

Supporting Information

Bulletproof Performance of Composite Plate Fabricated Using Shear Thickening Fluid and Natural Fiber Paper

Hyeonho Cho [†], Jongsuk Lee [†], Sungjin Hong and Sunghan Kim ^{*}

School of Mechanical Engineering, Chung-Ang University, Seoul 06974, Korea; ckror93@gmail.com (H.C.); wjrk2010@gmail.com (J.L.); hongluck36@gmail.com (S.H.)

^{*} Correspondence: sunghankim@cau.ac.kr; Tel.: +82-2-820-5265

[†] Hyeonho Cho and Jongsuk Lee contributed equally to this work.

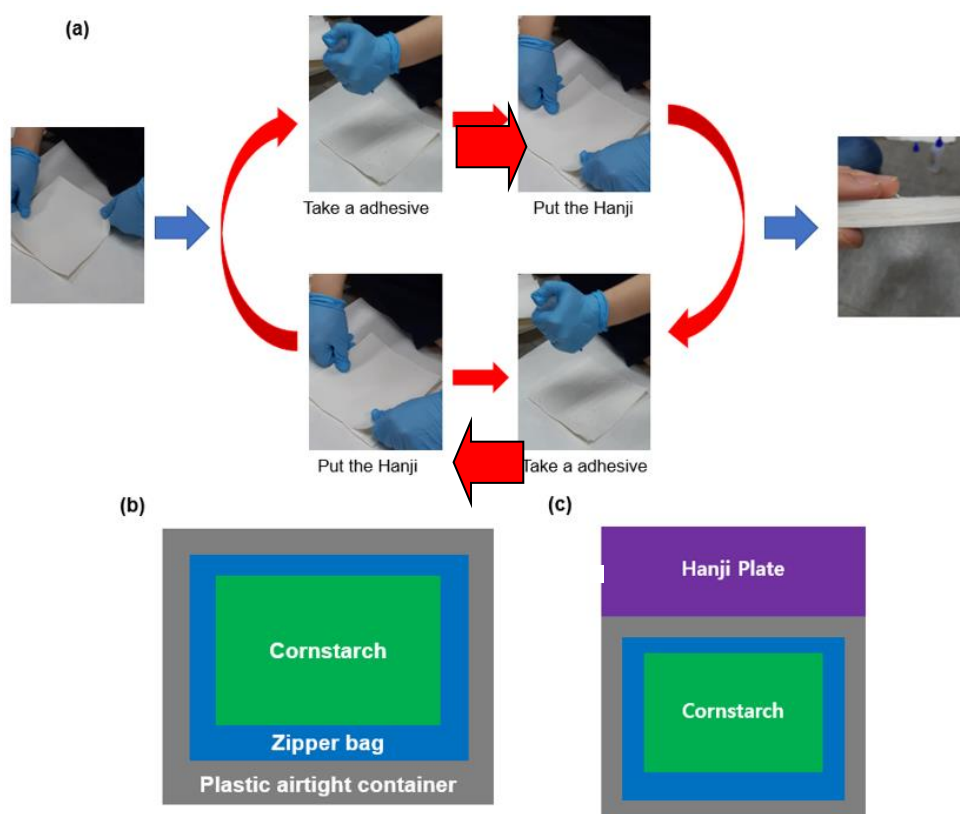


Figure S1. Fabrication of bulletproof composite plates using LbL method: (a) Assembling the Hanji layers by applying adhesive, (b) Cornstarch suspension stored in the zipper bag, and (c) composite plate formed by LbL of Hanji and applying cornstarch suspension.

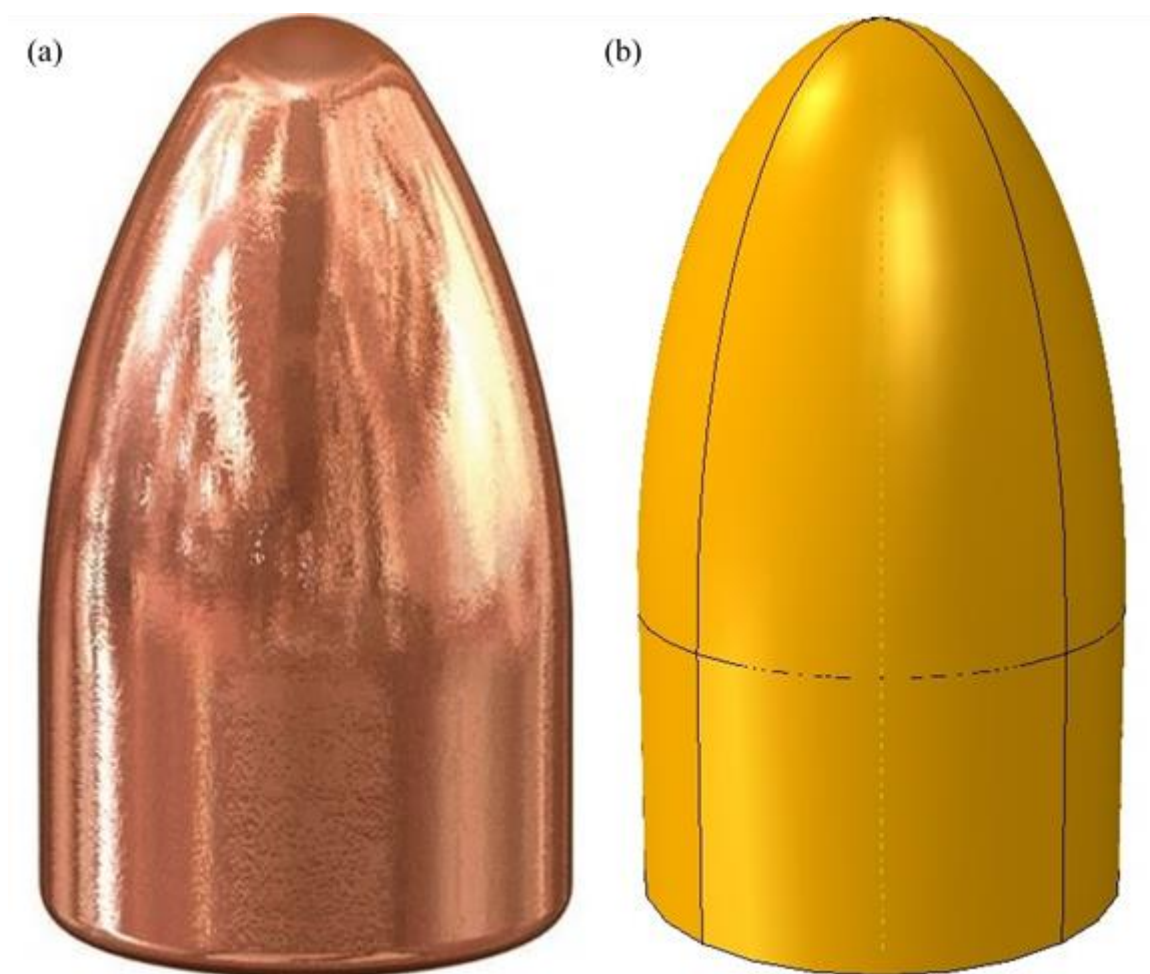


Figure S2. Comparison of (a) commercially available 9-mm bullet and (b) 9-mm bullet modeled in this study.

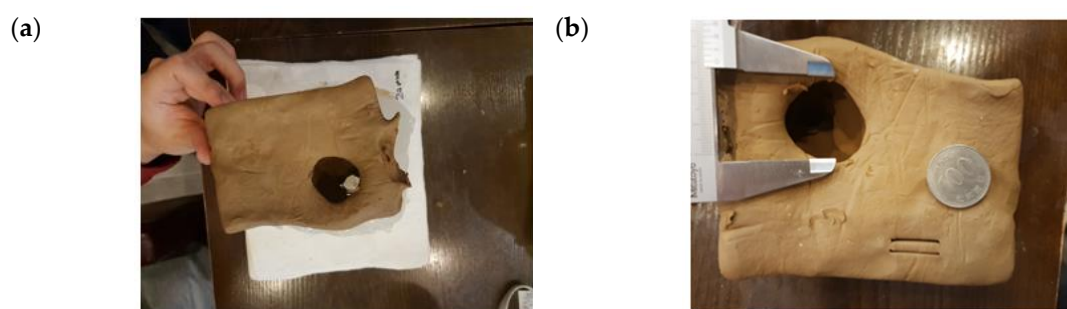


Figure S3. Actual images obtained during bulletproof experiments for (a) composite with 20-mm-thick cornstarch suspension layers and 60 sheets of Hanji and (b) composite with no cornstarch layers and 120 Hanji layers.

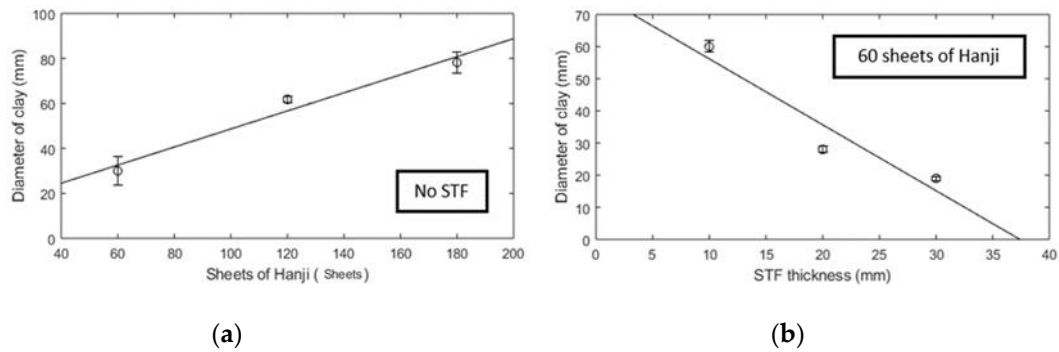


Figure S4. (a) Perforated diameter of clay after bulletproof experiments using composites with various Hanji layer sheets and (b) perforated diameter of clay after bulletproof experiments using hybrid composites composed of Hanji (60 sheets) and various thickness of cornstarch suspension (STF) layers.

Table S1. Mechanical properties of Hanji and cornstarch suspension.

Properties	Hanji	Cornstarch suspension
Young's M odulus (GPa / Pa)	8.23	349.60
Poisson's Ratio	0.45	0.3
Shear M odulus (GPa / Pa)	2.8379	134.46
Ultimate Strength (MPa / Pa)	167.9	324.50
Shear Failure	0.0204	0.9282

Built-in function in ABAQUS/CAE

The built-in function for calculating the equivalent plastic strain (PEEQ) in ABAQUS/CAE[®]. If the PEEQ value is higher than the pre-defined value of shear failure, the program will state that the element has failed [1] (1Abaqus, V. 6.14 Documentation. Dassault Systemes Simulia Corporation. 2014, 651.)

$$\varepsilon_{PEEQ} = \frac{2}{3} \sqrt{\frac{3(e_{xx}^2 + e_{yy}^2 + e_{zz}^2)}{2} + \frac{3(\gamma_{xy}^2 + \gamma_{yz}^2 + \gamma_{zx}^2)}{4}} \quad (1)$$

$$e_{ii} = +\frac{2}{3}\varepsilon_{ii} - \frac{1}{3}\varepsilon_{jj} - \frac{1}{3}\varepsilon_{kk} \quad (2)$$

$$\gamma_{ij} = 2\varepsilon_{ij} \quad (3)$$

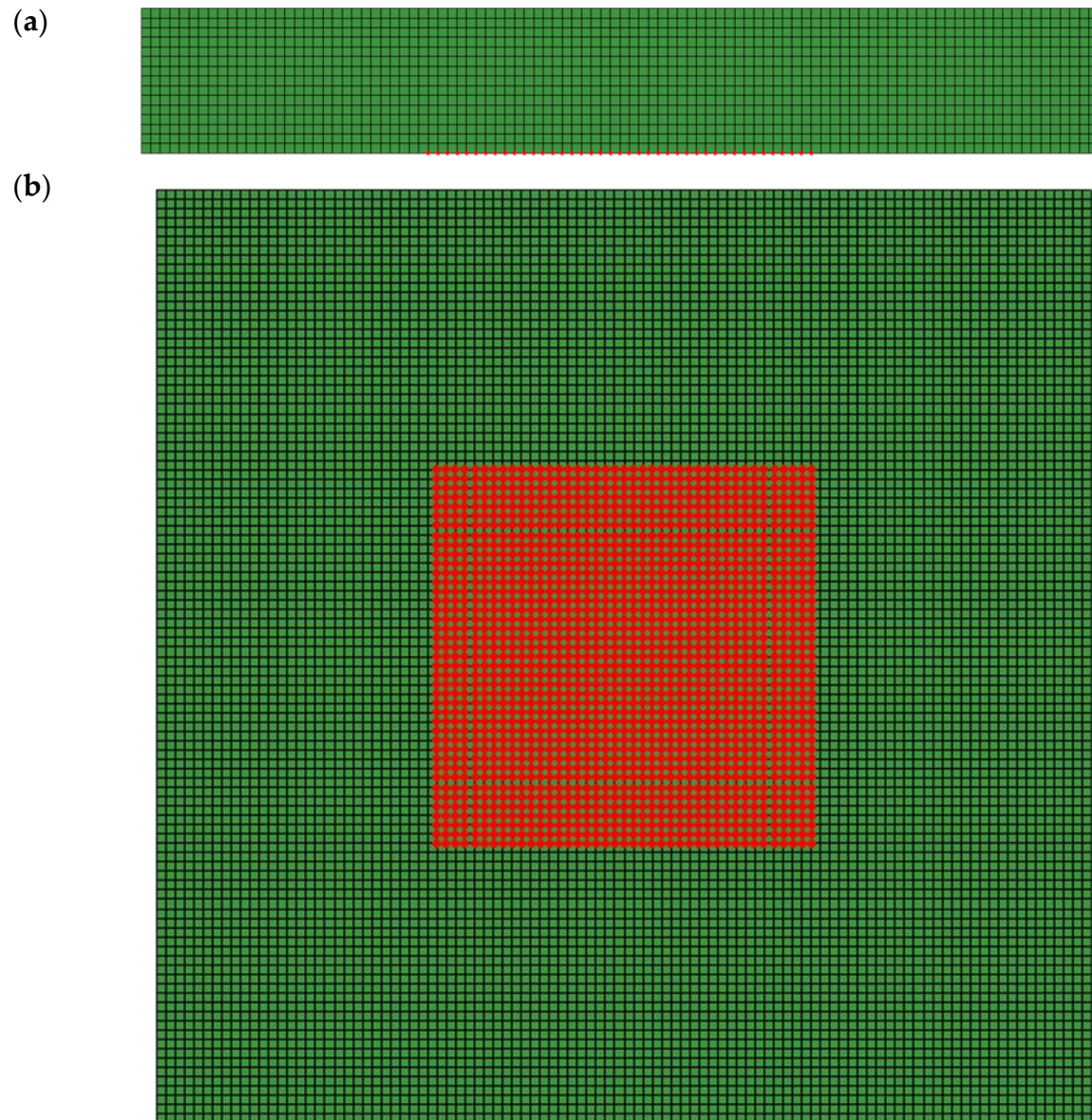


Figure S5. Nodes on the 40 mm ×40 mm region of the plate as viewed from the (a) side and (b) bottom.
