



Università degli Studi di Salerno

ELASTIC SOLUTIONS FOR MASONRY-LIKE WALLS.

M. Angelillo*, A. Fortunato* & L. Cardamone**

*Dipartimento di Ingegneria Civile, Università di Salerno, Via Ponte don Melillo, Fisciano – 84084 Salerno, Italia,
Email: mangelillo@unisa.it ; a.fortunato@unisa.it .

**Texas A&M University, College Station, Texas 77843, Email: lcaramo@unisa.it

Riferimenti

- Del Piero G. Constitutive equation and compatibility of the external loads for linear elastic masonry-like materials, *Meccanica*, **24**, (1989)
- Giacomini M., Giusti E., Researches on the Equilibrium of Masonry Structures, *Arch. Ration. Mech. Anal.*, **88**, (1985)
- Sacco, E.: Una procedura di omogeneizzazione non lineare per muratura periodica, *Workshop on Design for Rehabilitation of Masonry Structures*, Lacco Ameno (ISCHIA), 11-12 Ottobre 2007

GMA 2008

RIUNIONE DEL GRUPPO MATERIALI DELL'AIMETA, Associazione Italiana di Meccanica Teorica ed Applicata
Facoltà di Architettura, Università degli Studi di Genova, 29 febbraio-1 marzo 2008

Il Modello “Masonry-Like”

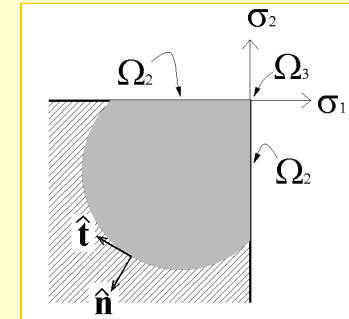
Materiale non reagente a trazione, con limitata resistenza a compressione: problemi di evoluzione quasi-statica, dipendenti dal percorso di carico ma indipendenti dalla scala del tempo.

Problemi 2D, Piccole deformazioni: $\mathbf{e} = \frac{1}{2}(\nabla \mathbf{u} + \nabla \mathbf{u}^T)$

Restrizioni materiali: $\boldsymbol{\varepsilon} \in \mathcal{K} \subset \mathbb{R}^{n \times n} \quad \mathbf{T} = \mathbf{C}\boldsymbol{\varepsilon} \quad \mathbf{T} \in \mathcal{T} = \mathbb{K} \cap NSym$

$$\boldsymbol{\lambda} \in PSym \Leftrightarrow tr \boldsymbol{\lambda} \geq 0, \quad det \boldsymbol{\lambda} \geq 0 \quad \mathbf{T} \boldsymbol{\lambda} = \mathbf{0}$$

$$(\mathbf{T} - \mathbf{T}^*) \cdot \dot{\boldsymbol{\varepsilon}}^p \geq 0, \quad \forall \mathbf{T}^* \in \mathbb{K} \quad (\text{Relazione di normalità, legge di flusso plastico associato})$$



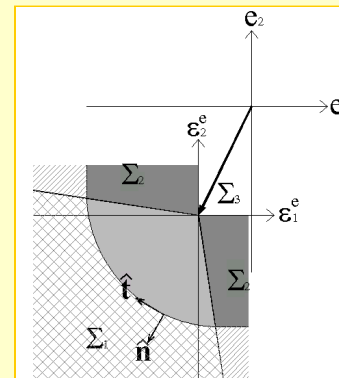
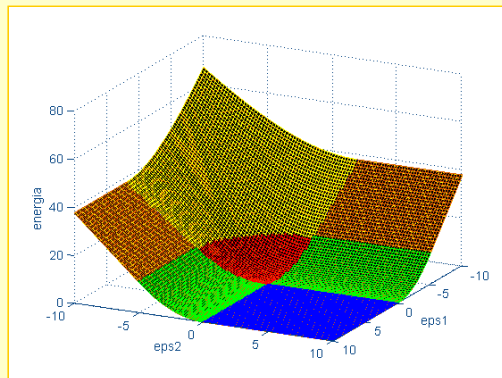
Formulazione del BVIP e discretizzazione temporale

$$div \mathbf{T}(t) + \mathbf{b}_t = \mathbf{0} \quad \mathbf{T}(t) \cdot \hat{\mathbf{n}} = \mathbf{p}_t \quad su \partial \Omega_p(t), \quad \mathbf{u} = \bar{\mathbf{u}} \quad su \partial \Omega_u(t) \quad s(0) = (\mathbf{u}(0), \mathbf{T}\boldsymbol{\lambda}(0), \boldsymbol{\varepsilon}(0), p(0))$$

Traiettoria quasi-statica: $s^0(t) = (\mathbf{u}^0(t), \mathbf{T}\boldsymbol{\lambda}(t), \boldsymbol{\varepsilon}(t), p(t)) \quad \forall t \in [0, T]$

ottenuta integrando nel tempo $d\mathbf{e}^0$. $d\mathbf{e}^0$ è il minimizzatore del funzionale $A(\dot{\mathbf{u}}) = - \int_{\Omega} \dot{\mathbf{b}} \cdot \dot{\mathbf{u}} da - \int_{\partial \Omega_N} \dot{\mathbf{p}} \cdot \dot{\mathbf{u}} ds + \int_{\Omega} \psi^p(\dot{\mathbf{e}}) da$

Strain -rate potential



Strain potential

Discretizzazione temporale

L'intervallo temporale $[0, T]$ è suddiviso in k sottointervalli per mezzo degli istanti: $0 = t_0 < t_1 < \dots < t_i < \dots < t_k = T$

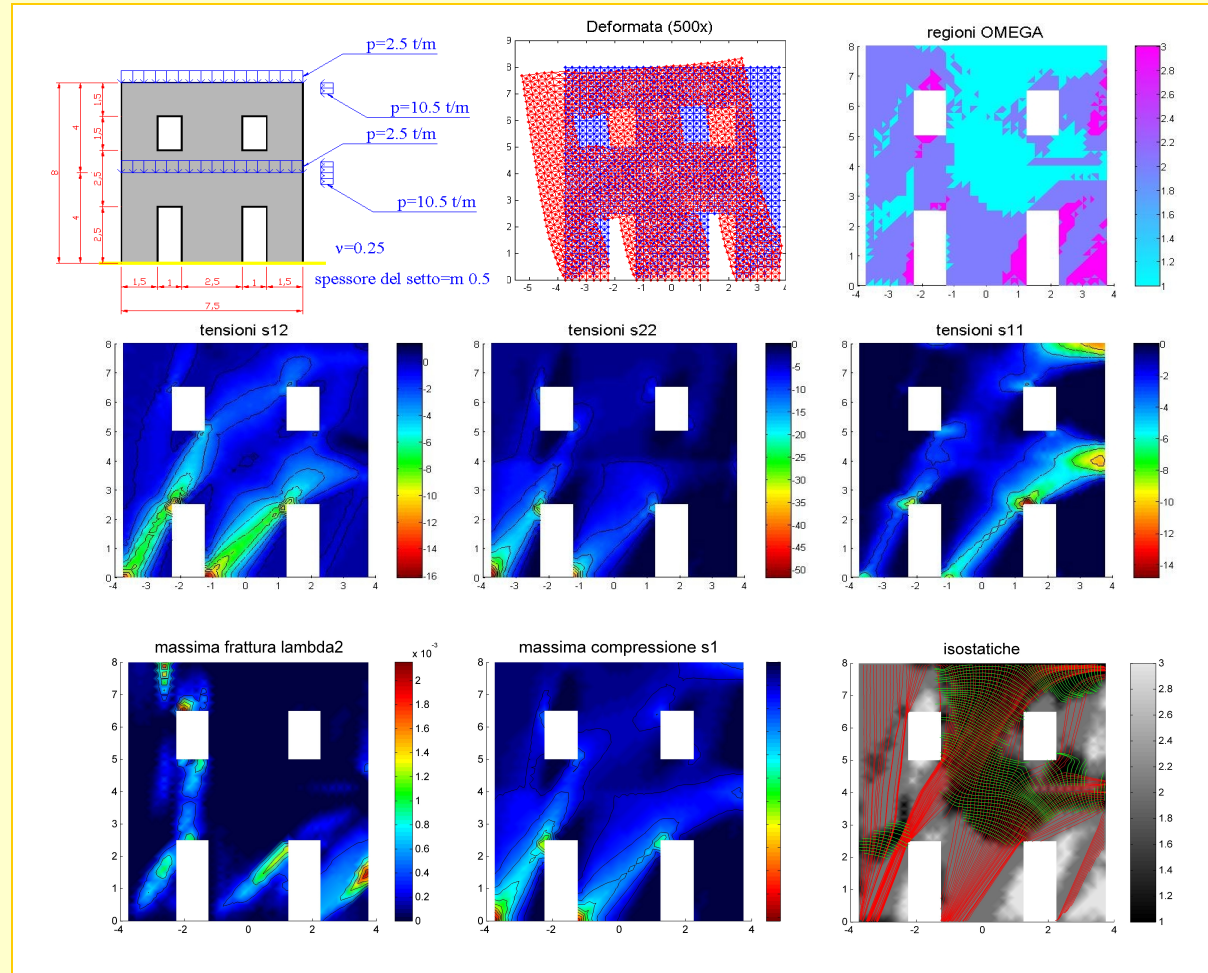
e la soluzione approssimata $s_{i+1}^0 = \left(\mathbf{u}_{i+1}^0, \mathbf{T}_{i+1}^0, \boldsymbol{\varepsilon}_{i+1}^0, p_{i+1}^0 \right)$ ad ogni tempo t_{i+1} è definita induttivamente come minimizzatore del funzionale

$$\mathcal{E}_{i+1} = - \int_{\partial \Omega_p^{i+1}} \mathbf{p}_{i+1} \cdot \mathbf{u} \, da - \int_{\Omega} \mathbf{b}_{i+1} \cdot \mathbf{u} \, dx + \int_{\Omega} \hat{\Psi} \left(\mathbf{e} \boldsymbol{\varepsilon}_i^p \right) \, dx$$

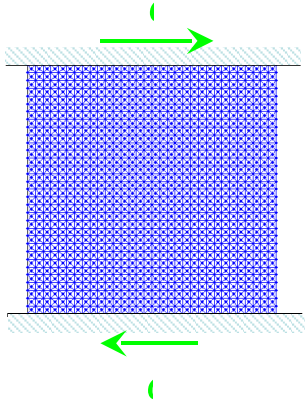
Per il problema variazionale incrementale di minimizzazione del funzionale si adotta una formulazione **lagrangiana totale** con condizione iniziale lo stato s_i^0 soluzione al passo i .

Parete di materiale NRT

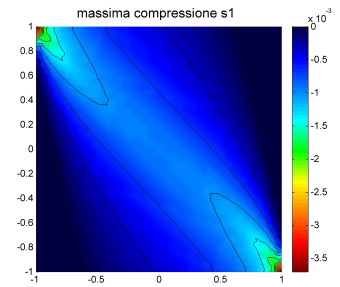
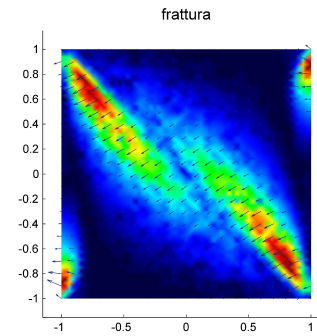
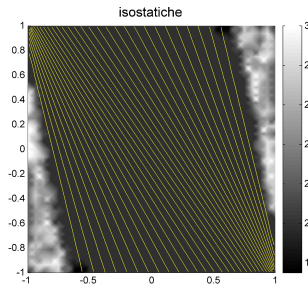
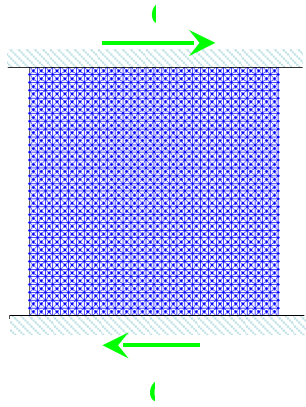
Si considera una parete di materiale NRT con $\nu=0.25$, aperture su due piani, sottoposta a carichi verticali che simulano scarichi di solai ed carichi orizzontali a livello dei solai che simulano carichi statici equivalenti da sisma.



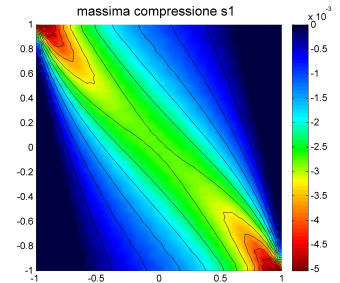
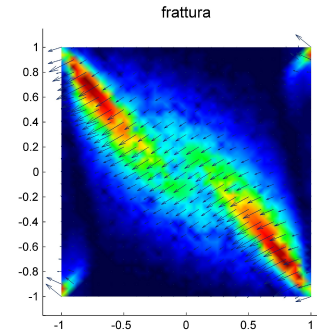
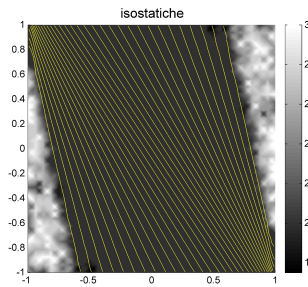
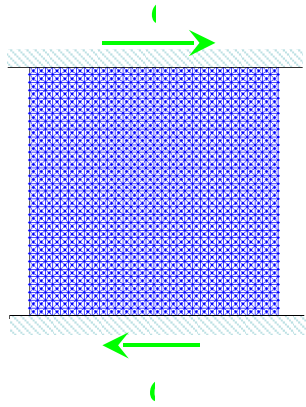
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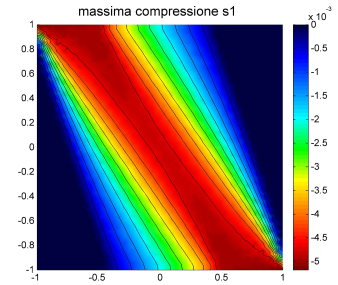
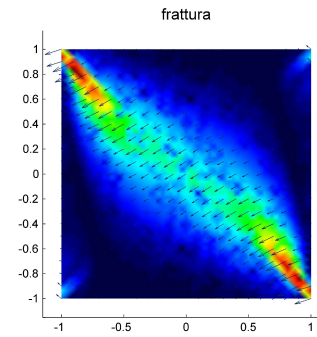
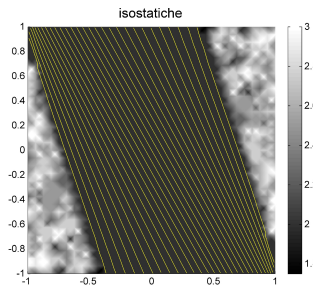
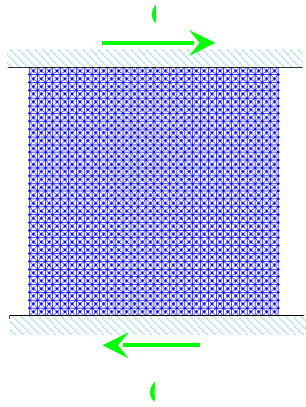
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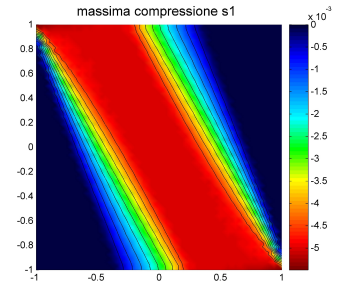
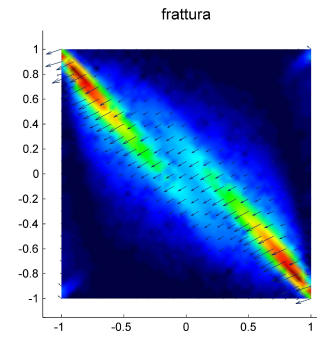
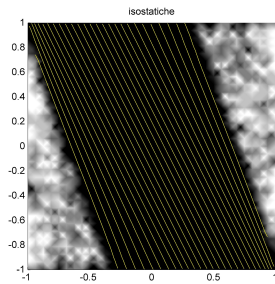
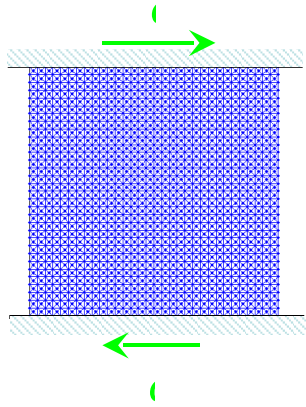
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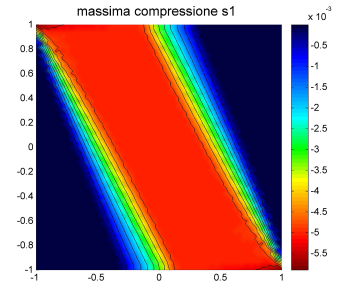
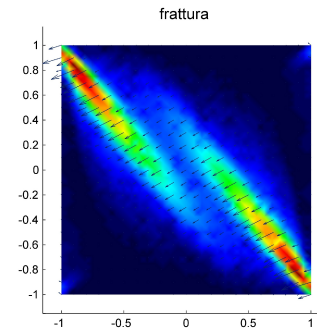
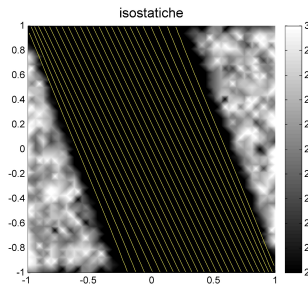
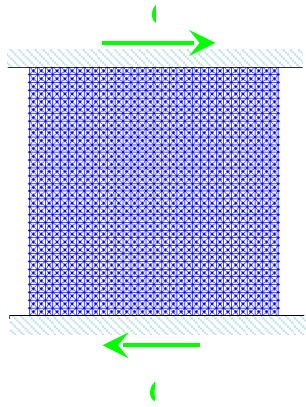
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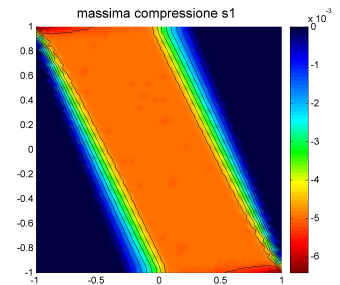
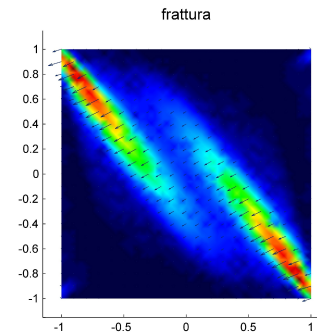
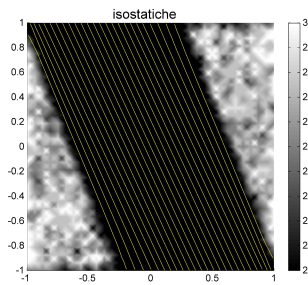
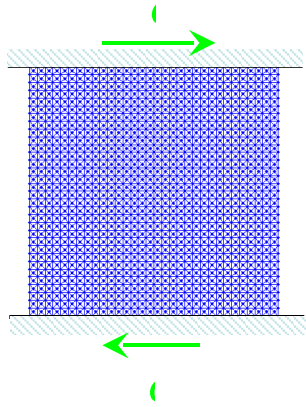
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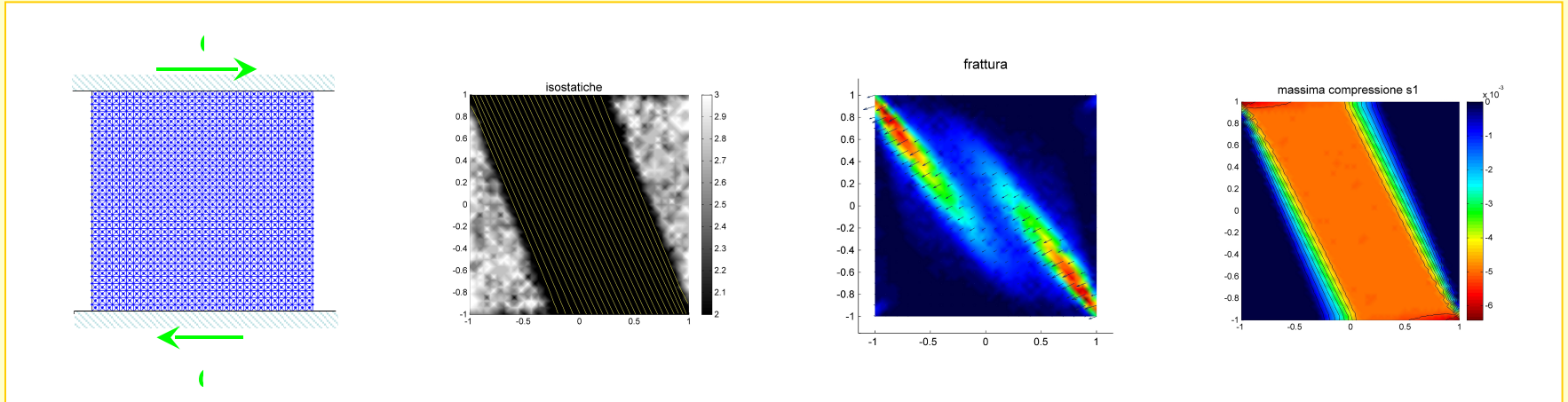
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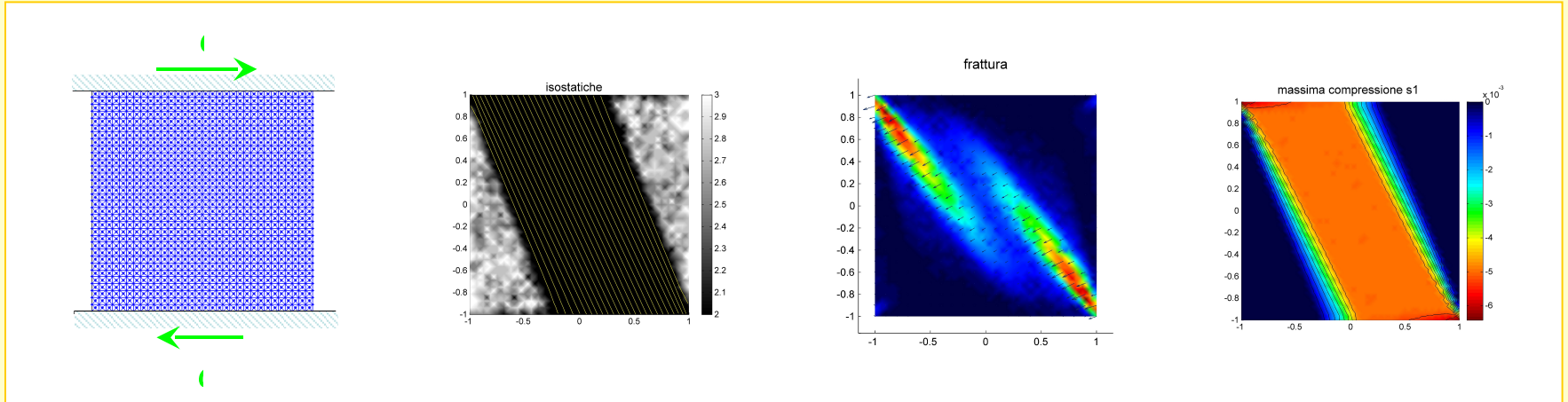


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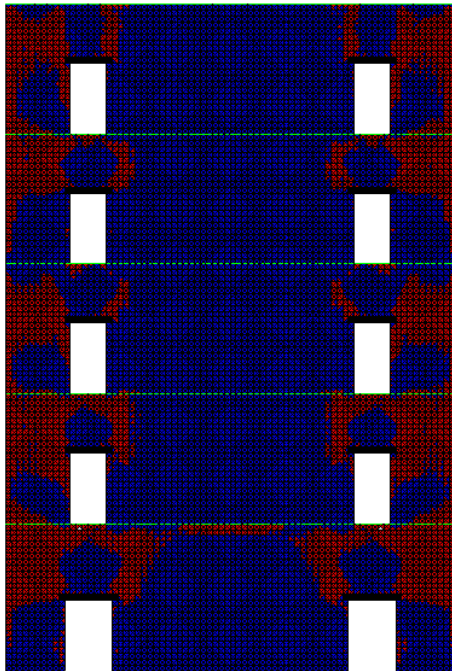


Apertura di forza in una parete

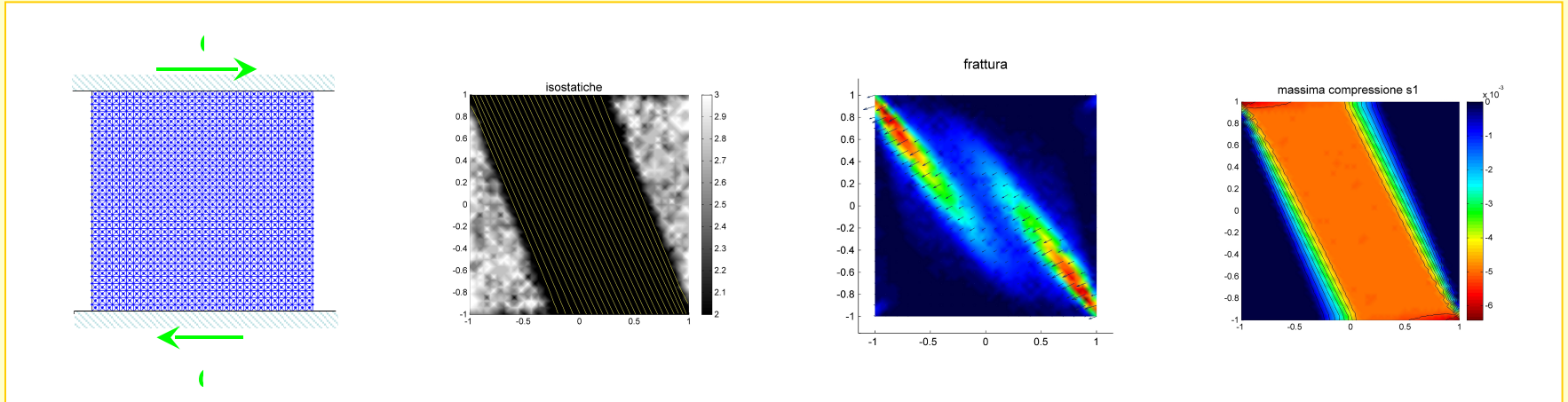
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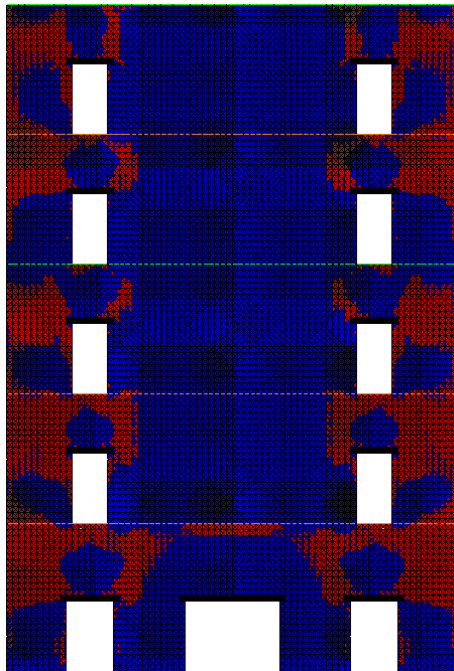
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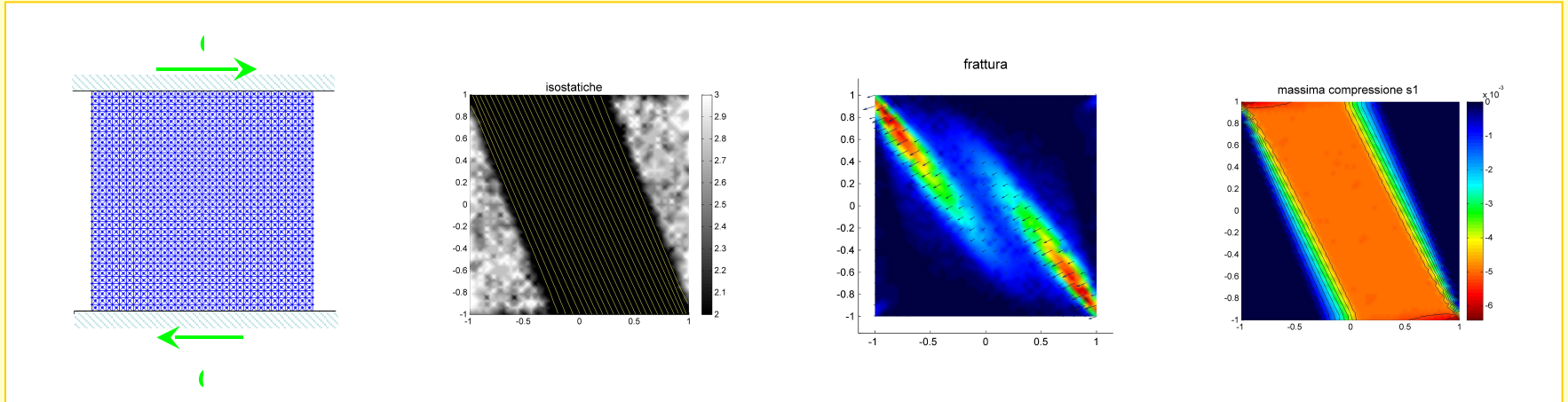
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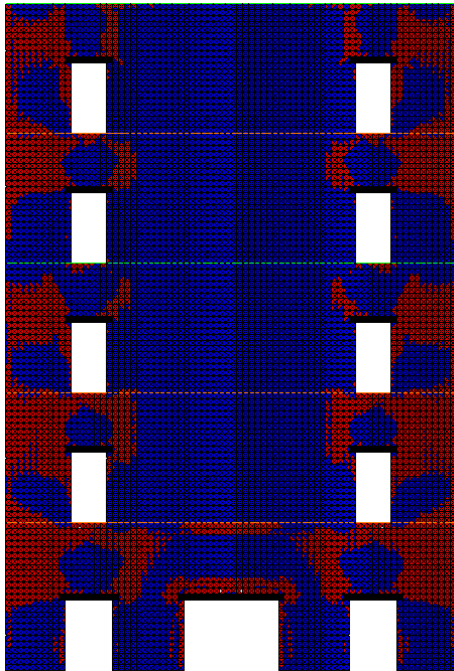
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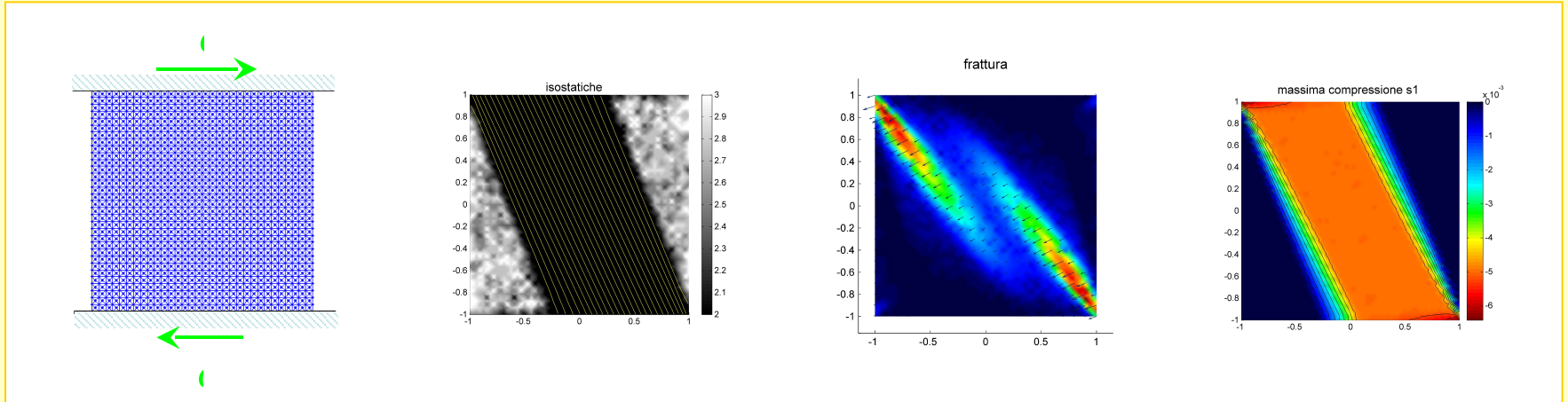
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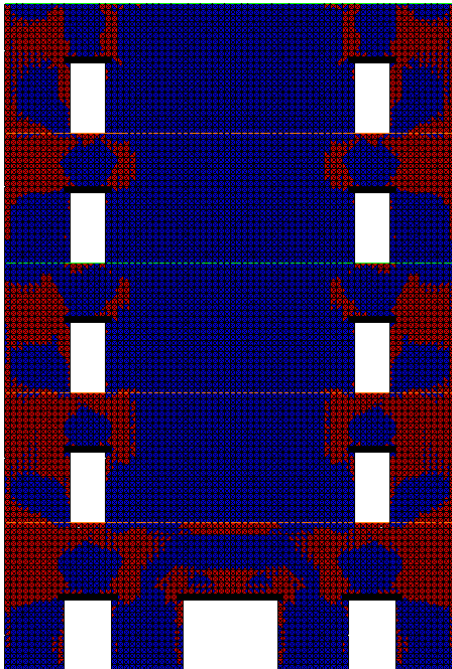
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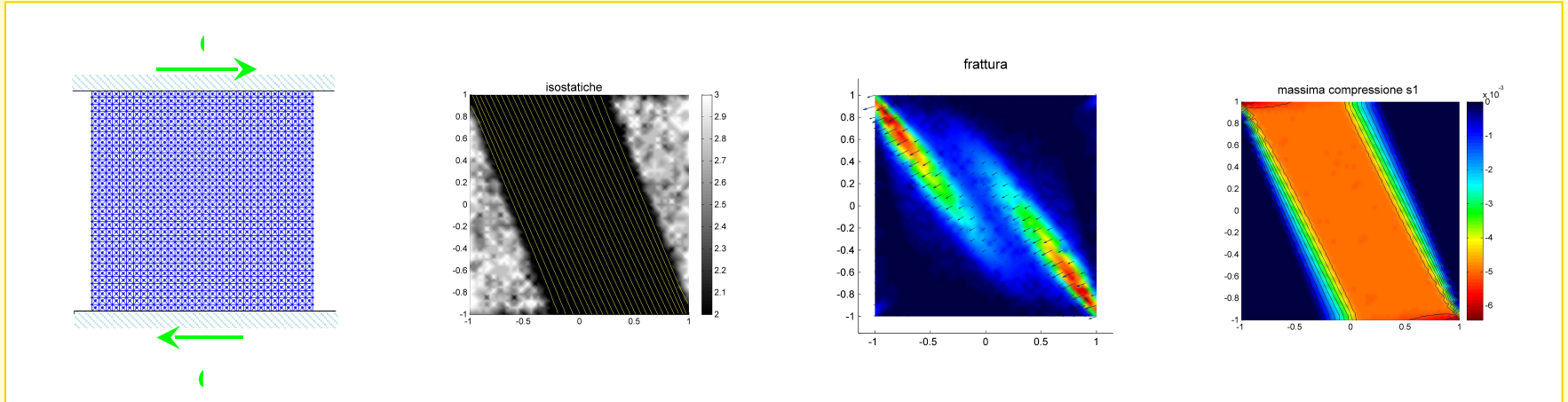
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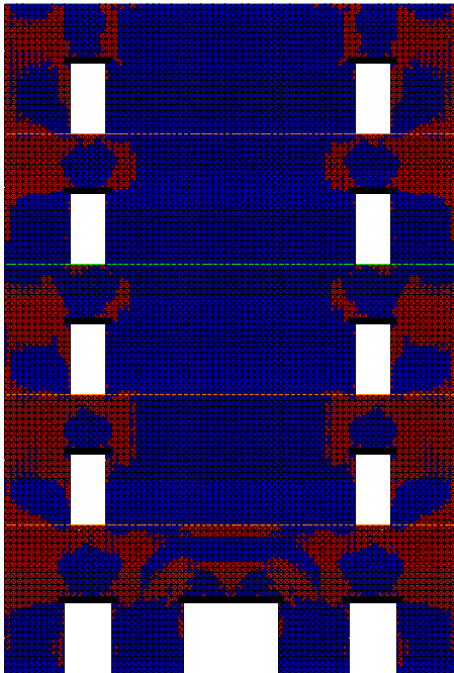
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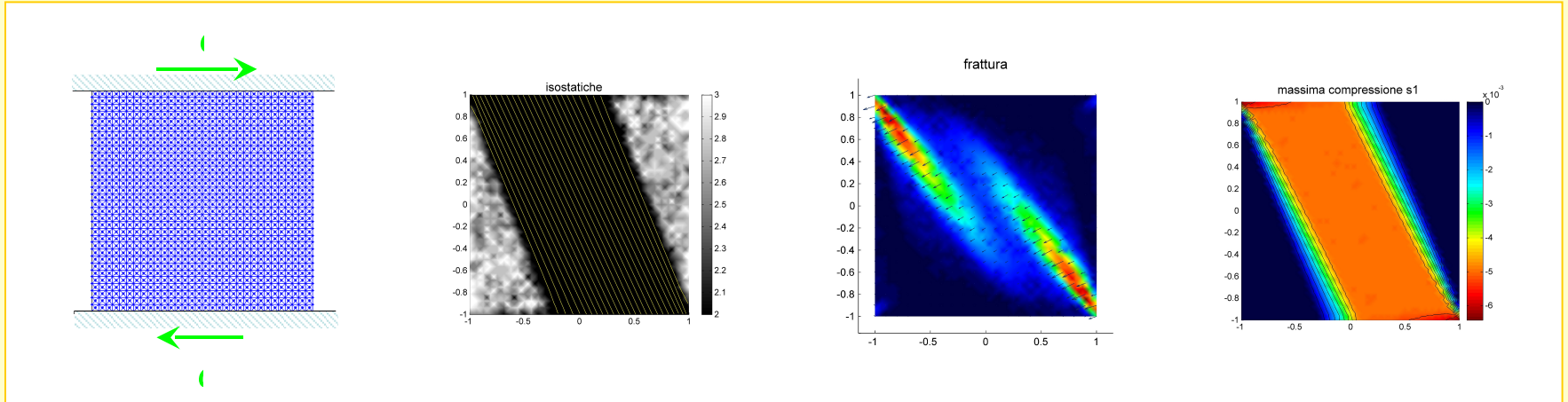
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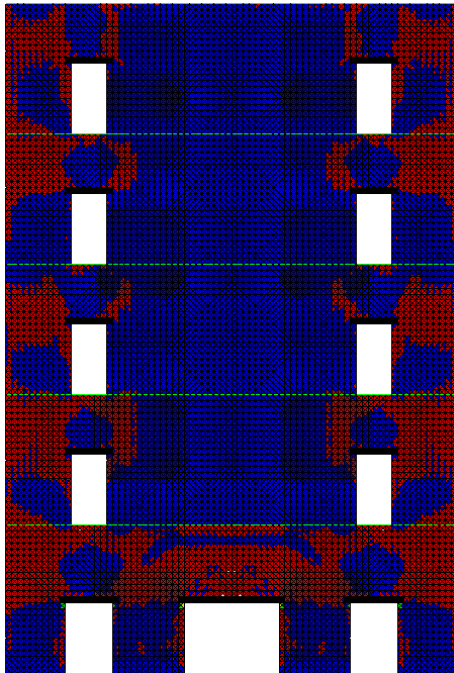
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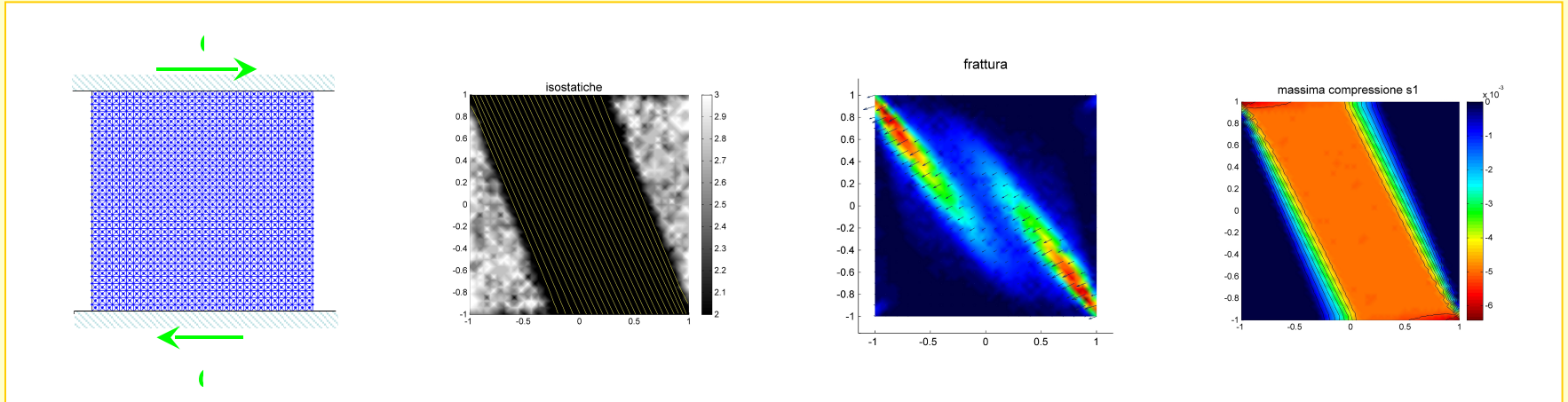
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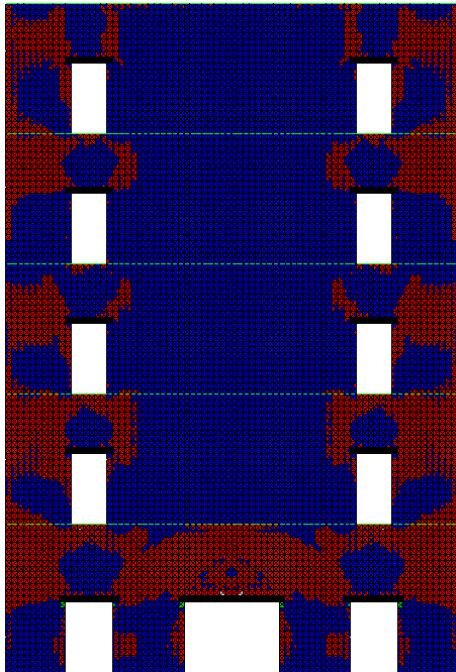
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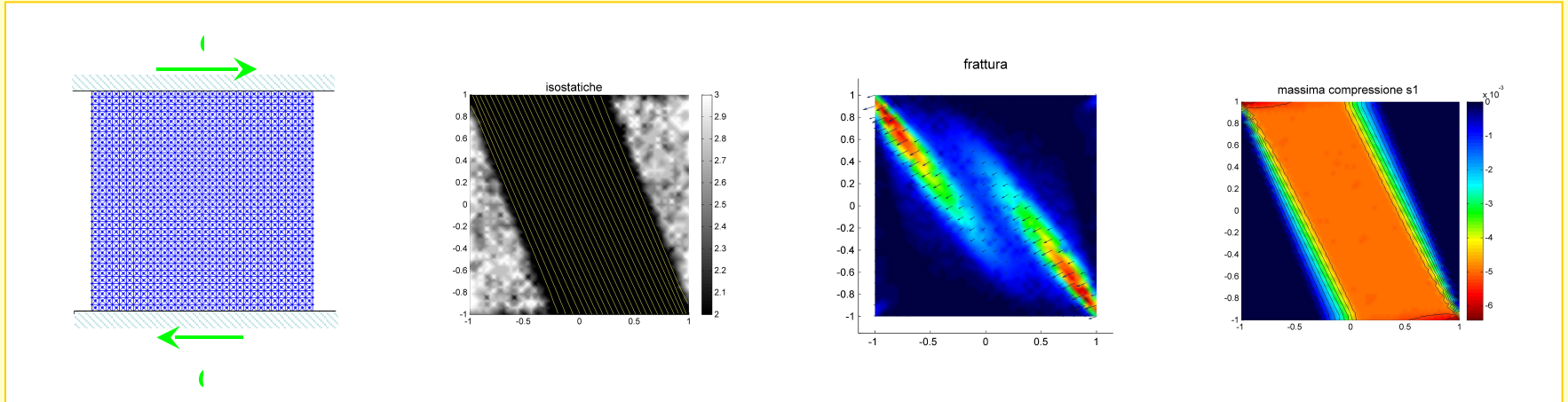
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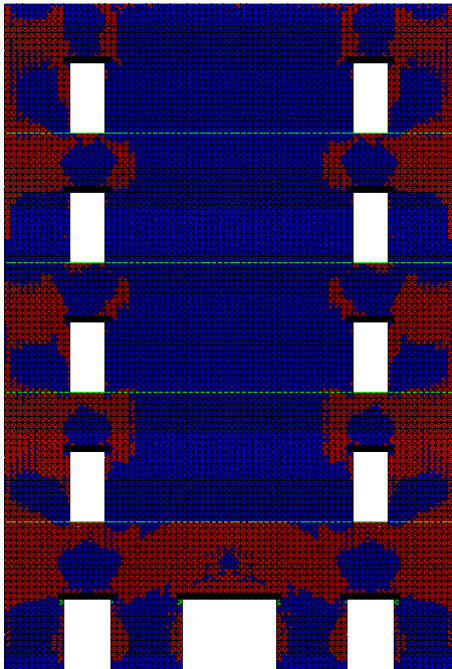
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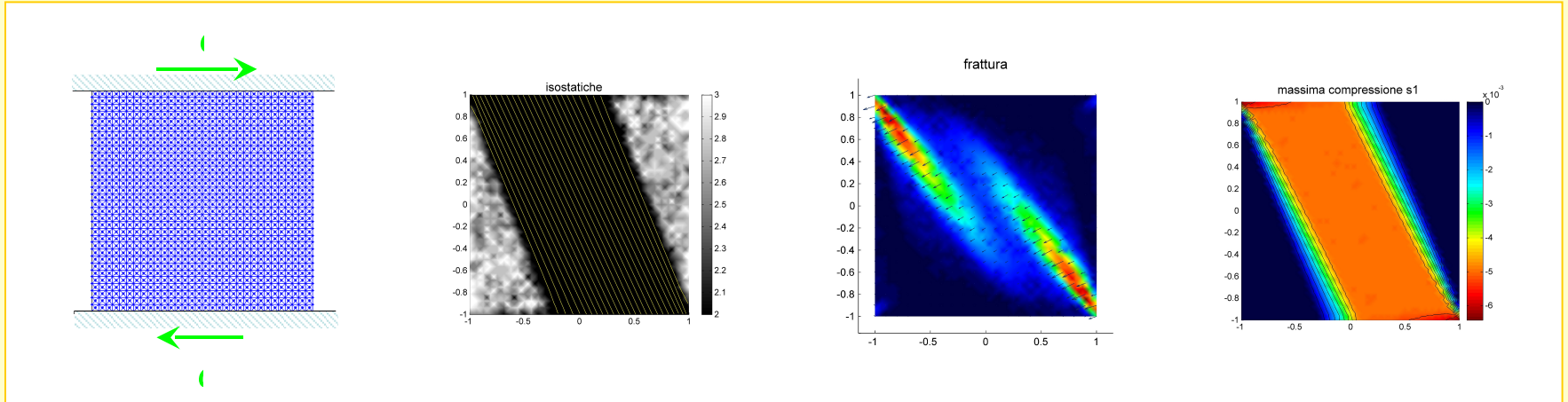
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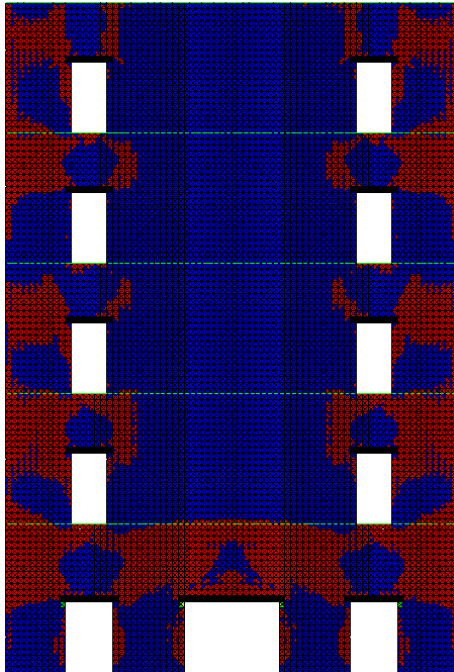
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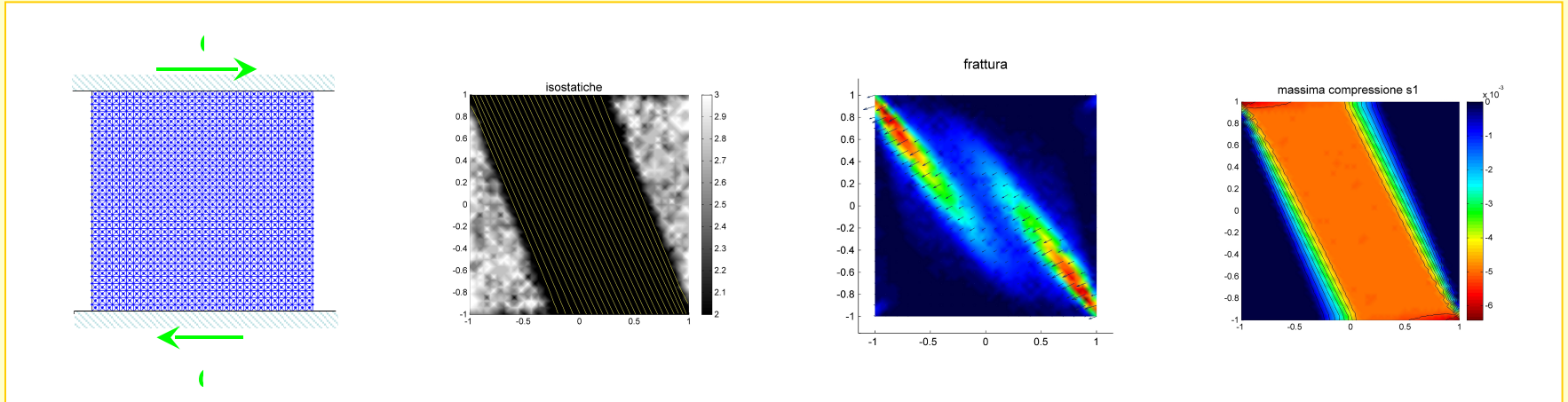
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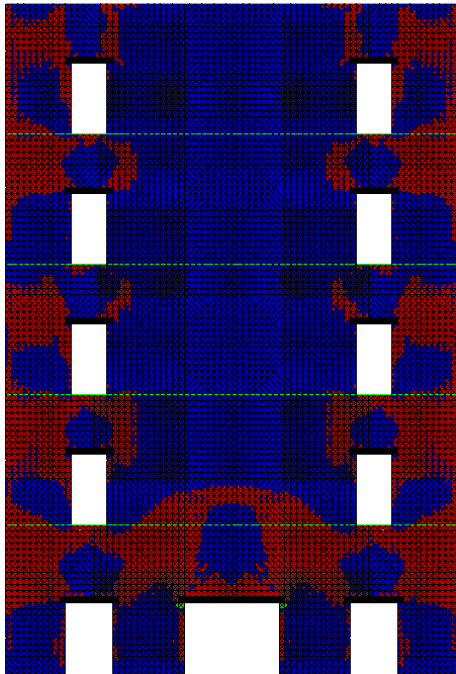
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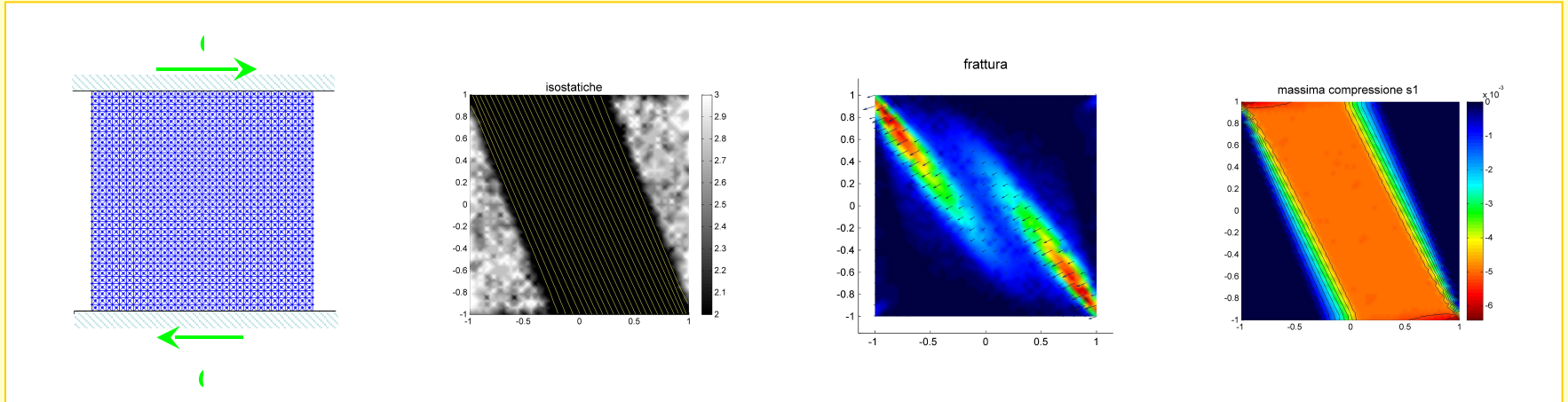
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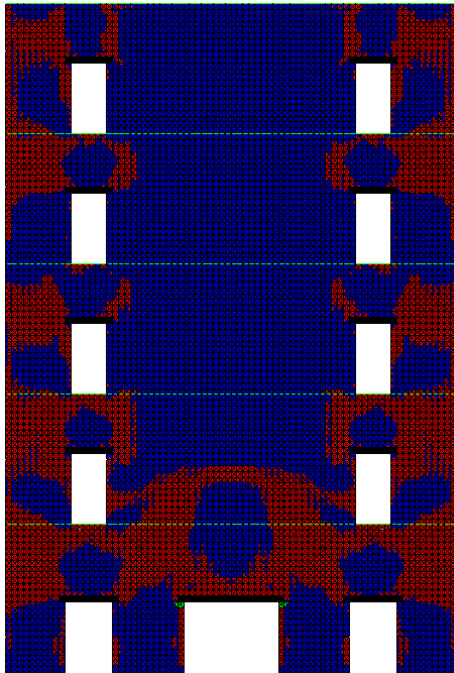
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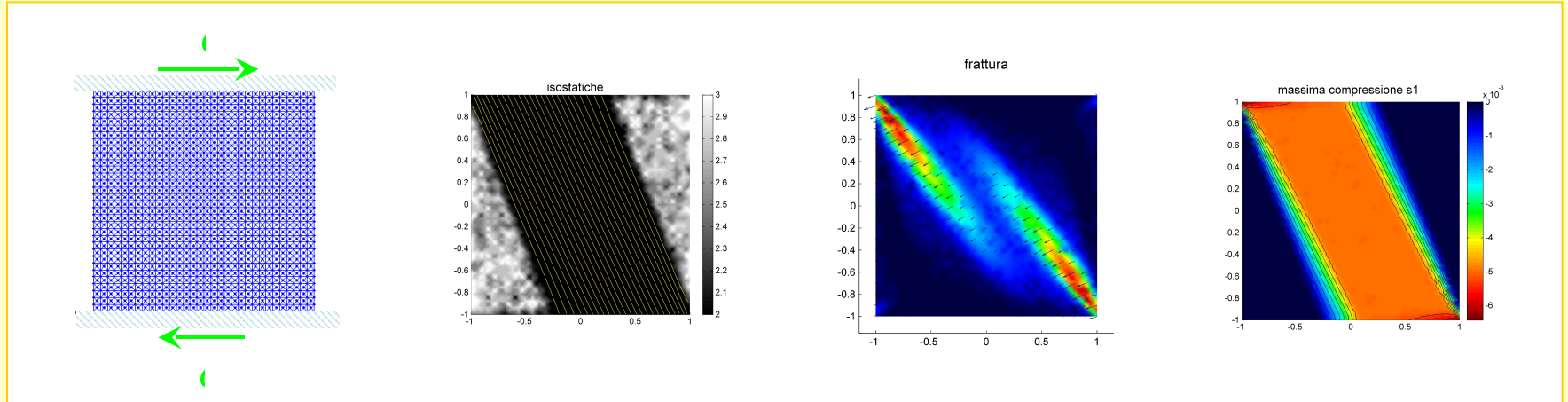
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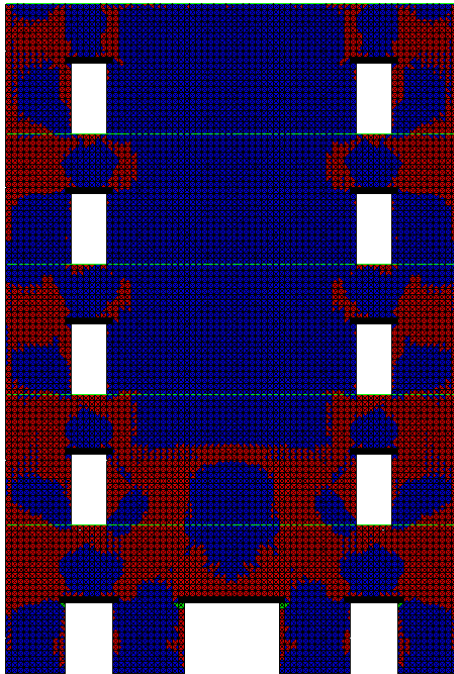
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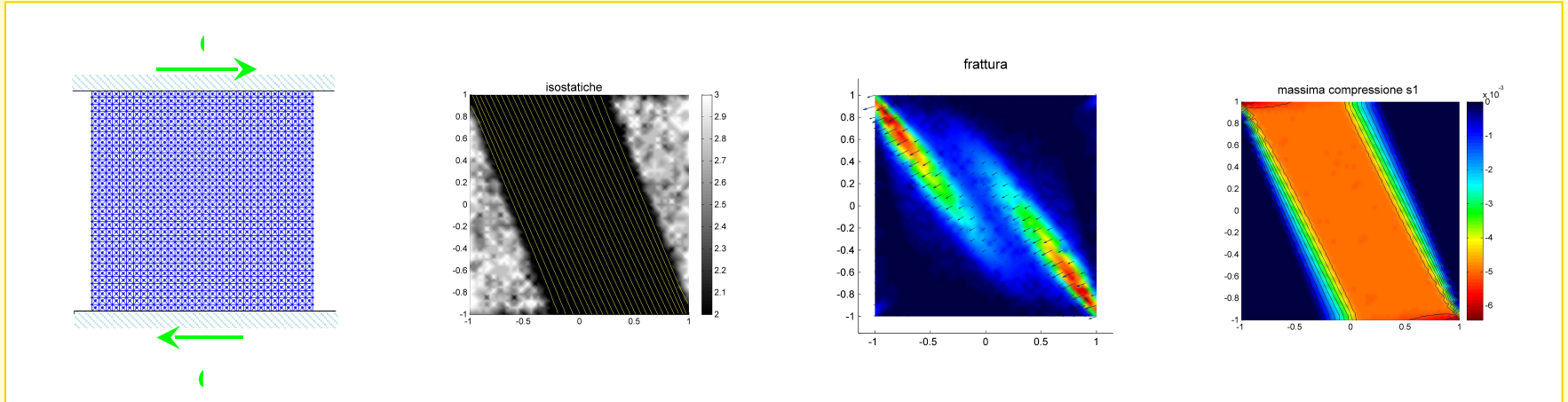
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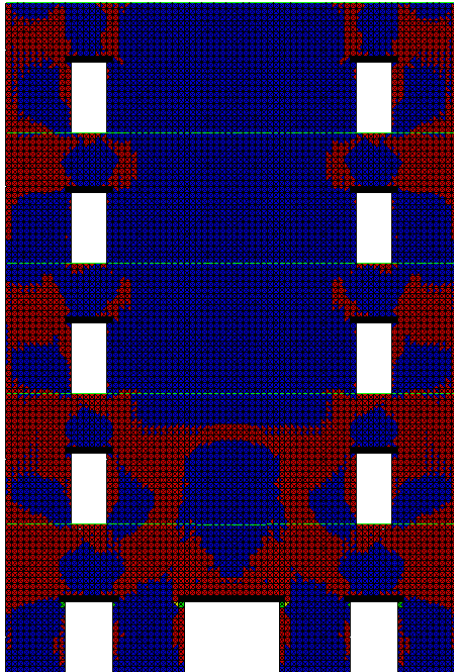
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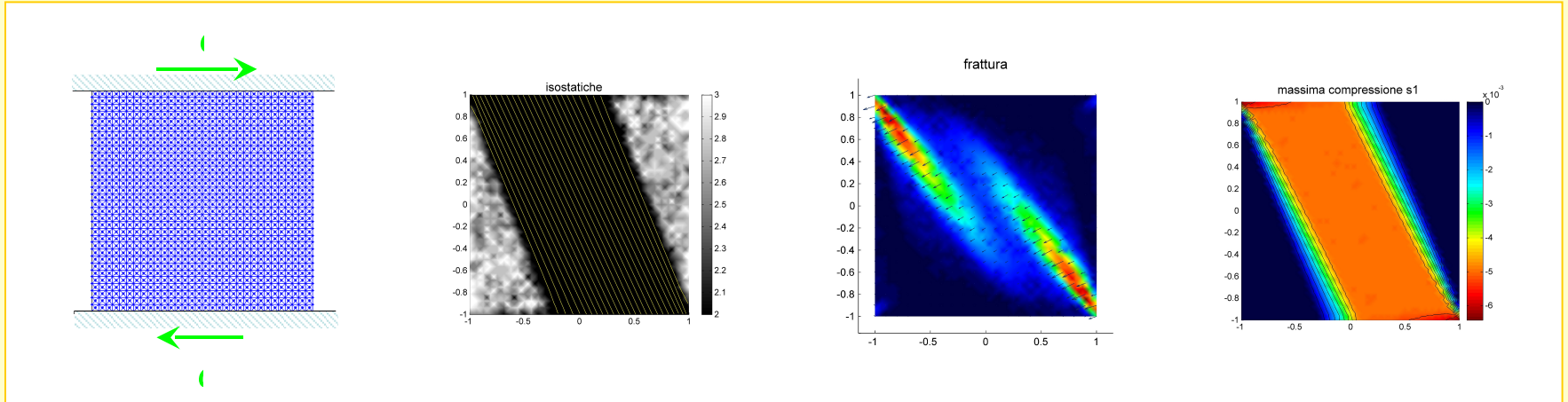
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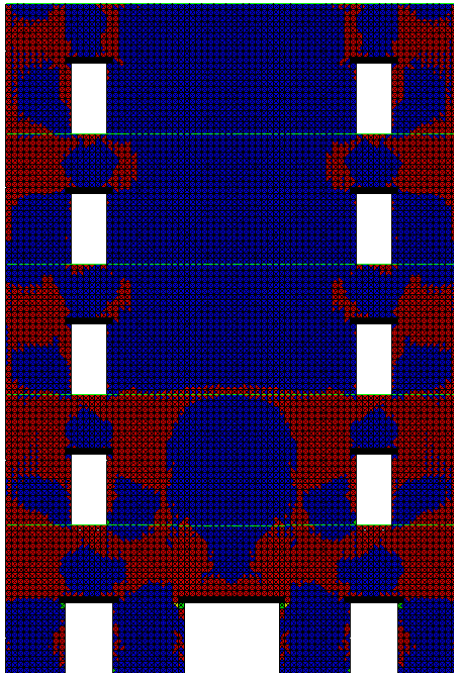
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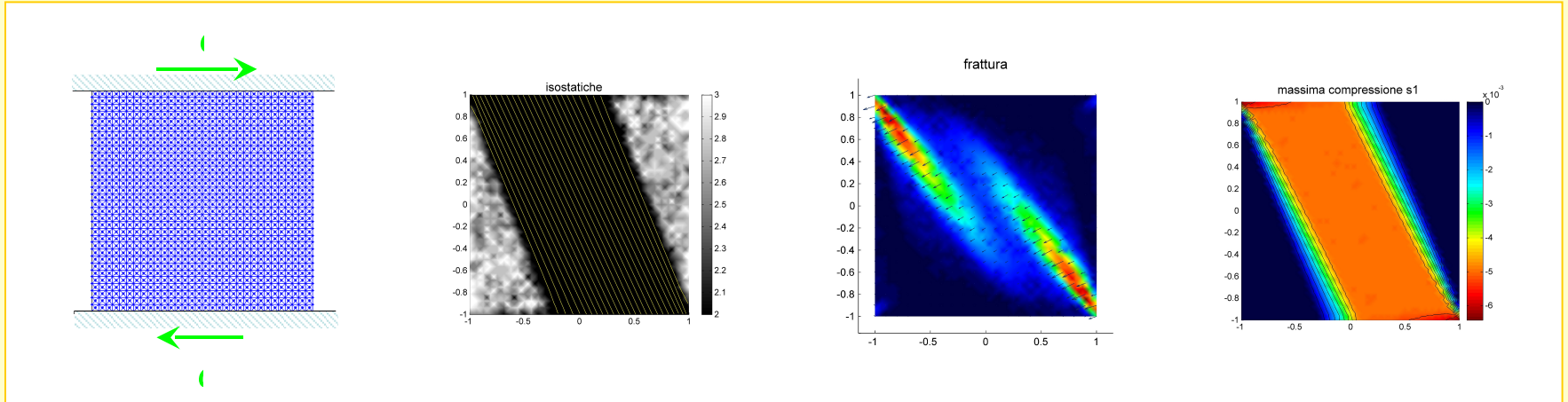
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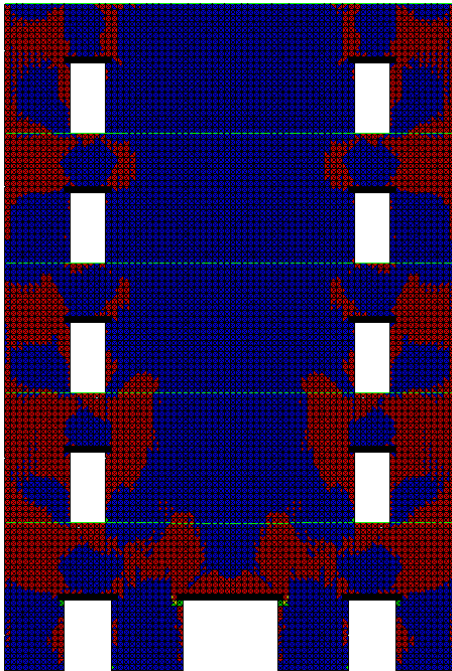
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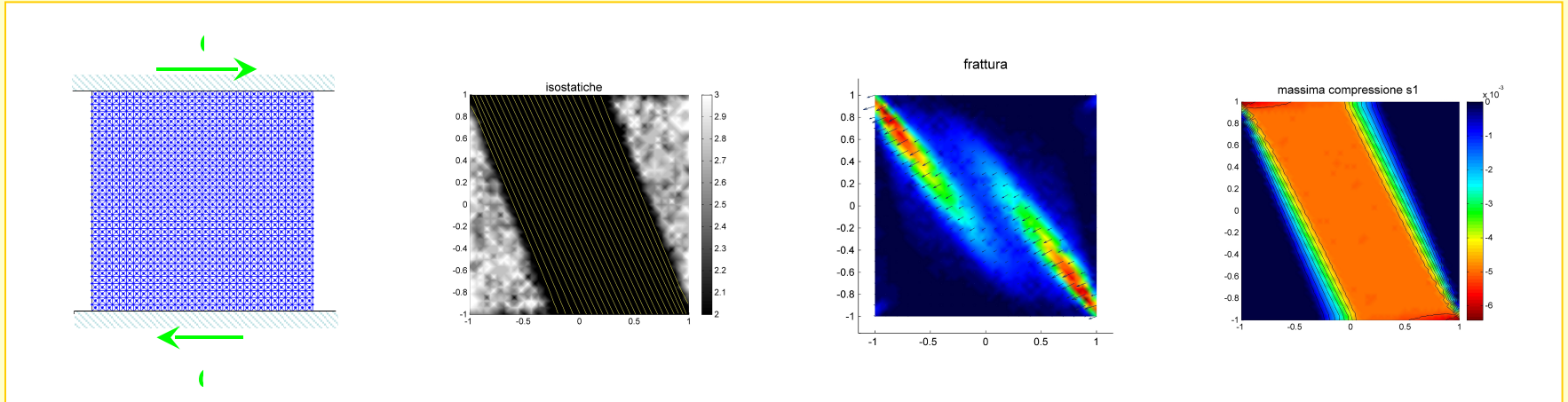
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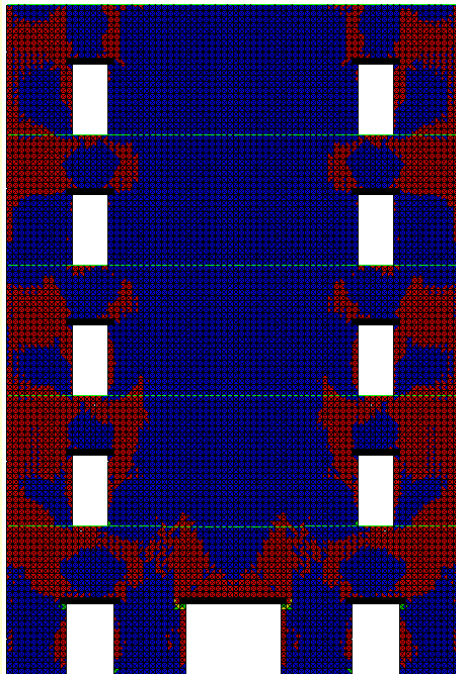
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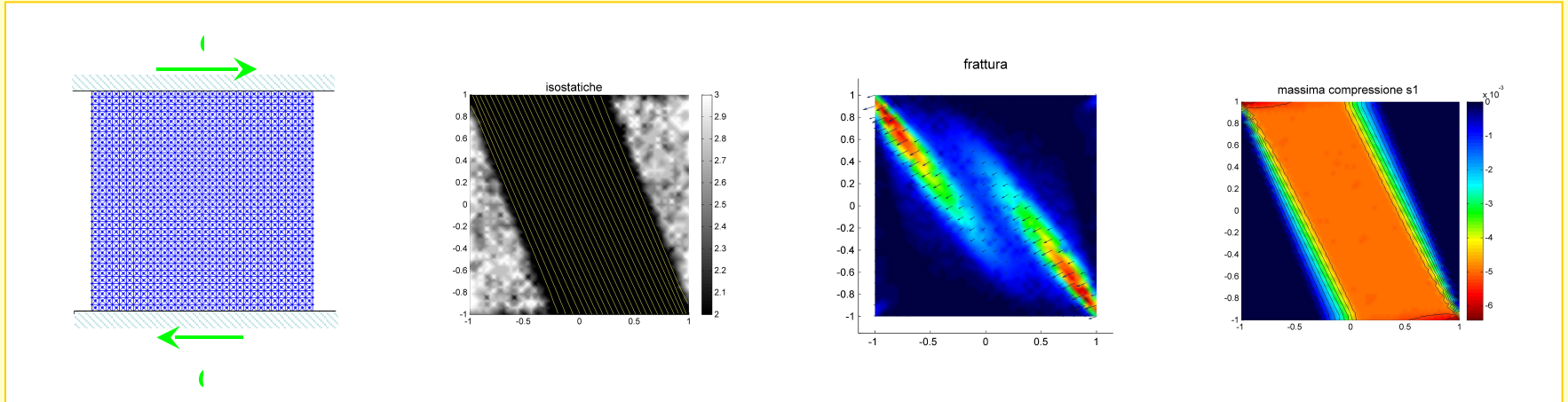
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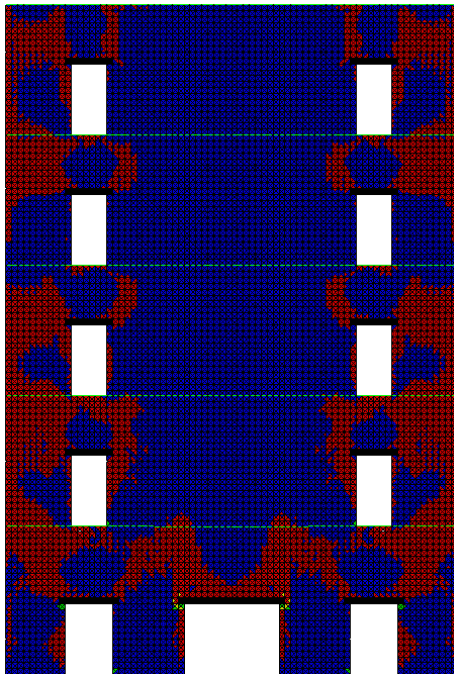
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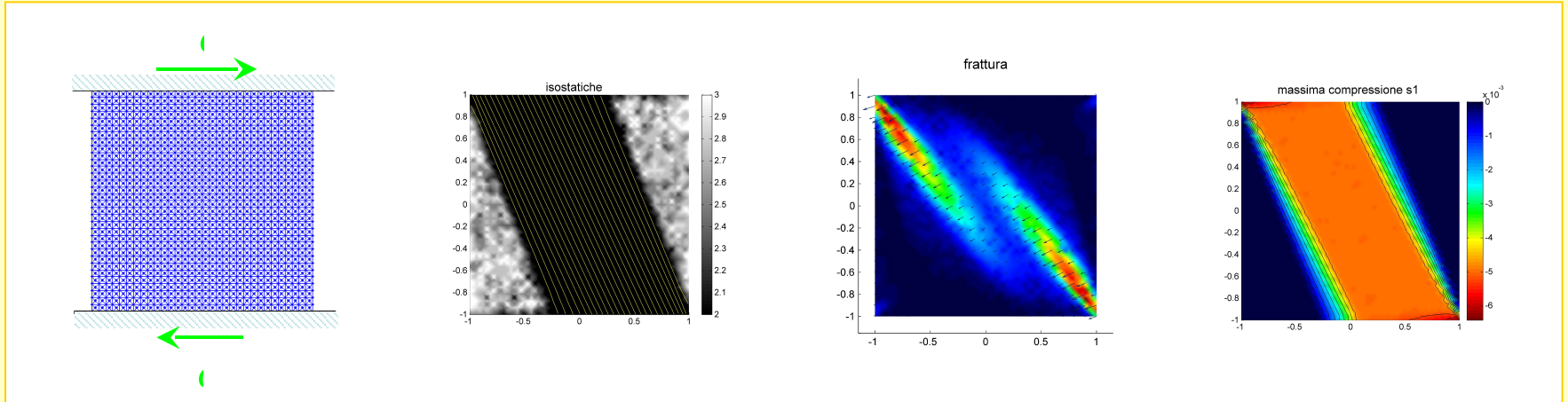
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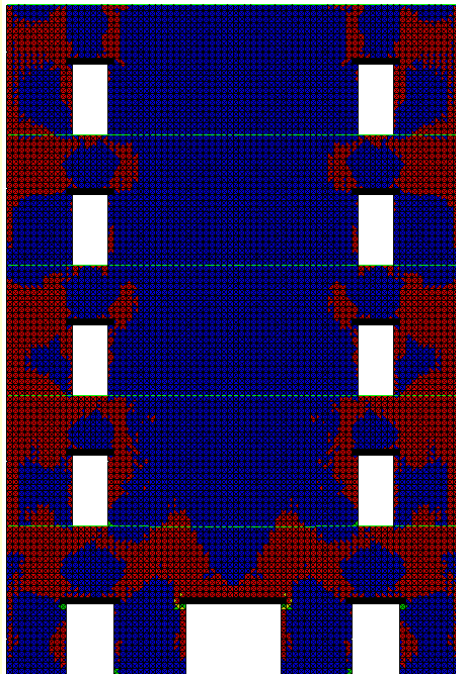
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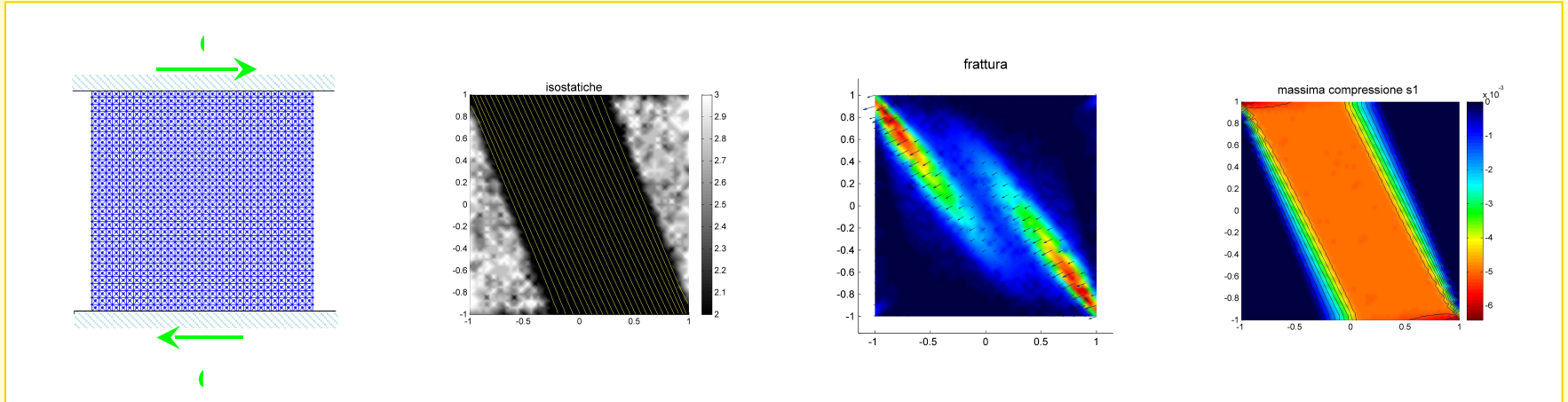
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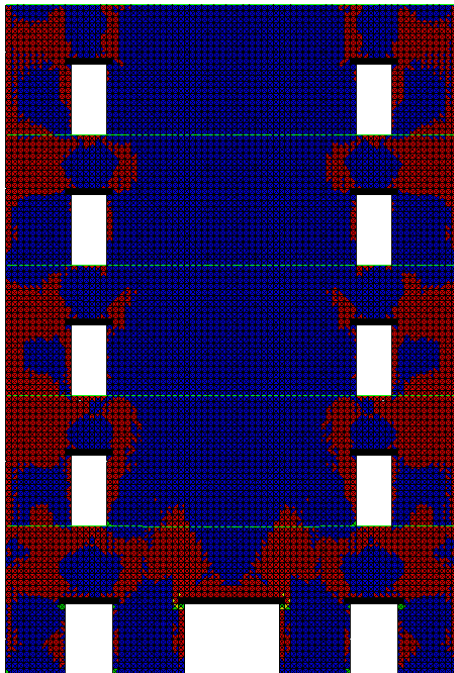
Apertura di forza in una parete



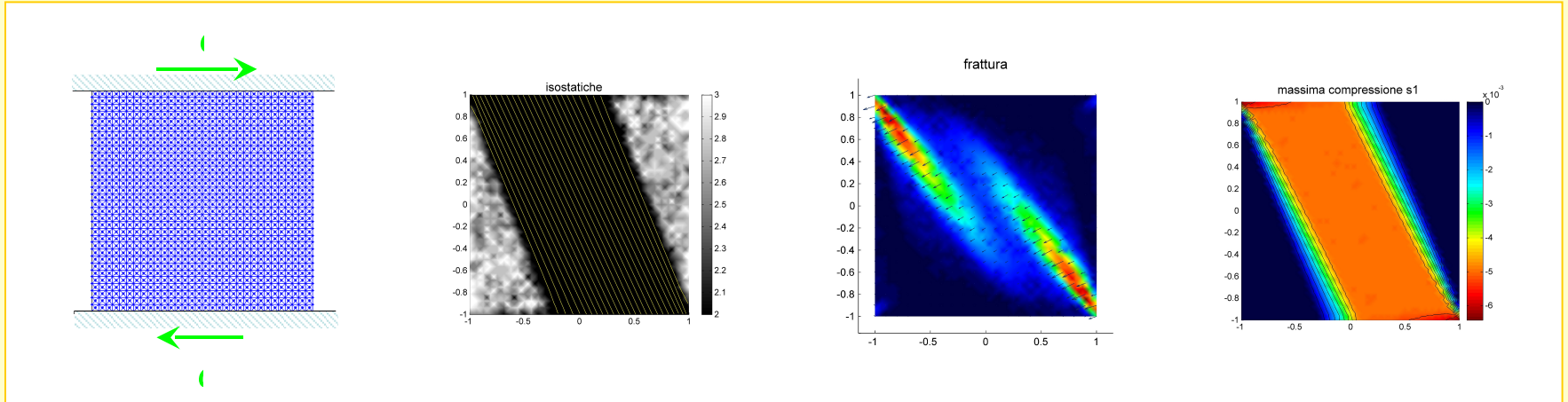
Pannello soggetto a scorrimento (AF, Elastic solutions for masonry-like panels, sottomesso a *Journal of Elasticity*)



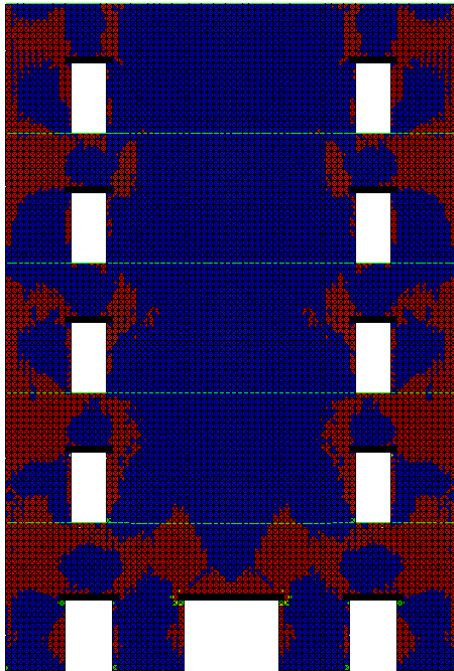
Apertura di forza in una parete



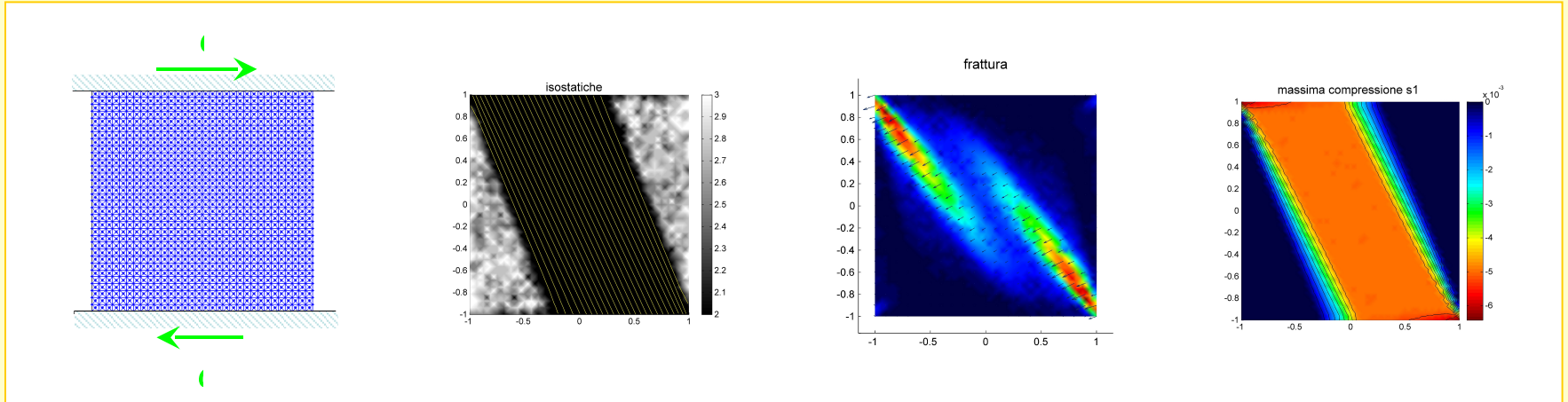
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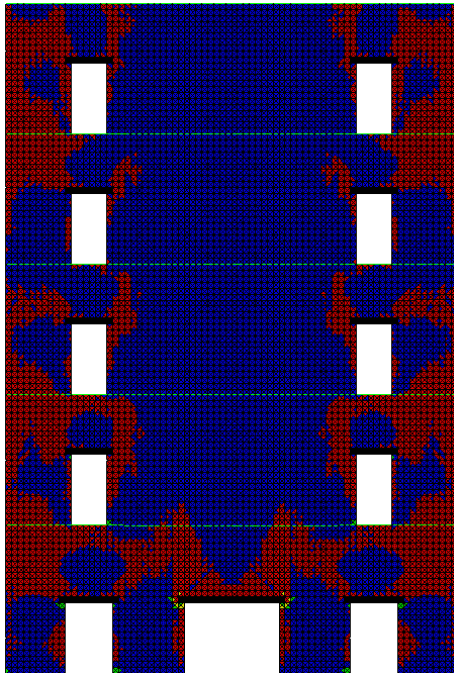
Apertura di forza in una parete



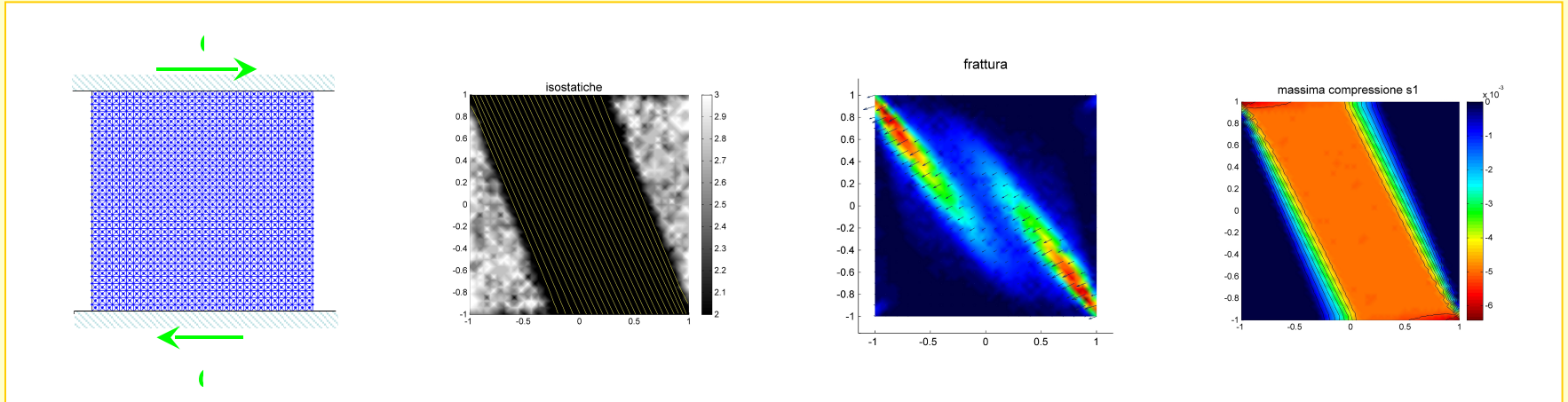
Pannello soggetto a scorrimento (AF, Elastic solutions for masonry-like panels, sottomesso a *Journal of Elasticity*)



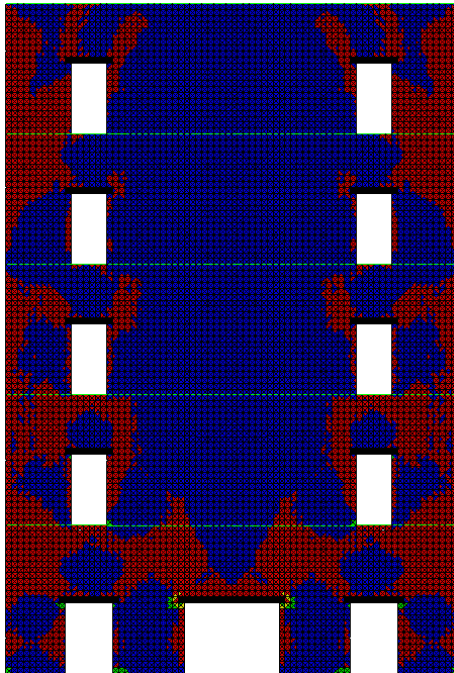
Apertura di forza in una parete



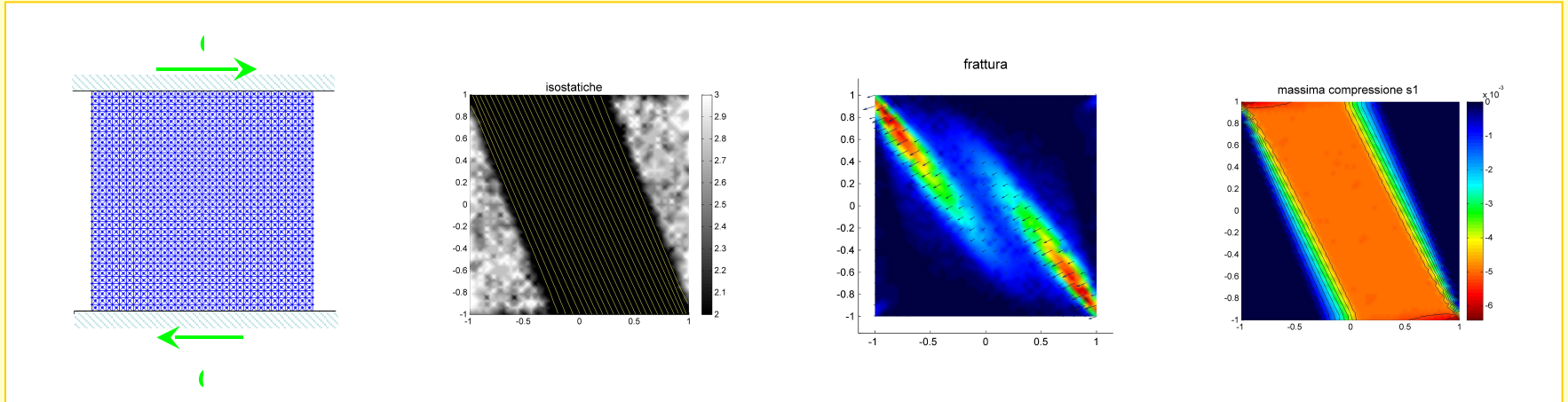
Pannello soggetto a scorrimento (AF, Elastic solutions for masonry-like panels, sottomesso a *Journal of Elasticity*)



Apertura di forza in una parete



Pannello soggetto a scorrimento (AF, Elastic solutions for masonry-like panels, sottomesso a *Journal of Elasticity*)



Apertura di forza in una parete

