OKLAHOMA CITY FEDERAL BUILDING

OKLAHOMA CITY, OKLAHOMA

On April 19, 1995, a truck filled with explosives planted by a domestic terrorist exploded outside the Alfred P. Murrah Federal Building in Oklahoma, tearing upward through the 10-story building and destroying one of its structural columns. The building was sliced in half: its front section collapsed layer on layer, and shattered glass covered entire sections of the city. A shattered structure was all that remained of the Federal Building, which had housed 15 federal agencies, several Department of Defense services, and a day care center. 168 people died and more than 700 were injured in the blast.

In 1997, the U.S. General Services Administration (GSA) embarked upon a design for a replacement complex just a few blocks away from the original site.[1] At the same time, a separate process was underway to create a memorial honoring the victims and survivors of the bombing through an international design competition. Designing a new building in the wake of the tragedy posed a series of unusual challenges to everyone involved in the process. Understandably, much of the initial discussion focused on how to make the new building secure. This included debate about how to balance a welcoming appearance with tough security measures, and practical concerns of how to design the building for new types of threats, in an absence of adequate security standards. The project team also needed to be sensitive in working with the tenants throughout the process, since many survivors of the Murrah Building attack would be working in the new facility. In addition to these core issues, the project team pursued sustainable design measures, and chose to form a contract directly with the lead designer in order to have more control over the end result.

[1] Blair Kamin, "Chicago Firm to Design Replacement for Bombed Federal Building," *Architectural Record*, April 1997, p. 37.

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CONTEXT

Oklahoma City

Even before the Murrah bombing, much of downtown Oklahoma City had suffered the effects of an urban and economic decline following a mid-1980s economic crisis.[2] Then-mayor Ron Norick had asked voters to approve a one-cent sales tax increase that would pay for nine major Metropolitan Area Projects (MAPS). In 1993 the MAPS Committee – an alliance of city and county officials and business leaders – created a master plan that focused on upgrading the city's cultural and recreational facilities. The April 1995 bombing dramatically impacted the already suffering downtown area. 39 square blocks of the North Downtown district suffered damage and a 12-block area was left completely vacant. According to former Oklahoma City planning director Garner Stoll, more than 300 buildings, 25 of which were listed on the National Register of Historic Places, were affected by the blast. After the bombing, Oklahoma City planning officials attempted to treat the situation as a planning opportunity to augment the existing downtown master plan.[3]

On July 24-25, 1995, just two months after the bombing, a charette was held in Oklahoma City to design a long-range plan to rebuild North Downtown.[4] Sponsored by the Design Arts Program of the National Endowment for the Arts (NEA), the workshop addressed not only the bombsite but also efforts to promote investment in the surrounding neighborhood by stressing preservation and reuse of existing buildings. Over the next five years, the city's improving economy created tax revenues of more than $350 million, with approximately $140 million in private-sector investment. Federal and private money was also secured for a national memorial and museum. After the city helped assemble the land, the state appropriated $5 million for the memorial and Congress provided an additional $5 million to establish it as a park service unit to be run in partnership with a private trust. The memorial was designed by Butzer Design Partnership, a German firm, selected through an international competition. It was mainly privately managed and financed and was taken over by the National Park Service.

In locating the new federal building in this context, GSA worked with representatives from the city's planning department and several neighborhood groups to focus on aspects of siting and design that might promote area economic development. GSA hoped to spur localized redevelopment by building the new building in an underperforming section of the city. This strategy proved successful when the anticipation of the new federal facility had the visible effect of spurring additional office and commercial square footage within the immediate context. All participants in the project agree that throughout this process, GSA Chief Architect Edward A. Feiner's influence in this aspect of design thinking was instrumental. By

[2] Louis Jacobson, "Many Projects Help Revive Downtown Oklahoma City," *Planning*, March 1999, pp. 22-23.
[3] Frankfurt Short Bruza Associates, "Oklahoma City Master Plan," *Architecture*, June 1995, pp. 36-37.
[4] Heidi Landecker, "Oklahoma City Charrette Addresses Bomb Site and Downtown," *Architecture*, pp. October 1995, pp. 24-25.

setting clear goals and constraints, GSA allowed the design team, in collaboration with the local community, to be creative within the framework of the expectations for the project.

National

The Murrah bombing spurred national discussions on building security and prevention of terrorism. A report released soon after the bombing noted that if the 1976 Murrah Building had been built using some of today's seismic building details, as much as 50-80% of the bombing's structural damage could have been prevented. Instead, the building had an "ordinary moment frame" design, typical of most office buildings not located in earthquake-prone areas. With this design, if one or more critical elements failed, they could cause partial or total collapse. Such a chain reaction caused most of the fatalities that resulted from the Oklahoma City bombing.[5] Consequently, one of GSA's initial requirements was the inclusion of design guidelines that would ensure that the proposed structural reinforcements would prevent the progressive collapse of a building in a worst-case scenario. The Murrah Building had not accounted for the effects of the loss of one structural column or for the uplifting effect of an explosion, both of which are addressed in the reinforced concrete structure of the proposed building to prevent progressive collapse.

The American Society of Civil Engineers added to the developing body of knowledge through a 1996 joint report with the Federal Emergency Management Agency (FEMA) entitled "The Oklahoma Bombing: Improving Building Performance Through Multi-Hazard Mitigation." The report includes specific design recommendations based on methods used to mitigate wind and earthquake damage. By using reinforcing details such as "special moment frames" or "dual moment-resisting and braced systems" that would allow the structure to "hang together" without collapsing, engineers can build in structural redundancy. Then, if some supports were damaged, other supporting mechanisms would still be able to carry most of the load. New buildings would be required to be engineered to withstand severe local damage and remain standing.

In 1998, the U.S. Department of Justice published enhanced security directives in their Vulnerability Assessment of Federal Facilities, and the GSA developed security criteria. To prevent access by potential terrorists, GSA released design standards on a need-to-know basis to engineers working on federal buildings and only after they had entered into security agreements guaranteeing that they would safeguard the proposed design. GSA's criteria addressed building systems and components ranging from improved window glazing to blast-resistant design techniques.

[5] Engineering News-Record 245, no. 2 (July 10, 2000), p. 26.

PROJECT INITIATION

In July 1995, within weeks of the bombing, Congress voted to allocate $40M for a new building to replace the Murrah building. Although this funding was in place much more quickly than normal, the time needed to develop a program for the new building, evaluate the damage that led to the Murrah collapse, and draft new security guidelines led to implementation delays. The architect for the new federal building was selected through GSA's Design Excellence program. Twenty firms responded to a request for qualifications, and five finalists were interviewed. In 1996, GSA selected the Chicago firm of Ross Barney + Jankowski (RBJ), which partnered up with local firm Atkins, Inc. As a result of the larger issues, the design process did not get seriously under way for two years, and it took two years more to approve the design scheme before construction could begin in 2001.

Together with RBJ's associates and the construction team, GSA strove to find design solutions that closely met the program requirements in terms of both aesthetics and budget. Under the leadership of Carol Ross Barney, the first female lead designer of a federal building, the design team approached the project with the philosophy that every project is unique and their job is to address the contextual sensitivities of each unique project site. The design team faced a steep learning curve in trying to work with security guidelines that were just beginning to be formulated. At the same time, both the design team and GSA property development personnel kept in mind Ed Feiner's caution not to get overwhelmed by the security guidelines. He wanted "the design to be not just about this past incident, but also about the new building's purpose and function." "The answer should be holistic," he stressed. "It's a building that will do its job, and part of that job is being secure – but that's not the only part."

From the beginning, the planning and design process emphasized dialogue with the survivors and sensitivity to their thoughts and fears. Consequently, one of the first tasks of the design team was to work on programming in conjunction with GSA, the city, the chamber of comerce and local community advocates, and several interest groups representing not only potential tenants but also survivors from the Murrah Building. In order to collect as much data as possible, both GSA and its technical advisors organized a series of interviews and public hearings. They sent out questionnaires to solicit responses to specific questions, as well as to learn the community's expectations and concerns about the proposed project. The tenant groups were asked numerous questions, such as whether they wanted a new federal building and whether they wanted law enforcement agencies included with the non-law enforcement groups.

As a result of the dialogue, the design team quickly realized that people did not want the new building to memorialize the tragic events of the bombing of the old Murrah Building, but rather to be about a better, safer, dynamic future. One clear point of consensus was that the majority of tenants wanted to house law enforcement agencies separately. However, tenant agencies were divided over whether the new facility

should be a single large building, or a campus of low-rise buildings. Initially, some tenants who had leased space throughout the city after the bombing were content with the idea of remaining scattered in a less urban location, in order to present a less identifiable target for terrorist attacks.

The project team was initially directed to pursue a campus strategy, and pursued a scheme consisting of three buildings, located on each of three city blocks. After developing this 3-building scheme for approximately a year, the decision was made to instead create a single building on a 2-block site. This shift was based on both practical factors and emotional considerations. As the program developed it became clear that the building's 180,00sf program did not justify the 3-block site. Also, problems arose in acquiring the third block when one of the businesses slated for relocation was found to be more lucrative than expected. The cost of relocating that business proved to be prohibitive. Another factor impacting the decision was the attitude shared by GSA and the tenant agencies after the attack. As time went on, many of the Murrah building tenants expressed a desire to be back together with their fellow tenants, in one building. After being scattered throughout the city in temporary accommodations, they wanted the sense of unity and camaraderie of reuniting after the tragedy. In addition, the government wanted to demonstrate that they would not succumb to terrorist threats and would not be forced out of central urban areas.

As a result of these factors, the GSA team insisted on a single, visible centralized building. The agencies felt strongly that the design should not exceed 4 stories. These comments led directly to the design of a single building that rises 3.5 stories created a hard, secure exterior perimeter organized around a more open and inviting core.

PROJECT TEAM

In developing a new federal facility in Oklahoma City after the Murrah Building bombing, the partnership between GSA, Oklahoma City, and the design team of RBJ and their associates had to reconcile two conflicting goals: suggesting and ensuring a safe environment, while giving a sense of invitation and community. RBJ's motto that in working in the public realm a designer has a responsibility not only to the client and its users but also to the community to which the building ultimately belongs fits well with the above goals. Further, it reinforces the development team's shared belief that good architecture and city planning could have a positive effect on how society works.

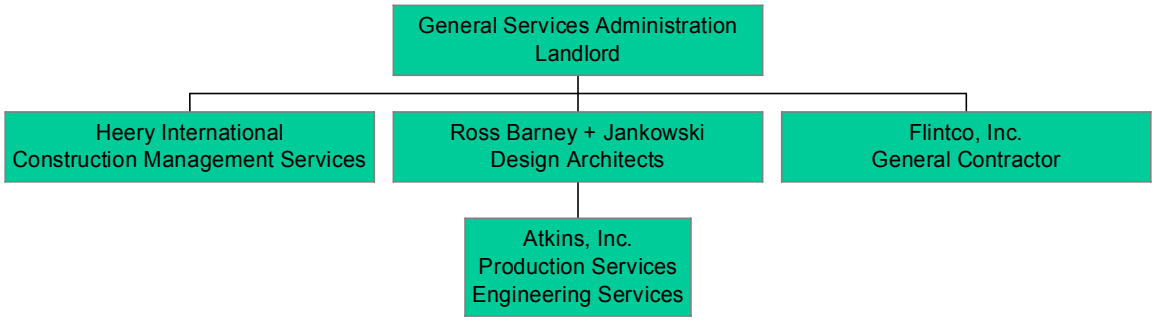
When the design team of RBJ and Atkins was selected in 1996, GSA chose to form the contract directly with RBJ. While GSA has the option to contract with either architecture firm, it is more common to contract with the local firm. In this case, the GSA team felt that by contracting the lead designer as architect of record, it would be easier to ensure the quality of design and would prevent changes based on cost or constructability without the approval of the design lead. According to GSA Project Manager Tim

Thury, this structure worked very well "The lead designer and executive architect worked together as a team. The key elements of the design were retained throughout the process, not changed by the executive architect in the Construction Documents phase."[6]

The original RFP mandated that 65% of the design fee would be spent in the state where the structure was going to be erected. Since RBJ was based in Chicago, the two firms had to divide the scope of work in a way that would meet this requirement and ensure a successful conclusion to the project. As the lead designer and architect of record, RBJ directed the building design and controlled process management while Atkins undertook construction documentation. This phase-based split required strong communication and trust between the two firms. RBJ had to communicate their design intent to Atkins at the end of the design development phase as they transitioned control of drawings produced by RBJ to Atkins. RBJ had worked with the Atkins engineering team from the very beginning of the design process. Later communication with the Atkins architecture and engineering groups was managed through several site visits, weekly conference calls that lasted 2-3 hours, and the exchange of redline sets and 3-D graphic representations.

As a result of this planned transition, RBJ's design development drawings and 3-D models contained many details that might normally be part of the construction documentation phase of a project. "A picture is worth a thousand words and a 3-D model is worth a thousand pictures," noted RBJ designers with regard to the communication of their design intent. For this reason, Atkins established a file transfer protocol (FTP) site, which made the sharing of large animation and CAD files between RBJ and Atkins fast and efficient.

In October 2001, GSA announced that Tulsa-based Flintco Inc. had won the $40,400,000 construction contract to build the new federal campus building.[7] Flintco, the largest Native American-owned contractor in the country, was chosen in a GSA source selection procurement. Heery International of Houston was chosen as construction manager.



[6] Interview with Tim Thury, October 2004.
[7] Engineering News-Record 247, no. 17 (October 22, 2001, p. 7.

The general impression by all the parties involved is that the entire design and construction team has worked very well together. They especially believe that the physical manifestation of this building could not have happened without Flintco's willingness to understand the design intent and work with the designers to achieve it. This is nowhere more evident than in the case of the decision to cast local creek stones into key façade locations around the building perimeter and in reception areas, as a way of grounding the building and relating the structure to its site context and indigenous geological ground formations. This required that the contractor find a way to incorporate these creek stones, seldom used by masons, by casting the structural wall first and devising a method to cast the stones as a veneer.

Due to its complexity, this feature was removed from the bid package with the intention of revisiting it once a contractor was selected. This allowed GSA to avoid a substantial contingency premium, and work out the best way to build this feature in collaboration with the contractor. In this and a very few other instances, the team generally agreed that the process could have been even more seamless had the contractor been involved earlier on in the design process, rather than using the design-bid-build project delivery method.

Murrah Building Tenants	**New Building Tenants**
Returning Tenants:	
General Services Administration	General Services Administration (PBS & FTS)
US Army Recruiting Battalion	US Army Recruiting Battalion
US Department of Veterans Affairs	US Department of Veterans Affairs
Department of Housing and Urban Development	Department of Housing and Urban Development
US Marine Corp Recruiting	US Marine Corp Recruiting
US Department of Agriculture	US Department of Agriculture
Other Tenants:	
Social Security Administration	SSA Office of Hearing and Appeals
US Secret Service	Food and Drug Administration
US Customs	Department of Homeland Security
Department of Alcohol, Tobacco & Firearms	Small Business Administration
Drug Enforcement Administration	Equal Employment Opportunity Commission
US Department of Labor	National Park Service
Federal Highway Administration	Bureau of Indian Affairs
Department of Health and Human Services	
US Postal Service	
Defense Investigative Services	
US Marshals Service	
US General Accounting Office	

TENANT RELATIONS

Six tenant agencies from the Murrah building returned to occupy the new building. The Department of Housing and Urban Development (HUD) lost 35 employees in the bombing, more than any other agency. Discussing the new building with HUD proved especially difficult, and due to their hesitation HUD had not committed to being a tenant at the time construction began. The main office of the Social Security Administration (SSA) lost 16 employees and 24 customers in the bombing. SSA moved to a strip mall in central Oklahoma City, citing as the reason that this location would be more convenient to customers.[8] A comparison of the Murrah building tenants and tenants in the new building illustrates which tenants chose to return.

The project team strove to meet the needs of this long list of tenants, particularly the returning tenants who understandably had additional concerns. At the time construction started, tenant agreements with some agencies had already been made. Tenants would visit the building while under construction, during lunch break. The building was 100% occupied within 8 months, and has remained fully occupied since then.

Aerial view of a digital model showing building massing, employee parking, and open space. Entry to the memorial site and water channel is visible beyond the building.

View looking out from the building's courtyard, toward the elliptical form in the open space.

[8] "New federal building opening near Oklahoma bombing site", October 17, 2003, http://www.cnn.com/2003/US/Southwest/10/17/oklahoma.bombing.ap

DESIGN

The goal for the building's footprint and massing was to protect the tenants while remaining open to the public and the city around it. Its layout and materiality, however, were designed to relate to the local history and culture, in order to locate the building in its specific context. Situated diagonally down the street from the bombed Murrah site, the new building engages the central business district with its formal south-facing massing while opening up to and framing a common green in the form of an ellipse at the center (below), which suggests both closure and protection.

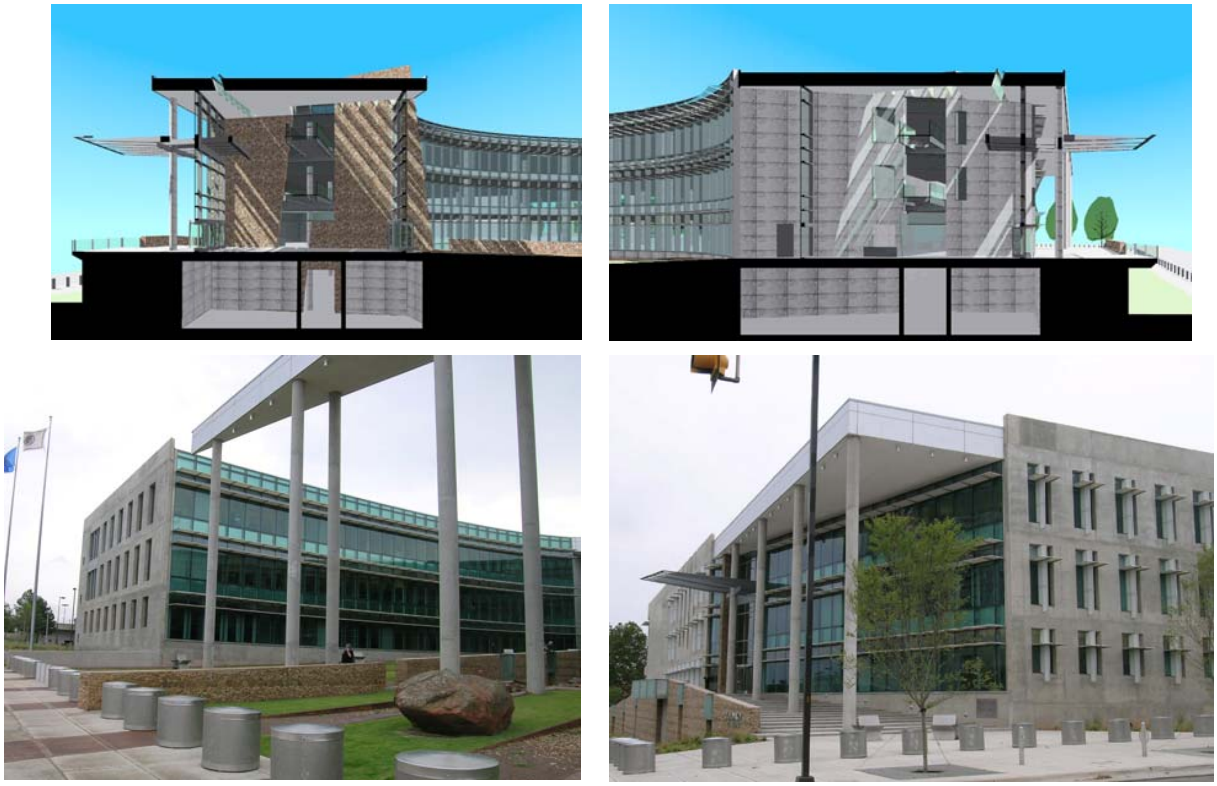
This distinctive feature, somewhat inspired by the Native American stomp grounds that the Five Civilized Tribes built after they were transported to Oklahoma, curves inward for a kind of sacred intimacy.[9] The open space was planned as the site for ceremonies of the Military Entrance Processing Station, one of the building's tenants, and also serves as a park for use by the public. Cutting diagonally through Oklahoma City's tight grid, it marks the juncture between residential and commercial areas, mediating the change in urban fabric from the busy downtown to the south to the residential neighborhood to the north. Its alignment to the publicly accessible atrium connecting the east and west wings of the building forms a gateway to the heart of Oklahoma City's downtown.

The new building uses a striking colonnade to separate this glass-enclosed courtyard from the adjacent street and communicate a sense of openness while maintaining both physical and emotional security. In addition, the roof overhangs, supported by the colonnade to the north and south, are an effort to integrate the building massing with the existing city grid, presenting the street with an uninterrupted edge. Carol Ross Barney has described the process of securing both safety and good design in several published interviews.[10] The firm's team of designers and consultants convened for a two-day charrette at the beginning of the schematic design phase to come up with an initial design response to the program at its proposed site. Nine months later, when GSA submitted the security design guidelines, this process was repeated so that the design team of architects and engineers could exchange ideas on how to best integrate these requirements into the design process for the final product.

The building design is based on the duality between security and openness: the building has both a soft side and a hard side, according to its principal designer. Carol Ross Barney refers to "expanses of the façade that resemble 'solar screens,' a curtain wall whose surface is activated by sunlight and reflections". To frame this softness, a "hard side" of massive exterior walls is composed of cast-in-place concrete, which, combined with thermally efficient windows, will conserve energy. In detailing the exterior

[9] The Native American tribes that settled in Oklahoma City would build their wooden houses on a grid and would use the stomp grounds – established by natural boundaries – as ceremonial spaces for dances, games, and other social events.
[10] Brian Libby, "Standing Strong – Architect Carol Ross Barney Brings Sensitivity and Security to Oklahoma City's New Federal Building," Metropolis, May 2002.

walls, the design team chose the color of the concrete to try to match the subtle reflection of the indigenous red soil in the area. Similarly, it incorporated locally gathered creek stones on key locations of the exterior and interior elevations to highlights such elements as entry and circulation.



Renderings and photos showing the "soft" glass curtain wall and the "hard" masonry wall with punched windows.

The lobby, located a floor above street level on the south side, is open to public circulation and features a processional ramp that descends to the open space on the building's north side. Visitors can enter and cross through the lobby area without passing through security screening. To enable the openness of this key design element, two massive framing walls of blast-resistant concrete were designed to confine damage from any explosion and direct it upward rather than toward the office areas. This defensive design gives rise to the triple-height space, in which two glass bridges cutting across the space break the vertical perspective while maintaining a sense of transparency.

Digital model of the lobby and blast resistant stone walls, and the finished wall.

SECURITY GUIDELINES

The design team for the new Oklahoma City Federal Building took their cues from Ed Feiner, who stressed that the bombing "served notice that public buildings needed to be made less vulnerable without sacrificing accessibility or aesthetic daring." In later a *Los Angeles Times* article[11] Feiner stressed that "Oklahoma City was our baptism of fire; 9/11 was a horrible tragedy, but we had a lot of, let's say, prep work, because we experienced a lot in the Murrah building. The new federal building under construction in Oklahoma City may be used as a template for new civic architecture after 9/11." He added that the new structure would be secure without being fortress-like, stylish without being extravagant. He stressed that the design of new federal buildings should rest on an important bottom line, which should be the crux of architecture's response to the more recent tragedy in New York; that is, "We can't make bad architecture."

The security requirements and performance standards for the proposed building, including actual security design criteria, did not reach the design team until they were nine months into the schematic design process. A number of these security standards were based on evaluation of the Murrah building damage and were intended to safeguard against similar events. The new guidelines affected key design decisions about the building siting, structural framing, and glazing.

Perimeter Setbacks and Parking

The new requirements include a recommended 100 foot building setback to create a safety barrier between the building and potential detonations in parked cars. While Murrah was nine stories high, the tenants insisted that the new building have only three or four stories. Based on further studies, discussions and test data from blasts, it was decided that 50 feet would be adequate in order to maintain

[11] Reed Johnson, "Response to Terror: A Changed America," *Los Angeles Times*, Dec. 21, 2001, p. A1.

a safe perimeter at the south, east and west wings Since this is half the setback recommended by the government, to account for the remaining 50 feet required by the guidelines, parking is only permitted along the far sidewalk, away from the building. GSA also requires that vehicular drop-off lanes be no closer than 20 feet from the building and that there be physical obstructions to maintain this distance. In response to this, the architects incorporated bollards in the design to create a ceremonial gateway into the site. Bollards will also run around the entire perimeter of the site but will be hidden in tall, native prairie grass.

In the early stages of design development the architectural team, in collaboration with Weidlinger Associates, explored several additional possibilities for maintaining a secure "stand-off" perimeter. One of the schemes examined was that of a collapsible grade. However, the engineering of this proved to be tricky, as the collapse could have been accidentally triggered. Even though this feature was not adopted, Carol Ross Barney believes that this type of solution will become more commonly used in the future. In the end, the design team adopted the subtle use of bollards and structural walls integrated with the landscape treatment for the building perimeter. This solution prevented vehicular access to the building, while allowing for fairly unobstructed pedestrian accessibility and circulation.[12]

Different types of bollards used for perimeter security at the building entry, walkways, and street.

Bollards and other security devices prevent street parking around the building. These bollards have been placed along the exterior site perimeter as well as the perimeter of the ellipse. In the latter case they have been paired and treated as cylinders of perforated stainless steel with interior light fixtures. These bollards are large enough to become part of the site furniture, serving as seating areas for those waiting

[12] A recent study by the National Capital Planning Commission (NCPC) released in the fall of 2001 features extensive studies on issues of security and urban design in the form of two reports: "Designing for Security in the Nation's Capital" and "National Capital Urban Design and Security Plan"; http://www.ncpc.gov/planning_init/security/security.html

for a ride or the bus. A 76-space visitor parking area was initially planned for the north parcel, adjacent to the park area. This feature was intended as another public amenity and part of the area revitalization. However, during the course of tenant negotiations this lot was instead allocated for use by the building tenants. While many federal buildings in urban locations have limited parking, many of these tenants had become accustomed to having parking in front of their workplace while temporarily relocated to multiple locations throughout the city, and wanted a similar amenity in the new building. Security precautions for controlled accessibility and supervision of the employee lot were put into place to protect government personnel.

Structural Framing

In order to prevent structural failure, the new guidelines focused on avoiding progressive collapse and maintaining the integrity of the structural system. One strategy to meet this goal is to incorporate more steel in the frame and window walls. "The structure should feature moment-resisting perimeter frames, compared to the simple concrete structure in Oklahoma City," said W. Gene Corley,[13] who served as the principal investigator on the building performance assessment team dispatched to Oklahoma City by the Federal Emergency Management Agency.[14]

With the recommendations of the various security studies and guidelines in mind, RBJ and Atkins, as well as structural and security engineers Weidlinger Associates, designed a robust and redundant structural frame so that the removal of any major structural member would not cause the rest of the structure to fail.

Curtain wall assembled on robust structural frame.

Exterior Glazing

The reports from Oklahoma City indicated the dramatic extent of damage inflicted by flying glass: "We walked on a seemingly endless carpet of broken glass as we made a long, spiraling trajectory outward from the remains of the Federal Building. Within two blocks of the epicenter, no glass in buildings survived intact." This observation was shared by Tom Harpole, a licensed explosives engineer, who

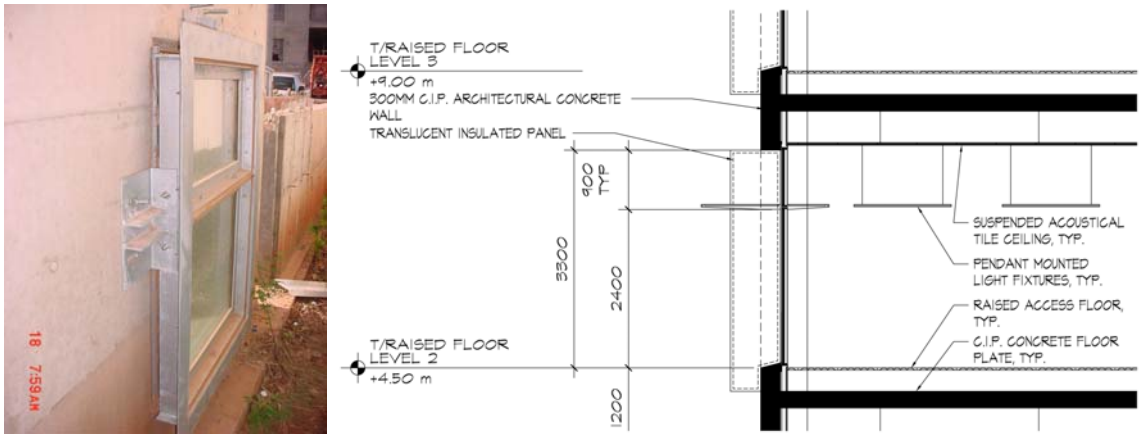
[13] Gene Corley is vice president of Construction Technologies Laboratory, Inc., Skokie, IL, and serves on the American Society of Civil Engineers' Technical Council on Forensic Engineering.
[14] Engineering News-Record 241, no. 14 (October 12), p. 179.

visited the site with Dr. Norville, director of Texas Tech's Glass Research Center and the world's leading researcher of blast effects on glass, and Milt Smith, a Texas Tech industrial engineering professor.[15] What they witnessed was the effect of "overpressure," an abnormally strong pressure generated by the blast, which threw glass into the buildings' interiors and onto the sidewalks, streets, and other areas. Approximately 70 buildings in a 25-block area were said to have sustained structural damage. Flying glass lacerated more than 80% of the people injured in Oklahoma City.

Timothy Thury, GSA project manager, noted that reports show that these percentages are typical: in approximately 75% of bombings the most significant damage to people and property comes from the failure of architectural glass. He also noted that some of the windows that endangered the occupants of buildings in Oklahoma City contained glass covered with an adhesive film, originally conceived for thermal performance but also thought to promote safety during a blast. Examples of glass coated with failed polyethylene terephthalate (PET) film were found as far as a mile from the site, he said. One of the objectives in designing the new Oklahoma City Federal Building was to engineer ways to keep glass shards from flying into the building and to determine how envelope design and materials could help protect people and property in an explosion's vicinity. Consequently, the reinforced building structure will be enveloped in blast-resistant laminated glass, which does not fragment in case of a blast.

All of the collaborators agreed with GSA's choice of laminated glass, which can cope with tremendous blows, absorb energy, move with it and bounce back. Even though it fractures, the interlayer holds the fractured glass in place, which is why this type of glass is used in automobile windshields. A further benefit of laminated glass is that by staying intact, it keeps the building weatherproof. After the bombing, heavy rain in Oklahoma City poured into neighboring buildings that had lost their windows. Many laminated-glass windows, however, continued to protect interiors even when the glass had cracked.[16] Standard laminated glass consists of two or more plies of glass bonded by polyvinyl butyral (PVB). Laminated security products can be made with any type of glass: annealed (plain plate glass), heat-strengthened (a hardened glass with more tensile strength), or fully tempered (glass that breaks in diced pieces rather than in shards). Consequently, RBJ specified laminated glass per GSA recommendations that incorporates two annealed sheets bonded together under heat and pressure by a thick PVB interlayer. The curtain-wall design was based on the requirements of the GSA Security Criteria at that time. The glazing was blasted tested in White Sands, New Mexico. The air and water infiltration on the curtain wall was tested in Montgomery, Alabama.

[15] Tom Harpole, "A Safety Lesson from Oklahoma City," *Progressive Architecture*, June 1995, pp. 65-66.
[16] In Europe laminated glass is employed in more than 45% of retail establishments. Australian stores use it almost exclusively. Though it frequently costs about 30% more than tempered glass, experts believe laminated glass should be used near any site where an explosion might occur.



Mock-up of the blast-resistant window assembly with laminated glass, and its construction detail.

Building Envelope and Entrance

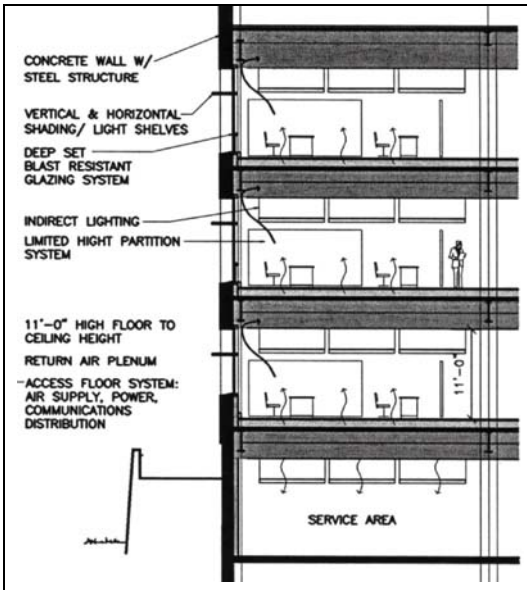
The building features thick concrete blast walls as a result of increased security consciousness at the entry, which doubles as a three-story lobby. Part of the design philosophy was to keep security measures effective but subtle. While concrete walls were originally specified for the lobby in order to meet the government's blast requirements, this was changed to a 3/4" thick steel plate that provided the same effective protection in a more elegant solution. This change also reduced the dead load on the structure and reduced costs. Specially designed smoke doors open into the lobby at these locations and provide access to the offices on east and west wings of the second and third floors.

GSA notes that architects will be expected to come up with more innovative design solutions in response to increasing security considerations. General contractor Flintco, in collaboration with Masonry Arts, the specialty building envelope systems subcontractor, and the design team at RBJ and Atkins spent considerable time detailing the building envelope and in particular the featured curtain wall. Masonry Arts had previous experience in secure building envelope design, having worked on the renovation and reconstruction of the Pentagon before and after 9/11.

The curtain wall system includes a rigid frame with structural silicone glazing, which is expected to have more flexibility in the event of a terrorist attack. The detailing of the connections between the building's structural frame wall, frame, glass curtain wall and window openings received extensive scrutiny to avoid a repetition of the Murrah Building tragedy. Had the designers chosen a traditional aluminum system for the curtain wall, the new security requirements would have resulted in mullions that were more than twenty inches deep. By introducing steel into the system, the depth could be reduced substantially to about twelve inches. At the same time, Weidlinger Associates carried out a constant finite element analysis – a process that involved performance evaluation of the moment-resisting structural elements and systems being developed and kept the architects informed of their design decisions.

SUSTAINABLE DESIGN

From the beginning, GSA wanted to explore increased sustainability and workplace productivity in the design of this building. Workplace requirements were added to the security requirements, and the team struggled to reach consensus on what portion of the construction budget to allocate to these concerns. The design team tried to achieve a good daylighting in the interior spaces by manipulating window height to maximize daylight penetration. The decision to install a raised floor with air distribution under the floor allowed the designers to reduce the floor-to-floor height by twelve inches while gaining eighteen inches of glass, thereby increasing perceived light for less energy. At the same time they reduced heat gains by introducing a light shelf that redirected most of the light toward the ceiling while shading the glass area below it. This device also eliminated most of the heat gain from infrared radiation.



Digital rendering of a proposed interior layout that addresses workplace comfort, flexibility and productivity issues. Building section showing raised floors and daylighting shelves.

Consideration was also given to the design and materiality of sun-shading awnings along the building's southern façade – which extend into light shelves inside the building interiors – as these might be torn free and turned into projectiles in the case of a blast. The material chosen for these daylighting control devices is a type of resilient cloth (a 10-15 year product with good UV performance and 87% solid so that rainwater falls through and does not puddle), which stretches around an aluminum frame that may be easily and inexpensively removed for maintenance or replacement. Lastly, the curtain wall's U-shape is intended to give employees a sense of security by allowing unobstructed surveillance of the open space.

Photos showing final design of exterior shades and interior light shelves

However, the original design intent was compromised regarding some proposed sustainable design features. The design intent was to create open workspaces along the building perimeter, with private offices further interior and treated with interior windows to allow for borrowed daylight. This scheme was the basis of design development decisions, and used to quantify power loads in the office areas. The design proposed the inclusion of interior light shelves (to bounce light deeper into the building interior) and perimeter lighting controls, which would save energy by automatically dimming the lights when the levels of daylight were adequate.

GSA has no control over the design of tenant improvements. So, a tenant plan based on more traditional space-planning practices, such as locating enclosed offices at the building perimeter, could render features like light shelves and daylight sensors ineffective. Given this possibility, the daylight controls were eventually eliminated from the project. The light shelves were installed during construction, but have limited effectiveness. The team feels that pre-educating the end user of the advantages of these features could lead to more efficient use of the space, and might also allow for the development of a mechanism to enforce the workplace productivity and sustainability initiative.

This project predated GSA's requirement that buildings pursue LEED certification, so the decision to incorporate sustainable features was made independent of any mandate. However, since a number of energy-efficient and sustainable strategies had been pursued during the building's design, the team did discuss LEED certification. Because construction had already started by that time, it was decided that it would not be feasible to pursue certification.

COST BENEFIT ANALYSIS

As a public entity, the federal government is organized differently than a private entity and has a longer-term outlook in the development of its buildings. Still, one of the biggest challenges faced in developing a building through the Design Excellence Program may be managing the conflicting expectations of the different GSA groups involved. For example, the Office of the Chief Architect pushes for a high level of architectural quality, while the Property Development group has to fund this service with an already tight budget. In addition, the Portfolio group, which uses a financial pro forma to evaluate the performance of a building, is often compelled to lease federal space to public tenants at a higher rate than the local market due to the higher design costs.

GSA is committed to building quality in its facilities with a lifespan of as much as one hundred years. The adopted model from the 1990s was to build space that could compete with the quality of the private market in terms of leasing. The proposed building, on the other hand, offers a quality of space, construction and amenities that cannot be found in a speculative office building in the Oklahoma City area. Many of these speculative office buildings are built to suit a specific single major tenant who is paying for specific amenities. However, the proposed building exhibits flexibility in design to accommodate multi-tenant use currently and in the future, which results in a substantial difference in marketing the space to potential lessees. The flexible space planning makes use of a federal government initiative to improve workplace comfort and productivity, which would also qualify the design for government funding.

Other marketing features that promote a sense of community, an important factor in a multi-tenant building, are the fitness center and the food court area with its associated indoor and outdoor public spaces. The real estate teach actually reacted negatively to the food court, since they had envisioned the building occupants going out to patronize neighborhood establishments and thereby contributing to the neighborhood revitalization. There is also a conference center, shared by all resident agencies, which is a sought-after amenity, especially for some of the smaller tenant agencies. Together with the security premiums included in the financial pro forma, GSA Portfolio Management mentioned that, instead of using a comparable market rate approach in ensuring the project's economic viability they used instead Net Operating Income (NOI) approach in which an extended cash flow was considered. The construction premium for security and cutting-edge workplace productivity considerations resulted in a markup of less than 10% of total cost. Operational and maintenance savings proved important in the long run. In the short run, however, the projected rent may be up to $24 / sq. ft. compared to $22 / sq. ft. for available downtown office space.

Views of the food court area and exterior decorative balcony and pool.

By completion, the building had 100% occupancy and a small waiting list for tenants hoping to move in. This is likely due to the amenities mentioned previously, which are difficult to find in available market office space in Oklahoma City. These successful features are due to rigorous marketing for the new facility by GSA personnel, who had to find the right balance to outline the increased security features in the new building without scaring tenants off by giving the impression of continued danger from terrorist attacks.

Lastly, all the participants were asked what these increased security considerations might do to the physical manifestation of federal buildings. They all agreed that retrofitting existing buildings is more difficult and expensive than building new ones, but installing additional structural walls, adding supplemental supporting frames, and encasing existing columns in reinforcement and concrete may be appropriate for those buildings deemed at risk. In terms of developing high-rise structures, the common opinion was that this is very much an issue of available real estate. More constricted sites will probably result in taller structures. This is unavoidable if the government wants to maintain downtown visibility, and as a result defensive measures will be taken through evolving security and surveillance technologies and through innovative design and construction assemblies. The Oklahoma City case, however, was unique in that the Murrah building tragedy was fresh in peoples' minds.

CONCLUSION

The project team for the new Oklahoma City federal building faced an unprecedented challenge. Tasked with designing in the wake of tragedy, they struggled with evolving security requirements and the concerns of returning tenants. GSA was able to have a positive impact on revitalizing downtown Oklahoma City through careful site selection. The architecture team of RBJ and Atkins, selected through the Design Excellence program, collaborated well with each other, and with the general contractor and the GSA team. Together this team delivered a design that responds to its urban context and sustainability

goals, as well as the overarching goal of balancing advanced security measures with a welcoming, open appearance.

APPENDIX A

SECURITY PRACTICES: CREATING A SAFE WORKPLACE[17]

The Murrah Building bombing also fostered discussion between the public and private sectors, leading to heightened understanding of security issues. That has had an enormous impact on the design of structures perceived to be vulnerable to attack. The conclusions, long held by security practitioners, are that despite the fact that terrorists can usually trump the best efforts of the design community, the resistance of public and private buildings to malevolent actions can be increased. In this context managing risk often means that building owners must find ways to become a harder target than others in their category, while simultaneously providing a creative and efficient workplace. The theory of crime displacement says that an increase in security at a specific facility will divert the adversary to equally attractive but less resistant targets.

CPTED Strategies

Crime Prevention Through Environmental Design (CPTED) is a design model that draws heavily on behavioral science rather than target-hardening strategies. The fundamental premise is that the physical environment can be altered to produce responses that reduce crime incidence. The four key elements are territoriality, natural surveillance, activity support, and access control. An example of the CPTED model is enhanced lighting, which contributes to natural surveillance.

Keeping a Distance

For high-level threats (explosive devices), facility and campus design plays a key role in how efficiently active security measures can be applied. The only effective tool available to counter this threat is distance. Campuses with greenbelts provide the opportunity to keep potential explosive devices at a safe

[17] Reprinted from Randy Nelson's, "Maintaining security in an insecure world: new strategies are emerging to help architects design without a bunker mentality," *Architectural Record*, December 2000, pp. 153-7.

distance from the main facilities. The definition of safe distance is entirely determined by the perceived threat and facility construction.

Personnel Control

Personnel access control is fundamental to a security program and greatly influenced by facility design. The electronic access-control industry has provided a broad array of tools that control personnel flow based on a combination of personal identification numbers (PINs), electronic credentials (access cards) or some physiological feature, such as a palm print of the individual requesting access (biometrics). They are inexpensive and effective in controlling unauthorized access.

Nowhere is this more evident than in the facility lobby. It is important that its design accomplish:

- Effectiveness: A balance must be achieved between the aesthetics of the lobby and its ability to provide a natural flow of personnel and a minimum number of security/reception desks. Close cooperation in design can accomplish this function within the defined architectural context.
- Efficiency: The security/reception desk must be designed to provide the utmost efficiency in performing a wide range of required tasks. The desk should have sufficient space for closed-circuit TV and PC monitors, local area network access and other communication devices.
- Convergence: As the lobby is the common traffic-flow point between the above- and-below-grade floors, all stairwells should empty into the lobby to prevent an individual from gaining access to the facility without first passing through the security/reception screening point.

Keeping the Doors Locked

Technology is also available for controlling personnel doors. The most common means involve:

- Electromagnetic locks: These devices hold a door in a secure position through the use of an electromagnetic field between the coil and the receiver plate. They are easy to install and have a high holding power, but they may not be accepted by code in some jurisdictions.
- Electric strikes: Located in the jamb and controlled by a solenoid, they release upon presentation of a valid credential or other access identifier. For retrofitting access-control systems, the use of electric strikes often requires modification of the doorjamb.
- Electric bolts: Using standard door strikes, the electric bolts utilize a solenoid to eject the bolt into the receiver plate. Electric bolts require pretreatment of the doors prior to installation and are therefore somewhat more expensive than use of the common electric strikes.
- Elevator control: One difficulty with elevator control is the inability to limit the individuals using the elevator to those authorized. For this reason, many facilities use a portal arrangement at either elevator lobby end on each floor to control access into the respective office spaces.

However, as electromechanical devices may fail, one should plan for such failure at each access-control point, through the use of CCTV coverage and intercoms for more efficient operation. While technology gives many tools to heighten security, facility design is key in providing an efficient, yet secure workplace. Applying basic security principles at the earliest stages of design should result in a complementary blend of design requirements and efficient security.

APPENDIX B

PROJECT TIMELINE

April 1995	Alfred P. Murrah Federal Building in downtown Oklahoma City is bombed.
July 1995	Congress appropriates $40,400,000 via P.L 104-19 for the replacement of the Alfred P. Murrah Federal Building in Oklahoma City.
May 1996	Feasibility Study contract issued to C.H. Guernsey & Company of Oklahoma City
August 1996	Feasibility Study completed.
June 1997	Environmental Assessment study contract issued.
July 1997	A/E contract issued thru the GSA Design Excellence program to Ross Barney + Jankowski Architects of Chicago, Illinois.
October 1997	PDS Program Report completed.
December 1997	Construction Management contract issued to Heery, International of Houston, Texas.
March 2001	Site demolition contract issued by GSA to M&M Wrecking of Blanchard, Oklahoma.
May 2001	Site property acquired by GSA via Declaration of Taking.
August 2001	Environmental Assessment study finalized.
October 2001	Site demolition completed.
	Construction contract issued to Flintco, Inc. of Tulsa Oklahoma in the amount of $31,223,000.
November 2003	Substantial completion of construction
December 2003	Federal agencies begin occupancy of building.