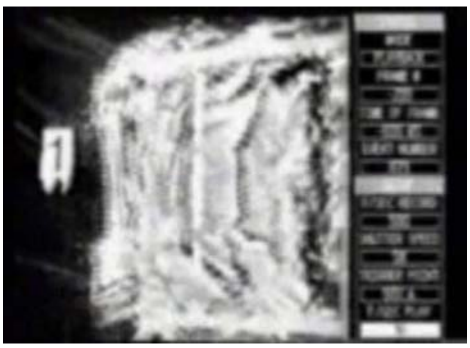
# Blast Mitigation In Public Areas.

A Paper Supporting a presentation originally given at **ExW4** at the Royal Gunpowder Mills, Waltham Abbey, May 2004 Author: Steve Holland of SJH Projects.
An abbreviated paper was presented at **UKELG**, 21st Sept 2005 at HSL, Buxton

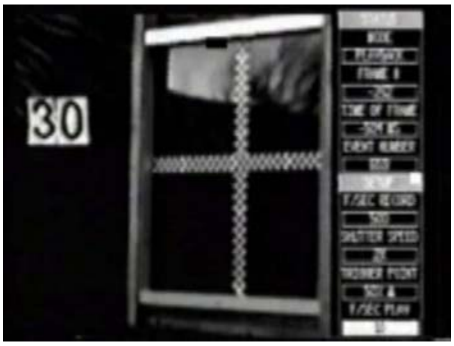
**Overview:**
To look at a range of technologies that can assist in minimizing the effects of blast in public spaces. This will include glazing, walls, doors, building layout, barriers and litterbins.
The conflict for designers of equipment and technologies for this role is to provide an adequate level of protection without creating a sense of living in a bunker or having people think that their routine or lifestyle is compromised. Indeed a significant effect on the public's ability to go about their business is a good result for the terrorist.

**Glazing:**
Prior to preparing my presentation for ExW4 I had a general awareness of window films and the way in which they work. It was only a few months previously as a passing comment during a conversation that someone mentioned to me that the typical way of installing such film was to stop it a few millimetres short of the frame. A quick and easy way to install it and I am sure that the customers were left with a warm fuzzy feeling that they were now safe. With a background in advanced fibre reinforced composites I appreciated straight away that unless such a system was anchored into the frame to create a continuous load path, the job was only half done and an opportunity missed. Of course fitting window film such that it is anchored is more expensive and until the customers are made properly aware of the dramatic difference in performance the suppliers of such systems will have a tough job on their hands.


*Plain Glass Shattering during blast tests. It has been shown to be a major cause of injury and damage.*



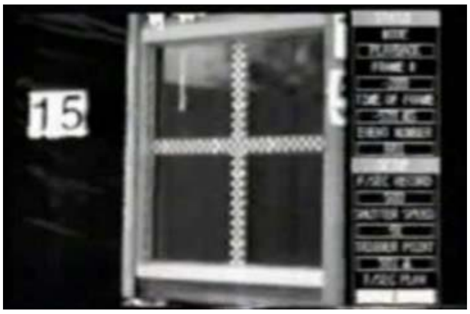

**************

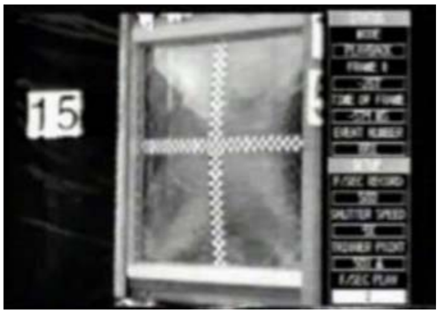




*Unanchored film – being hit by this will ruin your day as it has only partially achieved the objective.*

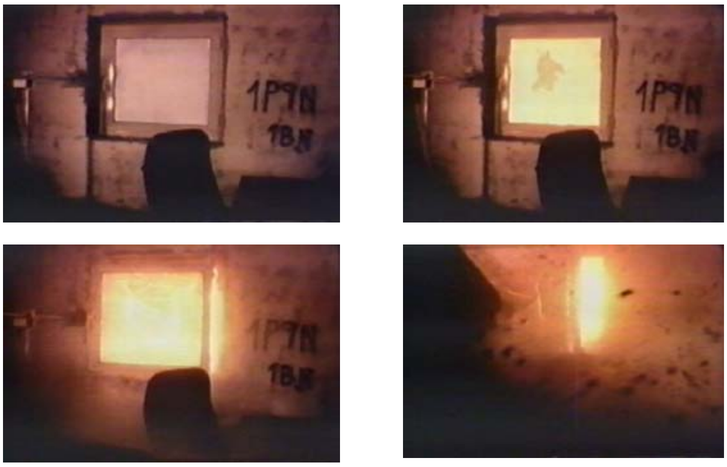

*************




*Anchored film over the same timeframe. It will cost more to install but could well pay for itself in terms of damage to property and not being sued over ‘duty of care’ by employees.*


Armoured or toughened glass has been around for many years both to protect against blast, ballistics and physical attack. Such glass is invariably manufactured from interleaved layers of glass and plastic. It usually comes in a suitably heavy weight frame. As with the window film the anchoring of such frames into the surrounding wall is crucial - a flying armour glass window is best avoided.

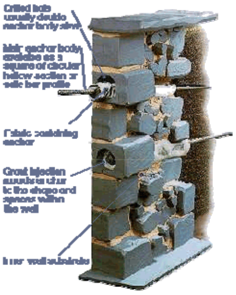


*An armoured glass window and frame that did not have sufficient anchoring to the wall.*

Sometimes used alone and more sensibly with a protective film are ‘bomb curtains’. Made from very high tensile strength fibres such as Spectra/Dyneema, they look like normal net curtains, if a little long, thick and functional. Should glass fragments be projected at the curtains they catch them and then ‘role with the punch’ and use their mass to absorb the momentum and leave a pile of glass under what was previously the window.
Windows are an obvious weak point when assessing a building for protection against the effects of blast. Having 'solved' this problem you cannot just walk away. What you next need to consider is, what is the next weakest point of the structure that you have now exposed as the failure mechanism for the building. Also by preserving the windows and not allowing the blast wave to be disrupted and dissipated by entering the building, you maintained a large sail area that may then act to knock the building over wholesale.

**Walls:**
With stunning logic there is only three locations available for the protection of walls, the outside, middle and inside. The choice depends not only on performance and cost but on appearance and the disruption caused during installation. There are buildings in London occupied by a foreign government that the tenants wished to upgrade in terms of blast protection. The most logical thing to do was to apply an outer facing and use the structural support of the wall to best advantage. The actual owner of the building was quite adamant that the façade could not be altered in the proposed way. One could have thought that protecting the building was in the interest of both parties but other factors can be deemed to be equal importance. The building in question has now been fitted with one of range of internal systems, it created more chaos during fitting but in the end both parties where satisfied.

External fitting: There is a range of systems available some of which link into the wall to reinforce it. Others act to absorb and attenuate energy so that the wall behind experiences less damage. This is of greater benefit to masonry walls rather concrete as they are more susceptible to the blast shockwave and a local weakness can lead to catastrophic failure.



Within the wall: The principal exponents of these techniques are CINTEC. The system was originally developed for invisibly reinforcing the masonry of historic buildings and structures. Metal bars and fixings are threaded throughout the walls where they are needed most. This internal bracing has obvious benefits in resisting blast.

Internal: The use of high tensile strength fibres in a gypsum type matrix is well established. One of the key players in this area is Achidatex of Israel. Once in place the system is invisible. Like window framing this type of system works best when the fibre net is anchored into the surrounding structure.

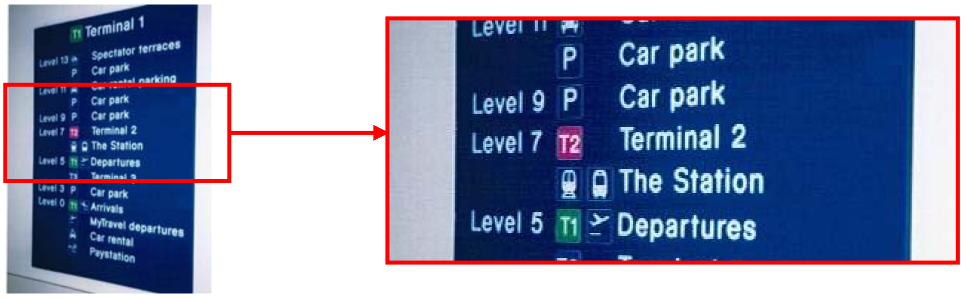
**Doors:**
There is a wide range of security doors on the market that perform well against physical attack and a range of ballistic threats. These attacks share a common characteristic in that they apply more or less a point loading. With a blast the whole face and frame is loaded very rapidly. A high velocity bullet may be about 850$ms^{-1}$ whereas a blast shockwave is often in thousands of metres per second and impacts on all of the door's exposed face at once. As with windows, the anchoring is all-important. In assisting various companies with trials, many is the time I have seen an apparently undamaged door panel fly backwards from the frame because the fixings have bent or sheared.

*Explosive trial using the BS EN 13124-2 Specification for testing Windows Doors and Shutters*.

As previously high lighted doors, and especially windows, are often the weak link protecting a building or structure against blast. By upgrading and strengthening them you may have achieved your objective, however it is just as likely that what you will do is expose the next weakest link such as poor quality masonry. Also by not letting the blast front to dissipate through the door and window apertures the whole building front will act as sail and could lead to much more damage to the structure and its integrity as a whole. Doors for specialist blast applications, in areas from which the public are prohibited, have the advantage of being able to open outward – that is in the event of a blast from the exterior the door is supported by the frame. An outward opening door in a public building or house would be unusual and not what people expect to encounter. Therefore much effort is going on to develop low cost blast doors that do not look unusual and open inward – indeed the user may not even be aware of its extra capabilities.

**Building Layout:**
Unless they are of the highest profile, and particularly, high security or an intrinsically hazardous processing or storage facility, it will have been rare for buildings to be built with threat of blast in mind. Below are some photos taken at a UK airport. They serve to show some of the opportunities afforded to someone with antisocial tendencies and a bag of high explosives. By no means are they intended as criticism, as these buildings were put up at a time when such issues were far down the architects list, today that same architect might take a different view.


Large glass frontage with cars able to park within a few feet. Even with the rigorous Police presence employed at an airport it would be easy for a Vehicle Borne IED to be used, especially as a suicide bomb. The lower elevation was similarly glazed with added benefit to the bomber of greater confinement, reflection surfaces and all the things you don't want to have to protect against.




Car parks above and below the main public areas or Arrivals and Departures. Apart from the potential death toll this would also destroy the main interface of the airport handling system with the public and a lot of valuable equipment. Many new multistorey car parks are now built remote from the termianal specifically to counter this threat.

Airports and other large public spaces benefit from being light and airy. The airport has to sell itself against its competitors so not feeling like a bunker is a commercial pressure. This amount of glass coming down as a result of a blast would provide a significant secondary threat on top of the blast itself. There is a lot that glass designers can do to help with this and as we have seen above, films can be useful when properly deployed. As glass in this situation does not have to prevent a forced entry it can designed more with safe failure in mind – that is not breaking into large shards.

On my travels one of the best examples of 'designing for the terrorist' that I have seen is shown here. Unfortunately by having the building straddling a busy road it has been designed to give the terrorist every opportunity. At times where there is a perception of a high threat, extra personnel and equipment are on hand - but someone targeting this building would not necessarily attack it then.

**Barriers:**
There are times when the threat is perceived to be at a level that a bit of impedance for the public is deemed to be a price worth paying and depending upon the location may be a necessity. Amongst the choices available there are benefits and drawbacks. Some examples are shown below with some associated comments.

Concrete blocks. Cheap, simple and robust, such blocks were put out around Westminster Square as a first line of defence when the current increased threat level first emerged. They do help as a physical barrier against forced entry by vehicle but given a large enough device, would act as rather large secondary projectiles. Would work better if anchored to the ground and to each other. They are also good in a multi-hit environment for both blast and ballistic threats.

Less architecturally appealing is the system now found throughout the Balkans and Iraq. In the class of 'why didn't I think of that?' is Hesco Bastion and its newer derivatives. In the simplest terms it is the sandbag meeting the industrial age and not before time for all of us who have had to do it the hard way. A concertina framework is pulled from the rear of a vehicle and plant machinery fills the pockets with sand, mud or whatever suitable is to hand. I have seen this system in close proximity to a Polish artillery shell initiation, and it performed very well and most importantly, despite some local damage, was ready to go again. Shown above is the system showing both sizes of pocket used to protect an ISO container serving as a temporary building. The is more substance than style but in the 'public' areas in hotspots around the world it is finding a valid place.

The final system to be considered under this heading is the newest. This is a system developed and marketed by MRP systems. In essence they are a series of large plastic containers designed to stack and lock together to produce larger structures. These plastic containers can easily be filled with water and for those with a bit more time on their hands could also be filled with sand. The benefits of water for blast mitigation are well proven. As well as the momentum transfer dictated by sheer mass of water, there is the work done in converting water to steam, quenching of fireball and drag on fragmentation. The problems with deploying water have been largely practical – creating a tall enough structure and one that is not too prone too damage. The MRP system address both of these issues well and by transporting empty and filling on site the lifting equipment becomes much more simple to arrange. Despite these benefits and water based system will be a shot affair. This means that its best use is in protecting against an accidental event rather than being deployed in a conflict zone. By changing the filling to sand a multi-shot capability is gained and with something that looks more suited to a public space than Hesco Bastion although the comparative thickness gives the edge to Hesco in straight performance terms.

**Litter Bins:**

The problem of the effect of devices placed in litterbins came to the for in the IRA Warrington bomb. The secondary fragmentation of the litter and the body of the bin itself were seen to be a real problem. As a consequence a range of products hit the market and the Police Scientific and Development Branch of the Home Office (PSDB) responded with a test specification to allow apples to be compared with apples. Since this initial flush development has been steady. The basis of most of the designs is to have a cylinder with high hoop strength to direct the blast upwards. Additional blast mitigation materials can be placed inside and/or above the cylinder to improve performance (for a cost penalty). The key to getting approval is to minimise the affects of the blast without having the bin fail in a way that contributes to the effects. This is where I will as a rule favour a fibre reinforced composite body over a metal one because sooner or later someone will use a device larger than has been designed for. The composite cylinder will not look pretty but not pose a significant hazard. A metal one of overloaded will act as a very large grenade.

*Testing a blast resistant litterbin. The strawboard fragmentation witness screen can be seen behind the bin.*

*A GRP bin (left) before and after testing with the standard fragmentation pack and a stainless steel bodied bin close to failure after testing*.

Conclusions: There are many things that can be done to improve the blast protection in public spaces. Some look prettier and less obtrusive than others. Some work better than others. They all however require the powers that be to admit to the problem and for money to be spent. Niether of these come easily to politicians – especially while the horse is standing quietly in its stable.

*Steve Holland acts a consultant on range of advanced material applications and previously designed and tested a number of blast mitigation products that are in service with military, governments and civil private industry worldwide.*

Contact: Steve Holland, Tel: +44 115 8497329
Email: Steve@sjhprojects.com, Web: www.sjhprojects.com