PHASE **2**


Washington State
School Seismic Safety Assessments Project

# MARY M. KNIGHT SCHOOL ELEMENTARY SCHOOL BUILDING

## Mary M. Knight School District 311

SEISMIC UPGRADES CONCEPT DESIGN REPORT

June 2021

PREPARED FOR

WASHINGTON DEPARTMENT OF NATURAL RESOURCES
SUPERINTENDENT OF PUBLIC INSTRUCTION WASHINGTON

PREPARED BY

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# WASHINGTON STATE SCHOOL SEISMIC SAFETY ASSESSMENTS PROJECT

# SEISMIC UPGRADES CONCEPT DESIGN REPORT

## Mary M. Knight School – Elementary School Building

Mary M. Knight School District 311

June 2021

Prepared for:

State of Washington
Department of Natural Resources

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# EXECUTIVE SUMMARY

This report documents the findings of a seismic evaluation of the Mary M. Knight Elementary School Main Building in Elma, Washington. This school building is a single-story, rectangular, 13,300-square-foot, wood-frame structure constructed in 1963. The building has two corridors arranged in a cruciform shape. There are approximately eight classrooms, including one science room, a library, and two administrative spaces. The mechanical room in the southeast corner of the building is accessed from the south façade. The roof framing system consists of tongue-and-groove straight sheathing over glulam beams at 8 feet on center. These beams are supported by girders at the corridor walls as well as at the exterior. Glulam posts and bearing walls carry roof gravity loads to traditional shallow footings. The first floor is similar: wood sheathing over tongue-and-groove straight sheathing, supported by a network for beams on short 6x6 posts at isolated pad footings or framing to a ledger supported at the exterior stem walls. The lateral system consists of straight-sheathed roof and elevated floor diaphragms. The roof loads are supported by the exterior walls and interior posts. Lateral loads are transferred through the roof and floor diaphragms to the exterior shear walls; none of the interior partition walls appears to be detailed to transfer shear.

WSP USA, Inc., 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 relate to three principal areas: first, shear walls, and second, diaphragm size and aspect ratio. Specifically, redundancy of shear walls, overstressing of existing shear walls, insufficiently braced wall lines with openings 80% of the length or more, and aspect ratio and spans of straight-sheathed diaphragms. Finally, many of the interior footings are neither tied together nor braced by surrounding soil, and there are no positive connections between the posts and the footings.

Conceptual seismic upgrade recommendations for the structural systems are provided to improve the performance of the building to meet the Life Safety structural performance objective criteria of ASCE 41-17. Sketches for the concept-level seismic upgrades are provided in Appendix B. The structural upgrades include adding shear walls to the exterior of the building, strengthening interior walls as shear walls along the corridor, plywood sheathing overlay on top of the existing tongue-and-groove decking, new concrete foundation stem walls in the crawlspace below the added interior shear walls, and positive clip connections of the crawlspace posts to the existing footings.

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 $1.22M and $2.29M with the baseline estimated total cost being $1.53M.

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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 | Architects-Engineers |
| 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

William Arild Johnson & Associates, April 18, 1963, existing drawings titled "Elementary-High School Building for the Mary M. Knight School District, No. 311" Matlock, Mason County, Washington

# 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.

Seventeen school buildings were selected in consultation with WGS and OSPI 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 school buildings. The concept-level seismic upgrades will include structural and nonstructural seismic upgrade recommendations, with concept-level sketches and rough order-of-magnitude (ROM) construction costs determined for each building. The 17 school buildings were selected from the list of schools with the intent of representing a variety of regions, building uses, construction eras, and construction materials.

The overall goal of the project is to provide a better understanding of the current seismic risk of our state's K-12 school buildings and what needs to be done to improve the buildings in accordance with ASCE 41 to meet seismic performance objectives.

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 school building records, such as relevant site data and record drawings, in advance of the field investigations. This research included searching school building records and contacting the districts and/or the Office of Superintendent of Public Instruction (OSPI) 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 41 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 assessments of the structural and nonstructural systems of the school buildings were performed in accordance with ASCE 41-17 Tier 1 Evaluation Procedures.

2. Conceptual Upgrades Design: Further seismic evaluation work was performed to provide concept-level seismic retrofits and/or upgrade designs for the selected school buildings based on the results of the Tier 1 seismic evaluations. The concept-level 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 school district 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 concept-level seismic upgrades report process, ProDims, LLC, provided opinions of probable construction costs for the concept-level seismic upgrade designs for the selected school buildings. These concept-level seismic upgrade designs and the associated opinions of probable construction costs are intended to be representative samples that can be extrapolated to estimate the overall capital needs of seismically upgrading Washington State schools.

### 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

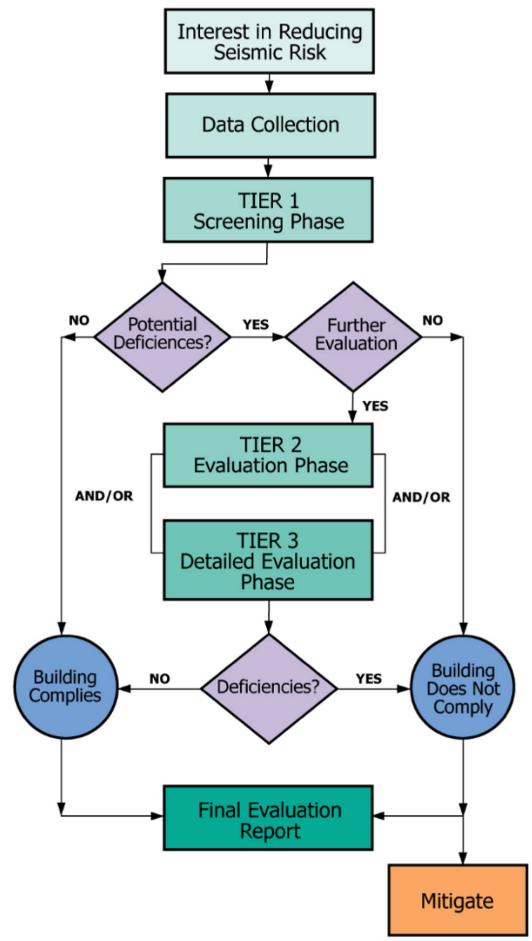


**Figure 2-1. Flow Chart and Description of ASCE 41 Seismic Evaluation Procedure.**

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. The Washington State Department of Natural Resources measured the time-averaged shear-wave velocity at each site to 30 meters (100 feet) below the ground surface, Vs30. This measured shear-wave velocity was used to determine the site class. The site class for this building was determined to be **Site Class C**.

### 2.2.2 Mary M. Knight Elementary School 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 1.253 g, and the design 1-second period spectral acceleration, $S_{D1}$, is 0.591 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 Mary M. Knight Elementary School that are considered in this study.

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

| BSE-1E<br>20%/50 (225-year) Event | | BSE-1N<br>2/3 of 2,475-year Event | | BSE-2E<br>5%/50 (975-year) Event | | BSE-2N<br>2%/50 (2,475-year) Event | |
|---|---|---|---|---|---|---|---|
| 0.2 Seconds | 0.676 g | 0.2 Seconds | 1.253 g | 0.2 Seconds | 1.406 g | 0.2 Seconds | 1.879 g |
| 1.0 Seconds | 0.237 g | 1.0 Seconds | 0.591 g | 1.0 Seconds | 0.67 g | 1.0 Seconds | 0.886 g |

### 2.2.3 Mary M. Knight Elementary School Structural Performance Objective

The school building is an Educational Group E occupancy (Risk Category III) structure and has not been identified as a critical structure requiring immediate use following an earthquake. However, Risk Category III buildings are structures that represent a substantial hazard to human life in the event of failure. According to ASCE 41, the BPOE for Risk Category III structures is the Damage Control structural performance level at the BSE-1E seismic hazard level and the Limited 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 **Life Safety** 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 Life-Safety performance level, the building may sustain damage while still protecting occupants from life-threatening injuries and allowing occupants to exit the building. Structural and nonstructural components may be extensively damaged, but some margin against the onset of partial or total collapse remains. Injuries to occupants or persons in the immediate vicinity may occur during an earthquake; however, the overall risk of life-threatening injury as a result of structural damage is anticipated to be low. Repairs may be required before reoccupying the building, and, in some cases, repairs may be economically unfeasible.

### *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). The school is classified in ASCE 41 Table 3-1 as a Wood Frame, Commercial or Industrial, shear wall building with flexible diaphragms, **W2**. Wood Frame, Commercial or Industrial, shear wall buildings (W2) include wood-framed buildings with a floor area of 5,000 square feet or more. Floor and roof frames consist of wood or steel trusses, glulam or steel beams, and wood posts or steel columns. Seismic forces are resisted by flexible diaphragms and exterior walls sheathed with plywood, oriented strand board, or straight or diagonal wood sheathing. Wall openings for storefronts and garages, where present, are framed by post-and-beam 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: 1963
Building Code: 1961 UBC

Number of Stories: 1
Floor Area: 12,900 SF

FEMA Building Type: W2
ASCE 41 Level of Seismicity: High
Site Class: C

The Mary M. Knight Elementary School Main Building is a single-story wood-framed building constructed in 1963. The building footprint is nearly rectangular, measuring approximately 170.5 feet by 74.5 feet, with a total area of 12,900 square feet. The building has a low-slope roof with an eave height of approximately 12 feet. The exterior walls at the two longitudinal walls have glazing at approximately 80% of the wall length, and 100% of the length of the north end wall is glazed. The building is situated on 3-foot-high raised concrete stem walls, with the interior wood-framed floor supported by posts on isolated concrete pads at the foundation.

### 3.1.2 Building Use

This building serves as the elementary school for the school district. There is a T-shaped central double-loaded corridor feeding several classrooms, a library, and a science classroom. The building has a large mechanical room at the south end, accessed from the exterior. The building also has a vault and office and a teacher space.

### 3.1.3 Structural System

**Table 3.1.3-1. Structural System Descriptions.**

| Structural System | Description |
|---|---|
| Structural Roof | The roof is wood framed with tongue-and-groove "car decking" laid up over wood beams reportedly at 8-foot centers. Some of the wood beams and girders are visible at the building interior. A metal roof appears to have been added after the original construction, but it is unclear if any upgrades or retrofits to the original roof structure have been made. |

**Table 3.1.3-1. Structural System Descriptions.**

| Structural System | Description |
|---|---|
| Structural Floor | The first floor is an elevated wood-framed system over crawlspace with wood structural sheathing applied to tongue-and-groove decking, supported by wood beams. The wood beams are supported by concrete stems at the exterior walls and a grid of isolated concrete pad footings with 6x6 posts (in most cases, these posts do not have any positive or shear connections). |
| Foundations | The exterior walls are supported by concrete stem walls. At the building interior is a grid of isolated concrete pad footings with 6x6 posts. The drawings indicate there is a dowel from footing to post, post to beam, to resist lateral movement, but these were not visually verified. The concrete pads appeared to be in good condition; however, it is unclear how deep into the soil they are embedded, and they are not interconnected. |
| Gravity System | Roof and floor loads are resisted by a tongue-and-groove decking on a system of beams and posts. There are a few bearing walls; however, these appear to be supported by beams and posts at the foundation level. |
| Lateral System | Roof and floor lateral loads appear to be transferred through straight-sheathed diaphragms to shear walls at the building exterior. The foundation plan does not suggest interior lines of resistance. The amount of wall available to resist shear at the two long walls appears very short, and there does not appear to be any shear walls at the north end wall. |

### 3.1.4 Structural System Visual Condition

**Table 3.1.4-1. Structural System Condition Descriptions.**

| Structural System | Description |
|---|---|
| Structural Roof | Good, no visible signs of damage or deterioration. |
| Structural Floor | Good, no visible signs of damage or deterioration. |
| Foundations | Fair. Minor hairline cracks at the exterior stem walls; however, no signs of settlement. The posts and interior isolated pad footings appeared to be in good condition. |
| Gravity System | Good, no visible signs of damage or deterioration. |
| Lateral System | Unknown. Locations of shear walls had to be inferred from the available exterior wall piers. |

## 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 |
|---|---|
| Redundancy | The building only appears to have a single line of resistance in the transverse direction. |
| Shear Stress Check | The wall piers inferred as shear walls are fairly short and appear to be overstressed. The length of glazing at three of the exterior walls results in a noncompliance for this check. |
| Openings | The north end wall has windows at 100% of its length with apparently no wood shear wall panel to brace the line. |
| Wood Posts | The drawings indicate a single steel dowel to resist shear loads. Site investigation indicated that some of the larger posts have positive connections but many of the posts do not. |
| Straight Sheathing | The aspect ratio is over 2 in the transverse direction, even if there was a shear wall at the north end wall (which there is not). |
| Spans | The roof appears to rely on straight sheathing (tongue-and-groove decking) to resist lateral loads. In both directions, the diaphragm appears required to span the full length from exterior wall to exterior wall. |

### 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 | "Very Low" liquefaction potential is identified per ICOS based on state geologic mapping. Requires further investigation by a licensed geotechnical engineer to determine liquefaction potential. |

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

| Deficiency | Description |
|---|---|
| Surface Fault Rupture | There does not appear to be record of surface faulting in this region; however, investigation by a licensed geotechnical engineer is necessary to verify the surface fault rupture potential. |
| Ties Between Foundation Elements | The construction drawings show the interior footings are partially buried in the surrounding soil; however, the site investigation revealed that they may simply be sitting on the soil surface. If they are partially buried, it is unclear if the soil was recompacted. Also, the liquefaction potential is believed to be low, but the soil site class is assumed to be D, thus it is unclear how effective the soil will be at bracing these footings. The A drawings indicate there are some 2x6 members bracing the posts near the connections to the footing, bracing back to the floor diaphragm. |
| Load Path and Transfer to Shear Walls | Connections of the roof diaphragm to shear walls and subsequently walls to foundations could not be visually verified during the site visit and the necessary information to confirm was not found on the available drawings. |

### 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-2 Tall Narrow Contents | Tall and narrow contents with a height more than 6 feet and a height-to-depth or height-to-width ratio greater than 3-to-1 should be anchored to the structure or to each other. |
| CF-3 Fall-Prone Contents | Equipment and stored items weighing more than 20 pounds whose center of mass is more than 4 feet above the adjacent floor level should be braced or otherwise restrained. |
| ME-1 Fall-Prone Equipment | There is a large tank suspended from the ceiling in the mechanical room. It has gravity supports, but it appears to lack any lateral bracing. |

### 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 school district 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 |
|---|---|
| HM-3 Hazardous Material Distribution | There are several smaller pipes in and around the boiler in the mechanical room; however, it is unclear which ones have hazardous materials or if they are properly braced. Further investigation is recommended. |
| HM-4 Shutoff Values | There appeared to be a fire alarm pull station adjacent to the boiler in the mechanical room; however, there did not appear to be any emergency shutoff switches. Further investigation is recommended. |
| HM-5 Flexible Couplings | There are several smaller pipes in and around the boiler in the mechanical room, but none of them appeared to have flexible couplings; it is unclear which pipes may require flexible couplings to comply with this check. Further investigation is recommended. |
| CG-8 Overhead Glazing | Several windows at the north end wall appear to be large enough to qualify for this check, but whether these panes were laminated annealed or heat-strengthened glass and detailed to remain in the frame when cracked is unknown. Further review is recommended. |

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# 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 Exterior Wood Shear Walls

Currently, there are no shear walls at the north exterior wall, which results in both a redundancy and opening deficiency. To mitigate these deficiencies, one or more shear walls should be added at the north exterior wall. To address the shear stress deficiency at the east and west exterior wall lines, additional shear wall length should be added at the exterior walls. The existing shear wall piers should be re-sheathed with a tighter panel edge-nailing pattern to achieve higher shear resistance. The conceptual retrofit plan in Appendix B shows the proposed shear wall locations.

### 4.1.2 Sheathe Select Interior Partition Walls for Shear Resistance

Select interior partition walls along the central corridors should be strengthened with plywood structural sheathing to behave as new interior shear walls. These will resist seismic loads in the two principal building directions and are intended to reduce the roof diaphragm ratio and long spans as well as mitigate the shear stress deficiency.

The conceptual retrofit plan in Appendix B shows proposed shear wall locations. These new shear walls will also require a new strip foundation to be added at the crawl space. The existing wall line will need to be temporarily shored to remove the existing crawl-space support beams, posts, and isolated pad footings, where they will be replaced with the new stem wall.

### 4.1.3 Structural Sheathing at Roof Diaphragm

The existing tongue-and-groove straight-sheathed roof is deficient in both aspect ratio and spans, thus the recommendation to add new interior shear walls below. However, in order to mitigate the diaphragm capacity deficiency, the existing tongue-and-groove straight-sheathed roof should be augmented by installing wood structural panels rated for sheathing. The existing decking can remain and serve as panel edge blocking. The existing roofing will have to be removed and replaced after the retrofits to the structural diaphragm are completed.

To mitigate the load path deficiency concern, the roof sheathing will be connected to the exterior and new interior shear walls to transfer shear. In addition, new continuous sheet metal (coil) straps should be added over wood blocking to create collector-distributer elements to deliver diaphragm loads to shear walls, where the diaphragm capacity is insufficient. Refer to the roof retrofit plan in Appendix B for suggested locations for new collector-distributor strap connections.

### 4.1.4 Added Stem Wall Foundations at New Interior Shear Walls

New concrete stem walls must be added below the interior partition walls that will be retrofitted to become shear walls. A concrete continuous strip footing will be required for each of these stem walls. In order to deliver the most economic design, stem walls may only be necessary directly below the shear walls above; however, it is recommended that the footings continue and interconnect as illustrated on the Foundation/Catwalk Retrofit Plan in Appendix B. This will provide additional bracing of the footings.

As many of these new foundation lines are required directly below partition walls above, and will intersect with existing pad footing supports, any load bearing gravity supports, whether posts and beams or bearing walls, will need to be temporarily shored until the stem wall construction is completed. The location of new strip footings without stem walls, serving merely to tie new footings together, can be adjusted to avoid interfering with existing floor supports.

Because of the rather generous head heights in the crawls space, it is expected that the ability for the contractor to construct formworks, pump in concrete, etc., will result in a reduced need to demolish the floor to create access.

### 4.1.5 Add Positive Connection Clips at Existing Footings

The construction drawings indicate that the typical floor support posts have a steel dowel from the isolated pad footing, running several inches into the support posts. This connection will provide some trivial resistance to shear load; however, this is not a positive connection. To mitigate this deficiency, sheet metal clips such as Simpson RPBZ retrofit post base clips or A35 clips should be installed at two opposite faces or opposite corners of each post. These clips will nail or screw into the wood post and shot pin into the concrete pad footing. These new clips will provide a positive connection as well as improved lateral resistance.

## 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 Washington State 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 Totem Middle School. 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, are 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 (classrooms, 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 to be in compliance with the ADA.

### *Hazardous Materials Survey*

Given the age of the building, existing construction elements such as floor tile and/or adhesive, pipe insulation, etc. could contain asbestos. A Hazardous Materials survey of the building should be performed prior to the start of any demolition work.

### *Interior Concrete Footings, Stem Walls Work*

Portions of floor sheathing and framing will need to be removed to provide access to interior foundation work. Attempting to match new floor finish with existing may prove difficult; replacing existing floor finish with new throughout work area may be required.

### *Exterior Wood Shear Walls*

Where existing shear walls are augmented and additional shear walls added, wood exterior siding must be removed and replaced with new to match existing. The integrity of the thermal envelope must be maintained; because of the extent of the work, insulation and vapor barrier must be upgraded to meet current code requirements. Wood-framed windows and doors in the exterior walls are substandard and should be replaced as part of this work.

Rooms in which windows in the exterior wall are replaced with plywood shear wall panels must be reevaluated to ensure current light and ventilation requirements are met.

Existing wood-framed windows and doors in the exterior walls are substandard and should be replaced as part of this work.

Portions of the existing suspended acoustical tile ceiling may need to be removed for access to shear wall to roof connections. 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 a part of an overall modernization project.

### Sheath Select Interior Partition Walls for Shear Resistance

Modified and new interior shear walls may require removal of the existing gyp board or plywood wall finishes. Fire-rated gypsum wall board should be installed over the plywood shear walls

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

### Structural Sheathing at Roof Diaphragm

Given the extent of additional nailing and new roof sheathing, this work would best be done in conjunction with a building reroof.

As part of a reroof project, we recommend installing an above-roof continuous rigid insulation of R-38 over the entire roof deck 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 achieve an R-49 rating.

### Added Shear Wall Foundation at New Interior Shear Walls

The modified and new interior shear walls will require modifications to existing foundations and some temporary shoring. Access through the existing floor to the crawl space is required. The flooring appears to be vinyl composition tiles and, 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.

### Add Positive Connection Clips at Existing Footings.

This work will take place within the crawl space and may require access through the existing floor structure in multiple locations, although vertical clearance in some areas appears to be generous. The new structural floor sheathing will need to flush out with existing floor sheathing all around the opening. New flooring will be required throughout the building, after VAT has been abated.

### Ceiling in Paths of Egress

The suspended ceiling in the main corridor 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 students and faculty evacuate the building following a seismic event. Portions of this ceiling will need to be removed to provide access to wall-roof seismic connections work. Depending on the extent of existing seismic bracing of ceiling grids, lights, ducts, etc., it might be cost-effective to replace the ceiling system.

#### *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 and facility 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*

Lockers lining the corridors will need to be removed to provide access for wall and floor/roof work. Lockers to be reinstalled in original locations and anchored to the corridor wall structure. Buildings often contain various tall and narrow furniture, such as shelving and storage units, that are freestanding away from any backing walls. High book shelving in the library, for example, can be highly susceptible to toppling if not anchored properly to the backing walls or to each other, and can become a life safety hazard. It is recommended that maintenance and facility staff verify that the tops of the shelving units are braced or anchored to the nearest backing wall or provide overturning base restraint. 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 students or faculty 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, creating falling hazards. Investigation of above-ceiling mechanical equipment and systems was not included in this study. 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 students and faculty below, further investigation by a structural engineer is recommended.

## 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 a -20% to +50%.

The estimated total cost (construction costs plus soft costs) to mitigate the deficiencies identified in the Tier 1 checklists of the Mary M. Knight Elementary School Main Building ranges between approximately $1.22M and $2.29M (-20%/+50%). The baseline estimated total cost to seismically upgrade this building is approximately $1.53M. On a per-square-foot basis, the baseline seismic upgrade cost is estimated to be approximately $118 per square foot in 4Q 2022 dollars, with a range between $94 per square foot and $177 per square foot.

### 4.5.1 Opinion of Probable Construction Costs

This conceptual opinion of construction cost 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 opinion 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 school staff and students 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 K-12 school 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 4$^{th}$ 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) |
|---|---|---|---|---|---|---|---|
| Mary M. Knight Elementary School Main Bldg | W2 | High / D | **Structural** | | | | |
| | | | Life Safety | 12,900 SF | $52 ($670K) - | $97 ($1.26M) | $65 ($838K) |
| | | | **Nonstructural** | | | | |
| | | | Life Safety | 12,900 SF | $16 ($201K) - | $29 ($377K) | $19 ($251K) |
| | | | **Total** | | | | |
| | | | | 12,900 SF | $68 ($871K) - | $126 ($1.63M) | $84 ($1.09M) |
| | | | | | | Estimated Soft Costs: | $436K |
| | | | | | | **Total Estimated Project Costs:** | **$1.53M** |

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

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# Appendix A: ASCE 41 Tier 1 Screening Report

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# 1. Mary M Knight, Mary M. Knight School, Elementary School

## 1.1 Building Description

| | |
|---|---|
| Building Name: | Elementary School |
| Facility Name: | Mary M. Knight School |
| District Name: | Mary M Knight |
| ICOS Latitude: | 47.1993 |
| ICOS Longitude: | -123.4322 |
| ICOS Building ID: | 50921 |
| ASCE 41 Bldg Type: | W2 |
| Enrollment: | 166 |
| Gross Sq. Ft. : | 13,333 |
| Year Built: | 1963 |
| Number of Stories: | 1 |
| $S_{XS\ BSE\text{-}2E}$: | 1.406 |
| $S_{X1\ BSE\text{-}2E}$: | 0.67 |
| ASCE 41 Level of Seismicity: | High |
| Site Class: | C |
| $V_{S30}$(m/s): | 427 |
| Liquefaction Potential: | Very Low |
| Tsunami Risk: | No |
| Structural Drawings Available: | Partial |
| Evaluating Firm: | WSP |

** Liquification Potential and Tsunami Risk is based on publicly available state geologic hazard mapping.*


This building is a single-story wood-framed building constructed in 1963. The building footprint is nearly rectangular, measuring approximately 170.5 feet by 74.5 feet, with a total area of 13,333 square feet. The building has a low-slope roof with an eave height of approximately 12 feet. The exterior walls at the two longitudinal walls have glazing at approximately 80% of the wall length, and 100% of length of the north endwall is glazed. The building is situated on 3-foot height raised concrete stem walls, with the interior wood framed floor supported by posts on isolated concrete pads, at the foundation.

### 1.1.1 Building Use

This building serves as the elementary school for the school district. There is a T-shaped central double-loaded corridor feeding several classrooms, a library and a science class room. The building has a large mechanical room at the south end, accessed from the exterior. The building also has a vault and office and a teacher space.

### 1.1.2 Structural System

**Table 1-1. Structural System Description of Mary M. Knight School**

| Structural System | Description |
|---|---|
| Structural Roof | The roof is wood framed with tongue-and-groove "car decking" laid up over wood beams reportedly at 8-foot centers. Some of the wood beams and girders are visible at the building interior. A metal roof appears to have been added after the original construction, but it is unclear if any upgrades or retrofits to the original roof structure have been made. |
| Structural Floor(s) | The first floor is an elevated wood-framed system with wood structural sheathing applied to tongue-and-groove decking, supported by wood beams. The wood beams are supported by concrete stems at the exterior walls and a grid of isolated concrete pad footings with 6x6 posts (in most cases, these posts do not have any positive or shear connections). |
| Foundations | The exterior walls are supported by concrete stem walls. At the building interior is a grid of isolated concrete pad footings with 6x6 posts. The drawings indicate there is a dowel from footing to post, post to beam, to resist lateral movement, but these were not visually verified. The concrete pads appeared to be in good condition, however, it is unclear how deep into the soil they are embedded and they are not interconnected. |
| Gravity System | Roof and floor loads are resisted by a tongue and groove decking on a system of beams and posts. There are a few bearing walls, however these appear to be supported by beams and posts at the foundation level. |
| Lateral System | Roof and floor lateral loads appear to be transferred through straight-sheathing to shear walls at the building exterior. The foundation plan does not suggest interior lines of resistance. The amount of wall available to resist shear at the two long walls appears very short, and there does not appear to be any shear walls at the north end wall. |

### 1.1.3 Structural System Visual Condition

**Table 1-2. Structural System Condition Description of Mary M. Knight School**

| Structural System | Description |
|---|---|
| Structural Roof | Good, no visible signs of damage or deterioration. |
| Structural Floor(s) | Good, no visible signs of damage or deterioration. |
| Foundations | Fair. Minor hairline cracks at the exterior stem walls, however no signs of settlement. The posts and interior isolated pad footings appeared to be in good condition. |
| Gravity System | Good, no visible signs of damage or deterioration. |

| | |
|---|---|
| Lateral System | Unknown. Locations of shear walls had to be inferred from the available exterior wall piers. |

**Figure 1-1. Main corridor at front rear entrance.**

**Figure 1-2. Typical hallway with lockers.**

**Figure 1-3. View in administrative area.**

**Figure 1-4. Panoramic view of classroom.**

**Figure 1-5. Panoramic view of classroom.**

**Figure 1-6. View of Library.**

**Figure 1-7. Crawl space below school.**

**Figure 1-8. North façade of building.**

**Figure 1-9. East façade of building.**

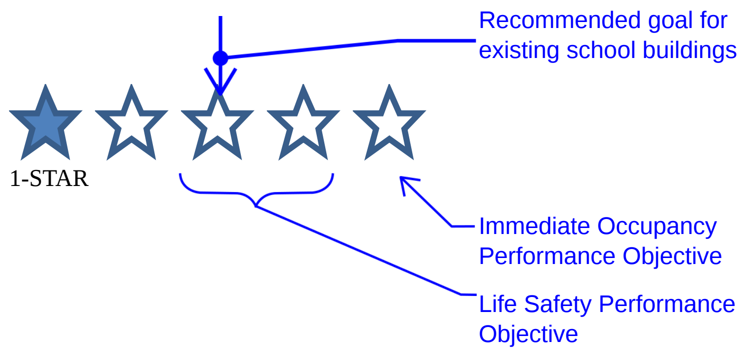
**Figure 1-10. Exposed roof framing at interior.**

## *1.1.4 Earthquake Performance Rating System - Structural Safety Rating*

The seismic evaluation items from the ASCE 41 Tier 1 seismic evaluation checklist have been translated to a Structural Safety star-rating using the *EPRS ASCE 41-13 Translation Procedure*. There are two other safety sub-ratings using the EPRS *Translation Procedure*: a Geologic safety sub-rating and a Nonstructural safety sub-rating, that are not included below.

The structural safety star-rating below is a preliminary rating based on the information available for this study. The geologic checklist items have been excluded from the structural safety star-rating. If a building's structural safety star-rating is to be improved, it may also be necessary to further assess the geologic conditions of the building site. Determining the final star-rating of a building is intended to be an iterative process and preliminary ratings will often times be conservative until more field investigation, structural analysis, and engineering judgment is performed by a structural engineer. The intent in providing a preliminary star-rating as part of this study is to provide school districts with the action lists below to further improve the seismic performance and safety of the buildings that were assessed. The tables below indicate the Unknown (U) or Noncompliant (NC) structural seismic evaluation items that should be mitigated or further investigated to improve the Earthquake Performance Rating System (EPRS) structural safety rating for this building.

**EPRS Structural Safety Rating for Mary M. Knight School, Elementary School:**




| | | |
|---|---|---|
| 1-STAR | ★ | Risk of Collapse in Multiple or Widespread Locations (Expected performance as a whole would lead to multiple or widespread conditions known to be associated with earthquake-related collapse resulting in injury, entrapment, or death.) |
| 2-STAR | ★★ | Risk of Collapse in Isolated Locations (Expected performance in certain locations within or adjacent to the building would lead to conditions known to be associated with earthquake-related collapse resulting in injury, entrapment, or death.) |
| 3-STAR | ★★★ | Loss of Life Unlikely (Expected performance results in conditions that are unlikely to cause severe structural damage or loss of life). A 3-star rating meets the Tier 1 Life Safety (LS) structural performance objective. |
| 4-STAR | ★★★★ | Serious Injuries Unlikely (Expected performance results in conditions that are associated with limited structural damage and are unlikely to cause serious injuries). |
| 5-STAR | ★★★★★ | Injuries and Entrapment Unlikely (Expected performance results in conditions that are associated with minimal structural damage and are unlikely to cause injuries or keep people from exiting the building). A 5-star rating meets the Tier 1 Immediate Occupancy (IO) structural performance objective. |

**Table 1-3. Identified Seismic Evaluation Items to Address for an improved 2-STAR Rating**

| Evaluation Item | Tier 1 Screening | Description |
|---|---|---|
| Load Path | Unknown | Connections of the roof diaphragm to shear walls and subsequently walls to foundations could not be visually verified during the site visit and the necessary information to confirm was not found on the available drawings. |
| Shear Stress Check | Noncompliant | The wall piers inferred as shear walls are fairly short and appear to be overstressed. The length of glazing at three of the exterior walls results in a noncompliance for this check. |
| Openings | Noncompliant | The north end wall has windows at 100% of its length with apparently no wood shear wall panel to brace the line. |

Note: All of the evaluation items in Table 3 need to be assessed as Compliant (C) in order to achieve a 2-Star Structural Safety Rating.

**Table 1-4. Additional Seismic Evaluation Items to Mitigate or Further Investigate for an improved 3-STAR Rating**

| Evaluation Item | Tier 1 Evaluation | Description |
|---|---|---|
| Ties Between Foundation Elements | Unknown | The construction drawings show the interior footings are partially buried in the surrounding soil, however the site investigation revealed that they may simply be sitting on the soil surface. If they are partially buried, it is unclear if the soil was recompacted. Also, the liquefaction potential is believed to be low, but the soil site class is assumed to be D, thus it is unclear how effective the soil will be at bracing these footings. The A drawings indicate there are some 2x6 members bracing the posts near the connections to the footing, bracing back to the floor diaphragm. |
| Redundancy | Noncompliant | The building only appears to have a single line of resistance in the transverse direction. |
| Wood Posts | Noncompliant | The drawings indicate a single steel dowel to resist shear loads. Site investigation indicated that some of the larger posts have positive connections, but many of the posts do not. |
| Straight Sheathing | Noncompliant | The aspect ratio is over 2 in the transverse direction, even if there was a shear wall at the north end wall (which there is not). |
| Spans | Noncompliant | The roof appears to rely on straight sheathing (tongue-and-groove decking) to resist lateral loads. In both directions, the diaphragm appears required to span the full length from exterior wall to exterior wall. |

Note: Tables 3 and 4 are cumulative. All of the evaluation items in Table 4 need to be assessed as Compliant (C) in addition to all of the evaluation items in Table 3 being assessed as Compliant (C), in order to achieve a 3-Star Structural Safety Rating.

The Structural Safety star-rating contained in this report is based on ASCE 41 Tier 1 Screening Checklists only. These seismic screening checklists are often the first step employed by structural engineers when trying to determine the seismic vulnerabilities of existing buildings and to begin a process of mitigating these seismic vulnerabilities. School district facilities management personnel and their design consultants should be able to take advantage of this information to help inform and address seismic risks in existing or future renovation, repair, or modernization projects.

It is important to note that information used for these school seismic screenings was limited to available construction drawings and limited site observations by our team of licensed structural engineers. In some cases, construction drawings were not available for review. Due to the limited scope of the study, our team of engineers were not able to perform more-detailed investigations above ceilings, behind wall finishes, in confined spaces, or in other areas obstructed from view. In many cases, further investigation and engineering analysis may find that items marked as unknown or noncompliant may not require seismic mitigation if it is shown that the existing structure is acceptable in its current state. In these cases, further investigation and engineering analysis should be conducted ahead of a seismic upgrade construction project, especially when a building is marked as having many unknown items.

## 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 1-5. Identified Structural Seismic Deficiencies for Mary M Knight Mary M. Knight School Elementary School**

| Deficiency | Description |
|---|---|
| Redundancy | The building only appears to have a single line of resistance in the transverse direction. |
| Shear Stress Check | The wall piers inferred as shear walls are fairly short and appear to be overstressed. The length of glazing at three of the exterior walls results in a noncompliance for this check. |
| Openings | The north end wall has windows at 100% of its length with apparently no wood shear wall panel to brace the line. |
| Wood Posts | The drawings indicate a single steel dowel to resist shear loads. Site investigation indicated that some of the larger posts have positive connections, but many of the posts do not. |
| Straight Sheathing | The aspect ratio is over 2 in the transverse direction, even if there was a shear wall at the north end wall (which there is not). |
| Spans | The roof appears to rely on straight sheathing (tongue-and-groove decking) to resist lateral loads. In both directions, the diaphragm appears required to span the full length from exterior wall to exterior wall. |

### *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 1-6. Identified Structural Checklist Items Marked as Unknown for Mary M Knight Mary M. Knight School Elementary School**

| Unknown Item | Description |
|---|---|
| Load Path | Connections of the roof diaphragm to shear walls and subsequently walls to foundations could not be visually verified during the site visit and the necessary information to confirm was not found on the available drawings. |
| Liquefaction | The liquefaction potential of site soils is unknown at this time given available information. Very Low liquefaction potential is identified per ICOS based on state geologic mapping. Requires further investigation by a licensed geotechnical engineer to determine liquefaction potential. |
| Surface Fault Rupture | There does not appear to be record of surface faulting in this region; however, investigation by a licensed geotechnical engineer is necessary to verify the surface fault rupture potential. |
| Ties Between Foundation Elements | The construction drawings show the interior footings are partially buried in the surrounding soil, however the site investigation revealed that they may simply be sitting on the soil surface. If they are partially buried, it is unclear if the soil was recompacted. Also, the liquefaction potential is believed to be low, but the soil site class is assumed to be D, thus it is unclear how effective the soil will be at bracing these footings. The A drawings indicate there are some 2x6 members bracing the posts near the connections to the footing, bracing back to the floor diaphragm. |

### *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 1-7. Identified Nonstructural Seismic Deficiencies for Mary M Knight Mary M. Knight School Elementary School**

| Deficiency | Description |
|---|---|
| CF-2 Tall Narrow Contents. HR-not required; LS-H; PR-MH. | Tall and narrow contents with a height more than 6 feet and a height-to-depth or height-to-width ratio greater than 3-to-1 should be anchored to the structure or to each other. |
| CF-3 Fall-Prone Contents. HR-not required; LS-H; PR-H. | Equipment and stored items weighing more than 20 lb whose center of mass is more than 4 ft above the adjacent floor level should be braced or otherwise restrained. |
| ME-1 Fall-Prone Equipment. HR-not required; LS-H; PR-H. | There is a large tank suspended from the ceiling in the Mechanical room. It has gravity supports, but it appears to lack any lateral bracing. |

### *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 1-8. Identified Nonstructural Checklist Items Marked as Unknown for Mary M Knight Mary M. Knight School Elementary School**

| Unknown Item | Description |
|---|---|
| HM-3 Hazardous Material Distribution. HR-MH; LS-MH; PR-MH. | There are several smaller pipes in and around the boiler in the Mechanical room, however it is unclear which ones have hazardous materials or if they are properly braced. Further investigation recommended. |
| HM-4 Shutoff Valves. HR-MH; LS-MH; PR-MH. | There appeared to be a fire alarm pull station adjacent to the boiler in the Mechanical room, however, there did not appear to be any emergency shutoff switches. Further investigation recommended. |
| HM-5 Flexible Couplings. HR-LMH; LS-LMH; PR-LMH. | There are several smaller pipes in and around the boiler in the Mechanical room, but none of them appeared to have flexible couplings; it is unclear which pipes may require flexible couplings to comply with this check. Further investigation recommended. |
| CG-8 Overhead Glazing. HR-not required; LS-MH; PR-MH. | Several windows at the north end wall appear to be large enough to qualify for this check, but whether these panes were laminated annealed or heat-strengthened glass and detailed to remain in the frame when cracked is unknown. Recommend further review. |

## Mary M Knight, Mary M. Knight School, Elementary School

## 17-2 Collapse Prevention 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.

### 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 | Connections of the roof diaphragm to shear walls and subsequently walls to foundations could not be visually verified during the site visit and the necessary information to confirm was not found on the available drawings. |
| 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 | | | | |
| 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 | | Building is a single story structure and does not appear to have a mezzanine. |

**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 | | Building 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 | | Building 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 | | Building 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 | | Building 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 | | Building 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 | | Flexible diaphragms are not subject to torsion. |

## Moderate Seismicity (Complete the Following Items in Addition to the Items for 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 | The liquefaction potential of site soils is unknown at this time given available information. Very Low liquefaction potential is identified per ICOS based on state geologic mapping. 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 | | The building is on a 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 | There does not appear to be record of surface faulting in this region; however, investigation by a licensed geotechnical engineer is necessary to verify the surface fault rupture potential. |

## 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 | | | | The inferred wall piers currently used as shear walls appear long enough to make this check compliant. |
| 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 | The construction drawings show the interior footings are partially buried in the surrounding soil, however the site investigation revealed that they may simply be sitting on the soil surface. If they are partially buried, it is unclear if the soil was recompacted. Also, the liquefaction potential is believed to be low, but the soil site class is assumed to be D, thus it is unclear how effective the soil will be at bracing these footings. The A drawings indicate there are some 2x6 members bracing the posts near the connections to the footing, bracing back to the floor diaphragm. |

## 17-6 Collapse Prevention Structural Checklist for Building Type W2

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.

## Low and Moderate 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 | | | The building only appears to have a single line of resistance in the transverse direction. |
| Shear Stress Check | The shear stress in the shear walls, calculated using the Quick Check procedure of Section 4.4.3.3, is less than the following values: Structural panel sheathing – 1,000 lb/ft; Diagonal sheathing – 700 lb/ft; Straight sheathing – 100 lb/ft; All other conditions – 100 lb/ft. (Tier 2: Sec. 5.5.3.1.1; Commentary: Sec. A.3.2.7.1) | | X | | | The wall piers inferred as shear walls are fairly short and appear to be overstressed. The length of glazing at three of the exterior walls results in a noncompliance for this check. |
| Stucco (Exterior Plaster) Shear Walls | Multi-story buildings do not rely on exterior stucco walls as the primary seismic-force-resisting system. (Tier 2: Sec. 5.5.3.6.1; Commentary: Sec. A.3.2.7.2) | | | X | | Building is a single story structure, thus this check is not applicable. However, no stucco was found. |
| Gypsum Wallboard or Plaster Shear Walls | Interior plaster or gypsum wallboard is not used for shear walls on buildings more than one story high with the exception of the uppermost level of a multi-story building. (Tier 2: Sec. 5.5.3.6.1; Commentary: Sec. A.3.2.7.3) | | | X | | Building is a single story structure, thus this check is not applicable. However, given the lack of a load path at the foundation level for supposed interior shear walls, it does not appear interior walls were used as shear walls. |
| Narrow Wood Shear Walls | Narrow wood shear walls with an aspect ratio greater than 2-to-1 are not used to resist seismic forces. (Tier 2: Sec. 5.5.3.6.1; Commentary: Sec. A.3.2.7.4) | X | | | | |
| Walls Connected Through Floors | Shear walls have an interconnection between stories to transfer overturning and shear forces through the floor. (Tier 2: Sec. 5.5.3.6.2; Commentary: Sec. A.3.2.7.5) | | | X | | The walls are directly connected to the foundation walls, and the first floor diaphragm is attached to the face of the same stem walls. There does not appear to be any holdowns, however. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Hillside Site | For structures that are taller on at least one side by more than one-half story because of a sloping site, all shear walls on the downhill slope have an aspect ratio less than 1-to-1. (Tier 2: Sec. 5.5.3.6.3; Commentary: Sec. A.3.2.7.6) | | | X | | Building is located on a flat site. |
| Cripple Walls | Cripple walls below first-floor-level shear walls are braced to the foundation with wood structural panels. (Tier 2: Sec. 5.5.3.6.4; Commentary: Sec. A.3.2.7.7) | | | X | | The cripple walls are concrete. |
| Openings | Walls with openings greater than 80% of the length are braced with wood structural panel shear walls with aspect ratios of not more than 1.5-to-1 or are supported by adjacent construction through positive ties capable of transferring the seismic forces. (Tier 2: Sec. 5.5.3.6.5; Commentary: Sec. A.3.2.7.8) | | X | | | The north end wall has windows at 100% of its length with apparently no wood shear wall panel to brace the line. |

**Connections**

| EVALUATION ITEM | EVALUATION STATEMENT | C | NC | N/A | U | COMMENT |
|---|---|---|---|---|---|---|
| Wood Posts | There is a positive connection of wood posts to the foundation. (Tier 2: Sec. 5.7.3.3; Commentary: Sec. A.5.3.3) | | X | | | The drawings indicate a single steel dowel to resist shear loads. Site investigation indicated that some of the larger posts have positive connections, but many of the posts do not. |
| Wood Sills | All wood sills are bolted to the foundation. (Tier 2: Sec. 5.7.3.3; Commentary: Sec. A.5.3.4) | X | | | | |
| 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 | | | | |

## High Seismicity **(Complete the Following Items in Addition to the Items for Low & Moderate Seismicity)**

**Connections**

| EVALUATION ITEM | EVALUATION STATEMENT | C | NC | N/A | U | COMMENT |
|---|---|---|---|---|---|---|
| Wood Sill Bolts | Sill bolts are spaced at 6 ft (1.8 m) or less with acceptable edge and end distance provided for wood and concrete. (Tier 2: Sec. 5.7.3.3; Commentary: Sec. A.5.3.7) | X | | | | Drawings indicate 1/2" bolts at 48 inch spacing. |

**Diaphragms**

| EVALUATION ITEM | EVALUATION STATEMENT | C | NC | N/A | U | COMMENT |
|---|---|---|---|---|---|---|
| Diaphragm Continuity | The diaphragms are not composed of split-level floors and do not have expansion joints. (Tier 2: Sec. 5.6.1.1; Commentary: Sec. A.4.1.1) | X | | | | |
| Roof Chord Continuity | All chord elements are continuous, regardless of changes in roof elevation. (Tier 2: Sec. 5.6.1.1; Commentary: Sec. A.4.1.3) | X | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Diaphragm Reinforcement at Openings | There is reinforcing around all diaphragm openings larger than 50% of the building width in either major plan dimension. (Tier 2: Sec. 5.6.1.5; Commentary: Sec. A.4.1.8) | | | X | | No large diaphragm openings were found. |
| Straight Sheathing | All straight-sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered. (Tier 2: Sec. 5.6.2; Commentary: Sec. A.4.2.1) | | X | | | The aspect ratio is over 2 in the transverse direction, even if there was a shear wall at the north end wall (which there is not). |
| Spans | All wood diaphragms with spans greater than 24 ft (7.3 m) consist of wood structural panels or diagonal sheathing. (Tier 2: Sec. 5.6.2; Commentary: Sec. A.4.2.2) | | X | | | The roof appears to rely on straight sheathing (tongue-and-groove decking) to resist lateral loads. In both directions, the diaphragm appears required to span the full length from exterior wall to exterior wall. |
| Diagonally Sheathed and Unblocked Diaphragms | All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 40 ft (12.2 m) and have aspect ratios less than or equal to 4-to-1. (Tier 2: Sec. 5.6.2; Commentary: Sec. A.4.2.3) | | | X | | Diaphragms appear to be straight sheathed. |
| Other Diaphragms | The 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 | | | | |

## Mary M Knight, Mary M. Knight School, Elementary School

## 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 | | No fire suppression system found. |
| 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 | | No fire suppression system found. |
| 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 | | |
| 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 | | No fire suppression system found. |
| 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 | | No equipment mounted on vibration isolators was found. |
| 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 | | Hazardous material storage not found in the building. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 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 | There are several smaller pipes in and around the boiler in the Mechanical room, however it is unclear which ones have hazardous materials or if they are properly braced. Further investigation recommended. |
| 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 | There appeared to be a fire alarm pull station adjacent to the boiler in the Mechanical room, however, there did not appear to be any emergency shutoff switches. Further investigation recommended. |
| 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 | There are several smaller pipes in and around the boiler in the Mechanical room, but none of them appeared to have flexible couplings; it is unclear which pipes may require flexible couplings to comply with this check. Further investigation recommended. |
| 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 | | No seismic joints found. |

**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 or masonry partitions 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 | | No URM or masonry partitions found. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 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 | | No rigid cementitious partitions found. |
| 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 | | No suspended lath and plaster ceilings observed. |
| 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 | | No suspended gypsum board ceilings observed. |
| 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 | | |

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|---|---|---|---|---|---|---|
| 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 | | Suspended grid ceiling system not observed. Most lights are either pendant supported or appear to be attached directly to the underside of the roof. |
| 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 | | No cladding or glazing systems found. |
| 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 | | No cladding or glazing systems found. |
| 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 | | No cladding or glazing systems found, and building is a single story structure. |
| CG-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 | | No cladding or glazing systems found. |
| 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 | | No cladding or glazing systems found. |

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|---|---|---|---|---|---|---|
| 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 | | No cladding or glazing systems found. |
| 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 | | No cladding or glazing systems found. |
| 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 | Several windows at the north end wall appear to be large enough to qualify for this check, but whether these panes were laminated annealed or heat-strengthened glass and detailed to remain in the frame when cracked is unknown. Recommend further review. |

**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 | | No masonry veneer found on this building. |
| 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 | | No masonry veneer found on this building. |
| 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 | | No masonry veneer found on this building. |
| 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 | | No masonry veneer found on this building. |
| 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 | | No masonry veneer found on this building. |

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| 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 | | No masonry veneer found on this building. |
| 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 | | No URM parapets or cornices were observed. |
| 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 | | Building has no concrete parapets. |
| 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 | | No masonry chimneys found. |
| 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 | | No masonry chimneys found. |

**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 | | No stairs found, building is a single story structure. |
| 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 | | No stairs found, building is a single story structure. |

**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 | | Industrial storage racks or pallet racks not found. |

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|---|---|---|---|---|---|---|
| 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 | | | Tall and narrow contents with a height more than 6 feet and a height-to-depth or height-to-width ratio greater than 3-to-1 should be anchored to the structure or to each other. |
| 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 | | | Equipment and stored items weighing more than 20 lb whose center of mass is more than 4 ft above the adjacent floor level should be braced or otherwise restrained. |
| 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 | | |

**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 | | | There is a large tank suspended from the ceiling in the Mechanical room. It has gravity supports, but it appears to lack any lateral bracing. |
| 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 | | No in-line equipment observed. |
| 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 | | No tall narrow mechanical equipment observed. |
| 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 | | |

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|---|---|---|---|---|---|---|
| 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 | | Building is a single story structure, no elevator was found. |
| 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 | | Building is a single story structure, no elevator was found. |
| 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 | | |

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| 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 | | |

# Appendix B: Concept-Level Seismic Upgrade Figures

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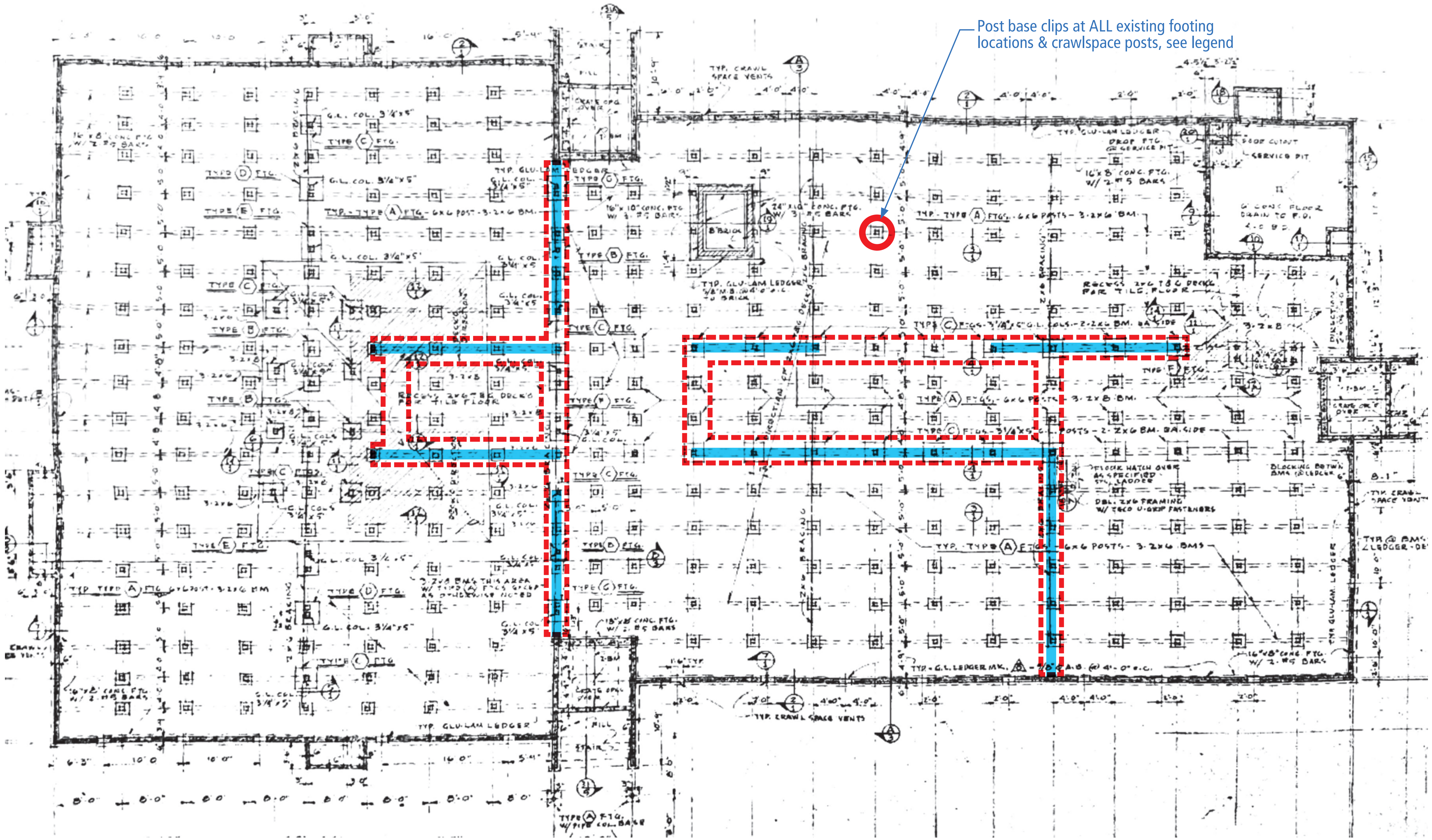



**LEGEND**

- Add New 8" Wide Concrete Stem Wall Centered Under New Interior Shear Walls (Refer To First Floor Retrofit Plan)
- Add New 24" Wide X 12" Deep Concrete Continuous Strip Footings As Indicated; Min. 9" Embedment Into Competent Soil
- Add New Post Base Clip At All Post-To-Footing Locations, Minimum 2 Per Post, Locate Clips On Opposite Faces Or Corners, See Illustration Below

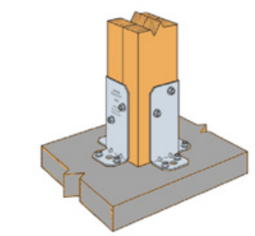
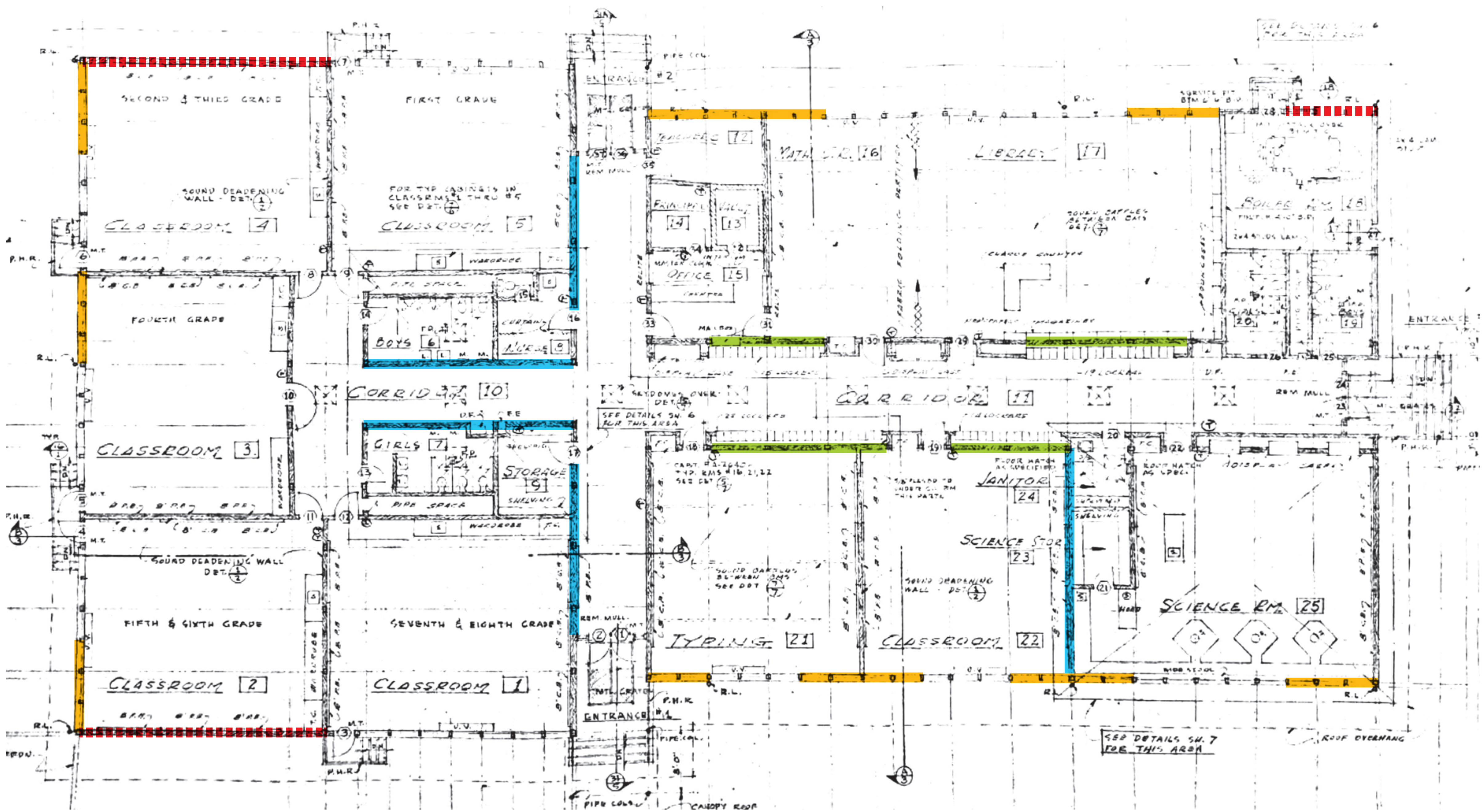




**Figure 1 –** Foundation/Crawl-Space Retrofit Plan




### LEGEND

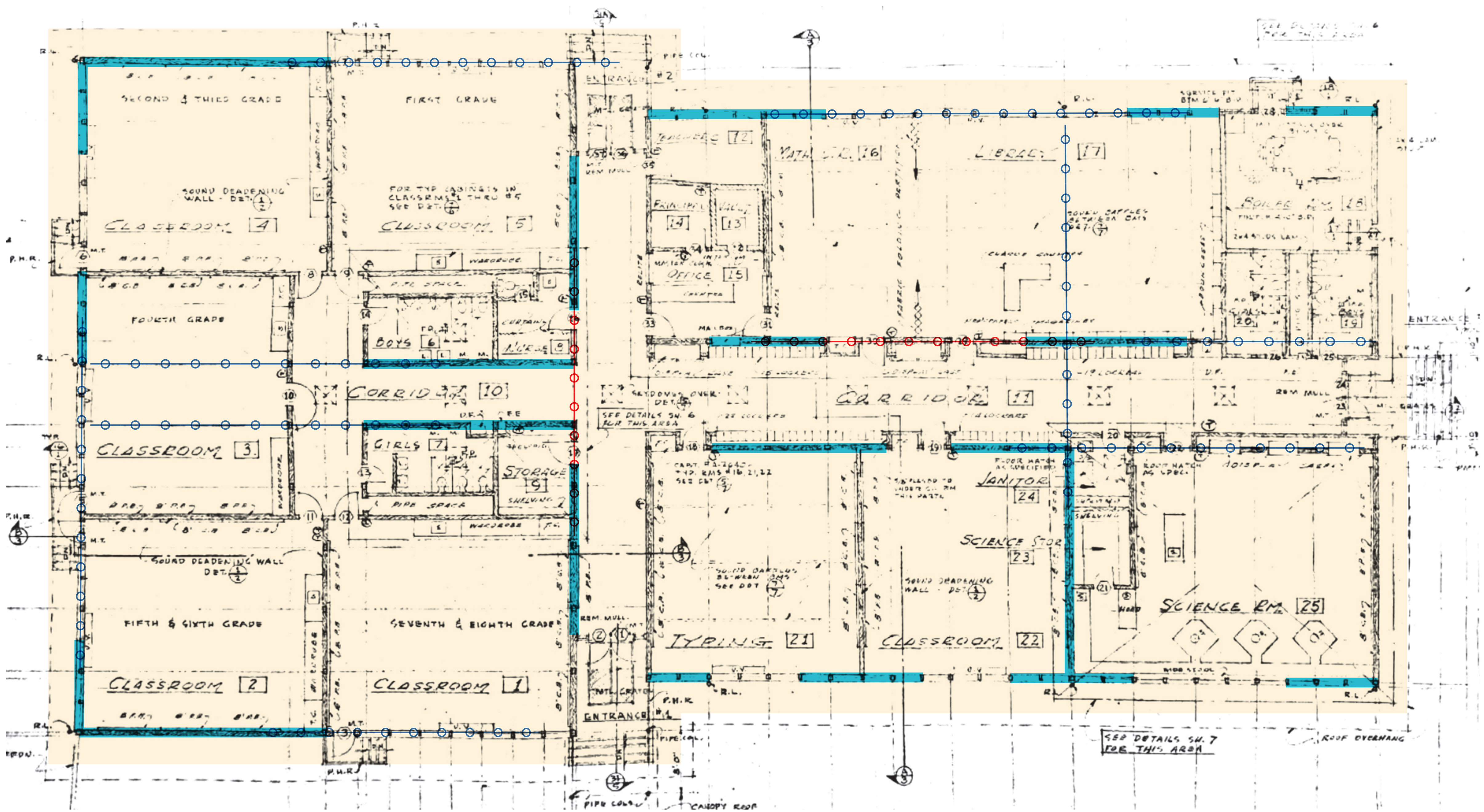
- **Red (dashed)**: Remove & Replace Existing Sheathing With New Wood Structural Panels Rated For Shear Resistance With Tighter Panel Edge Nailing Spacing To Increased Shear Resistance, Install New Hold Downs At Both Ends Of Piers That Have A Height-To-Length Ratio Greater Than 1:1
- **Orange**: Install New Shear Wall With Wood Structural Panels Rated For Shear Resistance, Install Anchor Bolts & Hold Downs As Necessary
- **Green**: Replace Existing Interior Partition Wall Sheathing With Wood Structural Panels Rated For Shear Resistance, Install New Anchor Bolts & Hold Downs To New Concrete Stem Walls, Shown Per Foundation Retrofit Sketch, Temporarily Move Lockers To Provide Access To The Corridor-Side Face Of The Existing Partition Walls
- **Blue**: Replace Existing Interior Partition Wall Sheathing With Wood Structural Panels Rated For Shear Resistance, Install New Anchor Bolts & Hold Downs To New Concrete Stem Walls, Shown Per Foundation Retrofit Sketch

ReidMiddleton wsp

**Mary M Knight School Seismic Upgrades – Elementary School Building**

Washington State School Seismic Safety Assessments Project – Mary M. Knight School District 311 – June 2021

**Figure 2 –** First Floor Retrofit Plan




**LEGEND**

- New Or Retrofitted Existing Shear Walls
- Install Sheet 16 Gage Sheet Metal Strap Over 2x Blocking As A Collector, Distributer, Where Indicated By The Following Symbol, Center Strap & Blocking Over Shear Wall
- Install New Wood Bracing Panels Between Existing Roof Framing Elements, Above Locations Where Partition Walls Will Be Converted To Shear Walls, Add New Blocking Panels At Roof Space, Between Shear Walls This Area
- Install New Wood Structural Panel Roof Sheathing At Entire Roof Area, Remove & Replace Existing Metal Roofing, Area To Be Re-Roofed With Wood Structural Panels



**Figure 3 –** Roof Retrofit Plan

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# Appendix C:  Opinion of Probable Construction Costs

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PRODIMS Project Management Services

520 Kirkland Way, Suite 301
Kirkland, WA 98033
tel: (425) 828-0500
fax: (425) 828-0700
www.prodims.com

| | |
|---|---|
| Name: | Wa State School Seismic Safety Assessment Phase 2 |
| Second Name: | Mary M. Knight Elementary School |
| Location: | Elma, WA |
| Design Phase: | ROM Cost Estimates |
| Date of Estimate: | December 14, 2020 |
| Date of Revision: | April 12, 2021 |
| Month of Cost Basis: | 1Q, 2021 |

# Mary M. Knight Elementary School

## Master Estimate Summary

| Project Name | Construction Cost Type | Estimated Construction Cost |
|---|---|---|
| Mary M. Knight Elementary School | Structural Costs | $837,767 |
| Mary M. Knight Elementary School | Non-Structural Costs | $251,330 |
| **TOTAL ESTIMATED CONSTRUCTION COST** | → | **$1,089,097** |

| Soft Costs | Soft Costs % Construction Cost | Estimated Soft Costs |
|---|---|---|
| **Project Soft Cost Allowance** | 40.0% | **$435,639** |
| | | Sum of the Above |
| **TOTAL ESTIMATED PROJECT COST** | → | **$1,524,735** |

**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.

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# Structural Costs

| | |
|---|---|
| Name: | Wa State School Seismic Safety Assessment Phase 2 |
| Second Name: | Mary M. Knight Elementary School |
| Location: | Elma, WA |
| Design Phase: | ROM Cost Estimates |
| Date of Estimate: | December 14, 2020 |
| Date of Revision: | April 12, 2021 |
| Month of Cost Basis: | 1Q, 2021 |

| Areas | sqft |
|---|---|
| Main Building Area | 12,900 |
| Total Areas | 12,900 |

## Mary M. Knight Elementary School

## Construction Cost Estimate

**Subtotal Direct Cost From the Estimate Detail Below $ 569,167**

| | Percentage of Previous Subtotal | Amount | | Running Subtotal | |
|---|---|---|---|---|---|
| Scope Contingency | 10.0% | $ | 56,917 | $ | 626,084 |
| General Conditions | 10.0% | $ | 56,917 | $ | 683,001 |
| Home Office Overhead | 5.0% | $ | 28,458 | $ | 711,459 |
| Profit | 6.0% | $ | 34,150 | $ | 745,609 |
| Escalation Included to 4Q, 2022 | 12.4% | $ | 92,157 | $ | 837,767 |
| 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 | | | | | |

| | | | $/sqft |
|---|---|---|---|
| **TOTAL ESTIMATED CONSTRUCTION COST--→** | **$** | **837,767** | **$ 64.94** |
| **-20% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --→** | **$** | **670,213** | **$ 51.95** |
| **+50% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --→** | **$** | **1,256,650** | **$ 97.41** |

**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** | | | | | | | | | | | |
| | Spread Footings System- Excavation, Backfill, Formwork, Concrete, Reinforcing and detailing. Inside Existing Building. | 21.2 | cuyd | $ 499.20 | $ 10,575.64 | $ 280.80 | $ 5,948.80 | $ 46.80 | $ 991.47 | $ 826.80 | $ 17,515.91 |
| | Concrete Shear Wall System, Formwork, Reinforcing and Detailing. Inside Existing Building. | 20.9 | cuyd | $ 860.80 | $ 18,006.98 | $ 484.20 | $ 10,128.93 | $ 80.70 | $ 1,688.15 | $ 1,425.70 | $ 29,824.06 |
| | Add Post Base Clips at Existing Post and Footing - Minimum 2 Clips per Post - 600 Clips, 300 Posts | 300 | each | $ 166.50 | $ 49,950.00 | $ 55.50 | $ 16,650.00 | $ 13.32 | $ 3,996.00 | $ 235.32 | $ 70,596.00 |
| **1 - Seismic Retrofit** | | | | | | | | | | | |
| **Superstructure** | | | | | | | | | | | |
| | Note 1 - Replace Sheathing with New Sheathing at Exterior Wall and Add Hold Downs as Required and Remove and Restore GWB System. | 910 | sqft | $ 4.86 | $ 4,422.60 | $ 4.14 | $ 3,767.40 | $ 0.54 | $ 491.40 | $ 9.54 | $ 8,681.40 |
| | Note 2 - New Shear Wall Sheathing at Exterior Wall and Anchor Bolts and Hold Downs as Required and Remove and Restore GWB System. | 1,425 | sqft | $ 4.86 | $ 6,925.50 | $ 4.14 | $ 5,899.50 | $ 0.54 | $ 769.50 | $ 9.54 | $ 13,594.50 |
| | Note 3 + 4 - Replace Sheathing with New Sheathing at Interior Walls and Add Hold Downs and Anchor Bolts as Required. Remove and Restore GWB System. | 2,350 | sqft | $ 4.86 | $ 11,421.00 | $ 4.14 | $ 9,729.00 | $ 0.54 | $ 1,269.00 | $ 9.54 | $ 22,419.00 |
| | HHDQ11 hold down System - With Fasteners to Wood and Drilled in Epoxy Anchor Bolt with Nut. Remove and Restore GWB System | 22 | each | $ 268.00 | $ 5,896.00 | $ 132.00 | $ 2,904.00 | $ 24.00 | $ 528.00 | $ 424.00 | $ 9,328.00 |
| | Remove Existing Metal Roofing System | 15,600 | sqft | $ 2.16 | $ 33,696.00 | $ 0.09 | $ 1,404.00 | $ 0.14 | $ 2,106.00 | $ 2.39 | $ 37,206.00 |
| | Install New Metal Roofing System - Including Roofing, New Insulation, Coverboard and Flashing and Trim for a Complete System | 15,600 | sqft | $ 10.53 | $ 164,268.00 | $ 8.97 | $ 139,932.00 | $ 1.17 | $ 18,252.00 | $ 20.67 | $ 322,452.00 |
| | Install New 1/2" Plywood Directly to T+G Deck with Specified Nailing Pattern | 15,600 | sqft | $ 0.68 | $ 10,530.00 | $ 0.58 | $ 8,970.00 | $ 0.08 | $ 1,170.00 | $ 1.33 | $ 20,670.00 |
| | Roof Note 2 - 16 GA Coil Metal Strap nailed down with 2X Blocking | 494 | lnft | $ 4.23 | $ 2,087.15 | $ 2.28 | $ 1,123.85 | $ 0.39 | $ 192.66 | $ 6.89 | $ 3,403.66 |

| WBS | Description | Quantity | U of M | Labor | Labor Total | Material | Material Total | Equipment | Equipment Total | Total $/U of M | Direct Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roof Note 3 - Install Wood Bracing/Blocking Panels between Roof Framing Elements Above/Between Shear Walls | 150 | lnft | $ 4.23 | $ 633.75 | $ 2.28 | $ 341.25 | $ 0.39 | $ 58.50 | $ 6.89 | $ 1,033.50 |
| **Interior Wall/Door/Casework/Specialties Systems** | | | | | | | | | | | |
| | Lockers at Hallways - Temporary relocation for Installation of Seismic Work | 12,900 | sqft | $ 0.77 | $ 9,978.15 | $ 0.14 | $ 1,760.85 | $ 0.05 | $ 704.34 | $ 0.96 | $ 12,443.34 |
| **Subtotal of the Direct Cost of Construction** | | | | **Mary M. Knight Elementary School** | | | | | | | **$ 569,167** |

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## Non-Structural Costs

| | | | |
|---|---|---|---|
| Name: | Wa State School Seismic Safety Assessment Phase 2 | Areas | sqft |
| Second Name: | Mary M. Knight Elementary School | Building Area | 12,900 |
| Location: | Elma, WA | | |
| Design Phase: | ROM Cost Estimates | | |
| Date of Estimate: | December 14, 2020 | | |
| Date of Revision: | April 12, 2021 | | |
| Month of Cost Basis: | 1Q, 2021 | Total Areas | 12,900 |

## Mary M. Knight Elementary School

## Construction Cost Estimate

**Subtotal Direct Cost From the Estimate Detail Below $ 170,750**

| | Percentage of Previous Subtotal | Amount | | Running Subtotal |
|---|---|---|---|---|
| Scope Contingency | 10.0% | $ | 17,075 | $ 187,825 |
| General Conditions | 10.0% | $ | 17,075 | $ 204,900 |
| Home Office Overhead | 5.0% | $ | 8,538 | $ 213,438 |
| Profit | 6.0% | $ | 10,245 | $ 223,683 |
| Escalation Included to 4Q, 2022 | 12.4% | $ | 27,647 | $ 251,330 |
| 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 | | | | |

| | | | $/sqft |
|---|---|---|---|
| **TOTAL ESTIMATED CONSTRUCTION COST--** | **$** | **251,330** | **$ 19.48** |
| **-20% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --** | **$** | **201,064** | **$ 15.59** |
| **+50% TOTAL ESTIMATED CONSTRUCTION COST VARIANCE --** | **$** | **376,995** | **$ 29.22** |

**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** | | | | | | | | | | |
| | Mechanical/Electrical/Fire Protection Systems * | 12,900 | sqft | $ 6.87 | $ 88,596.81 | $ 5.62 | $ 72,488.30 | $ 0.75 | $ 9,665.11 | $ 13.24 | $ 170,750.21 |
| | *Allows 30 percent of existing nonstructural systems M/E/P/FP require upgrades/replacement. | | | | | | | | | | |
| | **Subtotal of the Direct Cost of Construction** | | | **Mary M. Knight Elementary School** | | | | | | | **$ 170,750** |

# Appendix D: Earthquake Performance Assessment Tool (EPAT) Worksheet

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## Washington Schools Earthquake Performance Assessment Tool (EPAT)
## RESULTS SUMMARY

| | | |
|---|---|---|
| **District Name** | Mary M. Knight | **Existing Building Life Safety Risk & Priority for Retrofit or Replacement** |
| **School Name** | Mary M Knight Elementary School | |
| **Building Name** | Elementary School | Very High |

### Building Data

| | | |
|---|---|---|
| **HAZUS Building Type** | W2 | Wood, Commercial & Industrial (>5,000 SF) |
| **Year Built** | 1963 | These parameters determine the capacity of the existing building to withstand earthquake forces. |
| **Building Design Code** | <1973 UBC | |
| **Existing Building Code Level** | Pre | |
| **Geographic Area** | Coastal | |
| **Severe Vertical Irregularity** | No | Buildings with irregularities have greater earthquake damage than otherwise similar buildings that are regular. |
| **Moderate Vertical Irregularity** | No | |
| **Plan Irregularity** | No | |

### Seismic Data

| | | |
|---|---|---|
| **Earthquake Ground Shaking Hazard Level** | Very High | Frequency and severity of earthquakes at this site |
| **Percentile $S_s$ Among WA K-12 Campuses** | 93% | Earthquake ground shaking hazard is higher than 93% of WA campuses. |
| **Site Class (Soil or Rock Type)** | C | Very Dense Soil and Soft Rock |
| **Liquefaction Potential** | Very Low | Liquefaction increases the risk of major damage to a building |
| **Combined Earthquake Hazard Level** | Very High | Earthquake ground shaking and liquefaction potential |

### Severe Earthquake Event (Design Basis Earthquake Ground Motion)[1]

| **Building State** | **Building Damage Estimate**[2] | **Probability Building is not Repairable**[3] | **Life Safety**[4] **Risk Level** | **Most Likely Post-Earthquake Tagging**[5] |
|---|---|---|---|---|
| Existing Building | 67% | 64% | Very High | Red |
| Life Safety Retrofit Building | 18% | 9.9% | Very Low | Green/Yellow |
| Current Code Building | 15% | 6.6% | Very Low | Green |

1. 2/3rds of the 2% in 50 year ground motion
2. Percentage of building replacement value.
3. Probability building is in the Extensive or Complete damage states. For existing buildings, the probability that the building is not economically repairable may be higher: some buildings in the Moderate Damage state are also likely to be demolished.
4. Based on probability of Complete Damage State.
5. Most likely post-earthquake damage state per ATC-20.

### Source for the Data Entered into the Tool

| | |
|---|---|
| **Building Evaluated By:** | Ben Fisher |
| **Person(s) Who Entered Data in EPAT:** | Rami Sabra, Reid Middleton |
| **User Overrides of Default Parameters:** | Building Design Code Year, Site Class, Liquefaction |

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# Appendix E:  Existing Drawings

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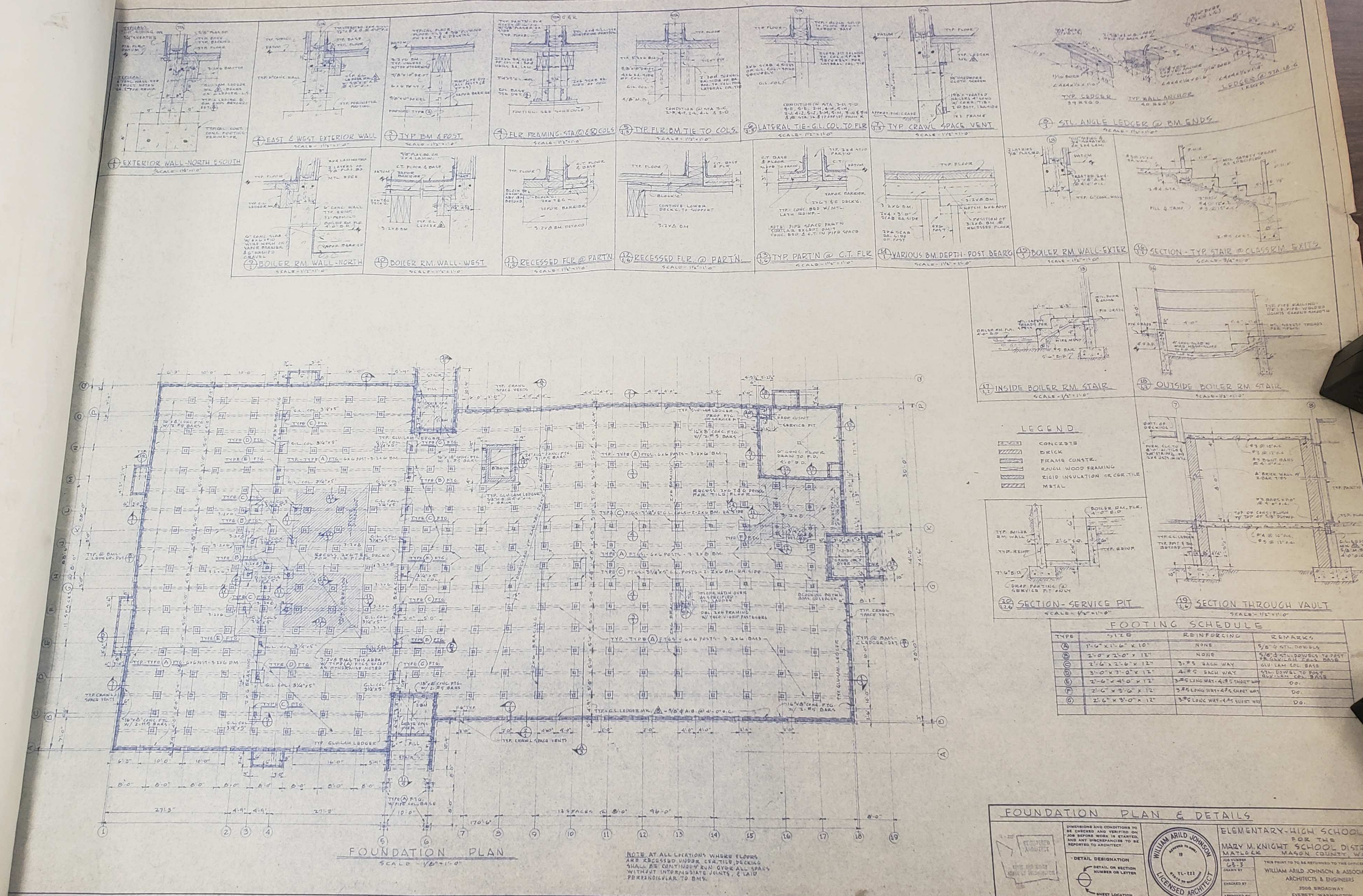



## FOOTING SCHEDULE

| TYPE | SIZE | REINFORCING | REMARKS |
|---|---|---|---|
| Ⓐ | 1'-6" x 1'-6" x 10" | NONE | 5/8" ∅ STL. DOWELS |
| Ⓑ | 2'-0" x 2'-0" x 12" | NONE | 5/8" ∅ STL. DOWELS TO POST OR GLU-LAM COLS. BASE |
| Ⓒ | 2'-6" x 2'-6" x 12" | 3-#5 EACH WAY | GLU-LAM COL. BASE |
| Ⓓ | 3'-0" x 3'-0" x 12" | 4-#5 EACH WAY | STL. DOWEL TO POST GLU-LAM COL. BASE |
| Ⓔ | 2'-6" x 4'-0" x 12" | 3-#5 LONG WAY-4-#5 SHORT WAY | DO. |
| Ⓕ | 2'-6" x 3'-6" x 12" | 3-#5 LONG WAY-4-#5 SHORT WAY | DO. |
| Ⓖ | 2'-6" x 3'-0" x 12" | 3-#5 LONG WAY-4-#5 SHORT WAY | DO. |

## FOUNDATION PLAN & DETAILS

DIMENSIONS AND CONDITIONS TO BE CHECKED AND VERIFIED ON JOB BEFORE WORK IS STARTED, AND ANY DISCREPANCIES TO BE REPORTED TO ARCHITECT

DETAIL DESIGNATION
DETAIL OR SECTION NUMBER OR LETTER
SHEET LOCATION

WILLIAM ARILD JOHNSON
TL-222
STATE OF WASHINGTON
LICENSED ARCHITECT

ELEMENTARY-HIGH SCHOOL BU[ILDING]
FOR THE
MARY M. KNIGHT SCHOOL DISTRICT
MATLOCK MASON COUNTY, WASH.

JOB NUMBER 63-3
DRAWN BY
CHECKED BY
APPROVED BY

THIS PRINT IS TO BE RETURNED TO THE OFFICES OF
WILLIAM ARILD JOHNSON & ASSOCIATES
ARCHITECTS & ENGINEERS
3506 BROADWAY
EVERETT, WASHINGTON

# new high school building

## MARY M. KNIGHT SCHOOL DISTRICT NO. 311
## MASON COUNTY, MATLOCK, WASHINGTON 98560

STATE BOARD OF EDUCATION PROJECT NO. 345-B2-22051

## SCHOOL BOARD MEMBERS:

RALPH COOK
HERB BREHMEYER JR.
LEROY VALLEY
JIM KILIZ
HARRY JONES

EUGENE O. FRENCH, SUPERINTENDENT

## ARCHITECTS:

**FALTER-MASINI AIA**
OLYMPIA, WASHINGTON ph. 943-6774

## MECHANICAL/ELECTRICAL

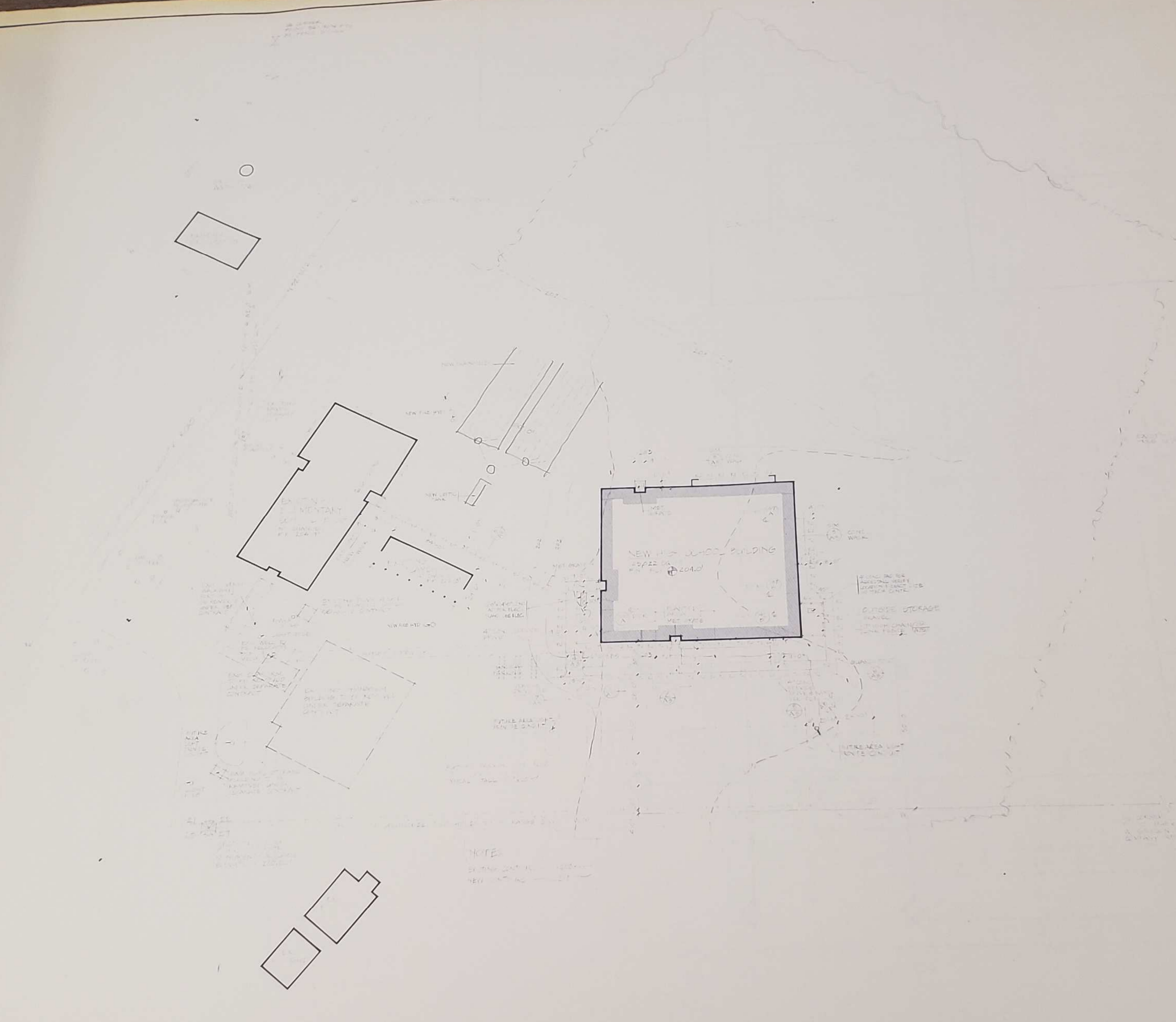
**BLUNT & HAMM ENGINEERS**
TACOMA, WASHINGTON ph. 572-2512

## STRUCTURAL ENGINEERS:

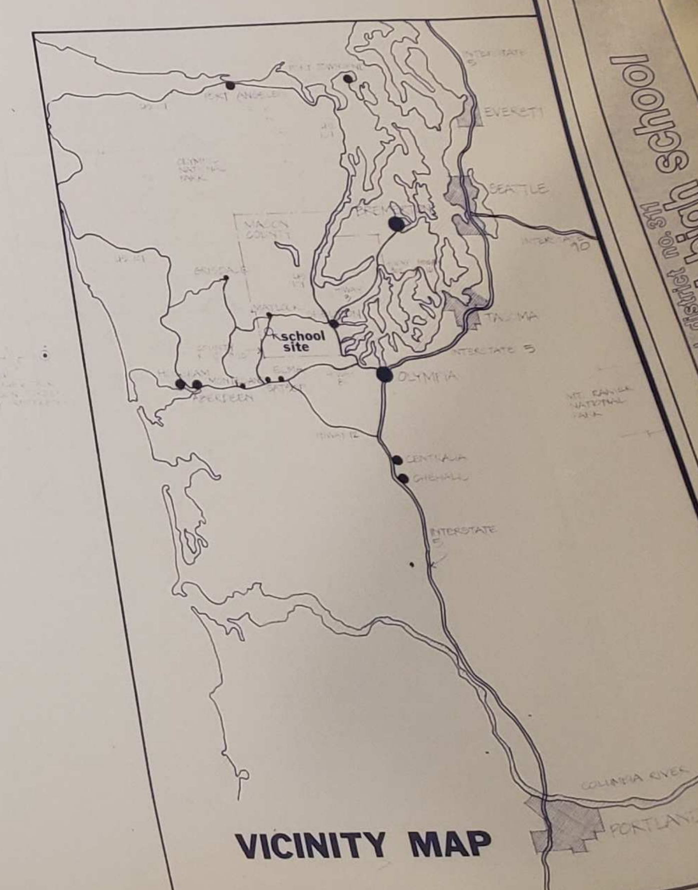
**CHALKER ENGINEERS**
TACOMA, WASHINGTON ph. 383-2797

## LANDSCAPE ARCHITECT

**JANE GARRISON**
OLYMPIA, WASHINGTON ph. 357-6807



## SITE PLAN



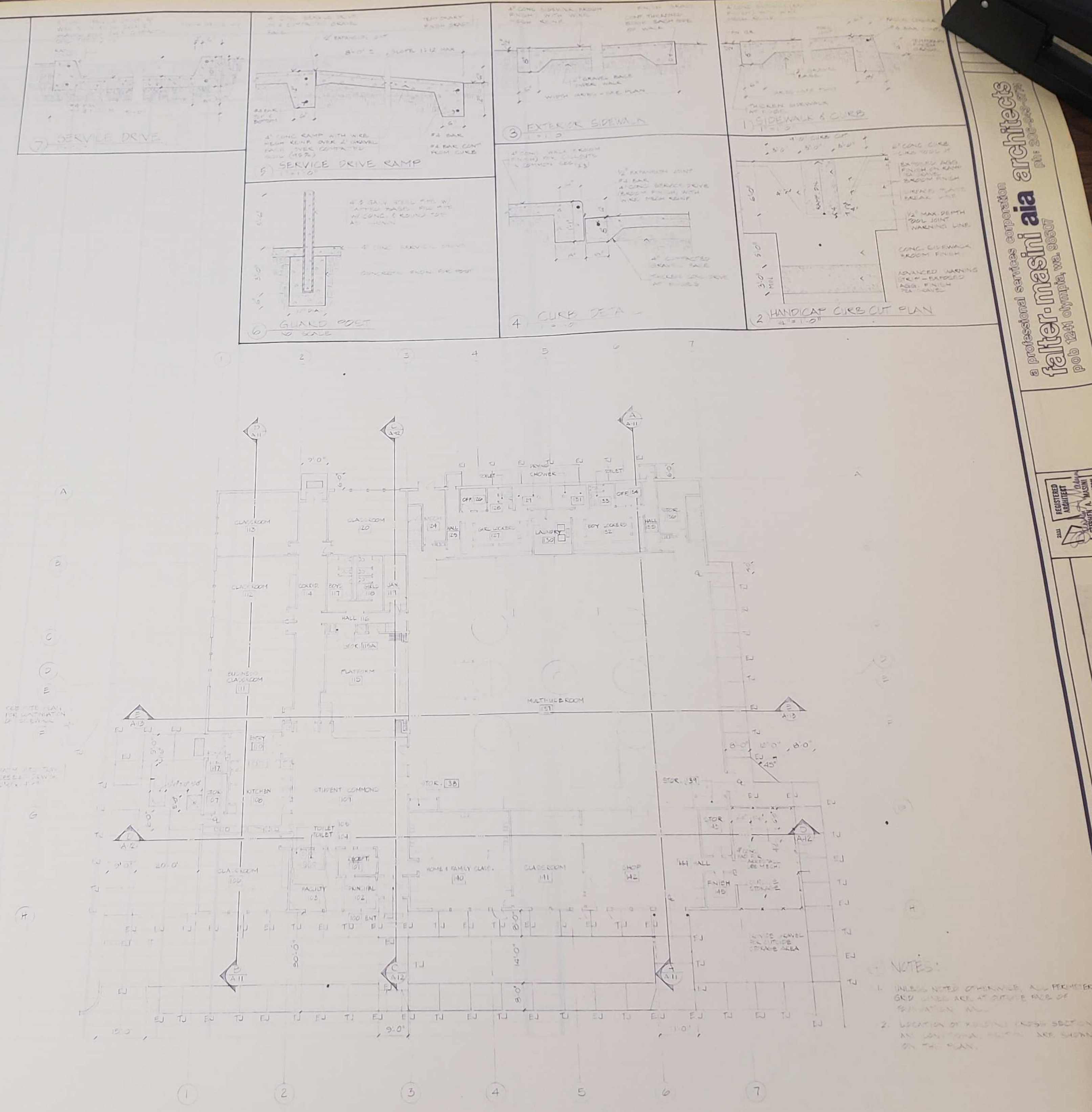

## VICINITY MAP

REGISTERED ARCHITECT

aia architects

school district no. 311

high school



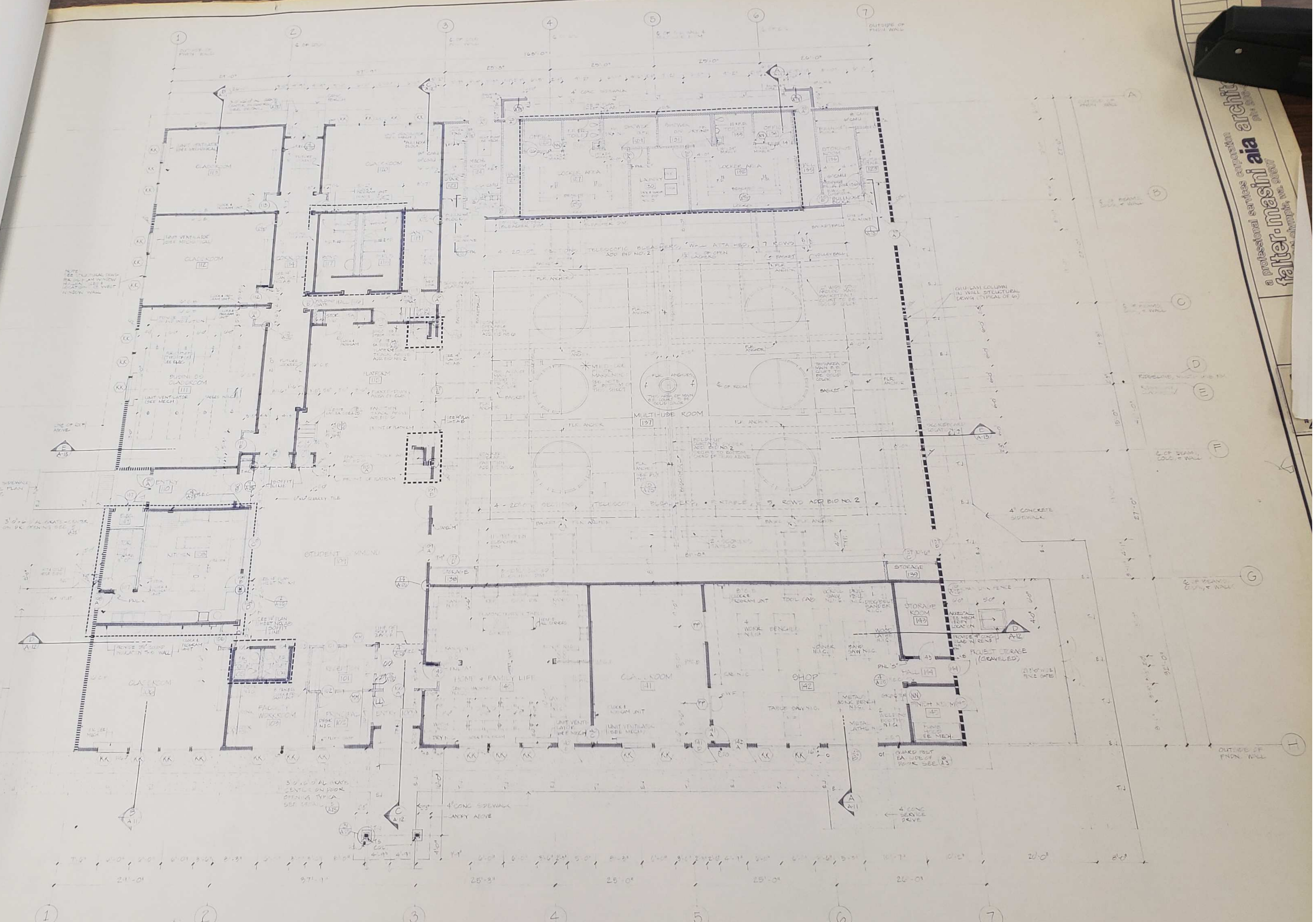
# FLOOR PLAN

SCALE: 1/16" = 1'-0"

a professional services corporation
**falter·mashni aia architects**
pob 1241 olympia, wa. 98507

mary m. knight school district no. 311
**mary m. knight high school**
matlock, washington

| | |
|---|---|
| CONTENTS | FLOOR PLAN & DETAILS |
| DATE | DEC. 6, 1979 |
| SCALE | 1/16" = 1'-0" |
| DRAWN | G.D. JSG |
| JOB | 79-101 |
| SHEET | **A3** |



NOTE:
PROVIDE MARKING ON MULTI-USE ROOM FLOOR:
- 50'x84' BASKETBALL COURT
- (2) 42'x70' BASKETBALL COURTS
- (4) 20'x44 BADMINTON COURTS
- (3) 30'x60' VOLLEYBALL COURTS

NOTE:
PROVIDE BACKING IN WALLS AT ALL CABINETS, FIXTURES, & ACCESSORIES FOR POSITIVE ATTACHMENT.

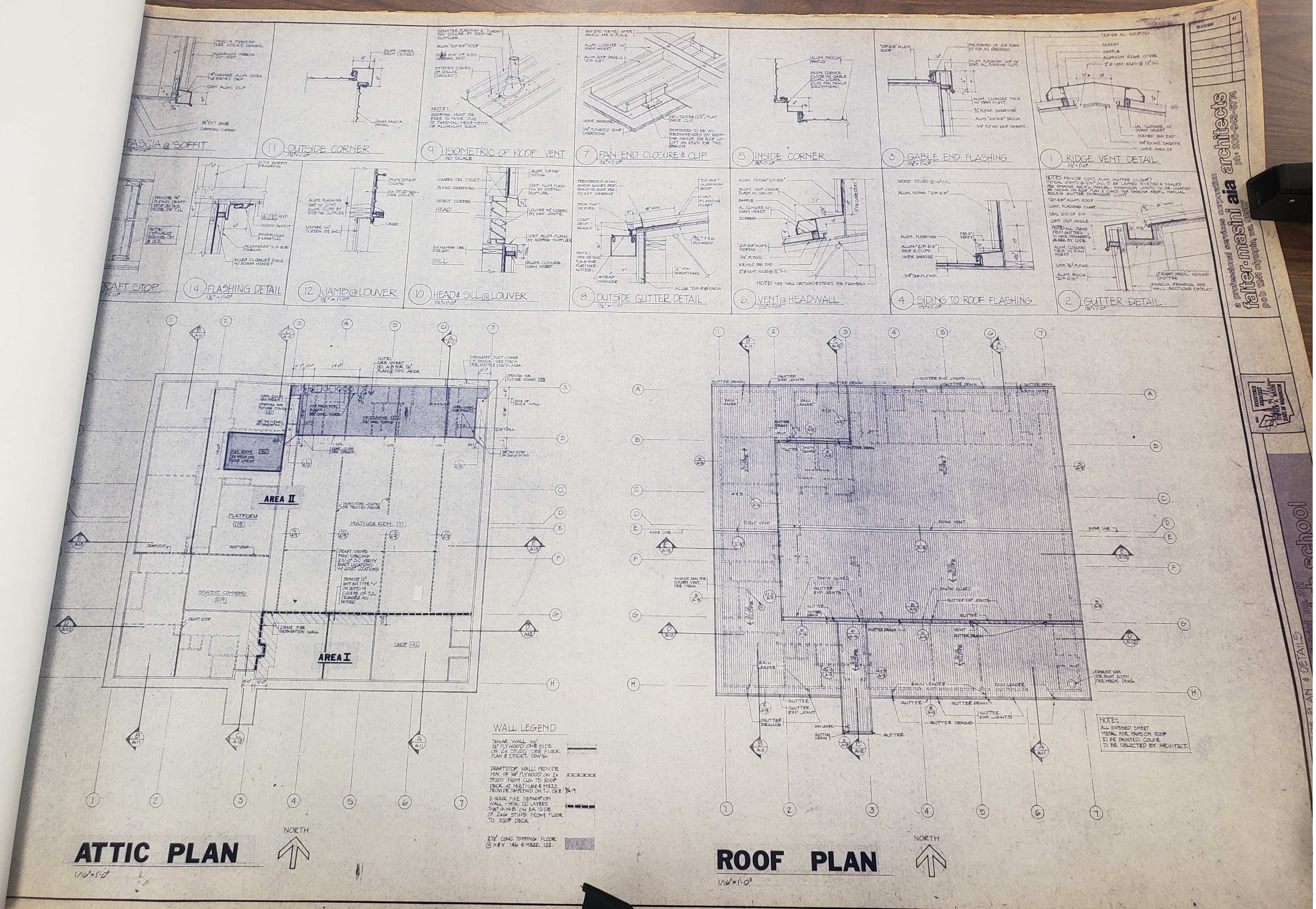
NOTE:
SEE SHEET NO. A-8 FOR LARGE SCALE PLANS & MEZZANINE FLOOR PLAN

# MAIN FLOOR PLAN

1/8" = 1'-0"

NORTH

INTERIOR ROOM ELEVATIONS



FASCIA @ SOFFIT
11 OUTSIDE CORNER
9 ISOMETRIC OF ROOF VENT
NO SCALE
7 PAN END CLOSURE & CLIP
5 INSIDE CORNER
3 GABLE END FLASHING
1 RIDGE VENT DETAIL
DRAFT STOP
14 FLASHING DETAIL
12 JAMB @ LOUVER
10 HEAD & SILL @ LOUVER
8 OUTSIDE GUTTER DETAIL
6 VENT @ HEADWALL
4 SIDING TO ROOF FLASHING
2 GUTTER DETAIL
AREA II
PLATFORM
MULTI-USE ROOM
STUDENT COMMONS
AREA I
SHOP
WALL LEGEND
ATTIC PLAN
1/16"=1'-0"
NORTH
ROOF PLAN
1/16"=1'-0"
NORTH
NOTE:
ALL EXPOSED SHEET METAL FOR FANS ON ROOF TO BE PAINTED. COLOR TO BE SELECTED BY ARCHITECT.
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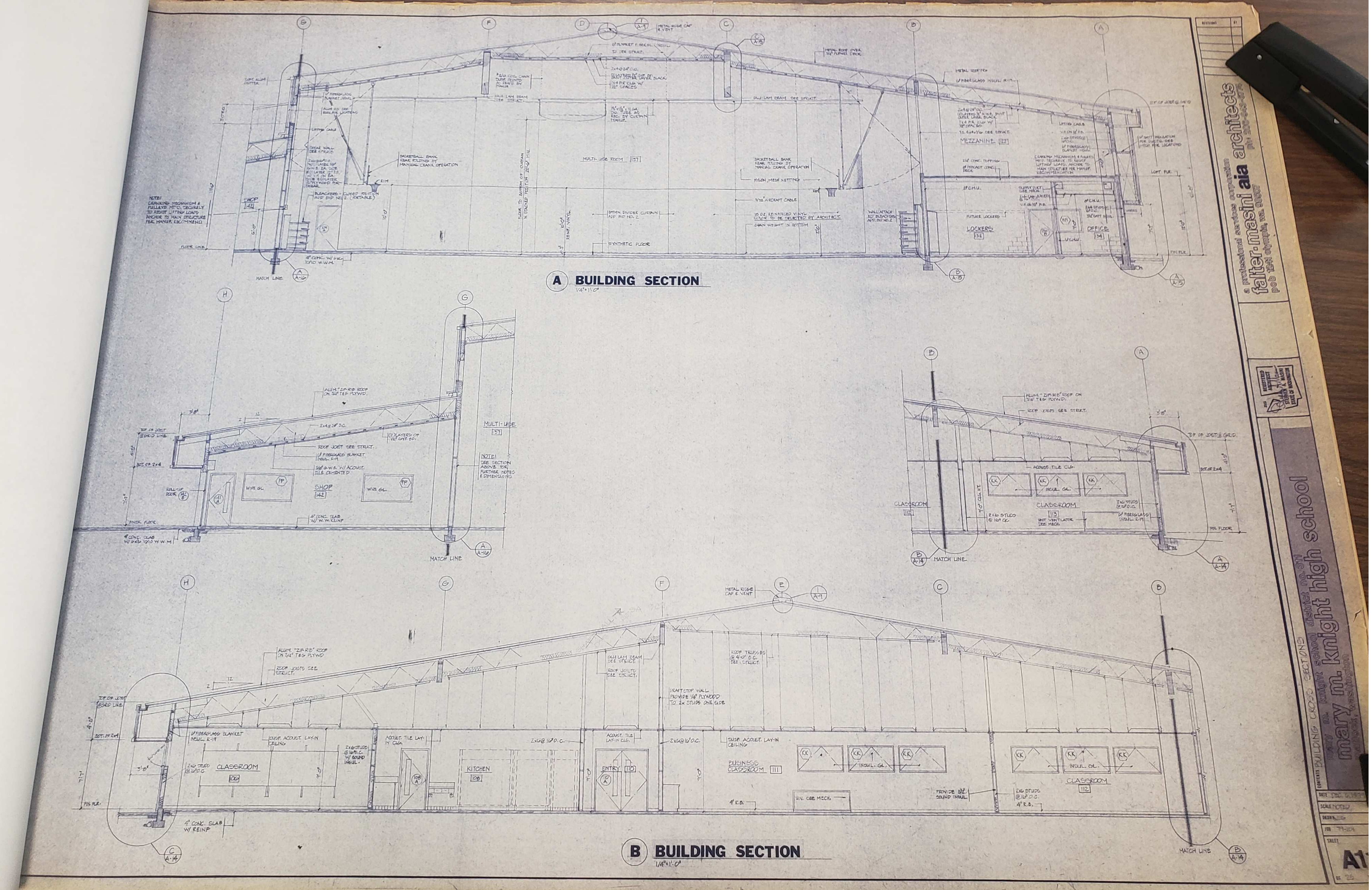
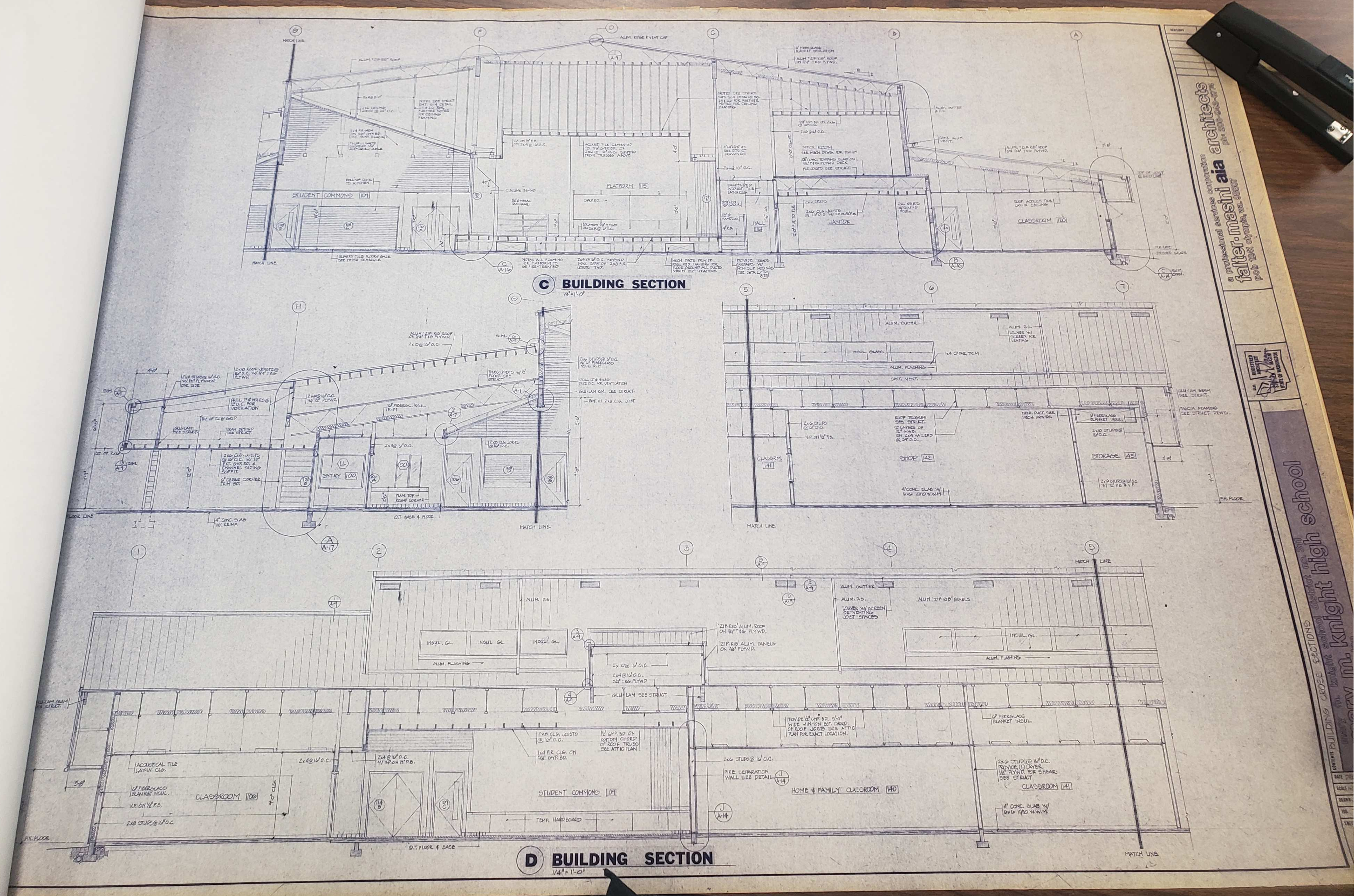
falter-masini aia architects


A BUILDING SECTION
B BUILDING SECTION
MEZZANINE
LOCKERS
OFFICE
SHOP
MULTI-USE
CLASSROOM
KITCHEN
ENTRY
BUSINESS CLASSROOM
MATCH LINE
a professional services corporation
fatter-mashni aia architects
mary m. knight high school



C BUILDING SECTION
1/4" = 1'-0"
STUDENT COMMONS 109
PLATFORM 115
JANITOR
CLASSROOM
ENTRY 100
CLASSRM. 141
SHOP 142
STORAGE 143
D BUILDING SECTION
1/4" = 1'-0"
CLASSROOM 106
STUDENT COMMONS 109
HOME & FAMILY CLASSROOM 140
CLASSROOM 141
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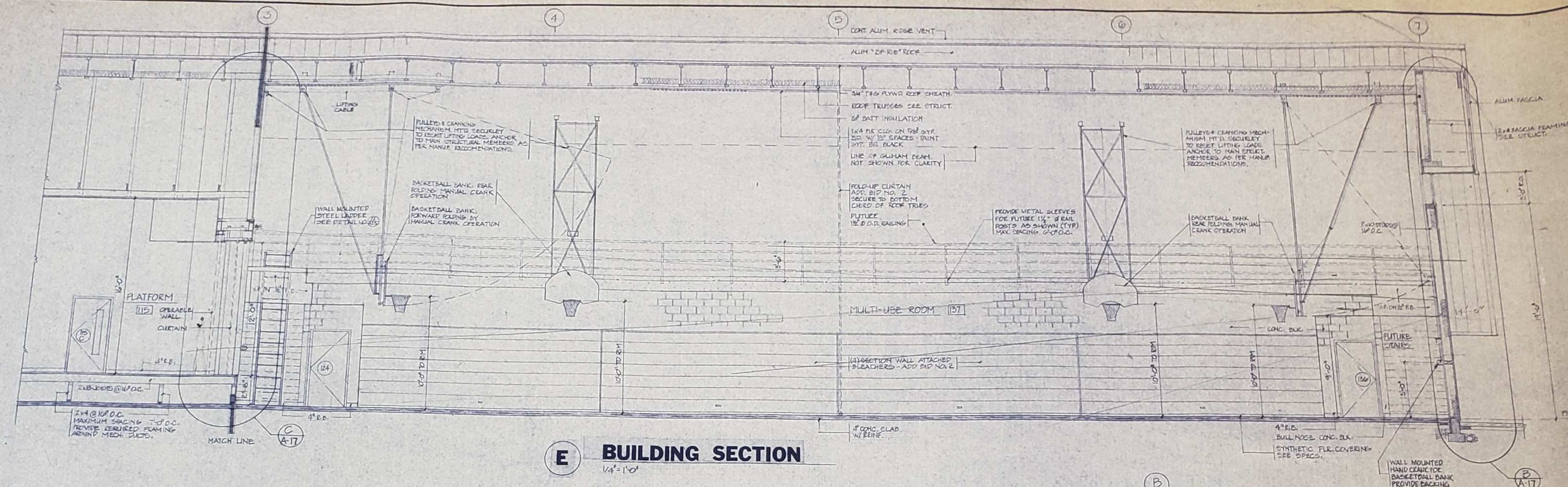
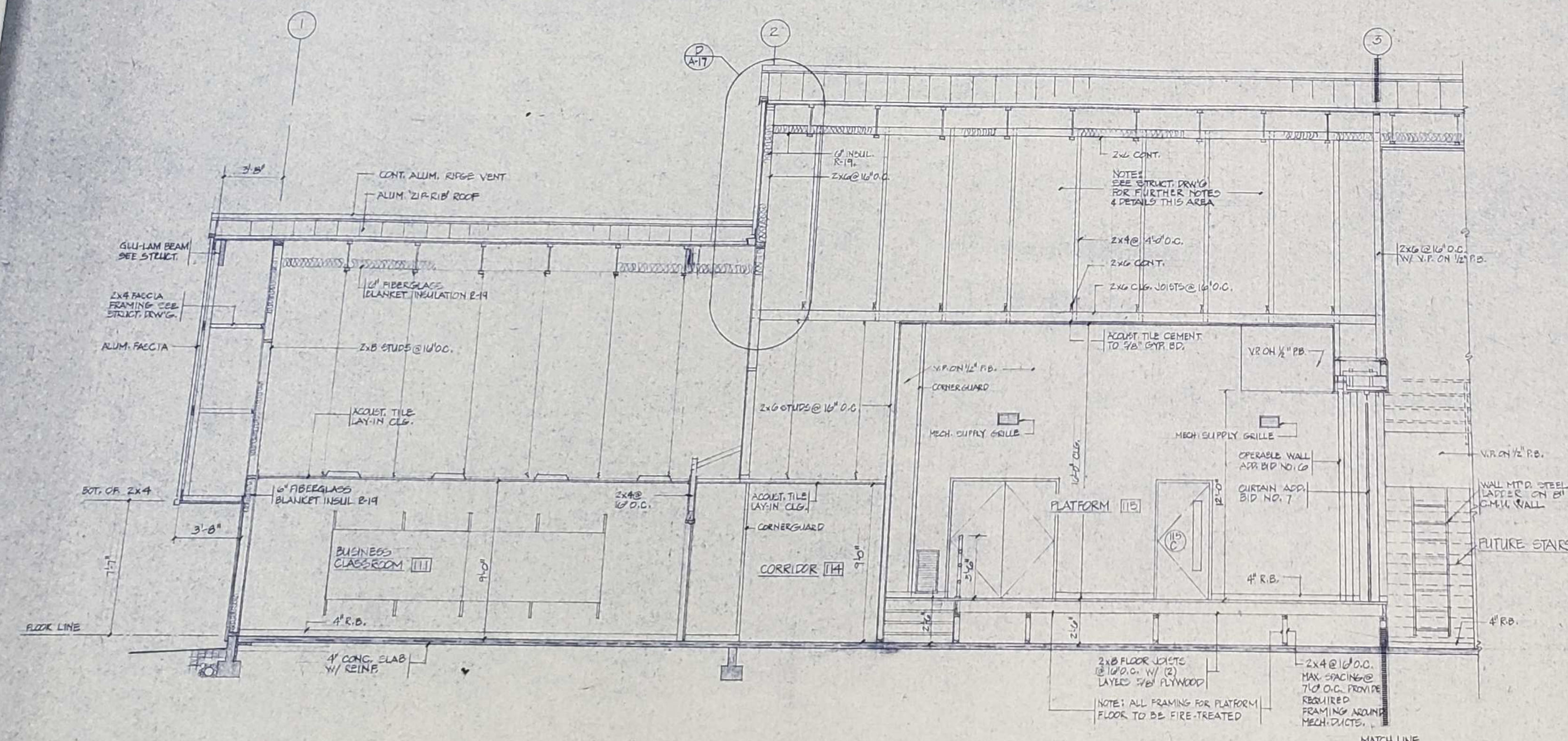
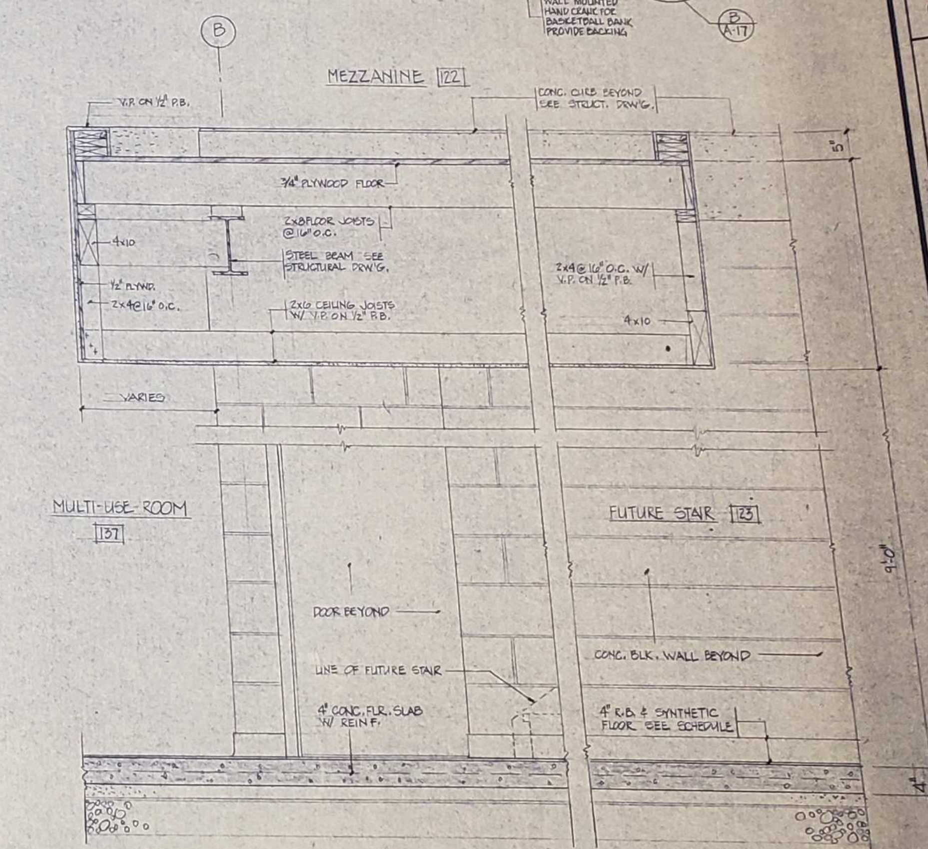
falter·masini aia architects
pob 1211 olympia, wa. 98507
REGISTERED ARCHITECT
STATE OF WASHINGTON
CONTENTS BUILDING CROSS SECTIONS
knight high school



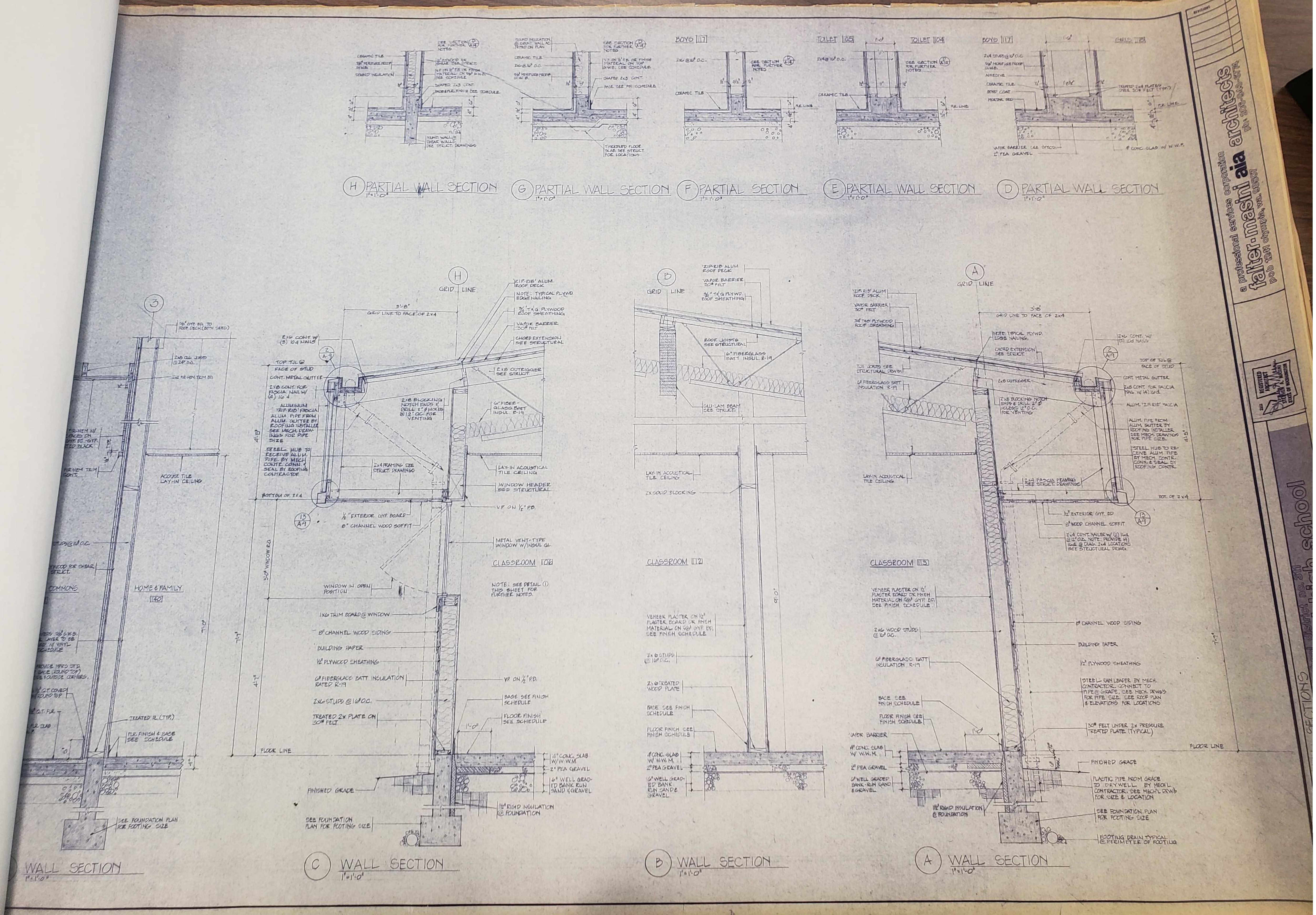

**E BUILDING SECTION**
1/4" = 1'-0"



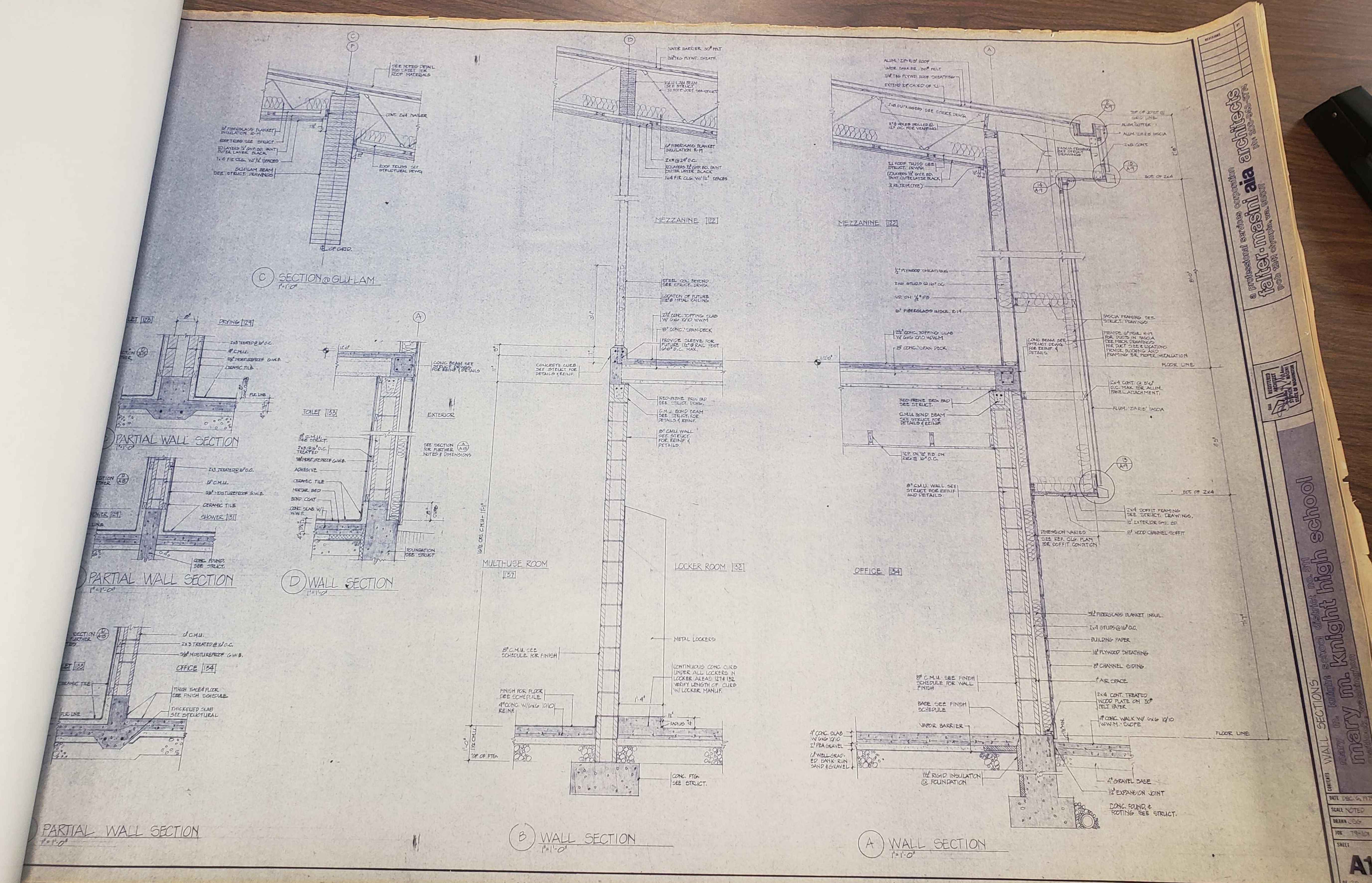



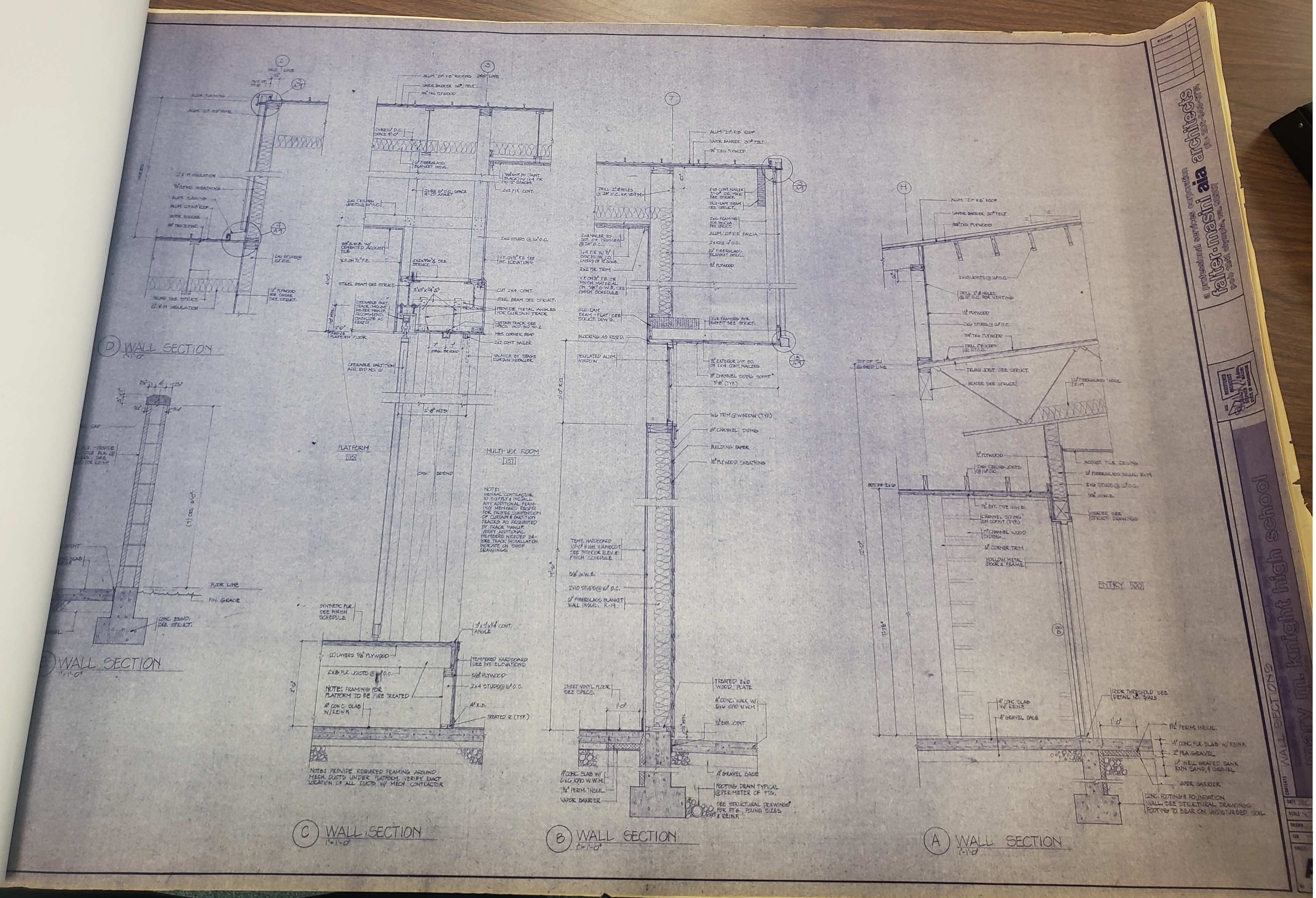

1 DETAIL @ FUTURE STAIR CEILING
1" = 1'-0"

a professional services corporation
falter-masini aia architects
pob 1241 olympia, wa. 98507 ph. 206-943-0174

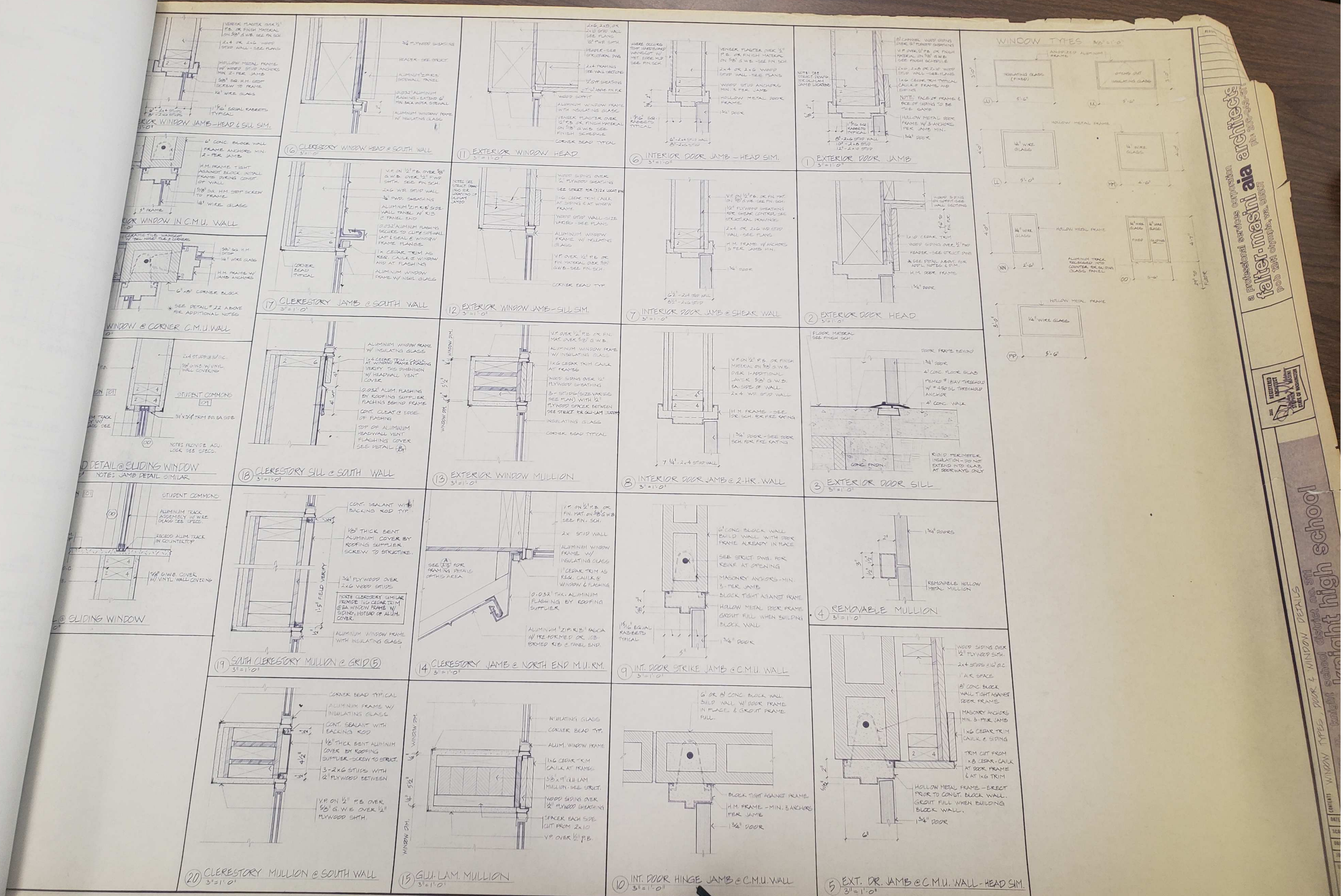


H PARTIAL WALL SECTION
1"=1'-0"
G PARTIAL WALL SECTION
1"=1'-0"
F PARTIAL SECTION
1"=1'-0"
E PARTIAL WALL SECTION
1"=1'-0"
D PARTIAL WALL SECTION
1"=1'-0"
BOYS 117
TOILET 105
TOILET 104
GIRLS 118
GRID LINE
CLASSROOM 108
CLASSROOM 112
CLASSROOM 113
HOME & FAMILY 140
FLOOR LINE
FINISHED GRADE
WALL SECTION
C WALL SECTION
1"=1'-0"
B WALL SECTION
1"=1'-0"
A WALL SECTION
1"=1'-0"
a professional services corporation
falter-mashni aia architects
SECTIONS
school


C SECTION @ GLU-LAM
1"=1'-0"
PARTIAL WALL SECTION
PARTIAL WALL SECTION
1"=1'-0"
D WALL SECTION
1"=1'-0"
PARTIAL WALL SECTION
1"=1'-0"
B WALL SECTION
1"=1'-0"
A WALL SECTION
1"=1'-0"
MEZZANINE [122]
MEZZANINE [122]
MULTI-USE ROOM [137]
LOCKER ROOM [132]
OFFICE [134]
TOILET [133]
EXTERIOR
OFFICE [134]
METAL LOCKERS
FLOOR LINE
BOT. OF 2x4
a professional services corporation
falter·masini aia architects
WALL SECTIONS
mary m. knight high school
DATE DEC. 6, 1979
SCALE NOTED
A15
OF 25



D WALL SECTION
C WALL SECTION
1"=1'-0"
B WALL SECTION
1"=1'-0"
A WALL SECTION
1"=1'-0"
PLATFORM
MULTI-USE ROOM
ENTRY 100
NOTE: FRAMING FOR PLATFORM TO BE FIRE TREATED
NOTES: PROVIDE REQUIRED FRAMING AROUND MECH. DUCTS UNDER PLATFORM. VERIFY EXACT LOCATION OF ALL DUCTS W/ MECH. CONTRACTOR
DOOR THRESHOLD SEE DETAIL NO. 9/A23
1½" PERIM. INSUL.
4" CONC. FLR. SLAB W/ REINF.
2" PEA GRAVEL
VAPOR BARRIER
CONC. FOOTING & FOUNDATION WALL SEE STRUCTURAL DRAWINGS FOOTING TO BEAR ON UNDISTURBED SOIL
a professional services corporation
falter-masini aia architects
pob 1241 olympia, wa. 98507
WALL SECTIONS
mary m. knight high school



WINDOW TYPES
16 CLERESTORY WINDOW HEAD @ SOUTH WALL
11 EXTERIOR WINDOW HEAD
6 INTERIOR DOOR JAMB - HEAD SIM.
1 EXTERIOR DOOR JAMB
17 CLERESTORY JAMB @ SOUTH WALL
12 EXTERIOR WINDOW JAMB - SILL SIM.
7 INTERIOR DOOR JAMB @ SHEAR WALL
2 EXTERIOR DOOR HEAD
18 CLERESTORY SILL @ SOUTH WALL
13 EXTERIOR WINDOW MULLION
8 INTERIOR DOOR JAMB @ 2-HR. WALL
3 EXTERIOR DOOR SILL
19 SOUTH CLERESTORY MULLION @ GRID 5
14 CLERESTORY JAMB @ NORTH END M.U.RM.
9 INT. DOOR STRIKE JAMB @ C.M.U. WALL
4 REMOVABLE MULLION
20 CLERESTORY MULLION @ SOUTH WALL
15 GLU-LAM. MULLION
10 INT. DOOR HINGE JAMB @ C.M.U. WALL
5 EXT. DR. JAMB @ C.M.U. WALL - HEAD SIM.
a professional services corporation
falter-mashni aia architects
knight high school
WINDOW TYPES, DOOR & WINDOW DETAILS

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# Appendix F: FEMA E-74 Nonstructural Seismic Bracing Excerpts

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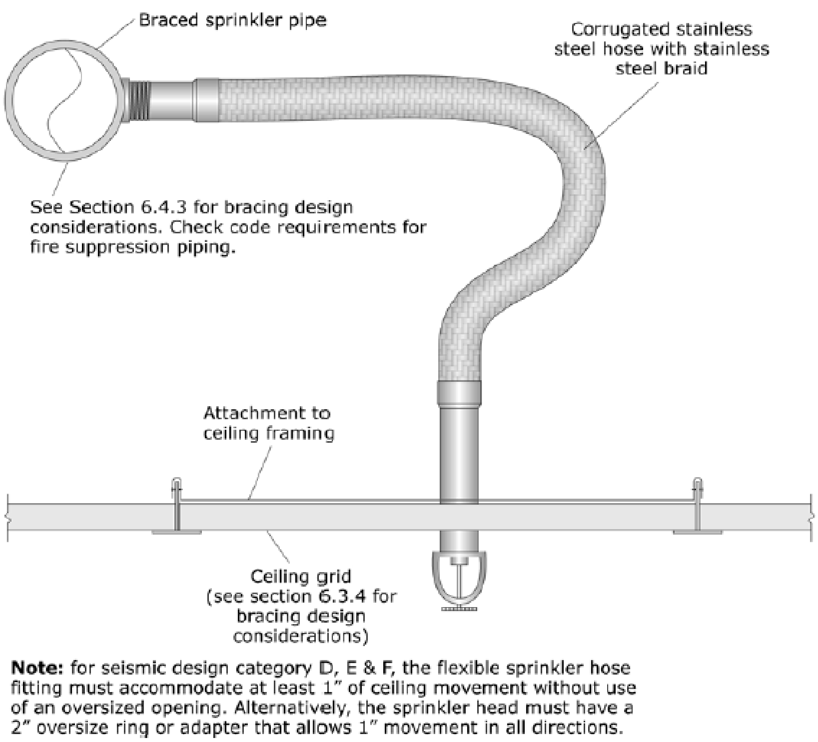



**Figure G-1. Flexible Sprinkler Drop.**

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

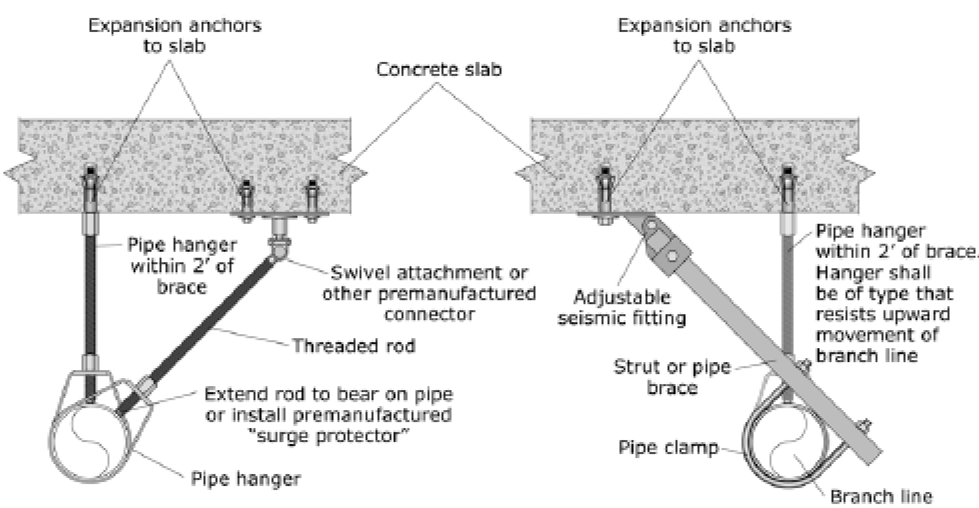



**Figure G-2. End of Line Restraint.**

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

## *Partitions*

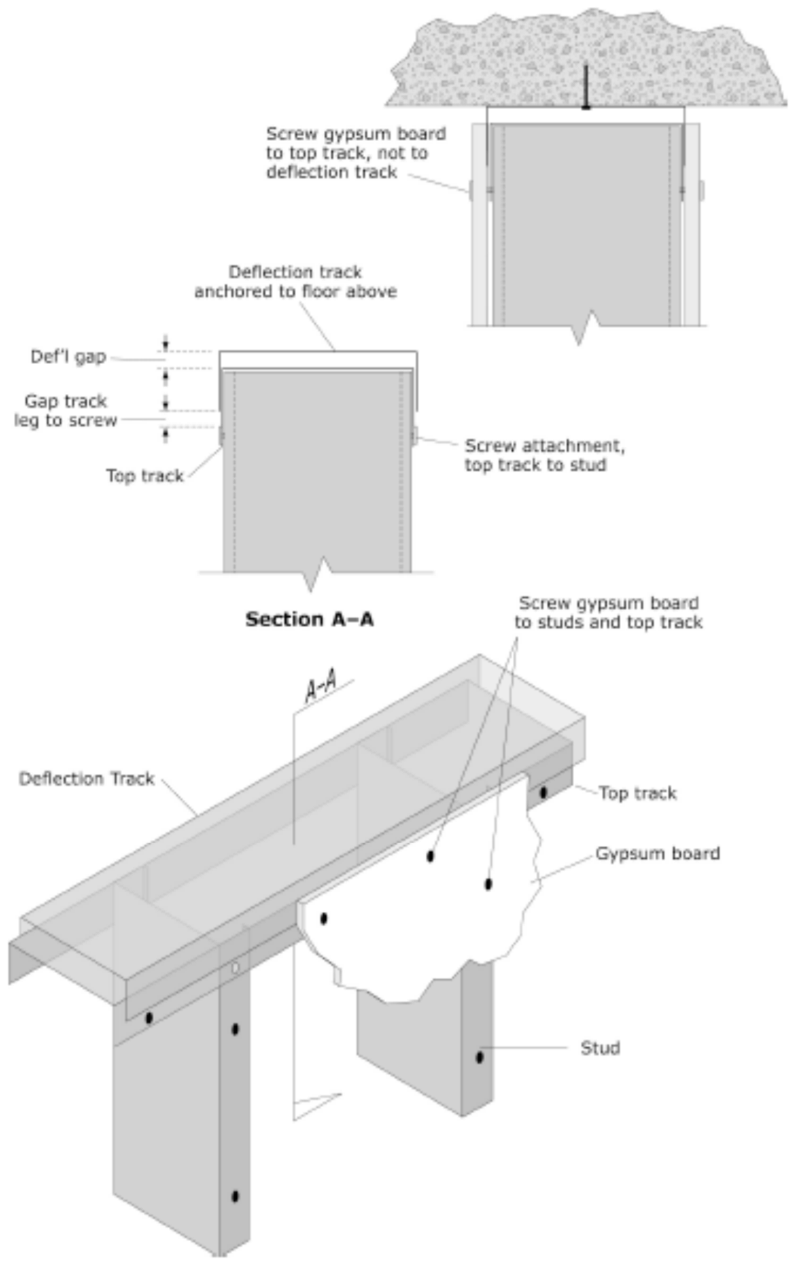



**Figure G-3. Mitigation Schemes for Bracing the Tops of Metal Stud Partitions Walls.**

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

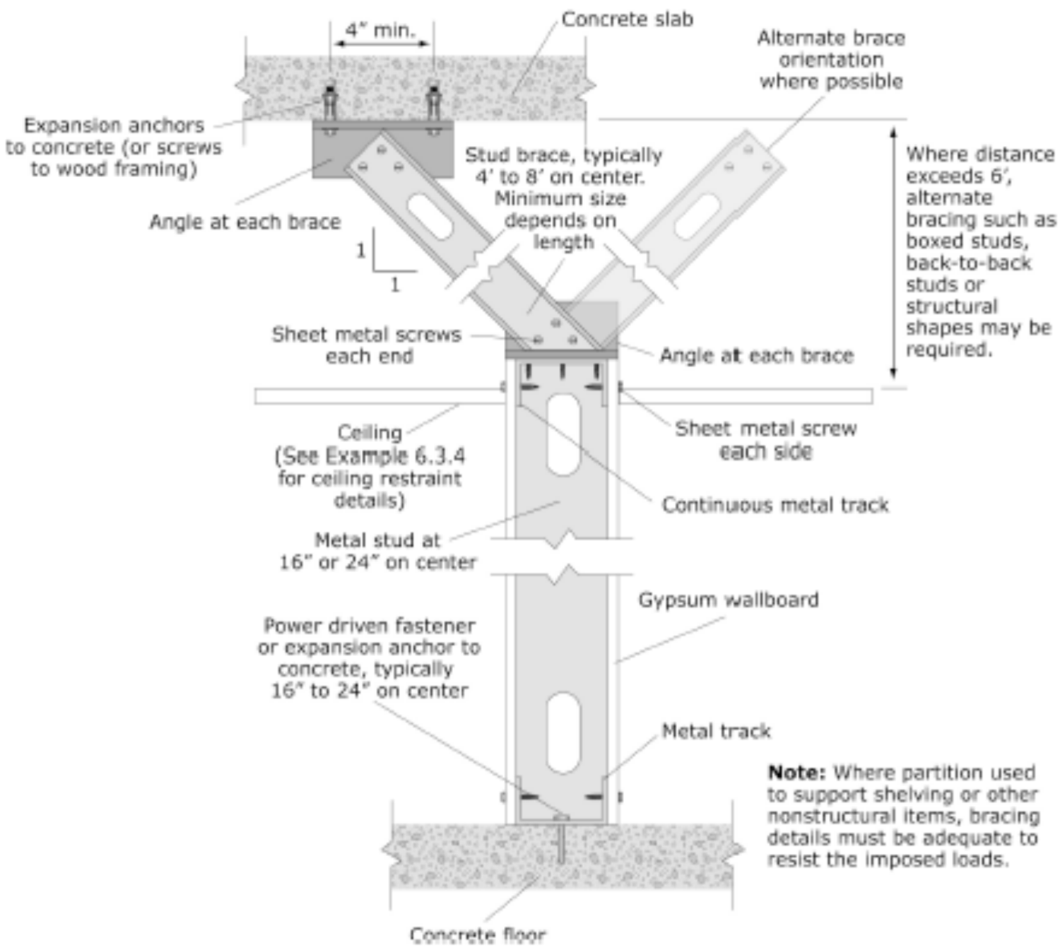



**Figure G-4. Mitigation Schemes for Bracing the Tops of Metal Stud Partitions Walls.**

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

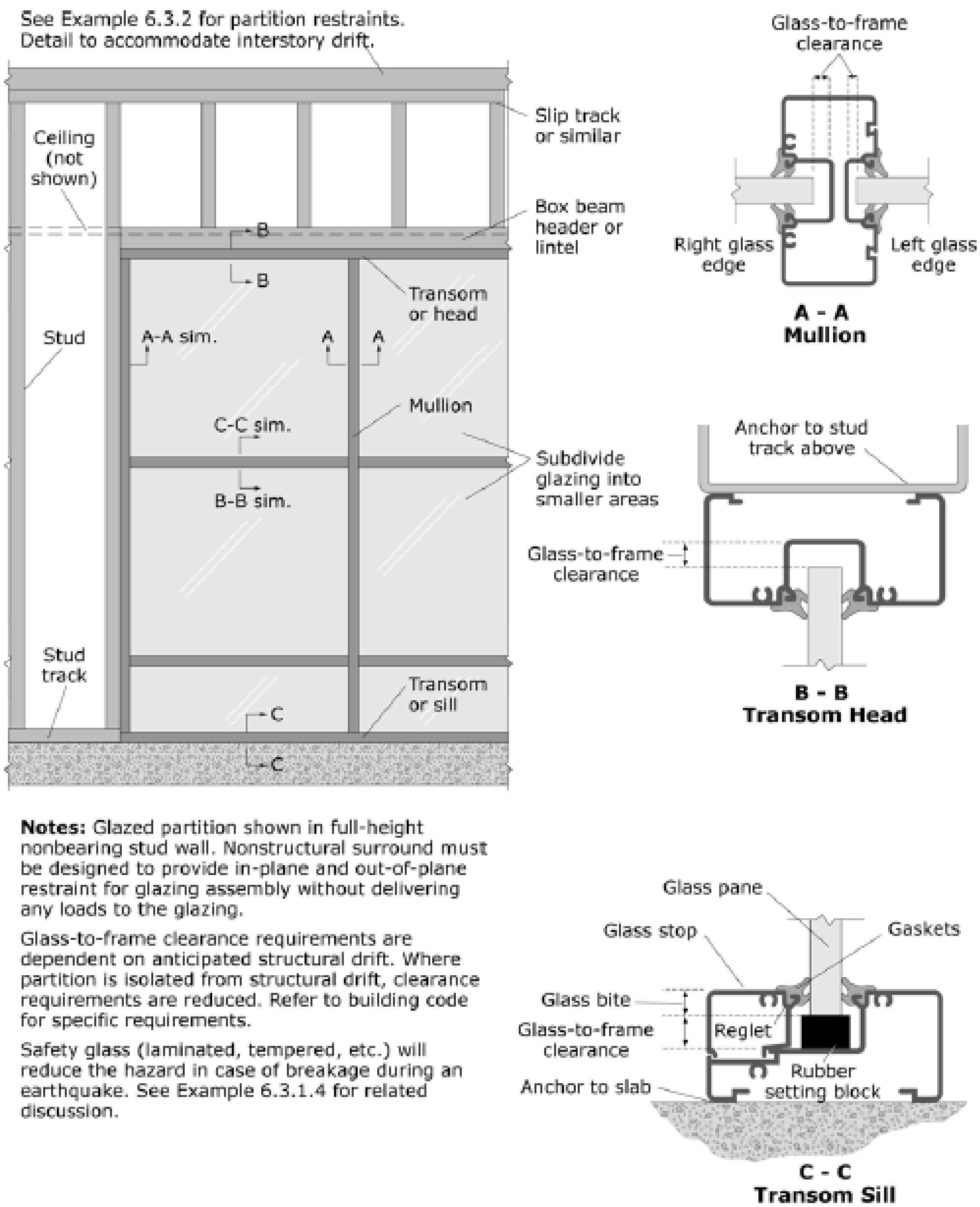



**Figure G-5. Full-height Glazed Partition.**

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

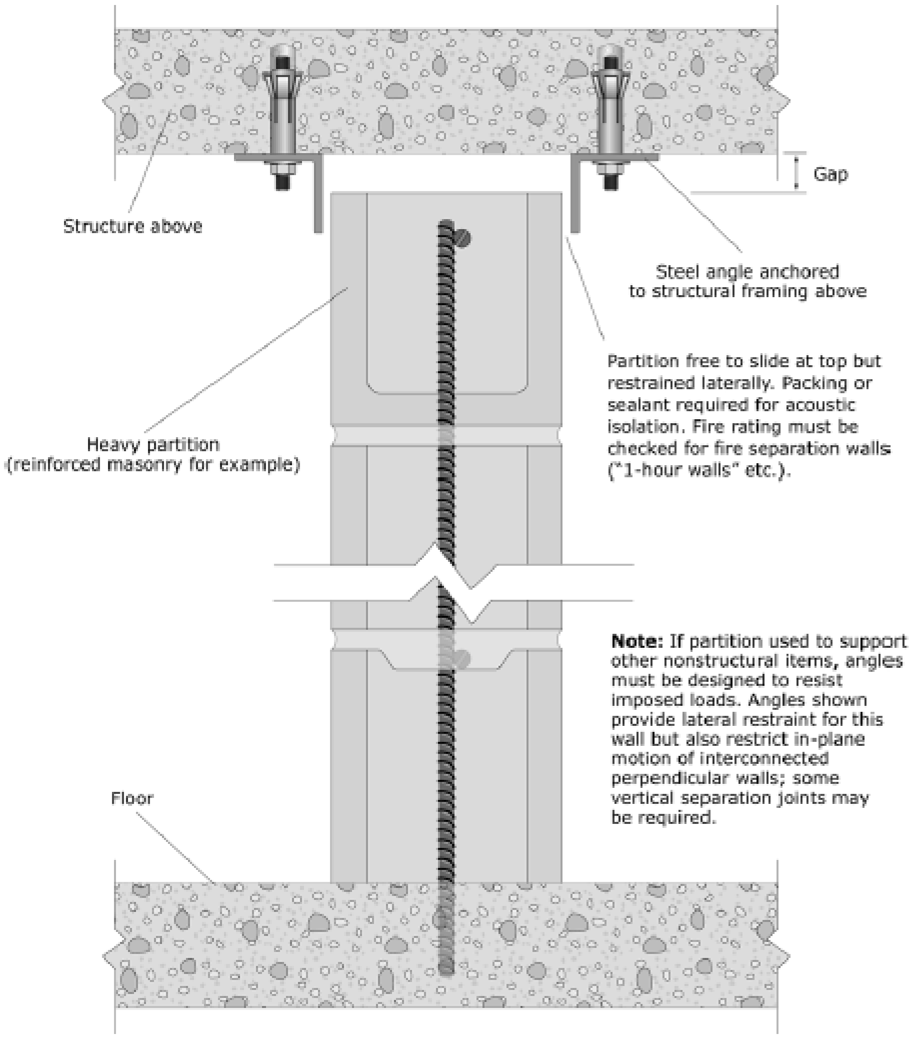



**Figure G-6. Full-height Heavy Partition.**

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

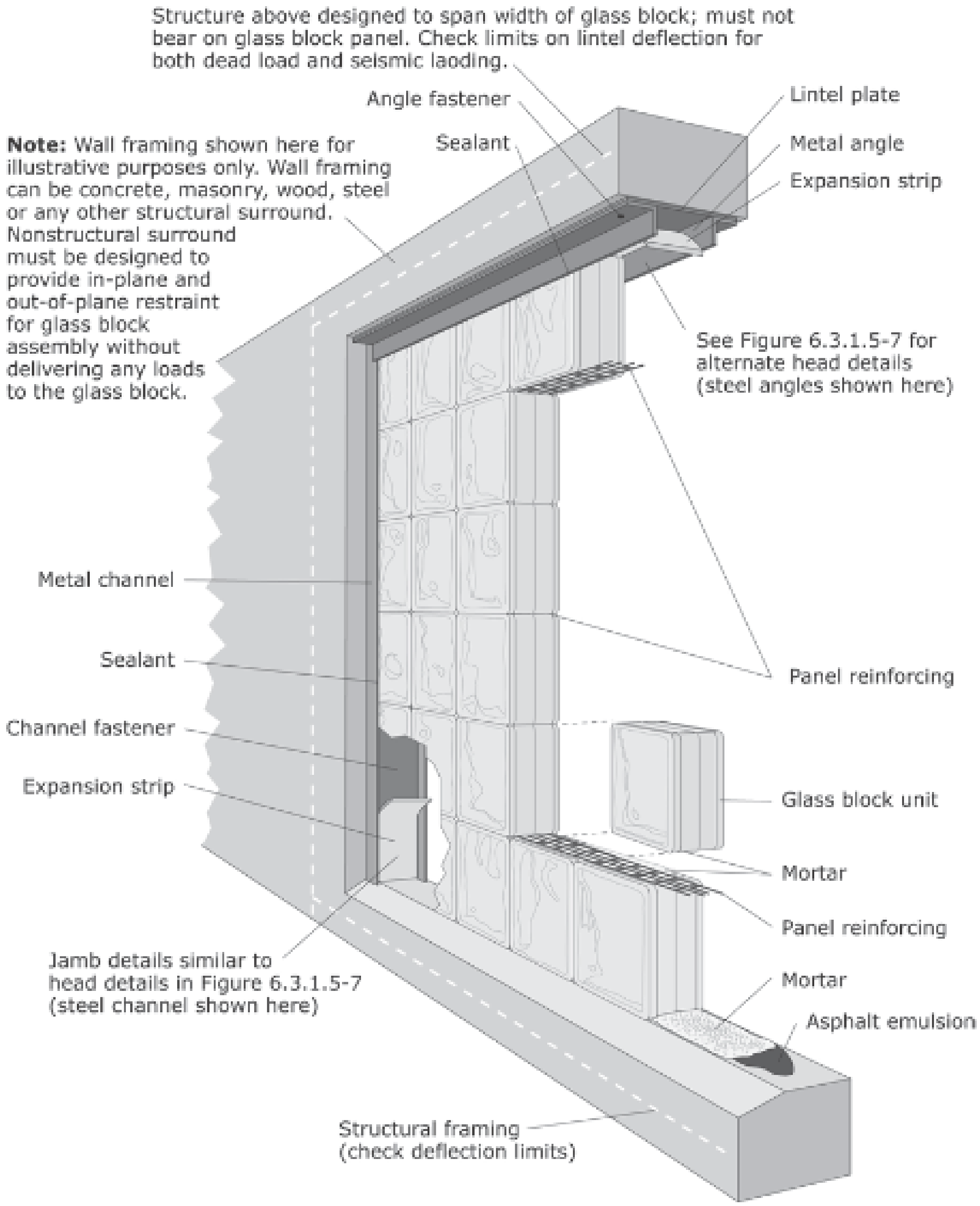



**Figure G-7. Typical Glass Block Panel Details.**

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

### *Ceilings*

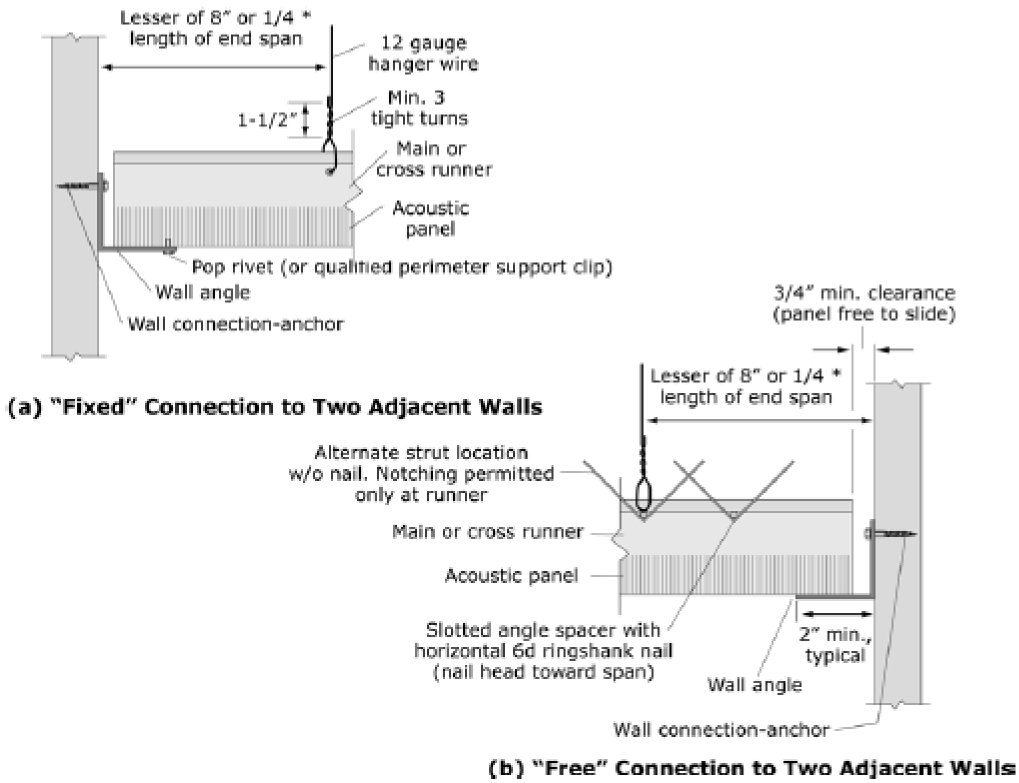
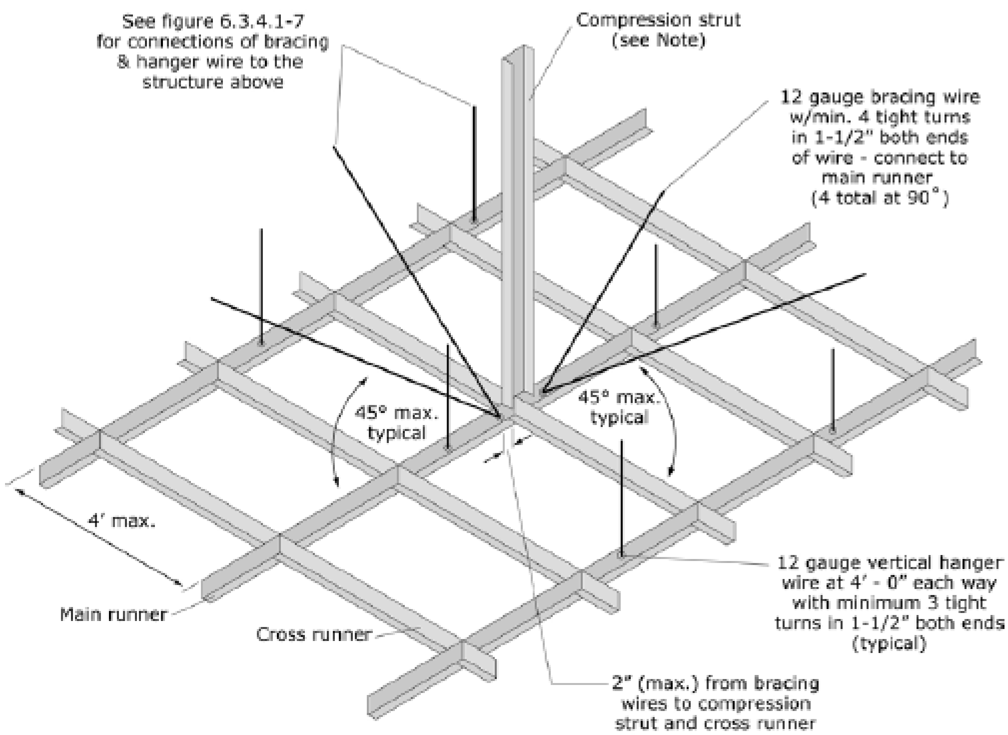



**Figure G-8. Suspension System for Acoustic Lay-in Panel Ceilings – Edge Conditions.**

***(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)***

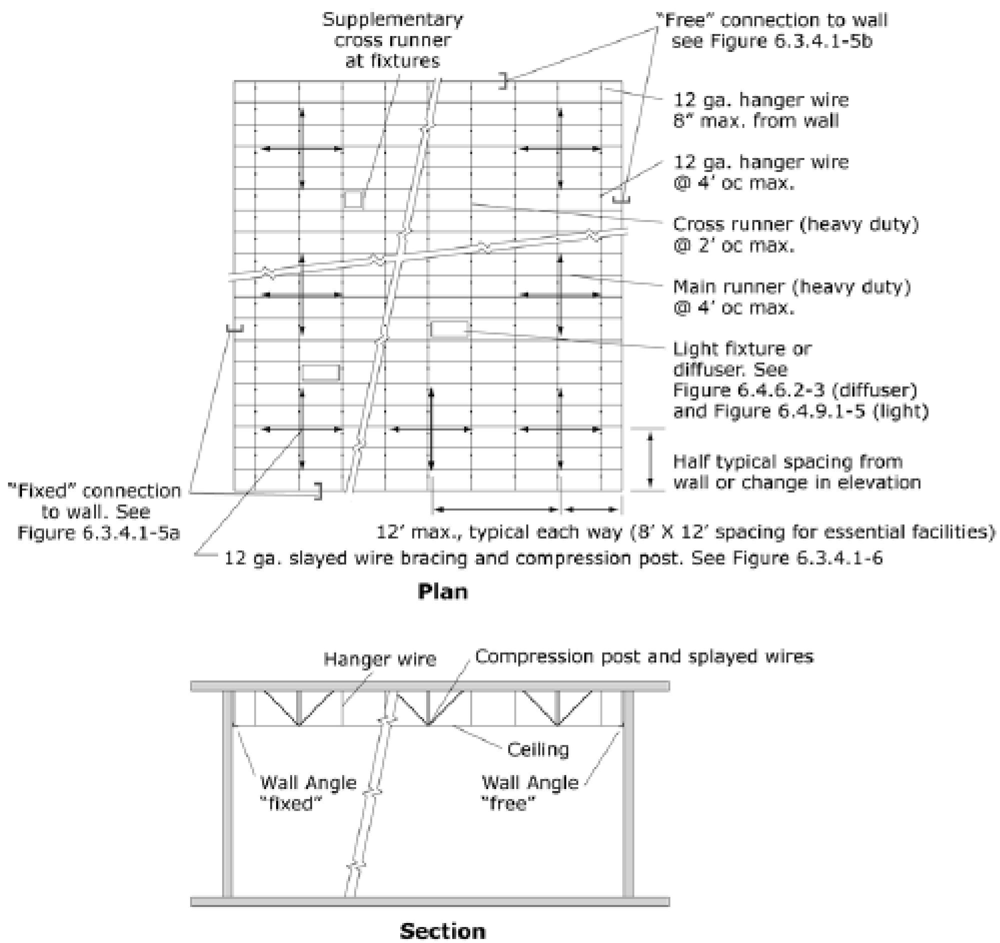



**Figure G-10. Suspension System for Acoustic Lay-in Panel Ceilings – General Bracing Layout.**

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

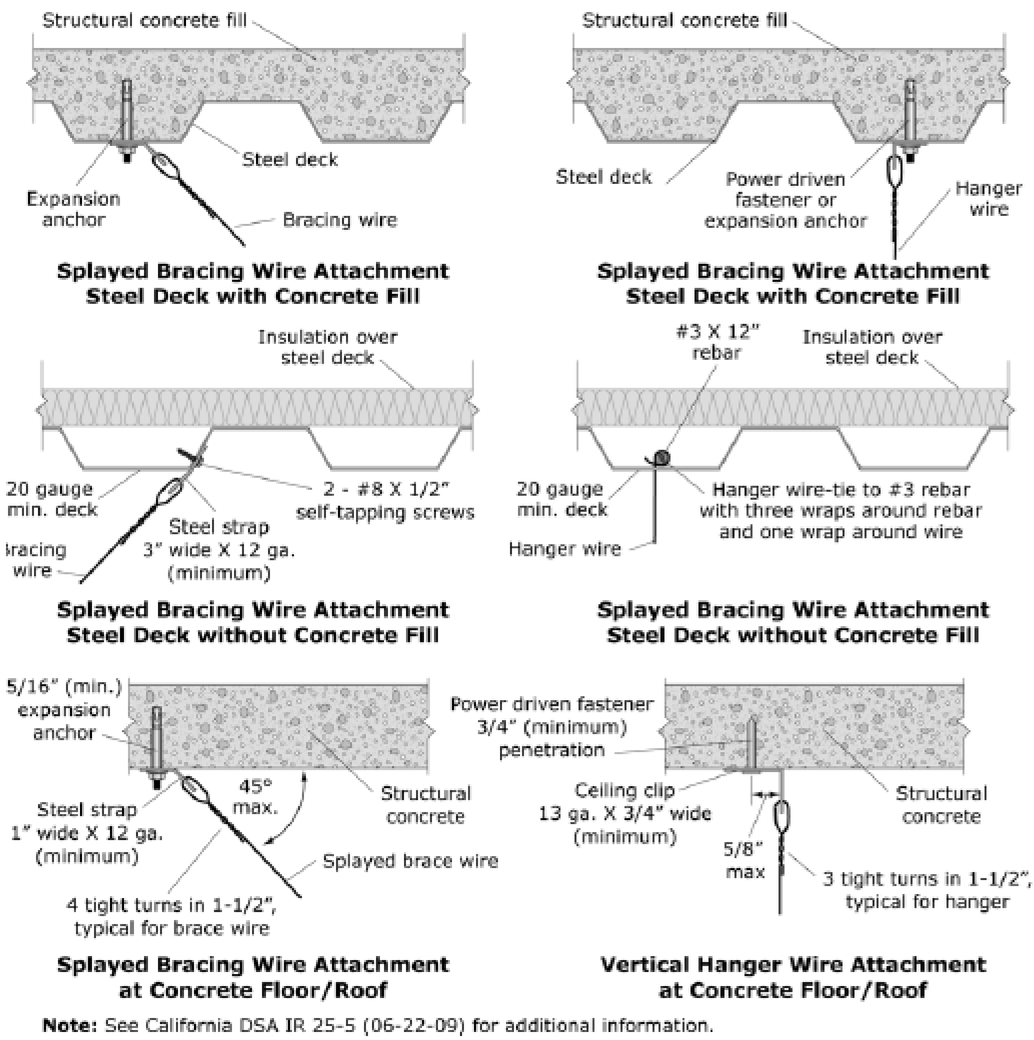



**Figure G-11. Suspension System for Acoustic Lay-in Panel Ceilings – Overhead Attachment Details.**

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

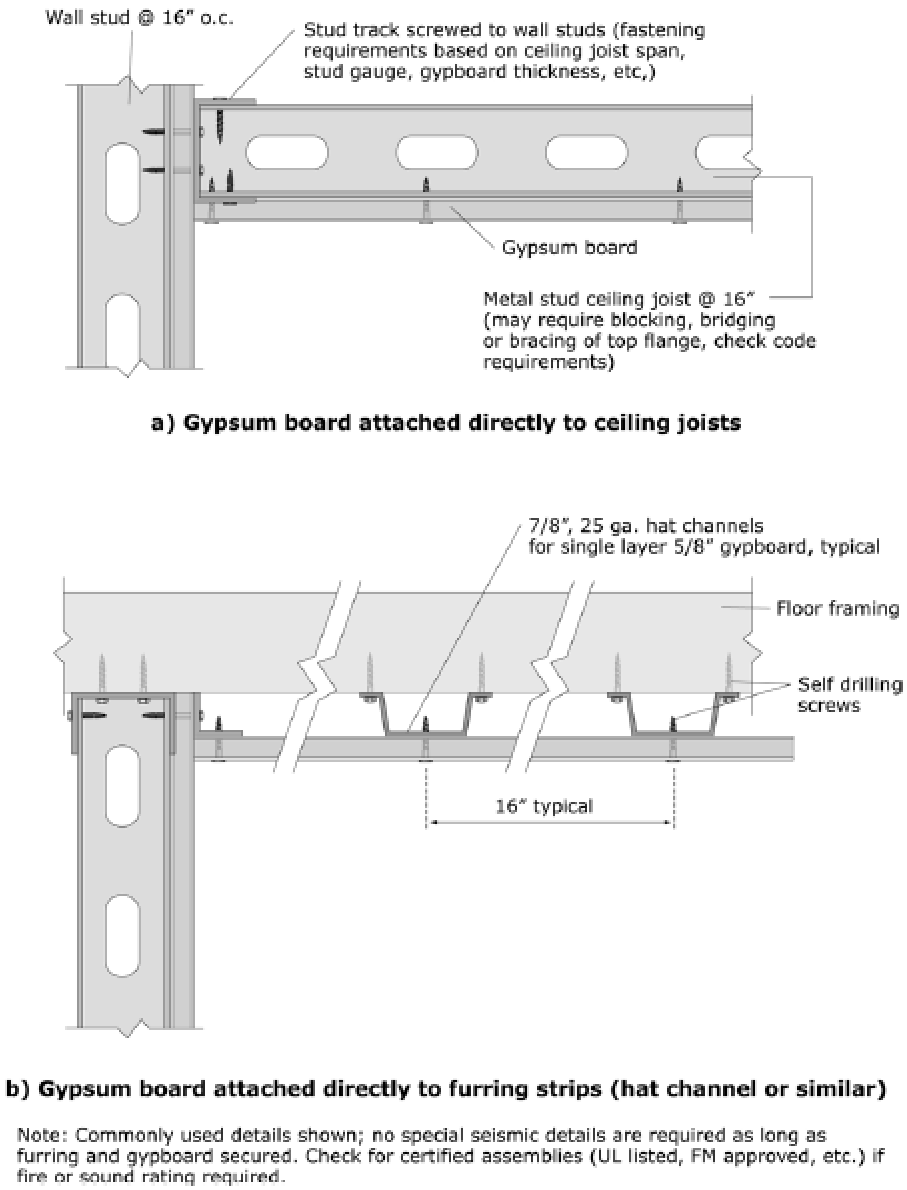



**Figure G-12. Gypsum Board Ceiling Applied Directly to Structure.**

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

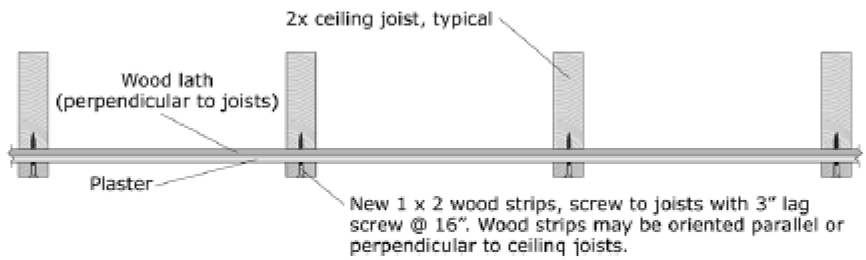



**Figure G-13. Retrofit Detail for Existing Lath and Plaster.**

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

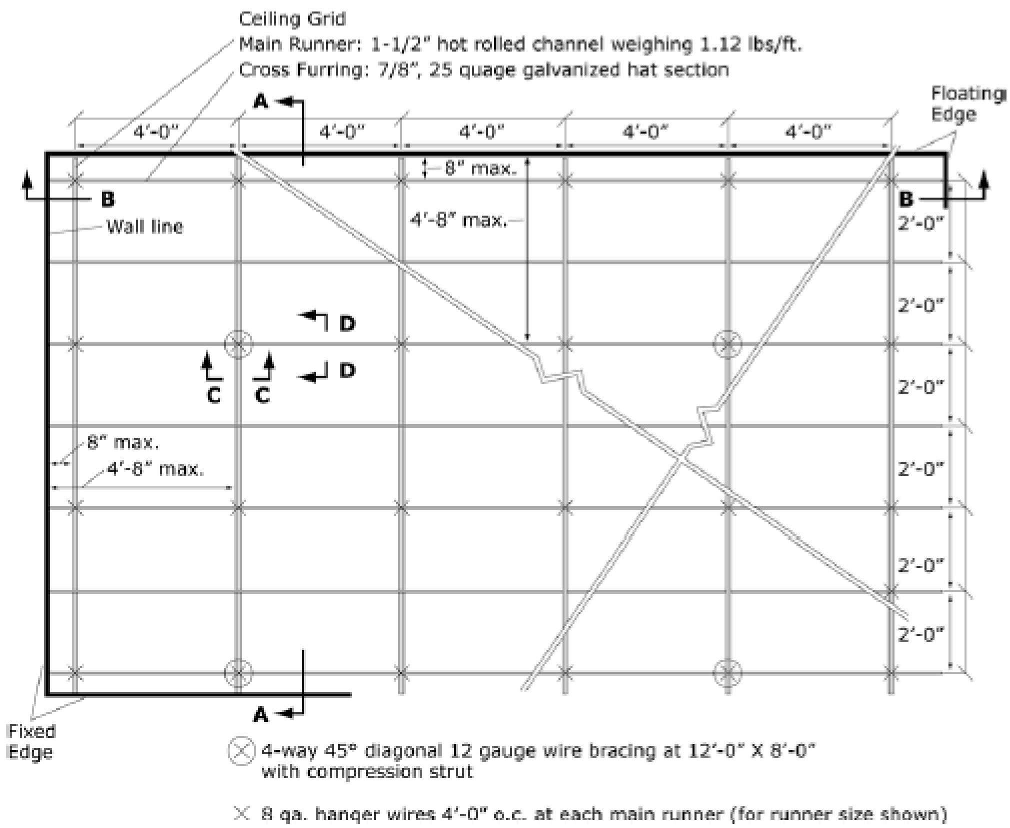



**Figure G-14. Diagrammatic View of Suspended Heavy Ceiling Grid and Lateral Bracing.**

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

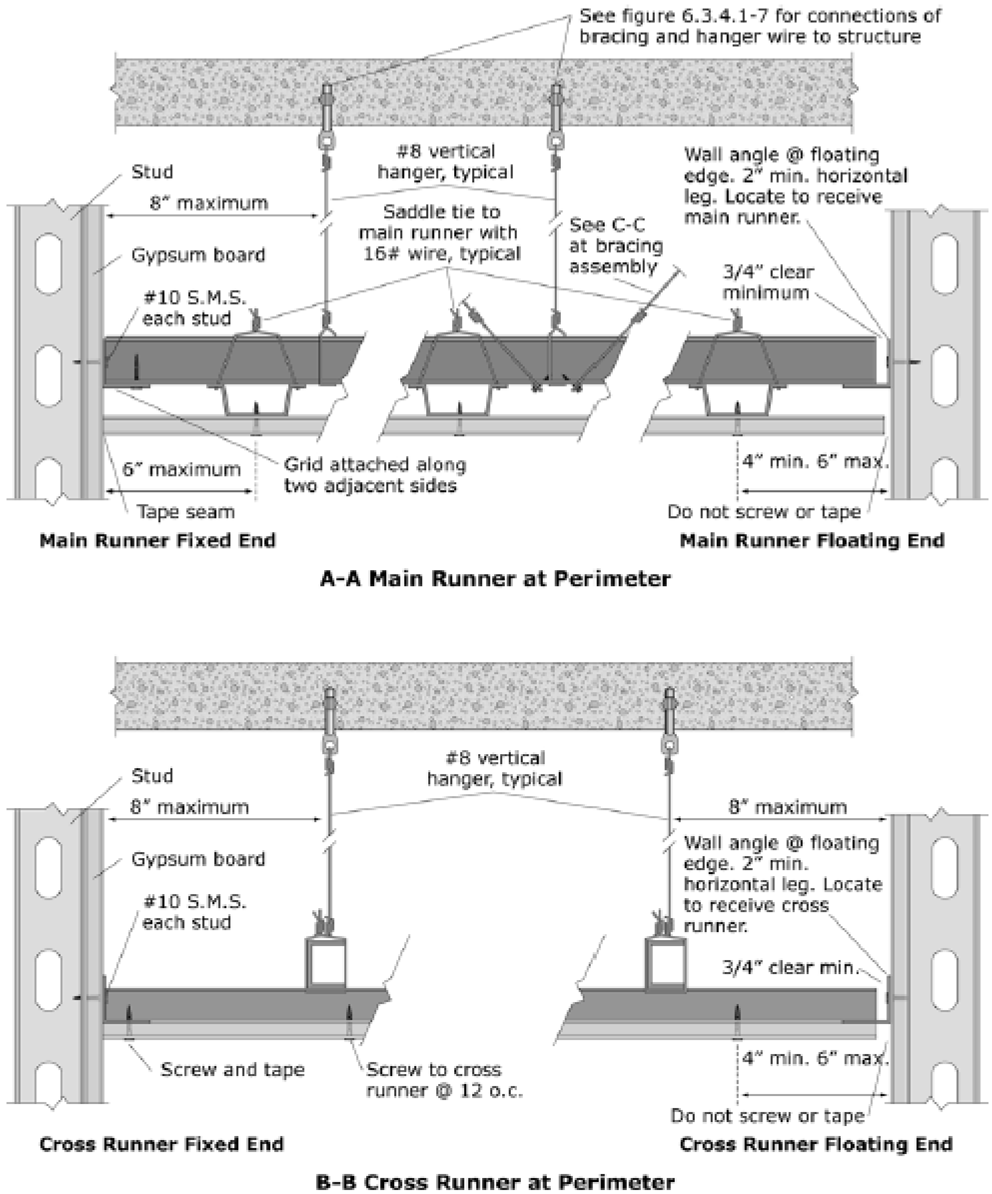
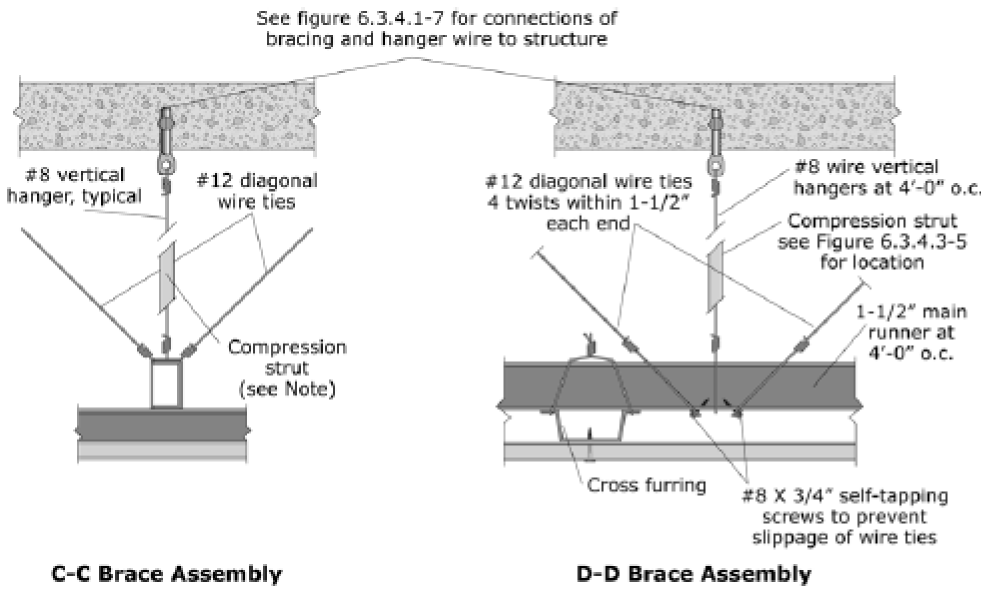



**Figure G-15. Perimeter Details for Suspended Gypsum Board Ceiling.**

***(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 ≤ 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*

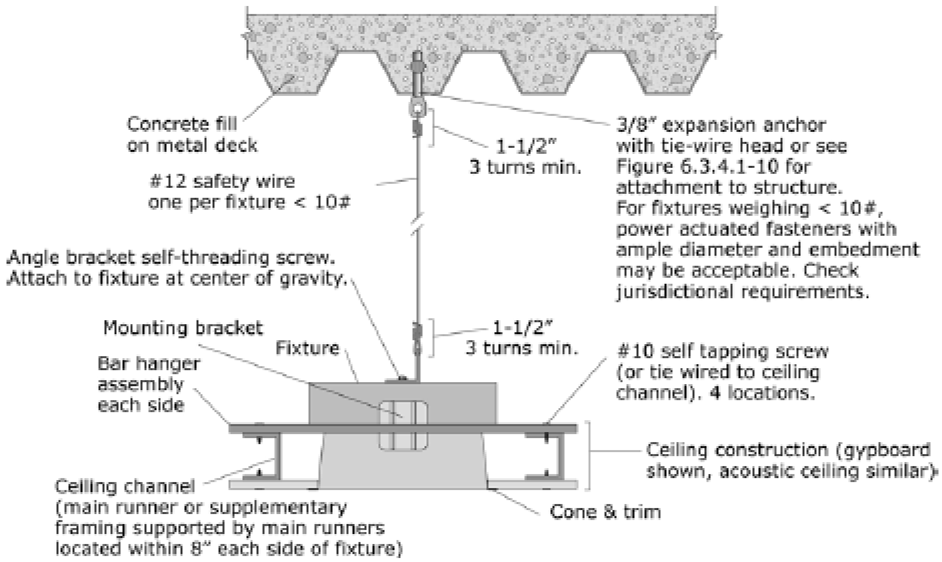



**Figure G-17. Recessed Light Fixture in suspended Ceiling (Fixture Weight < 10 pounds).**

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

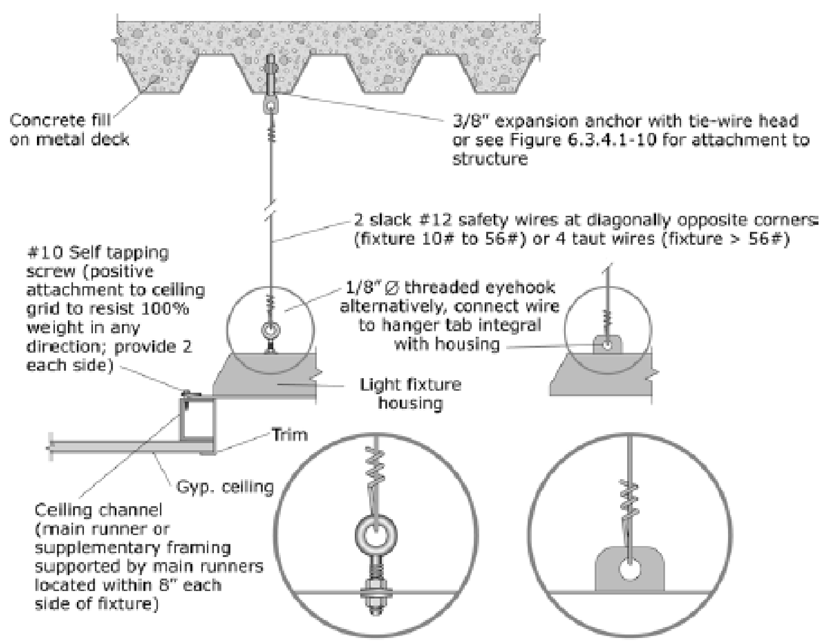



**Figure G-18. Recessed Light Fixture in suspended Ceiling (Fixture Weight 10 to 56 pounds).**

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

### *Contents and Furnishings*

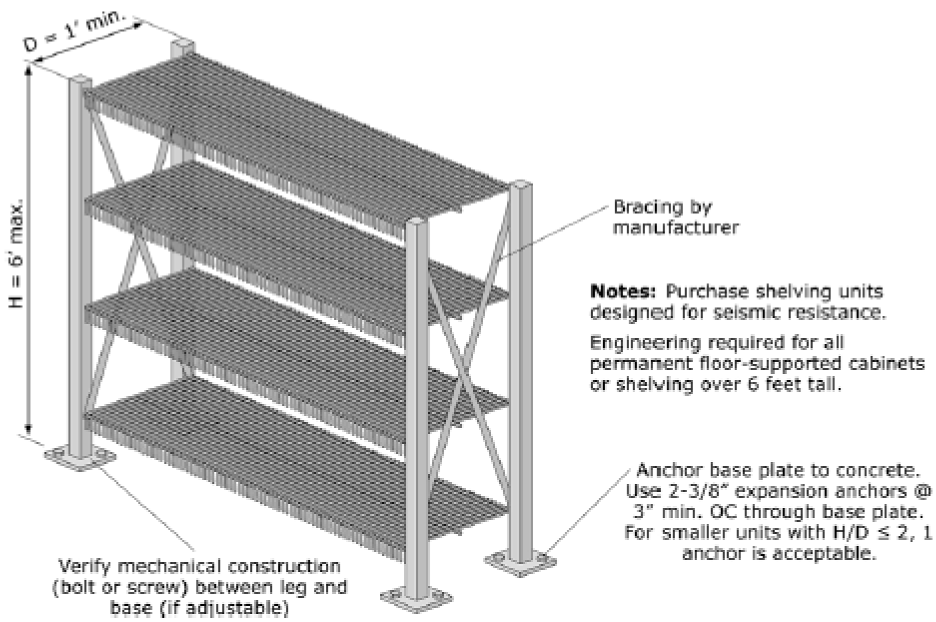



**Figure G-19. Light Storage Racks.**

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

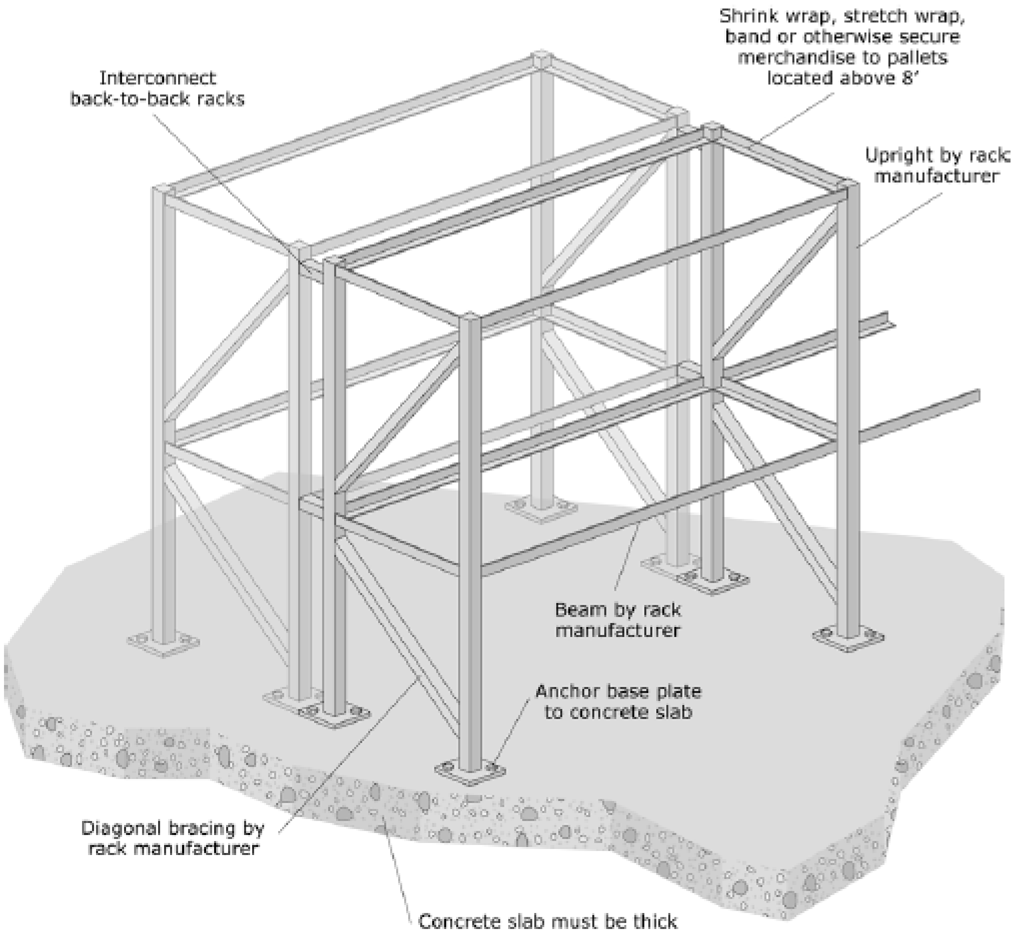



**Figure G-20. Industrial Storage Racks.**

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

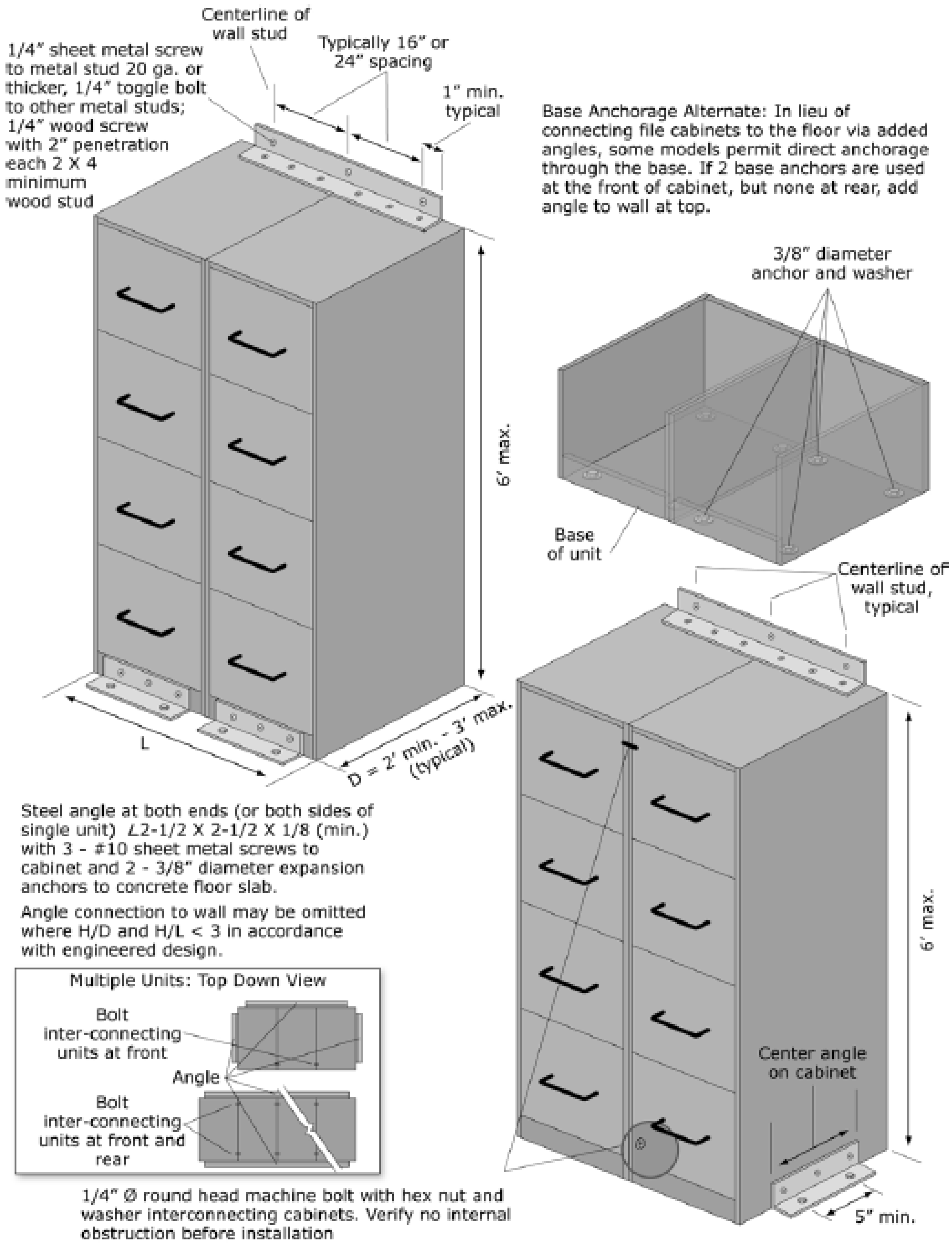



**Figure G-21. Wall-mounted File Cabinets.**

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

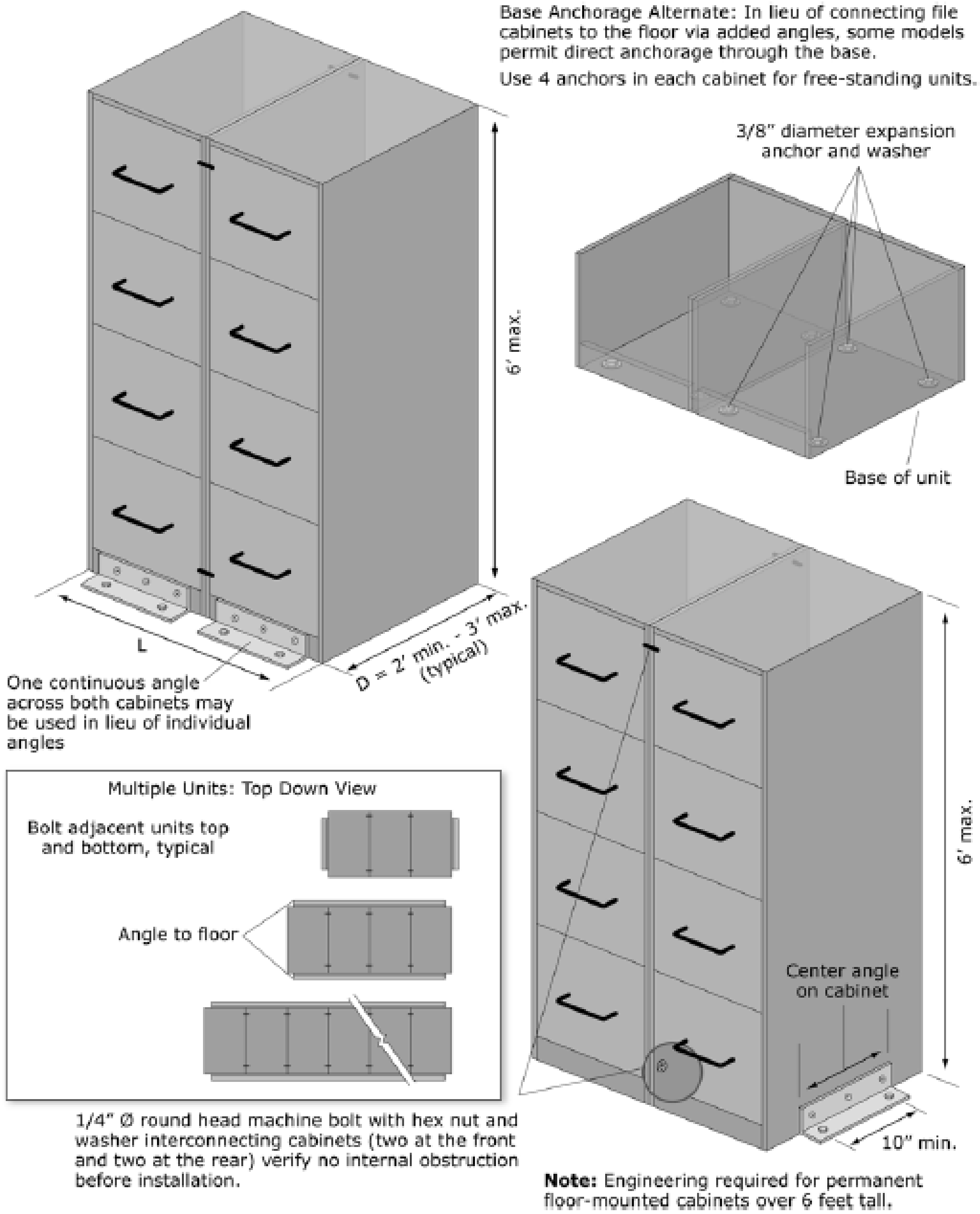



**Figure G-22. Base Anchored File Cabinets.**

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

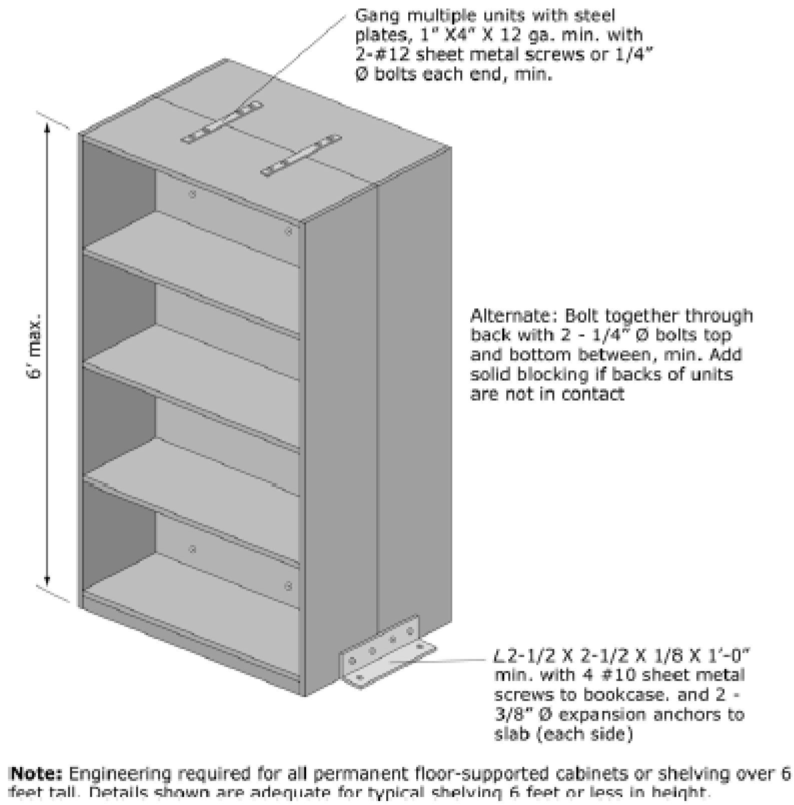



**Figure G-23. Anchorage of Freestanding Book Cases Arranged Back to Back.**

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

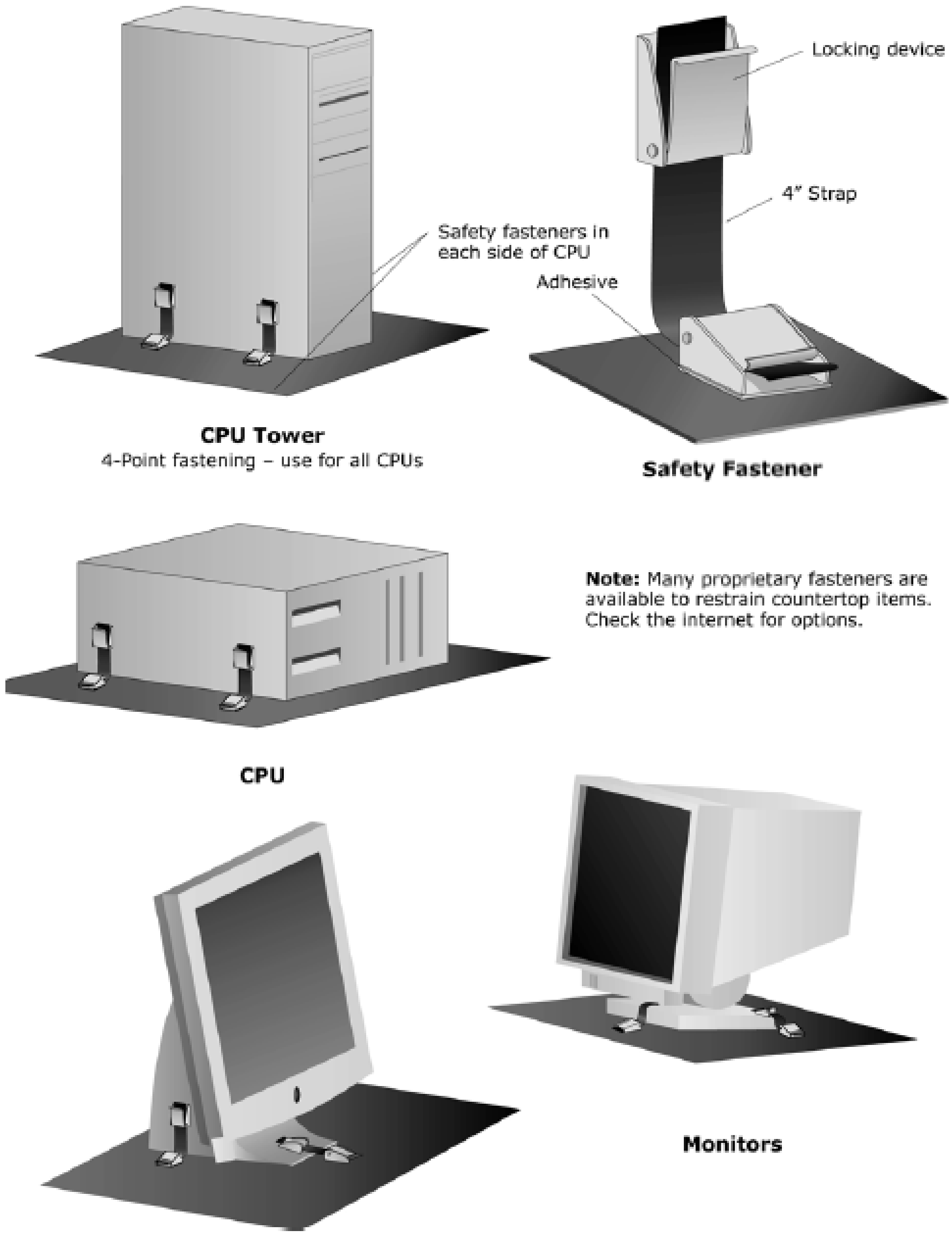



**Figure G-24. Desktop Computers and Accessories.**

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

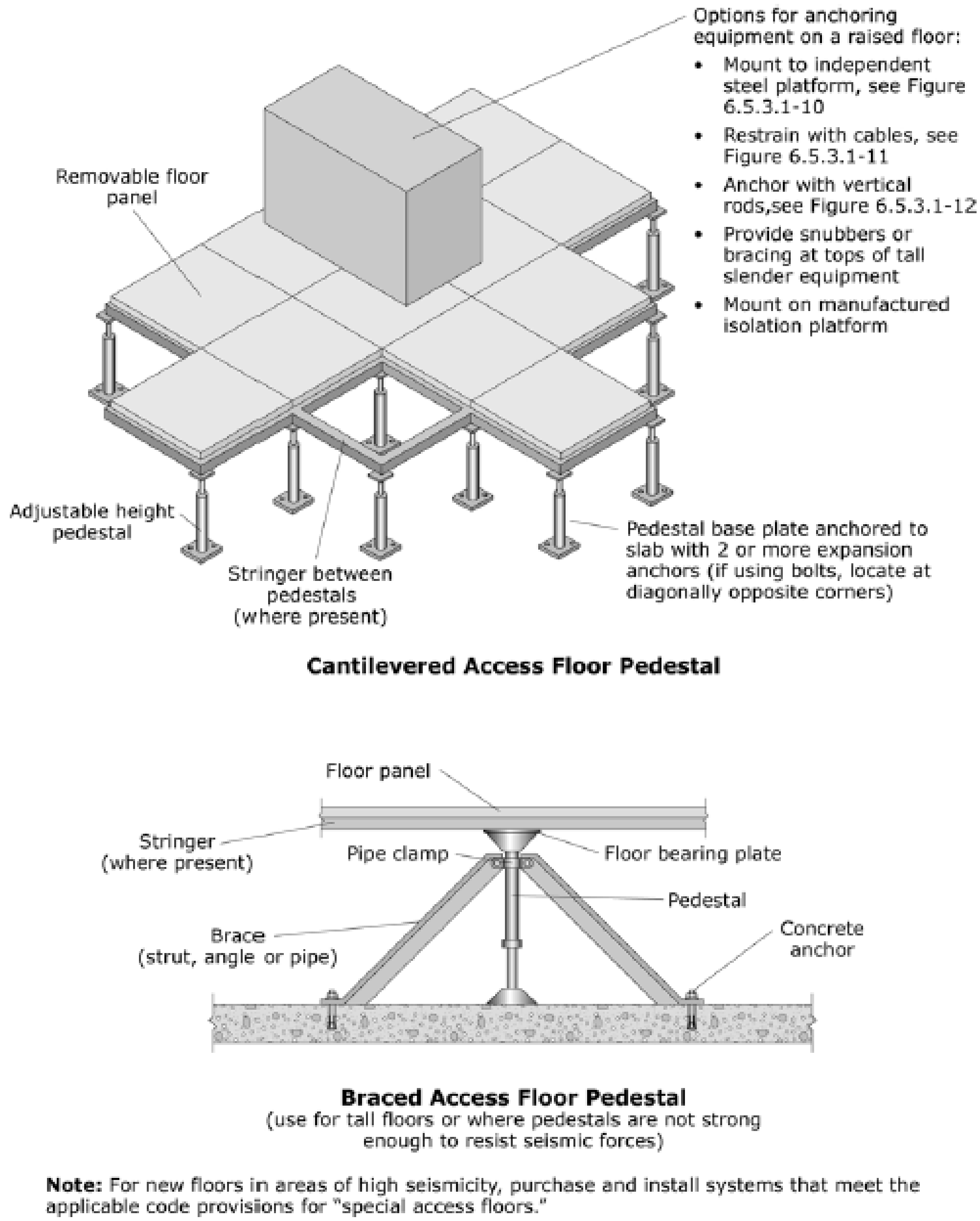



**Figure G-25. Equipment Mounted on Access Floor.**

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

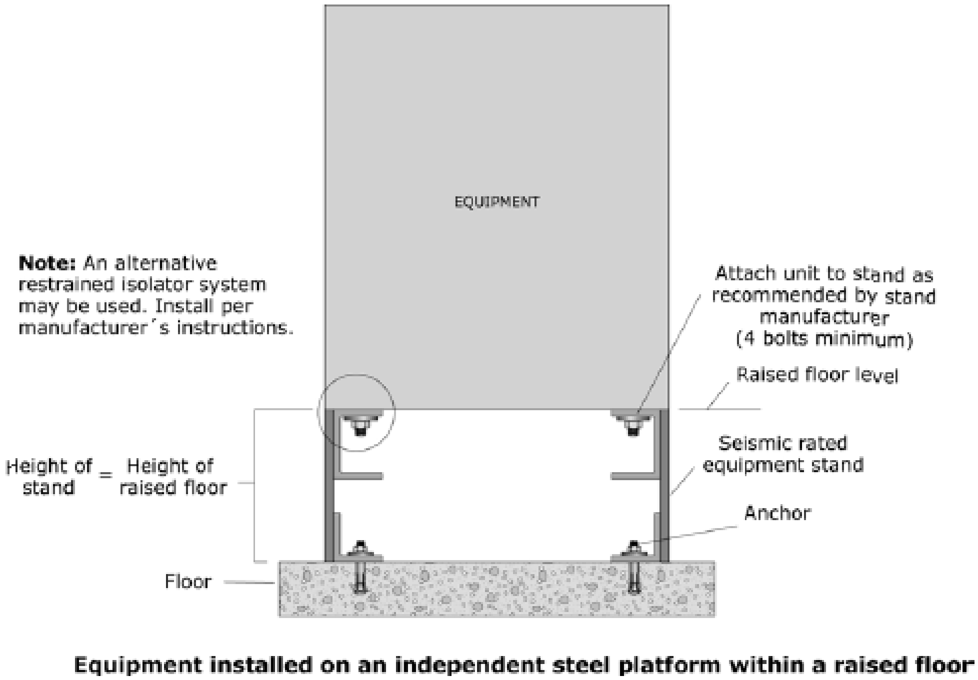



**Figure G-26. Equipment Mounted on Access Floor – Independent Base.**

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

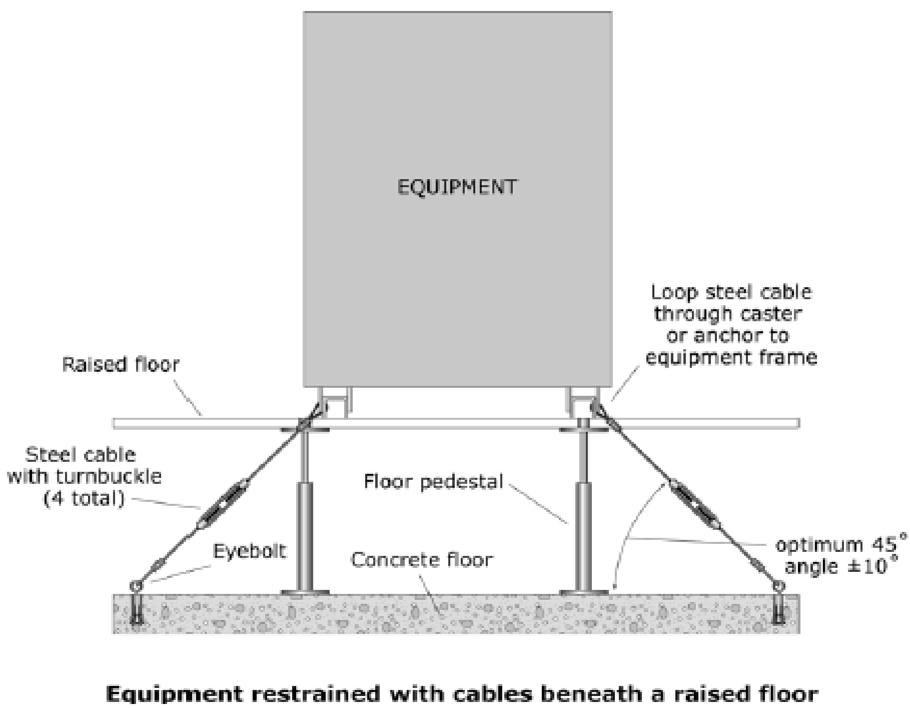



**Figure G-27. Equipment Mounted on Access Floor – Cable Braced.**

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

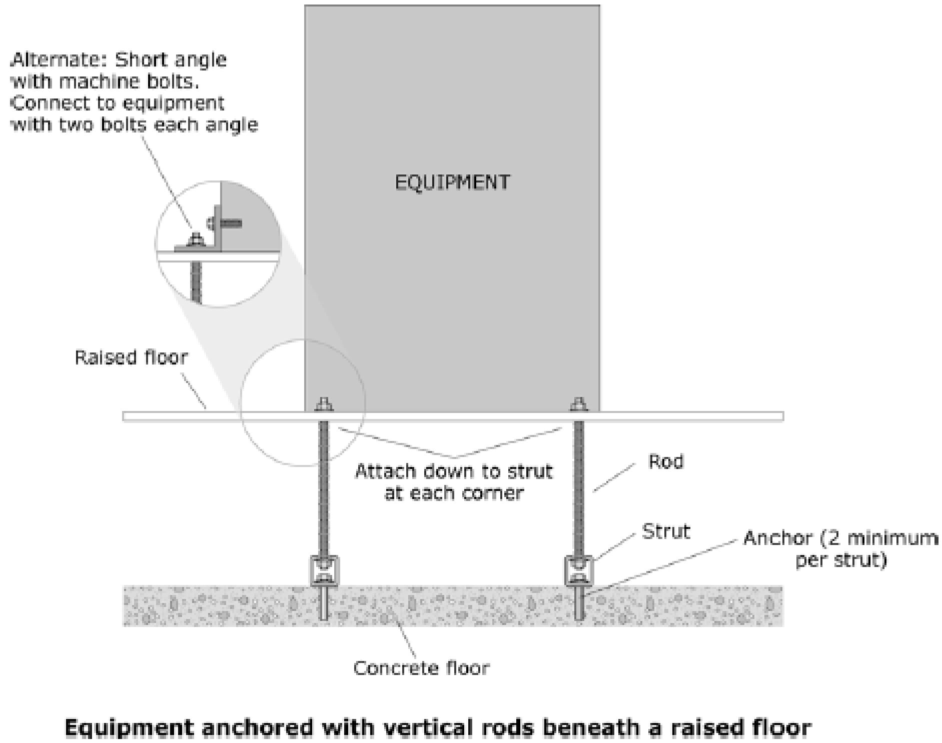
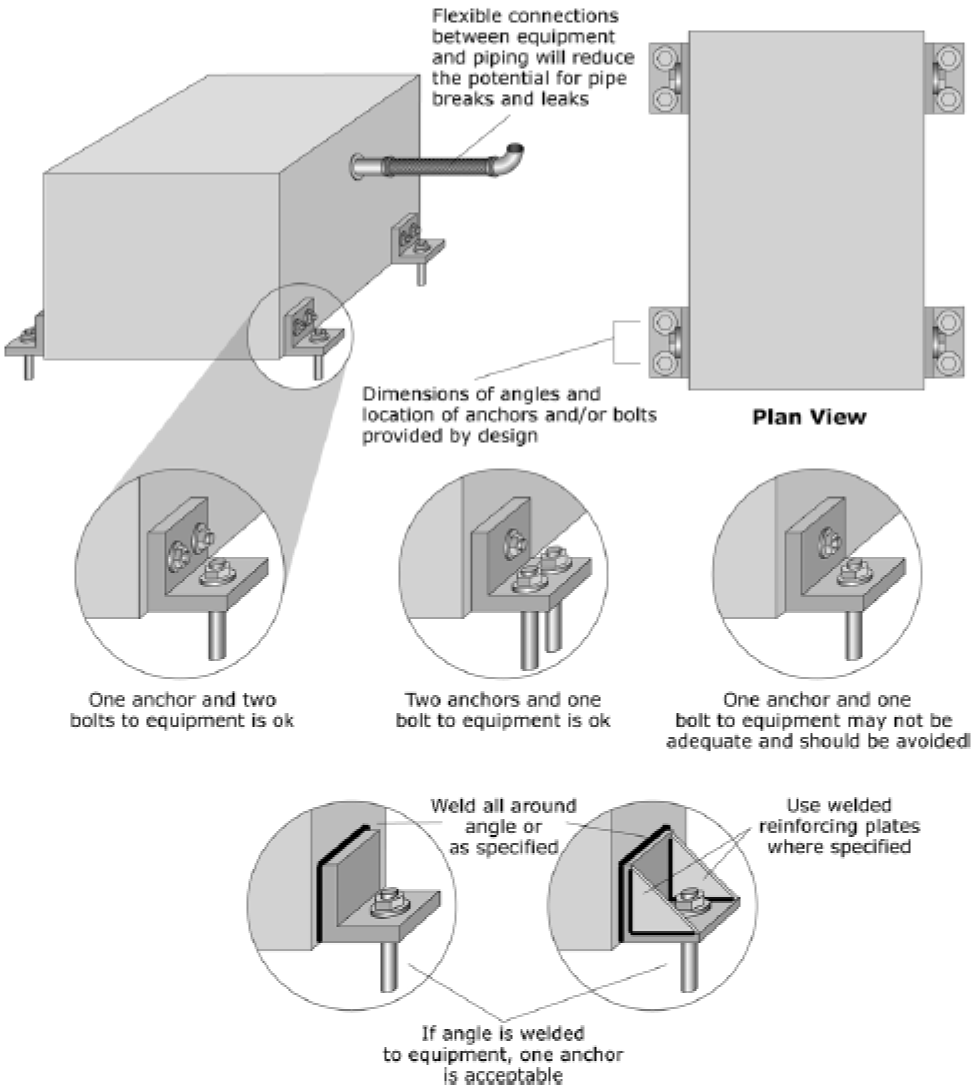



**Figure G-28. Equipment Mounted on Access Floor – Tie-down Rods.**

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

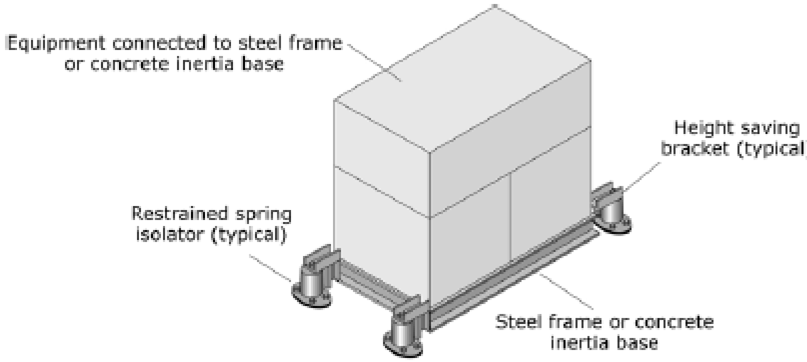
### *Mechanical and Electrical Equipment*



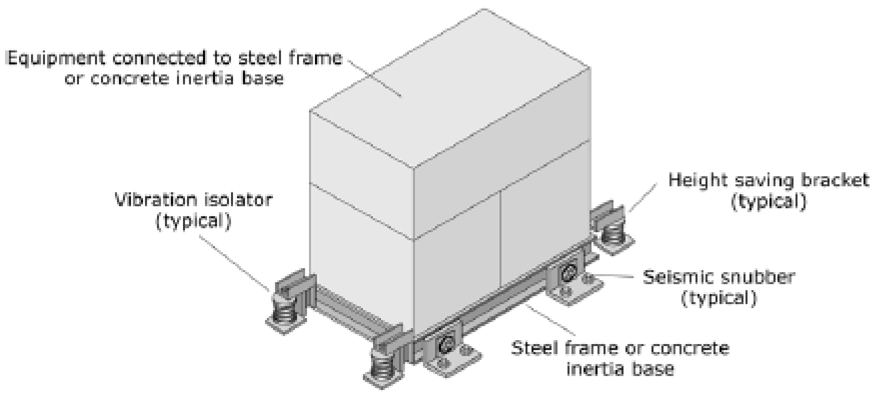

**Note: Rigidly mounted equipment shall have flexible connections for the fuel lines and piping.**

**Figure G-29. Rigidly Floor-mounted Equipment with Added Angles.**

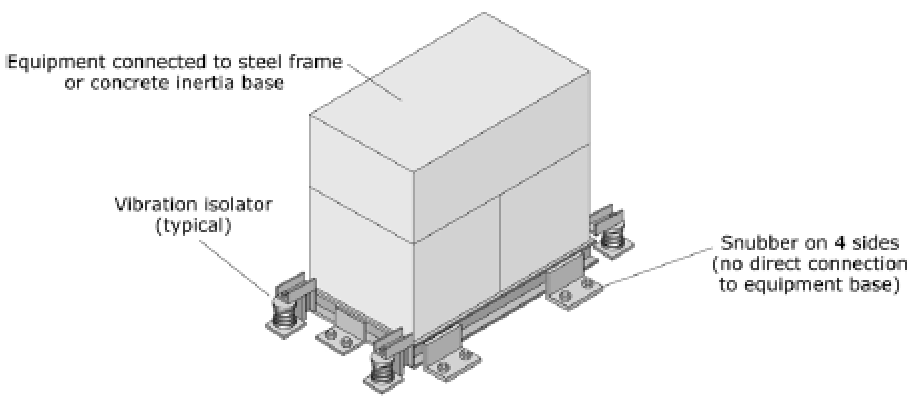
***(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)***




**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)***

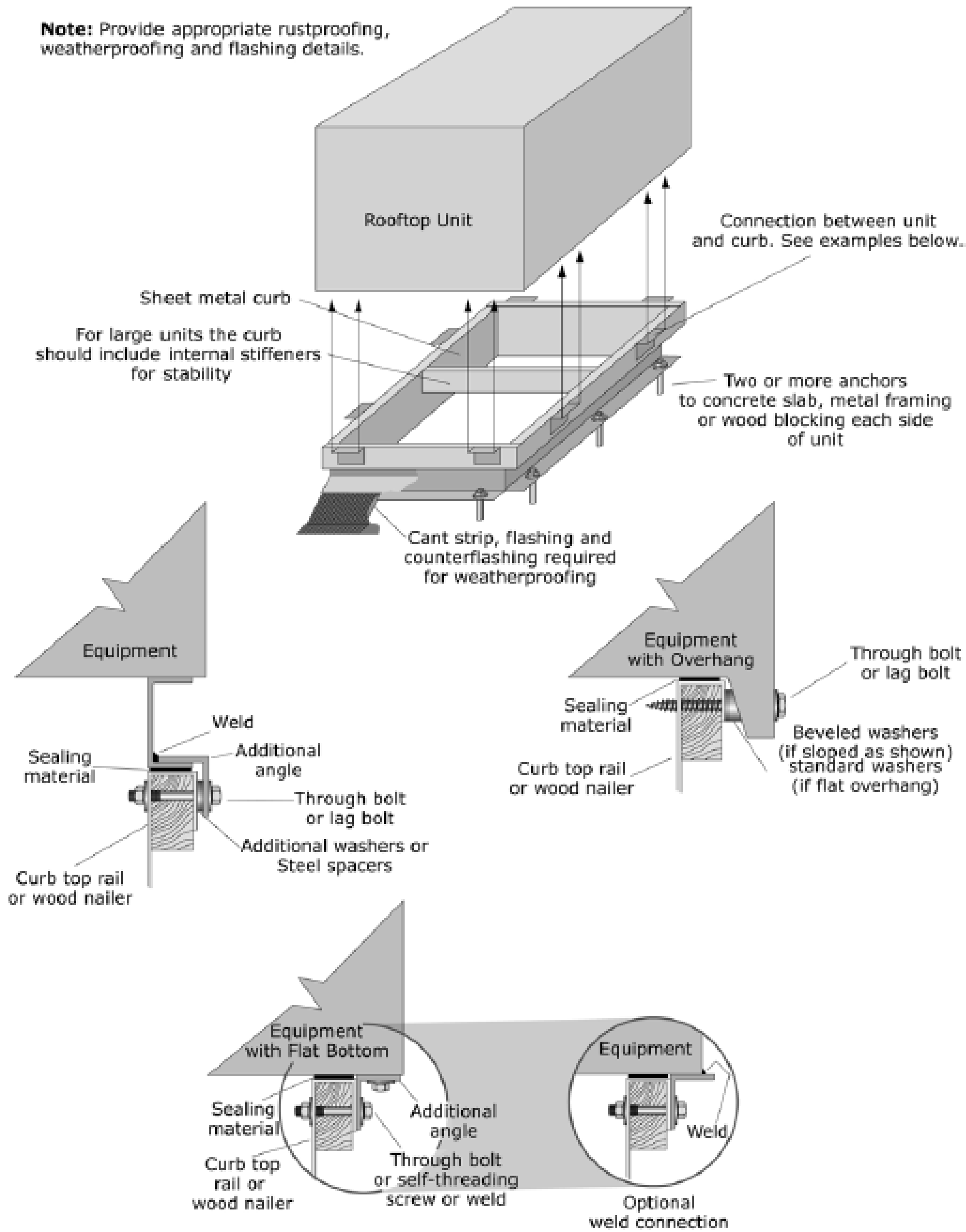



**Figure G-31. Rooftop HVAC Equipment.**

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

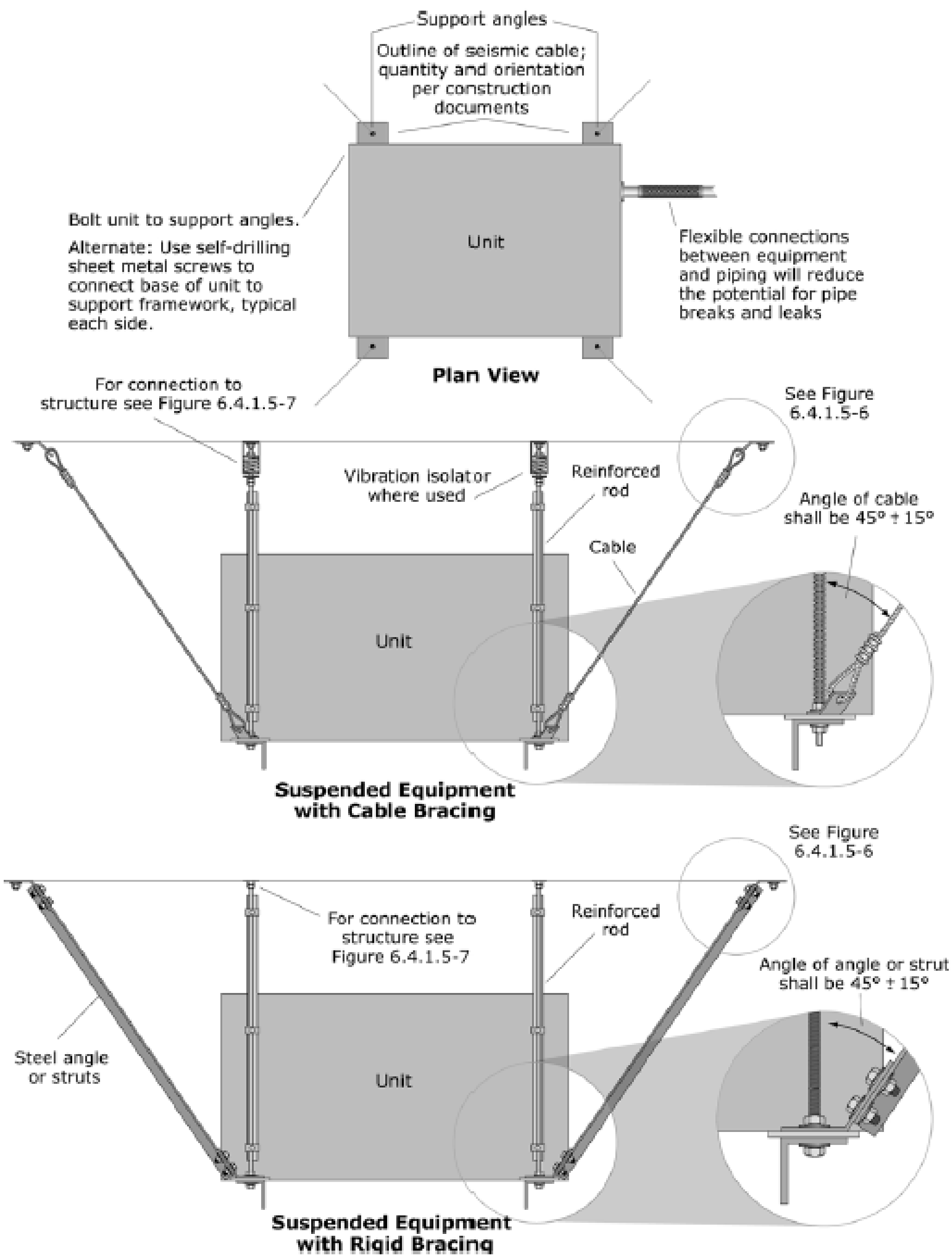



**Figure G-32. Suspended Equipment.**

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

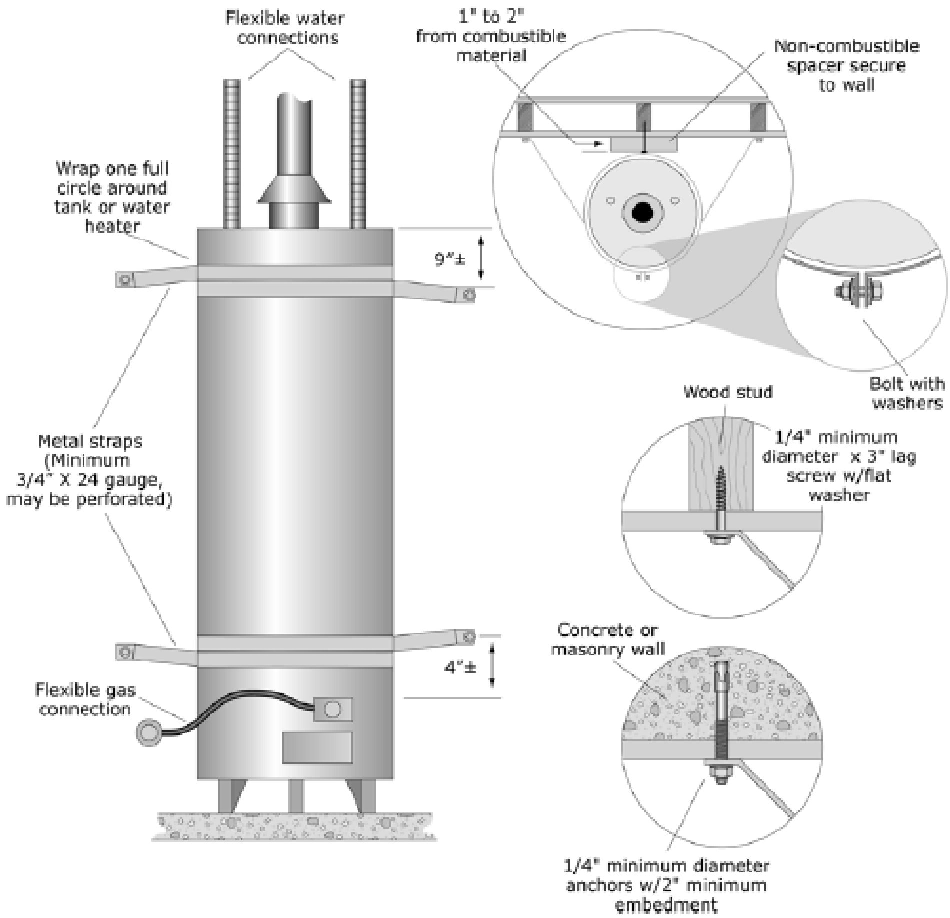



**Figure G-33. Water Heater Strapping to Backing Wall.**

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

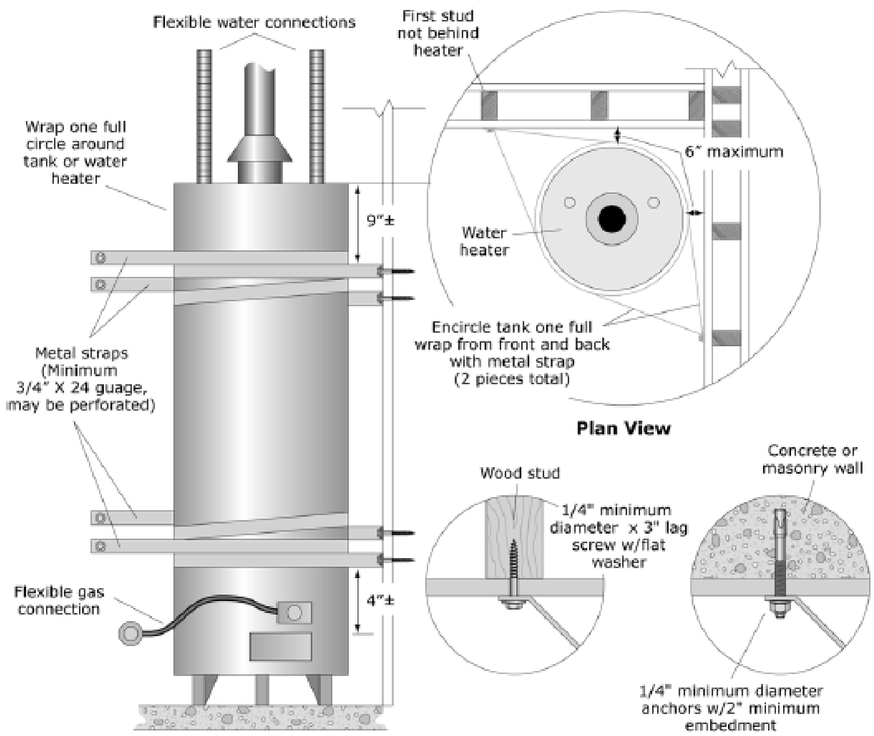



**Figure G-34. Water Heater – Strapping at Corner Installation.**

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

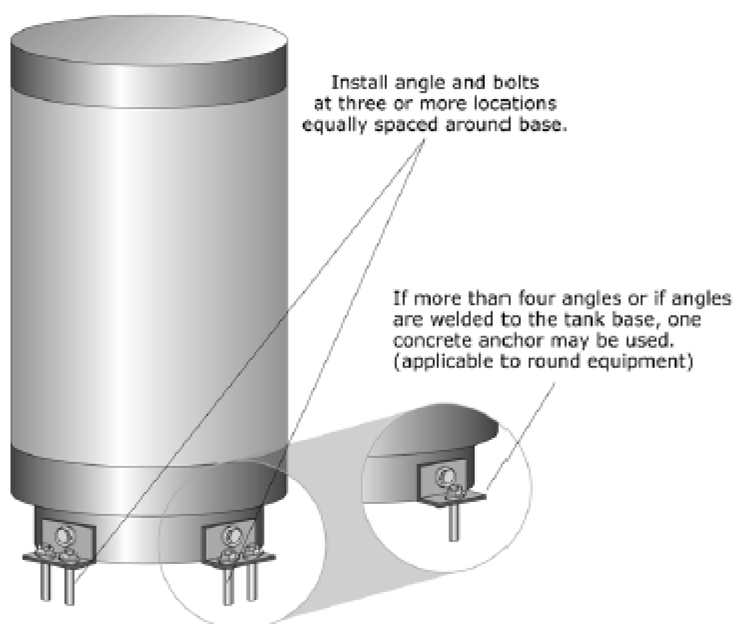



**Figure G-35. Water Heater – Base Mounted.**

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

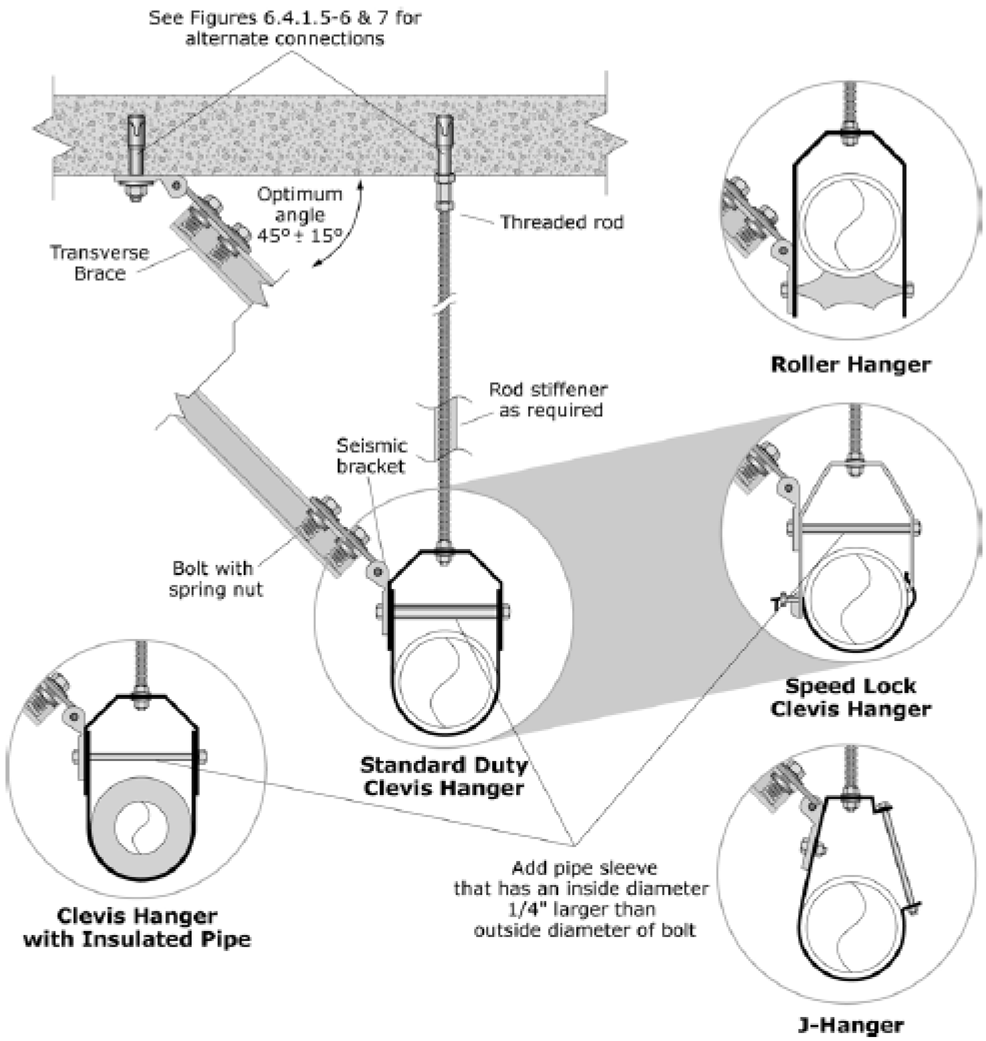



**Figure G-36. Rigid Bracing – Single Pipe Transverse.**

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

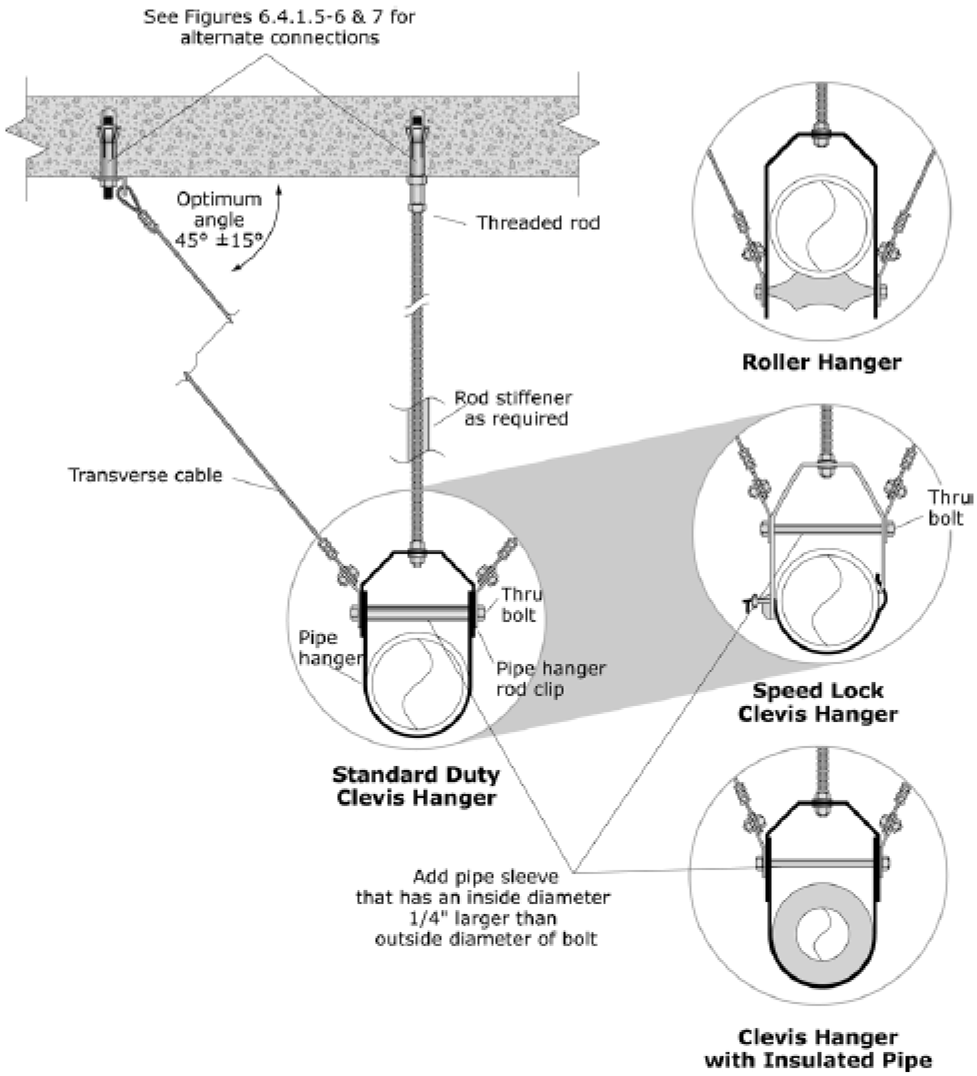



**Figure G-37. Cable Bracing – Single Pipe Transverse.**

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

## *Electrical and Communications*

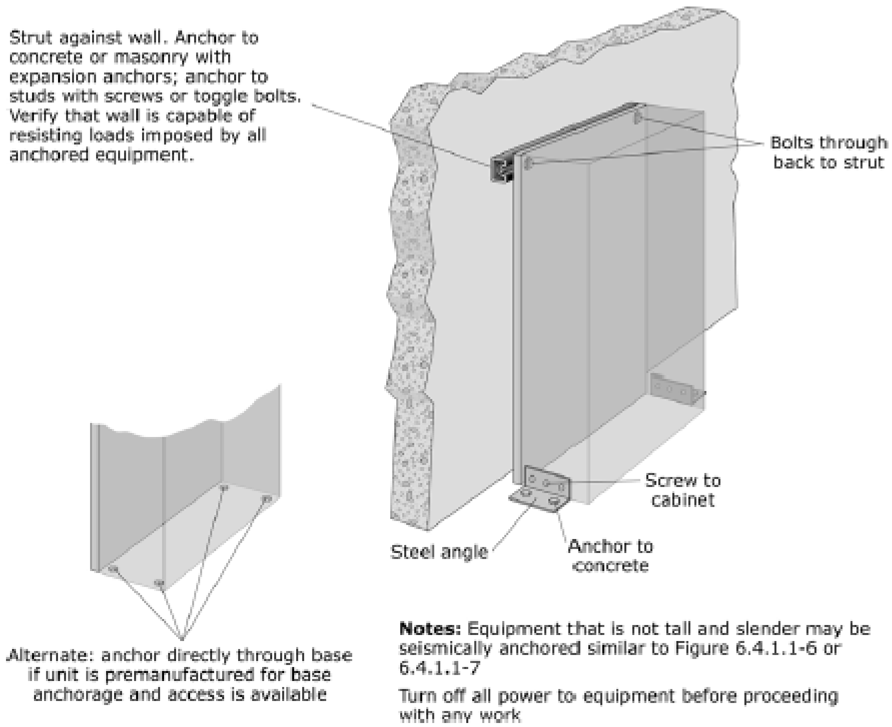



**Figure G-38. Electrical Control Panels, Motor Controls Centers, or Switchgear.**

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

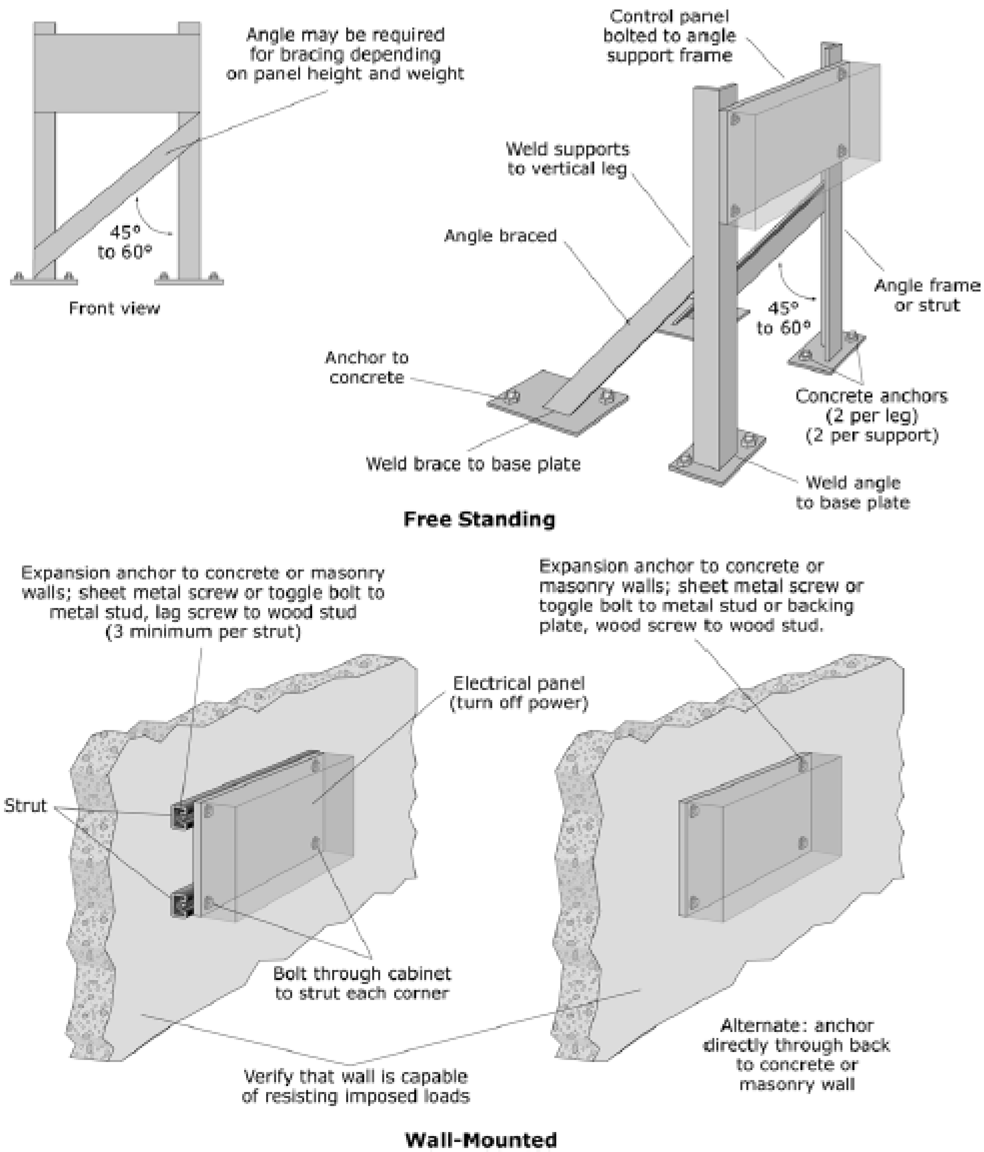



**Figure G-39. Freestanding and Wall-mounted Electrical Control Panels, Motor Controls Centers, or Switchgear.**

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

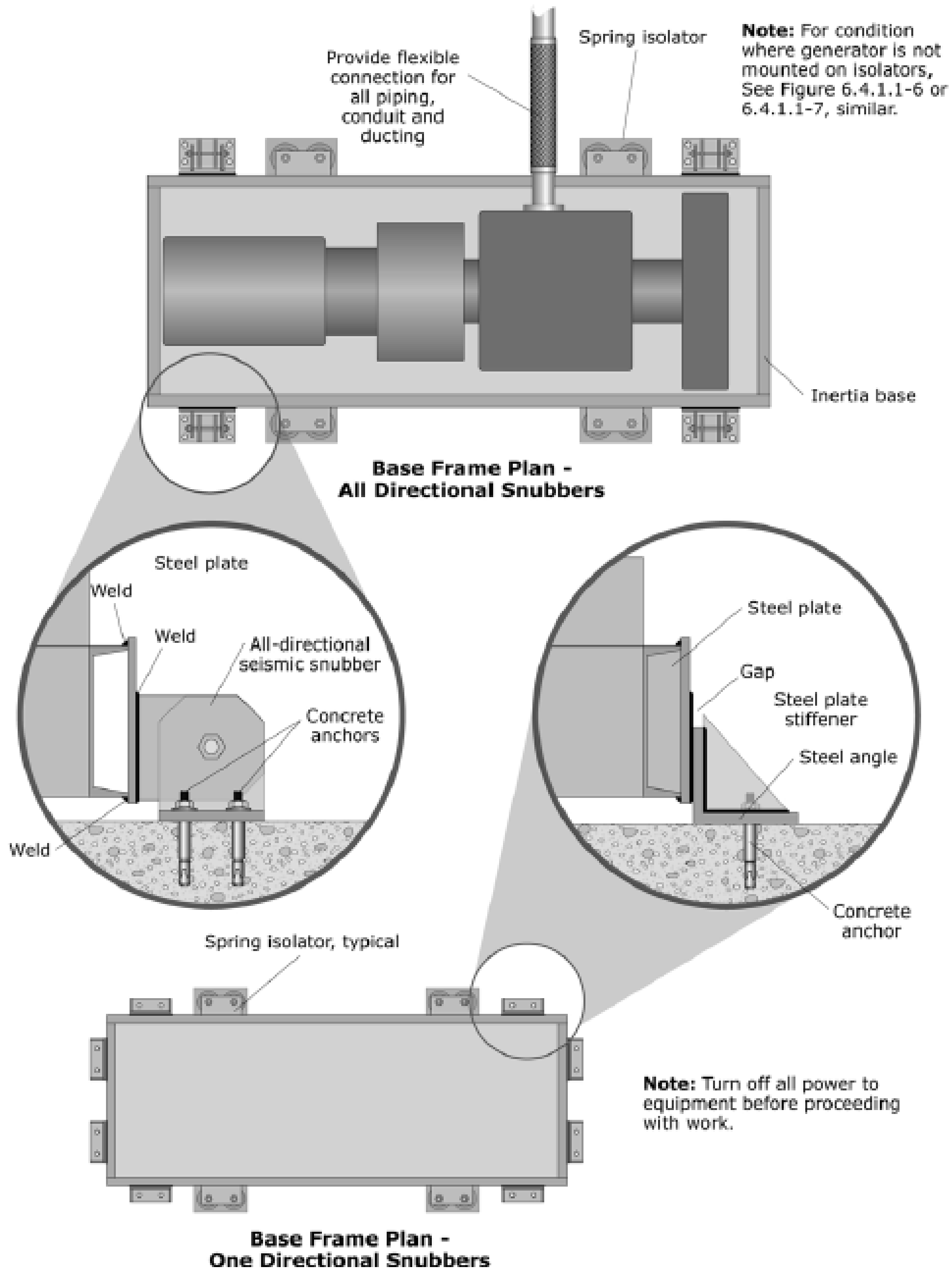



**Figure G-40. Emergency Generator.**
*(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)*