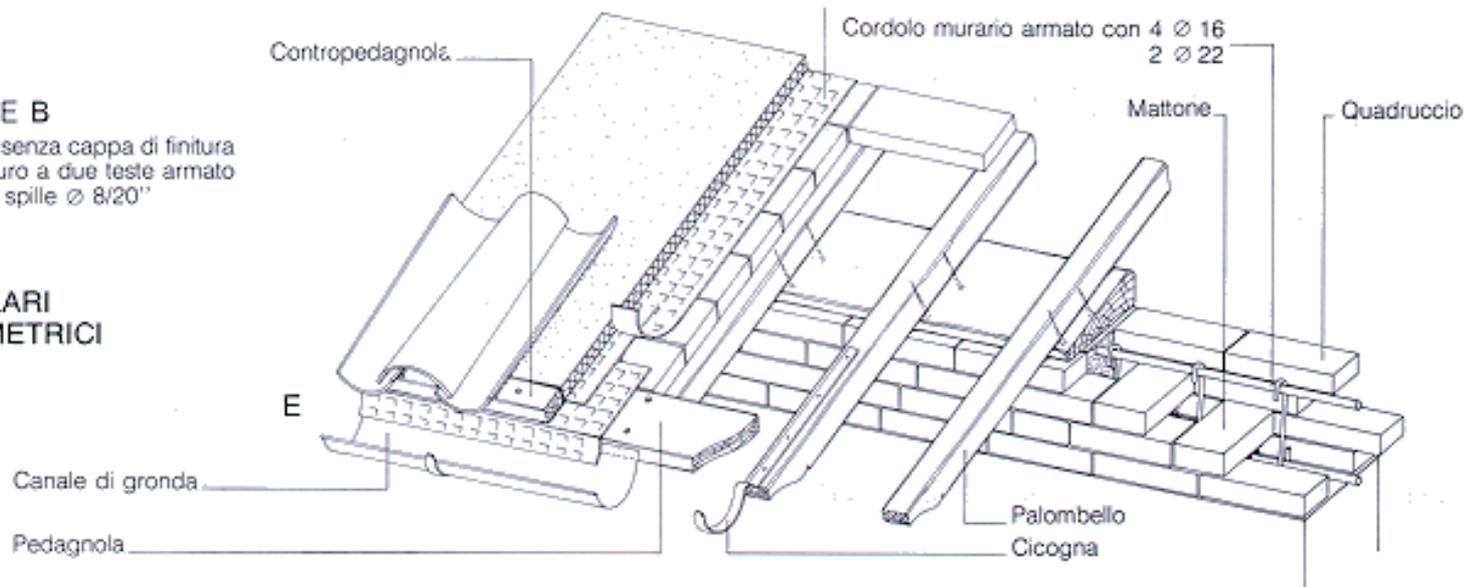
Particolari cordolo in muratura armata



SOLUZIONE B

Sovrastruttura senza cappa di finitura
Cordolo su muro a due teste armato
con 2 \varnothing 22 e spille \varnothing 8/20"

PARTICOLARI ASSONOMETRICI



Presidenza del Consiglio dei Ministri del 12/10/2007

Direttiva del Presidente del Consiglio dei Ministri per la valutazione la riduzione del rischio sismico del patrimonio culturale con riferimento alle norme tecniche per le costruzioni

(Gazzetta ufficiale 29/01/2008 n. 24)

29-1-2008

Supplemento ordinario alla GAZZETTA UFFICIALE

Serie generale - n. 24

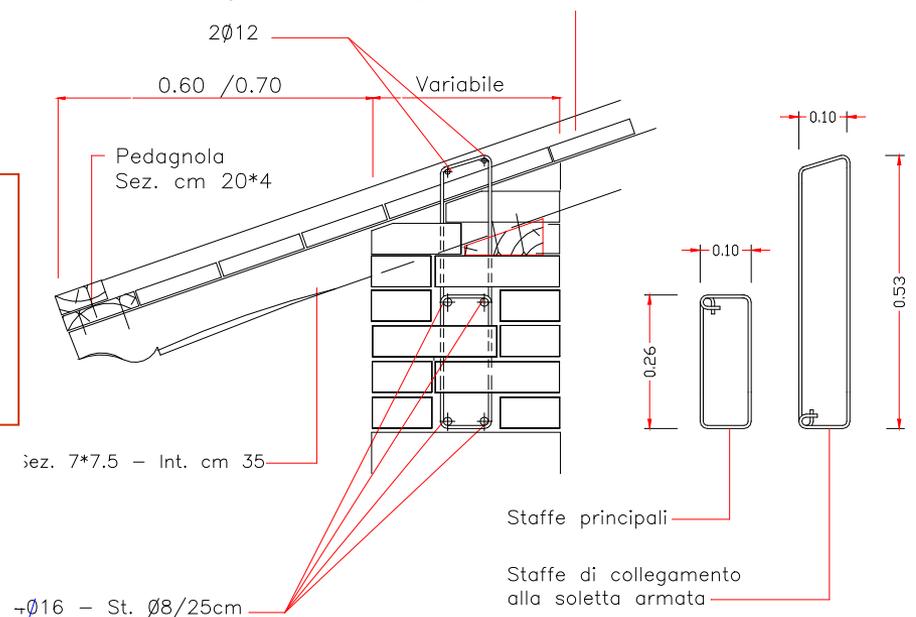
6.3.2 Interventi volti a ridurre le carenze dei collegamenti

Cordoli in sommità:

- in muratura armata, consentendo di realizzare il collegamento attraverso una tecnica volta alla massima conservazione delle caratteristiche murarie esistenti. Essi, infatti, devono essere realizzati con una muratura a tutto spessore e di buone caratteristiche

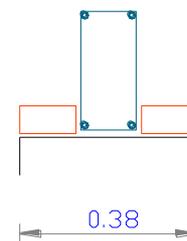
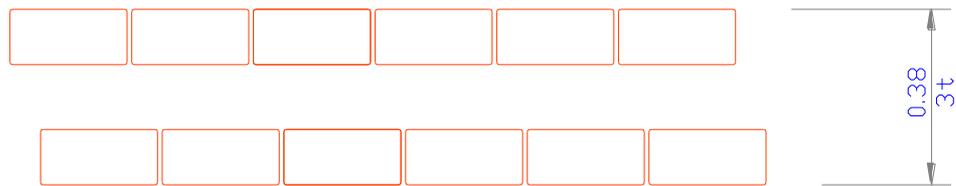
6.3.5 Interventi in copertura

Vanno in generale evitati i cordoli in cemento armato di elevato spessore per la diversa rigidità che essi introducono

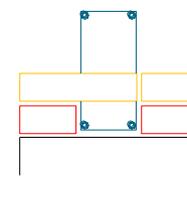


CMA3T – Cordolo in Muratura Armata su muro di 3 Teste

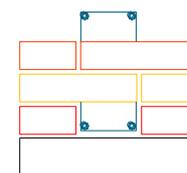
1° Filare



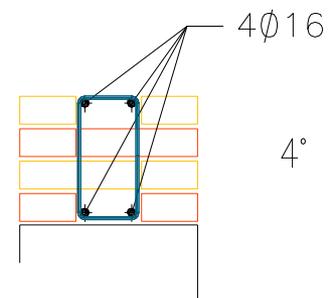
1° Filare



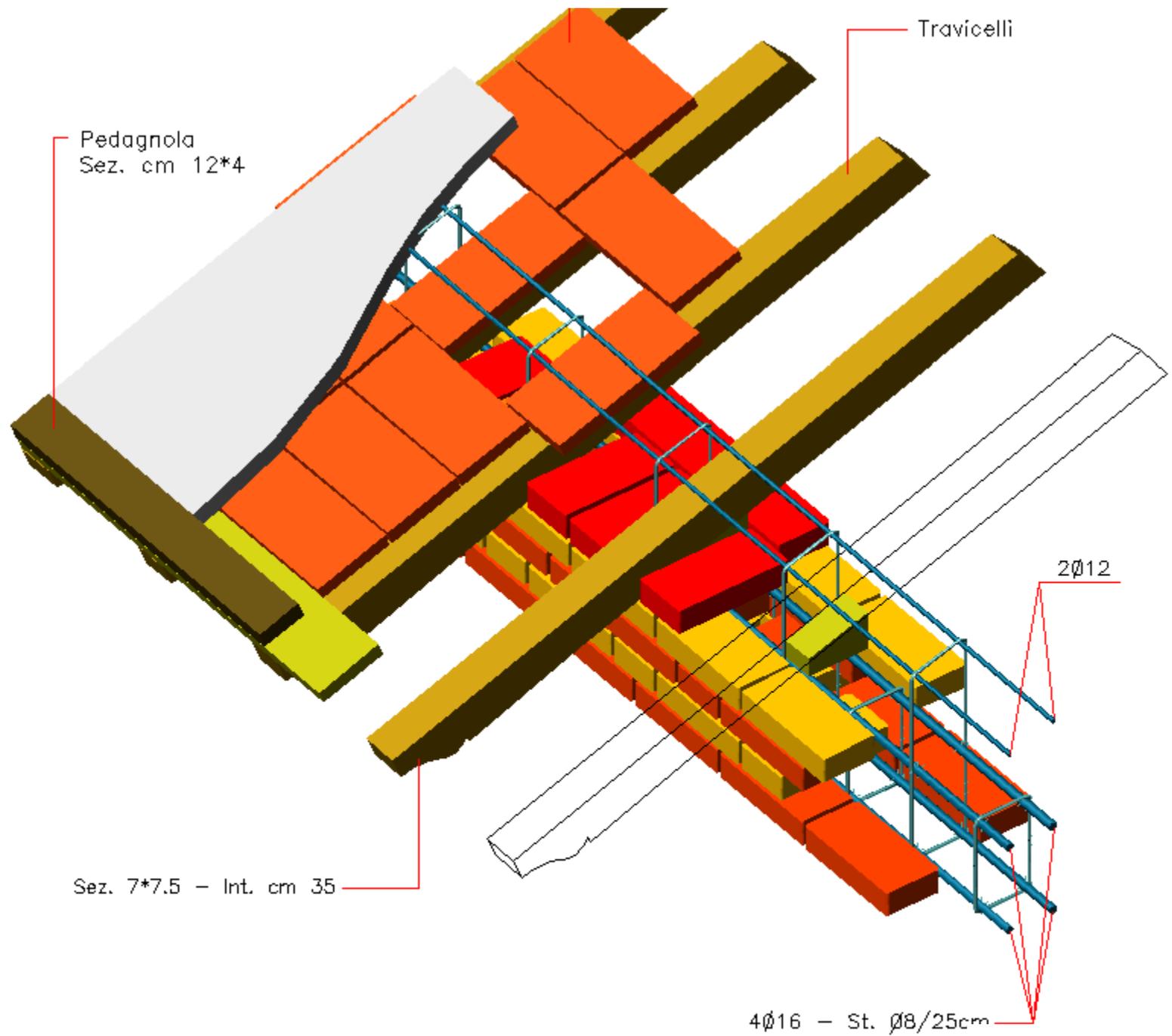
2° Filare



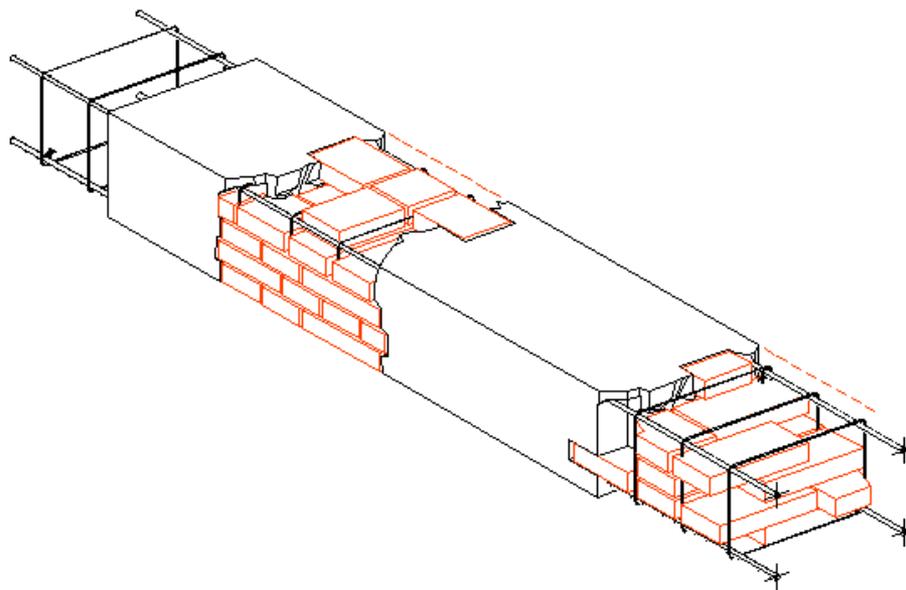
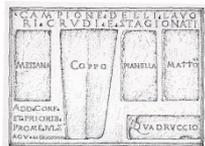
3° Filare



4° Filare







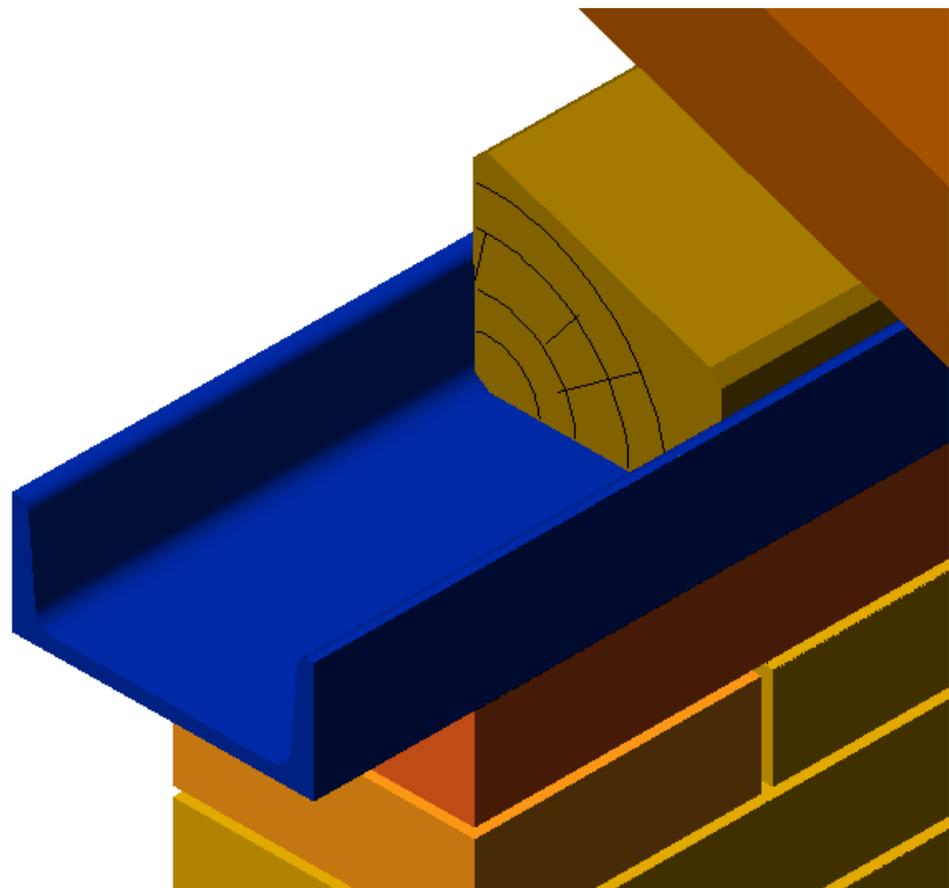
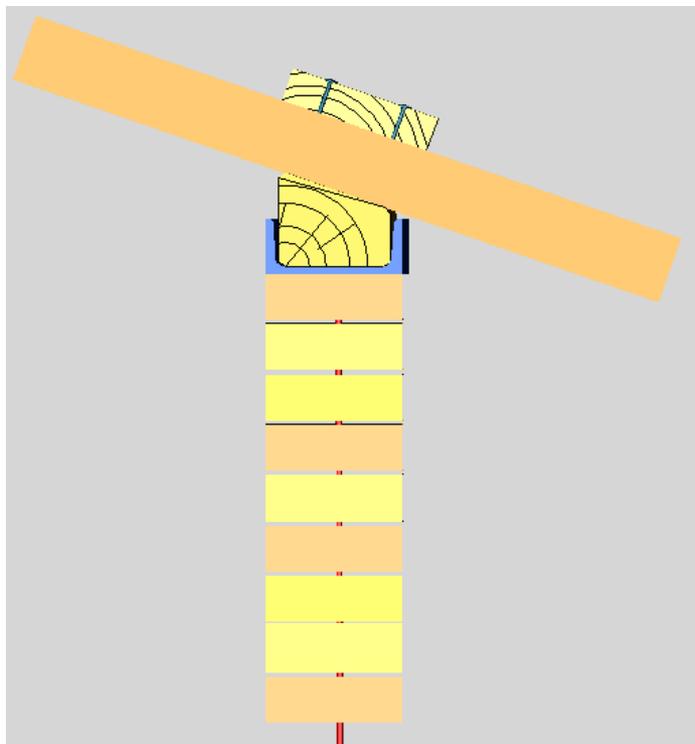
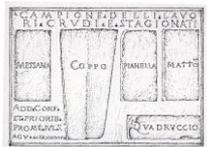
Modifica cordolo in cemento armato
per eliminazione dell'effetto trave



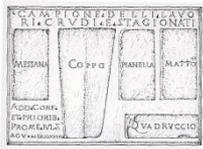








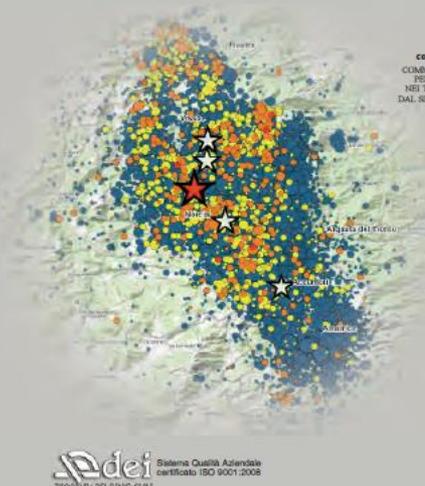
Cordoletto sommitale in legno e acciaio su muro di una testa di mattone



PREZZARIO UNICO DEL CRATERE DEL CENTRO ITALIA

ai sensi dell'art. 6, comma 7, del DL 189/2016, approvato con
**Ordinanza n. 7 del Commissario del Governo per la
Ricostruzione del 14/12/2016**

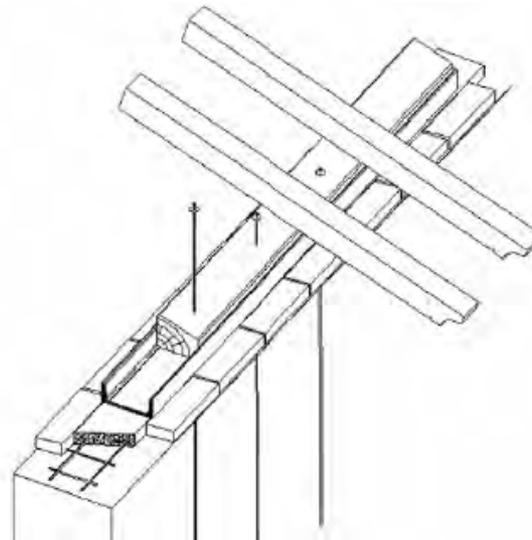

Presidenza del
consiglio dei ministri
COMMISSARIO DEL GOVERNO
PER LA RICOSTRUZIONE
NEI TERRITORI INTERESSATI
DAL SISMA DEL 24 AGOSTO 2016



 **Aedei**
Sistema Qualità Aziendale
certificato ISO 9001:2008
"MOCCIA DEL CINQUE CIVILE"

A05065 Cordolo in acciaio e legno su muratura a una o due teste. Realizzazione di cordolo in acciaio e legno costituito da profilato UPN140 con inserito all'interno elemento in legno massello di essenza dura con funzione di "ammortizzatore" atto a favorire l'efficacia dei perfori verticali di collegamento con la muratura sottostante e la buona realizzazione del vincolo di appoggio dei travetti costituenti lo sporto di gronda. Deve essere garantita la perfetta orizzontalità del piano di posa tramite la realizzazione di cuscino di appoggio in calcestruzzo armato con rete in acciaio o fibra di vetro. Sono compresi il profilato metallico e il legno necessari, i trattamenti protettivi e i perfori verticali sulla muratura d'imposta, la malta di allettamento, i tagli, gli sfridi, le saldature per garantire la continuità del profilato metallico. Compreso quanto necessario per dare l'opera finita secondo la regola dell'arte, anche in quota. Sono esclusi la demolizione di muratura se necessaria, la predisposizione del piano di posa, la realizzazione di muratura complementare se necessaria

m **75,00**





**Ordine degli Ingegneri
della Provincia di Macerata**
Commissione Strutture e Geotecnica

Evento organizzato con il contributo incondizionato di:

Leca
soluzioni leggere e isolanti
Laterlite


RUREGOLD
INNOVATION & SAFETY FOR BUILDINGS

SEMINARIO DI AGGIORNAMENTO PROFESSIONALE

CONSOLIDAMENTO DI EDIFICI ESISTENTI

- Elementi di meccanica delle murature e di archi e volte per la valutazione del comportamento statico e della risposta sismica degli edifici storici in riferimento al quadro normativo*
- Rilievo critico e restituzione grafica dell'organismo edilizio*
- Lettura e interpretazione dei quadri fessurativi*
- Meccanismi locali e comportamento globale per la valutazione della vulnerabilità sismica ai sensi delle NTC2018*

Ing. Giovanni Cangì – libero professionista