

Supporting Information

**From Ancient Wisdom to Modern Building Material: High-Strength, Low-Carbon
Bio-Mineral Composites Inspired by Traditional Architecture**

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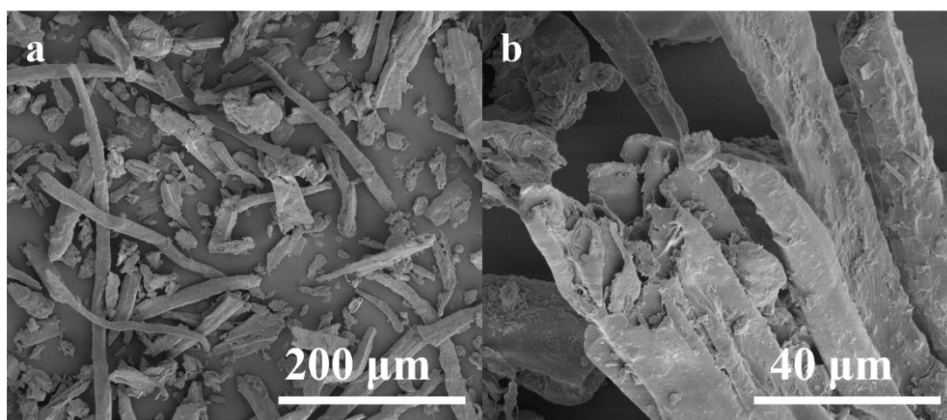


Figure S1 a) SEM images and b) higher magnification of wood chips.

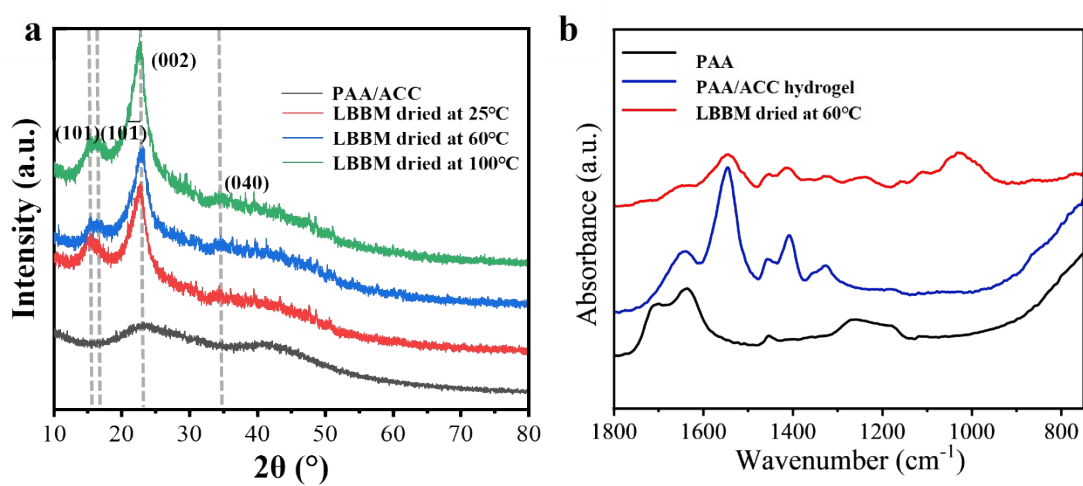


Figure S2 a) The XRD spectrum of PAA/ACC hydrogel and LBBM dried at 25 $^\circ\text{C}$, 60 $^\circ\text{C}$, 100 $^\circ\text{C}$. b) The ATR-FTIR spectra of PAA, PAA/ACC hydrogel and LBBM dried at 60 $^\circ\text{C}$.

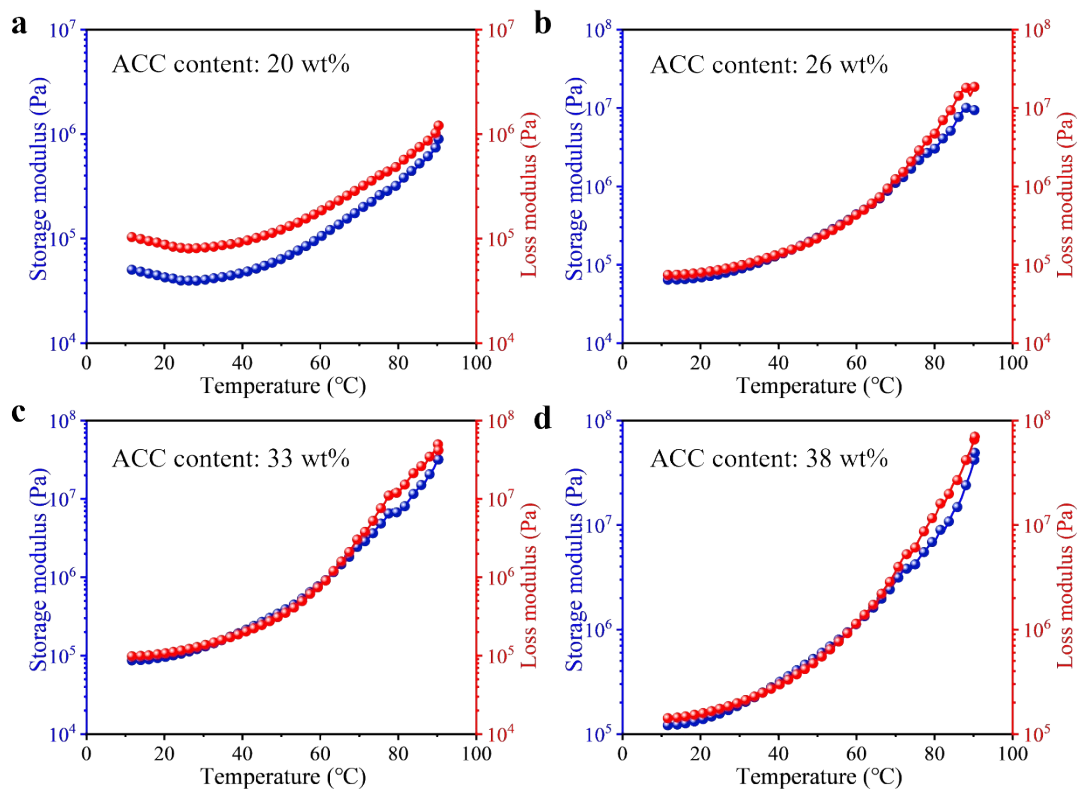


Figure S3 Temperature dependencies of the storage and loss modulus of PAA/ACC mineral hydrogel with different ACC content: a) 20 wt%, b) 26 wt%, c) 33 wt% and d) 38 wt%.

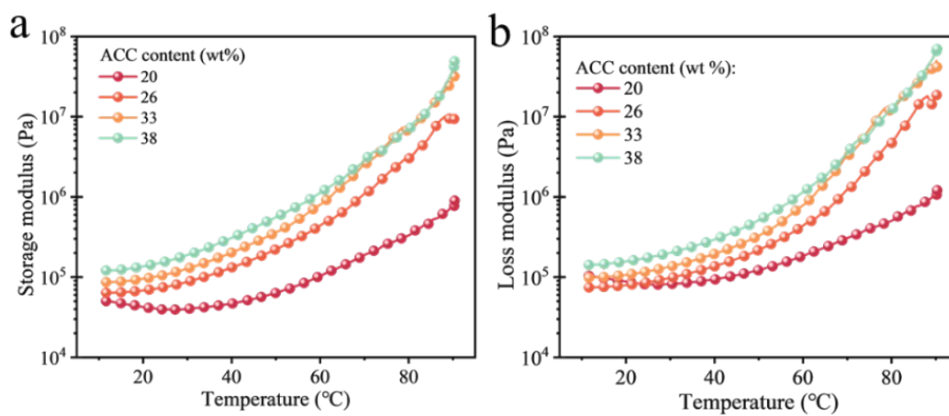


Figure S4 Temperature dependencies of the a) storage and b) loss modulus of PAA/ACC mineral hydrogel with different ACC content (from 20 wt% to 38 wt%).

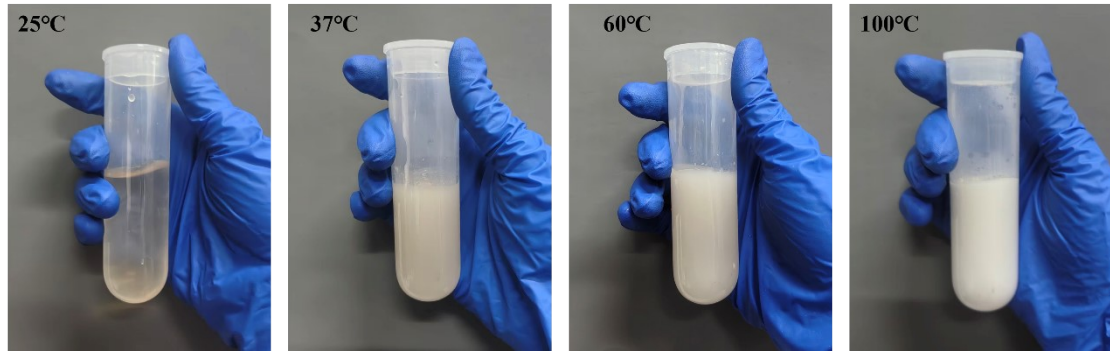


Figure S5 Physical diagram of the mineral hydrogel's response to different temperatures

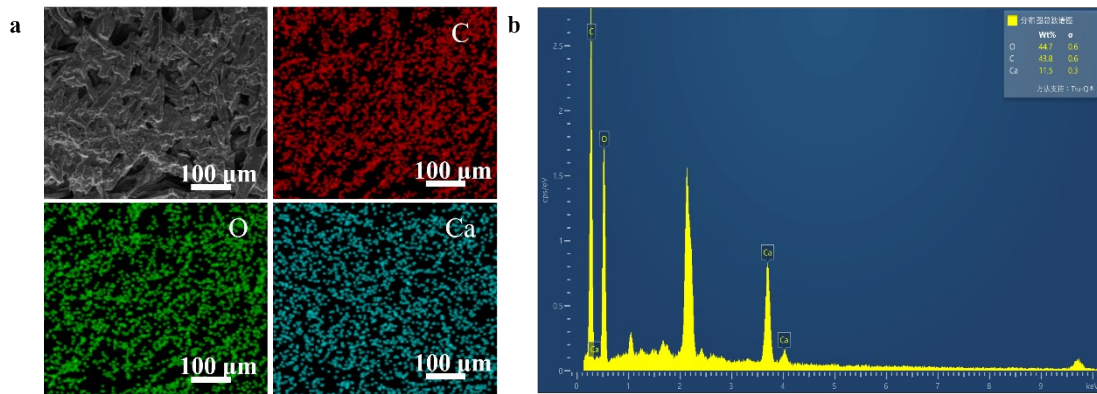


Figure S6 a) SEM image of the as-prepared 60 °C dried LBBM and the corresponding elemental mapping images of C, O and Ca in LBBM. b) EDS spectrum of cross-sections of the as-prepared dried LBBM.

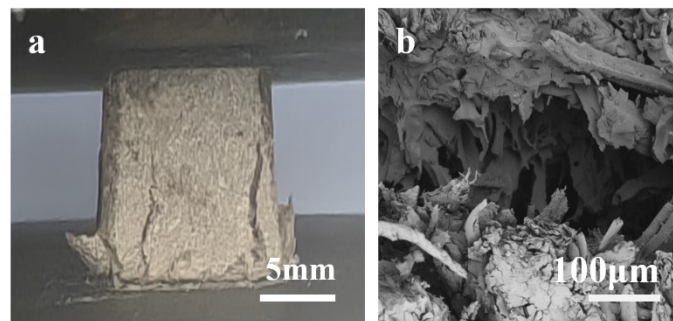


Figure S7 a) Optical images of LBBM under compression tests and b) SEM images of crack

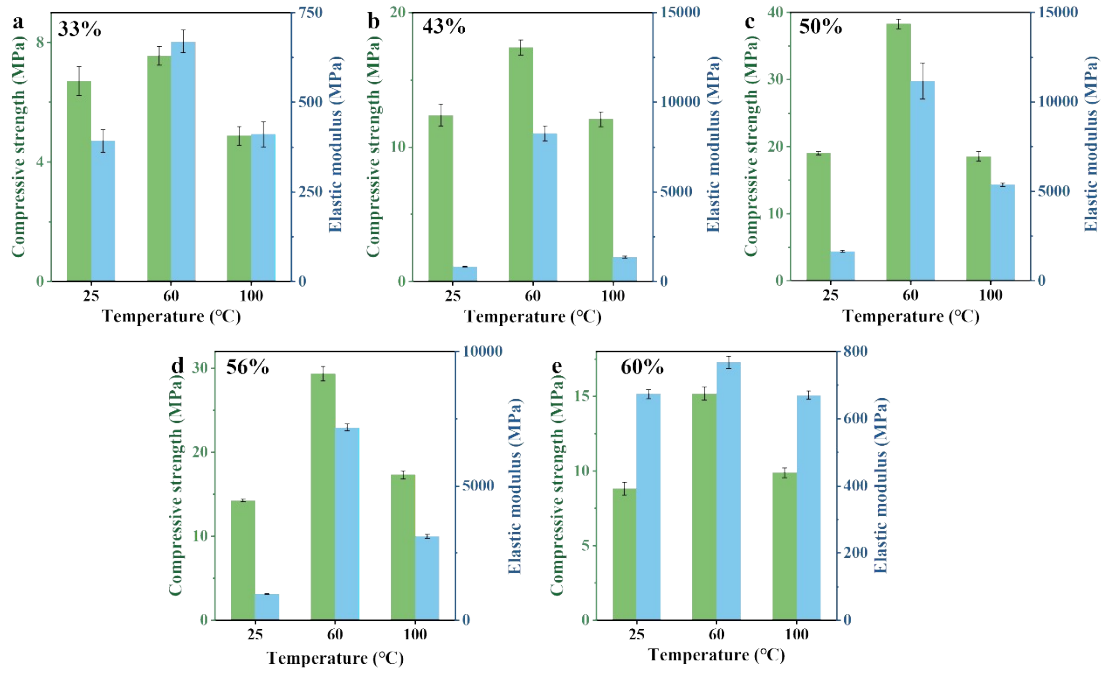


Figure S8 Compressive strength and elastic modulus of LBBM materials under different drying temperatures with varying mass percentage of WS: a)33%, b)43%, c)50%, d) 56% and e) 60%.

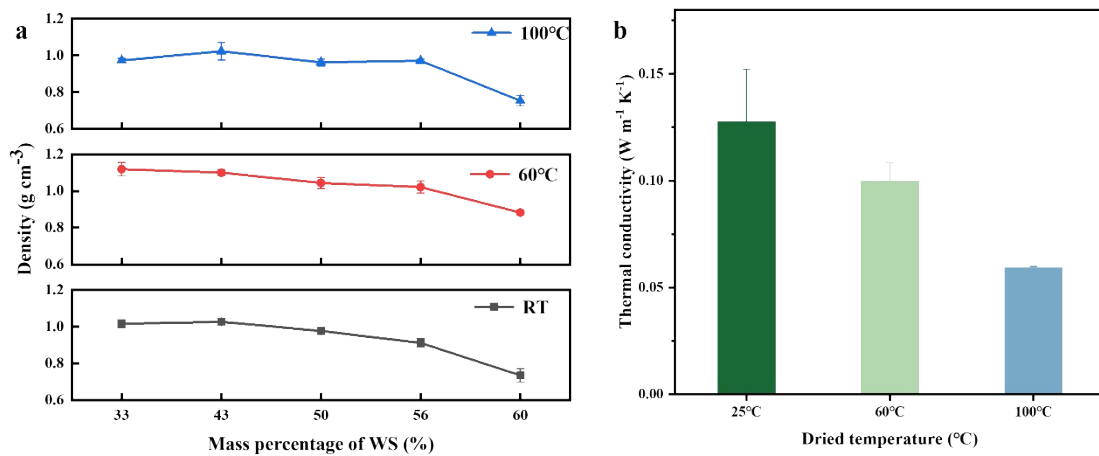


Figure S9 a) Density changes of LBBMs under different drying temperatures with varying mass percentage of WS. b) Thermal conductivity changes of LBBM composites dried at different temperatures with 50% WS content.

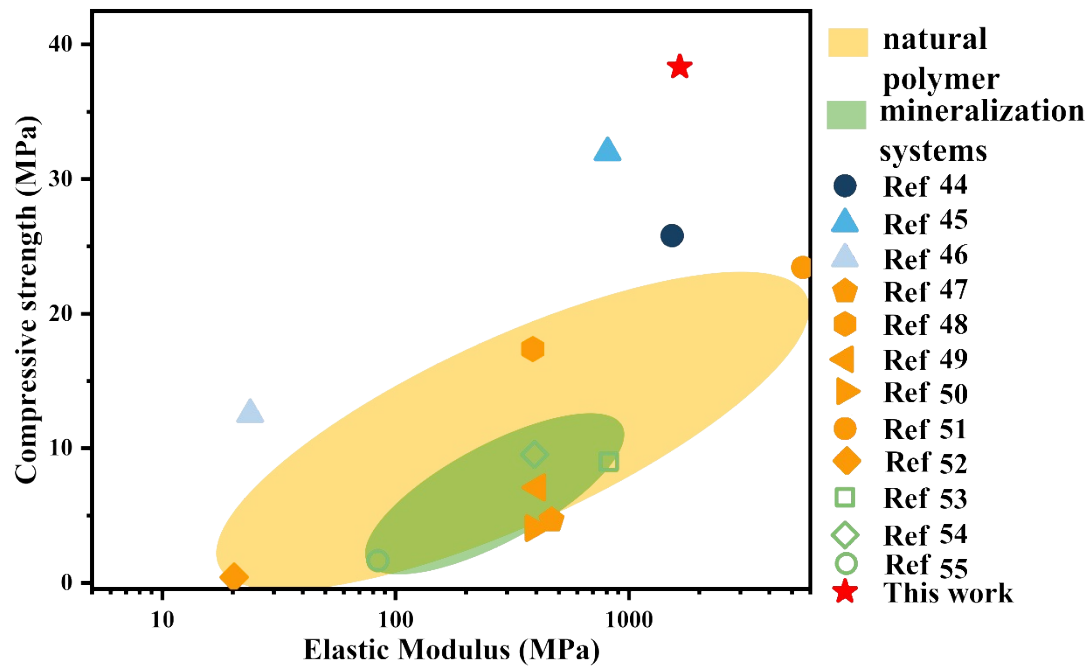


Figure S10 Comparison of compressive strengths and elastic modulus between LBBM with different bio-polymer adhesive contents and previously reported natural-based building materials, including natural polymer, mineralization systems and other newly reported innovative building materials.

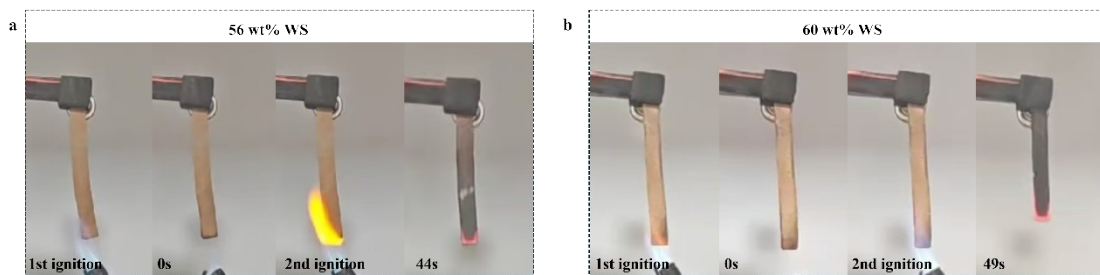


Figure S11 Digital photos of LBBM dried at 60 °C with 56 and 60 percent of WS content in vertical burning tests.

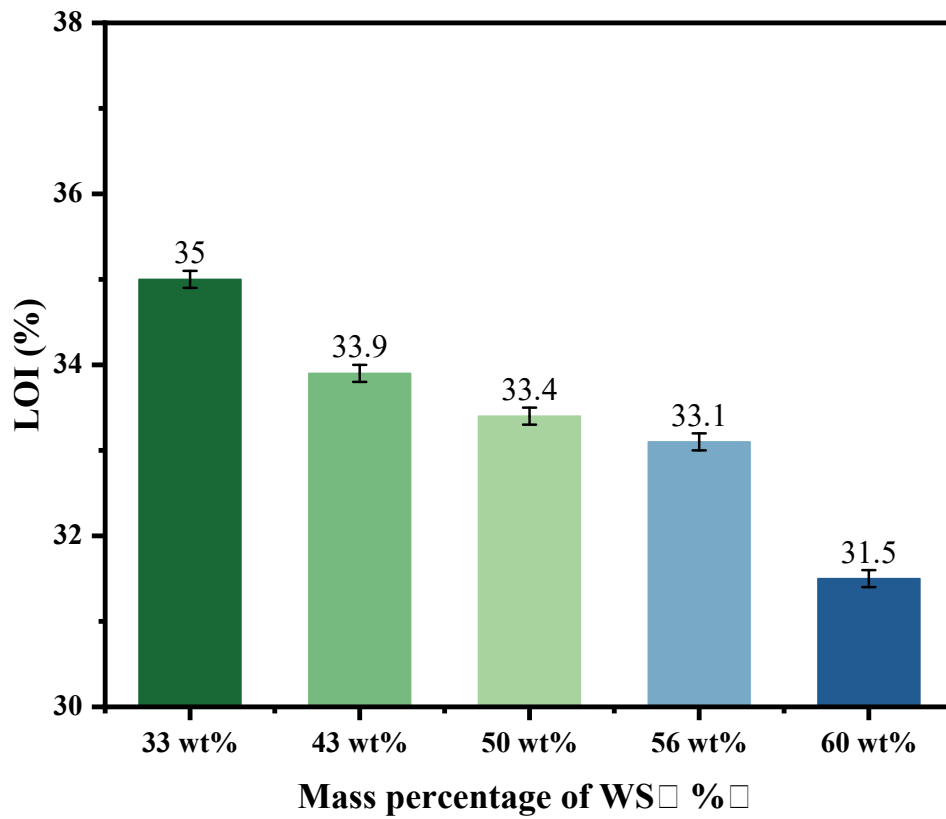


Figure S12 LOI testing results for LBBM dried at 60 °C with different mass percentage of WS content.

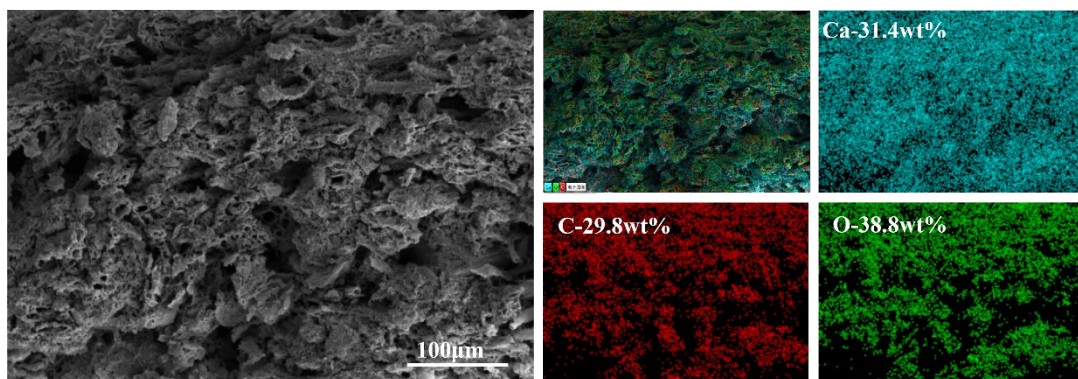


Figure S13 SEM images and EDS mappings of the top surface from LBBM dried at 60 °C with 50 percentage of WS content after burning.

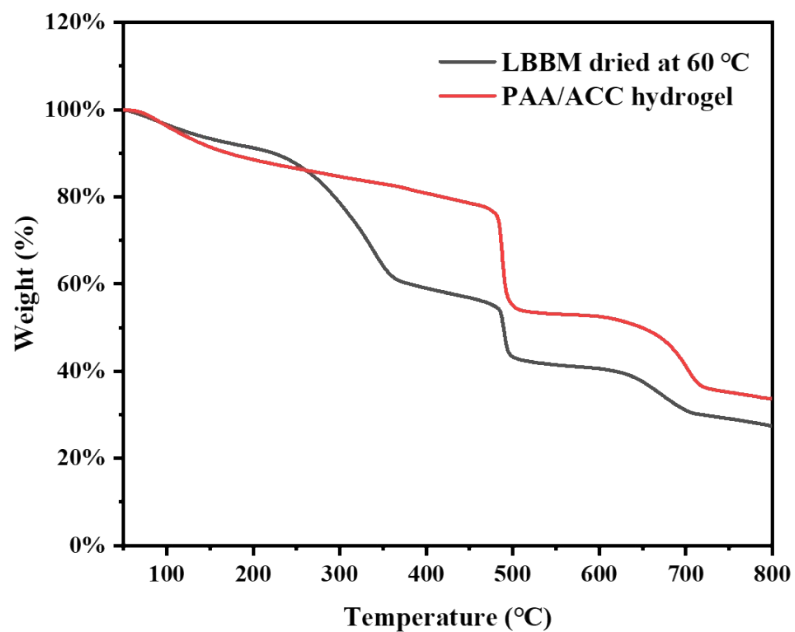


Figure S14 The thermogravimetric analysis of PAA/ACC hydrogel and LBBM dried at 60 °C with 50 wt% WS content.

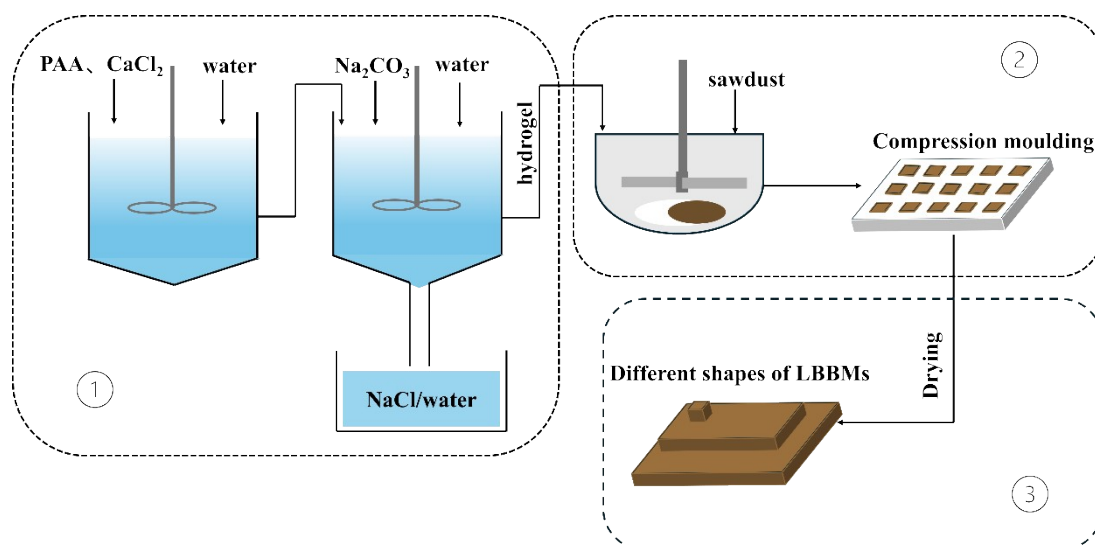


Figure S15 The chart of the LBBMs production.

Table S1 Multiplication results of the signs of each cross-peak in 2DCOS synchronous and asynchronous spectra of LBBM (Figure 2I).

2957	–	–	–	–	
3200	+	–	–		
3274	+	+			
3300	+				
3420					
	3420	3300	3274	3200	2957

According to Noda's rule, the final specific order for LBBM during heating is given as follows: 2957 → 3420 → 3300 → 3200 → 3274 cm⁻¹ (→ means prior to or earlier than), i.e. vs(CH₂) → v(OH) (strongly bound water) → v(OH) (moderately bound water).

Table S2 The UL-94 grade and LOI value of LBBM

Samples	UL-94			LOI
	T1	T2	Rating	
33 wt % WS	0s	0s	V-0	35%
50 wt % WS	0s	10s	V-0	33.4%
56 wt % WS	0s	44s	NR	33.1%
60 wt % WS	0s	49s	NR	31.5%

Table S3 Inputs and outputs of the LBBMs production process presented in this work.

Input/Output	Quantity	Unit
Step 1: Preparation of PAA/ACC hydrogels		
Input		
CaCl ₂	22.196	t
Na ₂ CO ₃	21.198	t
PAA	90.075	t
Water	1500.000	t
Energy	4583.700	kwh
Output		
NaCl/Water	1521.379	t
PAA/ACC hydrogels	112.060	t
Step 2: Mixture of saw dust and hydrogels		
Input		
Saw dust	60.000	t
PAA/ACC hydrogels	112.060	t
Energy	143.383	kwh
Output		
Mixture	172.060	t
Step 3: Drying of the mixture		
Input		
Mixture	172.060	t
Output		
LBBMs	116.03	t
Water vapour	56.03	t

(1) Step 1: Preparation of PAA/ACC hydrogels :

The power of the agitator is 22kW, the maximum stirring capacity is 20000 L, the stirring time is 2.778h.

A blender consumes a lot of electricity when working : $22 \times 2.78 = 61.116$ kWh,

The number of mixers required : $1500t \times 1000kg = 1.5 \times 10^6$ kg , 1.5×10^6 kg/1000kg per m³=1500 m³= 1.5×10^6 L, $1.5 \times 10^6 / 20000 = 75$,

Total power consumption : $75 \times 61.116 = 4583.700$ kWh

(2) Step 2: Mixture of saw dust and hydrogels:

The power of the concrete mixer is 11kW, the maximum stirring capacity is 5000 L, the stirring time is 20min.

A concrete mixer consumes a lot of electricity when in operation : $11 \div 3 \approx 3.667$

kWh,

The volume of the mixture of hydrogel and wood chips : Suppose the densities of the mixtures are close $0.88\text{g/cm}^3=0.88\text{kg/L}$, $172060\text{kg}\div 0.88\text{kg/L}\approx 195522.727\text{L}$

Total power consumption : $11\div 3*(195522.7273\text{L}/5000\text{L})\approx 143.383\text{ kWh}$

(3) Step 3: Drying of the mixture: Suppose solar energy is used for drying

Table S4 The benchmark parameter table of functional units for life cycle assessment (LCA):functional properties of the LBBMs and conventional building materials.

Materials	Average density (g/cm ³)	Average compressive strength (MPa)
Cement	2	18
Clay brick	1.6	12
Shale brick	2.2	20
LBBM	1.04	38.3

Table S5 Average environmental impacts of the LBBMs and conventional building materials.

	Cement	Clay brick	Shale brick	LBBM
Global warming impact (kg CO ₂ eq per cm ³ /MPa)	1.03E-04	3.63E-05	2.14E-05	1.47E-05
Mineral resource scarcity (kg Cu eq per cm ³ /MPa)	4.06E-07	1.95E-06	1.08E-07	3.97E-08
Fossil resource scarcity (kg oil eq per cm ³ /MPa)	9.95E-06	7.64E-06	6.76E-06	5.59E-06
Terrestrial acidification (kg SO ₂ eq per cm ³ /MPa)	1.67E-07	6.42E-08	4.27E-08	4.79E-08
Stratospheric ozone depletion (kg CFC 11eq per cm ³ /MPa)	5.48E-12	3.21E-12	5.60E-12	2.82E-12
Ozone formation, Human health (kg NO _x eq per cm ³ /MPa)	2.02E-07	7.76E-08	4.58E-08	3.74E-08
Freshwater eutrophication (kg P eq per cm ³ /MPa)	1.12E-08	4.91E-09	5.41E-09	4.75E-09
Freshwater ecotoxicity (kg 1,4-DCB per cm ³ /MPa)	1.10E-06	7.13E-07	1.62E-06	5.38E-07
Ionizing radiation (kBq Co-60 eq per cm ³ /MPa)	6.44E-07	4.73E-07	9.90E-07	3.85E-07
Fine particulate matter formation (kg PM _{2.5} eq per cm ³ /MPa)	6.83E-08	2.89E-08	2.55E-08	1.97E-08

Note : The influence brought by the moisture required for cement to form lumps was ignored.

