Indoor Range Backstop Design

Introduction

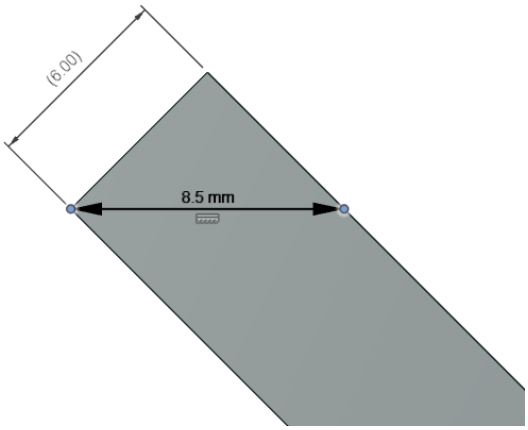
Unlike outdoor shooting ranges which typically benefit from a soft stop-butt and substantial distance between the shooter and the target area, indoor ranges rely heavily on meticulously designed backstops to catch all the projectiles fired and reduce the risk of ricochet and backsplash. In addition to the ballistic challenges, backstop design must take several environmental factors into account, such as noise pollution and airborne contaminants like lead. Outdoor ranges in the UK usually cater for shooting targets starting at 50 metres and sometimes extending out beyond 1000 metres, depending on the geography of the area and the club's safety certificate and insurance. Most indoor ranges are limited to 25 metres or 25 yards. This is adequate for a range of NSRA competitions, where short-range targets can be at 6 yards, 10 metres, 15 yards, 20 yards, 25 yards or 25 metres. My research indicates that rimfire ammunition against a hard target can project debris (backsplash) up to 22 metres away from the point of impact, which is why ranges shorter than 25 yards are very rarely encountered.

Existing Facilities

Indoor civilian ranges are generally designed and rated for use with relatively low-power rimfire rifles, the .22" Long Rifle (LR) being the most common by far. This is true of ######## Club who shoot for general practice and NSRA competitions solely with .22LR and air rifle. As we found out during our visit of the club's facilities, the current backstop is a simple arrangement of 6mm steel plates angled at 45° [Fig. 1]. The angle of the plates serves two purposes. Firstly, it means that the projectile has more material to travel through if it were to penetrate the metal. In this case, a projectile impacting 6mm of steel at 45° would have to pass through 8.5mm of material [Fig. 2]. This should not happen, as pure-lead projectiles are usually destroyed on impact with hard steel, but it is a benefit nonetheless and will help prevent spalling in the event of a very hard impact. Secondly, the angled plate directs ricochets and debris (fragments of the projectile) downwards rather than up into the ceiling or back towards the shooter which can occur if a projectile connects with a hard barrier perpendicularly. Research indicates that unless the debris is captured by the bullet trap or an anti-splash curtain, angled plate should be placed over a tray of soft media like sand or woodchip to decelerate and catch the material coming off the barrier at potentially high velocity.

[Fig. 1]

[Fig. 2]



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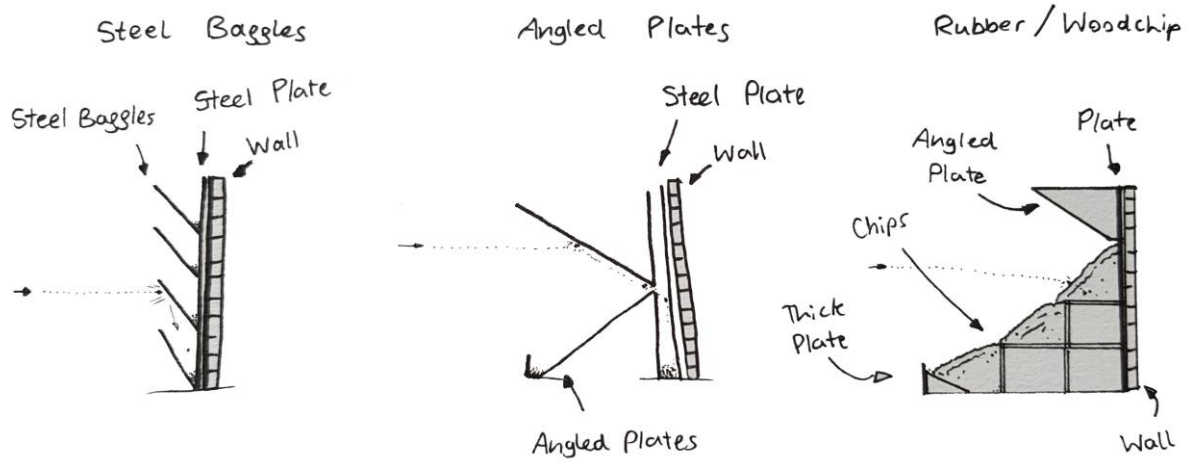
The current arrangement is more than adequate for safely stopping .22 LR, which with typical 'high-velocity' ammunition generates less than 200J of energy at the muzzle from a rifle. In my opinion the greatest disadvantage of the current backstop is that it only covers a small section of the back wall. This means that shooting can only be conducted from a specific and static position, in this case from prone. Shooting from a different position could put projectiles in an unprotected area which cannot be allowed. Since the club wants to allow for more NSRA disciplines to be to shot, the backstop will have to cover more of the back wall. For reference, the MOD has published the following measurements for typical target heights, from floor to centre of target: Standing 1500mm, Kneeling 800mm and Prone 300mm.

I have also taken into consideration the possibility that the club might like to cater to disciplines in the future that would require the use of different firearms. An example could be muzzle-loading pistol (competitions regulated by the Muzzle Loaders Association of Great Britain) or gallery rifle (governed by the National Rifle Association). Both disciplines are well suited to a 25-yard indoor range but will require a more heavily reinforced backstop since the energy produced by the firearms typically used in these disciplines exceed that of the venerable .22 rimfire. For instance, .38 Special, a traditional revolver cartridge commonly used in gallery rifles can produce up to 400J of energy at the muzzle and does so with a considerably heavier projectile than a .22 rimfire. Many muzzle-loading revolvers are loaded to mirror .38 Special ballistics which is known for being soft-shooting and accurate.

Initial Design Ideas

There are several ways to build an effective indoor shooting range backstop. Regardless of the type of bullet catcher or baffles used, there should be a backplate to cover the areas of the back wall that could be struck by a poorly aimed shot. Based on MOD range specifications, mild steel that meets BS EN 10025: S275JR is suitable for ranges where low velocity ammunition will be used (MV under 2145ft/sec). A 6mm mild steel backplate is suitable for rimfire and centrefire pistol/carbine shooting lead bullets (relevant for gallery rifle and/or muzzle loading pistol). As for the actual bullet-catcher or baffles (the area that is designed to take most shots), 6mm is suitable for rimfire, and 8mm is the minimum requirement for centrefire pistol/carbine or muzzle loading pistol (no jacketed bullets). In order to potentially repurpose the current 6mm plates, I believe that a double layer of 6mm might be the best solution. This would future-proof the club, allowing them to shoot a whole range of different disciplines in the future without having to further reinforce the backstop. 12mm plate would even be suitable for jacketed projectiles which are advantageous as they reduce lead contamination.

The next consideration is the configuration of the backstop. There are various ways of stacking and angling plates, and some solutions use a soft media bullet-catcher such as sand or granulated rubber. Below I have illustrated just a few of the many possible configurations for an indoor range backstop.



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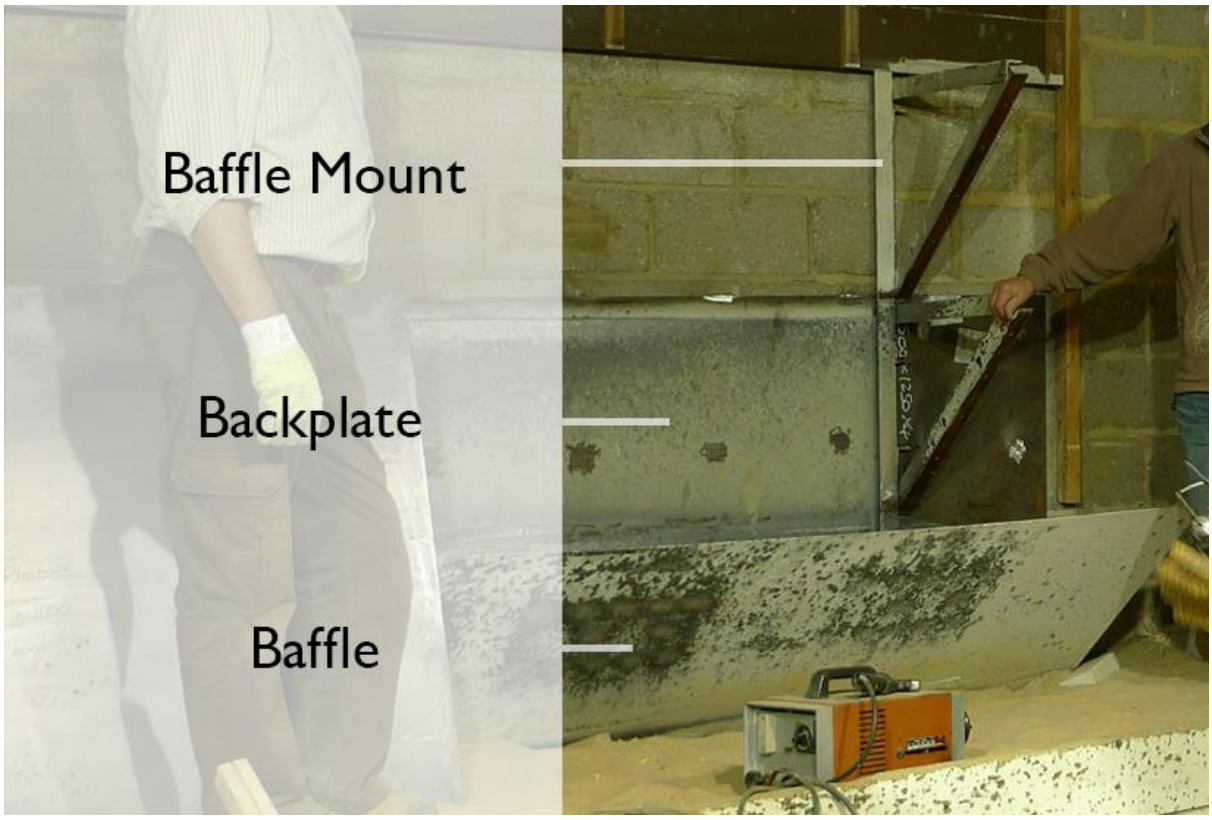
Research Visit

As part of my investigation I visited Parkstone Gun Club in Poole, where the facilities had been given a large upgrade in 2010 which included an improved baffle system and new benches/lane dividers. Originally, PGC was predominantly a pistol and rimfire rifle club. After the handgun ban in 1997 many shooters moved to gallery rifle shooting, part of the attraction being they could make use of their handgun ammunition and reloading gear which would otherwise be useless. More people using rifles indoors means more wear on the backstop - the longer barrel of a rifle means cartridges can burn their powder more completely, sometimes producing near double the energy the same cartridge might have from a pistol. The range was upgraded with a series of angled baffles stacked up the back wall. Originally 6mm thick, the current backstop uses three tiers of doubled-up 6mm mild steel, welded and staggered to reduce weak spots. The range is rated for muzzle energies up to 645J and muzzle velocities of 1750 fps, making it suitable for rimfire, muzzle-loading pistol and gallery rifle. Only lead projectiles can be used which reduces attrition on the plates and means that the lead deposits under the baffles don't have to be separated from copper when collected for recycling. A strength of this system is that it is somewhat modular; you can replace individual baffles if they wear out. Using a three-tiered design protects a substantial area without using unusually large plates. Shooting can be conducted from a range of positions and provided the target is placed in an appropriate position on the target retrieval system, all shots should hit one of the three baffles.

Below is an image of the 2010 upgrade in progress, courtesy of Parkstone Gun Club. Notice the angled framework which the three tiers of steel baffles will be fixed to, and the tray of sand underneath to decelerate and capture debris. I was not able to obtain specific details of the build, but the structure consists of 6mm mild steel backing plate, 50x50mm L-Section steel bar for the baffle mounts, a series of welded and staggered 6mm baffles (to make 12mm overall) and additional 6mm plates to protect the rest of the back wall, such as on the floor to contain the sand and protect from a low shot. The highest baffle is painted red to indicate it should not be shot at as the area above is not reinforced - if it is in your line-of-sight, your target should be moved lower.



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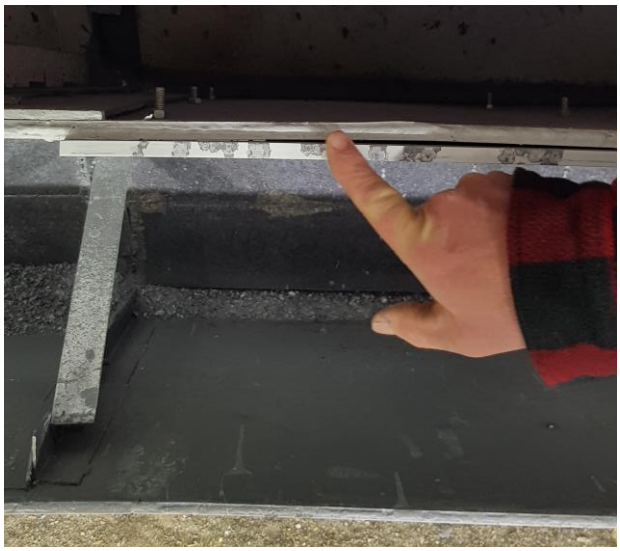
Below are a series of images that I took during my visit to the club in October 2020. The Club Armourer Bruce explained that one of the plates has taken a battering from somebody using ammunition that was too powerful, so it had been reinforced further with another 6mm plate, something that the modular design makes rather easy. Bruce was very helpful and said that he would be happy to discuss details with the client and even arrange a visit to the club if desired.



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Design Proposal

Based on my research and my visit to PGC, my recommendation is that a multi-tiered baffle system is built onto the back wall at ######### Club. I believe such a system will allow for a range of new disciplines to be shot and future-proof the club. From the measurements taken on-site, the back wall measures approximately 5 metres across and is split between 4 shooting lanes. The protected area measures approximately 2.25 metres from the ground up. I would recommend a tray of soft media underneath the baffles to catch debris that will be deflected off the steel plates at high speed. As with most of the build, 6mm mild steel is suitable and is another area where the plates currently in use could be repurposed. Below is a 3D model of what the tray might look like.

I have designed a set of brackets to be attached directly to the back wall (if structurally viable; I'm not an architect) via expansion bolts/anchors. These brackets are made from 50x50mm square steel tubing (4mm thick) cut to various lengths and welded onto flat 50x10x2250 metal bar. Three angled tube sections will be fixed to the bar to make a single baffle support, there will be 4 of these assemblies which will hold the baffles in place with bolts. The plates are 2000x1000mm S275JR mild steel. As these are simply bolted onto the brackets, the club has the choice of mixing plate thicknesses, such as selecting 6mm for the upper baffles as they should not be shot at regularly and using 12mm for the lower baffles that will take 99% of the shots. Detailed drawings of these components will be created once the client signs off on the concept. For now, I have created the following visuals to illustrate my design. These models were created in Fusion 360 and show various elevations of the backstop. Highlights include:

- Sand debris trap
- Three angles baffle sections, any plate thickness can be used but 12mm recommended
- 1 metre wide shooting area for each lane, with protection the full width of wall
- Full protection from the ground up to 2.25mm high
- Space behind each baffle section to allow debris to drop to the bottom

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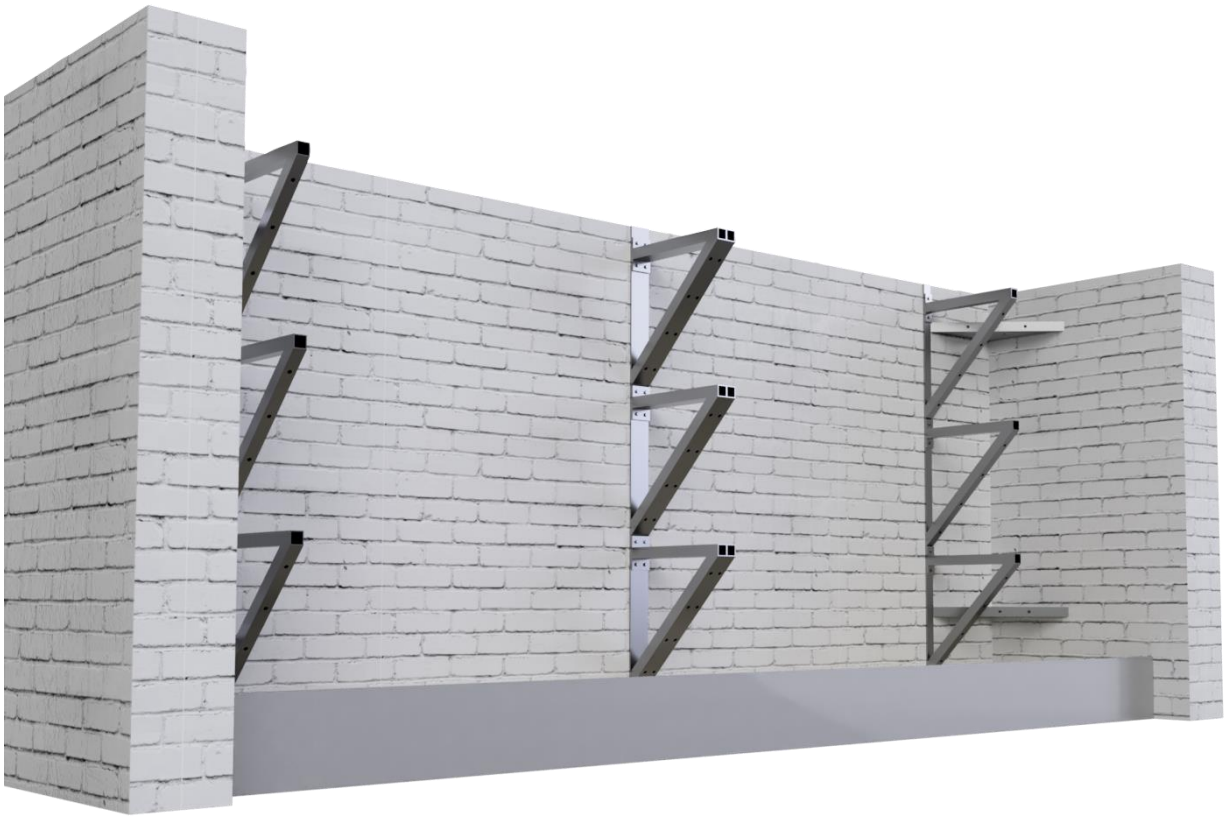

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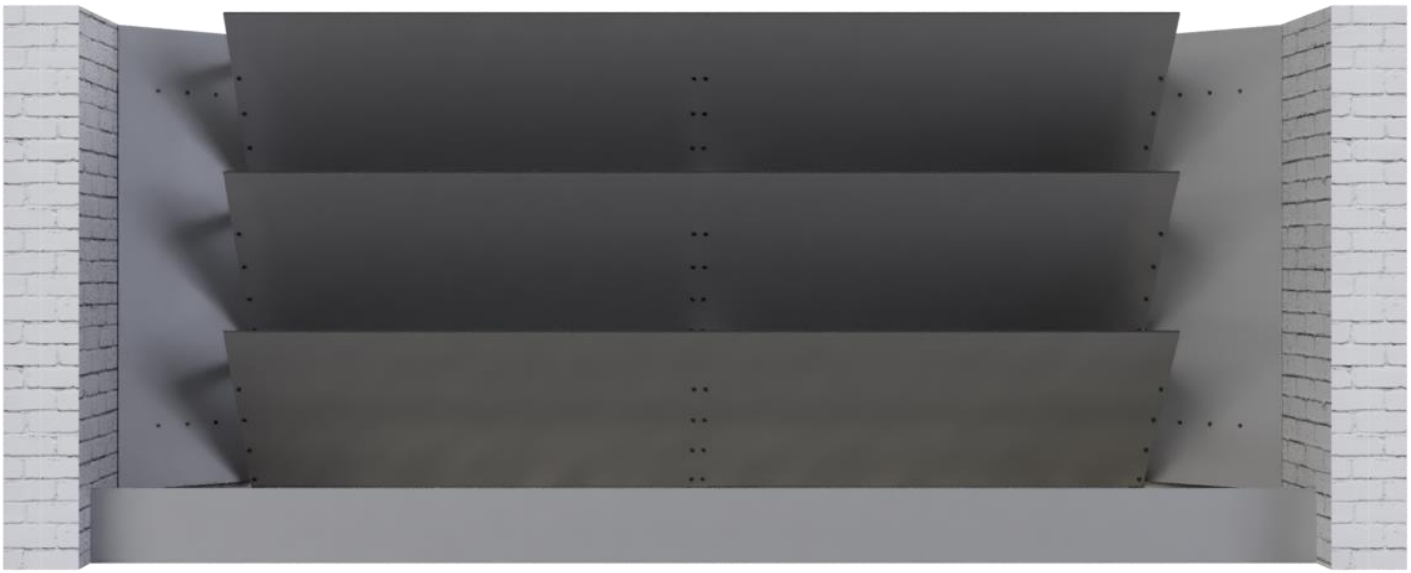

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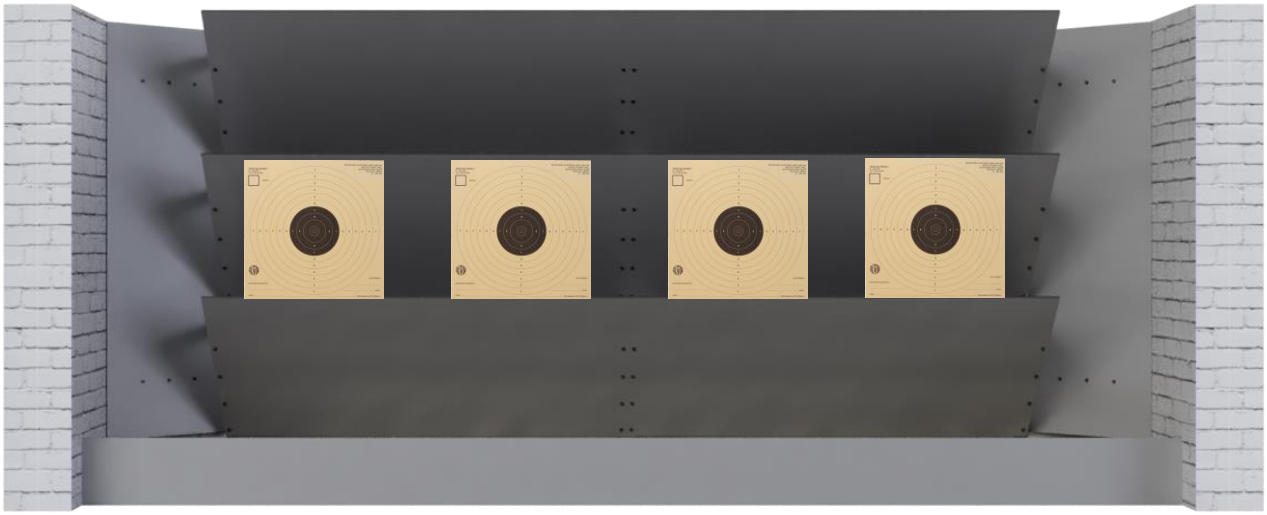
Components

6x 2000x1000mm S275JR steel plate, 6mm or 12mm (6mm for rimfire only)
2x 700x2000x6mm S275JR steel plate for side protection
2x 1900x2000x6mm S275JR steel plate for backplate
2x 2500x300x6mm S275J steel plate for front of tray, 5000x1000mm steel of any grade for tray bottom
~23 Metres of 50x50mm steel square tube, 4mm wall, cut to various lengths between 500 and 800mm
48 M12 hex countersunk bolts & nuts
4x 50x10x2250 metal bar

Additional Considerations

1) All holes in the steel plates for mounting to the brackets must be countersunk so the bolt head is flush with the plate. This will reduce the risk of ricochet if the mounting bolts are struck directly, although this is unlikely given their locations. Most shots should hit in between the mounting areas as illustrated below.



2) The above images brings up the issue of how targets will be mounted, since the current method of slotting them in directly over the shooting window (in front of the angled plate) will no longer be possible. I believe there are two solutions which I will detail in a separate report. To summarise though, one solution would be to fix mounts to the front plate of the sand tray to accept a fixed target stand. This would be the most cost-effective solution as it would utilise simple wooden construction. Each mounting frame would need to be around 1.5m tall so targets could be placed in positions from prone through to standing. The alternative, and one that I think the club should consider given the substantial budget of this project, would be a motorised target retrieval system. Such a system is safer and faster to set and inspect than any manually placed target, not having to clear the range before changing a target is a huge advantage and less time spent near the back wall also means less exposure to contaminants like lead.
3) To prevent damage to the structure of the building, adding protection to the beams was mentioned during our visit. Based on the range regulations I have access to, hard protection like steel plate produces debris and ricochet risk 22m back towards the shooter. For this reason, I can only recommend that the beams furthest away from the shooter (22m+) have any hard protection.