

STEEL Protection

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Steel provides flexible, cost-effective force protection for the Department of Defense at the new Pacific Command Center in Oahu, Hawaii.

Over the last few years, federal agencies and private owners of essential buildings have become concerned about increased terrorist bomb blast activity both at home and abroad. As with other government facilities, the design-build request for proposal (RFP) for the Department of Defense's new six-story 320,000 sq.-ft Pacific Command Headquarters Building, in Oahu, Hawaii, included Anti-Terrorism/Force Protection (AT/FP) criteria.

One element of the design-build RFP that was not fixed, and allowed for innovation was the selection and design of the structural system. As noted in the RFP, "the structural design is flexible and largely dictated by specific requirements such as force protection, by code, and architectural design." Although RFP documents called for a detailed concrete structure, the design-build team evaluated structural steel schemes at the same time that the proposed concrete structure was being priced.

PROJECT DESCRIPTION

In October of 1999 the Department of the Navy issued a solicitation for a modified design-build contract. It was the intent of the government for the contractor to design and construct a new military regional headquarters' building located at Camp H.M Smith, Oahu, Hawaii. The RFP indicated a concrete structure and included 105 sheets of "conceptual" structural drawings, reflecting a mix of cast-in-place and pre-cast, pre-stressed concrete for the structural frame. Structural steel was to be utilized only for the building's architecturally articulated high-pitch roofs.

As with many design-build projects, the submitting contractors were faced with numerous challenges:

- The RFP only set forth design criteria to be satisfied. The contractor ultimately was responsible to ensure that the final design and construction of the project complied with this criteria.
- The proposals were due in December 1999. With a short, three-month



View of a typical SidePlate connection.

time frame, complete design and cost estimates could not be performed.

- However, the contractor had to verify the adequacy of the RFP documents and make additive or deductive adjustments to prepare a “conceptual” cost estimate.
- Working with “conceptual” cost estimates required a careful assessment of the amount of “contingency” to add for the final design. Adding too much could have resulted in losing the project, while too little might have meant an insufficient budget.

Starting with a relatively comprehensive set of RFP drawings presented the design-build team with several ways to approach the competition. Because of the advanced level of detail in the RFP drawings, there was a temptation to bid the drawings “as is,” without complete scrutiny of either the drawings or the RFP requirements. This approach presupposed that the RFP drawings reflected a design that met all of the RFP requirements. A design-build competition based on this approach could have been risky, and might have eliminated innovation.

An equally problematic situation could have arisen if the design-build team had analyzed the RFP documents and discovered that some of the RFP requirements were not reflected completely in the drawings. This might have put the team at a disadvantage if requirements discovered “missing”

from the drawings added cost to their proposal.

The philosophy of the Dick Pacific Construction Co. team, however, was to be both cost competitive and provide the government with a “best value” proposal that exceeded RFP requirements. The team members understood the potential pitfalls of working only from RFP drawings. In order to achieve their goal, an evaluation of alternative structural systems that could provide better performance for less cost was needed. With a short time frame for the proposal development, Dick Pacific requested Baldridge & Associates Structural Engineering, Inc. to work under the direction of Atkins Benham to assist in evaluating an alternate structural steel system.

CONCRETE VS. STEEL

A common misperception is that reinforced concrete is the best material for buildings subjected to bomb blast loading. Both steel and reinforced concrete framing systems can be designed for protective design requirements. While concrete structures typically have more mass, steel systems are inherently more ductile. A lighter steel framing system is beneficial to the seismic design considerations and still has the capacity to accommodate the deformation reversals associated with the negative phase pressures and rebound of a blast load.

The pre-stressed concrete floor slab that was proposed in the baseline RFP design was not well suited to blast requirements. Pre-stressed systems are effective for typical gravity load cases. However, in blast situations, pressures might produce uplift forces that are contrary to gravity loads. A conventional pre-stressed floor slab is poorly suited to withstand the load reversals associated with these conditions. Significant and costly modifications of the pre-stressed floor slabs would have been required if the team followed the baseline RFP design.

The alternate structural steel scheme evaluated retained the cast-in-place concrete cores to resist required lateral wind, seismic and blast loads while utilizing an efficient steel frame to carry the majority of the gravity loads. A three-dimensional model of the structure was created using RAM Structural System software. This de-

sign method was selected to accelerate the process in producing both the preliminary design and a set of framing plans for conceptual pricing by the contractor and sub-contractors. This also provided the opportunity to facilitate the transfer of design information to Atkins Benham for their review process.

Alternates also were evaluated for the blast resistant façade indicated in the RFP. This included a cast-in-place concrete blast wall behind an architectural precast exterior that sheathed the building’s perimeter. This wall would be expensive to form, and once constructed, would block the flow of construction materials in and out of the building shell. The blast wall as detailed also created diagonal kicker loads into the bottom of the floor framing, and horizontal loads into the exterior columns, both conditions undesirable and potentially damaging to the structure. An innovative system that combined a ductile steel frame with a strengthened façade was designed to meet the blast requirements, similar to renovation work at the Pentagon. Not only was this more cost effective, but it also provided flexibility for the construction schedule and had significantly better performance characteristics.

The selection and economy of the structural steel systems allowed the Dick Pacific team to provide the military with a “best value” design that included gravity, seismic, wind and blast load capacities exceeding what was required in the RFP. This system was also several million dollars less expensive than the concrete scheme.

ADDITION OF “PROGRESSIVE COLLAPSE” DESIGN CRITERIA

Several months elapsed as the military evaluated the submitted proposals. The Dick Pacific team’s proposal provided them with a significant advantage from both a cost and performance standpoint. All of the proposals, however, were over the initial budget, and cost-cutting discussions began. Although the military would consider modifying some of the architectural elements of the project, an additional requirement to design the building for “progressive collapse” criteria was added to the proposal. The potential added cost of this requirement made

staying within the budget even more difficult.

In March 2000, the RFP was reissued with the Department of Defense's Anti-Terrorism/Force Protection Progressive Collapse criteria as an added requirement. The revised proposals would be due in May 2000 giving the teams three months to reduce the price while incorporating the additional design criteria. The Dick Pacific team saw this as an opportunity to move ahead of the competition.

The team viewed the addition of the progressive collapse requirement as a challenge vital to the military's needs and the project's success. The team researched methods of addressing these requirements. The design to prevent progressive collapse would need to be incorporated into the project with only a minimal impact on project cost in order to meet the budget requirements.

A new courthouse project in Laredo, TX, designed to the GSA's progressive collapse requirements, became the example of how the project's enhanced performance criteria could be met within tight cost constraints. The developer of the cost-effective steel connection system used in that project, Myers, Houghton & Partners, Inc.—SidePlate, was added to the team.

The alternate structural steel scheme was a global steel-frame structure designed to resist wind, earthquake and gravity loads. State-of-the-art SidePlate steel-frame connection technology created a structural-steel frame system that was capable of efficiently addressing the force protection standard to mitigate progressive collapse. By optimizing the location and orientation of the SidePlate connected moment frames, the steel scheme became a structure with enhanced redundancy, ductility and energy dissipation characteristics.

The original three-dimensional model of the structure was modified in RAM Structural System. The electronic files were exchanged between different team players to facilitate the analysis of this option in the short time frame provided. The resulting design can be compared to a light conventional steel frame structure with an efficient structural steel frame weight of less than 10 psf. This innovative solution was made possible by creatively exploring cost-saving alternatives and communi-



Above: Moment connections using SidePlate technology were shipped to the site fully assembled.

Below: Exterior of the Pacific Command Center.



ating carefully with all the design team members.

STEEL ADVANTAGE

The inherent economy of the selected structural steel frame system allowed the Dick Pacific project team to maintain their cost advantage while designing the project with the following features:

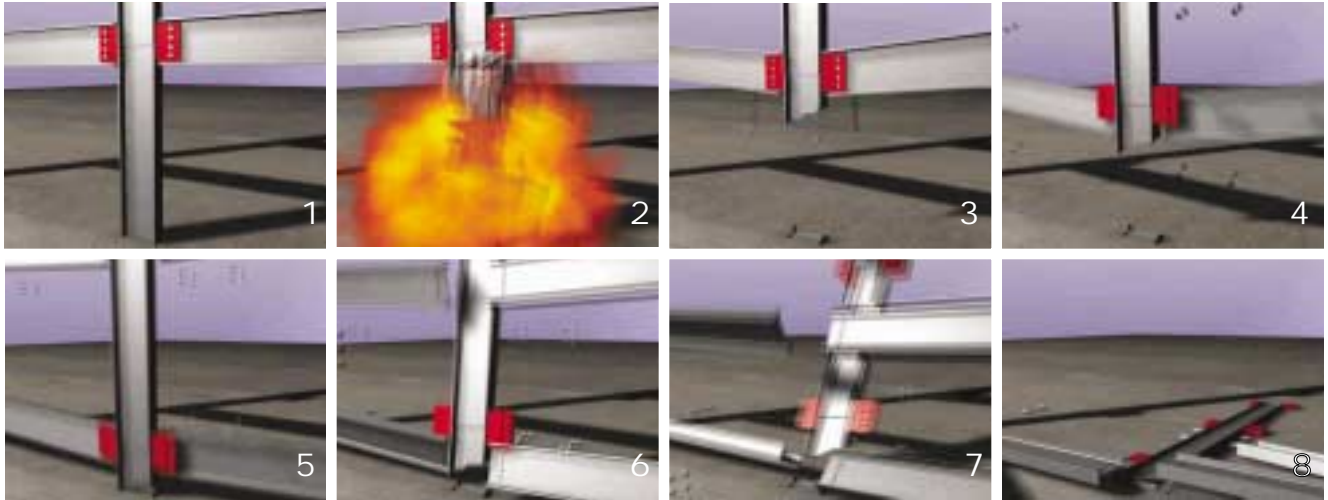
- Floor framing in some areas was designed for office live loads greater than required, allowing flexibility for changing space usage throughout the life of the building.
- The lateral resisting system was designed for more stringent seismic requirements than required by the

RFP. The SidePlate connection system incorporates technological advances developed as a result of the lessons learned during the Northridge earthquake.

- The building frame was designed for a greater wind speed than required by the RFP.
- Lateral-load-resisting steel frames inherently provide capacity to prevent progressive floor collapse throughout the structure.

The structural steel system provided other advantages inherent to steel framing:

- Ease of change: When office space programming needs to be change or upgraded, structural steel is easily



This sequence of images shows the theoretical behavior of a typical simple shear connection when a column is removed from the frame.



This sequence of images shows the theoretical behavior of a moment connection when a column is removed from the frame.

modified and reinforced to accommodate new requirements. Concrete structures are more difficult and costly to modify or strengthen.

- Superior seismic performance: The inherent ductility and lightness of the steel moment frames provides excellent earthquake performance, for both life safety and recoverability of the structure after a seismic event.
- Complete recyclability: Most steel today contains recycled materials, and nearly all structural steel from future building modifications or demolitions is recycled.
- Ease of grounding: A structural steel frame provides greater flexibility than concrete for changes to the building grounding since connections can be made anywhere to the frame.

The design-build team ultimately decided to propose an innovative

structural steel system because of its performance and cost advantages. The final design consists of strategically oriented and located special moment-resisting frames, coupled with SidePlate steel frame connection technology. The competitive process of design-build provided a rare opportunity to compare directly the cost savings and performance advantages of steel over concrete. ★

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