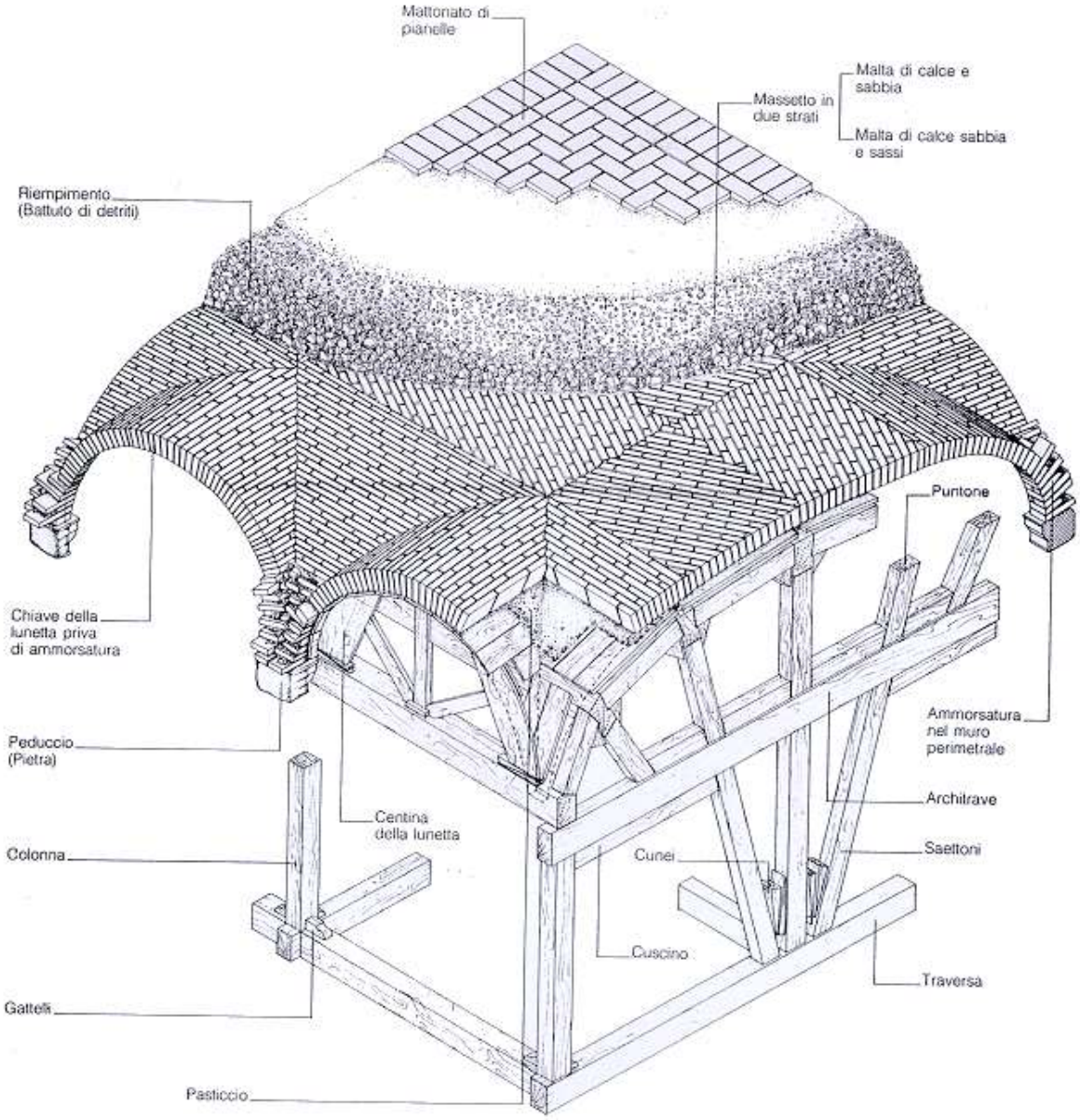
15:00 Ing. Giovanni Cangi - Relatore esterno

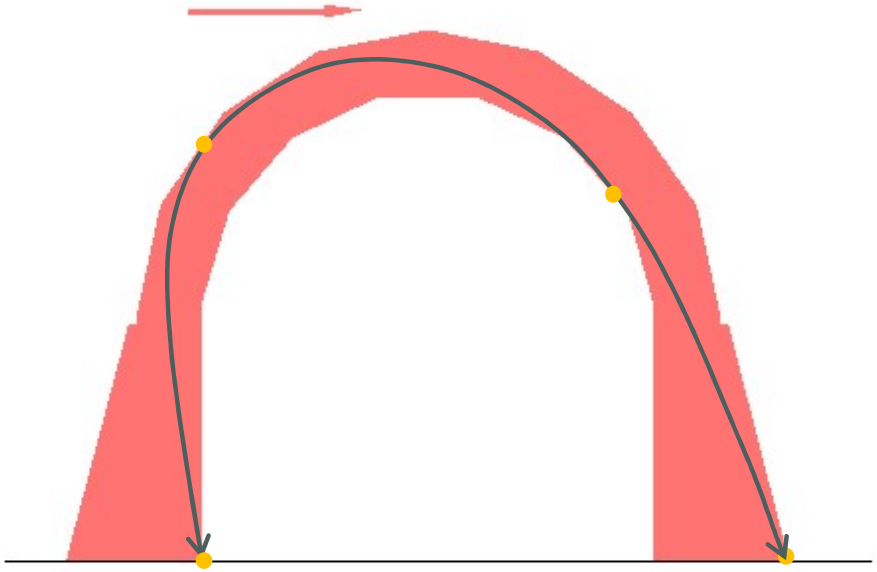
- Archi, volte e sistemi spingenti: tipologie costruttive, funzionamento meccanico, modalità di dissesto e provvedimenti tecnici d'intervento;
- Lettura critica d[illegible]adri fessurativi e della risposta sismica [illegible]difici in muratura riconducibili alla meccanica di archi e volte;
- Meccanismi locali e comportamento globale di strutture murarie per la valutazione delle vulnerabilità sismica ai sensi delle NTC 2018.

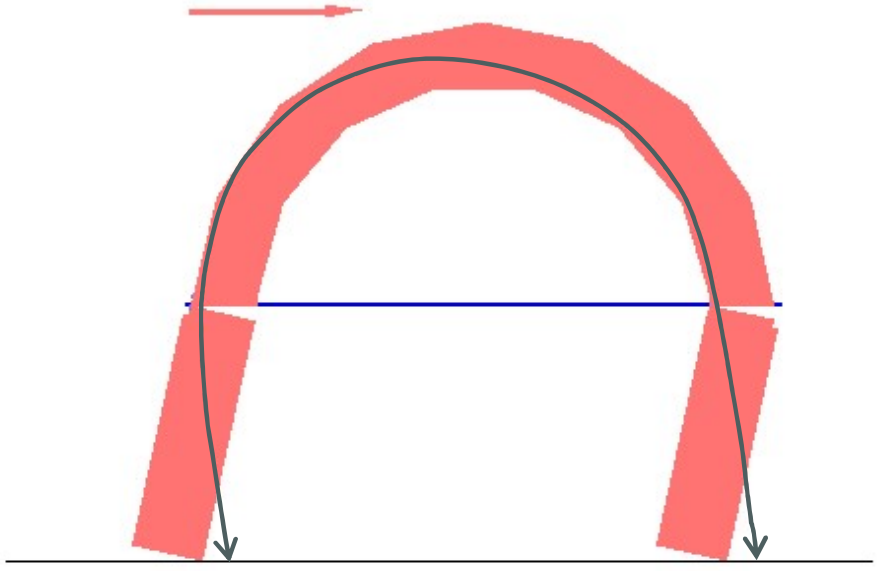
Laterlite
Leca | Lecablocco LecaSistemi | GRAS CALCE | RUREGOLD

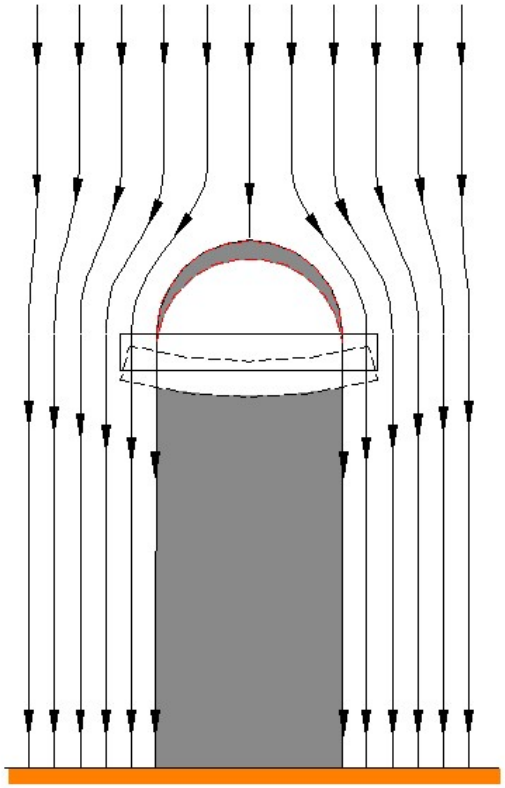



Mattonato di pianelle
Malta di calce e sabbia
Massetto in due strati
Malta di calce sabbia e sassi
Riempimento (Battuto di detriti)
Puntone
Chiave della lunetta priva di ammorsatura
Ammorsatura nel muro perimetrale
Peduccio (Pietra)
Architrave
Centina della lunetta
Cunei
Saettoni
Colonna
Cuscino
Traversa
Gattelli
Pasticcio



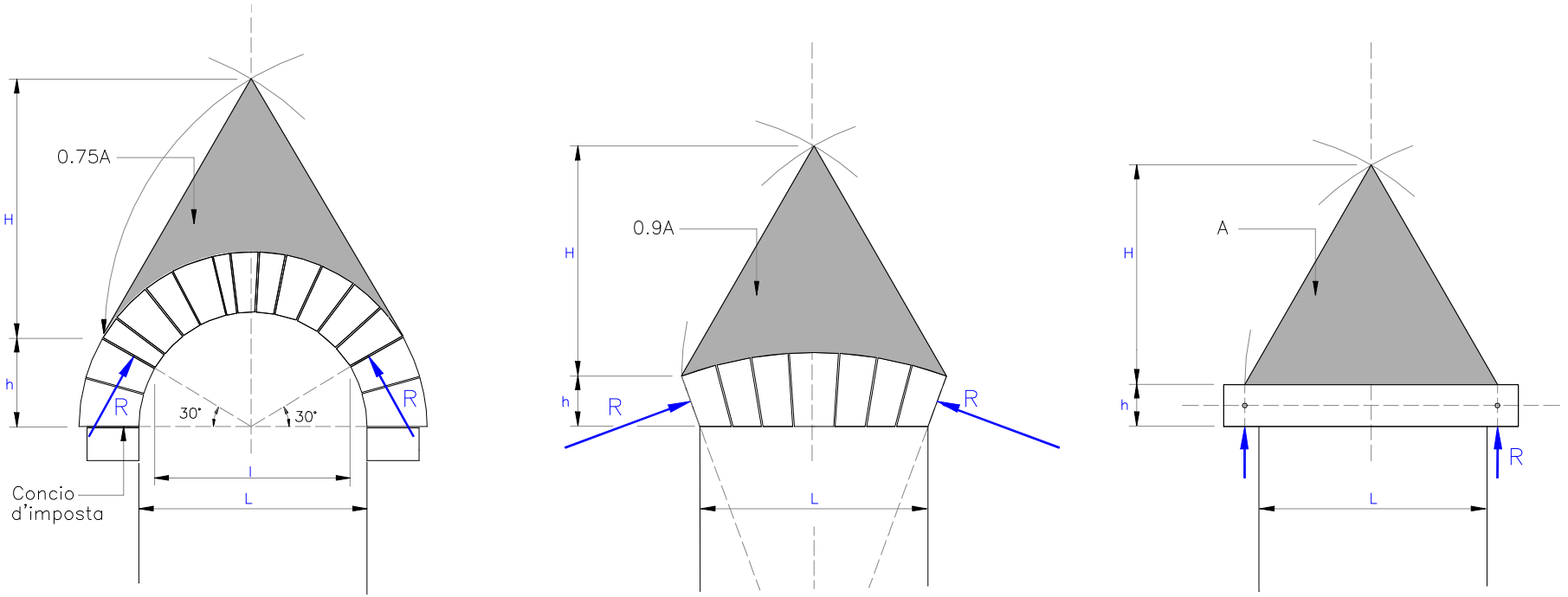




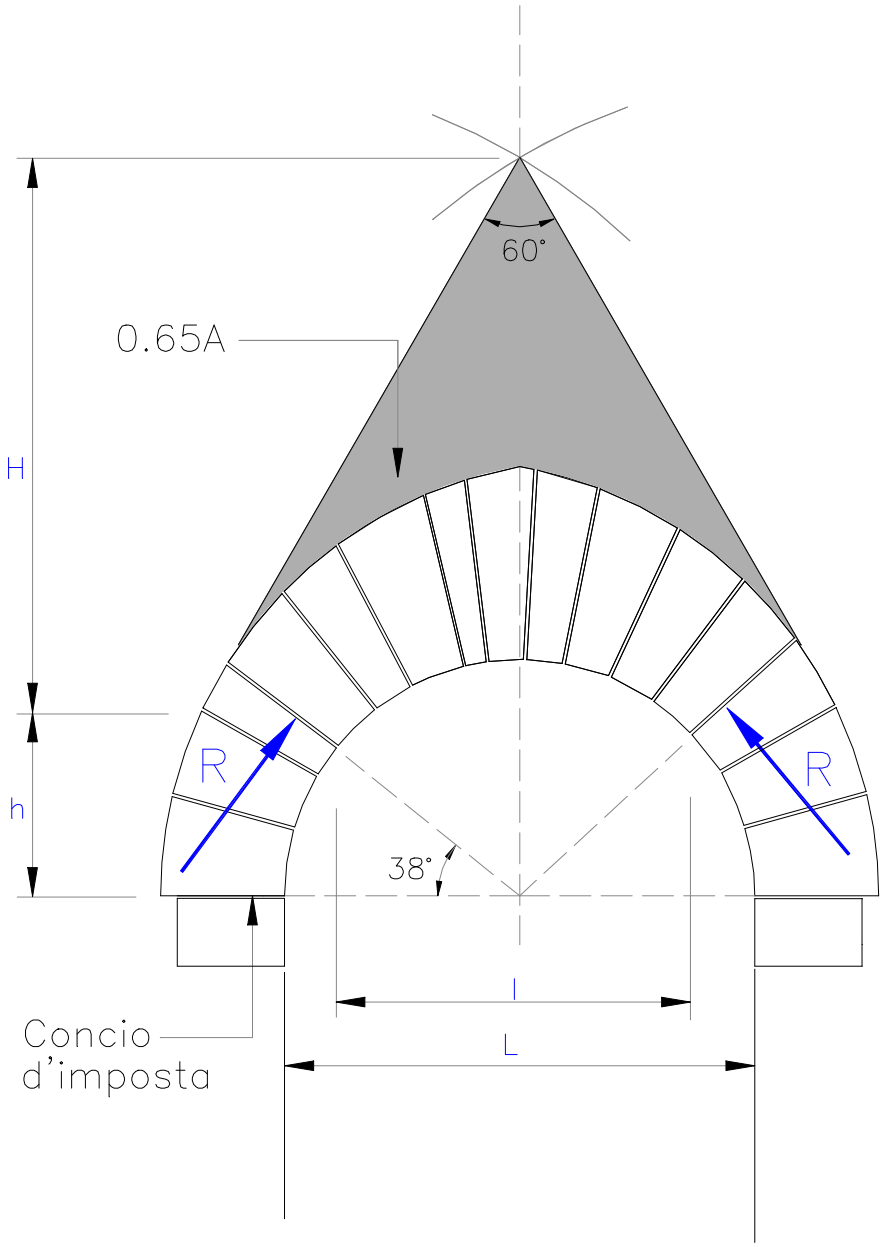




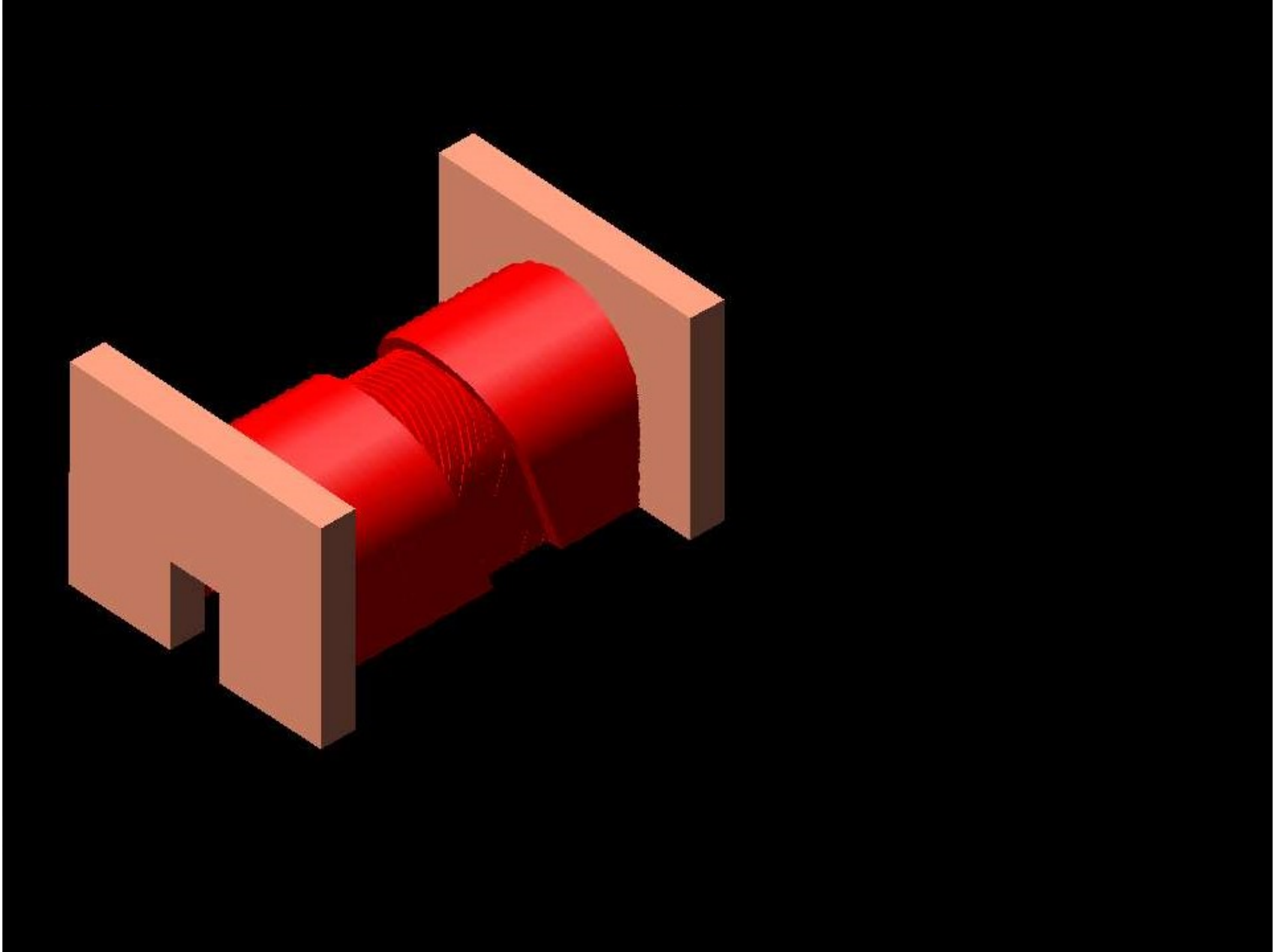
Variazione dei flussi di compressione e innesco di quadri fessurativi nella muratura
in conseguenza dell’inflessione o dell’assestamento di architravi agli appoggi

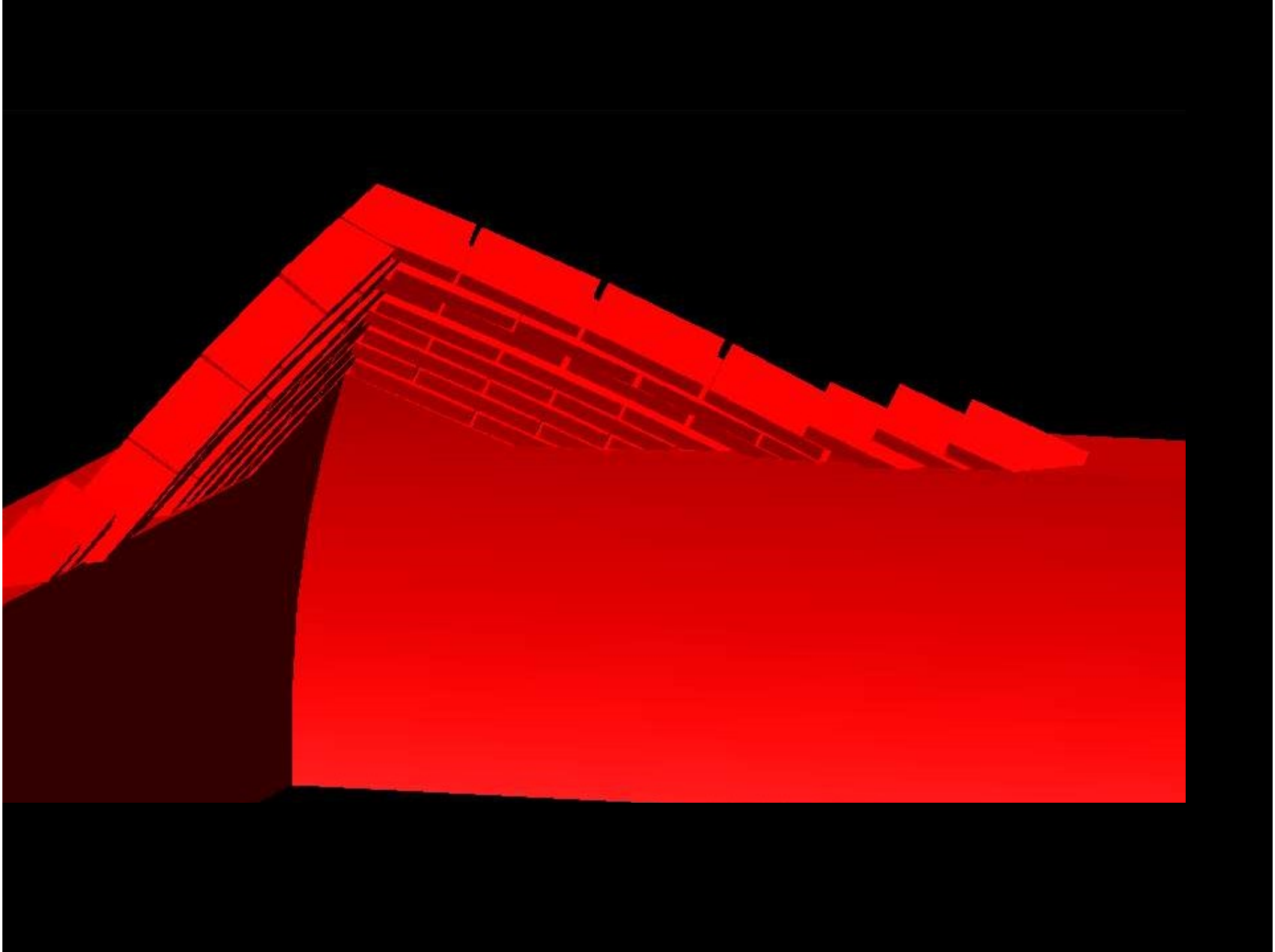


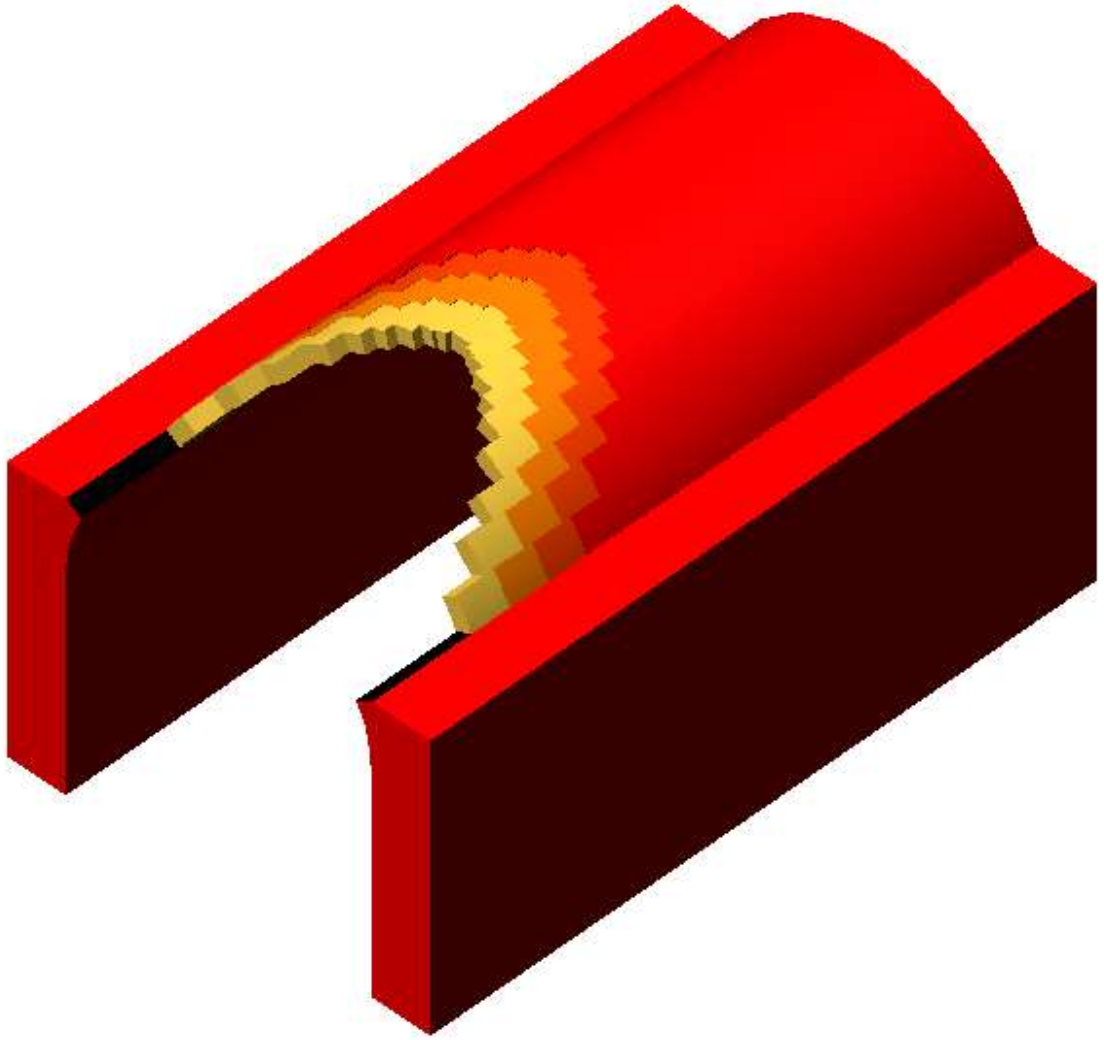
Porzione di muratura situata nella parte sovrastante l'apertura sostenuta rispettivamente da un arco a tutto sesto, da una piattabanda con estradosso curvo e da un architrave piano.

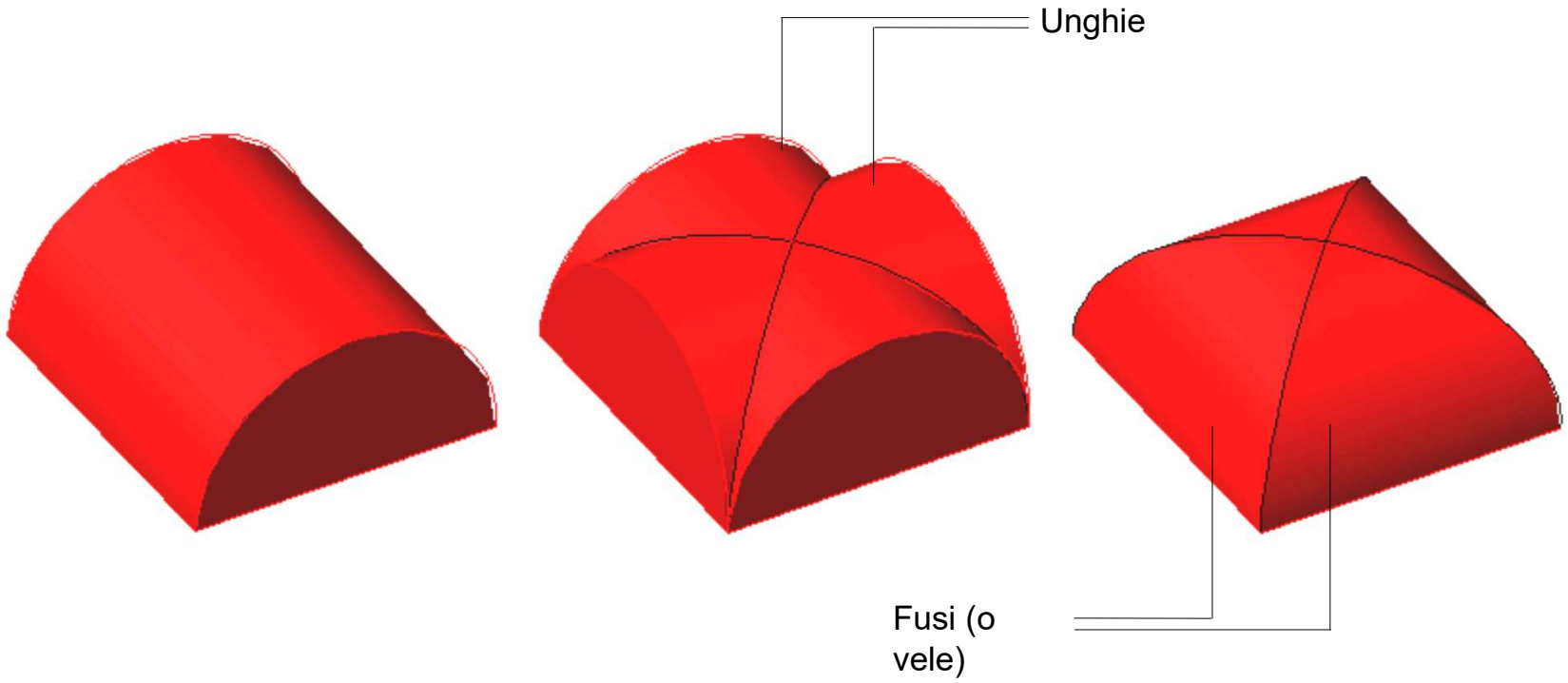


Riduzione delle masse murarie sostenute dall'arco ogivale.







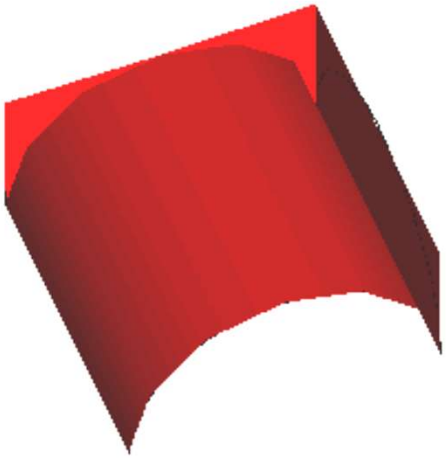


Volta a botte con profilo a tutto sesto

Volta a crociera ottenuta dall’unione di due volte a botte

Volta a padiglione ottenuta dall’intersezione di volte a botte

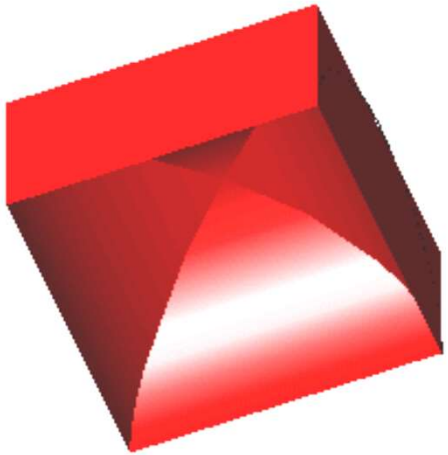
Classificazione di soffitti a volta secondo tipologie canoniche



a) Volta a botte
Vb= 13,41 mc

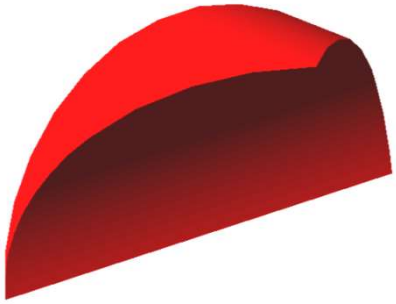


b) Volta a crociera
Vc= 5,99mc



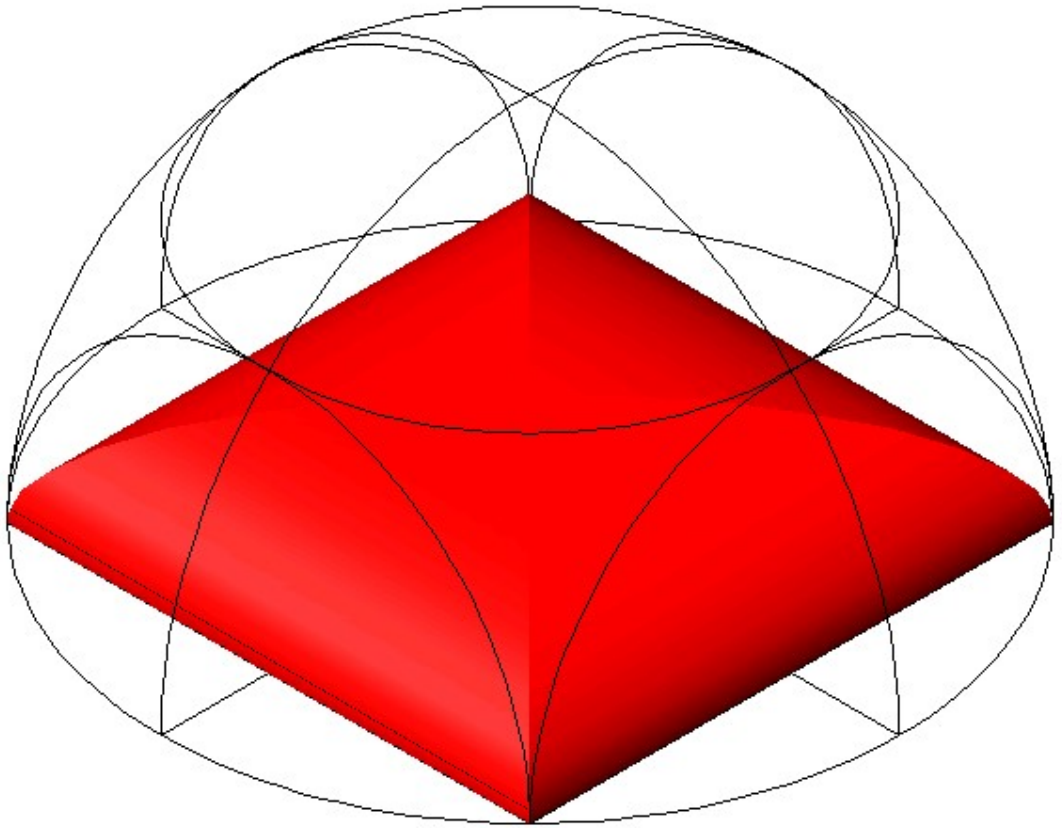
c) Volta a padiglione
Vp= 20,83 mc

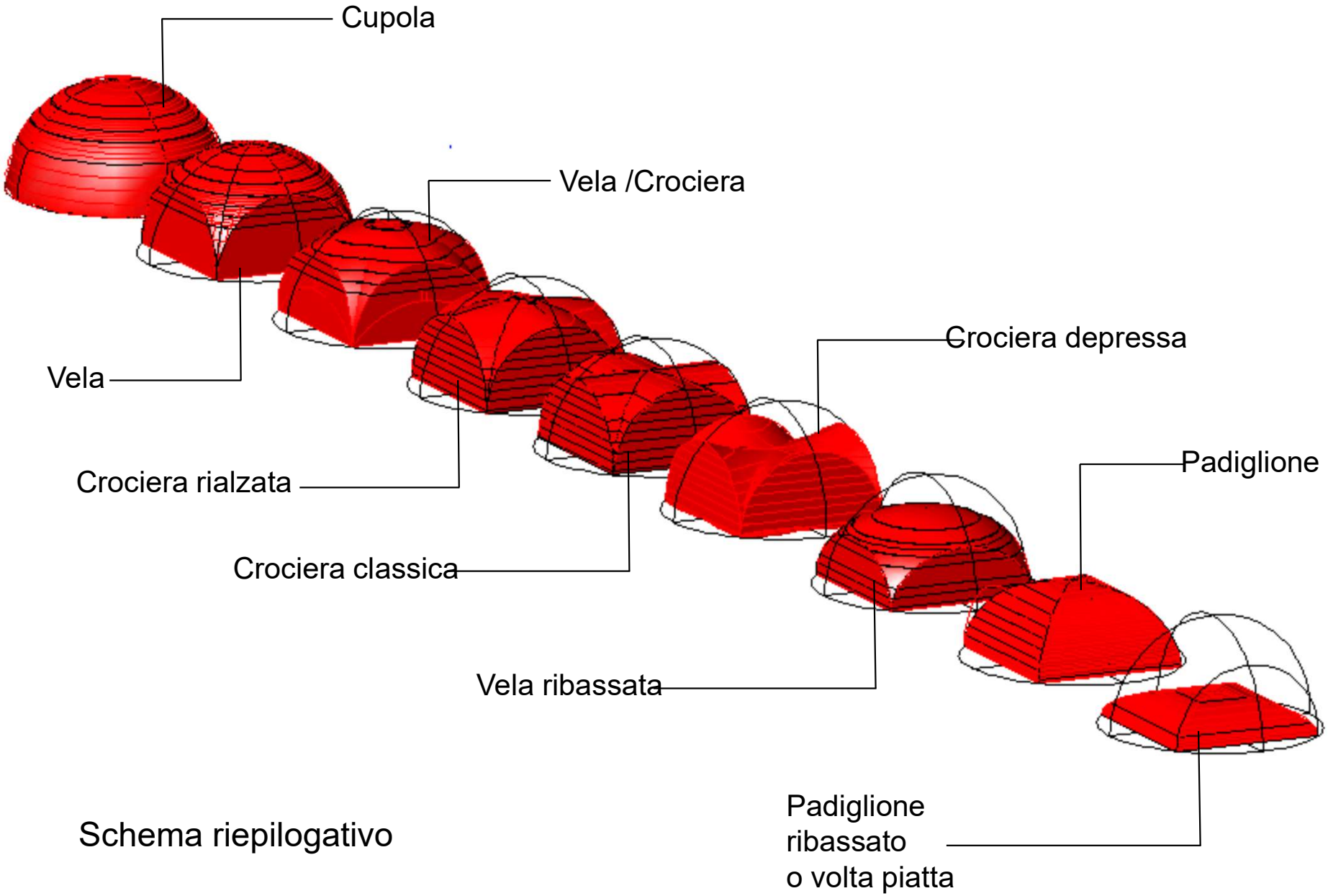
Caratteristiche geometriche e dimensionali di alcuni tipi di volte – I volumi strutturali si riferiscono a volte a tutto sesto impostate su ambienti a pianta quadrata con lato di ml 5



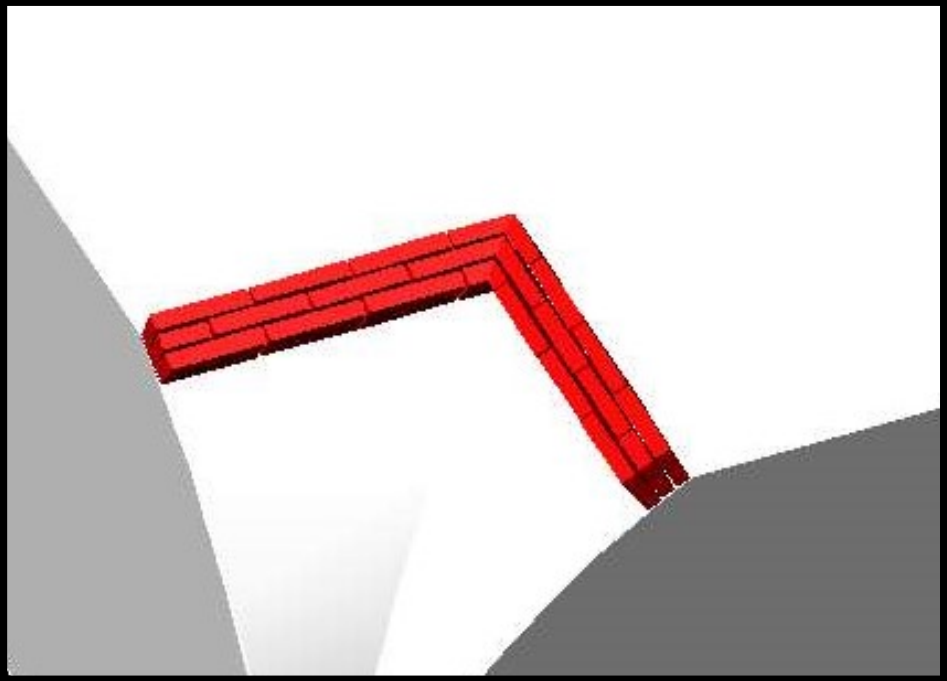
Unghia o lunetta
Vl=3,71mc

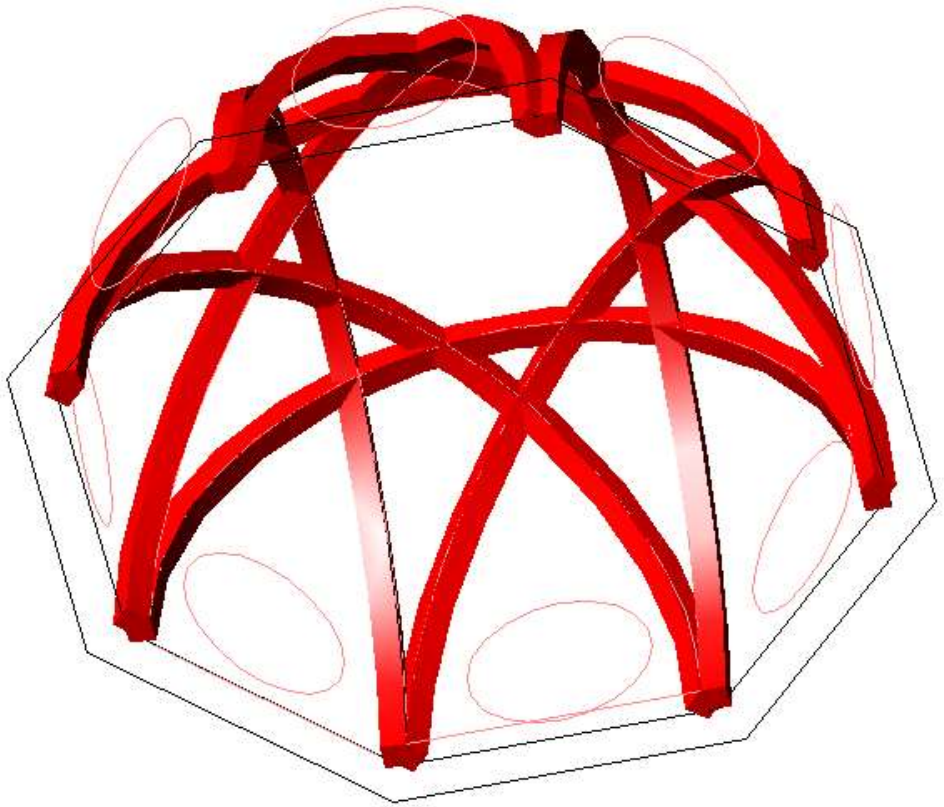
$$Vc = Vb-2Vl; \quad Vp = Vb+2Vl$$





Schema riepilogativo

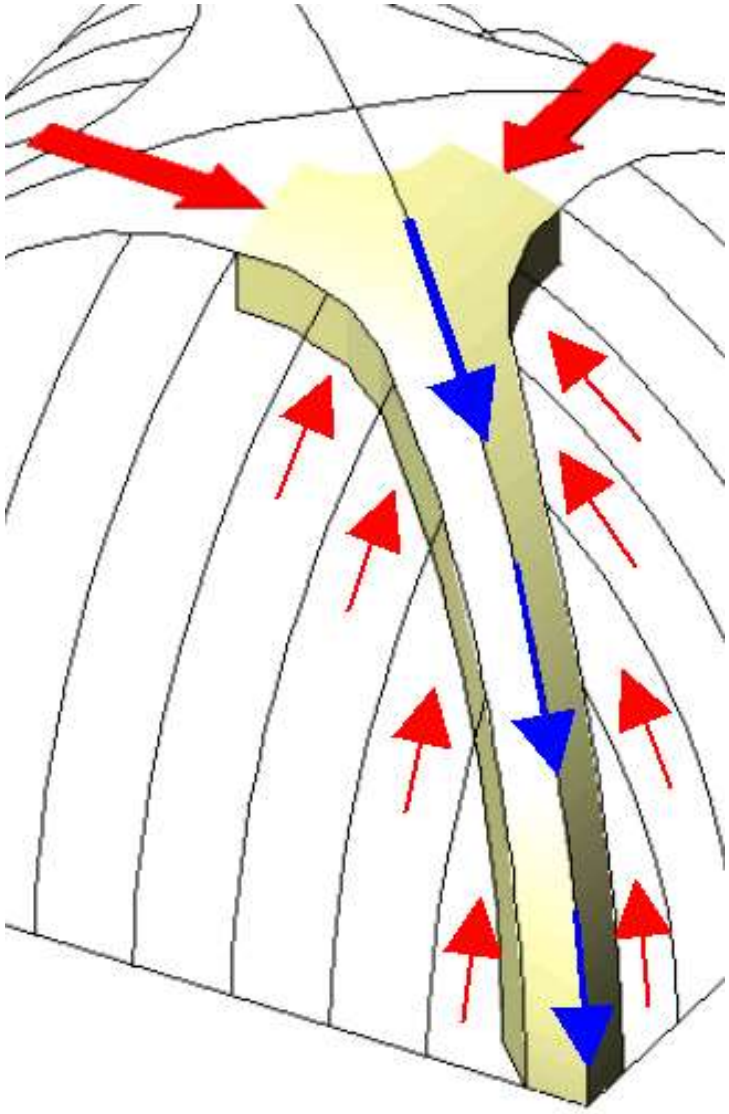


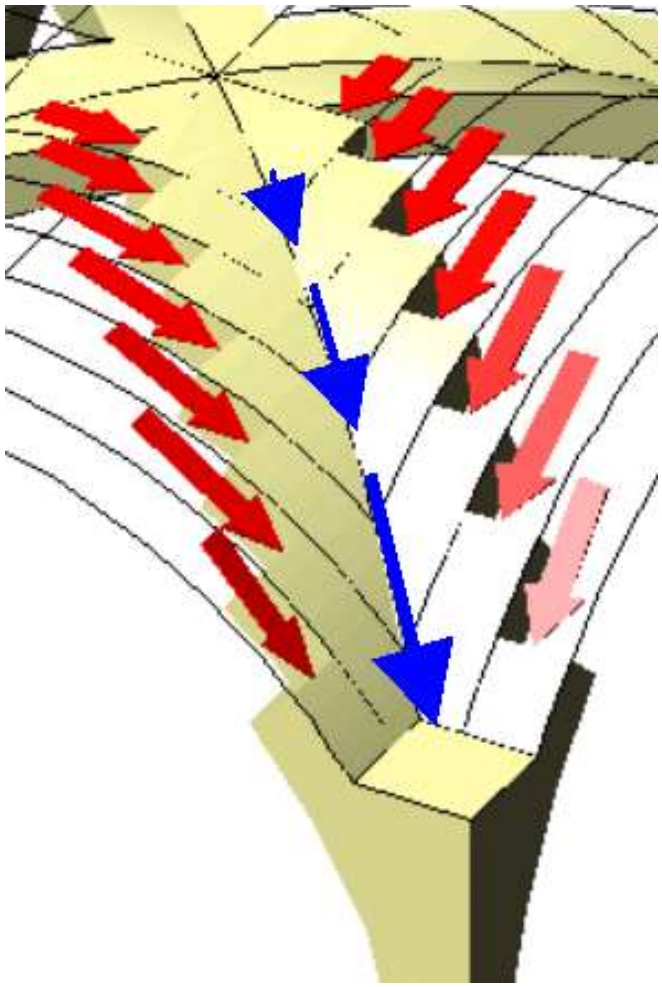


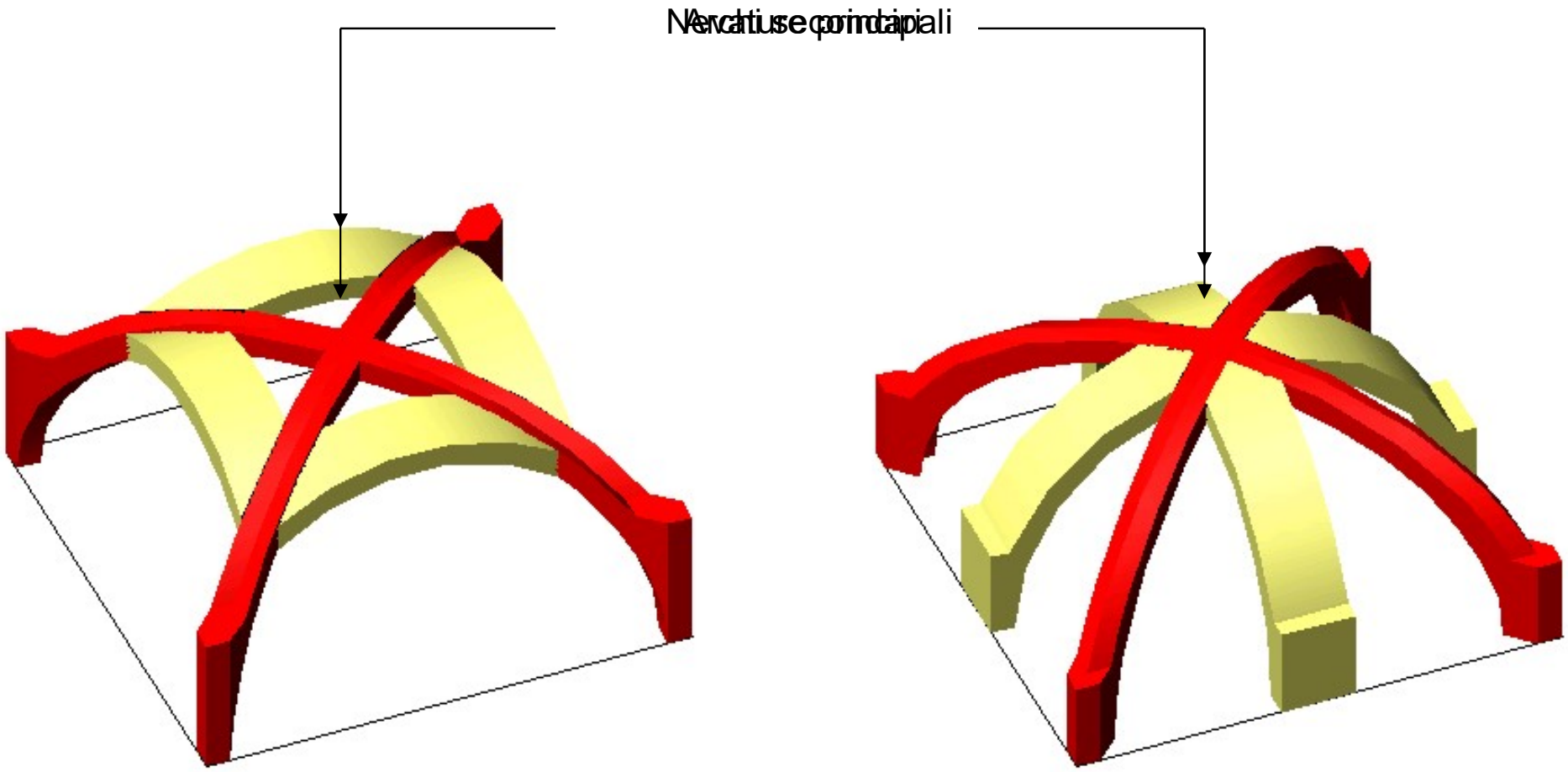
Schema strutturale



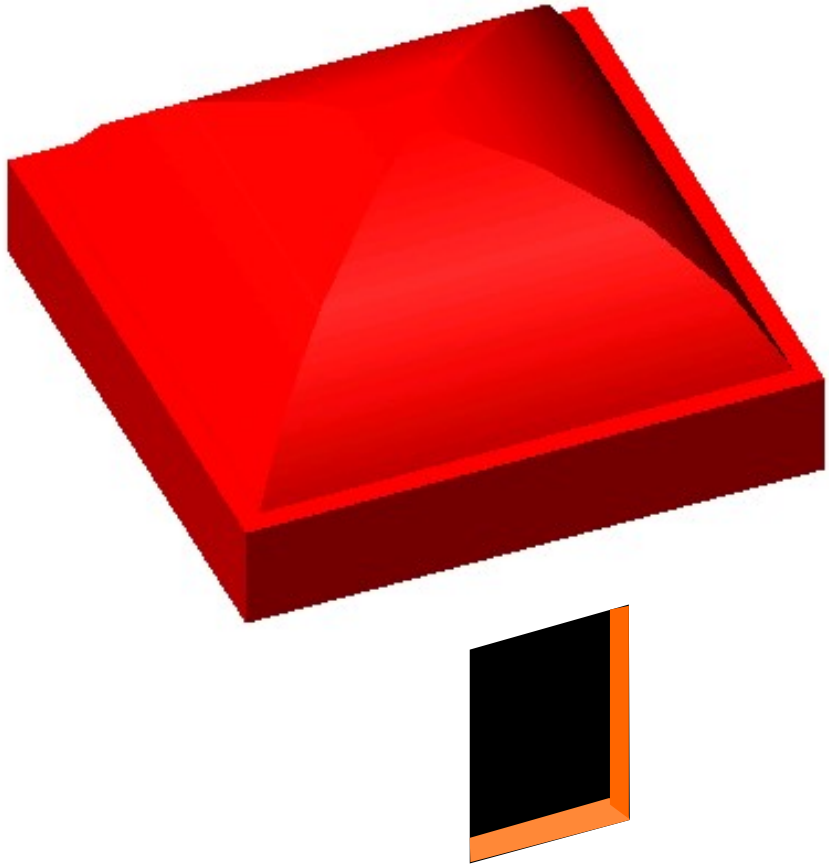
Torino, Cupola del Guarini nella chiesa di San Lorenzo

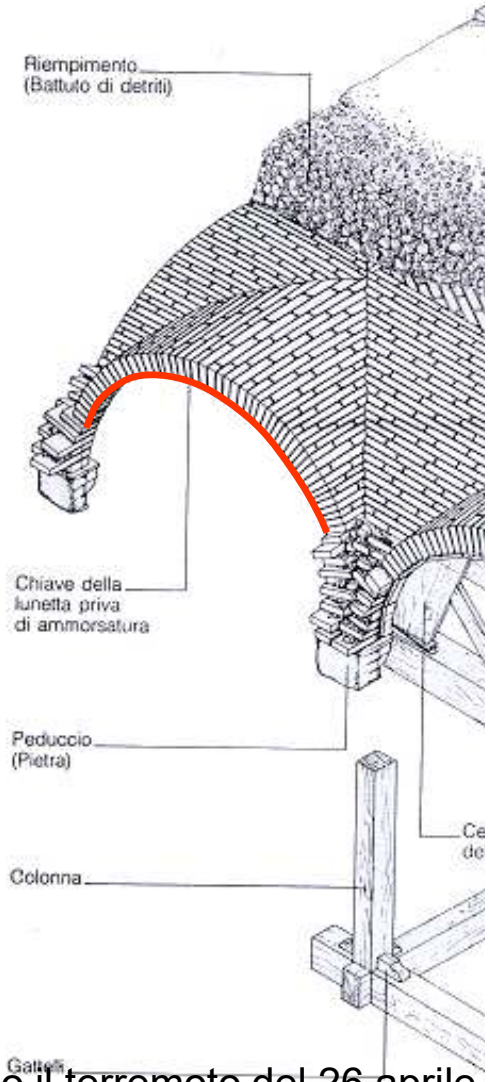





Nervature principali
Nervature principali



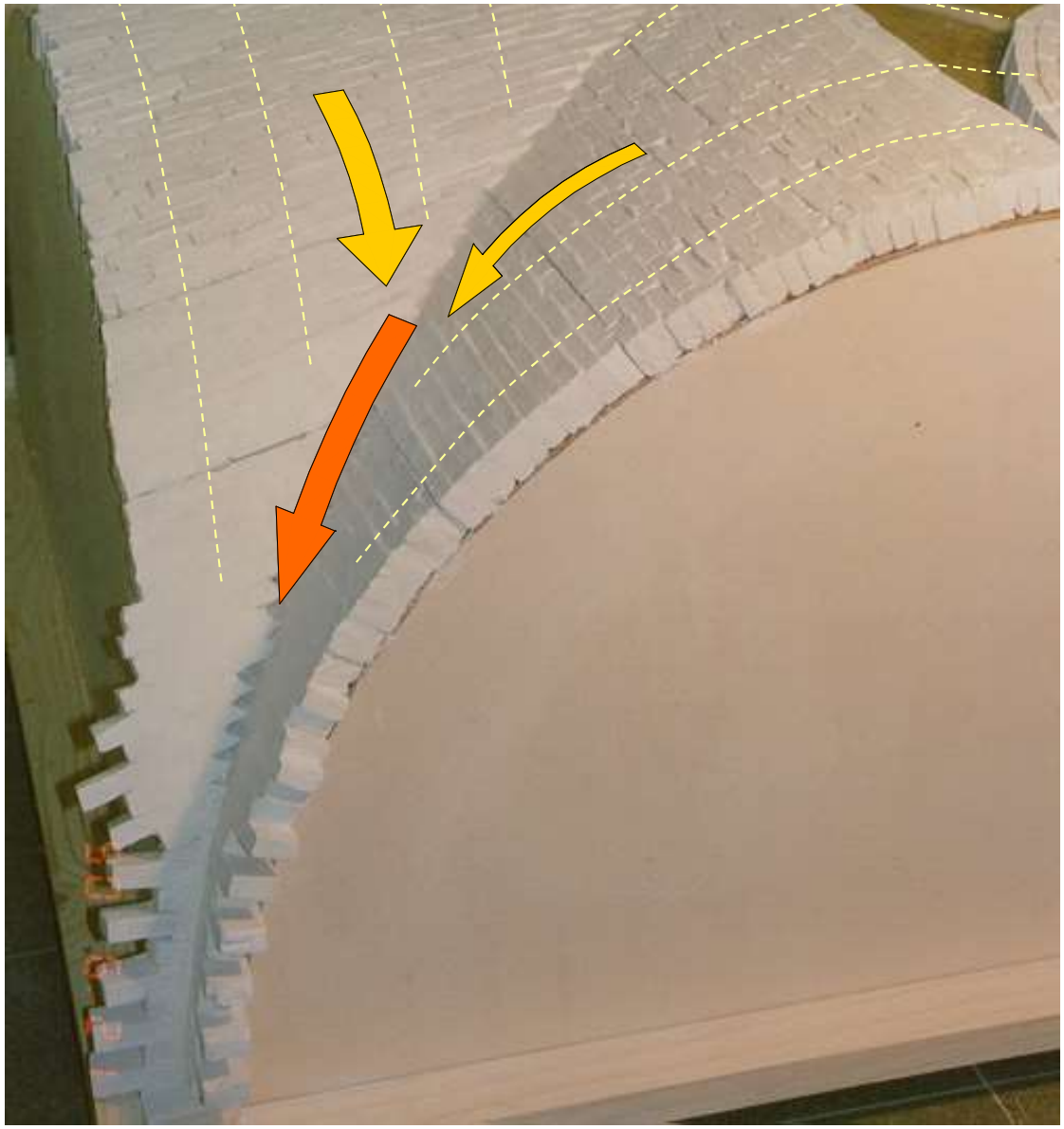




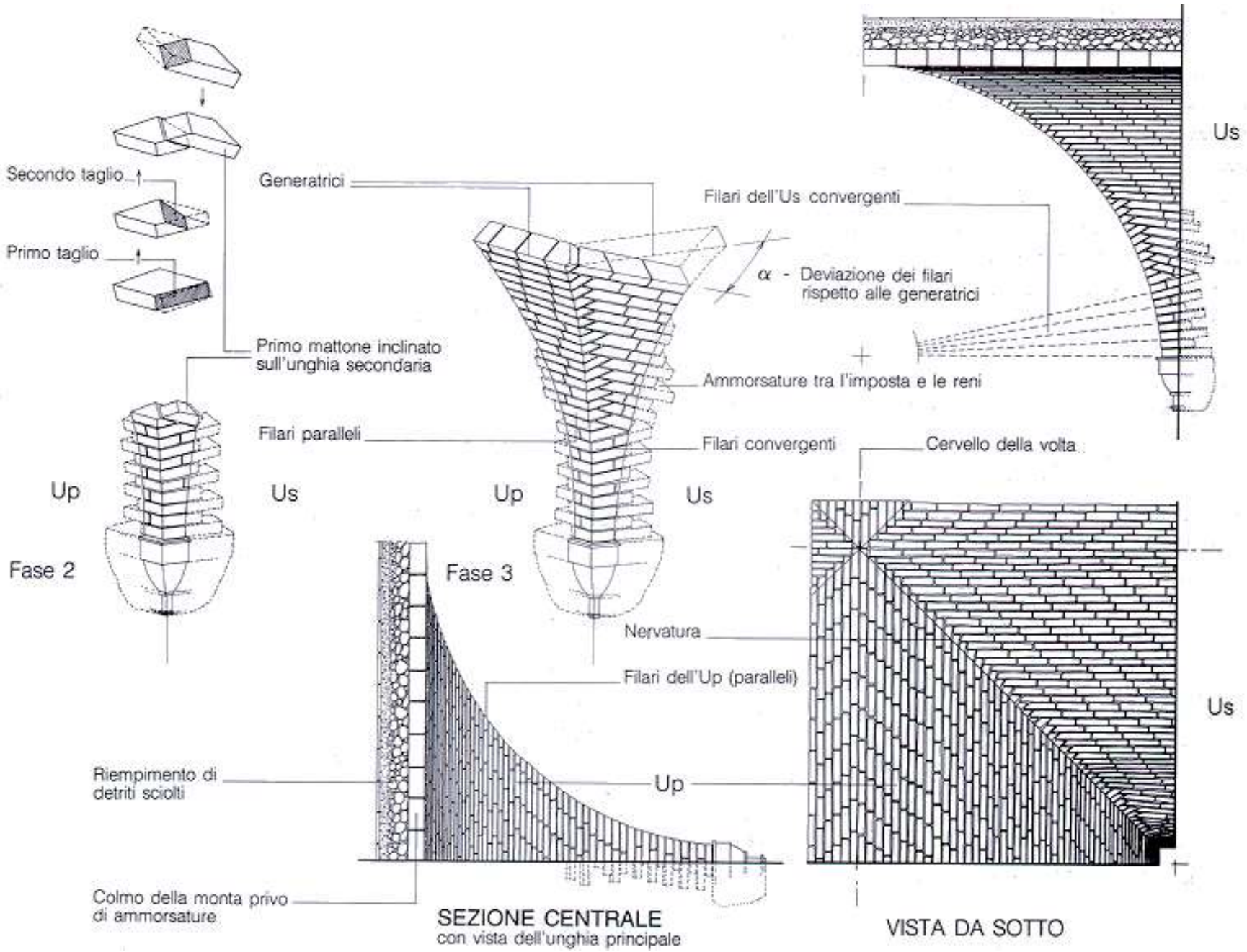


Citerna dopo il terremoto del 26 aprile 1917

Antichissima Chiesa di S. Giacomo

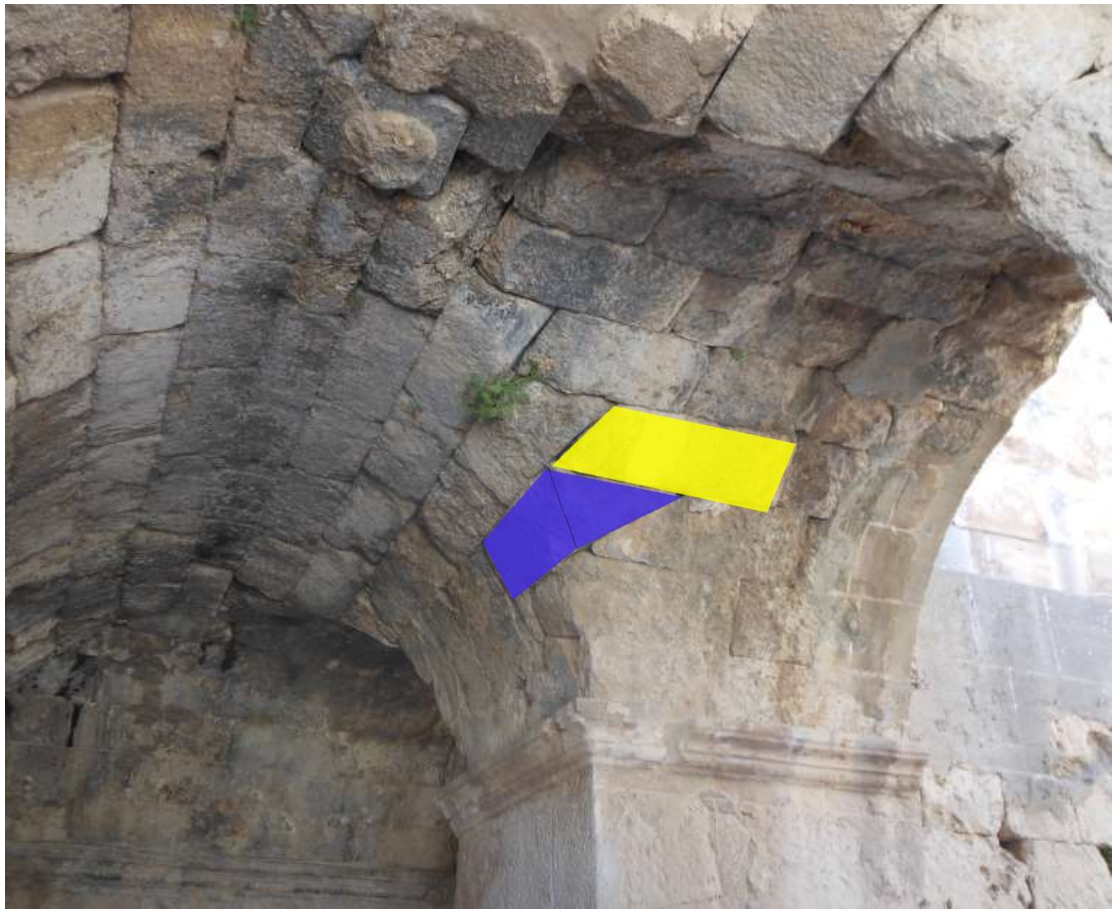


Tessitura longitudinale









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

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



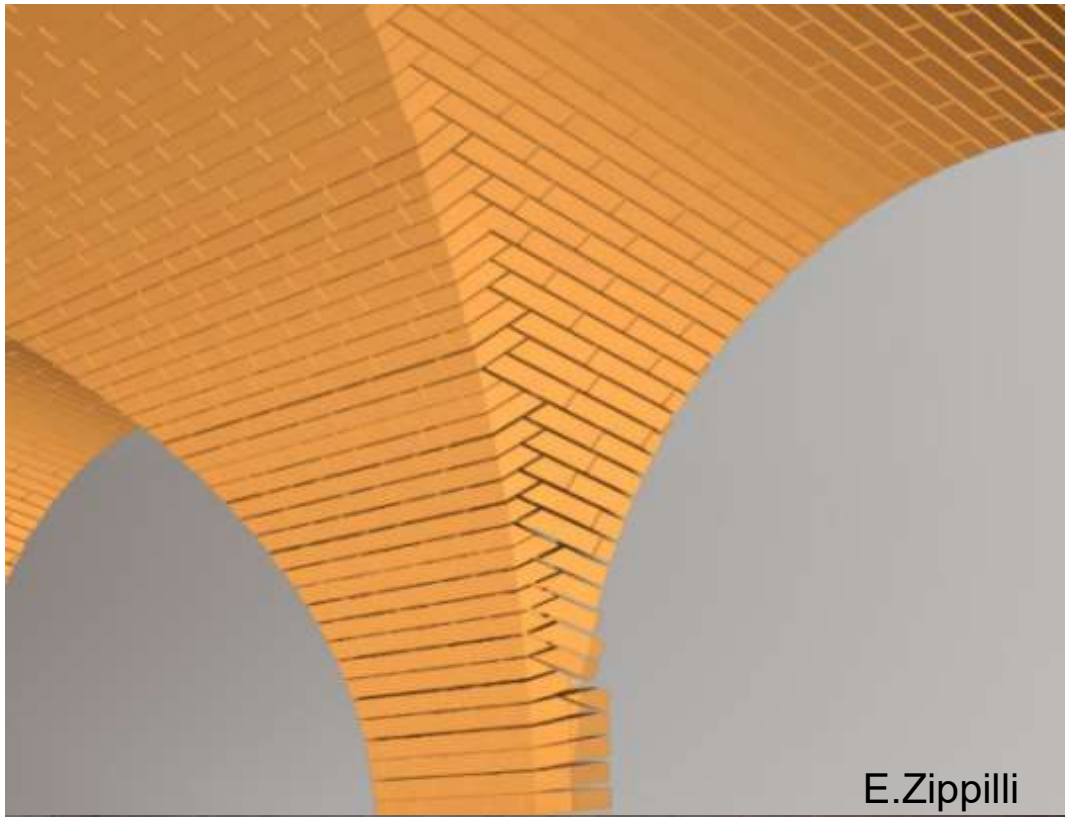






Prove per la disposizione dei mattoni lungo gli archi mediani e le nervature diagonali.





Intradosso della struttura subito dopo il disarmo.





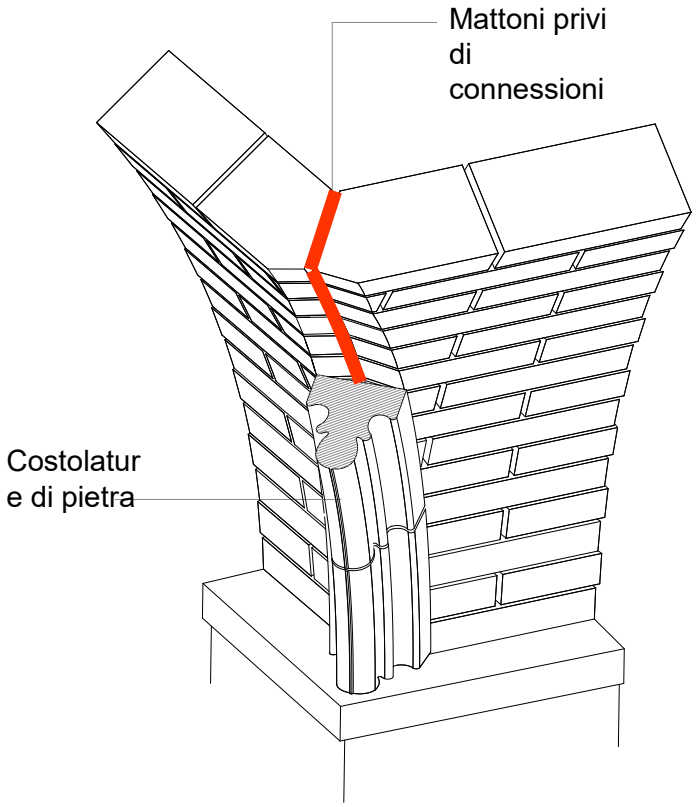
Esempio di volta laterizia a crociera con costolature.
Chiesa di San Galgano (Siena)
Copertura della navata laterale (Foto F. Massetti)



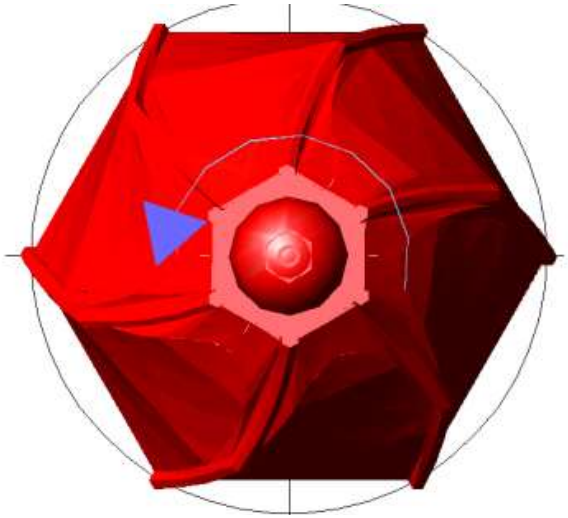
Esempio di volta a crociera lapidea con costolature.
Chiesa di San Galgano (Siena)
Copertura della navata laterale (Foto F. Massetti)



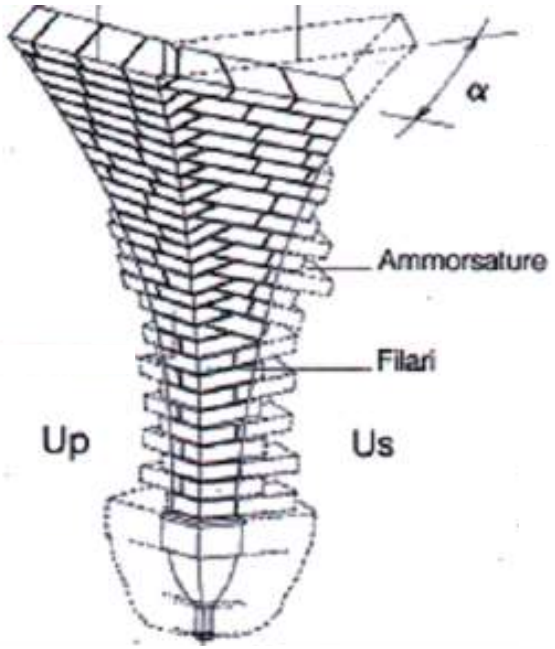
Costolature laterizie diagonali nelle volte laterizie a crociera della chiesa di San Galgano (Siena) – (Foto F.Massetti)



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







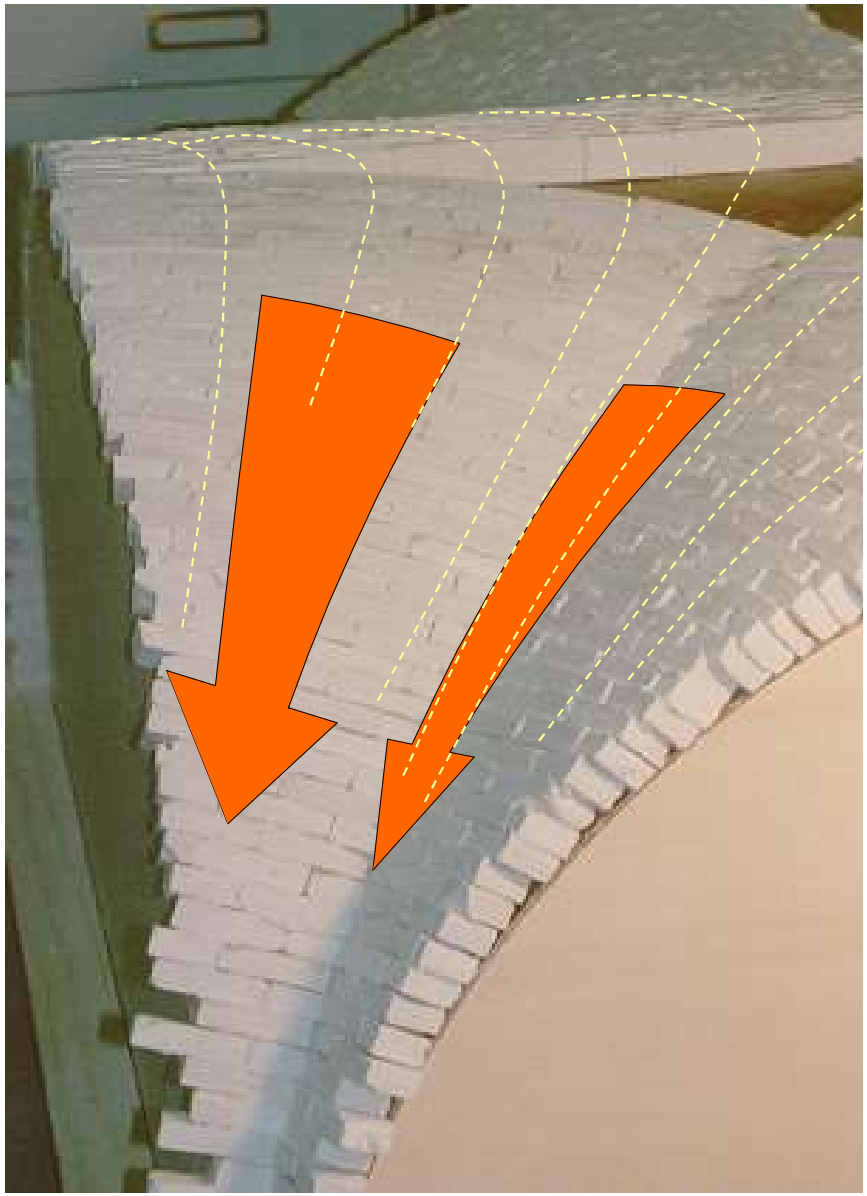
base esagonale con scorrimento delle nervature.

Tipo di nervatura con mattoni bene ingranati

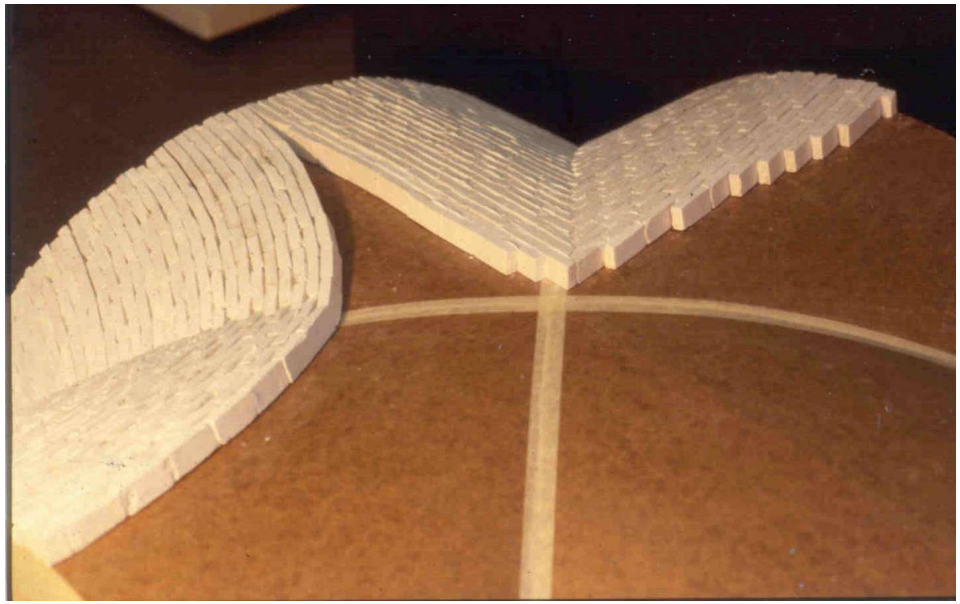
Volta laterizia di mattoni a coltello con tessitura diagonale



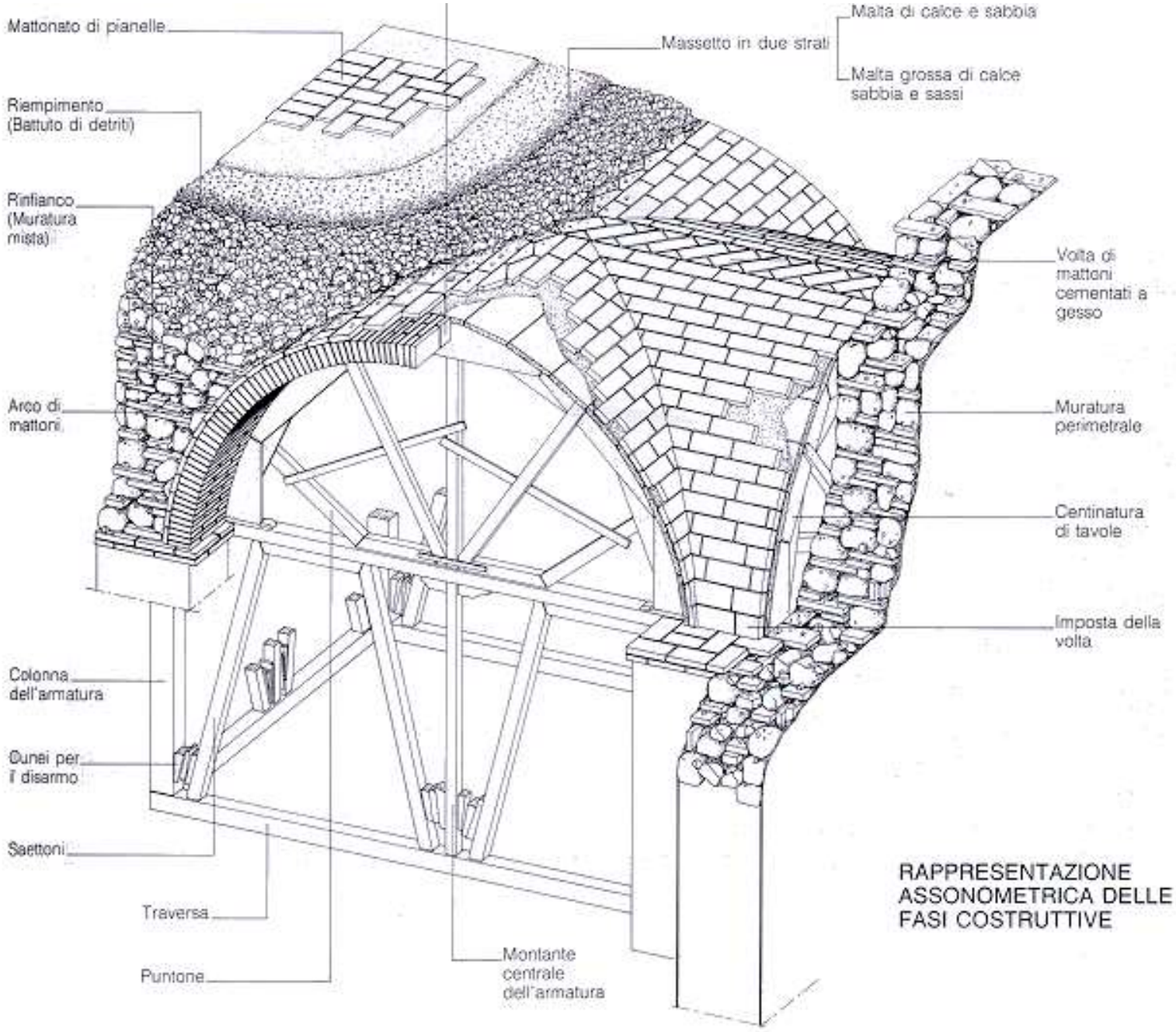
Posa “schianciana” (A. Giuffrè)



Diffusione delle tensioni nelle volte
a tessitura diagonale

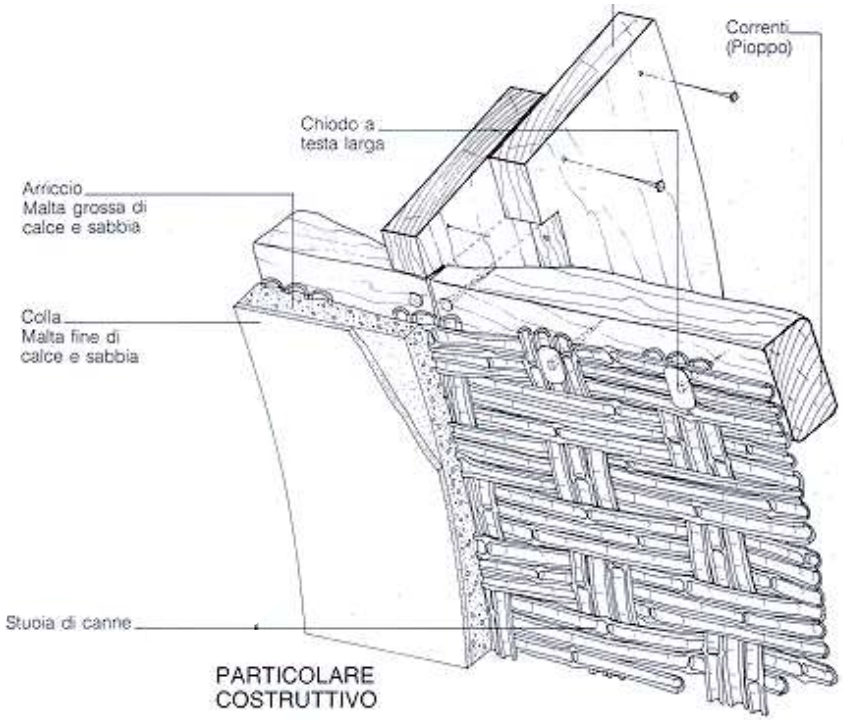


Tessiture a confronto

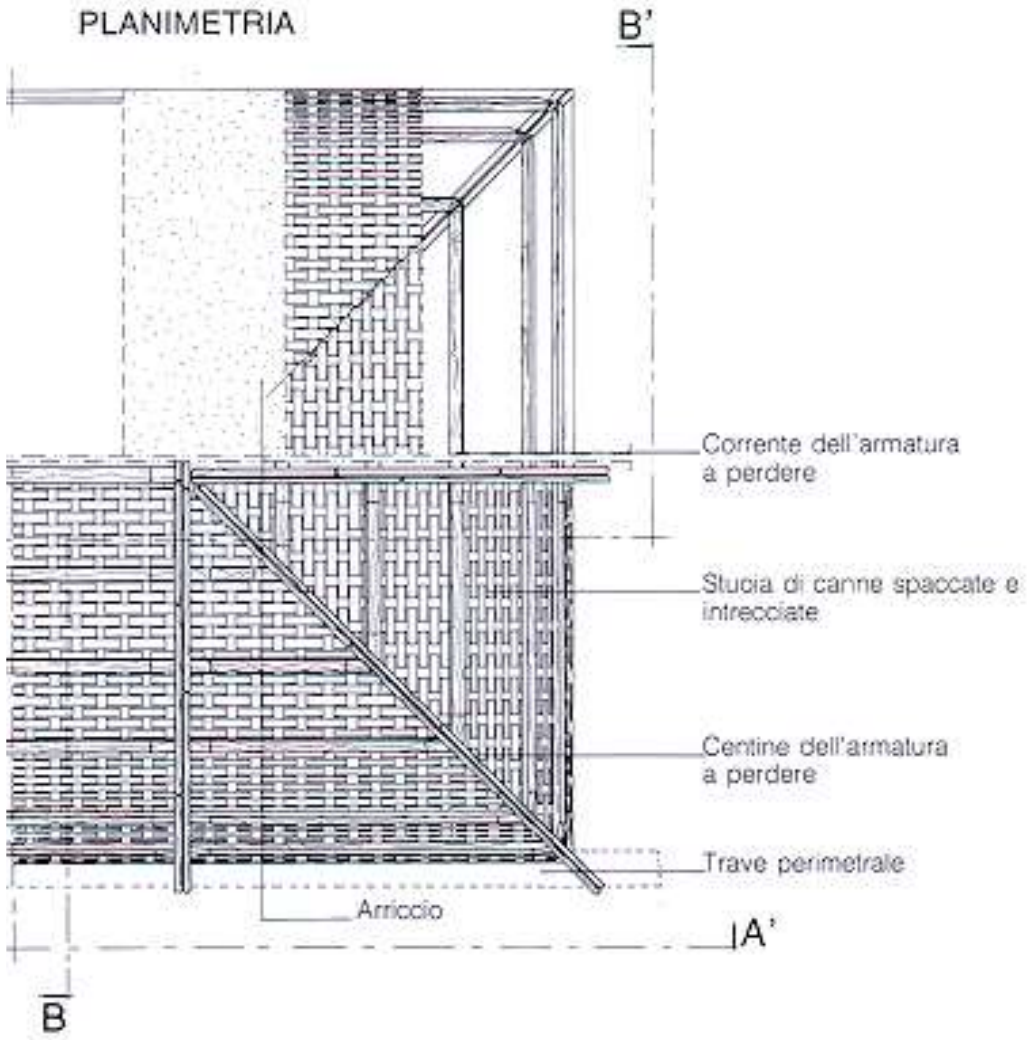


RAPPRESENTAZIONE ASSONOMETRICA DELLE FASI COSTRUTTIVE

Falsa volta in camera-canna



PARTICOLARE
COSTRUTTIVO

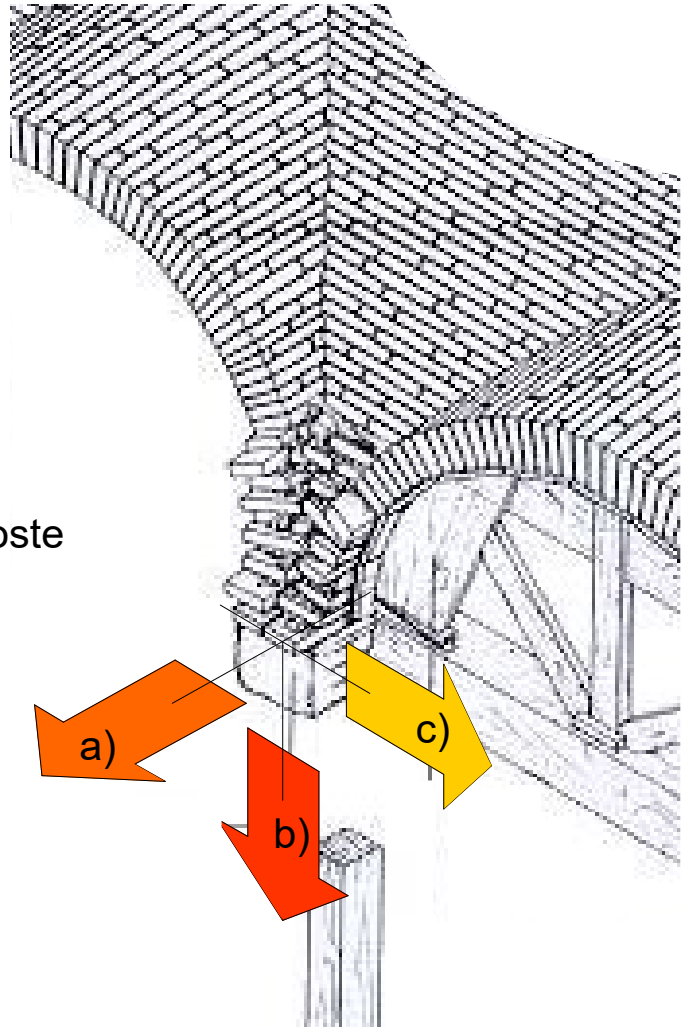


Componenti di spostamento relativo delle imposte

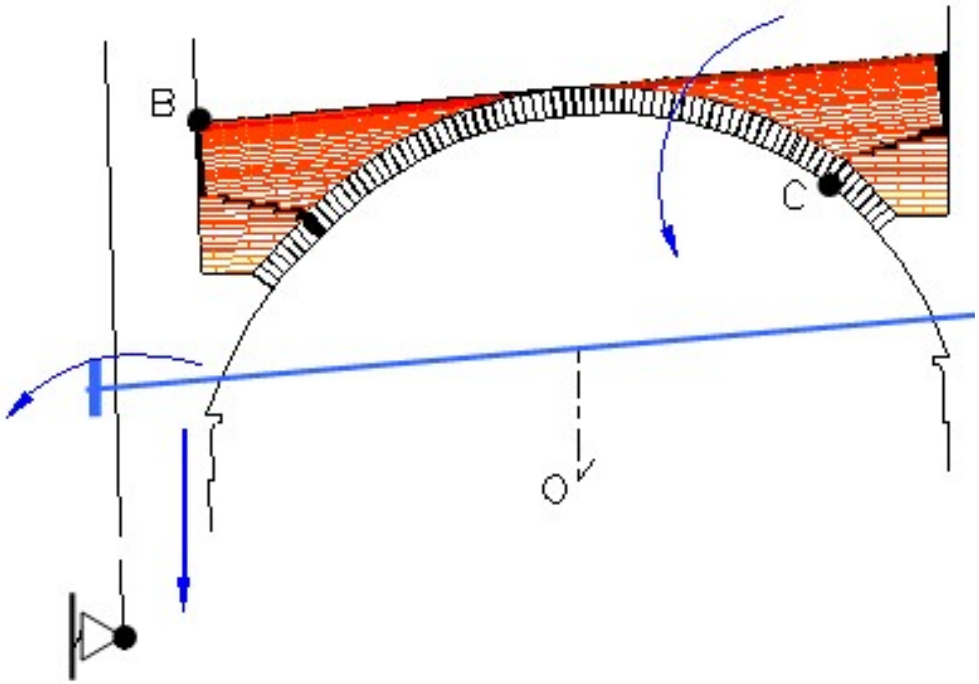
a) Allontanamento delle imposte

b) Cedimento differenziato

c) Scorrimento

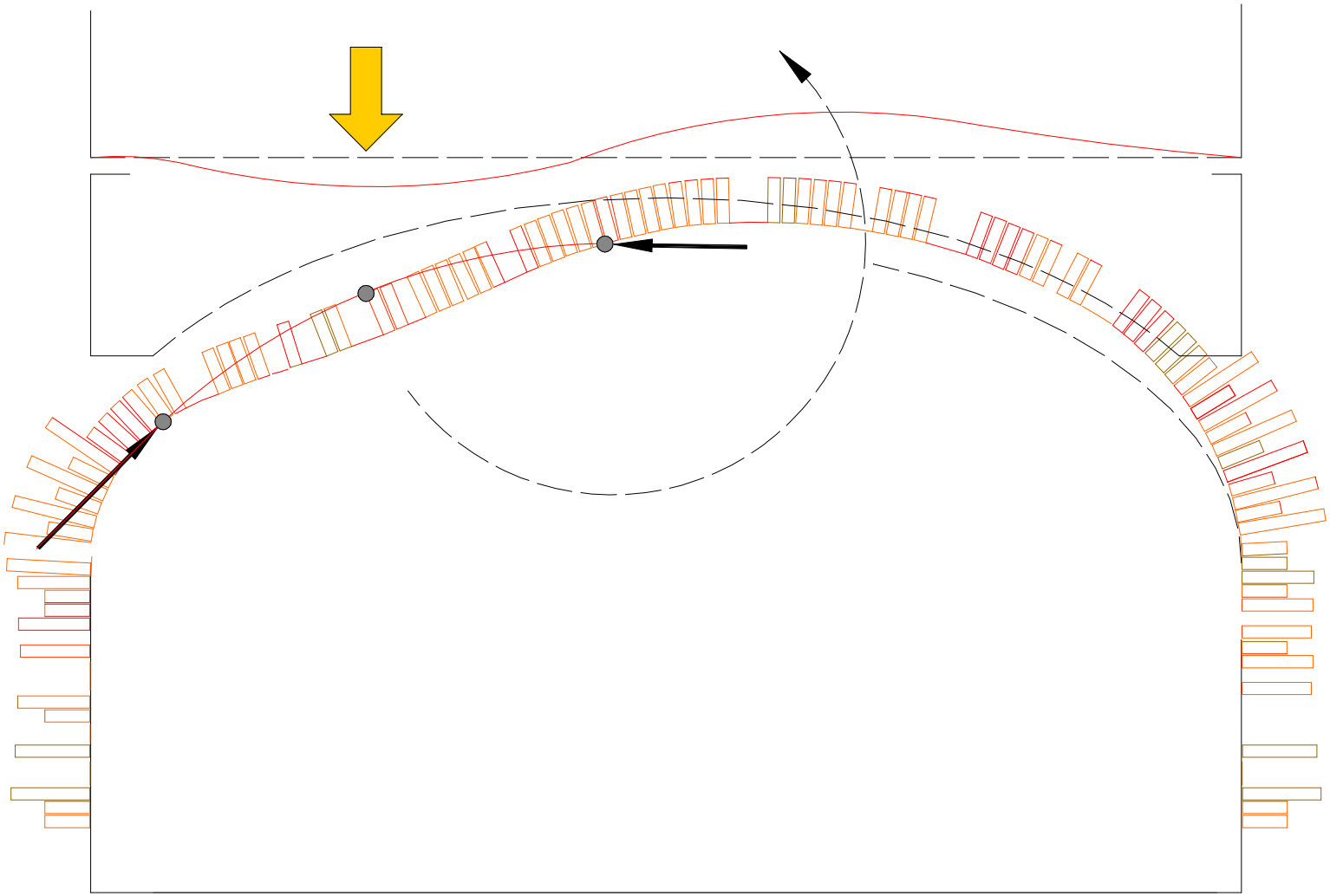




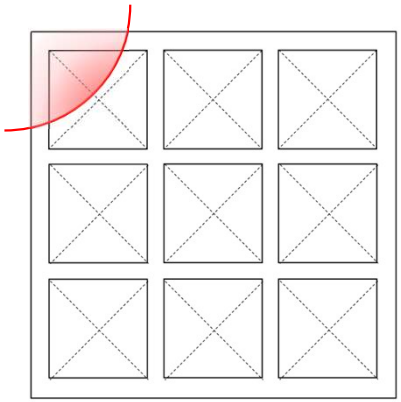


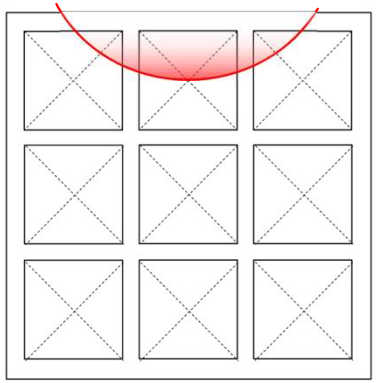


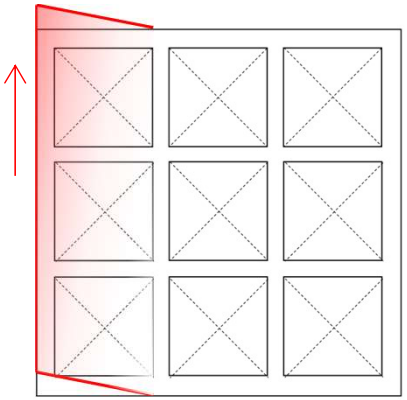
Quadro fessurativo di volte laterizie a crociera dovute a cedimento differenziato

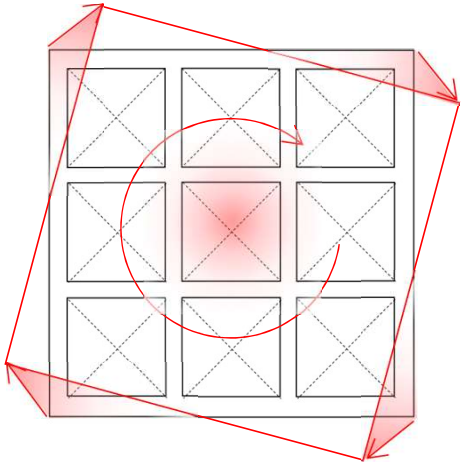


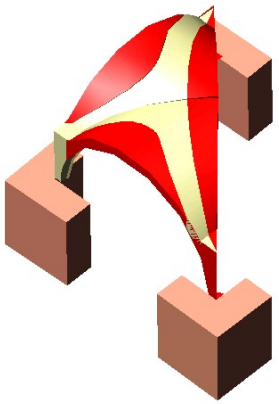
Meccanismo di danno per
instabilità del campo centrale





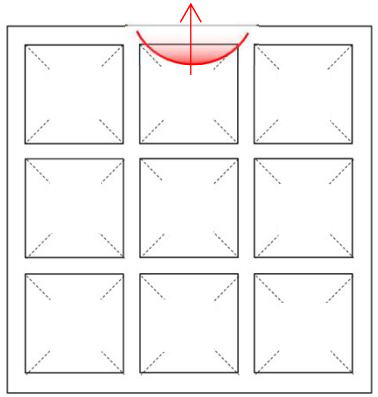




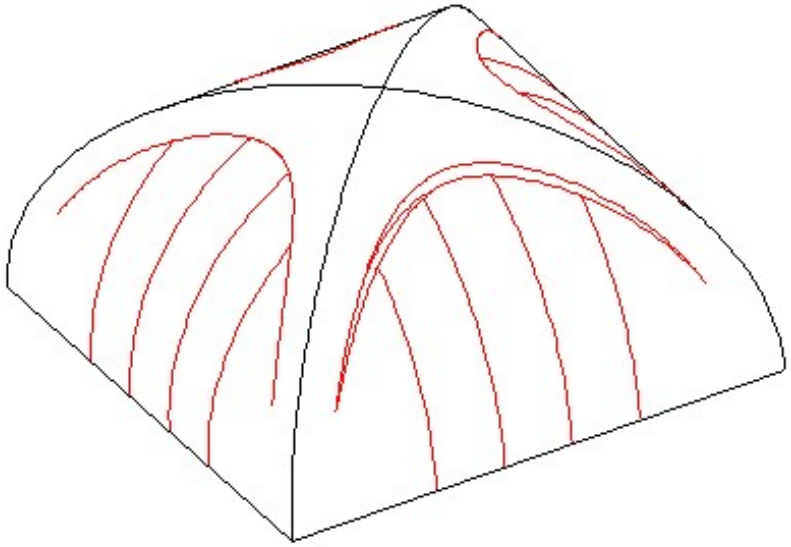


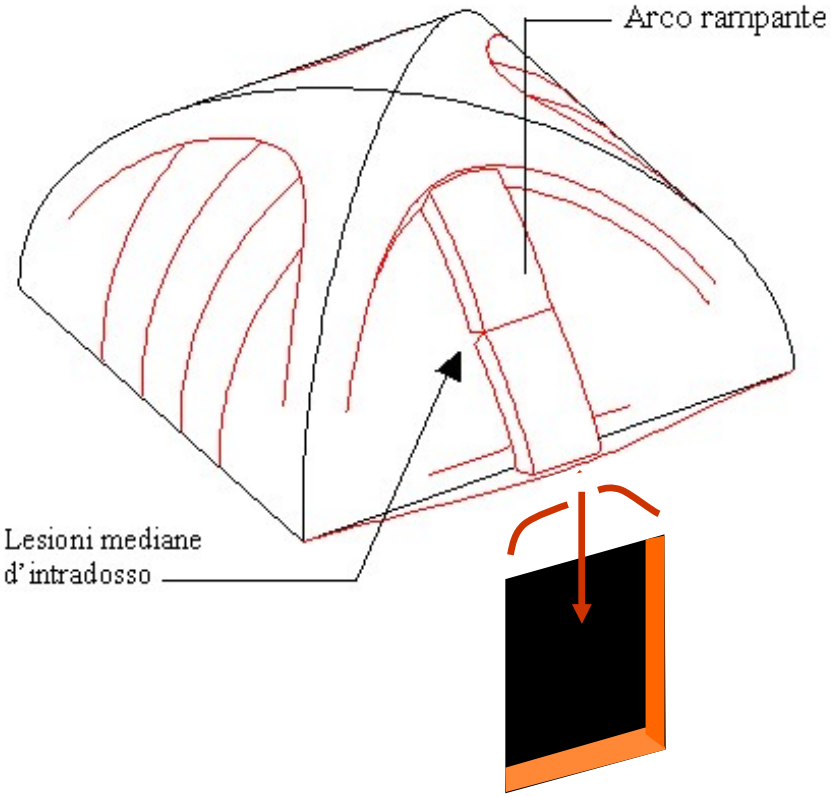
Schema d’impianto con volte a crociera

Tipo di danno in funzione della geometria strutturale e della posizione

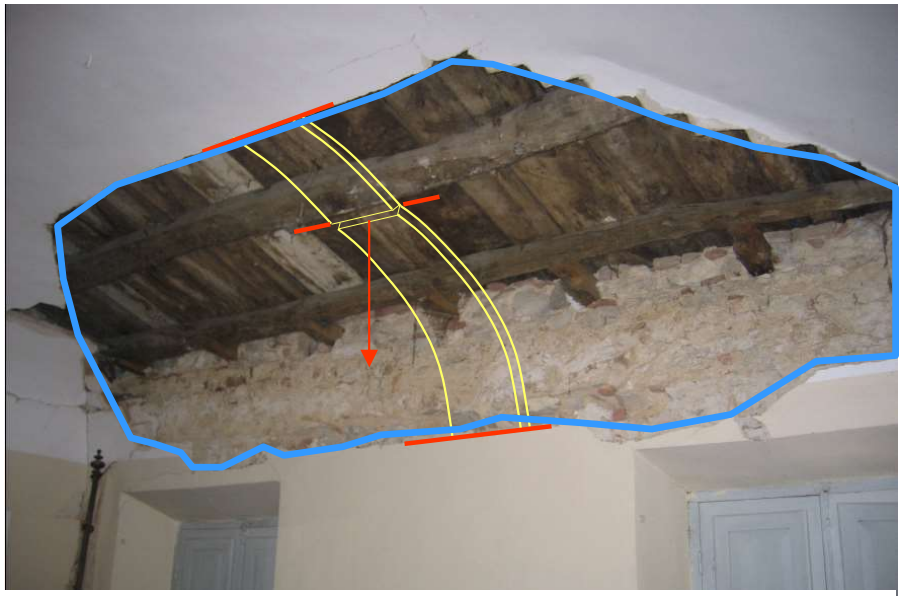


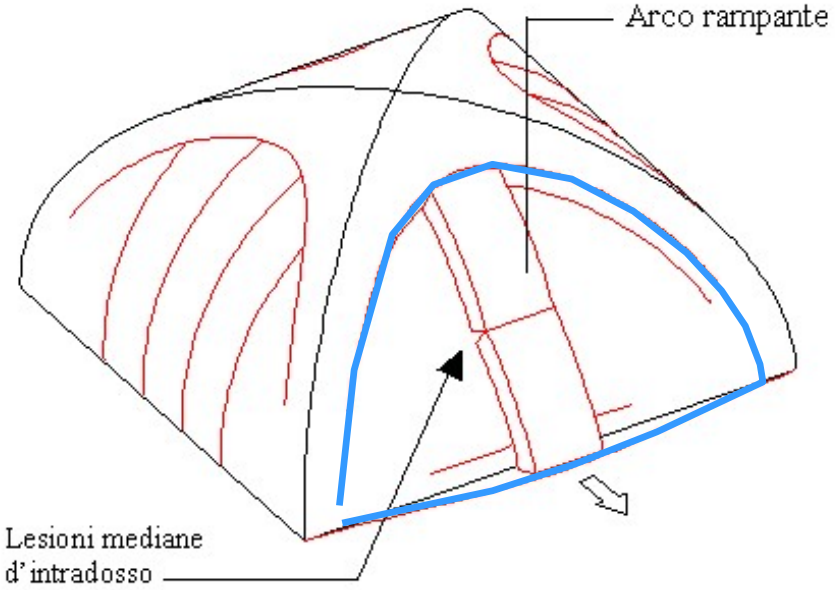
Volte a padiglione





Tipologie di dissesto: volte a a Padiglione



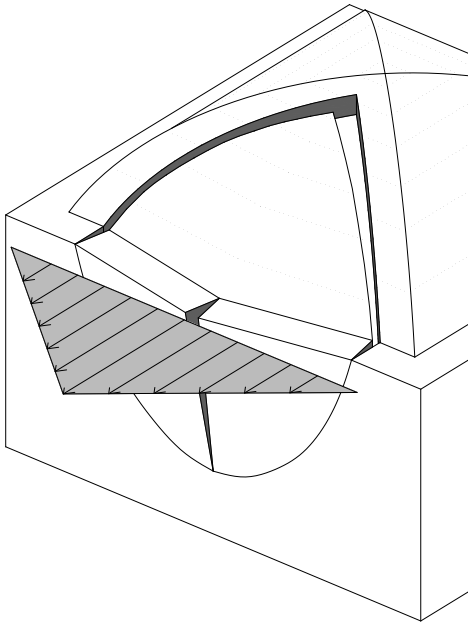


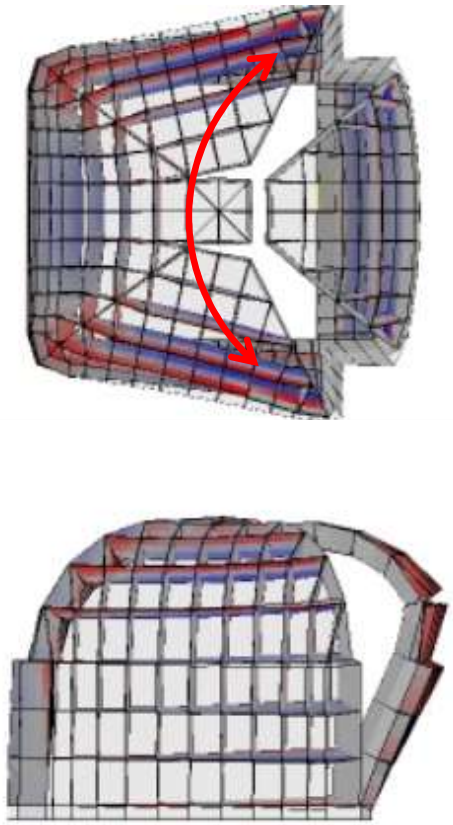
Tipologie di dissesto: volte a a Padiglione

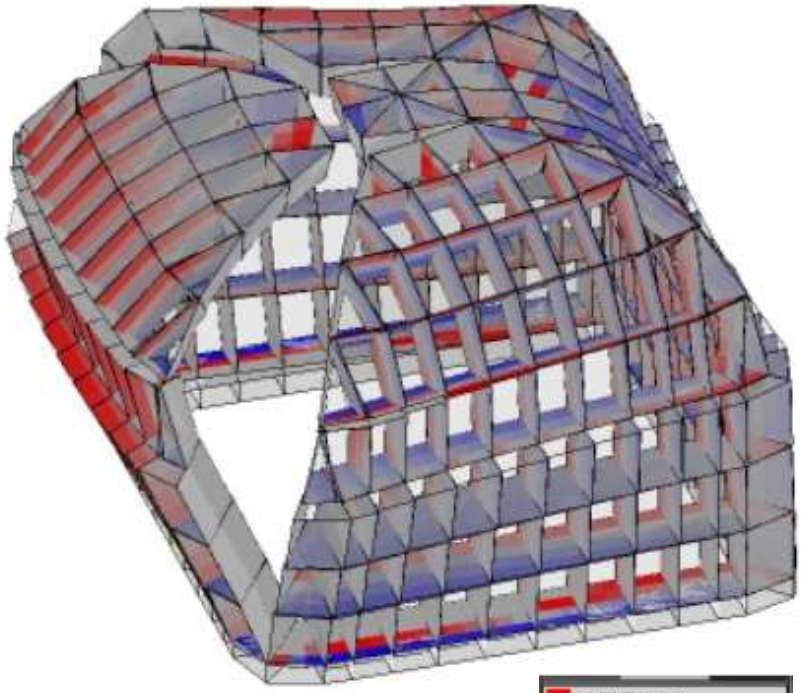


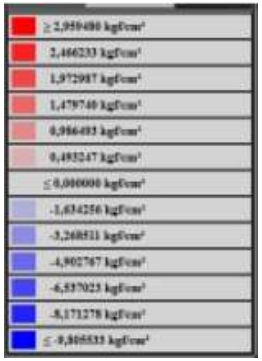
Foto: A. Borri

Cellule murarie con coperture spingenti









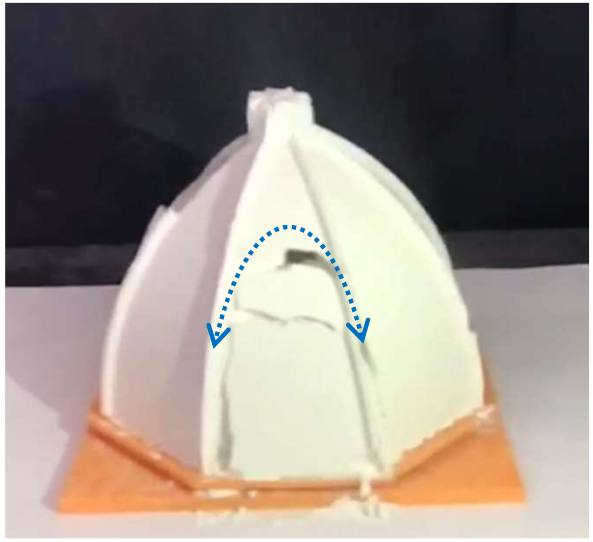
Meccanismo di rottura a flessione fuori del piano amplificato dalla spinta centrale del padiglione

HiStrA - Archi e Volte

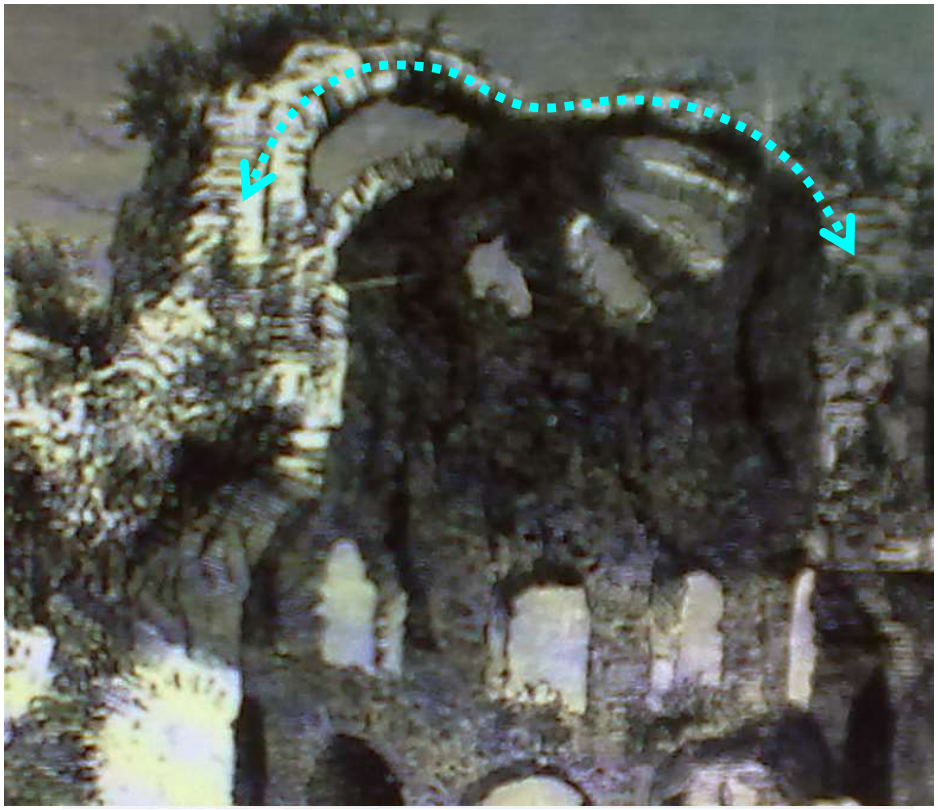
HISTORICAL STRUCTURES ANALYSIS

Software di modellazione e analisi non lineare

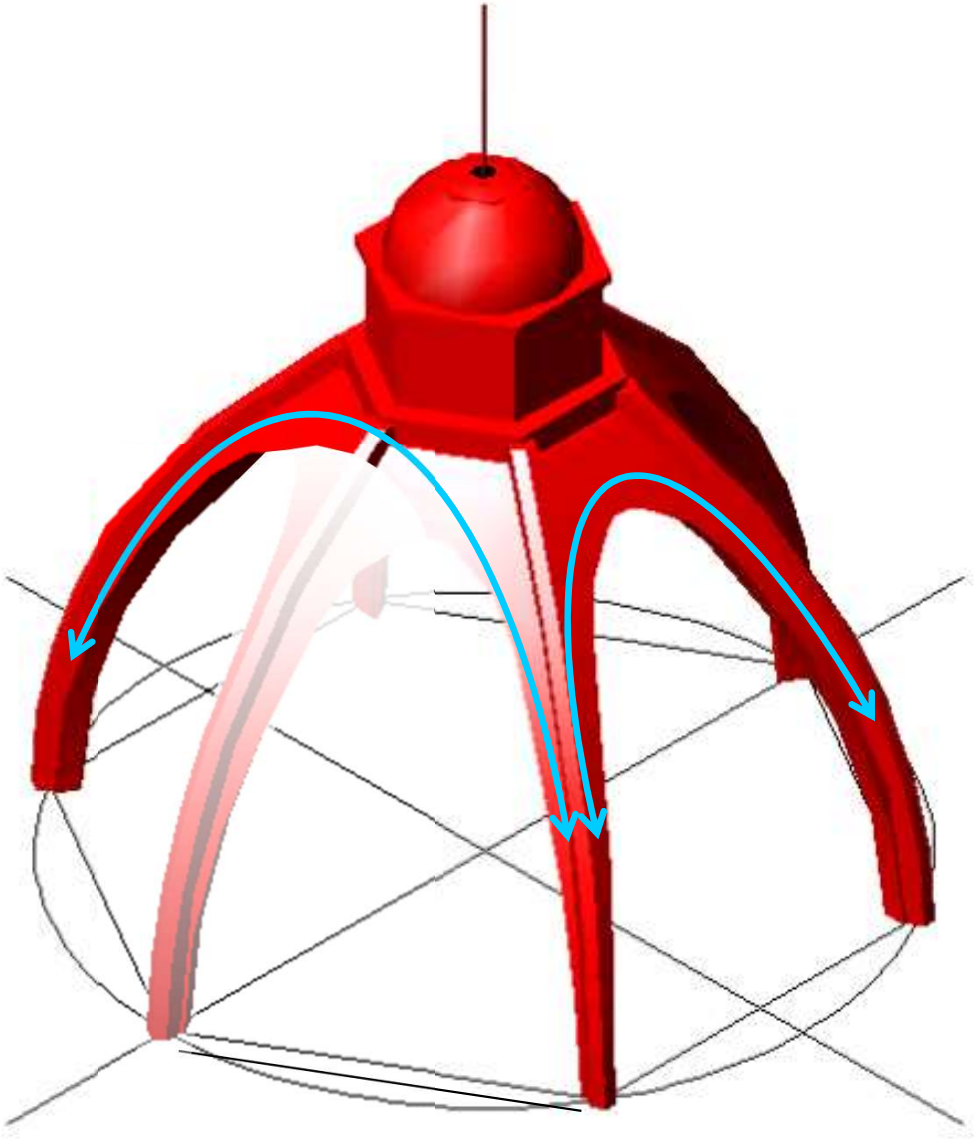
Gruppo Sismica (Catania)

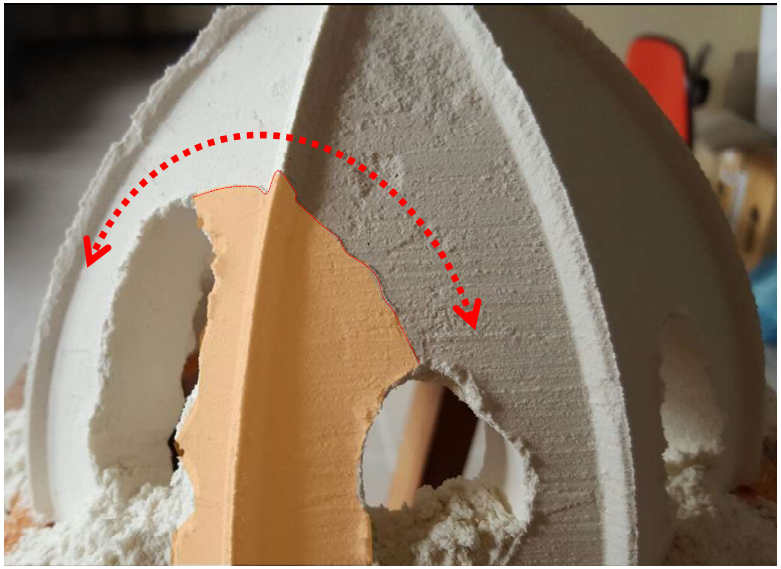


Comportamento statico delle cupole a base poligonale



Roma: Tempio di Minerva Medica
(Foto: Fulvio Cairoli Giuliani)



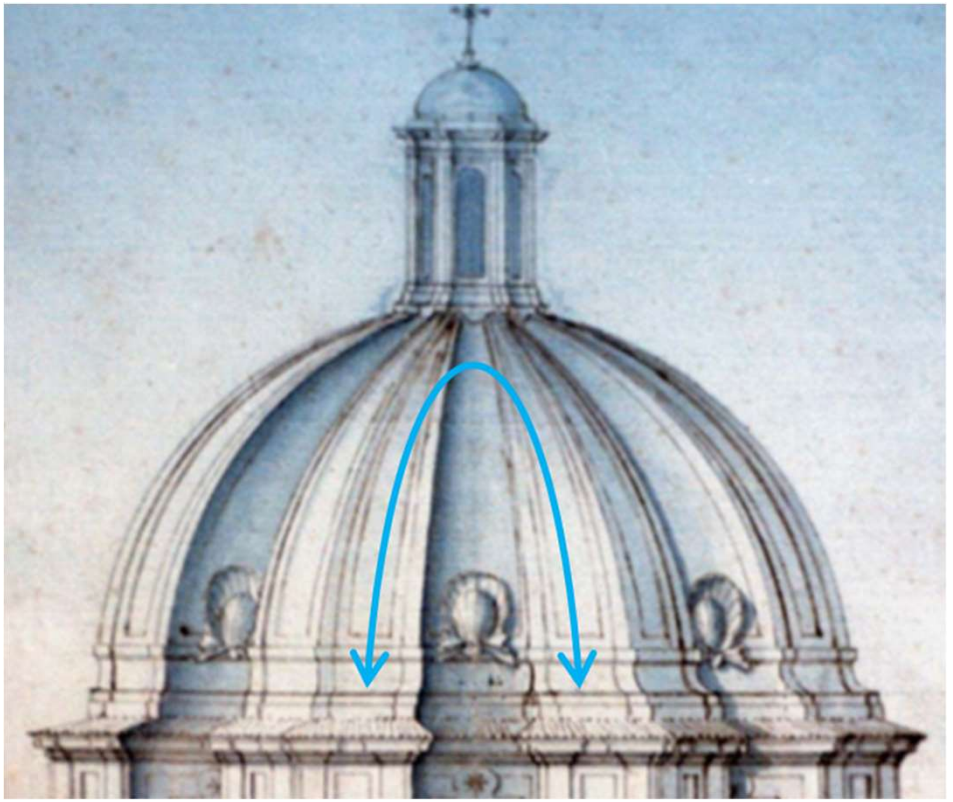




Prove sperimentali su cupole di farina

Comportamento statico delle cupole a base poligonale





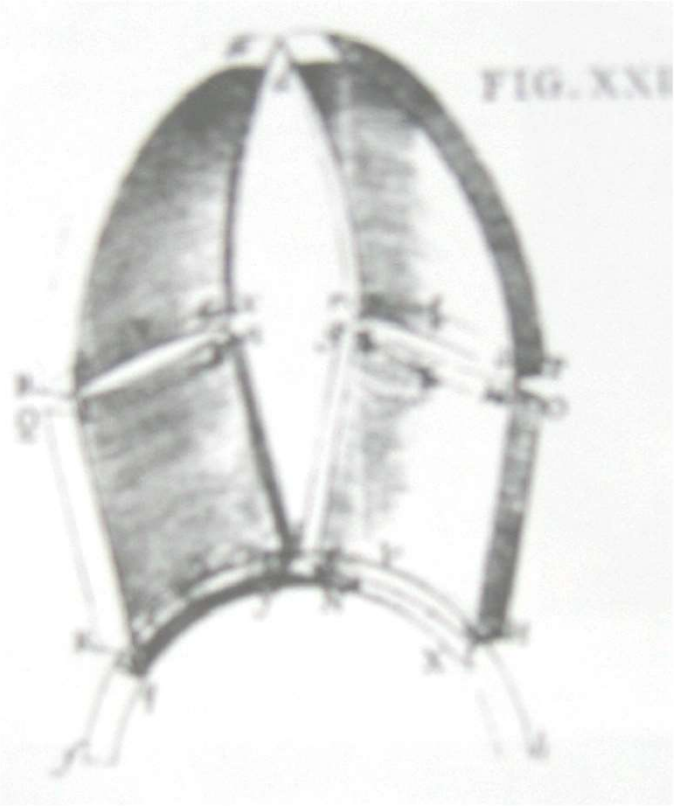
Cupola della Basilica di S. Margherita a Montefiascone (C. Fontana, 1674).

Maria Agostiano - Bollettino d'Arte del MIBACT, 2013

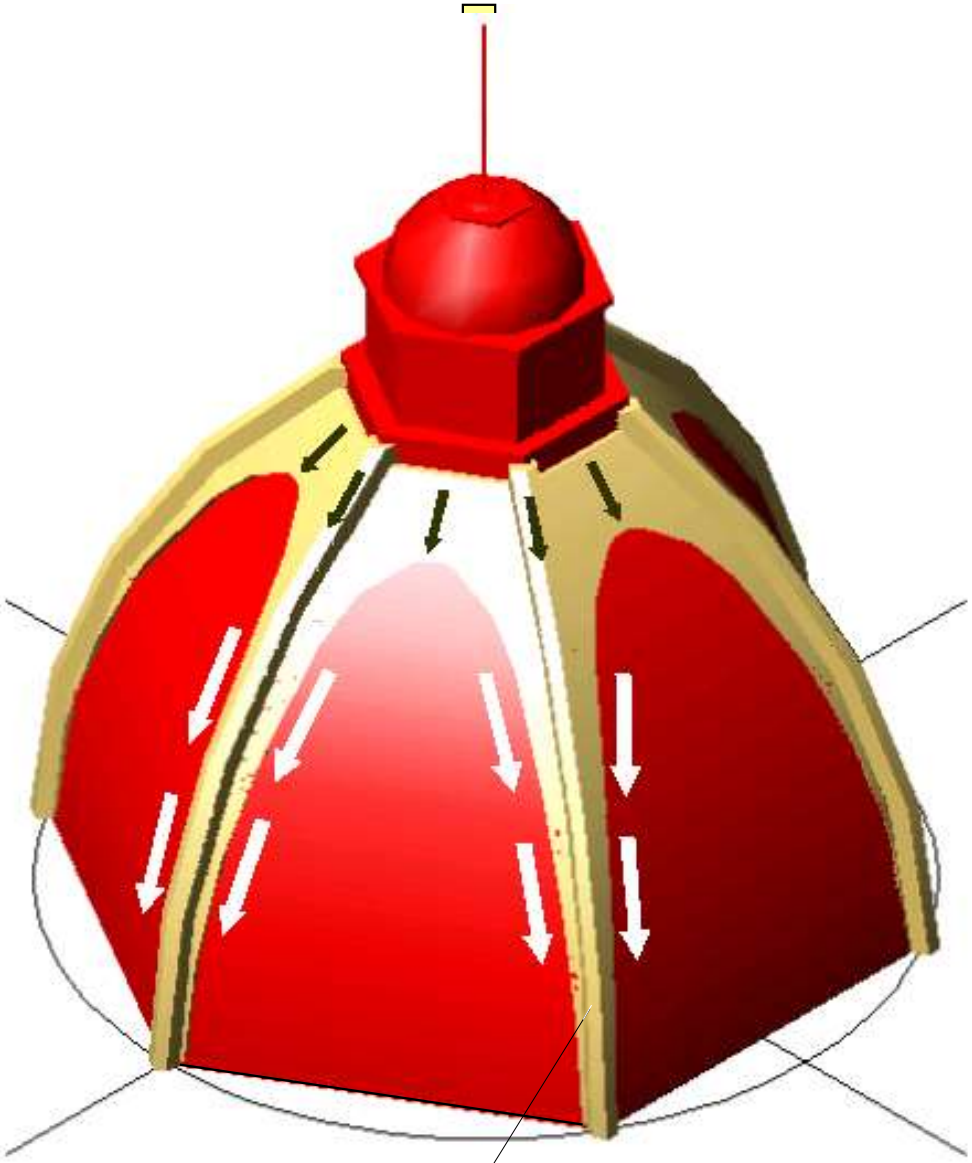


Nuestra Senora Reina del Los Angeles – Città del Messico

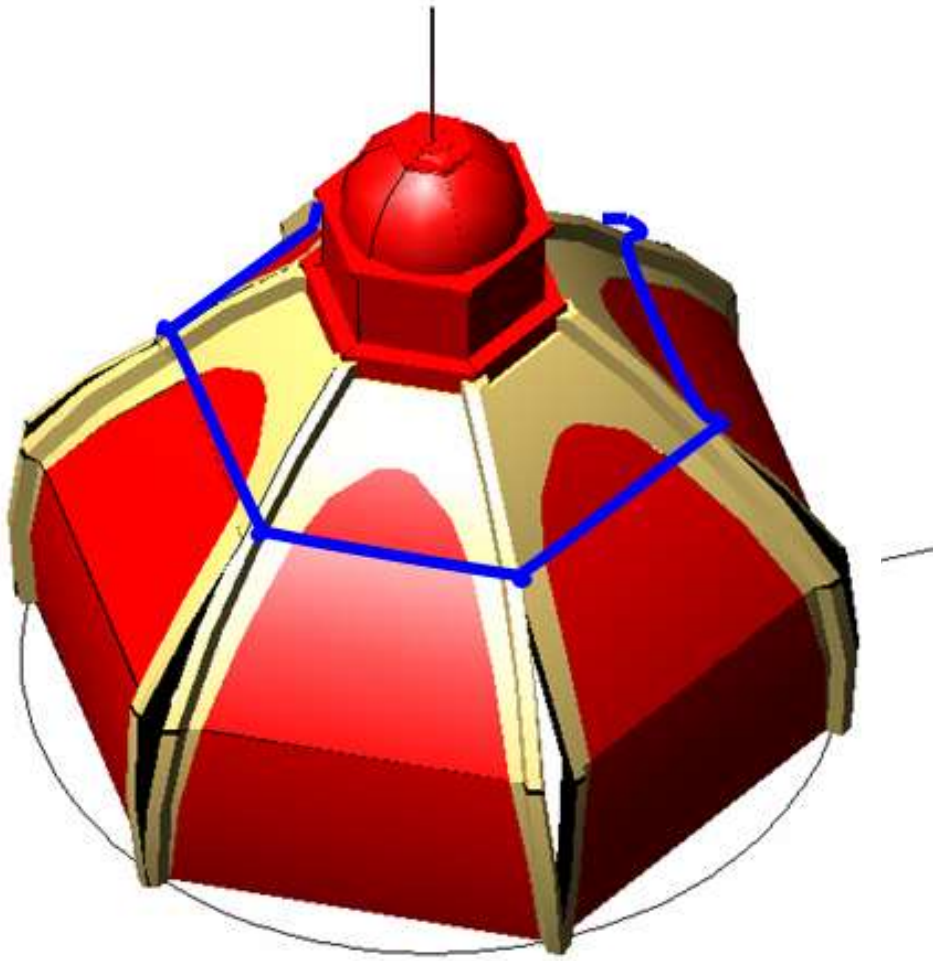
Comportamento statico delle cupole a base poligonale



Giovanni Poleni,
Studi per la cupola di S. Pietro - XVIII sec.

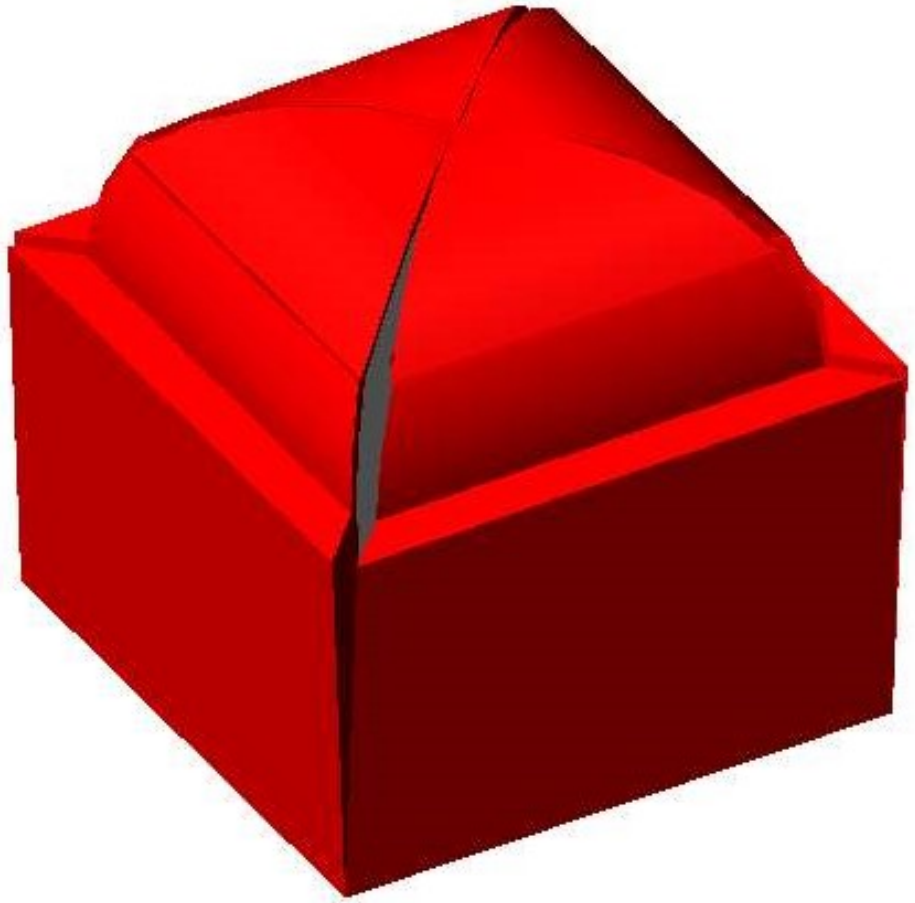


Filo esterno della nervatura in zona tesa

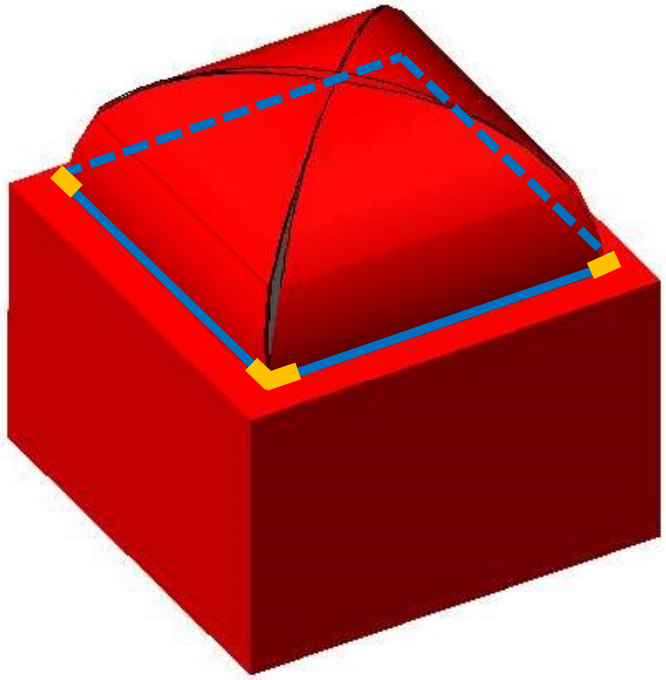


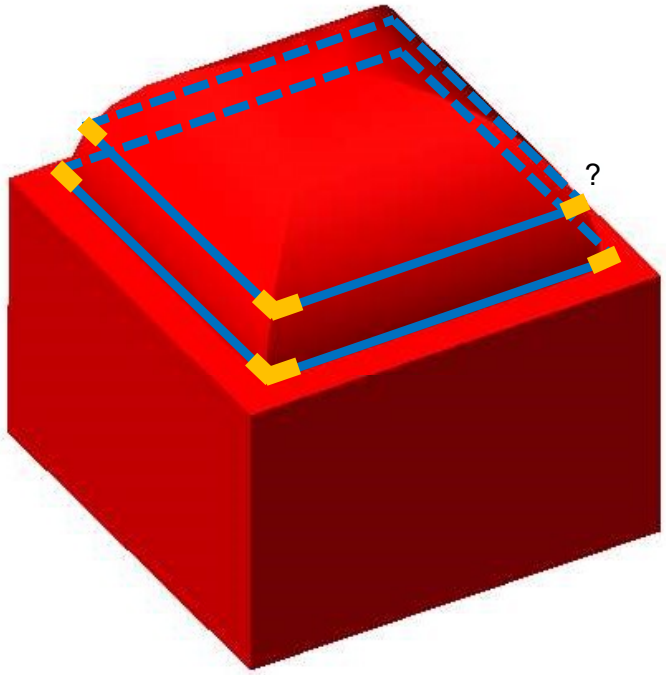
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G.Cangi



G.Cangi

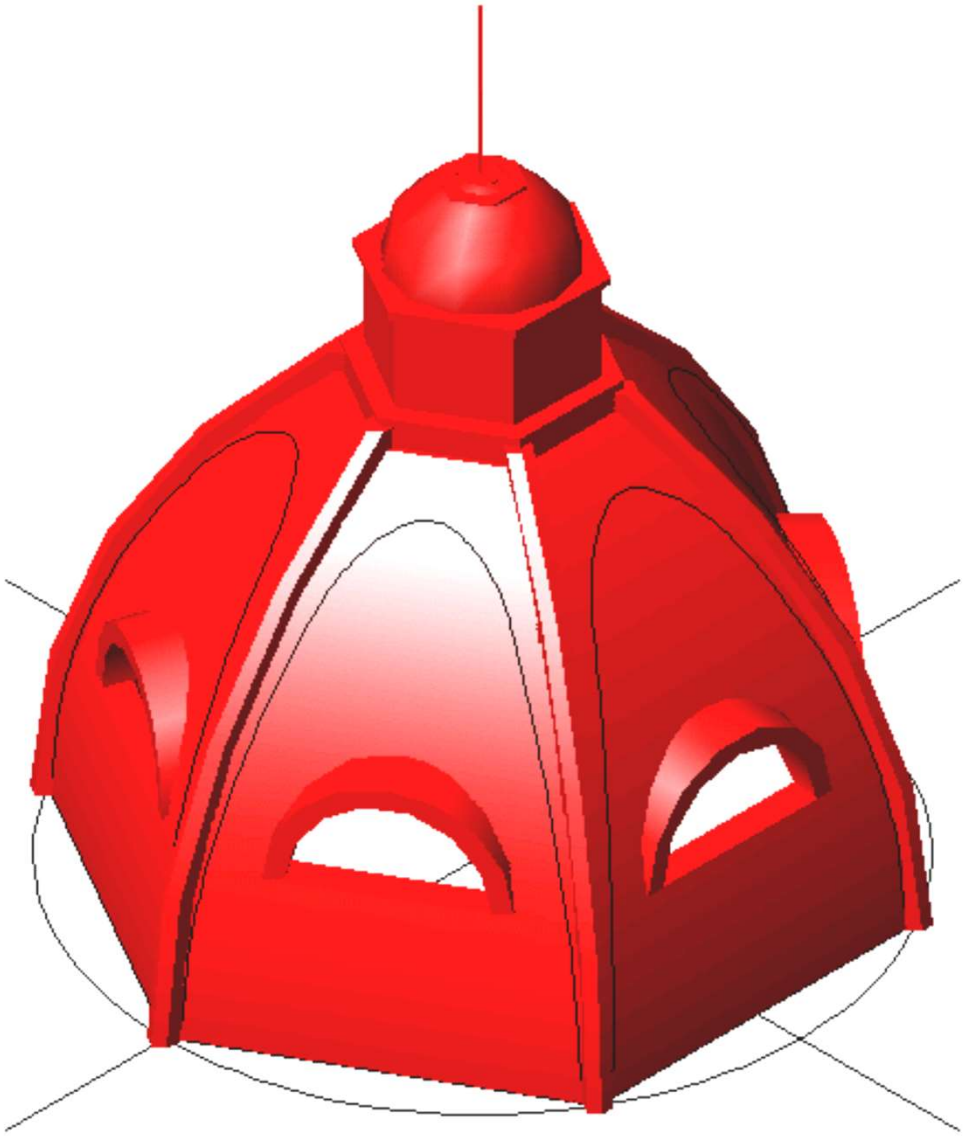




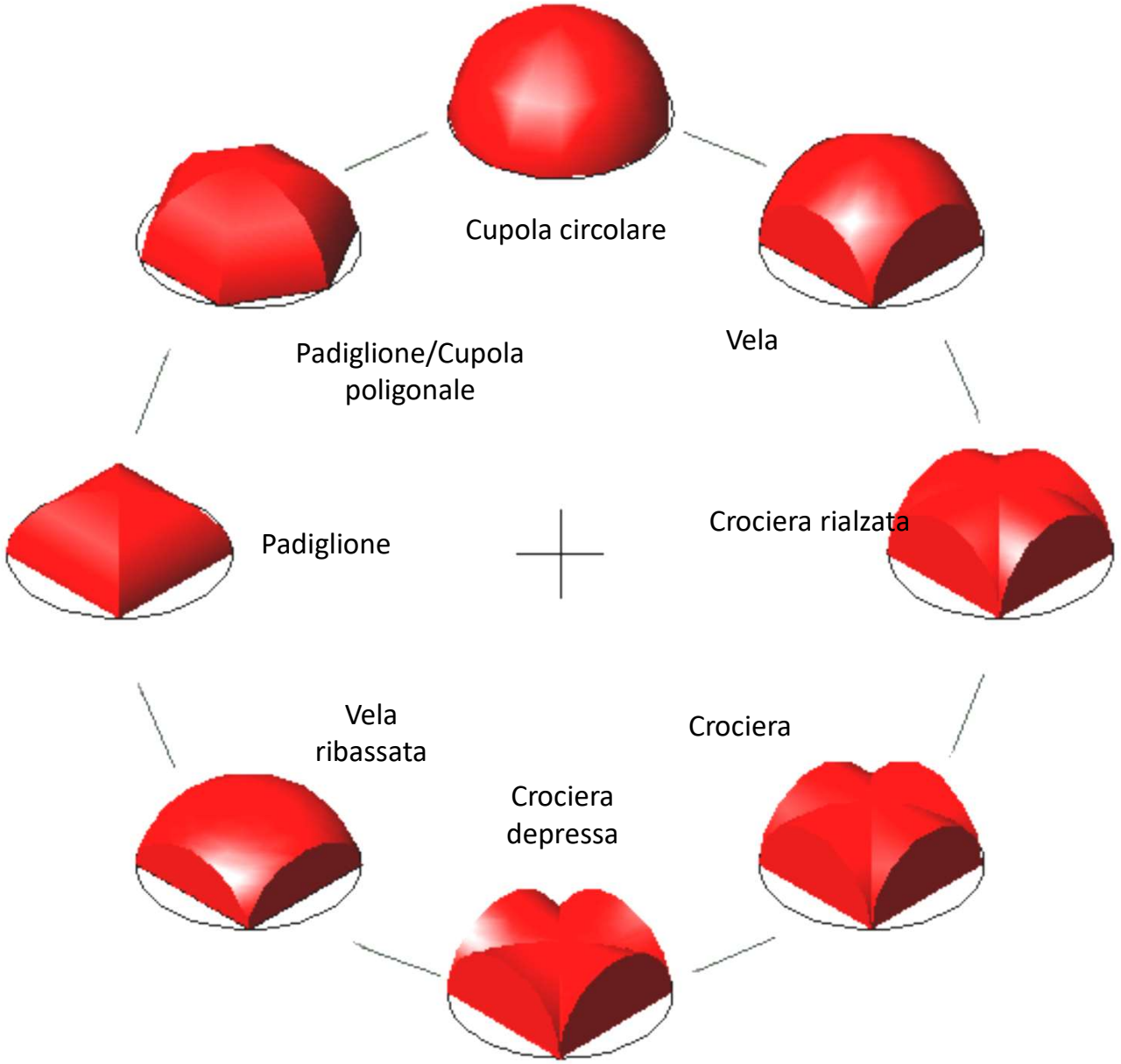
G.Cangi

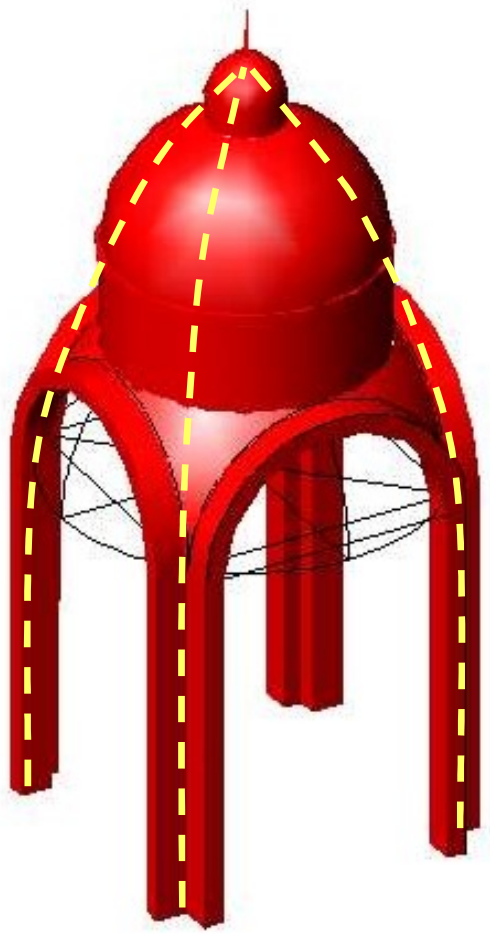


Modello in scala di farina
con foratura dei fusi

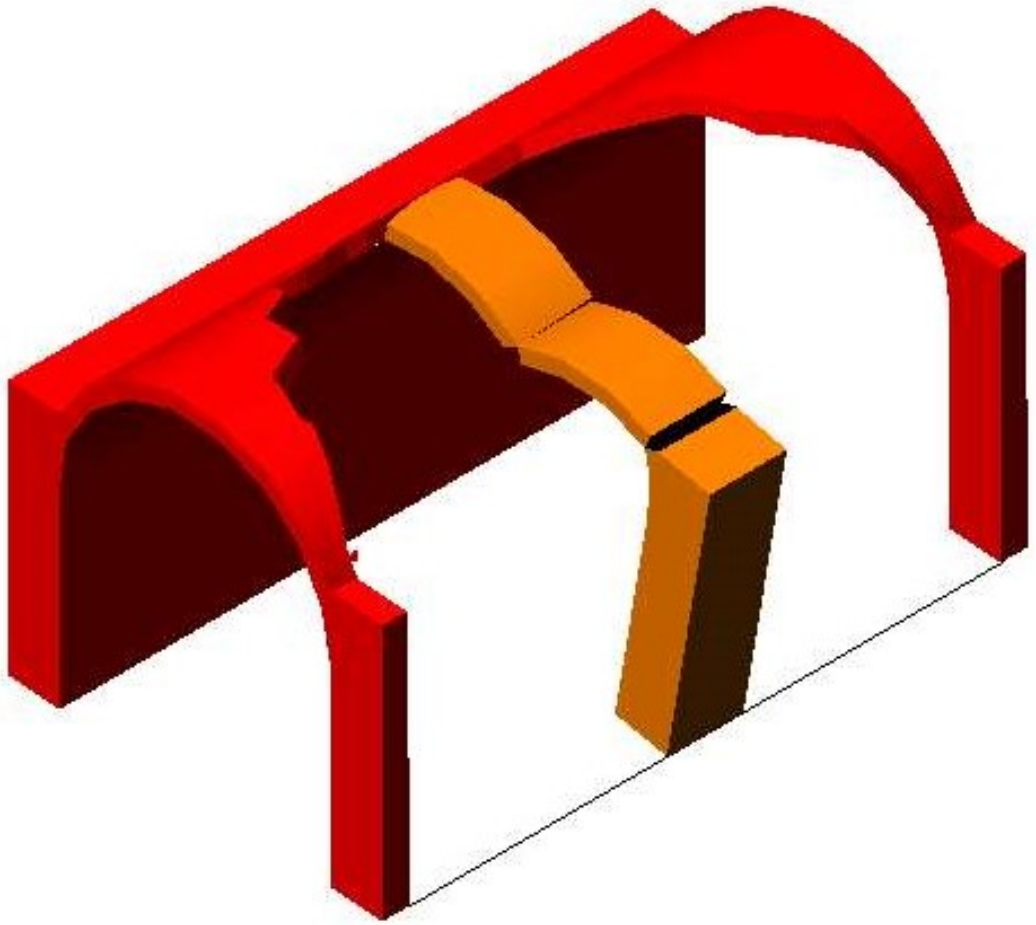


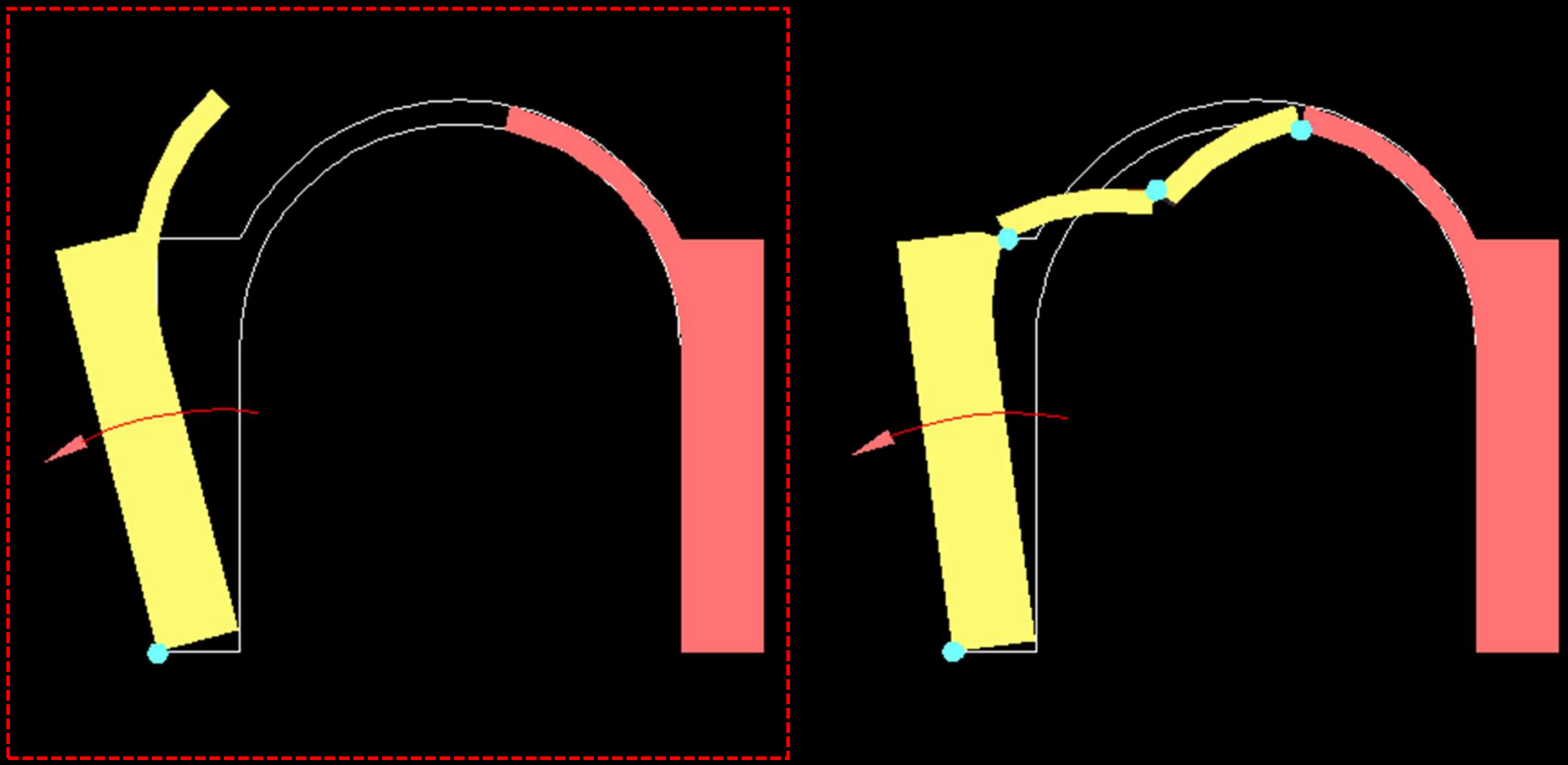
Cupole a base
poligonale con vele
lunettate

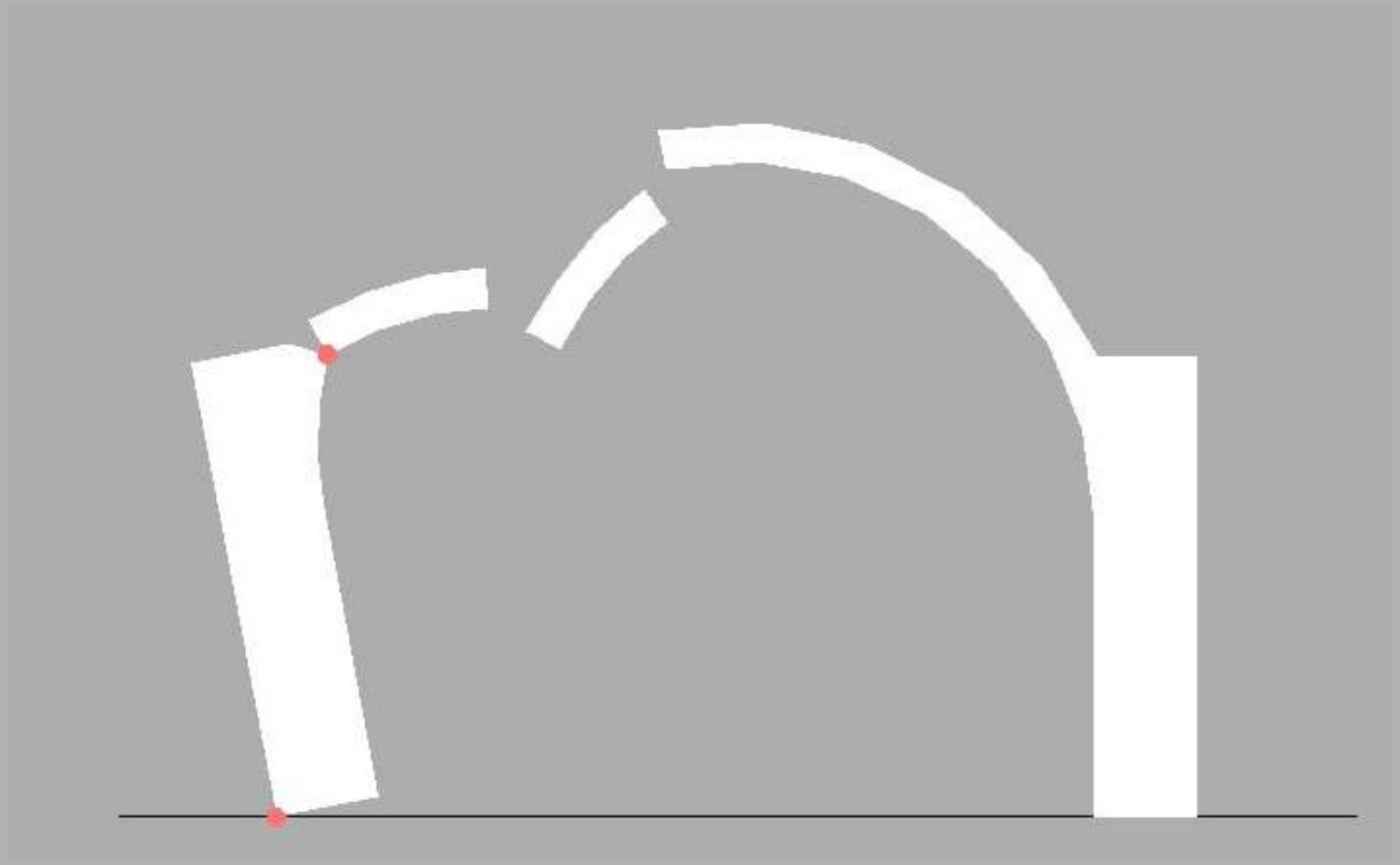

Cupola circolare
Vela
Crociera rialzata
Crociera
Crociera depressa
Vela ribassata
Padiglione
Padiglione/Cupola poligonale



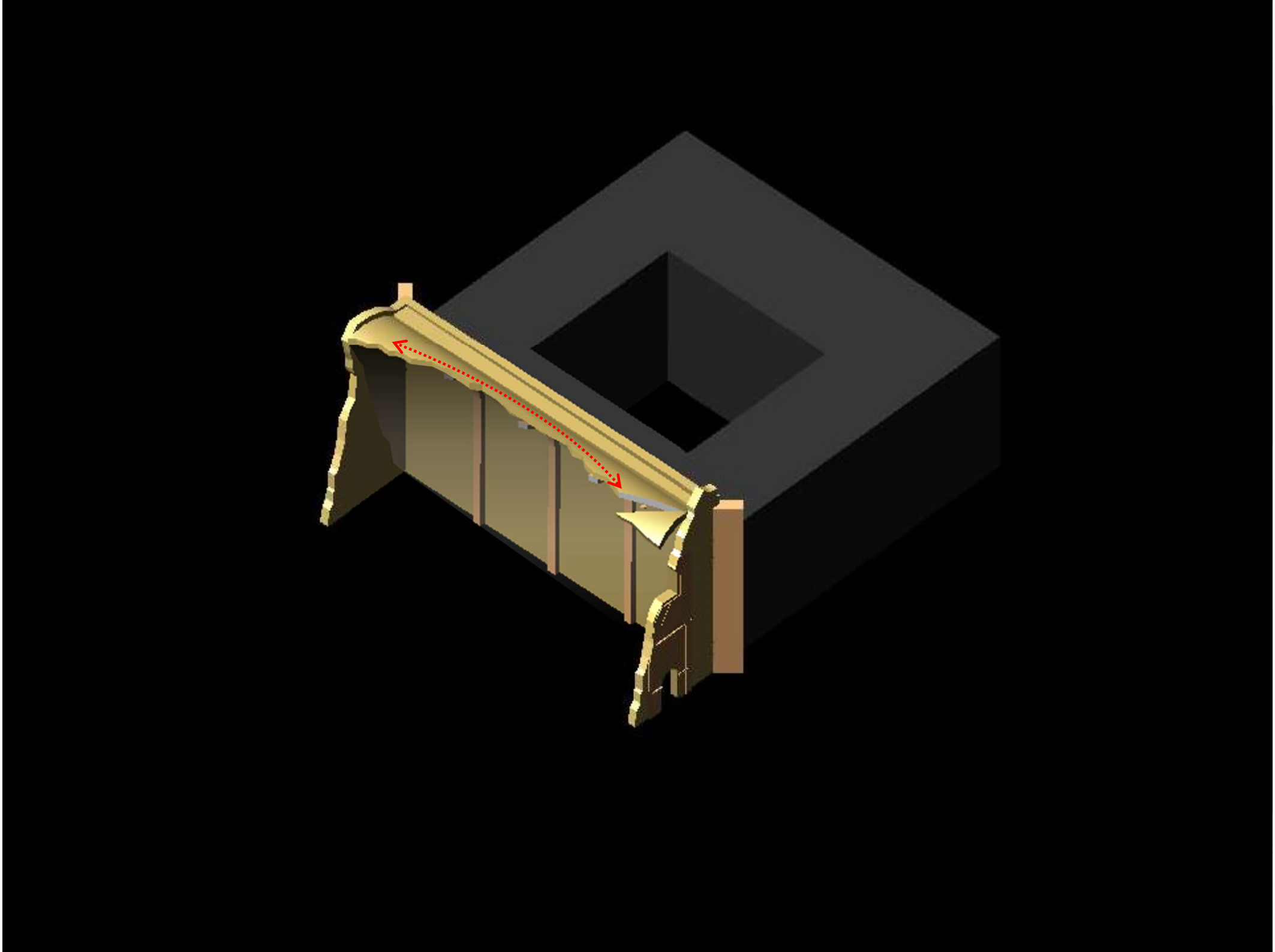
Volta a vela con tamburo e cupola

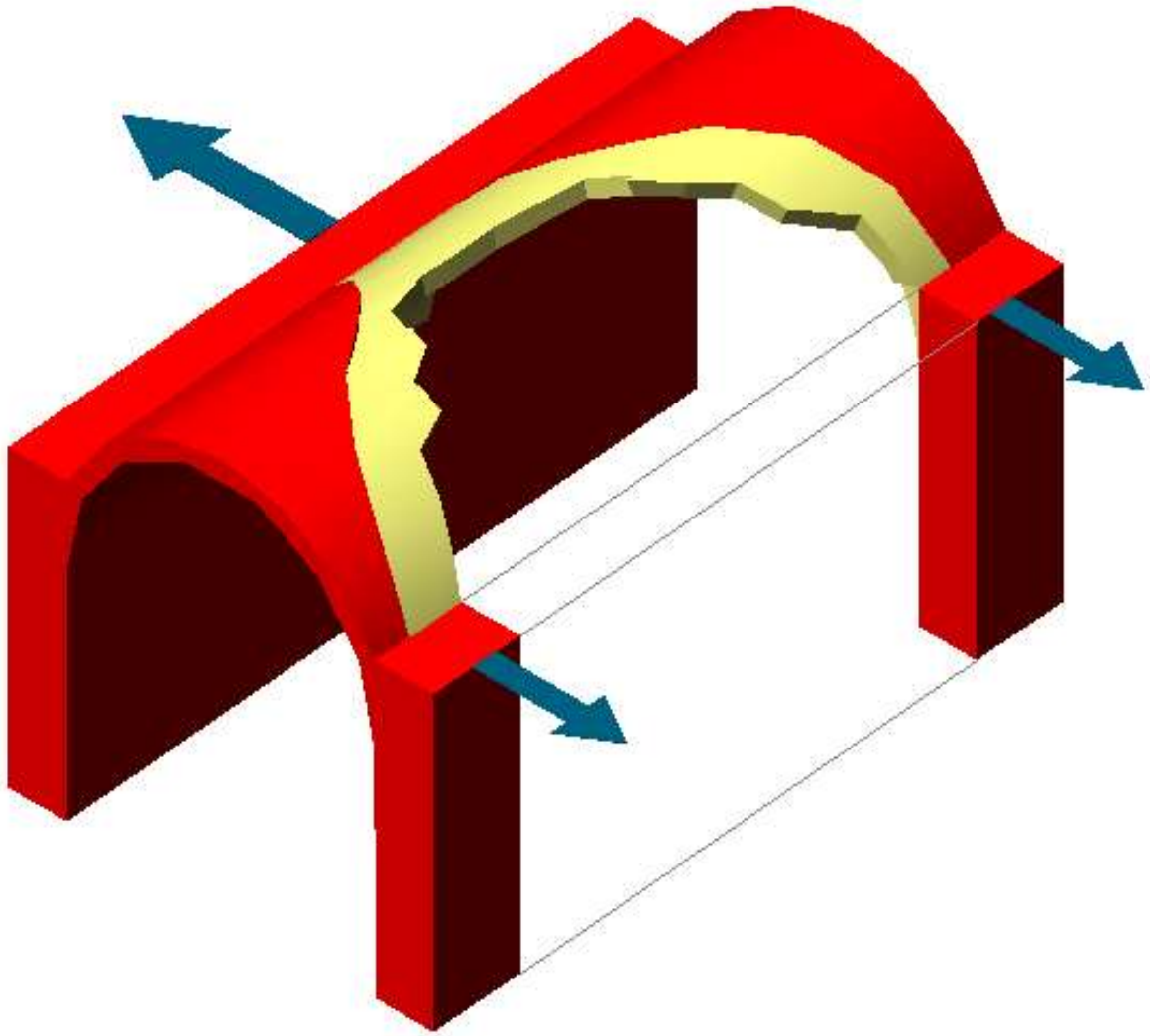


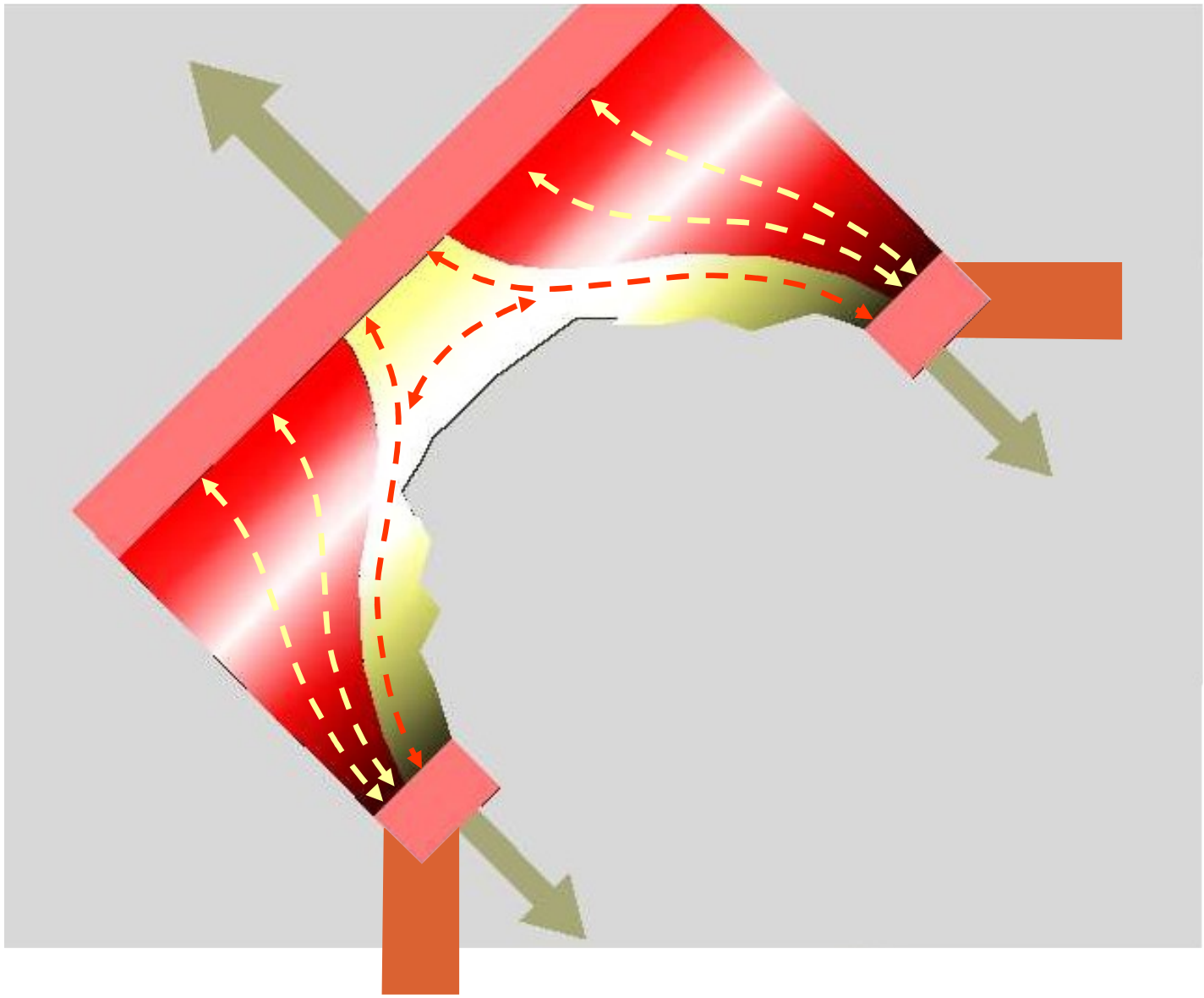


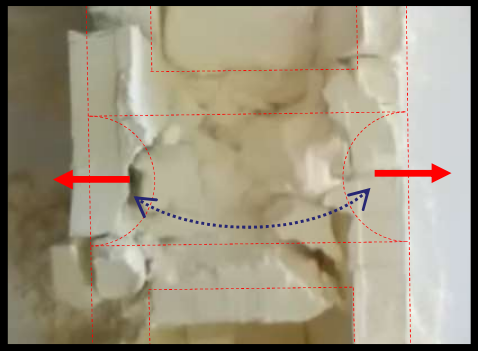












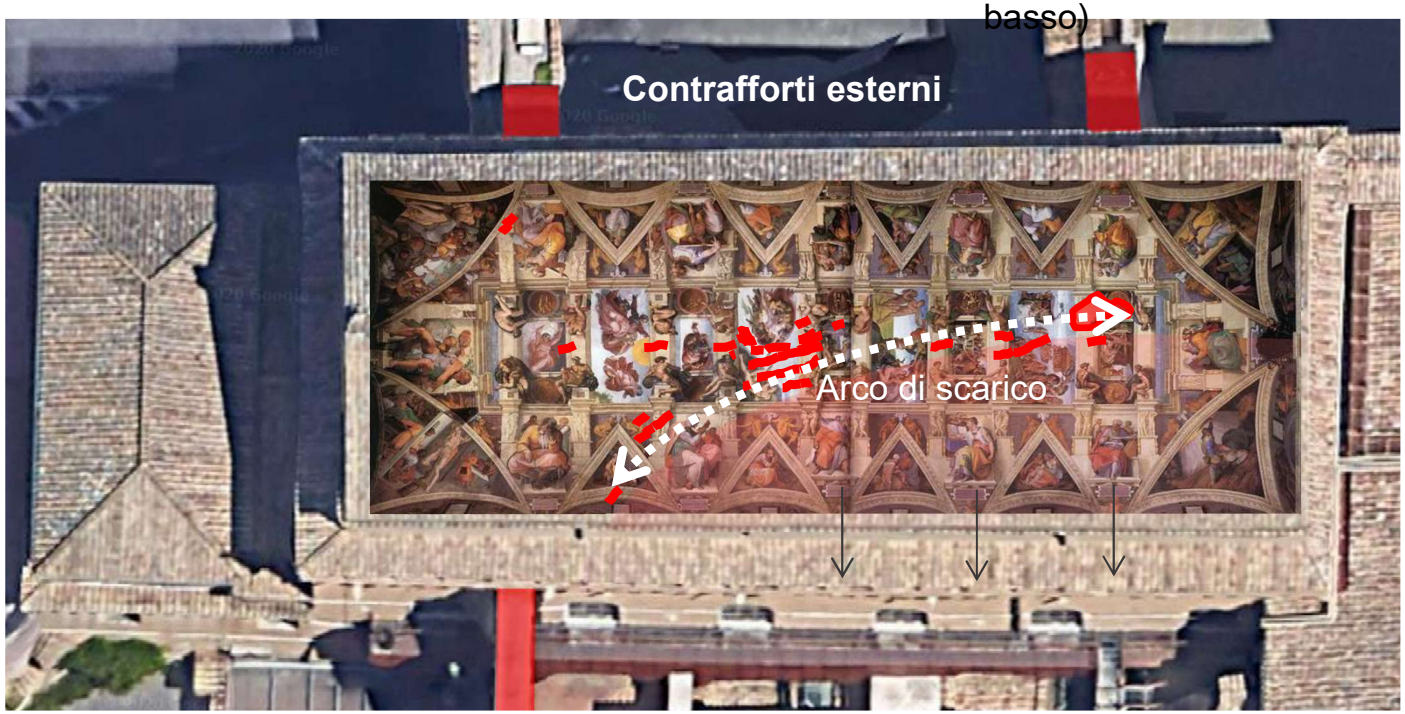
Dottorato di Ricerca in Architettura:
Innovazione e Patrimonio (ciclo XXXII)
Politecnico di Bari – Università Roma Tre

G.Ajò - G. Cangi

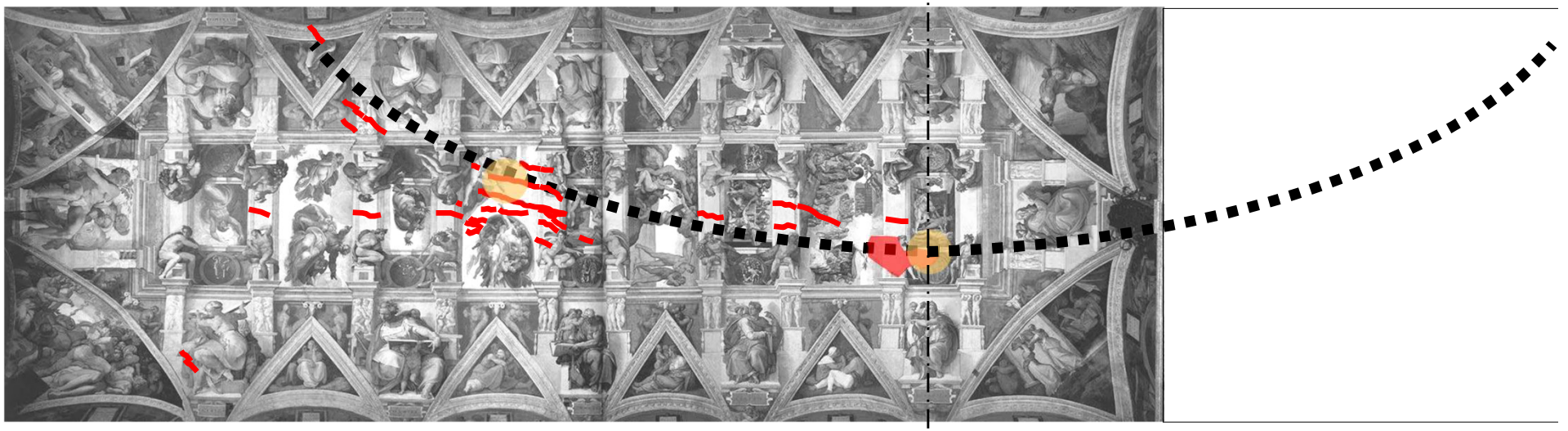




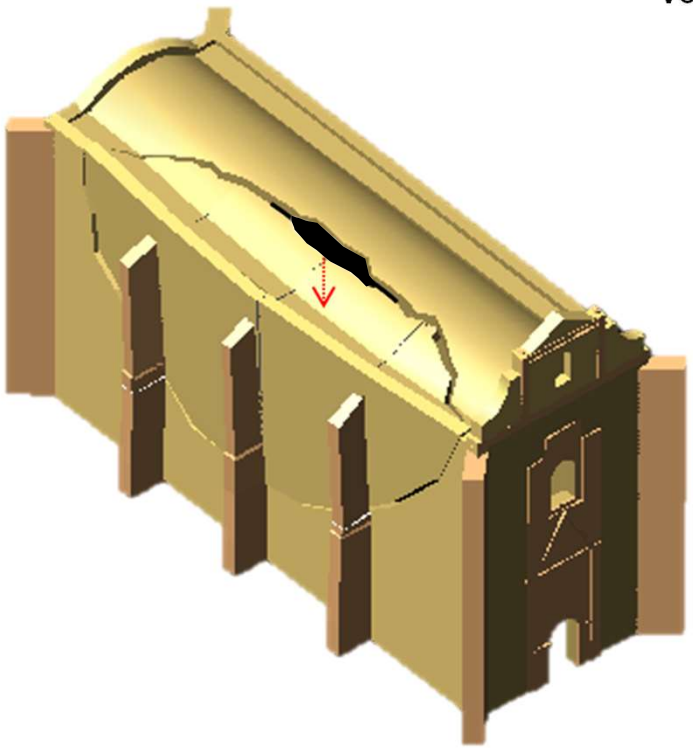
Quadro fessurativo della volta (vista dal basso)

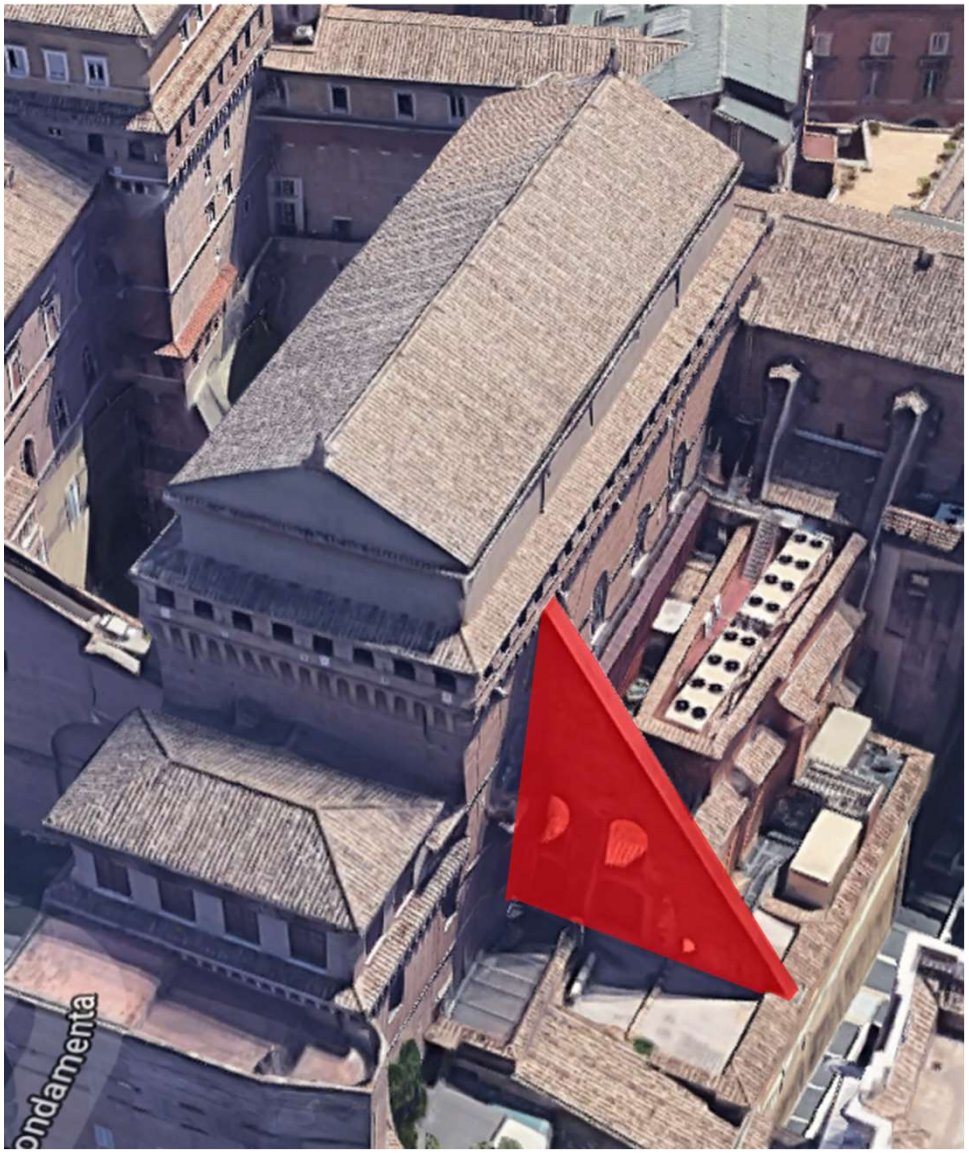


Impianto della Cappella Sistina con proiezione degli affreschi



Quadro fessurativo della volta (vista dal basso)

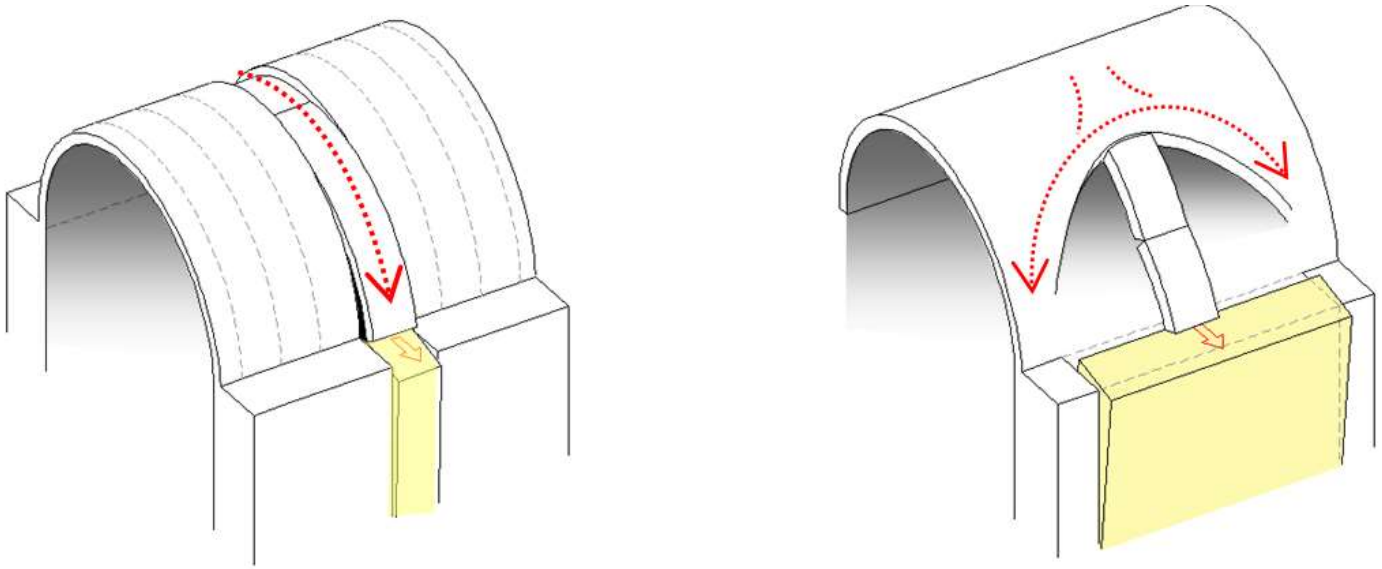




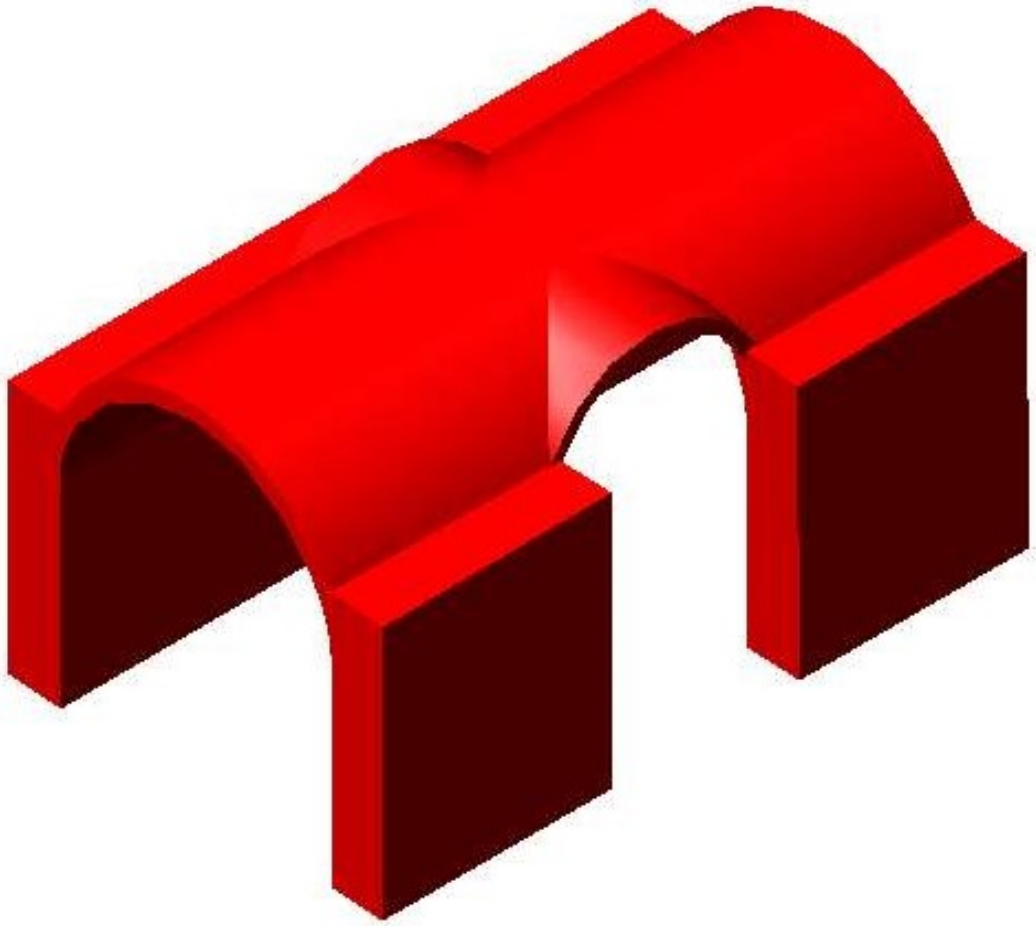


Bilanciamento della struttura sui due lati longitudinali mediante contrafforti murari

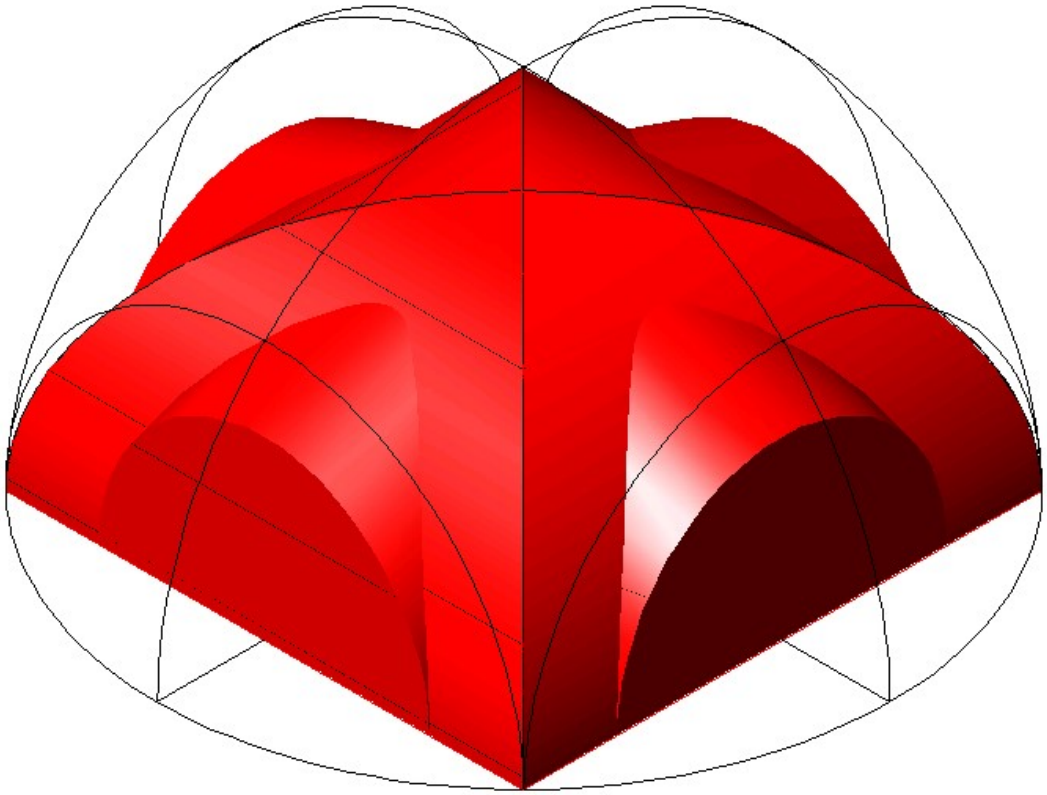
(**1565 - Vignola, Pirro Ligorio**)

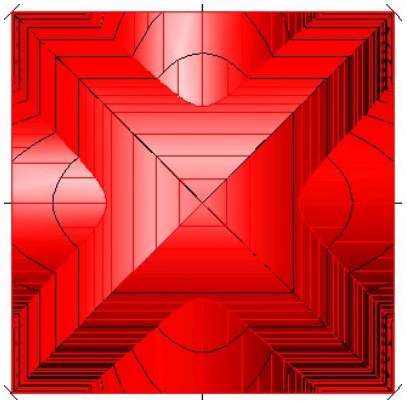


Passaggio dal meccanismo ad arco trasversale al meccanismo di difesa ad arco longitudinale



Volta a padiglione con lunette

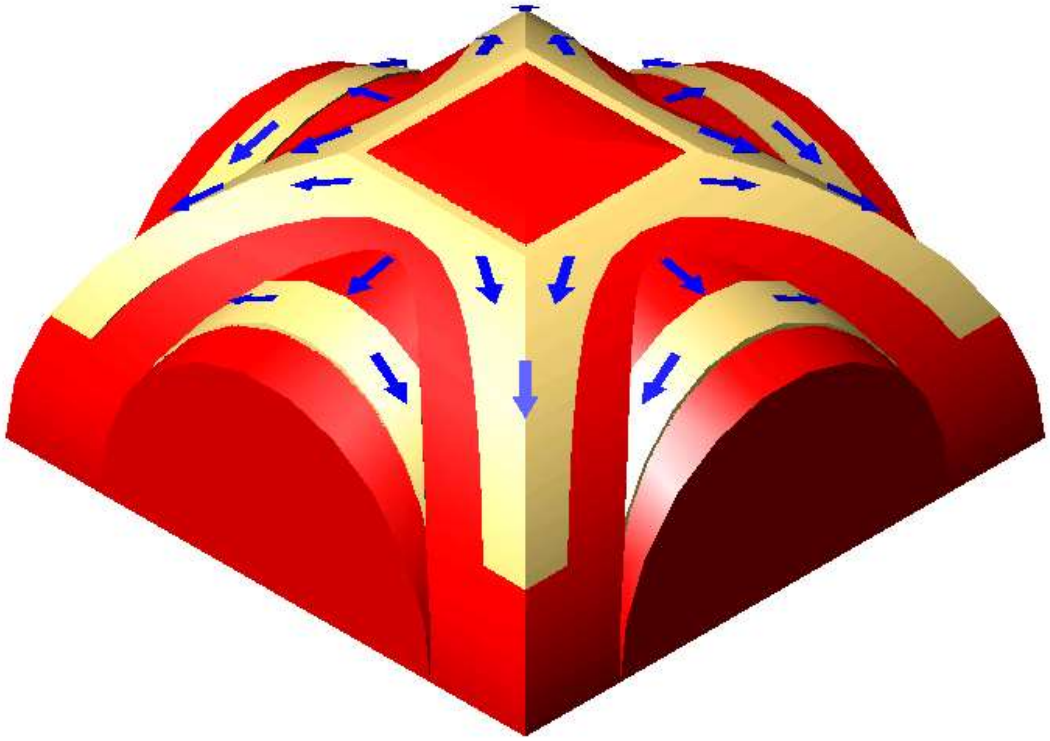


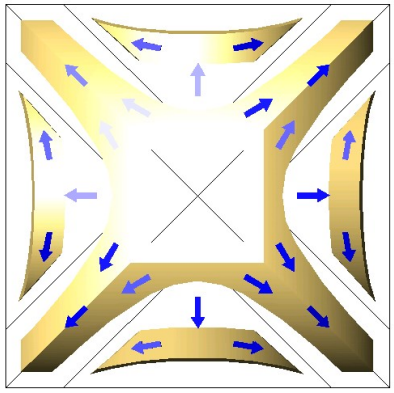


Classificazione delle volte in base alla configurazione geometrica

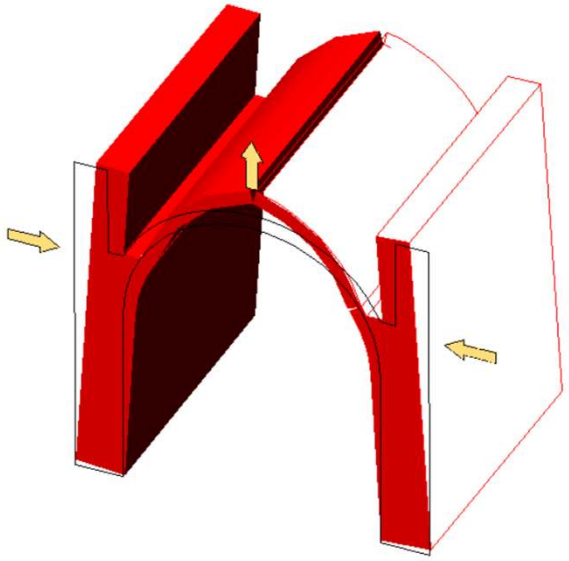
Volta a padiglione con lunette:

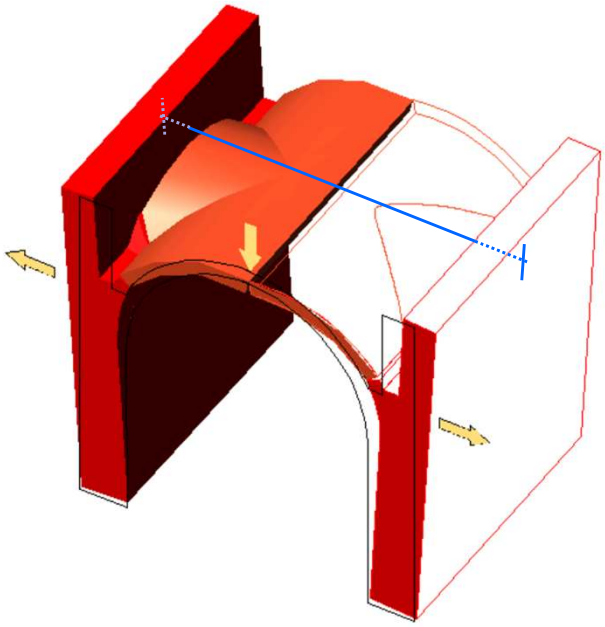
meccanismo resistente



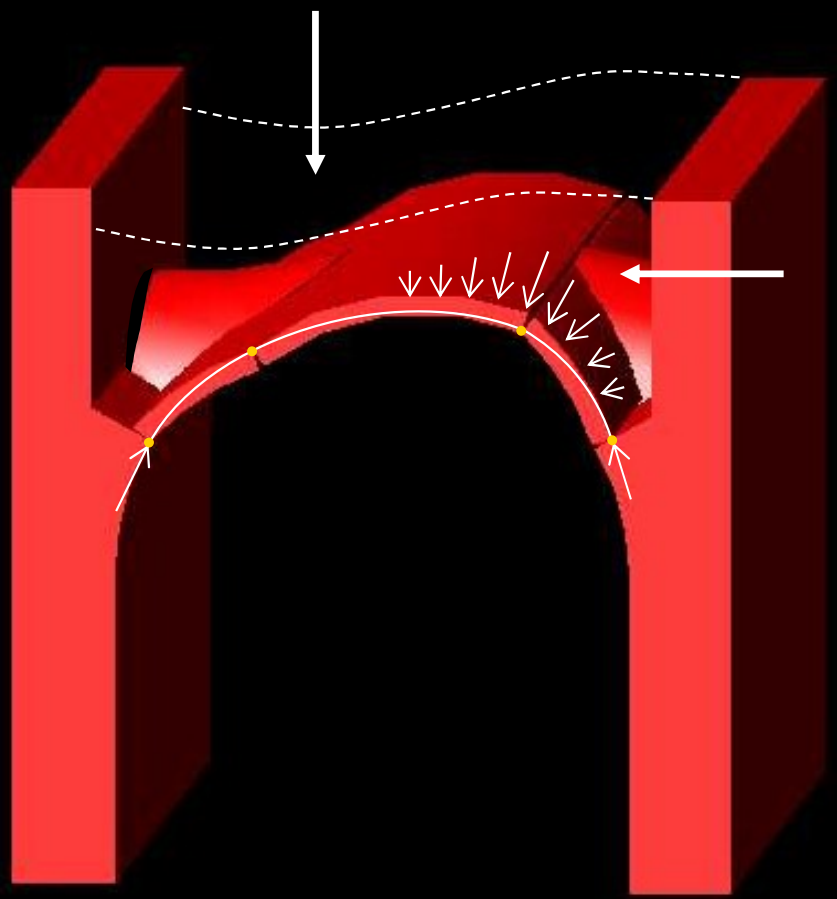


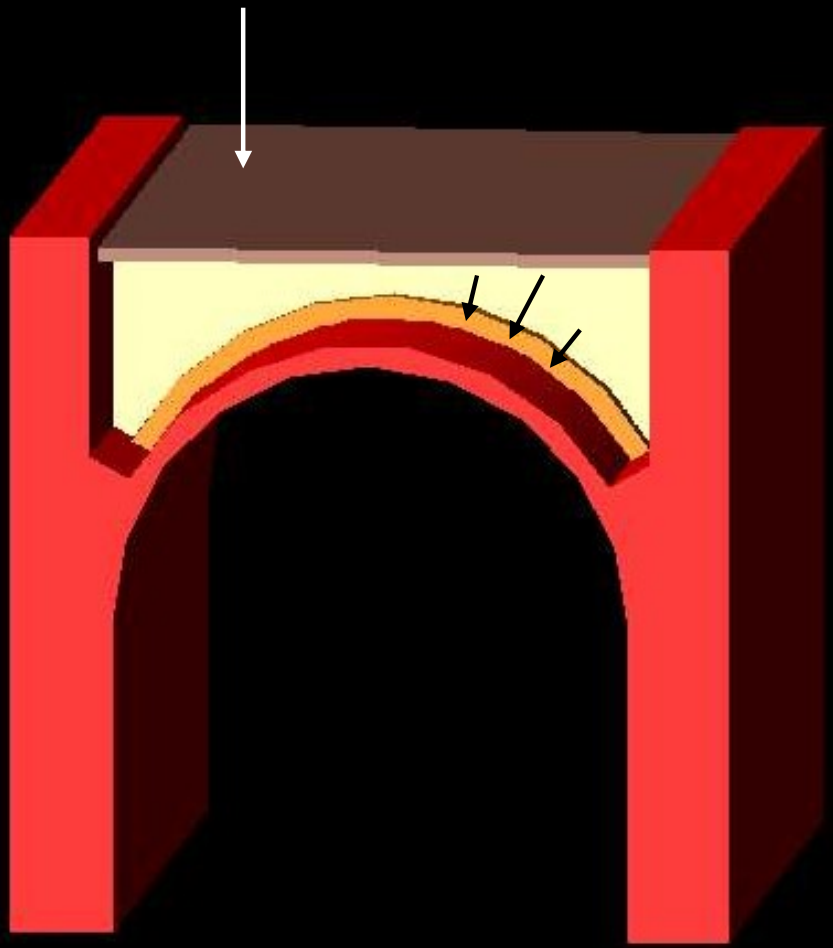
Meccanismi resistenti in funzione della configurazione geometrica





Volta a botte lunettata: la spinta attiva si riduce, mentre aumenta enormemente la reazione passiva





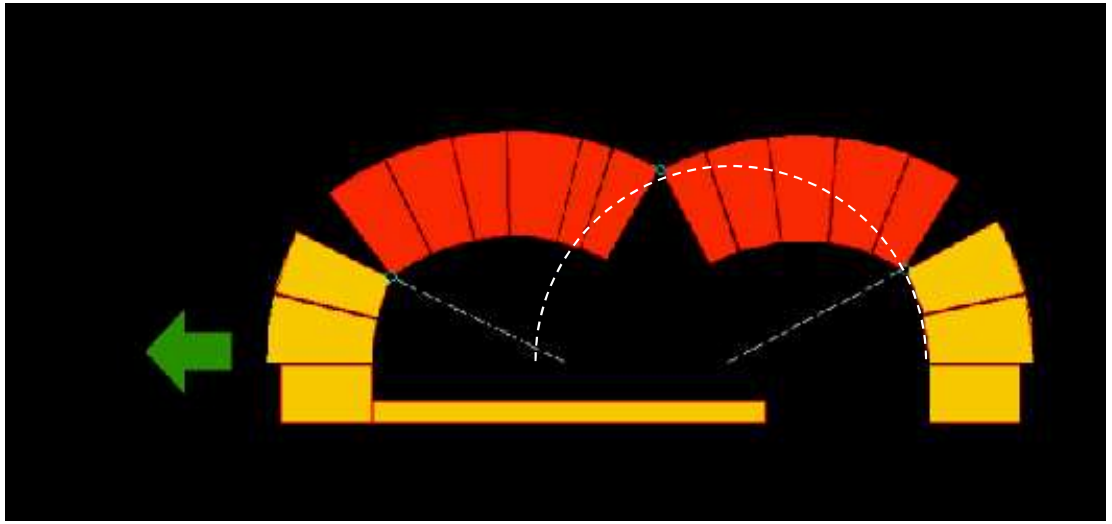




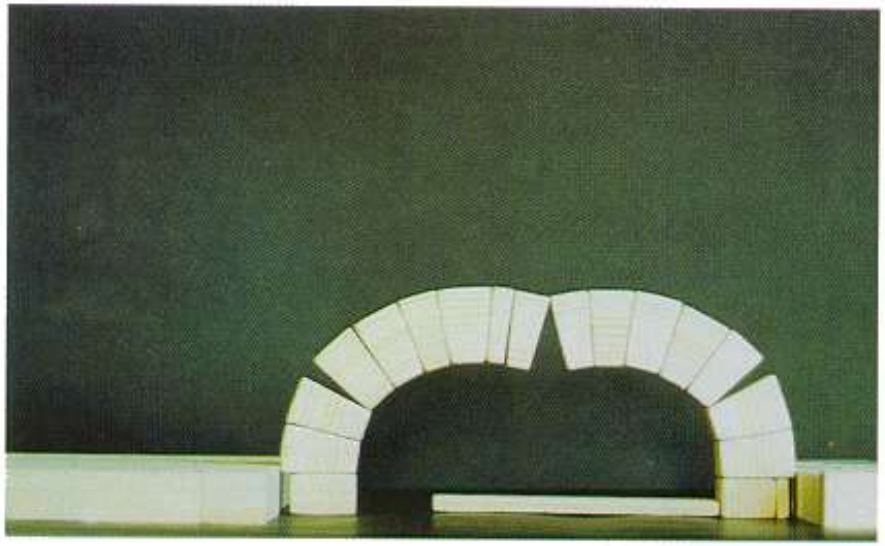
Frenelli su archi laterizi estradossati

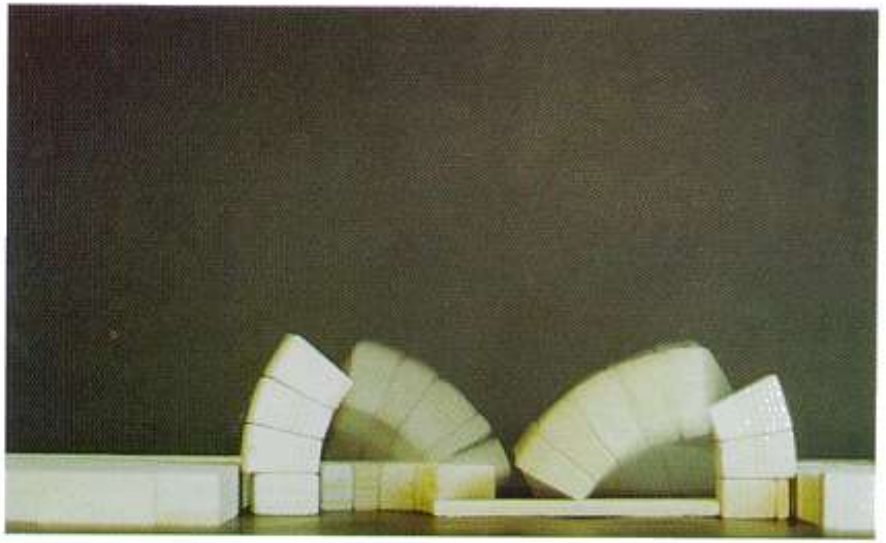
Dissesti di archi e volte

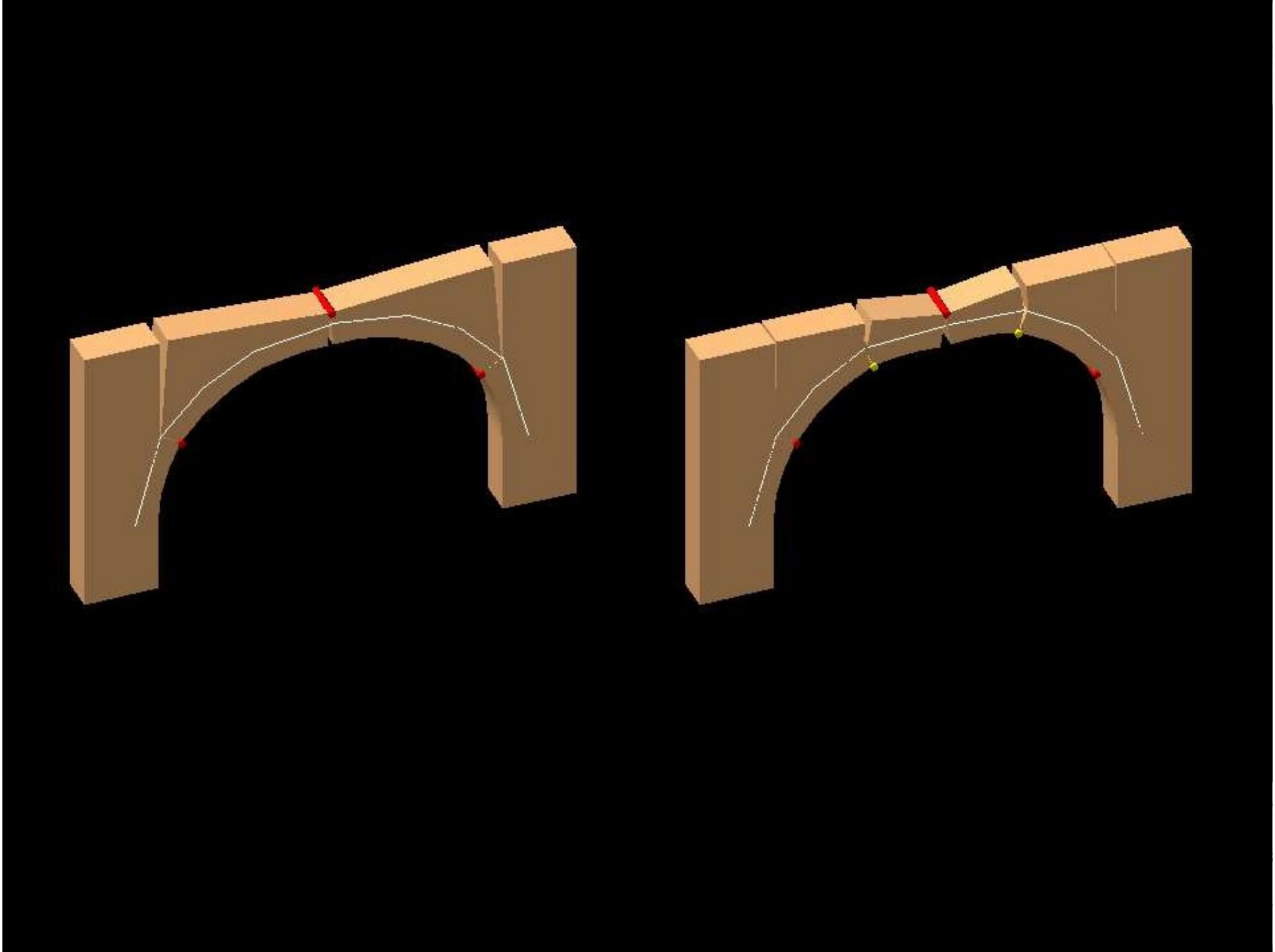
Meccanismo di rottura a flessione

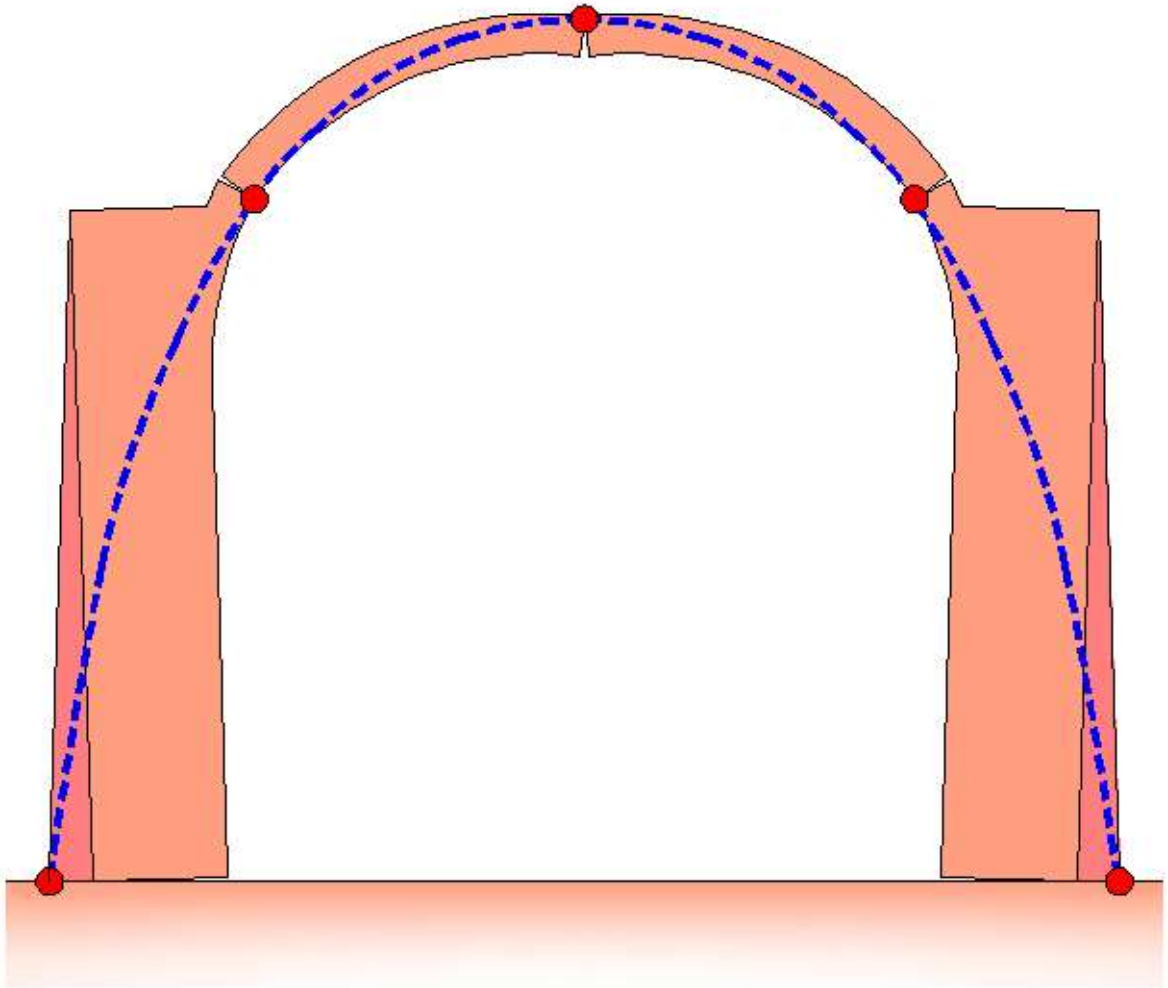


B) ALLONTAMENTO DELLE IMPOSTE E ROTAZIONE DEI CONCI SU ARCHI LIBERI



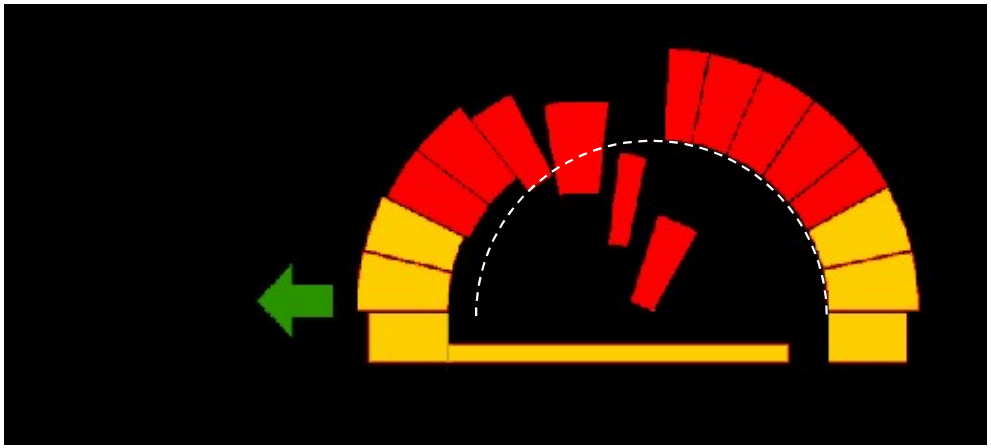




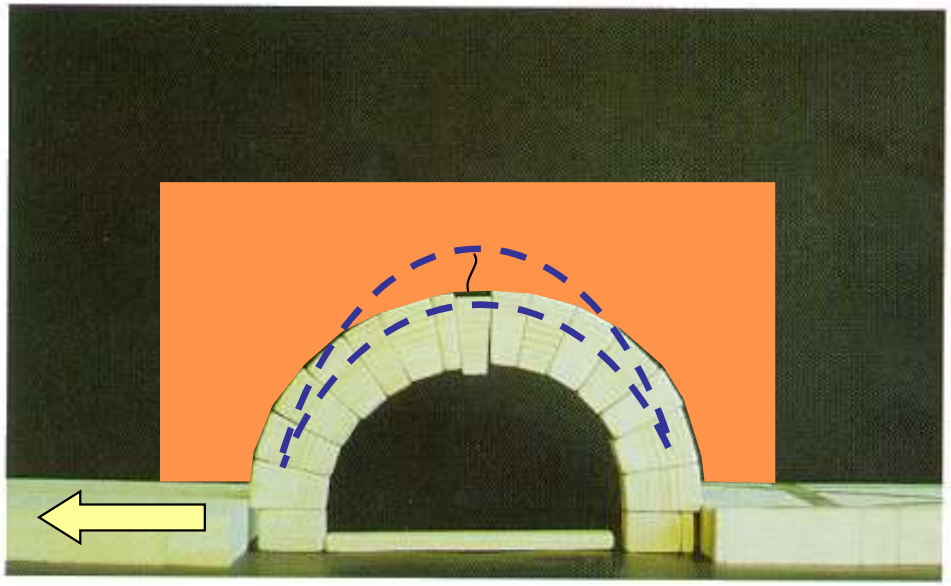


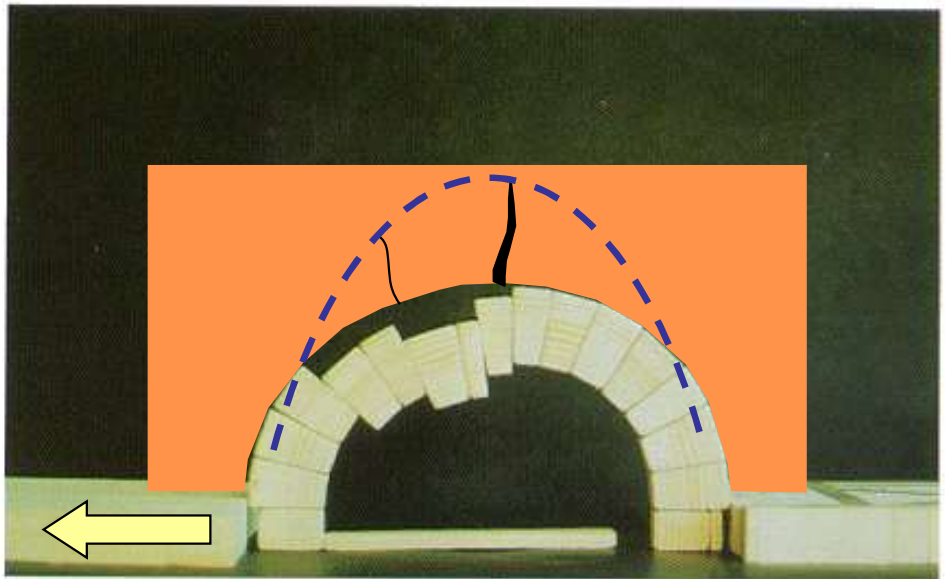
Dissesti di archi e volte

Meccanismo di rottura a taglio



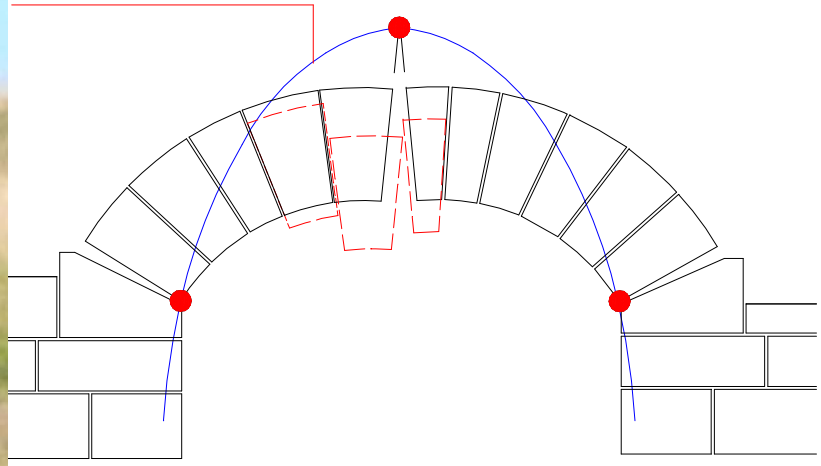
A) ALLONTANAMENTO DELLE IMPOSTE E SCORRIMENTO DEI CONCI



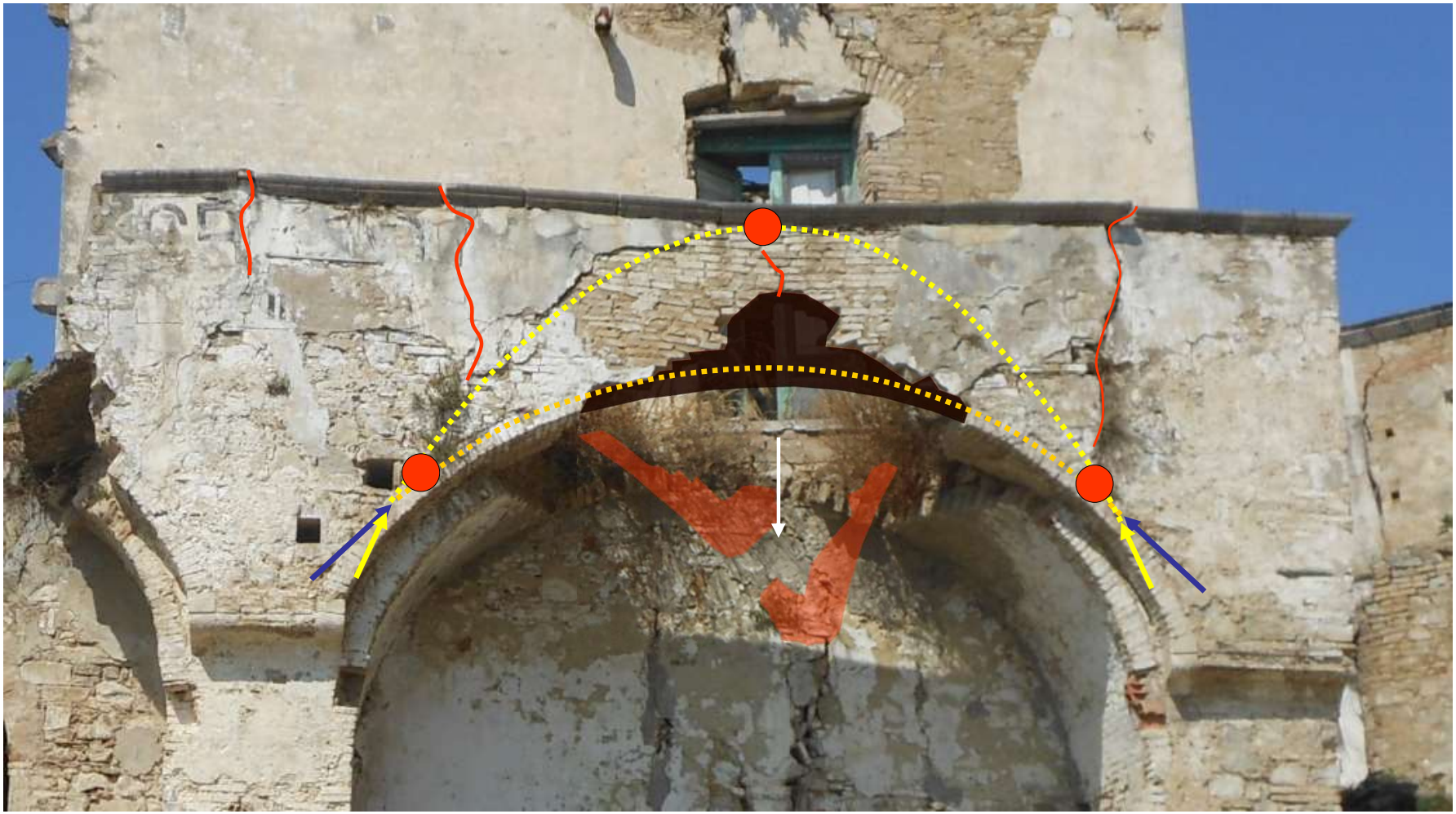


Meccanismi di danno a confronto



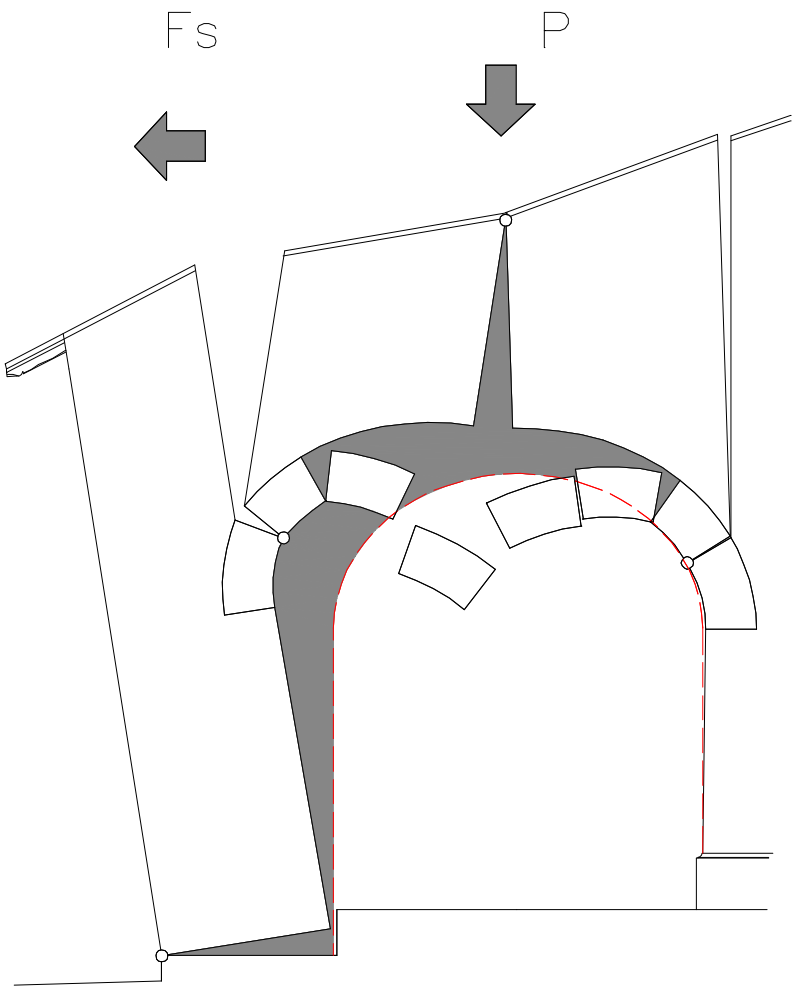


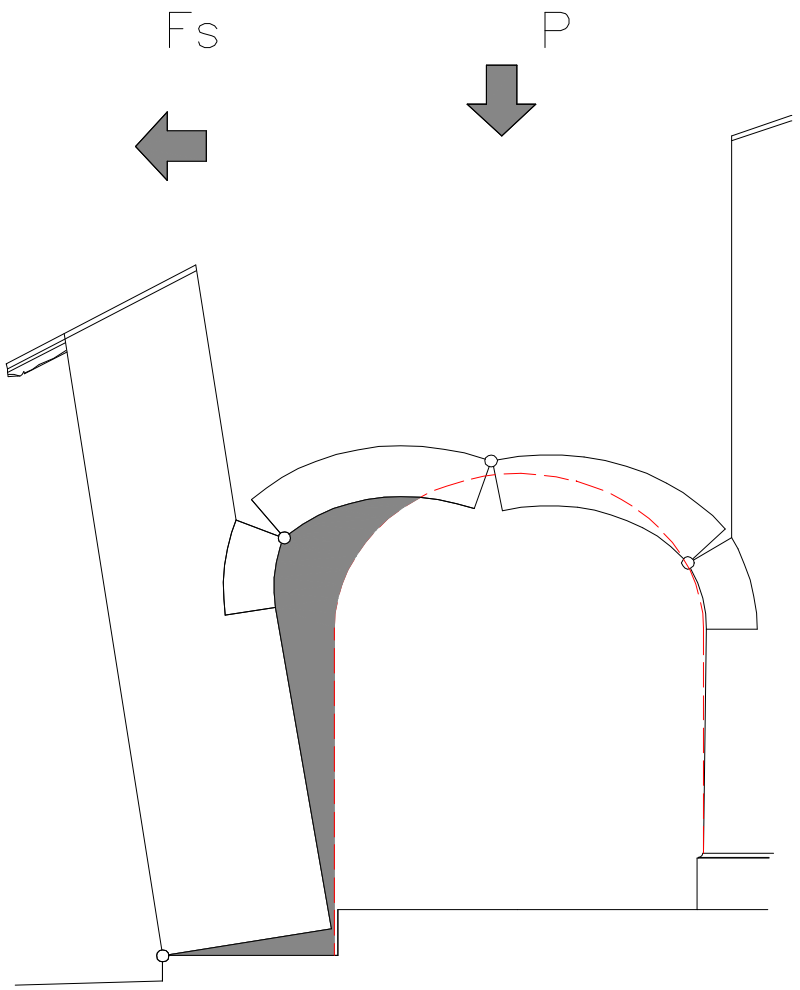
Rottura a flessione e taglio



Cinematismi elementari:
evoluzione classica del meccanismo a tre cerniere di un arco laterizio
con migrazione della cerniera di chiave




Fs
P

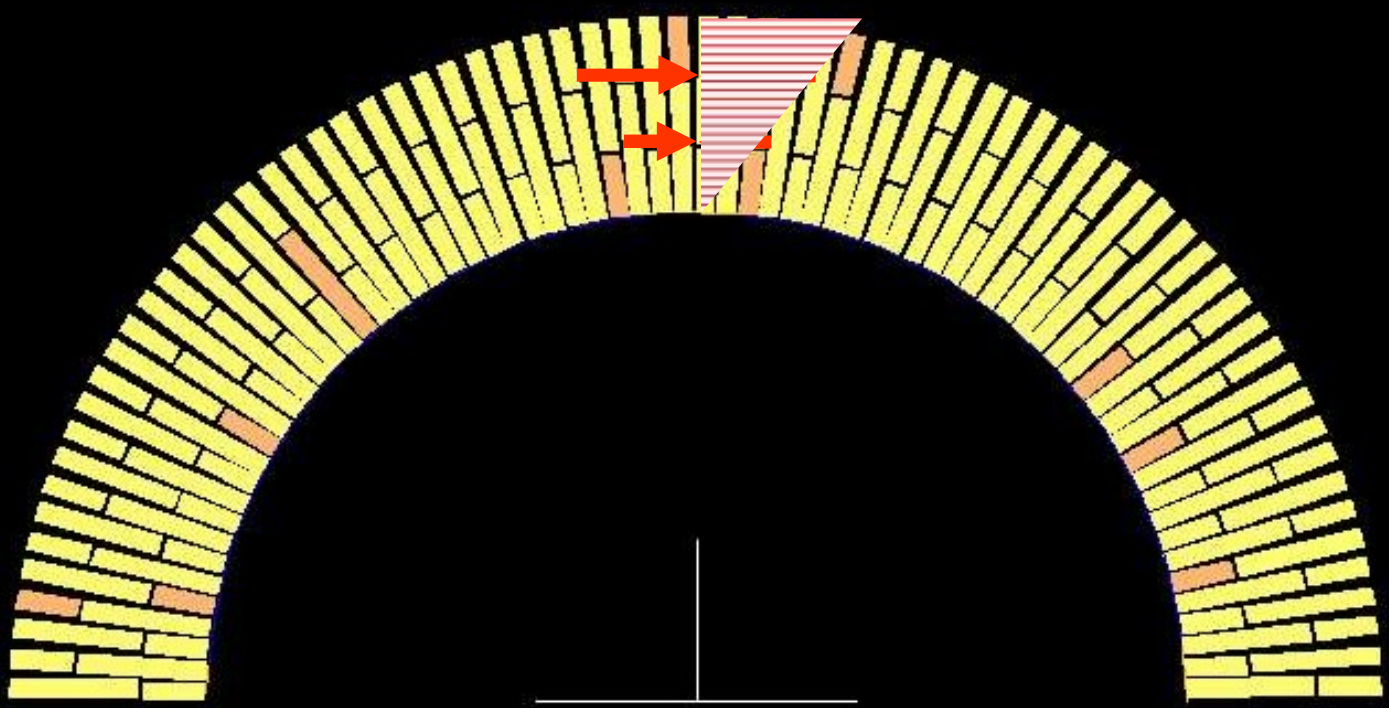

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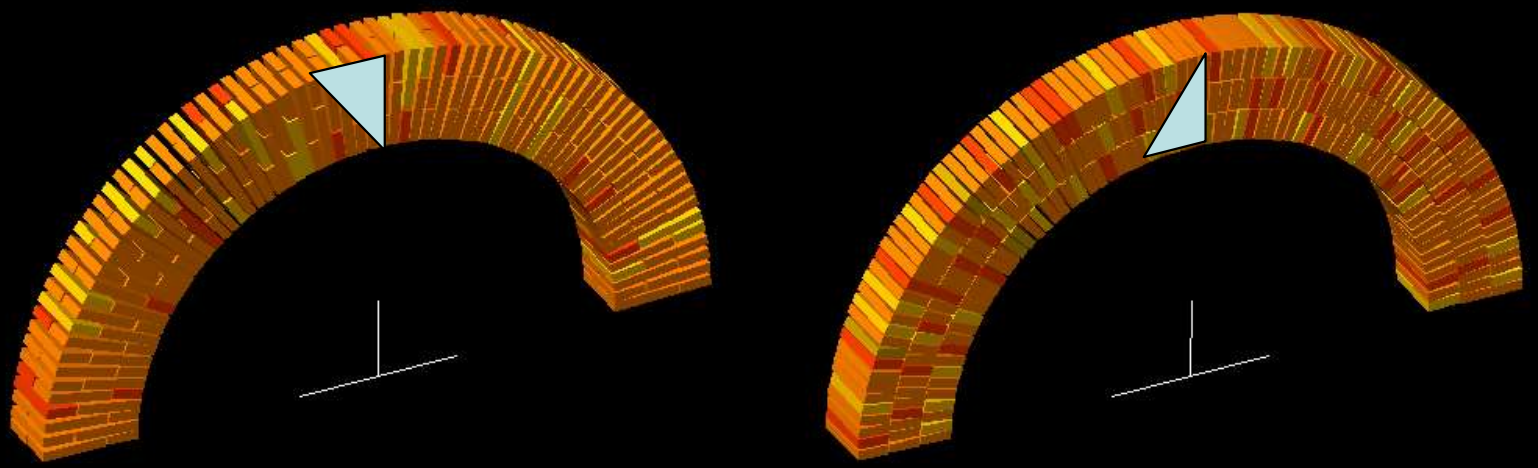


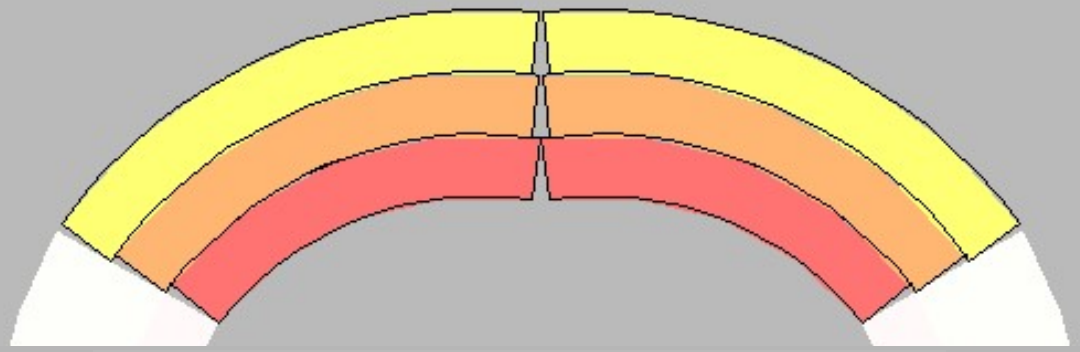


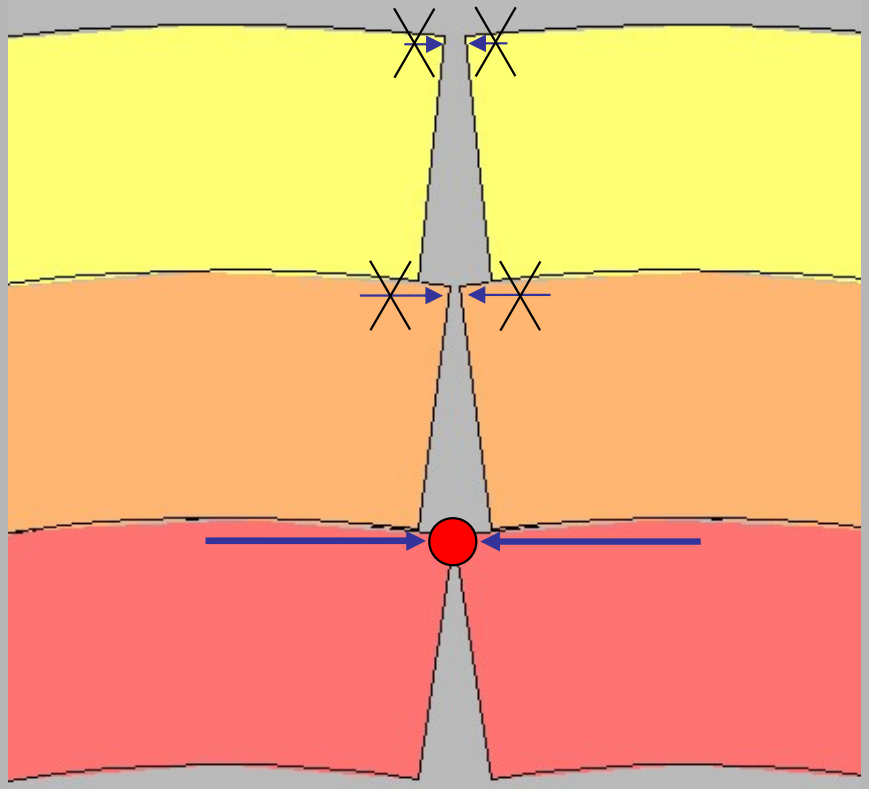
Nuestra Senora Reina del Los Angeles – Città del Messico
(Settembre 2017)







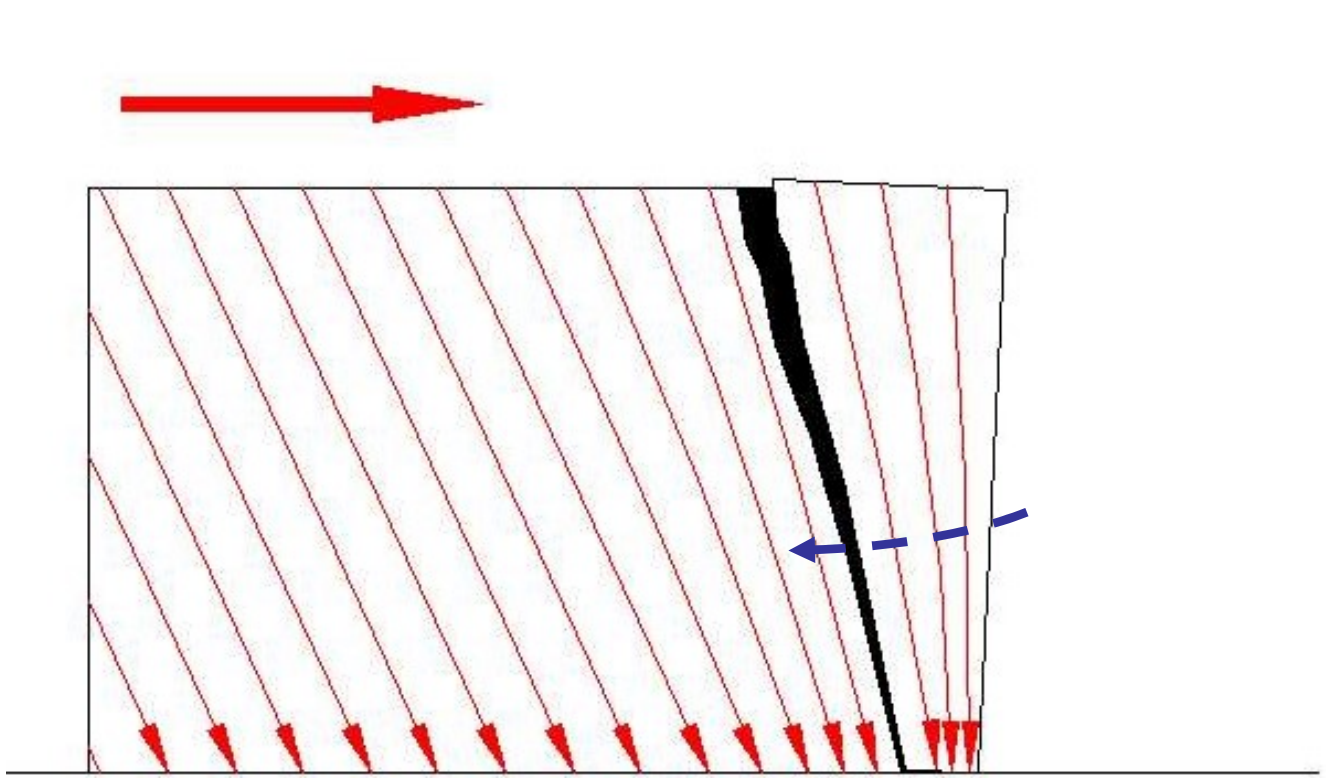


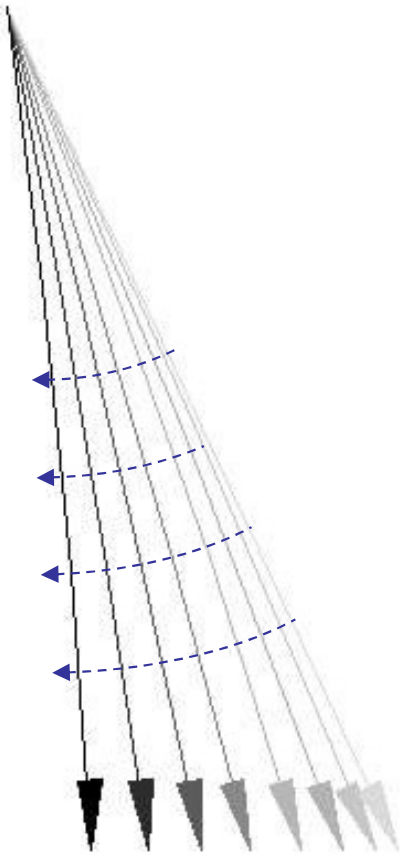


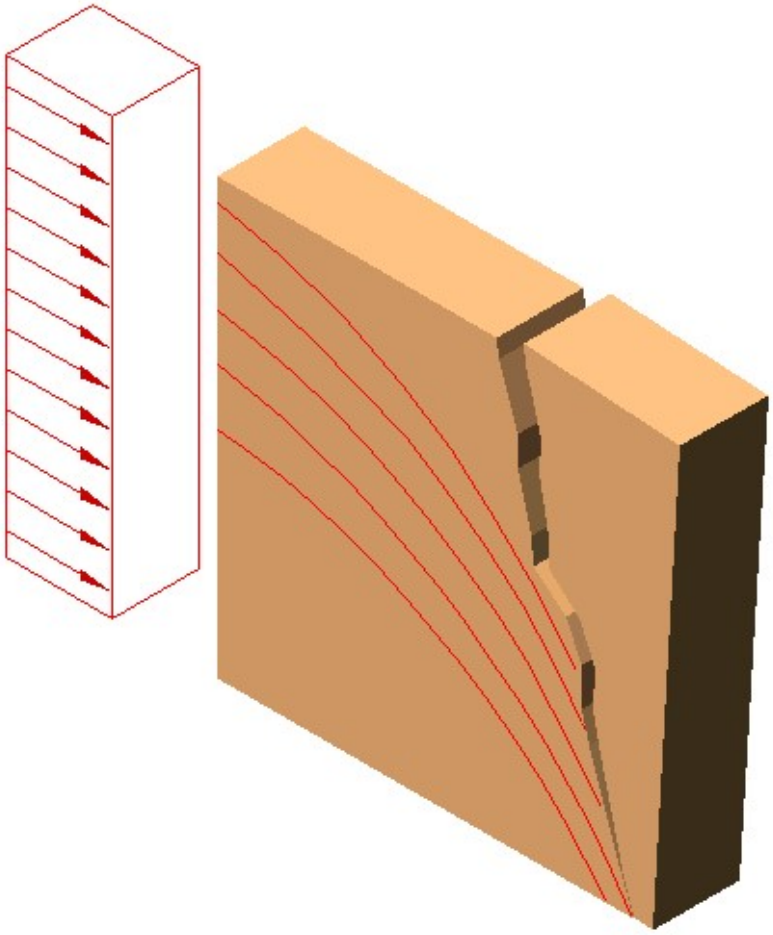




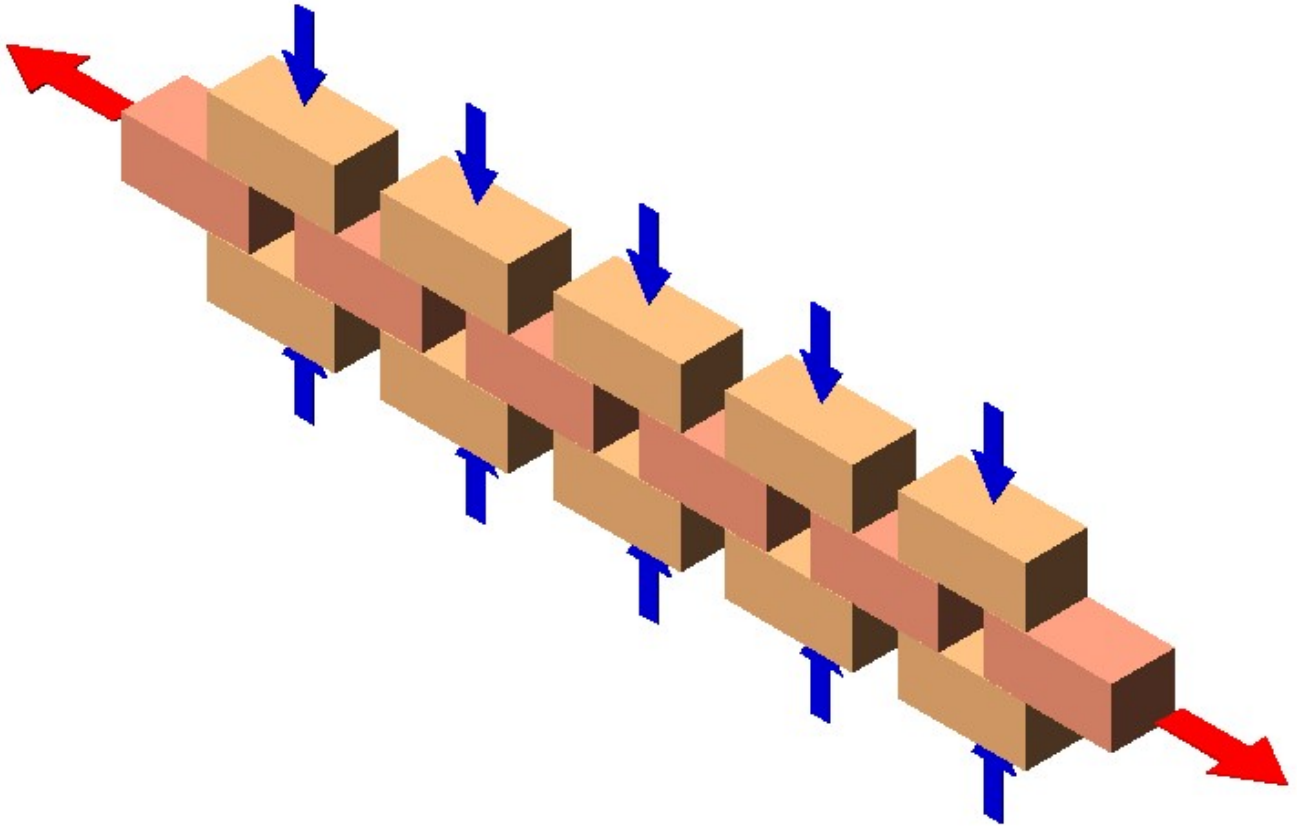
Siena:
Crollo della volta della chiesa di San Raimondo al Refugio per il terremoto del 26 maggio 1798



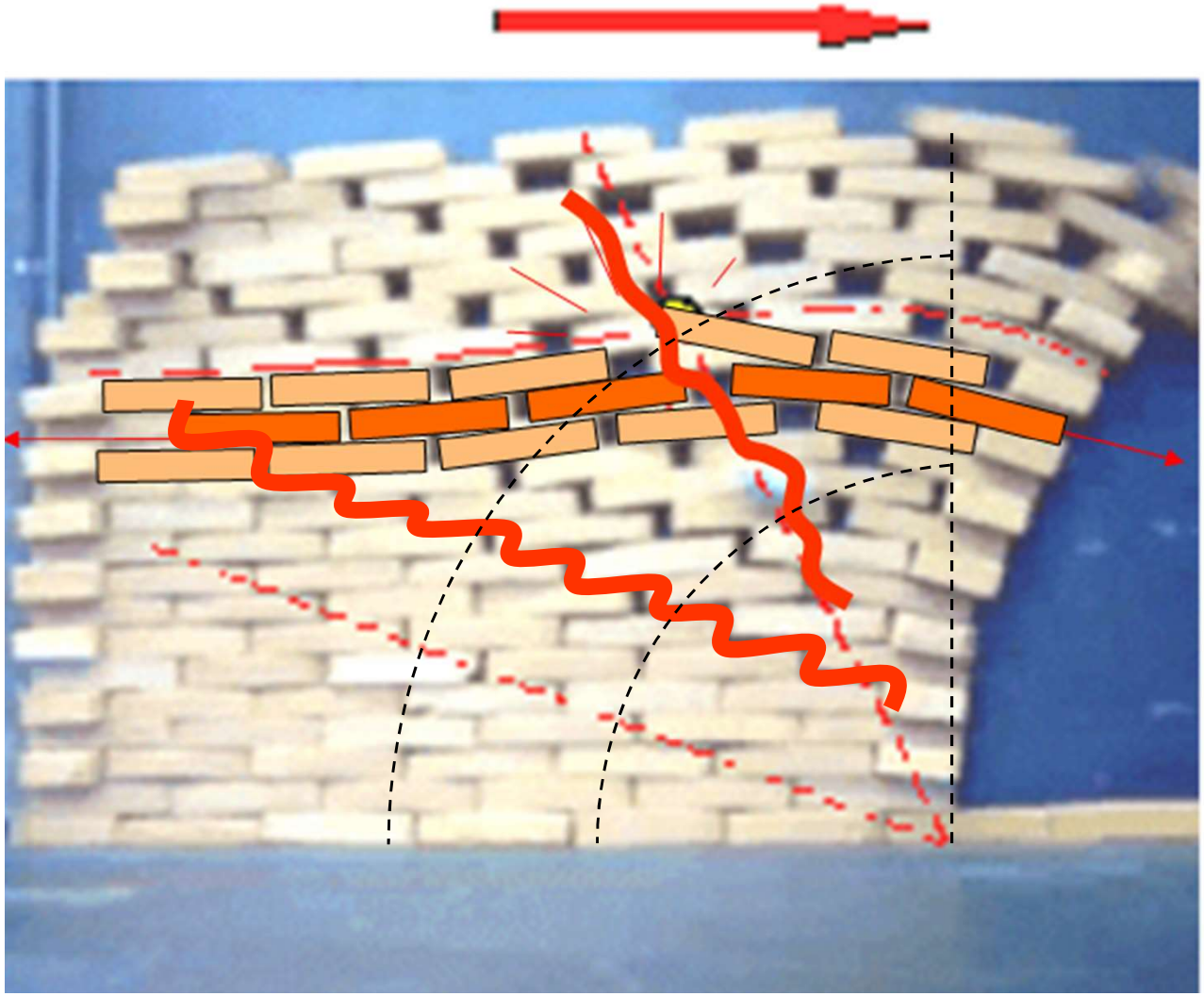








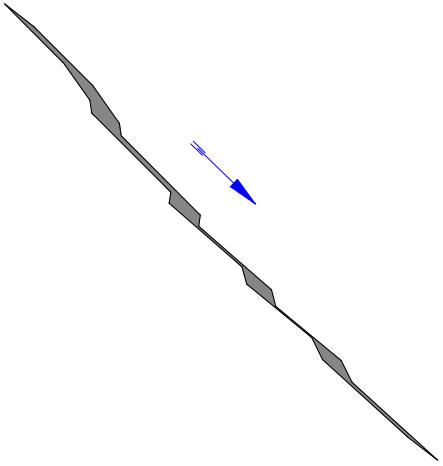
Effetto catena nelle murature incatenate,
garantito dall’attrito sulle superfici di contatto
fra gli elementi e dalla coesione della malta



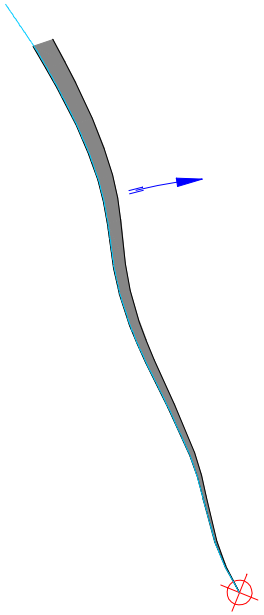
Schema dell’effetto catena in una parete di mattoni pieni ad una testa, evidenziato dalla dinamica di collasso di una parete sollecitata nel piano.



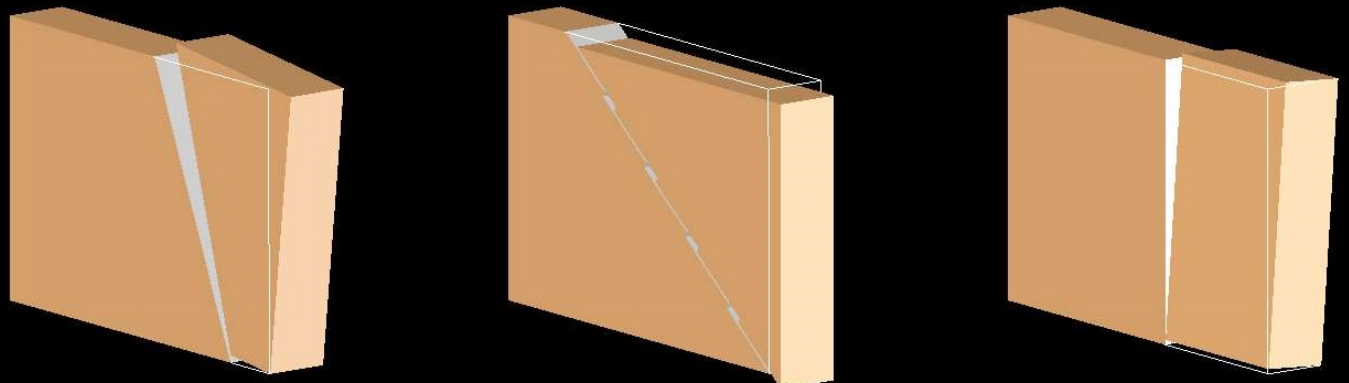
Prima classificazione tipologica delle lesioni



Scorrimento



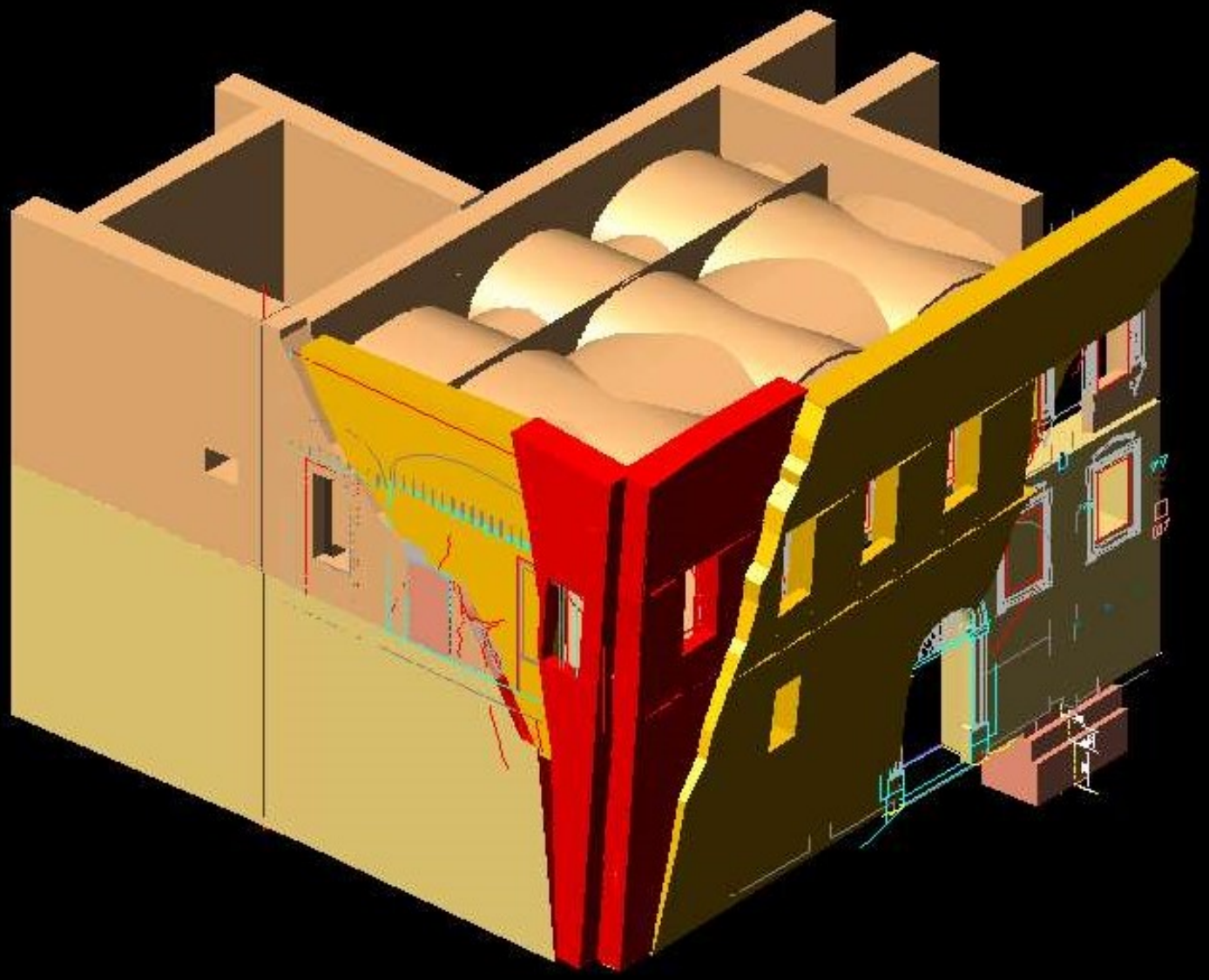
Rotazione

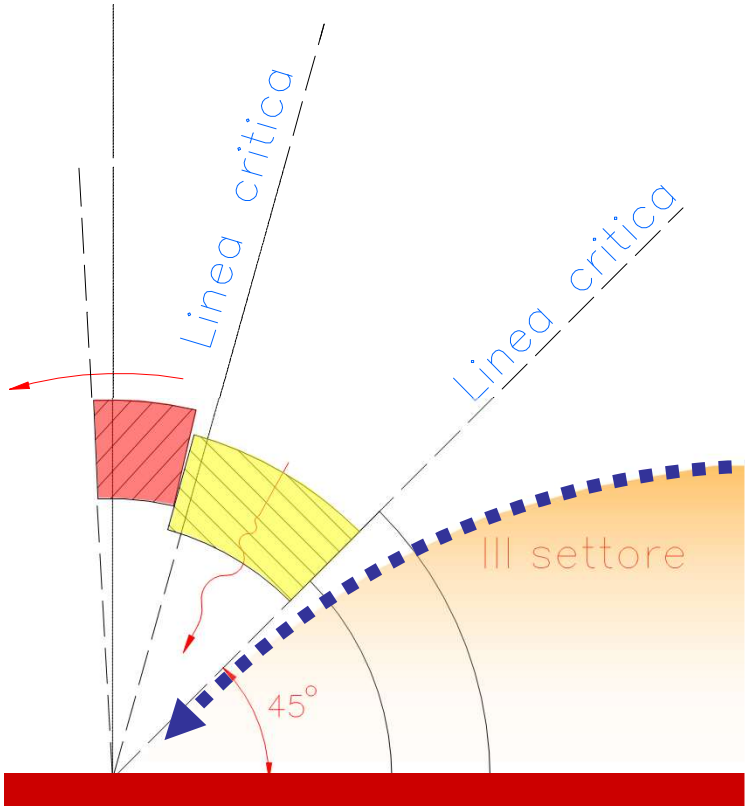


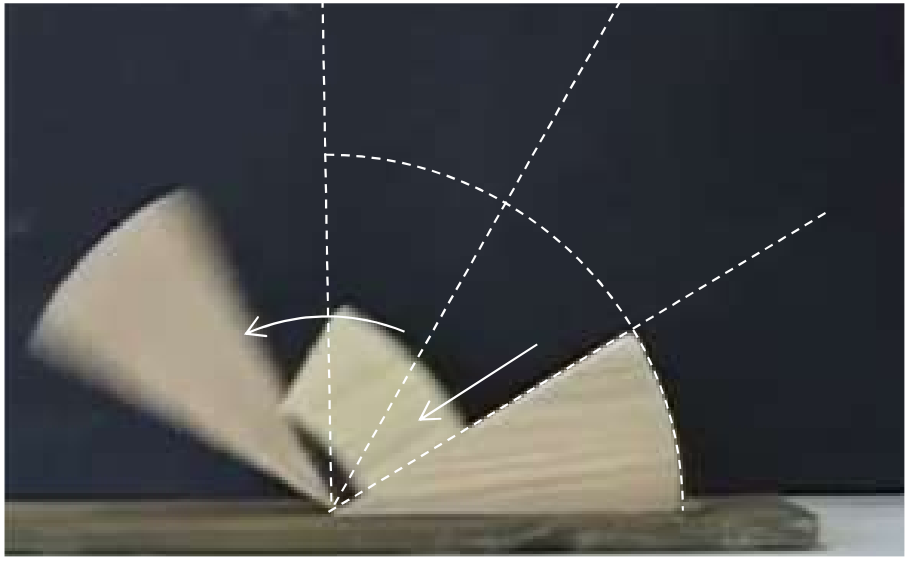
A) B) C)

Classificazione tipologica delle lesioni:

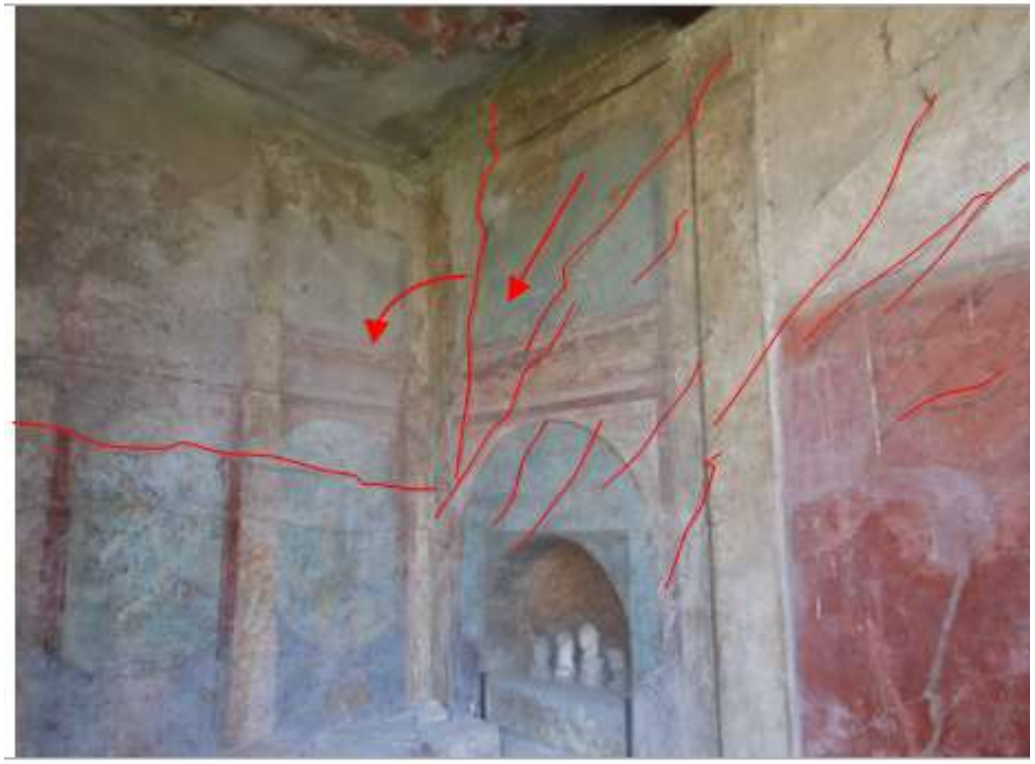
A) di strappo; B) di scorrimento nel piano; C) scorrimento fuori del piano







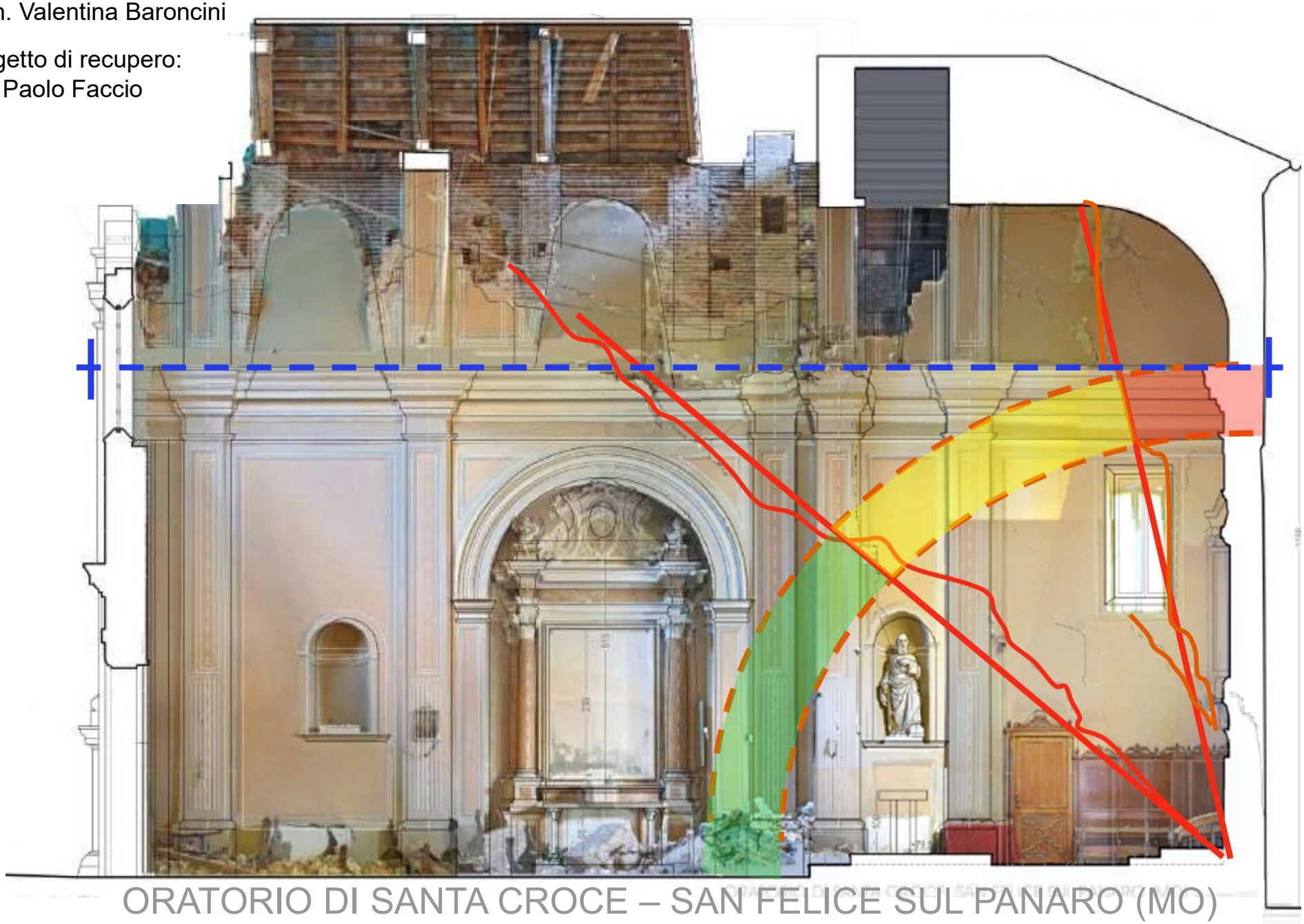
Configurazione della parete secondo il modello ad archi virtuali



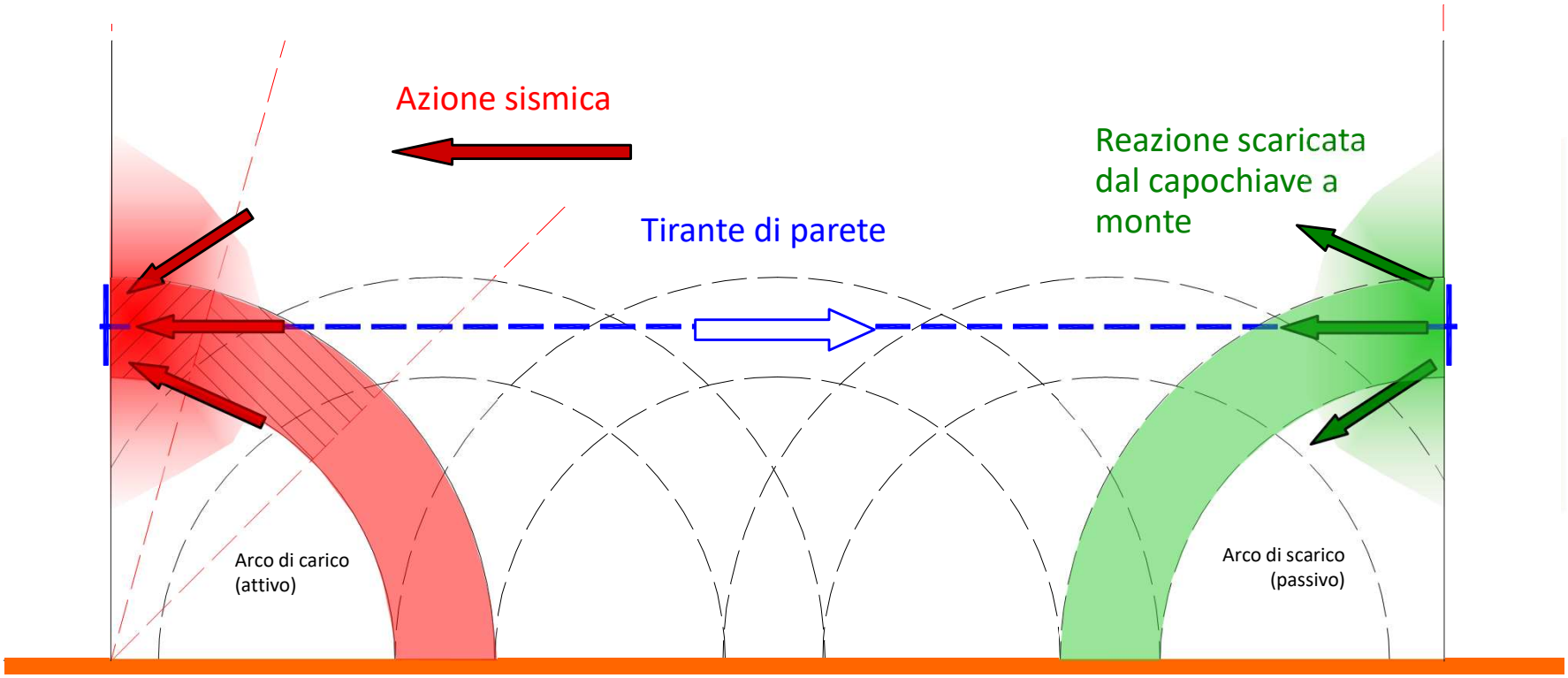
Pompei – Regio I (Casa del Menandro)
Terremoto del 62 d.C.

Rilievo:
Arch. Valentina Baroncini

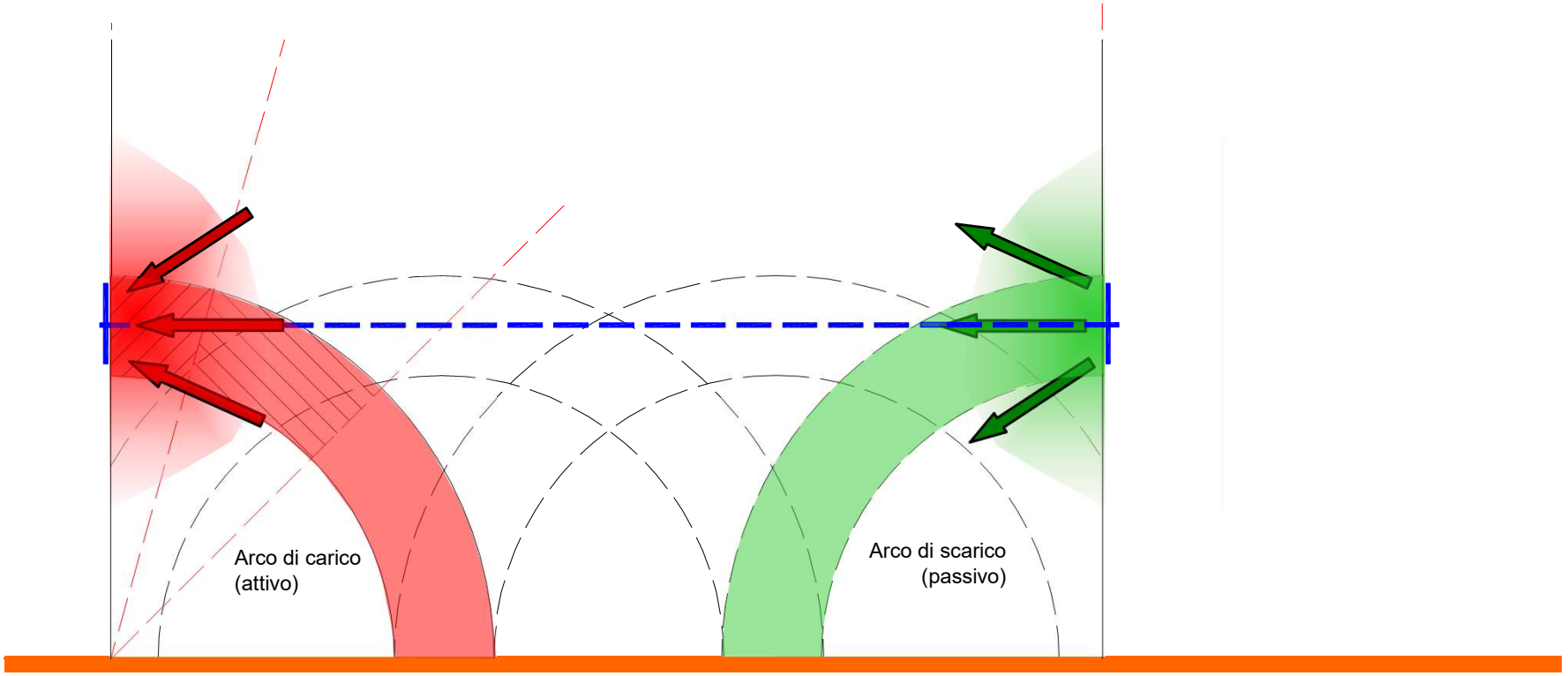
Progetto di recupero:
Ing. Paolo Faccio



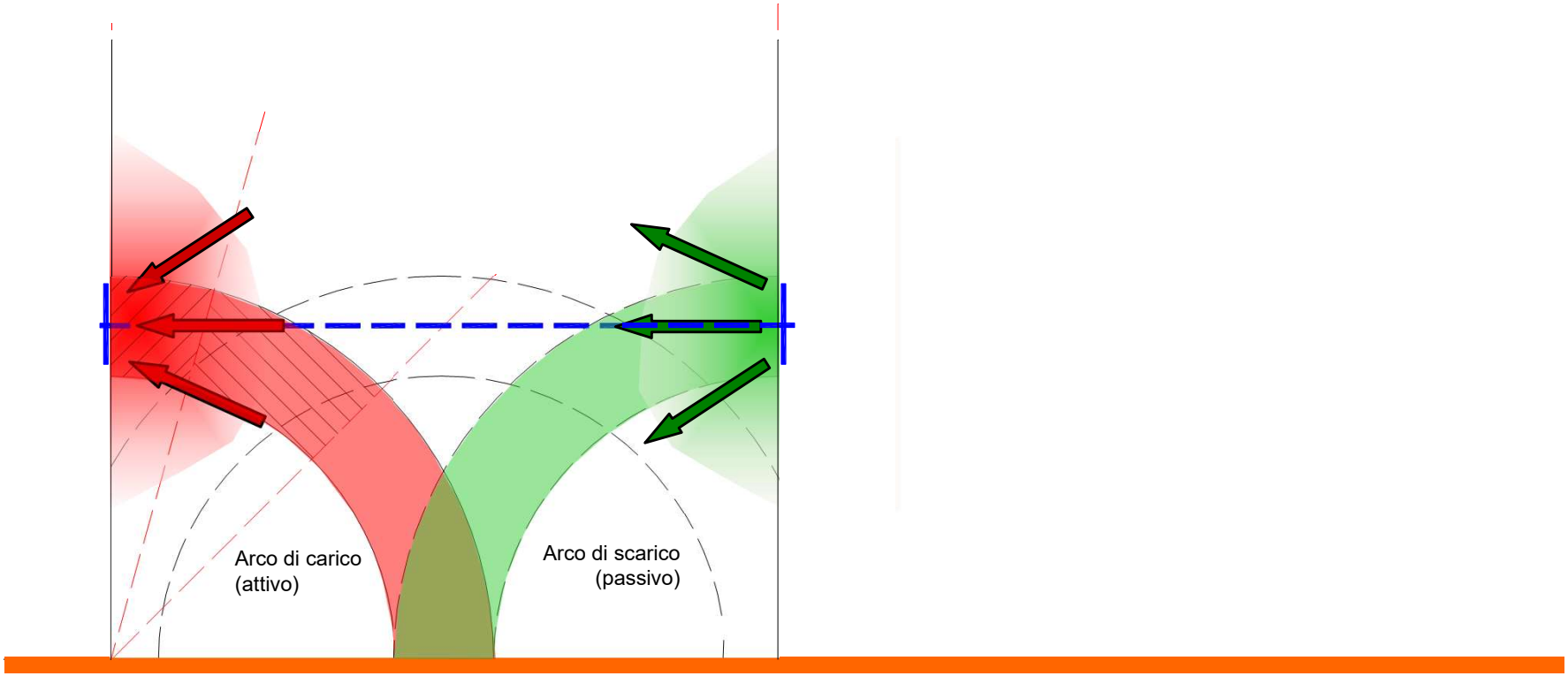
ORATORIO DI SANTA CROCE – SAN FELICE SUL PANARO (MO)



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

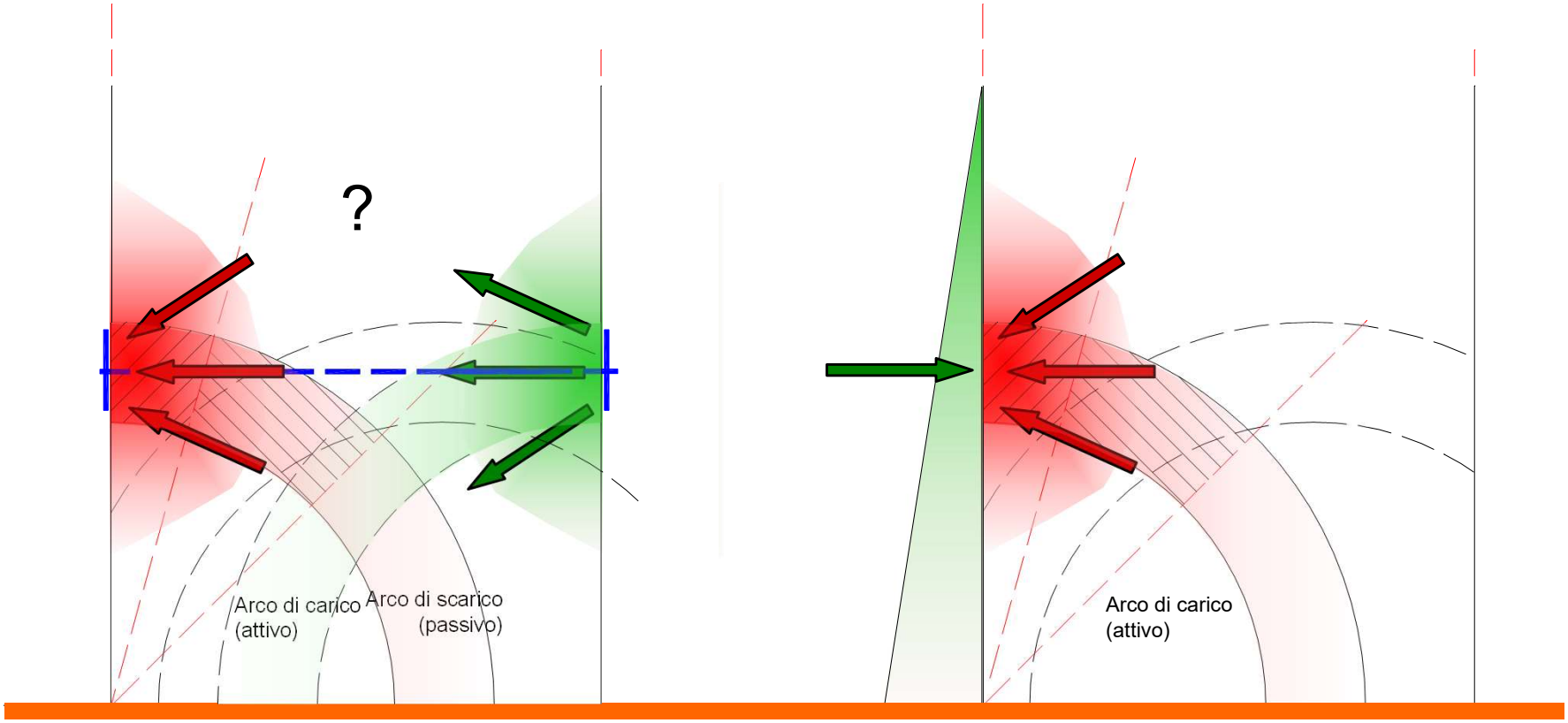


Schema di funzionamento dei tiranti di parete secondo il modello ad archi virtuali



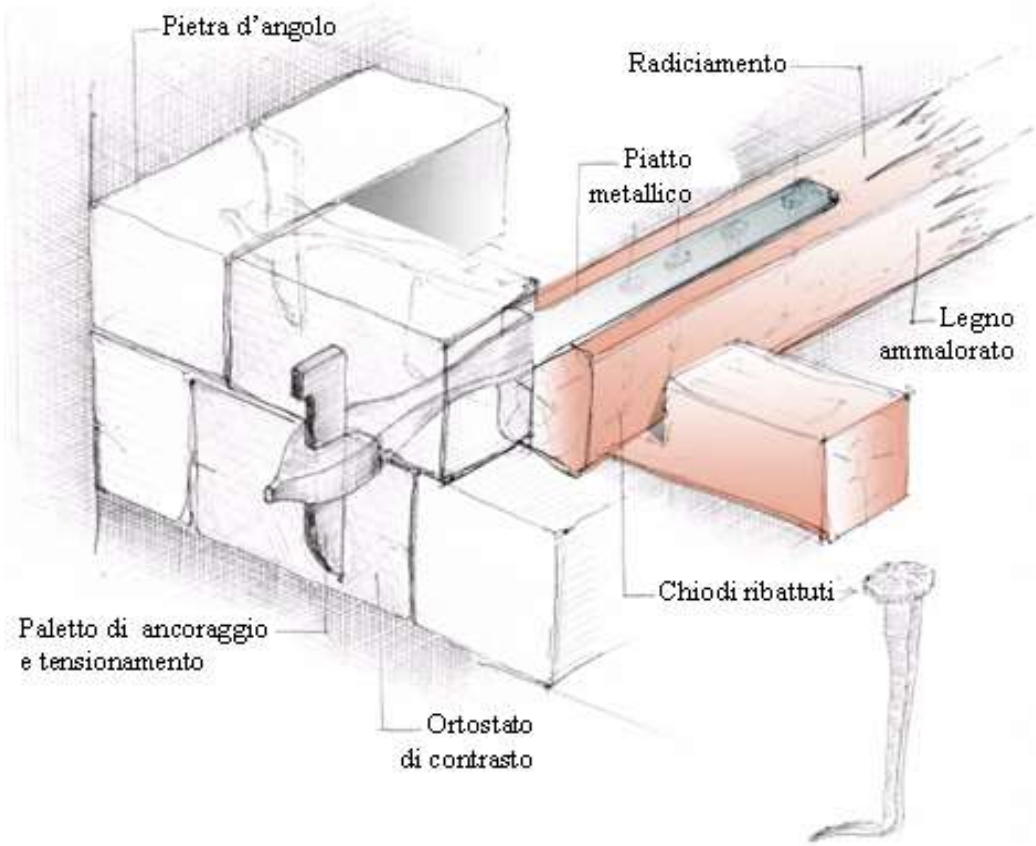
Schema di funzionamento dei tiranti di parete secondo il modello ad archi virtuali

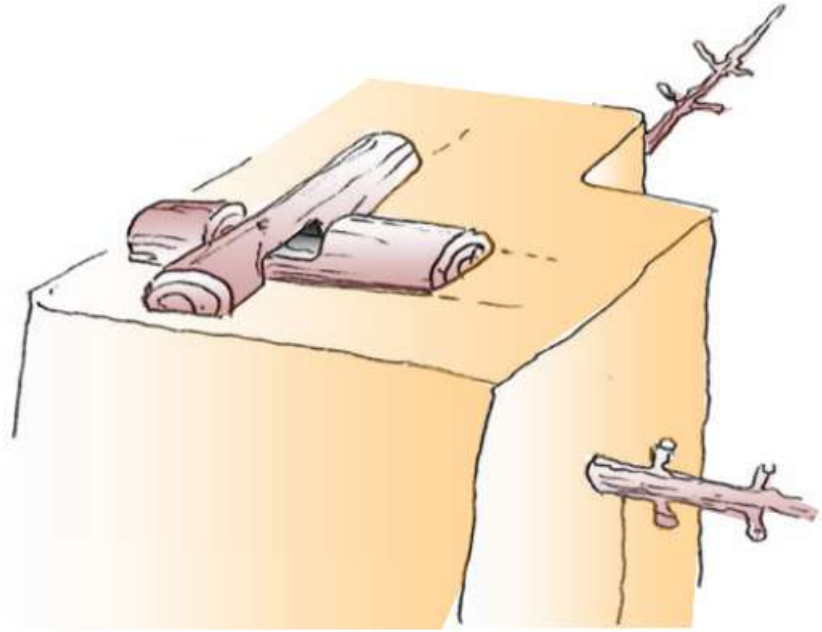
Limite di funzionamento



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

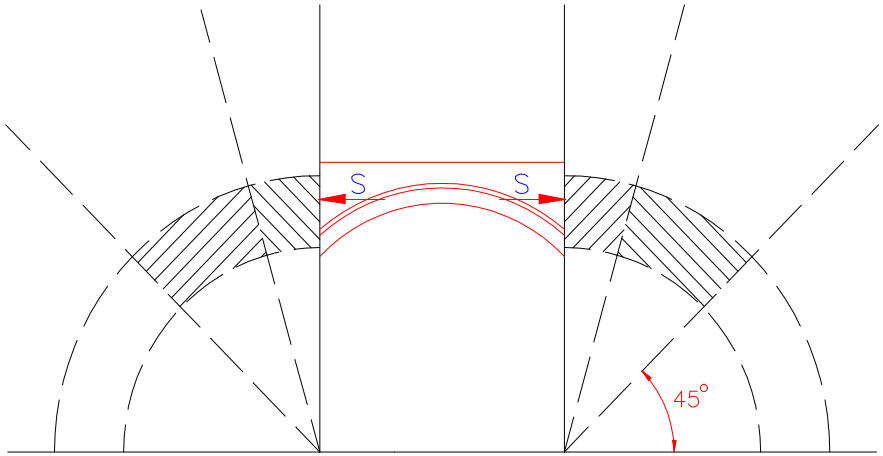
Limite di funzionamento – Intreccio fra l'arco di carico e l'arco di scarico


Pietra d'angolo
Radiciamento
Piatto metallico
Legno ammalorato
Chiodi ribattuti
Paletto di ancoraggio e tensionamento
Ortostato di contrasto





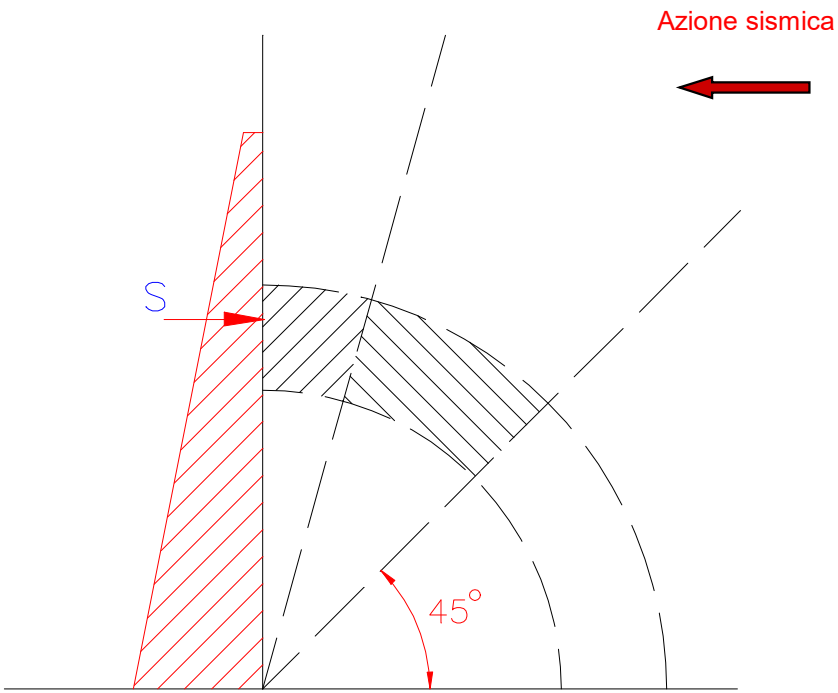
Archi di sbatacchio



Lugnano, 1917

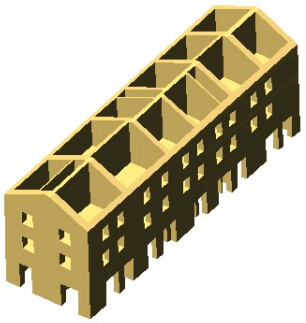


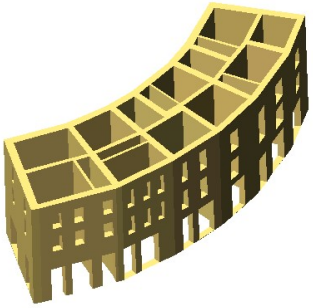
Archi di sbatacchio



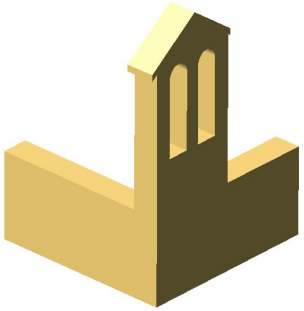
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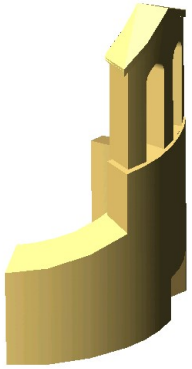


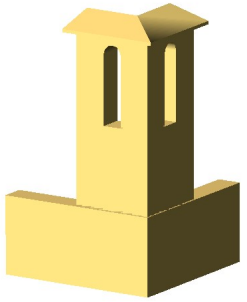




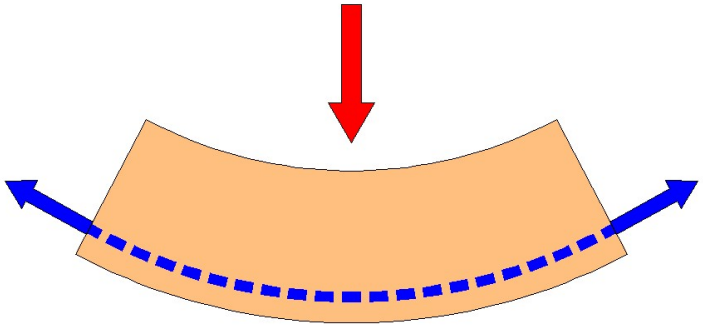




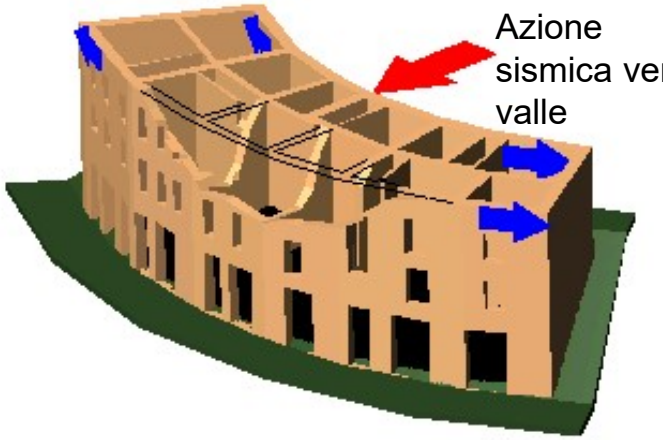


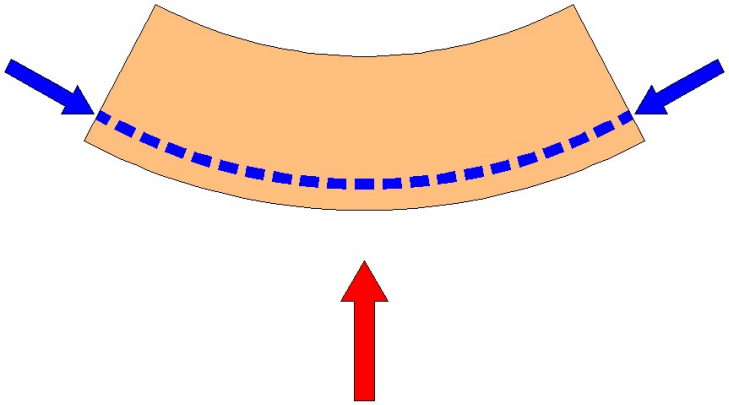


Effetti del sisma ortogonale negli isolati ad impianto curvilineo

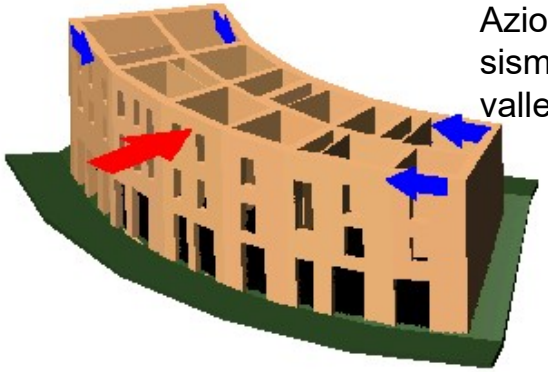


L'azione sismica verso valle mette in trazione la parete di facciata ((Allentamento parete di valle)

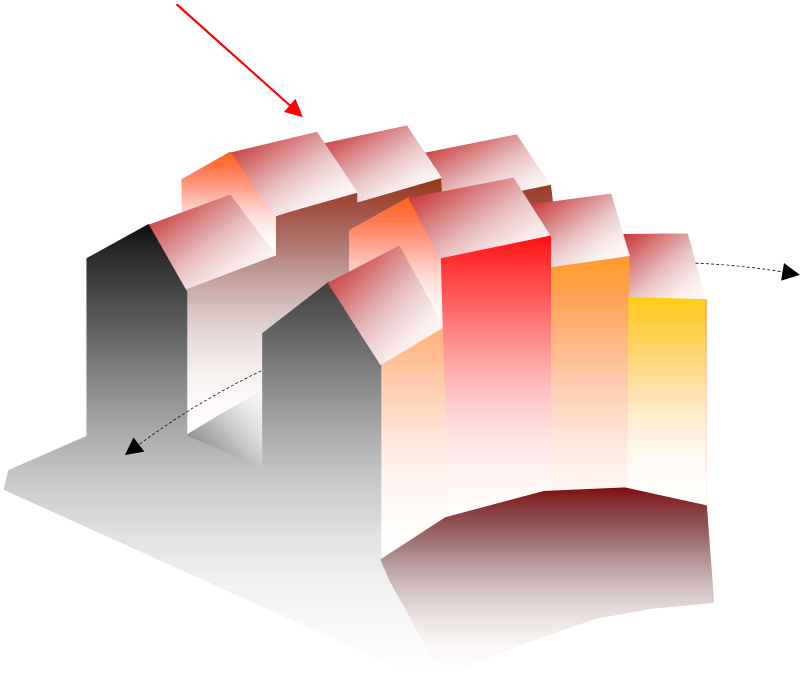




L'azione sismica verso monte comprime le pareti di facciata (Effetto arco)

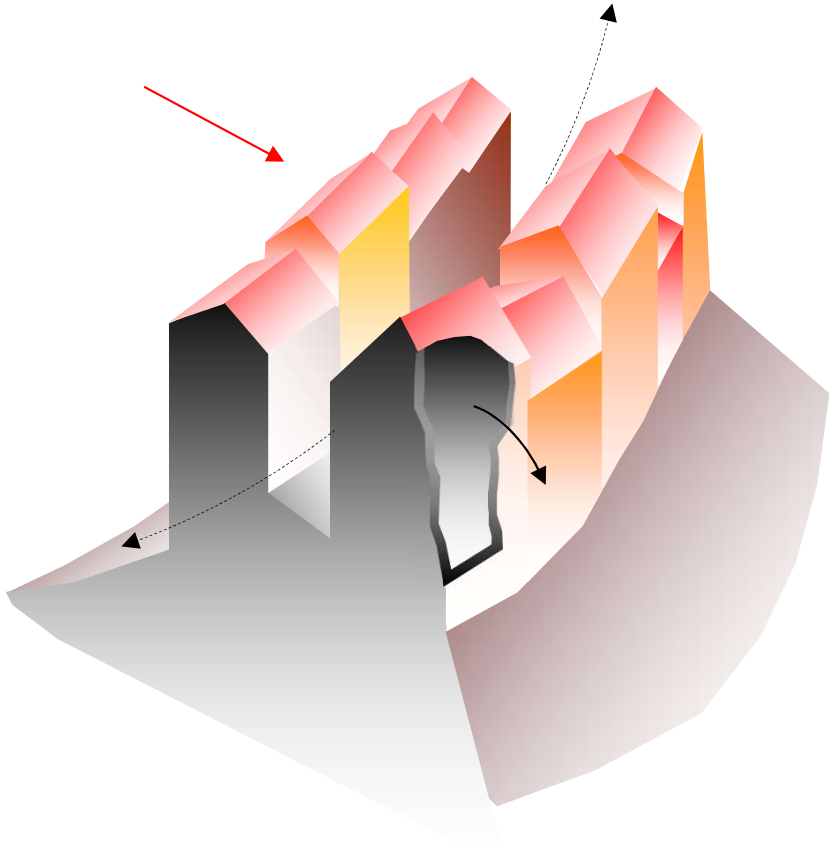


Valutazione del rischio sismico alla scala urbana

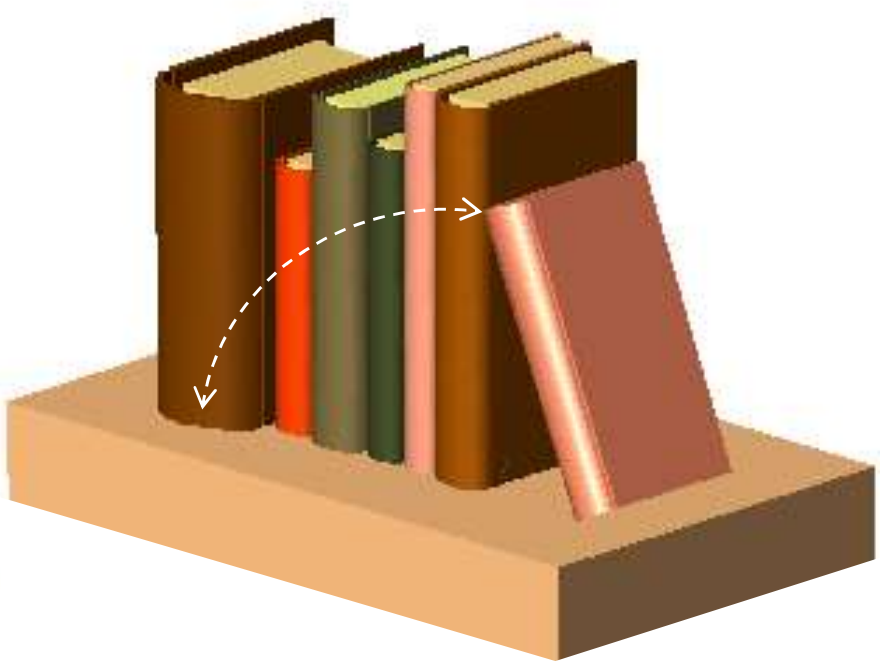


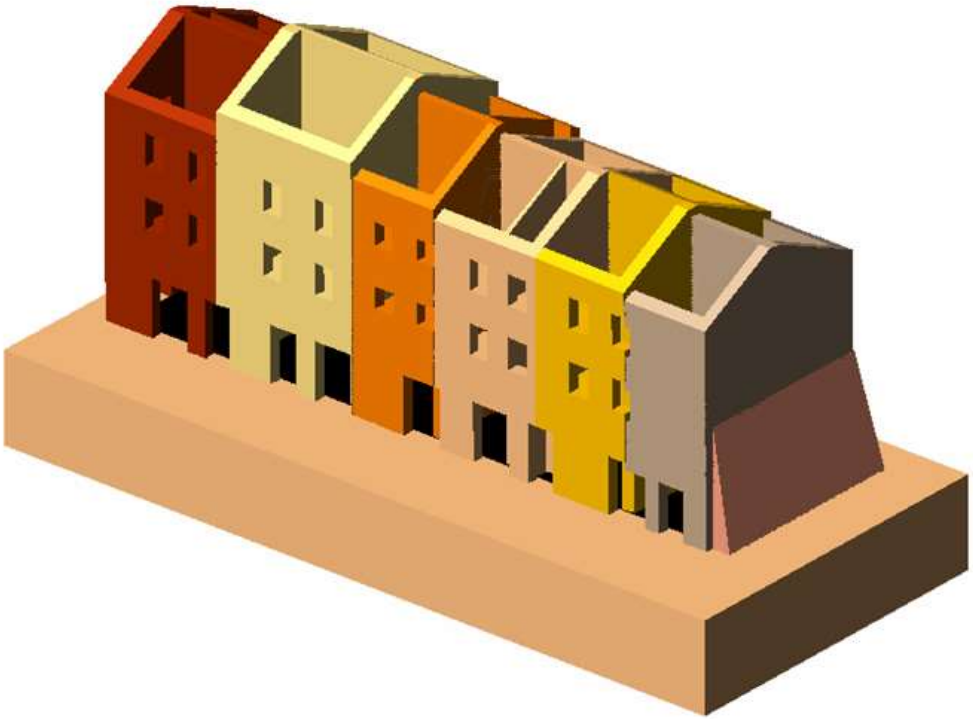


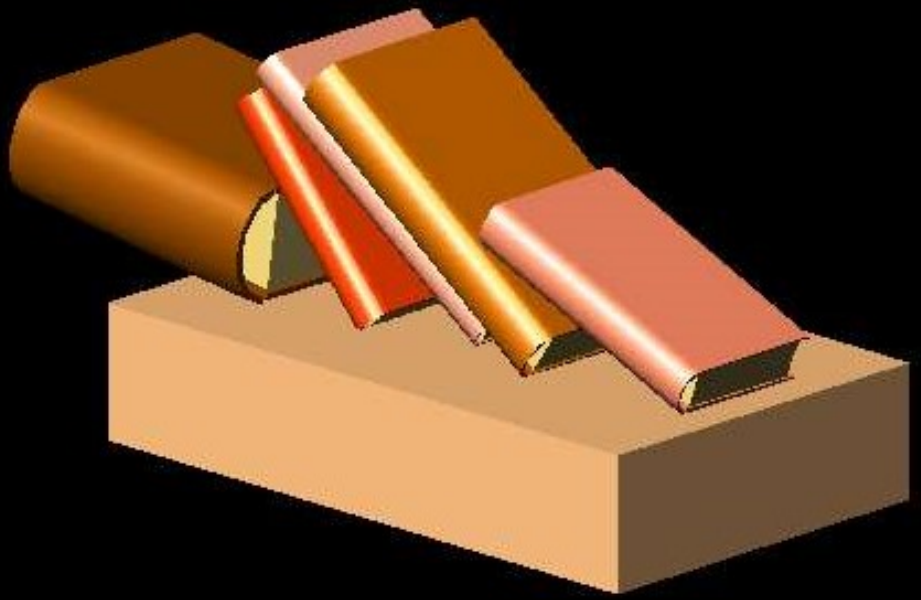
Valutazione del rischio sismico alla scala urbana

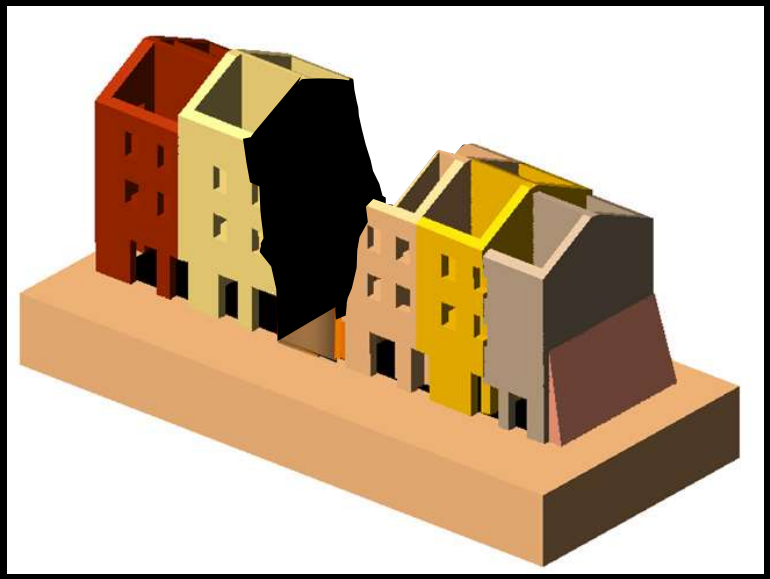






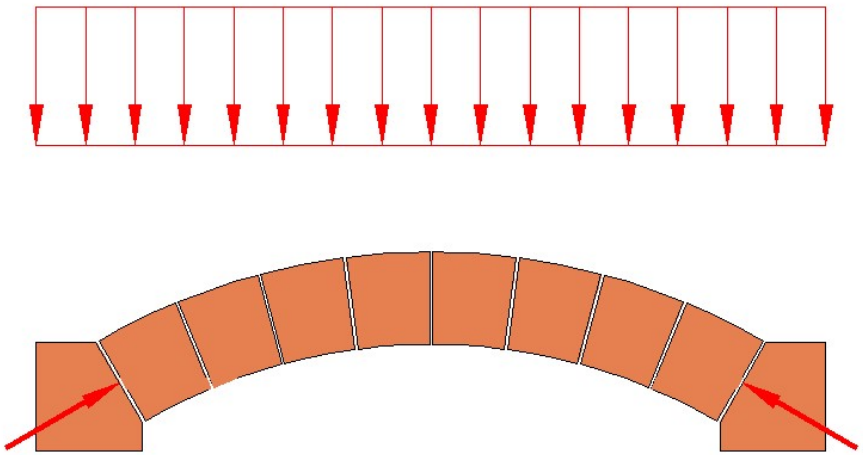


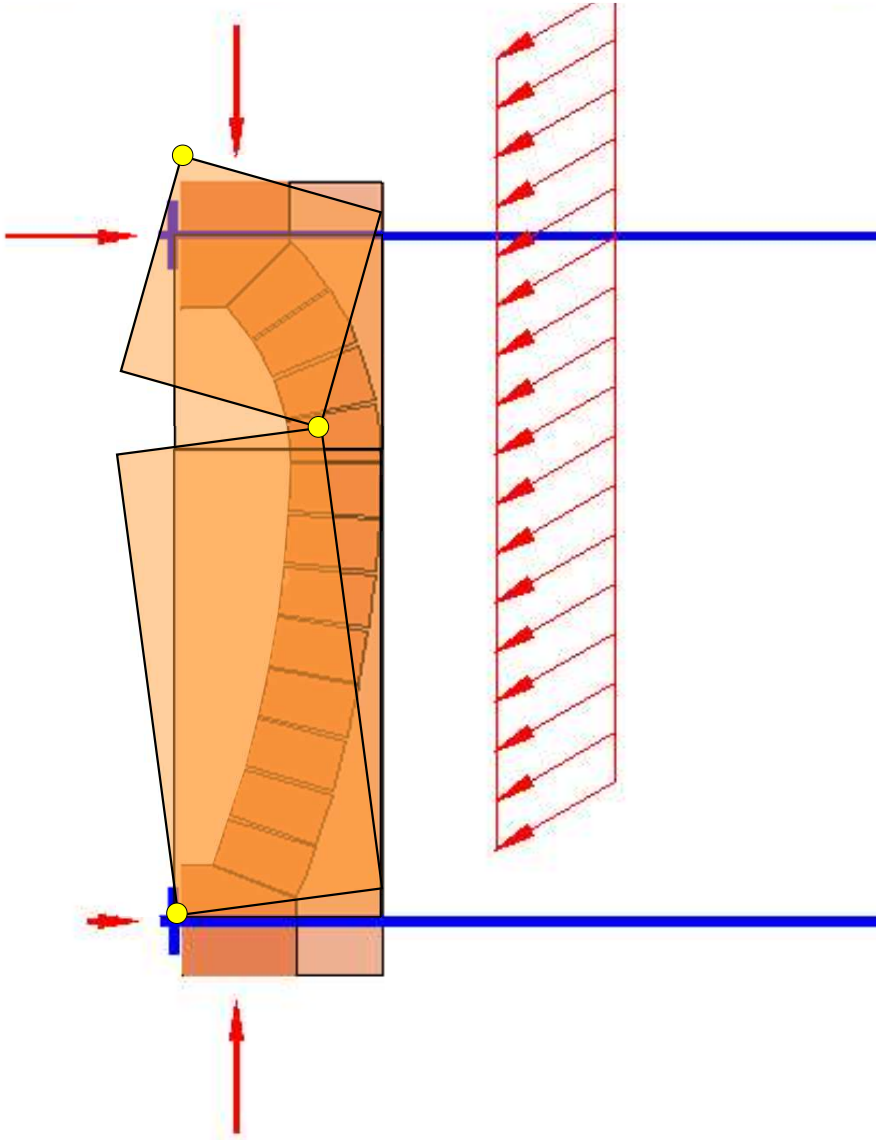


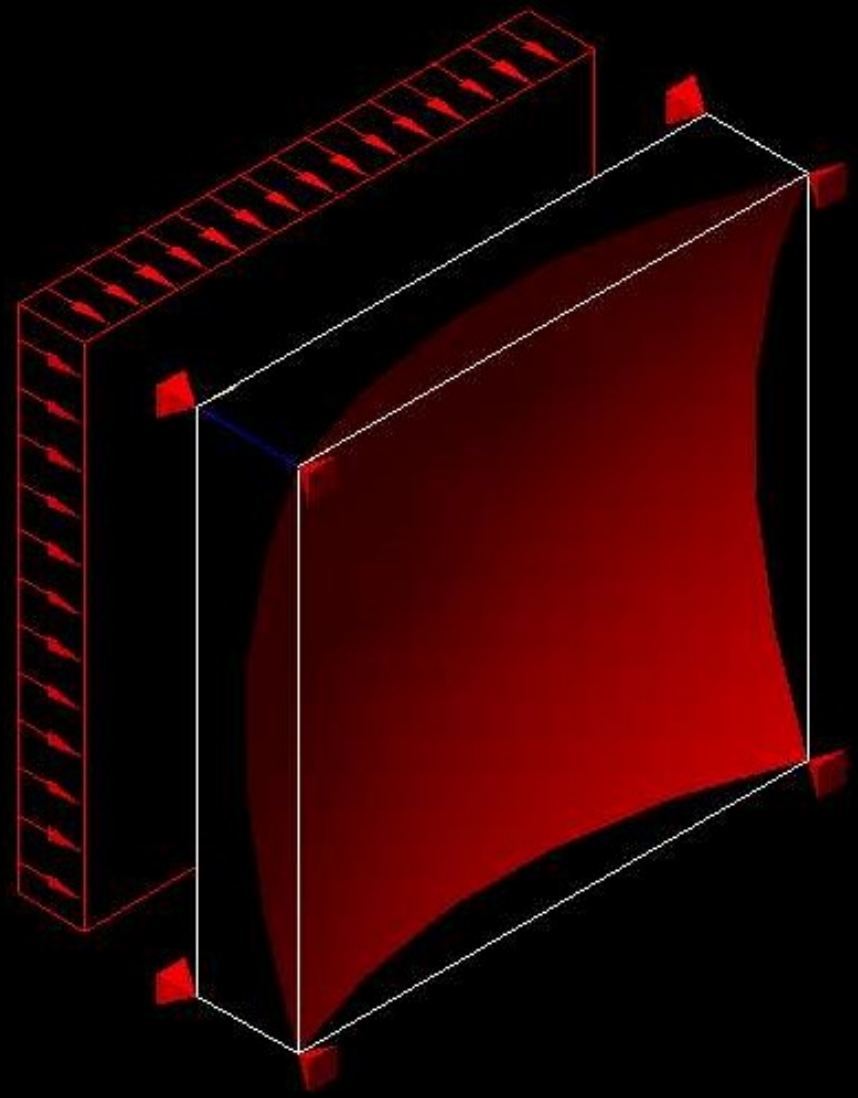


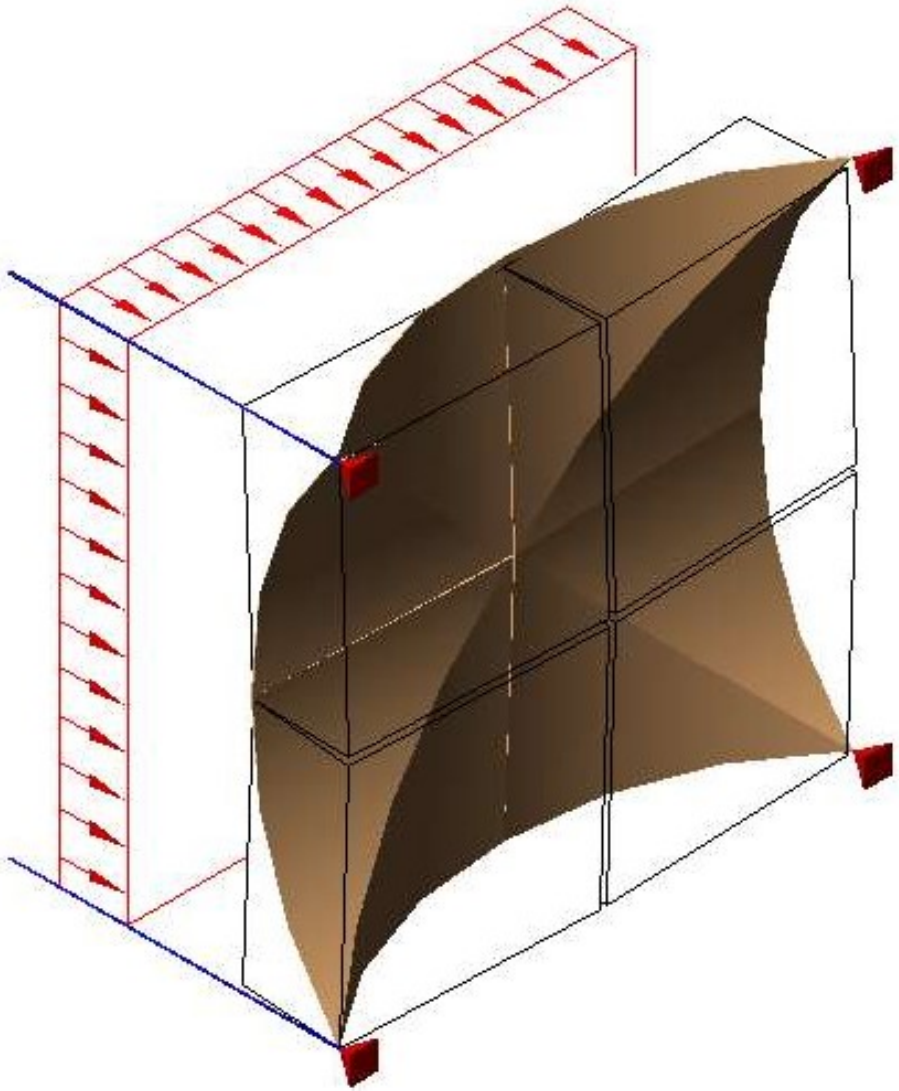


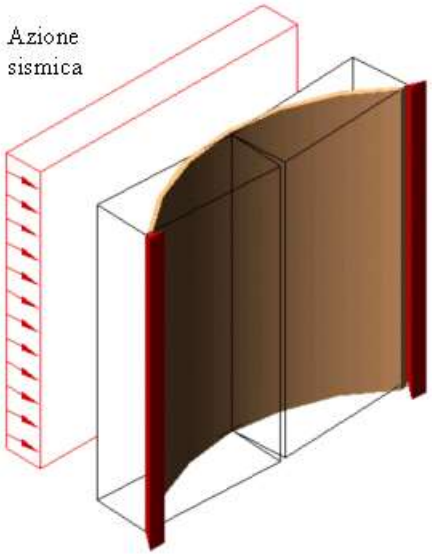
L’Aquila – 6 aprile 2009





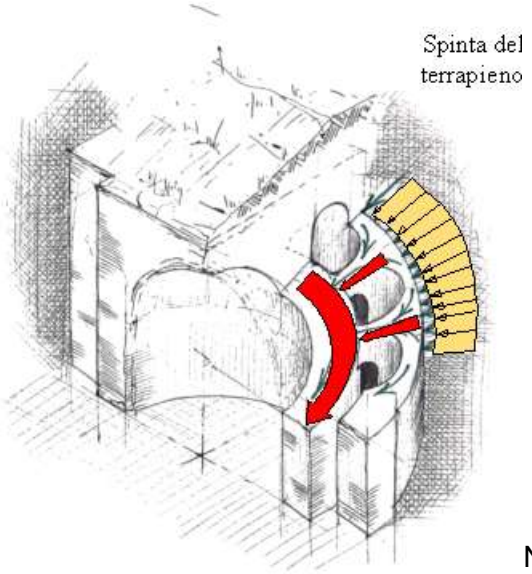






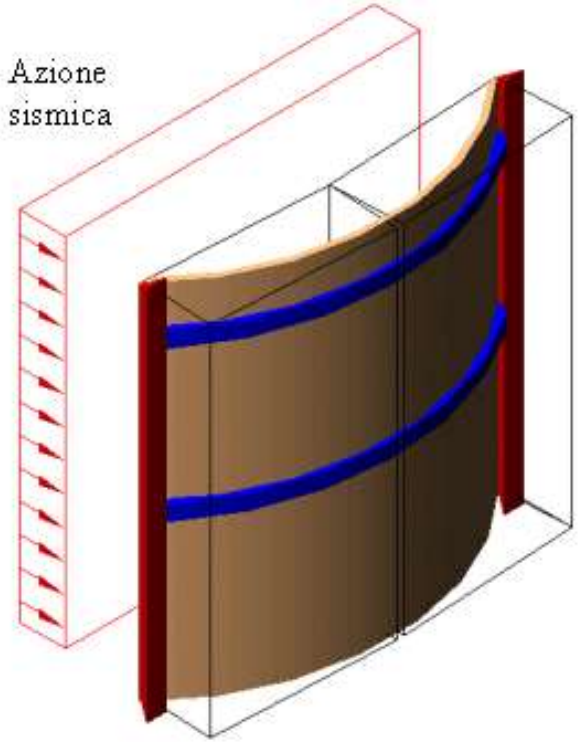


L'Aquila - Chiesa delle Anime Sante



Roma – Podio del Tempio di Claudio al Celio

Nicchioni lungo Via Claudia

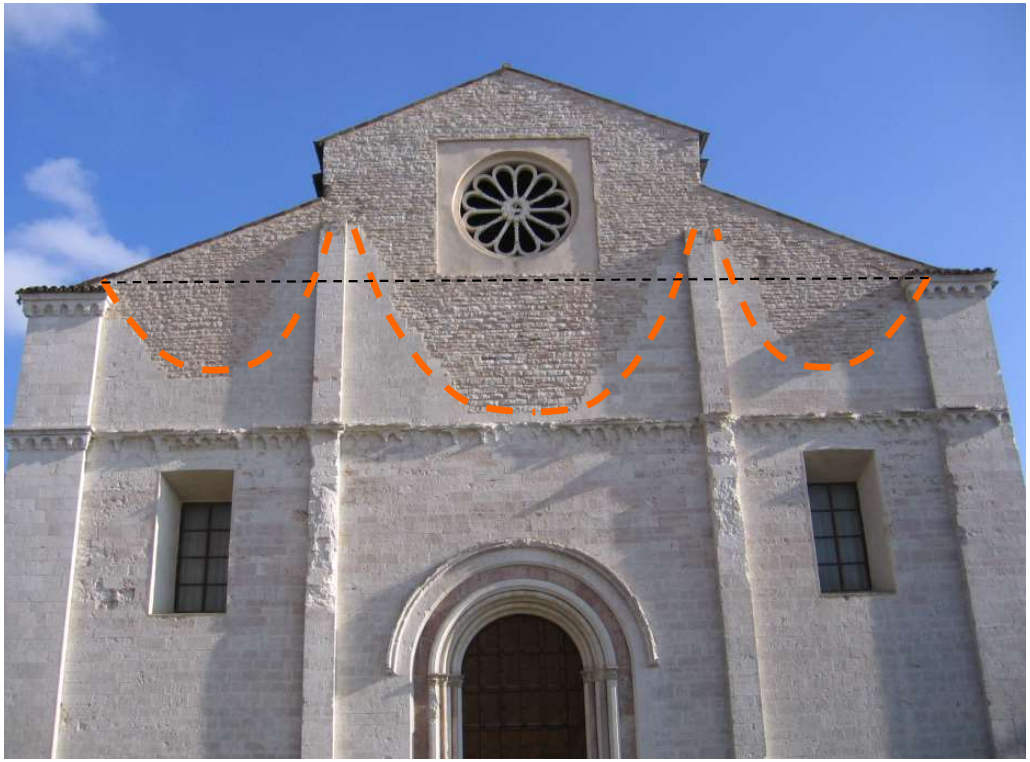


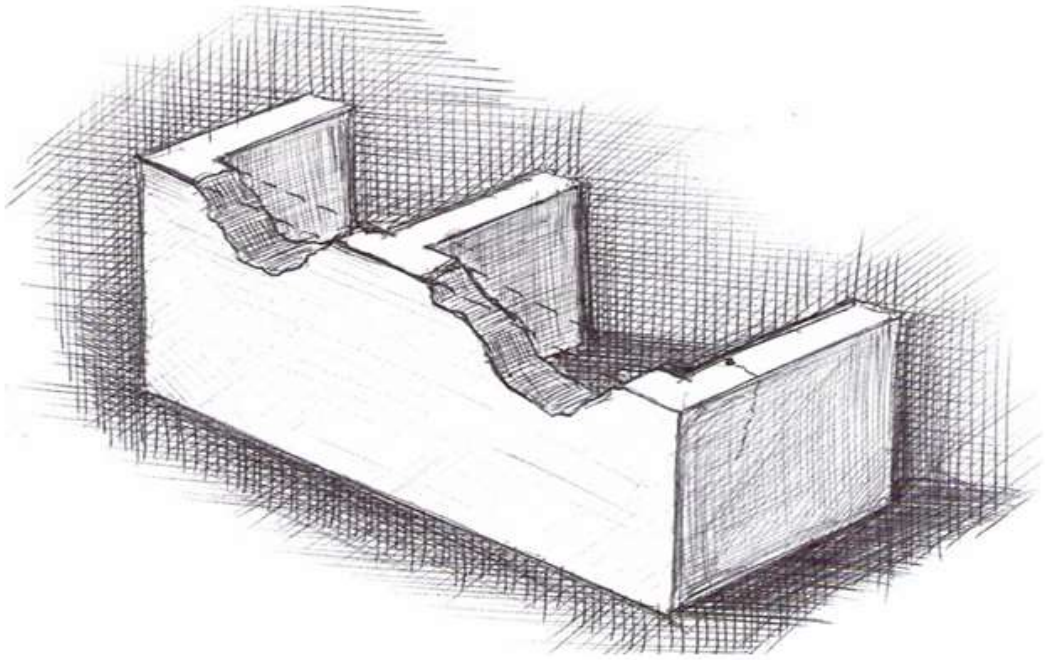


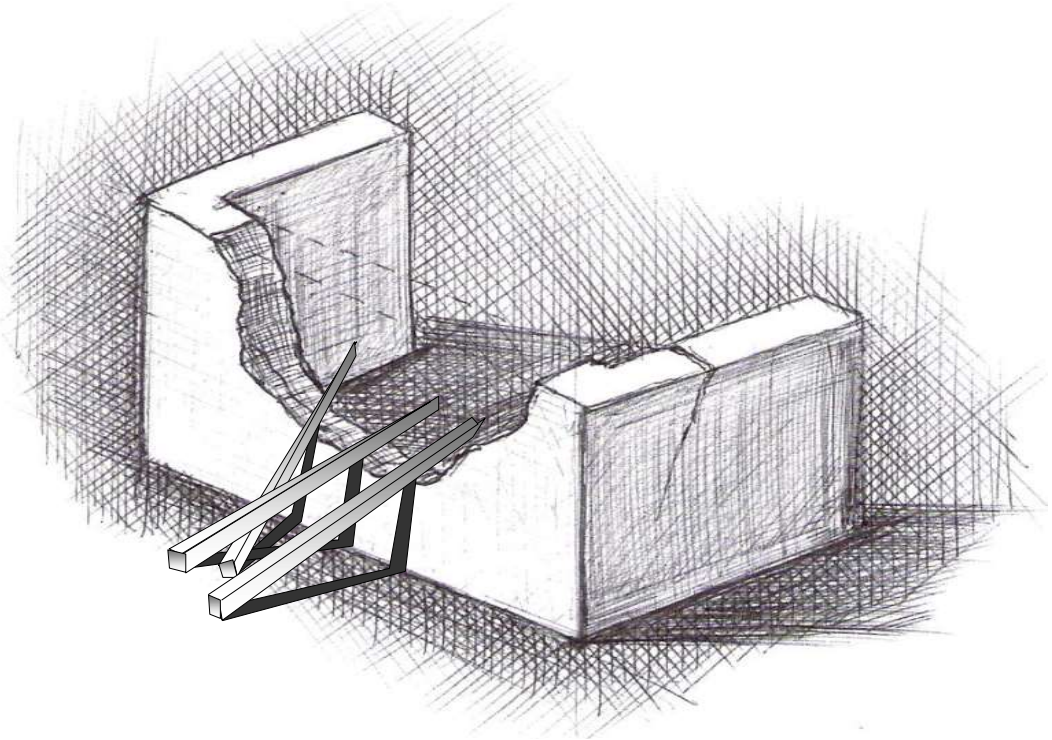
Chiesa dell'Immacolata a Paganica

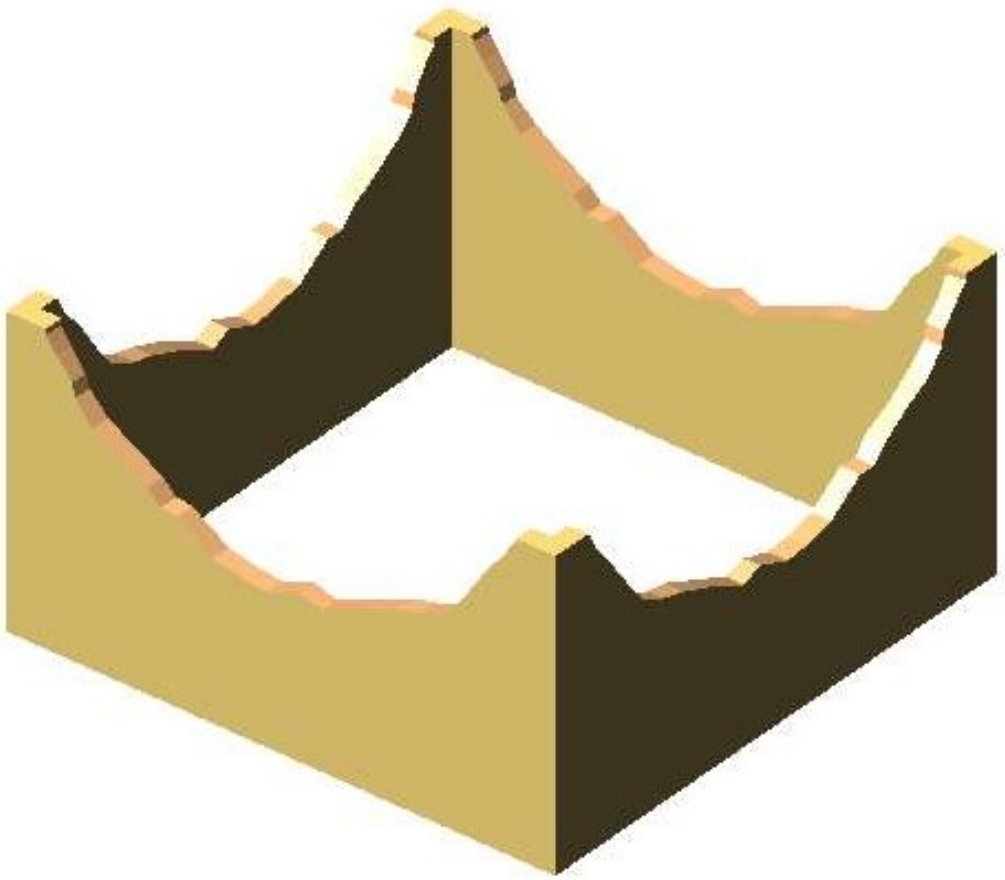


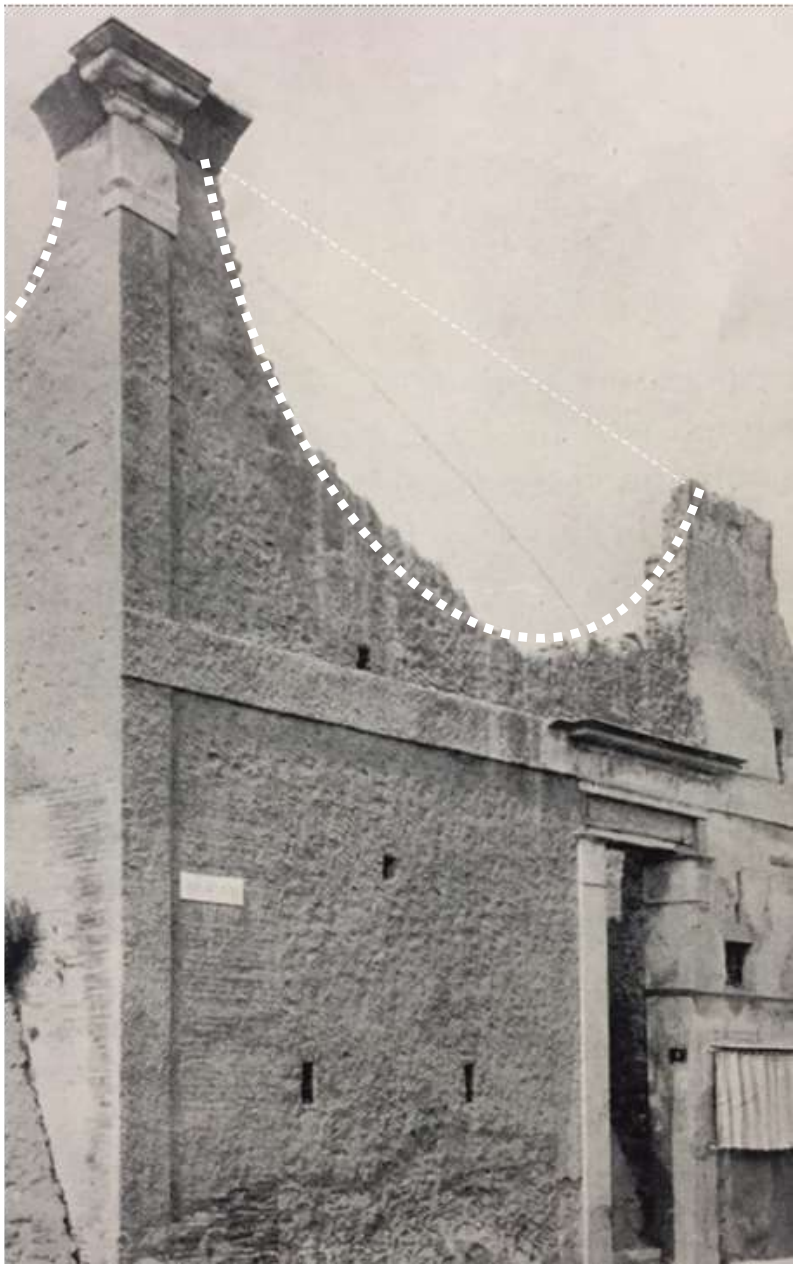




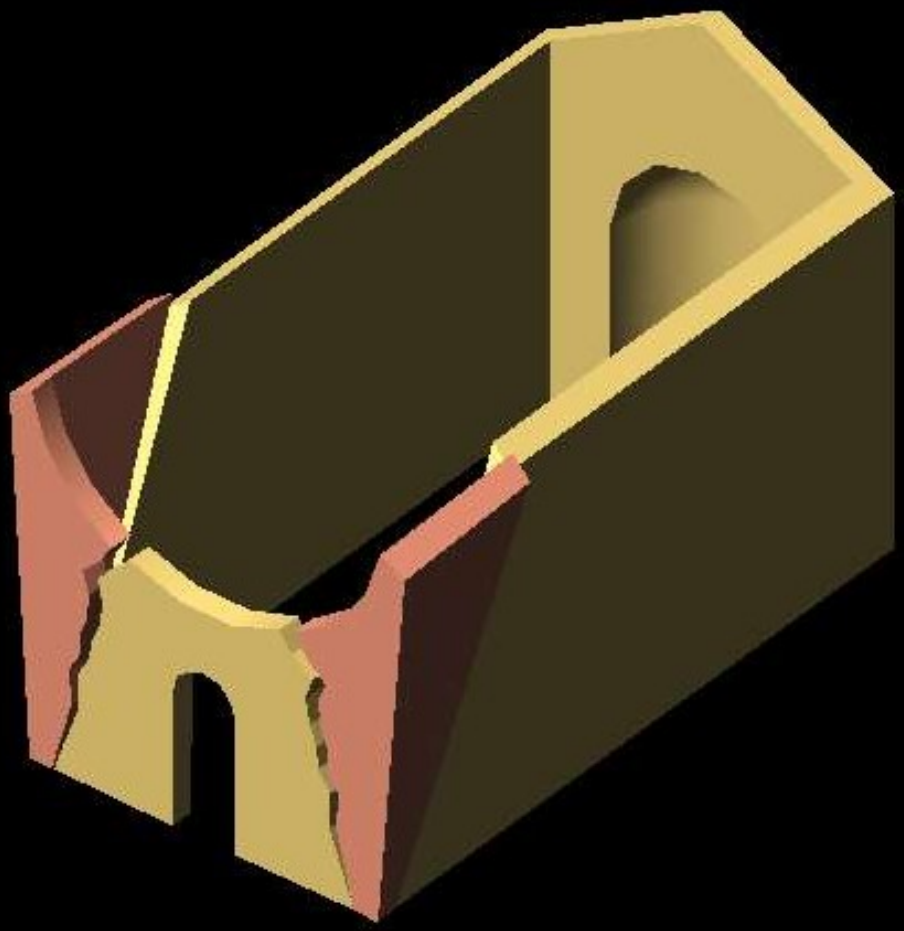


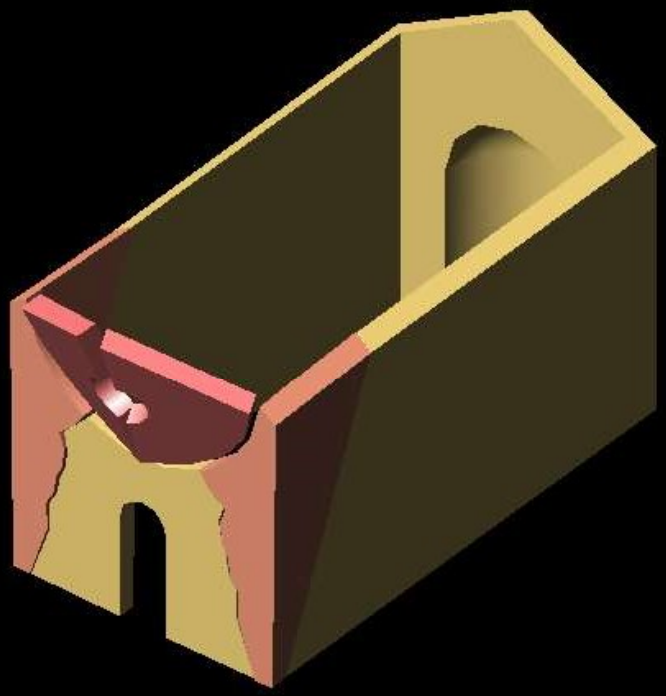




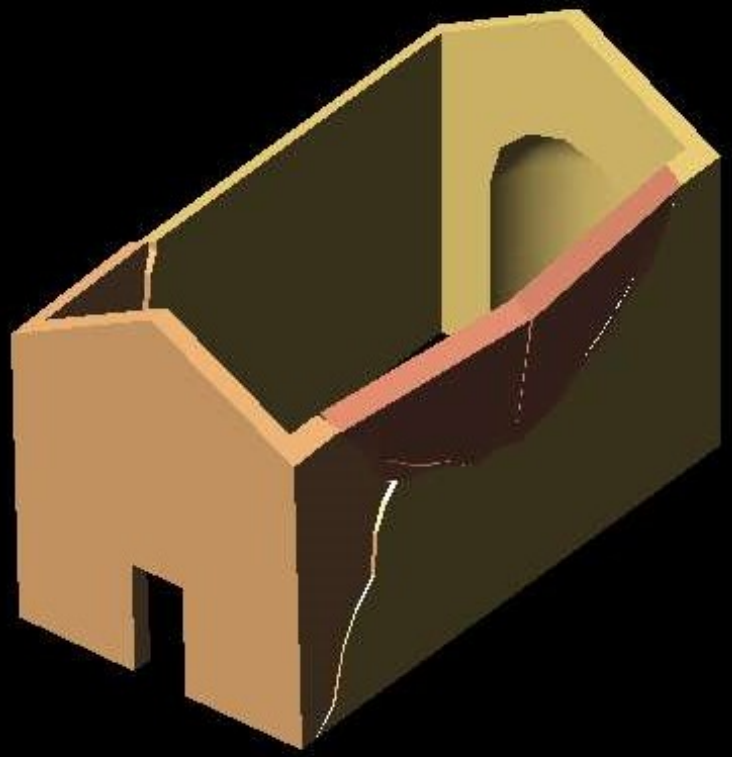


Pompei: Casa dei Polybii (IX, XIII, I-3)

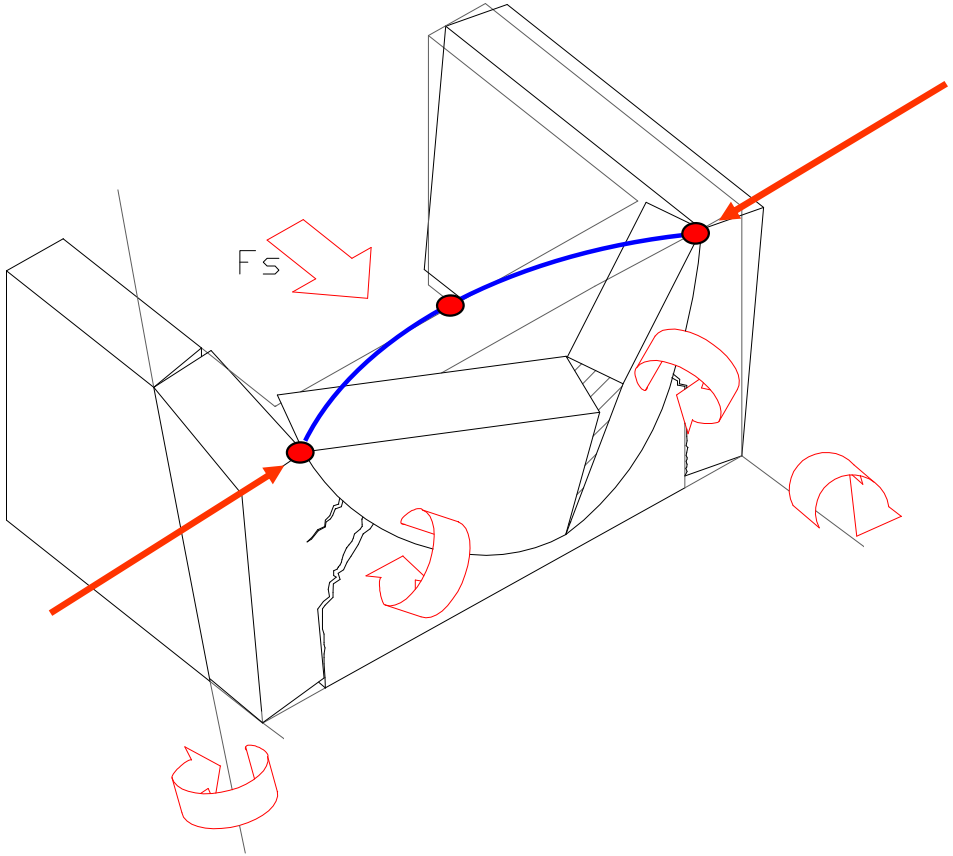




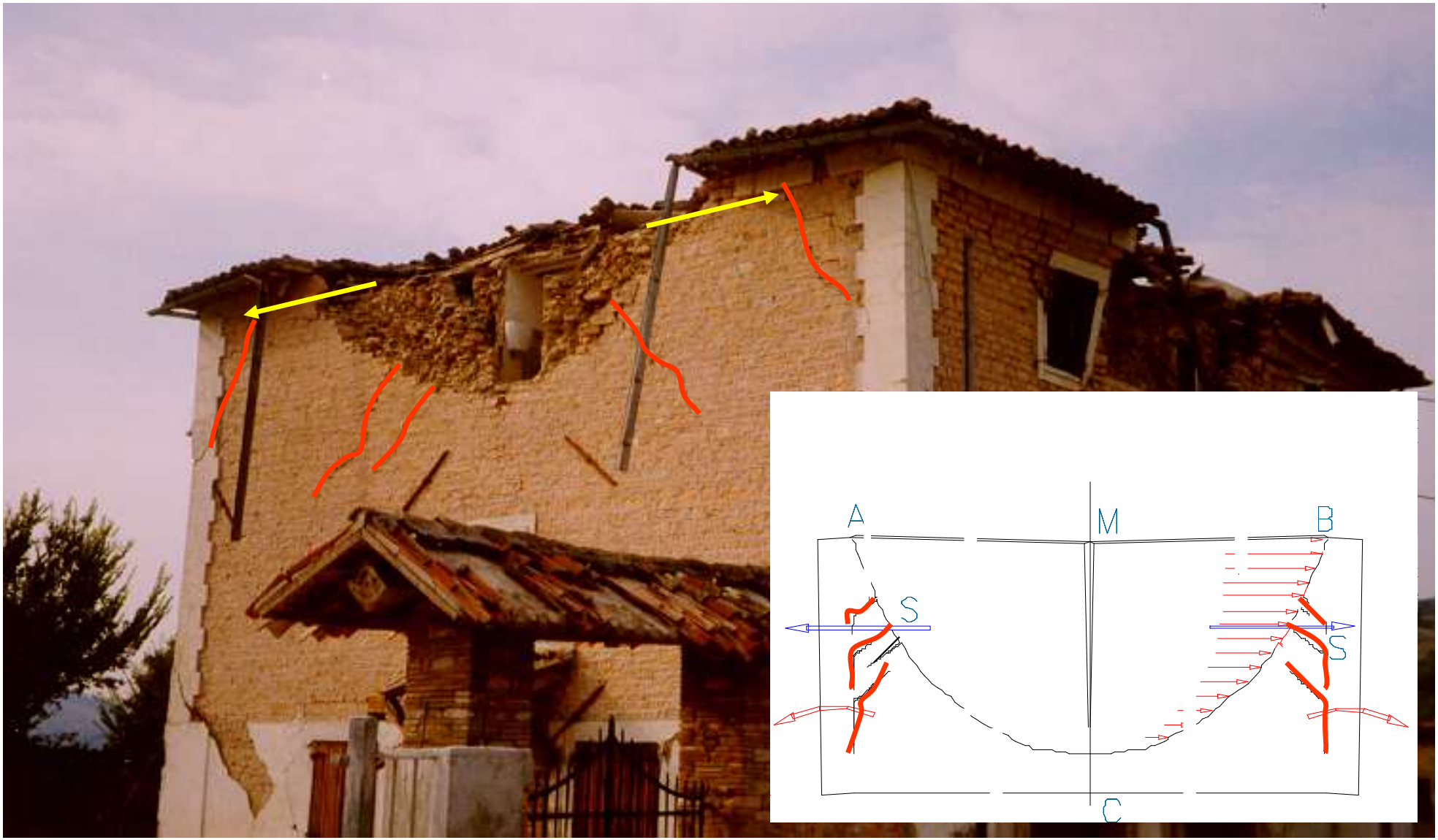




Cinematismi di danno tipici
delle chiese a navata unica



Ribaltamento pareti sollecitate da azioni ortogonali



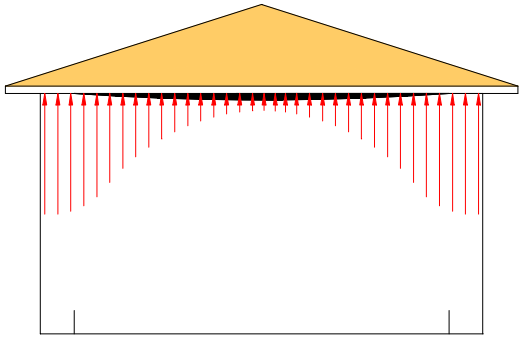
Edificio di Sellano (PG) danneggiato dal sisma del 1997

Foto Ing. A. Anastasi

Comportamento anomalo delle coperture rigide

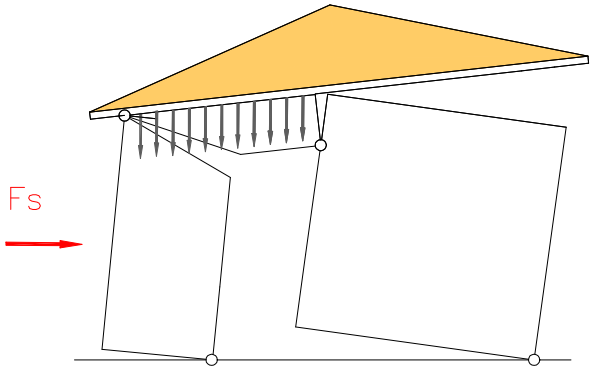


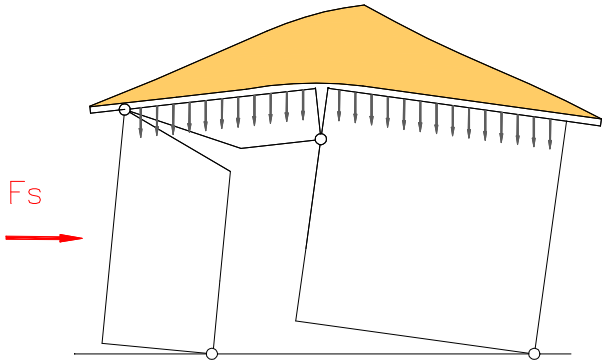
Umbria: terremoto 1997



Effetto trave

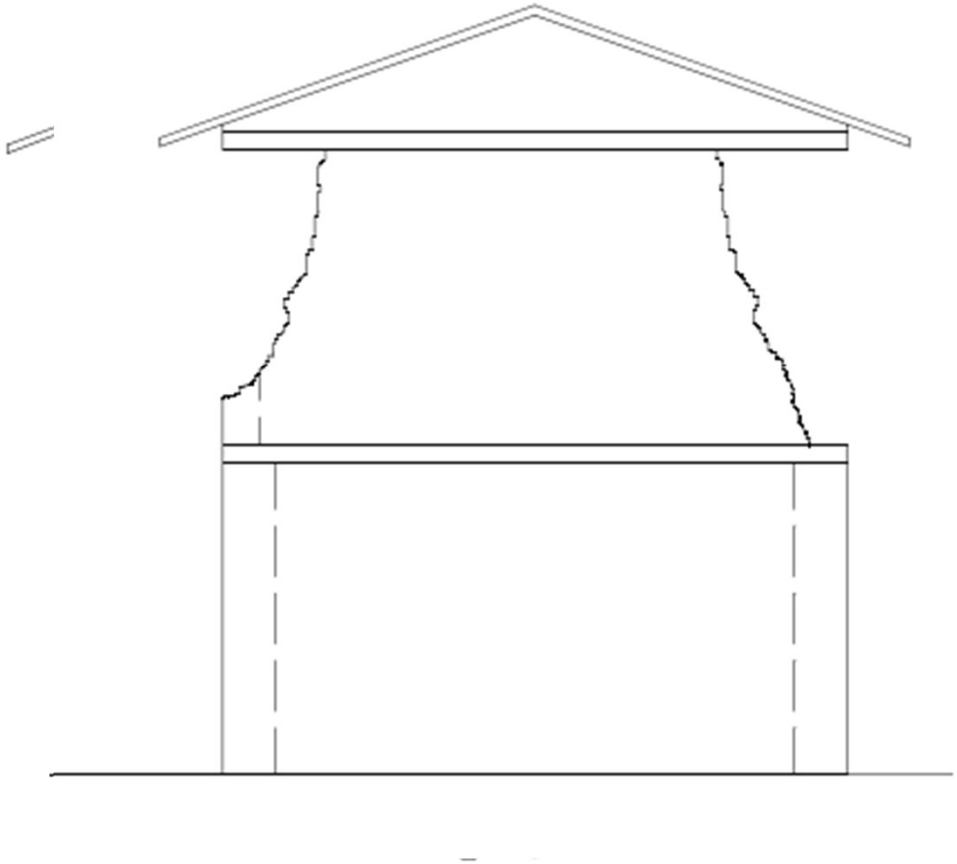
Comportamento statico delle coperture rigide





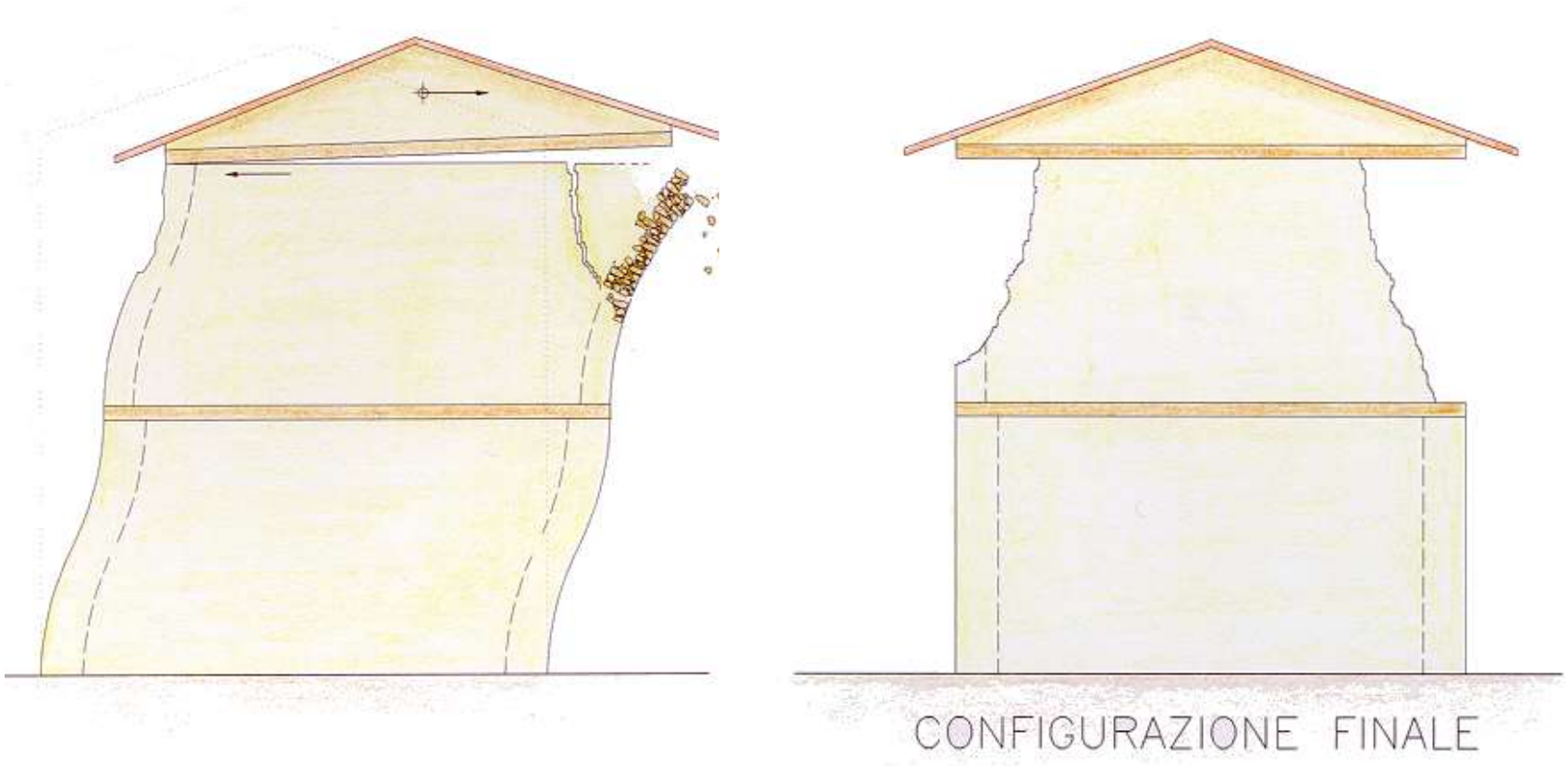
Comportamento cinematico in presenza di coperture rigide o deformabili

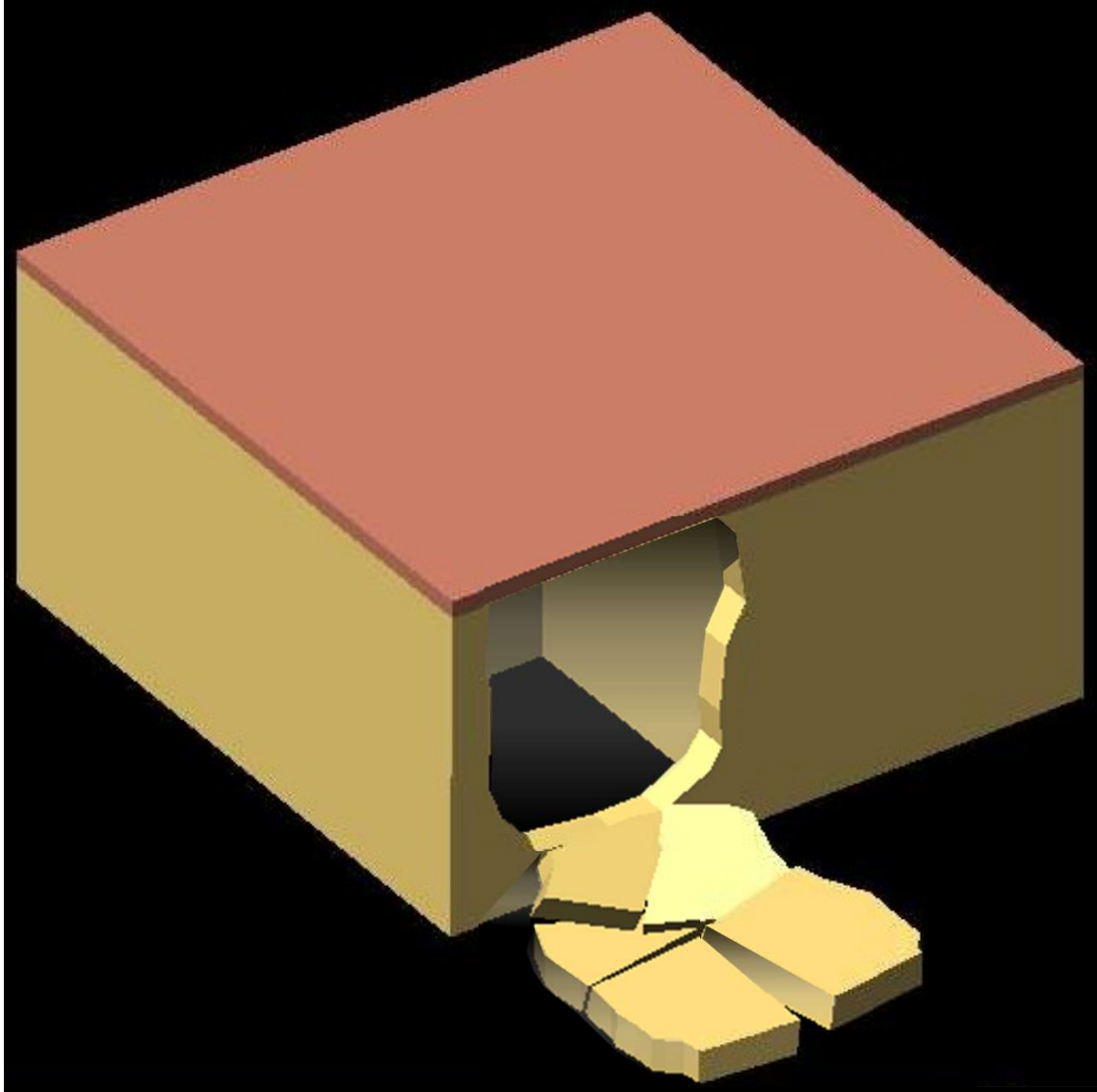
Effetti sull’irrigidimento
delle coperture con
cordoli in cemento armato



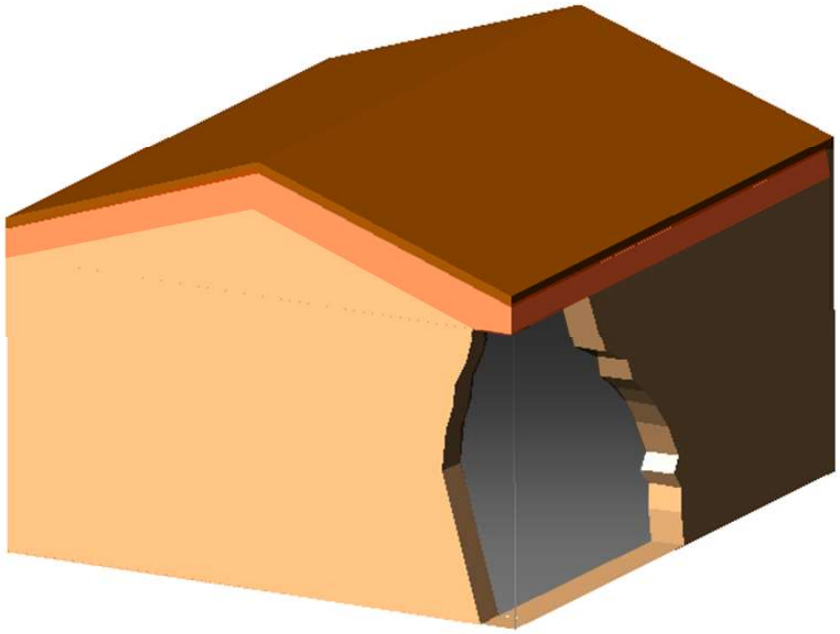
Effetto dinamico

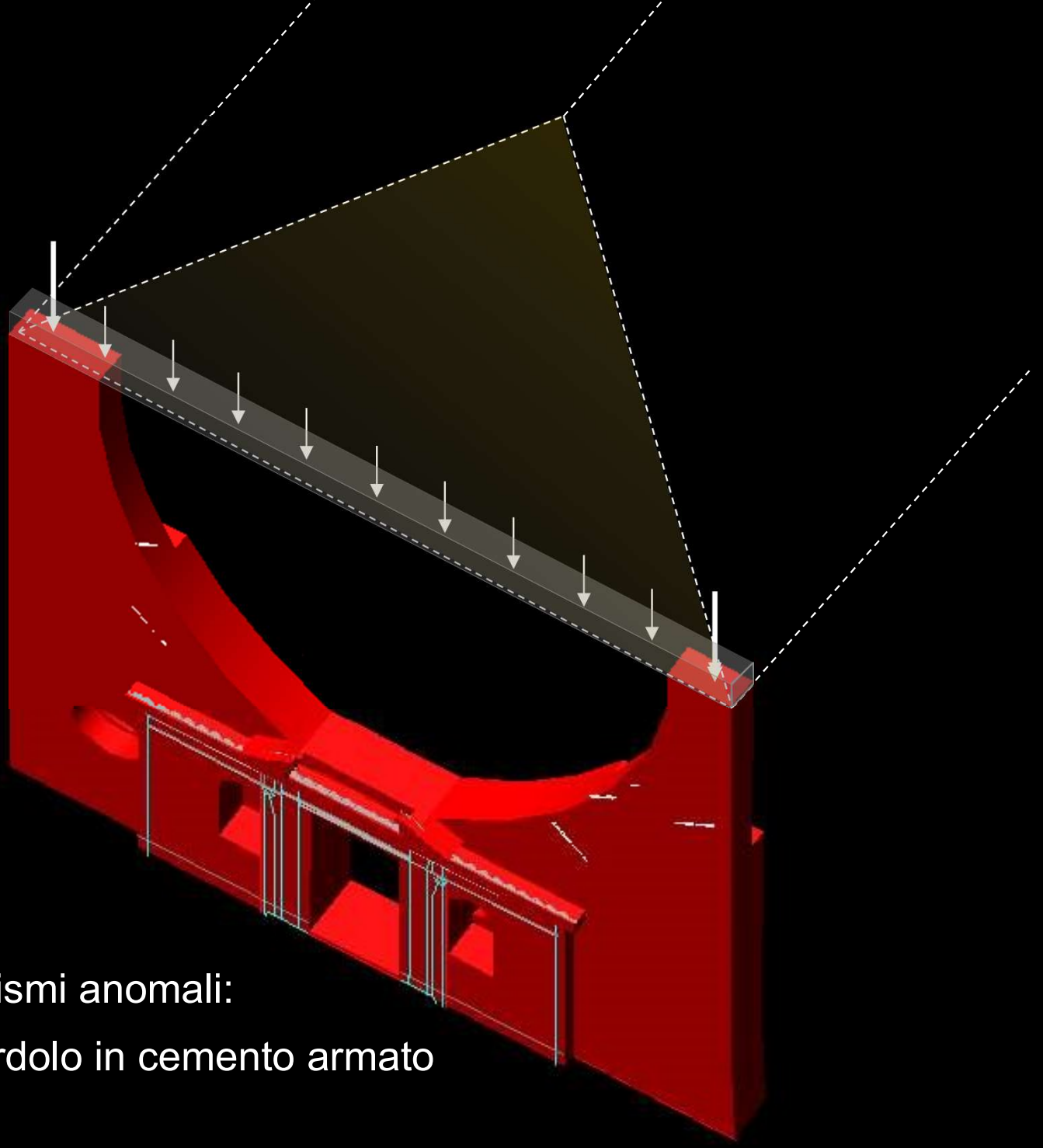
Effetti sull'irrigidimento delle coperture con cordoli in cemento armato











Meccanismi anomali:

«effetto trave» del cordolo in cemento armato

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)

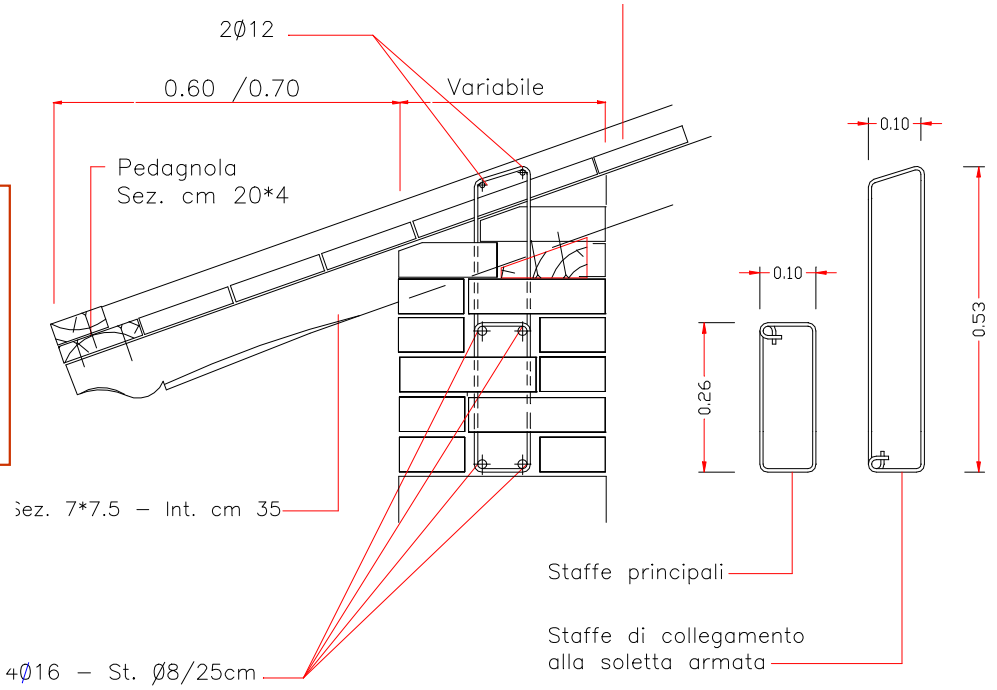
6.3.2 Interventi volti a ridurre le carenze dei collegamenti

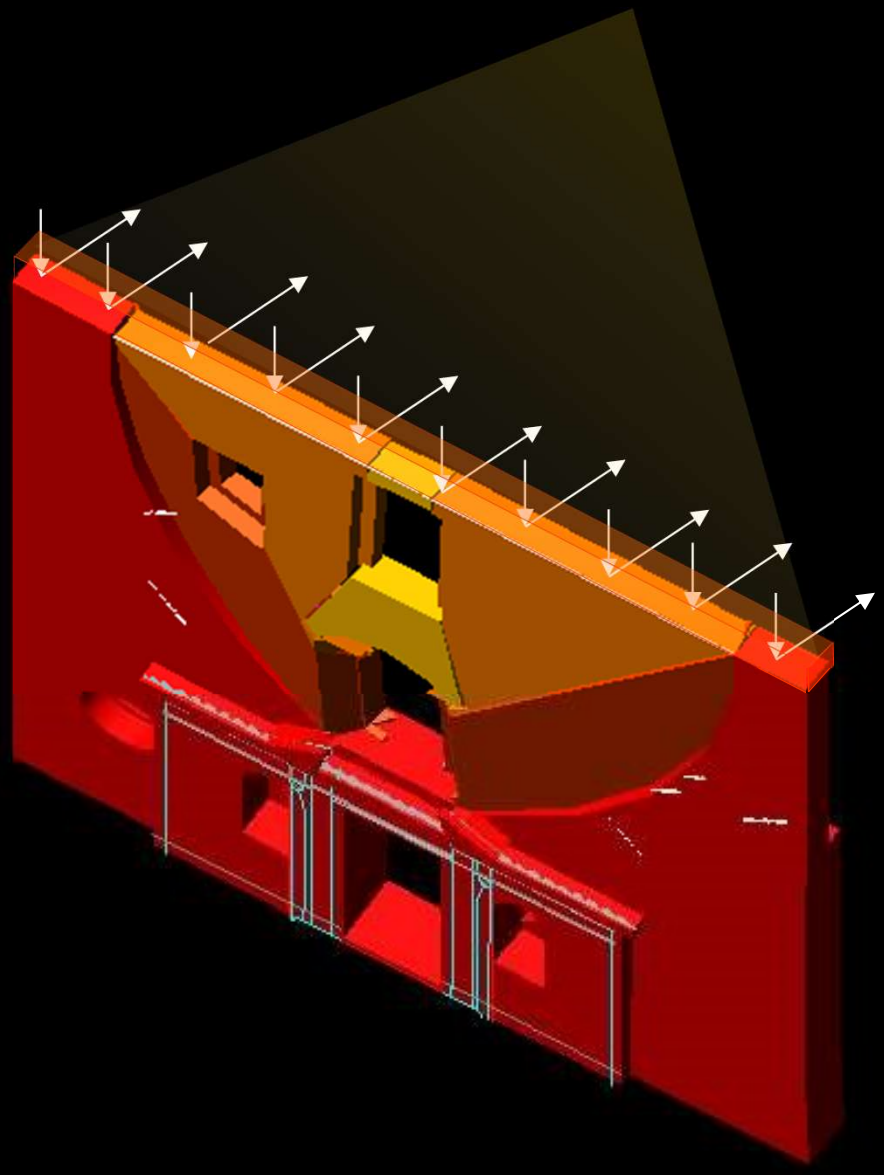
Cordoli in sommità:

- 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

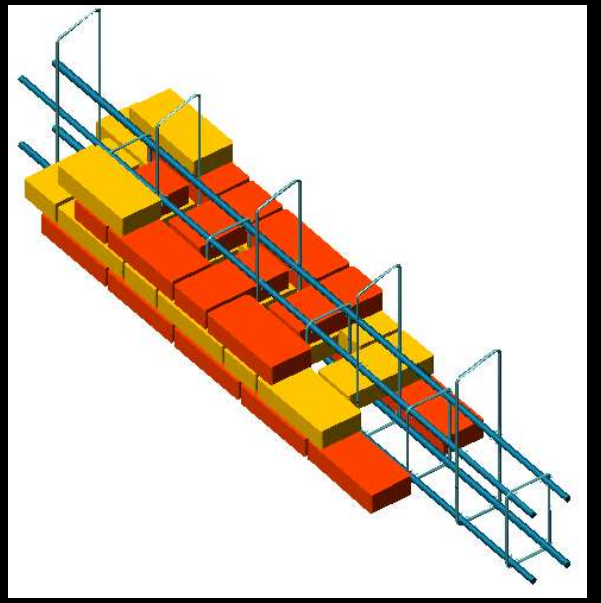
6.3.5 Interventi in copertura

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

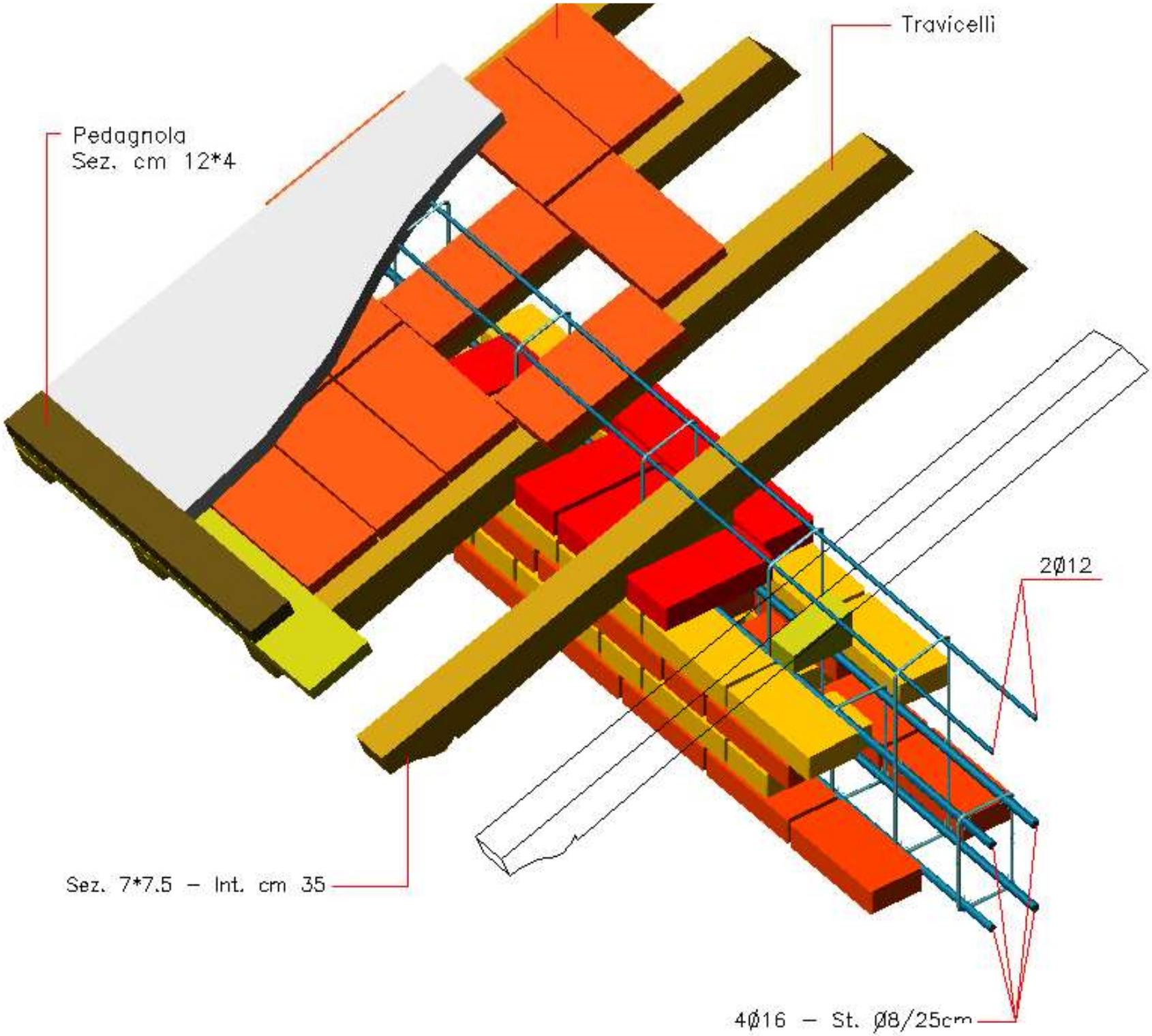


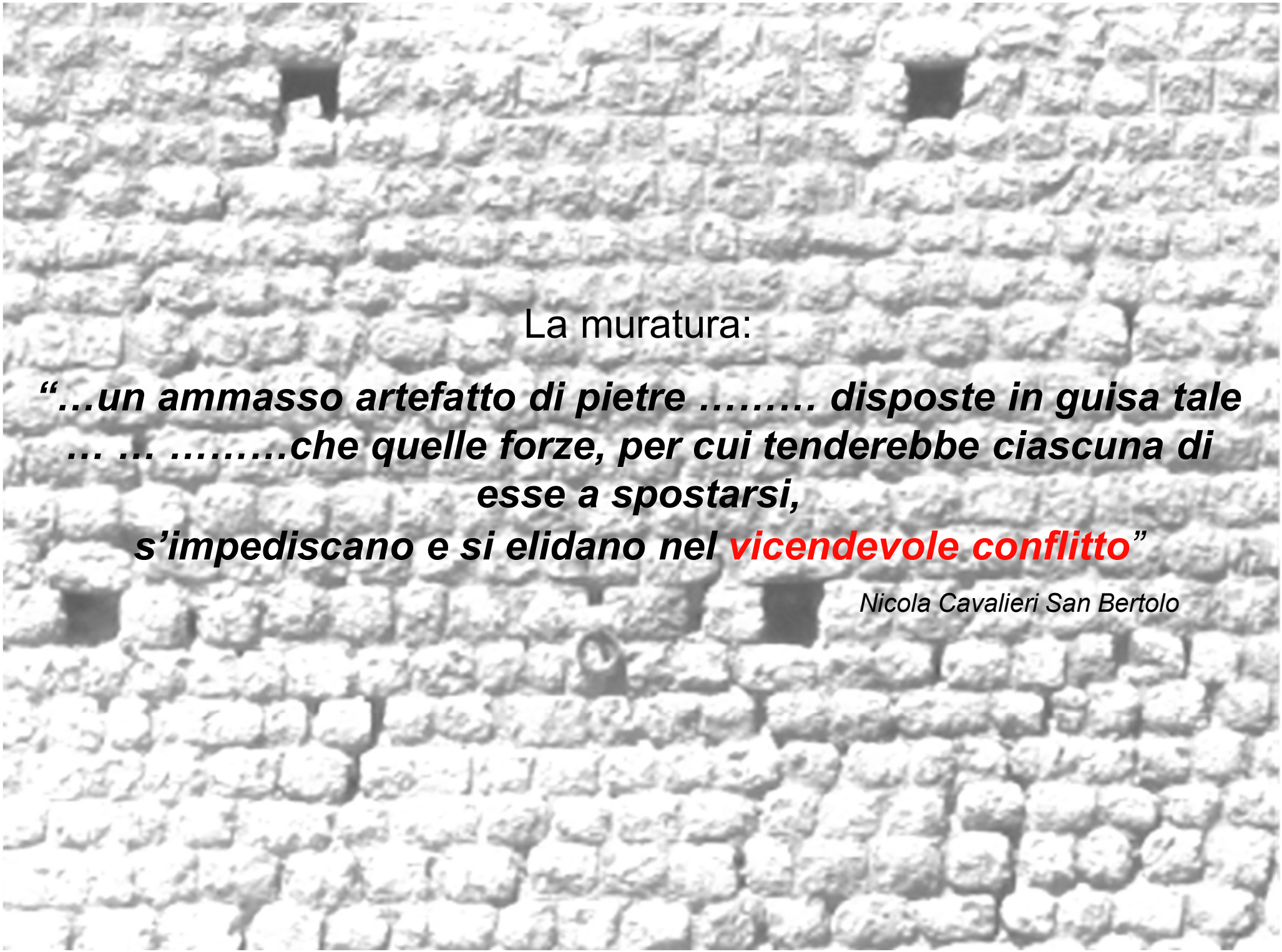


Cordolo in
muratura armata



A. Oelker - G. Cangi

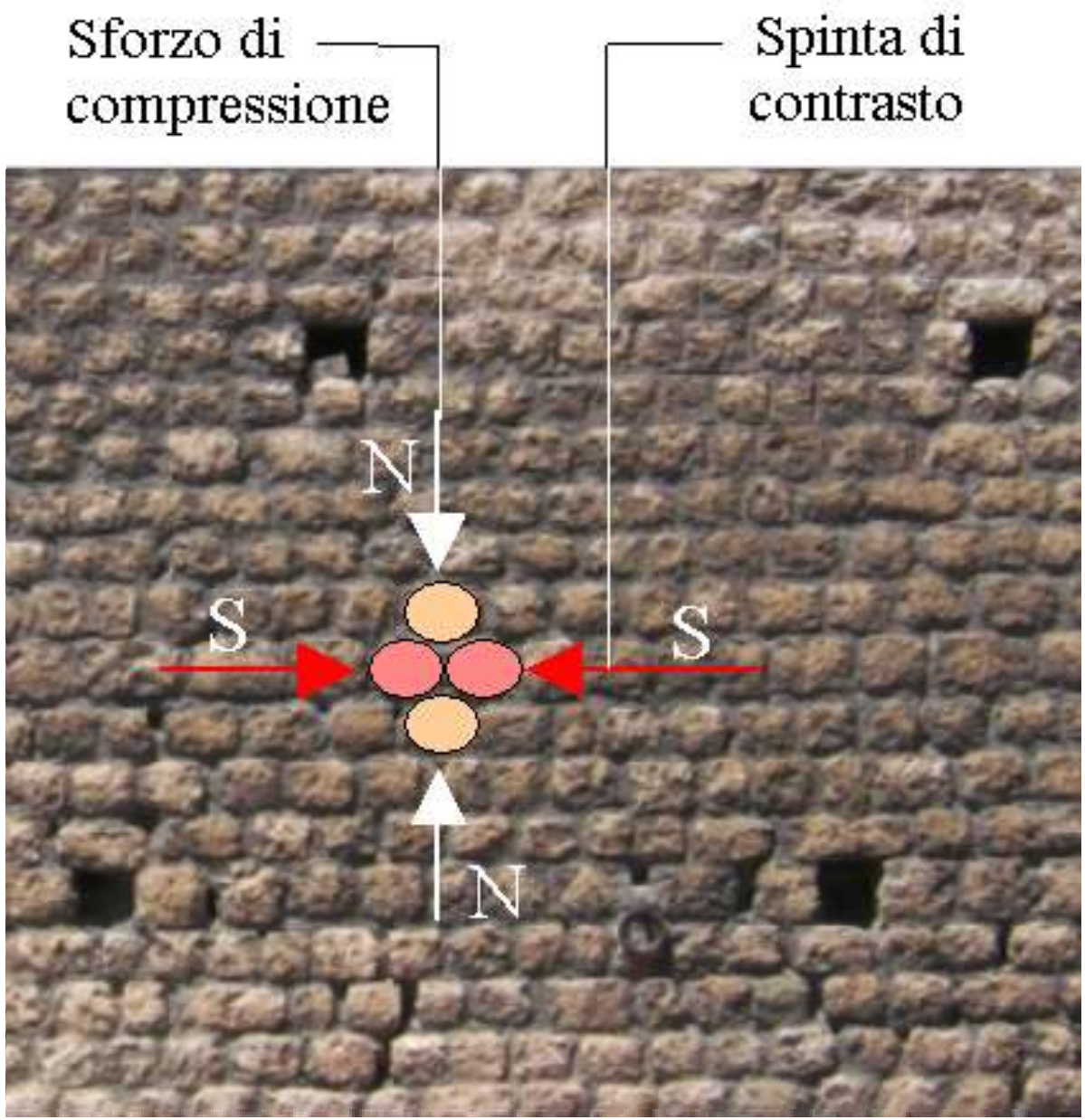

Travicelli
Pedagnola
Sez. cm 12*4
2Ø12
Sez. 7*7.5 – Int. cm 35
4Ø16 – St. Ø8/25cm



La muratura:

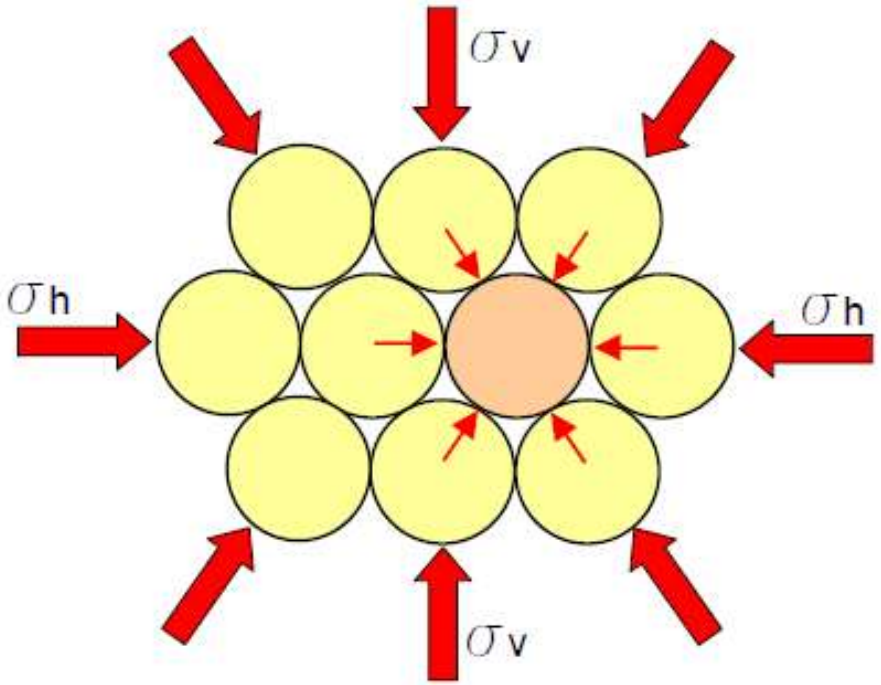
"…un ammasso artefatto di pietre …… disposte in guisa tale … … ……che quelle forze, per cui tenderebbe ciascuna di esse a spostarsi, s'impediscano e si elidano nel vicendevole conflitto"

Nicola Cavalieri San Bertolo

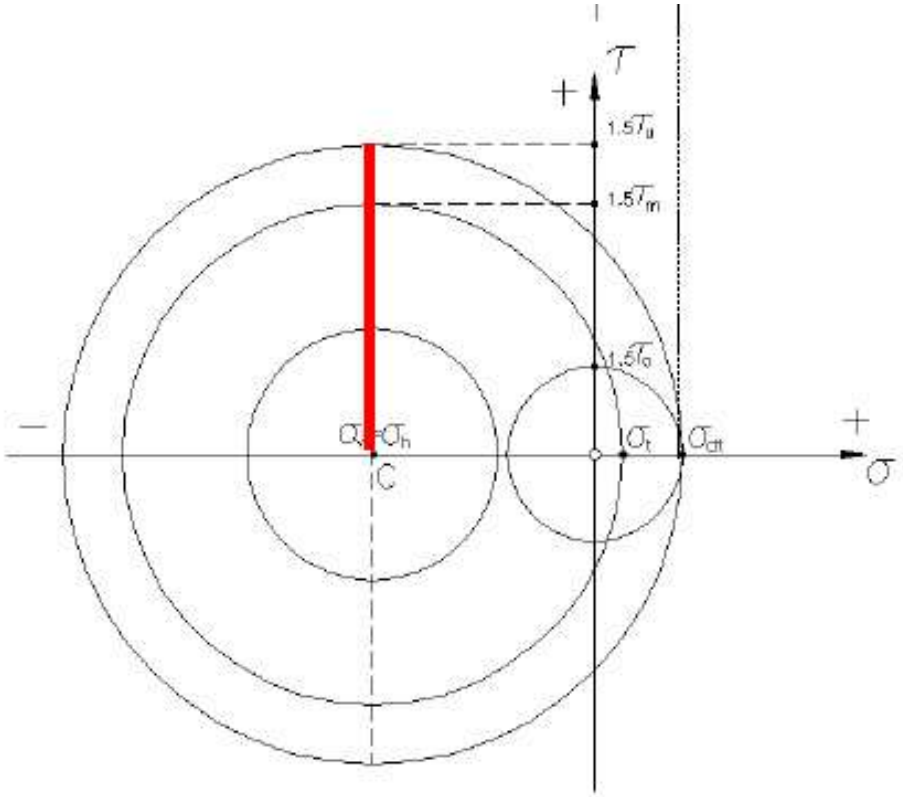

Sforzo di compressione
Spinta di contrasto
N
S
S
N



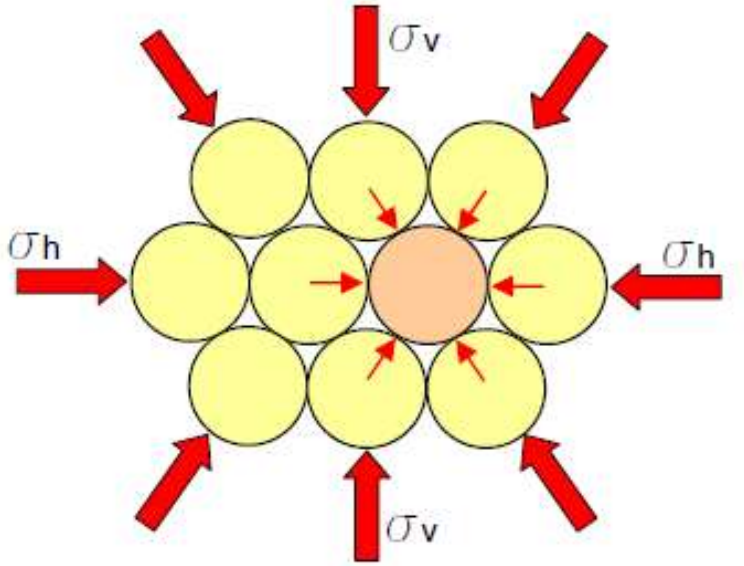
Palmira (Siria) – Rovine del tempio di Bel, con paramento costituito da rocchi di colonne riusate. Foto: F.Giovanetti



$\sigma h = \sigma v$



C)



σh=σv

Caratterizzazione meccanica dei materiali

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

. verifiche visive in situ

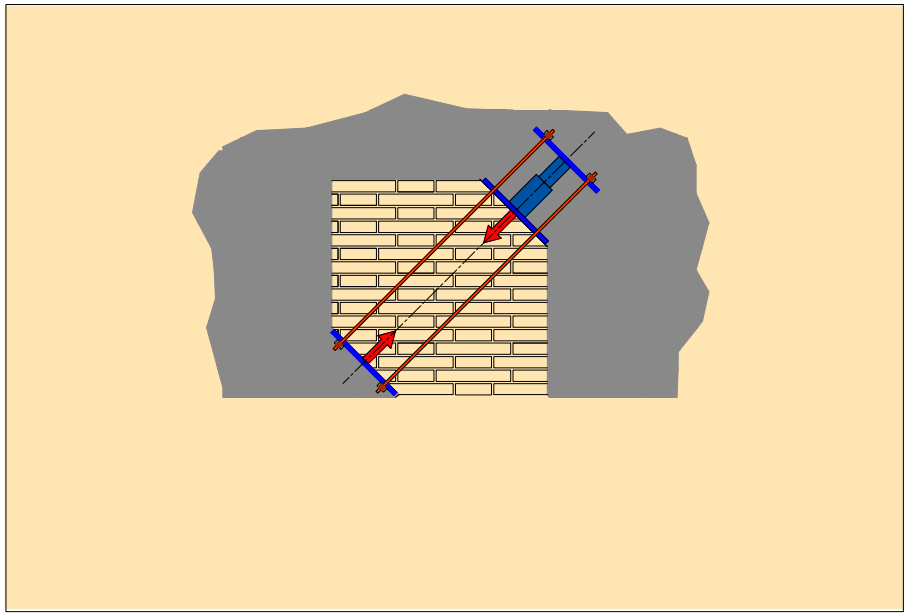
. analisi dati già disponibili

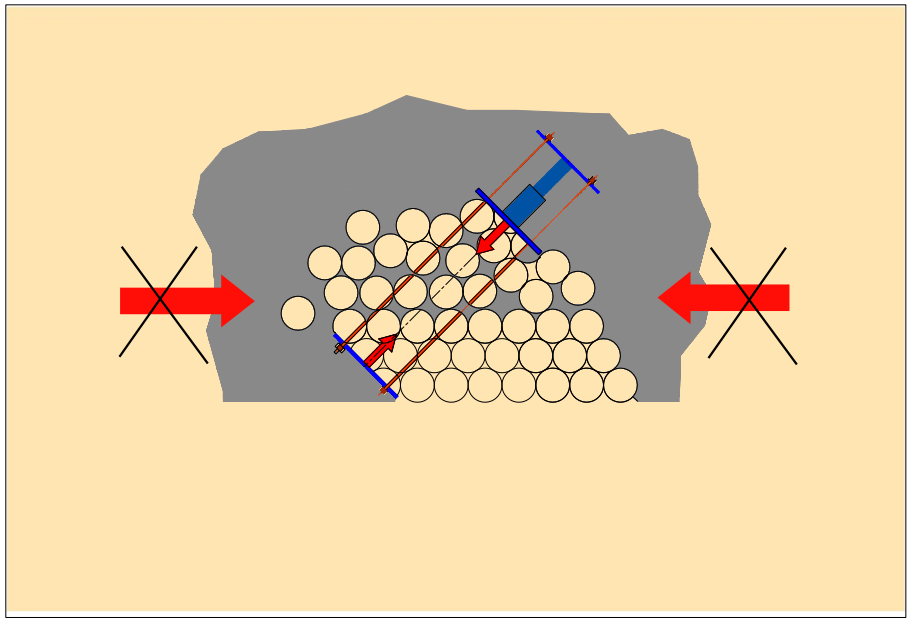
. prove sperimentali

Livelli di conoscenza

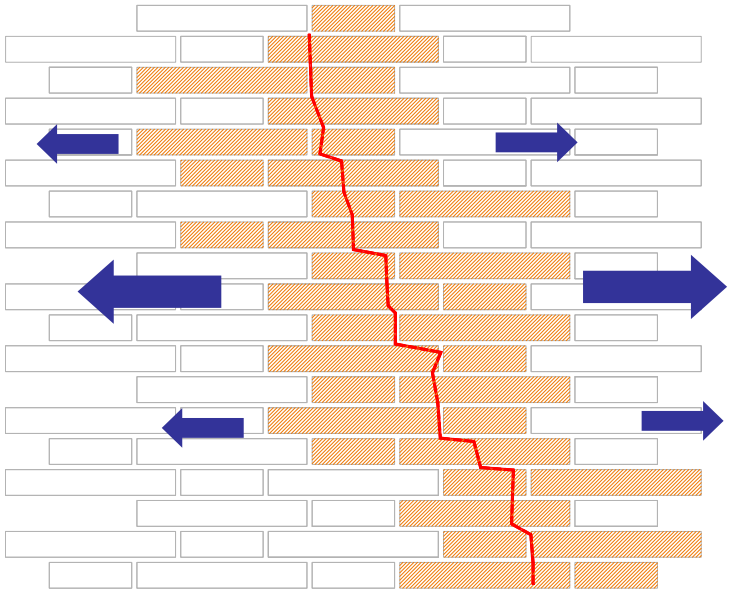
(LC1, LC2 e LC3)

Indagini limitate, estese, esaustive

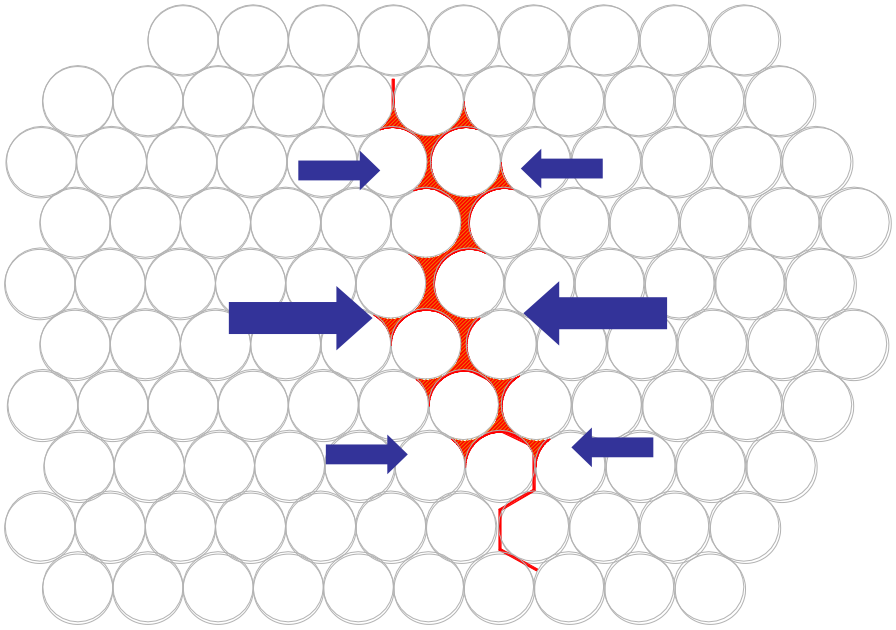




Interventi di cuci-scuci



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



Ripristino dell’azione di contrasto e dello stato di precompressione

VECCHIA NORMATIVA TECNICA PER LE COSTRUZIONI

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 estradossato, 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.

NUOVE NORME TECNICHE PER LE COSTRUZIONI

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 estradossali possono essere realizzati con elementi anche dotati di rigidezza 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 sollecitazione 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.

La realizzazione di soluzioni pesanti come cappe e contro-volte in calcestruzzo armato o meno va valutata con cautela a causa degli incrementi di peso che comporta

ottenute con frenelli o riempimenti coesivi leggeri

Presidenza del Consiglio dei Ministri del 12/10/2007

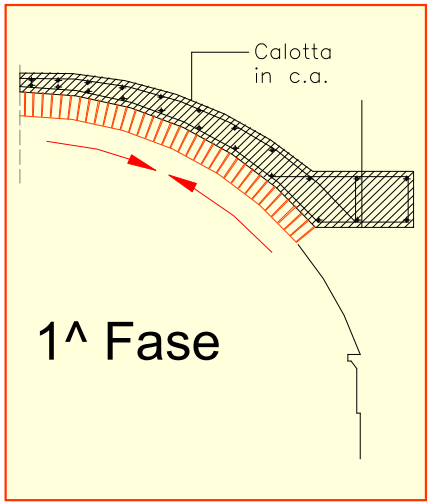
Direttiva del Presidente del Consiglio dei Ministri per la valutazione la riduzione del rischio sismico del patrimonio culturale con riferimento alle norme tecniche per le costruzioni

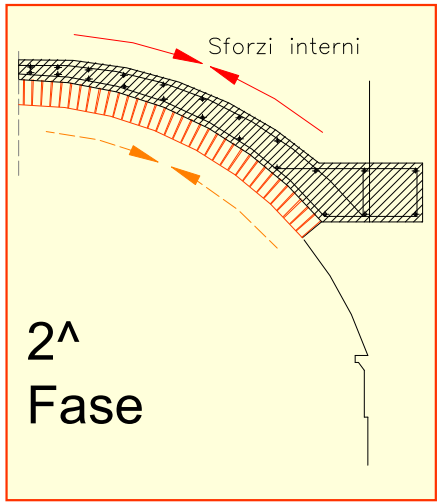
(Gazzetta ufficiale 29/01/2008 n. 24)

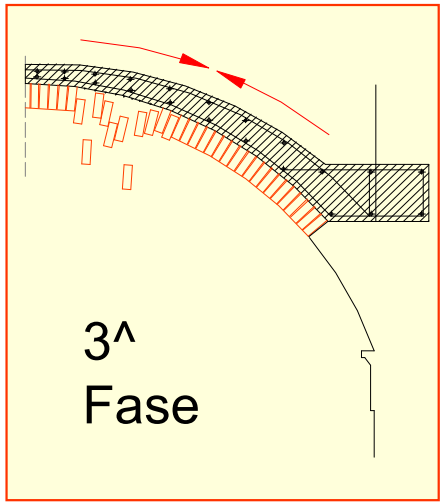
6.3.3 Interventi volti a ridurre la spinta di archi e volte ed al loro consolidamento

Archi e volte:

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.

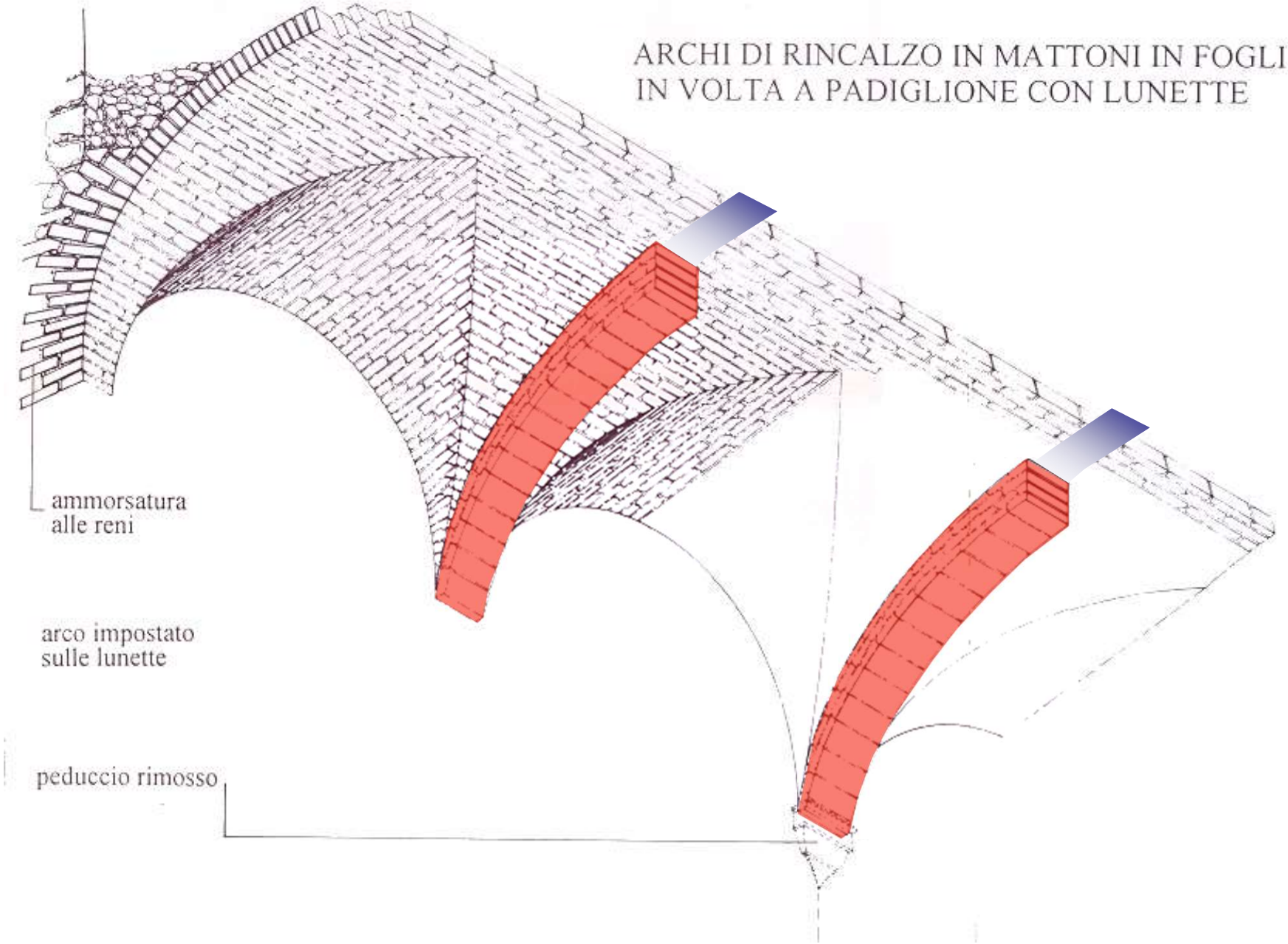


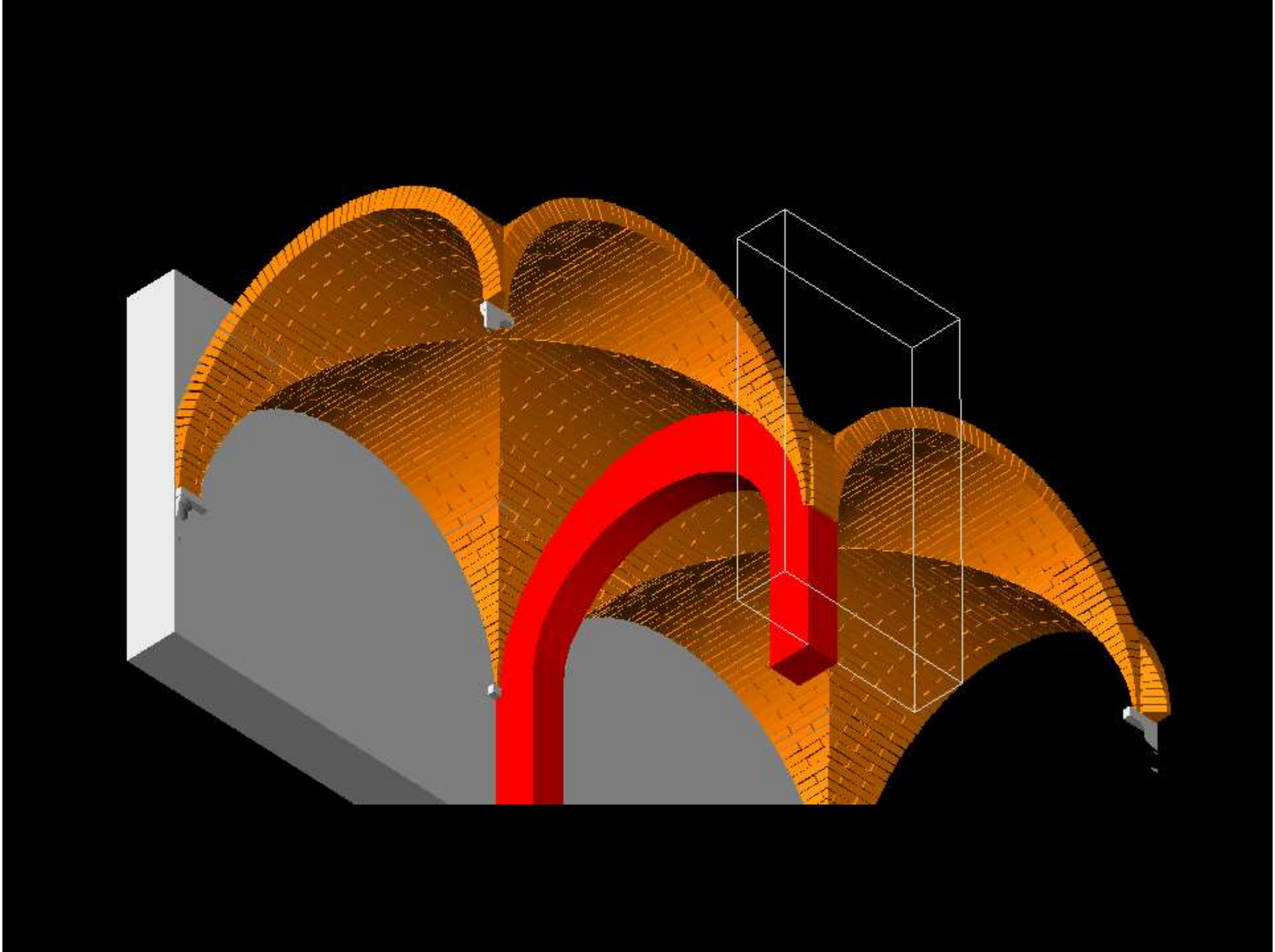


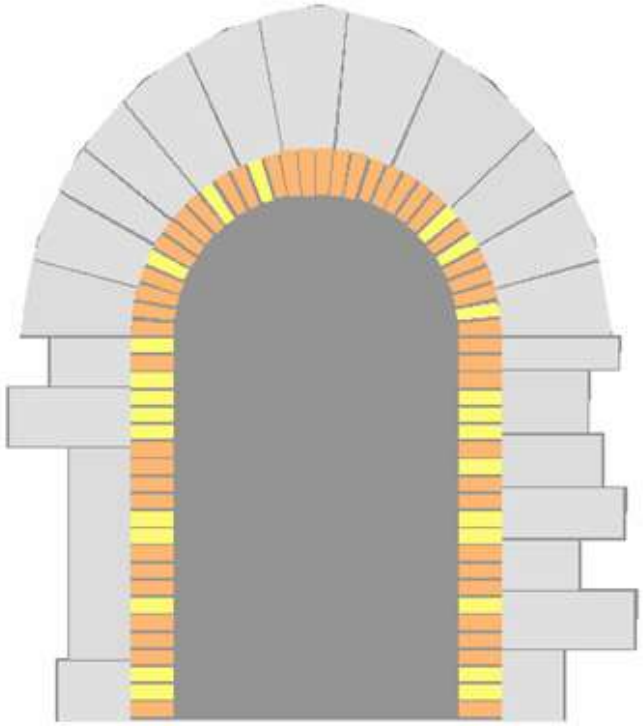


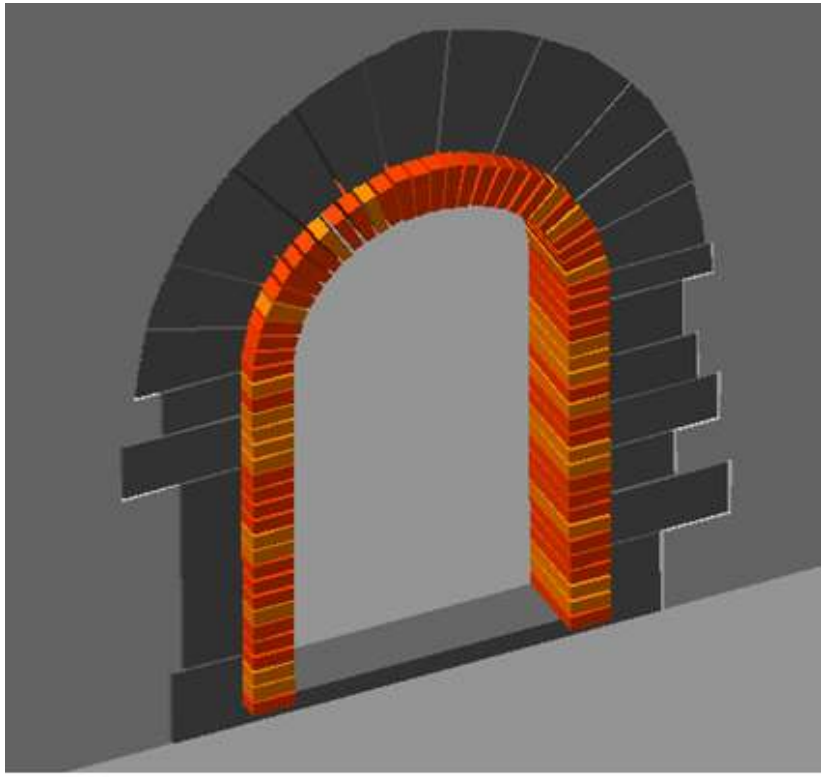
Conseguenze del consolidamento della volta con soletta in cemento armato d'estradosso

ARCHI DI RINCALZO IN MATTONI IN FOGLIO IN VOLTA A PADIGLIONE CON LUNETTE

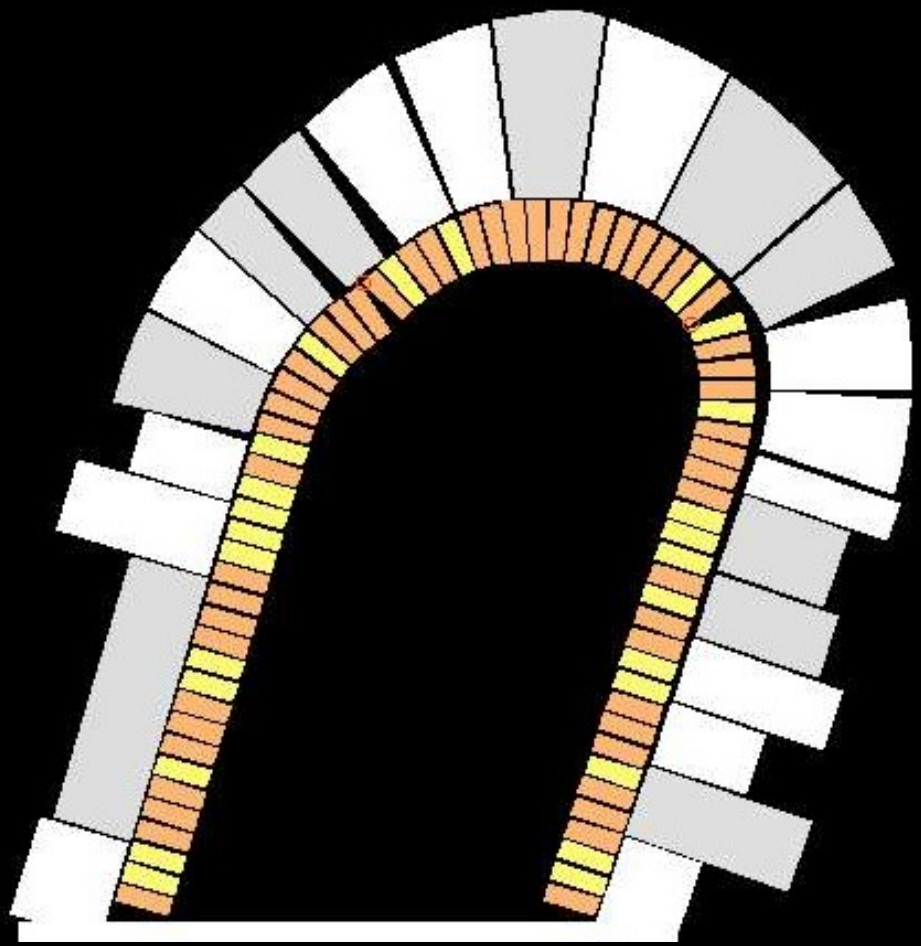


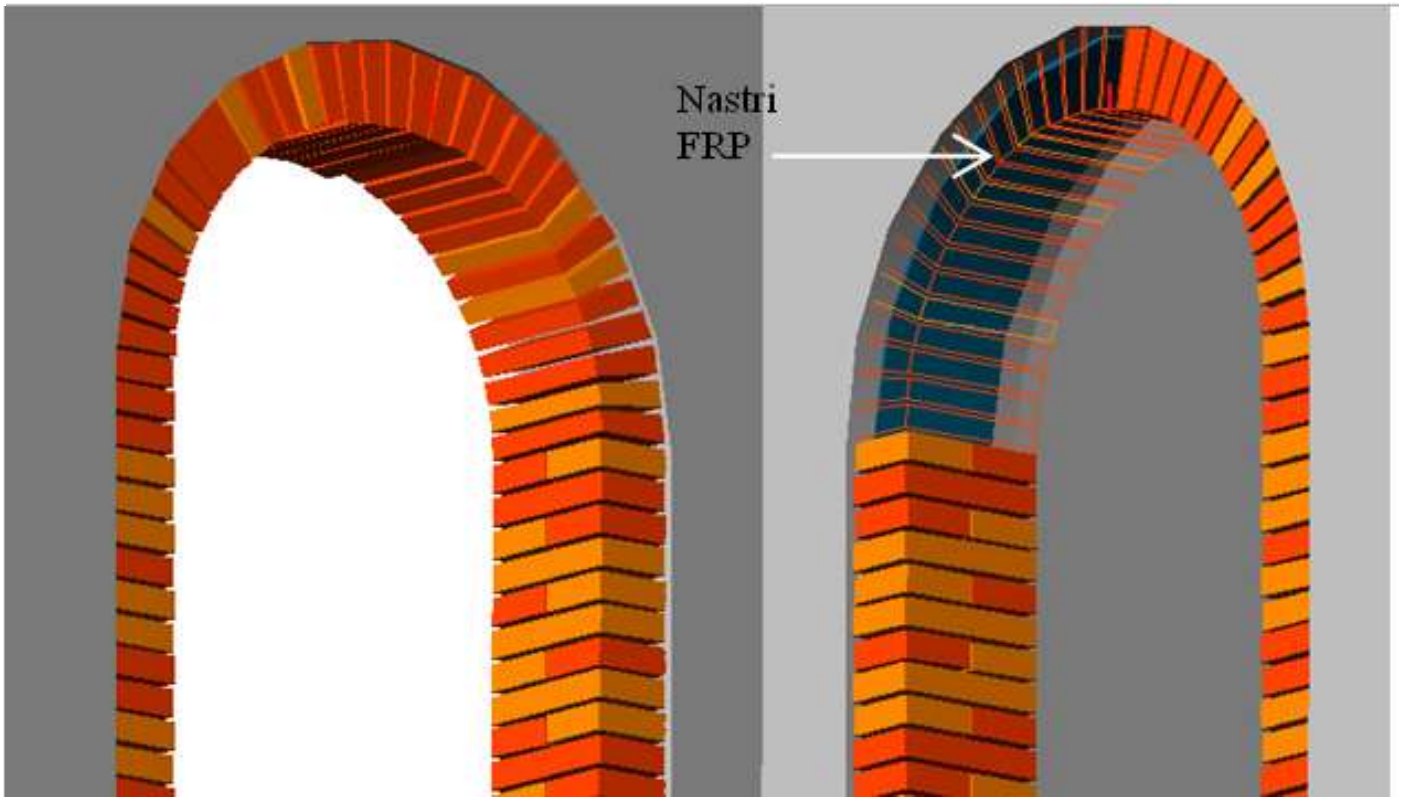






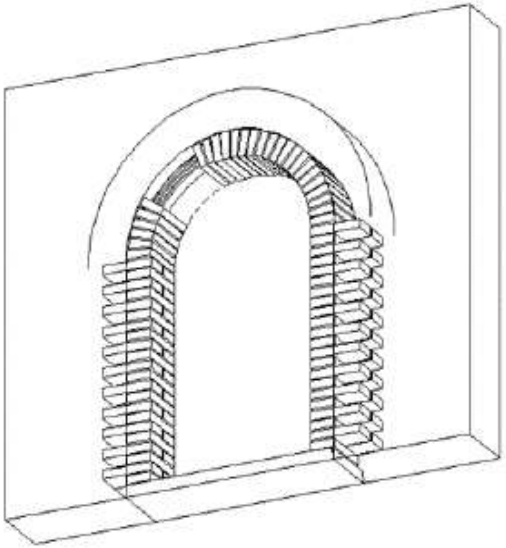
Tecniche antisismiche premoderne:
riduzione di aperture mediante creazione di cerchiature laterizie

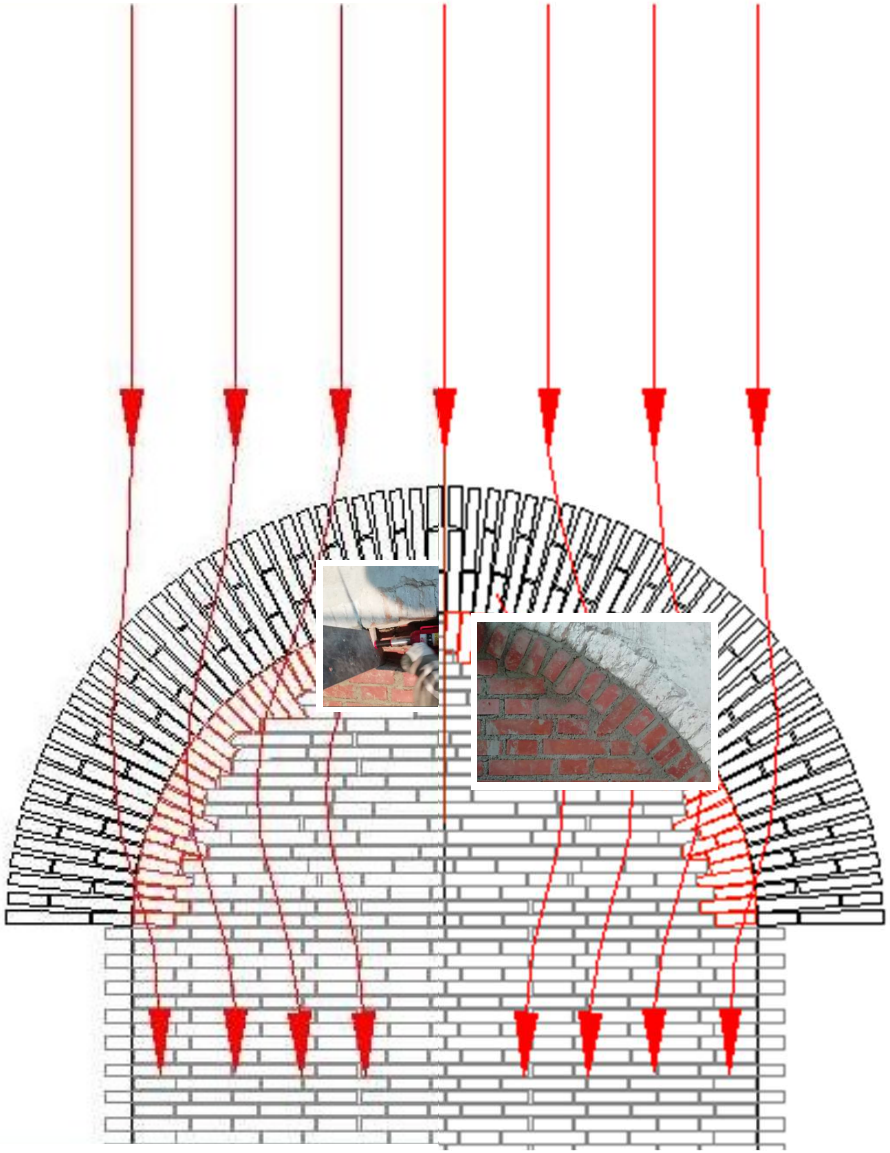


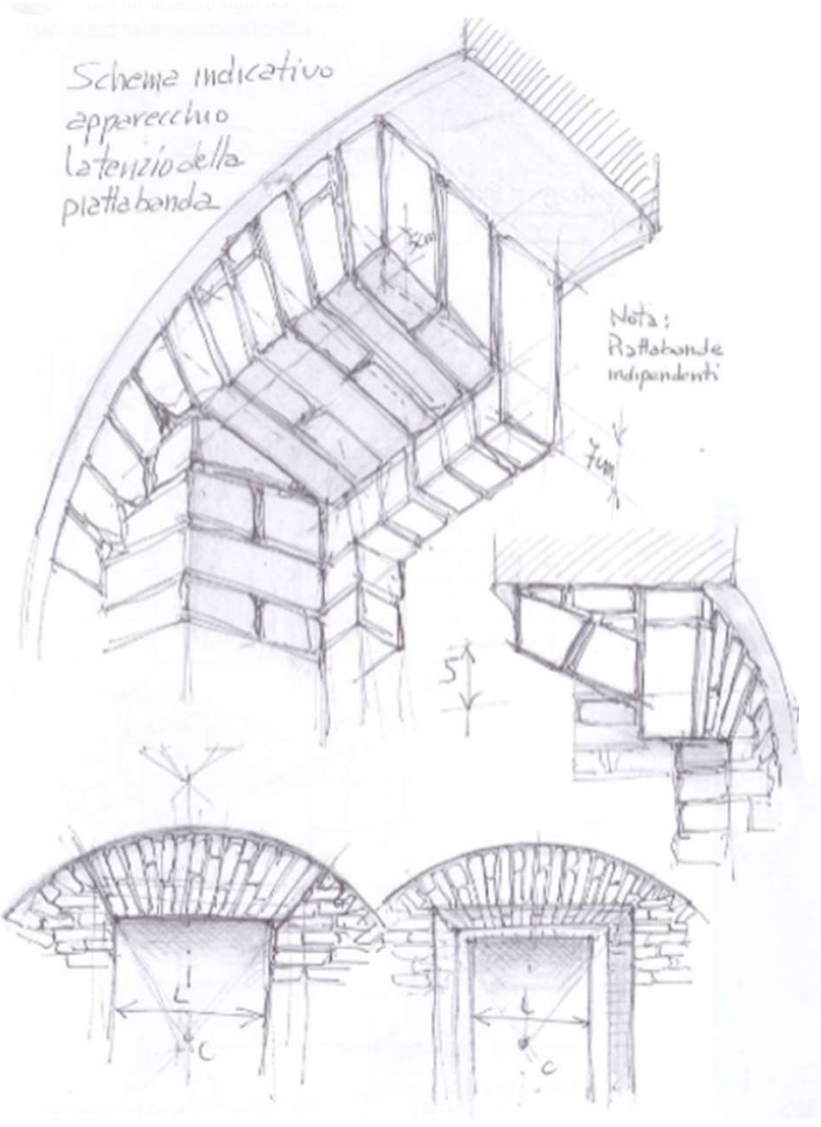

Nastri
FRP



A05059 Intervento di rinforzo di archi in muratura tramite la realizzazione di sotto-arco di mattoni pieni apparecchiati a 3 teste. Nella costruzione dell'elemento di rinforzo dovrà essere predisposto l'ammorsamento delle spalle laterali mentre l'arco non dovrà essere ingranato a quello esistente. Nell'interfaccia fra l'arco esistente e quello di nuova realizzazione sia posizionato un nastro in fibra di carbonio atto a migliorare il comportamento dell'elemento strutturale in fase sismica. Sono compresi la demolizione dell'intonaco e la pulitura dell'arco esistente al fine di predisporre la superficie d'intradosso all'applicazione del nastro in composito, gli scassi sulle spalle esistenti per favorire l'ingranamento delle nuove spalle, il nastro in fibra di carbonio fino alla larghezza di 25 cm, i mattoni e la malta per la formazione della muratura a tre teste costituente l'arco, i tagli, gli sfridi, la centina in legno per il montaggio del tratto curvo. Non sono comprese le opere di fondazione del nuovo arco e le eventuali opere di finitura quali intonaco e tinteggiatura ..... m **260,00**



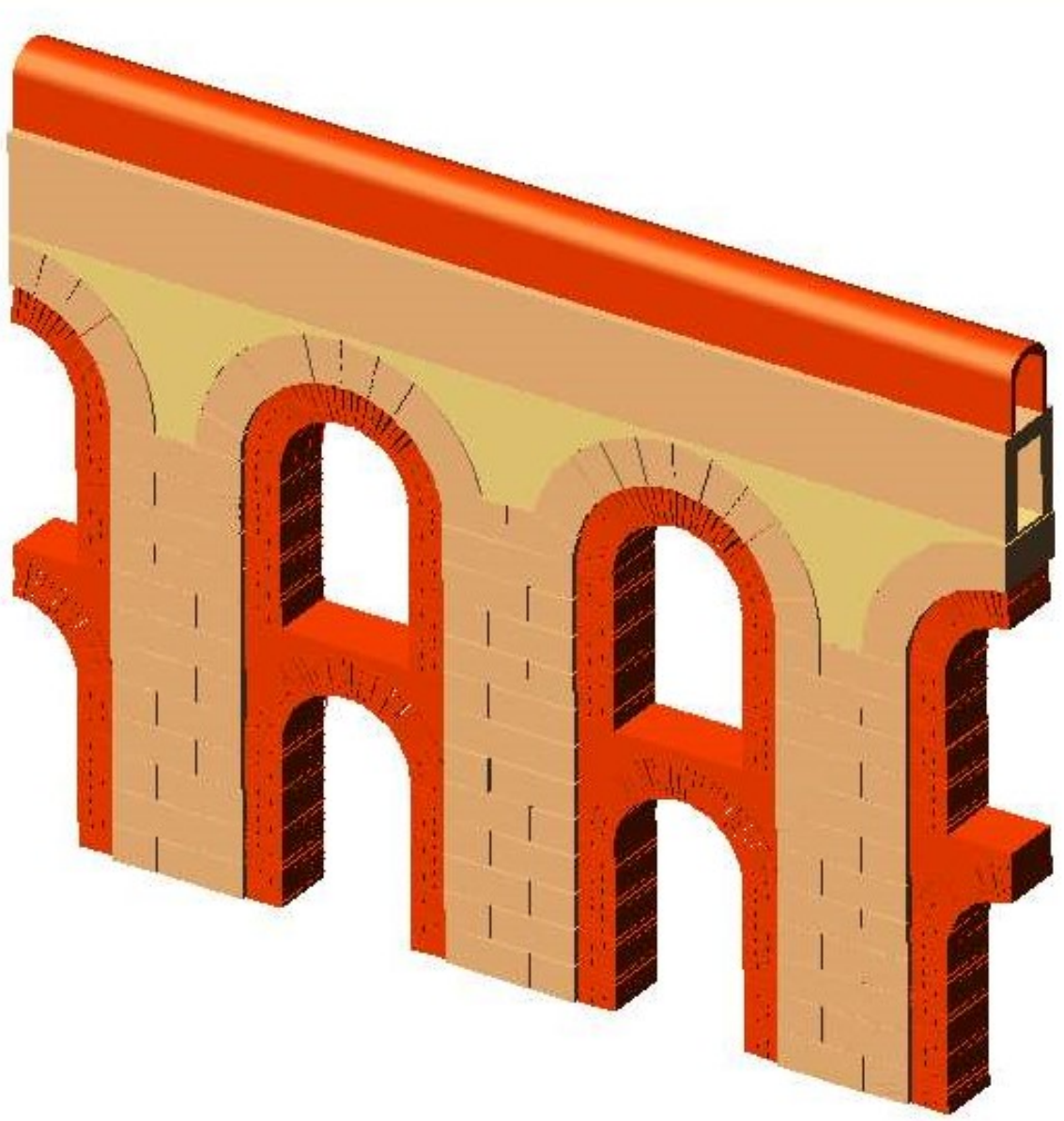








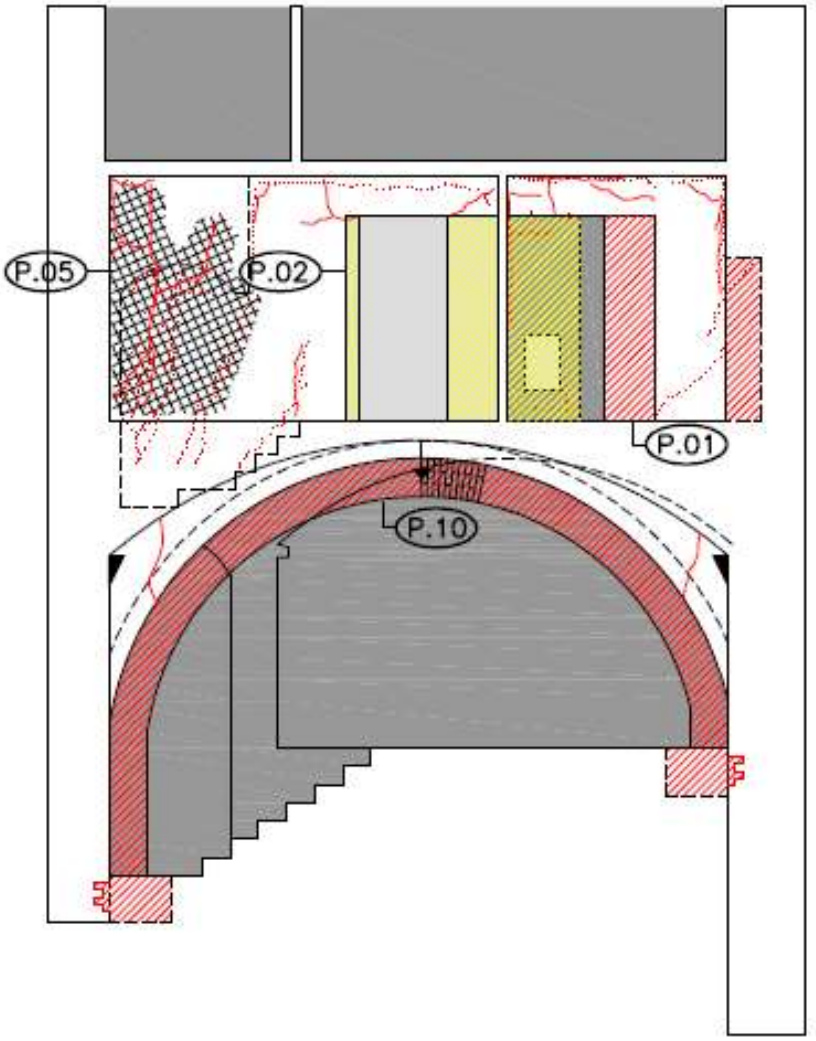
Tamponature strutturali con creazione di piattabande



Schema di consolidamento
utilizzato nell’acquedotto Claudio

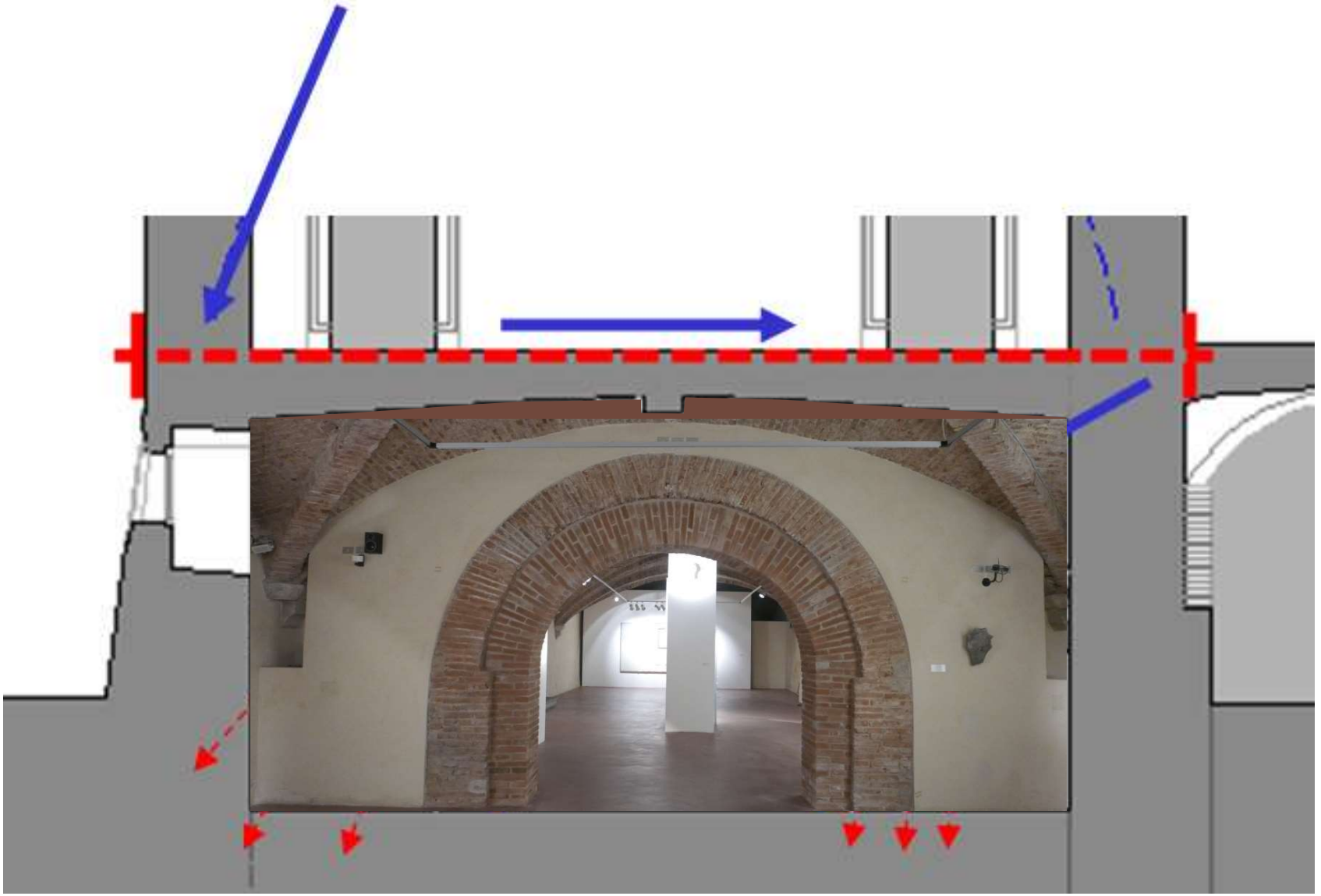




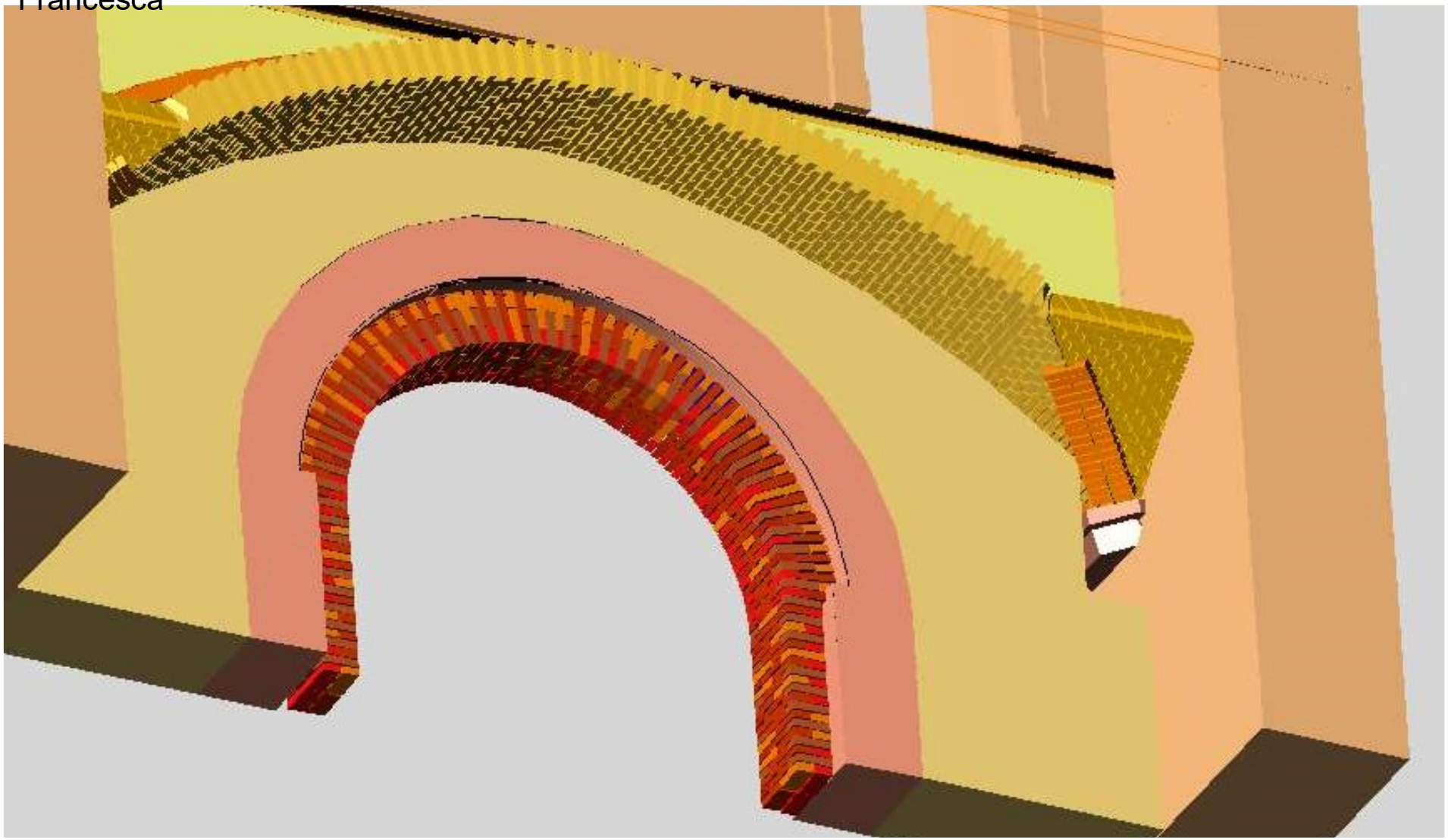


G.Cangi

Museo Civico Sansepolcro (AR): consolidamento parete di supporto della Resurrezione di Piero Della Francesca



Museo Civico Sansepolcro (AR): consolidamento parete di supporto della Resurrezione di Piero Della Francesca



Disposizione ghiera di mattoni d’intradosso con interposto nastro in materiale composito

Progetto e D.L.: Arch. R.Barciulli, Ing. G.Cangi, Ing. A.Petrani (Sansepolcro – AR)

Ditta esecutrice: Decoratori Artigiani

Museo Civico Sansepolcro (AR): consolidamento parete di supporto della Resurrezione di Piero Della Francesca



Progetto e D.L.: Arch. R.Barciulli, Ing. G.Cangi, Ing. A.Petrani (Sansepolcro – AR)

Ditta esecutrice: Decoratori Artigiani

Museo Civico Sansepolcro (AR): consolidamento parete di supporto della Resurrezione di Piero Della Francesca





Progetto e D.L.: Arch. R.Barciulli, Ing. G.Cangi, Ing. A.Petrani
(Sansepolcro – AR)

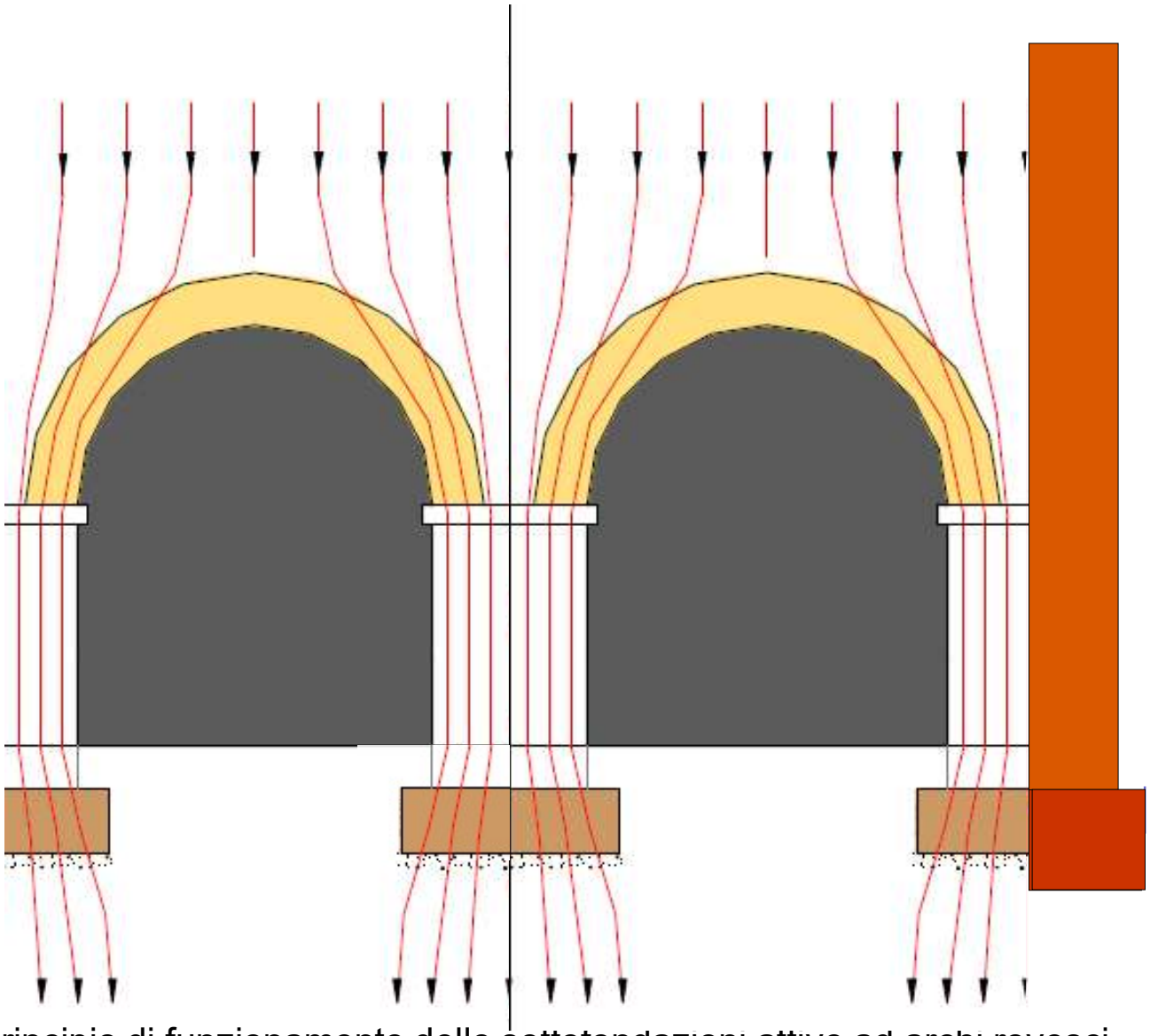
Ditta esecutrice: Decoratori Artigiani

Museo Civico Sansepolcro (AR): consolidamento parete di supporto della Resurrezione di Piero Della Francesca

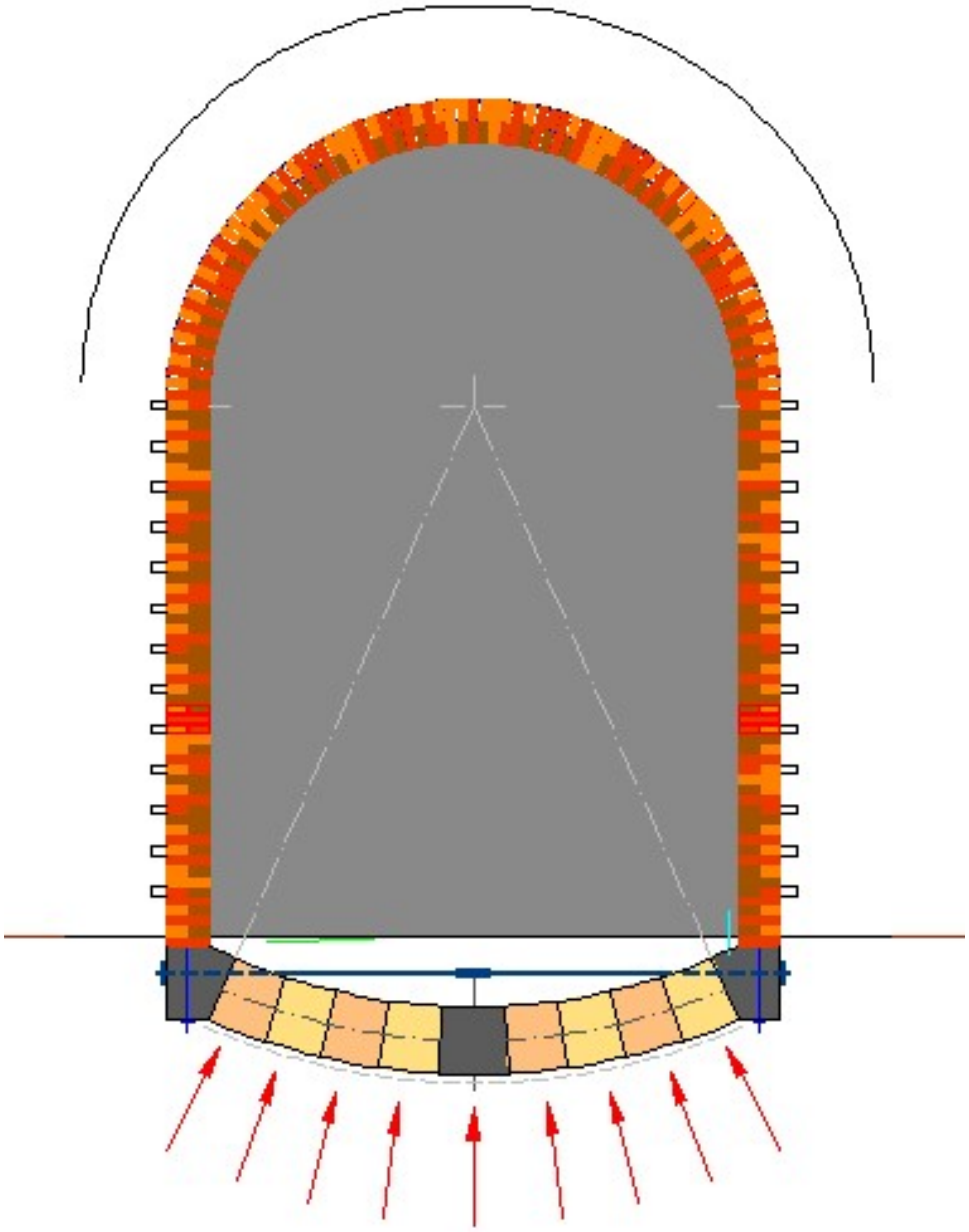


Progetto e D.L.: Arch. R.Barciulli, Ing. G.Cangi, Ing. A.Petrani
(Sansepolcro – AR)

Ditta esecutrice: Decoratori Artigiani



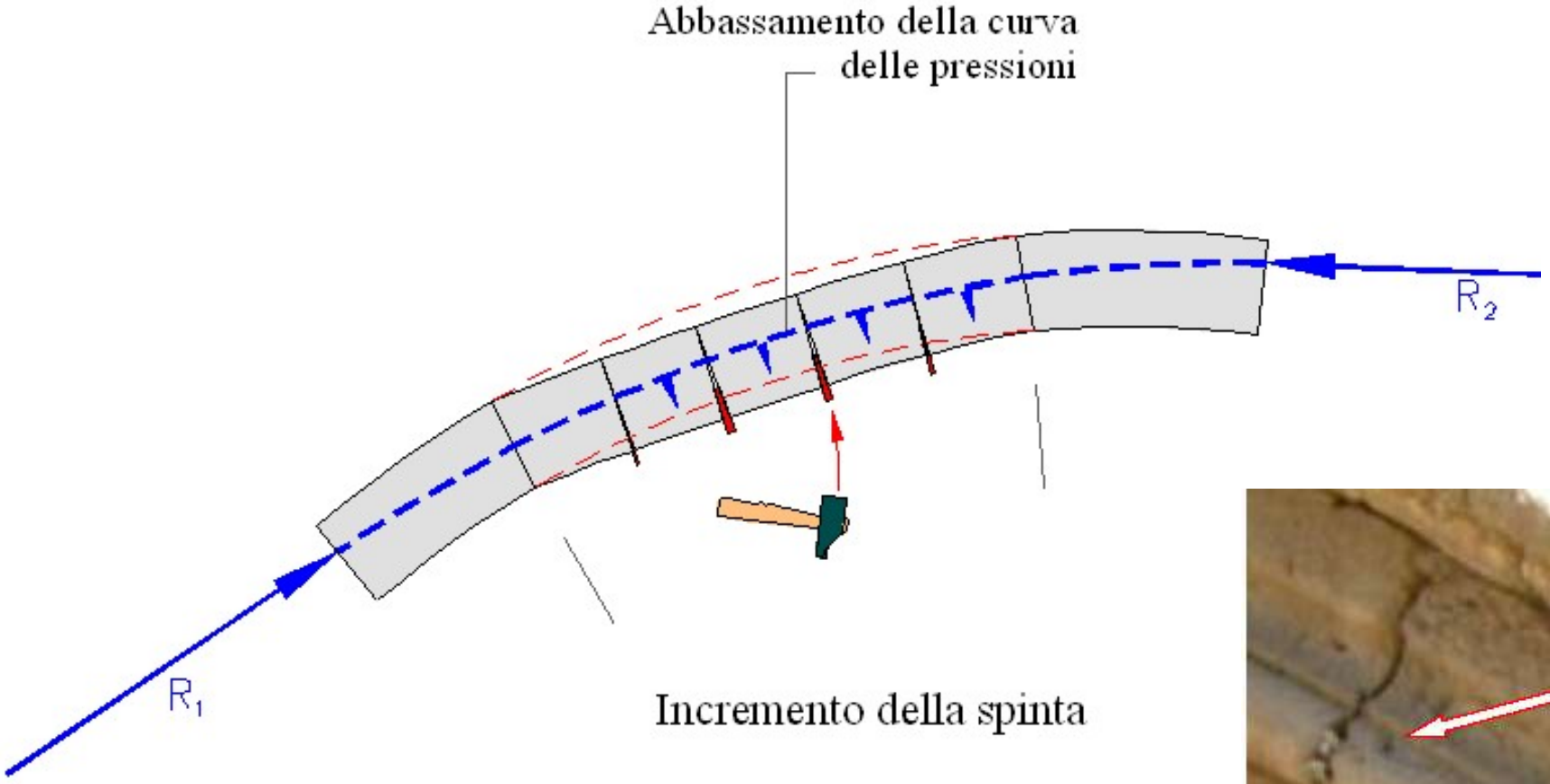
A2) Principio di funzionamento delle sottofondazioni attive ad archi rovesci

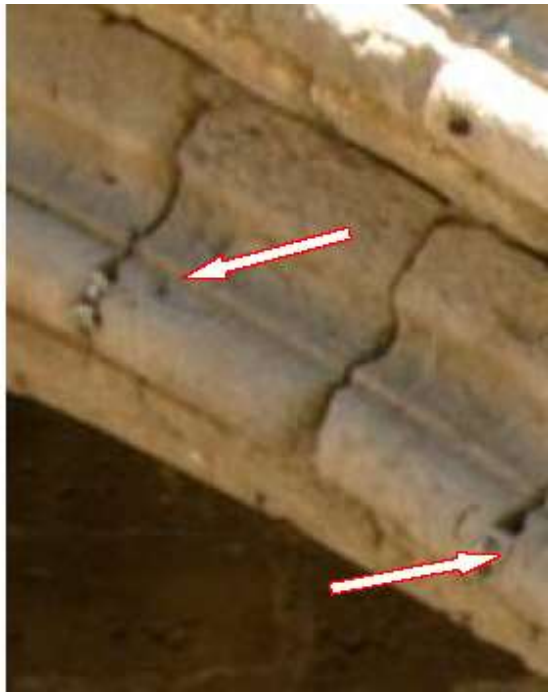


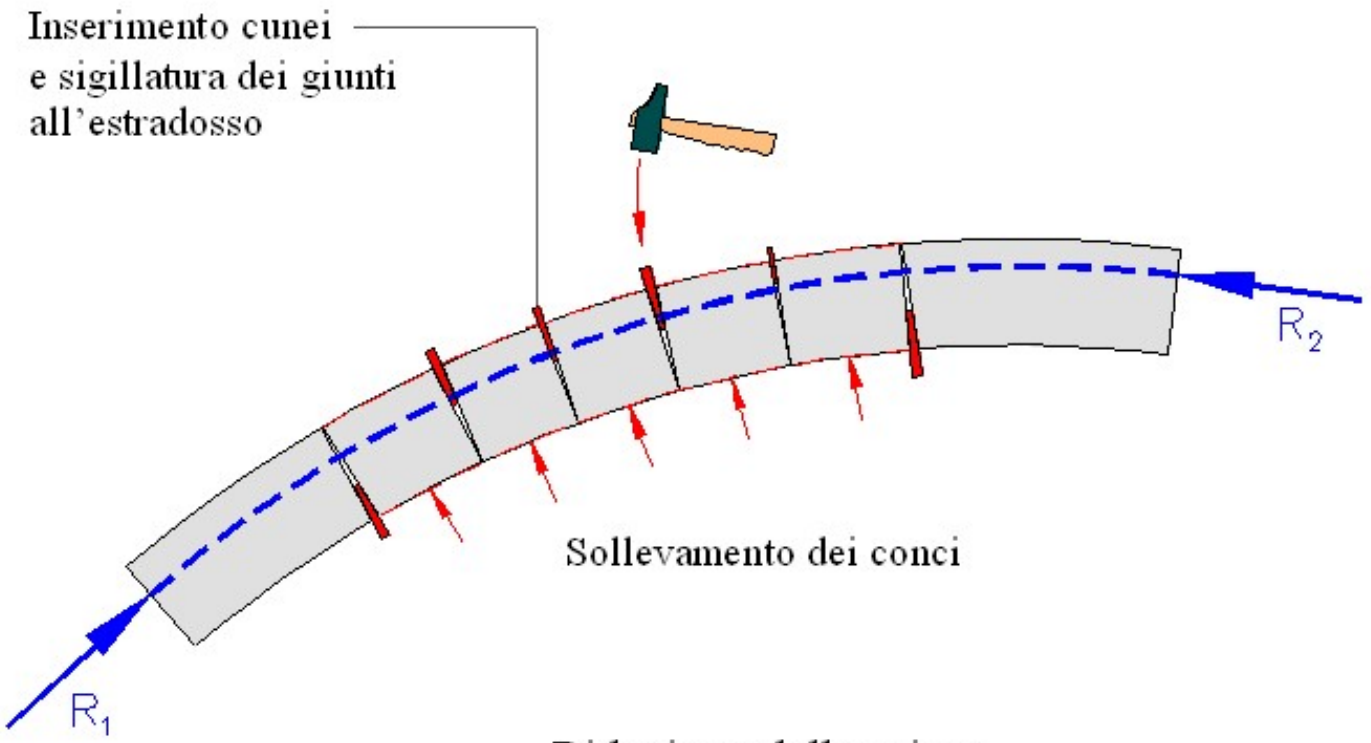




Rinforzo d’intradosso di crociera laterizia in foglio mediante sollevamento dal basso, applicazione di nastri di fibre al carbonio lungo la nervatura e realizzazione di costolatura di mezzane in foglio a tessitura diagonale


Abbassamento della curva
delle pressioni
R2
R1
Incremento della spinta





Riduzione della spinta



INTERVENTI SU ARCHI E VOLTE

A05058 Intervento di consolidamento delle strutture voltate in mattoni o pietrame al fine di ripristinare la linea delle pressioni per il corretto trasferimento degli sforzi ai muri d'imposta:

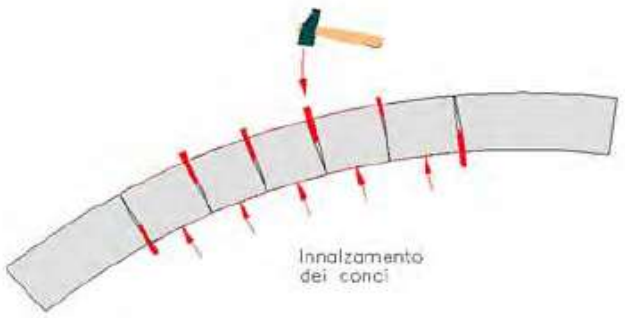
a intervento dal basso. L'intervento si esegue qualora non sia possibile accedere all'estradosso della volta. Sono compresi l'eventuale pulitura dell'elemento strutturale al fine metterlo in luce e predisporre la lavorazione, la scarnitura dei giunti di malta deteriorati, la sostituzione degli elementi laterizi fratturati o consunti, la rinzeppatura dei giunti con l'impiego di cunei di legno in essenza dura o di scaglie di laterizio, il reintegro e la stilatura dei giunti e quanto necessario per dare l'opera finita secondo la regola dell'arte. Non sono comprese le eventuali opere di finitura quali intonaco e tinteggiatura .....

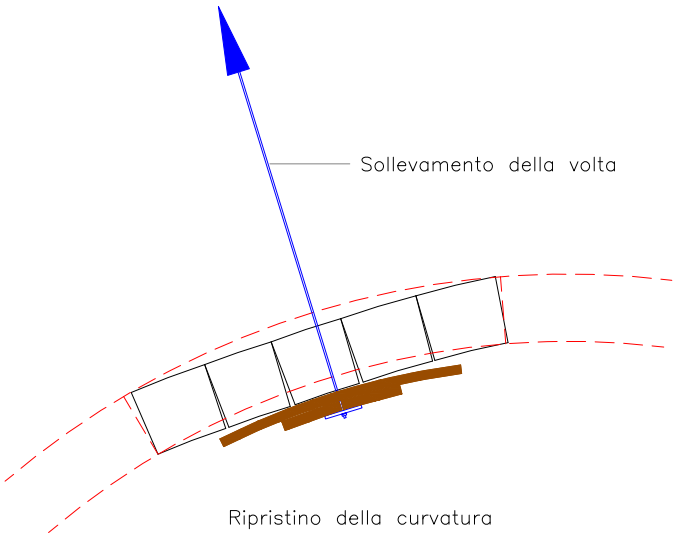


m² **180,00**

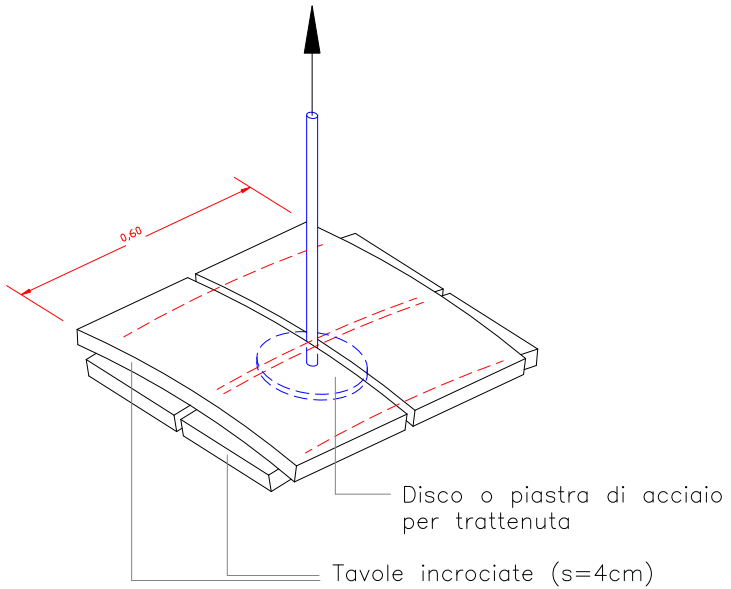
b Intervento dall'alto. L'intervento si esegue qualora sia possibile accedere all'estradosso della volta. Sono compresi l'installazione di centine d'intradosso attive al fine di procedere al recupero anche parziale della geometria della volta, l'eventuale pulitura dell'elemento strutturale sia all'intradosso che all'estradosso al fine metterlo in luce e predisporre la lavorazione, la scarnitura dei giunti di malta deteriorati, la sostituzione degli elementi laterizi fratturati o consunti, la rinzeppatura dei giunti con l'impiego di cunei di legno in essenza dura o di scaglie di laterizio, il reintegro e la stilatura dei giunti e quanto necessario per dare l'opera finita secondo la regola dell'arte. Non sono comprese le opere di rimozione di pavimenti e massetti soprastanti la volta, lo spostamento del materiale di riempimento, il riposizionamento dello stesso ad opera finita, nonché le eventuali opere di finitura quali intonaco e tinteggiatura .....

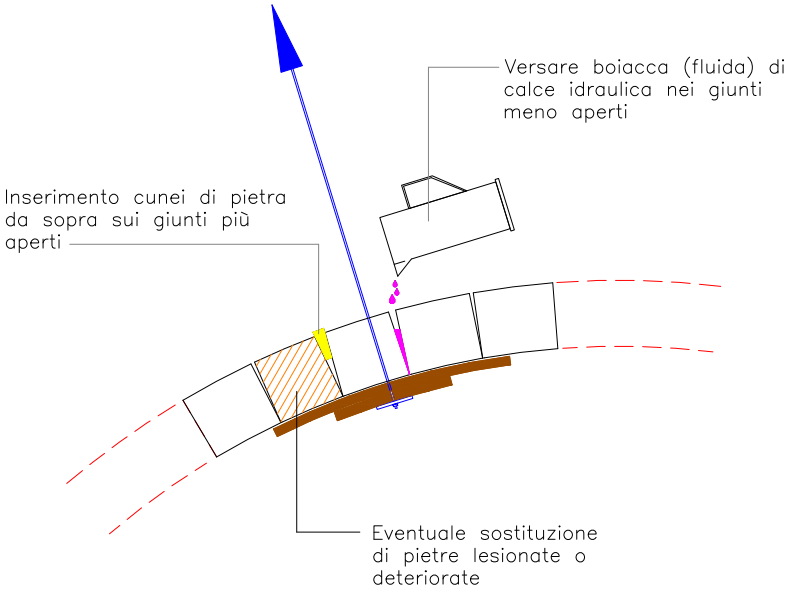
m² **550,00**

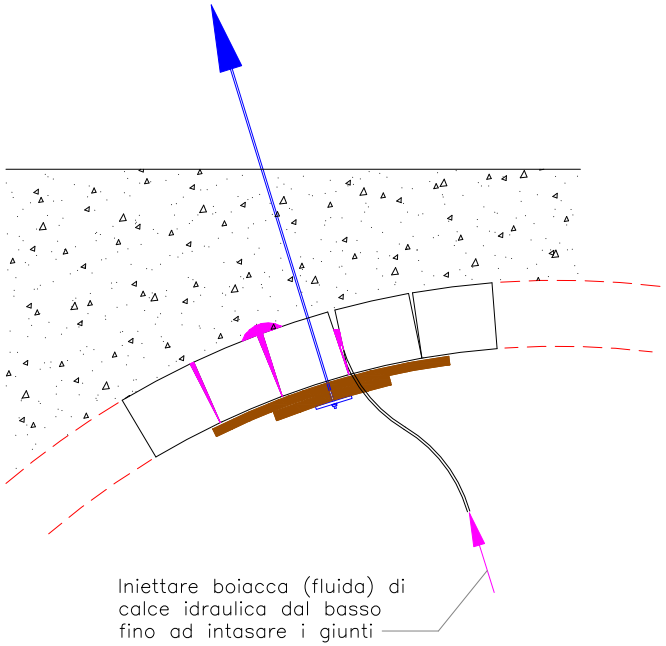


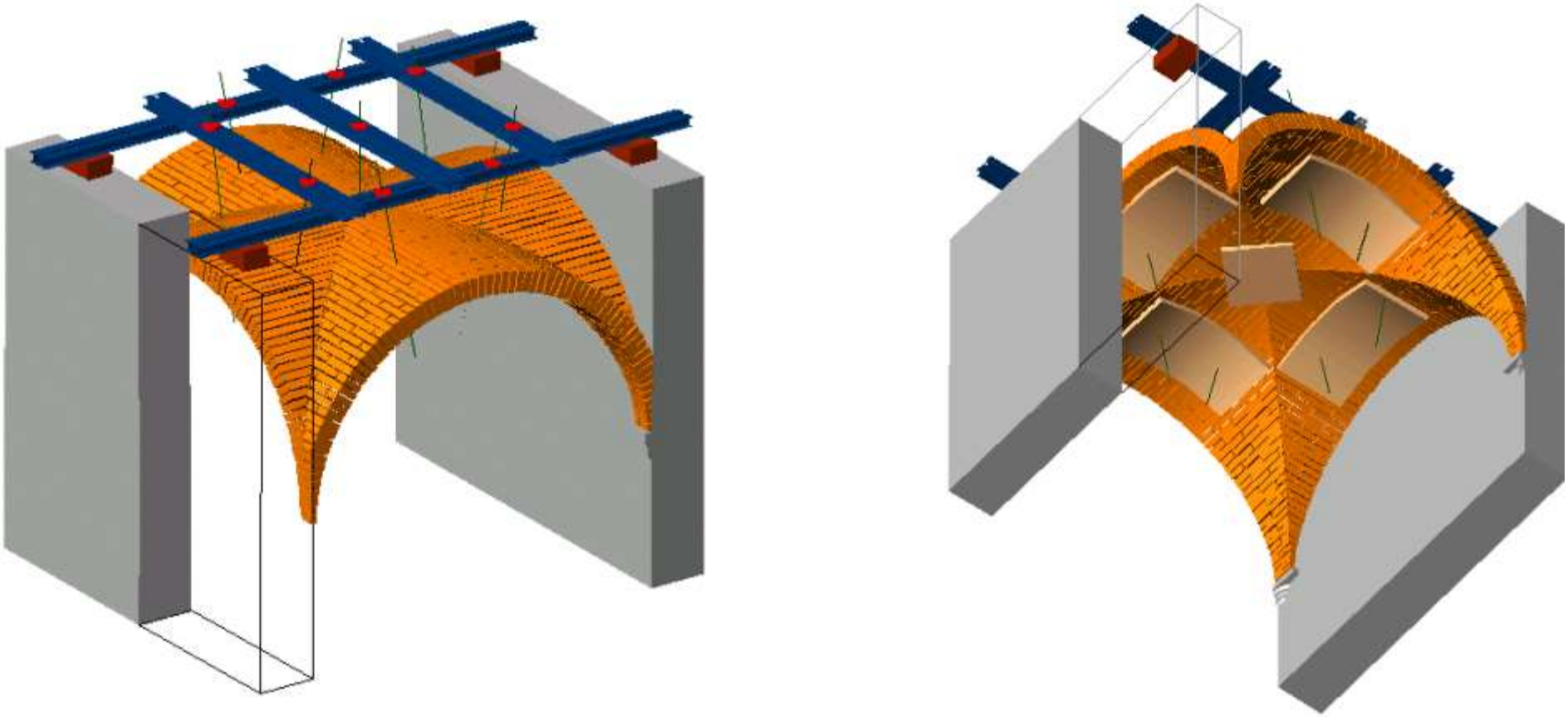


Ripristino della curvatura

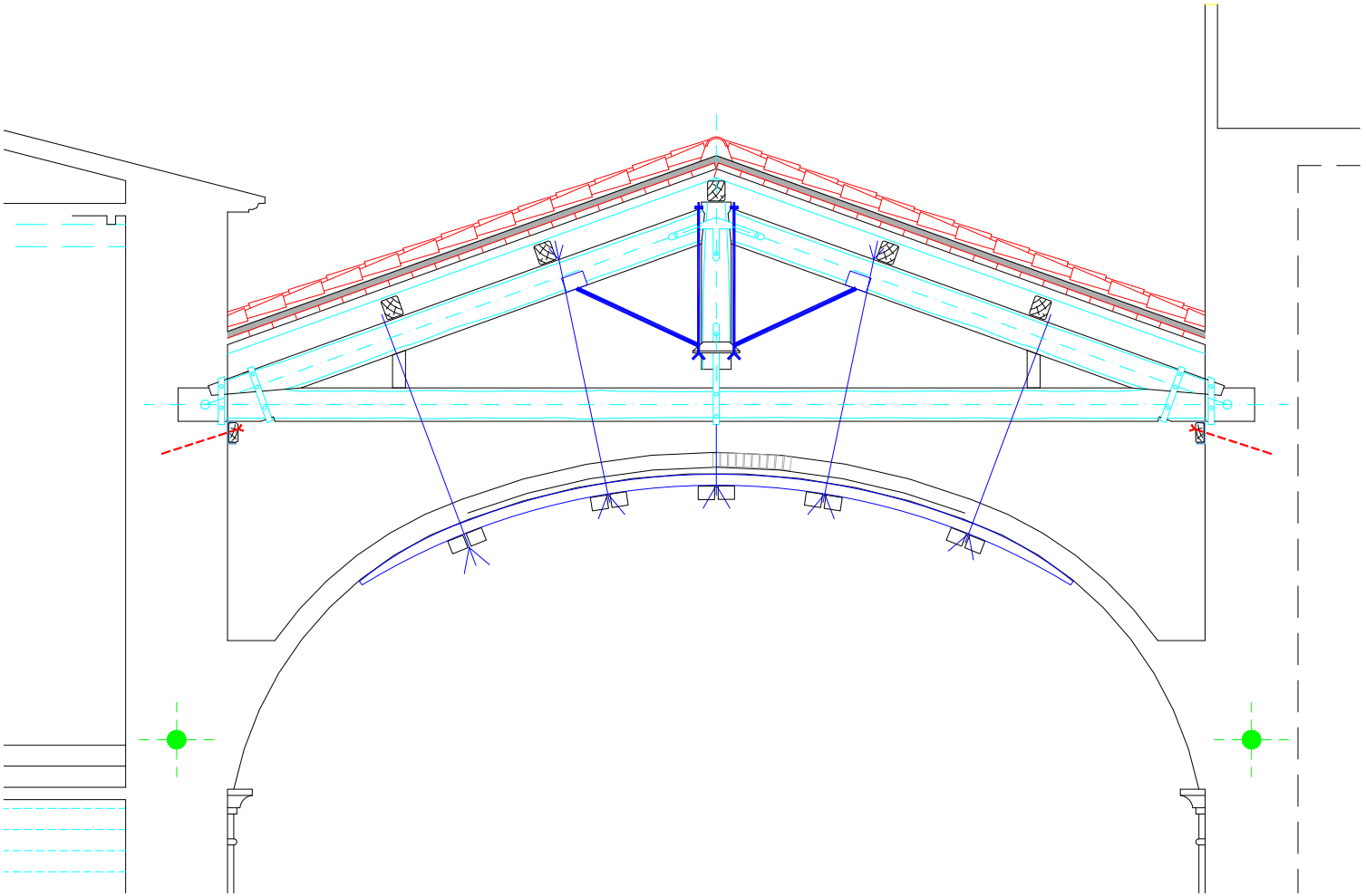








Sistema di sollevamento delle volte per il ripristino della geometria originaria mediante tiranti azionati dall’estradosso





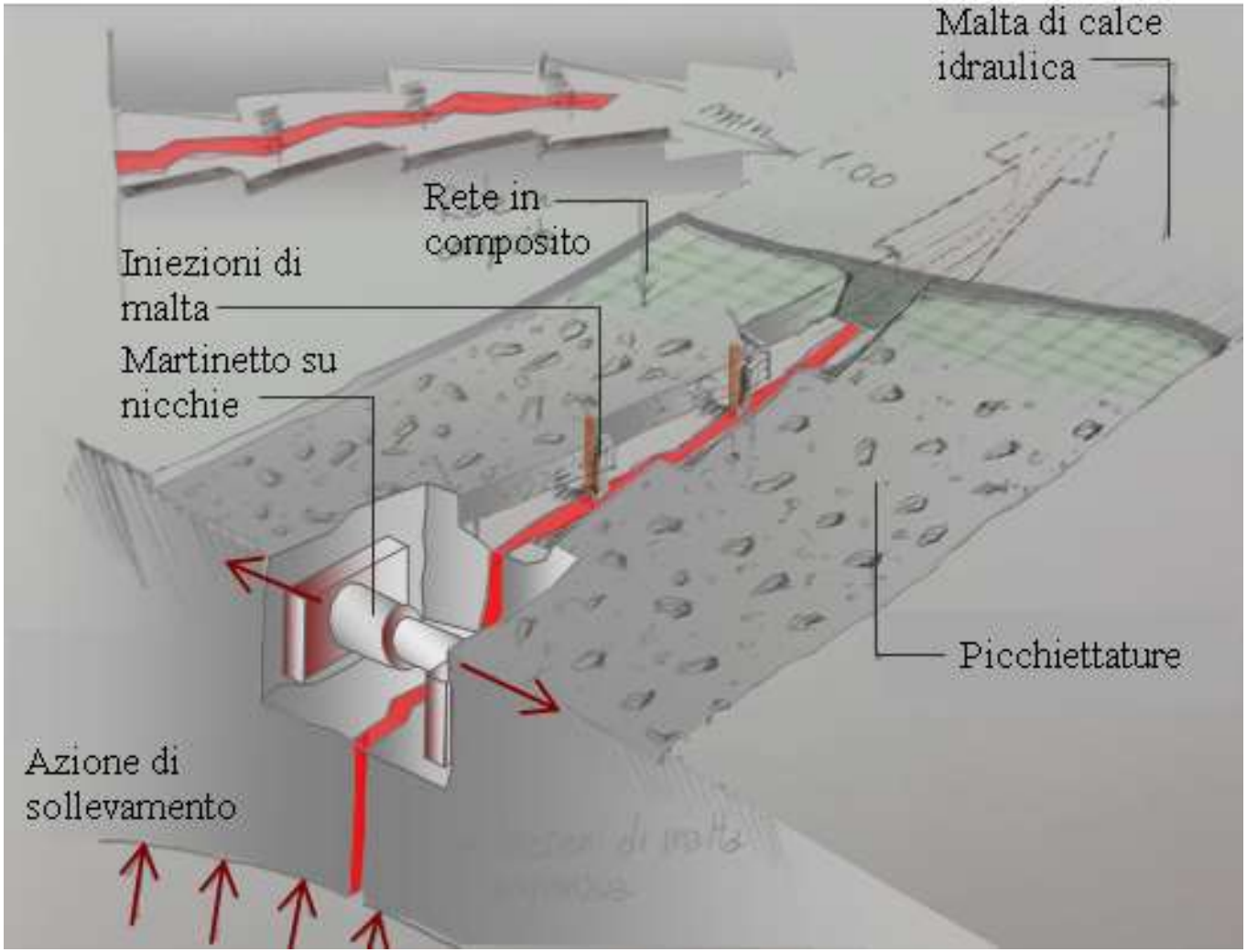
Consolidamento volta della chiesa di S.Francesco – Citerna (PG)

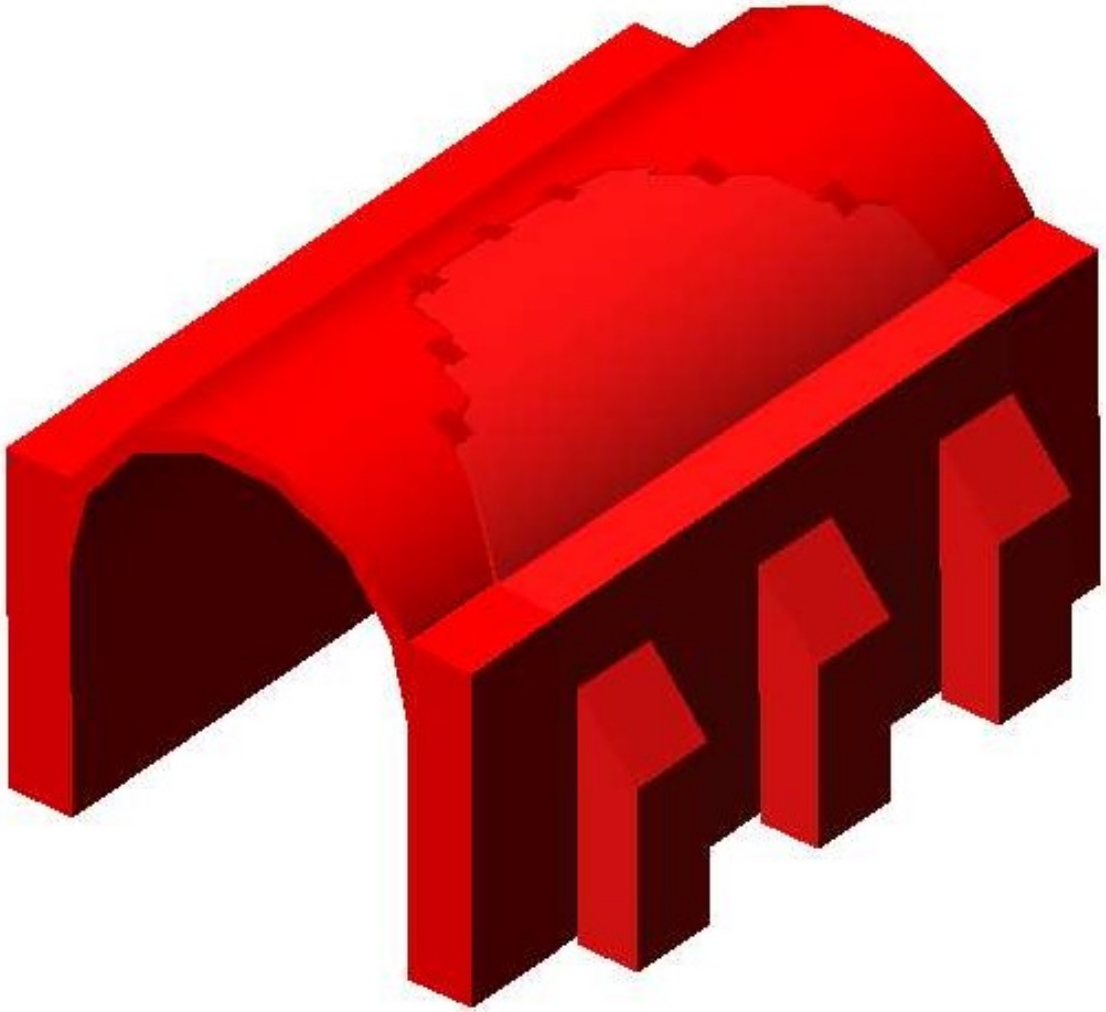
Arch. G.Tavernelli- Geom. S.Gabrielli

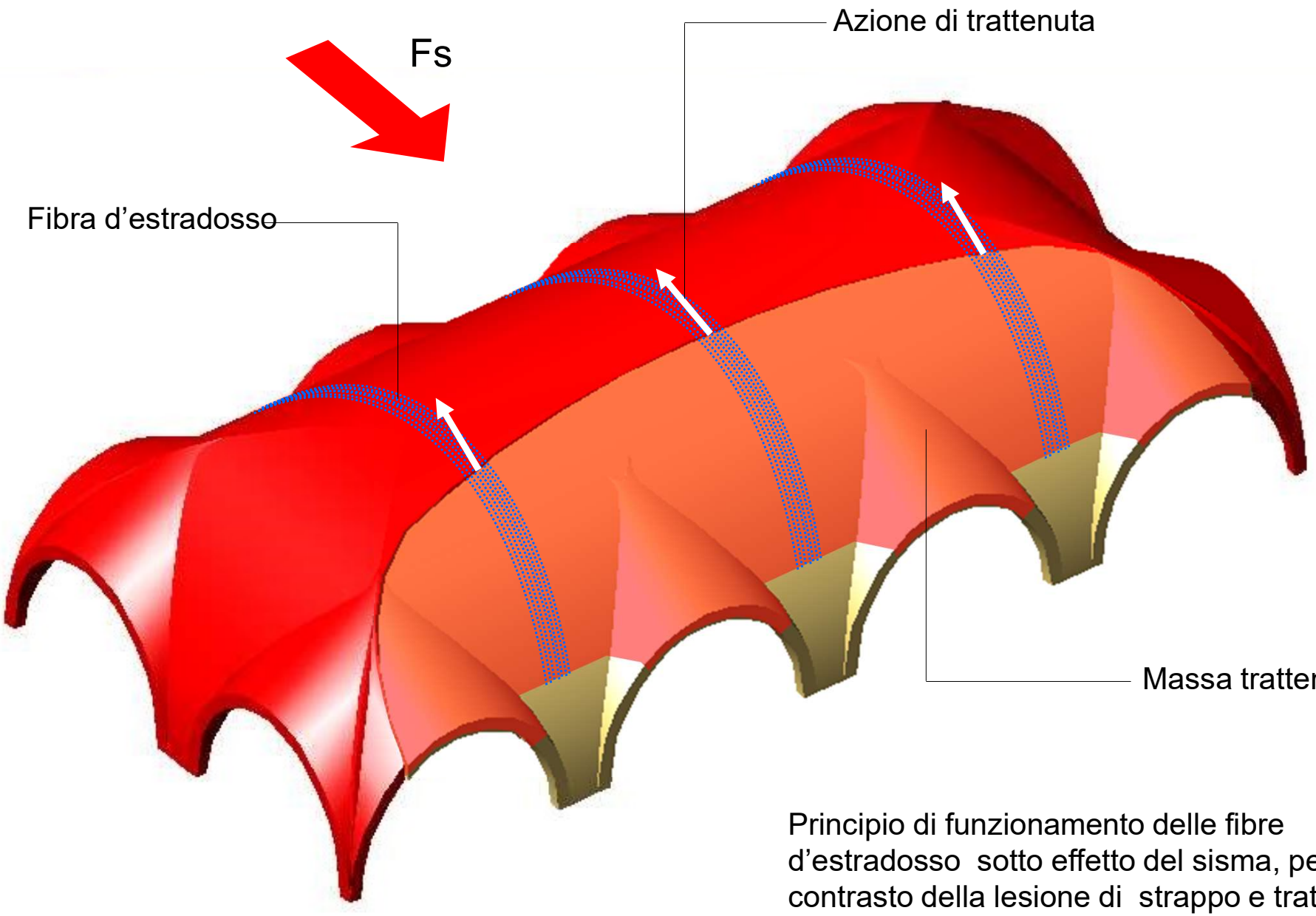
Impresa: CESA di Falcini Enzo – Città di Castello (PG)



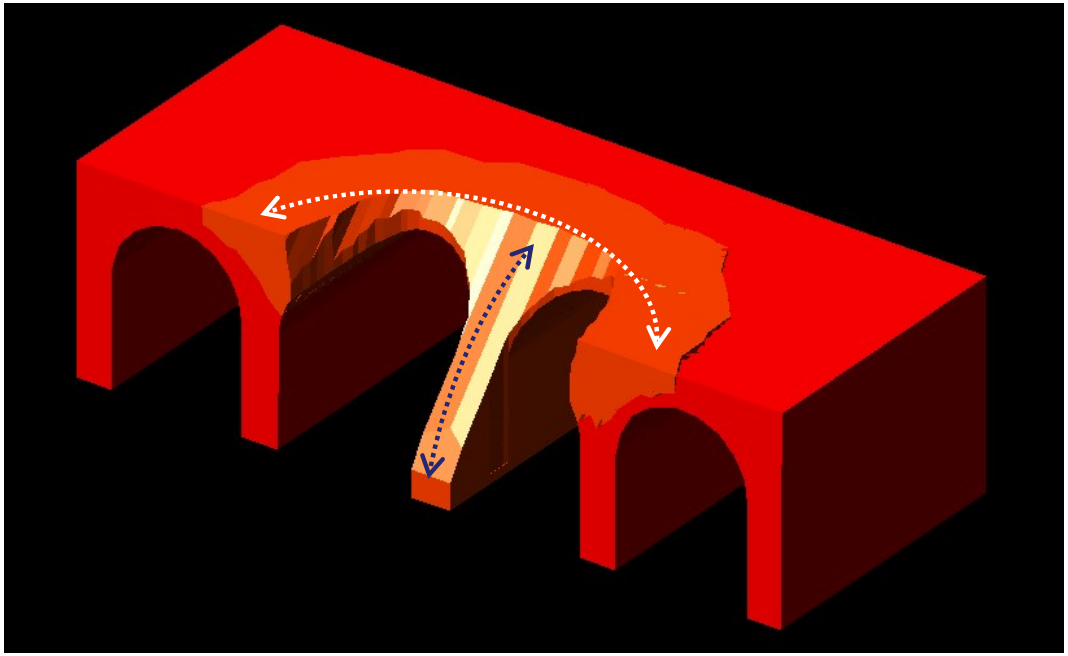



Malta di calce idraulica
Rete in composito
Iniezioni di malta
Martinetto su nicchie
Picchiettature
Azione di sollevamento

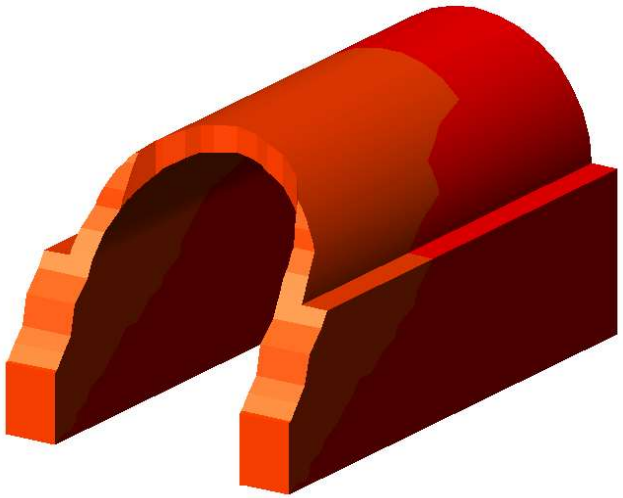




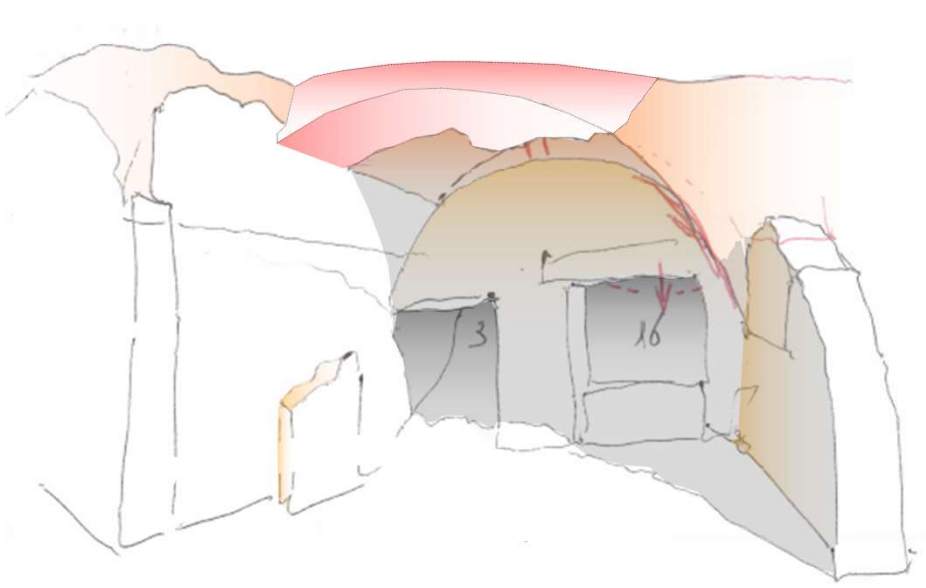
Principio di funzionamento delle fibre d'estradosso sotto effetto del sisma, per il contrasto della lesione di strappo e trattenuta della porzione di volta distaccata.

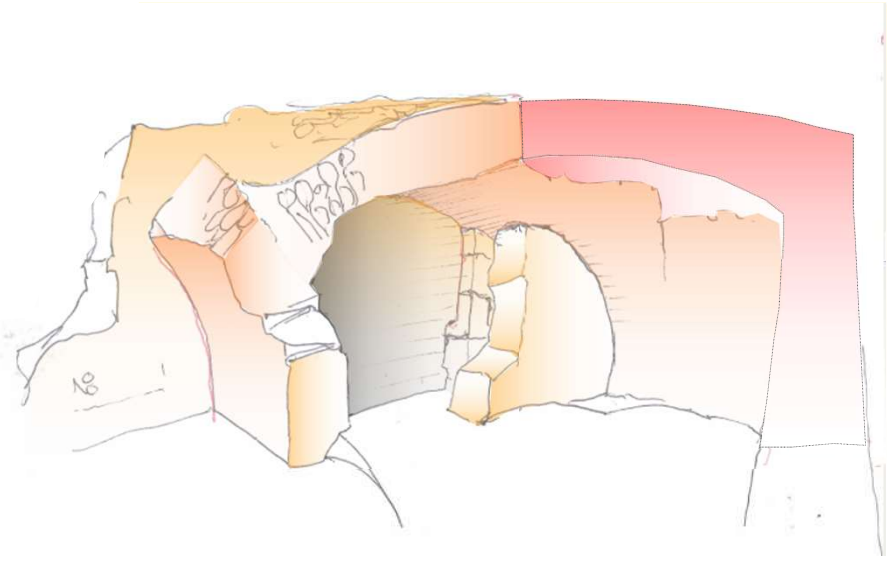


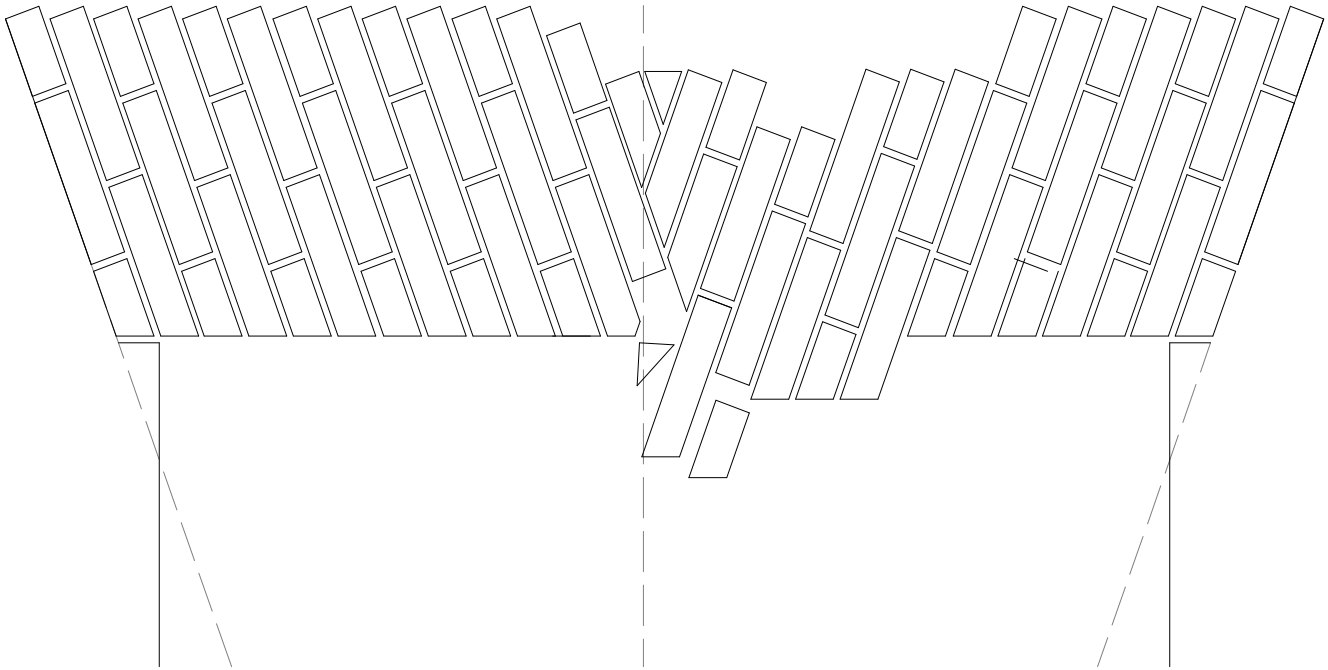
Modello ricostruttivo con reintegro parziale di volte collassate, ricostruzione dei setti murari con profilo a scarpa e regolarizzazione dei profili di crollo delle volte a botte

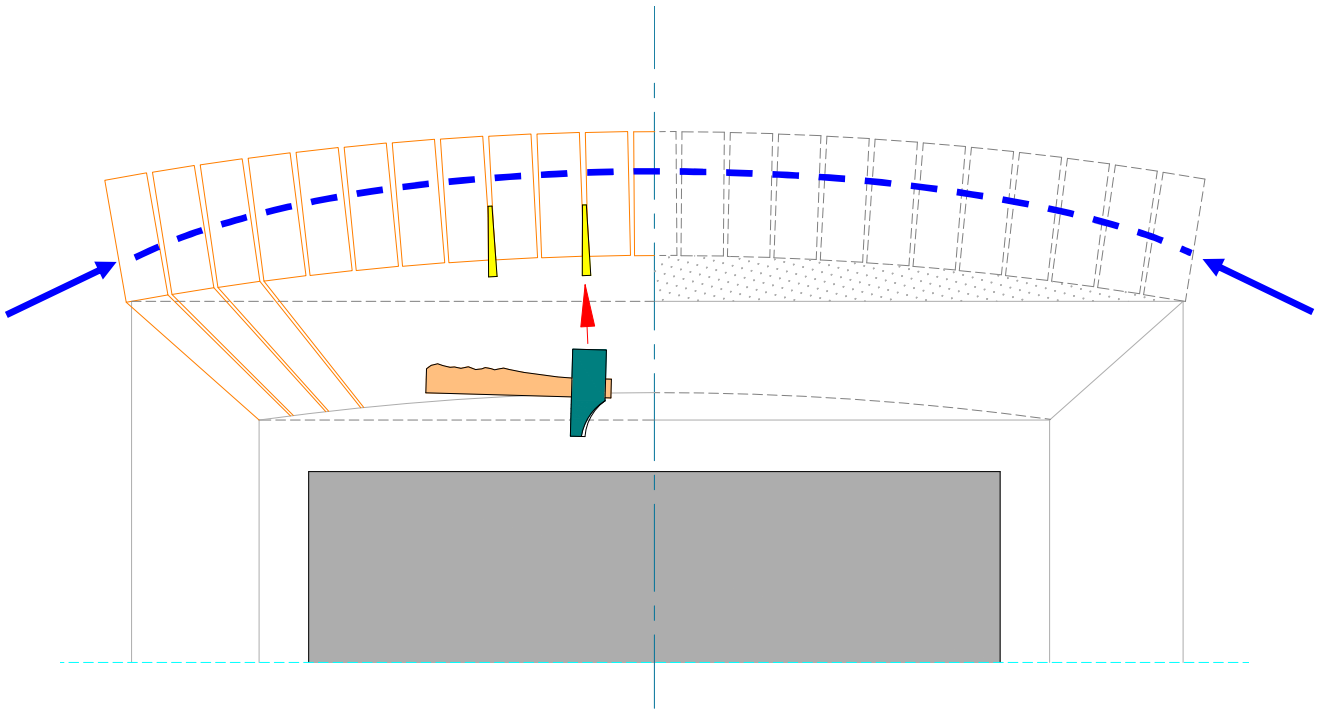


Intervento ricostruttivo parziale di volta a botte su singolo modulo strutturale con ripristino dei setti d’imposta da sagomare con profili a scarpa


3
16



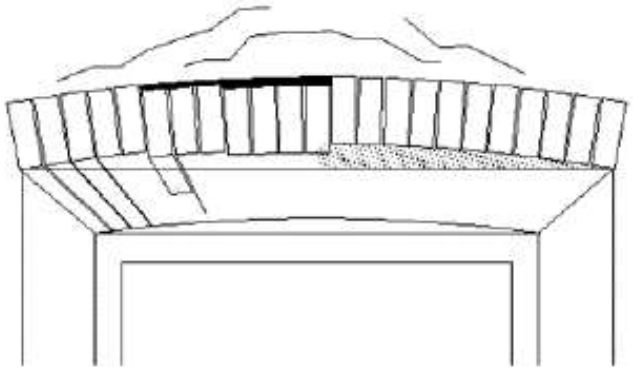


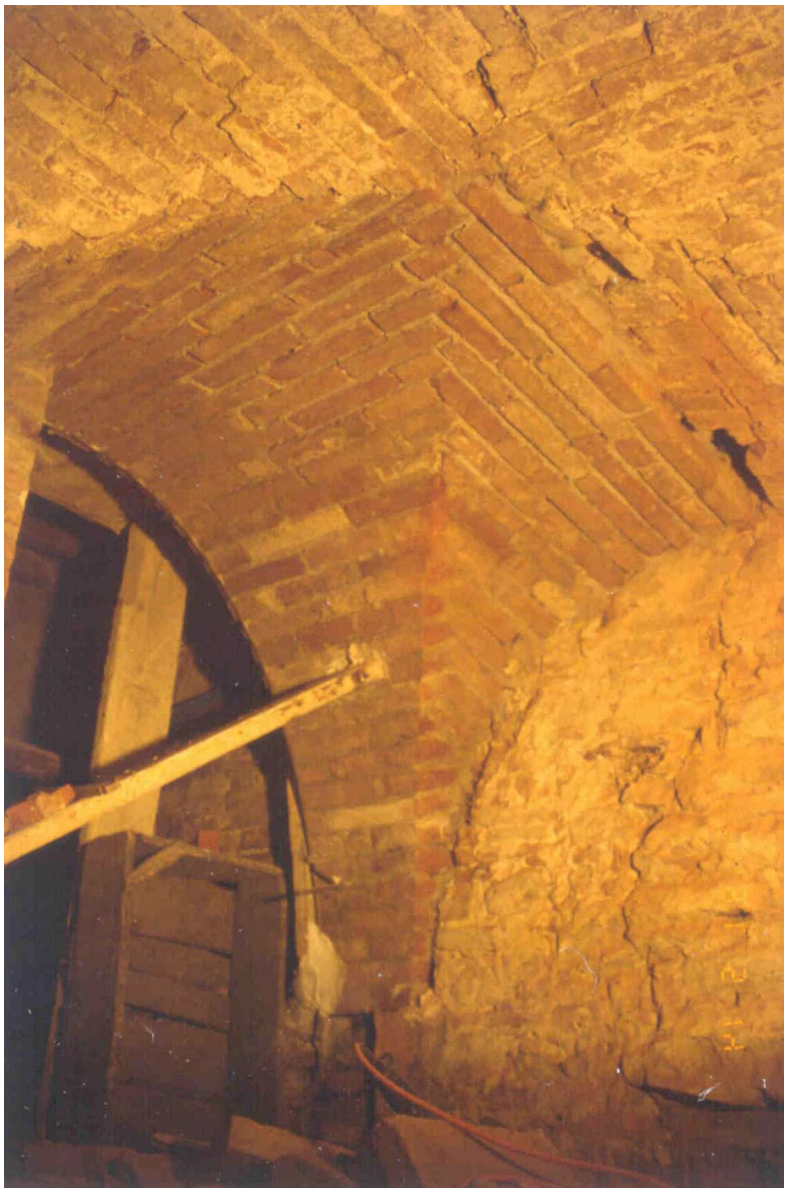




INTERVENTI SU PIATTABANDE E ARCHITRAVI

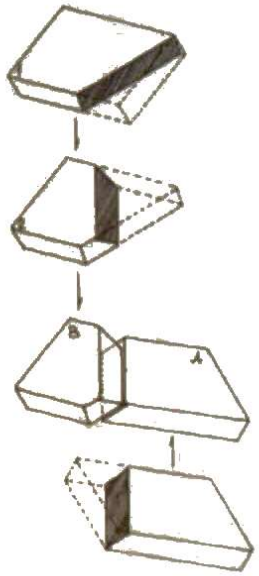
A06064 Consolidamento di piattabande tramite splintaggio degli elementi laterizi.Intervento da eseguire con mattoni pieni o parti di essi previa disposizione di supporti, finalizzato al ripristino della configurazione originaria dell'elemento di sormonto dell'apertura. Sono compresi l'eventuale pulitura dell'elemento strutturale al fine metterlo in luce e predisporre la lavorazione, la scarnitura dei giunti di malta deteriorati, la sostituzione degli elementi laterizi fratturati o consunti, la rinzeppatura dei giunti con l'impiego di cunei di legno in essenza dura o di scaglie di laterizio, il reintegro e la stilatura dei giunti e quanto necessario per dare l'opera finita secondo la regola dell'arte. Non sono comprese le eventuali opere di finitura quali intonaco e tinteggiatura. ..... m **123,00**

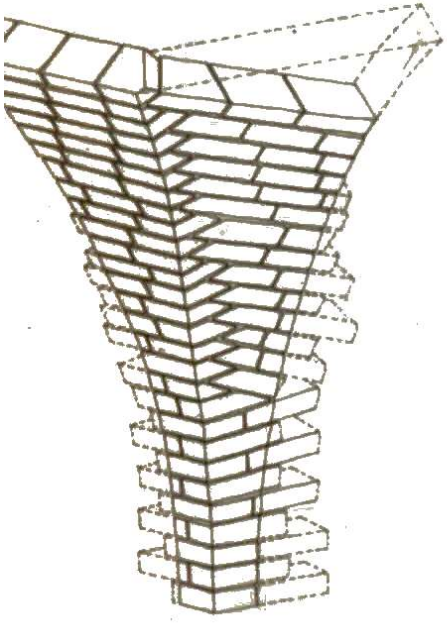




Ricostruzione da sotto

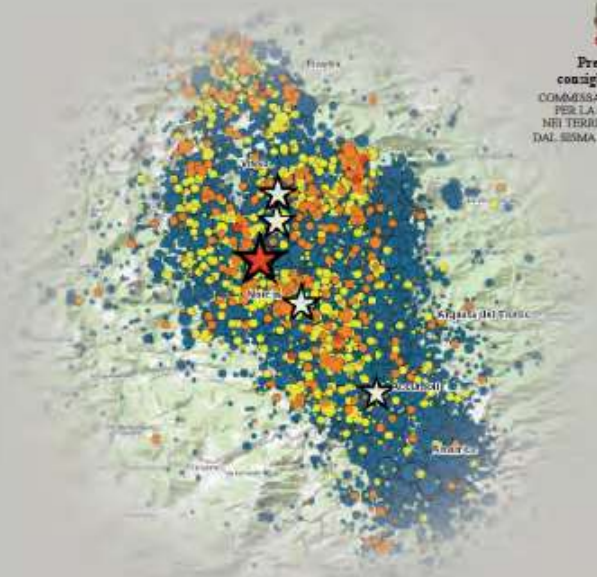






PREZZARIO UNICO DEL CRATERE DEL CENTRO ITALIA

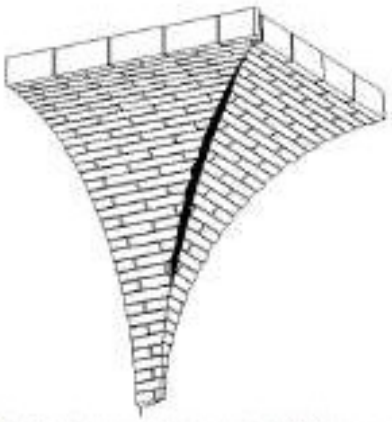
ai sensi dell'art. 6, comma 7, del DL 189/2016, approvato con **Ordinanza n. 7 del Commissario del Governo per la Ricostruzione del 14/12/2016**

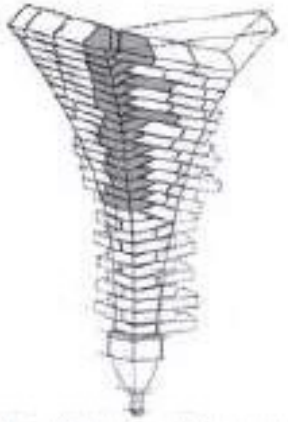


Presidenza del consiglio dei ministri
COMMISSARIO DEL GOVERNO PER LA RICOSTRUZIONE NEI TERRITORI INTERESSATI DAL SISMA DEL 24 AGOSTO 2016

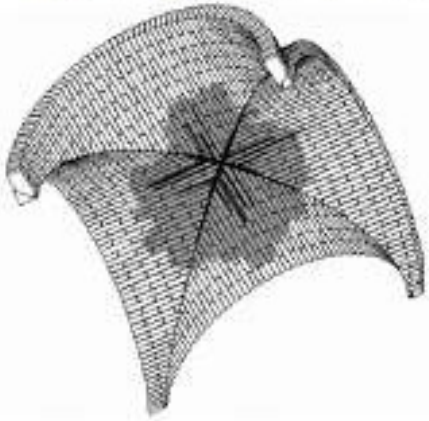
Sistema Qualità Aziendale certificato ISO 9001:2008

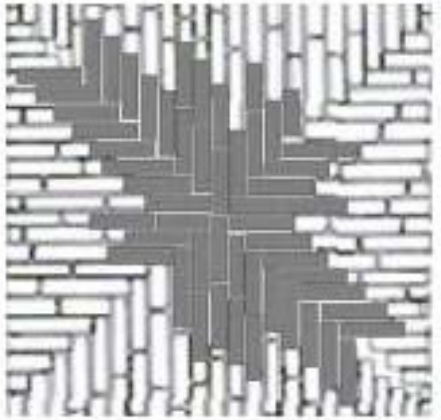
A05060 Ricostituzione con metodo scuci-cuci di nervature di volte laterizie di mattoni posti a coltello, con geometria a crociera o botte lunettata, eseguito dal basso, senza l'ausilio di centine.Computato a m di nervatura trattata ..... m **210,00**





A05061 Ricostituzione con metodo scuci-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**



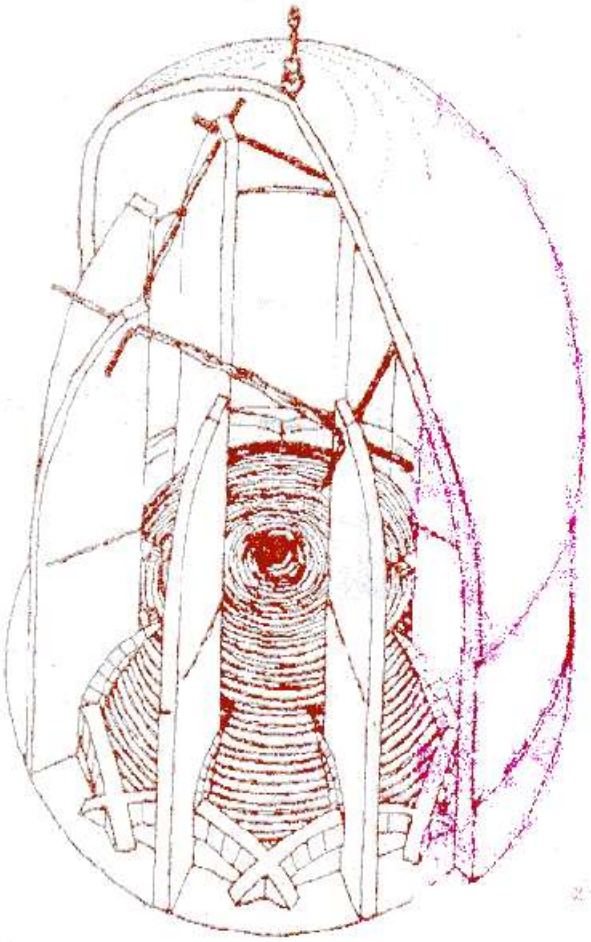


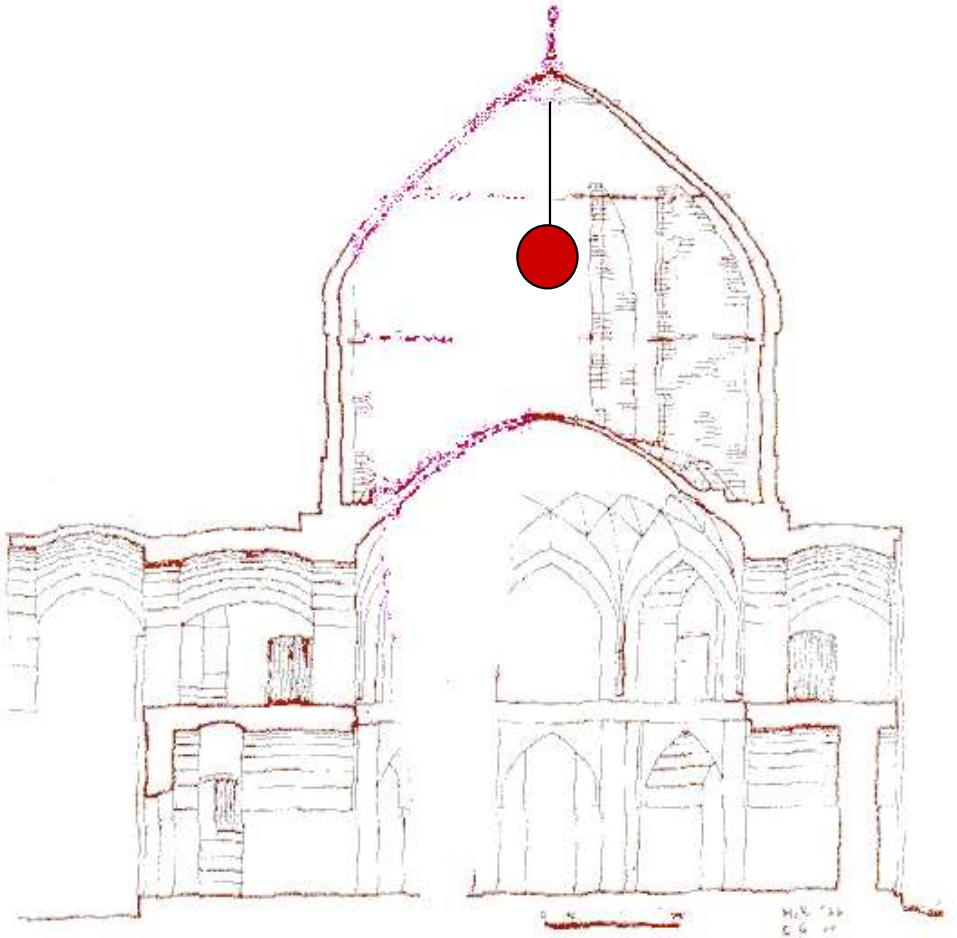
A05062 Ricostituzione con metodo scuci-cuci di spigoli di volte laterizie di mattoni posti in foglio, con geometria a crociera o botte lunettata, eseguito dal basso, senza l'ausilio di centine.Computato a m di nervatura trattata ..... m **150,00**

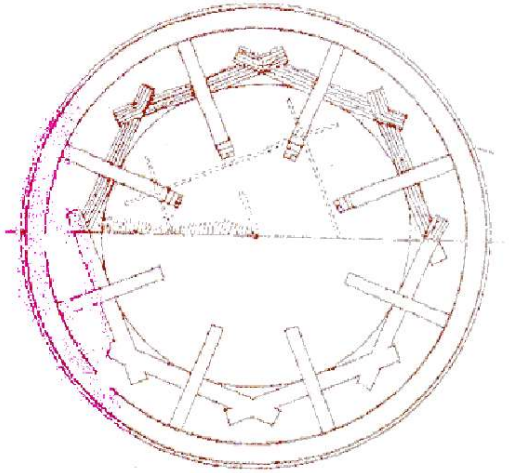




G. Cangi - A Petrani



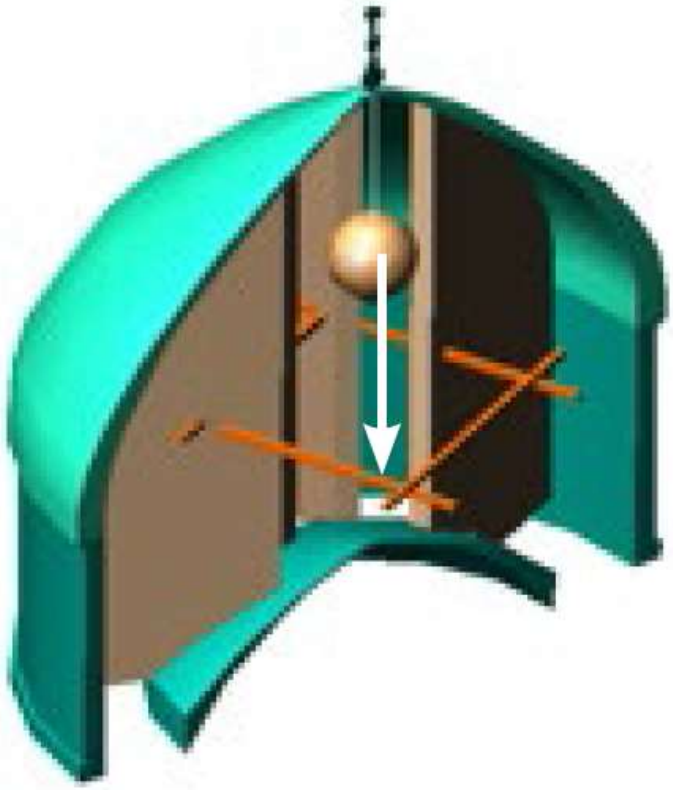




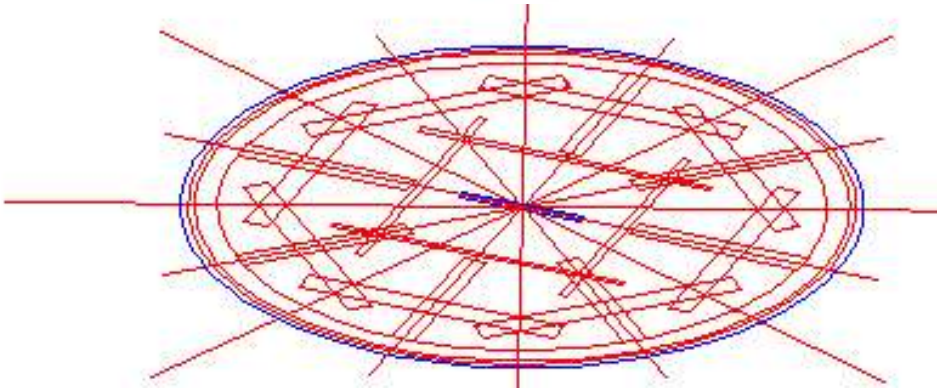
Struttura a doppia cupola con diaframmi interni.
Afushtè, *emanzadeh* Mir Seyed
(Mausoleo dedicato a Mir Cayed)

Elaborati estratti da “PALLADIO - Rivista di Storia dell’Architettura” – Anno XXII, 1972.
Rapporto di Mario FERRANTE ed Eugenio GALDIERI su alcuni Monumenti Timuridi ad Afushtè presso Natanz in Persia.
(Missione Italiana Is.M.E.O.- Maggio 1966)

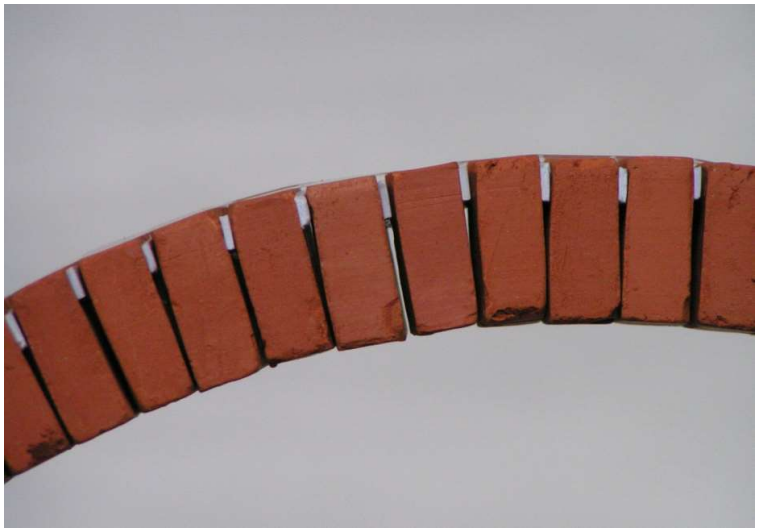
Struttura a doppia cupola con diaframmi interni.
Afushtè, *emanzadeh* Mir Seyed
(Mausoleo dedicato a Mir Cayed)





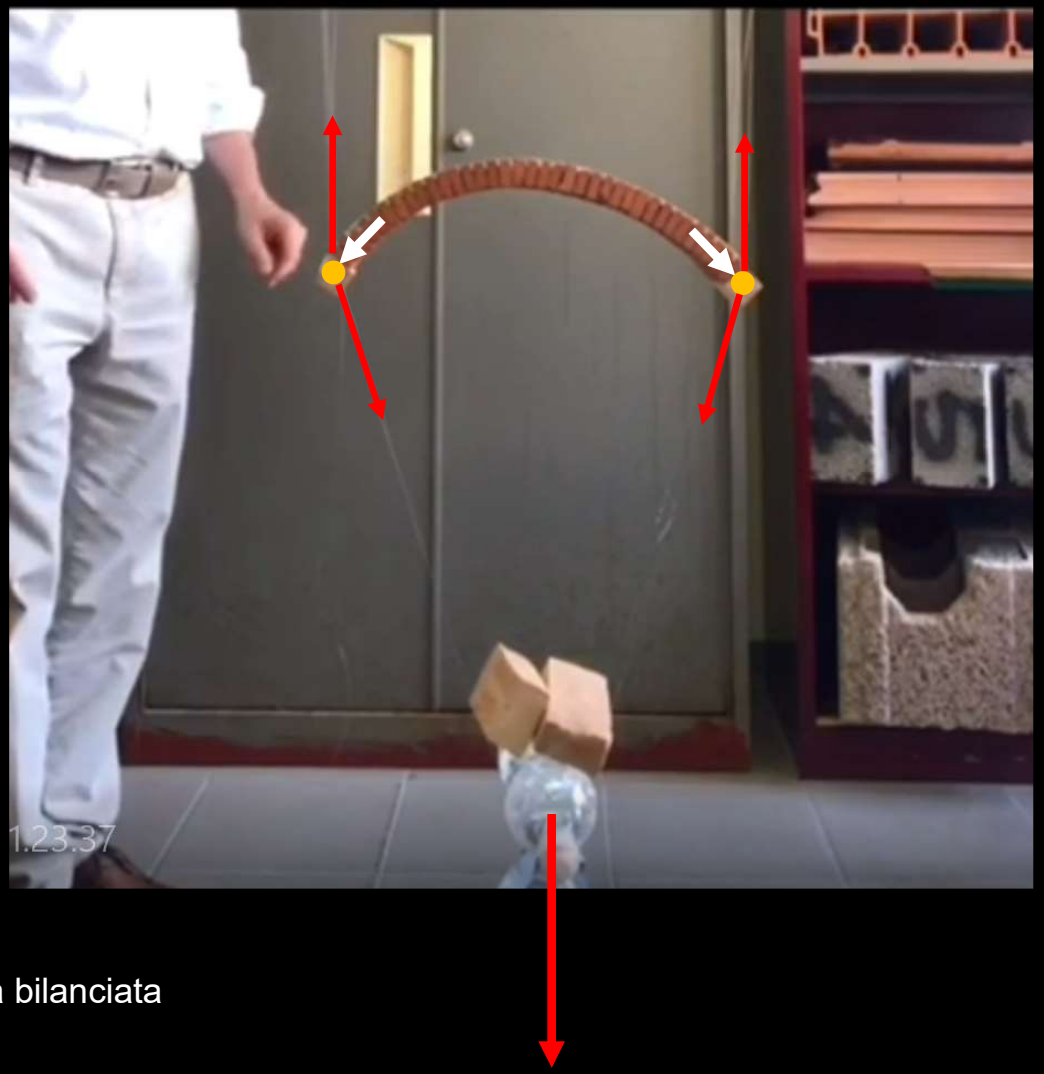




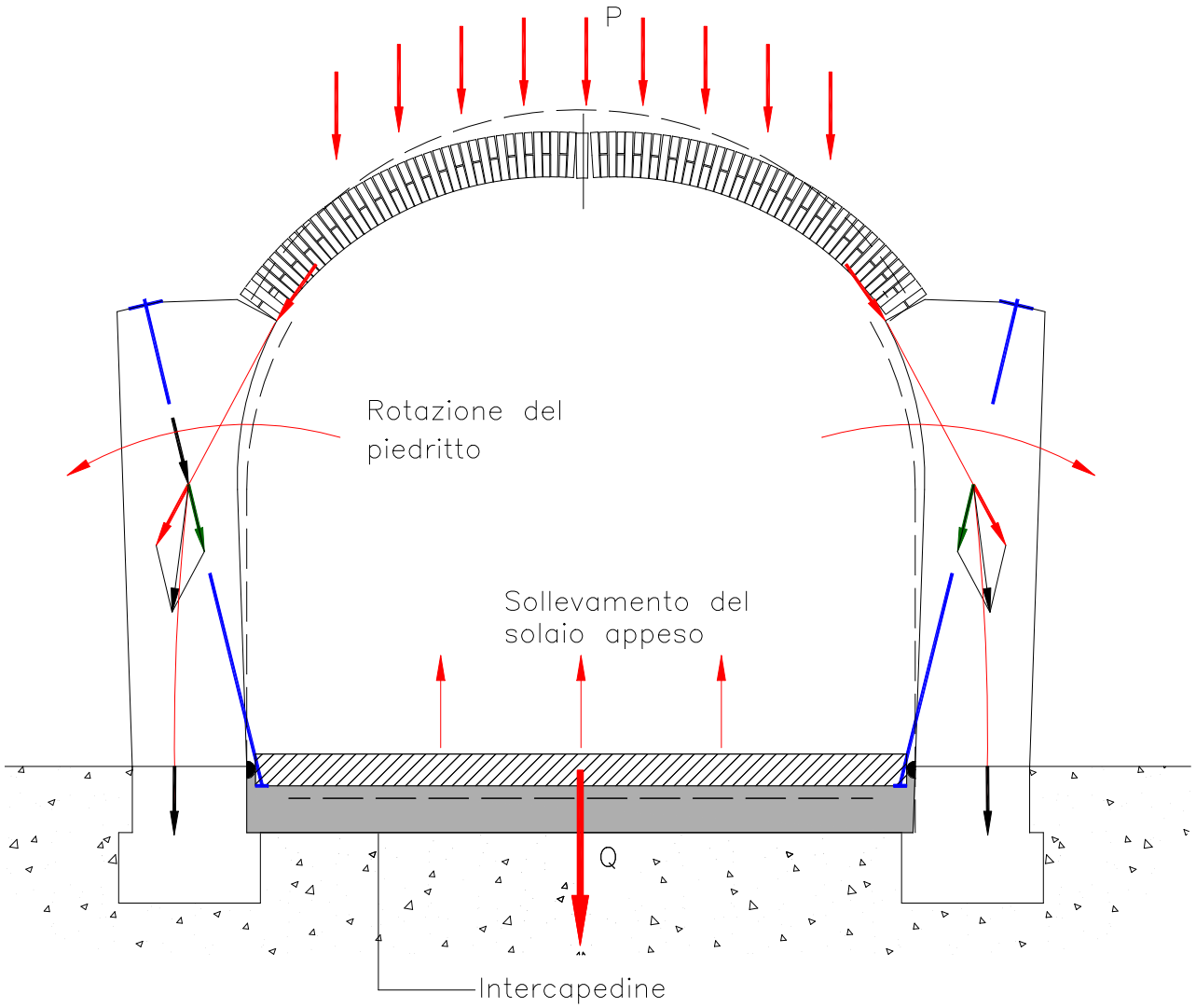


(P1+P2)/2 (P1+P2)/2

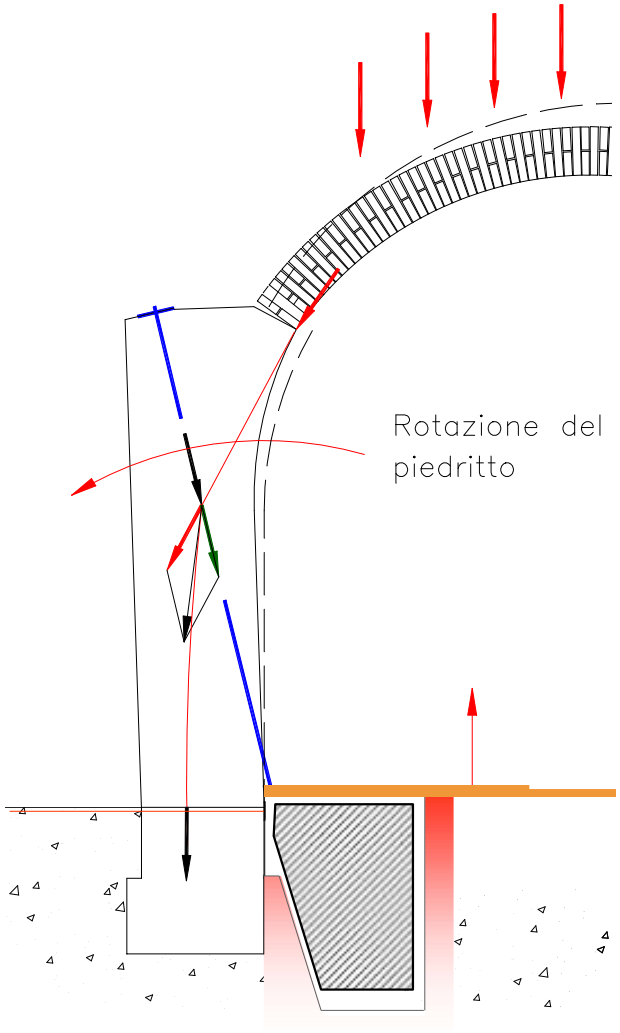




Arco appeso con spinta bilanciata

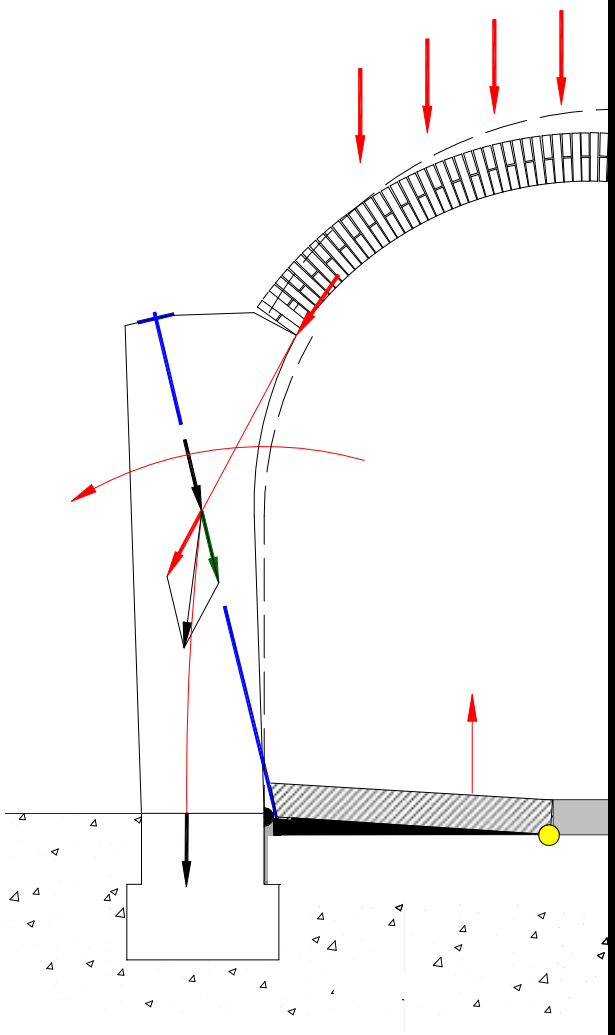


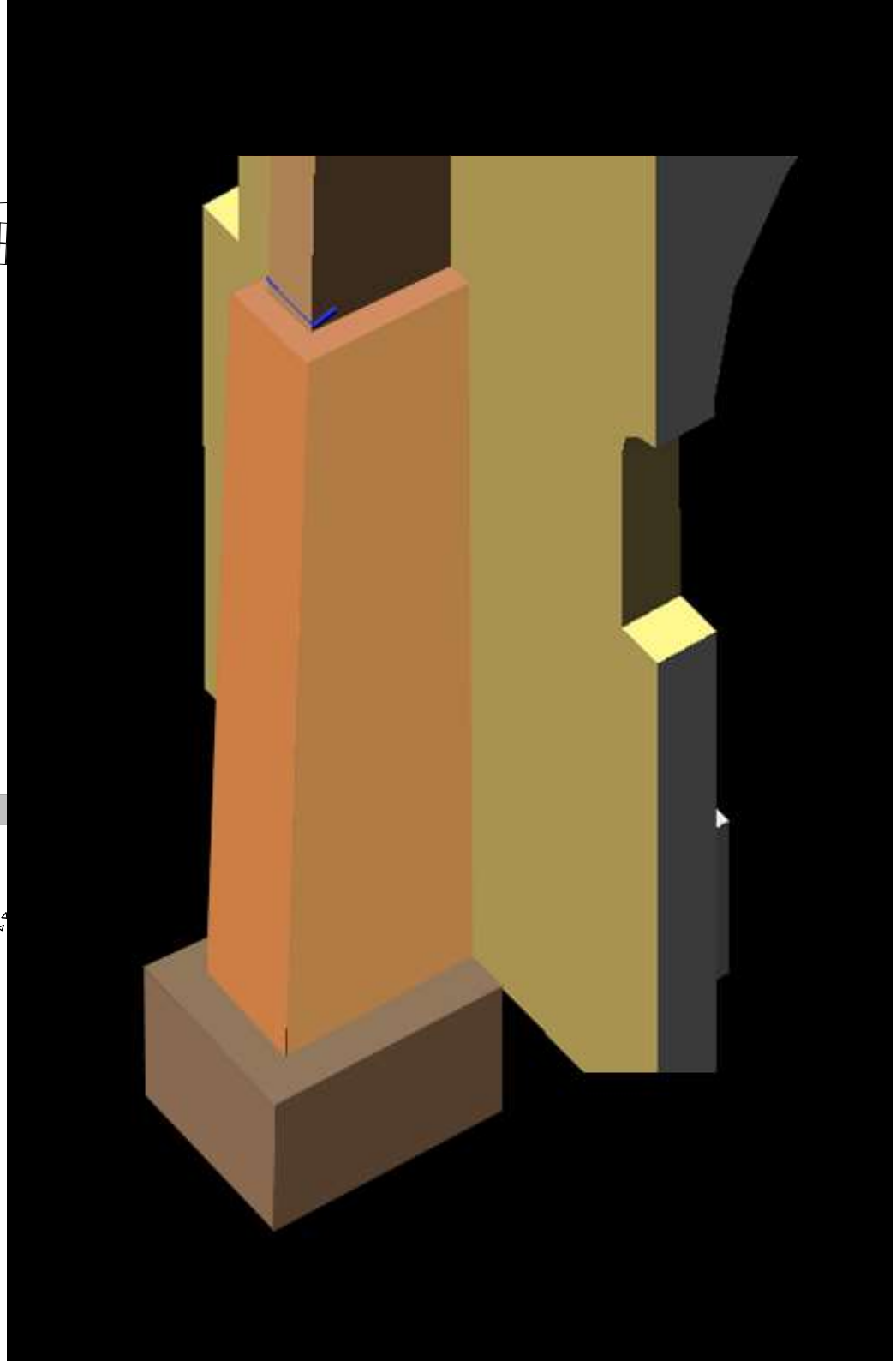
Schema statico della volta con sistema di bilanciamento ottenuto attraverso un carico appeso trasmesso dal solaio del piano terra. L'inflessione dell'arco/volta comporta il sollevamento del solaio sostenuto dai tiranti, mentre un eccessivo peso dello stesso può produrre un fenomeno opposto, con conseguente innalzamento del campo centrale della volta.
In ambedue i casi il movimento del solaio potrebbe essere regolato mediante un sistema di molle, con funzione di ammortizzatori strutturali, da disporre all'intradosso del solaio.



Il dispositivo non serve ad eliminare la spinta, ma a deviarle utilmente verso la base d’appoggio

Bilanciamento laterale con zavorra su base scorrevole





Bilanciamento laterale con zavorra a pavimento

Il dispositivo non serve ad eliminare la spinta, ma a deviarle utilmente verso la base d’appoggio

ESEMPIO: BEDESTAN (S-NICOLA DEGLI INGLESI)
Nicosia-Cipro

