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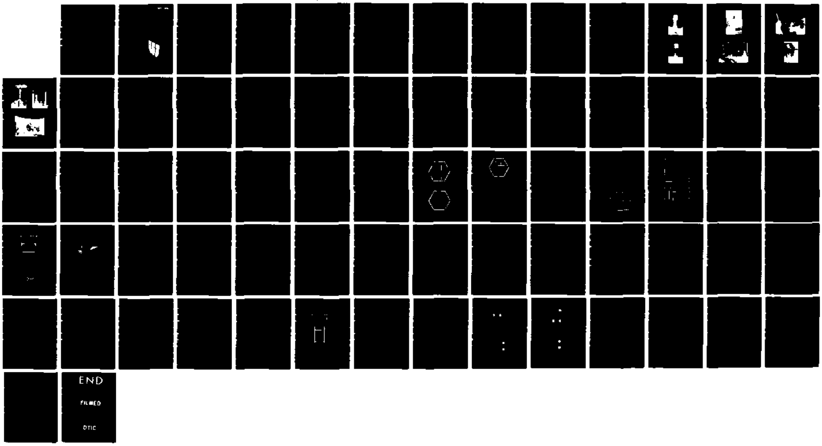

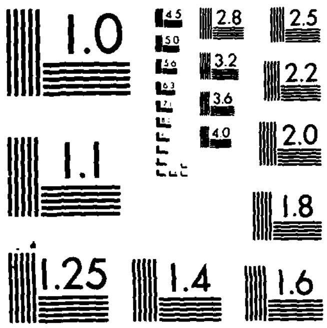

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US Army Corps of Engineers
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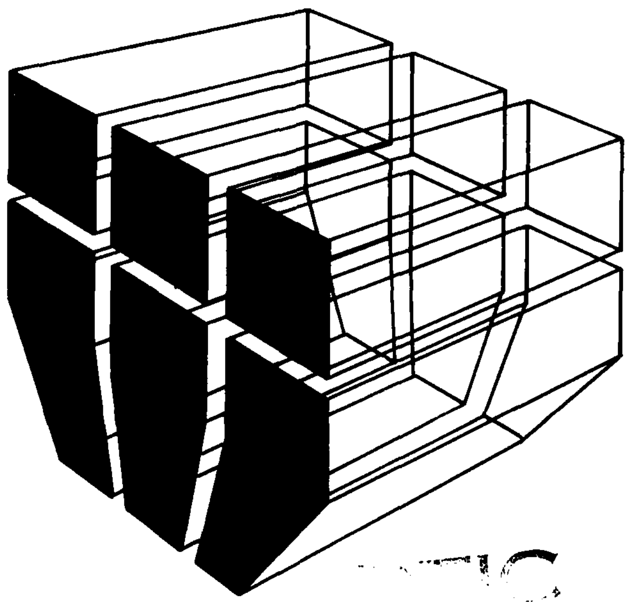
TECHNICAL REPORT P-85/13
June 1985

AD-A159 115

Design Criteria Upgrade for U.S. Army Type II Air Traffic Control Towers

by
Thomas R. Napier
W. Edward Back
Michael McCulley



This report documents research conducted to identify problem areas in the design of existing Type II Air Traffic Control Tower (ATCT) installations and to develop standard design criteria to avoid these problems in future installations. Many design problem areas were identified in the ATCT structure's architectural design, substructure, superstructure, roof systems, exterior walls, interior construction, mechanical systems, electrical systems, and air traffic control interfaces. For each of these areas, specific solutions to the problems were recommended. However, incorporation of these solutions must consider a specific site's location and environmental conditions.

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This report documents research conducted to identify problem areas in the design of existing Type II Air Traffic Control Tower (ATCT) installations and to develop standard design criteria to avoid these problems in future installations. Many design problem areas were identified in the ATCT structure's architectural design, substructure, superstructure, roof systems, exterior walls, interior construction, mechanical systems, electrical systems, and air traffic control interfaces. For each of these areas, specific solutions to the problems were recommended. However, incorporation of these solutions must consider a specific site's location and environmental conditions.

FOREWORD

This research was conducted for the US Army Air Traffic Control Activity (ATCA) under Project Order ASQ-85-01A, dated 10 January 1985. The work was conducted by the Facility Systems (FS) Division, U.S. Army Construction Engineering Research Laboratory (USA-CERL). The USA-CERL Principal Investigator was Mr. Thomas R. Napier. The ATCA Technical Monitor was Mr. Bruce Donaldson, ATCA-ASQ.

Mr. Stuart Dolde, FS, and Mr. Dahtzen Chu, Energy Systems Division, also provided assistance with the research.

Mr. E. A. Lotz is Chief of USA-CERL-FS. COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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DESIGN CRITERIA UPGRADE FOR U.S. ARMY TYPE II
AIR TRAFFIC CONTROL TOWERS

1 INTRODUCTION

Background

The U.S. Army Air Traffic Control Activity (ATCA) intended to include a Type II Air Traffic Control Tower (ATCT) for Fort Drum, NY, in the FY86 Military Construction, Army (MCA) program.

Since progress on construction documentation was critical to maintain the project's status in the FY86 program, it was anticipated that the Fort Drum facility design would rely heavily on documentation for a Type II ATCT previously constructed at Fort Wainwright, AK. However, ATCA has identified many problem areas in the Fort Wainwright structure, the Fort Huachuca, AZ, structure, and other Type II installations built according to a "standard" design, and is attempting to avoid repeating these problems at Fort Drum and in other future installations.

During the course of this study, this tower project was rescheduled into the FY87 MCA program. This relieves to a great degree the urgency of construction document production and will allow consideration of some of the longer range recommendations presented in this report.

The Type II ATCT is a tower structure with a control cab floor height of 60 ft* and an overall height of about 74 ft. Recent installations have been built with a cab floor height of 50 ft, thus reducing the overall height accordingly. The cab floor height is a function of the local site conditions.

The plan of the cab and the tower shaft are hexagonal, with an overall width of about 20 ft across corners. The most recent installation at Fort Wainwright has been enlarged to about 23 ft across corners. Each floor level houses administrative functions and/or Air Traffic Control (ATC) radio or radar equipment.

A support level directly below the cab provides a toilet, kitchenette, and break room. However, the current approach is to omit all radio, radar, and other ATC equipment from the tower structure and house them in an adjacent base building. The Fort Wainwright structure and subsequent Type II ATCTs, such as the one at Fort Drum, will house only the control cab and support spaces in the tower itself.

A general reference is made to construction documents for the Fort Wainwright ATCT and for previous Type II ATCTs to more completely describe the facilities' construction and supplement the discussions of problem areas. These documents are available from ATCA.

*Metric conversion factors are provided on p 69.

Objectives

The objectives of this research were to (1) identify problem areas in existing Type II ATCT installations and (2) develop standard design criteria to avoid these problems in future designs and installations.

Approach

The Type II ATCT at Fort Huachuca, AZ (Figures 1 through 7) was examined and problem areas were recorded based on observations and discussions with ATCA and tower personnel. Problem areas in other Type II ATCT installations were also compiled. Construction documents for towers at Fort Huachuca, Fort Wainwright, and other Type II ATCT installations were examined, and problem areas identified. Areas for which design and construction upgrades would be appropriate were then determined and upgrade tasks defined. Finally, design and construction criteria were developed that addressed the identified problem areas and provided guidance for avoiding them in future Type II installations.

This report addresses both the immediate application to the Fort Drum facility and longer-range applications to future Type II ATCTs. One architectural configuration is presented that represents an upgrade of the existing "standard" design. It was anticipated that this design would be applicable to the Fort Drum situation, given the original time constraints. A second architectural configuration represents a departure from the existing "standard" design. This design can now be incorporated into the Fort Drum project or developed into a standard design itself. The construction criteria presented in this report can be implemented for the installation's immediate need, but are equally applicable for future ATCT facility designs. The Corps of Engineers Field Operating Activity (FOA) or the Architect-Engineer (AE) under contract will be responsible for the definitive design and engineering of the Fort Drum and subsequent Type II ATCT facilities.

Scope

Since it was necessary to develop upgraded criteria in a short period of time, this study was conducted on a "quick reaction" basis. Therefore, it was limited to evaluating the existing "standard" design and developing recommendations that could be implemented without radically departing from that design. The study was not an effort to generate an entirely new design.

These findings are intended neither to serve as definitive construction documents nor to delineate all construction criteria applicable to this facility type.

Mode of Technology Transfer

It is recommended that the information in this report be disseminated directly to ATCA and their engineering personnel and to the Corps FOA administering design and construction of the Type II ATCT for use at Fort Drum. It is also recommended that the results of this work be incorporated into designs and construction documentation for future Type II ATCT installations.

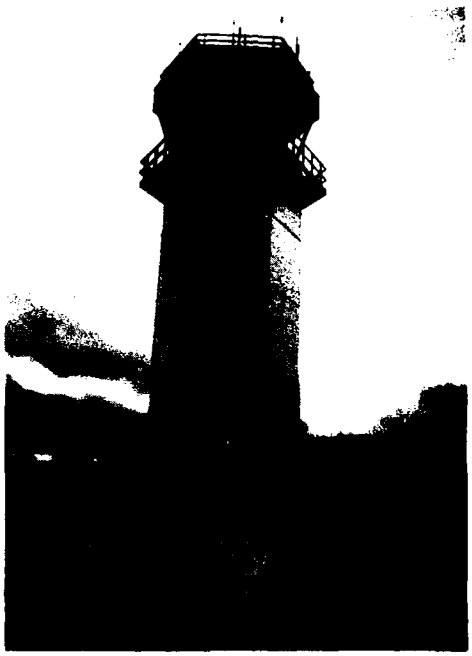

Figure 1. Type II ATCT exterior view (runway side).

Figure 2. Type II ATCT exterior view (back side).

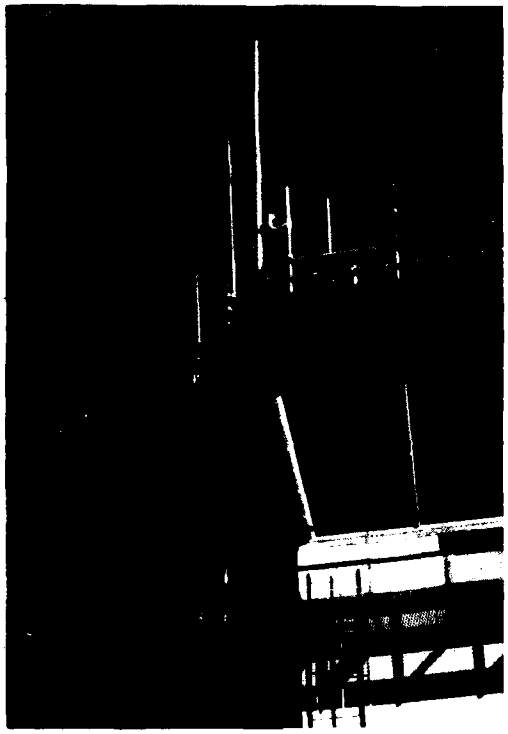

Figure 3. Exterior details of balcony and antennae on roof.

Figure 4. Interior view of control cab.

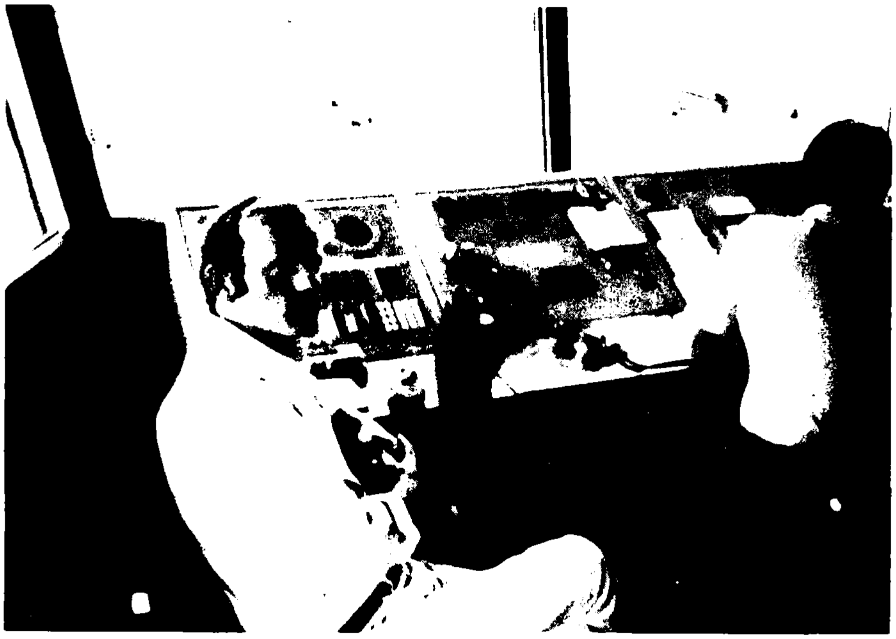

Figure 5. Controller station and console.

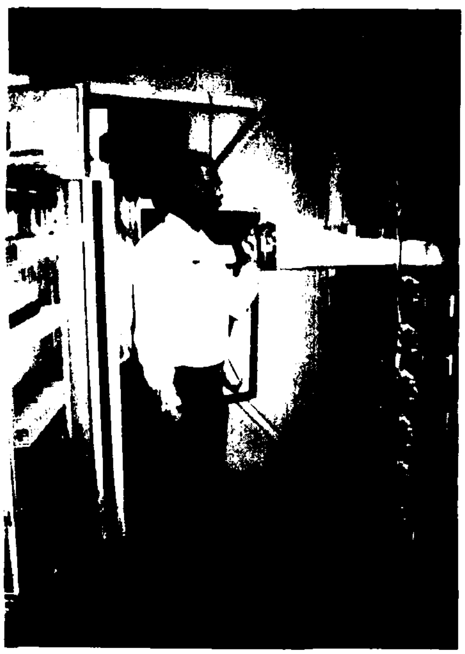

Figure 6. Interior views of equipment room.

equipment is often in "reaction" to building construction, rather than being the prime design and construction influence.

Expandability/Potential for Addition. There is no more room for additional consoles at the cab's front wall. Placement on adjacent walls may not be desirable because of the cab's hexagonal shape. There is no more room for additional radio/amp/radar equipment in existing towers unless administrative spaces are used; no additional equipment will be located in subsequent installations.

Serviceability/Repairability. Servicing and repairing are difficult because of inaccessibility to equipment and cables.

ATC Cables

Placement/Location. The cable runs that extend from the antennae to the consoles and down the tower shaft seem awkward and inconvenient. Cable access into the consoles is also inconvenient; it should be either from the wall behind the consoles or directly below. The vertical chase is at the far side of the tower from most ATC equipment location, creating long horizontal cable runs. Most cables require a large radius for bending (minimum 9 in.) and cannot be turned 90 degrees sharply. Cables are crowded and bent improperly because there is insufficient clearance in many areas.

Clearances (Vertical, Horizontal). Horizontal cable troughs are too close to the bottom of the deck above; a minimum of 18 in. is required. In some locations, electric power is too close to ATC cables.

Accessibility (for Inspection). There is inadequate clearance in horizontal troughs. Access through the lay-in ceiling is difficult and is destructive to the ceiling. There is also interference from building electrics, recessed lights, air diffusers, etc.

Interface (With Other Building Systems). Cable drops create holes and gaps in decks and ceilings. There are no provisions for smoke or acoustic control.

General Project Administration Problems

Requirements Development

Development of construction documents for a new Type II installation appears to rely heavily on previous documentation, but probably without a comprehensive review of ATC requirements, lessons learned from previous installations, or specific project conditions.

Project Design

How ATC equipment interfaces with the building construction is not always clear on construction drawings for previous Type II installations. This includes equipment descriptions and dimensions, placement of equipment, cable runs, etc. There are no distinct "ATC" drawings. A contractor's requirements for accommodating ATC equipment are not always clear.

Construction

Contractors often made their own interpretations of drawings regarding ATC equipment interface; these were sometimes incorrect or inappropriate. Neither the contractor nor the Corps of Engineers' project engineer probably has much, if any, experience with ATCTs, and problems may not be evident to them. Installation of ATC

Interface (With Other Building Systems). Electrical power interferes with ATC cable runs below the cab floor, because not enough clearance is provided. There is no fire/smoke control evident in chases, and no seal or blocks in the deck penetrations.

Lighting

Control/Operability. Dimmer switches on the fluorescent lights in the cab ceiling burn out lamps; the dimmer is not required.

Serviceability/Repairability. Cab downlights are hard to replace because of the ceiling height. The bulbs are also not commonly available and require special ordering.

ATC Equipment Interface Problems

Antennae, Indicators

No problems were noted.

Consoles, Instruments, Equipment

Placement/Location. Controller consoles are in the proper position but are not flush with the front wall of the cab because cables exit the cabinet at the back. Inserts through the cab floor are located at the base of the wall and protrude above the finish floor, preventing placement of the console against the wall. Radio/amp equipment, recorder, and radar equipment are crowded into available space in the tower shaft. Locating this equipment in the tower shaft is a problem for accessibility and repair, but may be preferable for electronic reasons.

Clearances (Vertical, Horizontal). Radio/amp equipment, radar equipment, and the recorder are all severely crowded. There is insufficient clearance on all sides for inspection, repair, maintenance, and installation of new equipment. A 3-ft clearance is required on all sides.

Cable Accessibility. Cables from rooftop antennae are hard to access. They must run down through the cab corner columns, below the cab floor into the support module, and then back up through the cab floor into the consoles. Cable access to the control consoles is difficult because sleeves are placed through the cab floor. Cables may enter the consoles from the bottom.

Interface (With Other Building Systems). Apparently, ATC equipment interface requirements are not always well-defined in construction documents. Examples were given of interference from other building elements, such as radiators and diffusers, which prevented ATC equipment from being placed in the proper positions. ATC cables are sensitive to interference from building electricals. Electrical power lines must be enclosed in conduit. Cable troughs do not have enough vertical clearance for cable inspection and reinstallation. The ceiling grid makes it difficult to access cable troughs. The transition from tubular cab columns to W-shape columns in the tower shaft obstructs cables if it is located at the cab floor level. This transition must occur far enough below the cab floor framing to allow cables to exit the tube columns above the support level ceiling.

Movability, Relocatability. Larger cabinets may be hard to move up winder stairs, such as the ones at Fort Huachuca. Cable installation is difficult because of crowding and interference from other building items.

Mechanical (Heating, Ventilating, and Air Conditioning) Problems

Heating, Ventilating, and Air-Conditioning Equipment

Adequacy/Capacity (Heating, Cooling, Dehumidification). Cabs overheat with solar gain during the summer, while floors above grade are reported to be cold during the heating season. Uncontrolled air infiltration is reported through wall panels, doors and windows, electrical boxes, and outlets, etc. The stairwell is not air-conditioned, and its ventilation is poor. At the Fort Huachuca tower, the fan is isolated from the stairwell by the cab door, and operable louvers at the base face the wrong direction. There is also no heat in the toilet spaces in the Fort Huachuca tower. Exhaust fans in toilet spaces are not closed to infiltration. There is no exhaust fan in the break room and no hood over the range. Heating and cooling capacities are reported to be inadequate at several installations. In one case, a mechanical system that had been designed for a particular location was duplicated at another installation with completely different environmental conditions; environmental control at the latter installation was grossly inadequate.

Location. Wall units in tower shaft spaces can obstruct ATC equipment and blow directly on personnel. The rooftop unit used at the Fort Huachuca tower may be inappropriate in other climates.

Acoustic (Generation). Wall units are noisy beyond acceptable levels.

Acoustic (Vibration/Reverberation). Wall units vibrate in frames. Attachment is undampened.

Serviceability/Repairability. Absence of wall units during servicing leaves a hole in the wall, creating a security problem. Wall units are also susceptible to penetration of wind-driven rain. Roof-mounted units are susceptible to damage and water leakage. Access to rooftop units interferes with cab operations.

Electrical Problems

Electrical Equipment

Adequacy/Capacity. Lightning rods are inadequate at the Fort Huachuca tower. The ones that were originally installed are of proper configuration, but are mounted too low (below the tops of antennae). Lightning rods of the right height are improperly constructed.

Miscellaneous. The fire alarm in the cab is too loud, which is disturbing to controllers who cannot leave their positions during drills. ATC personnel have suggested use of a muting switch.

Electrical Distribution

Electrical Code Compliance. Floor-mounted outlets in the Fort Huachuca tower are not in compliance with Underwriters Laboratory standards.

Location/Accessibility. The main power entrance intrudes into interior spaces. Ground boxes intrude into chases.

Acoustic (Transmission). Holes or gaps in the ceiling allow acoustic flanking and direct acoustic transmission.

Acoustic (Reverberation). The cab ceiling must be stained, rather than painted, to maintain acoustic properties.

Color/Gloss/Texture. Fixtures and attachments must be matte black.

General Detailing. Easier access to ATC cable troughs is required.

Serviceability/Repairability. An ample supply of spare panels must be maintained because of their susceptibility to damage.

Floor Finish

Cleanability. Steam-cleaning carpets is difficult because stairs make upper levels inaccessible to cleaning equipment.

Mechanical (Plumbing) Problems

Plumbing Equipment (Water Heaters, Coolers, Etc.)

No problems were noted.

Plumbing Distribution (Supply, Drain, Waste, and Vent)

Adequacy/Capacity. A drain obstruction caused toilet overflow and subsequent damage. If this happens during nonduty hours, it could be several hours before the problem is detected, and considerable water damage could occur. More serious is the potential for personnel injury by electrocution.

Protection From Physical Damage. Supply and drain, waste, and vent (DWV) lines in an unheated chase are susceptible to freezing.

Condensation. Condensation on uninsulated water supply lines is possible.

Operation (Valving, Zoning, Control). Branches and fixtures are not isolated in the Fort Huachuca tower, so repairs require shutting down the whole tower supply. There is also no anti-syphon valve on the water system to prevent water heater damage during pressure drops.

Interface (Penetration of Walls, Floors). There is no blocking/sealing around deck penetrations in chases. No smoke/fire control is evident at the Fort Huachuca tower.

Plumbing Fixtures

Protection From Physical Damage. One installation reported toilet breakage.

Attached Items

Strength. Surface attachments are apparently screwed only to outer skin of wall panel. Movement or accidental impact may cause withdrawal.

Thermal Transmission. Thermal bridging will occur at structural connections, such as the balcony and ladder, and at ground-level penetrations, such as the roof drain.

Water Leakage. There is no flashing or sealant evident at surface attachments, creating potential leakage sources. The balcony and ladder are susceptible to movement, which may open leakage sources at their attachments to the structure.

Condensation. Condensation may occur at penetrations which are not insulated or thermally broken.

Interior Construction Problems

Walls

Scratch/Abrasion Resistance. Minor damage on drywall surfaces from moving furniture and equipment was observed at the Fort Huachuca tower.

Acoustic (Transmission). Acoustic transmission occurs through all interior walls.

Doors

Air Infiltration. Interior doors are not weatherstripped or otherwise sealed for smoke control.

Acoustic (Transmission). Doors are not weatherstripped or otherwise sealed for acoustic control.

Casework

Adequacy/Capacity. There is no storage space for personal items in the tower. The kitchenette in the Fort Huachuca tower does not have any over-counter cabinets, although there is ample space.

Ceilings

Fire Resistiveness, Combustibility. Holes and gaps in the ceiling compromise the ceiling's fire rating.

Stain Resistance. Staining from water leakage was evident in the Fort Huachuca tower. Ceilings are susceptible to staining from cigarette smoke.

Cleanability. Ceiling surfaces are generally not cleanable.

Resistance to Physical Damage. Damage occurs during ATC equipment repair and maintenance. There is no designated access to ATC equipment, and panels are not durable enough for frequent removal and replacement. Suspension grid members are susceptible to damage.

sealed joint. The seal at doors, windows, and wall openings is also questionable; flashing is not returned under the exterior wall surface but only caulked on the outside face.

Windows

Strength (General). Window breakage in cabs was reported in several installations and attributed to wracking in frames and/or structural movement.

Resistance to Misuse. Some window handles were broken off operable sashes in the Fort Huachuca tower.

Thermal Transmission. The Fort Huachuca tower does not have thermal-break window frames, and it is unlikely that other installations do either. (Wood windows are specified for the Fort Wainwright tower.)

Air Infiltration. Infiltration was reported around frames and at operable sashes in tower shaft windows.

Water Leakage. Leakage was reported around frames and operable sashes in tower shaft windows.

Condensation. Condensation problems are possible in colder, more humid climates unless thermal-break frames are provided.

General Detailing. Flashing at window heads is entirely on the outer surface of the wall, and is not returned under the panel's exterior surface.

Doors

Horizontal Load. At the Fort Huachuca tower, opening doors are caught by prevailing winds, creating a hazard to personnel and damaging frames and hinges. The adjacent base building for the Fort Wainwright tower provides the opportunity for a sheltered tower entry.

Thermal Transmission. The balcony door in the Fort Huachuca tower radiates solar gain and is probably not insulated. The Fort Wainwright tower design calls for insulated exterior doors with thermal-break frames.

Air Infiltration. Infiltration is reported around doors and frames, especially in upper tower levels.

Water Leakage. Leakage is reported around doors and frames and under the entrance door sill during wind-driven rains.

Condensation. Condensation problems are possible in colder, more humid climates unless doors are insulated and frames are thermal-break.

Acoustic (Transmission). Flanking will occur around doors and frames without weatherstripping.

General Detailing. Flashing is entirely on the outside surface of the wall instead of returning under the panel skin, so leakage is possible.

Parapet/Gutters/Downspouts/Scuppers

Resistance to Weathering. Cracking around drains was evident at the Fort Huachuca tower.

Water Leakage. Undercapacity of downspouts (two at 1-1/2 in. each) is suspected to contribute to leakage problems at the Fort Huachuca tower.

Exterior Wall System Problems

Exterior Wall

Fire Resistiveness, Combustibility. If 2-hour fire resistivity is required for a "smokeproof enclosure" (per Uniform Building Code), the metal panel walls used in this design do not provide such protection.

Horizontal Loading. Deflections are evident in the wind. The tower's panel seams may open, allowing leakage from wind-driven rain. Panels span from floor to floor, unsupported; this may be too great a distance. In one case, wall panels were blown off a tower. Panel selection for the tower design may not have considered aircraft-generated windloads, reported by ATC personnel to be up to 100 knots.

Thermal Transmission. Panels that have been insulated in the field may have openings and irregularities. If leakage occurs as reported, wall panel insulation may be wet and its performance diminished. There are discontinuities in the insulation at the balcony attachment. Also, there is no insulation at the framing around the cab (above sill), which creates a thermal bridge. The Fort Wainwright design calls for insulation at the window sill detail; however, further improvements may be possible.

Infiltration. Daylight was seen at some wall panel connections to the superstructure, and gaps are evident at horizontal joints. Infiltration was reported around framed openings. Daylight was seen around wall air-conditioning units, and air leakage was evident at cab window sills.

Water Leakage. Leakage was reported through the wall system, which may result from seams opening in the wind under deflection. Gaps in horizontal flashing and trim pieces were observed at the Fort Huachuca tower. Stains in the ceiling at columns indicate possible leakage at corner closures. Stains in ceilings above doors suggest leaking at door heads. Water leakage was also observed at the cab window sills. Leakage may also occur into columns at cab corners; spot welded seams are open at upstream surfaces. Similar types of leakage are reported at other installations.

Acoustic (Transmission). Aircraft noise transmission is reported to affect interior spaces.

Acoustic (Structure-Borne). Wall panels resonate in the wind.

General Detailing. Gaps are evident in horizontal flashing between panels. Exposed fasteners that are not driven straight are vulnerable to leakage. Movement in wall panels caused by wind or thermal expansion also enlarges the holes from the fasteners, creating potential leakage sources. The seal at corner trim pieces is questionable, since fasteners penetrate the wall surface, and there is no continuously

Configuration. The third rail on the fire escape ladder is treacherous if exit is made without a safety belt because it obstructs movement. There is no cage on the exterior ladder.

Railing Height. The roof rail on the Fort Huachuca tower is too short.

Obstructions, Intrusions. Bolt heads protruding from stair riser surfaces create a tripping hazard.

Roof System Problems

General Configuration

Slope. A general statement may be made that "flat" roofs should be avoided where practical. Ponding and leakage were reported in several installations.

Runoff Collection/Disposal. Cracking and leakage are evident at two interior drains of the Fort Huachuca tower. Runoff drainage on the concrete apron at the tower base was reported to create a freezing and slipping hazard at some installations.

Location of Attached Items. The rooftop air-handling units and hoist are likely places for leakage problems to occur.

Accessibility to Attached Items. Removal of large mechanical equipment from the roof would probably be difficult, since the hoist is inaccessible from the roof surface.

Roof Access. The wind slams the roof hatch shut.

Thermal Transmission. The insulation in the Fort Huachuca tower has probably become soaked due to roof leakage.

General Detailing. No specific problems are discussed, but water leakage is a general problem.

Roofing/Membrane

Foot Traffic Protection. Foot traffic protection was not continuous around the perimeter of the Fort Huachuca tower, and there was no protection around the roof hatch.

Resistance to Weathering. Cracking around drain pockets was evident at the Fort Huachuca tower.

Water Leakage. Water leakage at the Fort Huachuca tower was attributed mostly to roof drains.

Serviceability/Repairability. The air-handling unit and the small working area of the roof may cause difficulties in servicing or repairing.

Foundation

General Detailing (at Superstructure). Rodent, snake, and insect intrusion and air infiltration were reported.

Floor Slab

Thermal Transmission. Floor slabs in the Fort Huachuca tower are not insulated. In colder climates, this could cause cold floors and condensation problems. The foundation and floor slab are insulated at the Fort Wainwright tower.

Serviceability/Repairability. The inaccessibility of underslab utilities may create maintenance difficulties.

Superstructure Problems

It is assumed that the structural design is at least adequate as designed and that no further structural analyses will be made.

Horizontal (Framing, Deck)

Deflection/Vibration. Foot traffic causes decks to bounce.

Thermal Transmission. Floors above grade are cold. There is direct thermal transmission from the exterior and structure; balcony anchorage creates thermal bridging.

Acoustic (Transmission). Gaps in deck, chases, and openings are not closed and create flanking paths for sound.

Acoustic (Structure-Borne). Decks transmit impact noise from foot traffic.

Vertical

Deflection/Vibration. Tower sway has been reported in several installations, although the magnitude was not noted. Movement and wracking is also suspected of causing cab windows to break.

Thermal Transmission. There is direct thermal transmission from the superstructure at the cab window sill and corner columns.

Serviceability/Repairability. There was evidence of water accumulation in the Fort Huachuca tower structure, which resulted in the dripping of rusty water. Open seams were observed in the cab corner columns which were vulnerable to water penetration. Besides being unsightly, this may indicate eventual rust damage.

Miscellaneous Metals (Stairs/Ladders/Balconies)

Location, Accessibility. Placement of the roof scuttle is inconvenient, since it interferes with access to the perimeter. Access to the Fort Huachuca roof is somewhat treacherous. The telescoping ladder descends unrestrained, and the intermediate "stub" ladder is not aligned with the telescoping ladder.

Fire Egress. The exterior ladder should be accessible to all levels, not just to the cab. An exit ladder at the front or sides of the tower may be susceptible to hazards (aircraft fire, etc.); therefore, it should be located away from aircraft ramp/parking.

Smoke Propagation Control. The stairwell smoke evacuation fan at the Fort Huachuca tower is isolated from the stairwell by the cab stair door. Furthermore, operable louvers at the bottom of the stairwell are facing in the wrong direction and will shut, not open, when the fan starts. Holes and gaps in the ceiling and deck between floors are not blocked for smoke control. There are no smoke/fire barriers in chases or in utility or cable penetrations. Interior doors have no weatherstripping or seals for smoke control.

Obstruction by Building Elements. Irregularly shaped interior spaces obstruct equipment placement, inspection, and maintenance. X-bracing reduces usable net interior space and makes trimming and finishing of interior items (ceiling, flooring) difficult.

Acoustic Control (Transmission). There is generally poor acoustic control. Tower cabs are reportedly affected by aircraft noise transmission through windows, through the floor deck from the support level below, and through chases, holes, and panel boxes, etc. Other spaces are affected in the same way. Foot traffic creates impact noise through decks.

Acoustic Control (Reverberation). Exterior wall panels resonate in the wind. Painted ceiling panels in the cab diminish acoustic absorption.

Lighting. Cab downlights are good, but are hard to maintain because of difficult access and nonavailability of bulbs. Work lights on the roof are of questionable utility because they are only a few inches above the roof surface.

Security; Intrusion Resistance. The intercom-controlled entrance is adequate, but problems with its dependability were reported. Intercom control in the cab is too remote from the controller position. Some ATC personnel preferred a 10-button cipher lock. Removal of HVAC wall units from lower levels for servicing leaves openings in walls and therefore causes security problems.

ATC Equipment Accessibility/Mobility. Doors at each level are unnecessary and create other wind and rain penetration problems. Most equipment can be carried by hand upstairs, although moving larger equipment and furniture is inconvenient. A hoist on the roof is desirable. Problems with gaining accessibility to restring ATCT cables were caused by interference from building utilities and by inaccessibility of cable runs.

Substructure Problems

For this discussion, it is assumed that the foundation designs are at least adequate as designed and that no structural analyses will be conducted. However, the existing "standard" design appears to be considerably overdesigned for many cases.

and administrative functions will be deleted from future Type II ATCT designs, solving many of these problems.

Aesthetics/Appearance. Interior spaces are not finished, and therefore do not look "professional." Framing members are exposed to the interior, and wall panel liners (interior surface) are unattractive.

Miscellaneous. Tower entries have no shelter or protection from the elements if they are not attached to a base building. An airlock vestibule is suggested.

Space (General, All Spaces)

Floor Area. The cab's floor area is adequate but could be somewhat larger. All other spaces are severely crowded. The support module is too small to accommodate personnel seated at a table (four or five are required) and lockers for personal items. Irregularity of space is also a problem. The stairwell prevents use of greater floor area in tower shaft spaces. (Other spaces are not discussed since they will not be included in future Type II tower designs.)

Ceiling Height. Cab ceiling height should not be reduced. Other spaces have 8-ft ceilings but can be reduced to 7 ft-6in. if necessary to accommodate utilities.

Number/Provision of Workstations. Controllers' positions in the cab are adequate, but room for additional ATC equipment is limited. Provision for supervisors in the cab is adequate but crowded. Provision for miscellaneous equipment (binoculars, radios) and personal items is inadequate. (Other spaces are not discussed, since they will not be included in future Type II installations.)

Ingress/Egress. The exterior exit is accessible from the cab only, but not at all levels of the cab and tower.

Placement of Doors, Windows. At Fort Huachuca, doors in the tower shaft, the stairwell windows, and the entrance door are all on the windward side of the tower and are susceptible to wind-driven rain. Doors swing in the wrong direction with regard to prevailing winds, opening to catch wind. This creates a safety hazard, as well as damages door hinges and frames. "Cargo" doors in the tower shaft are unnecessary. A single-leaf entry door is the only door needed. Cab windows are hard to clean from the interior, since there is nothing to stand on to clean their full height.

Placement of ATC Equipment. Control consoles are located properly, but there is little room for additional consoles or equipment. The intercom/entrance lock control is located too far from the controller's position. Radio and amp equipment, recorder, and radar console do not fit well into their allocated spaces. There is inadequate clearance at the front, sides, and rear for installation, inspection, and maintenance. ATC cable chases are at the opposite side of the tower from most ATC equipment. In future installations, all ATC equipment (except controller consoles) need not be located in the tower structure.

Placement of Building Utilities. Electrical boxes in the ground floor office, toilet spaces, and cab intrude into the working spaces. Plumbing chases are most often located in unheated spaces and are susceptible to freezing.

2 PROBLEM AREA IDENTIFICATION

The problem areas discussed in this chapter were identified primarily by examining the Fort Huachuca ATCT and the documented problems with other Type II ATCTs. Construction documents for several installations, including Fort Wainwright, were also examined to identify any potential problems that may not have been evident in site investigations or reports from other installations.

These problem areas are presented for the purpose of anticipating and avoiding future problems. They are most frequently discussed in the general case. This discussion is not intended as a retrospective examination of specific deficiencies in any given installation nor to attribute liabilities or responsibilities for any deficiencies.

Architectural Problems

General

Controller Visibility. Controllers' positions should be as close to the cab front window as possible. However, in some installations other building items such as mechanical equipment prevented placement of ATC consoles against the front wall, pushing the controllers into the center of the cab. Cab corner columns are typically built up from standard structural shapes into a hollow column to serve as a chase for ATC cables. These columns are frequently too wide, especially when window frames add to overall width. Preferences for the cab's shape are divided between rectangular and hexagonal. Users object to having parallel windows on opposite sides of the cab, because they create interfering reflections. A rectangular cab will have greater areas of parallel windows; however, there were no other objections to this configuration regarding visibility. Existing ceiling heights of 9 ft - 10 in. to 10 ft - 0 in. should not be reduced.

Tower Orientation. No problems were noted with orientation of the cab or other functions to airfield or aircraft activities. There were problems with placement and orientation of doors, windows, openings, door swings, etc., with regard to local prevailing winds and environmental conditions. The "standard" design had not been adjusted for these conditions.

Number of Floors/Levels. Subsequent installations will not require equipment or administrative spaces in the tower shaft; the cab and support level will be the only functional areas.

Accommodation of Functions. ATC functions in the cab are adequate but somewhat crowded. The support module is very crowded, needing more room for personnel seated at a table as well as locker space for personal items. ATC equipment spaces are severely crowded. There is no room for installation, inspection, or maintenance.

Rectangular equipment does not fit well into irregularly shaped spaces. New radar equipment will not fit into tower shaft spaces. No reasons were found why the tower shaft must be hexagonal, even if the cab is; it can be square or rectangular.

Administrative spaces are crowded, and there are no provisions for office furniture. Electrical panels and communications panels intrude into the space in the ground floor office. Large items (desks, etc.) are difficult to carry upstairs. Equipment

Figure 6. (Cont'd)

Figure 7. Interior view of administrative space.

3 GENERAL AREAS FOR CRITERIA UPGRADE

Based on the study of problem areas identified in existing Type II ATCTs, this chapter identifies general areas for which criteria upgrade is appropriate, stating the tasks needed to carry out these upgrades, and providing suggested specific guidance for certain task areas.

Architecture

1. Document criteria for space planning and architectural configuration.

2. Develop an upgraded architectural design within the configurations and dimensions of existing designs.

3. Develop a concept architectural design for an improved Type II ATCT, incorporating a rectangular tower shaft as appropriate.

Substructure

1. Develop "generic" foundation insulation and vapor retardant details.

2. Revise the detail for the foundation/wall panel connection.

3. Develop a "generic" slab access panel detail.

4. Develop guidance for deleting any indication of a definitive foundation design from a "standard" ATCT design.

Superstructure

1. Examine the overall framing approach. Address aircraft-generated wind loads, tower sway and torsional deflection, and deck deflection. Using this information, develop recommendations for upgrade accordingly.

2. Revise the detail for cab corner columns. Address visual obstruction, thermal transmission, and accommodation of ATC cables and roof drainage.

3. Revise the detail for lateral bracing so as not to intrude into occupied spaces.

4. Revise the detail for the telescoping ladder to the roof hatch, making a single ladder continuous to the roof level.

5. Develop guidance as follows:

a. Seal around penetrations in decks for fire and smoke control. Ensure that all structural seams and joints (welds, etc.) exposed to the exterior are completely closed and sealed.

b. Ensure that roof rail height conforms to Occupational Safety and Health Administration (OSHA) standards.

c. Upgrade stair detailing to prevent trip hazards caused by bolt heads and fasteners protruding from risers and other surfaces.

Roof System

1. Develop an alternative roofing approach and identify suitable roofing material. Address positive drainage, drain location, freeze protection, and foot traffic protection.

2. In areas of warmer climates, develop an alternative roof configuration for external guttering and drainage that will be simpler and less expensive.

3. Revise the detail for the weatherhead cable entrance.

4. Develop guidance as follows:

a. Avoid placing mechanical equipment (or anything else) on the roof.

Exterior Wall System

1. Examine the wall panel system used in existing installations, and select an alternative type as appropriate. Address aircraft-generated wind loads, unsupported length, attachment and support, wind deflection, thermal insulation and integrity of detailing, air and water infiltration and integrity of detailing, fire resistiveness requirements, and suitability of the interior finish. Indicate appropriate test methods and criteria.

2. Develop details for thermal protection of the cab superstructure.

3. Develop details for thermal protection at attached structural items, such as the balcony.

4. Develop guidance as follows:

a. Flash and seal around all items penetrating the exterior surface of the wall. Insulate penetrating items.

b. Provide sufficient anchorage for attached items.

c. Provide triple glazing for cab windows for thermal and acoustic control. Specify double glazing for tower shaft windows. Specify thermal-break frames for all windows. Identify appropriate tests and appropriate criteria for infiltration in operable windows.

d. Specify insulated exterior doors, thermal-break frames, and weatherstripping. Identify appropriate tests and appropriate criteria for infiltration. Address necessity for exterior doors labeled as fire exits.

e. Indicate preference for a 10-button cipher lock for entrance control.

Interior Construction

1. Develop a "generic" detail for finishing interior surfaces of exterior walls.

2. Select an upgraded ceiling system. Address durability of acoustic panels and protection during removal and reinstallation, coordination of the ceiling layout with the ATC cable layout, and coordination of the ceiling system with floor plans.

3. Develop guidance as follows:

a. Upgrade acoustic performance of tower spaces. Address wall and deck construction, closure of gaps and openings, weatherstripping of doors, locations of recessed boxes, and other acoustic-related details.

b. Seal around penetrations in walls and decks for fire and smoke control. Weatherstrip doors for smoke control. Address the need for doors labeled as fire exits in interior walls.

c. Specify factory-stained ceiling panels for the cab ceiling; avoid painting. Identify appropriate acoustic properties of cab ceiling panels. Specify that all attached items are to be matte black.

d. Specify foam-backed carpet for increased durability and acoustic control.

Mechanical (Plumbing)

1. Locate plumbing chases in heated spaces.

2. Develop details for overflow trays in toilet areas.

3. Develop guidance as follows:

a. Oversize DWV lines to preclude possible clogging and maintenance problems.

b. Provide control valves at supply branches. Provide cutoff valves at fixtures and an anti-syphon valve for the building.

c. Insulate supply and DWV lines if they pass through any unheated spaces.

Mechanical (Heating, Ventilating, and Air Conditioning)

1. Develop an alternative mechanical approach and layout for the tower. Address equipment selection and location, ventilation and smoke evacuation in the stairwell, acoustic control, "economy" operation for ventilation only, proper location for supply and return, fuel sources, and accessibility for maintenance.

2. Develop guidance as follows:

a. Insulate floors above non-air-conditioned and nonheated spaces.

b. Provide exhaust fans in toilet spaces and the break room. Specify operable louvers for exhaust fans to prevent backflow.

c. Provide a range hood in the kitchenette.

d. Drain mechanical equipment condensate directly into the DWV system.

e. Provide permanently mounted heating, ventilating, and air-conditioning control instructions in a prominent place in the tower.

Electrical

1. Locate the main power entrance so as not to intrude into occupied spaces.

2. Identify appropriate lightning rod details and specifications.

3. Identify appropriate cab downlight fixtures.

4. Develop guidance as follows:

a. When panel and ground boxes are located in occupied spaces, recess them into wall surfaces.

b. Seal around recessed panel boxes, outlets, switches, etc., for acoustic and air infiltration control.

c. Revise the detail for work lights on the roof. Either mount fixtures at an appropriate height, or delete them.

d. Replace the cab dimmer switch for overhead fluorescent lights with a standard toggle switch.

e. Avoid floor-mounted receptacles.

ATC Equipment Interface

1. Indicate ATC equipment and cable layouts in the architectural drawings and/or distinct "ATC" drawings.

2. Identify ATC equipment anchorage requirements, and develop details accordingly. Identify locations where ATC cable chases, troughs, and/or ladders interface with building elements and develop details accordingly.

3. Locate the tower entry intercom controls in the cab so that they will be convenient to controller positions.

General Project Administration

Develop recommendations for ATC facility design and construction administration. Address the following:

1. Detailed definition of ATC equipment requirements.

2. ATC personnel activity during design development.

3. ATC equipment requirements and interface conditions in construction documents.

4. ATC personnel activity during construction.

4 RECOMMENDED SPECIFIC DESIGN AND CONSTRUCTION CRITERIA UPGRADES

The following recommendations are made as upgrades to the existing Type II ATCT "Standard" design. Each problem area identified in Chapter 2 is addressed in these recommendations, although not always explicitly. In some cases, several problems are addressed in one recommendation and in others one problem area may be resolved through several recommendations. This material is not intended to represent definitive construction documentation or a delineation of all construction criteria applicable to this facility type. It is designed to serve as guidance to the Corps FOA or to the AE in developing definitive design and construction documentation.

Architectural

Scheme One

Scheme One for upgrade conforms to the existing hexagonal tower and cab configuration now used by ATCA (Figures 8 through 12). The architectural plans are consistent with the overall exterior dimensions that have been previously established for the Fort Wainwright tower design. This scheme should be applicable immediately to the Fort Drum facility. Primary concepts for this scheme are outlined in the following sections.

Ground Floor.

Stairway. The primary stairwell has been moved away from the 120-degree corners of the building. This allows the stairway to have free and unobstructed landings without winder stairs, greatly improving both the usefulness and safety of building circulation. Stair width is increased to 3 ft. This more conventional stairwell provides for quicker movement and removes the need for variability of tread dimensions for safer exiting. An additional exit to the fire escape ladder is provided at an intermediate level. This scheme provides for closet storage beneath the upper run of the stair. Vent fan louvers are needed at the base of the stair for stairwell ventilation. The new stairway allows ATC cables to be examined at every intermediate stair landing.

Vestibule. The tower structure and base building are joined by a vestibule. The vestibule protects the tower entry, making building orientation less sensitive to prevailing winds. Protection from wind will reduce infiltration and, therefore, heating leads. The tower entry is a single-leaf door (there are no other "cargo" doors in the tower). Where local conditions permit, the vestibule can be replaced by a simple canopy.

Support Floor. The support floor in Scheme One has been designed to be more efficient than in previous towers. The toilet contains only the water closet and has a pocket-door entry to conserve floor space. The toilet and kitchenette share a plumbing wall located directly adjacent to the stairway. The kitchenette includes an under-counter refrigerator, sink, overhead cabinets, under-counter water heater, and a small range. The kitchenette may be a prefabricated unit or a conventional arrangement of appliances and cabinetry. Furniture selected for the break area must be more space-conservative than in present designs. A countertop with stools, along with a sofa and chairs, can be used in the room without crowding. If a table is preferred, a round table is much better spatially.

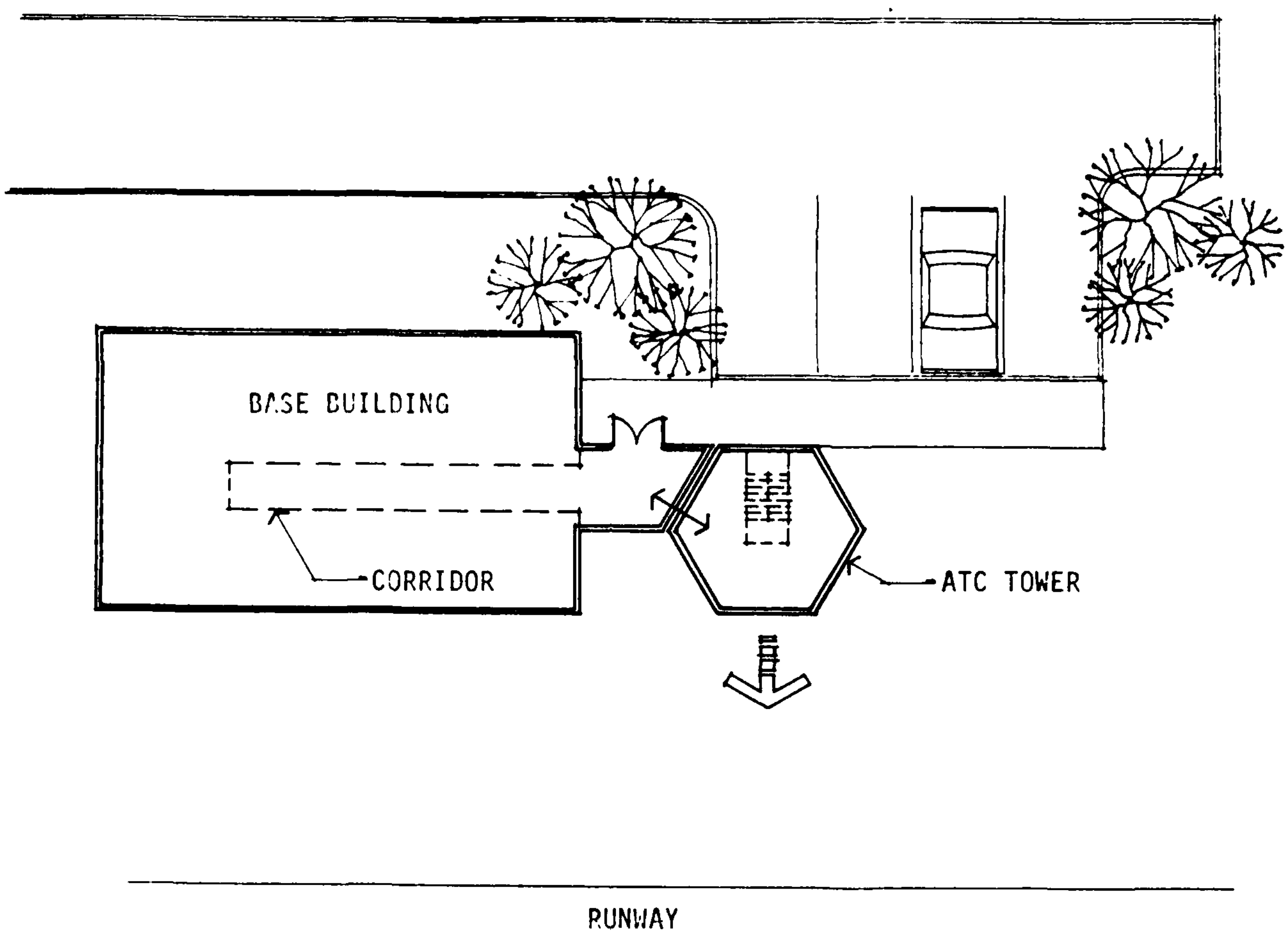

Figure 8. Scheme one--key plan.

Cab Floor. Although the hexagon configuration is somewhat constraining, it seems to work best at the cab level. Many problems encountered with the cab floor result from construction detail problems; however, the following planning suggestions are made.

The stairway entering the cab floor should be discontinuous from the primary building stairway. This would allow greater flexibility with respect to location and allow the designer to shorten the stair run by varying the riser-to-tread ratio. This can all be done without interfering with the primary stair below. At the turn of this stair section, a shelf can be created from the support floor below to carry the mechanical unit for the cab area. Air distribution can occur at the base of the railing enclosing the stair shaft. The drinking fountain will align directly over the plumbing wall below.

Bookshelving should be perpendicular to the cab wall to minimize obstruction at the cab perimeter. Roof access should be located at the turn of the stair to avoid interfering with controller workstations or other activities within the cab. Security control for the ground level should be within comfortable reach of the controller. Console equipment should be closer to the windows, and adequate space for trainee observation should be provided. Access to the exterior balcony should be from an intermediate stair landing.

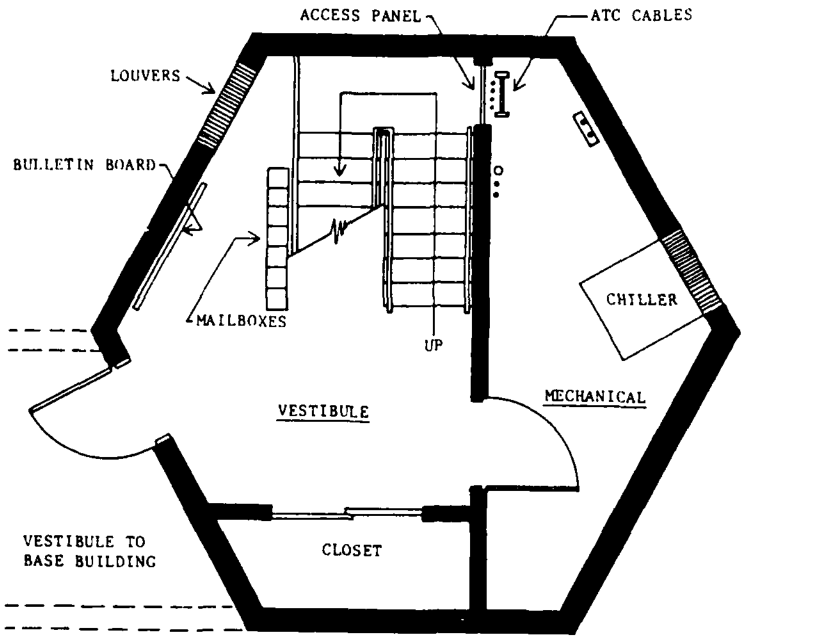

Figure 9. Scheme one--ground floor.

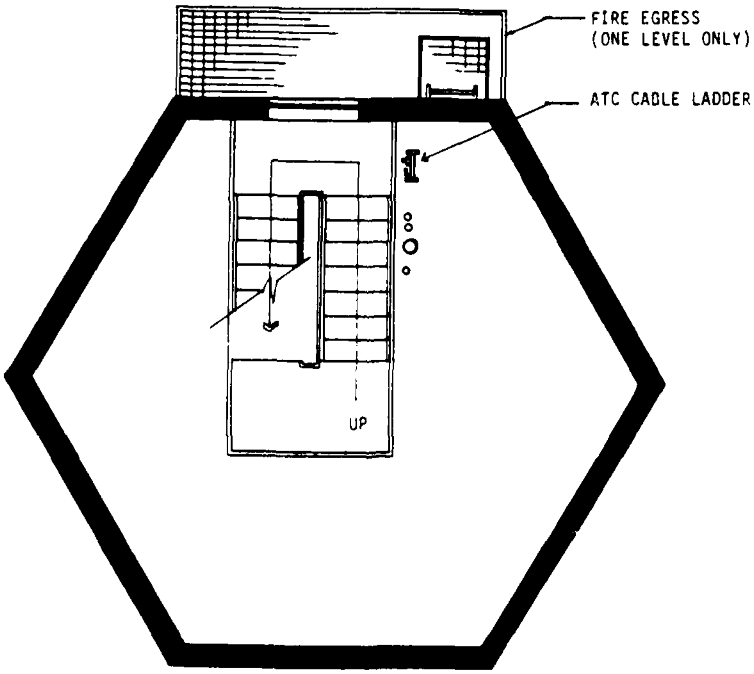

Figure 10. Scheme one--intermediate level plan.

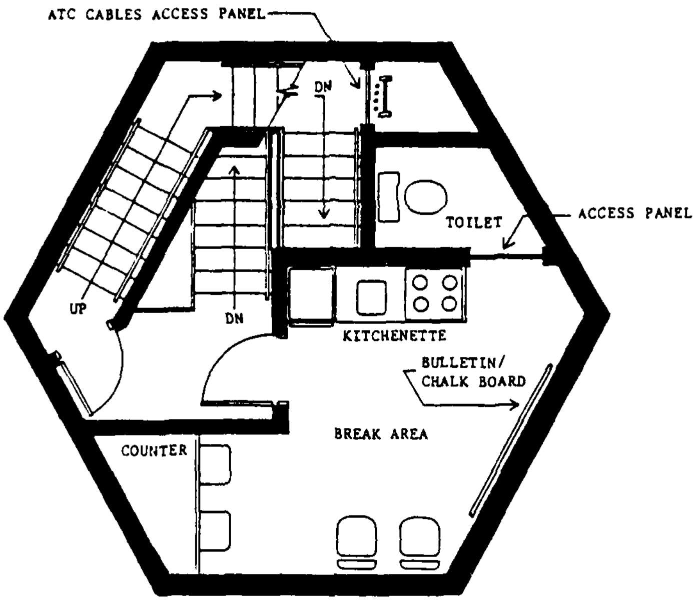

Figure 11. Scheme one--support floor.

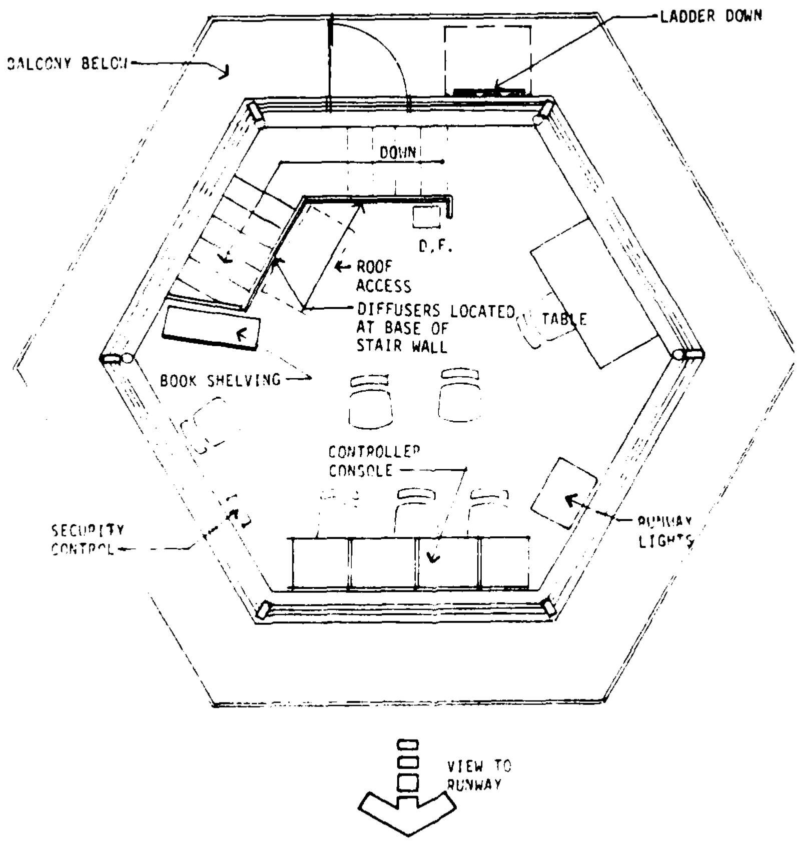

Figure 12. Scheme one--cab floor.

Scheme Two

Scheme Two is a rectangular tower with a hexagonal cab (Figures 13 through 17). Although the hexagonal cab may have advantages because it improves visibility, this configuration does not seem to work well for the other building functions in the tower shaft. Many elements, such as stairways, toilets, mechanical rooms, etc., are adversely affected by this departure from rectilinear construction. It is preferable to enclose these functions within a rectangular tower and have the hexagon cab on top of it. This scheme offers many advantages over the hexagonal tower approach with respect to spatial planning. Also, the building will probably be much less complex to build and thus more economical. This scheme should be appropriate for the Fort Drum project as new construction documents can be developed within available time constraints. Scheme Two will also apply to subsequent Type II ATCT installations.

Ground Floor. This scheme offers the advantage of providing a rectilinear stairway of conventional size and dimensions. The stair could probably be prefabricated and site-assembled. As in Scheme One, the stair provides intermediate landings that provide improved usefulness and safety as well as access for inspection of ATC cables. The stair configuration illustrated is in accordance with the Uniform Building Code, except for the last rise into the cab, where a steeper stair is acceptable. Access to the fire escape ladder is provided at an intermediate level.

Minimizing the obtuse angles of the hexagon allows the mechanical room and vestibule to be more functional and responsive to user requirements. The mechanical room can easily accommodate the chiller or compressor and can provide adequate space for plumbing and electrical service. The vestibule can now accommodate lockers to store coats or personal belongings, as well as ample storage space. There is enough wall surface for use as bulletin or chalk boards. The squaring-off of the corners allows a simpler connection to a base building. The entrance location can vary, but should be away from the runway side of the building. There is also potential for direct connection to a base building, which would allow common use or sharing of the mechanical room or entry vestibule.

Support Floor. The support floor benefits the most from the Scheme Two configuration. Again, there is much advantage to discontinuing the stairway and providing a separate stair run to the cab floor. Riser-to-tread ratios may vary, and stair-run length and location can be altered. Access to the fire escape ladder is provided directly from the break/kitchenette area.

As with the ground floor, building functions are less adversely impacted by eliminating odd corners. Rooms can be more efficient and responsive to user needs. The break room is much larger. There is enough room for round-table seating, a kitchenette, and a toilet. Mechanical chase space is less constrained and can provide limited closet space under the stairs. ATC equipment cables are strung in a chase recessed in the stairwell wall. This chase allows inspection of cables at the support level and aligns with the cable ladder at the landings below.

Cab Floor. All recommendations and improvements previously described for Scheme One are incorporated in Scheme Two.

The balcony must be located 2 ft-6 in. below the cab floor. Increasing the floor-to-floor height from the support to cab level allows the balcony to span over the roof of the support level below (the corners of the rectangle). This increased height also allows

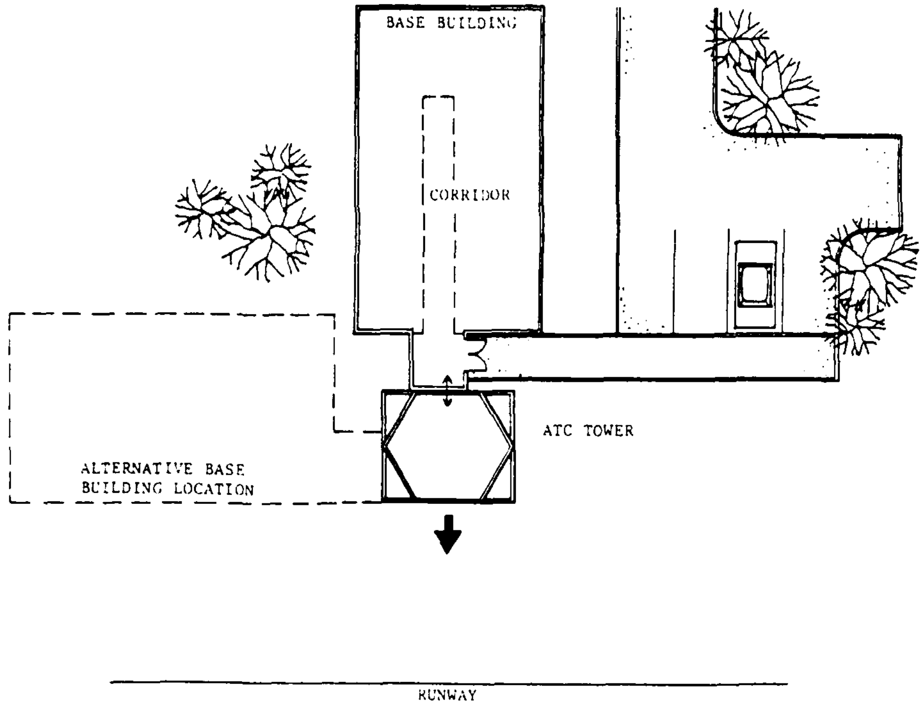

Figure 13. Scheme two--key plan.

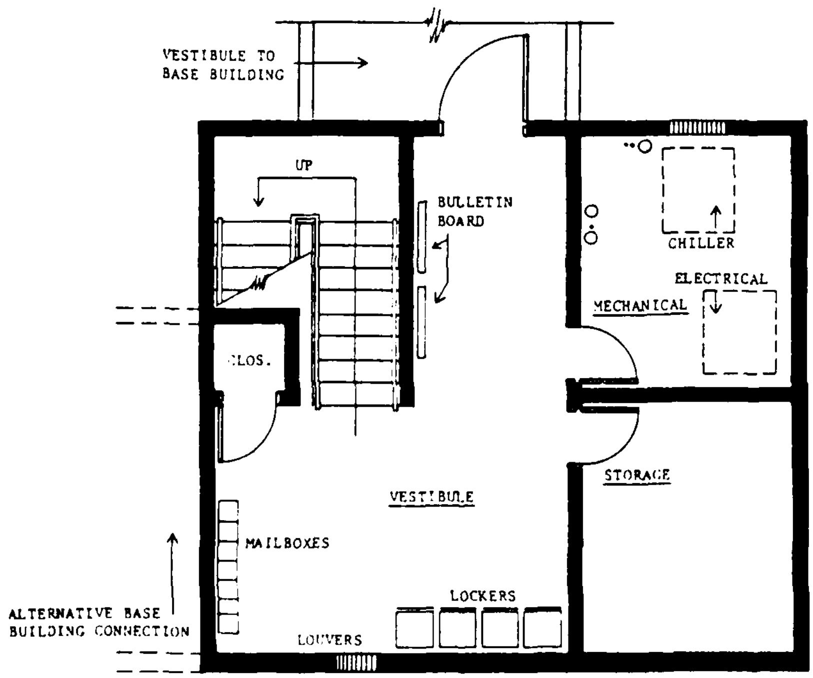

Figure 14. Scheme two--ground floor.

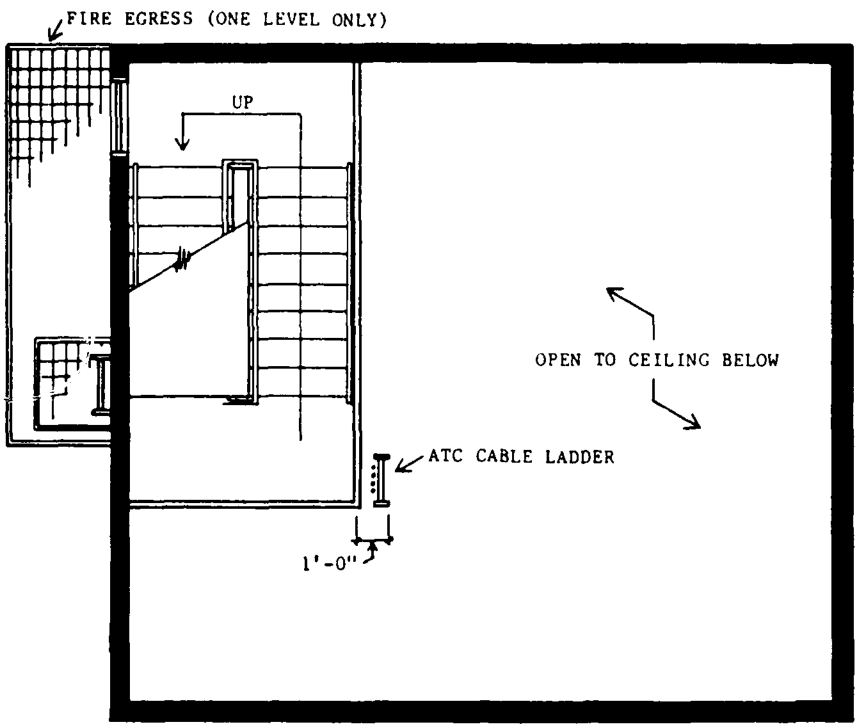

Figure 15. Scheme two--intermediate level plan.

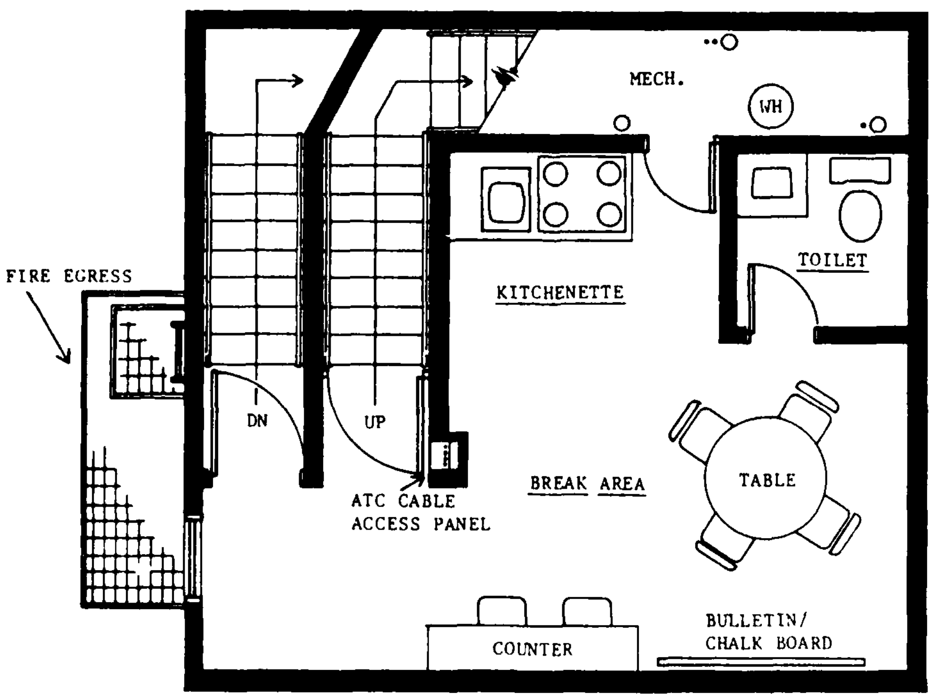

Figure 16. Scheme two--support floor.

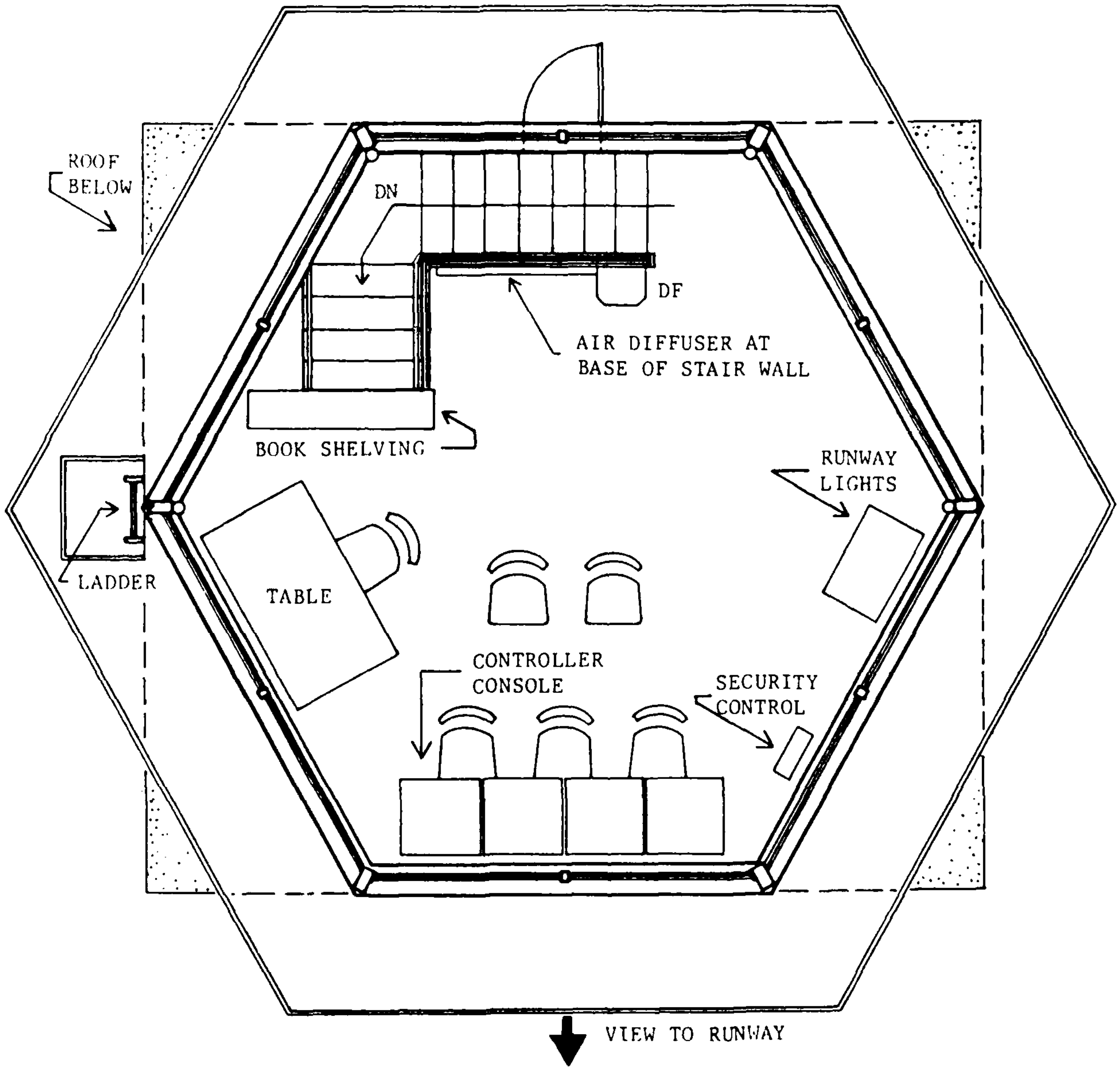

Figure 17. Scheme two--cab floor.

easier access to cable troughs under the cab floor for installation, inspection, and replacement of ATC equipment cables (Figure 18).

Substructure

Floor Slabs

A vapor retardant and insulation for floor slabs should be provided for installations in colder climates. A typical configuration is an 8-mil polyethylyne vapor retardant and 1-in. rigid insulation. Specification of closed-cell polystyrene insulation board is suggested. Insulation thickness may vary according to location (Figures 19 and 20).

Sealing

The seal at the interface of the foundation and wall panel should be improved. Wall panels should be extended a minimum of 3 in. below the edge of the foundation wall or slab and a closure strip and drip groove provided on the bottom edge of the panel. Flashing should be returned behind the panel interior face. The clip angle should be sealed or gasketed at the foundation and at the wall panel interior face (Figure 21).

Foundation Designs

The "standard" foundation configuration indicated for the existing ATCT installations may be substantially overdesigned for many cases. Therefore, it is suggested that there be no indication of the foundation design in future "standard" designs. Foundation design must be site-specific. A pier and grade beam approach may be appropriate under most ordinary conditions. Thus, the floor slab would be nonstructural.

Underslab Utilities

Routing underslab utilities under an accessible cover material is suggested for ease of repair, replacement, or reinstallation. Since frequent access should not be necessary, a utility trench is probably not cost-effective. Instead, underslab utilities could be covered with pavers, grating, or precast sections (Figure 22). This would require use of a nonstructural slab.

Superstructure

Structural Design

A braced-frame steel structure similar to those used at existing installations should be developed. The definitive structural design must be completed by the Corps FOA or AE.

Design Criteria. Structural design criteria are identified by the installation's location. A factor must be included for aircraft-generated wind loading. ATC personnel report that 100-knot (112-mph) winds are possible with certain rotary-wing aircraft.

Deflections. Torsional and lateral deflection can be resisted by K-bracing. K-bracing reduces the beam span length and the length of the compression diagonal and allows more convenient placement and framing of windows and doors. Since no adjacent

Thermal Protection

Thermal protection should be provided at the cab superstructure. Window frames should be attached toward the exterior of head and sill framing members and corner columns (Figures 34 and 35). Insulation should be packed around head and sill framing members at the bottoms and tops of wall panels; around the cab corner column and cover, it should be packed with a snap-on closure or mullion member. The color of exposed framing members and closures is to be light neutral to prevent excessive solar gain, and matte in finish to prevent glare into the cab.

Thermal protection at attachments of exterior structural items should be improved. Insulation should be packed around the connection of the balcony to the corner column. It should be placed at interiors of the corner columns in cab and support level (Figure 36).

General Guidance

General guidance is as follows:

1. Flash, gasket, or otherwise seal all wall surface penetrations and attachments to the exterior wall surface. These include drains, plumbing vents, light fixtures, vents and grills, signs, intercom, and lightning rod cables. The exterior ladder and balcony are susceptible to movement, so flash connections with flexible material to maintain closure. Minimize thermal bridging of items penetrating wall panels. Insulate drain pipes, conduits, etc., and pack openings with insulation. Gasket or otherwise isolate through-bolts at interior panel surfaces.

2. Ensure sufficient anchorage for attached items. Surface-attach only small items or items not susceptible to damage or withdrawal. Through-bolt items such as panel boards (or, preferably, support them independently of the wall).

3. Provide triple glazing to improve the thermal performance of cab windows and reduce acoustic transmission from the exterior. Specify thermal-break frames.

4. Provide operable tower windows in the stairwell for ventilation in case of power failure. Casement or double-hung windows would be appropriate if windows were to be used for egress; otherwise, awning windows would be appropriate. Specify double glazing for thermal and acoustic control. Specify thermal-break frames. Limit air infiltration to 0.5 cfm per linear foot of sash opening as tested according to ASTM E 282. Limit water penetration to no leakage at 2.86 psf static pressure as tested according to ASTM E 331. (See ANSI/AAMA 302.9-1977.)* Unless the stair tower is a "smokeproof enclosure" as defined by the Uniform Building Code, there should be no fire resistiveness requirements for window assemblies.

5. Specify insulated exterior doors and weatherstripping. Specify thermal-break door frames and frames around vision panels, as appropriate for the location. Limit air infiltration to 1.25 cfm per foot of crack length at static pressure of 1.567 psf when tested in accordance with ASTM E 283. (See Steel Door Institute [SDI] 116-79 for air infiltration test procedures and SDI 111-E for weatherstripping standards.) The

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*ANSI/AAMA 101-85 ("Voluntary Standards for Aluminum Prime Windows and Sliding Glass Doors") is a new standard replacing ANSI/AAMA 302.9-1977. Among other revisions, it upgrades air and water infiltration criteria.

Thermal Considerations

A maximum U-factor of 0.05 as tested by ASTM C 236 should be specified. Panel thickness is likely to be 2 1/2 to 3 in. Structural considerations, however, may dictate a thicker panel than thermal requirements. Joints between panels should be configured to overlap insulation and to break thermal continuity of metal surfaces. Insulation should be continuous over all column, beam, girts, and other structural member surfaces.

Air and Moisture Penetration

The widest panel practical should be selected to reduce the number of vertical joints; 36 to 42 in. or wider is preferable. The longest panel practical should be selected to reduce the number of horizontal joints; there need only be one horizontal joint between the cab window sill and the foundation. Panels should be attached to the superstructure with concealed clips and/or fasteners; fasteners that penetrate the panel's exterior face should be avoided. Vertical joints should be tongue-and-groove type (T&G) and have factory-installed sealant. Exterior battens or snap-on closure strips designed to cover or seal fasteners are also appropriate. Corner closures should be of similar configuration with no exposed fasteners. The bottom edges of bottom panels should have factory-installed closure strips. All flashing and trim accessories are to provide positive drainage to the exterior wall surface. Air infiltration should be limited to 0.06 cfm per sq ft of wall surface at 1.56 psf static pressure in accordance with ASTM E 238. Water penetration should be limited to no leakage at 6.24 psf static pressure (ASTM E 331). Test sections should include vertical and horizontal joints.

Fire Resistiveness

Steel panel skins must be noncombustible. Exterior walls in existing installations are not fire-resistive and do not provide "smokeproof enclosure" for stairwells in accordance with the Uniform Building Code. Therefore, there are no apparent fire-resistiveness requirements for the exterior walls. The Federal Aviation Administration's (FAA) Air Traffic Control Tower Design Standards require that nonloadbearing exterior walls be noncombustible.

Repair and Replacement

Bollards or similar protection should be provided at ground-level doors and other locations where equipment loading or vehicle access may be present. Installation of panel systems with the preferred joint detailing is generally progressive; i.e., a single panel cannot be removed from the middle of a wall. Nonprogressively installed panels will generally not use the preferred joint detailing. However, wall panels generally would not be subjected to such physical damage in typical ATCT installations.

Color

A light, neutral color should be selected to reduce heat gain during cooling seasons.

Interior Surface

If no more interior finishing will be provided, a suitable interior panel surface should be selected, considering surface texture, color, plumbness and flatness, and appearance of joints and details.

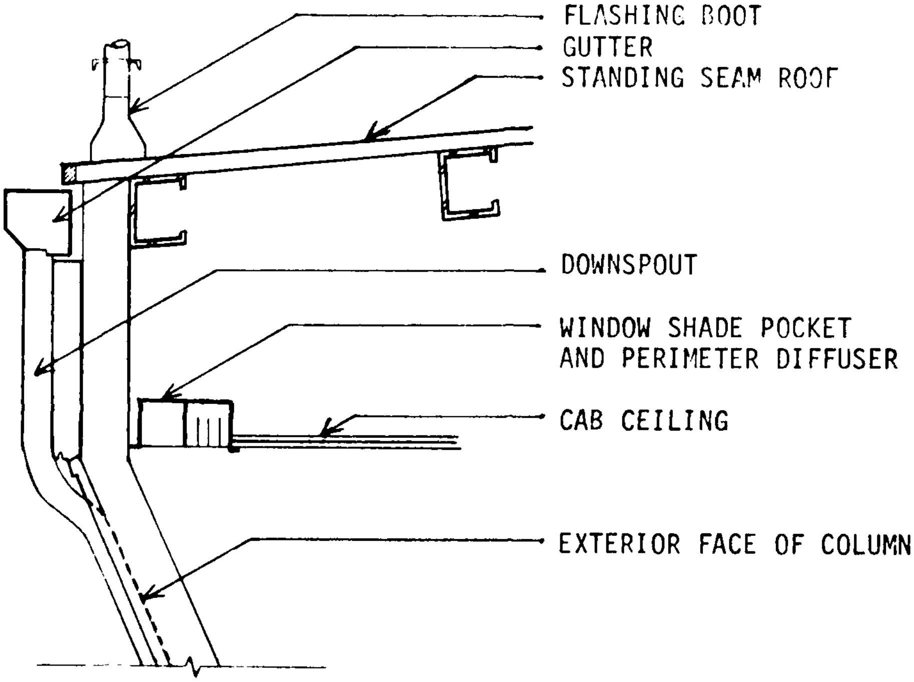

Figure 33. Roof drainage detail (standing seam metal roof with exterior drainage).

Exterior Wall System

A foam core sandwich panel wall system should be used. Typical construction is steel exterior and interior skins and polyurethane or isocyanurate foam cores. Panel faces are typically 26 to 22 gauge, galvanized. A variety of coating systems are available; "premium" coatings include polyvinyl resin, silicon polyester, and fluoropolymers (consult manufacturers' specifications). The exterior wall panel system should be designed, fabricated, delivered, and installed as an integrated system. The design of panels, fasteners, flashing, joint materials, closures, and accessories should be coordinated to provide an integrated performance.

Structural

Selection of panel thickness and span should consider aircraft-generated wind loads. Deflection should be limited to L/180 as tested in accordance with American Society for Testing and Materials (ASTM) E 330 or E 72. Support between floor levels will likely be required. The longest panels practical should be selected to span over multiple supports (this will reduce deflection and create fewer horizontal joints). Anchorage should be by concealed clips and/or fasteners.

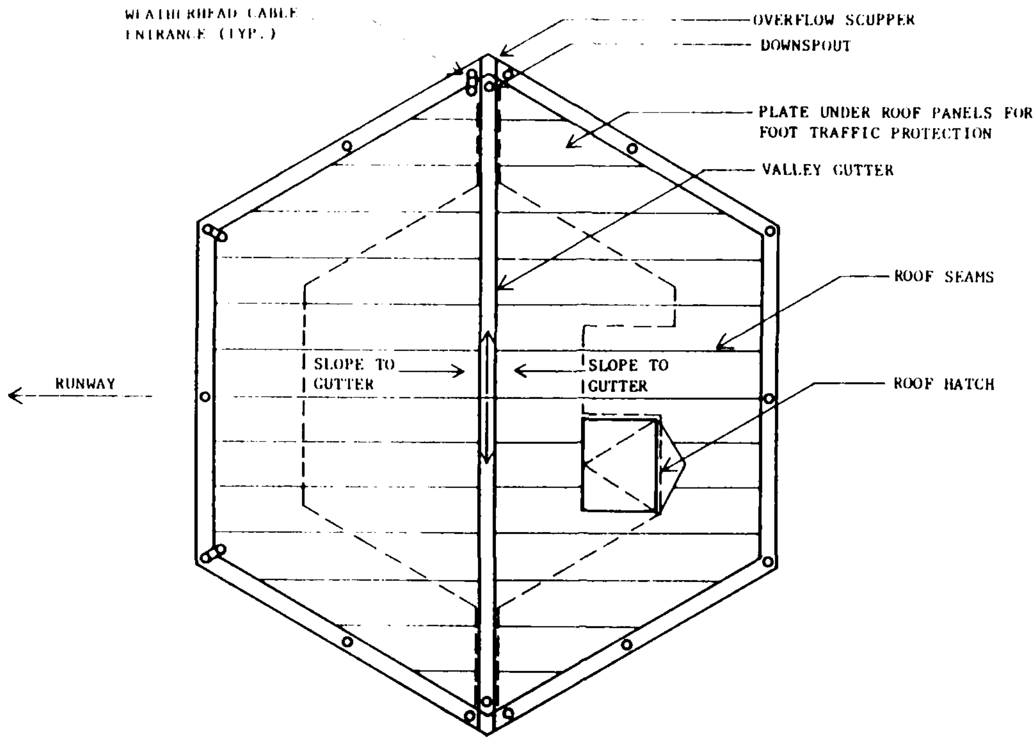

Figure 31. Roof plan--standing seam metal roof.

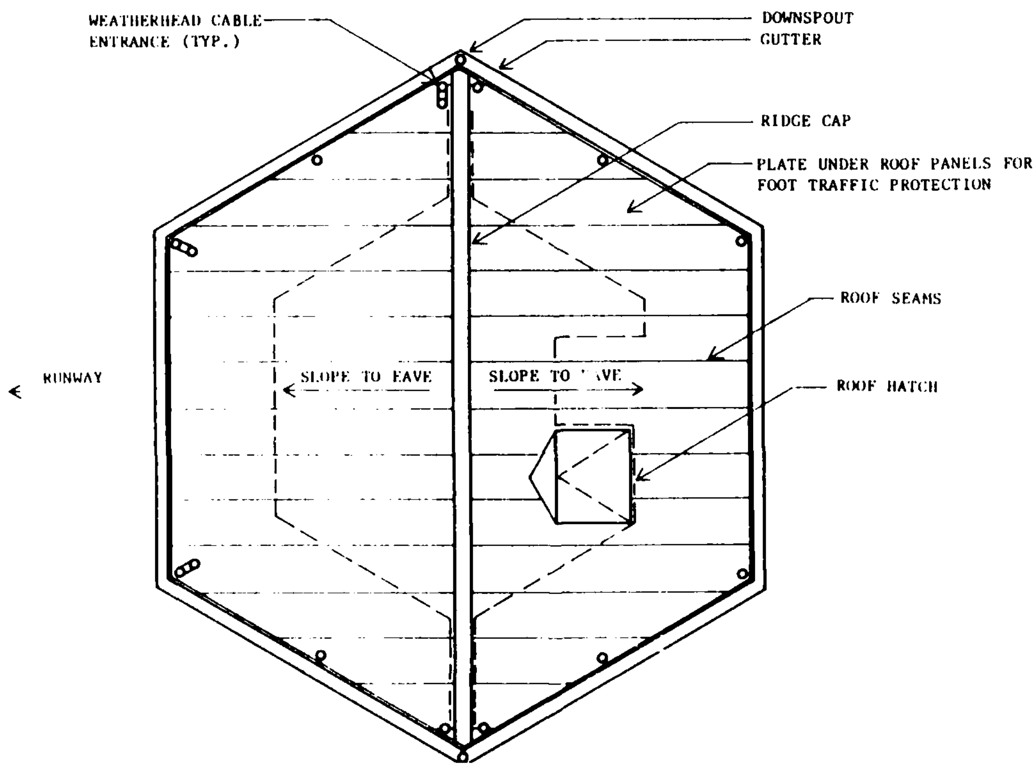

Figure 32. Roof plan--standing seam metal roof (exterior drainage).

Roof Hatch. The roof hatch should be located at the ridge to achieve positive drainage on all sides of the hatch and to avoid the need for a cricket. A "lock open" support should be specified for the roof hatch.

Alternative 2

A standing seam metal roof alternative may also be considered (Figure 31). However, the small size and irregular configuration of the ATCT roof may complicate this alternative, especially when the seams run bias to the parapet. However, a standing seam metal roof can be provided as an integrated system, including accessories such as curbs, jacks, flashing, guttering, and downspouts, and possibly fascia and architectural trim accessories. If provided by the same source as the wall panels, it may be a feasible and economical alternative. The designer should specify aluminized steel, galvanized steel with fluoropolymer coating system, or similar "premium" material. Attachment to the roof structure should be by concealed clips only, avoiding through-fasteners. Uplift resistance should be UL-90, and minimum seam height above the panel surface should be 1-1/4 to 1-1/2 in. Maximum U-factor should be 0.05; this can be achieved with rigid board or fiberglass batt insulation in accordance with the manufacturer's standard details. Thermal spacers should be used at the concealed clips.

Drainage. Two roof drains should be located at opposite corners of the roof as close to the perimeter as possible without interfering with flashing. Drains are to be a minimum of 3 in. each. Provide overflow scuppers near drains to prevent ponding of more than about 4 in. in the event of a downpour or clogging. Freezing should be avoided by running downspouts along the inner face of cab corner columns. Where warmer climatic conditions will permit, a considerably simpler and more economical configuration can be achieved by employing exterior guttering (Figures 32 and 33).

Slope. Slope should be a minimum of 1/4:12, preferably 1/2:12. As there is no purpose in having a "flat" roof, there is nothing to prevent adequate slope, even as high as 1:12.

Foot Traffic Protection. A rigid underlayment of plywood, particle board, or similar sheet material around the roof perimeter should provide adequate foot traffic protection. The purpose of the underlayment is to prevent loosening of the standing seams through repeated flexure.

Roof Hatch. The roof hatch should be located at the ridge to achieve positive drainage on all sides of the hatch and to avoid the need for a cricket. A "lock open" support should be specified for the roof hatch.

General Guidance

General guidance is as follows:

1. Integrate weatherhead cable entrances directly with roof railing posts, thereby eliminating additional penetrations to the roof system. Welds must be water-tight. Locate posts directly over cab corner columns. Railing posts may also be cab corner columns themselves.

2. Use a parapet cap that is either crowned or sloped toward the exterior of the building to minimize puddles and leakage at railing posts.

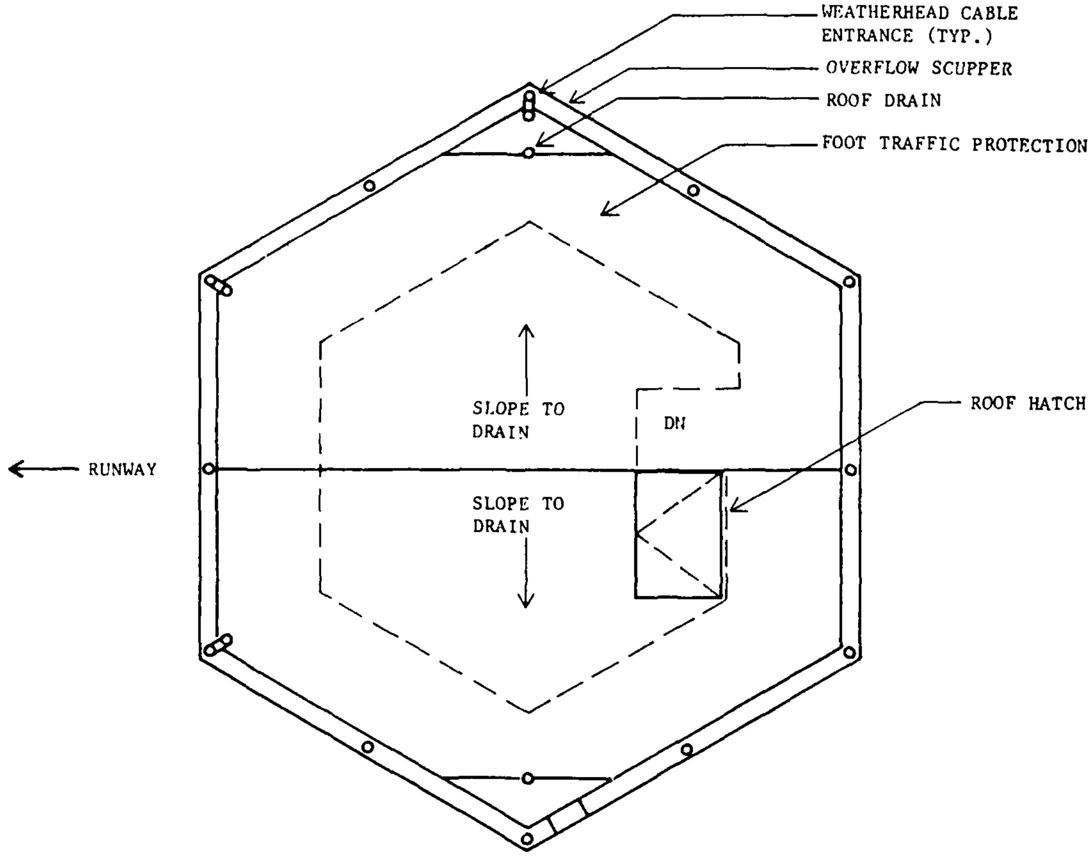

Figure 29. Roof plan--single ply roofing.

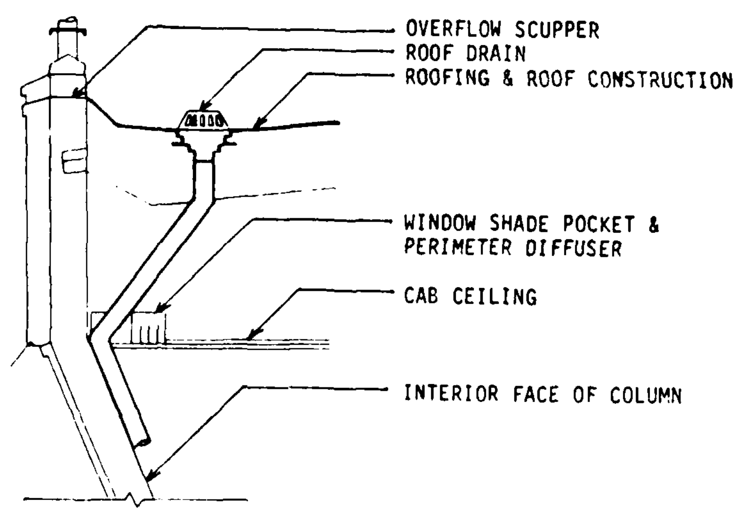

Figure 30. Roof drain detail.

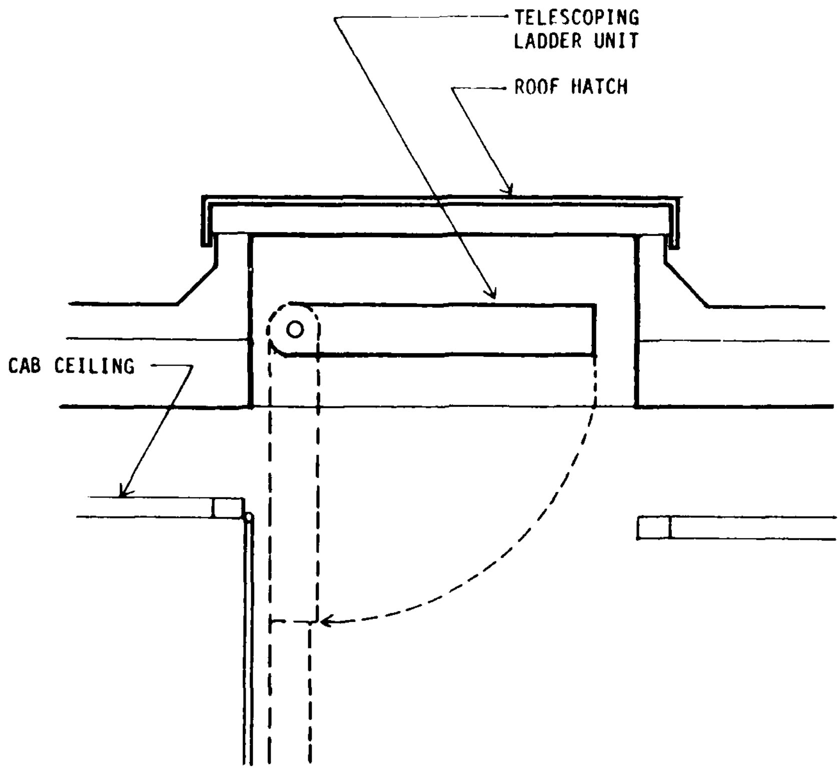

Figure 28. Roof ladder detail.

provided, and insulation specified that has a rigid surface on both the deck and membrane sides; materials are to be in accordance with the membrane manufacturer's recommendations. Avoid placing any equipment on the roof (Figure 29). (Corps of Engineers Guide Specification 07530 provides information on EPDM roofing specifications.)

Alternative 1

Drainage. Two roof drains should be placed at opposite corners of the roof and as close to the perimeter as practical without interfering with flashing. Drains are to be a minimum of 3 in. each. Overflow scuppers should be placed near drains to prevent ponding of more than about 4 in. of water if a downpour or clogging occurs. Freezing should be avoided by running downspouts along the inner face of cab corner columns (Figure 30) and removing insulation from around the drain pockets.

Slope. Slope should be at least 1/4:12, but preferably 1/2:12 or more. Since there is no purpose in having a "flat" roof, there is nothing to prevent constructing a roof with an adequate slope.

Foot Traffic Protection. One additional layer of EPDM adhered to the roofing membrane at the perimeter should protect the roof from foot traffic. However, if heavy use or any chance of abuse is anticipated, precast pavers can be laid on an adhered EPDM pad.

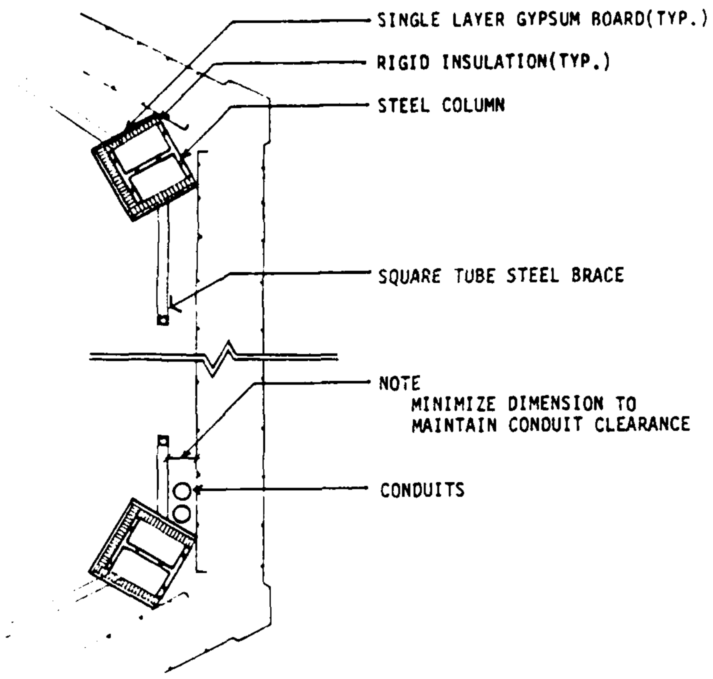

Figure 26. Insulated column with unfinished walls.

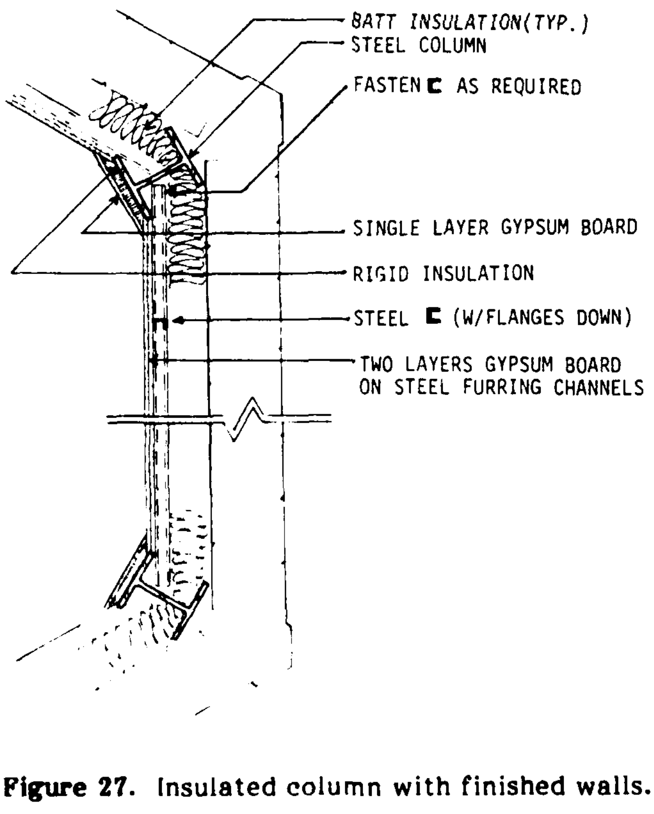

Figure 27. Insulated column with finished walls.

Bracing

K-bracing should be positioned to minimize intrusion into interior spaces. If no additional interior finishing is to be provided, tube shapes should be used in occupied spaces for a better appearance. Bracing should be located within the depth of the columns, as far toward the wall panel surface as possible, leaving only enough room to allow the conduit to run behind the bracing against the wall panel (Figure 26). If the space is to be finished, bracing should be located so as to be most convenient for the selected furring and finishing (Figure 27).

Ladders

Locate the telescoping ladder to the roof at the roof deck level, rather than at the ceiling level; this will avoid the need for an intermediate "stub" ladder, prevent misalignment between the ladder sections, and avoid irregular rung spacing (Figure 28). Alternatively, this detail can be similar to that shown in the Fort Wainwright ATCT design, where the telescoping ladder is vertical and aligns with the "stub" ladder.

A cage for the fire escape ladder is recommended in lieu of the "third rail" arrangement currently used.

General Guidance

General guidance for the superstructure's design is as follows:

1. Seal around penetrations in decks to provide smoke, fire, and acoustic control. Penetrations include those for power conduits, ATC cable raceways, plumbing, chases, and mechanical lines. Specify noncombustible material such as fiberglass insulation. Pack material around ATC cables in inserts through the deck below the consoles. Seal the wall panel/deck interface.

2. Increase the roof rail height to 42 in. above the roof surface in accordance with OSHA standards and UBC.

3. Improve stair detailing. Prevent bolt heads, nuts, or other fasteners and connections protruding from risers or treads from creating a trip hazard. Ensure that freestanding railings can resist a 200-lb horizontal load.

4. Consider installing a small hoist at the cab balcony level. Capacity need be only 300 lb or so. The hoist may be fixed or may be anchored to the tower structure and swing over the balcony. Allow enough clearance to lift items over the balcony rail.

5. Further investigate alternative structural approaches for future installations. These include use of precast/prestressed concrete, slip-form concrete, or other approaches to steel framing.

Roof System

A fully adhered single-ply roofing configuration using ethylene propylene diene monomer (EPDM) as the membrane material is suggested. The entire membrane can be installed as a single piece without seams. The membrane should be returned under the parapet cap to the outer surface of the parapet. A minimum U-factor of 0.05 should be

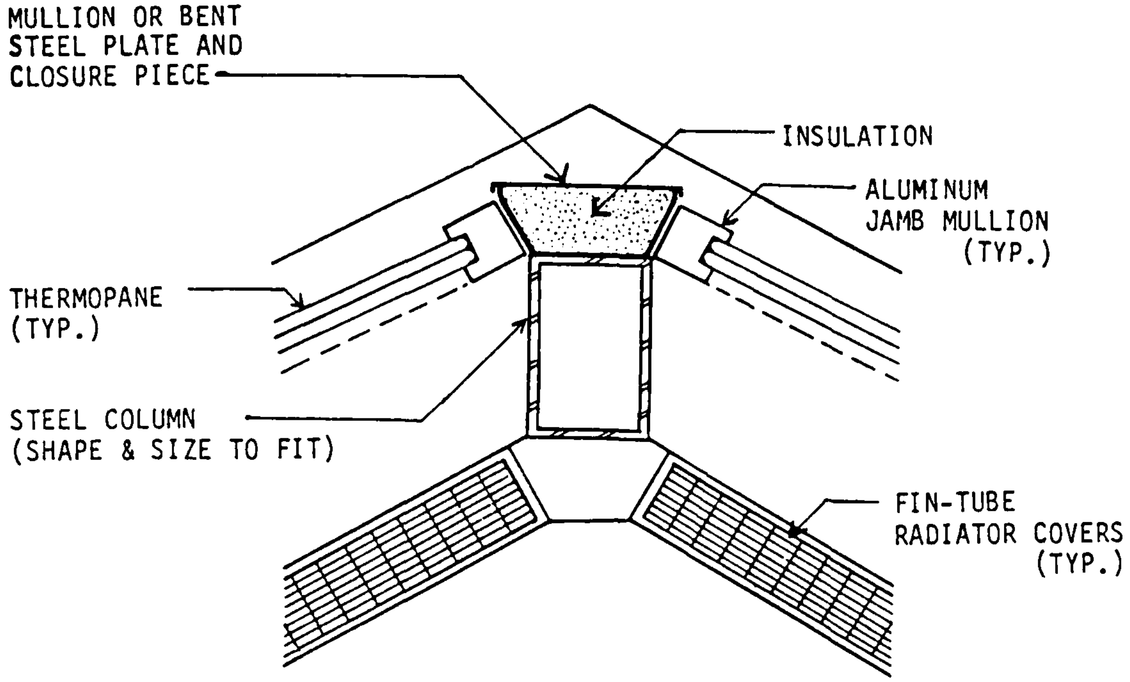

Figure 24. Column detail at corner.

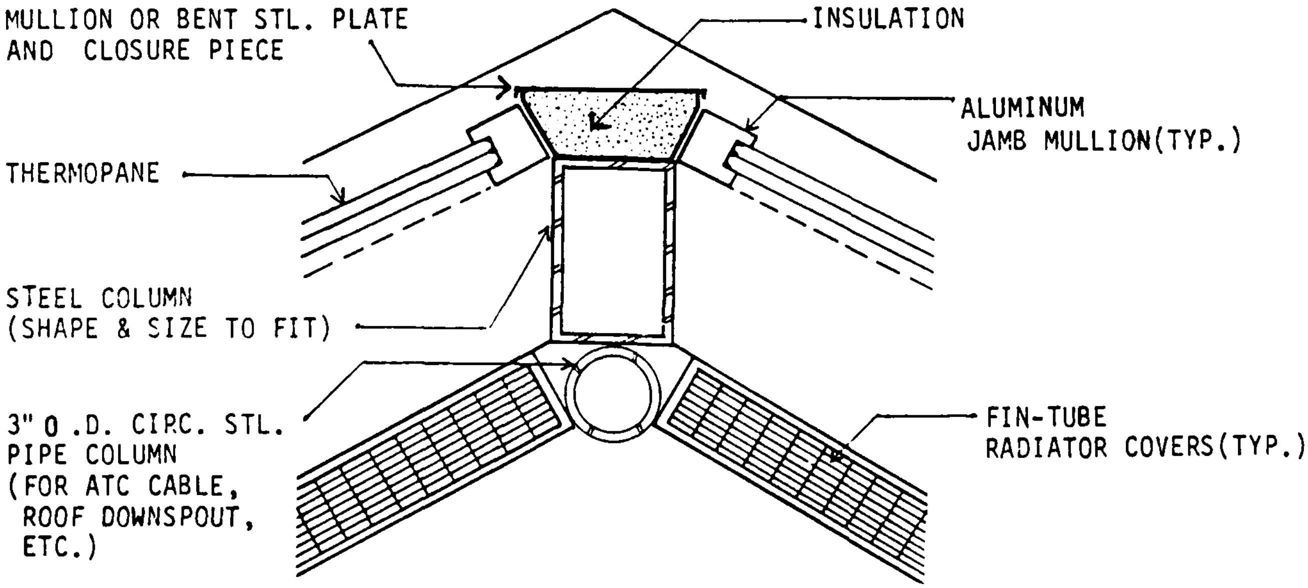

Figure 25. Column detail at corner (with chase).

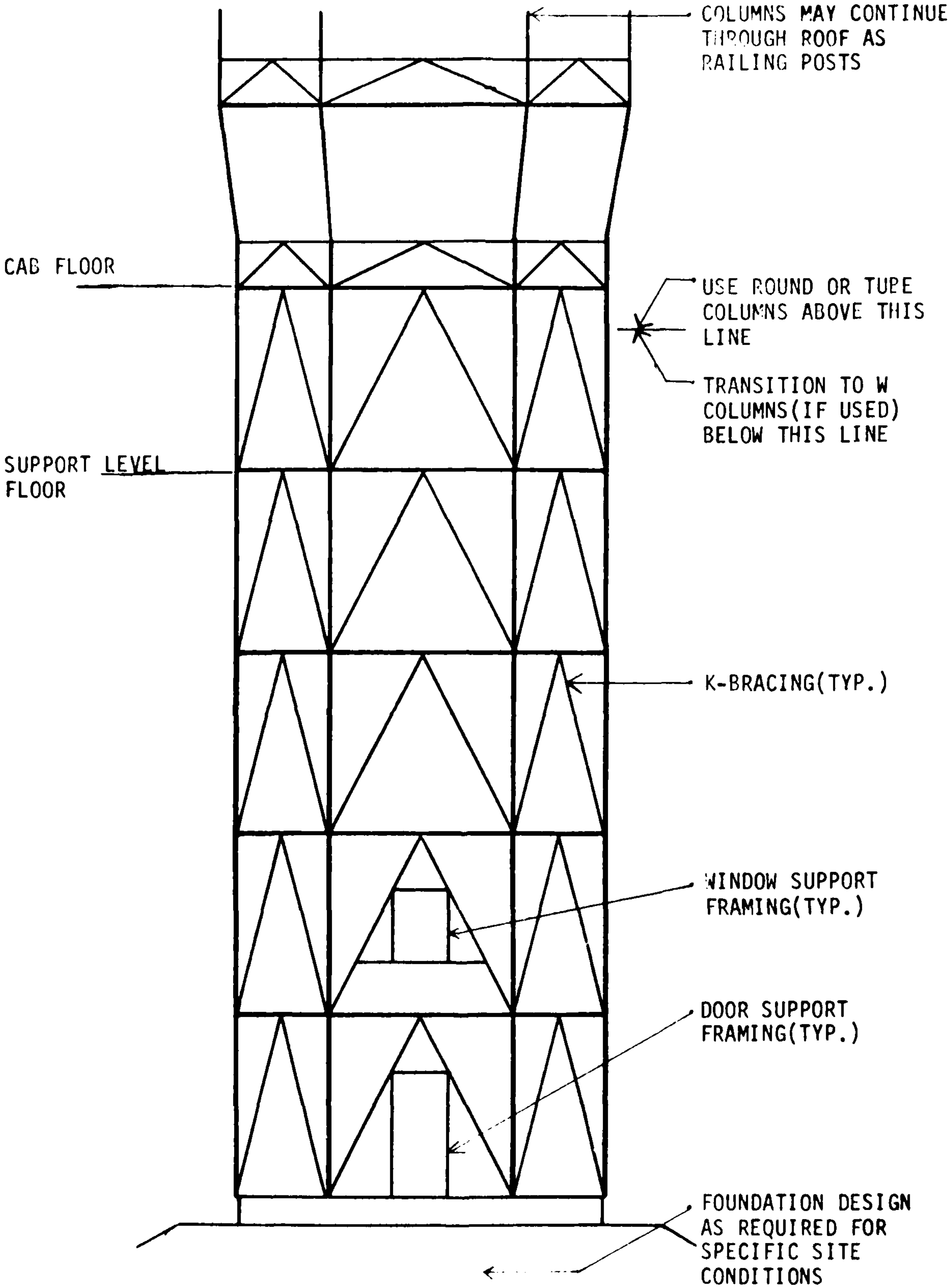

Figure 23. Framing elevation (hexagonal tower).

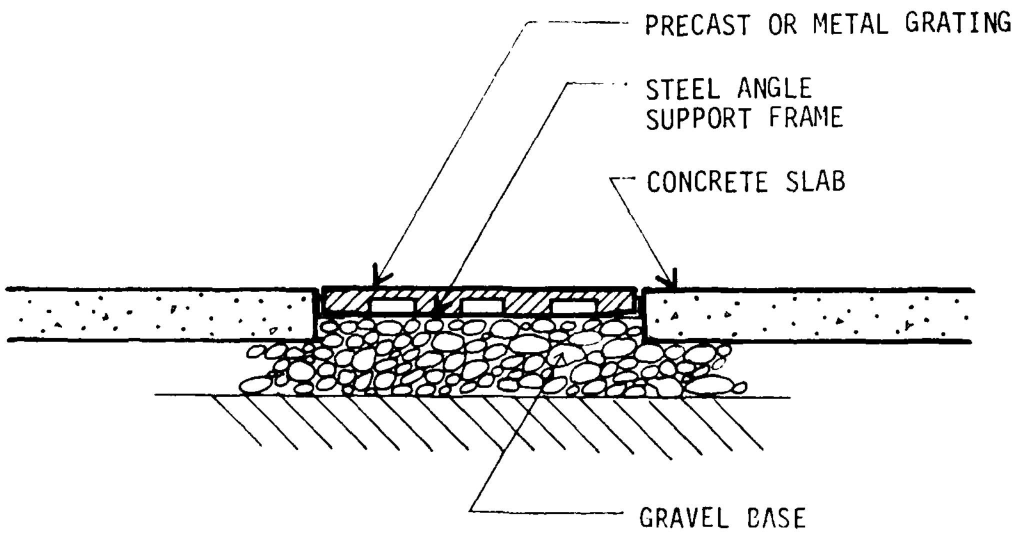

Figure 22. Utility trench access detail.

structural bays are in the same plane with the hexagonal shaft, bracing in each bay may be necessary (Figure 23).

Deck Construction. Floors above grade should be concrete on metal deck to reduce deflections and vibrations from mechanical equipment and to enhance acoustic control. Framing may be bar joists or beams. Concrete topping should be 2 in. minimum. Selection of deck depth and gage and framing shapes and sizes should be according to definitive design; consideration should be given to minimizing depth of floor construction. *Only the uppermost two levels will require floors.* Additional horizontal structure for lateral support and stair support should be provided as needed.

Framing

Vertical framing for the cab should be tube or round columns; the framing will also serve as ATC cable raceways. Built-up shapes may also be fabricated, if all exposed seams and joints are sealed against water penetration. However, standard shapes are likely to be less expensive and are therefore suggested. The tube or round columns should extend below the cab floor, where transition to W-columns (if used) can be made. Cab windows should be anchored toward the exterior face of the column to minimize thermal bridging to the cab's interior (Figure 24). This anchorage can be provided by bent plates welded to the exterior face of the column or by mullion sections supplied with the window framing. This should minimize additional visual obstruction. Alternatively, ATC cables, refrigerant lines, or electrical power may be enclosed in a 3-in. round raceway fastened to the interior face of the cab corner column (Figure 25). Visual obstruction should be no worse than with existing installations. Furthermore, if ATC cables or other building utilities are carried external to structural members, W-shapes may be used for cab framing. Besides using a more economical material, this will avoid the necessity of a transition between tube and W-columns below the cab floor.

If Scheme Two is used, the hexagonal cab must be carried by the rectangular tower shaft. A carrier beam or truss will be required to transfer loads from the six cab corner columns to the four shaft corner columns.

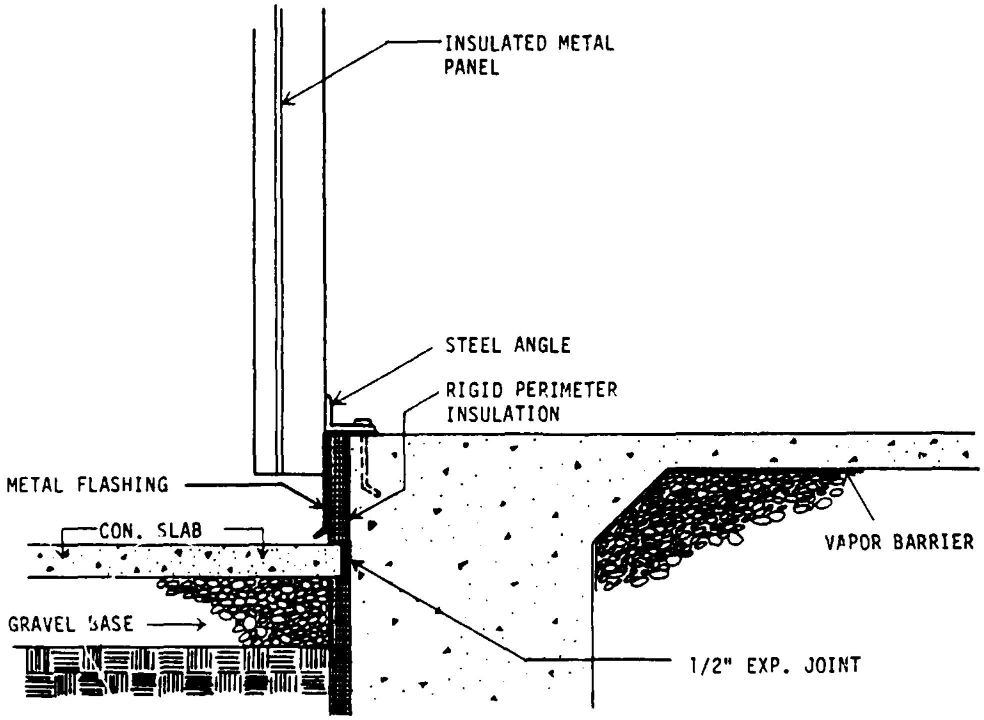

Figure 20. Foundation insulation detail (loadbearing slab).

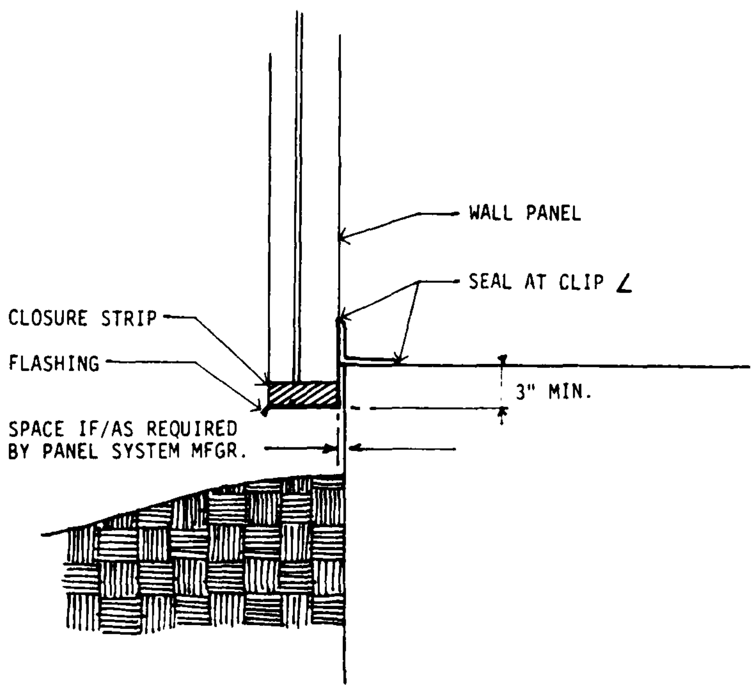

Figure 21. Wall panel detail at foundation.

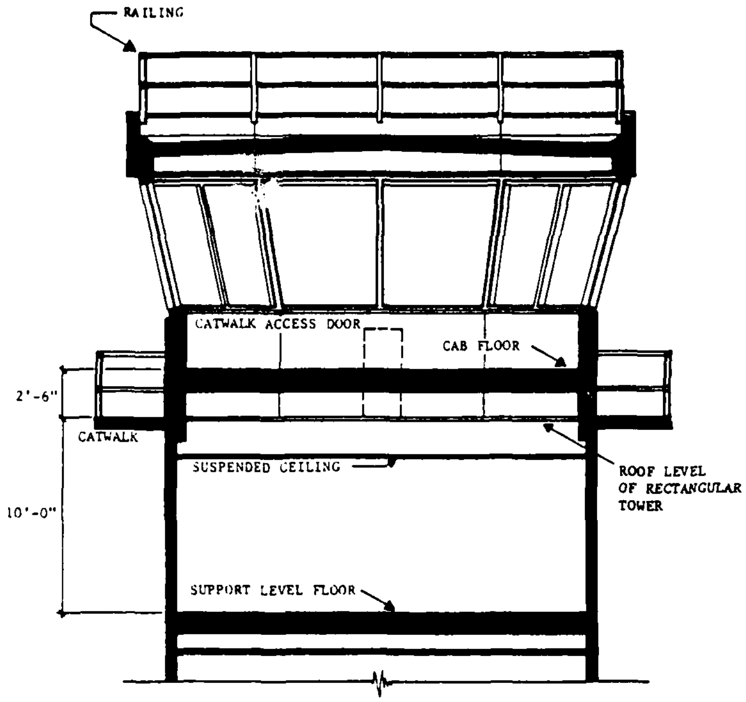

Figure 18. Scheme two--cab and support level section.

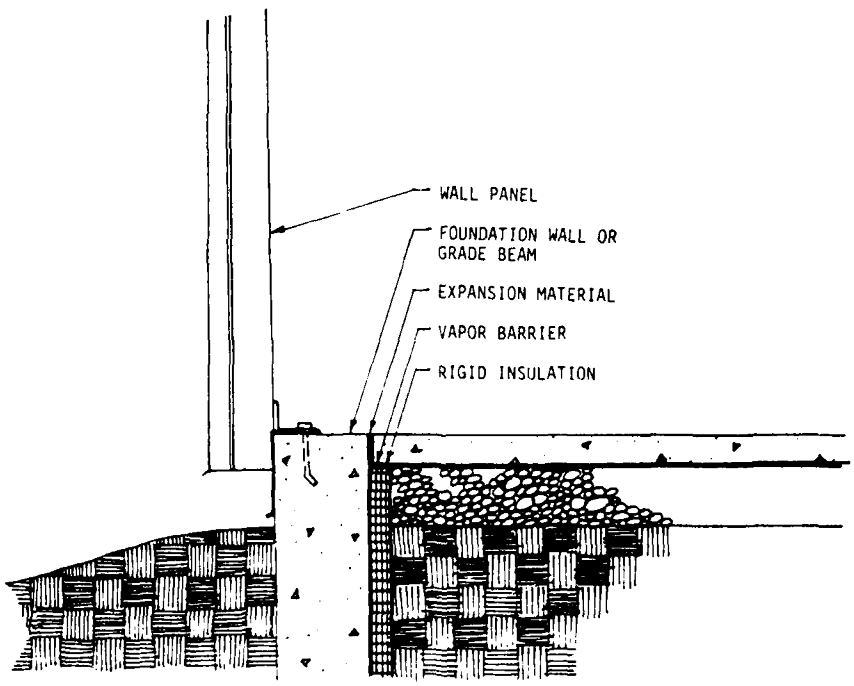

Figure 19. Foundation insulation detail (nonloadbearing slab).

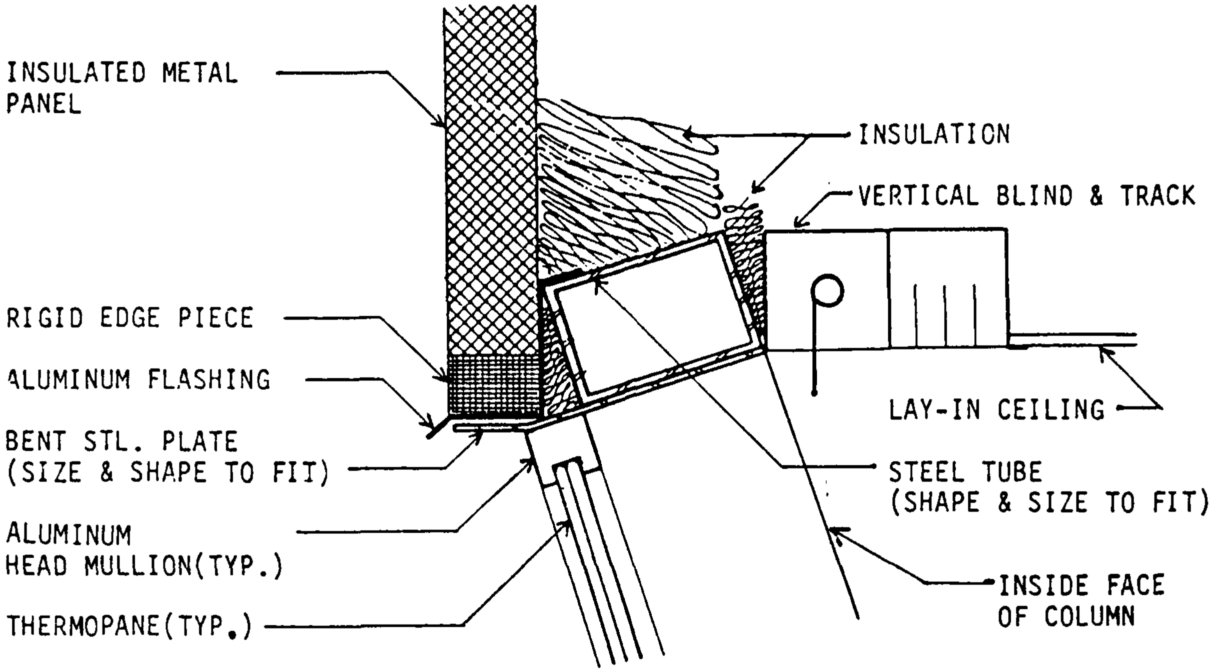

Figure 34. Head detail at column.

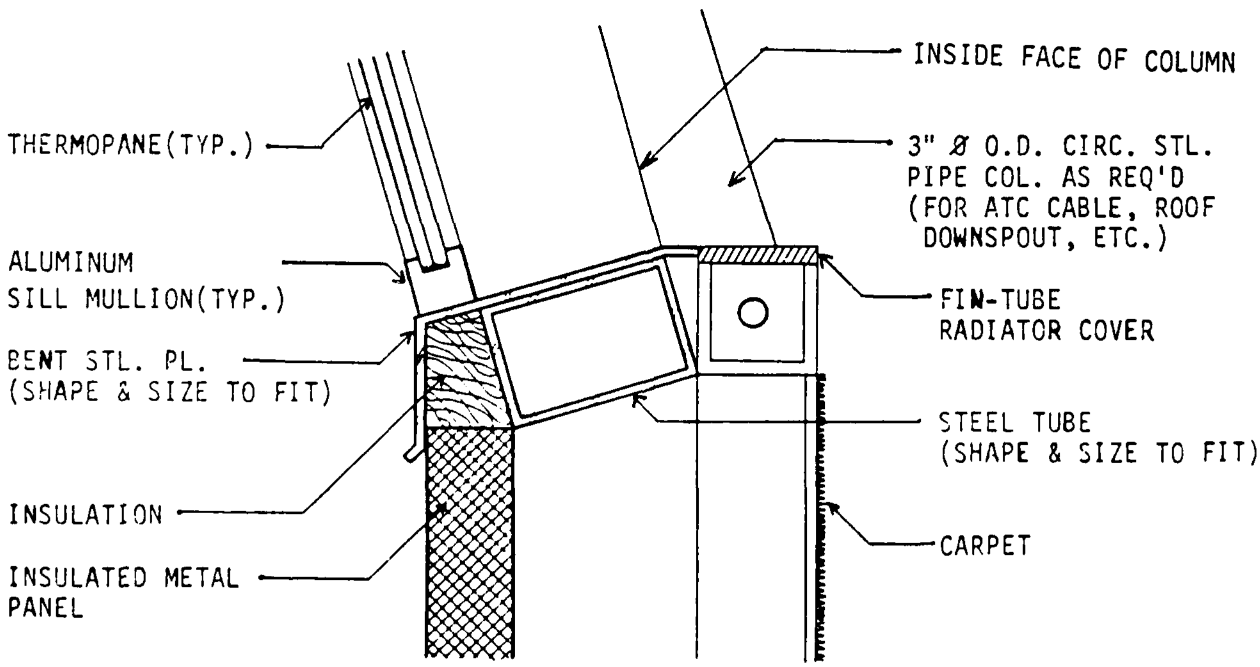

Figure 35. Sill detail at column (with chase).

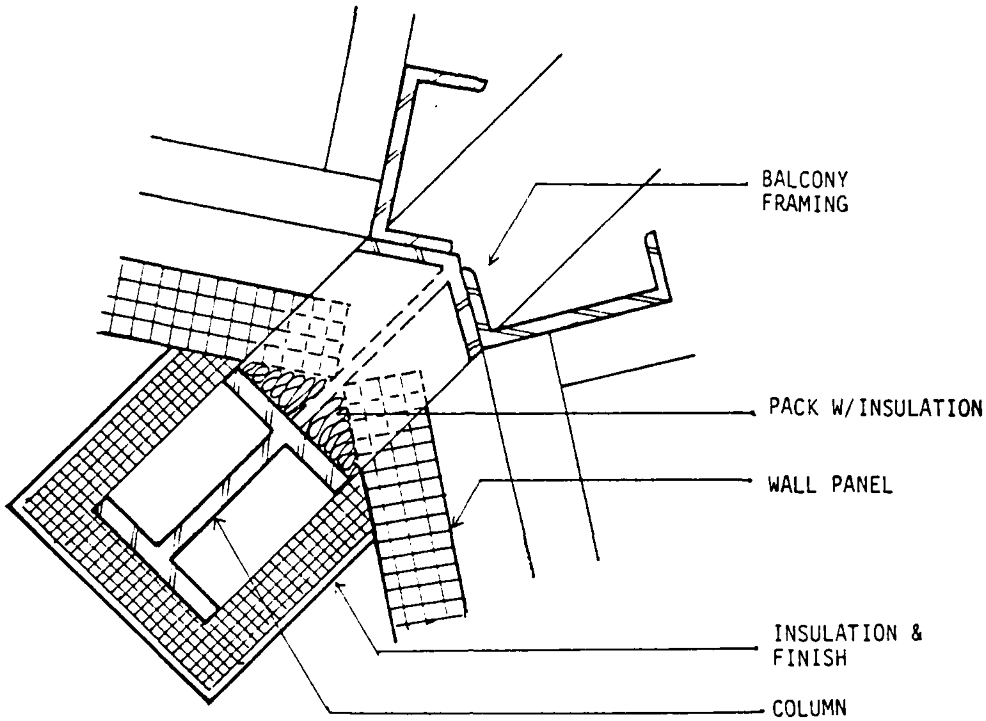

Figure 36. Column insulation detail.

requirement in existing "standard" designs for 1-1/2-hour fire-labeled exterior doors should be reconsidered. Exterior walls in existing installations do not provide 2-hour fire resistiveness for a "smokeproof enclosure" (per UBC) for the stairwell. This issue must be resolved among ATC, installation fire safety, and Corps FOA personnel.

6. ATC personnel prefer a 10-button cipher lock at the entrance door. The Fort Wainwright ATCT design includes a card-keyed lock system. Specify the preferred system.

Interior Construction

The interior finish of occupied spaces on the support level should be improved. (See the **Superstructure** and **Exterior Wall System** sections above for descriptions of K-bracing and panel surface selection.) This approach may provide a completely satisfactory solution at minimal extra expense. Acoustic performance should be improved somewhat with the recommended systems due to the increased stiffness of the panels and reduced tendency to vibrate or "drum," tighter joining, and the omission of a horizontal joint at the support level floor. Electrical power should be routed to the cab through a single chase to avoid a proliferation of conduit exposed in the support level. An upgraded interior finish may also be provided. Painted gypsumboard on metal channel furring would be appropriate (Figure 29). A sound transmission coefficient (STC) of about 45 would be achieved by adding double-layer, 5/8-in. gypsumboard. This rating can be increased by adding insulation in the wall cavity and/or resilient clips for gypsumboard attachment, although such measures may not be needed.

The durability of the support level ceiling should be improved to resist damage from inspection and servicing of ATC equipment. The layout of ATC cable troughs and the support level ceiling should be coordinated to the extent possible. Locate ceiling grid members to minimize interference while accessing cable troughs from the support level below. Locate ceiling diffusers, light fixtures, electrical conduit, etc., away from cable troughs. More durable ceiling panels should be specified. Metal-faced panels are preferable for durability, although the irregularly shaped spaces will require field cutting and therefore would be harder to install. Vinyl-faced acoustic panels intended for damage-resistant uses should also be appropriate. A fire-resistant facing should be specified for these panels (class A, flame spread of less than 25, in accordance with ASTM E 84). An ample supply of spare ceiling panels should be provided. It is suggested that a heavy-duty suspension grid (per ASTM C 635) be specified if frequent access to ATC cables is anticipated.

Acoustic control in interior construction should be improved. With regard to exterior walls, see p 30 for interior finish details. Carpet should be added to the cab wall interior surface for reverberation control.

For interior walls, a minimum STC of 45 should be specified. This can be achieved by a metal-framed partition with a single layer of gypsumboard on each side and insulation in the wall cavity, or by a single layer of gypsumboard on one side and a double layer on the other. Use of sound-deadening board and/or resilient clips for gypsumboard attachment can enhance acoustic control, although such measures may not be required. Sealing should be done around all items penetrating one or both surfaces of the wall. Electrical boxes and other items recessed into wall surfaces should not be located back-to-back. Base channels of wall framing at the deck surface should be sealed, and the ceiling grid should be sealed at partitions. If acoustic transmission between the stairwell and support level spaces is critical, that partition should be continued to the bottom of the cab floor deck and the joint sealed. Double-layer gypsumboard should be furred around stairs from the support level to the cab to reduce acoustic transmission. Weatherstripping and bottom sweeps should be specified for interior doors.

A minimum STC in the 40 to 44 range should be specified for ceilings in the support level and the cab. A minimum NRC of 0.70 to 0.80 should be specified for the cab ceiling. Sealing should be placed around all openings, penetrations, and recessed items, such as light fixtures and diffusers. Cab ceiling tiles are to be factory-stained; painting should be avoided.

Concrete deck construction will improve acoustic transmission and impact noise control over the existing installations' deck construction. (See the **Superstructure** section [p 28] regarding sealing around deck penetrations.)

The mechanical space ceiling on the ground level should be 1-hour fire-resistive.

General Guidance

General guidance is as follows:

1. The need for 2-hour fire-resistive partition construction and 1-1/2-hour fire-labeled doors in the stairwell should be reconsidered. The stairwell in existing installations is not a "smokeproof enclosure" per UBC, since exterior walls are not 2-hour

fire-resistive construction. The FAA's Air Traffic Control Tower Design Standards require noncombustible partition construction and 3/4-hour fire-labeled doors. One-hour fire-resistive construction may be appropriate for the mechanical room partitions and ceiling. This issue must be resolved among ATC, installation fire safety, and Corps FOA personnel.

2. Specify foam-backed carpet in the cab for improved durability and impact noise control.

3. Specify that all attachments to the cab ceiling, such as diffusers, light fixtures, and smoke alarms, be matte black.

4. Make sure that ground-level doors are wide enough to allow the passage of mechanical equipment for servicing.

Mechanical (Plumbing)

All supply and DWV lines should be located in heated spaces (Figures 8 through 19). An overflow tray for the support-level toilet room should be incorporated into the floor construction. The overflow tray should be drained independently of the fixtures.

General guidance is as follows:

1. Provide control valves at supply branches to avoid having to shut off the supply to the whole tower during repairs. Provide cutoff valves at fixtures. Provide an anti-syphon valve to protect the water heater in the event of a supply shutoff or low water pressure.

2. Vent DWV lines horizontally through exterior walls to avoid additional penetrations through the cab roof. Provide a grill at the vent. Flash or otherwise seal the grill at the wall.

3. It is suggested that the DWV system be oversized to preclude clogging problems.

4. Locate downspout cleanouts in the mechanical chase and stairwell in the support level.

5. Allow PVC for downspouts and DWV lines.

Mechanical (HVAC)

The following design considerations apply to the ATCT mechanical configuration:

Loads in the control cab are dominated by the large glass areas. The high heat transmission of the cab windows causes the air to stratify rapidly, resulting in atypical environmental control conditions. The cab will often require cooling when the support level requires heating. During the heating season, colder and denser air pools on the cab floor. During the cooling season, hot air rises from the glass and heated surfaces and stratifies at the cab ceiling.

With an overhead air handler, cooling air supplied from above is the optimum means for air mixing. Heated air that stratifies at the ceiling is picked up by the cooling system return, mixed with outside air, and cooled by the coil before being supplied to the cab. However, in the heating season overhead delivery and return of heated air is difficult because the heated air is very buoyant and must be thrown with considerable velocity to achieve any mixing before it rises to the cab ceiling. At the same time, the glass surfaces are cooling the air next to them; this air falls and pools on the cab floor. The overhead air return can only pick up the warmest air at the top of the cab, leaving the coldest air to pool on the floor. As a result, the controllers' lower bodies become uncomfortably cold. The overhead supply and return cannot provide adequate heating because of the extreme requirements imposed by the large cold glass areas.

In a heating situation, cold air that cascades down and pools on the floor must be picked up and heated at the lowest part of the cab. A fan coil unit that picks up the coldest air at floor level and reheats it would work well to prevent stratification problems. Perimeter baseboard convectors can also be used to heat floor-level cold air. However, this arrangement will not work well for cooling the cab. The dense cooling air must be thrown upward with considerable velocity to attain any mixing because it wants to fall to the lowest point in the space. The air heated by the warm surfaces rises to the ceiling and remains there. Since the hot air cannot be picked up for cooling, the controllers' lower bodies become overcooled, while their upper bodies may be too warm. A low supply and return cannot provide adequate cooling because of the air mixing problems.

Air leakage through the ATCT building envelope probably increases heating and cooling problems, causing some occupied spaces to become drafty and cold. Direct thermal continuity of structural members from the exterior to the interior contributes to excessive heat gain or loss during cooling and heating seasons, respectively. Water leakage is also evident, suggesting that these problems decrease insulation performance.

The following mechanical configuration (Figure 37) describes a suggested mechanical approach, equipment, and layout. The definitive mechanical analysis and engineering design must be completed by the Corps FOA or AE.

Cooling for each occupied space is provided at the perimeter by a variable air volume (VAV) system. VAV systems respond to different loads in multiple zones by supplying through a single duct and varying quantities of conditioned air at a constant temperature. Outlet dampers at each zone allow the total supply volume to vary in response to demand. VAV systems conserve energy because they generally do not depend on energy-wasting mixing for temperature control. Their flexibility allows for space conditioning only in areas that need it. Since air is not being delivered to all areas simultaneously, the system equipment can also be smaller. Refrigerant to the cooling coils may be either chilled water from a chiller or refrigerant from a compressor. The most convenient arrangement would be an electric direct expansion (DX) and compressor system located at ground level. Although refrigerant lines must run up the height of the tower, equipment can be sized accordingly. The remote location is preferable for acoustic and vibration control as well as for repair and maintenance accessibility. Alternatively, the compressor can be mounted below the support-level deck. A chiller may also be located in the base building. Through-the-wall air-conditioning units will not be used.

All occupied spaces should be heated by baseboard convectors. For all spaces except for the cab, the convectors should be located on the floor, as is typical. In the cab, the convectors should be located at the window sill to heat cold air flowing down off the glass surface and to keep them out of the way of ATC equipment. This location does not intrude any further into the cab's net floor area, since the convectors are mounted on

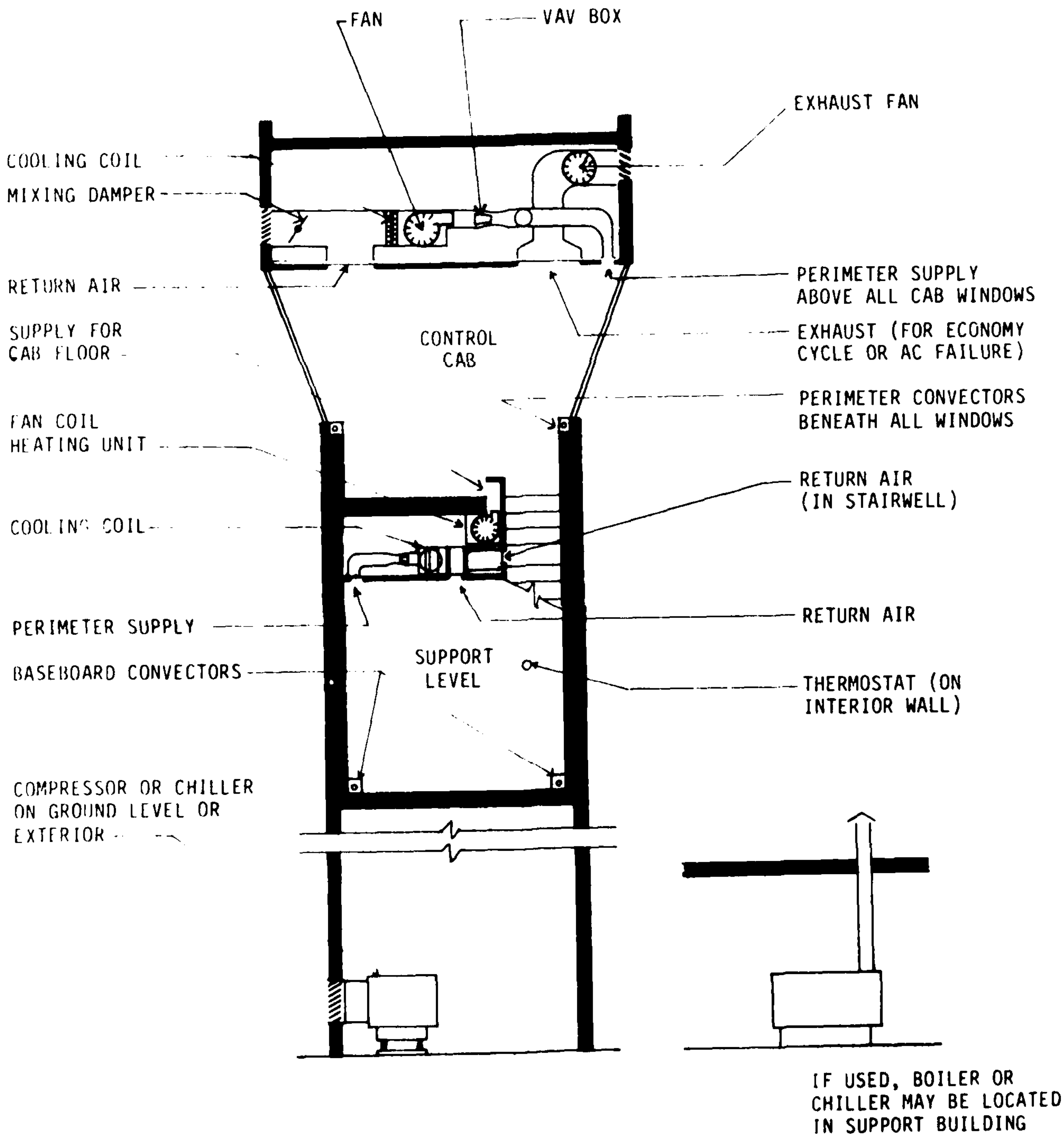

Figure 37. Mechanical section.

top of the wall finish framing. Heating for the cab is supplemented by floor-level diffusers that direct forced-air flow over the floor surface and are supplied by a fan-coil unit below the cab floor. The stairwell should be heated to a maximum of 55 degrees by a fan coil unit at the tower base. Convectors and coils may be electric or hot water, depending on the fuel and heat sources available at the site. Electric resistance heating is preferred, since electrical distribution is easier to accommodate in the building than hot water. Although hot water distribution is less convenient, it should not create any great problems. A boiler may be located in the base building, or hot water lines may be available from a central plant.

The energy source will be determined by local and site conditions and by relative life-cycle economies. An electric or fuel-fired boiler or a central plant source would all be appropriate.

The thermostat for each conditioned space should be located on an interior wall, away from hot and cold air supply and shielded from the sun at all times. Manual controls should be provided for diffuser dampers.

The fan coil units should be isolated from the tower structure by resilient mounting. The remote location of the compressor unit will preclude acoustic and vibration problems in the cab. To minimize noise generation, duct supply and return velocities should not exceed the RC or NC Criteria Range for "executive offices," as recommended by the 1984 *Systems Handbook* of the American Society for Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) (Table 19). Recommended and maximum duct velocities for conventional systems are listed in Table 16.4 of the ASHRAE *Handbook*.

General guidance is as follows:

1. Insulate floors above non- or minimally conditioned spaces. Specify a maximum U-factor of 0.10.

2. Provide exhaust fans in toilet spaces and the break room. Provide dampers to prevent backflow.

3. Provide a vent hood for the range in the kitchenette.

4. Drain compressor condensate directly into the DWV system.

5. Provide permanently mounted instructions for HVAC control in a prominent location in the tower. Secure an extra copy of the operating manuals in the tower structure.

Electrical

The lightning rod should extend a minimum of 3 ft-0 in. above the highest object on the roof, disregarding any potential antennae. The tip of the air terminal should be tapered to a point. (See Corps of Engineers Guide Specification 16601, *Lightning Protection*.)

General guidance is as follows:

1. Mount roof general illumination lights 8 ft above the roof surface. Alternatively, omit lights. Mount obstruction lights so bulbs can be changed while standing on the roof surface, without a stepladder.

2. Provide an ordinary toggle switch for the cab overhead light; delete the dimmer switch.

3. Provide a muting switch for the fire alarm in the cab only.

4. Select fixtures for cab downlights that use a more commonly available bulb. Fixtures are available that are designed for uses such as illuminating artwork and retail display; the fixtures currently used in Type II ATCTs are of this type. Although not able to be focused through a lens, an illuminated area of as little as about 3 ft in diameter (at the console surface) should be possible with the use of commonly available spotlight bulbs.

5. The balcony must be electrically bonded to the superstructure with no more than 1 milliohm (0.001 ohm) DC resistance between the balcony and the superstructure. The balcony must also be bonded to the lightning protection downleads.

6. All AC power for the building must be in conduit. Install conduits away from ATC cable troughs and ladders to avoid interference with ATC communications. Avoid locating any AC power (receptacles, conduits, etc.) on the front wall of the cab, and preferably on the two adjacent walls as well.

7. Provide a 4-in. conduit from the base of the tower to the cab for airfield lighting cables. This item should be part of the construction general contract. At the tower base, the conduit should run to the electrical manhole or night lighting transformer vault, as appropriate for the definitive electrical system.

8. Provide ground fault circuit interrupters (GFCI) for the bathroom and kitchenette areas and the branch circuit supplying drinking fountain equipment.

9. Locate the emergency generator outside the tower structure, protected by a metal enclosure.

ATC Equipment Interface

ATC antennae and other instrumentation located on the roof can be mounted on the roof railing in accordance with standard ATC details. ATC equipment in the cab consists of four consoles and a control panel for airfield lighting (Figures 8 and 12). ATC consoles should be placed flush against the front wall of the cab. (There is no other ATC equipment in the tower structure.) ATC cable routes are from roof instruments to the console, from the console down to the base building, and from roof instruments directly down to the base building. Horizontal cable troughs should be located under the cab floor and be accessible from the support-level ceiling (Figures 39 and 41). The trough collects cables from cab corner columns and from the ATC consoles and carries them to a vertical ladder in the ATC chase. The chase carries the cables down to ground level to a trough above the ground-level ceiling, which carries them over to the base building (Figures 38 and 40). ATCA must identify trough sizes appropriate for the specific installations. Electric power lines should be enclosed in conduit.

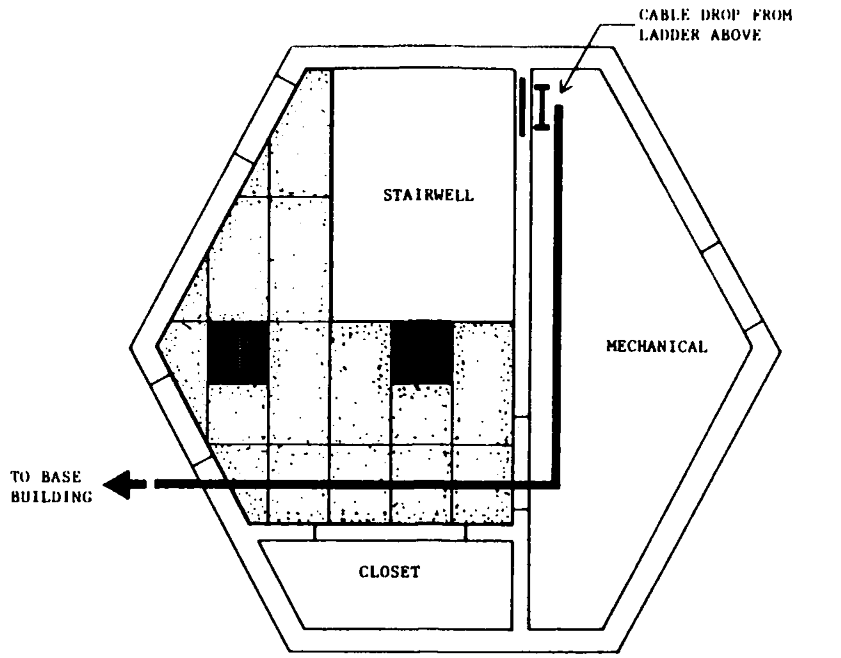

Figure 38. Scheme one--ATC cable trough layout (above ground floor ceiling).

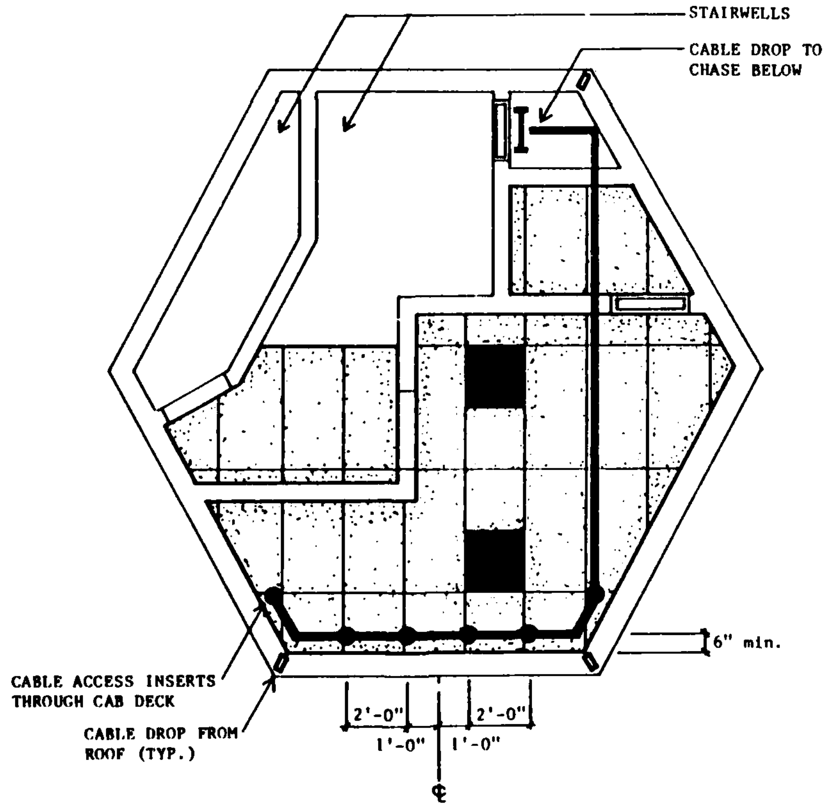

Figure 39. Scheme one--ATC cable trough layout (above support floor ceiling).

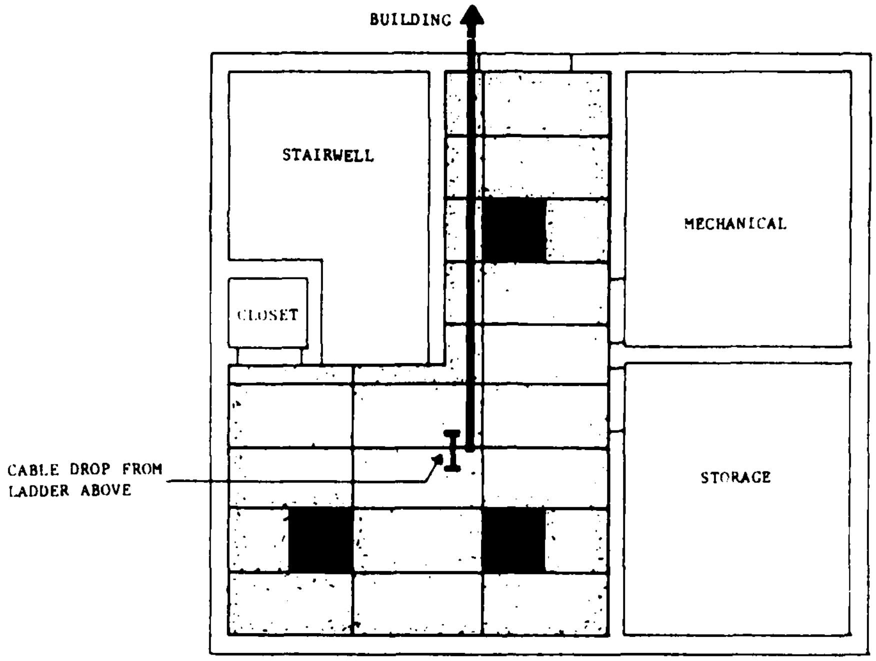

Figure 40. Scheme two--ATC cable trough layout (above ground floor ceiling).

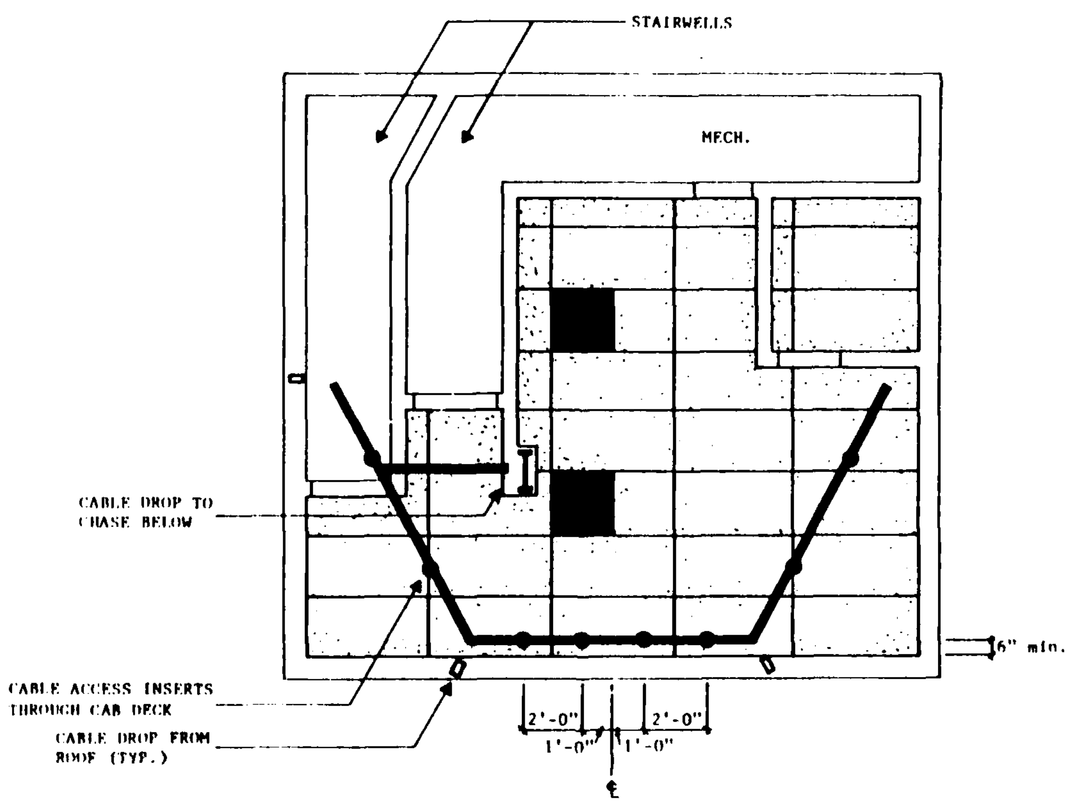

Figure 41. Scheme two--ATC cable trough layout (above support floor ceiling).

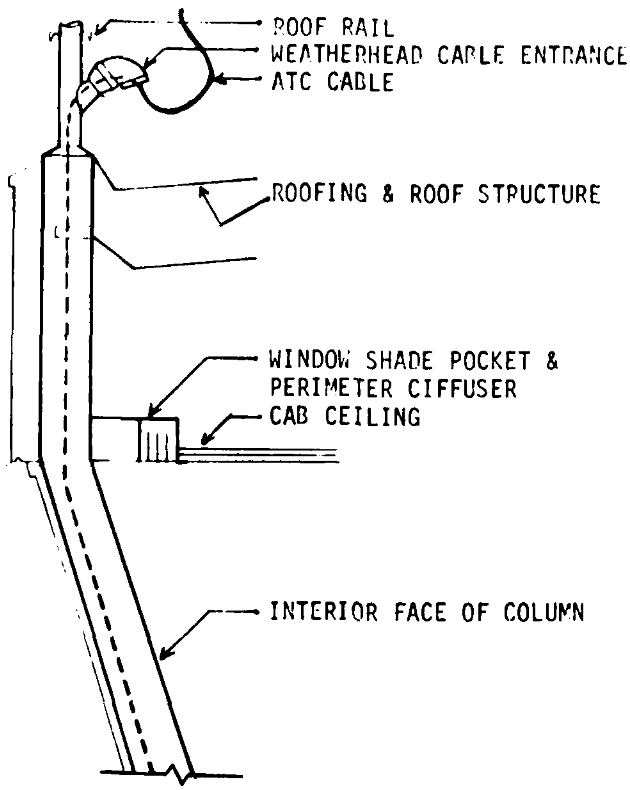

Figure 42. ATC cable entrance at roof through corner column.

Roof railings should incorporate 3-in. outside-diameter posts of circular cross-section, on which antennae and other instruments should be clamped. There are no other anchorage or attachment requirements for ATC equipment. ATC cables run through the cab corner columns, exiting the columns below the cab floor and entering horizontal troughs. A 3-in. opening should be provided in the side of the tube column, reinforced as required for the definitive structural design. Edges of the opening should be ground to be round and smooth. Cables from the consoles drop directly down through the bottom of the console; 3-in. inside-diameter inserts should be provided through the cab deck for each console. Inserts should have screw caps and be flush with the finish floor. Additional inserts should be provided for future ATC equipment requirements. Once ATC cables are installed, inserts should be packed with insulation for acoustic and smoke control. Cables should be able to bend with a radius of no less than 9 in. in any plane. A minimum of 18 in. clearance should be allowed from the top of the trough to the bottom of the cab deck. Enough clearance should be allowed below the troughs to remove ceiling tiles (Figures 42 and 43).

Weatherhead cable entrances should be incorporated directly into roof railing posts. An ample supply of spare weatherhead plugs should be specified and secured within the tower facility. Cables can run directly down the cab corner column; alternatively, they can be carried from the weatherhead to the inner face of the cab column (Figure 44). This will require a wider parapet; however, it will keep the cables out of structural members, allow the use of less expensive W-column shapes for the total height of the column, and obviate the need for a transition from tube column to W-column.

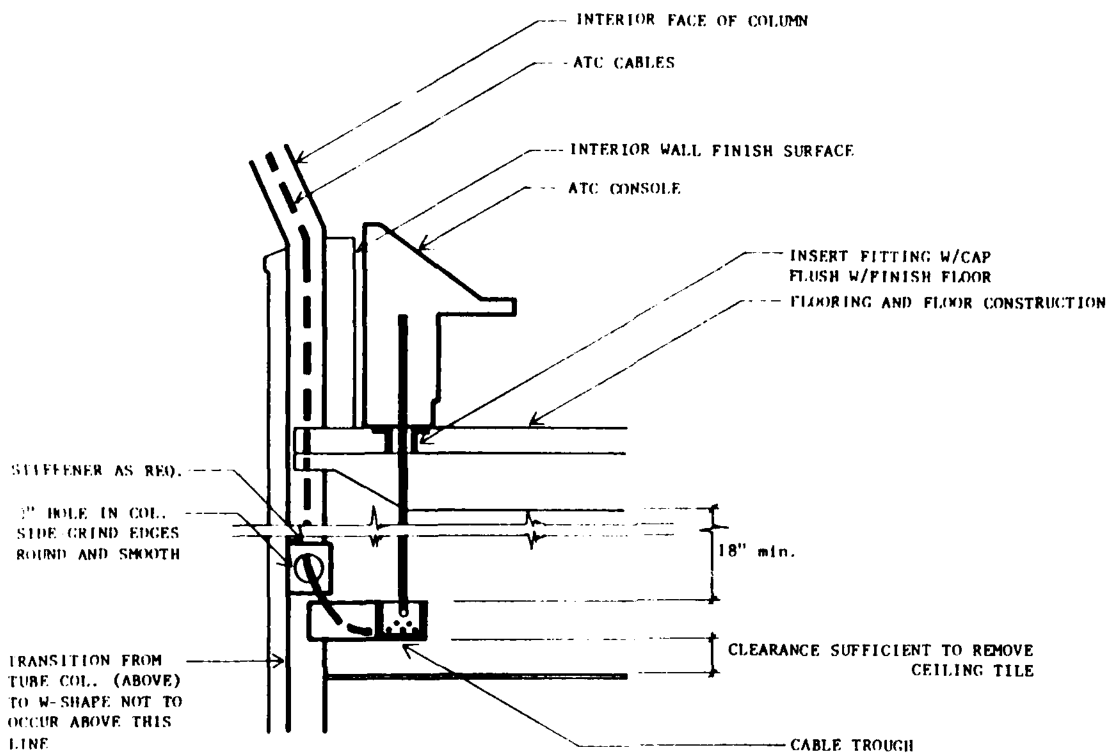

Figure 43. ATC cable access through cab floor.

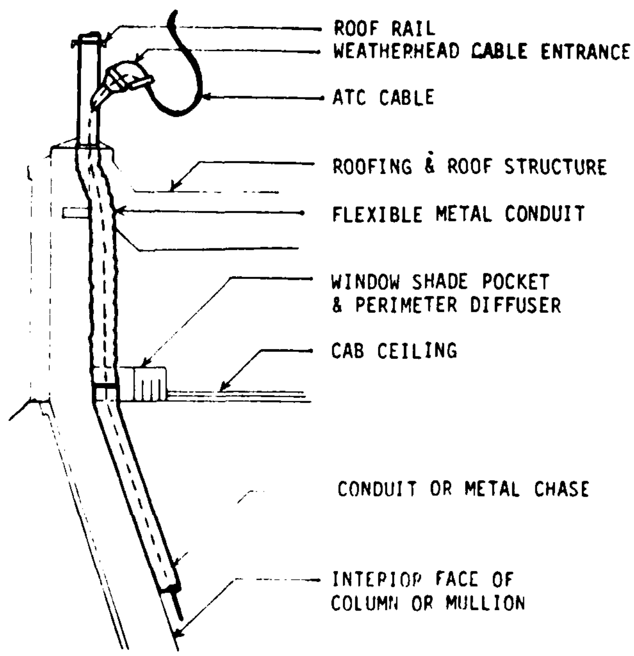

Figure 44. ATC cable entrance at roof inside corner column or window mullion.

General Project Administration

Administration of a facility's design and construction is a critical component of a project's successful completion; it is often as important, if not more important, than the details of engineering and building technology. It involves a coordinated effort among the using agency, the engineering agency (Corps FOA), and the contractor constructing the facility. "Upgrades" in this area are also appropriate. Recommendations for future ATC facility design and construction administration are as follows:

1. Develop a detailed definition of ATC equipment requirements. This should include a description of all equipment, dimensions and other physical data, required clearances for installation and servicing, descriptions of positioning or location, cable routes, cable trough or ladder dimensions and configurations, and other information needed to ensure proper accommodation in a new facility. Also include equipment wattage and other data needed to determine cooling loads for the building's mechanical design. Designate equipment to be located inside the building, as opposed to exterior or remote equipment. Include the appropriate information in the development of specific project requirements.

2. Ensure ATC personnel participation in the development of facility requirements and throughout design development and review. Review design requirements and construction documents within the context of identifying any ambiguities a contractor may have in the field and minimizing the necessity for on-the-spot interpretations. It may also be worthwhile to develop a design review system or checklist to help personnel who are not familiar with building construction understand the impacts of a facility's design and construction on ATC functions and operations and to identify possible problems.

3. Develop a distinct "ATC" section for construction documents similar to "Architectural" or "Structural" sections. Indicate equipment placement, required clearances, cable routes, sizes of cable troughs and ladders, anchorage requirements, and other information needed to describe proper accommodation of ATC equipment and operation. Indicate items that may not be contractor-furnished or -installed, so the contractor will be aware of critical interface conditions. Include a schedule of ATC equipment.

4. Include all ATC equipment anchorage, cable troughs and ladders, boxes, inserts, etc., in the construction contract. Minimize the Government-Furnished/Government-Installed work needed to bring a facility into operation.

5. Provide a "full time" ATC point of contact to the Corps of Engineers project engineer.

5 CONCLUSIONS AND RECOMMENDATIONS

ATCA and USA-CERL have identified many problem areas associated with the Type II ATCT "standard" design. Resolution of these problems will be necessary for the successful design, construction, and operation of future Type II ATCTs. Design and construction criteria upgrade is necessary; however, if these upgrades were to have been useful for the FY86 Fort Drum facility, they had to be implemented in a timely fashion without requiring extensive modifications to the existing design. Since the Fort Drum facility is now scheduled for FY87 construction, there will be opportunity to develop the more extensive revisions (Scheme Two) into the definitive design for this facility.

The upgrades are also appropriate for use in "standard" criteria for subsequent designs where time constraints are not so severe. Greater effort can then be devoted to developing a specific facility's design and construction documentation.

Existing construction documents (drawings and specifications) must not be duplicated in a new facility without ensuring their appropriateness for the specific site. This must include an analysis of the structural design, mechanical design, and exterior envelope to verify that these systems are adequate and safe for the specific location and environmental conditions. The preferred approach is to reengineer inadequate systems to provide the most efficient and economical solution for the new project.

It is recommended that construction documents for the Fort Drum facility and for subsequent ATC facilities contain a section to articulate ATC equipment requirements and their interface with building construction.

Development of an entirely new facility design may be appropriate for future work. This effort should include a comprehensive analysis and documentation of ATC functional and equipment requirements. The new design should be universally applicable to a variety of locations.

Administration of a facility's design and construction is a critical component of successful project completion. Recommendations for future ATC facility design and construction administration include: (1) developing a detailed description of ATC equipment requirements to be accommodated in a particular facility; (2) ensuring that ATC personnel participate in developing a facility's design requirements and in the design review; (3) minimizing the items to be procured and installed by the Government; and (4) providing a "full-time" ATC point of contact for the Corps project engineer. Development of a design review system or checklist may also be helpful to ATCA and other ATC personnel involved in the review.

METRIC CONVERSION FACTORS

1 ft = .3048 m	1 lb = .4535 kg
1 in. = 25.4 mm	1 cfm = .0283 m^3/min
1 mil = .0254 mm	1 sq ft = .0929 m^2
1 mph = 1.609 km/hr	1 psf = 4.8824 kg/m^2

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