

# BIOMECHANICAL ROLE OF COLLAGEN CROSS-LINKS IN BONE STRENGTH: FINITE ELEMENT STUDY

**OBJECTIVE:** Bone contains exclusively genetic Type I collagen. These collagens are identical sequences of amino acids that form the tropocollagen molecules linked by cross-links found at the end of each tropocollagen molecules. Collagen cross-linking, a major post-translational modification of collagen, plays important roles in the biological and biomechanical features of bone. The aim of this work is to use a 3D nano-scale finite element model of a sub structure in collagen fibril called mineralized collagen microfibril and to investigate the important roles of cross-links in the expression of bone strength and its capacity and ability to absorb energy.

## Finite element modelling of collagen mineralized microfibril

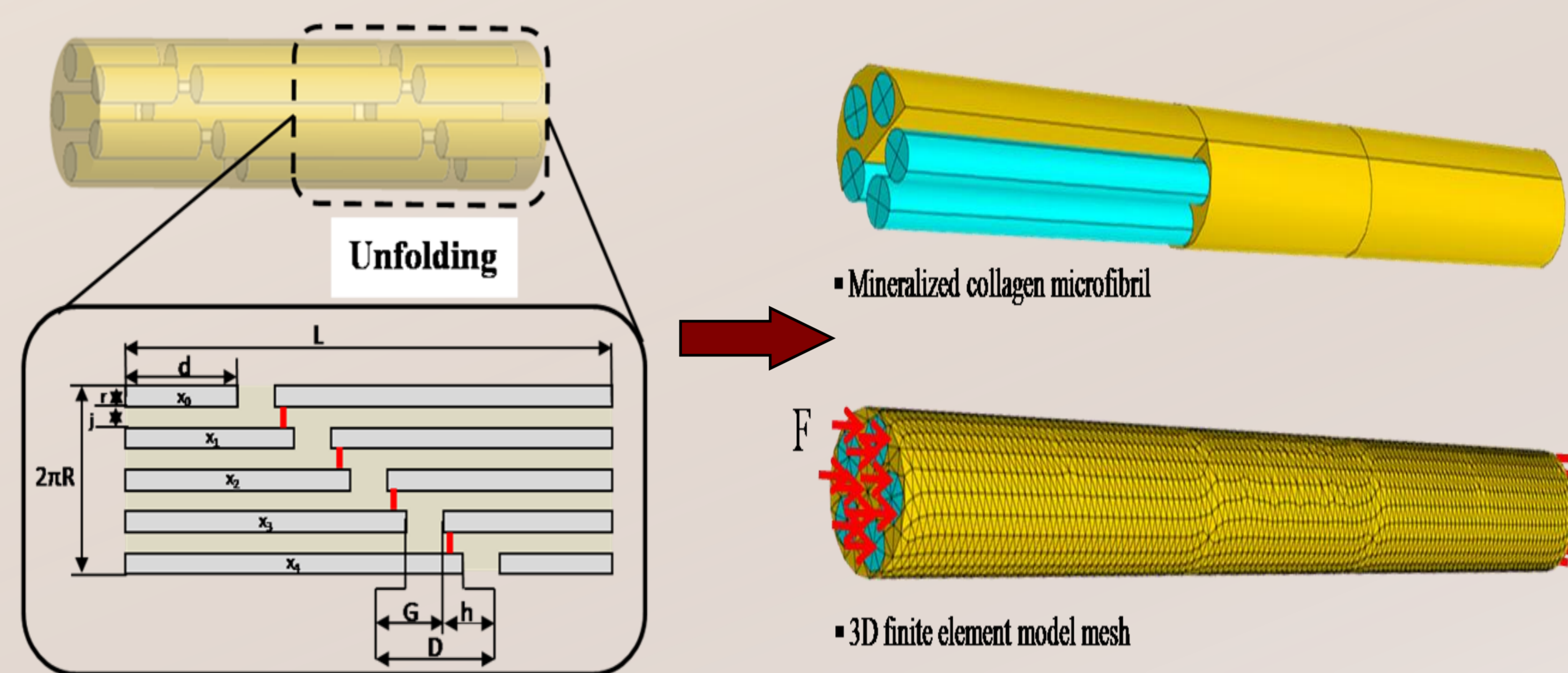
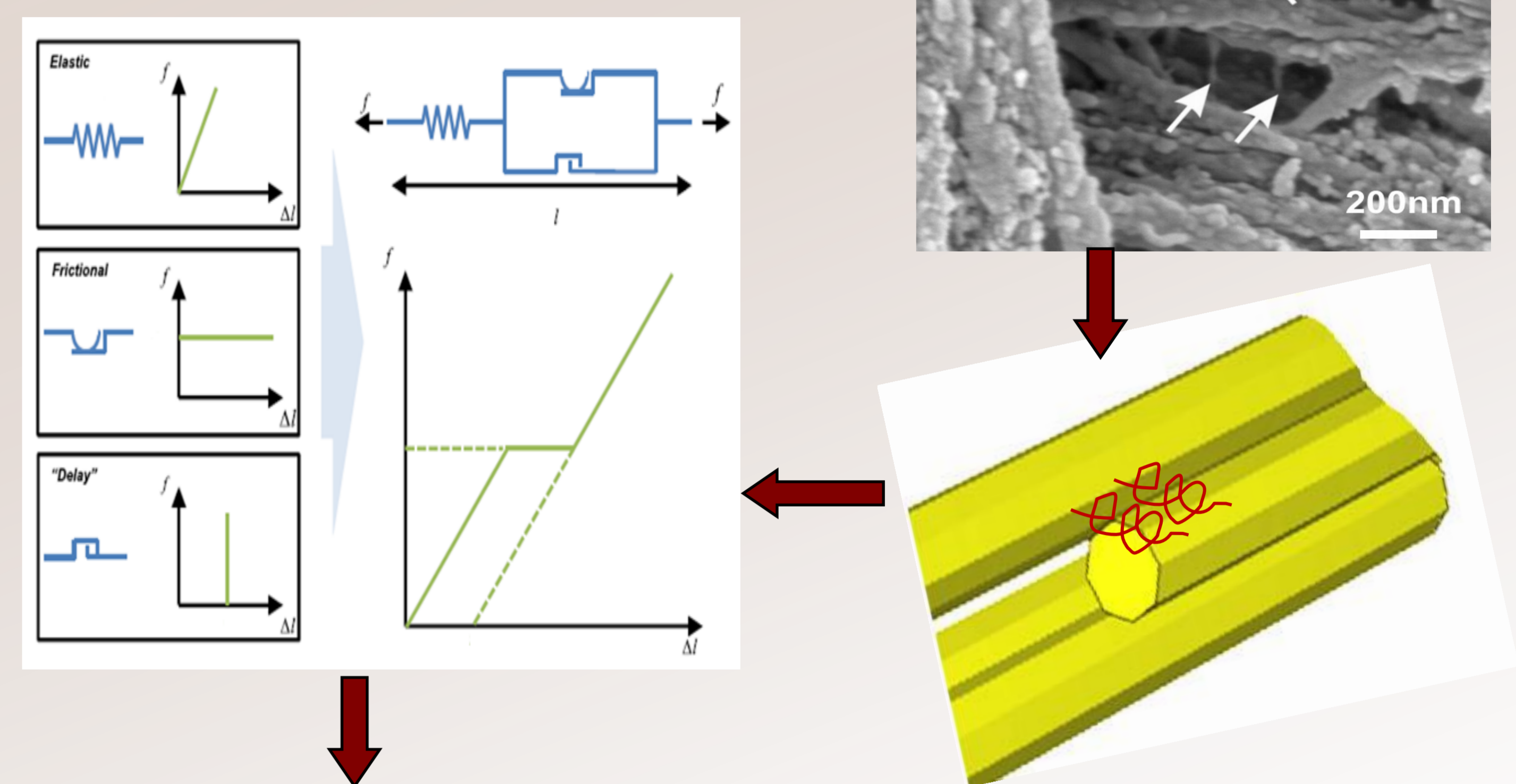


Illustration of real microfibril 3D finite element model of microfibril

$$\left\{ \begin{array}{l} \sigma_{app} = \frac{F}{A} \\ \varepsilon_{app} = \frac{\Delta l}{l_0} \end{array} \right. \Rightarrow E_{app} = \frac{\sigma_{app}}{\varepsilon_{app}}$$

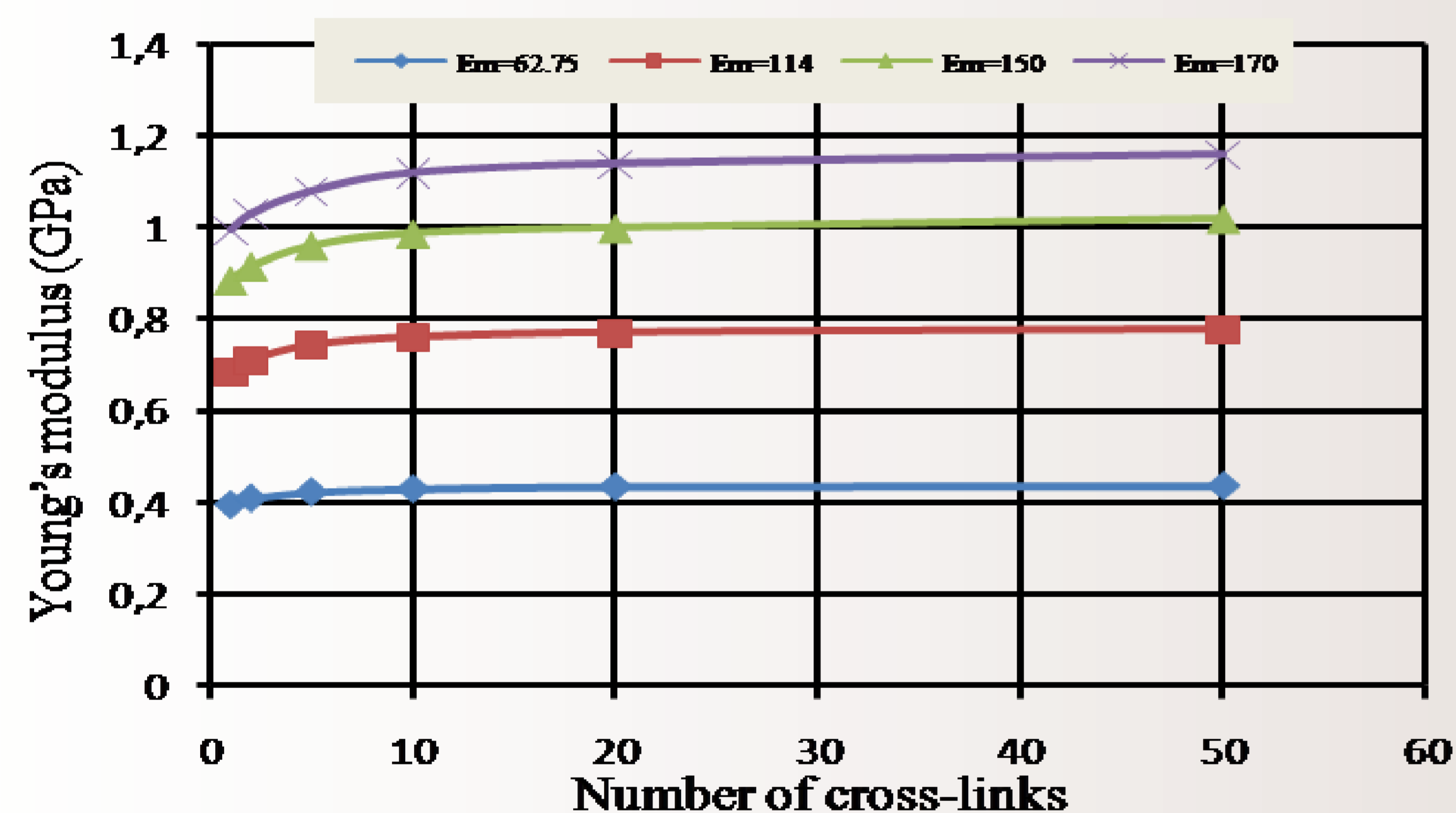
## METHOD

## Finite element modelling of collagen cross-links

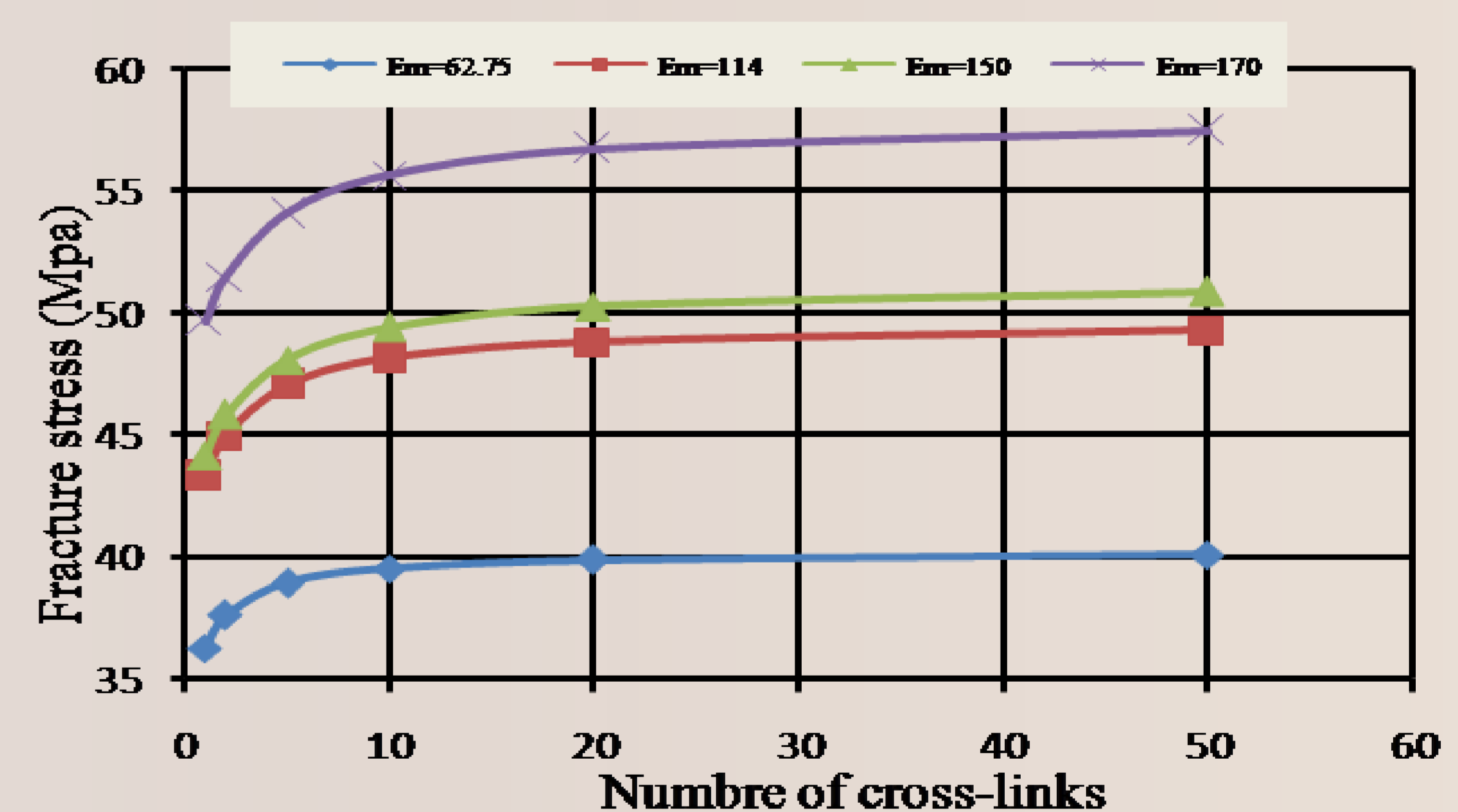


Rheological properties	Value	Source
Stiffness k ( N/nm)	1181.13 e-11	Buehler (2008)
Frictional parameter $f_{th}$ (pN)	466	Buehler et al. (2008)
Delayed spring response parameter d (nm)	10	Uzel and Buehler, (2011)

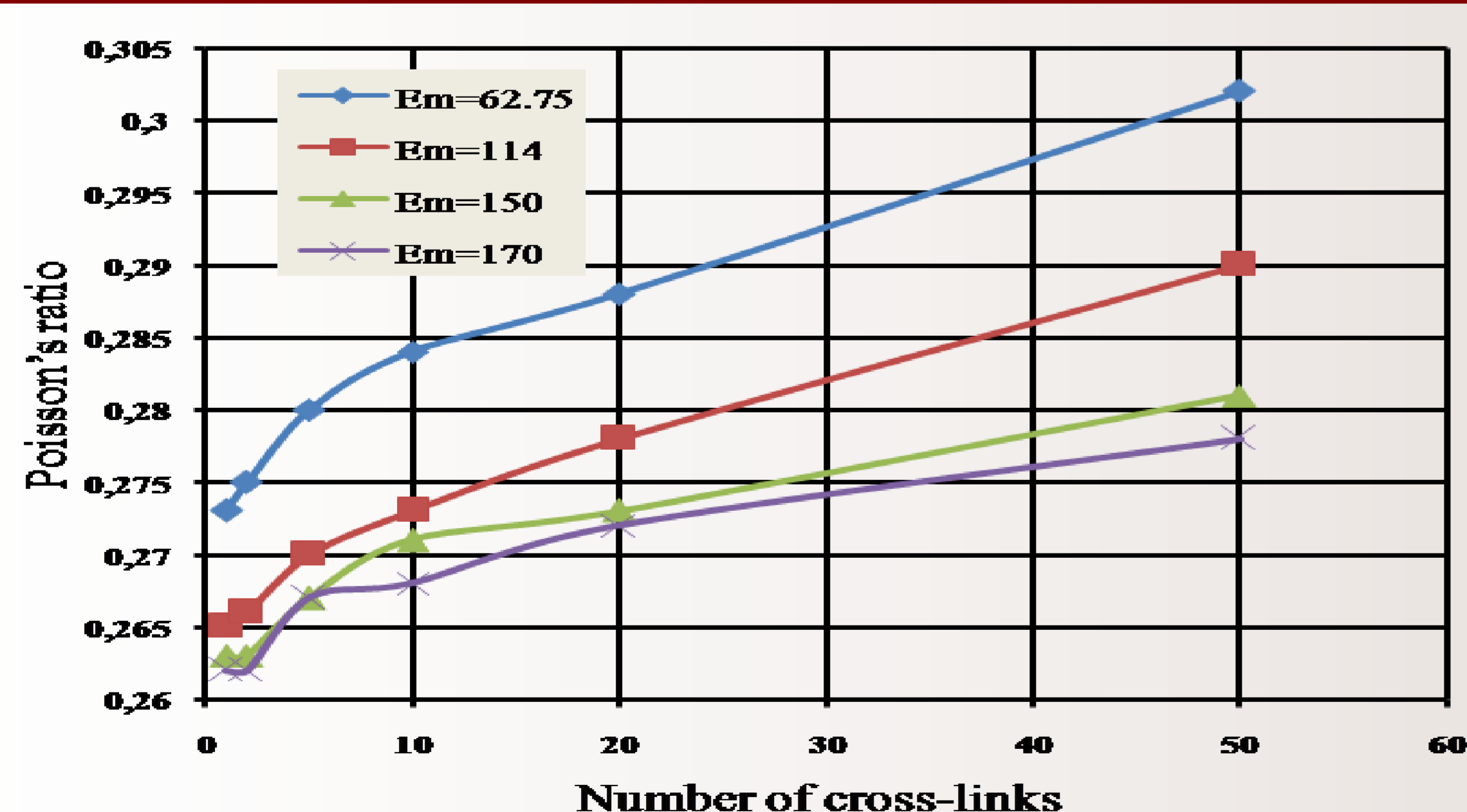
## RESULTS



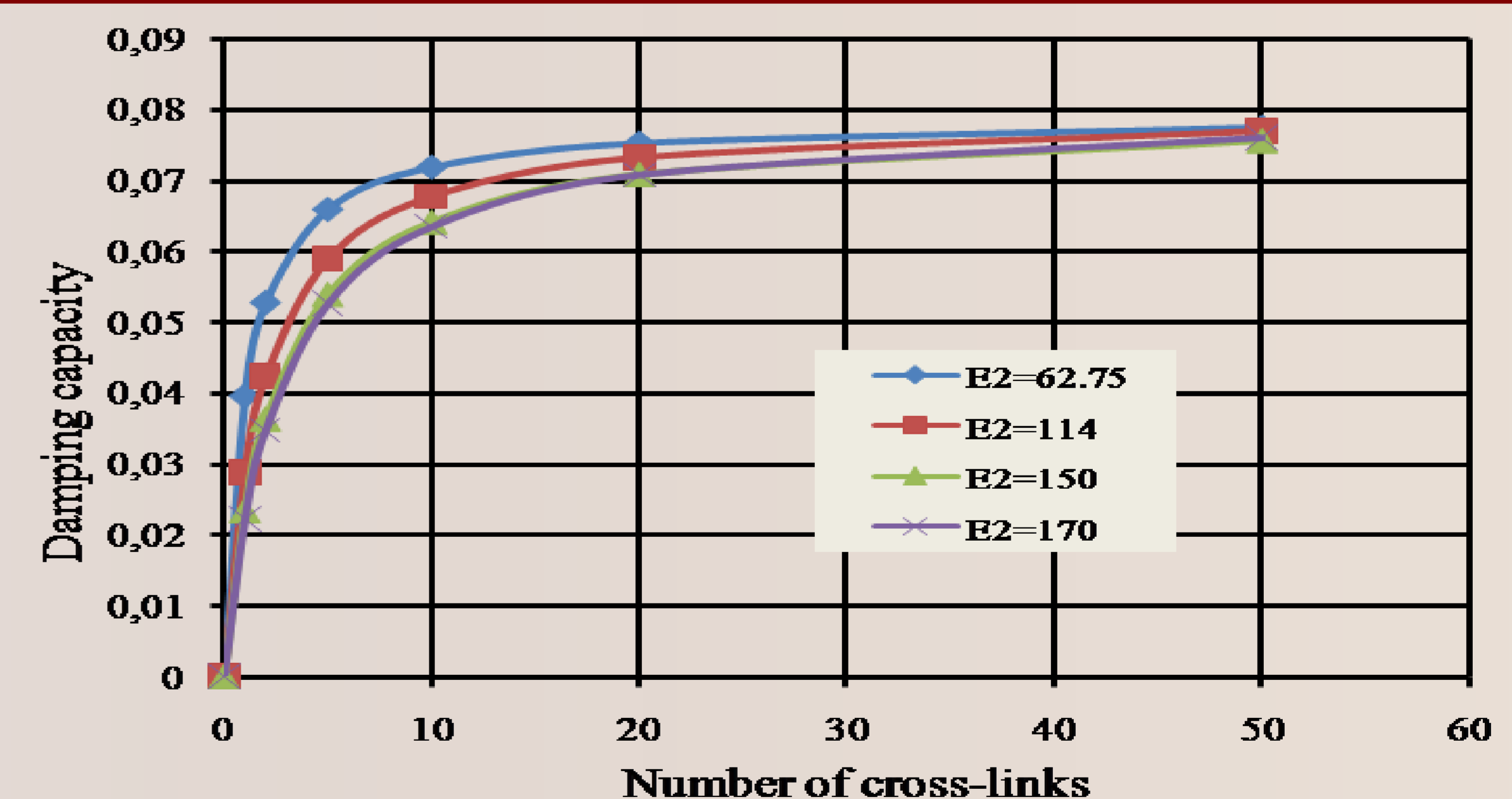
1) Equivalent Young's modulus of collagen microfibril as a function of the cross-link number under varying Young's modulus of mineral  $E_m$



3) Equivalent fracture stress of collagen microfibril as a function of the cross-link number under varying Young's modulus of mineral  $E_m$



2) Poisson's ratio of collagen microfibril as a function of the cross-link number under varying Young's modulus of mineral  $E_m$



4) Equivalent damping capacity of collagen microfibril as a function of the cross-link number under varying Young's modulus of mineral  $E_m$

**CONCLUSION:** In this study results were obtained under tensile loading with symmetric and periodic boundary conditions. These results show that the number of cross-link has a most influence on the increase of the elastic and failure proprieties.

**ACKNOWLEDGMENTS:** This work has been supported by French National Research Agency (ANR) through TecSan program (Project MoDos, n°ANR 09-TECS-018).

## REFERENCE:

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