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May 1988
One-Step and Two-Step Facility
Acquisition Procedures and Application of
Architectural Fabric Structure Technology

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Six Case Studies on Alternative Construction Methods: One-Step "Turnkey" Facility Acquisition and Architectural Fabric Structure Technology

by
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Building technologies and practices have emerged in recent years as alternatives to traditional design and construction in meeting cost, time, and quality goals of owners and builders. Some of these methods are used frequently in commercial construction markets, but are not yet widely accepted within U.S. Army Corps of Engineers (USACE) standard practice. The House of Representatives Committee on Armed Services (HASC) and Committee on Appropriations (HAC) are now encouraging the military departments to employ different construction techniques that may prove less costly than conventional methods.

The objective of the projects described in this report was to test two alternative construction methods and to evaluate their effectiveness in providing less costly facilities to the Army. These methods are: (1) One-Step Competitive ("Turnkey") Negotiation and (2) Architectural Fabric Structure technology.

USACE selected two projects from the FY84 MCA program for testing the One-Step "Turnkey" method. The projects were two physical fitness centers—one each at Forts Bliss, TX, and Stewart, GA.

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EXECUTIVE SUMMARY

- Building technologies and practices have emerged in recent years as alternatives to traditional design and construction in meeting cost, time, and quality goals of owners and builders. Some of these methods are used frequently in commercial construction markets, but are not yet widely accepted within U.S. Army Corps of Engineers (USACE) standard practice. The House of Representatives Committee on Armed Services (HASC) and Committee on Appropriations (HAC) are now encouraging the military departments to employ different construction techniques that may prove less costly than conventional methods.

The objective of the projects described in this report was to test two alternative construction methods and to evaluate their effectiveness in providing less costly facilities to the Army. These methods are: (1) One-Step Competitive ("Turnkey") Negotiation and (2) Architectural Fabric Structure technology.

One-Step "Turnkey" Test Projects

One-Step "Turnkey" procedures differ from the traditional design-bid-build procedures. Rather than advertising a single design for competitive bidding, the Government solicits proposals for the design-plus-construction price. A construction contract is awarded based on a proposal's price as well as other factors such as technical qualities or life-cycle cost benefits (not necessarily low price alone).

USACE selected two projects from the FY84 MCA program for testing the One-Step "Turnkey" method. The projects were two physical fitness centers--one each at Forts Bliss, TX, and Stewart, GA.

Architectural Fabric Structure Test Projects

Four military projects from the FY84 Military Construction, Army (MCA) program were chosen for Architectural Fabric Structure tests. The fabric structures involved in this test were the tensioned membrane type, in which a fabric membrane is supported by rigid structural members and prestressed to achieve its load-carrying capacity. Air-supported structures were not considered in this test. The projects were: (1) Division Air Defense (DIVAD) range general purpose building and target maintenance building, Fort Bliss, TX; (2) vehicle parts supply facility, Seoul, South Korea; (3) physical fitness training center, Muenster Army Depot (AD), West Germany; and (4) online storage facility, Milan AD, Milan, TN. The fourth project was to allow fabric structure technology as an option to preengineered metal building construction, whereas the first three specified fabric structures.

Project Summaries

Physical Fitness Training Center, Fort Bliss

The scope of this facility was 22,774 sq ft, with a Program Amount (PA) of \$2,806,000. The estimated cost for conventional construction was \$2,636,650. Four proposals were submitted and evaluated according to a predetermined scheme. Contract award was based on the best balance of price and technical quality following the One-

Step concept. The winning proposal's price was \$1,939,126 for both design and construction; final cost of the facility was \$1,969,345. Thus, total project cost, including all design efforts, contingencies, and supervision and administration (S&A) costs were approximately 28 percent less than estimated for conventional construction. The design and construction of this facility are reported to be of high quality and performance is satisfactory.

Physical Fitness Training Center, Fort Stewart

The scope of this facility was 62,000 sq ft. The PA was \$5,300,000 at the time of advertisement, which was reduced from the original PA. Based on the lower PA, the estimated cost for conventional construction was \$4,743,500. No proposals were submitted in response to the Request for Proposal (RFP); therefore, the RFP was revised and the project was readvertised with an estimated construction cost of \$5,280,000. Three proposals were submitted and evaluated according to the One-Step procedure. The winning proposal's price was \$4,575,000 for both design and construction. Construction is not yet complete, so a final construction cost is not available. The current working estimate (CWE) is \$4,643,250, which is only 1.5 percent above the contract amount. Using this CWE, the total project cost, including all design efforts, contingencies, and S&A costs, is approximately 16 percent less than estimated for conventional construction. Construction quality to date has been reported to be good.

Physical Fitness Training Center, Muenster

The scope of this multipurpose physical fitness training facility was 11,370 sq ft. The PA was \$1,320,000. As a fabric structure test project, the gymnasium portion of the facility (6900 sq ft) was to be built with a fabric roof, while the remainder of the facility was to be built using conventional construction. One-Step "Turnkey" procedures were initiated to encourage greater competition among fabric structure manufacturers. The contract was awarded for \$1,168,867. No final cost estimate was developed for conventional construction, so a precise cost comparison cannot be made. Design and construction quality have been reported as good and the using service is reported to be satisfied.

DIVAD Range Buildings, Fort Bliss

This project involved the construction of a weapons system training range for which two buildings were to be constructed using fabric structure technology. These were: a target maintenance building with a scope of 2400 sq ft, programmed at \$102,000; and a general purpose building with a scope of 5200 sq ft and PA of \$436,000. No final estimate was developed for conventional construction of these buildings; however, concept state estimates were \$91,000 for the target maintenance building and \$158,000 for the general purpose building (\$249,000 total). The project was advertised for competitive bid and the contract was awarded based on the low bid for the total facility (not just the two subject buildings). Total project cost, including all design efforts, contingencies, and S&A costs, were approximately 4 percent more than the concept estimate for conventional construction. Because the DIVAD weapons system has been discontinued, the buildings have not been occupied to date. However, the Resident Office reports that the fabric structures would be expected to accommodate the intended functions.

Commercial Vehicle Parts Supply Facility, Seoul

This project consisted of two buildings: a warehouse with a scope of 13,447 sq ft and a tire storage/major assembly building with a scope of 12,445 sq ft. The PA for the

facility was \$1,100,000. A final construction cost estimate was developed for conventional buildings (\$696,720). A construction contract for \$880,887 was negotiated, as is standard practice for construction in Korea. The cost for the two buildings was \$672,587. Three contract modifications increased the final cost by approximately \$15,000, although these related to neither construction operations nor fabric structure technology. Total building cost, including contingencies and S&A, was approximately 2 percent more than the estimate for conventional construction. Construction quality was reported to be good and the using service is satisfied with the facility.

Online Storage Facility, Milan Army Depot

This building was an open-sided shelter structure with a scope of 12,600 sq ft. Bidders were allowed the option of using preengineered metal buildings or fabric structures; however, they were required to bid both options. Bids for the preengineered metal building option ranged from \$171,134 to \$269,022, while those for fabric structures ranged from \$222,420 to \$333,278. A construction contract for \$171,134 was awarded based on metal building construction, which was approximately 25 percent less than the lowest fabric structure bid. Since a metal building was constructed, no further information on this project was acquired.

Conclusions

1. Both physical fitness training centers were designed and constructed at significantly lower cost than was estimated for conventional MCA procedures. Facility quality appears to be at least equal to similar facilities constructed under traditional MCA procedures.

2. Physical fitness training centers appear to be a suitable facility type for One-Step "Turnkey" design and construction procedures. The expertise and capability found in the private construction market were incorporated successfully into these USACE projects.

3. Standard MCA regulations, guidance, and practice reflect the traditional design-bid-build approach to design and construction. Certain features within the traditional MCA environment would inhibit the smooth, efficient execution of One-Step projects.

4. Based on test project experience, it appears that the costs of fabric structures are roughly comparable to those of preengineered metal building systems for enclosing large, clear-span spaces. The cost advantage of fabric structures appears to diminish with smaller clear spans. It must also be noted that the cost of fabric structures relative to conventional construction is likely to change as the building industry becomes more familiar with this construction type and the fabric structures industry becomes more sophisticated in its products and practices.

5. The fabric structures studied appear to be well suited to the intended functions of the buildings. Nothing in the test projects suggested that using a fabric structure for an appropriate facility type will compromise the facility's functional adequacy.

6. Architectural fabric structure technology can be viewed as an emerging building system alternative. When this technology is used for military facilities, it is important that all parties involved in the construction process have some familiarity with the unique properties of fabric structures.

FOREWORD

This research was conducted for the Directorate of Engineering and Construction, Headquarters, U.S. Army Corps of Engineers (HQUSACE), under Project 4A162731AT41, "Military Facilities Engineering Technology"; Task Area B, "Construction Management and Technology"; Work Unit 041, "One-Step and Two-Step Facility Acquisition Procedures and Application of Architectural Fabric Structure Technology." The HQUSACE Technical Monitor was Mr. Thomas R. Hodges, CEEC-EA.

The work was performed by the Facility Systems Division (FS) of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). Dr. Michael O'Connor is Chief, USA-CERL-FS. Dana Finney, USA-CERL Information Management Office, was the technical editor.

COL N. C. Hintz is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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SIX CASE STUDIES ON ALTERNATIVE CONSTRUCTION METHODS: ONE-STEP "TURNKEY" FACILITY ACQUISITION AND ARCHITECTURAL FABRIC STRUCTURE TECHNOLOGY

1 INTRODUCTION

Background

Military Construction, Army (MCA) requirements are projected to grow in the future as old structures are replaced or renovated. Both the House of Representatives Committee on Armed Services (HASC) and Committee on Appropriations (HAC) have urged the military services to explore alternative construction methods in an effort to minimize time and dollars spent for facilities acquisition while providing high-quality final products.

Several building technologies and practices have emerged in recent years as alternatives to traditional design and construction in attempts to meet cost, time, and quality goals of owners and builders. Some of these methods are used frequently in commercial construction markets, but are not yet widely accepted within military department standard practice. To gain acceptance in the military construction community, these methods need to be proven in terms of providing quality products at a lower cost than conventional methods.

The U.S. Army Corps of Engineers (USACE) has taken initiative in this direction by funding research to evaluate candidate techniques *under actual conditions in the field*. As part of this effort, the U.S. Army Construction Engineering Research Laboratory was asked to study six facilities selected from the FY84 MCA program as test projects using two different alternative construction methods: One-Step "Turnkey" Facility Acquisition and Architectural Fabric Structure Technology.

Two physical fitness centers, one each at Forts Bliss, TX, and Stewart, GA, were acquired using One-Step Competitive Negotiation ("Turnkey") procedures. With the One-Step "Turnkey" approach, the Government advertises a performance-oriented Request for Proposal (RFP) rather than a completed design. Proposals are submitted in response to the RFP and evaluated competitively on the basis of quality as well as price. Contract award is based on the proposal representing the best overall quality/price value to the Government.

Four facilities were designated as test projects for Architectural Fabric Structure technology: a covered storage building, Milan Army Depot (AD), Milan, TN; a physical fitness center, Muenster AD, Muenster, West Germany; two Division Air Defense (DIVAD) range buildings, Fort Bliss, TX; and a vehicle parts supply facility, Seoul, South Korea. Architectural Fabric Structures are buildings that use industrial fabrics as the enclosure material. The fabric structure involved in these tests was the tensioned membrane type. The fabric membrane is supported by rigid structural members and pre-stressed to achieve its load-carrying ability. Air-supported fabric structures were not considered in this test.

Objective

The objectives of this study were to:

1. Monitor the execution of each project and document experiences of the USACE Districts, Divisions, and other Army agencies involved
2. Identify any issue associated with the design, procurement method, or technology used in each case for or by the District or Division
3. Report the projects' results in terms of cost, schedule, and quality
4. Use lessons learned to provide guidance for future applications of these approaches by military elements including USACE and other Major Commands (MACOMs).

Approach

Contact was established and maintained with USACE Division, District, and field personnel throughout the projects' execution, and with the facilities' occupants upon closeout, where appropriate. Project data were provided by the USACE agencies. Project bidders and proposers also were contacted, both winners and losers, to assess the response from the construction community. Previous experience and documentation in USACE One-Step and Two-Step projects and Architectural Fabric Structures also provided background for this evaluation.

Scope

This study was limited to six MCA projects: two selected as One-Step "Turnkey" test projects, and four selected for testing Architectural Fabric Structure technology.

Mode of Technology Transfer

The results of this work are being used in developing USACE Engineering Manuals for One-Step Competitive Negotiation ("Turnkey") procedures, and for Architectural Fabric Structure technology as alternative construction methods.

2 PROGRAM DEVELOPMENT

One-Step "Turnkey" Test Projects

In the Military Construction Appropriations Bill,¹ HAC directed the Department of Defense (DOD) to pursue the use of nontraditional building methods. These methods were defined as:

1. Construction techniques
2. Turnkey (both One-Step and Two-Step)
3. Packaging
4. Standard design and One-Step procurement
5. Performance specifications
6. Legislative actions
7. Materials--modular and prefabricated.

The One-Step "Turnkey" approach has been used to procure Army Family Housing for more than 10 years. However, use of One-Step "Turnkey" procedures in the MCA program has been hampered by an uncertainty about its appropriateness in programs other than Family Housing. Headquarters, U.S. Army Corps of Engineers (HQUSACE) had been seeking clarification on this issue as well as an opportunity to evaluate One-Step "Turnkey" procedures in MCA projects; the provisions of HR 98-238 afforded that opportunity. In October 1983, HQUSACE selected two projects from the FY84 MCA program, citing HR 98-238 as the authority to initiate One-Step Competitive Negotiation ("Turnkey") procedures.

Two physical fitness centers, one each at Forts Bliss, TX, and Stewart, GA, were selected as One-Step "Turnkey" test projects. The physical fitness center was considered a suitable building type because (1) this type of facility is common in the commercial construction market and (2) a physical fitness center had recently been completed at Fort Benjamin Harrison, IN, and had successfully used Two-Step Sealed Bidding procedures (then called "Two-Step Formal Advertising"). HQUSACE selected the specific projects primarily on the basis of line-item descriptions.

Architectural Fabric Structure Test Projects

In May 1982, HASC requested a Tri-Service study on the feasibility of "flexible barrier technology" for Military Construction (MILCON) programs.² Subsequently, the U.S. Army Construction Engineering Research Laboratory (USA-CERL) evaluated the potential use of Architectural Fabric Structures for military facilities. This study, completed in November 1982, concluded that, in general, fabric structures are feasible for certain

¹House Report (HR) 98-238, *Military Construction Appropriations (1984)*.

²HR 97-525, *Military Construction Authorization Act (1983)*.

types of military facilities, but a definitive judgment should be made only on a project-specific basis.

In February 1983, HASC asked USA-CERL to evaluate the use of fabric structure technology for 16 projects selected from the FY84 MILCON program. Using USA-CERL's results as input, HASC designated six military facilities (three each for the Army and the Air Force) as test projects for Architectural Fabric Structure technology.³ The three Army projects were:

1. Fort Bliss, TX: DIVAD range general purpose building and target maintenance building
2. Seoul, South Korea: vehicle parts supply facility
3. Muenster, West Germany: physical fitness training center.

HQUSACE selected a fourth project, a covered storage facility at Milan AD, Milan, TN, to assess Fabric Structure Technology as an option to preengineered metal building construction.

To promote an effective demonstration, HASC included the following conditions for these projects: (1) One-Step "Turnkey" procedures would be allowed; (2) the widest possible competition among fabric structure manufacturers should be ensured; (3) the square-foot scope of the facilities would be allowed to increase to 120 percent of the original programmed scope; and (4) equivalent fire safety measures could be specified instead of existing criteria.

³HR 98 166, *Military Construction Authorization Act* (1984).

3 PHYSICAL FITNESS CENTER, FORT BLISS, TX

Project Description

The physical fitness center at Fort Bliss, TX, FY84 MCA Project Number (PN) 344, is a multipurpose facility containing a full gymnasium with bleacher seating for 864 spectators, six basketball backboards for practice, equipment and apparatus for a full program of athletics and gymnastics, three regulation handball courts, fully equipped exercise and weight rooms, men's and women's dressing rooms including saunas, whirlpools, and training rooms, and other necessary support and administrative areas. The facility's scope was 22,744 sq ft and the Program Amount (PA) was \$2,125,620. The USACE Fort Worth District (SWF) administered the design and construction of this project.

Predesign Activities

The physical fitness center was programmed for FY84 and SWF initiated design activities typical of an MCA project. Architect/engineer (AE) services were contracted and design progressed through concept development. The concept design fee was \$42,570.

On 30 September 1983, HQUSACE issued a directive to initiate One-Step Competitive Negotiation ("Turnkey") procedures for the project. This directive referenced HR 98-238 (discussing alternative construction methods), and included instructions to develop performance criteria "in such a manner to permit the widest possible competition and maximum participation."

HQUSACE convened a meeting of SWF, HQUSACE and USA-CERL representatives to discuss the project, One-Step "Turnkey" procedures, and Congressional interest in this project. Savannah District personnel also attended because a physical fitness center at Fort Stewart, GA, was targeted as a future One-Step "Turnkey" test project. SWF had previous experience in One-Step "Turnkey" Army Family Housing projects. A Request for Technical Proposal (RFTP) from a successfully completed Two-Step physical fitness center at Fort Benjamin Harrison, IN, and a USA-CERL Technical Report on Two-Step Facility Acquisition Procedures⁴ were provided for background. SWF foresaw no difficulty or extraordinary efforts involved with implementing One-Step "Turnkey" procedures; however, it was noted that a tight time schedule would be required in order to award a construction contract before the end of FY84.

Request for Proposal (RFP) Development

The SWF Engineering Division elected to develop the RFP in-house and to base it on the already completed concept design. This concept design had been based on another recently completed physical fitness center. The using agency (Morale Support) was familiar with this other facility and indicated preference for a similar facility.

⁴T.R. Napier and M.E. Lierman, *Industrialized Building System/Two-Step Procurement Pilot Projects: Three Case Studies*, Technical Report P-85/05/ADA153812 (U.S. Army Construction Engineering Research Laboratory [USA-CERL], January 1985).

SWF's Design Branch prepared the RFP essentially following conventional design project procedures. A Design Branch project coordinator delegated RFP preparation to the appropriate technical staff, including Architectural, Electrical, Estimating, Structural, Civil Engineering, and Mechanical Sections. The using agency was involved in the review of the draft RFPs, as was USACE Southwestern Division and the MACOM (U.S. Army Training and Doctrine Command--TRADOC). USA-CERL also participated in the RFP review process at SWF's invitation.

The RFP consisted of requirements for (1) proposal preparation and submittal, (2) the contract, (3) site development, and (4) building design. Also included was an appendix containing the technical evaluation manual that was to be used by USACE's evaluation team.

Architectural requirements were represented in the RFP by a floor plan, a table of area requirements, equipment and fixture schedules, and narrative descriptions of design requirements including esthetics and compatibility within the natural and architectural environments. Area requirements were expressed as minimum net areas. A maximum gross area was also specified as an attempt to adhere to the maximum authorized scope for the facility. This maximum scope was later deleted by an amendment. The RFP indicated that while the floor plan as shown represented an acceptable architectural design, proposers should feel free to develop original designs, as long as the substitute achieved all functional characteristics represented in the RFP design.

The facility's engineering requirements were included in specifications for structural, plumbing, heating, ventilating, and air-conditioning (HVAC), and electrical systems. Specifications were listed for items such as hardware, stucco, resilient flooring, and roofing. The technical specifications, for the most part, included basic functional or performance criteria and references to specifications and standards for various alternative construction types and materials.

The RFP was prepared from November 1983 through June 1984. SWF indicated that less time would have been required had there been more resources available. A total of \$112,620 was spent on "RFP development," although this figure includes the cost of the original concept design as well as advertisement and proposal evaluation. Figure 1 provides a timeline for the project's major events.

Advertisement

SWF's Procurement and Supply Division (P&S) administered the project's advertisement following conventional practice. Firms on the District's standard bidder's list were notified directly of the intent to acquire this facility using One-Step "Turnkey" procedures. Approximately 2200 companies received this advance notice and 25 requested RFPs. Because SWF intended to award the project in FY84 (i.e., by 30 September 1984), only 60 days were allowed for proposal development. The advertisement appeared in *Commerce Business Daily* on 29 June 1984 and proposals were due by 9 August 1984.

Development of Proposals

A preproposal meeting was held on 18 July 1984. Twelve firms attended the conference. Of these, 10 had not previously requested RFPs. Therefore, a total of 35 firms had requested RFPs and were considered to have a strong interest in the project.

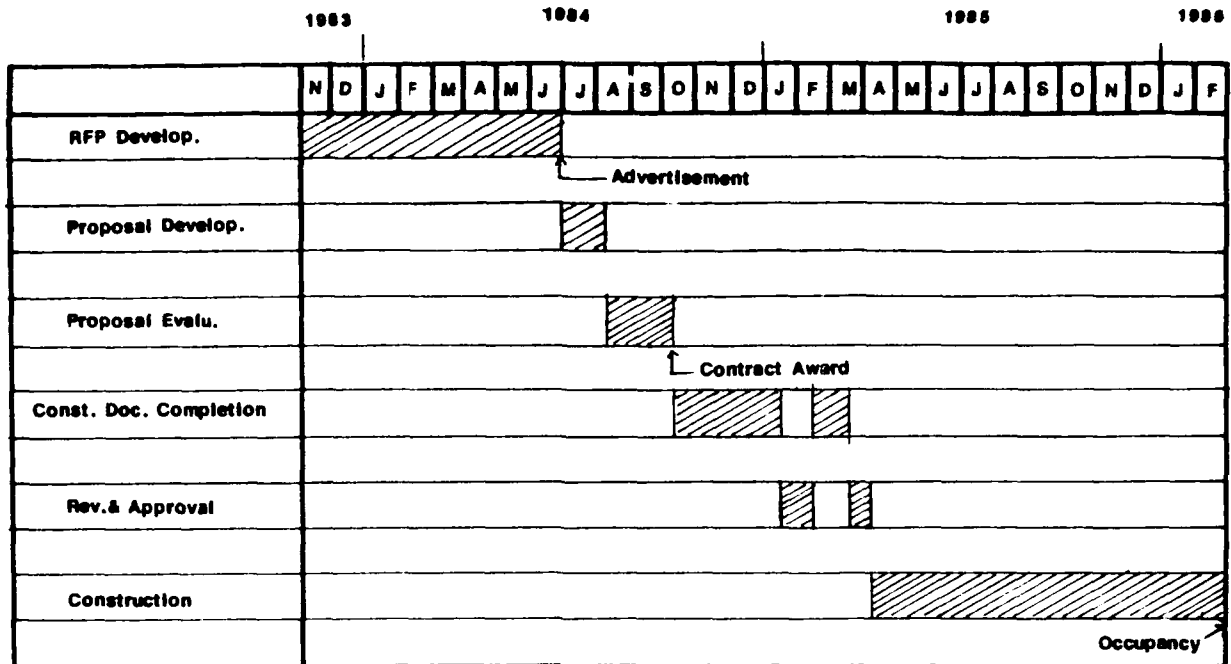


Figure 1. Project events by month—Fort Bliss physical fitness center.

Many critical questions were addressed at the meeting. One important issue was the maximum gross building area limitation in the RFP. One design/build firm representing a proprietary building system indicated that this area limitation would, in effect, disqualify that company from the project. The range between the minimum net area requirements and the maximum gross area limitation was so narrow that, in order to meet the minimum net area requirements using the firm's standard building system, the maximum scope would be exceeded. This firm also noted that, ironically, designing a custom building system would result in a significantly greater cost than using its standard building system for a larger facility.

Many issues were resolved verbally and would be confirmed later by amendment. The meeting results were recorded and distributed to all firms that had requested RFP packages; the appropriate amendments were also included. One amendment was to delete the maximum gross building area limitation. Eighty percent of the RFP changes made were the result of questions or comments from the preproposal meeting; the rest were identified by the District or Division. No further inquiries by proposers were received by SWF during the proposal development phase.

All proposers preferred that the facility requirements be expressed in a "functional" way. The maximum gross square-foot limitation and the minimum net area requirements were too close together (according to the eventual contractor) and limited creativity of the proposals. Although this limitation was deleted after the proposal meeting, it came too late in the proposal development phase to benefit many companies.

Proposers said that the schematic floor plan included in the RFP was too definitive. However, the plan was intended only to convey the required functions and spatial relationships as was stated in the RFP. Proposers could use this plan to save time and effort or could develop a completely original scheme that satisfied the design requirements. Of

the four proposals submitted, three contained plans very similar to the one in the RFP, with only one submitting an original scheme. This proposer scored first in quality points while submitting the highest proposal price; still, the price was below the Government estimate of \$2,636,650. Proposers said that including a definitive plan in the RFP implied a strong desire by USACE for this specific scheme; therefore, they viewed the included plan as an "unwritten requirement." If a variety of schemes is desired, it was recommended that RFPs be limited to narrative descriptions of functional and spatial relationships or to more conceptual diagrams.

Although three of the four proposals used essentially the same floor plan, there was considerable variety in the structural and construction approaches. Two proposals used preengineered building systems for the facility's superstructure and roof, with different conventional exterior wall materials. A third company proposed a combination of precast concrete wall panels and a conventional structural steel frame. The fourth proposal called for conventional steel frame and masonry construction. One of these four proposals used an exterior insulation and finish system in combination with concrete masonry wall construction.

All proposers agreed that the time allowed for proposal preparation was too short for the level of detail required. By the time most had received their RFP packages, they only had a few weeks to prepare their proposals.

Proposers suggested that the RFP specifications be simplified, especially if the time for proposal preparation is very limited as it was on this project. They believed too much detail was placed on minor portions of the project, such as the specialties, to the detriment of other, higher priority areas. Specifically, they recommended eliminating the mechanical and electrical details and, instead, referencing accepted standards and specifications.

Evaluation of Proposals

The four proposals were received by P&S and technical information was separated from the price and identifying material to confirm anonymity of proposers. No preliminary responsibility or "general responsibility" check was executed by P&S. (None could be executed as the identification of all participants in a proposal was not a specified requirement.) Bond submittals were checked to verify proposer responsibility. Technical evaluation occurred in two parts: a review for "technical conformity" and a "scoring evaluation." The Project Manager performed a "general conformity" check to confirm receipt of all technical submissions, then staffed technical submissions to the Design Branch Project Coordinator to review for "technical conformity." The Project Coordinator, in turn, routed the technical submissions to the appropriate Branch Sections.

SWF's Engineering Division reviewed proposals for technical conformity following a standard checklist that also gave guidance for structuring and documenting results of the review. Each Branch and Section reviewed portions of each proposal related to their functional areas. All proposals were in conformance and passed to the next stage of the evaluation.

The quality scoring evaluation was conducted by a team of USACE and using agency representatives following instructions contained in the RFP. The team included representatives from Fort Bliss, HQ TRADOC, SWF, and USACE Southwestern Division. Proposals were evaluated individually solely on the basis of the RFP criteria and were not judged in comparison to the other proposals. Each proposal was reviewed in turn by

each team member. Quality points were assigned first for conformance with minimum criteria; additional points were assigned for performance beyond the minimums. Results of the scores determined by each member were summed by proposal for a total score and then averaged. The final score for each proposal was the average of scores from the individual members. Results were compiled in a Disposition Form (DF) to P&S identifying team members, a rating summary, the rating broken out by major evaluation area, and justification remarks. The proposal prices were not divulged to the quality scoring team.

After point scoring, P&S established cost/quality ratios and made a recommendation for contract award. The Government cost ceiling was \$2,636,650, and the bidder's results were:

1. \$1,928,000--J. T. Construction Co. (General Contractor), with Foster, Henry, Henry & Thorpe (AE), second in quality points
2. \$1,847,300--Banes Co. (General Contractor), with George Staten & Associates (AE), fourth in quality points
3. \$2,974,441--Urban General Contractors, Inc., with Carr/Razloznik Architects, 176, third in quality points
4. \$2,561,186--Spartan Technologies, Inc., first in quality points.

Some of the evaluators found the evaluation to be somewhat difficult. The particular case discussed was the energy analysis. SWF indicated that its evaluators did not know how to rate the proposals and preferred that, in the future, energy analysis be made a conformity review item rather than a quality scoring item. After discussion, SWF agreed that if the evaluation criteria included a value against which the expressed proposal performance could be measured, then the raters could evaluate this item successfully. For this project, no such values had been listed in the RFP, leaving the evaluators with a proposed energy budget but with no basis of comparison to establish a score.

In the evaluation, some of the quality scoring team members had difficulty assigning points in some areas--mainly those outside their usual activities or expertise. Using agency scorers, for example, could easily judge the functional and architectural aspects of proposals, but could not always make valid judgments in areas such as mechanical and electrical design. They would have preferred to confine their involvement to their own areas of expertise.

This project exemplifies the purpose of One-Step Competitive Negotiation, which is to award the contract to the proposal representing the best balance between cost and quality. The winning proposal represented neither extreme of quality or price, but the second highest quality and second lowest price. It is notable that even the proposal judged as highest quality and most expensive was still \$75,464, or 3 percent, below the Government estimate.

Construction Documentation

The Notice to Proceed (NTP) was issued and final design initiated on 17 October 1984. A predesign conference was held between the contractor, the contractor's architect/engineer (AE), USACE, and the using agency. The RFP schedule was revised to reflect time required for USACE design reviews. The RFP required the contractor to

submit "prefinal" 100 percent complete documents within 60 days of receiving the NTP. USACE was to have 30 days for review and approval of the contractor's construction documents. If resubmittals were necessary, they were to be submitted within 21 days after receipt of USACE's comments and corrections. USACE would require 7 days for review and approval of the resubmitted material. The SWF Engineering Division reviewed and approved the contractor's construction documents.

No intermediate design reviews were held between contract award and prefinal submittal. SWF's Engineering Division suggested a review at the 50 percent stage of the design; however, the contractor preferred to continue straight through with the design, indicating that an intermediate review would increase costs.

The contractor and AE indicated that a 60-day period was not long enough to prepare full (100 percent complete) documents. Both indicated that at least 2 more weeks should have been given for a project of this size and detail. Because they were pressed for time, they devoted less attention to some items to finish the most important ones in time for the review.

The contractor's AE suggested that a requirement for a domestic hot water recycling system be deleted or modified. It was predicted that this step could reduce cost somewhat without diminishing the service desired from the facility. This suggestion was never developed into a Value Engineering proposal. Through informal discussions, it was determined that the District would not approve such a proposal, as it was uncertain whether Value Engineering provisions are applicable to a "Turnkey"-type project, and a fixed-price contract was already in effect. (The General Provisions in the RFP did include the standard contract clauses regarding Value Engineering Contractor Proposals.)

USACE received the prefinal construction drawings and specifications on time. The SWF Engineering Division reviewed the documents. Items requiring revision and resubmittal were noted in a letter and forwarded to the contractor. A review conference was held on 24 January 1985 between USACE's Project Managers, reviewers from SWF's Engineering Division, the contractor, and the AE to allow the contractor to respond to the reviewers' comments. According to the RFP, the contractor was given 21 days to revise the drawings and resubmit them for final approval. However, this process was delayed due to questions concerning the RFP requirements for the mechanical systems. The revised final design was approved by the SWF Engineering Division and construction began on 8 April 1985.

Later, the contractor remarked that he should have taken the opportunity to hold a review at the 50 or 60 percent completion stage. Having not done so, some items progressed through design completion, then were identified as being not satisfactory upon USACE's review. Had an interim review been conducted, these items could have been resolved with less effort and expense. Furthermore, the AE reproduced the drawings and specifications prior to the review conference with USACE, anticipating that this measure would expedite subcontract arrangement and material bidding and supply. Instead, the necessary revisions incurred a "double-printing" expense.

After submittal and review of the 100 percent drawings, USACE sent the contractor a letter with the review comments to which response was to be prepared prior to the 24 January meeting. The contractor and AE, however, stated that the letter did not arrive until just a few days before the meeting. They felt this was not enough time to respond to the comments.

It was approximately 5 weeks from the time the 100 percent complete construction documents were submitted until construction began. This period was somewhat longer than anticipated, partly because too little time was allotted to review the completed design considering this would be the design's first review and many revisions were needed. A difference of opinion arose over an alternative mechanical system which the contractor provided; this conflict delayed the 21-day revision and resubmittal time. In this case, there was an ambiguity in two sections of the RFP, each dealing with plumbing/mechanical systems. One section contained design criteria for the system while the other contained Contractor Quality Control criteria. The District's mechanical reviewer checked the proposal for conformance with the design criteria and found that it conflicted with the RFP's requirements in a few cases. The contractor believed that the design did, however, conform with specifications in the Quality Control Section, and therefore, should be approved. In one specific case, polyvinyl chloride (PVC) pipe was specified in the proposal where cast iron pipe was required in the RFP design section. It was eventually concluded that the design criteria governed and the contractor revised the design to conform with requirements.

In some instances, the reviewers attempted to enforce Corps of Engineers Guide Specifications (CEGS), even though the CEGS were not explicitly included or referenced in the RFP. One example involved the use of a particular type of hinges in the handball courts. There are no CEGS for hardware appropriate to this specific application, but the reviewers required hinges required by CEGS. Eventually, this requirement was not imposed and no major conflict arose.

Construction Administration

The RFP required that all work except landscaping be completed within 270 days from the NTP for construction, which was 8 April 1985. The building was scheduled for completion in January 1986. Five delays were granted for a total of 42 days. Two weather delays accounted for 13 days, one user-requested change resulted in a 5-day delay, and two construction agency changes accounted for 24 days. There was a total of seven change orders for the project: two weather-related modifications, three user requests, and three construction agency changes. The total increase over the contract amount was \$ 11,947. The facility was completed on schedule (as revised) and beneficial occupancy occurred on 14 February 1986. Fast-tracking was not considered necessary for this project.

According to the project engineer at the Fort Bliss Resident Office, construction administration for this project was easier than for a traditional design-bid-construct process. Participants also indicated that the quality of design and construction documents equaled that of traditional USACE projects. The construction activities showed no major problems, with the contracting firm working under its own schedule. Only typical minor problems were encountered and required corrective action by the contractor (e.g., correcting some telephone line conduit and a leak in a skylight).

At present, the contract has not yet been closed, pending correction of the items discussed above. To date, the actual construction cost is \$2,093,038. No additional costs are anticipated. Table 1 summarizes the cost data for this project.

Table 1

Cost Comparison Summary: Physical Fitness Center, Fort Bliss, TX

Government Estimate

1) Design*	\$158,199
2) Bid**	2,636,650
3) Construction contingencies***	131,832
4) Supervision & administration (S&A)+	<u>138,424</u>
5) Total est'd conventional design and construction	\$3,065,105

Actual Costs

1) Design (RFP prep., incl. concept design)	\$112,620
2) Proposal price	1,939,126
3) Construction contingencies	11,947
4) S&A+	<u>106,653</u>
5) Total actual design and construction	
≅ 29% less than conventional construction	1,926,653

Construction Costs Only

1) Government estimate	
Contract	\$2,636,650
Contingencies	131,832
S&A	<u>138,424</u>
Total construction cost	\$2,906,906
2) Actual	
Construction ++	\$1,820,000
Contingencies	11,947
S&A	<u>106,653</u>
Total construction cost	\$1,938,600
3) Construction cost difference	\$968,306
≅ 32% less than conventional construction	

*Conventional design estimated at 6 percent of the conventional construction estimate.

**Government estimate for construction, based on conventional estimate.

***Five percent of the Government estimate for construction.

+Five percent of the sum of the Government estimate for construction plus contingencies.

++Contract amount minus the contractor's design costs.

Building Technology

The building's construction uses precast concrete load-bearing wall panels with a structural steel interior frame and a steel truss-and-purlin roof system. The roof is a preengineered standing-seam metal system. A textured aggregate surface was applied to the precast concrete exterior after erection of the panels. Interior construction was generally conventional, using lightweight concrete masonry, except for the handball courts and plumbing chases and the suspended acoustical ceilings. Figures 2 through 4 represent various aspects of the facility's construction. Figures 5 through 7 show the finished facility.

Summary of Findings

This project was compatible with the One-Step "Turnkey" approach and was successful in terms of cost, time, and quality. Both USACE and Fort Bliss recognized that the physical fitness center building type is comparable to similar facilities found in the private construction market. The final total project cost was approximately \$860,000 (29 percent) less than would be estimated for a traditional approach. The facility was completed in a timely manner. Design and construction quality is at least as good as that normally expected in an MCA project of this type.

This project exemplifies the purpose of One-Step Competitive Negotiation, which is to award the contract to the proposal representing the best balance between cost and quality. The contract was awarded to a firm rated second for both quality and cost.

Proposers indicated that the RFP documentation was understandable and easy to use. However, all indicated a *desire for more flexibility in specified requirements*. Proposers indicated that specifications were too detailed in some areas that had relatively little impact on the total project, whereas other, more critical, areas were somewhat vague. All four proposers had had experience with traditional USACE projects.

Proposers and USACE evaluators noted that, in this case, specifying requirements by reference to CEGS would have simplified both preparation and evaluation of proposals. The evaluators were more familiar with CEGS and the proposers thought that their price proposals could have been more accurate based on their past experience with USACE projects.

The contractor indicated that proposal preparation requirements were too extensive, although this process would "weed out" smaller firms that were not able to absorb the cost if not awarded the contract. Proposals cost up to \$20,000 for this project. Proposers (including the winning contractor) generally agreed that they liked the "Turnkey" approach and would participate in other such projects in the future.

The time required for communications between USACE and prospective proposers during proposal preparation was described as critical, especially with a short deadline. RFP distribution, response to inquiries, and amendment distribution should be expedited to the greatest extent possible. (The last amendment for this project was issued on 30 July 1984, while proposals were due on 9 August 1984.) At least one potential proposer abandoned this project due to the inability to incorporate appropriate design changes in such a short period.

A preevaluation meeting would have been very beneficial to introduce the evaluation team to the procedures they would be using. Some team members felt unqualified to judge proposals in areas outside their expertise or normal practice. Evaluation by team should enable individuals to contribute in their own areas of expertise, but not require them to evaluate areas in which they do not feel qualified.

USACE, the contractor, and the AE all agreed that a review of the construction documents' development at the 50 percent completion stage would have helped. No intermediate reviews were specified in the RFP, and the contractor declined the opportunity to schedule one. Had an interim review been held, most of the errors could have been caught in the early stages, thus avoiding delays and expense during the review and revision process. If a 50 percent review is included, the time to prepare the construction documents will be increased, but that time will probably be saved in the final review and revision stages.

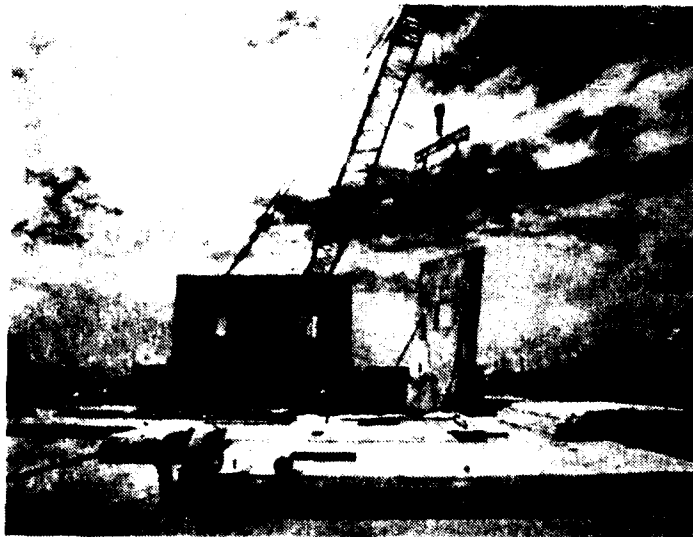


Figure 2. Precast concrete panel erection—Fort Bliss.



Figure 3. Precast concrete panel detail—Fort Bliss.



Figure 4. Interior construction—Fort Bliss.

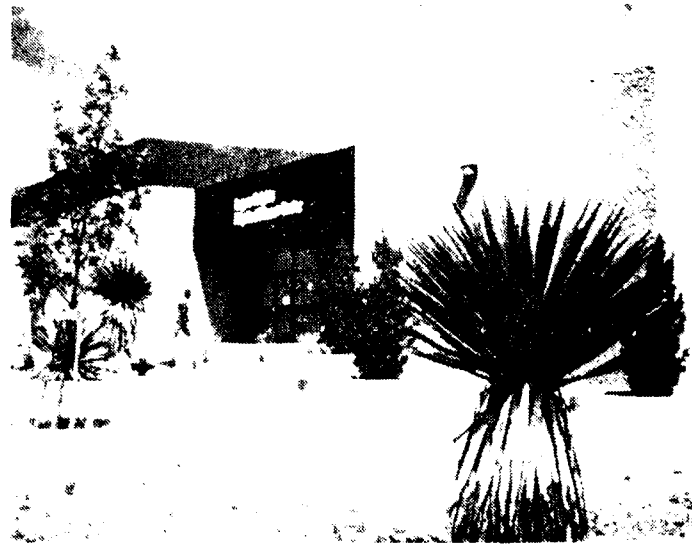


Figure 5. Completed physical fitness center—Fort Bliss.

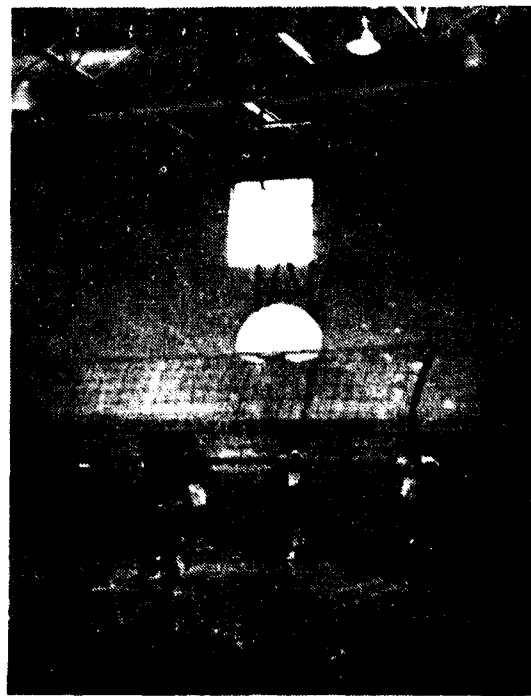


Figure 6. Gymnasium interior—Fort Bliss.

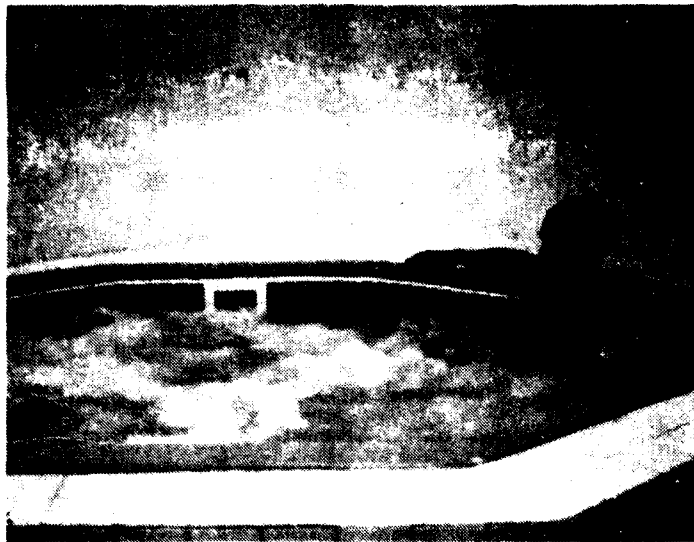


Figure 7. Whirlpool—Fort Bliss.

4 PHYSICAL FITNESS CENTER, FORT STEWART, GA

Project Description

The physical fitness center at Fort Stewart, GA, FY85 MCA PN 285, is a multi-purpose physical training facility. It includes a spectator competition gymnasium with a seating capacity of 3000, an indoor natatorium, five handball/racquetball courts, an exercise room, a weight training room, locker and dressing facilities, administrative and control areas, and storage and support spaces. The scope is 62,000 sq ft with a PA of \$5,300,000. The Morale Support Agency is the using service for the facility. This physical fitness center was obtained through One-Step "Turnkey" procedures. The USACE Savannah District (SAS) administered the design and construction of the facility. The project was still under construction at the time this report was written.

Predesign Activities

The physical fitness center was programmed for FY84 and SAS initiated design activities typical for an MCA project. AE services were contracted and design had progressed through concept development. This project was later reprogrammed to FY85, although this action had nothing to do with its being a One-Step test project.

On 30 September 1983, HQUSACE issued a directive to initiate One-Step Competitive Negotiation ("Turnkey") procedures for the project. This directive referenced HAC Report 98-238 (discussing alternative construction methods), and included instructions to develop performance criteria in a way that permits the widest possible competition and maximum participation.

HQUSACE convened a meeting of SAS, USA-CERL, and its own personnel to discuss the project, One-Step Facility Acquisition, and Congressional interest in this project. (SWF also attended as described in Chapter 3.) SAS had had previous experience with the "Turnkey" approach in Army Family Housing projects: the One-Step acquisition of a commissary at Fort Stewart and the Two-Step acquisition of a fire station at Fort Stewart. An RFTP from a successfully completed Two-Step physical fitness center at Fort Benjamin Harrison, IN, and USA-CERL Technical Report P-85/05 were provided at the meeting for background. SAS foresaw no difficulty or extraordinary efforts involved with implementing One-Step "Turnkey" procedures.

SAS did register one concern about the project. The District already had an investment in a concept design (about \$134K), which was believed to be excellent, and did not want to abandon it completely. SAS therefore planned to use the concept design to the extent practical as a basis for the RFP.

RFP Development

The SAS Engineering Division developed a draft RFP that, for the most part, reflected the original concept design. The draft RFP contained the floor plans, elevations, sections, wall sections, and various details from the original concept design. Specifications were mostly prescriptive, with references to industry standards for the construction type and materials used in the concept design. Some standard USACE design criteria documents were also included, such as seismic support for utilities, handicapped design standards, and swimming pool equipment specifications. Proposal

evaluation criteria were provided in the RFP. It was the District's intent that the original concept design would serve as a "benchmark" or prototype design for proposals--proposers could submit the design provided in the RFP or develop alternative designs that offered the same functions and performance as the prototype.

Both HQUSACE and USA-CERL expressed concerns about this approach. It was noted that this approach reduced a proposer's opportunity to initiate innovation or economy in a proposal, and that, as a result, participation in the procurement may suffer. HQUSACE instructed SAS to revise the RFP to be consistent with the objectives of maximizing competition and participation by prospective proposers. The revision entailed deleting some prescriptive material from the specifications, describing more building requirements in functional terms, and deleting construction details from the drawings.

During the RFP's development, the PA for the facility was reduced from \$6.2M to \$4.8M, or by about 20 percent. Thus, the maximum contract award was \$4.8M.

The RFP, as advertised, contained floor plans, elevations, and building sections from the original concept design. Site drawings depicted existing conditions but did not include a specific site design or arrangement; that was left as a proposer option. Instructions to proposers covered proposal preparation and submittal, as well as listing the maximum contract amount of \$4.8M. Specifications included functional requirements for the facility along with prescriptive specifications and references to industry standards for the materials and construction types represented in the concept design. The RFP also contained the standard USACE design criteria documents described earlier. Proposal evaluation criteria were provided. The RFP indicated that proposers could submit the design as shown, or propose an original design that achieved the same functions and performance as the RFP prototype.

As discussed further under **Development of Proposals** below, the project had to be readvertised. Two factors were the major reasons for this occurrence. First, the concept design and, subsequently, the RFP were developed around the original PA. However, the RFP was not adjusted to compensate for the reduced PA. Second, the design represented in the RFP (the original concept design) was definitive. That is, plan configuration, dimensions, appearance, architectural detailing, and structural layout were established by the design. Thus, it offered little flexibility for modification and limited the opportunity for proposers to exercise technical or economic innovation.

The RFP was revised significantly for the readvertisement. USA-CERL and HQUSACE cooperated with SAS, the Fort Stewart Directorate of Engineering and Housing (DEH), and the using agency in this revision.

A cost reduction exercise was conducted to adjust the facility requirements and promote a design more compatible with the reduced PA. The concept design was essentially abstracted to a single-line plan to represent the facility's basic requirements. Current USACE guidance on physical fitness center design was also incorporated into that plan. Tables and supporting text were developed to clarify requirements such as minimum floor areas, functional requirements for areas, critical dimensions, circulation within the building, finishes, and essential equipment. Descriptions of architectural appearance and detailing requirements also were written, along with the requirements for site design.

Much of the prescriptive specification material was deleted or revised, and functional requirements and industry standards for additional construction types and

SAS, through South Atlantic Division (SAD), requested permission from HQUSACE to readvertise the project. HQUSACE could authorize awarding a contract if the price were within 115 percent (i.e., an additional 15 percent) of the Government estimate. HQUSACE directed SAS to readvertise the project, increasing the allowable contract amount by 10 percent. This arrangement would still give the Government latitude to award a contract if prices were to be submitted within 105 percent of the revised maximum amount now indicated in the RFP.

The revised RFP (see previous section) was readvertised on 14 June 1985. The total period of time given to submit proposals was 45 days (30 July 1985).

Development of Proposals

A preproposal meeting was held at Fort Stewart about 2 weeks after the RFP was advertised for the first time. Twelve firms were present, most of which were general contractors who planned to coordinate with AE firms in developing proposals. SAS, HQUSACE, USA-CERL, Fort Stewart DEH, and the using agency also were represented. The primary discussion topic was the maximum allowable contract amount. The general consensus among potential proposers was that the facility represented in the RFP would be considerably more costly than the available contract funds could support.

Only one proposal was submitted in response to the RFP. It represented the design shown in the RFP (the original concept design); no additional design work was submitted. The proposal price was \$5,455,000, or \$655,000 over the maximum allowable contract amount of \$4,800,000. The proposer, however, included a list of items that could reduce the facility's cost to within the maximum awardable amount. Among these items were simplifying the floor plan, using a preengineered structural system (which was not addressed in the RFP), substituting a synthetic gymnasium floor for the wooden floor specified, and generally providing less expensive finish materials. No further description was provided for these items, however, and the District judged this proposal to be non-responsive.

No preproposal meeting was scheduled upon readvertisement of the RFP and there were no extraordinary inquiries or difficulties during the proposal period.

Three proposals were submitted in response to the RFP's second advertisement. These proposals showed a high degree of diversity. One followed the schematic plan included in the RFP very closely, one modified it to some extent, and one developed essentially an original design around the RFP schematic plan. Design approaches for exterior appearance also varied. All proposals used brick masonry exteriors, although all designs were distinctly different. One proposal called for a preengineered structural system and standing seam metal roof, while the others used conventional structural steel frame and masonry construction.

All proposers indicated that the proposal preparation time was too short, and that at least 3 more weeks should be allowed for a facility of this scope and complexity. The short proposal time discouraged at least one potential proposer from developing and submitting a proposal. Proposers also indicated that USACE should allow greater flexibility in using commercial standards and specifications.

Proposers were generally in favor of the One-Step "Turnkey" approach for military facilities. One advantage expressed was that the contractor is involved in the development of the design and the construction detailing and documents. Furthermore,

proposers acknowledged that any errors made in the construction documents would be their own liability and could not be claimed as contract modifications.

Evaluation of Proposals

SAS elected to evaluate proposals using a price/quality ratio as a numerical indicator of the best overall value to the Government. A proposal's price is divided by its quality point score, resulting in a "dollars-per-quality-point" ratio. This is the evaluation method used in all military Turnkey Family Housing programs.

The three proposals were received by the P&S Division. Technical material was separated from pricing materials for later determination of price/quality ratios, and reviewed to confirm that it contained no proposer identification. Bond requirements and other required submittals were checked.

The SAS Engineering Division Project Manager distributed the proposals to his personnel to evaluate them and verify their conformance with the provisions of the RFP. Some areas of nonconformance were noted for each proposal, although none serious enough to consider dropping a proposal from further consideration.

The quality scoring evaluation was conducted by representatives from SAS, SAD, HQUSACE, USA-CERL, the MACOM (U.S. Army Forces Command--FORSCOM), the using agency, and the Fort Stewart DEH. Each agency was to submit one evaluation representing all disciplines within that agency. A score would be the total of scores from each team. Each agency was to evaluate and score the proposals individually; then a meeting of all evaluators would be convened to discuss the proposals and revise the scoring if appropriate. All evaluation teams were provided a set of proposal documents at their own locations. Evaluation results were submitted to SAS.

The evaluation proceeded smoothly, except that all three proposals required some clarification, were lacking some necessary information, or were not in accordance with some requirements of the RFP. All such items were documented and each proposer was notified of the additional submittals required and of any deficiencies needing correction. One proposal required revision of the floor plan to provide the functional arrangement represented in the RFP. All three proposers submitted the appropriate clarifications and additional information.

A final evaluation meeting was held at Fort Stewart. The evaluation teams reexamined the additional submittals and amended their original scores as appropriate. Proposal prices were not divulged to the quality scoring personnel.

Following the point scoring evaluation, the Engineering Division Project Manager established the price/quality ratio and made a recommendation for contract award. The Government cost ceiling was \$5,280,000, with proposers finishing as follows:

1. \$4,575,000--McKnight Construction Co., third in quality points
2. \$5,034,000--Doster Construction Co., second in quality points
3. \$5,984,000--DAVCON Corp., first in quality points.

In this case, the price/quality ratio indicated that the McKnight proposal provided the best value to the Government.

SAS personnel indicated that, although the selected proposal presented an entirely satisfactory design, the other two were outstanding design and construction solutions. It must also be noted that each of the three proposals was scored the highest in quality points by at least one of the evaluating agencies. The selected proposal's price gave it the advantage with the price/quality ratio being the basis for contract award.

The evaluation process took 8 weeks in total, from receipt of proposals to determination of a winner.

Construction Documentation

The contract was awarded on 19 September 1985. NTP was given to the contractor on 9 December 1985, and the period for completing documentation and construction was 450 days, as specified in the RFP. There was no requirement for accelerating the construction schedule; therefore, fast-tracking was not considered, although site work was authorized while construction documents were still being developed.

The RFP required the contractor to submit Design Development Documents within 30 days after NTP, representing approximately 35 percent design completion. Final Construction Documents were required within 120 days after NTP. The final construction documents included design and engineering analyses, construction drawings, and specifications for the facility. The construction documents were to be reviewed and approved prior to the commencement of work.

The contractor submitted the complete construction document package for review and approval on 17 January 86. The District Engineering Division reviewed the documents and submitted a list of required revisions about 6 weeks later.

Some minor difficulties occurred with the revisions. The contractor noted that the ceiling system for the natatorium as specified in the RFP was inappropriate for that application. SAS concurred and allowed the contractor to provide a different ceiling material. The contractor also noted inconsistency in review comments at different submittals. This was attributed to different personnel reviewing different submittals.

One major problem was encountered during review and approval of the contractor's swimming pool design. This item is discussed below under **Construction Administration**.

The contractor was allowed to proceed with foundation construction, wall and structural construction, and utilities for those portions of the facility not impacted by the swimming pool design.

Overall, the contractor was anticipating a quicker turnaround time in review and approval of construction documents, although this phase was not assigned a time limit in the RFP. Thus, the Government had no deadline for review and approval. There also appeared to be some ambiguity regarding the RFP's provisions for the minimum time to which the Government was entitled.

SAS indicated that, in general, the quality of the contractor's construction documents was as good as normally expected with a conventional MCA price package.

Construction Administration

The contractor acknowledged receipt of NTP on 9 December 1985. The completion of the construction documents was scheduled for 17 January 1986 and site preparation work began almost 6 weeks later.

Construction activities progressed without incident, pending approval of the required resubmittals. Within 4 months of the start of construction, the foundations for one-third of the building were completed, the north wall for the gym was erected, under-slab utilities for the gymnasium and the handball/racquetball courts were placed, and excavation for the pool was completed. Figures 9 and 10 show construction in progress.

One major complication delayed the project. The problem involves the design for the in-ground swimming pool and accommodation of the high water table at Fort Stewart (see Figures 11 and 12). A stainless steel pool was required by the RFP for ease of maintenance, although this design would create a buoyancy condition when the pool was emptied for cleaning. Thus, uplift restraint was critical. The SAS Engineering Division did not feel comfortable with the contractor's swimming pool design and, therefore, did not approve it for construction. The contractor maintained that the design was suitable. An impasse occurred, with the District unable to prove conclusively that the contractor's design was not satisfactory, and the contractor unable to prove conclusively that his design was, indeed, suitable. Furthermore, there was no example available for this particular type of pool design in this situation, so there was no precedent on which to base a conclusion. No areas of nonconformance with the RFP could be identified. A stop work order was issued until the swimming pool design could be resolved. The District initiated an alternative design for the pool's anchorage system. After approximately 1 month, SAS approved the contractor's design, with revisions. No contract modifications or additional costs relative to the swimming pool were incurred by the Government. Table 2 summarizes cost data for this project.

Work resumed on 23 July 1986. Final approval of the construction documents was issued on 30 July 1986. Completion of the facility was originally scheduled for 24 April 1987. A time extension was granted, and the actual completion date was 3 September 1987.

Summary of Findings

Difficulties were encountered in this project's development and procurement. The first advertisement of the RFP resulted in only one proposal, which was judged to be non-responsive. Although many factors probably contributed to this situation, two seem to have had the greatest impact: (1) the RFP was not adjusted to reflect the new PA and (2) use of a definitive design in the RFP which allowed too little flexibility for modification, and therefore limited opportunity for proposers to exercise technical and economic innovation. This outcome demonstrates that a strong predisposition toward a definitive design is not consistent with a One-Step "Turnkey" approach when innovation and creativity are being sought from the design and construction communities. In contrast, the three proposals submitted in response to the readvertised RFP contained diversity in design and construction approaches, demonstrating the potential for technical and economical innovation, given the opportunity.

Another problem occurred with final approval of the contractor's swimming pool design. Essentially, the District and the contractor reached an impasse. If a similar situation occurs in future One-Step and Two-Step projects, it should be emphasized that

a resolution must be expedited to the greatest extent possible to avoid delays in construction and all adverse consequences therein. Both the contractor and the District must be willing to reach a conclusion in a short time.

The review and approval of the contractor's construction documents created some minor difficulties for the project. There were some inconsistencies in SAS review comments which resulted from a turnover in review personnel. The contractor indicated that this necessitated some duplicative revision efforts. No major problems resulted. In future projects, however, care should be taken to maintain consistency in instructions to the contractor. Of greater consequence was the turnaround time for review and approval of the documents. The contractor had expected a faster response from the District, although this period was unregulated in the contract documents. The RFP, in future One-Step and Two-Step projects, should indicate both minimum and maximum turnaround times for the Government's review and approval of the contractor's construction documents.

Despite setbacks in this project, it remains successful in terms of total cost. Actual project costs (including the original concept design and all RFP development costs), are significantly lower than were estimated for a conventional MCA project.

The project also is likely to remain successful in terms of quality. Although the winning proposal was third in quality points ranking, it represents a completely satisfactory design. In fact, at least one evaluation team scored this proposal as the highest of the three. Nothing to date indicates that construction quality has been compromised in any way due to the One-Step "Turnkey" approach. Using agency personnel have indicated that the facility is completely satisfactory and functions at least as well as expected. There are, however, some exceptions. The location of fire extinguisher cabinets and drinking fountains in the gymnasium (at the ends of the basketball courts) makes them susceptible to damage. They should have been located in more protected areas. Also, there are no outlets for power or scoreboard control from the scorer's table location. The user feels these items might have been detected during the completion of the design.

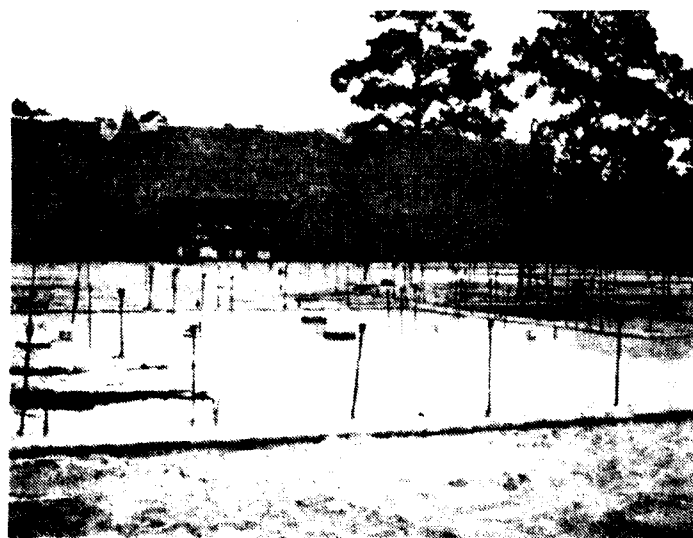


Figure 9. Gymnasium construction—Fort Stewart.



Figure 10. Swimming pool excavation—Fort Stewart.



Figure 11. Draining the swimming pool excavation—Fort Stewart.



Figure 12. Appearance of the water table—Fort Stewart.

Table 2

Cost Comparison Summary: Physical Fitness Center, Fort Stewart, GA

Government estimate

1) Design*	\$316,800
2) Bid**	5,280,000
3) Construction contingencies***	264,000
4) Supervision & administration (S&A)+	<u>277,200</u>
5) Total est'd, conventional design & construction	\$6,137,200

Actual

1) Design (RFP prep., incl. concept design)	\$279,153
2) Proposal price	4,575,000
3) Construction contingencies	68,625
4) S&A++	<u>240,188</u>
5) Total actual, design & construction	\$5,162,966

= 16% less than conventional

Construction Costs Only

1) Government estimate	
Contract cost	\$5,280,000
Contingencies	264,000
S&A	<u>277,200</u>
Total construction cost	\$5,821,200
2) Actual (to date)	
Construction cost+++	\$4,316,000
Contingencies	68,250
S&A++	<u>240,188</u>
Total construction cost	\$4,624,438
3) Construction cost difference	\$1,196,762

= 20% less than conventional

*Conventional design estimated at about 6 percent of the conventional construction estimate.

**Government estimate for construction, based on conventional.

+ Five percent of Government estimate.

++Five percent of the sum of the Government estimate plus construction contingencies.

+++Contract amount minus contractor's AE design costs.

5 PHYSICAL FITNESS TRAINING CENTER, MUENSTER AD, WEST GERMANY

Project Description

The physical fitness training center (FY84, MCA PN 419) is a facility with a 72 ft by 96 ft gymnasium (about 6900 sq ft) with accompanying locker room/administrative functions. Total area is 11,370 sq ft. This facility will house various activities including basketball and volleyball. Because this facility is outside the continental United States (OCONUS), it is classified as semipermanent. USACE European Division (EUD) administered design and construction of the facility using Architectural Fabric Structure technology.

Pre-design Activities

This facility was to be designed and constructed as a conventional steel frame and masonry building following the standard "indirect/indirect" practice. In this procedure, the design is executed under direction of USACE, but with the AE being contractually responsible to the German government (i.e., "indirect" design). Similarly, construction is administered by the USACE, but the construction contract is awarded by the German government (i.e., "indirect" construction). Figure 13 represents the original conventional design.

HASC, in HR 98-166, designated this project as an Architectural Fabric Structure test project. The conventional design was at the 90 percent complete stage when HQUSACE issued a directive to use the fabric structure technology for this project.

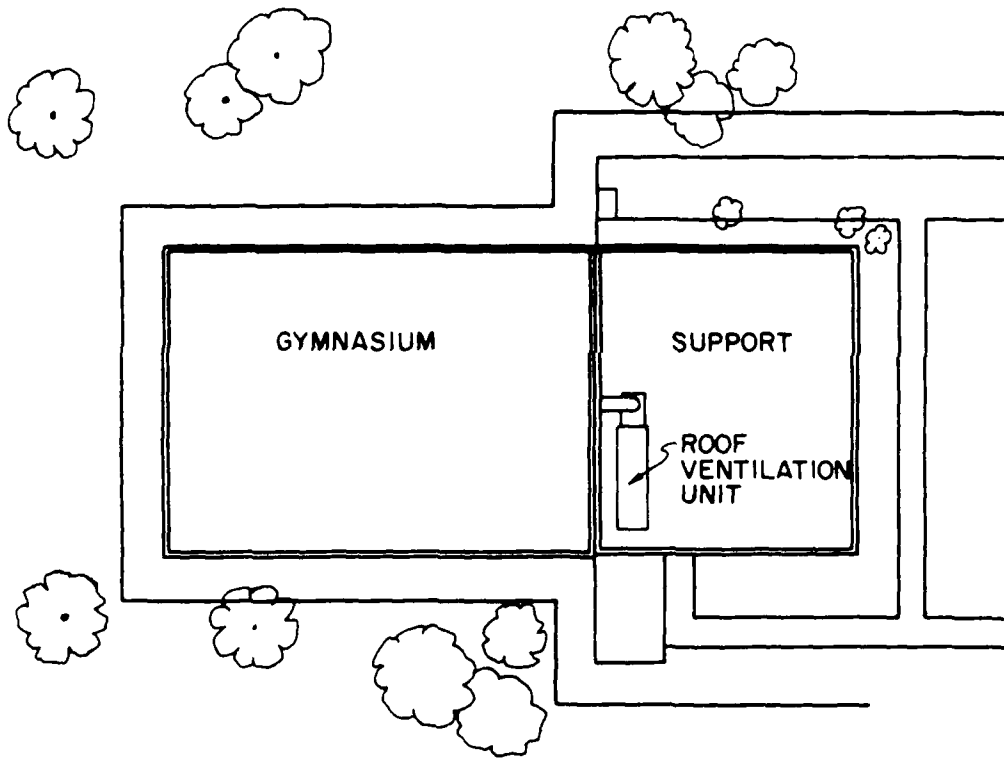
Three issues became evident at the outset of the fabric structure design:

1. Whether to set aside the project for U.S. fabric structure building systems only
2. Because U.S. building systems would be involved, whether to conduct either or both the design and construction phases as "direct"
3. How to design a fabric structure without precluding proprietary products from any single fabric structure manufacturer.

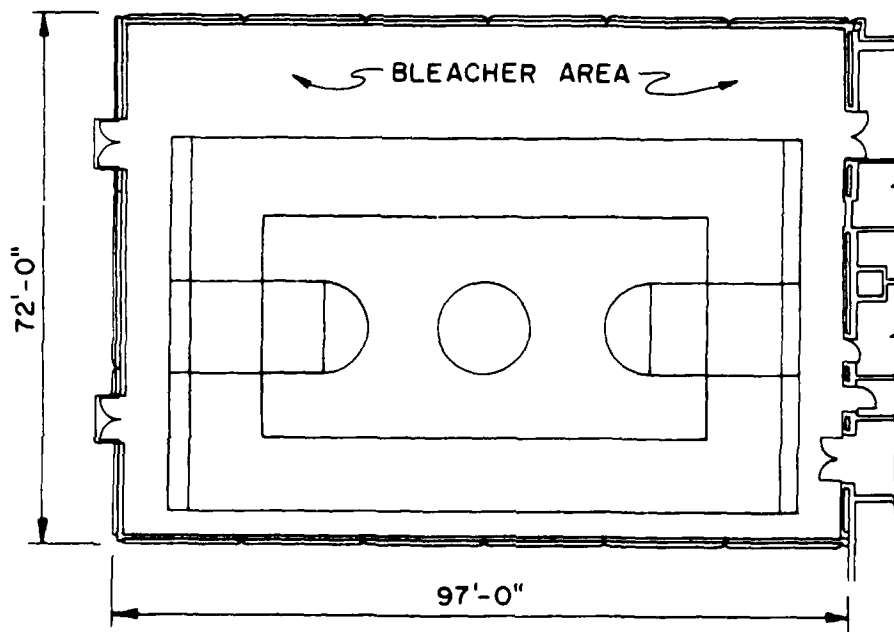
After much deliberation, these issues were resolved. The project would be open for both U.S. and German fabric structure building systems. The German government did not want to relinquish involvement with design and construction of this facility, so the "indirect/indirect" arrangement was maintained. A One-Step "Turnkey" approach was adopted to allow the proposal of a variety of design solutions for the facility.

Fabric Structure Design Development

Because fabric structures are better suited to larger, open-space requirements than to a cellular, subdivided space, it was decided that the gymnasium portion of the facility would be the fabric structure. The locker room "core" area would be constructed of conventional materials.



SITE PLAN



GYMNASIUM FLOOR PLAN

Figure 13. Original conventional design, physical fitness building.

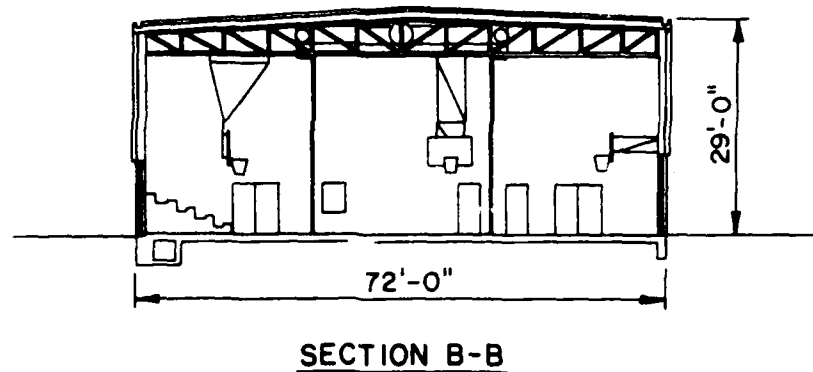


Figure 13. (Cont'd)

Another issue was raised: should this project use U.S. construction standards and criteria, should the German Standards Institute (DIN) standards be referenced, or should each potential source of fabric structure building system adhere to its own "native" design and construction criteria? Again, after much deliberation, it was decided to rely on the DIN standards as the basis for all technical specifications. One consideration was that, if U.S. manufacturers were to participate in European projects on an ongoing basis, they eventually would have to conform to European criteria. Complications anticipated with the German government's approval of a facility designed to standards other than those of DIN also influenced this decision.

Originally, the physical fitness center was not intended for spectator purposes and therefore would not be classified as an "assembly" occupancy for fire safety considerations. However, it became apparent that these facilities often support community-type events among the military families. Although not an "assembly" facility per se, it would have been unrealistic to assume that a large number of people--youth groups, etc.--would not occupy the facility on occasion. Therefore, it was concluded that abiding by the fire safety criteria of an "assembly" occupancy would be prudent.

This classification required that any part of the building not of 1-hr fire-resistive construction be no less than 25 ft above the floor and be classified as "noncombustible." This translated into a requirement for 25-ft-high, 1-hr fire-resistive walls for the gymnasium. The fabric structure would therefore be the gymnasium roof. To comply with the requirement for noncombustible materials, a Teflon[®]-coated fiberglass fabric interior liner was considered. However, vinyl-coated or vinyl-laminated polyester fabric was to be allowed because, although not noncombustible, it is fire-resistant and will not support combustion by itself.

Bid Documentation

The RFP was prepared by MMM GmbH, Frankfurt, West Germany. USA-CERL supplied design information, technical data, and specification guidance to EUD and to the AE. The AE and EUD gathered additional fabric structure information on their own.

The RFP included a performance specification for the fabric structure roof. Design requirements for the gymnasium were represented graphically as three different approaches to the fabric roof, although proposers were at liberty to develop their own designs. The remainder of the facility was designed and detailed as usual, and all conventional construction was specified by reference to DIN standards, as is customary for German construction.

RFP development had to address requirements for proposal preparation and submittal. It is standard practice in Germany for a construction contractor to seek reimbursement for any design documentation that may be required for a construction project. It was feared that all proposers would seek compensation for their proposal efforts. Therefore, the RFP contained language making it clear that proposers were not entitled to a reimbursement for proposals. It was assumed that the bulk of the proposal preparation effort would be borne by the fabric structure manufacturers and that little actual design work would be done by the local general contractors.

Procurement

The question arose as to how U.S. fabric structure manufacturers would participate in this project. Since the U.S. companies would have to coordinate with a German general contractor, they would have to know which contractors were interested in this project. However, while distributing plan-holder lists is common practice in CONUS USACE construction, it is prohibited under German law. Once a project is advertised, the German government will not divulge the identities of contractors requesting bid documents. Furthermore, it was feared that providing the German contractors with a list of U.S. fabric structure manufacturers would be interpreted as a "prequalification," or otherwise exclusionary. Also, it could not be guaranteed that all manufacturers would be included on such a list.

EUD resolved this issue by providing U.S. fabric structure manufacturers with a list of German general contractors who usually participate in USACE construction projects. It was emphasized that this listing was general, based on past project experience, and did not represent any special interests in the physical fitness center project. U.S. manufacturers were to make arrangements with German contractors as they saw fit.

The physical fitness center RFP was advertised according to normal German practice. RFPs were provided to 45 U.S. firms and 27 German firms. Seventy days were allowed for preparation and proposal of submittals.

German contractors' interest in U.S. fabric structure systems turned out to be quite low. Furthermore, many U.S. fabric structure manufacturers declined to participate in this project because they are not familiar with the DIN standards referenced in the specifications; also, it is difficult to make overseas business arrangements.

Proposals were evaluated by EUD and the German government. Since the procurement was intended to be a "Turnkey" approach, both quality and price could be factored into the contract award decision. However, because the German government was ultimately responsible for the construction contract (i.e., the "indirect" construction), they elected to award the construction contract based on the lowest price submitted.

The final current working estimate (CWE) based on contract award was \$1,168,867, which was about 12.5 percent lower than the PA of \$1,320,000. The winning proposal used a fabric structure roof designed and produced by Carl Nolte, GmbH, a well known German fabric and fabric structure manufacturer.

EUD did not develop an estimate for a conventional roof system as a basis of comparison for fabric structure roof construction. No separate cost for the fabric structure roof was provided by EUD for this report.

A concept stage design was developed for the facility based on projections for conventional construction; the Code B CWE* for that design was roughly \$1,040,200. Using this figure as a basis of comparison, the fabric structure alternative appears to have cost about 15 percent more than the cost estimated for conventional construction. However, it must be emphasized that this comparison cannot be considered precise because it compares a final CWE with a concept cost estimate. In addition, fluctuations in currency exchange rates during that period of time further distort a direct cost comparison.

Construction Documentation

The final construction contract documents were prepared by the winning contractor, with review and approval by the EUD Technical Branch and Construction Division. Most documentation (working drawings and specifications) for the conventionally constructed portions of the building were provided in the RFP documents. Nolte provided the engineering design and construction documents for the fabric structure roof. The quality and completeness of the construction documents were equal to those of traditional MCA project documents.

Construction Administration

No information is available from EUD on this project's construction administration. However, no construction problems of any consequence have been reported. The final construction cost (including contingencies) also is unavailable. It is understood that there were no extraordinary costs incurred above the contract award amount.

Building Technology

No details or photographs of the final design and completed facility are available.

Closeout and Occupancy

No specific information on the project's closeout and occupancy is available, but it is understood that the using agency is completely satisfied with the facility, which is said to be serving its purpose well. No problems with the facility's use or maintenance have been reported.

Summary of Findings

The total projected cost of the physical fitness center using a fabric structure roof was some 12 percent lower than the Government estimate. However, since no final estimate was developed for the facility as if it had been built completely conventionally, costs cannot be compared precisely. The final CWE was about 15 percent higher than the

*This is the concept-stage estimate based on 35 percent design.

concept stage estimate for all-conventional construction. Currency fluctuations, however, make such direct cost comparisons unreliable.

Little information could be obtained regarding construction and occupancy of the physical fitness center. However, all accounts indicate that no problems have been encountered and that the facility's performance is satisfactory.

The fire occupancy classification for the physical fitness center did not indicate an "assembly" requirement. However, it was determined that the activities likely to take place in the facility (unrelated to physical fitness training) suggested an "assembly" function. Although this change did not preclude the use of architectural fabric structure technology, it did require a modification to the design approach. Any future consideration of fabric structure technology for these types of facilities--that is, those which may serve multiple purposes in addition to the originally intended function--must address the requirements for all anticipated uses.

According to EUD, proposers said that a 70-day proposal period was too short. A 90-day period may have been more realistic.

EUD also reported that the One-Step "Turnkey" procurement approach was very difficult to implement in Germany, primarily because (1) German general contractors are not accustomed to preparing design proposals without compensation and (2) the "indirect/indirect" design and construction system places the ultimate decision for contract award with the German government, not USACE.

In retrospect, it is clear that U.S. fabric structure manufacturers had only a slight chance of providing products for this project because:

1. Unless this project was a set-aside for U.S. fabric structures only, local fabric structure building systems would hold a competitive advantage because of lower shipping costs and, if nothing else, convenience to the German construction community.
2. U.S. fabric structure manufacturers were generally not familiar with DIN standards and would have had to redesign their building systems. This fact discouraged many from participating in the project.
3. German law prevents the disclosure of firms requesting bid documents for public projects. Therefore, it would be difficult for U.S. fabric structure manufacturers to make appropriate contacts in the local construction community.

6 DIVAD RANGE BUILDINGS, FORT BLISS, TX

Project Description

The DIVAD Range is a target range facility on which several small buildings are located--the three subject buildings plus some others. The general purpose building (5200 sq ft) is a multiuse building expected to provide storage, shelter from inclement weather, and assembly of personnel for instruction. Building dimensions are approximately 52 ft wide by 100 ft long. The building also requires a height of about 20 ft. One overhead door is to be provided as well as personnel doors and windows.

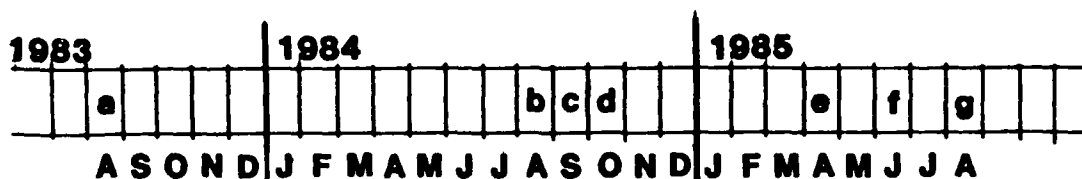
The target maintenance building (2400 sq ft) is approximately 33 ft wide by 68 ft long and 20 ft high. It is to have two overhead doors as well as personnel doors and windows. Two small offices will be enclosed with interior partitions. A ceiling-hung 2-ton crane is required in this building.

The two sun shelters (840 sq ft each) are simple open-sided pavilions approximately 22 ft wide by 40 ft long. Each is 16 ft high.

The general purpose building and target maintenance facility are fully enclosed, and require lighting and electrical systems, HVAC systems, plumbing, doors, and windows. All fabric structures require concrete foundations and floor slabs.

All facilities are considered to be permanent with a life expectancy of at least 25 years. To accommodate structures that use vinyl and polyester fabrics (which have a life expectancy of about 15 years), a minimum fabric life of 15 years is required, after which the fabric canopy can be replaced.

The USACE SWF administered the design and construction of this project (FY84, MCA PN 406). Figure 14 shows the project events by month.



- a. Directive to use AFS for Subject Buildings - Aug 1983**
- b. Invitations for Bid - Aug 1984**
- c. Bids Due - Sep 1984**
- d. Contract Award - 5 Oct 1984**
- e. Construction Documentation Approval - 19 April 1985**
- f. Start Construction - 6 July 1985**
- g. Finish Construction - 28 Aug 1985**

Figure 14. Project events by month--Fort Bliss DIVAD range fabric structures.

Predesign Activity

The consulting engineer firm of Freese and Nichols, Inc., Fort Worth, TX, was contracted to prepare the designs and construction documentation for the project. The subject buildings were originally designed as conventional metal structures (see Figures 15 and 16) and had progressed through the concept design stage. After HASC Report 98-166 designated the general purpose and target maintenance buildings as fabric structure test projects, these buildings had to be redesigned.

SWF obtained design and technical data directly from a list of fabric structure manufacturers maintained at USA-CERL. This information was relayed to the consulting engineer for use in preparing the specifications. USA-CERL was not consulted for any further assistance in obtaining information or input for the designs and specifications.

Fabric Structure Design Development

Requirements for the fabric structures were represented by brief specifications and drawings as part of the total construction document package for the training range. Specifications included items such as structural requirements (wind loads, snow loads, etc.), installation requirements (quality assurance, warranty, erection procedures, etc.), and submittal requirements (design calculations, test results, samples, etc.). The specifications allowed manufacturers to propose their standard building systems and did not prescribe specific details or practices. Therefore, the specifications required submittal of design analyses, material samples, and shop drawings during construction. The specifications indicated that the sun shelters could be built using fabric structures at the contractor's option. A "schematic" design included plans, sections, and elevations for the general purpose and target maintenance buildings. The drawings displayed definitive building dimensions and included no provision for deviating from those dimensions.

Bid Documentation

Bid documents were typical for those of a training range. Fabric structures were represented by a brief specification and two drawings within that package. The rest of the buildings' designs and site work for the range were developed as for conventional construction and specified in the usual descriptive way.

Procurement

Initially, the structures in this project were to be metal buildings, which was reflected in the PA and Government cost estimates. Estimates were then prepared for the use of fabric structures. For the two sun shelters, the contractor's selection of fabric structures was optional and therefore not required as a line item in the bid schedule.

The project was procured via traditional competitive bidding. The subject buildings were to be built using fabric structures, whereas the remaining buildings were to be of conventional or preengineered metal building construction. Bidders were required to identify the fabric structure costs as line items in their total bid for the project. Contract award was based on the low bid for the total project.

The subject buildings represented only about 3.5 percent of the entire construction cost for the range. No design, technical proposal, or documentation for the fabric structures was required for review prior to contract award. The choices of manufacturer and building system were left at the contractor's discretion.

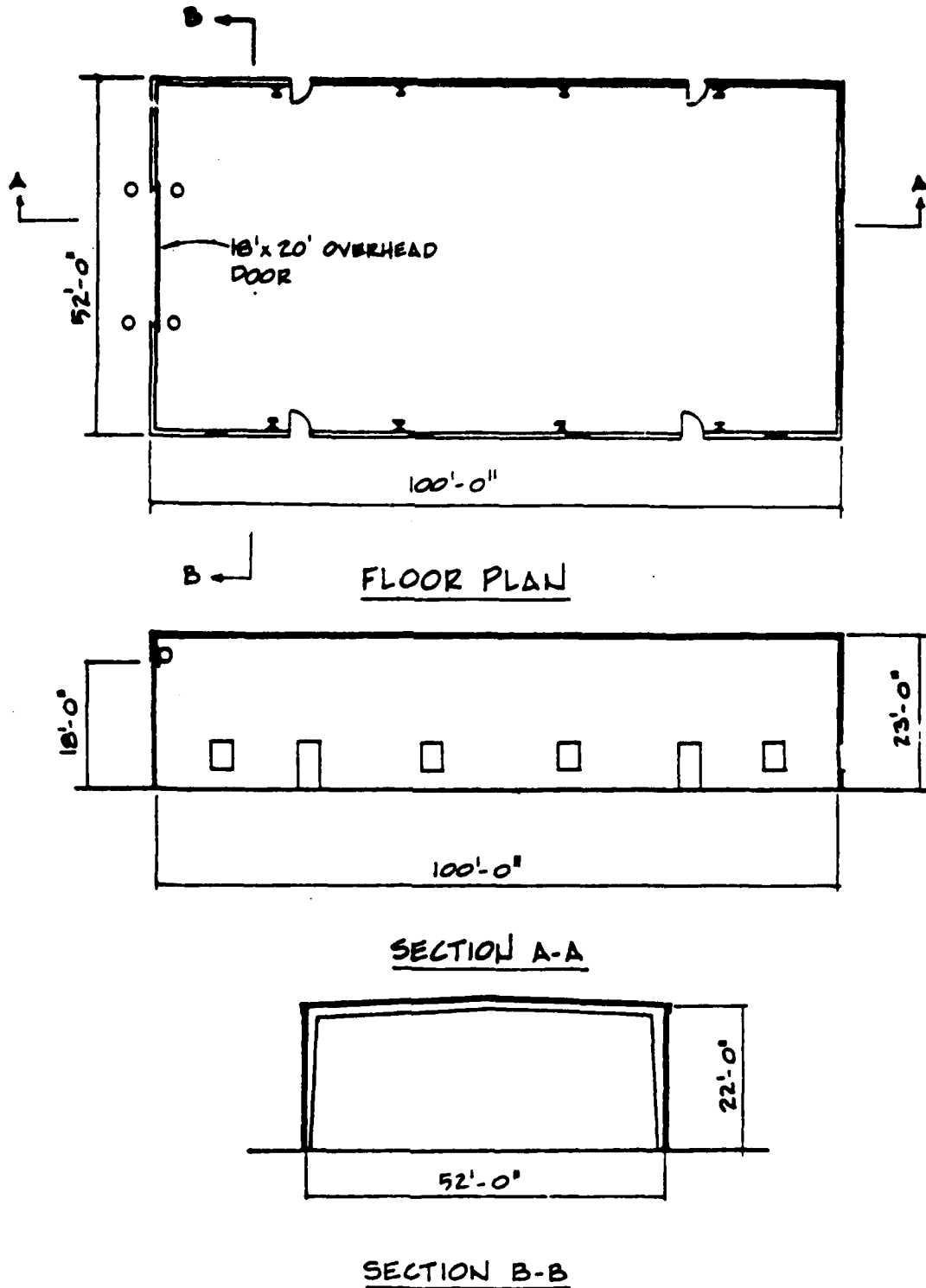


Figure 15. Original conventional design—general purpose building.

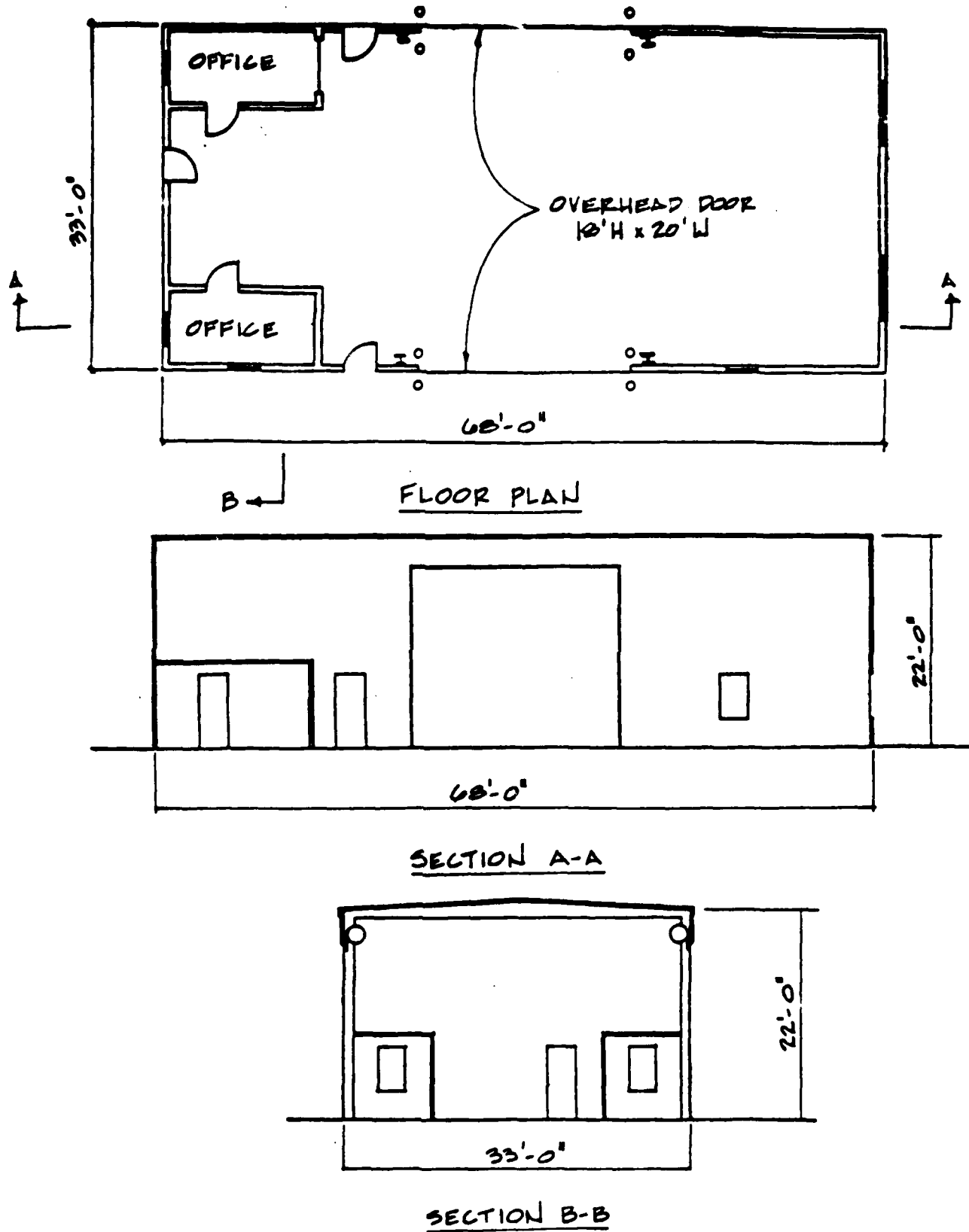


Figure 16. Original conventional design—target maintenance building.

Bids were received from five general contractors. Bid prices ranged from \$264K to \$450K for all of the fabric structures. The lowest price for the target maintenance building was \$102K, and \$120K for the general purpose building. The contract was awarded to Silverton Construction Co., El Paso, TX, which listed the price for the general purpose building as \$128K, and \$144K for the target maintenance facility. Prices for the sun shelters were neither requested nor provided in the bid schedule. It should be noted that line-item prices for the buildings were included for information only and could be considered as "bids" for the fabric structures. In preparing its bid, Silverton obtained fabric structure price quotes from two manufacturers and chose the fabric structure building system based on the lower value (Roder Building Systems).

A precise cost comparison between fabric structures and conventional construction is not possible for two reasons. First, a final Government estimate was not prepared for conventional construction; only a concept stage (35 percent design completion) Code B estimate was developed. Second, bidders were requested to identify fabric structure costs as line items in their bid schedules. However, since contract award was based on the low bid for the total project--not on the fabric structures alone--the fabric structure costs are not binding and can be considered only as information. It is assumed that the fabric structure costs indicated in the bid schedule are reasonable, if not precise. Furthermore, since the sun shelters were an option to the contractor, no separate line item cost was required. Therefore, no cost estimates are available to compare with those for conventional construction. A relative cost comparison can be found in Table 3.

Concept stage estimates for conventional construction of the general purpose and target maintenance buildings were \$33.50 and \$41.80 per sq ft, respectively, including contingency and supervision and administration (S&A) factors. The final costs of the fabric structures were \$25.85 per sq ft for the general purpose building and \$63 per sq ft for the target maintenance building. The fabric structure costs include the line item cost (from the bid schedule) and the standard S&A factor. There were no contingency costs. The average costs for both buildings were \$36.12 for conventional construction (concept estimate) versus \$37.58 for fabric structures (see Table 3).

Construction Documentation

Silverton submitted the Roder Building Systems design, engineering analysis, and shop drawings to SWF. Only at this time did it become evident that Roder Buildings could not be used for this project. Roder had its aluminum structure manufactured in Germany and shipped to the United States. This arrangement was not in accordance with the buy-American provisions of MCA construction contracts. At Roder's recommendation, Silverton contacted Fabric and Structures Technology (FAST); arrangements were made for FAST to design, fabricate, and supply the fabric structures.

The bid package drawings and specifications gave no indication that proposals could deviate from the building dimensions listed. Only the square footage requirements of the facilities were shown. The manufacturer and contractor noted that the dimensional requirements depicted on the drawings required them to depart from their standard building system dimensions and to design a "custom" building. Furthermore, the abbreviated timeframe under which FAST was working (due to the fact that it had entered the project late) forced this company to depart from its standard building system. To expedite the fabrication process, a steel frame was used instead of the standard aluminum frame. The manufacturer's unfamiliarity with the use of steel caused a minor delay in the documentation process for additional calculations and details needed on the fabric structures.

Both the USACE project engineer and the contractor said there was nothing extraordinary about the review and approval process. The designs and documentation for the fabric structures were approved on 19 April 1985.

Construction Administration

Construction began on the fabric structures on 6 July 1985. FAST anticipated that construction would only take two to three weeks. However, the project was not completed until 28 August 1985 (refer to Figure 14).

The USACE project engineer was at the construction site every day. In addition, FAST had a representative present to assist the contractor with erection of the fabric structures. Many onsite decisions were needed to expedite the construction process due to unforeseen problems with construction details of the structures. These problems did not become evident until installation of the fabric structures began. Decisions were made jointly among the contractor, USACE project engineer, and FAST representative.

Table 3

Cost Comparison Summary: DIVAD Range Buildings, Fort Bliss, TX

**Government Estimate (Concept):
Conventional Construction**

General purpose building	\$158,000
Target maintenance facility	<u>91,000</u>
	\$249,000
Contingencies	12,450
S&A	<u>13,073</u>
Total	\$274,523

Actual: Fabric Structures

General purpose building	\$128,000
Target maintenance facility	<u>144,000</u>
	272,000
Contingencies	0
S&A (assume all 5%)	<u>12,450</u>
Total	\$284,450

= 4% more than conventional construction.

Problems during construction mostly involved details for sections where an opening in the fabric membrane occurred. The framing for the windows and doors, and how the fabric would be connected to the frame to provide a weather-proof seal around these openings, concerned the contractor so that modifications in the detailing were needed. Details around openings for flues and ducting produced similar concerns. Another problem was the connection between the roof and wall fabrics, and how each section was to be anchored to the structural frame. Field modifications were made to rectify this problem. However, no change orders were required for these modifications.

During the construction process, the relationship between the contractor and the FAST representative became strained due to conflicts that arose about the design changes. The contractor and USACE Resident Office at Fort Bliss have enjoyed a good working relationship in previous projects, and this project did not alter that in any way. Eventually, the cooperative relationship among all participants expedited these modifications.

Building Technology

The target range is situated in a remote location in the desert in southeast New Mexico. The portion of the range that holds the structures is a small percentage of the total range area. The target maintenance facility (Figure 17), general purpose building (Figures 18 and 19), and sun shelters (Figure 20) are grouped with several other conventionally constructed buildings, all of which help support the total range function.

The target maintenance facility and general purpose building are fully enclosed structures (including endwalls, sidewalls, and roof) and are of the same general appearance. Both are rectangular in plan configuration and consist of a structural steel frame over which a vinyl-coated polyester fabric membrane is stretched. Each building contains lighting, windows, doors (personnel and overhead), a heat pump, and electrical and plumbing fixtures. The target maintenance facility also includes an overhead crane and two interior offices that are independent of the fabric structure.

The sun shelters have no sidewalls or endwalls and have the appearance of barrel vaults. One sun shelter is situated near the target maintenance facility and the other is by the general purpose building.

The FAST building system consists of a series of articulated arch frames extending transversely in longitudinally spaced vertical planes. Purlins are used as secondary structural members. Individual rectangular fabric sections extend transversely between corresponding adjacent pairs of the arch frames to provide the enclosing membrane. The ends of the fabric are pulled downward uniformly at the sides of the structure for tensioning the fabric sections. The fabric is tan-colored on both interior and exterior surfaces.

The basic approach to the fabric envelope design is a "flat panel" configuration, meaning there is minimal curvature to the fabric surface. Due to this configuration, it is imperative that the fabric be prestressed adequately--especially on the roof sections--to resist fluttering and water-ponding. The fabric contour of the subject buildings has a relatively loose appearance, suggesting that the fabric may have a low prestress value.

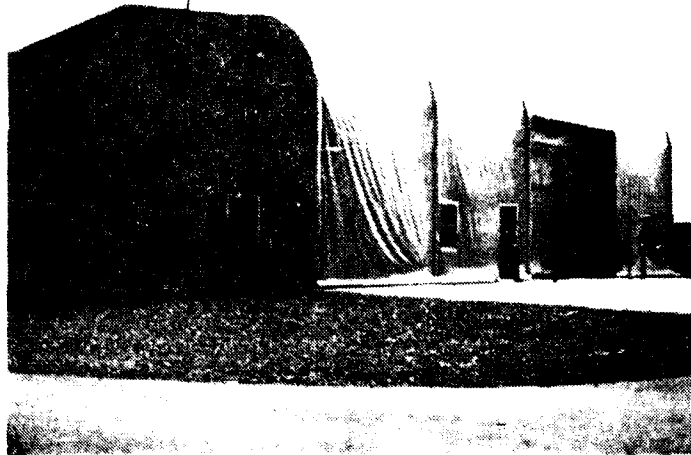


Figure 17. Target maintenance building—Fort Bliss.

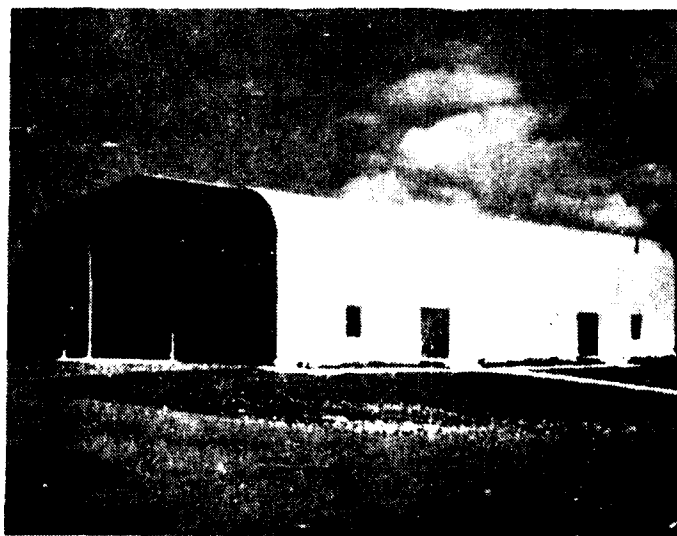


Figure 18. General purpose building—Fort Bliss.

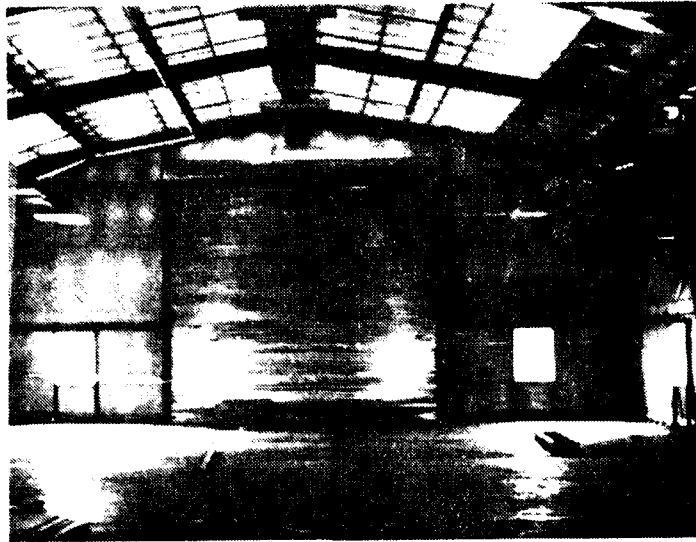


Figure 19. Interior of general purpose building—Fort Bliss.

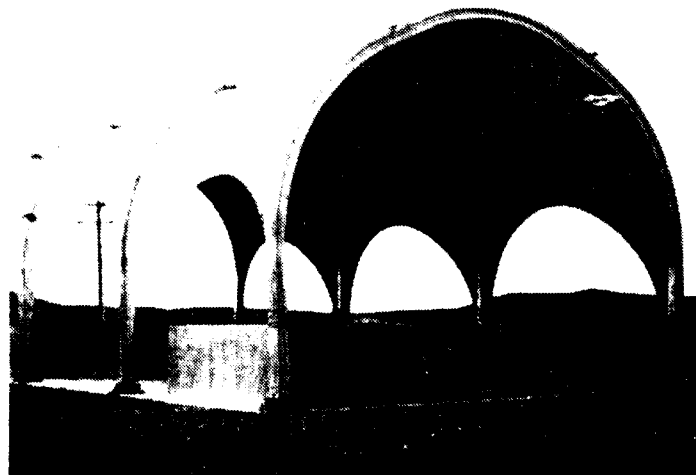


Figure 20. Sun shelter—Fort Bliss.

The sun shelters consist of a series of parallel aluminum arches anchored to a concrete foundation (Figure 20), with purlins as secondary structural members external to the fabric membrane. The fabric is tensioned in a catenary curve between the arch sections. Because of the frame's arch profile, the fabric envelope assumes a double-curved contour. No appreciable wrinkling or fluttering is evident.

Fabric connections consist of a series of "bonnet" or rope-tied connections. These connections occur wherever the fabric must be tied into the structure and wherever two fabric sections are joined.

Closeout and Occupancy

The intended use for the DIVAD Range was abandoned when the Sergeant York Defense System was discontinued, as it was to be used to train with that weapon system. However, the range will now be used for SHORAD training, although that program has not yet commenced.

The USACE resident and project engineers make frequent trips to the range to ensure that the structures remain in a usable condition. Several modifications have been made to the structures in response to climatic conditions.

Concern was expressed by the USACE resident engineer over the wind loading that was occurring. The site is occasionally subjected to strong winds that blow in through the mountains. The resident engineer indicated that whenever there is a wind greater than 10 mph and the overhead doors are open, the whole roof portion of the structure separates from the sidewalls and strains the connections to the structural frame. He fears that someday the roof is going to blow off. The resident engineer said this problem has most likely resulted from the connection detail between the roof and the sidewall fabric sections. The bonnet or rope-tied connections used have no sleeve or clamp for stability. It is the contractor's opinion that this detail is not appropriate for this situation. At the request of the USACE resident engineer, the contractor has anchored additional cables to the roof and tied them into the foundation at the sidewall ends of the structures to provide more uplift resistance.

Another problem expressed by the resident engineer was water ponding on the roof during rainy weather. Due to the structural shape of the buildings and the planar configuration of the fabric, water was accumulating and causing extreme sagging in the roof fabric. The purlins used as transverse support in the structural frame, coupled with the loose fabric, allowed ponding. The fabric tended to sag between the purlins which, in turn, provided an obstruction to water runoff. This behavior was not evident in the sun shelters, which are arched in profile with the fabric prestressed in an anticlastic curvature. To rectify this situation, the contractor (at the request of the USACE Resident Office) tensioned cables between the purlins to add support to the roof fabric and prevent the sagging. This problem had not been realized until after construction was complete.

A minor problem lies in the color and insulative qualities of the fabric that was selected. A tan fabric was used instead of white, thus reducing the structure's reflective quality. With the tan color, more heat is absorbed directly into the fabric and then into the structure, creating a hot interior. Although the tan fabric is esthetically pleasing, white would have offered better reflectance for lower inside temperatures. An alternative solution would have been to use an inner fabric layer for insulation. Hot air could have been ventilated through the fabric layers, thus reducing the interior heat. The

structures are equipped with heat pumps; however, this feature may not have been the optimal solution to the heat problem.

Summary of Findings

There was little difference between the cost of fabric structures and that estimated for conventional construction; the fabric structures cost approximately 4 percent more on the average. Given the nature of the cost data--a concept stage estimate for conventional construction and nonbinding line item prices for fabric structures--it must be concluded that the relative costs are roughly comparable.

Because the DIVAD weapons system has been discontinued, the buildings have not been occupied to date. Therefore, the suitability of fabric structures in meeting the facilities' requirements cannot yet be determined conclusively. However, the USACE Resident Office finds nothing to suggest that the fabric structures would not successfully accommodate the functions for which they were intended.

Neither the contractor nor USACE personnel involved with this project had any previous experience with fabric structures. As a consequence, several problems were encountered in the field that had not been anticipated during the fabric structure design process, design review and approval stage, and engineering document review. An overall unfamiliarity with fabric structures and the brevity of the fabric structure specification contributed to this situation.

A coordinated effort between the general contractor and the fabric structure manufacturer is necessary to provide a complete, usable facility to the Government. For the most part, this coordination was accomplished, but with some difficulty. Disagreements arose during the fabric structures' installation regarding the suitability of some construction details, and USACE requested modifications. Since the general contractor is ultimately responsible for the facility's successful construction, the initiative to resolve these details was largely his. Closer coordination between the contractor and manufacturer--ideally during the fabric structures' design stage--may have prevented some problems or at least expedited their resolution.

The fabric structure design and specification documents were intended to allow manufacturers to submit their standard building systems with few limitations. As a result, however, these project specifications provided very little in the way of engineering and technical criteria. The general contractor said that not enough guidance was available showing what was acceptable to the Government. The USACE Resident Office also found that the specifications provided too little guidance--first for reviewing and approving the fabric structure manufacturer's design and engineering data, then for enforcing the specification during construction. The fabric structure manufacturer noted that the specifications were unclear as to what exactly was required in the buildings (details, etc.) and therefore had trouble producing a structure with which he was completely satisfied. The dimensions required for the target maintenance and general purpose buildings did not fall within the fabric structure manufacturer's standard building system line. Instead, the manufacturer custom-designed a structure believed to meet the Government's design requirements.

Several problems were encountered with the fabric structure building system selected for the general purpose and target maintenance facilities. Because FAST designed a custom building and had joined the project late, the company could not fabricate its standard aluminum-frame building system fast enough to satisfy the schedule. A

steel frame was designed to expedite fabrication. The manufacturer had never worked with steel before, and therefore had difficulty with the design and construction details, as well as the installation of the buildings. The sun shelters, in contrast, had a different design approach and appeared not to suffer from the problems of the other buildings. It should be noted that the sun shelters were constructed using the FAST standard building system design.

7 COMMERCIAL VEHICLE PARTS SUPPLY FACILITY, SEOUL, SOUTH KOREA

Project Description

The commercial vehicle parts supply facility in Seoul, South Korea, consists of two buildings: a warehouse of 13,447 sq ft and a tire storage/major assembly shed of 12,445 sq ft. The PA was \$860,635. The warehouse measures 202 ft by 72 ft, and the tire storage shed is 182 ft by 72 ft. The facility is designed to provide storage for automotive replacement parts for nontactical vehicles in Korea. Both buildings are fabric structures consisting of fabric membranes tensioned over steel frames. The warehouse is insulated. The structures are considered semipermanent and are expected to have an economic life of 15 years as is the case for all overseas facilities. However, the basic structure of the facility is designed to have a useful life of more than 15 years and the fabric membrane is designed to have a useful life of at least 15 years, after which it may be replaced. Interior spaces use conventional rigid construction where enclosure is necessary. The USACE Far East District (FED) administered the facilities' design and construction (FY84 MCA PN 731) as an Architectural Fabric test project.

Pre-design Activities

The vehicle parts supply facility was originally designed to use conventional construction methods. Warehouse dimensions were 75 by 158 ft, whereas those of the tire shed were 75 by 150 ft. Both buildings had masonry walls, with steel bar joists and metal decking for the roof. Clerestory windows were used to introduce natural lighting into the structures. Figures 21 and 22 depict the original conventional design.

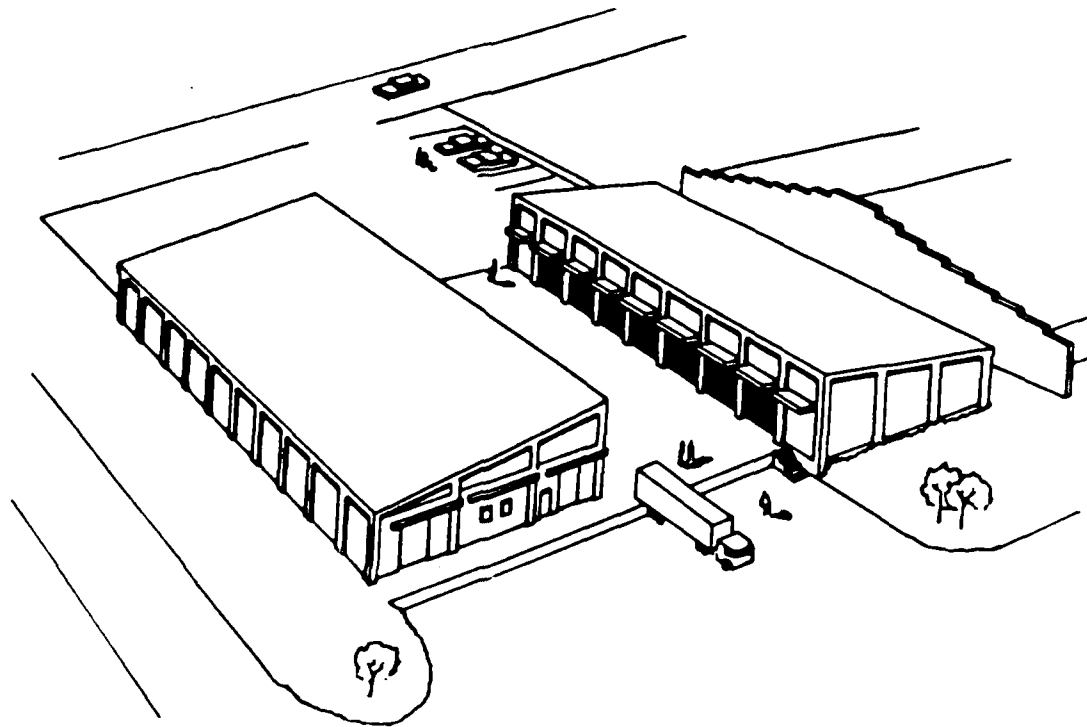


Figure 21. Original conventional design perspective—Seoul.

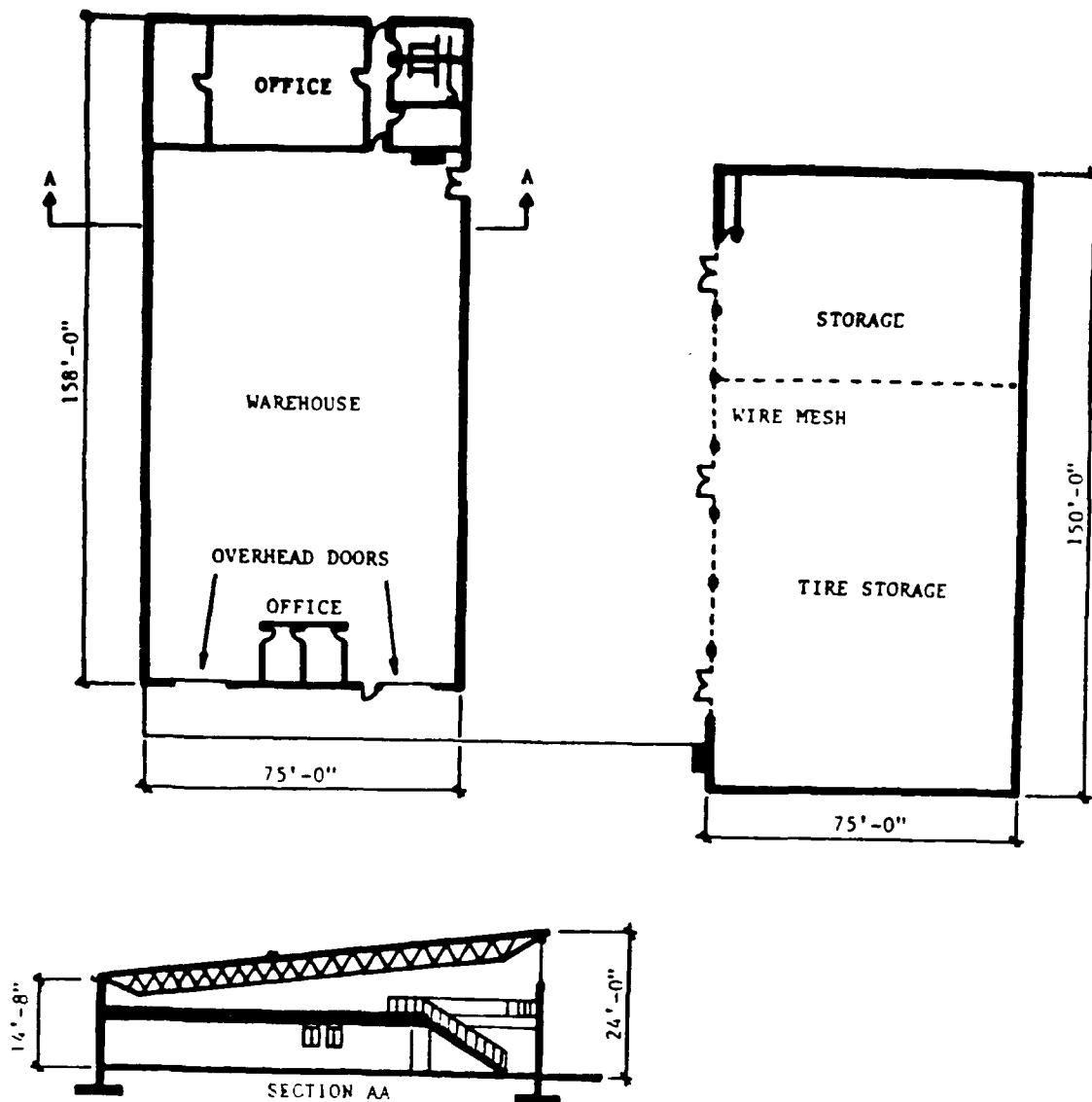


Figure 22. Original conventional design, plans, and section—Seoul.

HASC Report 98-166, dated 16 May 1983, directed the use of Architectural Fabric structures for the project. FED elected to complete the design for the fabric structure facilities in-house. This was the USACE Pacific Ocean Division's (POD's) and FED's first experience with fabric structures. All other predesign activities were conducted routinely.

Fabric Structure Design Development

HQUSACE provided architectural and engineering instructions (AEIs) for redesign. The AEIs allowed a 20 percent maximum increase over the original programmed square footage for conventional buildings. This increase was allowed for two reasons: (1) to permit fabric structure manufacturers to bid their standard designs and dimensions and (2) to compensate for fabric structure building systems that feature an arched profile

with curved sidewalls that result in nonfunctional area at the building perimeter. The Eighth U.S. Army (EUSA) using agency, the South Korean government, and South Korean building codes had no direct influence on the construction criteria used in the project. The fabric structure was designed in-house by FED with no major problems, although FED architects and engineers had no previous design experience with these structures.

The fabric structures industry was solicited for information and responses were received from several firms. One responding firm, Seaman Building Systems, offered about 3 hr of orientation to fabric systems, including a slide presentation, and provided a draft copy of a technical manual for the company's 72A Portomod system. The only previous fabric structures built for the military in South Korea were Seaman Portomod systems which were built by U.S. Air Force troops (Red Horse) at Osan Air Base. These structures were built under the supervision of a technical representative from Seaman Building Systems.

FED based its design on a standard fabric structure building system configuration using information supplied by the industry. The building has arched structural members spaced equidistant along its length. At the ends of the building, arched frame members were to be positioned radially, forming a semicircular configuration. This design, however, created problems in locating the vehicle access doors. The final design features semihexagonal ends, which allows the large overhead doors to be inserted there.

Given the PA established for this project, only vinyl-coated or vinyl-laminated fabrics were found to be economically feasible.

The directive to apply fabric structure technology to this project came after a significant portion of the design for conventional structures had been completed. Thus, to adapt the design to the fabric structure requirements, additional work was necessary. FED estimates that this additional design work required about 7 months and \$66,000. Figure 23 shows the sequence of major events for this project.



- a. Directive to use AFS for Subject Buildings - May 1983
- b. Redesign / Contractor Selection - Oct 1983
- c. Documents Issued to Contractor - May 1984
- d. Price Proposal Submitted - 29 Jun 1984
- e. Evaluation / Contract Negotiation - Aug 1984
- f. Contract Award - 18 Sep 1984
- g. Start Construction - Jan 1985
- h. Original Planned Completion Date - 24 Oct 1985
- i. Actual Completion Date - 28 Mar 1986

Figure 23. Project events by month for the vehicle parts supply facility—Seoul.

Bid Documentation

The final construction contract documents (drawings and specifications) were prepared by FED in-house. It took about 1500 manhours to prepare the documents, which were reviewed by the POD Engineering Division, HQUSACE Engineering Division, EUSA using agency and facilities engineers, and FED engineers. No major revisions were required.

Due to FED's minimal experience with fabric structures, there was concern at FED Engineering Division that some of the construction details for the contract documents may not have been compatible with the fabric system manufacturers' standard details. Shop drawings were to be in accordance with the manufacturer's standard details and submitted to the Resident Office for approval with a brief listing of building locations where similar designs had been used. Since no change orders were issued concerning the details, it is evident that either no problems surfaced or any minor problems were handled on a routine basis.

Procurement

FED Engineering Division prepared the design specifications for the project and submitted them to the P&S Division. The standard practice for construction in South Korea is to negotiate a price with the contractor who has been selected by the Sole Source Selection Board (see below for contractor's name and other information). Therefore, the project was not advertised for competitive bid. P&S Division issued the construction and contract documents to the contractor, who solicited prices from various trading companies. The contractor submitted the price proposal to P&S on 29 June 1984. The proposal was higher than the Government estimate of \$930,864.94. Therefore, the proposal and Government estimate were submitted to the Technical Analysis Unit for assessment and a copy of the proposal was sent to Defense Contract Audit Agency (DCAA) for audit. The proposal, technical analysis, and audit were forwarded to the Contract Administration Branch, which negotiated a satisfactory price of \$880,887.51 with the contractor. Materials and labor for the warehouse and tire storage shed amounted to \$672,587.71 while the remaining \$208,299.80 covered sitework, fencing, and exterior utilities. After review by the Board of Awards, the contract was awarded by P&S on 18 September 1984.

The contractor chose a trading company that had bid Seaman Building Systems model 72A Portomod for the fabric buildings. Major participants were:

Contractor:	Chin Hung International, Inc., #105-192, Fuam-Dong, Yongsan-Ku, Seoul, South Korea;
Supplier:	LT&H Trading Company, 651-1 Seocho-Dong, Kangnam-Ku, Seoul, South Korea;
Fabric Structure Manufacturer:	Seaman Manufacturing Co., 2028 E. Whitefield Ave., Sarasota, FL

The relative costs of conventional building versus the fabric structure system are not known because a negotiated cost is unavailable for the conventional construction design. However, an idea of the difference in cost can be obtained by comparing the CWE that was prepared for the conventional design with the actual cost of the fabric

structures. The values reflect only the construction costs (plus contingencies and S&A) associated with the warehouse and tire storage facility as these figures best show the impact of using architectural fabric structures.

The final design (Code C) estimate for conventional construction prepared 15 October 1983 stated the total cost for the two conventional structures as \$696,720. The CWE for the warehouse (13,285 sq ft) was \$354,852, or \$26.71/sq ft. The CWE for the tire storage facility (12,334 sq ft) was \$344,868, or \$27.96/sq ft. The average of the two facilities' cost per square foot is \$27.34.

Based on the final negotiated award, the construction cost for the two fabric structures was \$674,000. The warehouse is 13,447 sq ft at a cost of \$442,135, or \$32.88/sq ft and the tire storage facility is 12,445 sq ft at a cost of \$231,865, or \$18.63/sq ft. Three change orders totaling \$15,104 (the amount programmed for contingencies was \$44,004) were issued, which raised the total construction cost of the two fabric structures to \$689,104. The change order cost was related neither to construction operations nor fabric structure technology. To compare this value with the final design estimate for the conventional design, the appropriate S&A costs must be added to the fabric structure construction cost. S&A is estimated as 5 percent of the construction cost plus contingencies. This cost amounts to \$35,385 for the fabric structures. The comparable final CWE for the fabric structure is then \$724,489. The average cost per square foot of the two fabric structures is \$27.98.

These calculations show an additional construction cost of \$0.64/sq ft to construct the fabric structures compared with the estimated cost of the conventional structure. This figure represents an increase of about 2 percent.

Total costs of the entire project can be compared for both the conventional design and completed fabric structures (Table 4). However, it must be recognized that the differences in these values are the result of many more factors than just the use of fabric structure technology. For example, the design costs for fabric were not anticipated to be any more than those of conventional if the project had been designed as a fabric structure from the outset. Also, the sitework and related costs are included in the total project costs.

Because of the time and format differences between estimates and the fluctuating exchange rate of the U.S. dollar in South Korea, it is impossible to compare estimates precisely. However, the impact of these factors is considered to be relatively minor.

Construction Documentation

The construction documentation was prepared by FED. The contractor was not required to provide further documentation beyond shop drawing submittals. These documents consisted of construction drawings and specifications similar to those of a conventional bid package.

Construction Administration

The NTP was issued to the contractor on 19 September 1984 with a performance time of 400 calendar days; therefore, the original contract completion date (CCD) was 24 October 1985. Due to late release of the construction site by the using agency, the contractor was unable to mobilize until the first part of January 1985. The reasons for the

delay were that (1) using agency personnel and equipment were not relocated in time to start construction on schedule and (2) the motor pool was busy servicing vehicles for use in the "Team Spirit" exercise. These activities were occupying the site.

Table 4

**Cost Comparison Summary: Commercial Vehicle Parts Facility,
Seoul, South Korea (1987 Dollars)**

**Estimated Costs for Conventional Construction
(Government estimate: Code C - 15 Oct 83):**

1) Design costs (actual negotiated for the project)	\$60,529
2) Estimated construction cost (ECC)	765,799
3) Construction contingencies	38,290
4) Supervision and administration (S&A)	52,265
5) Engineering after award	<u>4,281</u>
Estimated cost for the total project*	\$921,164

Actual Costs for Fabric Construction:

1) Design costs (original + redesign costs)	\$100,461
2) Negotiated price (construction cost)	853,459
3) Construction contingencies (change orders)	15,104
4) S&A	<u>46,940</u>
Actual cost for the total project**	\$1,015,964

*The CWE formula is the one used by the AE in preparing the Code C cost estimate (prepared 15 Oct 83):

$$\begin{aligned} \text{Total estimated cost} &= \begin{matrix} (1) & & (2) \\ \text{[Design costs} & = & 0.045 \times \text{ECC]} & + & \text{CWE} \end{matrix} \\ \\ \text{CWE} &= \begin{matrix} (2) & (3) & (4) & (5) \\ \text{[[[ECC} & \times & 1.05] & \times & 1.065] & \times & 1.005] \end{matrix} \end{aligned}$$

**The CWE formula is the one used by HQUSACE in determining the CWE for FY84 projects. The formula yields a construction contingency of \$44,044, of which only \$15,104 was actually used:

$$\begin{aligned} \text{Total actual cost} &= \begin{matrix} (1) \\ \text{[Design costs} & = & 34,461 & + & 66,000] & + & \text{CWE} \end{matrix} \\ \\ \text{CWE} &= \begin{matrix} (2) & (3) & (4) \\ \text{[[[Const. cost} & \times & 0.05] & \times & 0.05] \end{matrix} \end{aligned}$$

The contractor requested an extension. The only time extension authorized was due to the late release of the site. The change order extended the contract performance time by 118 days and was negotiated at \$15,104. All critical submittals had been approved by May 1985. Work on the site, foundation, and offices and mechanical rooms proceeded from March 1985 through November 1985. Assembly of the structural steel arches began in November 1985. A manufacturer's representative visited the site in early January 1986 to provide technical assistance during erection of the steel arches and installation of the fabric. The fabric structures were completed by the end of January 1986. However, the facilities were not transferred to the user until 28 March 1986 due to various construction deficiencies and contractor inefficiency. Figures 24 through 29 show the construction activities.

Three change orders were awarded with the following scopes of work:

1. 15 October 1984: administrative change to incorporate updated changes to the contract clauses; no cost/no time.
2. 29 October 1985: extended the contract performance time by 118 days due to Government-caused delays in clearing and vacating the construction site; negotiated at \$15,104.
3. 12 November 1985: a change to incorporate revised specifications to delete the requirement for providing an environmental control system (not part of manufacturer's package), change R-value of insulation from R-31 to R-30 (9.5 in.) per manufacturer's recommendation, and change the final topcoat for the outer layer of fabric from "Tedlar" to an acrylic coating (manufacturer's recommendation due to a scheduled factory shutdown).

These changes did not result from deficiencies in the fabric construction, except for the unavailability of the manufacturer to supply the Tedlar cladding for the fabric, which may have a longer useful life than the acrylic topcoat that was used. Any effects on longevity of the fabric are yet to be determined.

However, other problems occurred throughout construction. On a daily basis, there were not enough tools or manpower. In addition, many of the workers did not have basic construction skills. The fabric manufacturer's representative stated that the finished work was of high quality but that the job had been subcontracted to a company that was too small to handle the job.

Building Technology

The Seaman Building Systems Portomod structure is a clear span design available in several standard widths. The Seoul vehicle parts supply facility uses the 72-ft width. The structure is composed of a series of curvilinear galvanized structural steel trusses over which a flexible membrane is tensioned. A flame-resistant roof membrane constructed of a woven Dacron polyester coated with vinyl is supported by the frame. An acrylic topcoat on the exterior face of the fabric provides protection from ultraviolet deterioration. The lower edge of the roof has a pocket weld that holds a catenary cable. The cable extends between each laterally spaced truss and attaches to a tensioning assembly located at the base of each column.

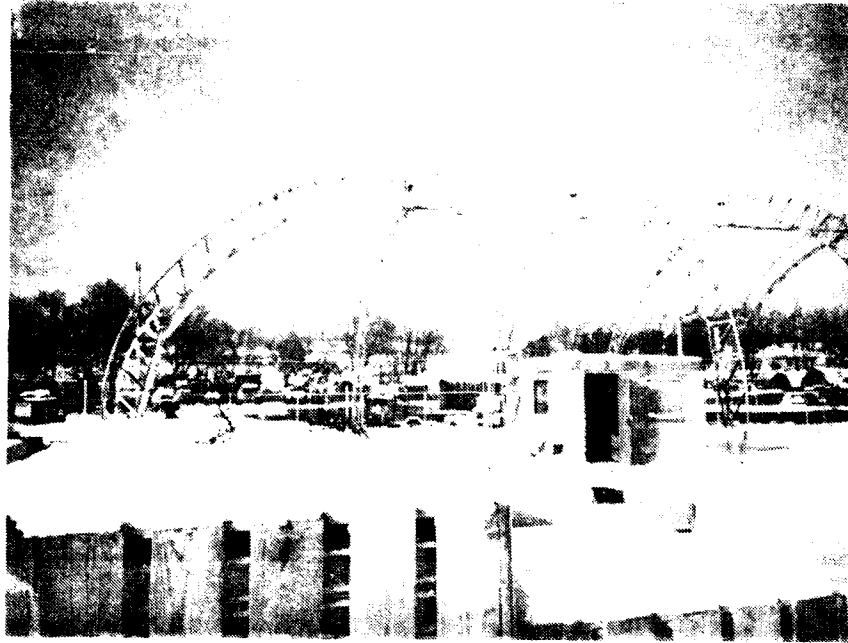


Figure 24. Assembly of structural arches—Seoul.

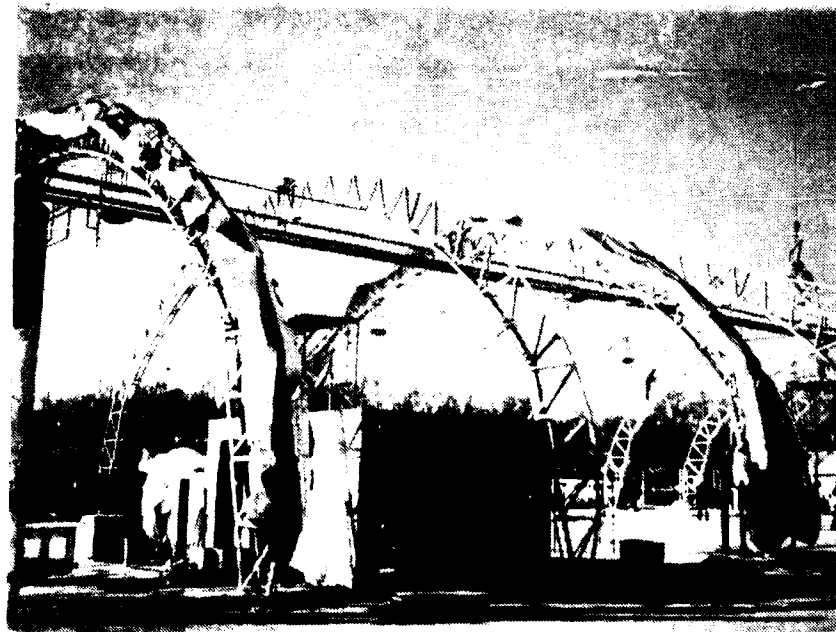


Figure 25. Placement of the fabric—Seoul.

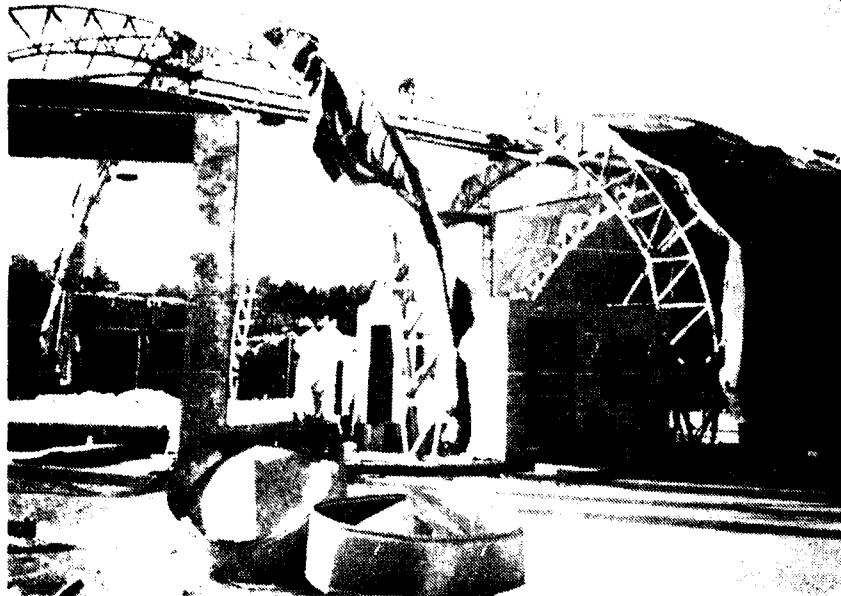


Figure 26. Installation of the fabric—Seoul.

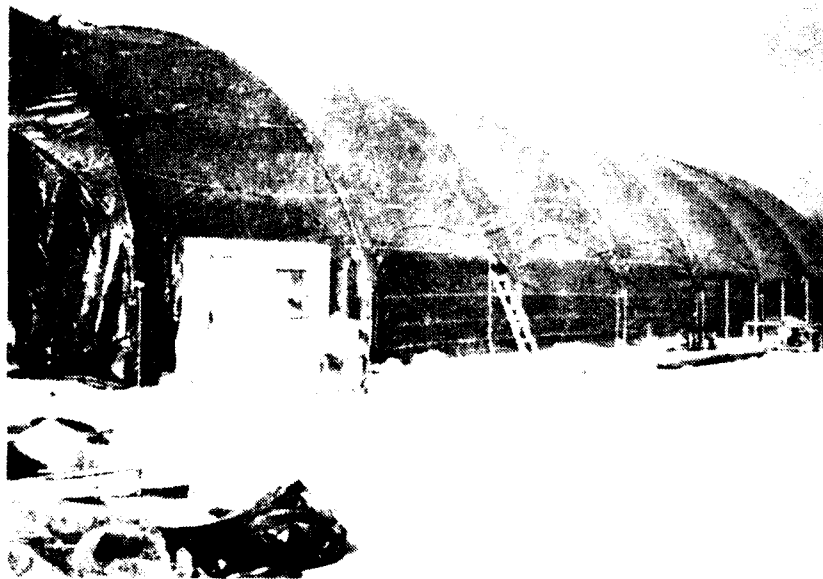


Figure 27. Installation of the fabric—Seoul.

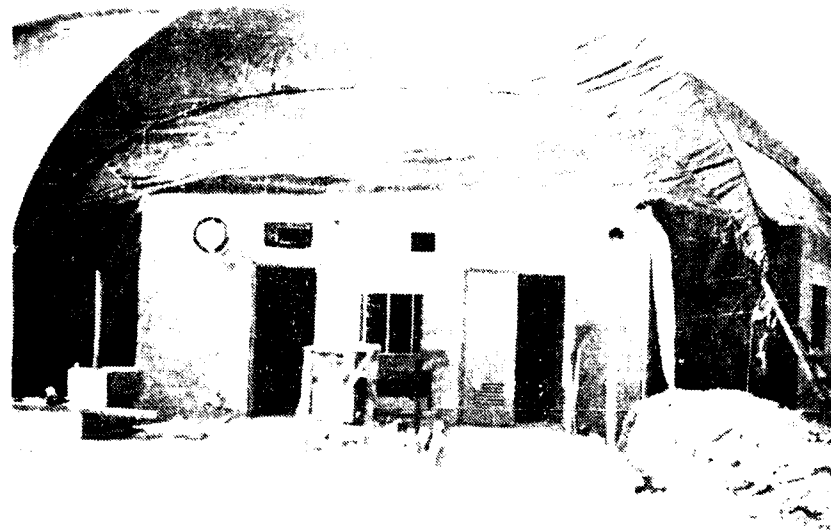


Figure 28 Interface of fabric and masonry construction.

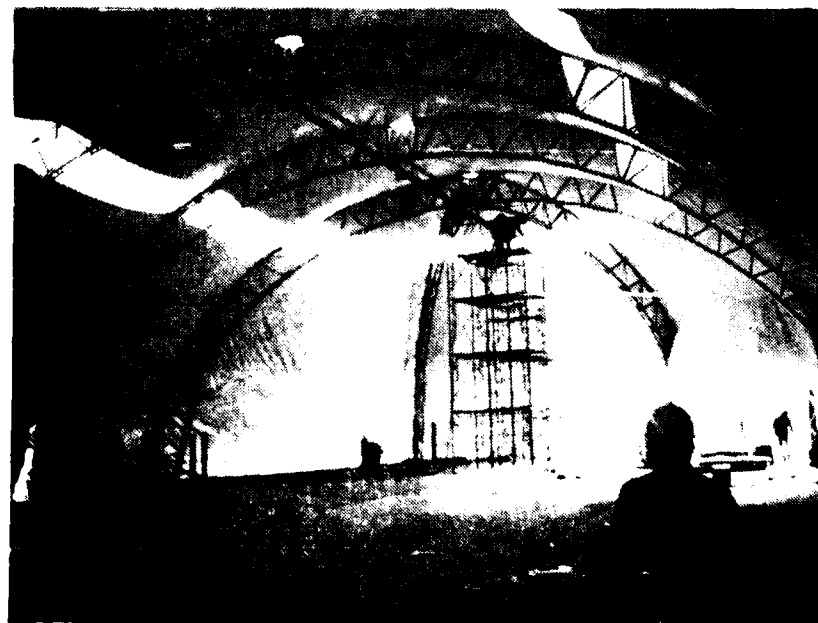


Figure 29. Building interior.

The fabric structures meet all standard requirements for fire resistance (flammability and flame spread rating) and loading caused by wind (designed for up to 120-mph wind loads), snow (curvature causes snow to slide off), and earthquake (designed to meet the seismic loading requirements of risk zone 4). Sprinkler systems are installed for both buildings and are supported by the structural frame. Insulation is provided in the warehouse/office facility with 9-1/2-in. batt insulation placed between the outer and inner liners.

Interior offices use conventional masonry construction. Personnel doors, vehicle overhead doors, and windows are framed rigidly within the fabric enclosure. Chain-link fencing surrounds the perimeter of the buildings with access provided by gates at key locations.

Closeout and Occupancy

No problems have been reported with the facilities since the using agency has occupied them.

Summary of Findings

Architectural fabric structures are appropriate and feasible for this facility. It is impossible to make a precise cost comparison between conventional and fabric structure designs since conventional design was never completed and outside factors such as perceived risk to the contractor may have influenced final cost. As previously noted, the difference in cost between the conventional design CWE and the actual fabric structure costs (expressed as a CWE) is about 6 percent, once the lost design costs have been removed from the fabric structure total project cost. Therefore, the difference in cost between the conventional and fabric designs is not great enough to conclude that fabric structures were either more or less economical on this project than a conventional structure would have been. Except for the initial delay and costs associated with switching from conventional to fabric design, this project is considered to be relatively comparable in both time and cost to conventional construction. According to FED, it does not appear that any more time was required to prepare the fabric structure design than had been required to complete the conventional proposal, despite the fact that the District had no previous fabric structure experience.

A drawback to standard fabric structure systems, as with most standard preengineered building systems, is that the design must conform to predetermined building geometry and dimensions. Facilities that require use of special materials or that will perform unique functions may not be feasible candidates for fabric structure systems. In general, the vehicle parts supply facility was well suited for fabric structures. However, a few minor inconsistencies resulted from using the Portomod system. The north end of the warehouse, where offices, restrooms, and mechanical spaces are contained within rigid partitions, has problems commonly found with designing interior spaces around non-rectilinear building shapes. The semihexagonal geometry results in strangely shaped rooms and unusable floor area. Although the semihexagonal design is an improvement over the original semicircular design, a square-ended arrangement would have been more appropriate. Square-ended construction would have:

- Kept unusable floor space to an absolute minimum
- Allowed easier access for vehicles

- Permitted interior conventional construction to be better integrated with the fabric structure. This condition probably would have saved time and money in construction costs and avoided complex details, such as the ones found in the offices and restrooms in the north end of the warehouse.

It should be noted that most fabric structure manufacturers can provide standard building systems with square-ended, or nearly square-ended, configurations.

Finally, some advantages seen during this project can be applied to subsequent fabric structure construction at FED. In the future, FED may save time in the design and construction phases for these projects due to the experience and lessons learned from this project; also, FED's accumulation of standardized design details and construction methods should result in cost savings on future projects through reduced design effort.

8 ONLINE STORAGE FACILITY, MILAN AD, TN

Project Description

The online storage facility at the Milan Army Ammunition Plant, Milan, TN consists of one 12,600-sq ft building. The basic function of the facility is to provide storage for packaging and packing materials. It is an open-sided structure approximately 60 ft wide by 210 ft long. The site has a somewhat restrictive width due to adjacent private property on one side and a road on the opposite. The facility is designed to provide a canopy-type shelter against rain and ultraviolet light. There is a minimum of additional construction in the building (such as partitions), so it is essentially a shelter only. Vehicular access is required around the perimeter of the building for loading and unloading materials, which requires clearance between the building and the perimeter fence. This facility is considered permanent. The USACE Mobile District administered design and construction for the facility (FY84 MCA PN03).

Predesign Activities

A conventional metal building design had been initiated for this project by Mobile District Engineering Division staff. Design had progressed to the concept stage. Figure 30 depicts the original conventional design.

HASC Report 98-166 directed that fabric structures were to be considered as a feasible solution to this project. Since the costs for conventional metal building and fabric structure construction were estimated to be essentially the same, HQUSACE directed Mobile District to allow both types of structures in this procurement. The project was bid competitively, allowing both the metal building and fabric structure proposals.

Fabric Structure Design Development

The online storage facility was designed by the Mobile District. Because this was the District's first fabric structure project, it mandated a product research exercise that normally would not have been required for a conventional project. The District obtained design and technical data directly from the list of fabric structure manufacturers maintained at USA-CERL. The Laboratory also provided design and technical information and participated in design and specification development.

Bid Documentation

The bid package contained design and specification documents typical of a building construction project. Descriptive design and specifications were included for the metal building option. The specifications were based on standard CEGS. A "schematic" design and performance specification were included for the fabric structure option which allowed manufacturers to bid their standard building systems. The performance specification for the fabric structure option was consistent with the metal building specification format. All other building items (e.g. concrete, electrical utilities) were designed and specified in the usual descriptive manner. Fabric structure manufacturers indicated that the specifications were reasonable and imposed no undue constraints.

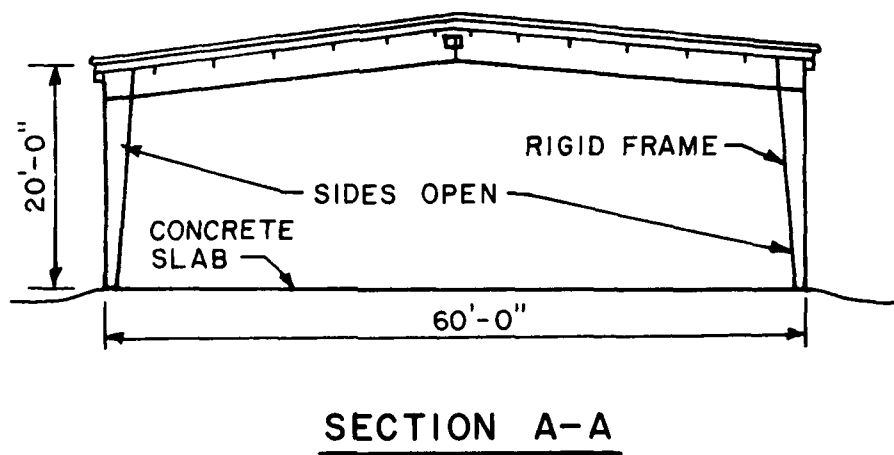
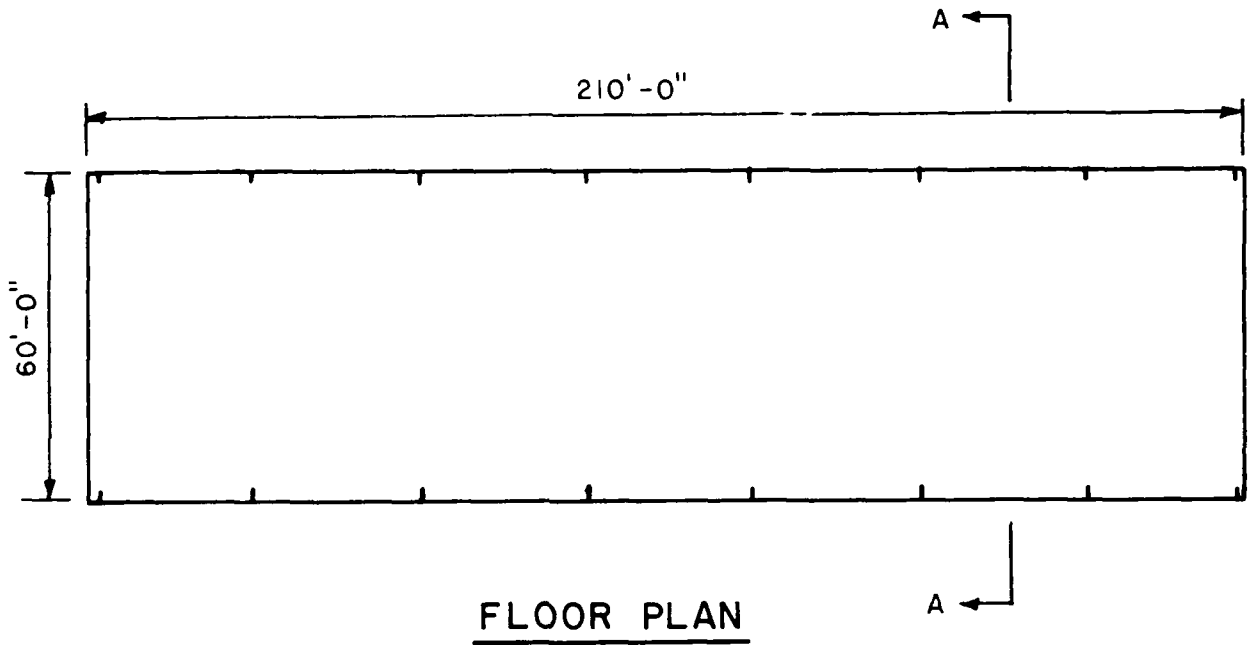


Figure 30. Original metal building design—Milan, TN.

The only unusual requirement of any consequence was the vertical clearance necessary for vehicles to load and unload at the building's perimeter. However, fabric structure manufacturers reported no special design or engineering problems related to this item.

Procurement

The Government estimate for the project was \$246,800 for the preengineered metal building option and \$279,029 for the fabric structure option. These figures included building, site work, and utilities. The fabric structure estimate was based primarily on manufacturer's quotes obtained by Mobile District. The project was advertised in the *Commerce Business Daily (CBD)* in the usual way. In addition, USA-CERL directly notified several fabric structure manufacturers upon publication of the *CBD* ad. Mobile District required each bidder to submit both metal building and fabric structure bids.

There were nine bidders for the project, most of whom were general construction contractors. Metal building and fabric structure manufacturers were to act as suppliers for the general contractor. Four fabric structure firms were represented in the bidding: Seaman Building Systems, FAST, Alpha Structures, Inc., and ODC, Inc. Each of the four were subcontractors to a general contractor; however, FAST also submitted a bid as primary contractor.

Bids for the fabric structure option ranged from \$222,420 to \$333,278. The range was \$171,134 to \$269,022 for the metal building option. FAST's metal building bid of \$750,000 is not considered in the range, since it deviated widely from the trend. FAST was the only respondent to bid a metal building higher than their fabric structure. All others bid the fabric structure option approximately \$37,000 to \$95,000 higher (20 to 50 percent) than their metal building bids.

The construction contract was awarded to the Phelan Co., Inc., Trenton, TN, for \$171,134. This bid was based on an Inryco preengineered metal building system.

The general contractors reported that the fabric structure manufacturers had been helpful and informative, providing enough information to enable them to develop a bid and, if awarded, to construct the building. A few bidders, however, did remark that they had had some trouble obtaining adequate technical and cost information from some manufacturers. In these cases, the general contractor could not develop a bid with a great deal of confidence.

Construction Activities

Due to the selection of preengineered metal buildings over fabric structures for this project, USA-CERL ended its investigation at this point. Documentation, scheduling, and closeout information for the project are not pertinent to the study. The findings reported below reflect the first four phases of the project only.

Summary of Findings

Overall, fabric structures were less cost-competitive than preengineered metal buildings for this project, although some fabric structure bids were lower than some metal building bids. Considering the lengths to which Mobile District went to provide

opportunities for fabric structures manufacturers to compete, participation by that industry was not extensive. Several factors may have contributed to the low response.

First, some fabric structure manufacturers acknowledged that it would be difficult to compete with a preengineered metal building on a project with a small scope such as this. Fabric structures are more competitive at spans wider than 60 ft. Metal buildings usually represent the most economical construction method for buildings configured like the one in this project.

Second, fabric structure manufacturers are generally not prepared to assume a primary construction contract and must become associated with a general contractor who is willing to bid the project. The fabric structure industry has not yet developed a network of contacts, dealers, and franchised contractors. Since general contractors are not as familiar with fabric structures as they are with metal buildings, the task of convincing them to bid fabric structure options is more difficult for fabric structure manufacturers. Contractors unfamiliar with fabric structures may perceive some element of uncertainty (or risk) when developing a fabric structure bid. None of the general contractors bidding this project had previous experience with fabric structures.

Finally, many of the bidders were franchised contractors for metal building systems. Although not generally under an obligation to build metal buildings exclusively, their familiarity with these products would be expected to place the metal building option at a competitive advantage.

9 OVERALL FINDINGS

One-Step "Turnkey" Test Projects

Both physical fitness centers were designed and constructed (or will be constructed) at significantly lower cost than was estimated for conventional MCA procedures--approximately 16 and 28 percent less. Facility quality appears to be at least equal to similar facilities constructed under traditional MCA procedures. One project was completed on schedule with no extraordinary problems. Although the other facility has experienced some major difficulties, its schedule is being maintained. These projects have been executed within the normal MCA environment and have not been treated as "research" or otherwise specially handled projects.

The physical fitness training center appears to be a suitable facility type for One-Step "Turnkey" design and construction procedures. Expertise and capability in this facility type found in the private construction market were incorporated successfully into these USACE projects. District participants expressed one reservation about this type of procurement: whether private construction practices are suitable for building "military" facilities. In response to this question, it should be noted that the term "military" refers to the funding appropriation (Military Construction Authorization) and the rules and practices implied therein--not the physical characteristics of the facility.

Standard MCA regulations, guidance, and practice reflect the traditional design-bid-build approach to design and construction. However, there are certain features within the traditional MCA environment that inhibit the smooth, efficient execution of One-Step projects. These features create ambiguities and inconsistencies relative to One-Step procedures. Although not insurmountable, such issues require special attention and effort, and therefore detract from otherwise efficiently conducted projects.

At times, there was discontinuity in the involvement of USACE personnel in management, administrative, and technical activities; that is, the same personnel were not always involved from start to completion of a particular task. Although no major problems or difficulties were encountered, this discontinuity sometimes detracted from a smooth project administration.

Some user-requested modifications were required during construction of the physical fitness centers. Although no major problems resulted, these changes indicated that not all user requirements may have been reflected adequately in the RFPs. This situation can occur with any design and any project. However, developing an RFP presents a somewhat different situation from developing a complete design. User requirements must be conveyed to proposers largely through schematic design material and functional or performance-type criteria--not a completed design. The using agency and USACE must be careful when defining facility requirements in functional terms, and USACE must ensure that all such requirements are represented in the RFP.

Including a definitive floor plan in the RFP was perceived as an "unwritten requirement" by some proposers, although the intention was only to provide a graphic representation of design requirements. If a floor plan is included in an RFP as an "example" design or a graphic representation of the design requirements, it must be made absolutely clear to proposers that they are at liberty to develop original design configurations. Conversely, if USACE wants proposers to abide by the design included in the RFP, this too must be clarified.

It is essential to describe minimum net areas for spaces and functional areas in a facility's design requirements. Limiting the maximum gross area for a facility can greatly curtail proposers' opportunities for design and economic innovation and creativity. This constraint becomes more severe when the range between minimum and maximum areas is very narrow. If there are no conditions that make additional building area impractical or undesirable, it is to the Government's advantage not to impose a maximum scope limitation on proposals.

Similarly, including detailed plan arrangements, elevations, and construction details in the RFP inhibits the opportunities for proposers to use originality. These details must be avoided wherever possible. Requirements can be expressed in the RFP by using schematic graphics and by writing functional or performance-oriented specifications.

The RFPs for the two One-Step test projects (and RFTPs for Two-Step "pilot" projects 2 years earlier) differed greatly in composition, content, and format. This finding suggests the lack of a uniform approach to RFP development, composition, and format. While not to imply that all RFPs must be identical, a more standardized approach is necessary to expedite RFP development by USACE as well as to provide contractors with more consistent, comprehensible construction documentation.

Although enough satisfactory proposals were developed and submitted in the time allowed, proposers remarked that the specified proposal preparation time was too short. For projects of \$3 to \$5 million, a proposal time of somewhat longer than 6 to 8 weeks might be allowed. Also, issuing an advanced notice to potential proposers would enable AEs and general contractors to make preliminary arrangements prior to advertisement of the RFP.

Preproposal meetings provide the opportunity for potential proposers, USACE, and the using agency to discuss the project, explain procedures, and resolve questions. However, this meeting must be held early enough in the proposal process to allow proposers to incorporate this information into their submittals.

The cost of preparing proposals was reported to be approximately three times the cost of preparing conventional bids. While proposers generally accepted this situation as a "cost of doing business," they suggested that some sort of remuneration be offered to losing proposers. This would help defray proposal costs and encourage greater competition in One-Step projects. Some proposers suggested that debriefings on their proposals be held. Most proposers remarked that they wanted to be kept apprised of Districts' intentions for future One-Step projects.

Evaluation team members should be allowed to confine their evaluations to areas within their professional expertise. In one case, the using agency personnel most familiar with the functional aspects of physical fitness facility designs were tasked with evaluating proposals for engineering sufficiency and qualities. All evaluators need not evaluate all features of the proposals.

When time allowed, proposers were given the opportunity to correct or upgrade their proposals. Proposers took this opportunity and positive results were achieved. Thus, more proposals remained in consideration and, therefore, competition was enhanced.

Since the RFP is the enforced contract document, the contractor is not bound by criteria not included therein. During USACE's review and approval of the contractor's construction documents, it must be made clear that criteria and specifications not

included in the RFP are not enforceable in the final design and cannot be imposed upon the contractor without a change order. If, however, enforcement of a CEGS or other specific criteria is critical to the quality of the project, that specification or those criteria must be included in the RFP.

Contractors said that 60 days was not enough time to complete and submit the final design and construction documents for facilities of this size and type. The contractors did meet their deadlines, but felt their construction documents could have been improved given a little more time. A period of 80 days may be more appropriate for facilities of this scope.

The One-Step approach presents a different situation from traditional design and construction regarding Value Engineering (VE) because design and construction are both contractor responsibilities. On one occasion, a VE proposal was not developed and submitted because USACE questioned whether VE proposals were appropriate. Integrating design and construction responsibilities, however, should not preclude the opportunity for a contractor to improve upon his/her own design. VE provisions should apply to a One-Step project, although the details of implementation require further development. Care must be taken to avoid any appearance of impropriety and to prevent the contractor from having an unfair advantage by "building in" potential VE proposals in his/her proposal and completed design.

The contractors for both One-Step test projects provided final design and construction documentation as a single submittal. There were no interim submittals or reviews. In one case, revisions and resubmittals were required that may have been avoided, or the effort reduced, had the item been detected during design development rather than after its completion. When preparing design and construction documents, it may be advantageous to both the contractor and the District to require interim design reviews. This decision depends on the size and complexity of the facility, as well as the time available.

Turnaround times for District review and approval of the contractors' final design and construction documents were not defined clearly (and, in one case, was contradictory) in the RFPs. Contractors were expecting a minimum response time so that they could proceed with work on the project. The RFPs, however, left this arrangement "open-ended" without designating a maximum time that the District could take for approval. The contractors indicated they could have been vulnerable to unexpected delays in approval which would have cost them time and money. These problems may have been avoided or reduced had the RFP indicated minimum *and* maximum turnaround times for document review and approval. However, maximum turnaround times must also be realistic with regard to a District's routine workload.

During the review and approval of contractor-generated design and construction documentation, it is possible for the Government and the contractor to reach an impasse on the suitability of the proposed design. Neither the contractor nor the Government may be able to prove its position conclusively. In this case, it is critical that a solution be resolved quickly to avoid construction delays and the adverse consequences thereof. One approach is that, if the Government cannot conclusively disprove the suitability of the contractor's solution, the contractor may be allowed to proceed at his/her own liability. Requiring the contractor to upgrade warranty provisions for the item in contention may provide additional protection for the Government. Alternatively, if the Government elects not to rely on contractor liability or warranty enforcement, the Government may develop and provide a design to the contractor. In this case, the Government assumes the liability for performance of the design as well as any additional costs incurred during construction.

District personnel reviewing contractors' resubmitted design and construction documents sometimes were not the original reviewers. Although no major problems occurred, there were some minor discrepancies and contradictions in review comments. Thus, continuity in management and technical personnel should be maintained throughout a project as much as possible.

Architectural Fabric Structure "Test" Projects

Based on test project experience, the costs of Architectural Fabric structure buildings are comparable to those of preengineered metal building systems for enclosing large, clear-span spaces. However, the cost competitiveness of fabric construction appears to diminish as the length of the clear-span space is reduced. It must be noted that the costs were compared between concept estimates on preengineered metal buildings and the actual construction costs of the fabric structures; therefore, a precise comparison cannot be made. Still, based on accuracies and cost levels, there are no trends to indicate that fabric structures are significantly more or less expensive. It must also be noted that costs of fabric structures relative to conventional construction are likely to change as the building industry becomes more familiar with this construction type and as the fabric structure industry becomes more sophisticated in its products and practices.

It appears that the fabric structures studied are well suited to the intended functions of the buildings. There is nothing evident in the test projects studied to suggest that using a fabric structure compromises the functional adequacy of the facility.

Architectural Fabric structure technology can be viewed as an emerging building system alternative. Therefore, not everyone in the construction field is familiar with the design and construction of these structures. When fabric structures are selected for military construction, it is important that all parties involved in the project have some familiarity with the unique properties of these systems. The contractor and USACE personnel involved should have a working knowledge of the design considerations, construction techniques, and structural qualities of fabric structure technology. With the proper information, the contractor and USACE should be able to identify suitable fabric systems for any given application. USACE personnel should also be familiar with the design and construction of architectural fabric structures in order to effectively evaluate the construction documents and administer construction of the building.

Specifications provided to the contractor and fabric structure manufacturer should be comprehensive to ensure a good product and serve as an enforceable construction contract document. Properly written specifications will help ensure that no discrepancies arise over the delivered product.

Designs and specifications should be performance-oriented. Requirements should not arbitrarily restrict the use of any one manufacturer's standard building system. Building requirements should be flexible enough to allow for standard building system dimensions and configurations. An additional 20 percent has been allowed to accommodate standard building system dimensions and curved sidewall configurations (this 20 percent allowance is included in HR 98-116).

Architectural Fabric structure manufacturers most often provide building systems as suppliers to a prime contractor since they are usually unequipped to assume a prime construction contract. Therefore, it is the responsibility of others to supply the design and construction capabilities necessary to provide a "complete and usable facility" to the Government.

Most fabric structure manufacturers supply standard preengineered buildings. In most cases, manufacturers are reluctant to greatly change their standard product(s). Therefore, deviation from the standard should not be required of manufacturers unless it is critical to the function of the facility. If it becomes necessary to deviate from the standard product, additional engineering and costs will result.

Because of the diversity of the available systems, it may be advisable to use a design-build or "Turnkey" (One-Step or Two-Step) procurement approach. This method would allow fabric structure manufacturers to propose complete solutions based on their standard products.

10 CONCLUSIONS

USA-CERL has monitored six military construction projects that used procurement methods and technology representing alternatives to those of traditional MCA. The two concepts studied were One-Step ("Turnkey") Facility Acquisition and Architectural Fabric Structure technology. The projects were implemented without interference from the researchers in order to collect information about actual conditions in the field. The specific issues investigated included design, procurement method, effect of building technology, cost, scheduling, and quality of the final product.

One-Step "Turnkey" Approach

Two physical fitness centers were acquired using the One-Step Turnkey method. In general, this facility type is well suited to procurement using the One-Step approach; of the problems encountered on these projects, few appeared directly related to the method of acquisition. Some lessons learned from this experience should facilitate USACE's use of One-Step procurement for future projects:

1. Give special attention to identifying the user's needs and ensure that all are addressed in the RFP; features not specified in that document can be added only through a change order once the contract has been awarded.
2. A definitive floor plan need not always be attached to the RFP. If a floor plan is included, make it clear that proposers are encouraged to submit original designs in keeping with the One-Step concept. Dimensions, detailed elevations, and other construction details inhibit the proposers' opportunities for innovation and should be avoided unless necessary to facility function. Replace specific requirements with schematic graphics and general requirements expressed in functional or performance-oriented terms.
3. Specifying limits on maximum gross area is not recommended unless site constraints or other project conditions require a limitation on scope. The proposer should have the option of specifying this area as long as minimum net area requirements are met and no adverse consequences result.
4. Allow proposers enough time to develop submittals based on the project scope. For projects under \$5 million, the usual 6 to 8 weeks probably will suffice, but those with higher programmed amounts or special functions may require additional time. Advance notice of the Government's intent to advertise an RFP also is an option that will allow prospective respondents time to prepare and is strongly recommended.
5. Ensure that proposal evaluation team members assess factors within their professional expertise; it is not necessary for all reviewers to rate all features of the proposal.
6. Specify both minimum and maximum turnaround times for the Government's review and approval of construction documentation.

As USACE and the construction industry become more familiar with the One-Step approach, the process should flow more smoothly and efficiently than was observed in these two projects. Also, with increased experience, it should become possible for

USACE to develop a systematic method for preparing RFPs to reduce the time and upgrade consistency between projects.

Architectural Fabric Structure Technology

Four different MCA projects were designated to use fabric structures technology. Three of the four projects specified fabric structures. In the fourth project, proposers had the option of using fabric structures; the contract was awarded to a company proposing preengineered metal buildings.

For the facilities that used fabric structure technology, all are functioning as expected, with no apparent compromise to performance. Minor problems were noticed during inspection of one facility but were corrected at no additional cost to the Government.

The evaluations showed that the cost of Architectural Fabric structures is comparable to that of conventional preengineered metal building systems for enclosing large, clear-span spaces. The fabric structures' cost-competitiveness is greatest with larger clear spans and declines with smaller ones. It should be noted in this cost analysis that a precise comparison was not possible due to a lack of comprehensive data and to the different parameters to be considered between systems. Nevertheless, there are no trends to suggest that fabric structures are categorically more or less expensive than metal construction.

These test projects revealed a trend in which the fabric structure manufacturer acts as subcontractor to the general contractor, who must develop the proposal and bid using information supplied by the manufacturer. Thus, many general contractors may perceive a greater risk in the bidding and be reluctant to participate. Despite this drawback, enough bids were received on these projects to make a selection based on competition. Lessons learned include:

1. Ensure that all parties to be involved in a fabric structure project (i.e., USACE, the contractor, and the contract administrator) have a working knowledge of the design considerations, construction techniques, and structural qualities inherent in this technology.
2. Provide comprehensive specifications to the contractor and fabric structure manufacturer to ensure an enforceable contract document and avoid misunderstandings about the product to be supplied.
3. Make designs and specifications performance-oriented for flexibility; allow proposers an increase over the programmed scope to afford them the option of specifying their standard building systems. (In the past, MCA acts designating fabric structures technology have allowed a 20 percent increase.) Manufacturers should not be required to make drastic changes to their standard product line unless modification is critical to the facility's function.

Architectural Fabric structure technology is still a relatively new concept with which many in the field are unfamiliar. As these building systems see wider use, it should become easier for contractors to make realistic bids, thus lowering their risk and perhaps improving the competitive edge of this technology for many applications.

ABBREVIATIONS

AD	Army Depot
AE	architect/engineer
CCD	contract completion date
CEGS	Corps of Engineers Guide Specifications
CWE	current working estimate
DCAA	Defense Contract Audit Agency
DEH	Directorate of Engineering and Housing
DF	Disposition Form
DIN	Deutsches Institut fuer Normung (German Standards Institute)
DIVAD	Division Air Defense
DOD	Department of Defense
EUD	Corps of Engineers European Division
EUSA	Eighth U.S. Army
FAST	Fabric and Structures Technology, Inc.
FED	U.S. Army Corps of Engineers Far East District
FORSCOM	U.S. Army Forces Command
FY	Fiscal Year
HAC	House of Representatives Committee on Appropriations
HASC	House of Representatives Committee on Armed Services
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HR	House Report
HVAC	heating, ventilating, and air-conditioning
MACOM	Major Command
MCA	Military Construction, Army
MILCON	Military Construction

NTP	Notice to Proceed
PA	Program Amount
PN	Project Number
POD	U.S. Army Corps of Engineers Pacific Ocean Division
P&S	Procurement and Supply
RFP	Request for Proposal
RFTP	Request for Technical Proposal
SAD	South Atlantic Division
S&A	supervision and administration
SAS	Savannah District
SWF	Fort Worth District
TRADOC	U.S. Army Training and Doctrine Command
USACE	U.S. Army Corps of Engineers
VE	Value Engineering

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