A new type of blast-proof curtain that gets thicker, not thinner, when stretched is being developed to provide better protection from the effects of bomb explosions. The EPSRC-funded project is being led by Professor Ken Evans at the University of Exeter in collaboration with spin-out company Auxetix Ltd and three other partners.

The new curtain is designed to remain intact and capture debris such as flying glass when windows are blown in. Debris of this kind can cause severe, sometimes life-threatening injuries to people working or living in buildings within a blast zone.

**BLAST-PROOF PROTECTION**

The curtain is primarily designed to be fixed over the inside of windows in buildings that are potential terrorist targets, such as government and high-profile commercial properties. Potential uses could also include protecting building occupants from the effects of severe weather events such as typhoons and hurricanes.

“The blast curtain we’re working on... will be capable of dispersing the shock from an explosion extremely effectively...”

Professor Ken Evans

Blast curtains currently in use essentially consist of thick net-curtain fabric and work in conjunction with an anti-shatter film applied to the window to prevent fragments of glass from tearing the material. The new curtain aims to remove the need for anti-shatter films by using stronger, more resilient fibres woven into a carefully controlled textile structure.

The secret lies in the yarn the curtain is made from. A stretchy fibre provides the core of the yarn and a stiffer fibre is then wound around it. When the stiffer fibre is put under strain, it straightens. This causes the stretchy fibre to bulge out sideways, effectively increasing the yarn’s diameter. Scientifically speaking, the yarn is an ‘auxetic’ material – one that gets thicker when stretched.

**AN AUXETIC YARN**

The research team has identified a whole range of widely available, tough fibres that can be used in the yarn. Producing the yarn and turning it into a textile are also completely conventional processes. Auxetic materials can also be found in nature, e.g. cat skin and bone from the human shin.

The extent of the auxetic effect is determined by the precise angle at which the second fibre is wound around the first fibre, and also by the two fibres’ relative stiffness and diameters. Altering these parameters enables the yarn’s performance to be fine-tuned for specific applications (e.g. to withstand different levels of blast). The project team have focused considerable effort in this area.
Another key feature of the new curtain is that, when stretched, small pores open up in it. Although too tiny for flying debris to penetrate, these pores are designed to let through some of an explosion’s shock wave. This reduces the force the curtain is subjected to and so helps ensure it doesn’t rip.

At just 1-2mm thick, the new type of curtain can also be designed to let in a reasonable amount of natural light. It is currently being tested in situations similar to car bomb explosions.

"In the 1995 Oklahoma City bombing, glass accounted for nearly two thirds of all eye and head injuries,” says Professor Evans. “The blast curtain we’re working on, which will be capable of dispersing the shock from an explosion extremely effectively, will be backed up by robust scientific understanding vital to ensuring it really can block flying debris and achieve widespread use.”

**FURTHER DEVELOPMENT**

The fabric could also be used in other areas such as:

- The manufacture of smart, self-healing auxetic bandages. Wounds that swell would put the bandage under tension opening up pores that are impregnated with an antibiotic which would then be released.
- Dental floss that expands when you pull it, to fill in gaps to make cleaning more effective for teeth.
- Civil engineering for the reinforcement of soils and for storm and flood mitigation.

Testing at a government-approved facility has already commenced. Following rigorous certification procedures, the new curtain could be on the market within three to five years.

Project partners include the Centre for the Protection of National Infrastructure, the Home Office Scientific Development Branch and Monofil Trading Company.

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**90%**

of bomb blast injuries are caused by flying shards of glass.

**250**

The number of nearby buildings with shattered glass resulting from the Oklahoma City bombing in April 1995.

*Good yarn – to give the curtain its remarkable properties, a stiffer fibre is wound around a stretchy core fibre.*

*...GLASS ACCOUNTED FOR NEARLY TWO THIRDS OF ALL EYE AND HEAD INJURIES.*

Professor Ken Evans