Computation Methods for Applied Mechanics Problem

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CONTENTS

- Smartphone chipset estimation in Multiphysics field
- Constitutive model algorithm for composites
- Bioinspired structural design of composite materials
- Fracture study of dentin microstructure
- Machine learning methods on airfoil noise
- Neural network algorithms for water discharge rate

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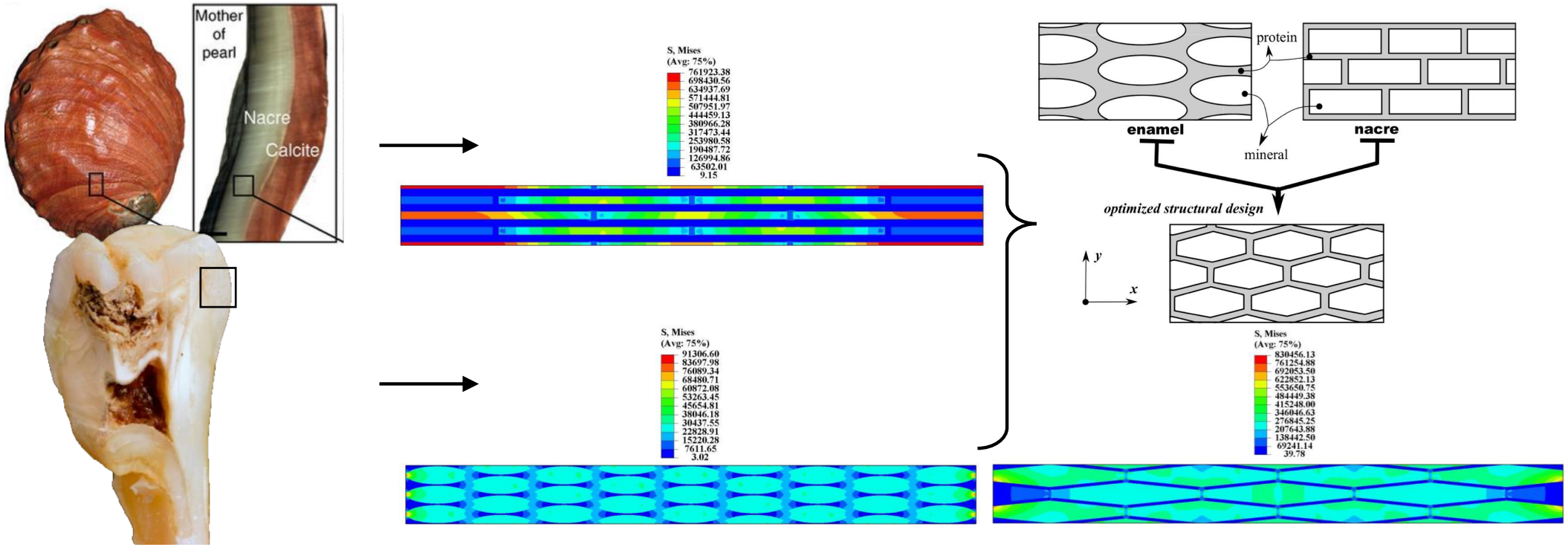
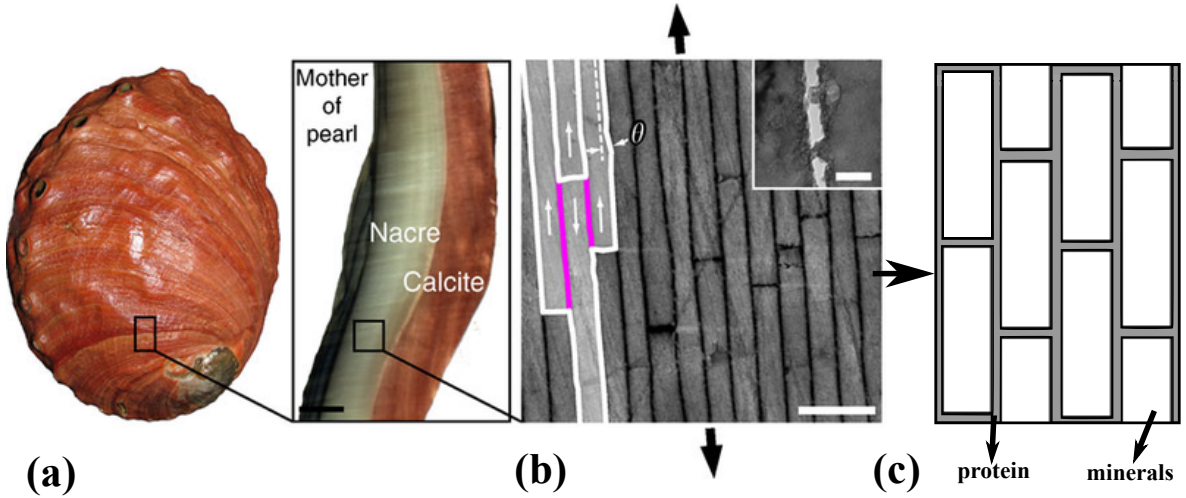
Bioinspired structural design of composite materials

Structural Designation of Composite Materials with Superior Mechanical Behaviors: Lesson from the Microstructure of Nacre and Enamel

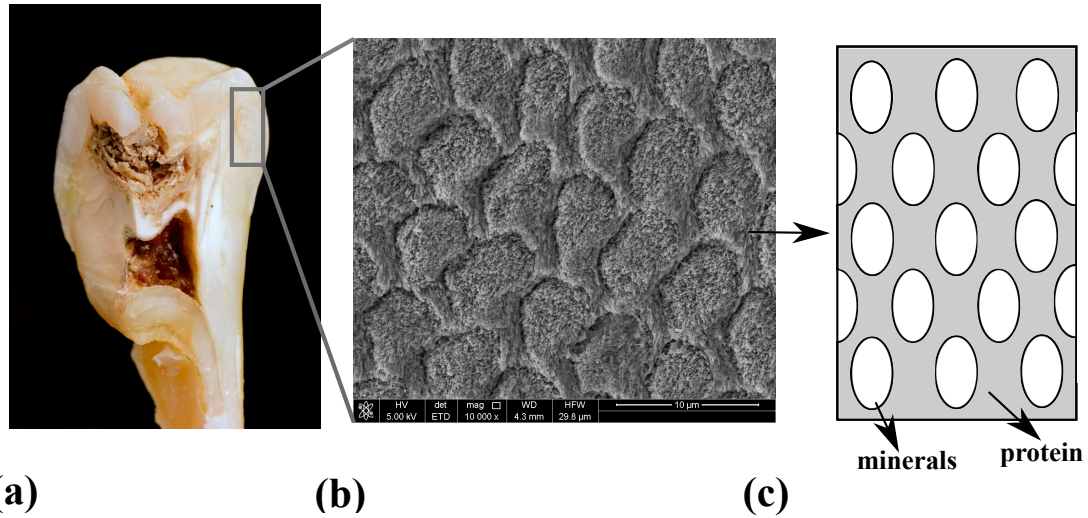


INTRODUCTION

The work started by the inspiration from the microstructure of nature materials



(Barthelat, *Bioinsp. Biomim*., 2010)

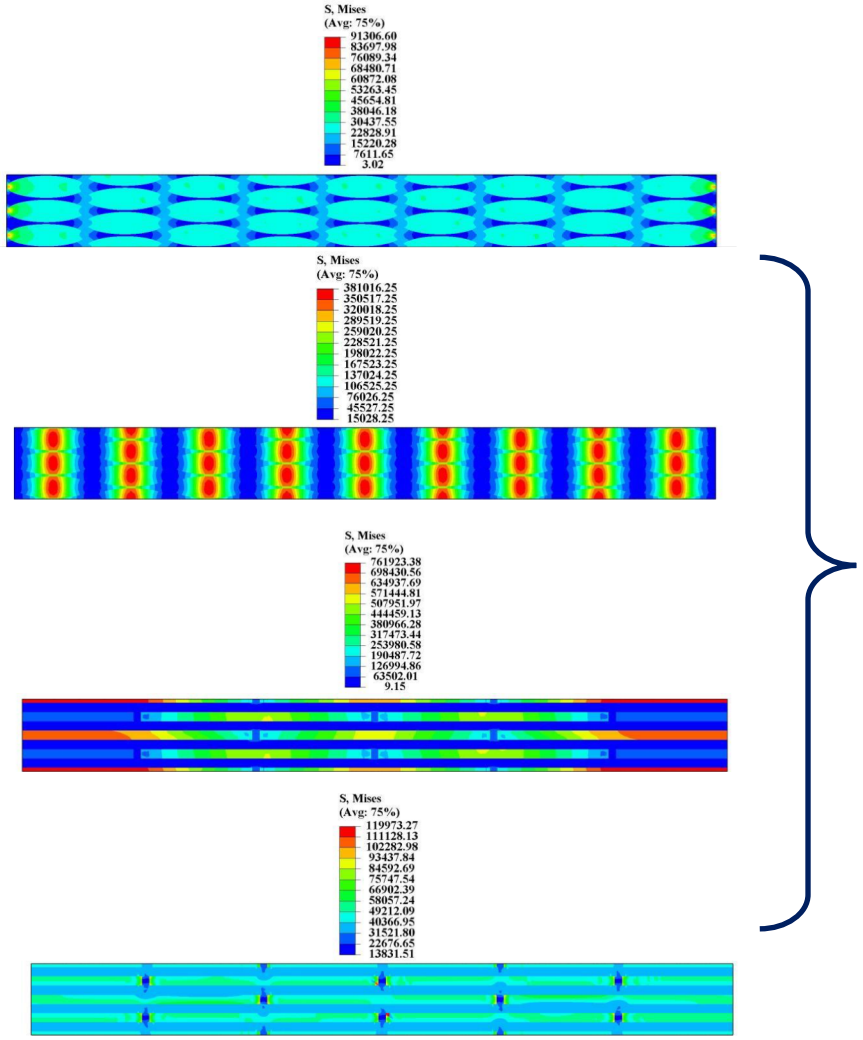


Material	Elastic Modulus	Poisson's Ratio	Yield Stress
Mineral	20.7GPa	0.3	
Protein	1MPa	0.3	9MPa

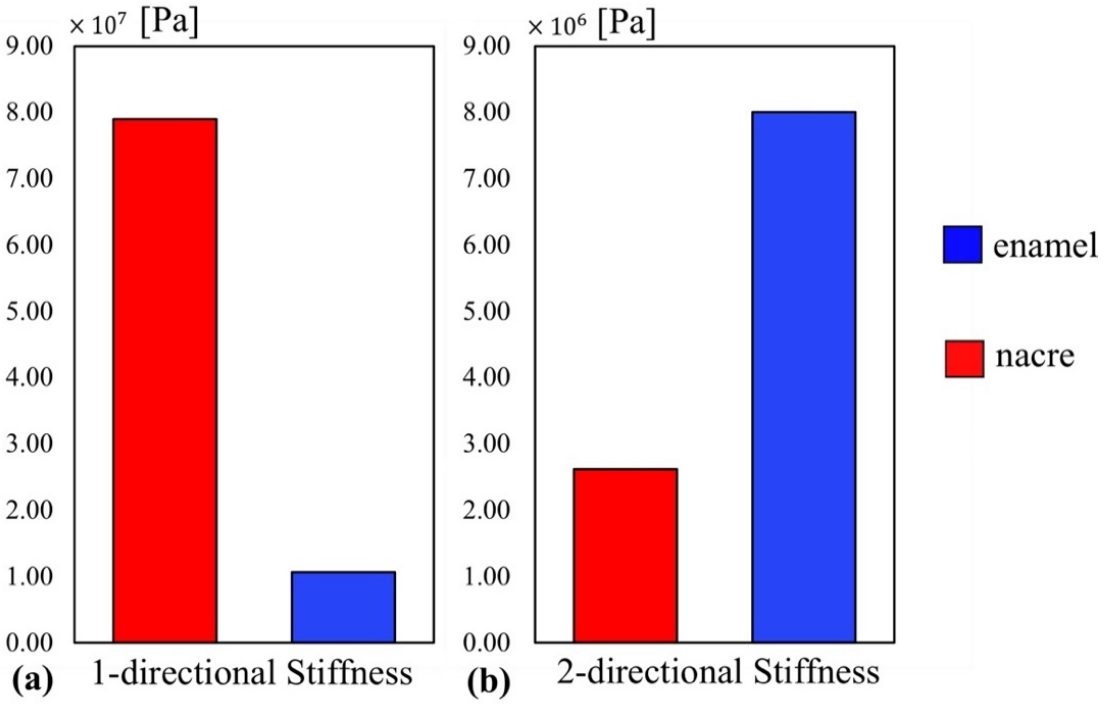
(An, *Int. J. Solid Struc*., 2016)

The mechanical properties of the martials is judged by the stiffness and fracture resistance of the composite.

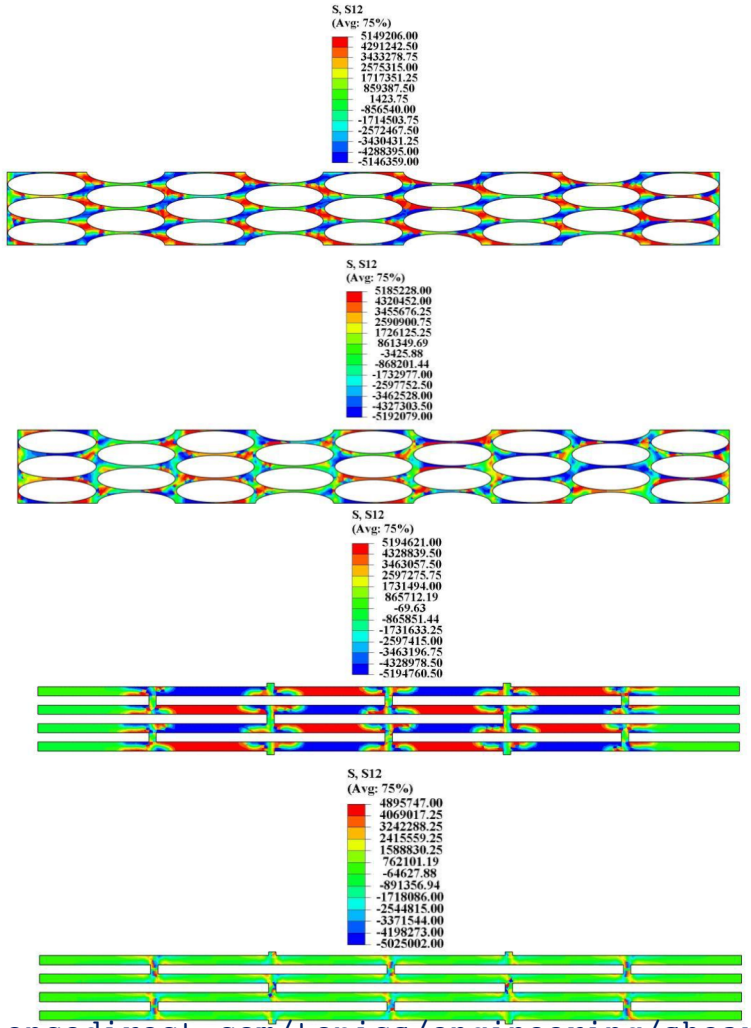
RESULTS & DISCUSSION

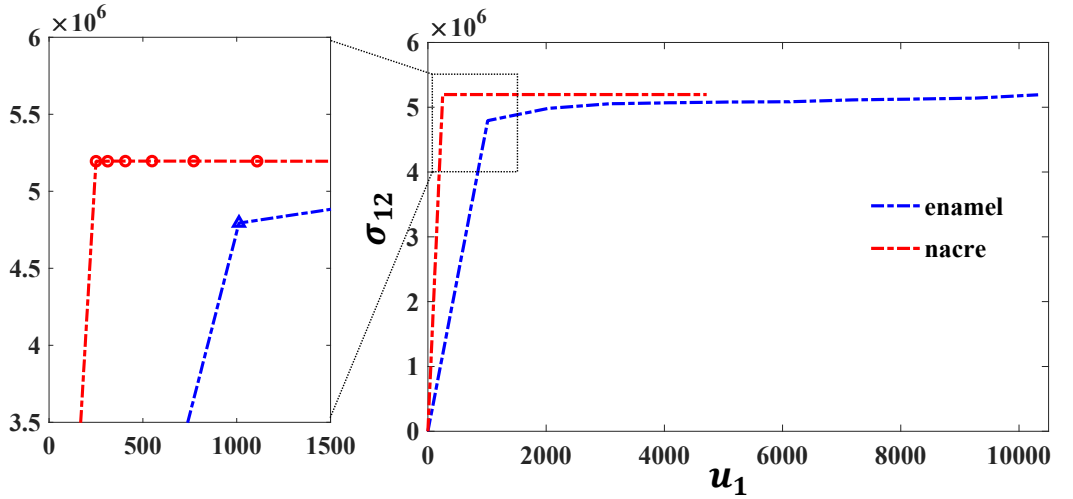


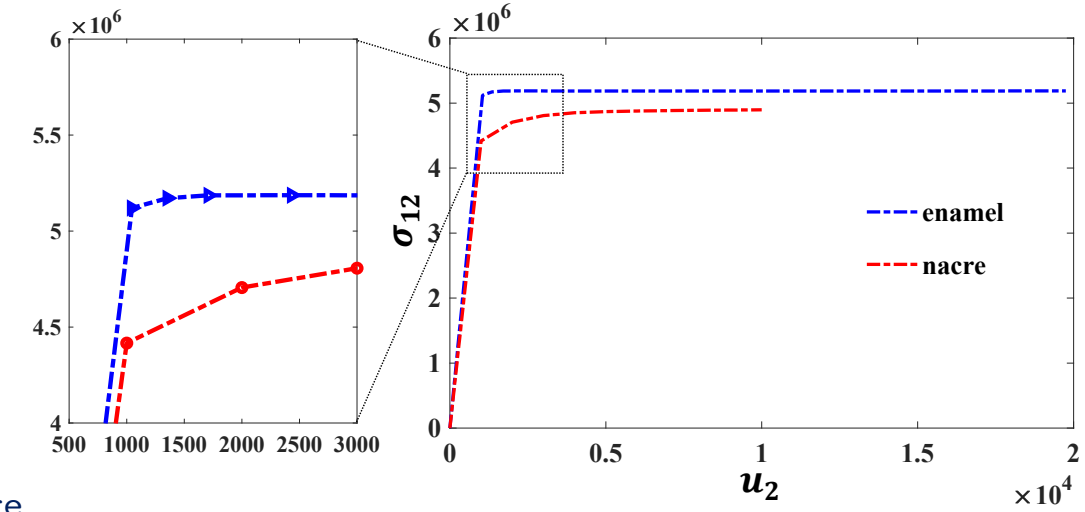
Stiffness calculation based on uniaxial tests



RESULTS & DISCUSSION



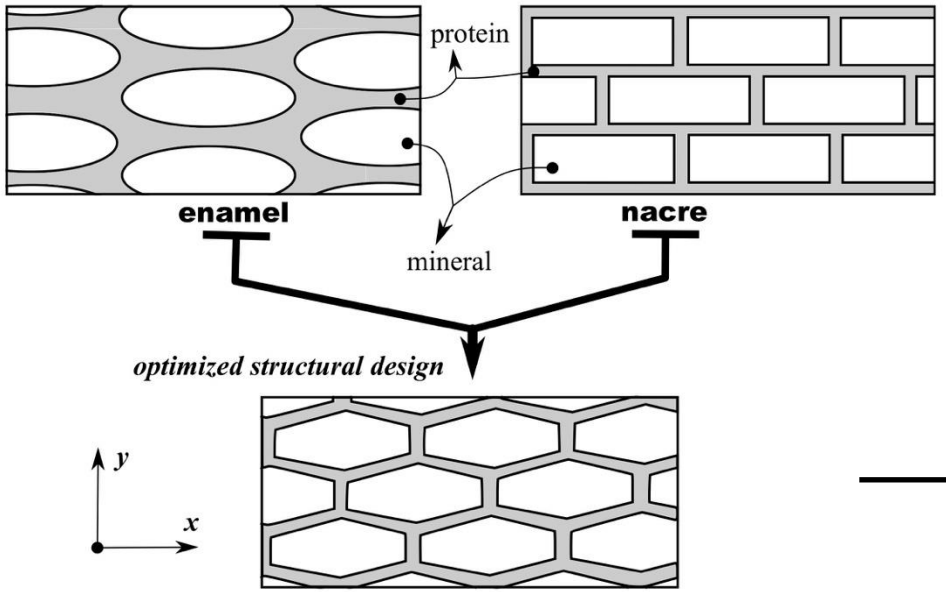


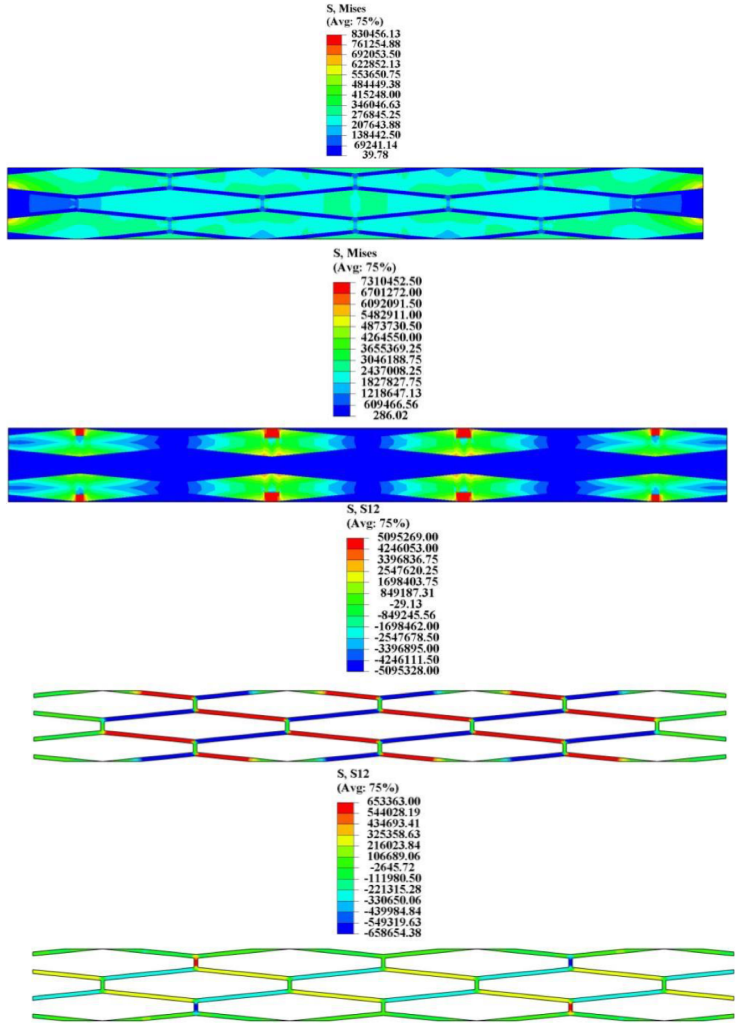


https://www.sciencedirect.com/topics/engineering/shear-fracture

RESULTS & DISCUSSION

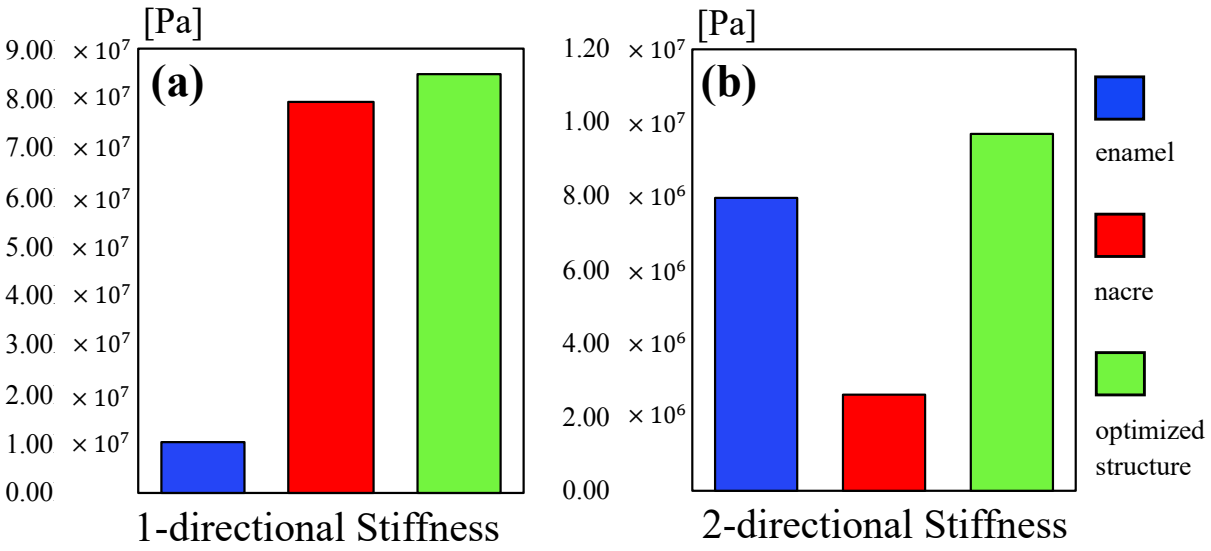
New composite material designing based on previous mechanical simulation of the biomaterials.

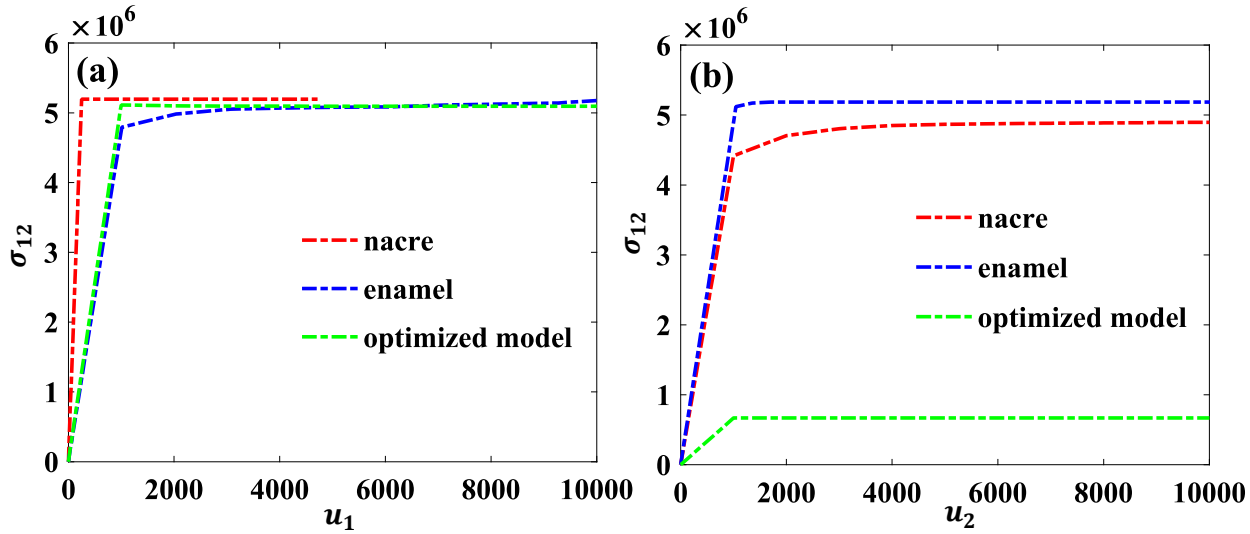




RESULTS & DISCUSSION

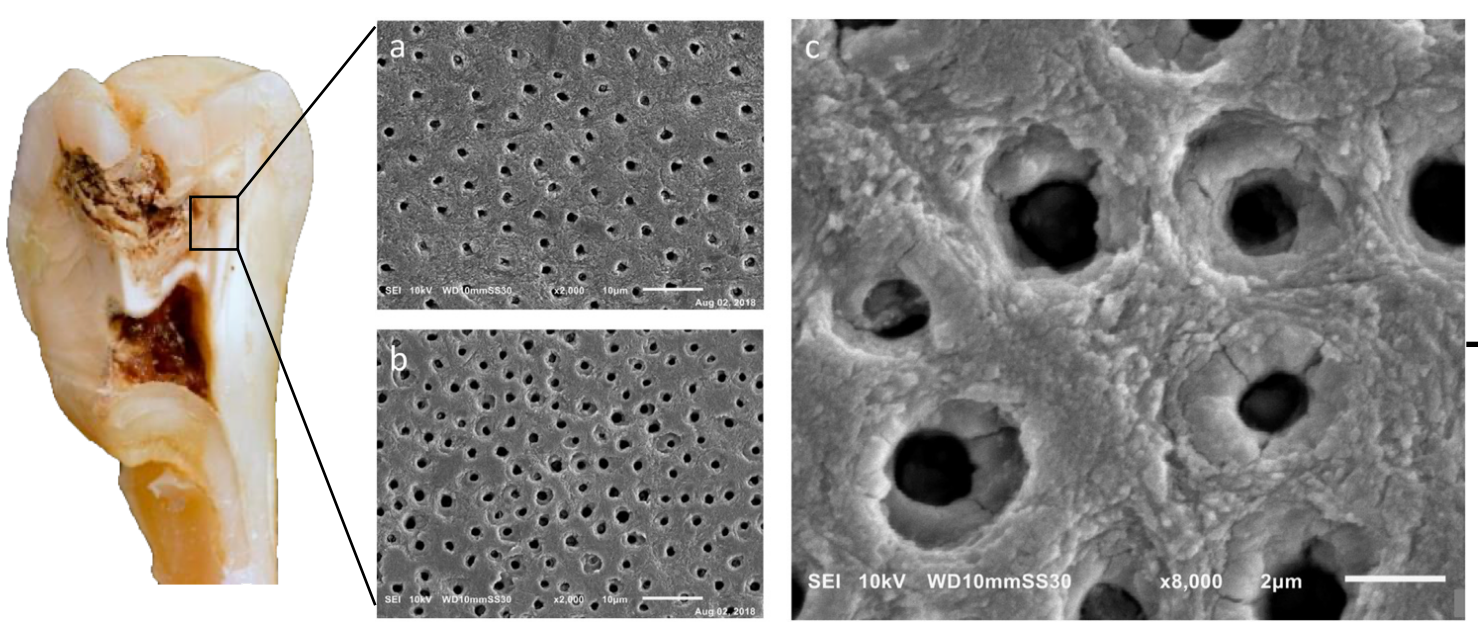
A significant increase of mechanical properties for new designed composite materials



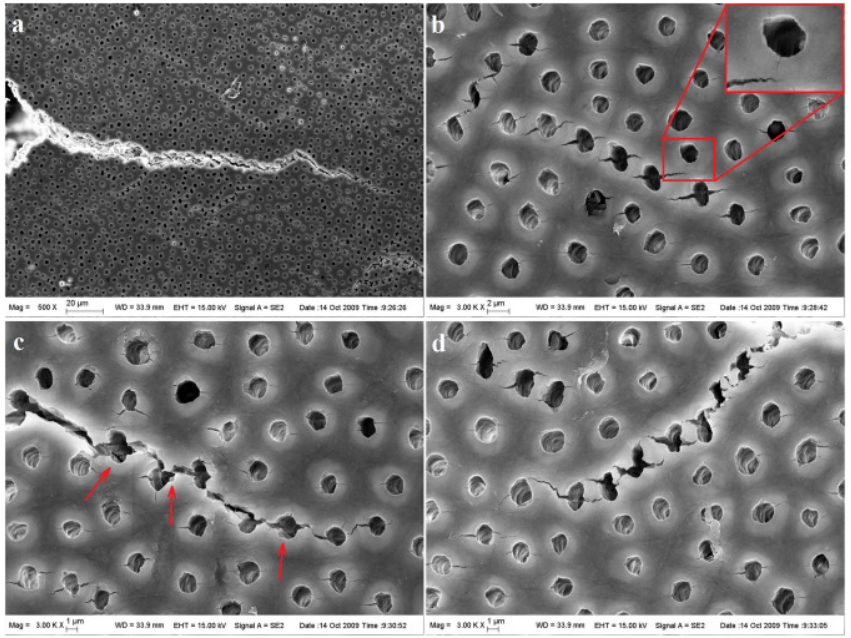


Fracture study of dentin microstructure

An investigation of the elastoplastic nature of ITD on the toughness of the dentin microstructure

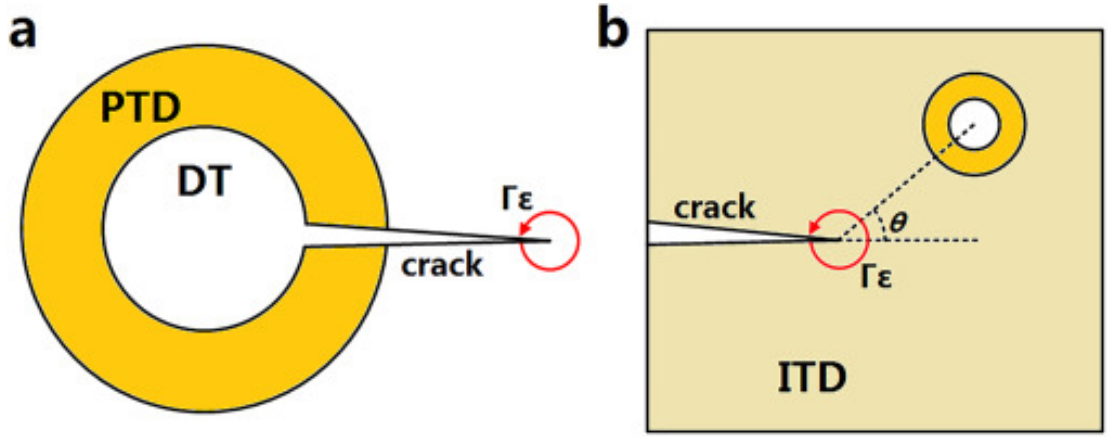


(Nazari *et al.*, *J. Mech. Behave. Biomed. Mat.*, 2009)



(Wang *et al.*, *J. Mech. Behave. Biomed. Mat.*, 2019)

METHOD

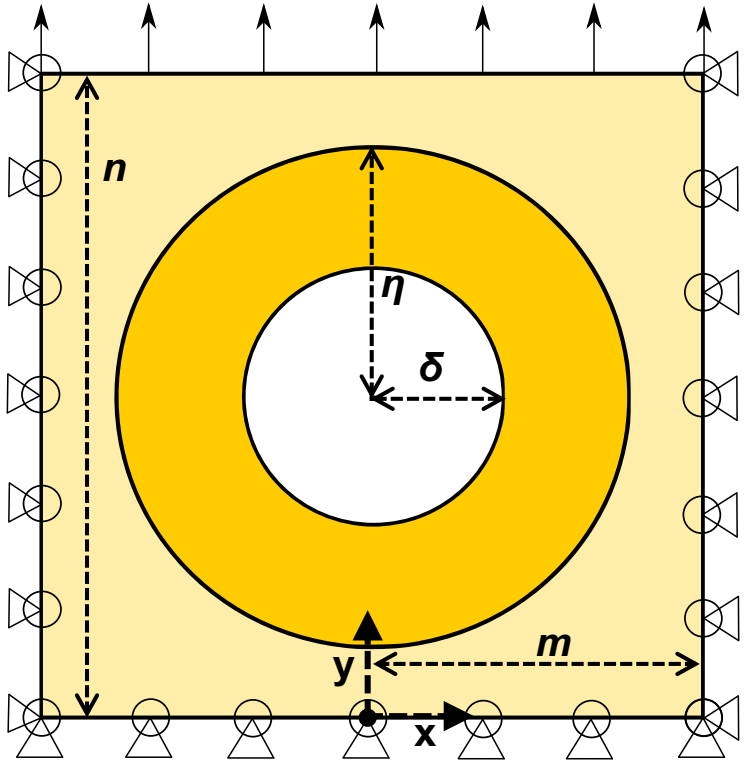


(Wang *et al.*, *J. Mech. Behave. Biomed. Mat.*, 2019)

Youngs modulus	Poisson's ratio
200GPa	0.3

Youngs modulus	Poisson's ratio	Yield stress
20GPa	0.3	70MPa

(An, *Int. J. Solid Struc.*, 2016)



The geometric parameters: $\delta = 2, \eta = 4, m = 5, n = 2m$, in μm. Note that x axis is also recognized "1-direction", y axis is also recognized "2-direction".

METHOD

Normal mode	Shear mode			Normal mode	Shear mode		
Fracture energy	Fracture energy (1-direction)	Fracture energy (2-direction)	Power	Fracture energy	Fracture energy (1-direction)	Fracture energy (2-direction)	Power
43000	43000	43000	1(Linear)	5000	5000	5000	1(Linear)

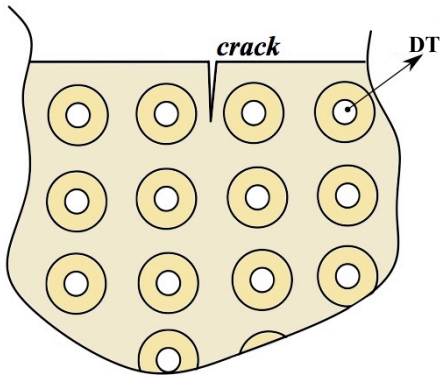
A linear damage model with $\alpha = 1$

Youngs modulus	Poisson's ratio	Maximum principal stress
20GPa	0.3	10MPa

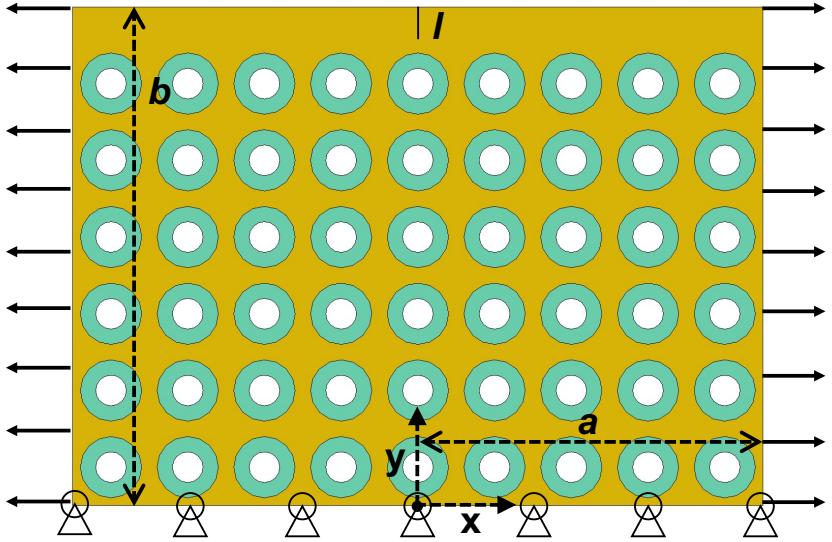
ITD parameters for fracture simulation

Youngs modulus	Poisson's ratio	Maximum principal stress
200GPa	0.3	86MPa

PTD parameters for fracture simulation



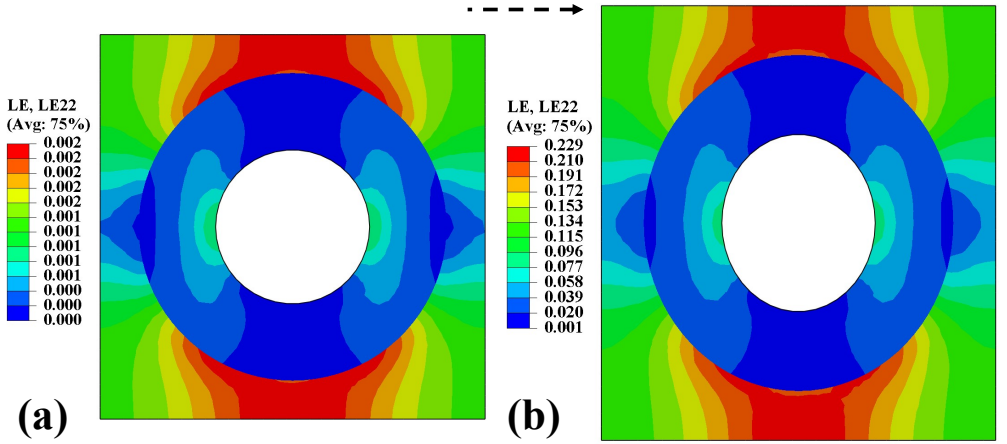
(a)

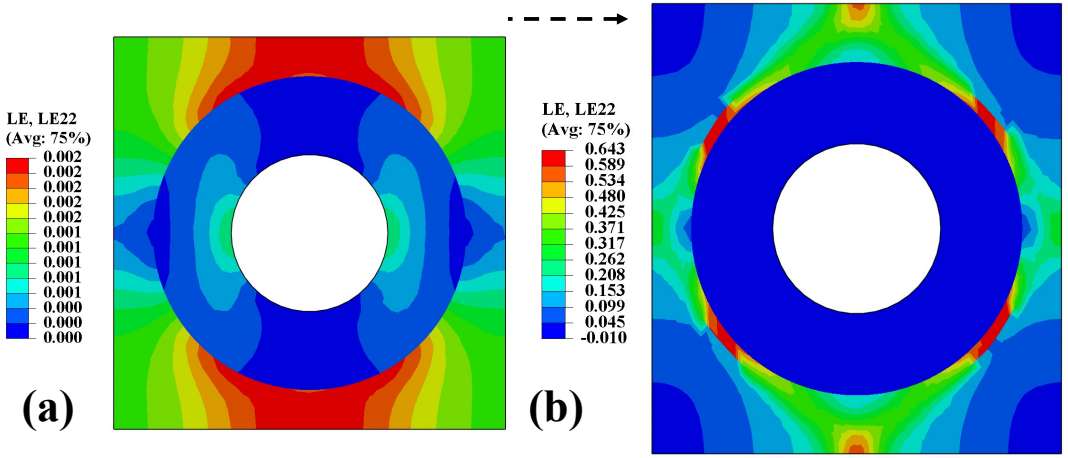


(b)

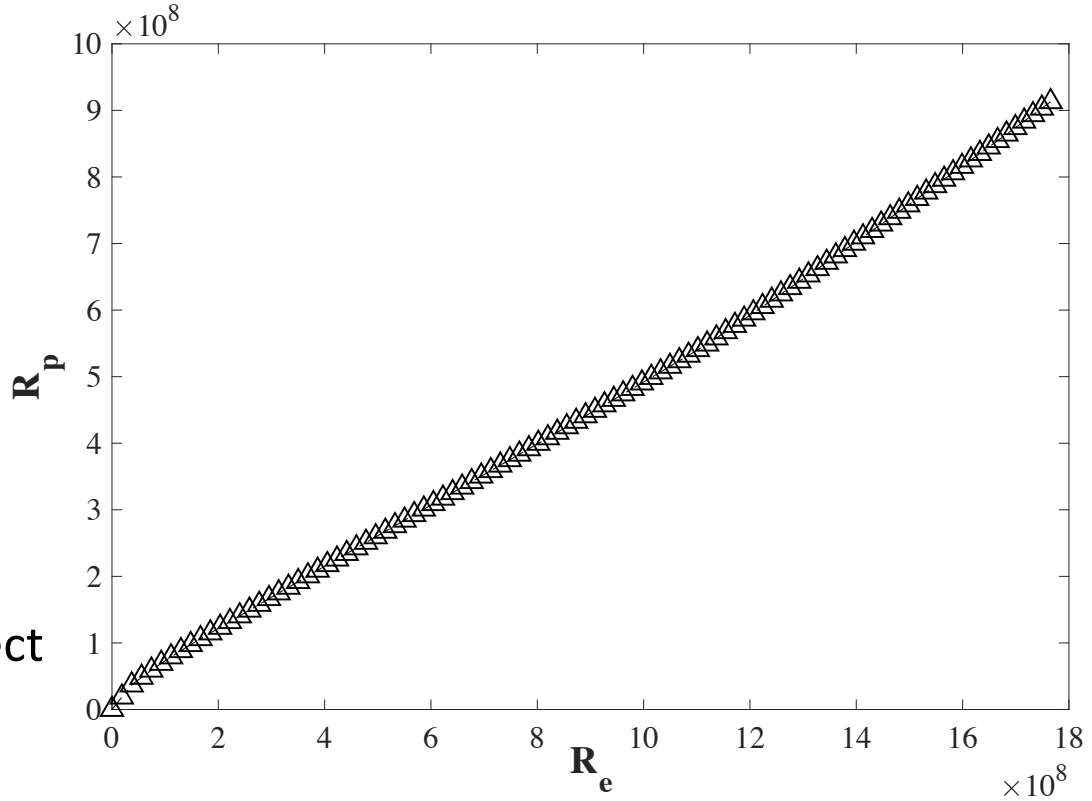
1-directional loading is $u_{-1} = -1$, $u_{+1} = 1$, initial crack length $l = 5$ (μm).

RESULTS & DISCUSSION



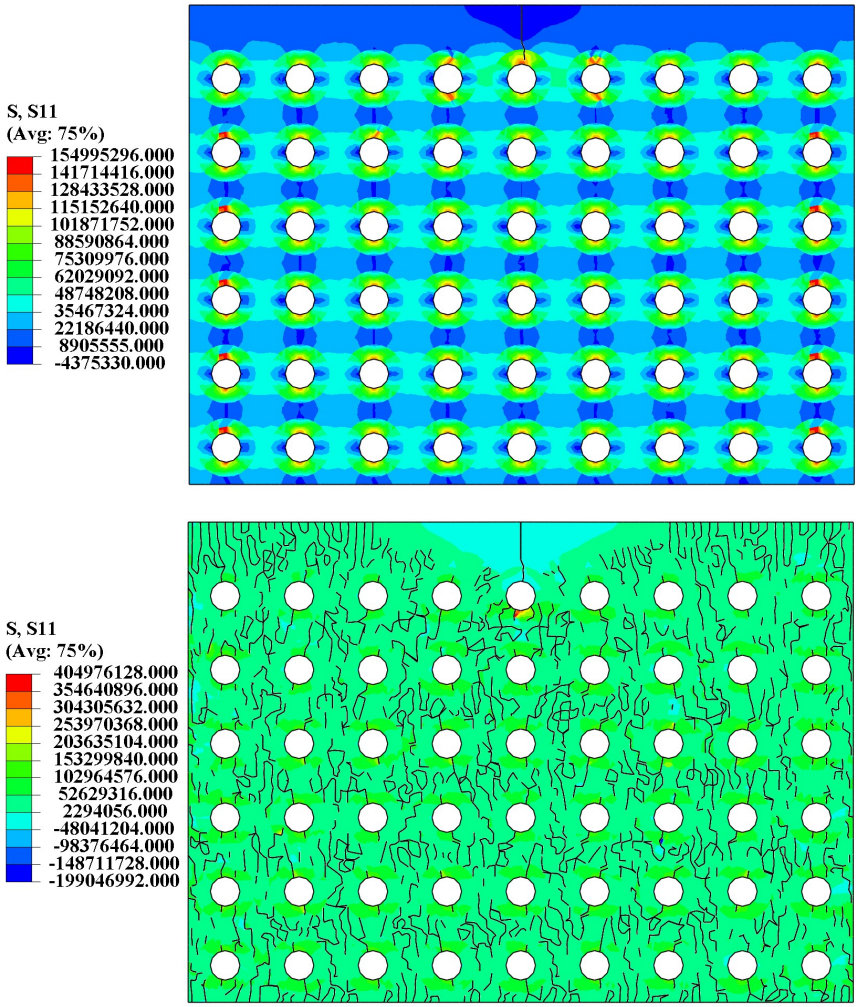


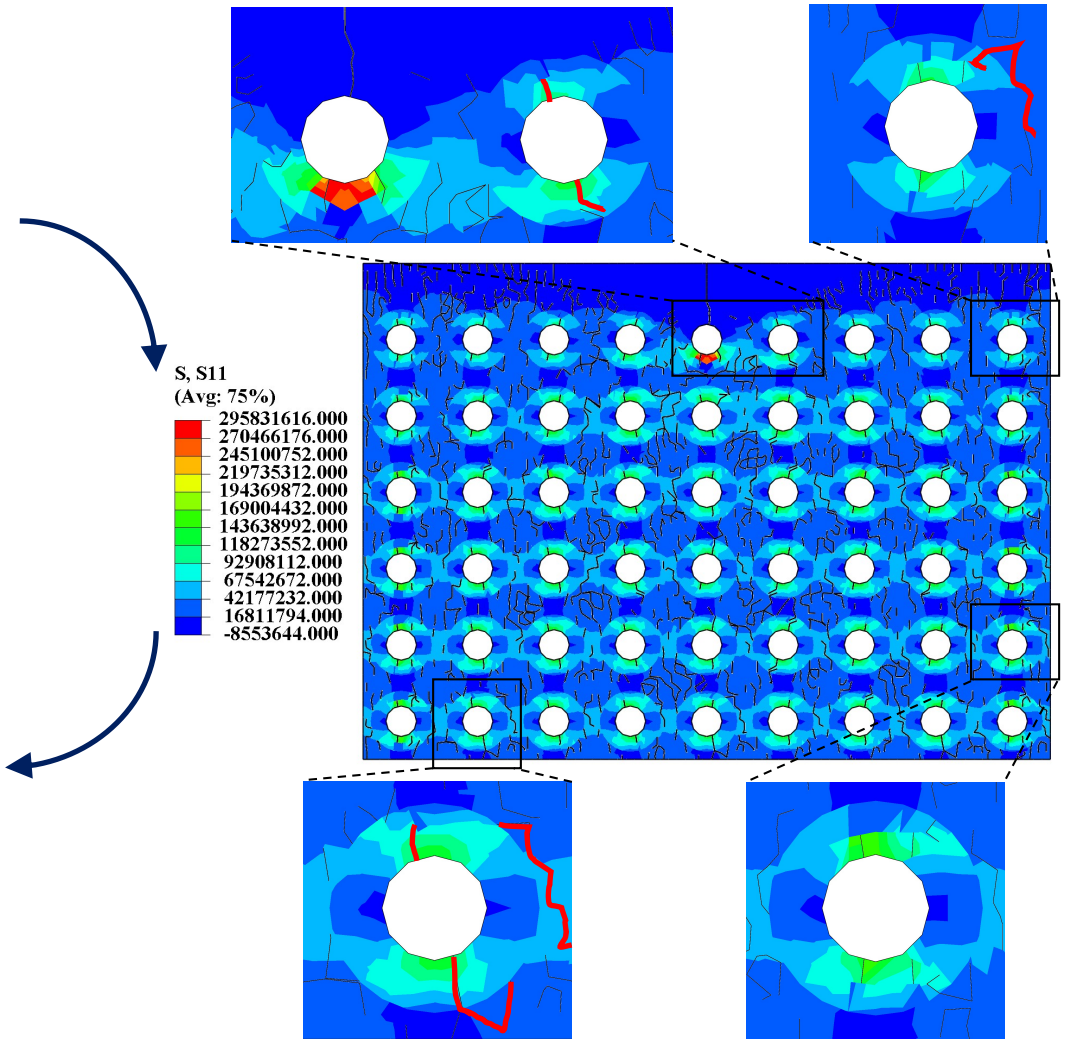
Plasticity effect



The relationship between the reaction force with the model of elastic ITD and perfectly plastic ITD

RESULTS & DISCUSSION

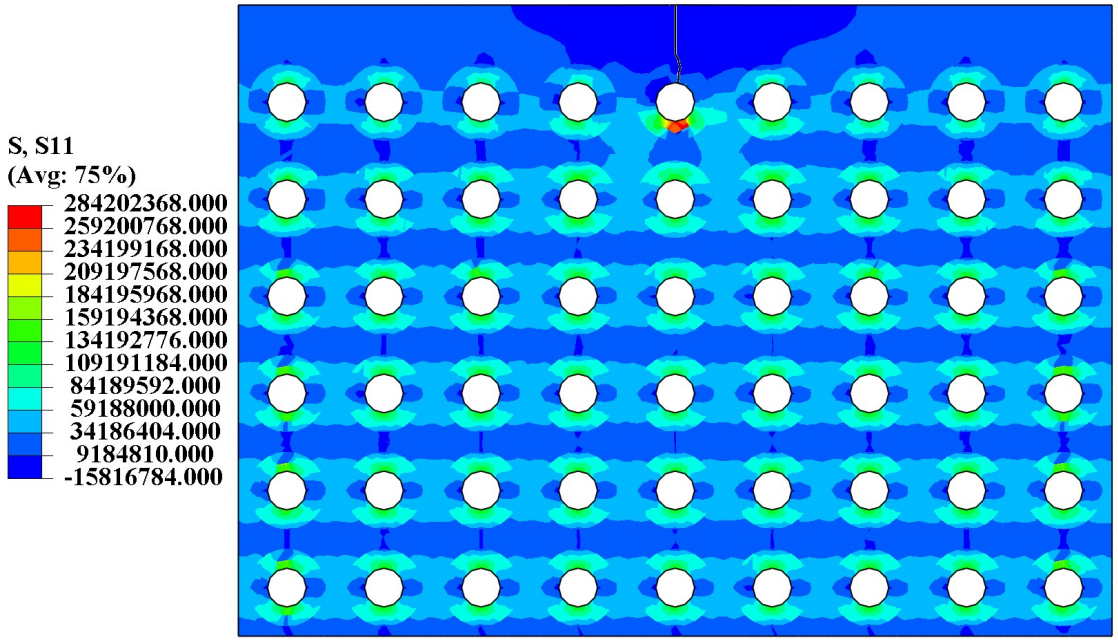


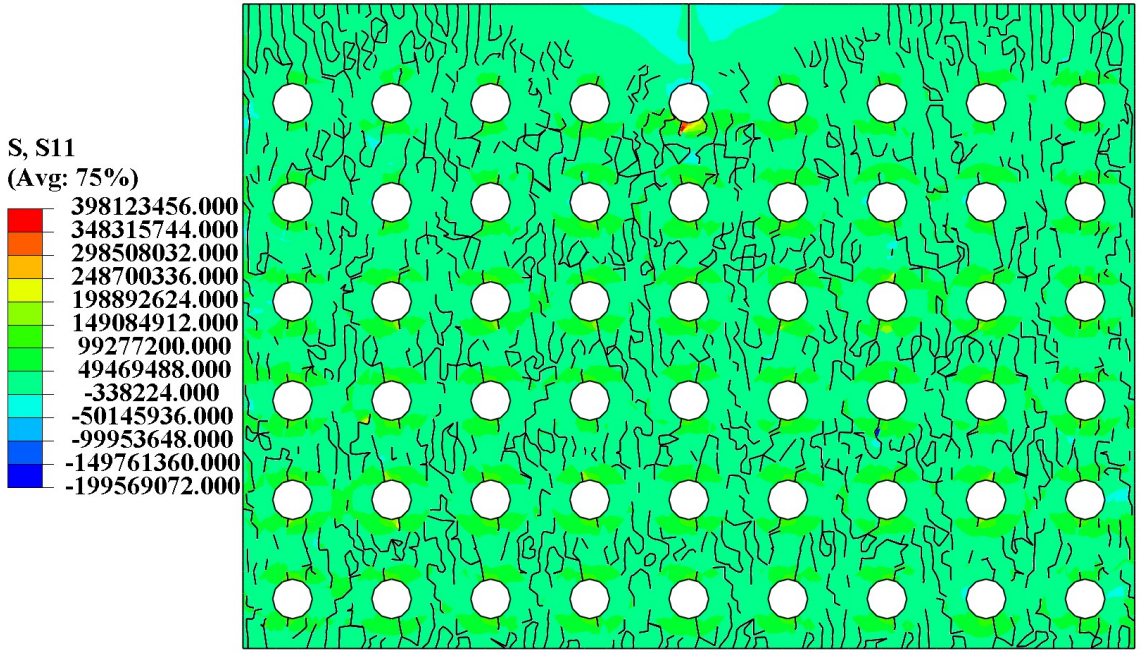


Two types of cracks observed

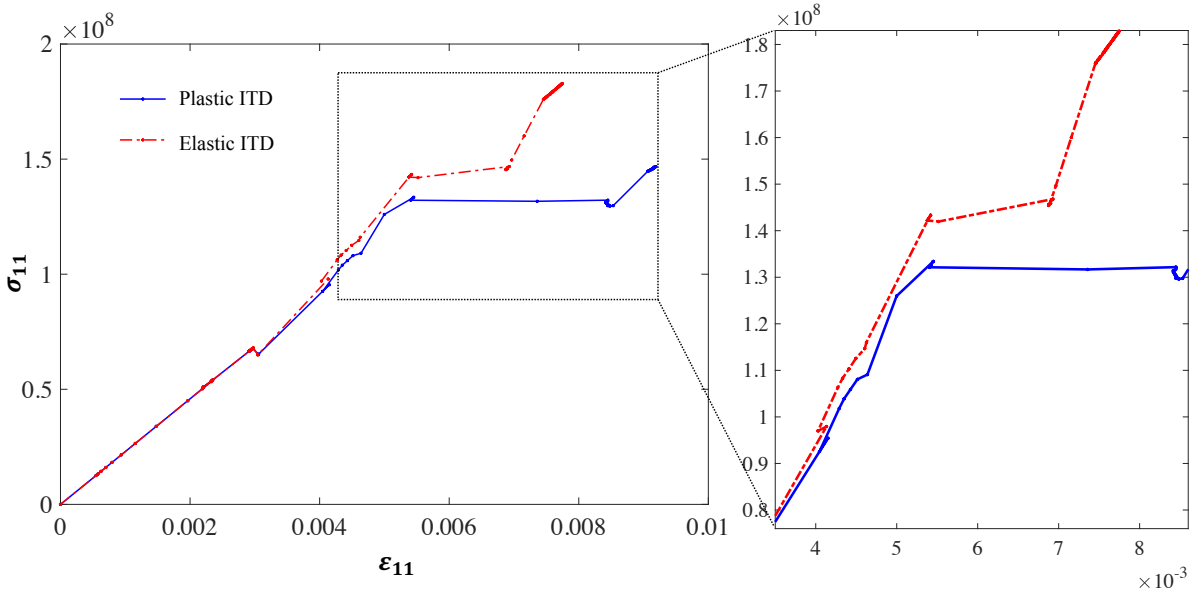
RESULTS & DISCUSSION

Plastic ITD → more evenly distributed stress

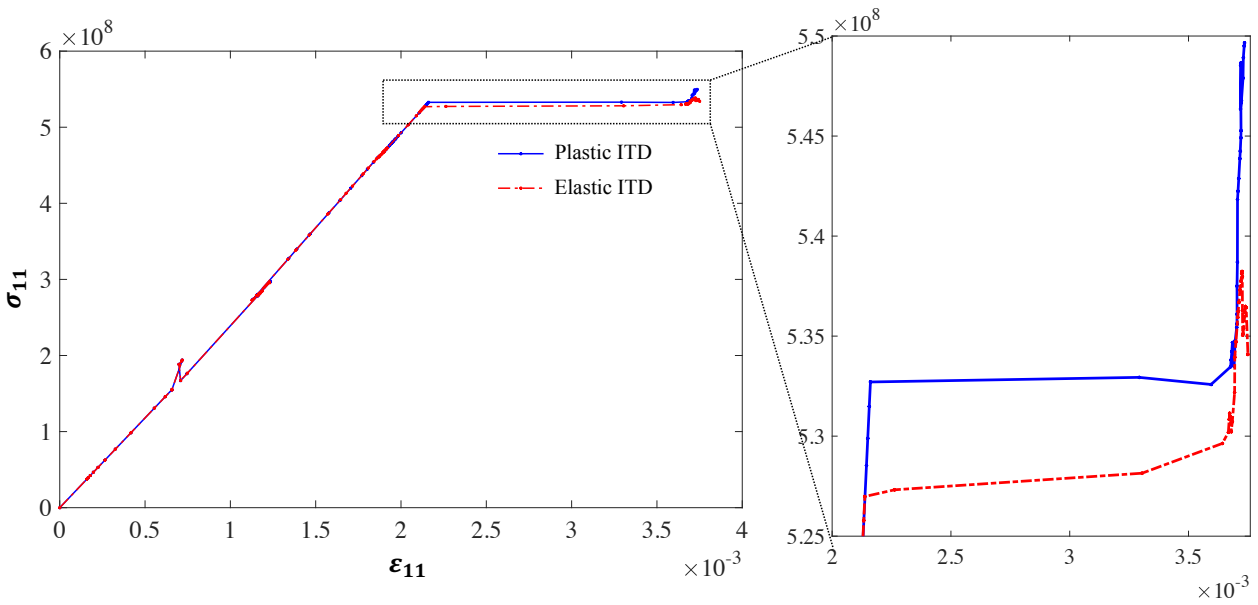




RESULTS & DISCUSSION

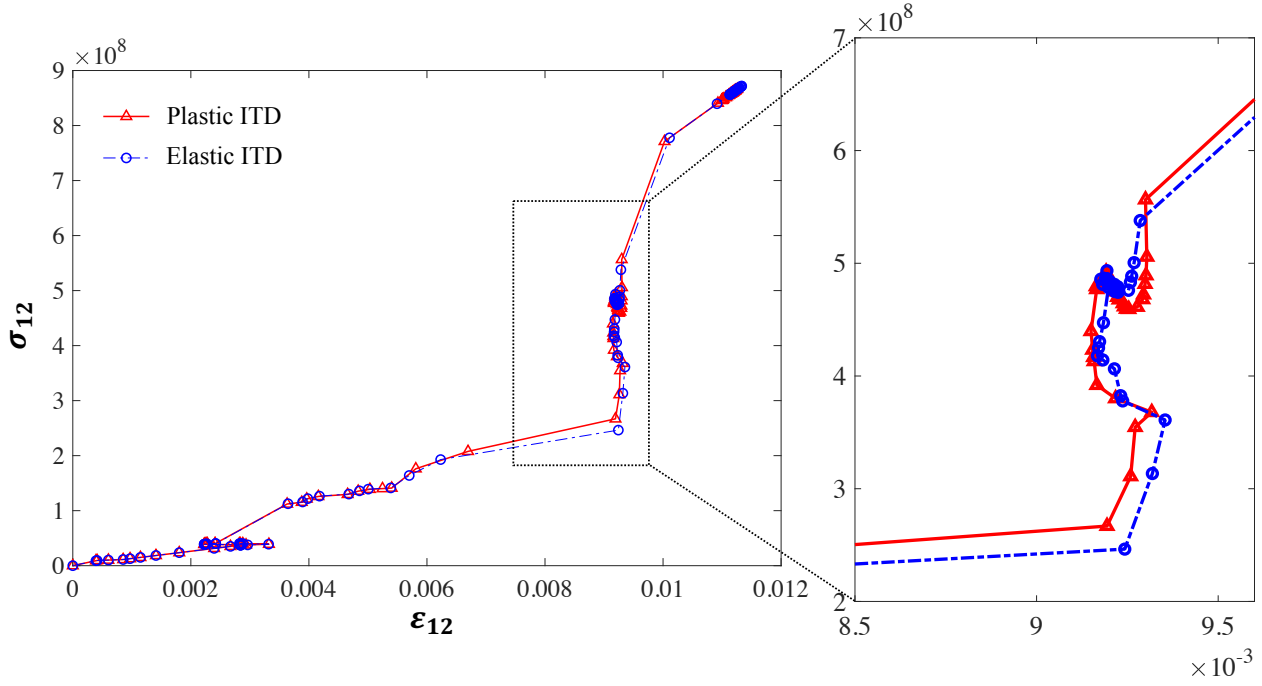


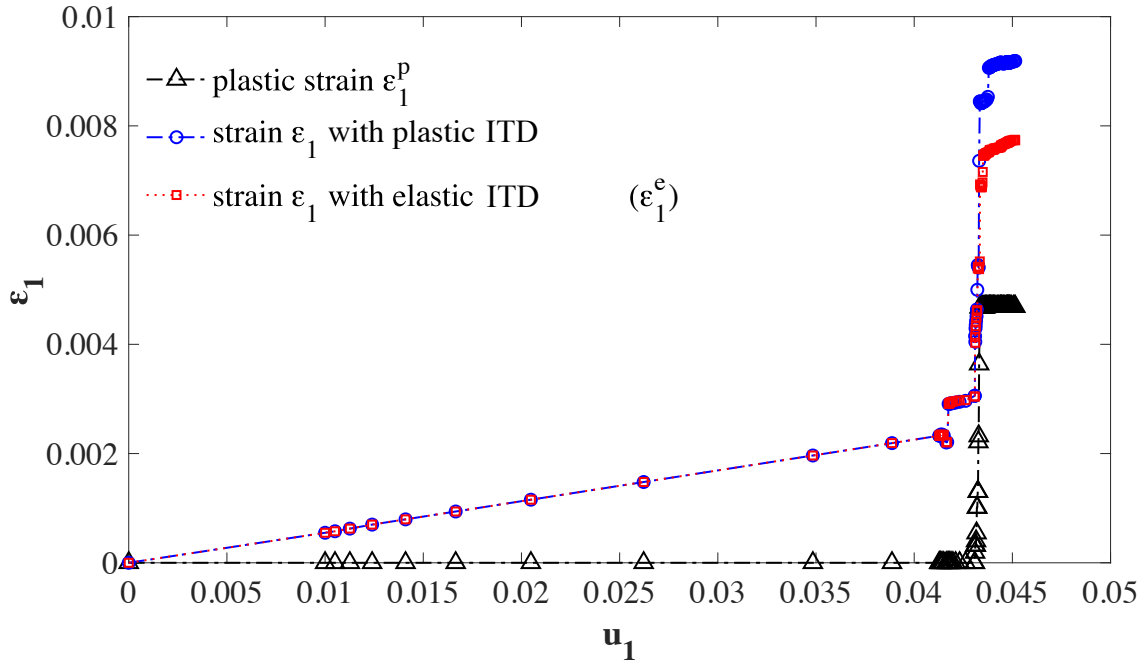
1-direction stress-strain relationship of the PTD with the crack propagation, comparing elastic and perfectly plastic ITD, respectively.



1-direction stress-strain relationship of the ITD with the crack propagation, comparing elastic and perfectly plastic ITD, respectively.

RESULTS & DISCUSSION





The shearing stress-strain relationship of the bonding interface with the crack propagation, comparing elastic and perfectly plastic ITD, respectively.

1-directional strain evolution with the growing 1-directional displacements, in which the plastic strain, total strain of the elastic and perfectly elastic ITD is presented respectively.

- The End -

Any Questions…?