Running shoe material inspired 3D-printed design to protect buildings from impact damage

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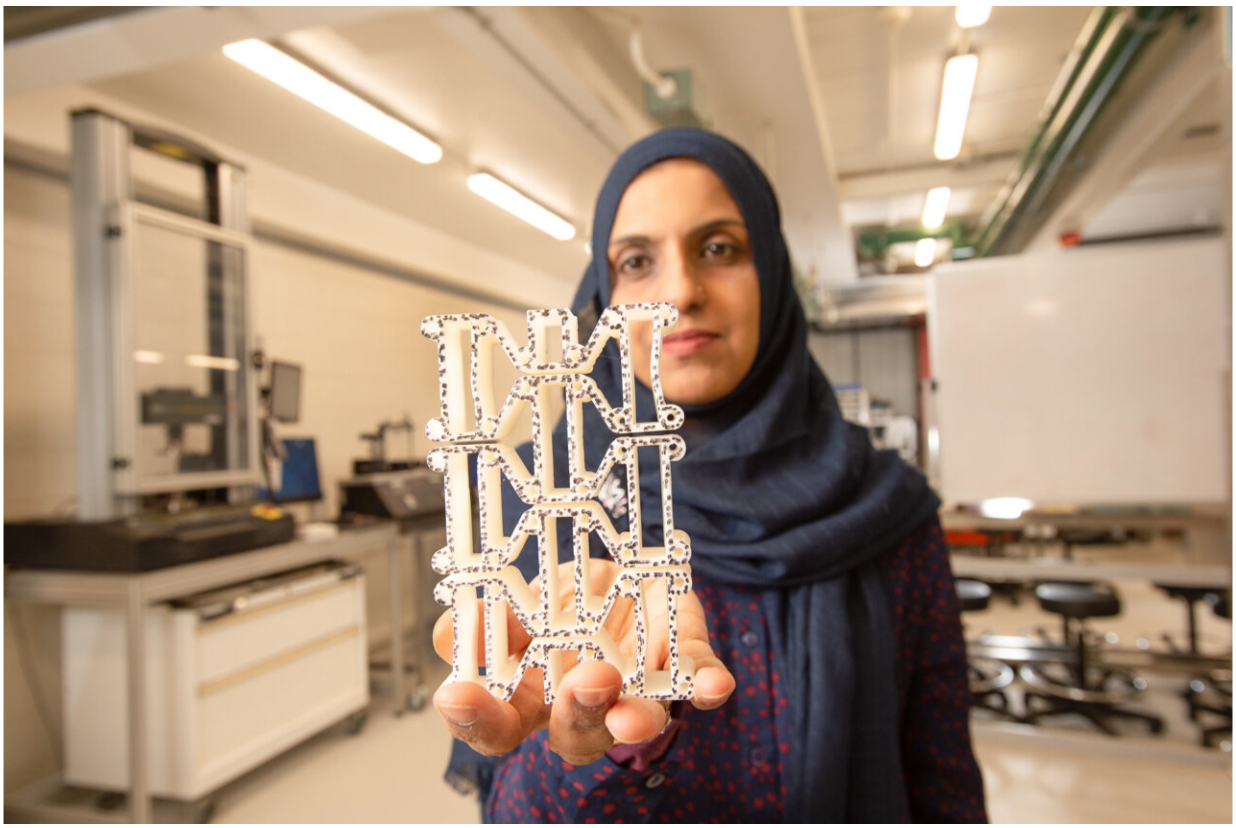

Dr Tatheer Zahra was inspired by a material used in running shoes and memory foam pillows to design a 3D-printed product that could help protect buildings from collision damage and other high impact forces, equivalent to a car traveling at 60km/hr. Credit: QUT

A material used in running shoes and memory foam pillows has inspired the design of a 3-D-printed product that could help protect buildings from collision damage and other high impact forces, equivalent to a car traveling at 60km/hr.

Published in *Smart Materials and Structures*, Dr. Tatheer Zahra from the QUT Centre for Materials Science and QUT School of Civil and Environmental Engineering used off-the-shelf bioplastic to 3-D print geometric shapes that mimic the behavior of auxetic materials.

"Rather than flattening when stretched or bulging when compressed, auxetic materials expand or contract in all directions at once, which makes them highly energy-absorbent and load resistant," Dr. Zahra said.

"But existing commercial auxetic material is expensive and not locally available, so I designed geometric shapes that achieved the same behavior."

Dr. Zahra said 3-D printing auxetic geometries could potentially replace steel and fiber reinforced polymer mesh reinforcements in composites, and could also be used as a flexible and widely applicable protective wall render.

She said the energy absorption would be equivalent to a 20mm thick reinforced composite protective render over a full-scale building wall, which could potentially withstand the impact force of a car traveling at 60km/hr.

"At scale, composites embedded with these geometries could theoretically resist high impact or shock energy caused by gas explosions, earthquakes and wind forces, and car collisions."

"In Australia, there's an estimated 2000 vehicular crashes each year.

Direct building damage cost at 2.5 per cent would put the damage bill at about $38.65M/year for housing."

"Since vehicles also crash into apartments, office building, restaurants and convenience stores, this cost of building damage would probably be higher."

"Loss of life would be the highest cost."

Dr. Zahra said protection for masonry walls was especially important because it was an essential part of most commercial and residential buildings.

"Masonry is a very cheap material that is resilient to noise, heat, and has better fire protection properties compared to wood or steel, but its mortar joints weaken the overall structural strength."

Credit: QUT

"If auxetic geometries were embedded into the mortar to make protective composites, they would also be protected from microorganisms and temperatures over 60°C, and should last the design life of the structure," she said.

Proven at lab scale, Dr. Zahra now aims to test the designs on full scale masonry and concrete structures at the QUT Banyo Pilot Plant.

"The designs would be good prospects for commercialisation through additive manufacturing because the production process is flexible and materials are readily available," Dr. Zahra said.

"3-D printing would also allow us to change the material, size or design of geometric shapes to suit different structures and load requirements."

Dr. Zahra said bioplastics provided a more sustainable, low carbon emission alternative to fiber-reinforced plastic or other non-biodegradable polymers.

She said it was also more cost effective than using available auxetic fabrics, which could cost up to $400 per square meter and were not biodegradable.

More information: Tatheer Zahra, Behaviour of 3D Printed Re-entrant Chiral Auxetic (RCA) Geometries under In-Plane and Out-of-Plane Loadings, *Smart Materials and Structures* (2021). [DOI: 10.1088/1361-665X/ac2811](DOI: 10.1088/1361-665X/ac2811)

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