PHASE **2**

Washington State
School Seismic Safety Assessments Project

TACOMA FIRE DEPARTMENT FIRE STATION 4

City of Tacoma

SEISMIC UPGRADES CONCEPT DESIGN REPORT

June 2021

PREPARED FOR

PREPARED BY

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WASHINGTON STATE SCHOOL SEISMIC SAFETY ASSESSMENTS PROJECT

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Tacoma Fire Department – Station No. 4

City of Tacoma

June 2021

Prepared for:

State of Washington
Department of Natural Resources

Prepared by:

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EXECUTIVE SUMMARY

This report documents the findings of a seismic evaluation of the Tacoma Fire Station No. 4, which is located at 1453 Earnest S. Brazil Street in Tacoma, Washington. The 6,100-square-foot building was built in in 1935 in two rectangular sections that include an apparatus bay that is approximately 1,700 square feet (33 feet by 52 feet) and the remainder of the building, which is living quarters and offices over a basement. The structure has a roof height of 15 feet in the apparatus bay and a maximum height of 32 feet at the hose tower. Building construction consists of load-bearing multiwythe unreinforced masonry (URM) walls that support a wood-framed roof, wood-framed floors, and a concrete floor at the kitchen and hose tower founded on continuous concrete basement walls and footings. The lateral system of the building consists of wood diaphragms and URM shear walls founded on concrete basement walls and footings. This building is listed on the National Register of Historic Places as Tacoma Fire Station No. 5.

Reid Middleton performed a Tier 1 screening in accordance with the ASCE 41-17 standard *Seismic Evaluation and Retrofit of Existing Buildings*. The evaluation included field observations and review of record drawings to verify the existing construction. The structural seismic evaluation indicated that the building has multiple seismic deficiencies; the most susceptible ones being inadequate shear wall strength, inadequate roof diaphragm capacity, collapse-susceptible URM hose tower, out-of-plane wall anchorage and bracing, continuous diaphragm cross-ties, and wood ledgers susceptible to cross-grain bending.

Conceptual seismic upgrade recommendations for the structural systems are provided to improve the performance of the building to meet the Immediate Occupancy structural performance objective criteria of ASCE 41-17 for Risk Category IV buildings. Sketches for the concept-level seismic upgrades are provided in Appendix B. The structural upgrades include increasing shear strength of the exterior URM walls by adding new shotcrete walls, adding wood shear walls at the interior of the building, lowering the hose tower to the roof line, adding plywood sheathing and cross ties over the roof structure, and adding collector elements and wall ties to the diaphragm-to-wall connections. From a post-earthquake immediate occupancy perspective, the lowering of the URM hose tower and chimney is the structurally preferred option. However, because this building is on the National Historic Register, any modification or alternation to the original aesthetic of the building is recommended to be approved by the State Historic Preservation Office. Alternate recommendations to preserve the hose tower include internal bands of structural steel bracing spaced vertically up the projected portion of the hose tower.

The recommendations for nonstructural upgrades are to provide braces for the hosepipe tracks in the apparatus bay, provide braces for the mechanical units in the roof space in the apparatus bay, and brace tall shelves and cabinets in the apparatus bay to the structure.

An opinion of probable construction costs is provided in Appendix C. It is our opinion that the total cost (construction costs plus soft costs) to upgrade the structure would range between $1.36M and $2.54M, with the baseline estimated total cost being $1.69M.

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Acronyms

AACE	Association for the Advancement of Cost Engineering
ADA	Americans with Disabilities Act
ASCE	American Society of Civil Engineers
A-E	Architect-Engineer
BPOE	Basic Performance Objective for Existing Buildings
BSE	Basic Safety Earthquake
CMU	Concrete Masonry Unit
CP	Collapse Prevention
DNR	Department of Natural Resources
DCR	Demand-to-Capacity Ratio
EERI	Earthquake Engineering Research Institute
EPAT	EERI Earthquake Performance Assessment Tool
FEMA	Federal Emergency Management Agency
GC/CM	General Contractor / Construction Manager
GWB	Gypsum Wallboard
IBC	International Building Code
ICOS	Information and Condition of Schools
IEBC	International Existing Building Code
IO	Immediate Occupancy
LS	Life Safety
MCE	Maximum Considered Earthquake
MEP	Mechanical/Electrical/Plumbing
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
OSPI	Office of Superintendent of Public Instruction
PBEE	Performance-Based Earthquake Engineering
PR	Position Retention
ROM	Rough Order-of-Magnitude
SSSSC	School Seismic Safety Steering Committee
UBC	Uniform Building Code
URM	Unreinforced Masonry
USGS	United States Geological Survey
WF	Wide Flange
WGS	Washington Geological Survey
WSSSSAP	Washington State School Seismic Safety Assessments Project

Reference List

Codes and References

2018 IBC, *2018 International Building Code,* prepared by the International Code Council, Washington, D.C.

AACE International Recommended Practice No. 56R-08, 2020, *Cost Estimate Classification System*, prepared by the Association for the Advancement of Cost Engineering International, Fairmont, West Virginia.

ASCE 7-16, 2017, *Minimum Design Loads for Buildings and Other Structures*, prepared by the Structural Engineering Institute of the American Society of Civil Engineers, Reston, Virginia.

ASCE 41-17, 2017, *Seismic Evaluation and Retrofit of Existing Buildings*, prepared by the Structural Engineering Institute of the American Society of Civil Engineers, Reston, Virginia.

FEMA E-74, 2011, *Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide*, prepared by Applied Technology Council, Redwood City, California.

Structural Engineers of Northern California, 2017, Earthquake Performance Rating System ASCE 41-13 Translation Procedure: The Buildings Ratings Committee, a sub-committee of the Existing Buildings Committee of The Structural Engineers Association of Northern California.

Structural Engineers of Northern California, 2015, Earthquake Performance Rating System User's Guide: The Buildings Ratings Committee, a sub-committee of the Existing Buildings Committee of The Structural Engineers Association of Northern California.

Drawings

Silas E. Nelsen Architect, Dated December 15, 1933, existing drawings titled "Engine House No. 5 Being Built with State Emergency Fund Grant No C275.

1.0 Introduction

1.1 Background

In 2018-2019, the Washington Geological Survey (WGS), a division of the Department of Natural Resources (DNR), led a Washington State School Seismic Safety Assessments Project (WSSSSAP) that seismically and geologically screened 222 school buildings and 5 fire stations across Washington State to better understand the current level of seismic risk of Washington State's public-school buildings. This first phase of the WSSSSAP was executed with the help of Washington State's Office of Superintendent of Public Instruction (OSPI) and Reid Middleton, along with their team of structural engineers, architects, and cost estimators.

Building upon the success of Phase 1, WGS, OSPI, and Reid Middleton's team embarked on Phase 2 of this project to seismically and geologically screen another 339 school buildings and 2 fire stations, mostly located in the high-seismic risk regions of Washington State. Similar to Phase 1, the two main components of Phase 2 of this seismic safety assessments project are: (1) geologic site characterization, and (2) the seismic assessment of buildings. As a part of the seismic assessments, Tier 1 screening of structural systems and nonstructural assessments were performed in accordance with the American Society of Civil Engineers' (ASCE) Standard 41-17 *Seismic Evaluation and Retrofit of Existing Buildings*. Concept-level seismic upgrades were developed to address the identified deficiencies of a select number of school buildings to evaluate seismic upgrade strategies, feasibilities, and implementation costs.

As part of this statewide study, two fire stations were selected in consultation with WGS and the Washington State Emergency Management Division to receive concept-level seismic upgrade designs utilizing the ASCE 41 Tier 1 evaluation results. This report documents the concept-level seismic upgrade design for one of those two fire station buildings. The concept-level seismic upgrades will include structural and nonstructural seismic upgrade recommendations, with concept-level sketches and opinion of probable concept seismic upgrades costs for each building.

The seismic evaluation consists of a Tier 1 screening for the structural systems performed in accordance with ASCE 41-17.

1.2 Scope of Services

The project is being performed in several distinct and overlapping phases of work. The scope of this report is as listed in the following sections.

1.2.1 Information Review

1. Project Research: Reid Middleton and their project team researched available building records, such as relevant site data and record drawings, in advance of the field investigations. This research included searching city records and contacting the fire departments to obtain building plans, seismic reports, condition reports, or related construction information useful for the project.

2. Site Geologic Data: Site geological data provided by the WGS, including site shear wave velocities, was utilized to determine the project Site Class in accordance with ASCE 41, which is included in the Tier 1 checklists and concept-level seismic upgrades design work.

1.2.2 Field Investigations

1. Field Investigations: Each of the identified buildings was visited to observe the building's age, condition, configuration, and structural systems for the purposes of the ASCE 41 Tier 1 seismic evaluations. This task included confirmation of general information in building records or layout drawings and visual observation of the structural condition of the facilities. Engineer field reports, notes, photographs, and videos of the facilities were prepared and utilized to record and document information gathered in the field investigation work.

2. Limitations Due to Access: Field observation efforts were limited to areas and building elements that were readily observable and safely accessible. Observations requiring access to confined spaces, potential hazardous material exposure, access by unsecured ladder, work around energized equipment or mechanical hazards, access to areas requiring Occupational Safety and Health Administration (OSHA) fall-protection, steep or unstable slopes, deteriorated structural assemblies, or other conditions deemed potentially unsafe by the engineer were not performed. Removal of finishes (e.g., gypsum board, lath and plaster, brick veneer, roofing materials) for access to concealed conditions or to expose elements that could not otherwise be visually observed and assessed was not performed. Material testing or sampling was not performed. The ASCE checklist items that were not documented due to access limitations are noted.

1.2.3 Seismic Evaluations and Conceptual Upgrades Design

1. Seismic Evaluations: Limited seismic evaluations of the structural and nonstructural systems of the school buildings and fire stations were performed using ASCE 41-17 Tier 1 Evaluation procedures and checklists.

2. Conceptual Upgrades Design: Further seismic evaluation work was performed to provide conceptual seismic retrofits and/or upgrade designs for the selected school buildings and fire stations based on the results of the Tier 1 seismic evaluations. The conceptual seismic upgrades design work included narrative descriptions of proposed seismic retrofits and/or upgrade schemes and concept sketches depicting the extent and type of recommended structural upgrades.

3. Architectural Review: The seismic upgrade concept developed by the structural engineers was reviewed by Rolluda Architects, Inc., for general guidance and consideration of the architectural aspects of the seismic upgrade. The architects discussed the seismic upgrade concepts with the structural engineer and reviewed existing drawings that were available, pictures taken during the engineer's field investigations, and the ASCE 41 Tier 1 Screening reports. However, field visits by the architect and meetings with the fire

department and facilities personnel to discuss phasing and programming requirements were not included in the project scope of work. The architectural considerations are discussed in Section 4.4 Nonstructural Recommendations and Considerations. These conceptual designs were reviewed with high-level recommendations. Future planning for seismic improvements should include further review with a design team.

4. Cost Estimating: Through the conceptual seismic upgrades report process, ProDims, LLC, provided opinions of probable construction costs for the conceptual seismic upgrade designs for the selected fire station building. This conceptual seismic upgrade design and the associated opinions of probable construction cost is intended to be one of many cost data points still needed to estimate the overall capital needs of seismically upgrading fire stations in the high seismic hazard areas of Washington State.

1.2.4 Reporting and Documentation

1. Conceptual Upgrade Design Reports: Buildings that were selected to receive a conceptual upgrade design will have a report prepared that will include an introduction summarizing the overall findings and recommendations, along with individual sections documenting each building's seismic evaluation, list of deficiencies, conceptual seismic upgrade sketches and opinions of probable construction costs.

2. Building Photography: Photos were taken of each building during on-site walkthroughs to document the existing building configurations, conditions, and structural systems. These are available upon request through DNR/WGS.

3. Existing Drawings: Select and available existing drawings and other information were collected during the evaluation process. These are available upon request through DNR/WGS.

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2.0 Seismic Evaluation Procedures and Criteria

2.1 ASCE 41 Seismic Evaluation and Retrofit Overview

The current standard for seismic evaluation and retrofit (upgrades) of existing buildings is ASCE 41-17. ASCE 41 provides screening and evaluation procedures used to identify potential seismic deficiencies that may require further investigation or hazard mitigation. It presents a three-tiered review process, implemented by first following a series of predefined checklists and "quick check" structural calculations. Each successive tier is designed to perform an increasingly refined evaluation procedure for seismic deficiencies identified in previous tiers in the process. The flow chart in Figure 2.1 illustrates the evaluation process.

TIER 1 – Screening Phase
- Checklists of evaluation statements to quickly identify potential deficiencies
- Requires field investigation and/or review of record drawings
- Analysis limited to "Quick Checks" of global elements
- May proceed to Tier 2, Tier 3, or rehabilitation design if deficiencies are identified

TIER 2 – Evaluation Phase
- "Full Building" or "Deficiency Only" evaluation
- Address all Tier 1 seismic deficiencies
- Analysis more refined than Tier 1, but limited to simplified linear procedures
- Identify buildings not requiring rehabilitation

TIER 3 – Detailed Evaluation Phase
- Component-based evaluation of entire building using reduced ASCE 41 forces
- Advanced analytical procedures available if Tier 1 and/or Tier 2 evaluations are judged to be overly conservative
- Complex analysis procedures may result in construction savings equal to many times their cost

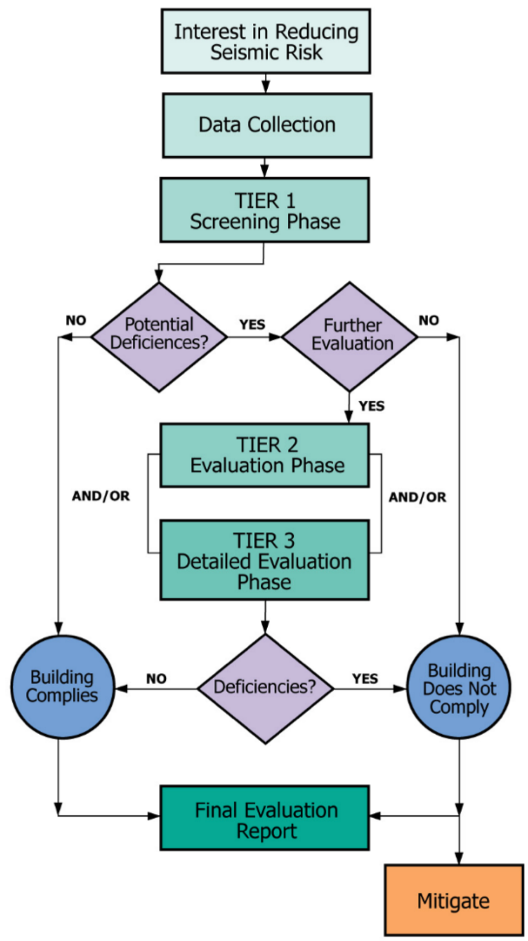

Figure 2-1. Flow Chart and Description of ASCE 41 Seismic Evaluation Procedure.

The Tier 1 checklists in ASCE 41 are specific to each common building type and contain seismic evaluation statements based on observed structural damage in past earthquakes. These checklists screen for potential seismic deficiencies by examining the lateral-force-resisting systems and details of construction that have historically caused poor seismic performance in similar buildings. Tier 1 screenings include basic "Quick Check" analyses for primary components of the lateral system. Tier 1 screenings also include prescriptive checks for proper seismic detailing of connections, diaphragm spans and continuity, and overall system configuration.

Tier 2 evaluations then follow with more-detailed structural and seismic calculations and assessments to either confirm the potential deficiencies identified in the Tier 1 review or demonstrate their adequacy. A Tier 3 evaluation involves an even more detailed analysis and advanced structural and seismic computations to review each structural component's seismic demand and capacity. A Tier 3 evaluation is similar in scope and complexity to the types of analyses often required to design a new building in accordance with the International Building Code (IBC), with a comprehensive analysis aimed at evaluating each component's seismic performance. Generally, Tier 3 evaluations are not practical for typical and regular-type buildings due to the rigorous and complicated calculations and procedures. As indicated in the Scope of Services, this evaluation included a Tier 1 screening of the structural systems.

2.2 Seismic Evaluation and Retrofit Criteria

Performance-Based Earthquake Engineering (PBEE) can be defined as the engineering of a structure to resist different levels of earthquake demand in order to meet the needs and performance objectives of building owners and other stakeholders. ASCE 41 employs a PBEE design methodology that allows building owners, design professionals, and the local building code authorities to establish seismic hazard levels and performance goals for individual buildings.

2.2.1 Site Class Definition

The building site class definition quantifies the site soil's propensity to amplify or attenuate earthquake ground motion propagating from underlying rock. Site class has a direct impact on the seismic design forces utilized to design and evaluate a structure. There are six distinct site classes defined in ASCE 7-16, Site Class A through Site Class F, that range from hard rock to soils that fail such as liquefiable soils. Buildings located on soft or loose soils will typically sustain more damage than similar buildings located on stiff soils or rock, all other things being equal. Based on predicted mapping, surrounding measurements, and consultation with the geologists at the Department of Natural Resources, the site class used for this conceptual seismic upgrade design for this building is **Site Class C**.

2.2.2 Fire Station No. 4 Seismicity

Seismic hazards for the United States have been quantified by the United States Geological Survey (USGS). The information has been used to create seismic hazard maps, which are currently used in building codes to determine the design-level earthquake magnitudes for building design.

The Level of Seismicity is categorized as Very Low, Low, Moderate, or High based on the probabilistic ground accelerations. Ground accelerations and mass generate inertial (seismic) forces within a building (Force = mass x acceleration). Ground acceleration therefore is the parameter that classifies the level of seismicity. From geographic region to region, as the ground accelerations increase, so does the level of seismicity (from low to high). Where this building is located, the design short-period spectral acceleration, S_{DS}, is 1.087 g, and the design 1-second period spectral acceleration, S_{D1}, is 0.469 g. Based on ASCE 41 Table 2-4, the Level of Seismicity for this building is classified as **High**.

The ASCE 41 Basic Performance Objective for Existing Buildings (BPOE) makes use of the Basic Safety Earthquake – 1E (BSE-1E) seismic hazard level and the Basic Safety Earthquake – 2E (BSE-2E). The BSE-1E earthquake is defined by ASCE 41 as the probabilistic ground motion with a 20 percent probability of exceedance in 50 years, or otherwise characterized as a ground motion acceleration with a probabilistic 225-year return period. The BSE-2E earthquake is defined by ASCE 41 as the probabilistic ground motion with a 5 percent probability of exceedance in 50 years, or otherwise characterized as a ground motion acceleration with a probabilistic 975-year return period. The BSE-2N seismic hazard level is the Maximum Considered Earthquake (MCE) ground motion used in current codes for the design of new buildings and is also used in ASCE 41 to classify the Level of Seismicity for a building. The BSE-2N has a statistical ground motion acceleration with 2 percent probability of exceedance in 50 years, or otherwise characterized as a ground motion acceleration with a probabilistic 2,475-year return period.

Table 2.2.1-1 provides the spectral accelerations for the 225-year, 975-year, and 2,475-year return interval events specific to Fire Station No. 4 that are considered in this study.

Table 2.2.1-1. Spectral Acceleration Parameters (Sit Class C).

BSE-1E 20%/50 (225-year) Event		BSE-1N 2/3 of 2,475-year Event		BSE-2E 5%/50 (975-year) Event		BSE-2N 2%/50 (2,475-year) Event	
0.2 Seconds	0.664 g	0.2 Seconds	1.087 g	0.2 Seconds	1.25 g	0.2 Seconds	1.63 g
1.0 Seconds	0.236 g	1.0 Seconds	0.469 g	1.0 Seconds	0.528 g	1.0 Seconds	0.704 g

2.2.3 Tacoma Fire Station No. 4 Structural Performance Objective

The fire station is a mixed-use occupancy that is considered an essential facility (Risk Category IV) that would be required to be immediately occupiable following an earthquake. According to ASCE 41, the BPOE for Risk Category IV structures is the Immediate Occupancy structural performance level at the BSE-1E seismic hazard level and the Life Safety structural performance level at the BSE-2E seismic hazard level. The ASCE 41 Tier 1 evaluations were conducted in accordance with ASCE 41 requirements and ASCE 41 seismic performance levels. Concept-level upgrades were developed for the **Immediate Occupancy** structural performance level at the **BSE-1N** seismic hazard level in accordance with DNR direction, the project scope of work, and the project legislative language.

At the Immediate Occupancy structural performance level, only very limited structural damage should occur following an earthquake. The building's vertical and lateral force resisting systems should also retain almost all of its pre-earthquake strength and stiffness and it is anticipated that continued use of the building would not be limited by its structural conditions. However, there may be limited damage or disruption to nonstructural elements of the building. The overall risk of life-threatening injury as a result of structural damage is anticipated to be very low and although some minor structural repairs might be necessary, these repairs would generally not be required before reoccupying the building.

Knowledge Factor

A knowledge factor, *k*, is an ASCE 41 prescribed factor that is used to account for uncertainty in the as-built data considering the selected Performance Objective and data collection processes (availability of existing drawings, visual observation, and level of materials testing). No in-situ testing of building materials was performed; however, some material properties and existing construction information were provided in the existing record drawings. If the concept design is developed further, additional materials tests and site investigations will be required to substantiate assumptions about the existing framing systems.

ASCE 41 Classified Building Type

Use of ASCE 41 for seismic evaluations requires buildings to be classified from a group of common building types historically defined in previous seismic evaluation standards (ATC-14, FEMA 310, and ASCE 31-03). This fire station is classified in ASCE 41 Table 3-1 as an unreinforced masonry shear wall building with flexible diaphragms, **URM**. Unreinforced masonry shear wall buildings (URM) include those that have bearing shear walls constructed of unreinforced masonry with elevated floor and roof framing structural systems consisting of wood framing.

2.3 Report Limitations

The professional services described in this report were performed based on available record drawing information and limited visual observation of the structure. No other warranty is made as to the professional advice included in this report. This report provides an overview of the seismic evaluation results and does not address programming and planning issues. This report has been prepared for the exclusive use of DNR/WGS and is not intended for use by other parties, as it may not contain sufficient information for purposes of other parties or their uses.

3.0 Building Description & Seismic Evaluation Findings

3.1 Building Overview

3.1.1 Building Description

Original Year Built: 1935
Building Code: Unknown

Number of Stories: 1
Floor Area: 6,115 SF

FEMA Building Type: URM
ASCE 41 Level of Seismicity: High
Site Class: C

Tacoma Fire Station No. 4 is a one-story, URM structure with a basement, located at 1453 Earnest S. Brazil Street in Tacoma, Washington (formerly 1453 S 12th Street). The building was built in in 1935 in two rectangular sections that include an apparatus bay that is approximately 1,700 square feet (33 feet by 52 feet) and the remainder of the building, which is living quarters and offices over a basement. The structure has a roof height of 15 feet in the apparatus bay and a maximum height of 32 feet at the hose tower. Building construction consists of load-bearing multi-wythe URM walls that support a wood-framed roof, wood-framed floors, and a concrete floor at the kitchen and hose tower that is founded on continuous concrete basement walls and footings. The apparatus bay floor and basement floor is concrete slab on grade. The building is listed on the National Register of Historical Places as Fire Station No. 5.

3.1.2 Building Use

Tacoma Fire Station No. 4 is currently staffed by five firefighters, one engine, and one medic unit.

3.1.3 Structural System

Table 3.1.3-1. Structural System Descriptions.

Structural System	Description
Structural Roof over Apparatus Bay and Living Spaces	At the roof over the apparatus bays, sheathing (thickness unknown) is supported on 6x18 wood joists at approximately 4 feet on center. At the rest of the building, roof sheathing is supported on 3x14 wood joists at 16 inches on centers. At the hose tower, roof sheathing is supported on 4x8 wood joists (spacing not known). The wood joists are supported on exterior unreinforced masonry walls.

Table 3.1.3-1. Structural System Descriptions.

Structural System	Description
Structural Floor(s)	The floor over the basement in the dayroom area consists of 4x decking with 1/2-inch concrete topping supported by 2x10 wood joists at 16 inches on center that span from exterior concrete basement walls to interior concrete basement walls and 6x girders. The 6x girders are supported on 6x6 wood posts and diagonal kickers at each end. The floors over the original boiler room, drying room, and supporting the existing kitchen are one-way reinforced concrete slabs supported by concrete girders and basement walls. The apparatus bay and the basement floors are concrete slabs on grade.
Foundations	Exterior unreinforced masonry walls and interior concrete walls are supported on continuous concrete footings. The interior wood posts are supported on pier blocks and 18-inch by 18-inch concrete spread footings.
Gravity System	Wood-framed roof spanning to multiwythe URM bearing walls and interior wood stud bearing walls and wood-framed and concrete-framed floor framing supported by concrete basement walls. URM walls, basement walls, wood stud bearing walls, and wood posts founded on conventional spread footings.
Lateral System	Flexible wood tongue-and-groove roof diaphragms span to multiwythe URM shear walls to resist lateral loads in both directions. The URM shear walls and main floor diaphragms span to concrete basement walls.

3.1.4 Structural System Visual Condition

Table 3.1.4-1. Structural System Condition Descriptions.

Structural System	Description
Structural Roof	Fairly Good. A couple of wood joists at the apparatus bay roof had cracks.
Structural Floor(s)	Fairly Good. At a small area under the hose tower, there is water damage.
Foundations	Foundations and slabs on grade appear to be in good structural condition, as there did not appear to be significant signs of settlement. However, there is evidence of moisture penetration through the basement walls based on the efflorescence and bubbled and peeled paint that was observed.
Unreinforced Masonry Walls	The multiwythe URM walls appear to be in decent condition. However, there were vertical cracks observed in the inner wythe of the URM walls near the windows on the east wall of the apparatus bay and some stair step cracks observed in the exterior wythe of the east apparatus bay walls.

3.2 Seismic Evaluation Findings

3.2.1 Structural Seismic Deficiencies

The structural seismic deficiencies identified during the Tier 1 evaluation are summarized below. Commentary for each deficiency is provided based on this evaluation.

Table 3.2.1-1. Identified Structural Seismic Deficiencies Based on Tier 1 Checklists.

Deficiency	Description
Wall Anchorage	Exterior and interior masonry bearing walls were not detailed to have out-of-plane anchorage or bracing to the roof diaphragm.
Wood Ledgers	The roof is supported by wood ledgers without wall anchor ties directly attached to the diaphragm.
Transfer to Shear Walls	The existing drawings and field observations do not indicate a clear and adequate load path from the roof diaphragms to the URM shear walls.
Girder-Column Connection	Wood posts and wood beams in the basement do not have positive connections such as steel plates and bolts and do not have direct vertical support at the ends of the 6x girders (supported by diagonal 4x6 kickers).
Shear Stress Check	Shear stress in the unreinforced masonry shear walls is more than 70 psi using the Quick Check procedure.
Cross Ties	Continuous cross-ties are not present in longitudinal and transverse direction.
Straight Sheathing	The aspect ratio for the roof decking diaphragms exceeds the 1:1 ratio prescribed in ASCE 41-17.
Proportions	The URM wall height to wall thickness ratio is 15 at the apparatus bay and 19 at the hose tower, both of which exceed the prescribed ratio of 13 in ASCE 41-17.

3.2.2 Structural Checklist Items Marked as "U"nknown

Where building structural component seismic adequacy was unknown due to lack of available information or limited observation, the structural checklist items were marked as "unknown". These items require further investigation if definitive determination of compliance or noncompliance is desired. The unknown structural checklist items identified during the Tier 1 evaluation are summarized below. Commentary for each unknown item is provided based on the evaluation.

Table 3.2.2-1. Identified Structural Checklist Items Marked as Unknown.

Deficiency	Description
Liquefaction	"Low" liquefaction potential is identified in the state geologic hazards database. This requires further investigation by a licensed geotechnical engineer to determine liquefaction potential.
Slope Failure	Requires further investigation by a licensed geotechnical engineer to determine susceptibility to slope failure. The structure appears to be located on a relatively flat site.
Surface Fault Rupture	Requires further investigation by a licensed geotechnical engineer to determine whether site is near locations of expected surface fault ruptures.

3.2.3 Nonstructural Seismic Deficiencies

Table 3.2.3-1 summarizes the seismic deficiencies in the nonstructural systems. The Tier 1 screening checklists are provided in Appendix A.

Table 3.2.3-1. Identified Nonstructural Seismic Deficiencies based on Tier 1 Checklists.

Deficiency	Description
CF-3 Fall Prone Contents; & CF-6 Suspended Contents	Cabinets more than 6 feet tall behind east wall in the apparatus bay are not anchored to the structure. The tall shelves are in front of the exit door and are in the path of egress.
ME-1 Fall-Prone Equipment; ME-2 In-Line Equipment	Mechanical units in the apparatus bay roof structure need to be braced to the structure. Middle hosepipe track is not braced back to the structure and shall be braced adequately.

3.2.4 Nonstructural Checklist Items Marked as "U"nknown

Where building nonstructural component seismic adequacy was unknown due to lack of available information or limited observation, the nonstructural checklist items were marked as "unknown". These items require further investigation if definitive determination of compliance or noncompliance is desired. The unknown nonstructural checklist items identified during the Tier 1 evaluation are summarized below. Commentary for each unknown item is provided based on the evaluation.

Some nonstructural deficiencies may be able to be mitigated by fire department staff. Other nonstructural components that require substantial mitigation may be more appropriately included in a long-term mitigation strategy. Some typical conceptual details for the seismic upgrade of nonstructural components can be found in the FEMA E-74 Excerpts appendix.

Table 3.2.4-1. Identified Nonstructural Checklist Items Marked as Unknown.

Deficiency	Description
LSS-1 Fire Suppression Piping; LSS-2 Flexible Couplings	A fire suppression system was observed in the apparatus bay and the basement floor areas; whether it meets current NFPA 13 requirements should be verified.
LSS-3 Emergency Power	This was not observed during the site visit; however, if emergency power is being used, further investigation is recommended to see if this equipment is adequately anchored or braced.

4.0 Recommendations and Considerations

4.1 Seismic-Structural Upgrade Recommendations

Concept-level seismic upgrade recommendations to improve the lateral-force-resisting system were developed. The sketches in Appendix B depict the concept-level structural upgrade recommendations outlined in this section. The following concept recommendations are intended to address the structural deficiencies noted in Table 3.2.1-1. This concept-level seismic upgrade design represents just one of several alternative seismic upgrade design solutions and is based on preliminary seismic evaluation and analysis results. Final analysis and design for seismic upgrades must include a more-detailed seismic evaluation of the building in its present or future configuration. Proposed seismic upgrades include the following.

4.1.1 Strongbacking of Existing Unreinforced Masonry Walls

Existing URM shear walls on all sides of the building are recommended to be strengthened for out-of-plane and in-plane seismic forces. The anchor ties are recommended to provide out-of-plane support for the shear walls. In order to increase the in-plane seismic force capacity of the existing lateral-force-resisting system, we recommend shotcrete walls along all the inside of the exterior URM walls in select locations, see Appendix B. Out-of-plane roof tie anchors such as Simpson LTT connectors are recommended at all URM walls spaced approximately 32 inches on center. The strongback shotcrete wall is recommended to be full height along the URM shear wall, anchored to the inside of the URM wall, and connected at the top with the existing roof diaphragm. The shotcrete walls are recommended to be 6 to 8 inches thick and dowels are recommended at the foundation level. The existing URM walls may have to be shored when shotcrete is applied.

4.1.2 New Interior Wood Shear Wall

New interior wood shear walls are recommended for lateral strengthening in both directions by sheathing existing interior wood shear walls with plywood. See Appendix B for locations. These shear walls will increase the seismic-force-resisting capacity of the lateral-force-resisting system and reduce the diaphragm spans and aspect ratios over the living quarters area. These shear walls may require holdown overturning anchorage to concrete foundation stem walls below or to wood floor framing below and will need to be further investigated during the design of a future retrofit project.

4.1.3 Plywood Sheathing Overlay and Cross Ties for the Existing Roof Structure

The existing wood tongue-and-groove roof diaphragm is not adequate to distribute the seismic forces to the shear walls. The roof diaphragms also do not have adequate cross-ties in the north-south direction (perpendicular to the joists spans over the living quarters and apparatus bay). We recommend providing a plywood sheathing overlay on the existing tongue-and-groove roof decking and installation of blocking and strapping perpendicular to the roof framing to strengthen and stiffen the roof diaphragm that supports out-of-plane loading from the exterior

URM walls. The existing roofing will need to be removed to install the plywood overlay and then re-insulated and re-roofed. Re-roofing projects are an opportune time to add a plywood overlay due to the relatively inexpensive cost to install plywood compared to the overall cost to re-roof. Also note that bracing of URM parapets is required by the International Existing Building Code (IEBC) when doing re-roofing projects for URM buildings.

4.1.4 Upgrading Load Path of Existing Wood Roof Diaphragms to Shear Walls

Existing drawings and field observations do not indicate a clear and adequate load path from the roof diaphragms to the URM shear walls. At the apparatus bay, we recommend providing blocking between the 6x18 beams that are epoxy-bolted to the URM shear walls and fastened to the underside of the tongue-and-groove diaphragm. We also recommend the 6x beams on the inside face of the north and south URM walls of the apparatus bay be epoxy-bolted to the URM shear walls and fastened to the underside of the tongue-and-groove diaphragm. These ledger beams should also be protected against cross-grain bending with the use of Simpson LTT or HTT wall anchors that are connected to the tongue-and-groove diaphragm either directly or through wood blocking. At the living quarters area, the connections of the lower roof framing to the URM walls were not visible; however, the existing drawings also do not indicate a load path from the roof diaphragm to the exterior URM shear walls. Similar to the apparatus bay, blocking between floor joists should be connected to the existing roof decking and anchored to the URM walls with epoxy-grouted anchor rods.

4.1.5 Lowering and Partial Demolition of URM Hose Tower and Chimney

The URM hose tower at the north end of the apparatus bay is 32 feet in height and projects about 18 feet above the apparatus bay roof. The hose tower is a serious falling hazard due to the URM construction, which is known from past large and long duration seismic events to suffer sudden and brittle failures. These sudden and brittle failures make tall, unanchored, URM structures highly susceptible to collapse. Therefore, from a post-earthquake Immediate Occupancy and Life Safety perspective, we recommend removing the projected portion of the hose tower to the apparatus bay roof elevation. Removal of the hose tower will also reduce the seismic weight and force demands on the overall structure, which will also help improve the overall structural performance of the lateral system. However, because this building is on the National Historic Register, any modification or alternation to the original aesthetic of the building is recommended to be approved by the State Historic Preservation Office. If the Authority Having Jurisdiction requires that the URM hose tower and chimney remain, we recommend the URM walls extending above the apparatus bay roof be braced internally with bands of structural steel framing within the hose tower spaced no more than 6 feet on center vertically. See the alternate preservation bracing scheme in Figures 2 and 3 of Appendix B.

4.2 Foundations and Geotechnical Considerations

A detailed geotechnical analysis of the site soils was not included in the scope of this study. As a result, the geotechnical seismic effects on the existing building and its foundations, such as the presence of liquefiable soils and allowable soil bearing pressures, are unknown at this time. However, based on state of Washington liquefaction mapping, the building is located on soils classified with a very low susceptibility to liquefaction. Future seismic upgrade projects should consider doing a geotechnical investigation to verify that the underlying soils are not susceptible to liquefaction and to determine the nature of the liquefaction hazard and the characteristics of the site soils. Foundation mitigation and ground improvement may be required, and the recommended geotechnical investigation could have a major impact on the scope of work required for seismic retrofit

Liquefaction is the tendency of certain soils to saturate and lose strength during strong earthquake shaking, causing it to flow and deform similar to a liquid. Liquefaction, when it occurs, drastically decreases the soil bearing capacity and tends to lead to large differential settlement of soil across a building's footprint. Liquefaction can also cause soils to spread laterally and can dramatically affect a building's response to earthquake motions, all of which can significantly compromise the overall stability of the building and possibly lead to isolated or widespread collapse in extreme cases. Existing foundations damaged as a result of liquefiable soils also make the building much more difficult to repair after an earthquake.

Buildings that are not founded on a raft foundation or deep foundation system (such as grade beams and piles), and those with conventional strip footings and isolated spread footings that are not interconnected well with tie beams, are especially vulnerable to liquefiable soils. Mitigation techniques used to improve structures in liquefiable soils vary based on the type and amount of liquefiable soils and may include ground improvements to densify the soil (aggregate piers, compaction piling, jet grouting), installation of deep foundations (pin piling, augercast piling, micro-piling), and installation of tie beams between existing footings.

4.3 Tsunami Considerations

The building is not located in a tsunami inundation zone according to Washington State Department of Natural Resources tsunami inundation mapping. It is not necessary to consider tsunamis when planning seismic upgrades to this building.

4.4 Nonstructural Recommendations and Considerations

Table 3.2.3-1 identifies nonstructural deficiencies that do not meet the performance objective selected for Tacoma Fire Station No. 4. It is recommended that these deficiencies be addressed to provide nonstructural performance consistent with the performance of the upgraded structural lateral-force-resisting system. As-built information for the existing nonstructural systems, such as fire sprinklers, mechanical ductworks, and piping, was not available for review. Only limited visual observation of the systems was performed during field investigation due to limited access or visibility to observe existing conditions. The conceptual mitigation strategies provided in this study are preliminary only. The final analysis and design for seismic rehabilitation should include a detailed field investigation.

4.4.1 Architectural Systems

This section addresses existing construction that, while not posing specific hazards during a seismic event, would be affected by the seismic improvements proposed.

For any remodel project of an existing building, the International Existing Building Code (IEBC) would be applicable. The intent of the IEBC is to provide flexibility to permit the use of alternative approaches to achieve compliance with minimum requirements to safeguard the public health, safety, and welfare insofar as they are affected by the work being done.

Energy Code

Elements of the exterior building envelope to be affected by the proposed seismic upgrade work may be required to be brought up to the current Washington State Energy Code per Chapter 5, where applicable.

Accessibility

It should also be noted that, as a part of any upgrade to existing buildings, the IEBC will require that any altered primary function spaces (equipment bay, gyms, entrances, offices) and routes to these spaces, be made accessible to the current accessibility standards of the Americans with Disabilities Act (ADA), unless technically infeasible.

This would include but is not limited to accessible restrooms, paths of travel, entrances and exits, parking, signage and Life Safety alarm systems. Under no circumstances should the facility be made less accessible. The IEBC does, however, have exceptions for areas that do not contain a primary function (storage room, utility rooms) and states that costs of providing the accessible route are not required to exceed 20 percent of the costs of the alterations affecting the area of Primary Function.

As with any major renovation and modernization, an ADA study should be performed to determine the extent to which an existing facility would need to be improved in order to comply with current ADA requirements.

Hazardous Materials Survey

Given the age of the building, there may be existing construction elements such as floor tile and/or adhesive, pipe insulation, etc., that could contain asbestos. Verify that a hazardous materials survey and abatement of the building has been performed prior to the start of any demolition work.

Strongbacking of Existing Unreinforced Masonry Walls

Exterior walls to receive 6-inch strongback shotcrete on the interior face will require demolition of both ceilings and floors in those areas. Basement walls are below grade, so digging through floor slab to provide foundation anchorage will compromise existing slab moisture barriers and insulation. Main level floor finishes will be cut back to install anchors at strongback base.

A five-foot portion of the existing metal lath and plaster and furred tile ceiling at the main level will need to be removed for access to masonry above at the new strongback walls and anchors on the main level. It may be difficult to match the existing acoustic ceiling tiles that are currently installed. Given the age and condition of the tiles, it may be best to replace all existing ceiling tiles as part of an overall modernization project.

Existing electrical outlets, switches, and other items will need to be reinstalled in new 6-inch strongback wall locations. Paint and new rubber base would be installed to match adjacent wall finishes.

New Interior Wood Transverse Shear Walls

New interior shear walls will require removal of the flooring materials at least three feet out from the walls in order to construct the new foundations. The flooring appears to be vinyl composition tiles. Given the age of the building, the tile and/or adhesive could contain asbestos. An asbestos survey of the building would be recommended prior to any demolition.

Existing electrical outlets, switches, and other items will need to be reinstalled in new 2x6 stud shear walls with 5/8-inch gypsum board on both sides. Paint and new rubber base would be installed to match adjacent wall finishes.

Plywood Sheathing Overlay and Cross Ties for the Existing Roof Interior Wood Structure

The reroof project may require additional roof insulation as part of alterations. The drawings show batt insulation laid above the interior ceiling surfaces, creating an unconditioned attic space above. As part of a reroof project, we recommend installing an above-roof continuous rigid insulation of R-38 over the entire roof to comply with current energy code. Any mechanical equipment curbs should be raised to accommodate the thicker insulation. Alternately, additional batt insulation above the ceilings at the bottom of the trusses would need to be added to increase the existing R-13 insulation to an R-49. Parapet bracing roof penetrations must be detailed as required by roof system manufacturer.

Upgrading Load Path of Existing Wood Roof Diaphragms to Shear Walls

Installation of blocking between beams and URM walls in the apparatus bay will require the removal and reinstallation of utility lines, electrical conduit, vehicle exhaust ducts, etc. Existing URM exterior walls in the apparatus bay are simply painted on the interior side, and roof framing is exposed, so will require repainting after completion of the work. Existing URM exterior walls in the main level living quarters typically have metal lath and plaster wall and ceiling finish. Where strongback and shear walls will require metal lath and plaster finish to match existing adjacent walls. Repair ceilings with metal lath and plaster to match existing.

The basement areas where blocking between floor joists occurs are generally painted foundation walls and exposed floor framing. Repainting will be required once work is complete.

Lowering and Partial Demolition of URM Hose Tower and Chimney

Removal of the hose tower, while improving the overall structural performance of the lateral system in a seismic event, will also remove an important design element, one in which various elements of the brick vocabulary come together, relating back to the main structure below. The hose tower includes a chimney, which originally served a broiler in the basement. We were unable to determine if the chimney is still in use or has been abandoned. Because this building is on the National Historic Register, any modification or alternation to the original aesthetic of the building must be approved by the State Historic Preservation Office before implementation.

Ceiling in Paths of Egress

The suspended ceiling in the personnel areas is an integrated acoustical ceiling system, likely with a suspended metal T-grid. Because this corridor is a main path of egress, it is recommended that the ceiling grid support system be further investigated and checked for proper seismic bracing and compression support for every 12 square feet of area and proper edge clearance detailing at the corridor walls. Preventing the risk of a fallen integrated ceiling system will mitigate the risk of obstructions impeding the paths of egress as occupants evacuate the building following a seismic event.

Lighting Fixtures in Paths of Egress

The light fixtures observed in the main corridor are supported within an integrated ceiling system that is over a main path of egress. Maintenance staff should verify that each fixture is independently supported to the roof structure from opposite corners and add wire supports as necessary.

Contents and Furnishings

Buildings often contain various tall and narrow furniture, such as shelving and storage units, that are freestanding away from any backing walls. Heavy items weighing more than 20 pounds on upper shelves or cabinet furniture should also be restrained by netting or cabling to avoid becoming falling hazards to occupants below.

4.4.2 Mechanical Systems

The main seismic concerns for mechanical equipment are sliding, swinging, and overturning. Inadequate lateral restraint or anchorage can shift equipment off its supports, topple equipment to the ground, or dislodge overhead equipment, making them falling hazards. Investigation of above-ceiling mechanical equipment and systems was not part of this study, but an initial investigation for the presence of mechanical equipment bracing can be performed by maintenance and facility staff to see if equipment weighing more than 20 pounds with a center of mass more than 4 feet above the adjacent floor level is laterally braced. If bracing is not present, and the equipment poses a falling hazard to occupants below, further investigation is recommended by a structural engineer.

4.5 Opinion of Probable Conceptual Seismic Upgrades Costs

An opinion of probable project costs of the concept-level seismic upgrade recommendations provided in this report is included in Appendix C. The input of the scope of work to develop the probable costs is the Tier 1 checklists and the preliminary concept-level seismic upgrades design recommendations and sketches. These preliminary concept-level design sketches depict a design concept that could be implemented to improve the seismic safety of the building structure. It is important to note the preliminary seismic upgrades design concept is based on the results of the Tier 1 seismic screening checklists and engineering design judgement and has not been substantiated by detailed structural analyses and calculations.

For this preliminary opinion of probable costs, the estimate of construction costs of the preliminary scope of work is developed based on current 1st Quarter (1Q) 2021 costs. Costs are then escalated to 4Q 2022 at 6% per year of the baseline cost estimate. Costs are developed based on the Tier 1 checklist, concept-level seismic upgrade design sketches, and project narratives.

A range of the cost estimate of -20% (low) to +50% (high) is used to develop the range of the construction cost estimate for the concept-level scope of work. The -20% to +50% range guidance is from Table 1 of the AACE International Recommended Practice 56R-08, *Cost Estimate Classification System*. This estimate is classified as a Class 5 based on the level of design of 0% to 2%. The range of a Class 5 construction cost estimate based on the AACE guidance selected for this estimate is -20% to +50%.

The estimated total cost (construction costs plus soft costs) to mitigate the deficiencies identified in the Tier 1 checklists of the Tacoma Fire Station No. 4 ranges between approximately $1.36M and $2.54M (-20%/+50%). The baseline estimated total cost to seismically upgrade this building is approximately $1.69M. On a per-square-foot basis, the baseline seismic upgrade cost is estimated to be approximately $277 per square foot in 4Q 2022 dollars, with a range between $222 per square foot and $416 per square foot.

4.5.1 Opinion of Probable Construction Costs

This conceptual opinion of construction costs includes labor, materials, equipment, and scope contingency, general contractor general conditions, home office overhead, and profit. This is based on a public sector design-bid-build project delivery method. Project delivery methods such as negotiated, State of Washington GC/CM, and design-build are not the basis of the construction costs. Owner's soft costs are described below in Section 4.5.2.

The cost is developed in 1Q 2021 costs. The costs are then escalated to 4Q 2022 using an escalation rate of 6.0% per year. If the mid-point of construction will occur at a date earlier or later than 4Q 2022, then it is appropriate to adjust the escalation to the revised mid-point of construction. Construction costs excluded from the estimate are site work, phasing of construction, additional building modifications not directly related to the seismic scope of work, off hours labor costs, accelerated schedule overtime labor costs, replacement/relocation/additional FF+E, and building code changes that occur after this report.

For project budget planning purposes, it is highly recommended that the opinion of probable project costs is determined including: the overall construction budget of the seismic upgrade and additional scope of work for the building via the services of an A/E design team to study the proposed seismic mitigation strategies to refine the concept-level seismic upgrades design approach contained in this report, determine the construction timeline to adjust the escalation costs, define the construction phasing, if any, and the project soft costs.

4.5.2 Opinion of Probable A-E Design Budgets and Owner's Additional Project Costs (Soft Costs)

Additional owner's project costs would likely include owner's project administration costs, including project management, financing/bond costs, administration/contract/accounting costs, review of plans, value engineering studies, building permits, bidding costs, equipment, fixtures, furnishings and technology, and relocation of the fire department staff and operations during construction. These costs are known as soft costs.

These soft costs have been included in the opinion of probable costs at 40% of the baseline probable construction cost for the seismic upgrade of this building.
The soft costs used for the projects that total to 40% are:
A+E Design - 10%
QA/QC Testing - 2%
Project Administration - 2%
Owner Contingency - 11%
Average Washington State Sales Tax - 9%
Building Permits - 6%

It is typical for soft costs to vary from owner to owner. Based upon our team members' experience on fire station projects in the state of Washington, it is our opinion that an allowance of 40% of the average probable construction cost is a reasonable and appropriate soft cost recommendation for planning purposes. We also recommend that each owner develop their own soft costs as part of their budgeting process and not rely solely on this recommended percentage.

4.5.3 Opinion of Escalation Rates

A 6.0%/year construction cost escalation rate is used for planning purposes for the conceptual estimates. The rate is compounded annually to the projected midpoint of construction. This rate is representative of the escalation based on the previous five years of market experience of construction costs throughout the state of Washington and is projected going forward for these projects. This rate is calculated to the 4th Quarter of 2022 as an allowance for planning purposes. The actual construction schedule for the project is to be determined, and we recommend the escalation cost be revised based on revised construction schedule using the 6%/year rate.

Table 4.5.3-1. Seismic Upgrades Opinion of Probable Construction Costs.

Building	FEMA Bldg Type	ASCE 41 Level of Seismicity / Site Class	Structural Performance Objective	Bldg Gross Area	Estimated Seismic Upgrade Cost Range $/SF (Total)			Estimated Seismic Upgrade Cost/SF (Total)
Tacoma Fire Department Station No. 4	URM	High / C	**Structural**					
			Immediate Occupancy	6,115 SF	$102 ($624K)	-	$192 ($1.17M)	$128 ($781K)
			Nonstructural					
			Immediate Occupancy	6,115 SF	$56 ($343K)	-	$106 ($644K)	$70 ($429K)
			Total					
				6,115 SF	$158 ($967K)	-	$298 ($1.81M)	$198 ($1.21M)
					Estimated Soft Costs:			$484K
					Total Estimated Project Costs:			**$1.69M**

W: Wood-Framed; URM: Unreinforced Masonry; RM: Reinforced Masonry; C: Reinforced Concrete; PC: Precast concrete; S: Steel-framed

Appendix A: ASCE 41 Tier 1 Screening Report

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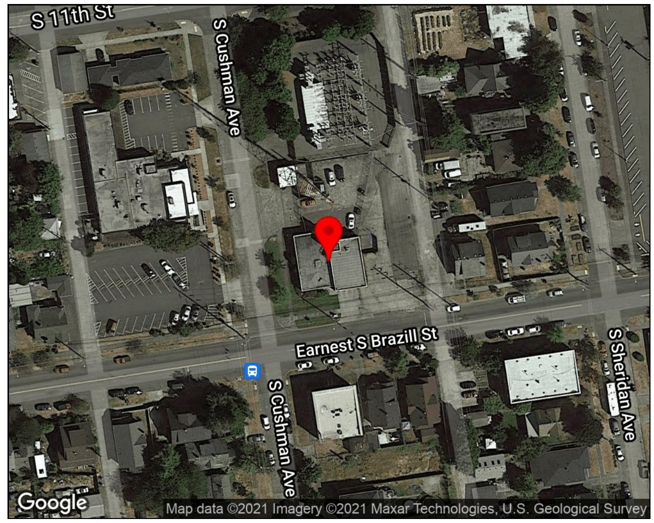
1. Tacoma, WA, Tacoma Fire Department, Tacoma Fire Station #4

1.1 Building Description

Building Name:	Tacoma Fire Station #4
Facility Name:	Tacoma Fire Department
District Name:	Tacoma, WA
Latitude:	47.250639
Longitude:	-122.456963
Gross Sq. Ft. :	6115
Number of Stories:	1 + Basement
Year Built:	1935
Has Building Been Seismically Upgraded?	No
Years of Seismic Upgrade:	
Record Drawings or Other Documents Available?	No
ASCE 41 Level of Seismicity:	High
Is Site Class Known?	Assumed
Site Class:	C
Are the Site Soils Expected to Be Suspecptible to Liquefaction?	No
Tsunami Risk:	Low
S_s (BSE-2N)	1.358
S_1 (BSE-2N)	0.469
S_{xs} (BSE-2N)	1.63
S_{x1} (BSE-2N)	
S_{xs} (BSE-2E)	1.25
S_{x1} (BSE-2E)	0.528
S_{ds} (BSE-1N)	1.087
S_{d1} (BSE-1N)	
S_{xs} (BSE-1E)	0.664
S_{x1} (BSE-1E)	0.236



Tacoma Fire Station #4 is a one story, unreinforced masonry structure with a basement, located at 1453 Earnest S. Brazil Street in Tacoma, Washington (formerly 1453 S 12th Street). The building was built in in 1935 in two rectangular sections that includes an apparatus bay that is approximately 2,000 square feet (33 feet by 52 feet) and the remainder of the building being the living quarters and offices over a basement. The structure has a roof height of 15 feet in the apparatus bay and a maximum height of 32 feet at the hose tower. Building construction consists of load-bearing multiwythe URM walls that supports a wood framed roof, and wood framed floors, and a concrete floor at the kitchen and hose tower founded on continuous concrete basement walls and footings. The apparatus bay floor and basement floor is concrete slab on grade. The building is listed on the National Register of Historical Places as Fire Station No. 5.

1.1.1 Building Use

Tacoma Fire Station #4 is currently staffed by five fire fighters one engine and one medic unit.

1.1.2 Structural System

Table 1.1-1. Structural System Description of Tacoma Fire Department

Structural System	Description
Structural Roof	At the roof over the apparatus bays, sheathing (thickness unknown) is supported on 6x18 wood joists at approximately 4 feet on center. At the rest of the building, roof sheathing is supported on 3x14 wood joists at 16 inches on centers. At the hose tower, roof sheathing is supported on 4x8 wood joists (spacing not known). The wood joists are supported on exterior unreinforced masonry walls.
Structural Floor(s)	The floor over the basement in the dayroom area consists of 4x decking with ½-inch concrete topping supported by 2x10 wood joists at 16 inches on center that span from exterior concrete basement walls to interior concrete basement walls and 6x girders. The 6x girders are supported on 6x6 wood posts and diagonal kickers at each end. The floors over the original boiler room, drying room, and supporting the existing kitchen are one-way reinforced concrete slabs supported by concrete girders and basement walls. The apparatus bay and the basement floors are concrete slabs-on-grade.
Foundations	Exterior unreinforced masonry walls and interior concrete walls are supported on continuous concrete footings. The interior wood posts are supported on pier blocks and 18-inch x 18-inch concrete spread footings.
Gravity System	Wood-framed roof spanning to multiwythe URM bearing walls and interior wood stud bearing walls; wood-framed and concrete-framed floor framing supported by concrete basement walls. URM walls, basement walls, wood stud bearing walls, and wood posts founded on conventional spread footings.
Lateral System	Flexible wood T&G roof diaphragms span to multiwythe URM shear walls to resist lateral loads in both directions. The URM shear walls and main floor diaphragms span to concrete basement walls.

1.1.3 Structural System Visual Condition

Table 1.1-2. Structural System Condition Description of Tacoma Fire Department

Structural System	Description
Structural Roof	Fairly Good. Couple of wood joists at the apparatus bay roof had cracks.
Structural Floor(s)	Fairly Good. At a small area under the hose tower there was water damage.
Foundations	Foundations and slabs on grade appear to be in good structural condition as there did not appear to be significant signs of settlement. However there is evidence of moisture penetration through the basement walls based on the efflorescence and bubbled and peeled paint that was observed.
Gravity System	Fairly Good. No visible signs of damage or deterioration.

Lateral System	The multiwythe URM walls appear to be in decent condition. However there were vertical cracks observed in the inner wythe of the URM walls near the windows on the east wall of the apparatus bay and some stair stepped cracks observed in the exterior wythe of the east apparatus bay walls.

Photos:

Figure 1-1. Figure-1 Building North Elevation

Figure 1-2. Figure-2 Building South Elevation

Figure 1-3. Figure-3 Apparatus Bay Roof Framing & Ducts

Figure 1-4. Figure-4 Apparatus Bay Roof Framing, Mech. Unit & Ducts

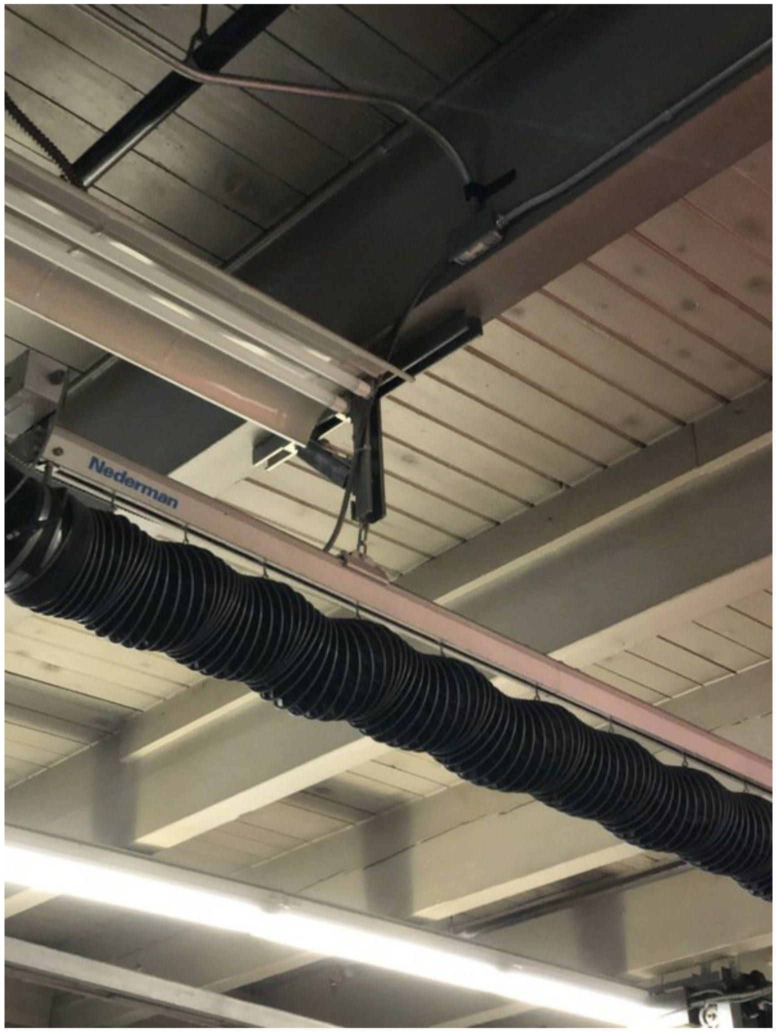


Figure 1-5. Figure-5 Apparatus Bay Roof Framing & Tracks at Hose Pipe

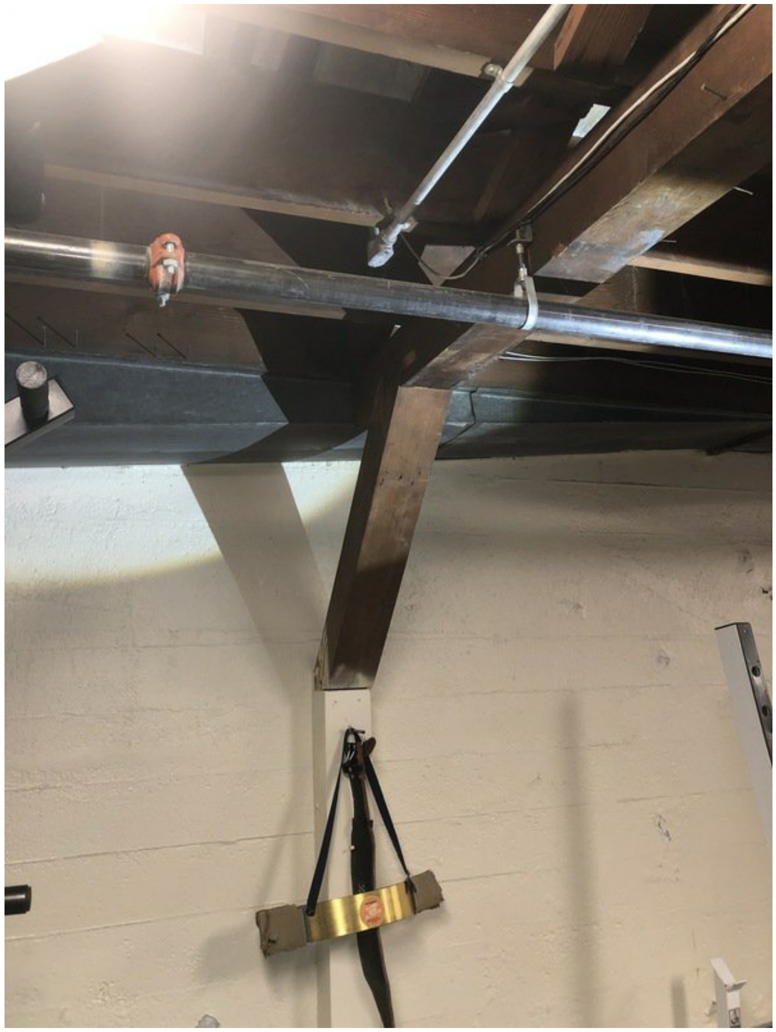


Figure 1-6. Figure-6 Basement Floor Framing & Ducts at Periphery to Concrete Wall

Figure 1-7. Figure-7 Floor Framing at Crawl Space Under Living Quarters

Figure 1-8. Figure-8 Mechanical Units in Basement

1.2 Seismic Evaluation Findings

1.2.1 Structural Seismic Deficiencies

The structural seismic deficiencies identified during the Tier 1 evaluation are summarized below. Commentary for each deficiency is also provided based on this evaluation.

Table 1.2-1. Identified Structural Seismic Deficiencies for Tacoma, WA Tacoma Fire Department Tacoma Fire Station #4

Deficiency	Description
Shear Stress Check	Shear stress in the unreinforced masonry shear walls is more than 70 psi using the Quick Check procedure.
Wall Anchorage	Exterior and interior masonry bearing walls were not detailed to have out-of-plane anchorage or bracing to the roof diaphragm.
Wood Ledgers	The roof is supported by wood ledgers without wall anchor ties directly attached to the diaphragm.
Transfer to Shear Walls	The existing drawings and field observations do not indicate a clear and adequate load path from the roof diaphragms to the URM shear walls.
Girder-Column Connection	Wood posts and wood beams in the basement do not have positive connections such as steel plates and bolts, and do not have direct vertical support at the ends of the 6x girders (supported by diagonal 4x6 kickers)
Proportions	The URM wall height to wall thickness ratio is 15 at the apparatus bay and 19 at the hose tower, both of which exceeds the prescribed ratio of 13 in ASCE 41-17.
Cross Ties	Continuous cross-ties are not present in longitudinal and transverse direction.
Straight Sheathing	The aspect ratio for the roof decking diaphragms exceed the prescribed 1:1 ratio prescribed in ASCE 41-17.

1.2.2 Structural Checklist Items Marked as Unknown

Where building structural component seismic adequacy was unknown due to lack of available information or limited observation, the structural checklist items were marked as "unknown". These items require further investigation if definitive determination of compliance or noncompliance is desired. The unknown structural checklist items identified during the Tier 1 evaluation are summarized below. Commentary for each unknown item is also provided based on the evaluation.

Table 1.2-2. Identified Structural Checklist Items Marked as Unknown for Tacoma, WA Tacoma Fire Department Tacoma Fire Station #4

Unknown Item	Description
Liquefaction	"Low" liquefaction potential is identified in the state geologic hazards database. This requires further investigation by a licensed geotechnical engineer to determine liquefaction potential.
Slope Failure	Requires further investigation by a licensed geotechnical engineer to determine susceptibility to slope failure. The structure appears to be located on a relatively flat site.
Surface Fault Rupture	Requires further investigation by a licensed geotechnical engineer to determine whether site is near locations of expected surface fault ruptures.

1.3.1 Nonstructural Seismic Deficiencies

The nonstructural seismic deficiencies identified during the Tier 1 evaluation are summarized below. Commentary for each deficiency is also provided based on this evaluation. Some nonstructural deficiencies may be able to be mitigated by school district staff. Other nonstructural components that require more substantial mitigation may be more appropriately included in a long-term mitigation strategy. Some typical conceptual details for the seismic upgrade of nonstructural components can be found in the FEMA E-74 Excerpts appendix.

Table 1.3-1 Identified Nonstructural Seismic Deficiencies for Tacoma, WA Tacoma Fire Department Tacoma Fire Station #4

Deficiency	Description
CF-3 Fall-Prone Contents. HR-not required; LS-H; PR-H.	Cabinets more than 6’-0” tall behind east wall in the apparatus bay are not anchored to the structure. The tall shelves are in front of the exit door and is in the path of egress.
CF-6 Suspended Contents. HR-not required; LS-not required; PR-H.	Cabinets more than 6’-0” tall behind east wall in the apparatus bay are not anchored to the structure. The tall shelves are in front of the exit door and is in the path of egress.
ME-1 Fall-Prone Equipment. HR-not required; LS-H; PR-H.	Mechanical units in the apparatus bay roof structure need to be braced to the structure. Middle hose pipe track is not braced back to the structure and shall be braced adequately.
ME-2 In-Line Equipment. HR-not required; LS-H; PR-H.	Mechanical units in the apparatus bay roof structure need to be braced to the structure. Middle hose pipe track is not braced back to the structure and shall be braced adequately.

1.3.2 Nonstructural Checklist Items Marked as Unknown

Where building nonstructural component seismic adequacy was unknown due to lack of available information or limited observation, the nonstructural checklist items were marked as "unknown". These items require further investigation if definitive determination of compliance or noncompliance is desired. The unknown nonstructural checklist items identified during the Tier 1 evaluation are summarized below. Commentary for each unknown item is also provided based on the evaluation.

Some nonstructural deficiencies may be able to be mitigated by school district staff. Other nonstructural components that require more substantial mitigation may be more appropriately included in a long-term mitigation strategy. Some typical conceptual details for the seismic upgrade of nonstructural components can be found in the FEMA E-74 Excerpts appendix.

Table 1.3-2 Identified Nonstructural Checklist Items Marked as Unknown for Tacoma, WA Tacoma Fire Department Tacoma Fire Station #4

Unknown Item	Description

Tacoma, WA, Tacoma Fire Department, Tacoma Fire Station #4

17-3 Immediate Occupancy Basic Configuration Checklist

Building record drawings have been reviewed, when available, and a non-destructive field investigation has been performed for the subject building. Each of the required checklist items are marked Compliant (C), Noncompliant (NC), Not Applicable (N/A), or Unknown (U). Items marked Compliant indicate conditions that satisfy the performance objective, whereas items marked Noncompliant or Unknown indicate conditions that do not. Certain statements might not apply to the building being evaluated.

Very Low Seismicity

Building System - General

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Load Path	The structure contains a complete, well-defined load path, including structural elements and connections, that serves to transfer the inertial forces associated with the mass of all elements of the building to the foundation. (Tier 2: Sec. 5.4.1.1; Commentary: Sec. A.2.1.10)	X				Structure has a complete load path, lateral loads are transferred through URM walls to the foundation
Adjacent Buildings	The clear distance between the building being evaluated and any adjacent building is greater than 0.25% of the height of the shorter building in low seismicity, 0.5% in moderate seismicity, and 1.5% in high seismicity. (Tier 2: Sec. 5.4.1.2; Commentary: Sec. A.2.1.2)	X				There are no other buildings in the vicinity.
Mezzanines	Interior mezzanine levels are braced independently from the main structure or are anchored to the seismic-force-resisting elements of the main structure. (Tier 2: Sec. 5.4.1.3; Commentary: Sec. A.2.1.3)			X		There is no mezzanine present.

Building System - Building Configuration

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Weak Story	The sum of the shear strengths of the seismic-force-resisting system in any story in each direction is not less than 80% of the strength in the adjacent story above. (Tier 2: Sec. 5.4.2.1; Commentary: Sec. A.2.2.2)	X				This is a single story structure
Soft Story	The stiffness of the seismic-force-resisting system in any story is not less than 70% of the seismic-force-resisting system stiffness in an adjacent story above or less than 80% of the average seismic-force-resisting system stiffness of the three stories above. (Tier 2: Sec. 5.4.2.2; Commentary: Sec. A.2.2.3)	X				This is a single story structure.
Vertical Irregularities	All vertical elements in the seismic-force-resisting system are continuous to the foundation. (Tier 2: Sec. 5.4.2.3; Commentary: Sec. A.2.2.4)	X				This is a single story structure.

Geometry	There are no changes in the net horizontal dimension of the seismic-force-resisting system of more than 30% in a story relative to adjacent stories, excluding one-story penthouses and mezzanines. (Tier 2: Sec. 5.4.2.4; Commentary: Sec. A.2.2.5)	X				This is a single story structure.
Mass	There is no change in effective mass of more than 50% from one story to the next. Light roofs, penthouses, and mezzanines need not be considered. (Tier 2: Sec. 5.4.2.5; Commentary: Sec. A.2.2.6)	X				This is a single story structure.
Torsion	The estimated distance between the story center of mass and the story center of rigidity is less than 20% of the building width in either plan dimension. (Tier 2: Sec. 5.4.2.6; Commentary: Sec. A.2.2.7)	X				This is a single story structure.

Low Seismicity (Complete the Following Items in Addition to the Items for Very Low Seismicity)

Geologic Site Hazards

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Liquefaction	Liquefaction-susceptible, saturated, loose granular soils that could jeopardize the building's seismic performance do not exist in the foundation soils at depths within 50 ft (15.2 m) under the building. (Tier 2: Sec. 5.4.3.1; Commentary: Sec. A.6.1.1)				X	"Low" liquefaction potential is identified in the state geologic hazards database. This requires further investigation by a licensed geotechnical engineer to determine liquefaction potential.
Slope Failure	The building site is located away from potential earthquake-induced slope failures or rockfalls so that it is unaffected by such failures or is capable of accommodating any predicted movements without failure. (Tier 2: Sec. 5.4.3.1; Commentary: Sec. A.6.1.2)				X	Requires further investigation by a licensed geotechnical engineer to determine susceptibility to slope failure. The structure appears to be located on a relatively flat site.
Surface Fault Rupture	Surface fault rupture and surface displacement at the building site are not anticipated. (Tier 2: Sec. 5.4.3.1; Commentary: Sec. A.6.1.3)				X	Requires further investigation by a licensed geotechnical engineer to determine whether site is near locations of expected surface fault ruptures.

High Seismicity (Complete the Following Items in Addition to the Items for Low and Moderate Seismicity)

Foundation Configuration

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Overturning	The ratio of the least horizontal dimension of the seismic-force-resisting system at the foundation level to the building height (base/height) is greater than 0.6Sa. (Tier 2: Sec. 5.4.3.3; Commentary: Sec. A.6.2.1)	X				
Ties Between Foundation Elements	The foundation has ties adequate to resist seismic forces where footings, piles, and piers are not restrained by beams, slabs, or soils classified as Site Class A, B, or C. (Tier 2: Sec. 5.4.3.4; Commentary: Sec. A.6.2.2)	X				

17-37 Immediate Occupancy Checklist for Building Types URM & URMa

Building record drawings have been reviewed, when available, and a non-destructive field investigation has been performed for the subject building. Each of the required checklist items are marked Compliant (C), Noncompliant (NC), Not Applicable (N/A), or Unknown (U). Items marked Compliant indicate conditions that satisfy the performance objective, whereas items marked Noncompliant or Unknown indicate conditions that do not. Certain statements might not apply to the building being evaluated.

Very Low Seismicity

Seismic-Force-Resisting System

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Redundancy	The number of lines of shear walls in each principal direction is greater than or equal to 2. (Tier 2: Sec. 5.5.1.1; Commentary: Sec. A.3.2.1.1)	X				There are two shear walls in each principal direction
Shear Stress Check	The shear stress in the unreinforced masonry shear walls, calculated using the Quick Check procedure of Section 4.4.3.3, is less than 30 lb/in.2 (0.21 MPa) for clay units and 70 lb/in.2 (0.48 MPa) for concrete units. (Tier 2: Sec. 5.5.3.1.1; Commentary: Sec. A.3.2.4.1)		X			Shear stress in the unreinforced masonry shear walls is more than 70 psi using the Quick Check procedure.

Connections

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Wall Anchorage	Exterior concrete or masonry walls that are dependent on the diaphragm for lateral support are anchored for out-of-plane forces at each diaphragm level with steel anchors, reinforcing dowels, or straps that are developed into the diaphragm. Connections have strength to resist the connection force calculated in the Quick Check procedure of Section 4.4.3.7. (Tier 2: Sec. 5.7.1.1; Commentary: Sec. A.5.1.1)		X			Exterior and interior masonry bearing walls were not detailed to have out-of-plane anchorage or bracing to the roof diaphragm.
Wood Ledgers	The connection between the wall panels and the diaphragm does not induce cross-grain bending or tension in the wood ledgers. (Tier 2: Sec. 5.7.1.3; Commentary: Sec. A.5.1.2)		X			The roof is supported by wood ledgers without wall anchor ties directly attached to the diaphragm.
Transfer to Shear Walls	Diaphragms are connected for transfer of seismic forces to the shear walls, and the connections are able to develop the lesser of the shear strength of the walls or diaphragms. (Tier 2: Sec. 5.7.2; Commentary: Sec. A.5.2.1)		X			The existing drawings and field observations do not indicate a clear and adequate load path from the roof diaphragms to the URM shear walls.

Girder-Column Connection	There is a positive connection using plates, connection hardware, or straps between the girder and the column support. (Tier 2: Sec. 5.7.4.1; Commentary: Sec. A.5.4.1)		X			Wood posts and wood beams in the basement do not have positive connections such as steel plates and bolts, and do not have direct vertical support at the ends of the 6x girders (supported by diagonal 4x6 kickers)

Foundation System

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Deep Foundations	Piles and piers are capable of transferring the lateral forces between the structure and the soil. (Commentary: Sec. A.6.2.3)			X		
Slopping Sites	The difference in foundation embedment depth from one side of the building to another does not exceed one story. (Commentary: Sec. A.6.2.4)	X				

Low, Moderate & High Seismicity (Complete the Following Items in Addition to the Items for Very Low Seismicity)

Seismic-Force-Resisting-System

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Proportions	The height-to-thickness ratio of the shear walls at each story is less than the following: top story of multi-story building, 9; first story of multi-story building, 15; all other conditions, 13. (Tier 2: Sec. 5.5.3.1.2; Commentary: Sec. A.3.2.5.2)		X			The URM wall height to wall thickness ratio is 15 at the apparatus bay and 19 at the hose tower, both of which exceeds the prescribed ratio of 13 in ASCE 41-17.
Masonry Layup	Filled collar joints of multi-wythe masonry walls have negligible voids. (Tier 2: Sec. 5.5.3.4.1; Commentary: Sec. A.3.2.5.3)	X				

Flexible Diaphragms

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Cross Ties	There are continuous cross ties between diaphragm chords. (Tier 2: Sec. 5.6.1.2; Commentary: Sec. A.4.1.2)		X			Continuous cross-ties are not present in longitudinal and transverse direction.
Straight Sheathing	All straight-sheathed diaphragms have aspect ratios less than 1-to-1 in the direction being considered. (Tier 2: Sec. 5.6.2; Commentary: Sec. A.4.2.1)		X			The aspect ratio for the roof decking diaphragms exceed the prescribed 1:1 ratio prescribed in ASCE 41-17.
Diagonally Sheathed & Unblocked Diaphragms	All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 30 ft (9.2 m) and aspect ratios less than or equal to 3-to-1. (Tier 2: Sec. 5.6.2; Commentary: Sec. A.4.2.3)			X		

Nonconcrete Filled Diaphragms	Untopped metal deck diaphragms or metal deck diaphragms with fill other than concrete consist of horizontal spans of less than 40 ft (12.2 m) and have aspect ratios less than 4-to-1. (Tier 2: Sec. 5.6.3; Commentary: Sec. A.4.3.1)	X				
Other Diaphragms	Diaphragms do not consist of a system other than wood, metal deck, concrete, or horizontal bracing. (Tier 2: Sec. 5.6.5; Commentary: Sec. A.4.7.1)	X				

Connections

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
Stiffness of Wall Anchors	Anchors of concrete or masonry walls to wood structural elements are installed taut and are stiff enough to limit the relative movement between the wall and the diaphragm to no greater than 1/8 in. (3 mm) before engagement of the anchors. (Tier 2: Sec. 5.7.1.2; Commentary: Sec. A.5.1.4)	X				
Beam, Girder & Truss Supports	Beams, girders, and trusses supported by unreinforced masonry walls or pilasters have independent secondary columns for support of vertical loads. (Tier 2: Sec. 5.7.4.4; Commentary: Sec. A.5.4.5)			X		

Tacoma, WA, Tacoma Fire Department, Tacoma Fire Station #4

17-38 Nonstructural Checklist

Notes:
C = Compliant, NC = Noncompliant, N/A = Not Applicable, and U = Unknown.
Performance Level: HR = Hazards Reduced, LS = Life Safety, and PR = Position Retention.
Level of Seismicity: L = Low, M = Moderate, and H = High

Life Safety Systems

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
LSS-1 Fire Suppression Piping. HR-not required; LS-LMH; PR-LMH.	Fire suppression piping is anchored and braced in accordance with NFPA-13. (Tier 2: Sec. 13.7.4; Commentary: Sec. A.7.13.1)				X	A fire suppression system was observed in the apparatus bay and the basement floor areas and should be verified whether it meets current NFPA 13 requirements.
LSS-2 Flexible Couplings. HR-not required; LS-LMH; PR-LMH.	Fire suppression piping has flexible couplings in accordance with NFPA-13. (Tier 2: Sec. 13.7.4; Commentary: Sec. A.7.13.2)				X	A fire suppression system was observed in the apparatus bay and the basement floor areas and should be verified whether it meets current NFPA 13 requirements.
LSS-3 Emergency Power. HR-not required; LS-LMH; PR-LMH.	Equipment used to power or control Life Safety systems is anchored or braced. (Tier 2: Sec. 13.7.7; Commentary: Sec. A.7.12.1)				X	This was not observed during our site visit, however if emergency power is being used further investigation is recommended to see if this equipment is adequately anchored or braced.
LSS-4 Stair and Smoke Ducts. HR-not required; LS-LMH; PR-LMH.	Stair pressurization and smoke control ducts are braced and have flexible connections at seismic joints. (Tier 2: Sec. 13.7.6; Commentary: Sec. A.7.14.1)			X		
LSS-5 Sprinkler Ceiling Clearance. HR-not required; LS-MH; PR-MH.	Penetrations through panelized ceilings for fire suppression devices provide clearances in accordance with NFPA-13. (Tier 2: Sec. 13.7.4; Commentary: Sec. A.7.13.3)			X		
LSS-6 Emergency Lighting. HR-not required; LS-not required; PR-LMH	Emergency and egress lighting equipment is anchored or braced. (Tier 2: Sec. 13.7.9; Commentary: Sec. A.7.3.1)			X		

Hazardous Materials

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
HM-1 Hazardous Material Equipment. HR-LMH; LS-LMH; PR-LMH.	Equipment mounted on vibration isolators and containing hazardous material is equipped with restraints or snubbers. (Tier 2: Sec. 13.7.1; Commentary: Sec. A.7.12.2)			X		
HM-2 Hazardous Material Storage. HR-LMH; LS-LMH; PR-LMH.	Breakable containers that hold hazardous material, including gas cylinders, are restrained by latched doors, shelf lips, wires, or other methods. (Tier 2: Sec. 13.8.3; Commentary: Sec. A.7.15.1)			X		
HM-3 Hazardous Material Distribution. HR-MH; LS-MH; PR-MH.	Piping or ductwork conveying hazardous materials is braced or otherwise protected from damage that would allow hazardous material release. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.4)			X		
HM-4 Shutoff Valves. HR-MH; LS-MH; PR-MH.	Piping containing hazardous material, including natural gas, has shutoff valves or other devices to limit spills or leaks. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.3)			X		
HM-5 Flexible Couplings. HR-LMH; LS-LMH; PR-LMH.	Hazardous material ductwork and piping, including natural gas piping, have flexible couplings. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.15.4)			X		
HM-6 Piping or Ducts Crossing Seismic Joints. HR-MH; LS-MH; PR-MH.	Piping or ductwork carrying hazardous material that either crosses seismic joints or isolation planes or is connected to independent structures has couplings or other details to accommodate the relative seismic displacements. (Tier 2: Sec. 13.7.3, 13.7.5, 13.7.6; Commentary: Sec. A.7.13.6)			X		

Partitions

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
P-1 Unreinforced Masonry. HR-LMH; LS-LMH; PR-LMH.	Unreinforced masonry or hollow-clay tile partitions are braced at a spacing of at most 10 ft (3.0 m) in Low or Moderate Seismicity, or at most 6 ft (1.8 m) in High Seismicity. (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.1.1)			X		No URM partition walls in the building were found.
P-2 Heavy Partitions Supported by Ceilings. HR-LMH; LS-LMH; PR-LMH.	The tops of masonry or hollow-clay tile partitions are not laterally supported by an integrated ceiling system. (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.2.1)			X		
P-3 Drift. HR-not required; LS-MH; PR-MH.	Rigid cementitious partitions are detailed to accommodate the following drift ratios: in steel moment frame, concrete moment frame, and wood frame buildings, 0.02; in other buildings, 0.005. (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.1.2)			X		
P-4 Light Partitions Supported by Ceilings. HR-not required; LS-not required; PR-MH.	The tops of gypsum board partitions are not laterally supported by an integrated ceiling system. (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.2.1)			X		

P-5 Structural Separations. HR-not required; LS-not required; PR-MH.	Partitions that cross structural separations have seismic or control joints. (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.1.3)			X		
P-6 Tops. HR-not required; LS-not required; PR-MH.	The tops of ceiling-high framed or panelized partitions have lateral bracing to the structure at a spacing equal to or less than 6 ft (1.8 m). (Tier 2: Sec. 13.6.2; Commentary: Sec. A.7.1.4)			X		

Ceilings

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
C-1 Suspended Lath and Plaster. HR-H; LS-MH; PR-LMH.	Suspended lath and plaster ceilings have attachments that resist seismic forces for every 12 ft2 (1.1 m2) of area. (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.3)			X		
C-2 Suspended Gypsum Board. HR-not required; LS-MH; PR-LMH.	Suspended gypsum board ceilings have attachments that resist seismic forces for every 12 ft2 (1.1 m2) of area. (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.3)			X		
C-3 Integrated Ceilings. HR-not required; LS-not required; PR-MH.	Integrated suspended ceilings with continuous areas greater than 144 ft2 (13.4 m2) and ceilings of smaller areas that are not surrounded by restraining partitions are laterally restrained at a spacing no greater than 12 ft (3.6 m) with members attached to the structure above. Each restraint location has a minimum of four diagonal wires and compression struts, or diagonal members capable of resisting compression. (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.2)			X		
C-4 Edge Clearance. HR-not required; LS-not required; PR-MH.	The free edges of integrated suspended ceilings with continuous areas greater than 144 ft2 (13.4 m2) have clearances from the enclosing wall or partition of at least the following: in Moderate Seismicity, 1/2 in. (13 mm); in High Seismicity, 3/4 in. (19 mm). (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.4)			X		
C-5 Continuity Across Structure Joints. HR-not required; LS-not required; PR-MH.	The ceiling system does not cross any seismic joint and is not attached to multiple independent structures. (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.5)			X		
C-6 Edge Support. HR-not required; LS-not required; PR-H.	The free edges of integrated suspended ceilings with continuous areas greater than 144 ft2 (13.4 m2) are supported by closure angles or channels not less than 2 in. (51 mm) wide. (Tier 2: Sec. 13.6.4 ; Commentary: Sec. A.7.2.6)			X		
C-7 Seismic Joints. HR-not required; LS-not required; PR-H.	Acoustical tile or lay-in panel ceilings have seismic separation joints such that each continuous portion of the ceiling is no more than 2,500 ft2 (232.3 m2) and has a ratio of long-to-short dimension no more than 4-to-1. (Tier 2: Sec. 13.6.4; Commentary: Sec. A.7.2.7)			X		

Light Fixtures

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
LF-1 Independent Support. HR-not required; LS-MH; PR-MH.	Light fixtures that weigh more per square foot than the ceiling they penetrate are supported independent of the grid ceiling suspension system by a minimum of two wires at diagonally opposite corners of each fixture. (Tier 2: Sec. 13.6.4, 13.7.9; Commentary: Sec. A.7.3.2)			X		
LF-2 Pendant Supports. HR-not required; LS-not required; PR-H.	Light fixtures on pendant supports are attached at a spacing equal to or less than 6 ft. Unbraced suspended fixtures are free to allow a 360-degree range of motion at an angle not less than 45 degrees from horizontal without contacting adjacent components. Alternatively, if rigidly supported and/or braced, they are free to move with the structure to which they are attached without damaging adjoining components. Additionally, the connection to the structure is capable of accommodating the movement without failure. (Tier 2: Sec. 13.7.9; Commentary: Sec. A.7.3.3)			X		
LF-3 Lens Covers. HR-not required; LS-not required; PR-H.	Lens covers on light fixtures are attached with safety devices. (Tier 2: Sec. 13.7.9; Commentary: Sec. A.7.3.4)			X		

Cladding and Glazing

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
CG-1 Cladding Anchors. HR-MH; LS-MH; PR-MH.	Cladding components weighing more than 10 lb/ft2 (0.48 kN/m2) are mechanically anchored to the structure at a spacing equal to or less than the following: for Life Safety in Moderate Seismicity, 6 ft (1.8 m); for Life Safety in High Seismicity and for Position Retention in any seismicity, 4 ft (1.2 m) (Tier 2: Sec. 13.6.1; Commentary: Sec. A.7.4.1)			X		
CG-2 Cladding Isolation. HR-not required; LS-MH; PR-MH.	For steel or concrete moment-frame buildings, panel connections are detailed to accommodate a story drift ratio by the use of rods attached to framing with oversize holes or slotted holes of at least the following: for Life Safety in Moderate Seismicity, 0.01; for Life Safety in High Seismicity and for Position Retention in any seismicity, 0.02, and the rods have a length-to-diameter ratio of 4.0 or less. (Tier 2: Sec. 13.6.1; Commentary: Sec. A.7.4.3)			X		
CG-3 Multi-Story Panels. HR-MH; LS-MH; PR-MH.	For multi-story panels attached at more than one floor level, panel connections are detailed to accommodate a story drift ratio by the use of rods attached to framing with oversize holes or slotted holes of at least the following: for Life Safety in Moderate Seismicity, 0.01; for Life Safety in High Seismicity and for Position Retention in any seismicity, 0.02, and the rods have a length-to-diameter ratio of 4.0 or less. (Tier 2: Sec. 13.6.1; Commentary: Sec. A.7.4.4)			X		

C-4 Threaded Rods. HR-not required; LS-MH; PR-MH.	Threaded rods for panel connections detailed to accommodate drift by bending of the rod have a length-to-diameter ratio greater than 0.06 times the story height in inches for Life Safety in Moderate Seismicity and 0.12 times the story height in inches for Life Safety in High Seismicity and Position Retention in any seismicity. (Tier 2: Sec. 13.6.1; Commentary: Sec. A.7.4.9)			X		
CG-5 Panel Connections. HR-MH; LS-MH; PR-MH.	Cladding panels are anchored out of plane with a minimum number of connections for each wall panel, as follows: for Life Safety in Moderate Seismicity, 2 connections; for Life Safety in High Seismicity and for Position Retention in any seismicity, 4 connections. (Tier 2: Sec. 13.6.1.4; Commentary: Sec. A.7.4.5)			X		
CG-6 Bearing Connections. HR-MH; LS-MH; PR-MH.	Where bearing connections are used, there is a minimum of two bearing connections for each cladding panel. (Tier 2: Sec. 13.6.1.4; Commentary: Sec. A.7.4.6)			X		
CG-7 Inserts. HR-MH; LS-MH; PR-MH.	Where concrete cladding components use inserts, the inserts have positive anchorage or are anchored to reinforcing steel. (Tier 2: Sec. 13.6.1.4; Commentary: Sec. A.7.4.7)			X		
CG-8 Overhead Glazing. HR-not required; LS-MH; PR-MH.	Glazing panes of any size in curtain walls and individual interior or exterior panes more than 16 ft2 (1.5 m2) in area are laminated annealed or laminated heat-strengthened glass and are detailed to remain in the frame when cracked. (Tier 2: Sec. 13.6.1.5; Commentary: Sec. A.7.4.8)			X		

Masonry Veneer

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
M-1 Ties. HR-not required; LS-LMH; PR-LMH.	Masonry veneer is connected to the backup with corrosion-resistant ties. There is a minimum of one tie for every 2-2/3 ft2 (0.25 m2), and the ties have spacing no greater than the following: for Life Safety in Low or Moderate Seismicity, 36 in. (914 mm); for Life Safety in High Seismicity and for Position Retention in any seismicity, 24 in. (610 mm). (Tier 2: Sec. 13.6.1.2; Commentary: Sec. A.7.5.1)			X		
M-2 Shelf Angles. HR-not required; LS-LMH; PR-LMH.	Masonry veneer is supported by shelf angles or other elements at each floor above the ground floor. (Tier 2: Sec. 13.6.1.2; Commentary: Sec. A.7.5.2)			X		
M-3 Weakened Planes. HR-not required; LS-LMH; PR-LMH.	Masonry veneer is anchored to the backup adjacent to weakened planes, such as at the locations of flashing. (Tier 2: Sec. 13.6.1.2; Commentary: Sec. A.7.5.3)			X		
M-4 Unreinforced Masonry Backup. HR-LMH; LS-LMH; PR-LMH.	There is no unreinforced masonry backup. (Tier 2: Sec. 13.6.1.1, 13.6.1.2; Commentary: Sec. A.7.7.2)			X		

M-5 Stud Tracks. HR-not required; LS-MH; PR-MH.	For veneer with coldformed steel stud backup, stud tracks are fastened to the structure at a spacing equal to or less than 24 in. (610 mm) on center. (Tier 2: Sec. 13.6.1.1, 13.6.1.2; Commentary: Sec. A.7.6.)			X		
M-6 Anchorage. HR-not required; LS-MH; PR-MH.	For veneer with concrete block or masonry backup, the backup is positively anchored to the structure at a horizontal spacing equal to or less than 4 ft along the floors and roof. (Tier 2: Sec. 13.6.1.1, 13.6.1.2; Commentary: Sec. A.7.7.1)			X		
M-7 Weep Holes. HR-not required; LS-not required; PR-MH.	In veneer anchored to stud walls, the veneer has functioning weep holes and base flashing. (Tier 2: Sec. 13.6.1.2; Commentary: Sec. A.7.5.6)			X		
M-8 Openings. HR-not required; LS-not required; PR-MH.	For veneer with cold-formed-steel stud backup, steel studs frame window and door openings. (Tier 2: Sec. 13.6.1.1, 13.6.1.2; Commentary: Sec. A.7.6.2)			X		

Parapets, Cornices, Ornamentation, and Appendages

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
PCOA-1 URM Parapets or Cornices. HR-LMH; LS-LMH; PR-LMH.	Laterally unsupported unreinforced masonry parapets or cornices have height-tothickness ratios no greater than the following: for Life Safety in Low or Moderate Seismicity, 2.5; for Life Safety in High Seismicity and for Position Retention in any seismicity, 1.5. (Tier 2: Sec. 13.6.5; Commentary: Sec. A.7.8.1)	X				
PCOA-2 Canopies. HR-not required; LS-LMH; PR-LMH.	Canopies at building exits are anchored to the structure at a spacing no greater than the following: for Life Safety in Low or Moderate Seismicity, 10 ft (3.0 m); for Life Safety in High Seismicity and for Position Retention in any seismicity, 6 ft (1.8 m). (Tier 2: Sec. 13.6.6; Commentary: Sec. A.7.8.2)			X		
PCOA-3 Concrete Parapets. HR-H; LS-MH; PR-LMH.	Concrete parapets with height-to-thickness ratios greater than 2.5 have vertical reinforcement. (Tier 2: Sec. 13.6.5; Commentary: Sec. A.7.8.3)			X		
PCOA-4 Appendages. HR-MH; LS-MH; PR-LMH.	Cornices, parapets, signs, and other ornamentation or appendages that extend above the highest point of anchorage to the structure or cantilever from components are reinforced and anchored to the structural system at a spacing equal to or less than 6 ft (1.8 m). This evaluation statement item does not apply to parapets or cornices covered by other evaluation statements. (Tier 2: Sec. 13.6.6; Commentary: Sec. A.7.8.4)			X		

Masonry Chimneys

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
MC-1 URM Chimneys. HR-LMH; LS-LMH; PR-LMH.	Unreinforced masonry chimneys extend above the roof surface no more than the following: for Life Safety in Low or Moderate Seismicity, 3 times the least dimension of the chimney; for Life Safety in High Seismicity and for Position Retention in any seismicity, 2 times the least dimension of the chimney. (Tier 2: Sec. 13.6.7; Commentary: Sec. A.7.9.1)			X		
MC-2 Anchorage. HR-LMH; LS-LMH; PR-LMH.	Masonry chimneys are anchored at each floor level, at the topmost ceiling level, and at the roof. (Tier 2: Sec. 13.6.7; Commentary: Sec. A.7.9.2)			X		

Stairs

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
S-1 Stair Enclosures. HR-not required; LS-LMH; PR-LMH.	Hollow-clay tile or unreinforced masonry walls around stair enclosures are restrained out of plane and have height-to-thickness ratios not greater than the following: for Life Safety in Low or Moderate Seismicity, 15-to-1; for Life Safety in High Seismicity and for Position Retention in any seismicity, 12-to-1. (Tier 2: Sec. 13.6.2, 13.6.8; Commentary: Sec. A.7.10.1)			X		
S-2 Stair Details. HR-not required; LS-LMH; PR-LMH.	The connection between the stairs and the structure does not rely on post-installed anchors in concrete or masonry, and the stair details are capable of accommodating the drift calculated using the Quick Check procedure of Section 4.4.3.1 for moment-frame structures or 0.5 in. for all other structures without including any lateral stiffness contribution from the stairs. (Tier 2: Sec. 13.6.8; Commentary: Sec. A.7.10.2)			X		

Contents and Furnishings

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
CF-1 Industrial Storage Racks. HR-LMH; LS-MH; PR-MH.	Industrial storage racks or pallet racks more than 12 ft high meet the requirements of ANSI/RMI MH 16.1 as modified by ASCE 7, Chapter 15. (Tier 2: Sec. 13.8.1; Commentary: Sec. A.7.11.1)			X		
CF-2 Tall Narrow Contents. HR-not required; LS-H; PR-MH.	Contents more than 6 ft (1.8 m) high with a height-to-depth or height-to-width ratio greater than 3-to-1 are anchored to the structure or to each other. (Tier 2: Sec. 13.8.2; Commentary: Sec. A.7.11.2)			X		

CF-3 Fall-Prone Contents. HR-not required; LS-H; PR-H.	Equipment, stored items, or other contents weighing more than 20 lb (9.1 kg) whose center of mass is more than 4 ft (1.2 m) above the adjacent floor level are braced or otherwise restrained. (Tier 2: Sec. 13.8.2; Commentary: Sec. A.7.11.3)		X			Cabinets more than 6'-0" tall behind east wall in the apparatus bay are not anchored to the structure. The tall shelves are in front of the exit door and is in the path of egress.
CF-4 Access Floors. HR-not required; LS-not required; PR-MH.	Access floors more than 9 in. (229 mm) high are braced. (Tier 2: Sec. 13.6.10; Commentary: Sec. A.7.11.4)			X		
CF-5 Equipment on Access Floors. HR-not required; LS-not required; PR-MH.	Equipment and other contents supported by access floor systems are anchored or braced to the structure independent of the access floor. (Tier 2: Sec. 13.7.7 13.6.10; Commentary: Sec. A.7.11.5)			X		
CF-6 Suspended Contents. HR-not required; LS-not required; PR-H.	Items suspended without lateral bracing are free to swing from or move with the structure from which they are suspended without damaging themselves or adjoining components. (Tier 2: Sec. 13.8.2; Commentary: Sec. A.7.11.6)		X			Cabinets more than 6'-0" tall behind east wall in the apparatus bay are not anchored to the structure. The tall shelves are in front of the exit door and is in the path of egress.

Mechanical and Electrical Equipment

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
ME-1 Fall-Prone Equipment. HR-not required; LS-H; PR-H.	Equipment weighing more than 20 lb (9.1 kg) whose center of mass is more than 4 ft (1.2 m) above the adjacent floor level, and which is not in-line equipment, is braced. (Tier 2: Sec. 13.7.1 13.7.7; Commentary: Sec. A.7.12.4)		X			Mechanical units in the apparatus bay roof structure need to be braced to the structure. Middle hose pipe track is not braced back to the structure and shall be braced adequately.
ME-2 In-Line Equipment. HR-not required; LS-H; PR-H.	Equipment installed in line with a duct or piping system, with an operating weight more than 75 lb (34.0 kg), is supported and laterally braced independent of the duct or piping system. (Tier 2: Sec. 13.7.1; Commentary: Sec. A.7.12.5)		X			Mechanical units in the apparatus bay roof structure need to be braced to the structure. Middle hose pipe track is not braced back to the structure and shall be braced adequately.
ME-3 Tall Narrow Equipment. HR-not required; LS-H; PR-MH.	Equipment more than 6 ft (1.8 m) high with a height-to-depth or height-to-width ratio greater than 3-to-1 is anchored to the floor slab or adjacent structural walls. (Tier 2: Sec. 13.7.1 13.7.7; Commentary: Sec. A.7.12.6)			X		

ME-4 Mechanical Doors. HR-not required; LS-not required; PR-MH.	Mechanically operated doors are detailed to operate at a story drift ratio of 0.01. (Tier 2: Sec. 13.6.9; Commentary: Sec. A.7.12.7)			X		
ME-5 Suspended Equipment. HR-not required; LS-not required; PR-H.	Equipment suspended without lateral bracing is free to swing from or move with the structure from which it is suspended without damaging itself or adjoining components. (Tier 2: Sec. 13.7.1, 13.7.7; Commentary: Sec. A.7.12.8)			X		
ME-6 Vibration Isolators. HR-not required; LS-not required; PR-H.	Equipment mounted on vibration isolators is equipped with horizontal restraints or snubbers and with vertical restraints to resist overturning. (Tier 2: Sec. 13.7.1; Commentary: Sec. A.7.12.9)			X		
ME-7 Heavy Equipment. HR-not required; LS-not required; PR-H.	Floor supported or platform-supported equipment weighing more than 400 lb (181.4 kg) is anchored to the structure. (Tier 2: Sec. 13.7.1, 13.7.7; Commentary: Sec. A.7.12.10)			X		
ME-8 Electrical Equipment. HR-not required; LS-not required; PR-H.	Electrical equipment is laterally braced to the structure. (Tier 2: Sec. 13.7.7; Commentary: Sec. A.7.12.11)			X		
ME-9 Conduit Couplings. HR-not required; LS-not required; PR-H.	Conduit greater than 2.5 in. (64 mm) trade size that is attached to panels, cabinets, or other equipment and is subject to relative seismic displacement has flexible couplings or connections. (Tier 2: Sec. 13.7.8; Commentary: Sec. A.7.12.12)			X		

Piping

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
PP-1 Flexible Couplings. HR-not required; LS-not required; PR-H.	Fluid and gas piping has flexible couplings. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.2)			X		
PP-2 Fluid and Gas Piping. HR-not required; LS-not required; PR-H.	Fluid and gas piping is anchored and braced to the structure to limit spills or leaks. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.4)			X		
PP-3 C-Clamps. HR-not required; LS-not required; PR-H.	One-sided C-clamps that support piping larger than 2.5 in. (64 mm) in diameter are restrained. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.5)			X		
PP-4 Piping Crossing Seismic Joints. HR-not required; LS-not required; PR-H.	Piping that crosses seismic joints or isolation planes or is connected to independent structures has couplings or other details to accommodate the relative seismic displacements. (Tier 2: Sec. 13.7.3, 13.7.5; Commentary: Sec. A.7.13.6)			X		

Ducts

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
D-1 Duct Bracing. HR-not required; LS-not required; PR-H.	Rectangular ductwork larger than 6 ft2 (0.56 m2) in cross-sectional area and round ducts larger than 28 in. (711 mm) in diameter are braced. The maximum spacing of transverse bracing does not exceed 30 ft (9.2 m). The maximum spacing of longitudinal bracing does not exceed 60 ft (18.3 m). (Tier 2: Sec. 13.7.6; Commentary: Sec. A.7.14.2)			X		
D-2 Duct Support. HR-not required; LS-not required; PR-H.	Ducts are not supported by piping or electrical conduit. (Tier 2: Sec. 13.7.6; Commentary: Sec. A.7.14.3)			X		
D-3 Ducts Crossing Seismic Joints. HR-not required; LS-not required; PR-H.	Ducts that cross seismic joints or isolation planes or are connected to independent structures have couplings or other details to accommodate the relative seismic displacements. (Tier 2: Sec. 13.7.6; Commentary: Sec. A.7.14.4)			X		

Elevators

EVALUATION ITEM	EVALUATION STATEMENT	C	NC	N/A	U	COMMENT
EL-1 Retainer Guards. HR-not required; LS-H; PR-H.	Sheaves and drums have cable retainer guards. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.1)			X		
EL-2 Retainer Plate. HR-not required; LS-H; PR-H.	A retainer plate is present at the top and bottom of both car and counterweight. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.2)			X		
EL-3 Elevator Equipment. HR-not required; LS-not required; PR-H.	Equipment, piping, and other components that are part of the elevator system are anchored. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.3)			X		
EL-4 Seismic Switch. HR-not required; LS-not required; PR-H.	Elevators capable of operating at speeds of 150 ft/min or faster are equipped with seismic switches that meet the requirements of ASME A17.1 or have trigger levels set to 20% of the acceleration of gravity at the base of the structure and 50% of the acceleration of gravity in other locations. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.4)			X		
EL-5 Shaft Walls. HR-not required; LS-not required; PR-H.	Elevator shaft walls are anchored and reinforced to prevent toppling into the shaft during strong shaking. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.5)			X		
EL-6 Counterweight Rails. HR-not required; LS-not required; PR-H.	All counterweight rails and divider beams are sized in accordance with ASME A17.1. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.6)			X		
EL-7 Brackets. HR-not required; LS-not required; PR-H.	The brackets that tie the car rails and the counterweight rail to the structure are sized in accordance with ASME A17.1. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.7)			X		

EL-8 Spreader Bracket. HR-not required; LS-not required; PR-H.	Spreader brackets are not used to resist seismic forces. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.8)			X		
EL-9 Go-Slow Elevators. HR-not required; LS-not required; PR-H.	The building has a go-slow elevator system. (Tier 2: Sec. 13.7.11; Commentary: Sec. A.7.16.9)			X		

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Appendix B: Concept-Level Seismic Upgrade Figures

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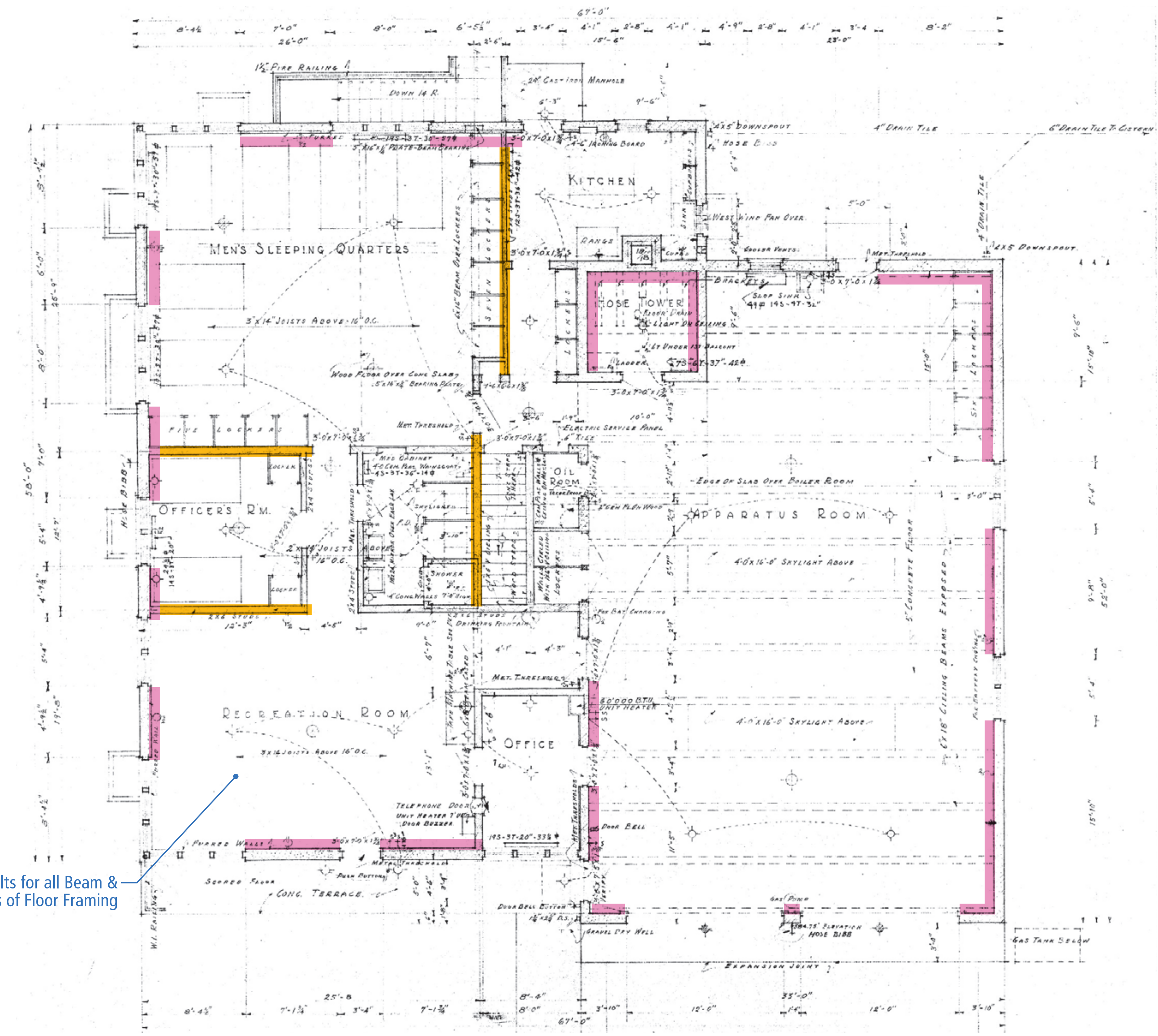


FIRST FLOOR PLAN OF MAIN BUILDING

LEGEND

- Pink: Shotcrete Interior Walls, Sheathe Existing Wood Stud Walls with 1/2" Plywood & Nail as Shear Walls
- Orange: Plywood Shear Walls, Foundation at Basement Level May Be Required Under New Full Height Strongback Shotcrete Walls, Basement Slab on Grade May Have to Be Saw Cut

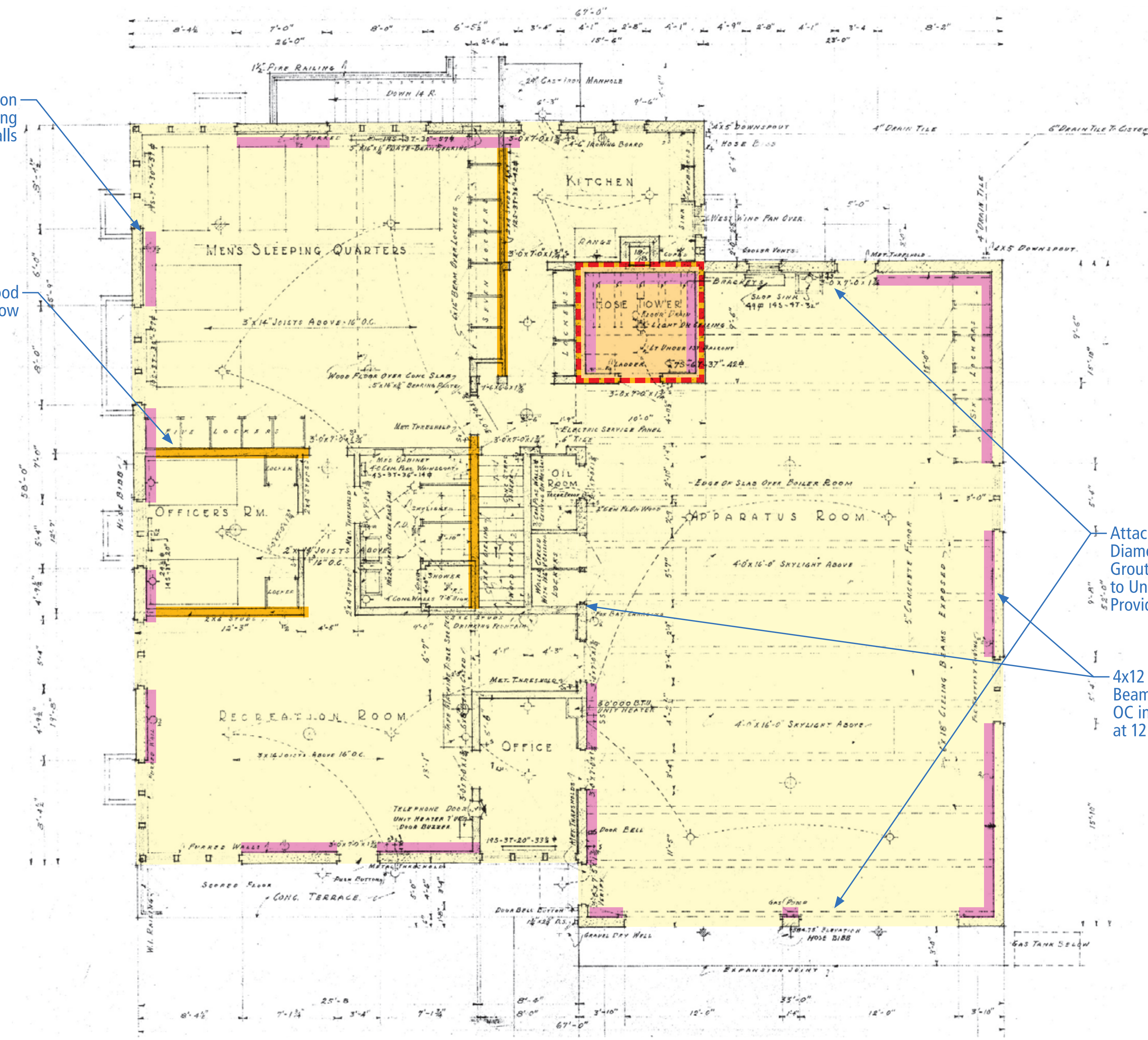
NOTES

1. Re-sheath roof with plywood overlay, add collector elements and roof wall ties.

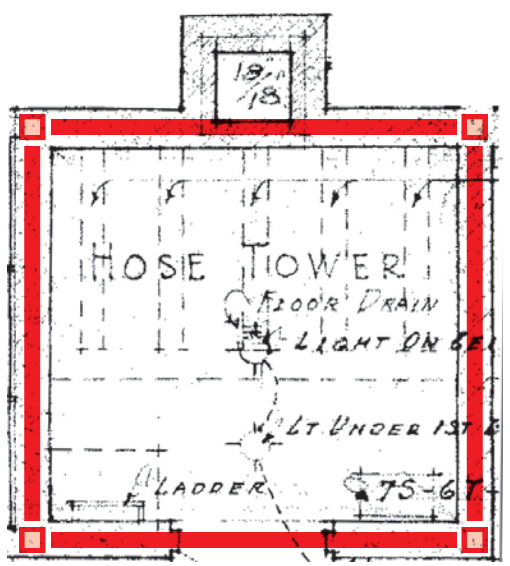
Figure 1 – Floor Plan

Out-Of-Plane Wall Anchors (Simpson LTT At 32" OC) & In-Plane Blocking Connections at All Perimeter Shear Walls

Diaphragm Connections to New Plywood Shear Walls Below



ROOF PLAN OF MAIN BUILDING



ALTERNATE HOSE TOWER PRESERVATION BRACING

LEGEND

- Shotcrete Interior Walls Below
- Plywood Shear Walls Below
- Remove Roof & Install 1/2" Plywood Sheathing Overly on Existing T&G Decking
- Demolish & Reduce Height Of Hose Tower & Chimney to the Apparatus Bay Roof (This Will Require Approval By the State Historic Preservation Office)
- HSS Steel Band Each Side at 6' OC Vertically Above Apparatus Bay Roof
- HSS Steel Column Each Corner

Attach Ledger Beam With 3/4" Diameter Bolts At 24" OC in Epoxy Grouted Holes & A35 Clips At 12" OC to Underside of T&G Decking, Also Provide LTT Wall Anchors at 32" OC

4x12 Blocking Between Existing 6x Beams With 3/4" Diameter Bolts at 24" OC in Epoxy Grouted Holes & A35 Clips at 12" OC to Underside of T&G Decking

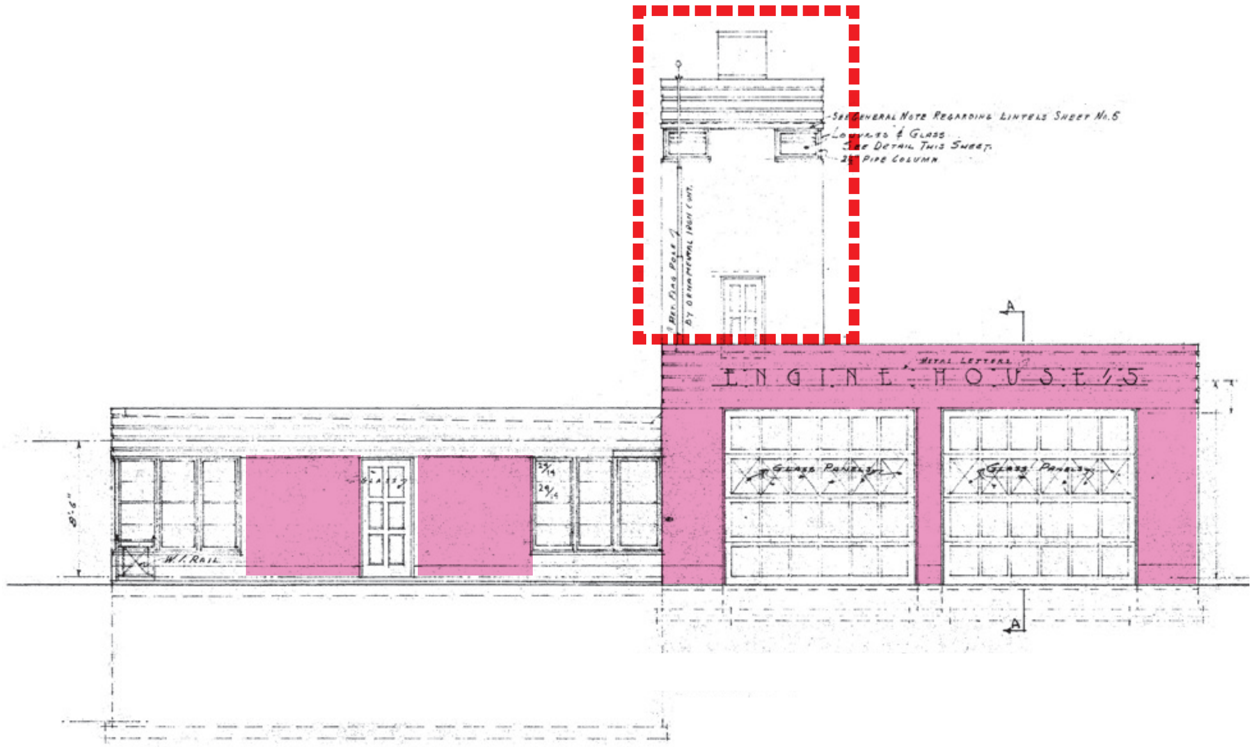
NOTES

1. Re-sheath roof with plywood overlay, add collector elements and roof wall ties.

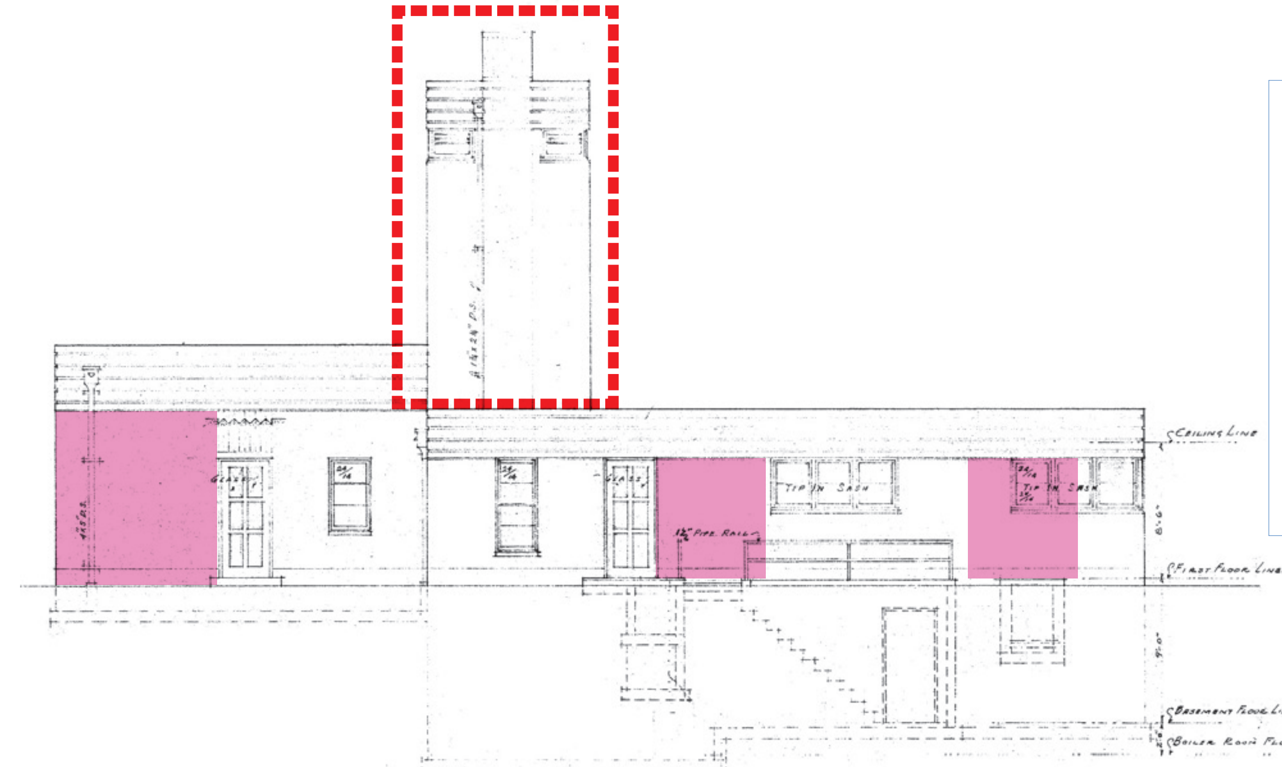
Figure 2 – Roof Plan

LEGEND

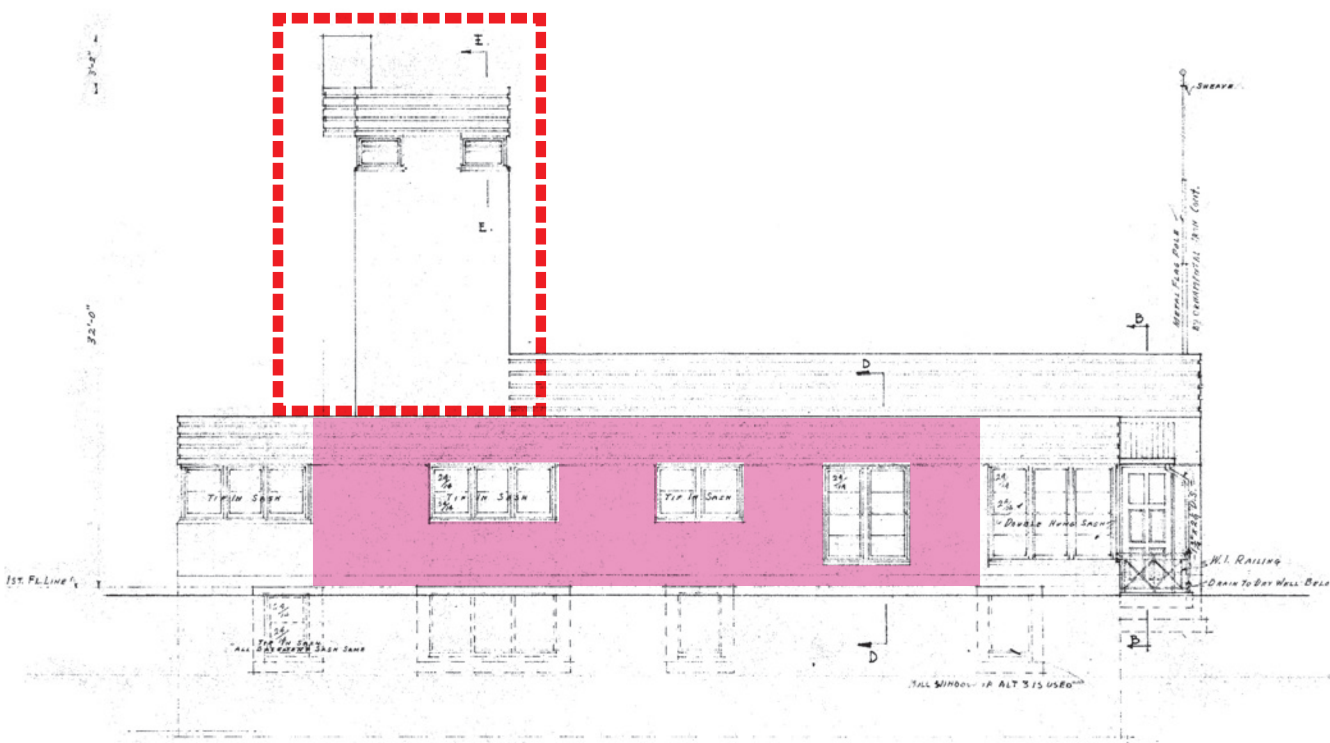
- Shotcrete Interior Walls
- Demolish Hose Tower (Requires Approval From SHPO)
- HSS Column Each Corner
- HSS Band at 6' OC
- HSS Brace Each Side



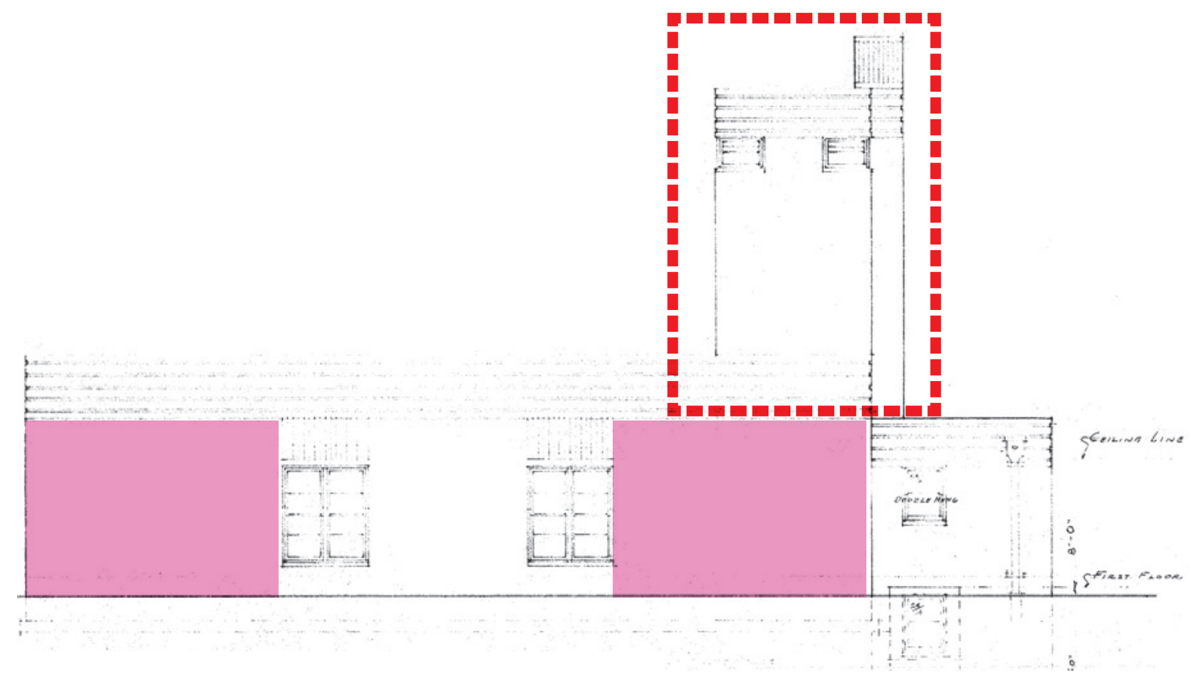
ELEVATION ON 12TH AVENUE



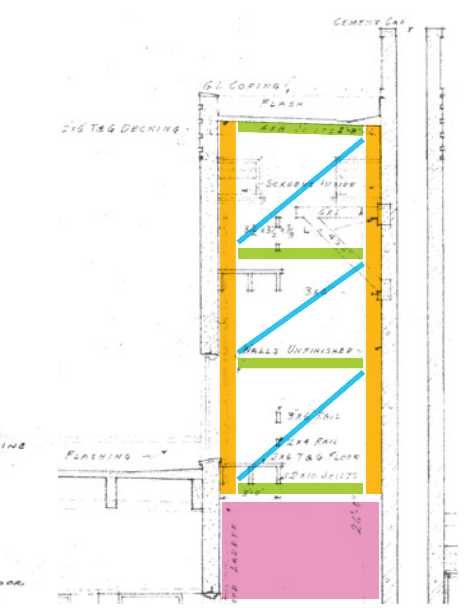
NORTH ELEVATION



ELEVATION ON CUSHMAN STREET



EAST ELEVATION



ALTERNATIVE HOSE TOWER PRESERVATION BRACING

Figure 3 – Elevations

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Appendix C: Opinion of Probable Construction Costs

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PRODIMS
520 Kirkland Way, Suite 301
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Name:	**Wa State School Seismic Safety Assessment Phase 2**
Second Name:	**Tacoma Fire Station #4**
Location:	**Tacoma, WA**
Design Phase:	**ROM Cost Estimates**
Date of Estimate:	**April 14, 2021**
Date of Revision:	
Month of Cost Basis:	**1Q, 2021**

Tacoma Fire Station #4

Master Estimate Summary

Project Name	Construction Cost Type	Estimated Construction Cost
Tacoma Fire Station #4	Structural Costs	$780,568
Tacoma Fire Station #4	Non-Structural Costs	$429,312
TOTAL ESTIMATED CONSTRUCTION COST →		**$1,209,880**

Soft Costs	Soft Costs % Construction Cost	Estimated Soft Costs
Project Soft Cost Allowance	40.0%	**$483,952**
		Sum of the Above
TOTAL ESTIMATED PROJECT COST →		**$1,693,832**

Estimate Assumptions:

The ROM Construction Cost estimates are based on the Concept Design Report for the Project.
Construction Escalation is not included. Costs are current as of the month of Cost Basis noted above right.

Estimate Qualifications:

The ROM estimates are not be relied on solely for proforma development and financial decisions.
Further design work is required to determine construction budgets.
All Buildings Estimated to the 5' foot line for Utilities, All Sitework is estimated to go with any combination of the buildings and alternatives.
The ROM estimates do not include any Hazardous Material Abatement/Disposal.
For Construction Cost Markups they are additive, not cumulative. Percentages are added to the previous subtotal rather than the direct cost subtotal.
Owner Soft Costs Allowance are: A/E design fees, QA/QC, Project Administration, Owners Project Contingency, Average Washington State Sale Tax and
Estimated labor is based on an 8 hour per day shift 5 days a week. Accelerated schedule work of overtime has not been included.
Estimated labor is based on working on unoccupied facility without phased construction.
Estimate is based on a competitive public bid with at least 3 bona fide submitted and unrescinded general contractor bids.
Estimate is based on a competitive public bid with a minimum 6 week bidding schedule and no significant addendums within 2 weeks of bid opening.
State of Washington General Contractor/ Construction Manager (GC/CM) contracts typically raises construction costs. It is Not Included in this estimate.
Estimated construction cost is for the entire project. This estimate is not intended to be used for other projects.
Please consult the cost estimator for any modifications to this estimate. Unilaterally adding and deleting markups, scope of work, schedule, specifications, plans and bid forms could incorrectly restate the project construction cost.
Construction reserve contingency for change orders is not included in the estimate.
Sole source supply of materials and/ or installers typically results in a 40% to 100% premium on costs over open specifications.

PRODIMS

Structural Costs

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Kirkland, WA 98033
Phone: 425-828-0500 Fax: 425-828-0700
www.prodims.com

Name:	Wa State School Seismic Safety Assessment Phase 2	Areas	sqft
Second Name:	Tacoma Fire Station #4	Building Area	6,100
Location:	Tacoma, WA		
Design Phase:	ROM Cost Estimates		
Date of Estimate:	April 14, 2021		
Date of Revision:			
Month of Cost Basis:	1Q, 2021	Total Areas	6,100

Tacoma Fire Station #4

Construction Cost Estimate

Subtotal Direct Cost From the Estimate Detail Below $ 530,307

	Percentage of Previous Subtotal	Amount	Running Subtotal
Scope Contingency	10.0%	$ 53,031	$ 583,338
General Conditions	10.0%	$ 53,031	$ 636,369
Home Office Overhead	5.0%	$ 26,515	$ 662,884
Profit	6.0%	$ 31,818	$ 694,703
Escalation Included to 4Q, 2022	12.4%	$ 85,865	$ 780,568
Washington State Sales Tax - Included in Soft Costs			

Total Markups Applied to the Direct Cost 47.19%
Markups are multiplied on each subtotal- They are not multiplied from the direct cost

		$/sqft
TOTAL ESTIMATED CONSTRUCTION COST--→	**$ 780,568**	**$ 127.96**
-20% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --→	**$ 624,454**	**$ 102.37**
+50% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --→	**$ 1,170,852**	**$ 191.94**

Please see the Master Summary for Assumptions and Qualifications for ROM Cost Estimates

Direct Cost of Construction

WBS	Description	Quantity	U of M	Labor	Labor Total	Material	Material Total	Equipment	Equipment Total	Total $/U of M	Direct Cost
1 - Seismic Retrofit											
Foundations											
	Wall Foundation System Improvements for Shotcrete Shear Walls, Concrete, Formwork, Reinforcing and Detailing. Inside Existing Building.	6,100	fpa	$ 6.84	$ 41,724.00	$ 5.16	$ 31,476.00	$ 0.72	$ 4,392.00	$ 12.72	$ 77,592.00
Substructure											
	Demo/Reinstall Slab on Grade System for New Footings Installation - Allowance	1,525	sqft	$ 9.90	$ 15,097.50	$ 8.10	$ 12,352.50	$ 1.08	$ 1,647.00	$ 19.08	$ 29,097.00
Superstructure											
Upper Floor Systems											
	New Shearwall with 1/2" Plywood Sheathing At Existing Wood Stud Walls - Connect Above - Remove GWB and Reinstall	10	sqft	$ 1.19	$ 11.86	$ 0.58	$ 5.84	$ 0.11	$ 1.06	$ 1.88	$ 18.76
	Steel Plate and Bolts For Beam and Post Connections at Floor Framing	6,100	sqft	$ 1.62	$ 9,882.00	$ 1.38	$ 8,418.00	$ 0.18	$ 1,098.00	$ 3.18	$ 19,398.00
Roof Systems											
	Shotcrete 6" Thick Shear Wall with Rebar Including Drill and Epoxy in Rebar	57.9	cuyd	$ 543.75	$ 31,477.08	$ 181.25	$ 10,492.36	$ 43.50	$ 2,518.17	$ 768.50	$ 44,487.61
	Add 1/2" Plywood Sheathing at Existing Wood Stud Wall	860	sqft	$ 1.89	$ 1,625.40	$ 1.61	$ 1,384.60	$ 0.21	$ 180.60	$ 3.71	$ 3,190.60
	New Shearwall Connection to Roof Diaphragm Connection	57	lnft	$ 18.20	$ 1,037.40	$ 9.80	$ 558.60	$ 1.68	$ 95.76	$ 29.68	$ 1,691.76
	Structural Steel Bands, Columns and Diagonal Braces at Hose Tower Walls	9.6	ton	$ 6,825.00	$ 65,301.60	$ 3,675.00	$ 35,162.40	$ 630.00	$ 6,027.84	$ 11,130.00	$ 106,491.84
	New 4x12 Blocking with 3/4" Anchor Bolts at 24" o.c. and A35 Clip at 12" o.c.	110	lnft	$ 60.26	$ 6,628.38	$ 40.17	$ 4,418.92	$ 6.03	$ 662.84	$ 106.46	$ 11,710.14
	New 4x12 Ledger with 3/4" Anchor Bolts at 24" o.c. and A35 Clip at 12" o.c.	68	lnft	$ 54.52	$ 3,707.36	$ 39.48	$ 2,684.64	$ 5.64	$ 383.52	$ 99.64	$ 6,775.52
	Add 1/2" Plywood Sheathing at Existing Roof	4,250	sqft	$ 0.94	$ 4,005.63	$ 0.51	$ 2,156.88	$ 0.09	$ 369.75	$ 1.54	$ 6,532.25
	Wall to Joist Anchorage - Allow a LTT with Nails to Joist with 5/8" Dia Epoxy Anchor Bolt with Nut and Washer	68	each	$ 210.80	$ 14,334.40	$ 99.20	$ 6,745.60	$ 18.60	$ 1,264.80	$ 328.60	$ 22,344.80

WBS	Description	Quantity	U of M	Labor	Labor Total	Material	Material Total	Equipment	Equipment Total	Total $/U of M	Direct Cost
Roofing System											
	Remove Roofing System Down to Plywood Deck	4,250	sqft	$ 4.04	$ 17,159.38	$ 0.21	$ 903.13	$ 0.26	$ 1,083.75	$ 4.51	$ 19,146.25
	New Low Slope Roofing System with R-38 Rigid Insulation, Flashing and Trim and Downspout Roof Drainage System	4,250	sqft	$ 8.78	$ 37,293.75	$ 10.73	$ 45,581.25	$ 1.17	$ 4,972.50	$ 20.67	$ 87,847.50
Interiors Systems											
Interior Wall/Door/Casework/Specialties Systems											
	Remove and Reinstall Floor Finish Systems-Allow 90% of the Floor Area	5,490	sqft	$ 3.01	$ 16,508.43	$ 1.84	$ 10,118.07	$ 0.29	$ 1,597.59	$ 5.14	$ 28,224.09
	Remove and Reinstall Wall Finish Systems-Allow 90% of the Floor Area	5,490	sqft	$ 2.79	$ 15,317.10	$ 1.71	$ 9,387.90	$ 0.27	$ 1,482.30	$ 4.77	$ 26,187.30
	Remove Ceiling and Reinstall New ACT Ceiling Systems-Allow 90% of the Floor Area	5,490	sqft	$ 4.22	$ 23,145.84	$ 2.58	$ 14,186.16	$ 0.41	$ 2,239.92	$ 7.21	$ 39,571.92
Subtotal of the Direct Cost of Construction				**Tacoma Fire Station #4**							**$ 530,307**

PRODIMS

520 Kirkland Way, Suite 301
Kirkland, WA 98033
Phone: 425-828-0500 Fax: 425-828-0700
www.prodims.com

Non-Structural Costs

Name:	Wa State School Seismic Safety Assessment Phase 2	Areas	sqft
Second Name:	Tacoma Fire Station #4	Building Area	6,100
Location:	Tacoma, WA		
Design Phase:	ROM Cost Estimates		
Date of Estimate:	April 14, 2021		
Date of Revision:			
Month of Cost Basis:	1Q, 2021	Total Areas	6,100

Tacoma Fire Station #4

Construction Cost Estimate

Subtotal Direct Cost From the Estimate Detail Below $ 291,669

	Percentage of Previous Subtotal	Amount	Running Subtotal
Scope Contingency	10.0%	$ 29,167	$ 320,836
General Conditions	10.0%	$ 29,167	$ 350,003
Home Office Overhead	5.0%	$ 14,583	$ 364,586
Profit	6.0%	$ 17,500	$ 382,086
Escalation Included to 4Q, 2022	12.4%	$ 47,226	$ 429,312
Washington State Sales Tax - Included in Soft Costs			

Total Markups Applied to the Direct Cost 47.19%
Markups are multiplied on each subtotal- They are not multiplied from the direct cost

		$/sqft
TOTAL ESTIMATED CONSTRUCTION COST--→	**$ 429,312**	**$ 70.38**
-20% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --→	**$ 343,450**	**$ 56.30**
+50% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --→	**$ 643,968**	**$ 105.57**

Please see the Master Summary for Assumptions and Qualifications for ROM Cost Estimates

Direct Cost of Construction

WBS	Description	Quantity	U of M	Labor	Labor Total	Material	Material Total	Equipment	Equipment Total	Total $/U of M	Direct Cost
	2- Non- Structural Demo/Restoration*										
	M/E/P/FP systems										
	Interior Wall/Door/Casework/Specialties Systems										
	Mechanical/Electrical/Fire Protection Systems *	6,100	sqft	$ 24.81	$ 151,337.71	$ 20.30	$ 123,821.76	$ 2.71	$ 16,509.57	$ 47.81	$ 291,669.04
	*Allows 55 percent of existing nonstructural systems M/E/P/FP require upgrades/replacement.										
	Subtotal of the Direct Cost of Construction			**Tacoma Fire Station #4**							**$ 291,669**

Appendix D: Not Used

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Appendix E: Existing Drawings

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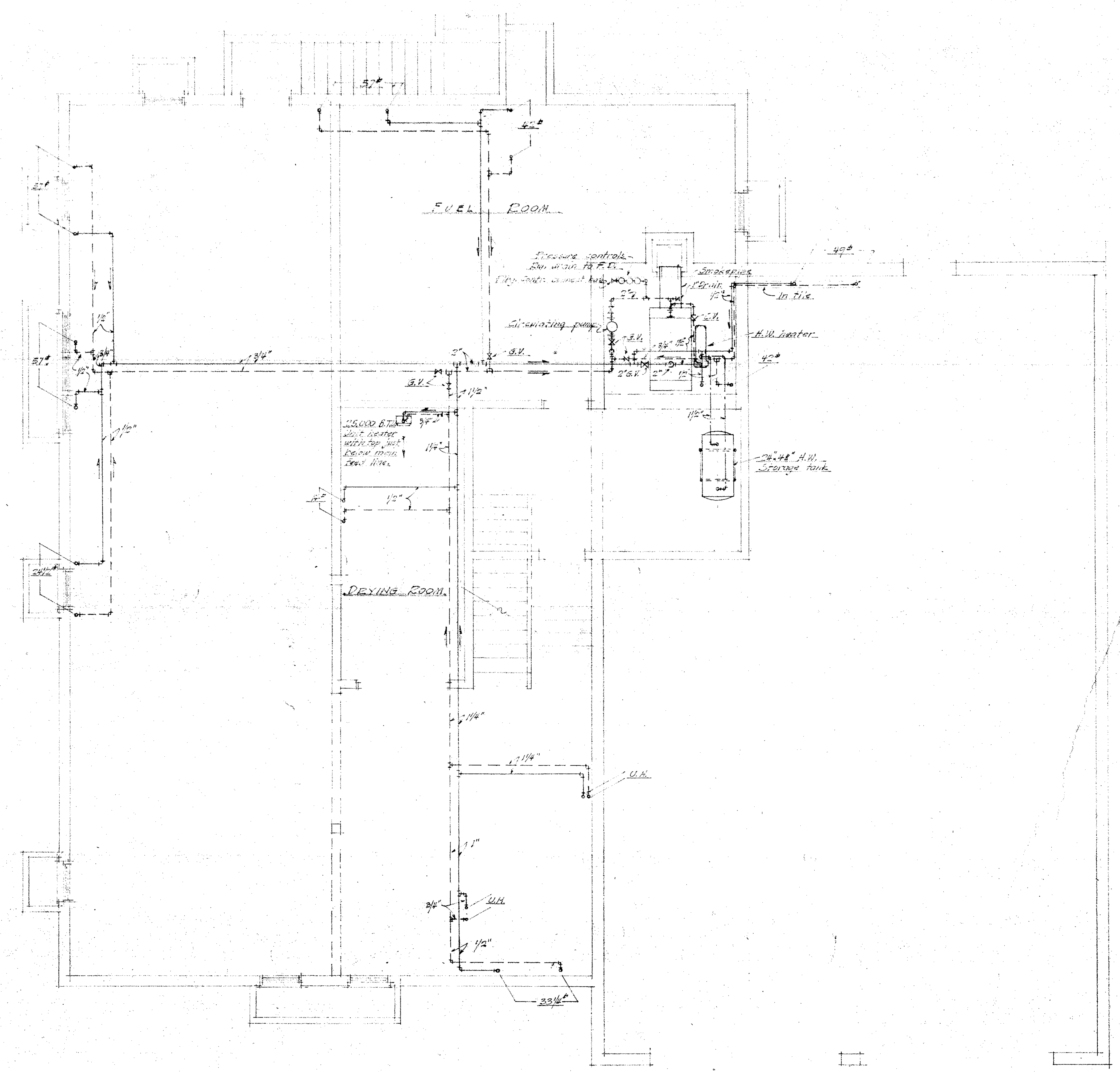


BASEMENT PLAN
SCALE 1/4"=1'0"

Station #4 1453 South 12th Street
(Originally was station #5)

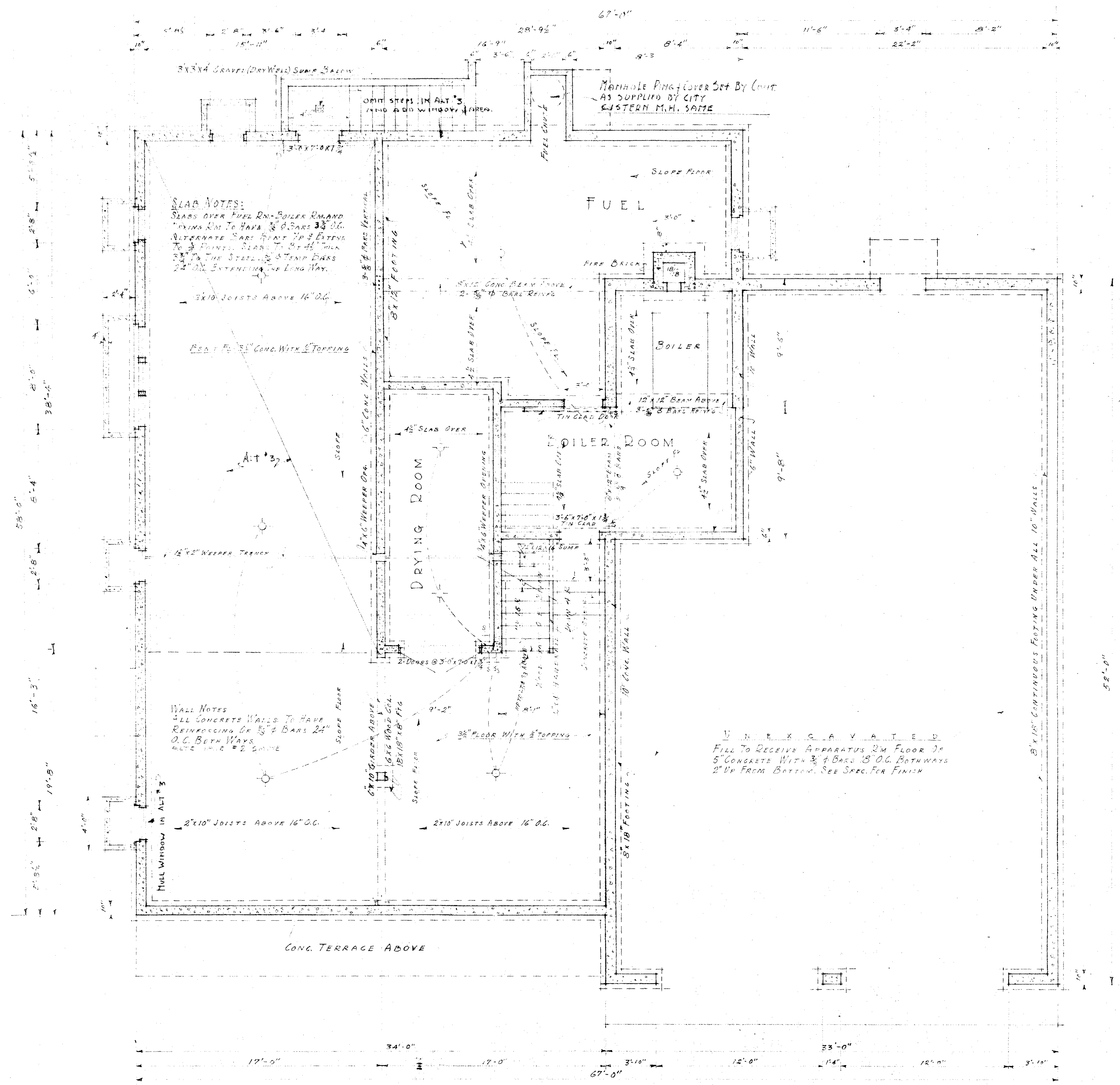
ENGINE HOUSE No 5
BEING BUILT WITH
STATE EMERGENCY FUND/GRANT No C275

FOR
PUBLIC SAFETY DEP'T
DYER DYMENT COMMISSIONER
BY
PUBLIC WORKS DEPT.
A.R. BERGERSEN COMMISSIONER
CITY OF TACOMA.

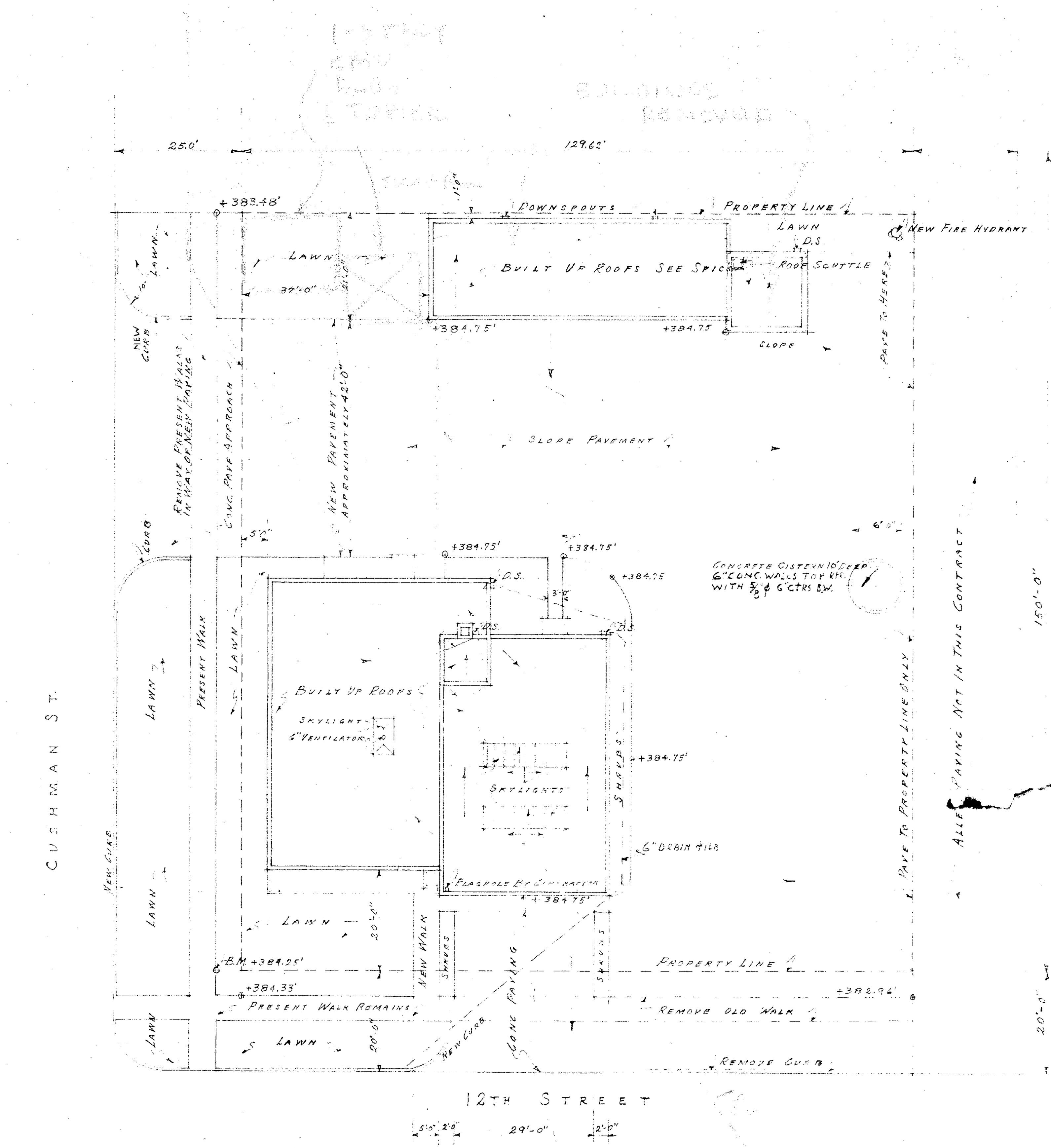
HEATING

DRN. BY D.C.G.
CHECKED BY
REVISIONS

SILAS E. NELSEN
ARCHITECT
TACOMA, W



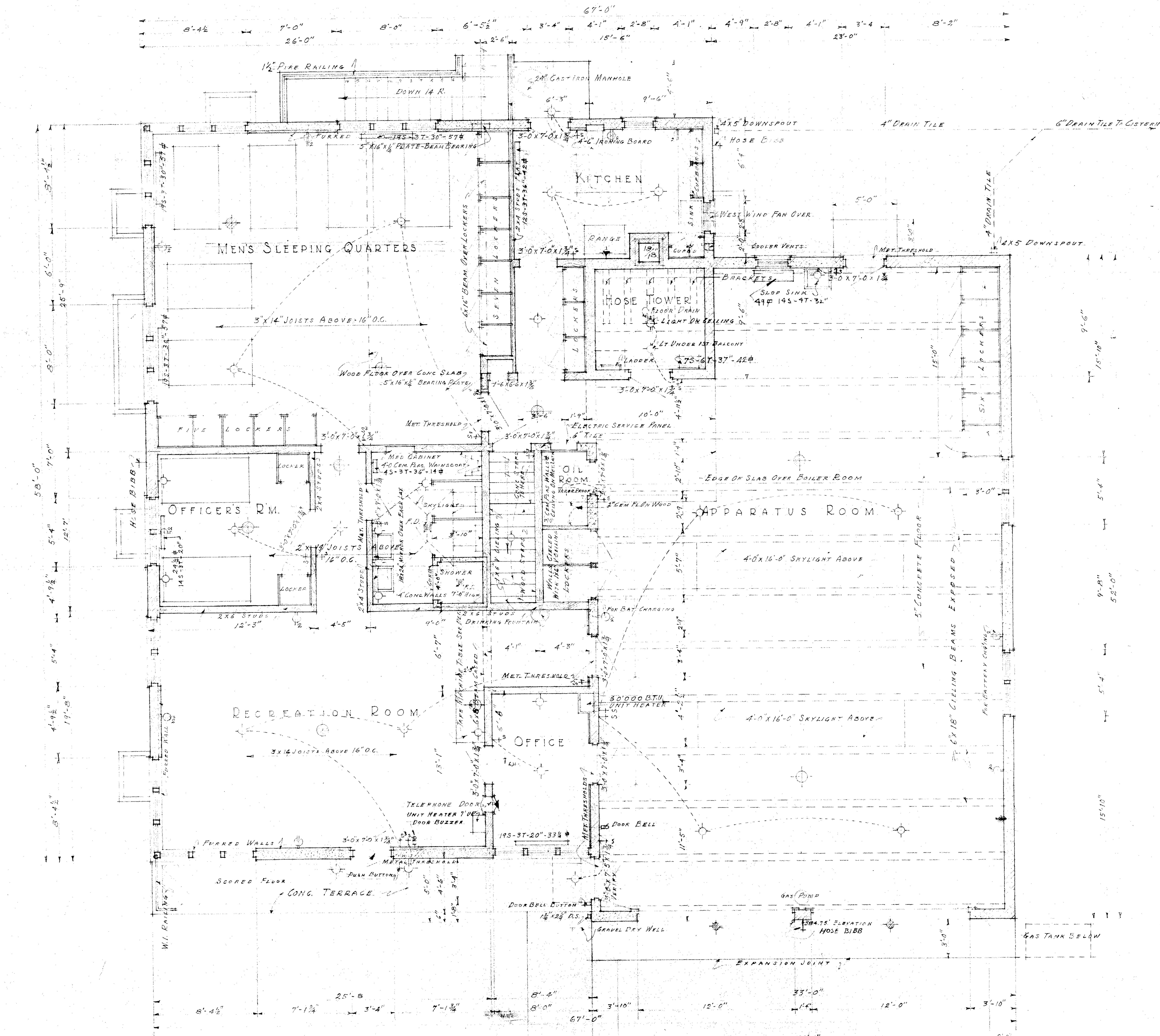
BASEMENT FLOOR PLAN
SCALE ¼" = 1'-0"



PLOT PLAN
SCALE ⅛" = 1'-0"

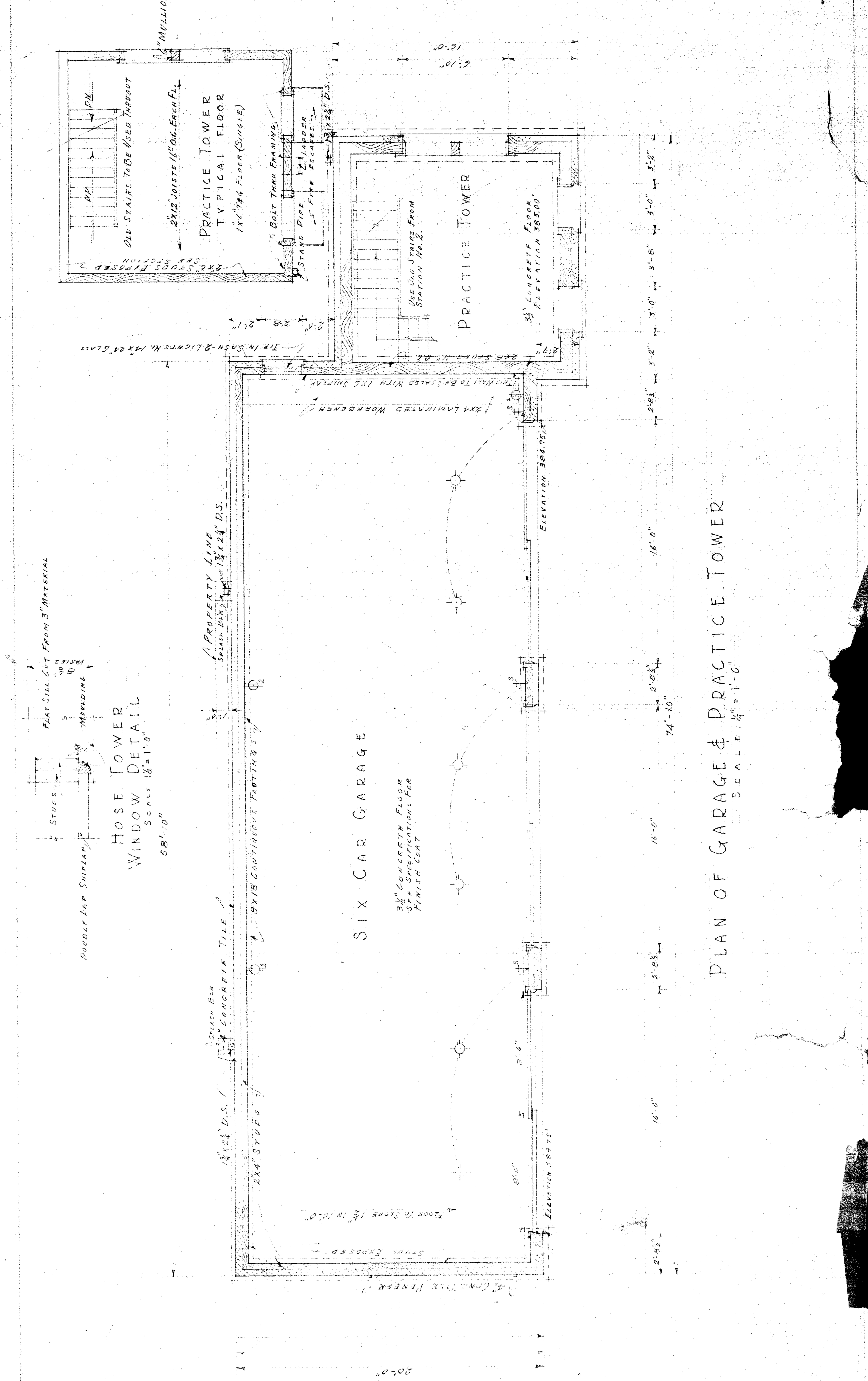
NOTE
POSITION OF GARAGE-DRILL TOWER-HYDRANT & CISTERN TENTATIVE ONLY. EXACT POSITION TO BE GIVEN BEFORE ROOF IS ON MAIN BLDG.

ENGINE HOUSE Nº 5 BEING BUILT WITH STATE EMERGENCY FUND GRANT Nº C275		
FOR PUBLIC SAFETY DEPT. DYER DYMENT COMMISSIONER. BY PUBLIC WORKS DEPT. A. R. BERGERSEN COMMISSIONER CITY of TACOMA	B'S'MT. FLOOR PLAN DRAWN BY P G B — CHECKED BY — REVISIONS SILAS E. NELSEN ARCHITECT TACOMA WASHINGTON	DATE 12-15-33 COMM NO. 405-33-19 DRAWING 1



FIRST FLOOR PLAN OF MAIN BUILDING
SCALE ¼" = 1'-0"

NOTE—
FIRE LIGHTS SHOWN THUS
OTHER LIGHTS SHOWN THUS



PLAN OF GARAGE & PRACTICE TOWER
SCALE ⅛" = 1'-0"

ENGINE HOUSE No 5
BEING BUILT WITH
STATE EMERGENCY FUND GRANT No C275

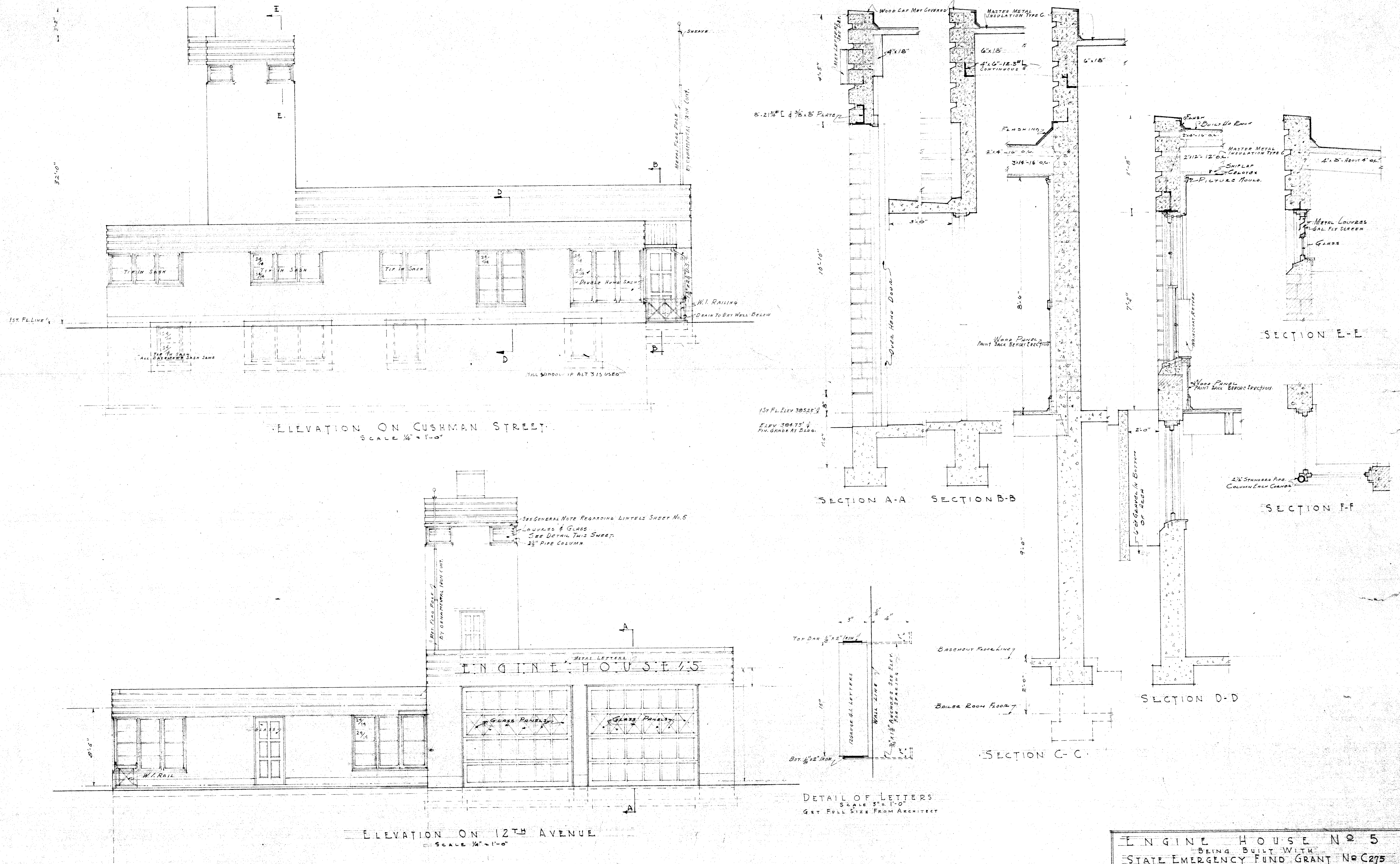
FOR
PUBLIC SAFETY DEPT.
DYE R. DYMENT COMMISSIONER
BY
PUBLIC WORKS DEPT.
A. R. BERGERSEN COMMISSIONER
CITY of TACOMA

FIRST FLOOR PLANS

DRAWN BY
CHECKED BY
REVISIONS

SILAS E. NELSEN
ARCHITECT
TACOMA WASHINGTON

DATE
COMM. No
DRAWING
2



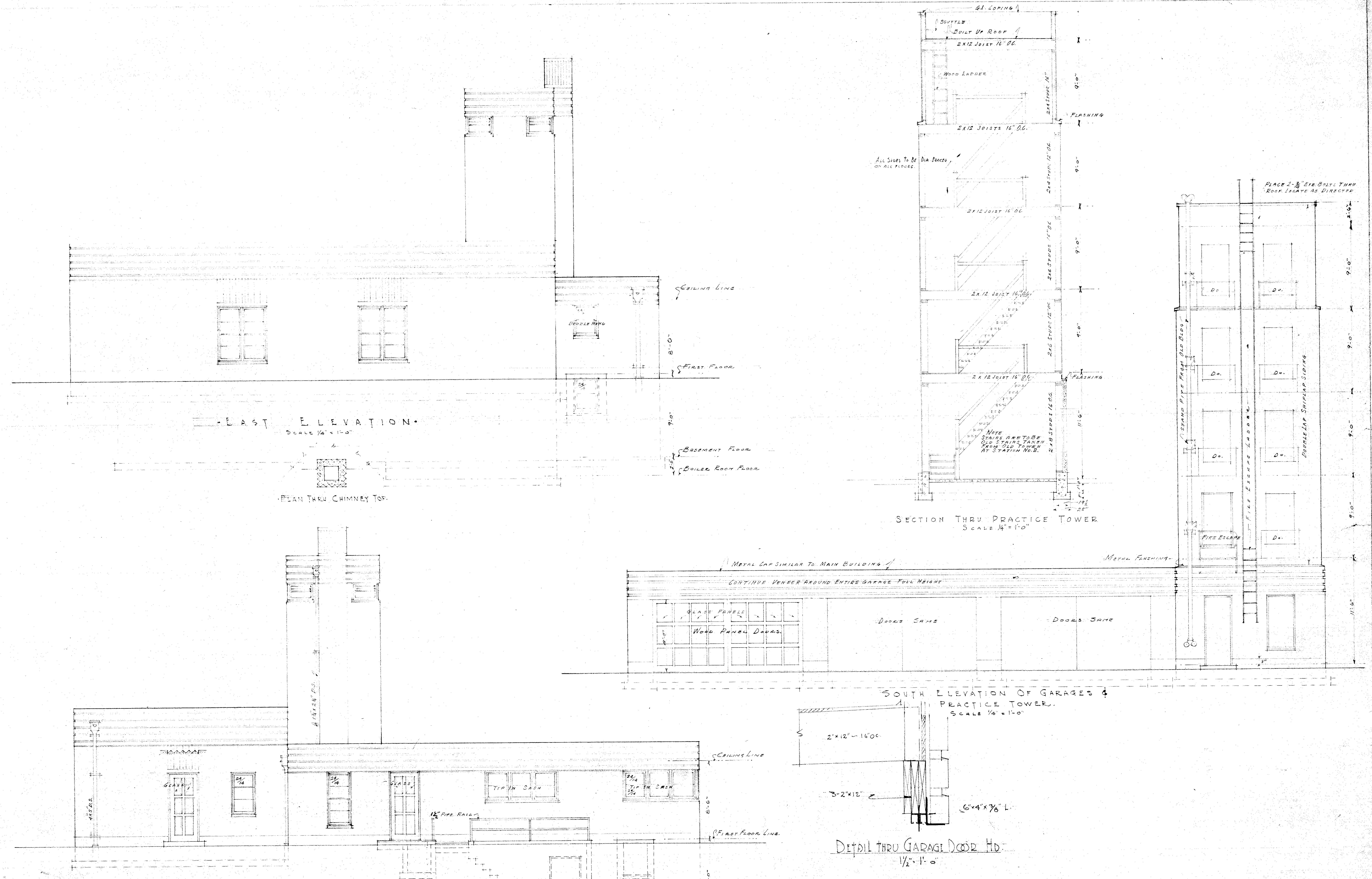
ENGINE HOUSE № 5
BEING BUILT WITH
STATE EMERGENCY FUND GRANT № C275

FOR
PUBLIC SAFETY DEPT.
DYER DYMENT COMMISSIONER
BY
PUBLIC WORKS DEPT.
A. R. BERGERSEN COMMISSIONER
CITY of TACOMA

ELEVATIONS ON CUSHMAN
ST & 12TH STREET

SILAS E. NELSEN
ARCHITECT
TACOMA WASHINGTON

DRAWING 3



ENGINE HOUSE No 5
BEING BUILT WITH
STATE EMERGENCY FUND GRANT No C275

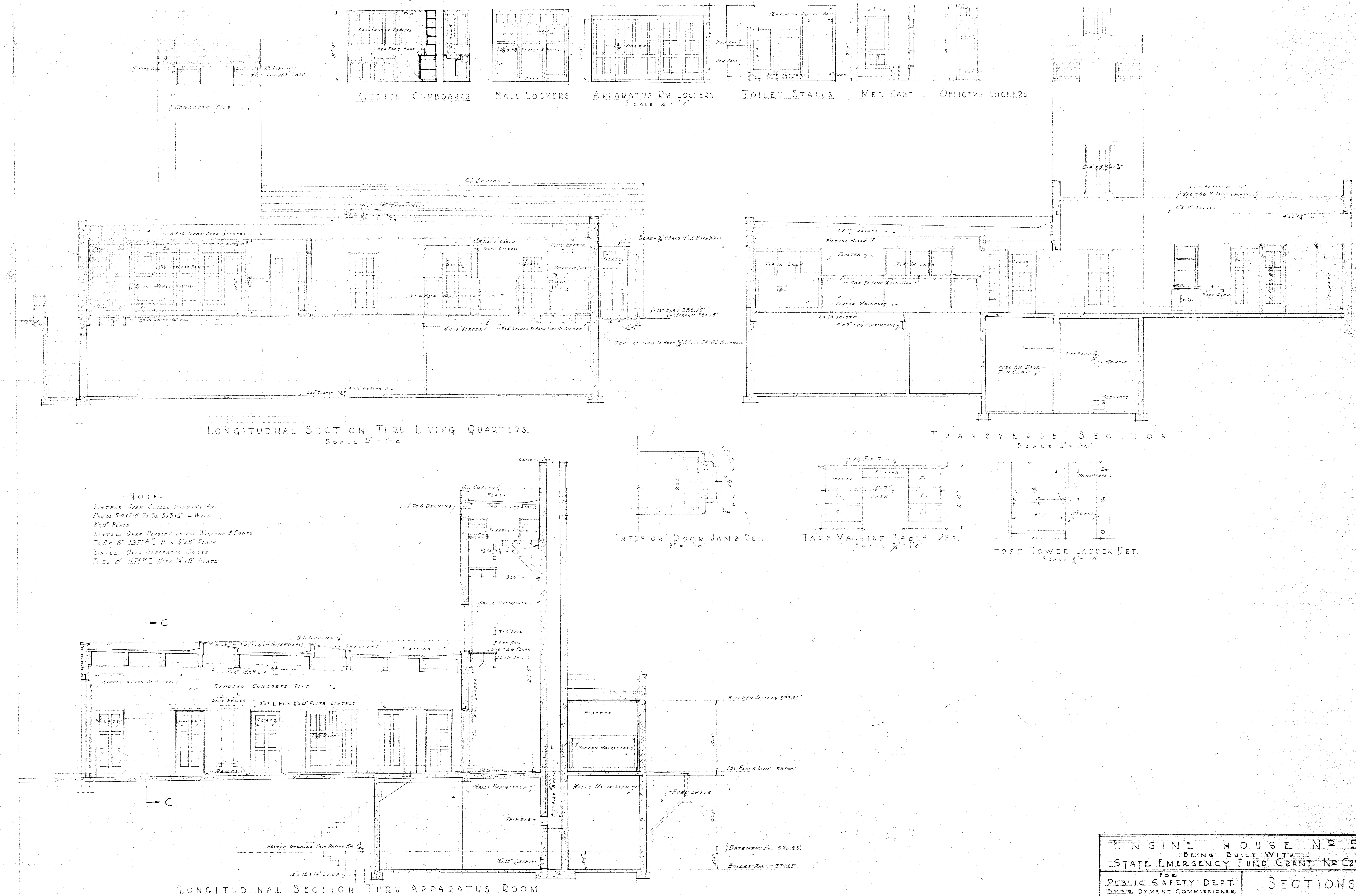
FOR
PUBLIC SAFETY DEPT.
DYER DYMENT COMMISSIONER
BY
PUBLIC WORKS DEPT.
A.R. BERGERSEN COMMISSIONER.
CITY of TACOMA

NO. & EAST ELEVATION
& PRACTICE TOWER ELEV.

DRAWN BY ASC & PGB
CHECKED BY
REVISIONS.

SILAS E. NELSEN
ARCHITECT
TACOMA WASHINGTON

DATE 12-15-33
COMM. No. 405-33-19
DRAWING 4



· NOTE ·

Lintels Over Single Windows And Doors 3'-0"x7'-0" To Be 3"x3"x¼" L With ¼"x8" Plate.

Lintels Over Double & Triple Windows & Doors To Be 8"-13.75# [With ¼"x8" Plate

Lintels Over Apparatus Doors To Be 8"-21.75# [With ⅜"x8" Plate

ENGINE HOUSE Nº 5
BEING BUILT WITH
STATE EMERGENCY FUND GRANT Nº C275

FOR
PUBLIC SAFETY DEPT.
DYER DYMENT COMMISSIONER
BY
PUBLIC WORKS DEPT.
A.R. BERGERSEN COMMISSIONER
CITY of TACOMA

SECTIONS

DRAWN BY P.G.B.
CHECKED BY
REVISIONS

SILAS E. NELSEN
ARCHITECT
TACOMA WASHING[illegible]

Appendix F: FEMA E-74 Nonstructural Seismic Bracing Excerpts

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Life Safety Systems

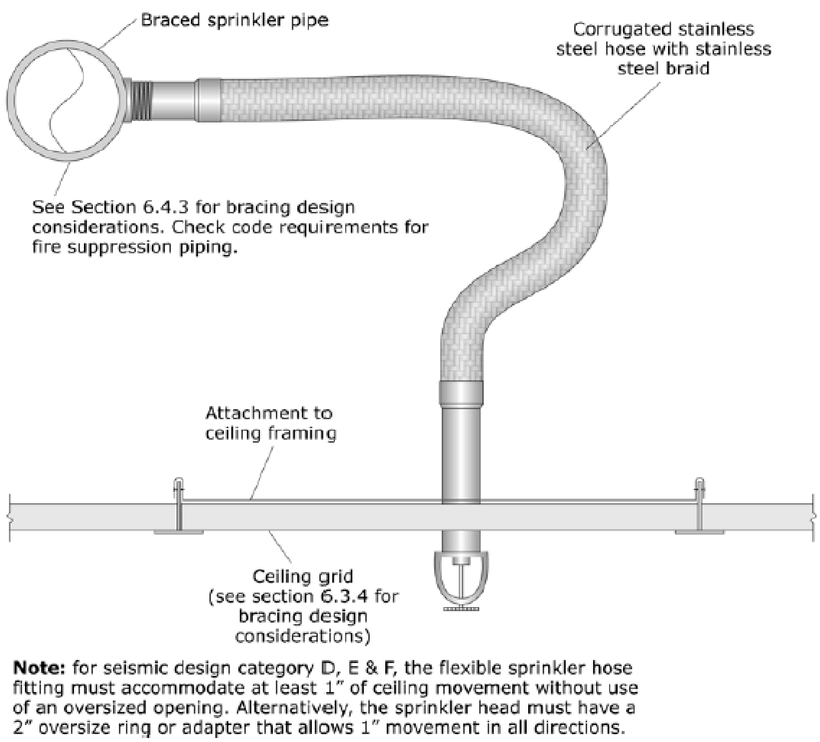


Figure G-1. Flexible Sprinkler Drop.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

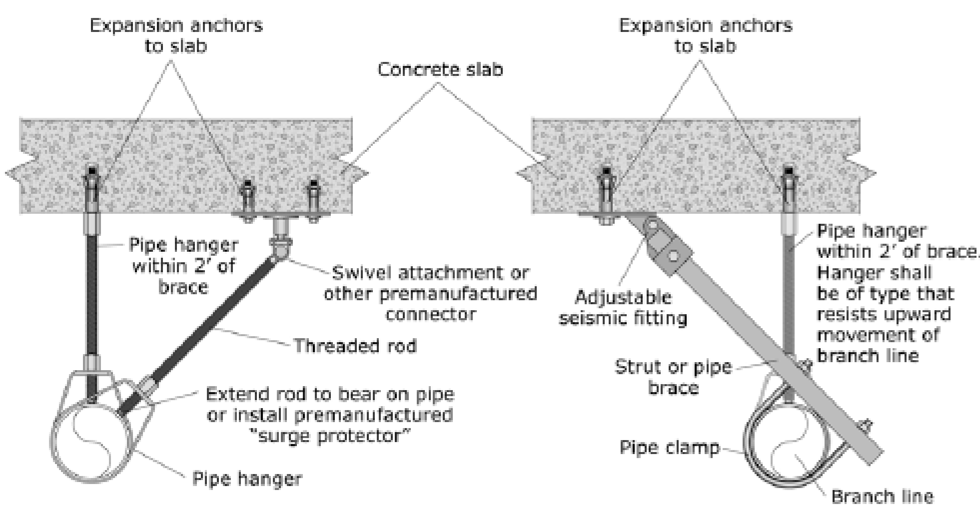


Figure G-2. End of Line Restraint.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Partitions

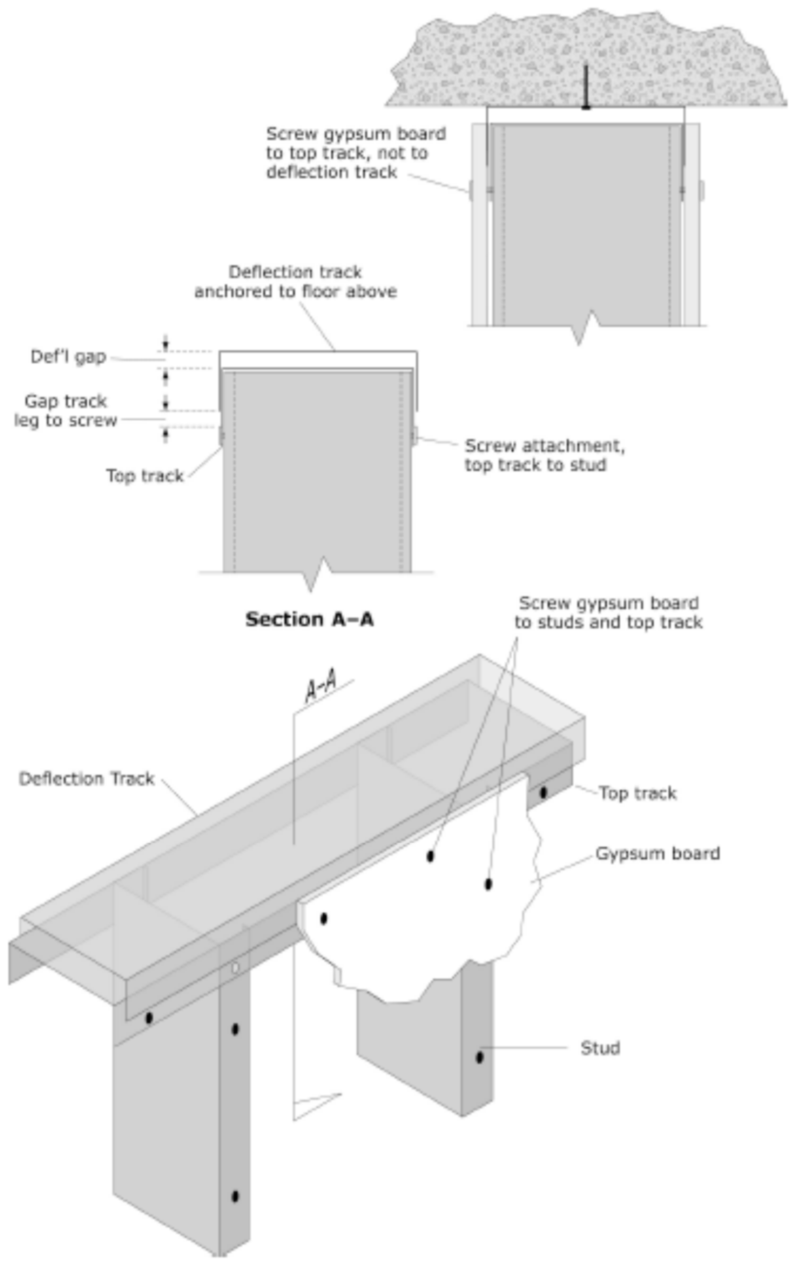


Figure G-3. Mitigation Schemes for Bracing the Tops of Metal Stud Partitions Walls.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

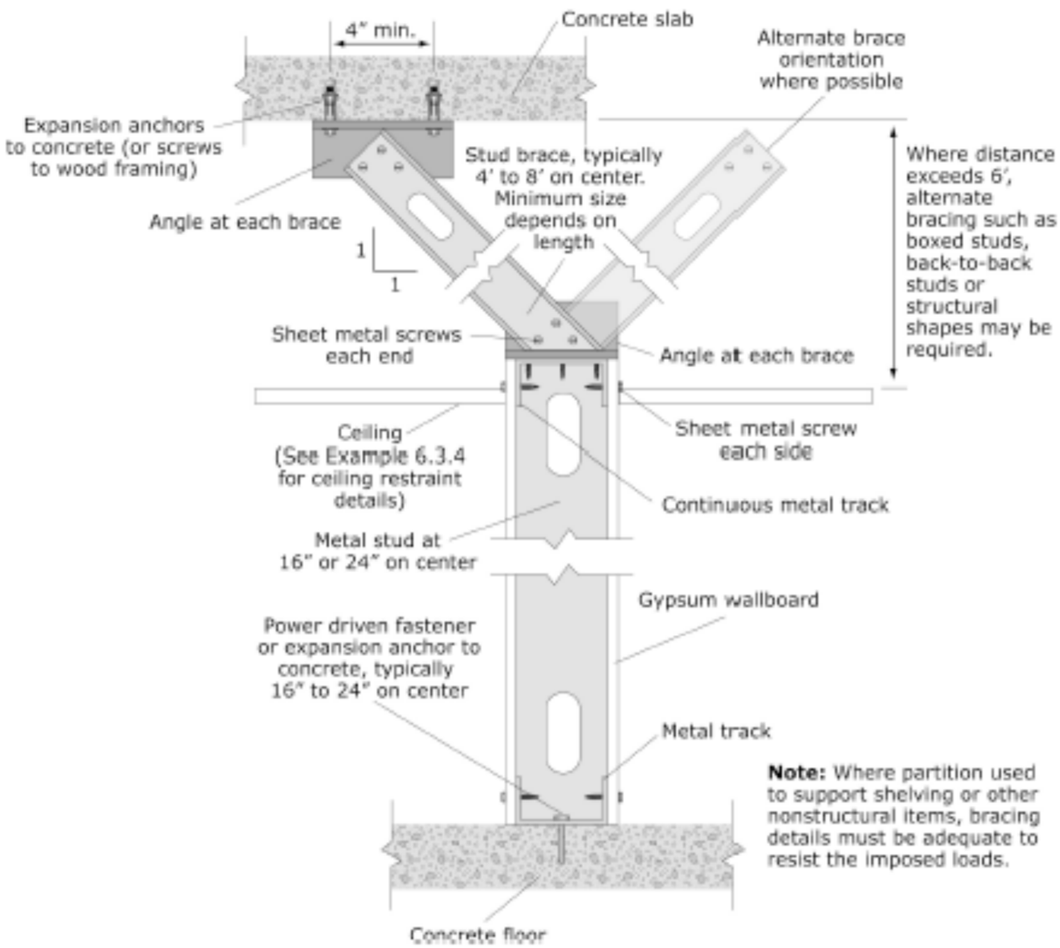


Figure G-4. Mitigation Schemes for Bracing the Tops of Metal Stud Partitions Walls.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

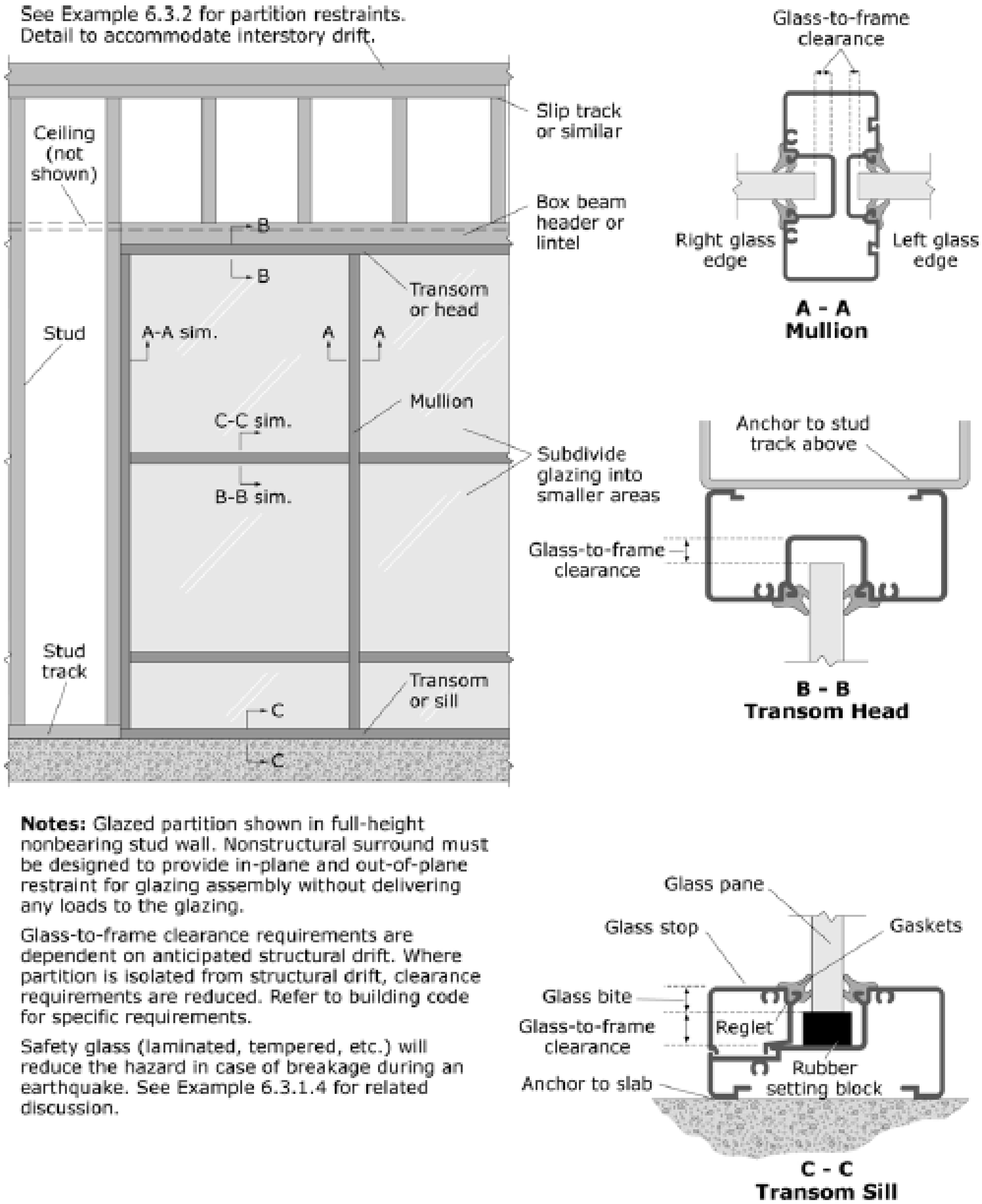


Figure G-5. Full-height Glazed Partition.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

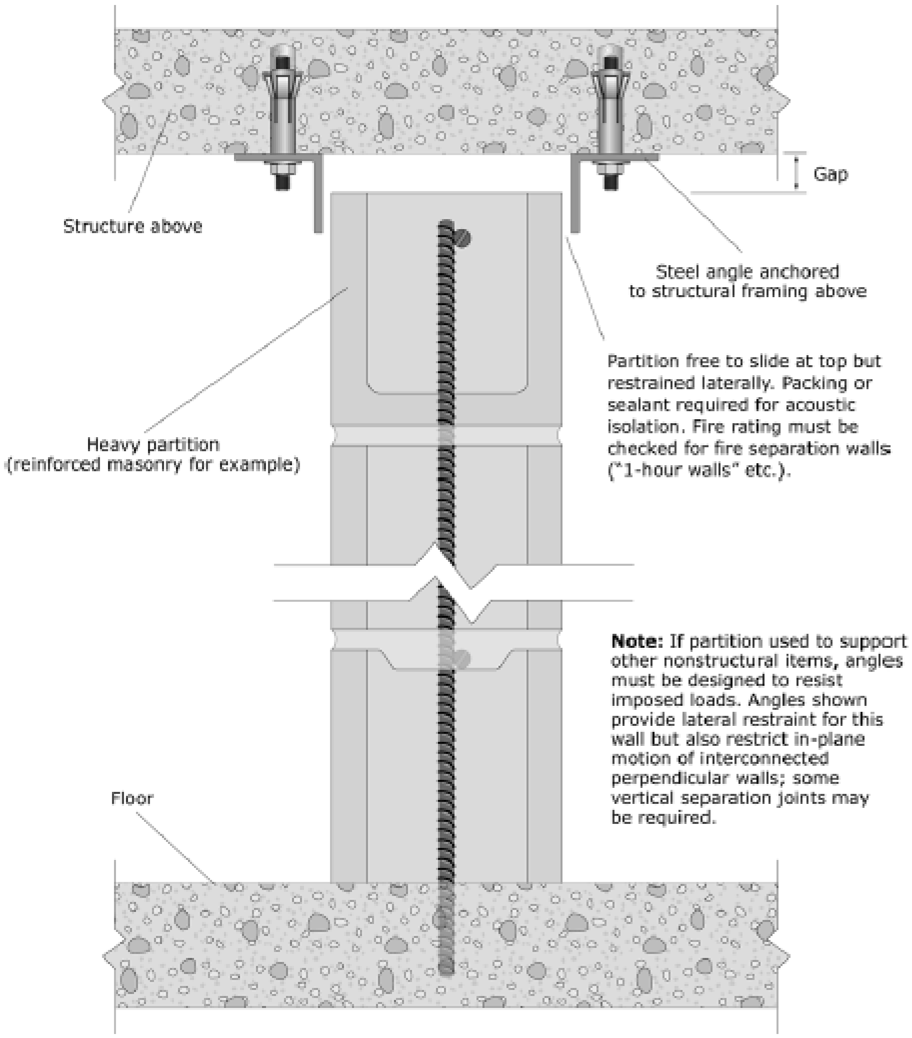


Figure G-6. Full-height Heavy Partition.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

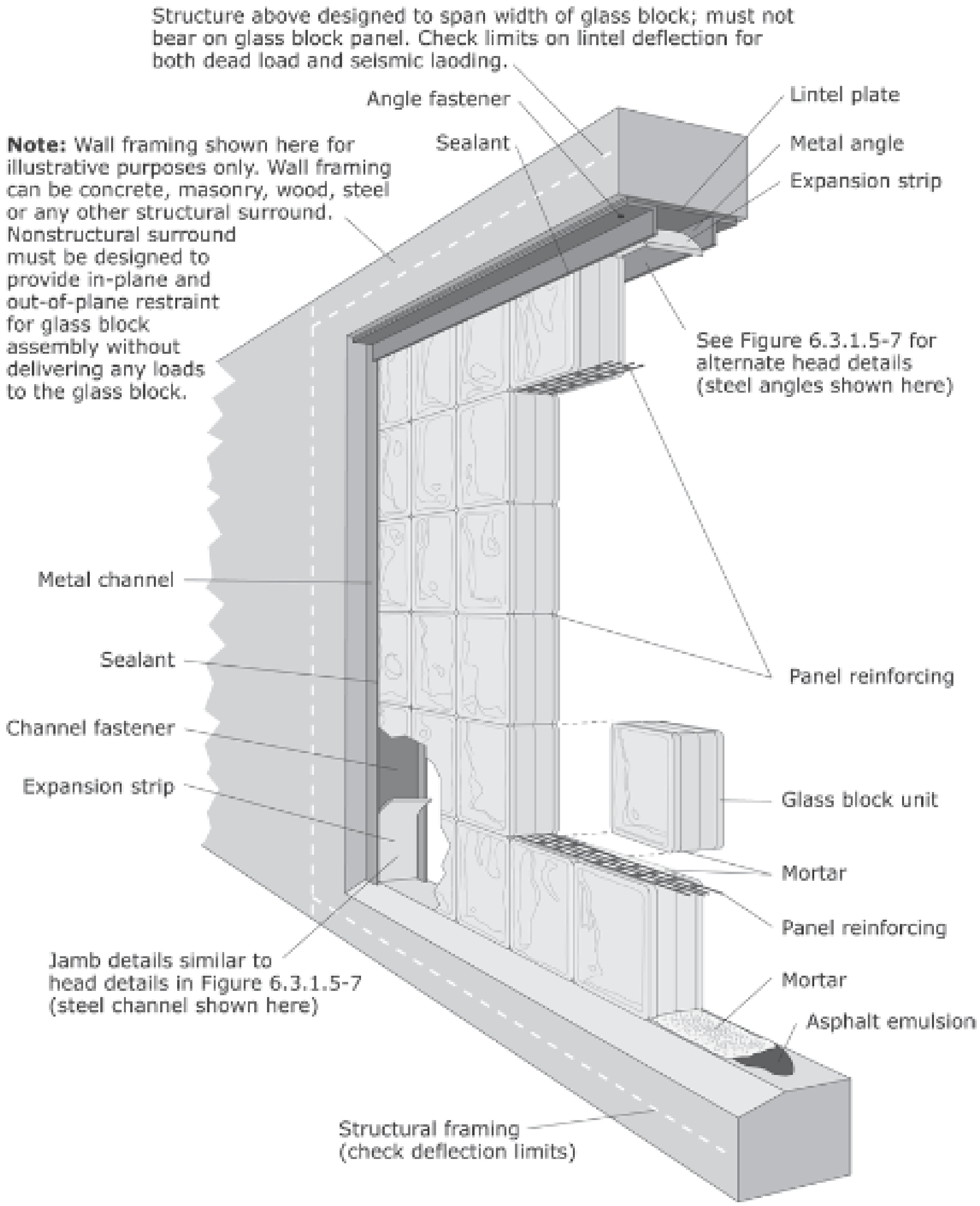


Figure G-7. Typical Glass Block Panel Details.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Ceilings

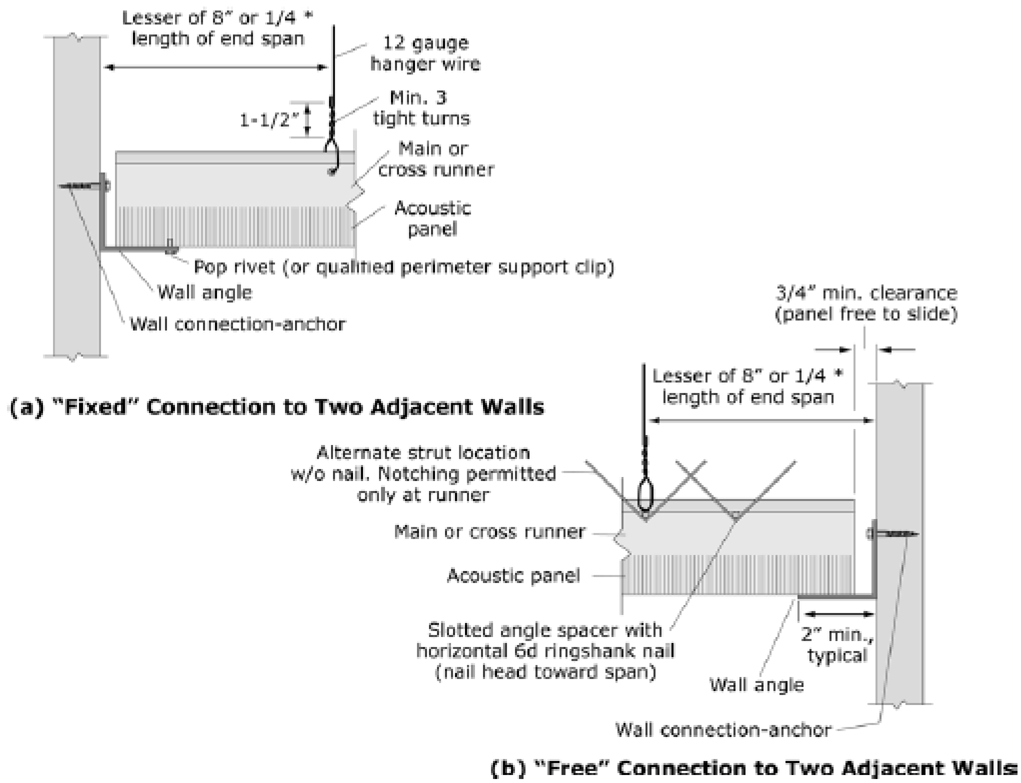
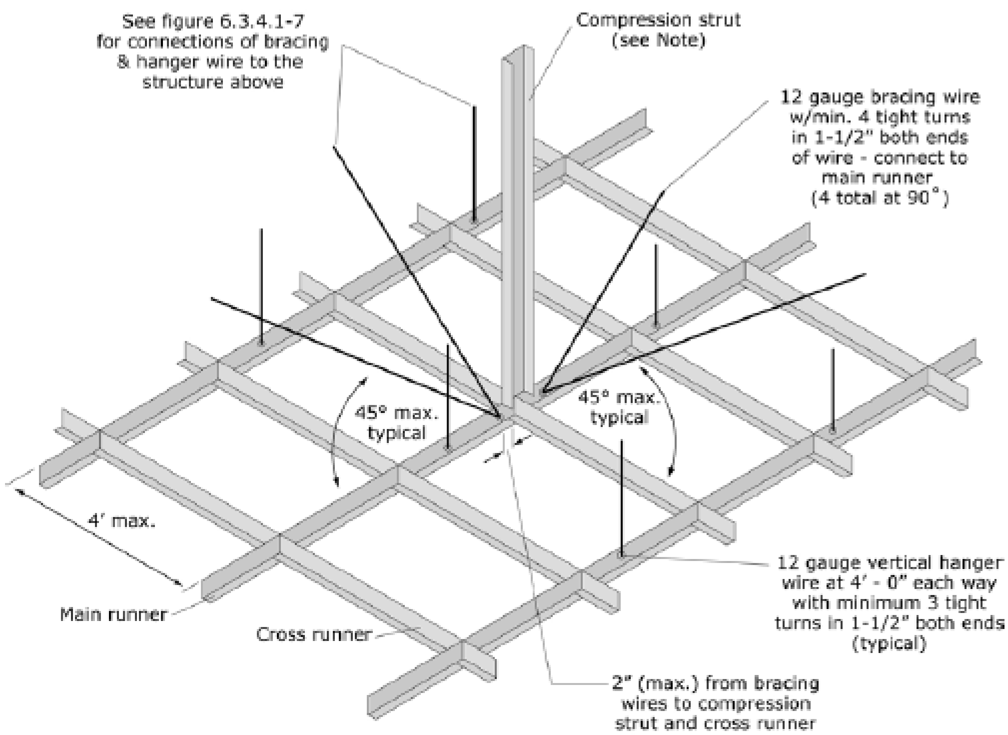


Figure G-8. Suspension System for Acoustic Lay-in Panel Ceilings – Edge Conditions.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Note: Compression strut shall not replace hanger wire. Compression strut consists of a steel section attached to main runner with 2 - #12 sheet metal screws and to structure with 2 - #12 screws to wood or 1/4" min. expansion anchor to structure. Size of strut is dependent on distance between ceiling and structure (l/r ≤ 200). A 1" diameter conduit can be used for up to 6', a 1-5/8" X 1-1/4" metal stud can be used for up to 10'

Per DSA IR 25-5, ceiling areas less than 144 sq. ft, or fire rated ceilings less than 96 sq. ft., surrounded by walls braced to the structure above do not require lateral bracing assemblies when they are attached to two adjacent walls. (ASTM E580 does not require lateral bracing assemblies for ceilings less than 1000 sq. ft.; see text.)

Figure G-9. Suspension System for Acoustic Lay-in Panel Ceilings – General Bracing Assembly.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

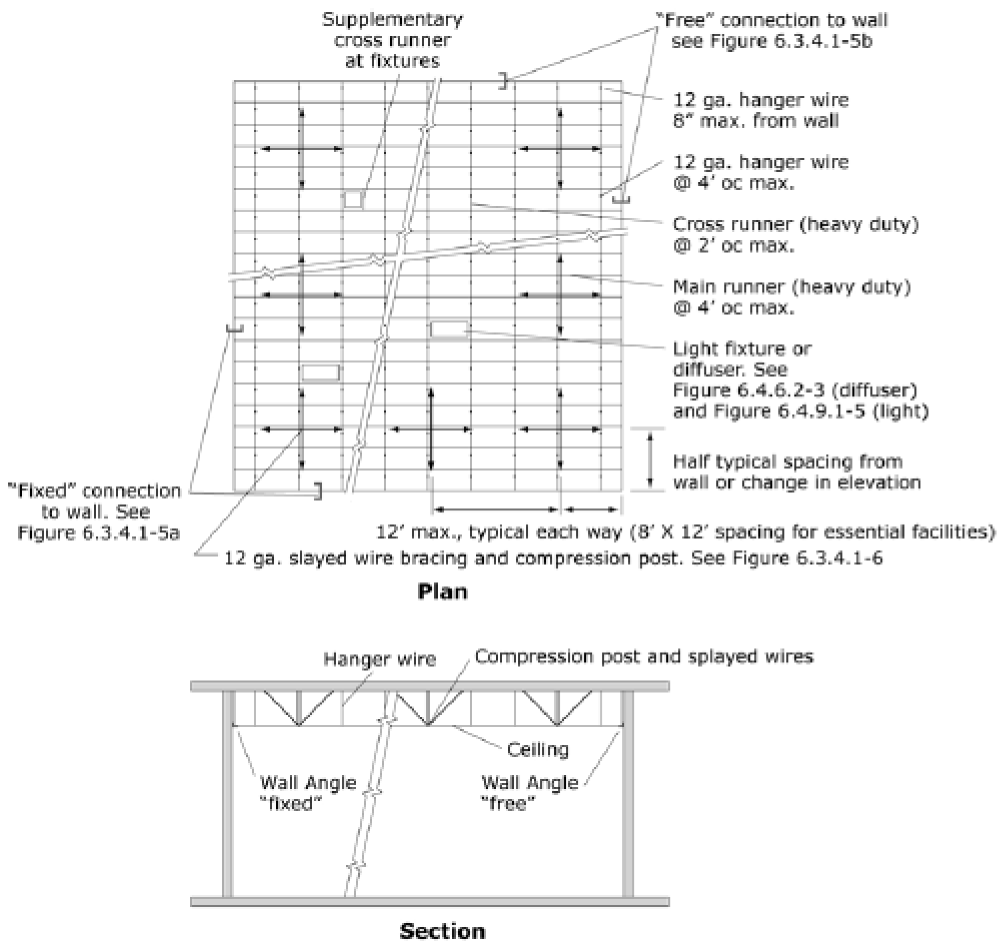


Figure G-10. Suspension System for Acoustic Lay-in Panel Ceilings – General Bracing Layout.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

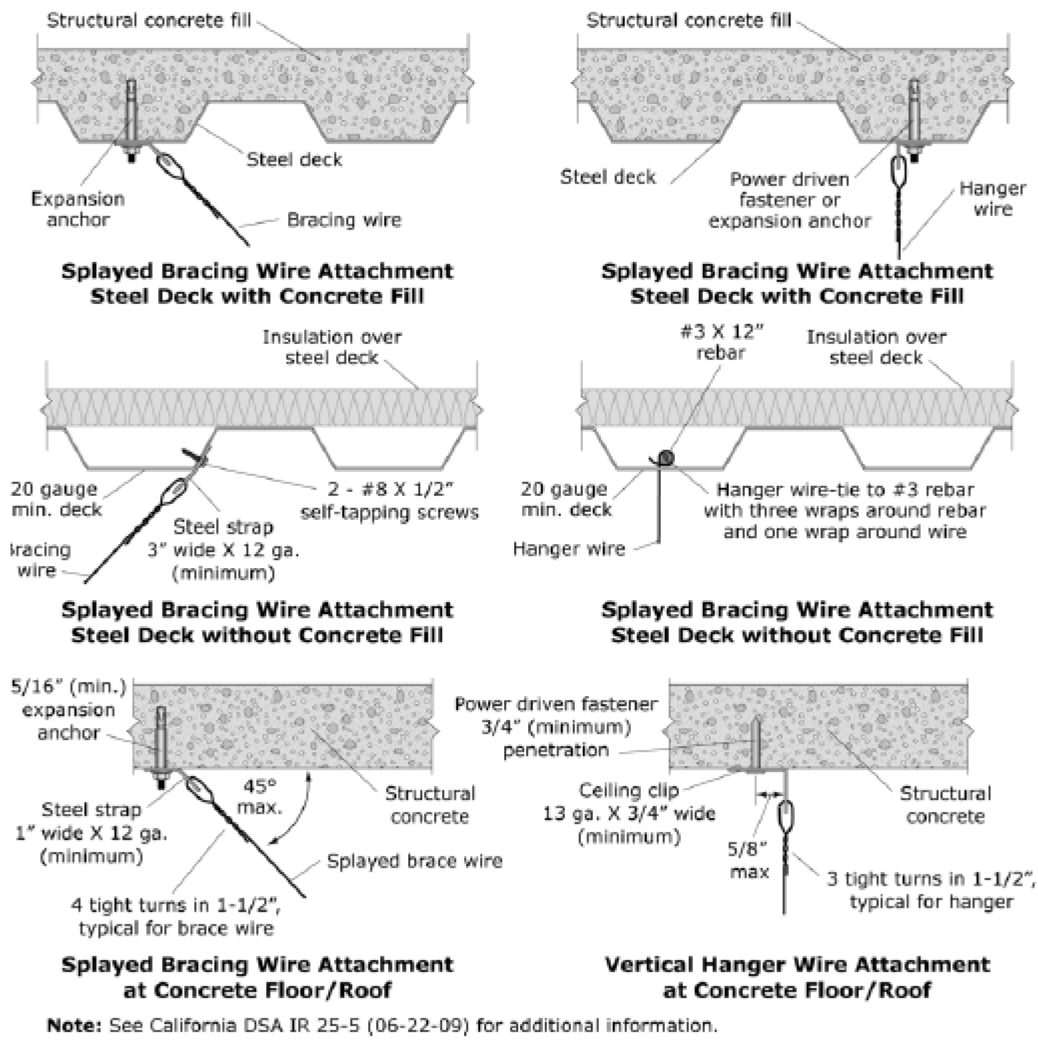
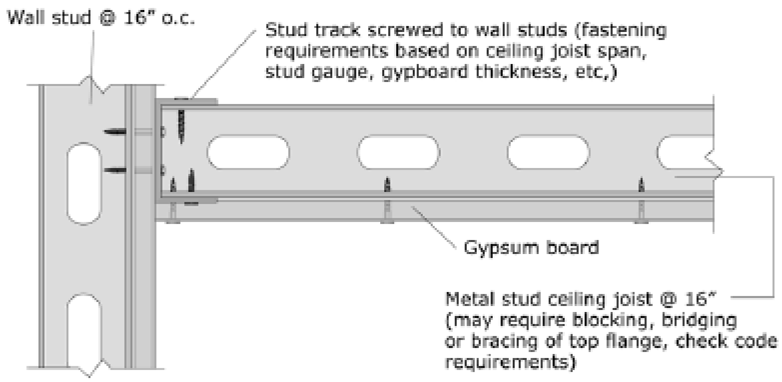
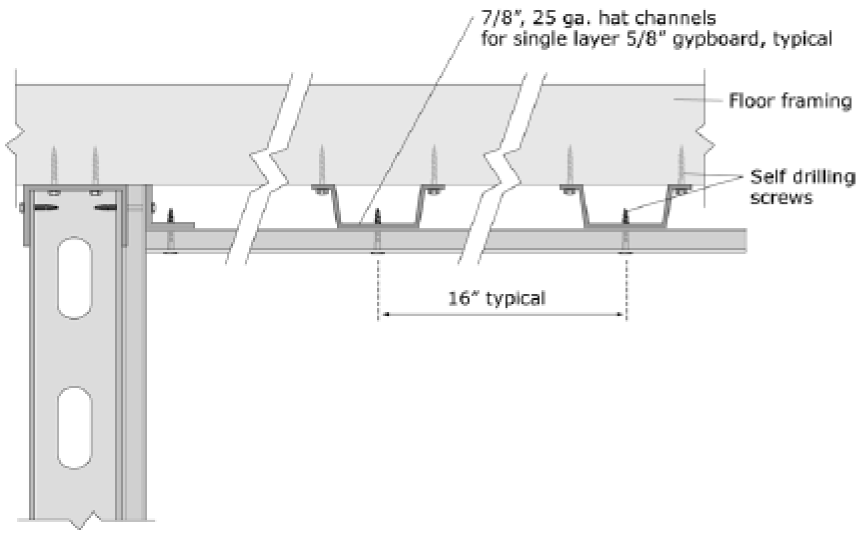


Figure G-11. Suspension System for Acoustic Lay-in Panel Ceilings – Overhead Attachment Details.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



a) Gypsum board attached directly to ceiling joists



b) Gypsum board attached directly to furring strips (hat channel or similar)

Note: Commonly used details shown; no special seismic details are required as long as furring and gypboard secured. Check for certified assemblies (UL listed, FM approved, etc.) if fire or sound rating required.

Figure G-12. Gypsum Board Ceiling Applied Directly to Structure.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

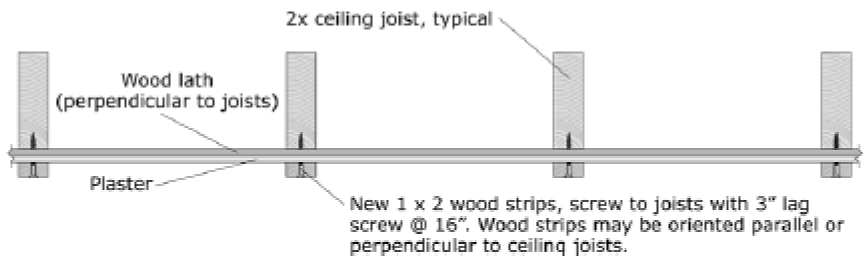


Figure G-13. Retrofit Detail for Existing Lath and Plaster.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

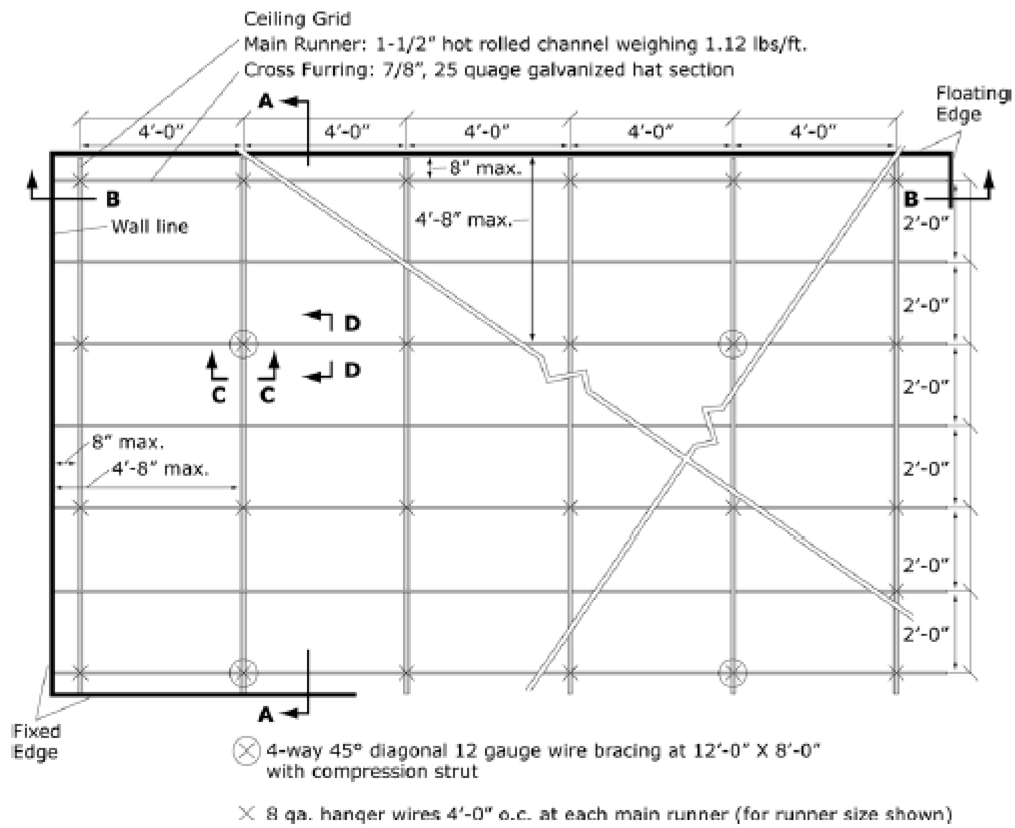
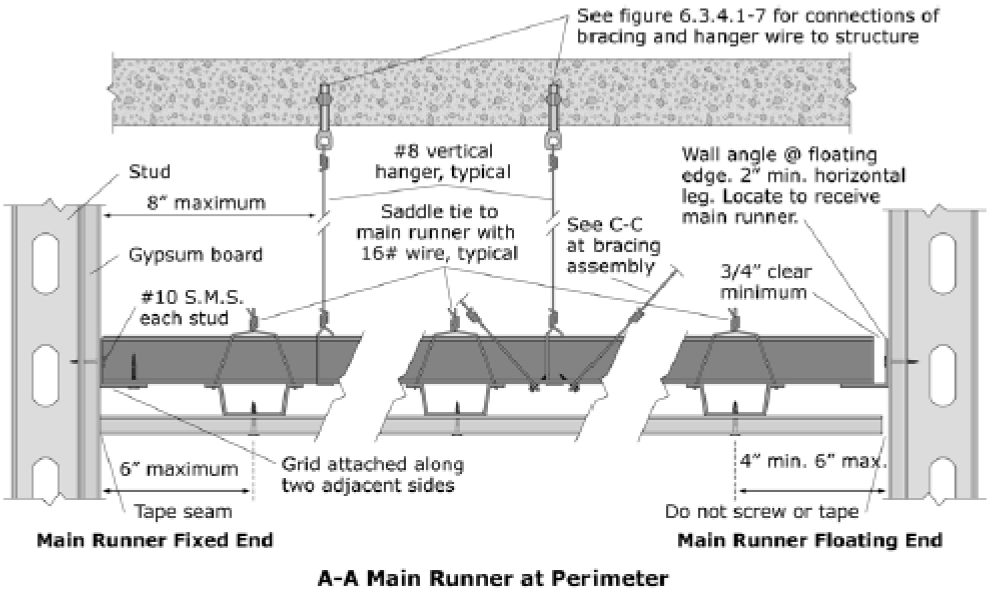


Figure G-14. Diagrammatic View of Suspended Heavy Ceiling Grid and Lateral Bracing.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



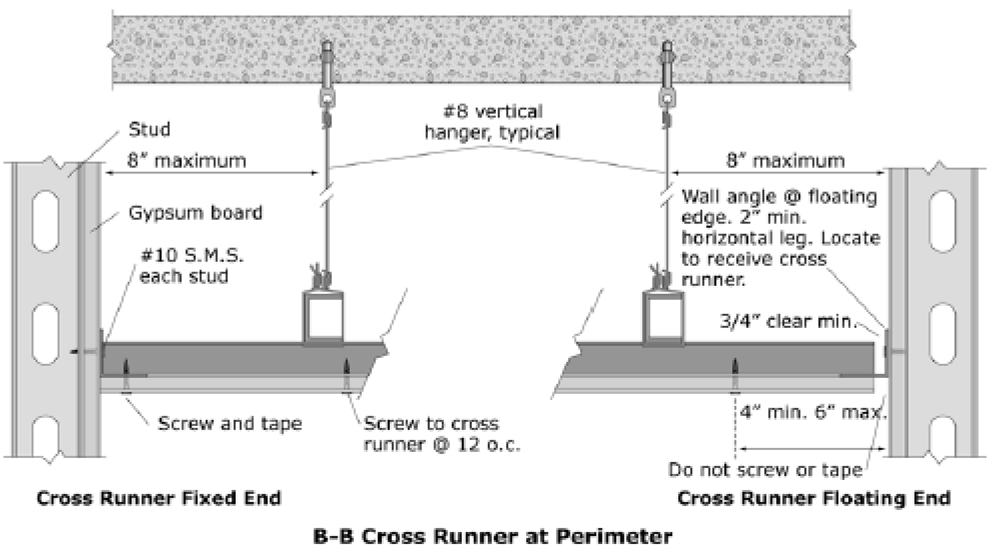
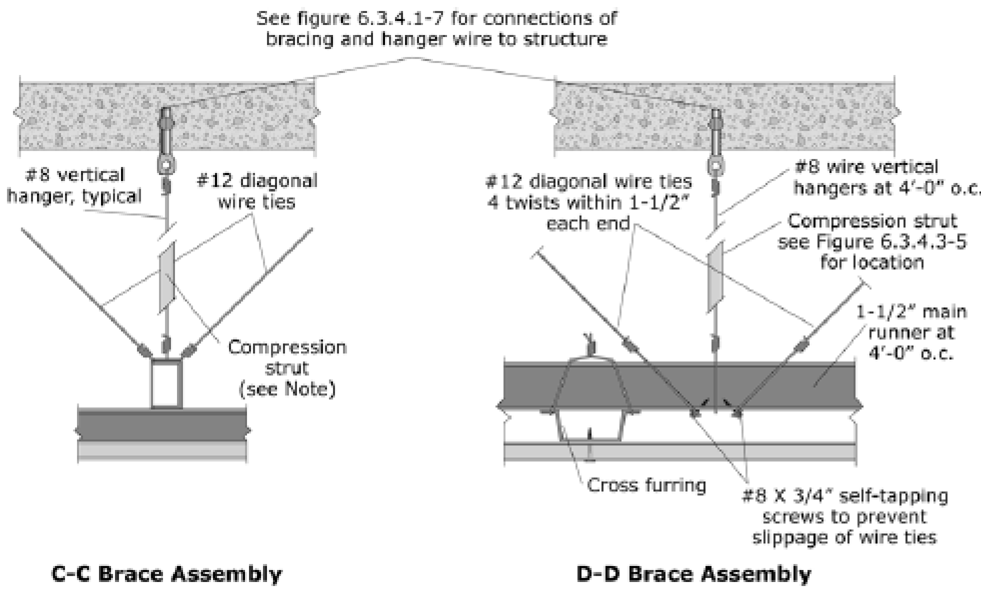


Figure G-15. Perimeter Details for Suspended Gypsum Board Ceiling.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Note: Compression strut shall not replace hanger wire. Compresion strut consists of a steel section attached to main runner with 2 - #12 sheet metal screws and to structure with 2 - #12 screws to wood or 1/4" min. expansion anchor to concrete. Size of strut is dependent on distance between ceiling and structure ($l/r \leq 200$). A 1" diameter conduit can be used for up to 6', a 1-5/8" X 1-1/4" metal stud can be used for up to 10'. See figure 6.3.4.1-6 for example of bracing assembly.

Figure G-16. Details for Lateral Bracing Assembly for Suspended Gypsum Board Ceiling.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Light Fixtures

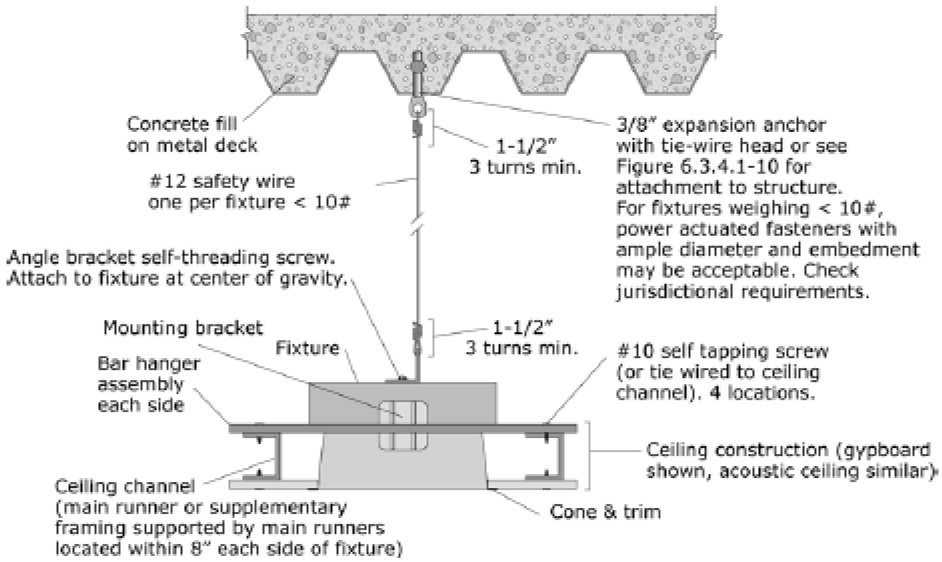


Figure G-17. Recessed Light Fixture in suspended Ceiling (Fixture Weight < 10 pounds).

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

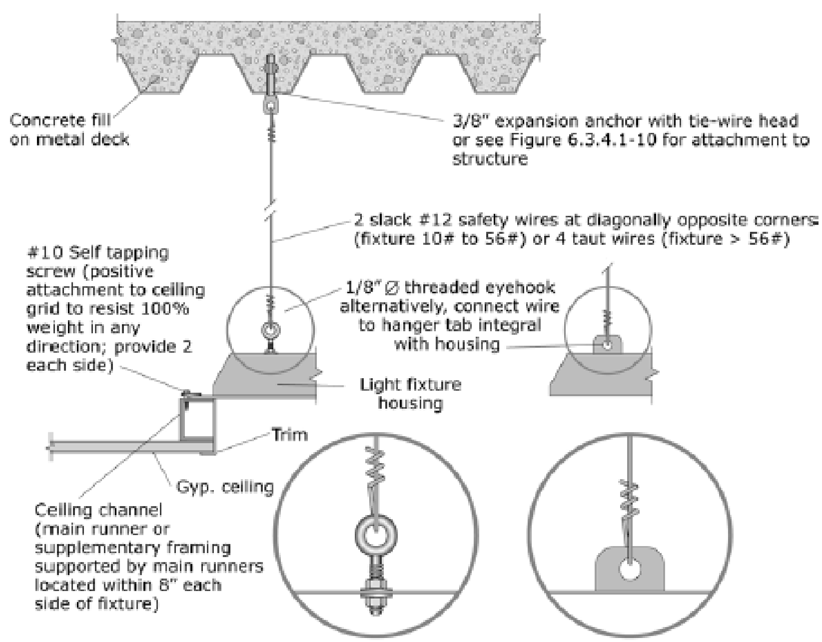


Figure G-18. Recessed Light Fixture in suspended Ceiling (Fixture Weight 10 to 56 pounds).

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Contents and Furnishings

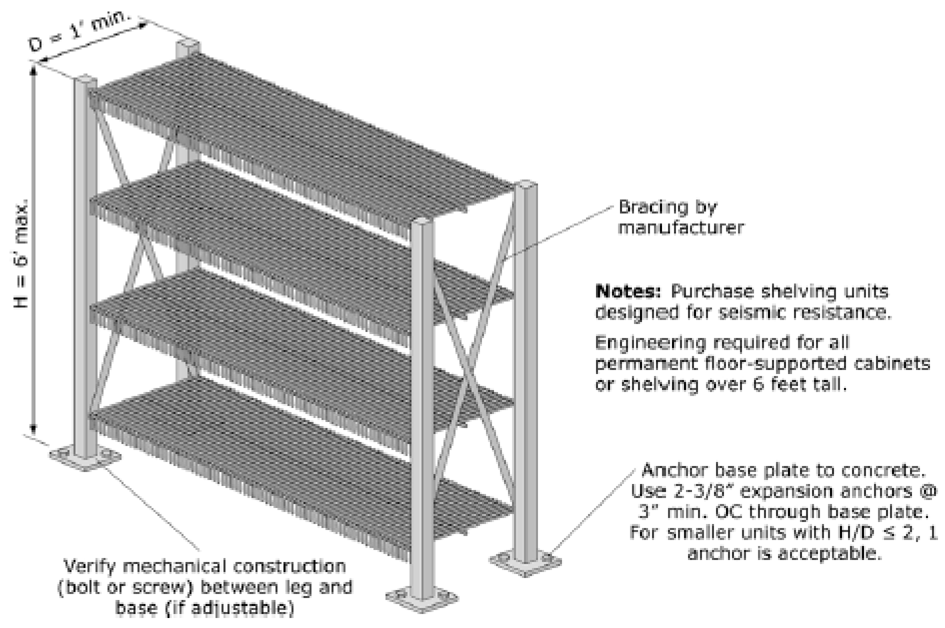


Figure G-19. Light Storage Racks.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

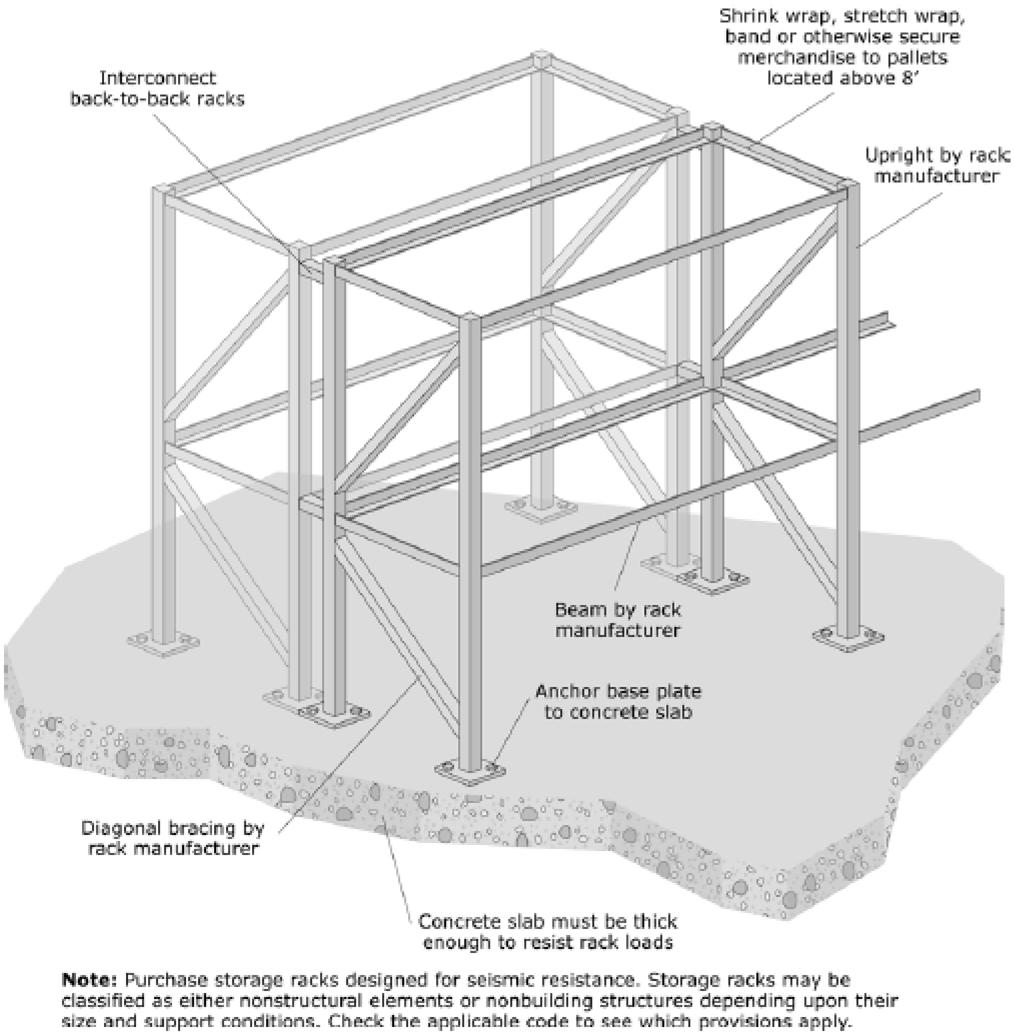


Figure G-20. Industrial Storage Racks.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

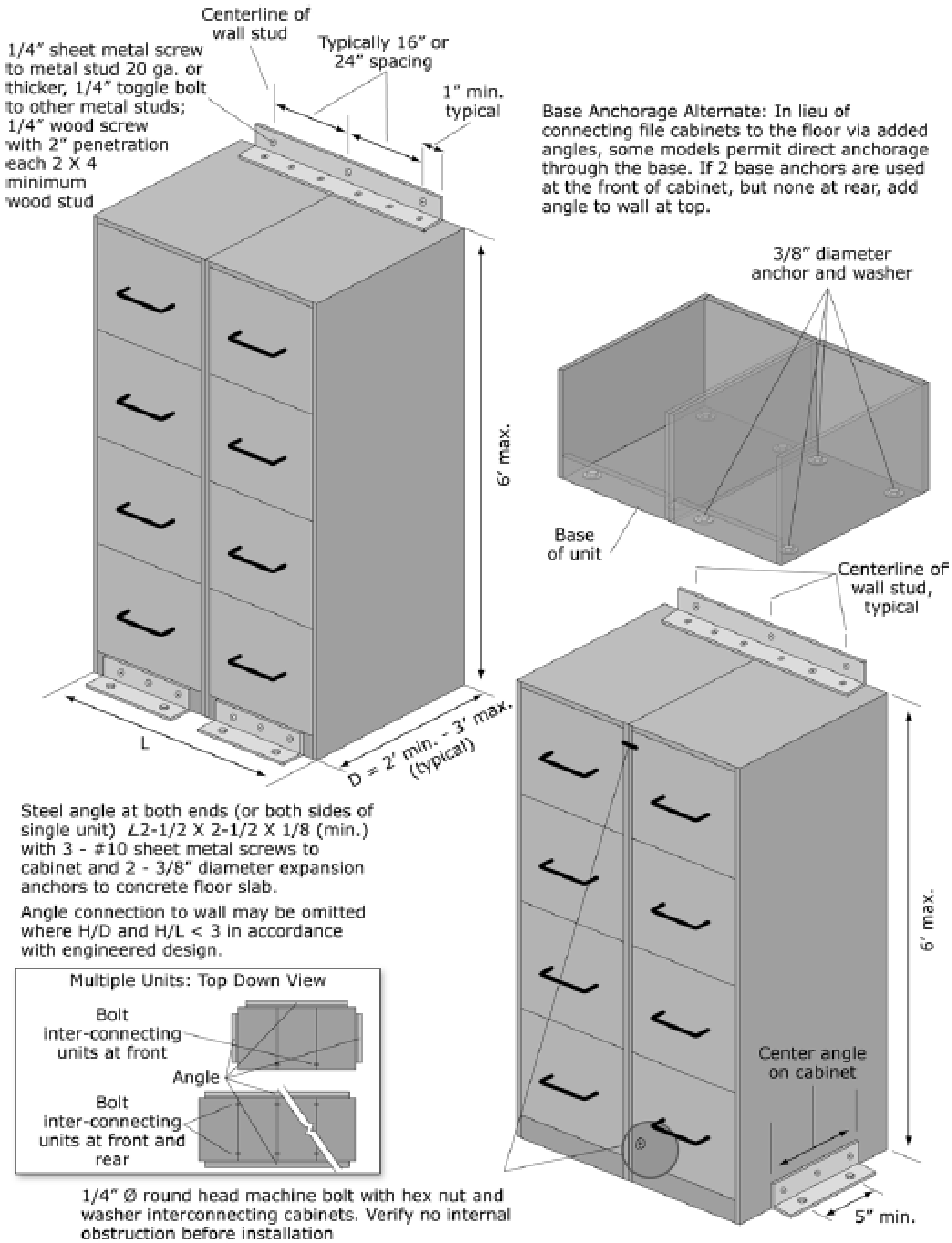


Figure G-21. Wall-mounted File Cabinets.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

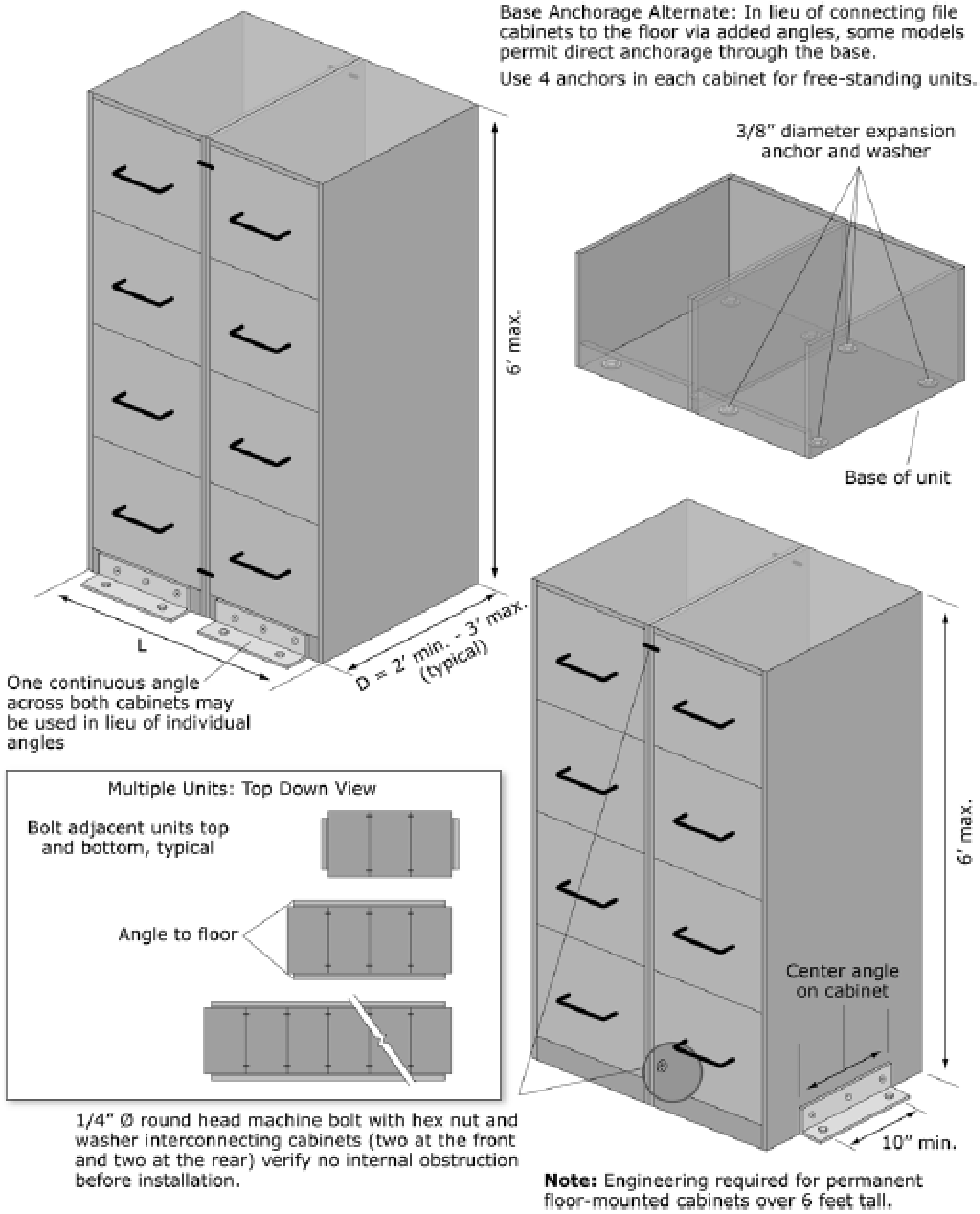


Figure G-22. Base Anchored File Cabinets.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

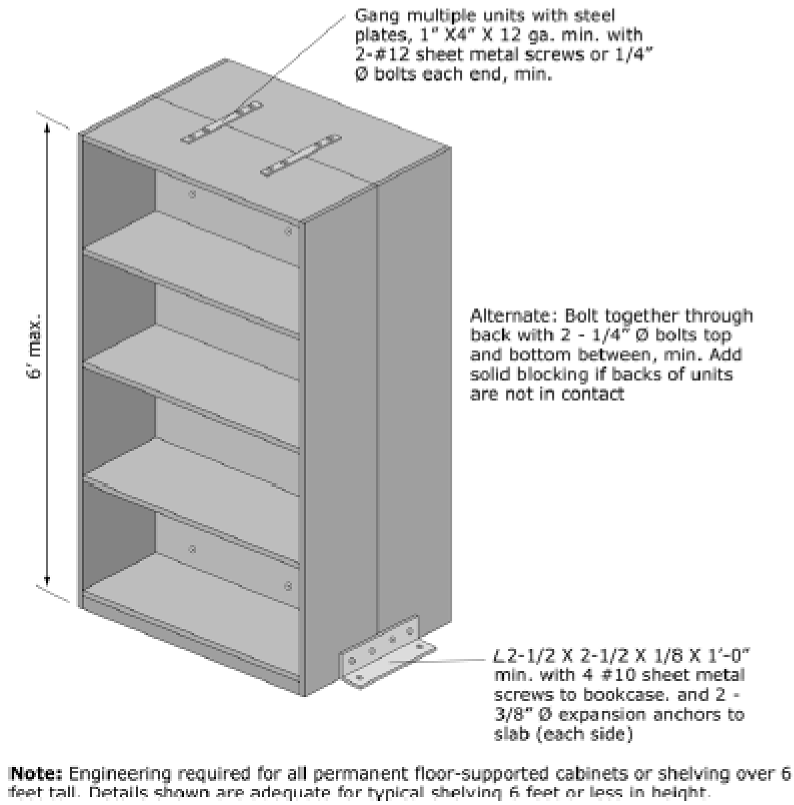


Figure G-23. Anchorage of Freestanding Book Cases Arranged Back to Back.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

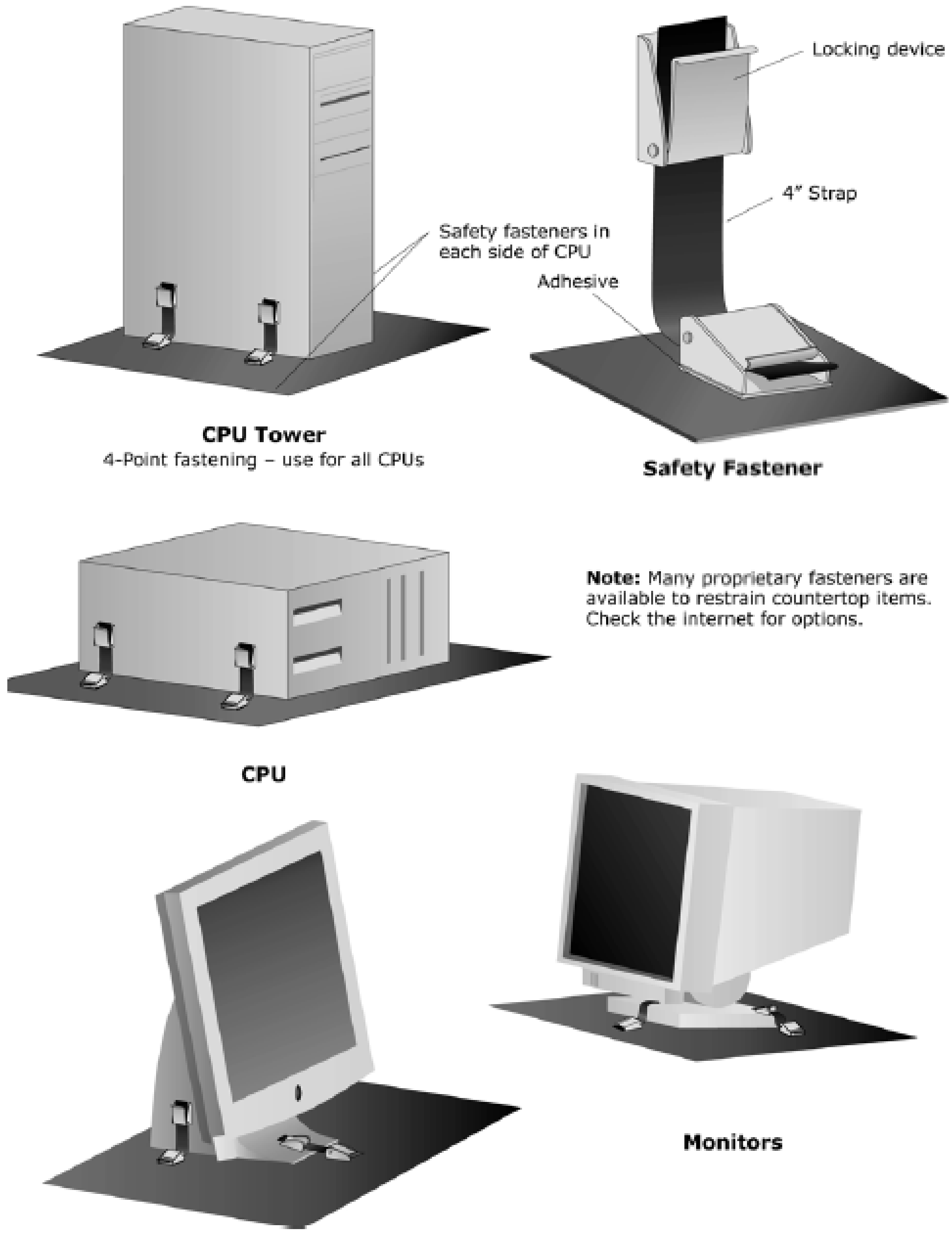


Figure G-24. Desktop Computers and Accessories.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

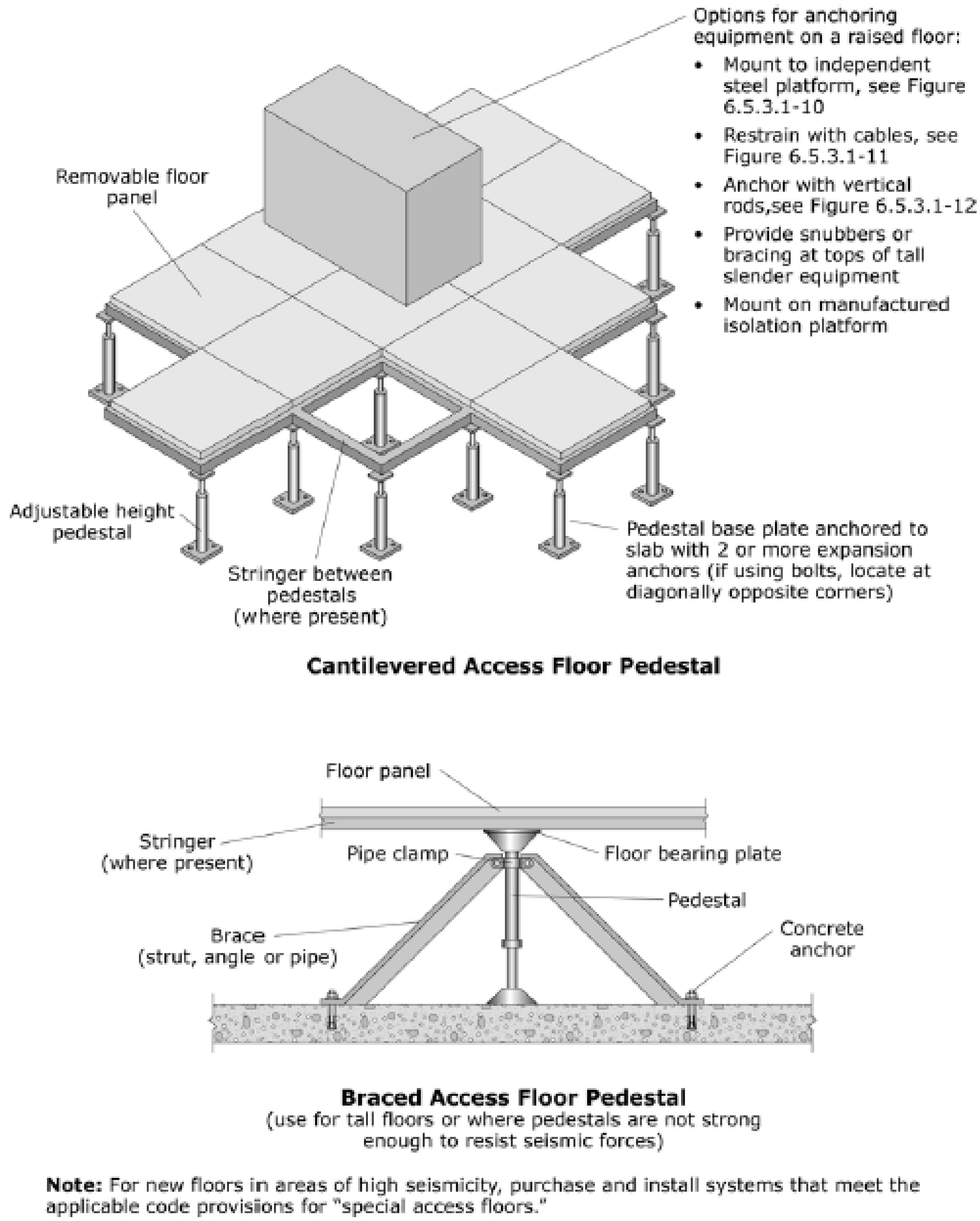
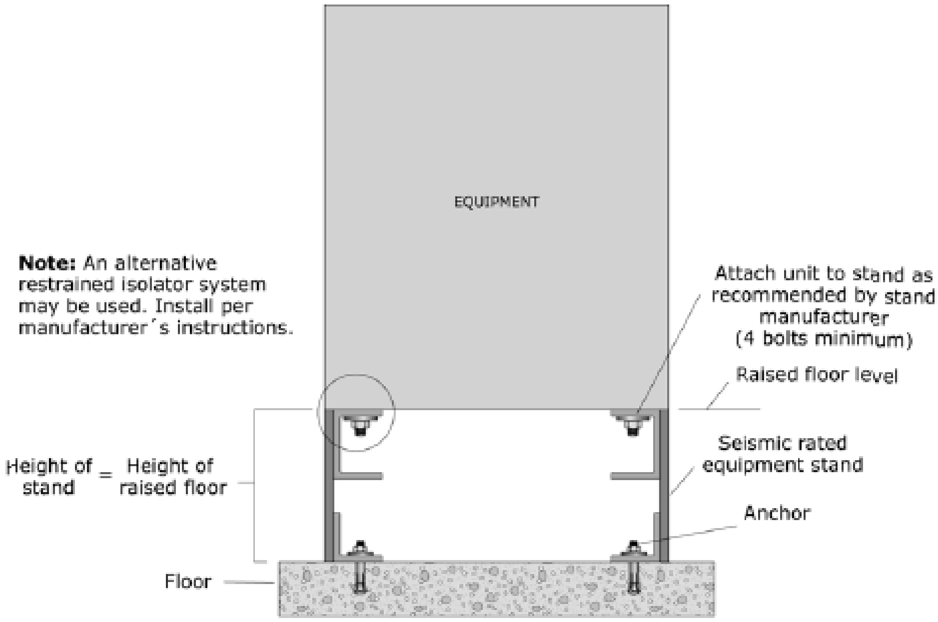


Figure G-25. Equipment Mounted on Access Floor.

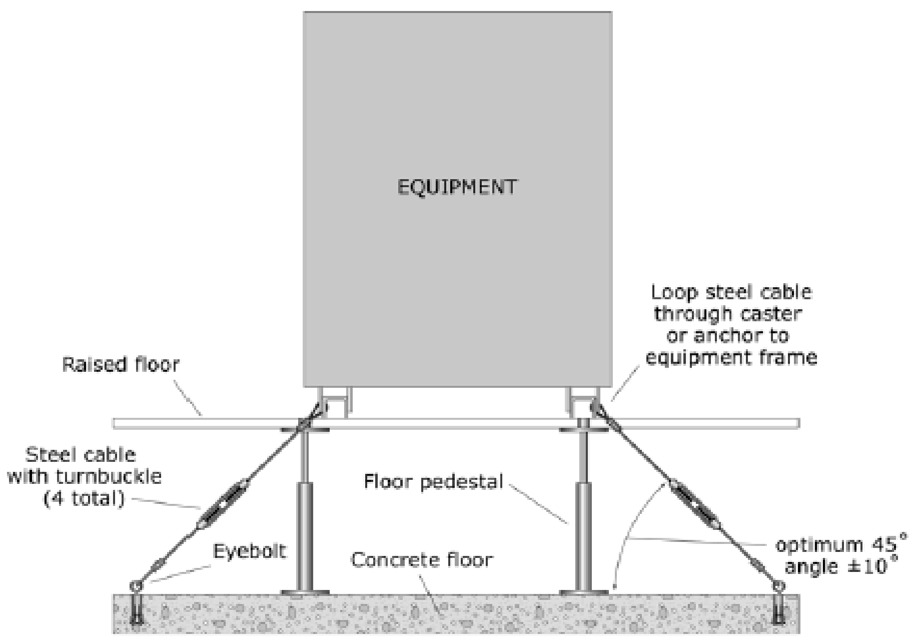
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Equipment installed on an independent steel platform within a raised floor

Figure G-26. Equipment Mounted on Access Floor – Independent Base.

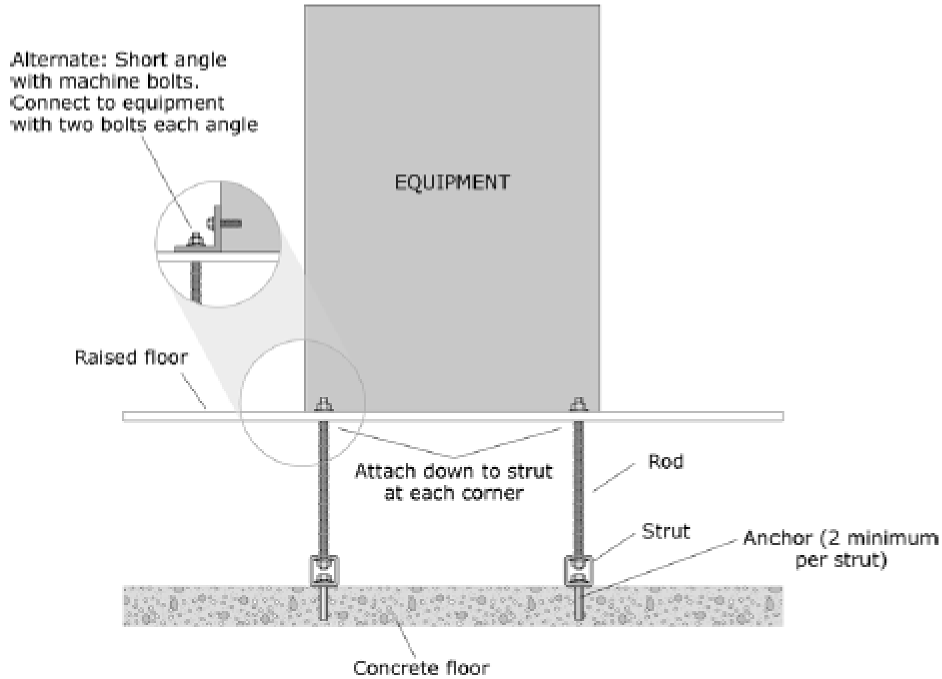
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Equipment restrained with cables beneath a raised floor

Figure G-27. Equipment Mounted on Access Floor – Cable Braced.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

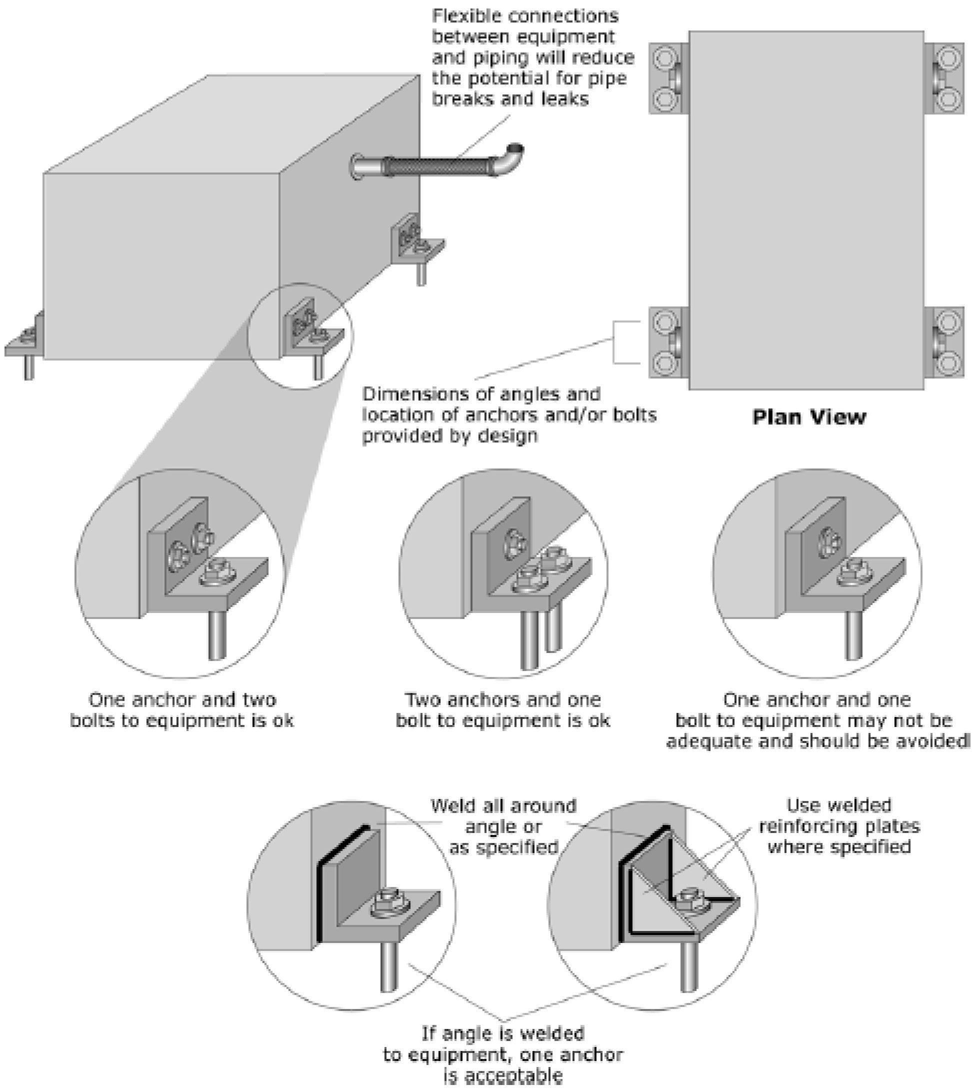


Equipment anchored with vertical rods beneath a raised floor

Figure G-28. Equipment Mounted on Access Floor – Tie-down Rods.

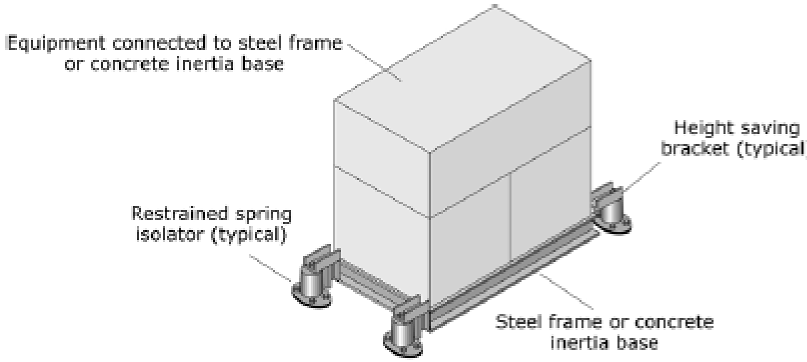
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Mechanical and Electrical Equipment

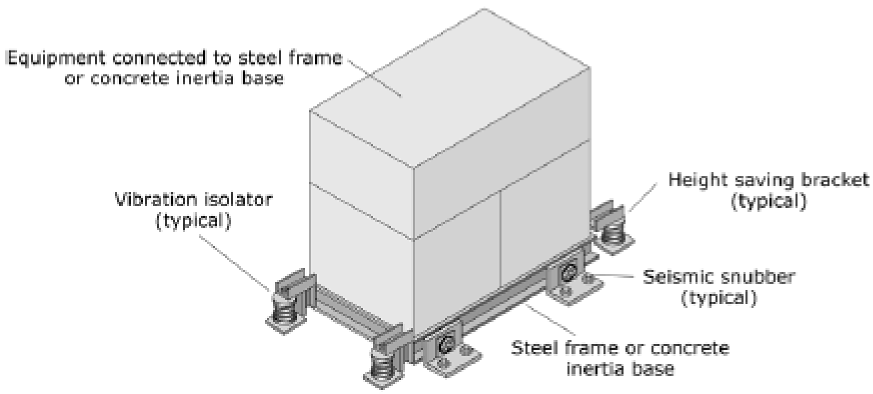


Note: Rigidly mounted equipment shall have flexible connections for the fuel lines and piping.

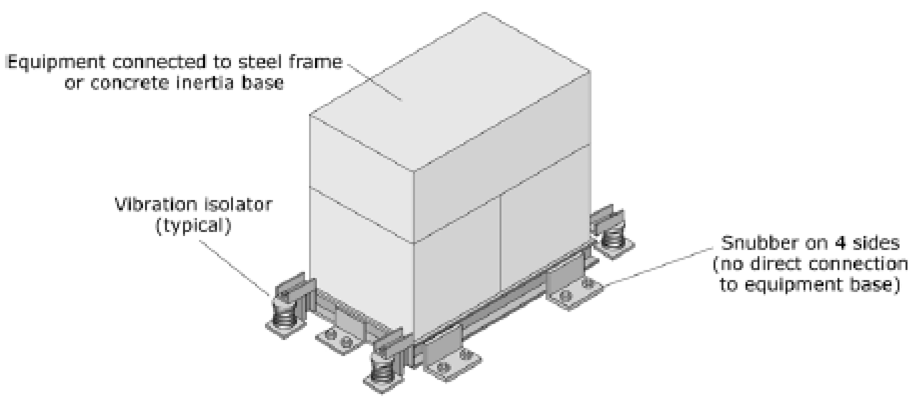
Figure G-29. Rigidly Floor-mounted Equipment with Added Angles.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Supplemental base with restrained spring isolators



Supplemental base with open springs and all-directional snubbers



Supplemental base with open springs and one-directional snubbers

Figure G-30. HVAC Equipment with Vibration Isolation.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

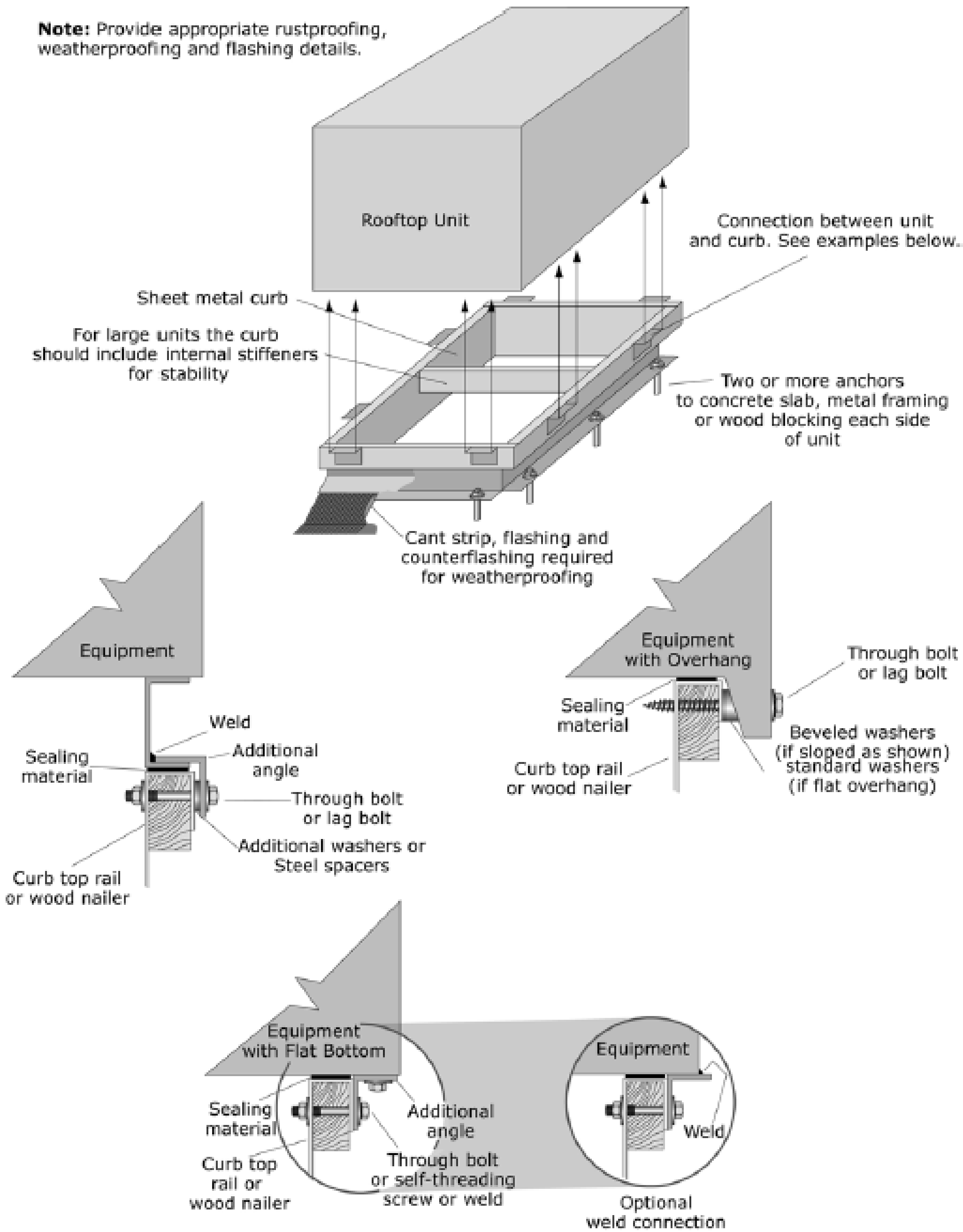


Figure G-31. Rooftop HVAC Equipment.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

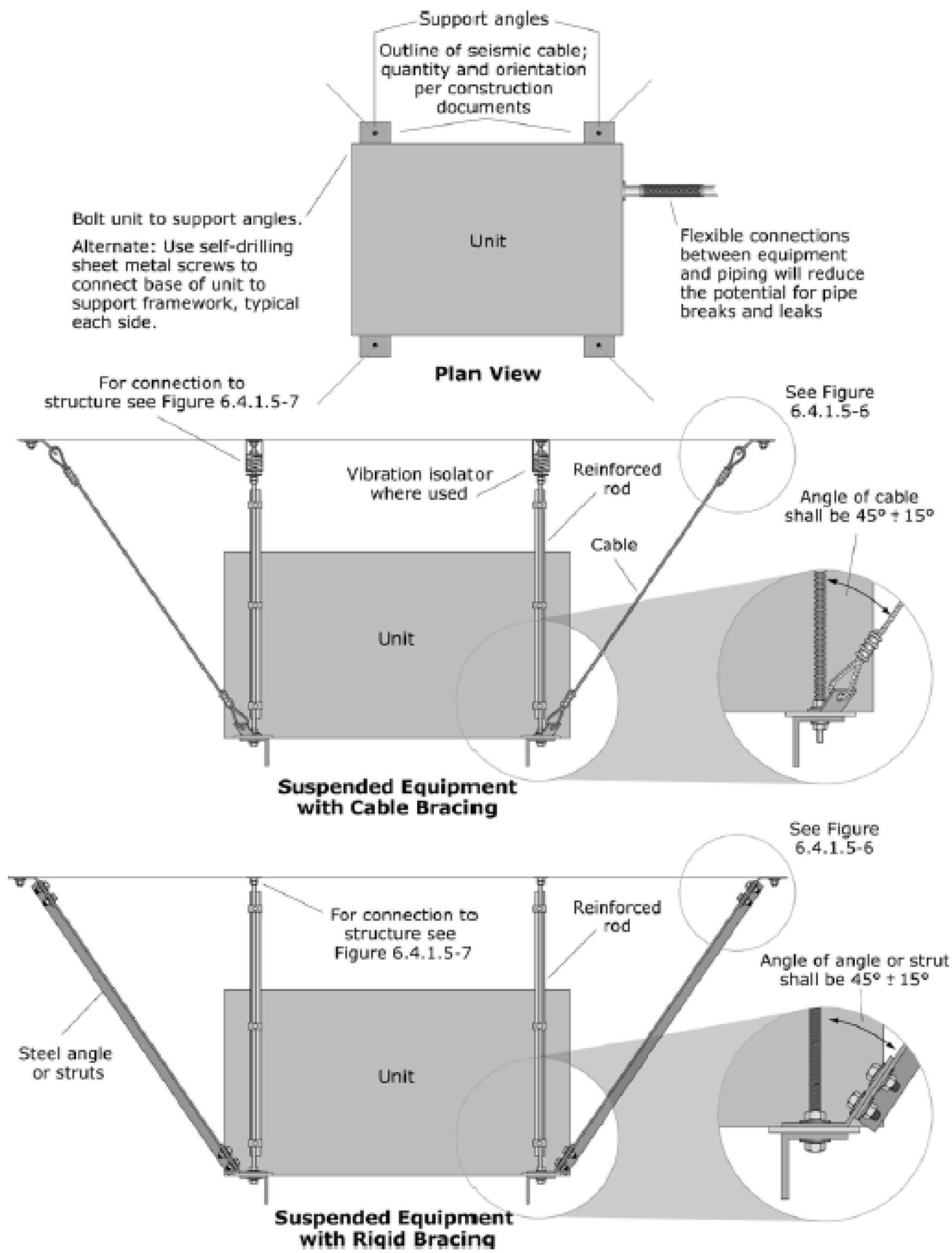


Figure G-32. Suspended Equipment.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

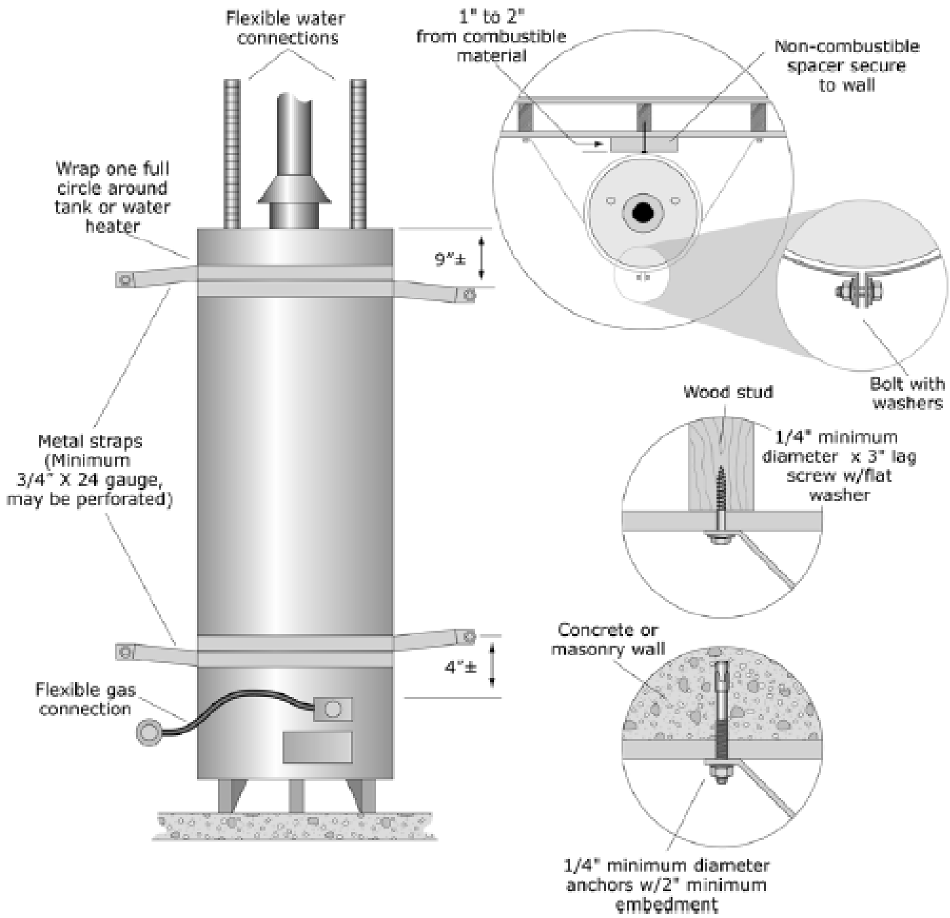


Figure G-33. Water Heater Strapping to Backing Wall.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

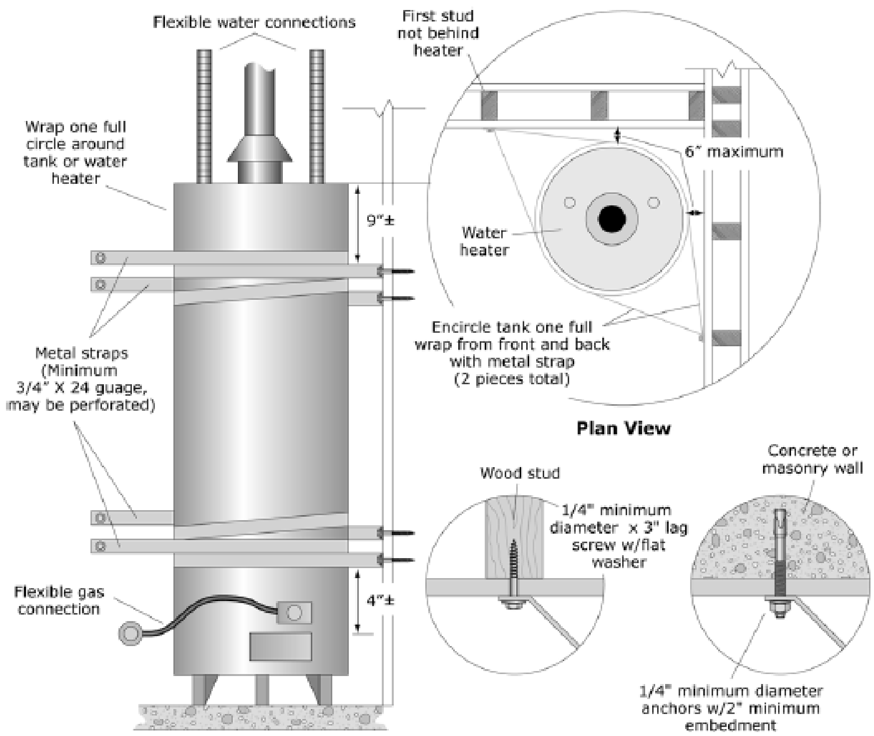


Figure G-34. Water Heater – Strapping at Corner Installation.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

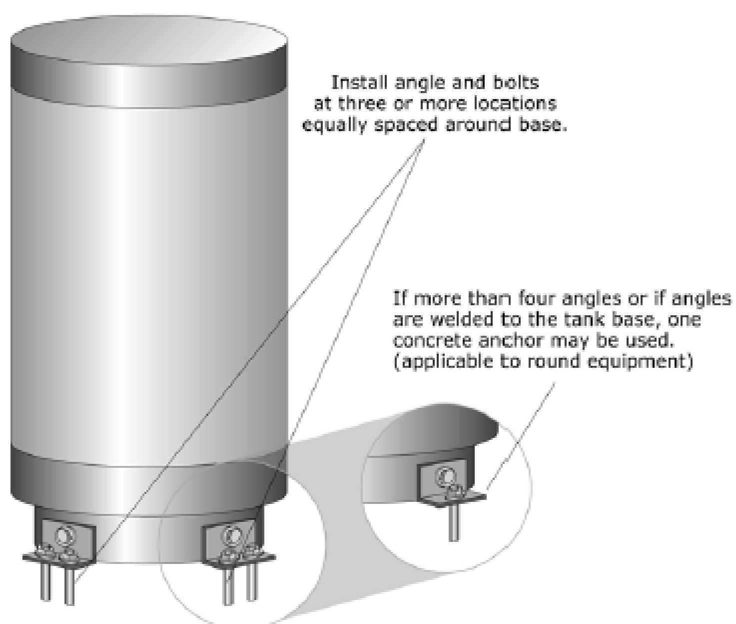


Figure G-35. Water Heater – Base Mounted.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

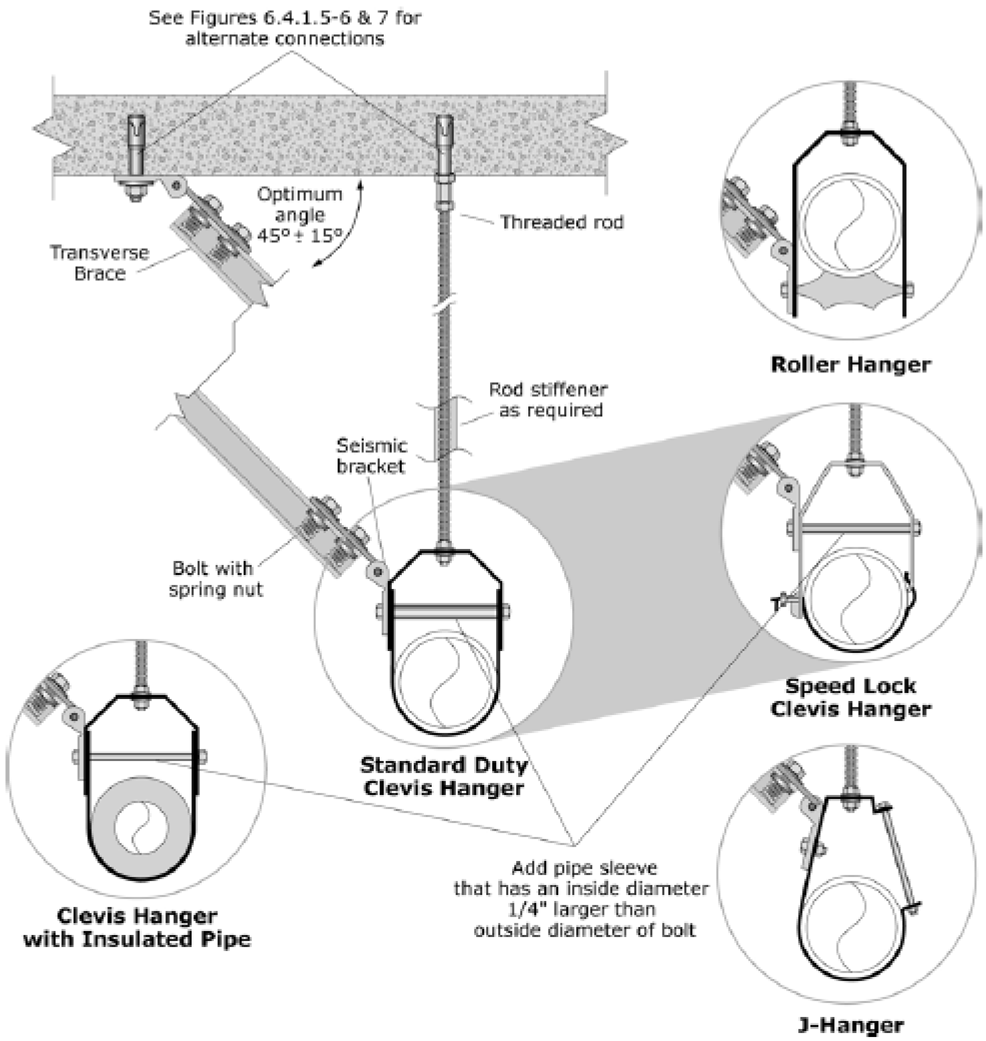


Figure G-36. Rigid Bracing – Single Pipe Transverse.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

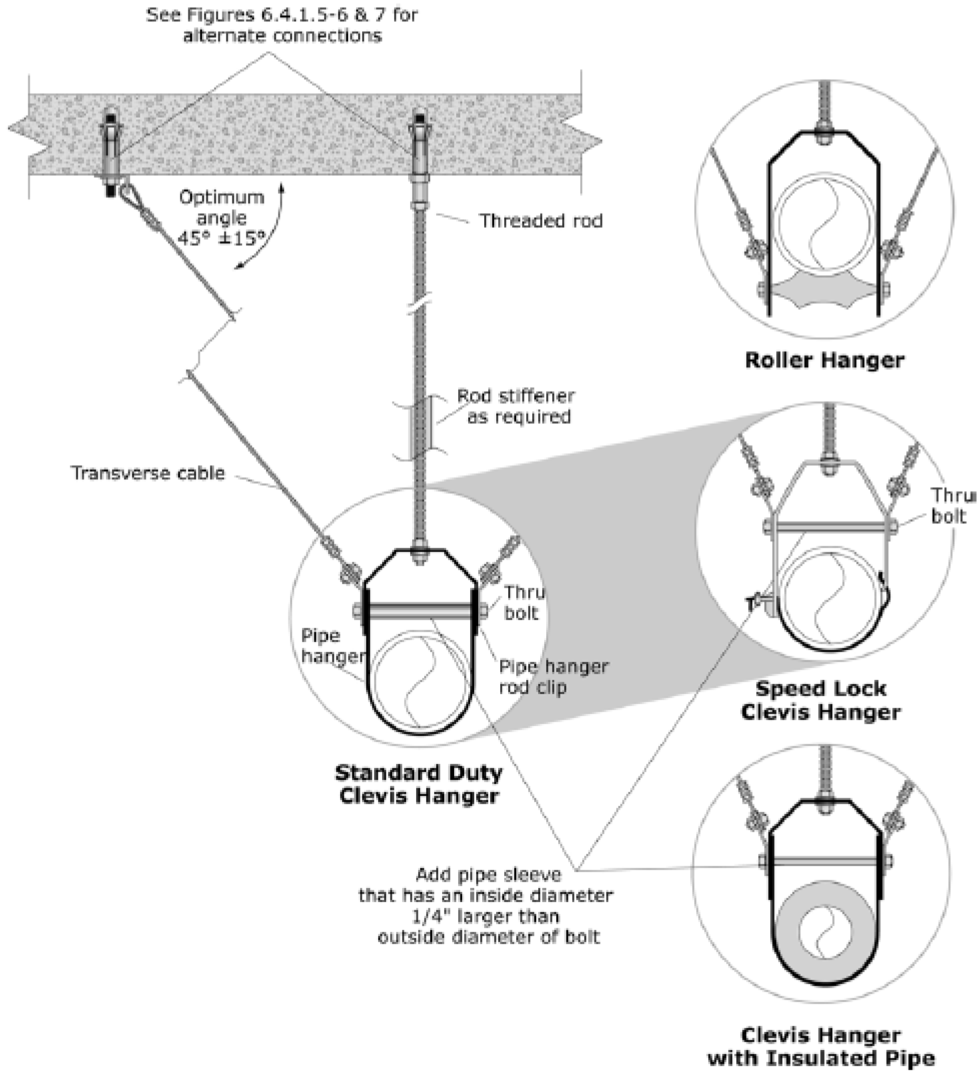


Figure G-37. Cable Bracing – Single Pipe Transverse.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Electrical and Communications

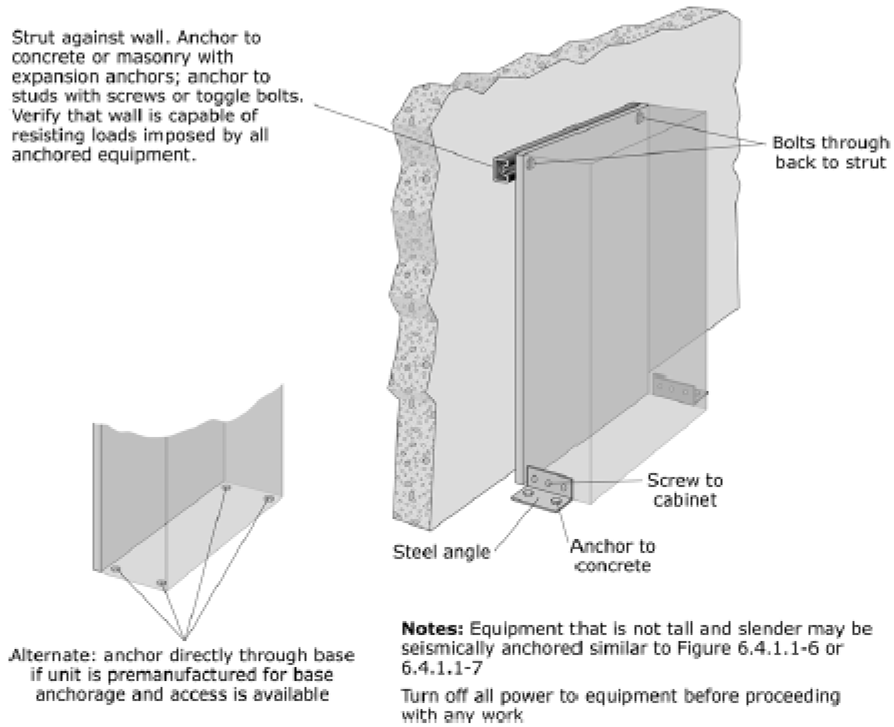


Figure G-38. Electrical Control Panels, Motor Controls Centers, or Switchgear.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

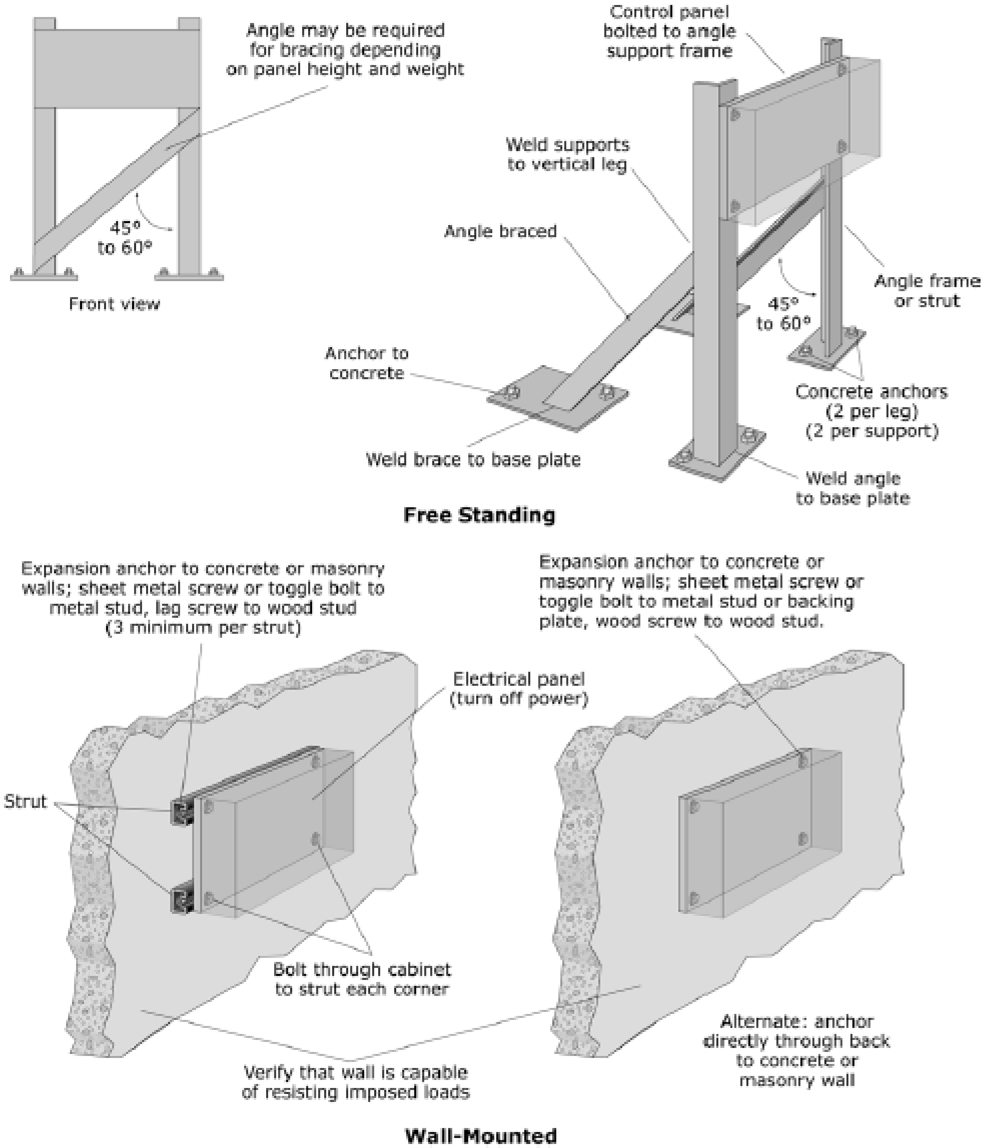


Figure G-39. Freestanding and Wall-mounted Electrical Control Panels, Motor Controls Centers, or Switchgear.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

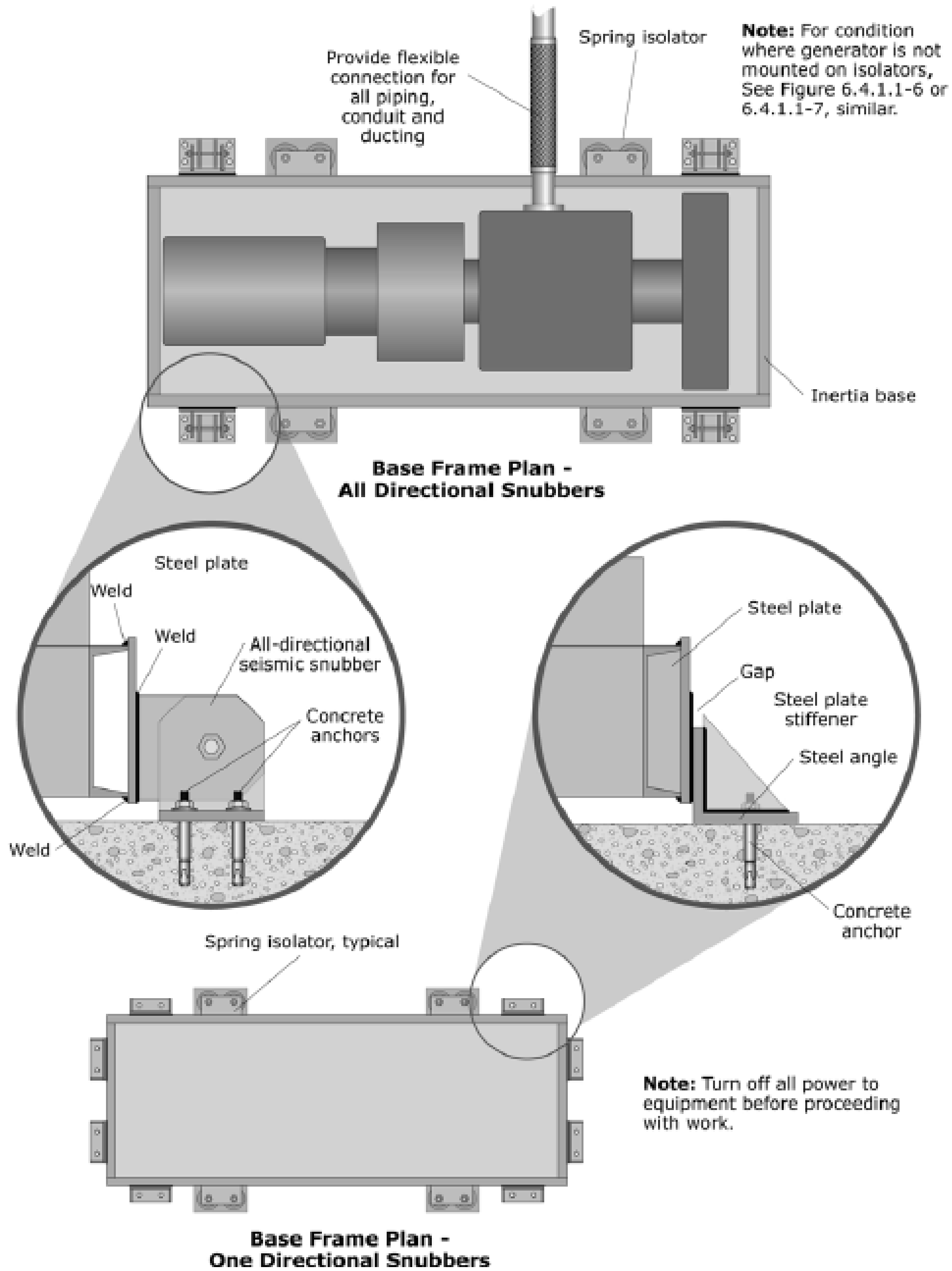


Figure G-40. Emergency Generator.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)