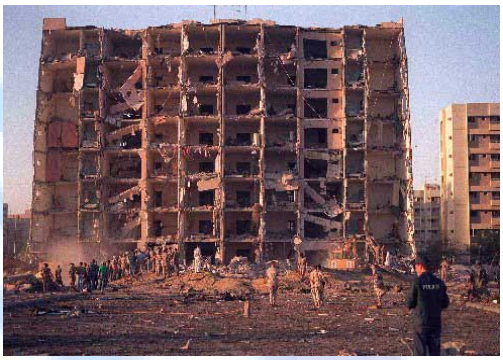
Architectural Precast Concrete Security Barriers: Securing the Perimeter

This white paper examines architectural precast concrete products and their use in creating effective security barriers. This installment highlights a historical perspective of architectural precast concrete barriers and sheds light on many of the questions and decisions that must be considered when choosing a product that balances security, life cycle costs and aesthetics.

Introduction



Khobar Towers – June 25, 1996
Courtesy US Air Force News

Terrorist bombings like those at the Murrah Federal Building in Oklahoma City, OK (1995), Khobar Towers in Dhahran, Saudi Arabia (1996) and the US Embassy in Nairobi, Kenya (1998) highlight the need for effective facility security design. The majority of injuries and/or deaths in bombing events occur from flying glass and/or progressive collapse of the structure. As such, tremendous effort is expended to better understand those architectural measures necessary to incorporate security design features into both new and retrofit construction environments. Architectural terms and security phrases such as "setback or standoff distance," (herein referred to as setback distance) “blast resistance”, “glass hazard mitigation” and “perimeter barrier systems” became commonplace as security and design practitioners began to sensitize us to the architectural considerations necessary to limit damage from car and truck bombs. Architectural precast concrete security barriers have become one method of achieving ‘Setback Distance’. So why do we need ‘Setback Distance’?

In very simple terms, most of the damage that results during a bombing incident is caused by the air-blast shockwave that is created during the explosion. The amount of damage to the building is in direct proportion to the amount of pressure and its duration. Design and security professionals use three approaches to limit these factors and subsequent damage. First, they establish as much distance as possible between the threat (bomb) and the asset (building, occupants, etc.). This concept is known as the ‘Setback Distance’. The farther away we can keep the threat, the less impact the air-blast shockwave will have on the asset: hence the need for and use of architectural precast barriers as *one* means of accomplishing this goal. Second, they ‘harden’ the building by incorporating security technologies that are specifically designed to resist the effects of the threat (e.g. doors, windows, glass, wall systems, etc.). Both approaches are necessary and work hand-in-hand. The third and last approach is a combination of the first two. A detailed analysis is conducted based on the size of the bomb and its location. Depending on the results of the analysis, the security and design practitioners will try to maximize the standoff distance, but may also need to harden the facility near the potential blast location since the ideal standoff distance may not be achievable. [Our apologies to our colleagues in the blast engineering field for oversimplifying a very complex topic]

A Little History

Following the events of 9/11, “Jersey Barriers” (coined for their use as traffic median safety barriers in New Jersey - introduced in 1955) became the concrete barrier of choice due to their ready availability and low cost. These barriers were deployed as *temporary* physical security barrier systems to define ‘Setback Distance’ and reduce the attractiveness of a building as a potential terrorist target. However, much like the term ‘Xerox’ became synonymous with copiers, ‘Jersey Barriers’ became synonymous with concrete barrier systems.

These concrete barriers were used at federal buildings, gate entrances, parking areas, flight lines, commercial building entrances, mess halls, piers, barracks, munitions areas, and virtually any location which was seen as a potential terrorist target. These barrier systems retained their concrete gray color and standard "basement floor" finish. Due to the immediate nature of the ‘need’ and the fact that ‘Jersey Barriers’ were considered only "temporary" solutions, aesthetics were generally not considered. Unfortunately, the original intent of a ‘*temporary barrier*’ often took on a sense of permanency and many cities are dotted with concrete barriers that challenge our sense of balanced security design and an ‘open society’.

So Why Use Concrete?

Concrete has been used for decades in a variety of barrier applications. Its inherent characteristics exhibit a number of application and production advantages that compliment barrier system design: readily available, low maintenance, weight/mass, portability, design/shape flexibility and relative low cost.

Precast concrete barriers require little to no maintenance compared to other construction materials. Due to the inherent properties of concrete, there are limited issues with corrosion and degradation. With a typical density of 3500 to 3700 pounds per cubic yard, concrete barriers can be very heavy while being moderately sized. This trait often allows for “freestanding installation” (not anchored) making the barriers portable. This allows barriers to be quickly repositioned to meet changing security requirements. Simple physics demonstrate that if you place sufficient mass between the threat (moving vehicle) and the asset (target) you can create a viable barrier system.

Another primary advantage is affordability. When comparing factors that determine the viability of a variety of barrier types (material availability, required maintenance, ability to stop or slow down an attack vehicle, speed of deployment), concrete barriers often represent a cost effective alternative. As such, concrete barriers have often become a ‘first’ choice when selecting a barrier system for fortifying potentially targeted sites, directing traffic flow, and increasing setback distances. They serve to deter potential attackers and, should an attack be attempted, they can prevent vehicular intrusion when designed accordingly.

Balancing Form and Function

The architectural community recognizes the value of precast concrete as one possible element in an effective, balanced perimeter barrier system. However, they also expect aesthetics to be a component of the solution. This has led the industry to develop new products and designs that meet not only the security barrier requirement but also the need for architecturally friendly products that compliment the landscape design and match the architectural and historical elements of the site. Precast concrete barrier suppliers have evolved their manufacturing and design processes and developed new suites of products that satisfy these objectives.

Architects, engineers, owners and security practitioners recognize the benefits of these specialized architectural precast concrete products and incorporate them as part of a permanent, yet flexible, security solution.

Advantages of Architectural Precast Concrete Barriers

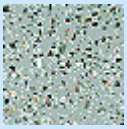
Modern architectural precast concrete products are produced using computer designed molds. This capability allows the architect to work hand-in-hand with the manufacturer to design products that satisfy the aesthetic requirements of the site. This also means that the security and architectural communities have an almost limitless assortment of modern and traditional styles to choose from.

In short, the wide assortment of available shapes, colors and textures, concrete products may be designed to compliment virtually any landscape, architectural theme and historical requirement. For instance, the wide variety of integral colors (dyes added to the concrete during the mixing process and evenly distributed throughout the cement), aggregates (small stones or pebbles incorporated in the concrete mix), and textured finishes insure the barrier system be matched to virtually any existing building finish. The use of integral color in the mixing process also ensures many years of exposure to the elements without the need for any treatments, staining, or paint.

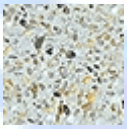
Manufacturers use several methods to modify the visual appearance of the final product. Following the selection of dye color and aggregates (size, color, density) the manufacturer will use one of several methods to finalize the aesthetic objective including sandblasting and chemical treatments. This provides end users and architects a high degree of flexibility. Examples include:

Smooth (SK)

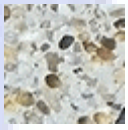
Light Sandblast (LSB)



Medium Sandblast (MSB)



Heavy Sandblast (HSB)



Exposed Aggregate (EX)

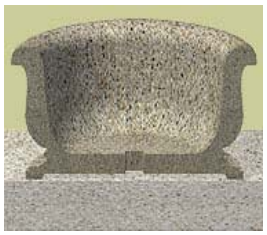
Some security applications still do not require an architecturally friendly product and allow suppliers to pour the concrete on the jobsite to save freight costs. There are, however, a number of drawbacks to the use of onsite batch plants. These include a limited ability to insure uniformity of finish and achieving target psi strengths with fluctuating environmental conditions. Factory produced architectural precast concrete products, however, afford more architecturally friendly designs and a much higher level of quality control of the finished product. Concrete filled molds can be closely monitored and regularly vibrated to ensure that air bubbles are removed and that the end result is both structurally sound and aesthetically pleasing. This aesthetic flexibility, combined with the fact that most structures and landscapes already use concrete in some fashion (walls, columns, sidewalks, foundations, curbs), makes architectural precast concrete barriers a virtually universal addition when properly selected and incorporated into a balanced security design.

Common Product Configurations

The new demand for aesthetically pleasing architectural precast concrete barriers has resulted in a variety of product types. These products can be supplied in a wide range of shapes, styles, and sizes. These are typically grouped into four main categories:

1. **Planters** – are available in round, square, rectangular or custom configurations. They can be filled with plants such as annuals, shrubs or trees to increase their landscape appeal. Planters are constructed either as traditional (deep planting well) or as monolithic (concrete filled to just below Traditional

   Planter Monolithic Planter the top rim) for added mass and security.

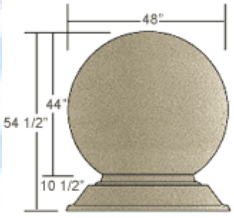

Traditional Planter


Monolithic Planter

2. **Bollards** – are typically installed over heavy walled steel pipes for maximum security. Bollards are available in a wide variety of configurations, colors and finishes to match the site. They are also available with numerous accessories including lighting packages, chain connections and insignias.

3. **Architectural Walls** – are available in a number of configurations. These may be spaced apart or linked together to form an uninterrupted line of security. They are available in either straight or angled pieces to create engineered systems with a high degree of design flexibility. Walls can be configured to introduce other security enhancements including crash cabling systems.

4. **Custom Configurations** (examples: Spheres & Statuary) – The design flexibility of architectural precast concrete allows the supplier and architect to introduce a high degree of creative latitude. As such, a number of products can be created that introduce unique shapes and figures that blend the barrier system into the landscape. These can resemble animals or common forms such as spheres and other art objects.



Product Selection Considerations

Each product category has certain advantages that are suited to specific security applications. While sizes, color, and finish are driven by design preference, there are other product considerations that are driven by security and site requirements. To this end, the end user should ask him/herself a series of questions.

What is the Acceptable Level of Security?

Although this question may appear straightforward, it is not. One of the more common misperceptions is that all concrete barrier systems have been tested and certified to meet certain impact ratings. This is not true. In fact, most of the architectural precast concrete barrier systems deployed have not been tested. While concrete barriers or Jersey Barriers are used in roadway and highway applications, these barriers are tested and certified to meet a specified 'safety' level according to the National Cooperative Highway Research Program Report 350. This testing is mandatory to check safety compliance versus security

capability. The distinction between 'safety' and 'security' is a critical distinction that security practitioners should be aware of. Most concrete barriers whether they are Jersey barriers or architectural precast barriers rely on the physics of mass and inertia to effectively slow down the threat vehicle. There are three approaches to applying architectural concrete barriers in a security application:

1. Leverage Inherent Benefits of Concrete Barrier: Although the system may not have been tested, the mass of the system will provide a level of protection against vehicle penetration by virtue of its weight and size. The presence of the security barrier creates a visible deterrent that will also provide a measure of protection, look nice at an affordable price and reduce the attractiveness of the facility as a target. In this case there is an understanding that we're 'keeping the honest people honest and affording a physical barrier that will cause significant damage to a threat vehicle.

2. Perform Engineering Analysis: Independent engineering assessments can be performed that provide metrics to the resistance of based on the weight, mass and anchoring of the barrier selected in contrast to the weight, speed, and angle of impact of a vehicular threat. There are several very competent US-based engineering firms that specialize in performing assessments of this nature on perimeter barrier systems.

3. Use a Certified Barrier System: Very few systems have actually been tested. However, the US Department of State (DOS) has tested certain concrete barrier systems that can be constructed on site. Some security practitioners will also incorporate bollard systems that have tested to the US Department of State criteria into their recommendations. For instance, they may specify planters or walls that incorporate a 'block-out' to receive a tested steel bollard.

Who Are My Stakeholders?

The introduction of security barriers typically impacts a number of stakeholders (architects, engineers, first responders (e.g. fire/rescue), facility managers, local code authorities, historic preservation, legal representation, etc.). It is always wise to communicate with these other constituents before implementing the new barrier system. In doing so, the design can be adapted to satisfy as many parties as possible. The decision to consult with affected parties can save both time and costs in the long run.

For instance, International Fire Code (IFC) Section 503 addresses *Fire Apparatus Access Roads*. In this case anything that prevents the unrestricted movement of a Fire Apparatus (e.g. fire truck) from the fire station to a facility, building or portion thereof is often through a fire lane, public street, private street, parking lot lane or access road is often prohibited. Here again, there are design considerations that must balance 'safety' and 'security'.

Is This a Temporary Barrier Application?

While permanent barrier systems typically involve considerable engineering, planning and construction, temporary barrier systems are often treated more casually. With temporary barrier systems there are 3 items to remember.

1. Portability – Architectural concrete barriers can be designed with forklift slots or lifting rings that allow them to be moved from point to point. The weight of the barrier selected, though, may limit its portability. The term *temporary* carries with it two connotations. First, the barrier will be placed in a single location and removed once a permanent solution is installed. Second, the barrier will be available for rapid deployments as security levels rise. Understanding which case prevails is important. This latter designation drives two other considerations.

2. Repair – If the architectural concrete barrier is going to be moved from time to time, it is more prone to damage. Concrete chips and breaks (spall). We have all seen the unsightly chipped corners that tarnish the appearance of the product. Suppliers can introduce a number of design enhancements that reduce the likelihood of damage including the use of 5000 psi concrete. Additionally, it is recommended that integral colors be required. This minimizes the visual impact of a break when it occurs. Finally, suppliers routinely supply patch kits that can restore unsightly cracks.

3. Equipment considerations – If the barrier will be moved from time to time, confirm that your equipment is rated to the weight of the barrier. All too often the barriers arrive only to find out that either the forklift cannot accommodate the weight or there is insufficient manpower to repeatedly move the barriers. Also, confirm the width of the forks on the equipment to insure the forklift holes are appropriately sized and located.

What Are My Other Design Considerations?

There are a number of other design considerations that will drive product selection. Some of these considerations include, but are not limited to the following:

Geographic Coverage What is the overall linear distance that must be protected? Consider first the linear coverage provided by each type of barrier. Compare this with product cost. For instance, walls typically cost 2 to 3 times that of a bollard but a typical wall barrier system can be provided with up to 16 linear feet of protection. Bollards with standard spacing only offer 4 feet of protection. Once a product type is selected, the Physical Security Professional (PSP) employed by your suppliers can provide a CAD footprint showing the proposed system as an overlay on the area being protected. This, in turn, will drive the budgeting process among alternatives before final selection and purchase.

Some systems are engineered to the configuration and topography of the site. For instance, architectural concrete walls can be supplied with a variety of angle components (e.g. 45 degree, 90 degree, etc.) that allow the system to turn corners. In these instances it is helpful to engage other stakeholders to insure the final product satisfies the engineering intent.

Ingress/Egress Pedestrian ingress/egress is another consideration. If employees/visitors will be crossing the line of an established perimeter barrier system, bollards, planters, and spheres may represent better options. Typically, architectural walls may be more appropriate for areas where there is to be little or no pedestrian traffic. However, these walls can be used to funnel pedestrian flow to cross walks or preferred building entrances. Additionally, ADA considerations should also be taken into account. Finally, look at the operational needs of the site as it relates to lawn care and required access by site vehicles. Your perimeter barriers will impede traffic and designated ingress/egress points should be defined prior to installation.

Landscape Considerations How will the new barriers impact your existing landscaping? If the desired perimeter encloses existing flower beds or other landscape features, bollards could be the desired product since walls, spheres, and planters may partially or totally impede view of your landscape architecture features. On the other hand, a combination of perimeter protection and landscape feature can be designed and installed that would soften the security appearance and follow the architectural intent along with the principles set forth in Crime Prevention Through Environmental Design (CPTED.

Grading Due to their design, wall barriers and planters tend to highlight unleveled/uneven surfaces when installed in a freestanding configuration. As such, the existing grade should be taken into account. Many end users request concrete leveling pads be installed prior to the final offload and set.

Environmental Considerations Some users must comply with current 'Green Procurement Guidelines'. For instance, the US Department of Defense, as mandated under its Defense Acquisition and Procurement Policy, introduced its Green guidelines that REQUIRE purchasing entities to acquire green products and services that involve building construction, renovation and maintenance (including landscape), and traffic control. As such, it is important to know whether the architectural precast concrete products are produced, in part, from environmentally friendly products including recycled pot ash.

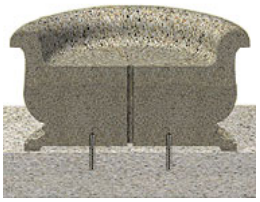
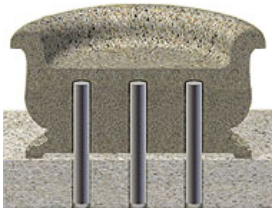
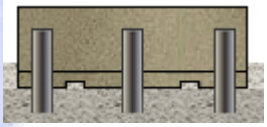
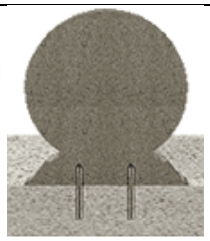
What Installation Methods Are Available?

Products can be installed in a variety of ways. The more common method is to place the barrier directly onto the ground or a leveling pad without anchorage. This is known as 'freestanding'. With this method, the freestanding barrier will rely strictly on the weight/mass and inertia of the system selected to slow down the vehicle.

There are also a variety of anchoring methods that increase the capabilities of the system. These include:

Available Installation Methods

	Installation Method	Description of Installation	Rating	Illustration
Bollards	**Surface Mount**	All-thread is inserted into bollard. Holes are then drilled into existing concrete and the bollard is installed using construction epoxy.	Installation not tested	
	Subterranean Mount	All thread is inserted into bollard. Bollard is then set in place and concrete is poured to around it.	Installation not tested	
	Anti-Ram Mount	Steel pipe bollard is installed per user specification. Bollard is then sleeved over for decorative appearance.	Installation Rated if using a certified bollard system (e.g. US Department of State K-rated installation method)	

Planters	**Surface Mount**	All-thread is inserted into planter. Holes are then drilled into existing concrete and planter is installed using construction epoxy.	Installation not tested	
	Anti-Ram Mount	Steel pipe bollard(s) is installed per user specification. Planter is then set over bollard(s).	Installation Rated if using a certified bollard system (e.g. US Department of State K-rated installation method)	
Architectural Walls	**Surface Mount**	All-thread is inserted into wall. Holes are then drilled into existing concrete and wall is installed using construction epoxy.	Installation not tested	
	Anti-Ram Mount	Steel pipe bollard(s) is installed per user specification. Wall is then set over bollard(s).	Installation Rated if using a certified bollard system (e.g. US Department of State K-rated installation method)	
Custom Configurations (example: Spheres)	**Surface Mount**	All-thread is inserted into sphere. Holes are then drilled into existing concrete and sphere is installed using construction epoxy.	Installation not tested	
	Anti-Ram Mount	Steel pipe bollard(s) is installed per user specification. Sphere is then set over bollard(s).	Installation Rated if using a certified bollard system (e.g. US Department of State K-rated installation method)	

What is My Life Cycle Cost of Ownership?

When selecting the appropriate architectural precast concrete barrier system the life cycle cost of the product is often overlooked. This, however, should be an initial consideration. Security barriers are often purchased with limited funds that are earmarked for 'immediate use'. In these cases, the immediate tendency is to see how much coverage can be accomplished with the money available. Recognize there are often hidden costs that are not usually considered when making a product selection. Suppliers can work closely with the end user to insure maximum geographic coverage while balancing life cycle costs. The following table is provided to sensitize end users to some of the cost factors associated with the purchase, installation and maintenance of the product.

Some Considerations when Calculating the Life Cycle Costs of an Architectural Precast Barrier

	COMPONENTS OF COST						
PRODUCT TYPE	**Product Cost (+)**	**Freight Costs (+)**	**Installation Costs (Offload and Set) (+)**	**Construction Costs (+)**	**Other Related Costs (+)**	**Long Term Maintenance Costs (+)**	**Life Cycle Cost (=)**
Bollards	**Yes**	**Yes**	**Yes**	**Yes**	**Depends on Configuration**	**Minimal**	**$xx.xx**
Planters	**Yes**	**Yes**	**Yes**	**Depends on Installation Method**	**Yes**	**Yes**	**$xx.xx**
Walls	**Yes**	**Yes**	**Yes**	**Depends on Installation Method**	**No**	**Minimal**	**$xx.xx**
Custom Configurations (example: Spheres)	**Yes**	**Yes**	**Yes**	**Depends on Installation Method**	**Depends on Configuration**	**Depends on Configuration**	**$xx.xx**

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Examples of life cycle costs for each product type may include:

Bollards: Bollards typically represent the highest upfront costs in that they are typically installed using conventional construction methods. As such all common construction costs should be considered including, but not limited to, engineering costs, bollard pipes, underground encumbrances, concrete/rebar, utility relocation, sod/seed, and more. Once installed, the bollard system has very low maintenance costs.

Planters: The installation method will drive the overall costs. If the planter is set as a freestanding unit the construction costs are reduced unless a concrete leveling pad is required. If the planter is installed as an anti-ram mount then all related construction costs will apply. Planters also infer the

use of plantings (annuals, shrubs, trees). These represent an initial upfront cost as well a recurring maintenance costs (watering, replacement, pest/disease control, weeding, trash collection, etc.).

Walls: A key advantage of architectural walls is their lower life cycle costs as well as their ability to span greater distances also at lower costs. The installation method will drive the overall costs. If the wall is set as a freestanding unit the construction costs are reduced unless a concrete leveling pad is required. If the wall is installed as an anti-ram mount then all related construction costs will apply. Once installed, the wall system has a very low maintenance cost.

Custom Configurations (e.g. Spheres): The installation method will drive the overall costs. If the custom configuration is set as a freestanding unit the construction costs are reduced unless a concrete leveling pad is required. If the custom configuration is installed as an anti-ram mount then all related construction costs will apply. Once installed, the maintenance costs will vary depending on the function of the system.

Conclusion

Architectural precast concrete barriers represent one component of an effective perimeter barrier solution that establishes setback distance for a building. Effective communication between suppliers, end users and the design community will insure the products selected balance security, safety, costs and aesthetics.

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