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Prepared for:
Sandy Fire District No 72

Prepared by:
Mackenzie

Project Number
2140211.00

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Main Station Seismic Assessment
2140211.00

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Structural Engineer
53,087
Expires: 12/31/14
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PROJECT TEAM

Sandy Fire District
- Deputy Fire Chief Phil Schneider

Mackenzie
- Jeff Humphreys, AIA, LEED AP BD+C — Project Principal
- Josh McDowell, SE, LEED AP — Structural Principal
- Tim Schweitzer, SE — Structural Engineer
- David Linton, PE — Structural Designer

Construction Focus, Inc.
- Steve Gunn — Construction Cost Estimator

EXECUTIVE SUMMARY

An ASCE 41-13 Tier 1 seismic evaluation of the existing Main Fire Station building was conducted for the Sandy Fire District No 72. As part of the review the existing drawings were reviewed and a site visit was conducted on June 16, 2014. The two-story fire station has several significant deficiencies in the structure that do not meet the standards for a critical infrastructure building to meet the required performance level of Operational. The hose tower and apparatus bay have an insufficient lateral load path and will require significant upgrades for the building to meet Operational performance standards. A cost estimate was prepared for the proposed seismic upgrades with an anticipated total project cost as follows:

- Construction: $ 867,021
- Consultants: $ 272,227
- Owner: $ 47,145
- Total: $1,186,393 ($87.64/SF)

ASCE 41-13 ANALYSIS BACKGROUND

The seismic evaluation was conducted using ASCE 41-13 Seismic Evaluation and Retrofit of Existing Buildings. This document is not a code, but a nationally-recognized standard used by engineers to evaluate and retrofit existing buildings. Previously, there were two separate documents for the evaluation and retrofit of existing buildings: ASCE 31 and ASCE 41, respectively. Recently, these documents were combined into the updated version, ASCE 41-13, to help alleviate some of the inconsistencies that occurred when a building made the transition from seismic evaluation to the retrofit/upgrade process. New building codes include many provisions that require or encourage design and detailing practices that improve the seismic performance of a building, including regular building
1. INTRODUCTION

configuration, ductile detailing, and high quality materials. Most existing buildings will not meet these criteria that new construction would be designed and detailed for; however, it is recognized that these existing structural systems still have capacity that the new code doesn't recognize. The ASCE 41-13 includes guidelines and methods for evaluating the capacities of existing structural elements that might otherwise be insufficient when analyzed using the new building code provisions.

Within the ASCE 41-13 there are four building Performance Levels (lower to higher performance): Collapse Prevention (5-E), Life Safety (3-C), Immediate Occupancy (1-B), and Operational (1-A). Unless otherwise required by code (i.e. emergency response facilities, prisons, or other essential facilities), the majority of buildings are designed for the Performance Level of Life Safety (LS). The LS performance level is meant to ensure the safety of building occupants; however, buildings with this performance level will likely experience significant damage that may or may not be repaired or occupied after the earthquake. For critical facilities that need to retain full function immediately post-earthquake to provide emergency response to the community, such as a fire station, the building is evaluated to the higher standard of Operational. It should be noted that for structural evaluation the Operational and Immediate Occupancy criteria are the same. The difference in the two levels is that the equipment is operational, see Figure 1. Figure 2 includes a brief summary of each performance level and the anticipated damage for a building designed to each performance level.

ASCE 41-13 incorporates a multi-tier methodology for evaluating existing structures. Tier 1, which was chosen for this analysis, is a preliminary screening phase which utilizes a checklist approach to identify potential seismic hazards. It should be noted that at this stage, any identified risks are preliminary and may or may not be justifiable using a higher tier analysis. Tier 2 and Tier 3 are the evaluation and detailed evaluation phases, respectively, which were not conducted at this time. If a deficiency is identified in the Tier 1 screening phase further Tier 2 or Tier 3 analysis can be used to show the specific item is acceptable. After the seismic evaluation is completed ASCE 41-13 may be used to complete a seismic retrofit design to address issues identified in the evaluation stage. As a part of
1. INTRODUCTION

Figure 2
Damage Control and Building Performance Labels

<table>
<thead>
<tr>
<th>Overall damage</th>
<th>Structural components</th>
<th>Nonstructural components</th>
<th>Comparison with performance intended for typical buildings designed to codes or standards for new buildings, for the design earthquake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>Little residual stiffness and strength to resist lateral loads, but gravity load-bearing columns and walls function. Large permanent drifts. Some exits blocked. Building is near collapse in aftershocks and should not continue to be occupied.</td>
<td>Extensive damage. Infills and unbraced parapets failed or at incipient failure.</td>
<td>Significantly more damage and greater life safety risk.</td>
</tr>
<tr>
<td>Moderate</td>
<td>Some residual strength and stiffness left in all stories. Gravity-load-bearing elements function. No out-of-plane failure of walls. Some permanent drift. Damage to partitions. Continued occupancy might not be likely before repair. Building might not be economical to repair.</td>
<td>Falling hazards, such as parapets, mitigated, but many architectural, mechanical, and electrical systems are damaged.</td>
<td>Somewhat more damage and slightly higher life safety risk.</td>
</tr>
<tr>
<td>Light</td>
<td>No permanent drift. Structure substantially retains original strength and stiffness. Continued occupancy likely.</td>
<td>Equipment and contents are generally secure but might not operate due to mechanical failure or lack of utilities. Some cracking of facades, partitions, and ceilings as well as structural elements. Elevators can be restarted. Fire protection operable.</td>
<td>Less damage and low life safety risk.</td>
</tr>
<tr>
<td>Very light</td>
<td>No permanent drift. Structure substantially retains original strength and stiffness. Minor cracking of facades, partitions, and ceilings as well as structural elements. All systems important to normal operation are functional. Continued occupancy and use highly likely.</td>
<td>Negligible damage occurs. Power and other utilities are available, possibly from standby sources.</td>
<td>Much less damage and very low life safety risk.</td>
</tr>
</tbody>
</table>

Source: Table C2-3, page 35; ASCE Standard – ASCE/SEI 41-13: American Society of Civil Engineers - Seismic Evaluation and Retrofit of Existing Buildings

The Tier 1 screening phases, various analyses or “Quick Checks” are to be performed where specifically required. Not all items that pass the quick check will necessarily meet more detailed checks nor are they guaranteed to meet current code requirements.

The Tier 1 analysis consists of a visual survey, which was conducted on June 16, 2014. For each of the Tier 1 checklist items, an evaluation of Compliant (C), Non-compliant (NC), or Not Applicable (N/A) is marked. NC does not necessarily mean that the issue cannot be justified with a higher tier evaluation phase; rather, that it does not pass the Tier 1 screening criteria.

SCOPE AND LIMITATIONS

This limited Tier 1 analysis is based on site observations of only readily visible items and evaluation of available drawing documents listed herein. It should be noted that other deficiencies might exist that have not been identified by this screening phase and quick checks. In addition, no material or other testing was performed at this time for review. Limited Tier 1 quick check calculations have been performed and a more in-depth detailed analysis may be performed, though it is likely to have minimal impact on the results of this evaluation.
2. ASSESSMENT
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EXISTING BUILDING DESCRIPTION

The existing fire station is located at 17460 Bruns Avenue in Sandy, Oregon. The original building (Figures 3-10) was built in 1965 and was constructed with CMU masonry walls. There was one addition to the fire station in 1980, where the apparatus bay was extended to the south and west. As part of the 1980 addition, a second floor was added. The addition was constructed with a combination of CMU masonry walls and light frame wood walls above. The roof of the original building is constructed of 2x framing with structural sheathing. The roof of the addition is framed with TJJs and structural sheathing and the floor is framed with TJs and structural sheathing.

The expansion and remodel documents prepared by Ivars Lazdins Architect, dated August 1980, were available for review. No drawings from the original construction were available, and no geotechnical report was available.

The seismic provisions in the current Oregon Structural Specialty Code have changed significantly since the facility was originally designed, and the purpose of this report is to identify potential seismic deficiencies in the structural system.
2. ASSESSMENT

EVALUATION RESULTS

Evaluation Criteria

This building was evaluated for a seismic event with a probability of exceedance of 10% in 50 years or a 500 year event (BSE-1) for a Performance Level of Operational. This is the same design earthquake ground motion hazard to which new buildings are designed. The level of seismicity was determined at the site and compared to the ASCE 41-13 level definitions (see Figure 11). For this fire station, SDS=0.612 and SD1=0.387; therefore, the site is considered to be in an area of high seismicity.

Based on this seismicity definition and an Operational performance objective, the required checklists can be determined, see Figure 12. The Basic Configuration, Immediate Occupancy Structural Checklists, and Position Retention Nonstructural checklists are required.

ASCE 41-13 has different checklists depending on the building construction type. This building type is classified as a combination of W1, wood light frame shear panel construction and RM1, reinforced masonry bearing walls construction.

Summary of ASCE 41-13 Tier 1 Evaluation

The Tier 1 screening phase identified numerous structural and non-structural items as non-compliant. Non-compliant issues require further evaluation in order to determine their full impact on the seismic performance of the building, but these issues are a relatively good indicator of potential performance issues. A summary of non-compliant issues is presented below organized by each checklist. Copies of the Tier 1 checklists and calculations are included in this report in Appendices A and B.

Figure 12
Checklists Required for a Tier 1 Screening

<table>
<thead>
<tr>
<th>Level of Seismicity(^a)</th>
<th>Level of Building Performance(^b)</th>
<th>Very Low Seismicity Checklist (Sec 16.1.1)</th>
<th>Basic Configuration Checklist (Sec. 16.1.2)</th>
<th>Life Safety Checklist through 16.15LS</th>
<th>Immediate Occupancy Checklist through 16.15IO</th>
<th>Life Safety Nonstructural Checklist (Sec. 16.17)</th>
<th>Position Retention Nonstructural Checklist (Sec. 16.17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>LS</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very low</td>
<td>IO</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Low</td>
<td>LS</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Low</td>
<td>IO</td>
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</tr>
<tr>
<td>Moderate</td>
<td>LS</td>
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<td>X</td>
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<td>High</td>
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<td>X</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

\(^a\)An X designates the checklist that must be completed for a Tier 1 screening as a function of the level of seismicity and level of performance.

\(^b\)Defined in Section 2.5.

\(^c\)LS = Life Safety Performance Level, and IO = Immediate Occupancy Performance Level (defined in Section 2.3.3).

Source: Table 4-7, page 67; ASCE Standard – ASCE/SEI 41-13: American Society of Civil Engineers – Seismic Evaluation and Retrofit of Existing Buildings

Sandy Fire District

August 11, 2014

2-2
Immediate Occupancy Basic Configuration Checklist

- **Load Path** – Original documents indicate there is not a well-defined load path to transfer seismic shear forces out to the main shear walls. The connections between the second floor addition and the original building do not provide a direct load path. The lateral load path between the hose tower and the rest of the building is also a concern due to offset in-plane shear elements.

- **Geometry** – The structural building system is geometrically irregular due to the concentration of the second story in the southwest part of the building. Geometric irregularities may lead to unexpected concentrations in stress and unexpected behavior in earthquakes.

- **Overturning** – Tier 1 analysis indicates the southwest CMU piers are likely to overturn.

- **Liquefaction** – There is no geotechnical report to confirm that this site has soil typical to this area, and is not susceptible to liquefaction.

Immediate Occupancy Structural Checklist for Building Types RM1

- **Shear Stress Check** – The southwest piers at the apparatus bay, see Figure 13, failed the quick check for shear stress.

- **Reinforcing Steel** – Typical vertical and horizontal reinforcement is spaced at 48 inches, which is usually inadequate in high seismic areas such as Oregon.

- **Wood Ledgers** – Detailing of the connections along the south wall rely on wood ledgers in cross-grain bending, an unacceptable load path in wood construction, so the floor and roof in these areas is susceptible to collapse.

- **Transfer to Shear Walls** – Calculation of the anchor bolts responsible for transferring shear from the diaphragm into the shear walls indicates the connection is inadequate.

- **Wall Anchorage** – Calculation of the anchor bolts and straps responsible for transferring out-of-plane loads from walls into the diaphragm indicates their capacity is inadequate.

- **Proportions** – Height to thickness ratios of the hose tower walls, see Figure 14, exceeds the check, so these walls are slender.

- **Openings at Shear Walls** – The roof hatch opening and adjacent roof vent at the hose tower roof does not allow the diaphragm to fully transfer shear to the shear walls.

- **Plan Irregularities** – Tension strapping at reentrant corners is not apparent, indicating the building does not have enough capacity to resist the increase in stresses typical at these corners.

- **Stiffness of Wall Anchors** – There is not sufficient structural information at connections to identify whether the anchors were installed sufficiently taut.
2. ASSESSMENT

Immediate Occupancy Structural Checklist for Building Types W1

- **Shear Stress Check** – The check of the shear stress in the wooden shear walls exceeds the allowable values.
- **Girder/Column Connection** – No connection between the rim joists and the stud walls is apparent.
- **Hold-Down Anchors** – Anchors at shear walls are not properly detailed as hold-downs.

Non-Structural Checklist

- **Ceiling Edge Clearance** – There is insufficient information to determine whether the edges of suspended ceilings are greater than 3/4”, so it is likely that this is insufficient.
- **Ceiling Edge Support** – As shown in Figure 15, it is apparent that the edges of suspended ceilings are not supported by closure angles or channels.
- **Light Fixture Independent Support** – There is insufficient information about the bracing for light fixtures to determine whether the fixtures are adequately braced.
- **Light Fixture Lens Covers** – There is insufficient information about the light fixtures to determine whether the fixtures have safety devices attached to lens covers, however from site visit photos it is apparent that not all light fixtures have covers. Thus, these lights may pose a falling hazard.
- **Glazing Overhead** – There is insufficient information to determine whether the windows are detailed to remain in the frame when cracked.
- **Tall Narrow Contents** – There is insufficient information to determine whether the shelves greater than 6 feet high are anchored. Since these shelves are not on the plans, it is assumed that they are not anchored.
- **Fall-Prone Contents** – There are boxes which may weigh over 20 lb. which are stored more than 4 ft. above the floor, and bracing is not apparent.
- **Mechanical and Electrical Equipment Mechanical Doors** – There is insufficient information to determine whether the mechanical doors of the apparatus bay have been detailed to operate with story drift of 0.01.
- **Mechanical and Electrical Equipment Conduit Couplings** – There is insufficient information to determine whether there are conduits greater than 2.5 inches. These would require flexible couplings.
- **Piping Flexible Couplings** – There is insufficient information to determine whether the fluid and gas piping have flexible couplings.
- **Duct Bracing** – There is insufficient information to determine whether the ducts are braced.

Figure 15
*Suspended ceilings in station office*
Additional Concerns from Site Visit

- The diaphragm continuity across the north CMU demising wall between the apparatus bay and offices appears to be insufficient. See Figure 16 for suspect girder drag connection over wall.
- The east wall has significant cracking visible and paint spalling, see Figures 17 and 18. This should be investigated further to ensure the structure does not have water damage or is settling.
- The NW wall next to the front door has a large diagonal crack, see Figure 19, that is potentially caused by differential settlement between the original building and addition. Further investigation is necessary to determine a cause and any repair recommendations.
- The southwest stair tower has efflorescent and spalling CMU visible, see Figures 20 and 21. In addition the flooring was damaged and appeared to have water damage. This should be investigated further to identify any water leaks.
- The lower roof has insufficient slope and drainage in areas, see Figure 22. At this time it is unknown if the roof has been leaking, however this could lead to structural damage to the wood structure below if left unaddressed.

Figure 16
Girder attachment

Figure 17
Cracking at southeast corner

Figure 18
Spalling paint at northeast corner

Figure 19
Crack in stucco by front entry

Figure 20
Damaged CMU and flooring from water leaks

Figure 21
Water damage to stair tower ceiling

Figure 22
Standing water on roof
3. RECOMMENDATIONS
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REPAIR RECOMMENDATIONS

The Tier 1 deficiencies listed above will require further evaluation (ASCE 41-13 Tier 2 or 3 analyses) for the design of the seismic retrofits listed below. For a facility, such as a fire station, to meet the Operational Performance Level, each of these items will need to be further evaluated and brought up to meet current code requirements. The following narrative describes the approximate scope of one possible upgrade scheme to address the identified deficiencies. Plans of the upgrade scheme are provided in Appendix C.

Basic Structural Recommendations:

1. Drag struts in the second floor framing must be upgraded to ensure a well-defined load path. These drag struts are identified on the 2nd Floor Plan of the upgrade scheme.

2. Diaphragms should be upgraded, which will require re-roofing, to ensure the load path is adequate. 10d nails at 3” O.C. should be used for all the diaphragms.

3. The hose tower should be seismically isolated with seismic joints to decrease stress concentrations due to geometric irregularity.

4. Along the apparatus bay doors, new steel moment frames (Type A) with W18x65 beams and W14x145 columns need to be added on the exterior of the apparatus bay with connections back through the building façade to connect to the diaphragm. Wrap the moment frames in wood trellis at roof and floor to meet City of Sandy design review requirements.

5. Install three new BRB brace frames (Type B) for additional capacity at the interior of the building. All new framing must be connected to the existing roof and floor diaphragms.

6. Provide a new grade beam to support the proposed braces adjacent to the west apparatus bay wall. The grade beam should be 1'-6” deep, 1'-6” wide, and continuous under the brace.

7. Provide new spread foundations for each proposed moment frame. Each footing should be at least 1'-6” deep, 4'-0” wide, and continuous under each bay.
3. RECOMMENDATIONS

Reinforced Masonry Recommendations:
1. All CMU walls should be connected to the diaphragm with new straps and anchors to ensure a well-defined load path. HTT5 straps at 2'-0" O.C. and 1/2" diameter epoxy anchors with a minimum 5" embedment should be used. Additional framing must be provided as required for a well-defined load path.

Wood Framed Recommendations:
1. Wooden shear walls at the second story should be reinforced. Two HTT5 hold-down straps should be provided to prevent overturning. Shear capacity of the west and north-east wooden shear walls should be increased by adding 10d nails at 3" O.C. at the panel edges. The opening oriented east-west on the north wall of the southern portion of the second story should be in-filled with ½” plywood nailed with 6d nails at 3” O.C. to act as a new shear wall.
2. Provide foundation sill anchorage at all wood framed shear walls. Post-installed sill anchors may be installed to the foundation.

Non-Structural Recommendations:
1. All Non-Structural checklist items should be addressed during the design of the T.I. or building modifications for an Operational level facility. Reference the checklist items for additional information. Veneers in compliance with the building regulations of the City of Sandy should be coordinated with all visible structural retrofits.

CONCLUSIONS
A complete analysis of the building and seismic force resisting system must be conducted to fully understand all the issues that would require to be repaired, which is beyond the scope of this investigation. Depending on the results of these investigations, there may be changes to the list of repairs above. Once a complete analysis and design of a seismic upgrade has been completed, the Sandy Fire Station can be expected to remain occupied and functional after a seismic event of the size expected in the region.

Cost Considerations
Following completion of the seismic assessment, Mackenzie evaluated cost impacts of the rehabilitation scheme. The following cost summary projects a total development cost, including estimated construction costs, design costs and owner costs.

Development costs of a project are not limited to construction costs alone and require consideration of other variables. These variables differ between new construction and renovation or expansion, and invariably change from one project to the next depending on site conditions.
3. RECOMMENDATIONS

conditions, existing building conditions, building codes, seismic zones and the environment of the construction industry. While differences arise depending on the design approach taken, the construction costs, design and engineering costs, and owner costs for furniture, fixtures and equipment are constants. New construction can often differ substantially due to the single variable of land acquisition.

**Construction costs** reflect the raw costs incurred by a general contractor for overhead and profit, bonding and insurance, securing of materials and general construction of the site and building. In addition to the identified construction costs, a design contingency is recommended to ensure dollars are carried through construction for owner changes, design omissions, unforeseen conditions or jurisdictional requirements, among others.

**Consultant costs** reflect the costs incurred for project management and design of the project from conceptual design through construction administration. Though design fees can vary, these costs are generally factored using a fee based on the construction costs for the project. In addition to architectural and engineering services, costs include marketing materials and required services such as geotechnical analysis and special inspections. A contingency is provided for this category for any unforeseen or additionally requested design and/or engineering services throughout the project.

**Owner costs** reflect the costs generally incurred directly by the owner throughout the project. This includes all items the owner may wish to contract separately from the general construction of the project. Additional owner-related costs include land costs, equipment and furnishing costs, relocation into the new facility, legal documentation and counsel for project documents and issuances, and jurisdictional fees associated with design review, building permits, and L&I fees. A contingency is provided in this category for any unforeseen or undefined costs not currently represented.

The following project development cost estimate examines the construction values of the programmed design concept based on the anticipated Construction, Consultant and Owner Costs. Detailed break-out of the anticipated construction costs and permit costs have been provided in Appendix D to describe elements proposed.
### 3. Recommendations

#### Project Cost Summary

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<td>General Conditions</td>
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<table>
<thead>
<tr>
<th>Consultants Costs</th>
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<td>A/E Design and Construction - Base</td>
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<td>A/E LEED Design and Documentation</td>
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<td>Owner’s Project Manager</td>
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<td>Topo and Boundary Survey</td>
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<table>
<thead>
<tr>
<th>Owner Costs</th>
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<tbody>
<tr>
<td>Land Acquisition</td>
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<td>Relocation of Over Head Power Lines to Underground</td>
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<td>Fixtures, Furniture &amp; Equipment (FF&amp;E)</td>
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<td>Lockers/Shelving</td>
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<td><strong>Total Owner Costs</strong></td>
<td><strong>$47,145.20</strong></td>
</tr>
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</table>

| Total Project Cost | **$1,186,392.74** |

**Building Size:** 13,537 SF

Exclusions: Off-site improvements to public right-of-way or utilities

---

Sandy Fire District

*August 11, 2014*
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A. ASCE 41-13 CHECKLIST

Required Information:
- Level of Performance
- Level of Seismicity
- General Bldg. Description

Chapters 2 & 3

Benchmark Building? [Section 4.3]

Yes

Selection of Checklists [Section 4.4]

No

Very Low Level of Seismicity & Life-Safety Level of Performance? [Section 16.1.1]

Yes

Complete the Level of Very Low Seismicity Checklist

No

Complete the Basic Configuration Checklist
- Quick Checks

Very Low Seismicity IO or Low, Moderate, or High Seismicity (LSIO)? [Section 16.1]

Yes

Complete the Building System Structural Checklist
- Quick Checks

No

Complete the Nonstructural Checklist

Summarize Deficiencies

Further Evaluation Required? [Section 3.3]

Tier 1: Screening Phase

FIG. 4-1. Tier 1 Evaluation Process
16.1.2IO IMMEDIATE OCCUPANCY BASIC CONFIGURATION CHECKLIST

Very Low Seismicity

Building System

General

C NC N/A U LOAD PATH: The structure shall contain 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. (Commentary: Sec. A.2.1.1. Tier 2: Sec. 5.4.1.1)

C NC N/A U ADJACENT BUILDINGS: The clear distance between the building being evaluated and any adjacent building is greater than 4% of the height of the shorter building. This statement need not apply for the following building types: W1, W1a, and W2. (Commentary: Sec. A.2.1.2. Tier 2: Sec. 5.4.1.2)

C NC N/A U MEZZANINES: Interior mezzanine levels are braced independently from the main structure or are anchored to the seismic-force-resisting elements of the main structure. (Commentary: Sec. A.2.1.3. Tier 2: Sec. 5.4.1.3)

Building Configuration

C NC N/A U WEAK STORY: The sum of the shear strengths of the seismic-force-resisting system in any story in each direction shall not be less than 80% of the strength in the adjacent story above. (Commentary: Sec. A.2.2.2. Tier 2: Sec. 5.4.2.1)

C NC N/A U SOFT STORY: The stiffness of the seismic-force-resisting system in any story shall not be 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. (Commentary: Sec. A.2.2.3. Tier 2: Sec. 5.4.2.2)

C NC N/A U VERTICAL IRREGULARITIES: All vertical elements in the seismic-force-resisting system are continuous to the foundation. (Commentary: Sec. A.2.2.4. Tier 2: Sec. 5.4.2.3)

C NC N/A U 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. (Commentary: Sec. A.2.2.5. Tier 2: Sec. 5.4.2.4)

C NC N/A U MASS: There is no change in effective mass more than 50% from one story to the next. Light roofs, penthouses, and mezzanines need not be considered. (Commentary: Sec. A.2.2.6. Tier 2: Sec. 5.4.2.5)

C NC N/A U 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. (Commentary: Sec. A.2.2.7. Tier 2: Sec. 5.4.2.6)

Low Seismicity: Complete the Following Items in Addition to the Items for Very Low Seismicity.

Geologic Site Hazards

C NC N/A U LIQUEFACTION: Liquefaction-susceptible, saturated, loose granular soils that could jeopardize the building’s seismic performance shall not exist in the foundation soils at depths within 50 ft under the building. (Commentary: Sec. A.6.1.1. Tier 2: 5.4.3.1)

C NC N/A U SLOPE FAILURE: The building site is sufficiently remote from potential earthquake-induced slope failures or rockfalls to be unaffected by such failures or is capable of accommodating any predicted movements without failure. (Commentary: Sec. A.6.1.2. Tier 2: 5.4.3.1)

C NC N/A U SURFACE FAULT RUPTURE: Surface fault rupture and surface displacement at the building site are not anticipated. (Commentary: Sec. A.6.1.3. Tier 2: 5.4.3.1)

Moderate and High Seismicity: Complete the Following Items in Addition to the Items for Low Seismicity.

Foundation Configuration

C NC N/A U 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 0.65. (Commentary: Sec. A.6.2.1. Tier 2: Sec. 5.4.3.3)

C NC N/A U 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. (Commentary: Sec. A.6.2.2. Tier 2: Sec. 5.4.3.4)
16.2IO IMMEDIATE OCCUPANCY STRUCTURAL CHECKLIST FOR BUILDING TYPES W1: WOOD LIGHT FRAMES AND W1A: MULTI-STORY, MULTI-UNIT RESIDENTIAL WOOD FRAME

Very Low Seismicity

Seismic-Force-Resisting System

- **REdundancy**: The number of lines of shear walls in each principal direction is greater than or equal to 2. (Commentary: Sec. A.3.2.1.1. Tier 2: Sec. 5.5.1.1)
- **Shear Stress Check**: The shear stress in the shear walls, calculated using the Quick Check procedure of Section 4.5.3.3, is less than the following values (Commentary: Sec. A.3.2.7.1. Tier 2: Sec. 5.5.3.1.1):
  - Structural panel sheathing: 1,000 lb/ft
  - Diagonal sheathing: 700 lb/ft
  - Straight sheathing: 100 lb/ft
  - All other conditions: 100 lb/ft
- **Stucco (Exterior Plaster) Shear Walls**: Multi-story buildings do not rely on exterior stucco walls as the primary seismic-force-resisting system. (Commentary: Sec. A.3.2.7.2. Tier 2: Sec. 5.5.3.6.1)
- **Gypsum Wallboard or Plaster Shear Walls**: Interior plaster or gypsum wallboard are not used as shear walls on buildings more than one story high with the exception of the uppermost level of a multi-story building. (Commentary: Sec. A.3.2.7.3. Tier 2: Sec. 5.5.3.6.1)
- **Narrow Wood Shear Walls**: Narrow wood shear walls with an aspect ratio greater than 2-to-1 are not used to resist seismic forces. (Commentary: Sec. A.3.2.7.4. Tier 2: Sec. 5.5.3.6.1)
- **Walls Connected Through Floors**: Shear walls have an interconnection between stories to transfer overturning and shear forces through the floor. (Commentary: Sec. A.3.2.7.5. Tier 2: Sec. 5.5.3.6.2)
- **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 2. (Commentary: Sec. A.3.2.7.6. Tier 2: Sec. 5.5.3.6.3)
- **Cripple Walls**: Cripple walls below first-floor-level shear walls are braced to the foundation with wood structural panels. (Commentary: Sec. A.3.2.7.7. Tier 2: Sec. 5.5.3.6.4)
- **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. (Commentary: Sec. A.3.2.7.8. Tier 2: Sec. 5.5.3.6.5)

Connections

- **Wood Posts**: There is a positive connection of wood posts to the foundation. (Commentary: Sec. A.5.3.3. Tier 2: Sec. 5.7.3.3)
- **Wood Sills**: All wood sills are bolted to the foundation. (Commentary: Sec. A.5.3.4. Tier 2: Sec. 5.7.3.3)
- **Girder/Column Connection**: There is a positive connection using plates, connection hardware, or straps between the girder and the column support. (Commentary: Sec. A.5.4.1. Tier 2: Sec. 5.7.4.1)

Foundation System

- **Deep Foundations**: Piles and piers are capable of transferring the lateral forces between the structure and the soil. (Commentary: Sec. A.6.2.3.)
- **Sloping Sites**: The difference in foundation embedment depth from one side of the building to another shall not exceed one story high. (Commentary: Sec. A.6.2.4)
A. ASCE 41-13 CHECKLIST

Low, Moderate, and High Seismicity: Complete the Following Items in Addition to the Items for Very Low Seismicity.

Seismic-Force-Resisting System

C NC N/A U HOLD-DOWN ANCHORS: All shear walls have hold-down anchors, constructed per acceptable construction practices, attached to the end studs. (Commentary: Sec. A.3.2.7.9. Tier 2: Sec. 5.5.3.6.6)

C NC N/A U NARROW WOOD SHEAR WALLS: Narrow wood shear walls with an aspect ratio greater than 1.5-to-1 are not used to resist seismic forces. (Commentary: Sec. A.3.2.7.4. Tier 2: Sec. 5.5.3.6.1)

Diaphragms

C NC N/A U DIAPHRAGM CONTINUITY: The diaphragms are not composed of split-level floors and do not have expansion joints. (Commentary: Sec. A.4.1.1. Tier 2: Sec. 5.6.1.1)

C NC N/A U ROOF CHORD CONTINUITY: All chord elements are continuous, regardless of changes in roof elevation. (Commentary: Sec. A.4.1.3. Tier 2: Sec. 5.6.1.1)

C NC N/A U PLAN IRREGULARITIES: There is tensile capacity to develop the strength of the diaphragm at reentrant corners or other locations of plan irregularities. (Commentary: Sec. A.4.1.7. Tier 2: Sec. 5.6.1.4)

C NC N/A U DIAPHRAGM REINFORCEMENT AT OPENINGS: There is reinforcing around all diaphragm openings larger than 50% of the building width in either major plan dimension. (Commentary: Sec. A.4.1.8. Tier 2: Sec. 5.6.1.5)

C NC N/A U STRAIGHT SHEATHING: All straight sheathed diaphragms have aspect ratios less than 1-to-1 in the direction being considered. (Commentary: Sec. A.4.2.1. Tier 2: Sec. 5.6.2)

C NC N/A U SPANS: All wood diaphragms with spans greater than 12 ft consist of wood structural panels or diagonal sheathing. (Commentary: Sec. A.4.2.2. Tier 2: Sec. 5.6.2)

C NC N/A U DIAGONALLY SHEATHED AND UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 30 ft and aspect ratios less than or equal to 3-to-1 ft. (Commentary: Sec. A.4.2.3. Tier 2: Sec. 5.6.2)

C NC N/A U OTHER DIAPHRAGMS: The diaphragm does not consist of a system other than wood, metal deck, concrete, or horizontal bracing. (Commentary: Sec. A.4.7.1. Tier 2: Sec. 5.6.5)

Connections

C NC N/A U WOOD SILL BOLTS: Sill bolts are spaced at 4 ft or less, with proper edge and end distance provided for wood and concrete. (Commentary: Sec. A.5.3.7. Tier 2: Sec. 5.7.3.3)
### 16.15IO IMMEDIATE OCCUPANCY STRUCTURAL CHECKLIST FOR BUILDING TYPES RM1: REINFORCED MASONRY BEARING WALLS AND RM1A: REINFORCED MASONRY BEARING WALLS WITH STIFF DIAPHRAGMS

#### Very Low Seismicity

**Seismic-Force-Resisting System**

| C | NC | N/A | U | REDUNDANCY: The number of lines of shear walls in each principal direction is greater than or equal to 2. (Commentary: Sec. A.3.2.1.1. Tier 2: Sec. 5.5.1.1) |
| C | NC | N/A | U | SHEAR STRESS CHECK: The shear stress in the reinforced masonry shear walls, calculated using the Quick Check procedure of Section 4.5.3.3, is less than 70 lb/in.². (Commentary: Sec. A.3.2.4.1. Tier 2: Sec. 5.5.3.1.1) |
| C | NC | N/A | U | REINFORCING STEEL: The total vertical and horizontal reinforcing steel ratio in reinforced masonry walls is greater than 0.002 of the wall with the minimum of 0.0007 in either of the two directions; the spacing of reinforcing steel is less than 48 in., and all vertical bars extend to the top of the walls. (Commentary: Sec. A.3.2.4.2. Tier 2: Sec. 5.5.3.1.3) |

**Connections**

| C | NC | N/A | U | WOOD LEDGERS: The connection between the wall panels and the diaphragm does not induce cross-grain bending or tension in the wood ledgers. (Commentary: Sec. A.5.1.2. Tier 2: Sec. 5.7.1.3) |
| C | NC | N/A | U | TRANSFER TO SHEAR WALLS: Diaphragms are connected for transfer of seismic forces to the shear walls, and the connections are able to develop the lesser of the shear strength of the walls or diaphragms. (Commentary: Sec. A.5.2.1. Tier 2: Sec. 5.7.2) |
| C | NC | N/A | U | FOUNDATION DOWELS: Wall reinforcement is dowelled into the foundation, and the dowels are able to develop the lesser of the strength of the walls or the uplift capacity of the foundation. (Commentary: Sec. A.5.3.5. Tier 2: Sec. 5.7.3.4) |
| C | NC | N/A | U | GIRDER–COLUMN CONNECTION: There is a positive connection using plates, connection hardware, or straps between the girder and the column support. (Commentary: Sec. A.5.4.1. Tier 2: Sec. 5.7.4.1) |
| C | NC | N/A | U | WALL ANCHORAGE: Exterior concrete or masonry walls that are dependent on the diaphragm for lateral support are anchored for out-of-plane forces at each diaphragm level with steel anchors, reinforcing dowels, or straps that are developed into the diaphragm. Connections shall have adequate strength to resist the connection force calculated in the Quick Check procedure of Section 4.5.3.7. (Commentary: Sec. A.5.1.1. Tier 2: Sec. 5.7.1.1) |

**Stiff Diaphragms**

| C | NC | N/A | U | TOPPING SLAB: Precast concrete diaphragm elements are interconnected by a continuous reinforced concrete topping slab. (Commentary: Sec. A.4.5.1. Tier 2: Sec. 5.6.4) |
| C | NC | N/A | U | TOPPING SLAB TO WALLS OR FRAMES: Reinforced concrete topping slabs that interconnect the precast concrete diaphragm elements are dowelled for transfer of forces into the shear wall or frame elements. (Commentary: Sec. A.5.2.3. Tier 2: Sec. 5.7.2) |

**Foundation System**

| C | NC | N/A | U | DEEP FOUNDATIONS: Piles and piers are capable of transferring the lateral forces between the structure and the soil. (Commentary: Sec. A.6.2.3) |
| C | NC | N/A | U | SLOPING SITES: The difference in foundation embedment depth from one side of the building to another shall not exceed one story high. (Commentary: Sec. A.6.2.4) |

**Low, Moderate, and High Seismicity: Complete the Following Items in Addition to the Items for Very Low Seismicity.**

**Seismic-Force-Resisting System**

| C | NC | N/A | U | REINFORCING AT WALL OPENINGS: All wall openings that interrupt rebar have trim reinforcing on all sides. (Commentary: Sec. A.3.2.4.3. Tier 2: Sec. 5.5.3.1.5) |
| C | NC | N/A | U | PROPORTIONS: The height-to-thickness ratio of the shear walls at each story is less than 30. (Commentary: Sec. A.3.2.4.4. Tier 2: Sec. 5.5.3.1.2) |
### A. ASCE 41-13 CHECKLIST

#### Diaphragms (Stiff or Flexible)

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<td>OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls are less than 15% of the wall length. (Commentary: Sec. A.4.1.4. Tier 2: Sec. 5.6.1.3)</td>
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<td>OPENINGS AT EXTERIOR MASONRY SHEAR WALLS: Diaphragm openings immediately adjacent to exterior masonry shear walls are not greater than 4 ft long. (Commentary: Sec. A.4.1.6. Tier 2: Sec. 5.6.1.3)</td>
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<td>PLAN IRREGULARITIES: There is tensile capacity to develop the strength of the diaphragm at reentrant corners or other locations of plan irregularities. (Commentary: Sec. A.4.1.7. Tier 2: Sec. 5.6.1.4)</td>
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<td>DIAPHRAGM REINFORCEMENT AT OPENINGS: There is reinforcing around all diaphragm openings larger than 50% of the building width in either major plan dimension. (Commentary: Sec. A.4.1.8. Tier 2: Sec. 5.6.1.5)</td>
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#### Flexible Diaphragms

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<td>CROSS TIES: There are continuous cross ties between diaphragm chords. (Commentary: Sec. A.4.1.2. Tier 2: Sec. 5.6.1.2)</td>
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<td>STRAIGHT SHEATHING: All straight sheathed diaphragms have aspect ratios less than 1-to-1 in the direction being considered. (Commentary: Sec. A.4.2.1. Tier 2: Sec. 5.6.2)</td>
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<td>SPANS: All wood diaphragms with spans greater than 12 ft consist of wood structural panels or diagonal sheathing. (Commentary: Sec. A.4.2.2. Tier 2: Sec. 5.6.2)</td>
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<td>DIAGONALLY SHEATHED AND UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 30 ft and aspect ratios less than or equal to 3-to-1. (Commentary: Sec. A.4.2.2. Tier 2: Sec. 5.6.2)</td>
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<td>NONCONCRETE FILLED DIAPHRAGMS: Untopped metal deck diaphragms or metal deck diaphragms with fill other than concrete consist of horizontal spans of less than 40 ft and have aspect ratios less than 4-to-1. (Commentary: Sec. A.4.3.1. Tier 2: Sec. 5.6.3)</td>
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<td>OTHER DIAPHRAGMS: The diaphragm does not consist of a system other than wood, metal deck, concrete, or horizontal bracing. (Commentary: Sec. A.4.7.1. Tier 2: Sec. 5.6.5)</td>
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#### Connections

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<td>STIFFNESS OF WALL ANCHORS: Anchors of concrete or masonry walls to wood structural elements are installed taut and are stiff enough to limit the relative movement between the wall and the diaphragm to no greater than 1/8 in. before engagement of the anchors. (Commentary: Sec. A.5.1.4. Tier 2: Sec. 5.7.1.2)</td>
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### 16.17 NONSTRUCTURAL CHECKLIST

#### Life Safety Systems

- **Fire Suppression Piping**: Fire suppression piping is anchored and braced in accordance with NFPA-13. (Commentary: Sec. A.7.13.1, Tier 2: Sec. 13.7.4)
- **Flexible Couplings**: Fire suppression piping has flexible couplings in accordance with NFPA-13. (Commentary: Sec. A.7.13.2, Tier 2: Sec. 13.7.4)
- **Emergency Power**: Equipment used to power or control life safety systems is anchored or braced. (Commentary: Sec. A.7.12.1, Tier 2: Sec. 13.7.7)
- **Stair and Smoke Ducts**: Stair pressurization and smoke control ducts are braced and have flexible connections at seismic joints. (Commentary: Sec. A.7.14.1, Tier 2: Sec. 13.7.6)
- **Sprinkler Ceiling Clearance**: Penetrations through panelized ceilings for fire suppression devices provide clearances in accordance with NFPA-13. (Commentary: Sec. A.7.13.3, Tier 2: Sec. 13.7.4)
- **Emergency Lighting**: Emergency and egress lighting equipment is anchored or braced. (Commentary: Sec. A.7.3.1, Tier 2: Sec. 13.7.9)

#### Hazardous Materials

- **Hazardous Material Equipment**: Equipment mounted on vibration isolators and containing hazardous material is equipped with restraints or snubbers. (Commentary: Sec. A.7.12.2, Tier 2: 13.7.1)
- **Hazardous Material Storage**: Breakable containers that hold hazardous material, including gas cylinders, are restrained by latched doors, shelf lips, wires, or other methods. (Commentary: Sec. A.7.15.1, Tier 2: Sec. 13.8.4)
- **Hazardous Material Distribution**: Piping or ductwork conveying hazardous materials is braced or otherwise protected from damage that would allow hazardous material release. (Commentary: Sec. A.7.13.4, Tier 2: Sec. 13.7.3 and 13.7.5)
- **Shut-Off Valves**: Piping containing hazardous material, including natural gas, has shut-off valves or other devices to limit spills or leaks. (Commentary: Sec. A.7.13.3, Tier 2: Sec. 13.7.3 and 13.7.5)
- **Flexible Couplings**: Hazardous material ductwork and piping, including natural gas piping, has flexible couplings. (Commentary: Sec. A.7.15.4, Tier 2: Sec.13.7.3 and 13.7.5)
- **Piping or Ducts Crossing Seismic Joints**: 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. (Commentary: Sec. A.7.13.6, Tier 2: Sec.13.7.3, 13.7.5, and 13.7.6)

#### Partitions

- **Unreinforced Masonry**: Unreinforced masonry or hollow-clay tile partitions are braced at a spacing of at most 10 ft in Low or Moderate Seismicity, or at most 6 ft in High Seismicity. (Commentary: Sec. A.7.1.1, Tier 2: Sec. 13.6.2)
- **Heavy Partitions Supported by Ceilings**: The tops of masonry or hollow-clay tile partitions are not laterally supported by an integrated ceiling system. (Commentary: Sec. A.7.2.1, Tier 2: Sec. 13.6.2)
- **Drift**: 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. (Commentary A.7.1.2 Tier 2: Sec. 13.6.2)
# A. ASCE 41-13 CHECKLIST

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<tr>
<th>Section</th>
<th>Category</th>
<th>Compliance</th>
<th>Notes</th>
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<tbody>
<tr>
<td>13.6.2</td>
<td>Ceilings</td>
<td>LS-not required; PR-MH. LIGHT PARTITIONS SUPPORTED BY CEILINGS: The tops of gypsum board partitions are not laterally supported by an integrated ceiling system. (Commentary: Sec. A.7.2.1. Tier 2: Sec. 13.6.2)</td>
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<tr>
<td>13.6.2</td>
<td>Ceilings</td>
<td>LS-not required; PR-MH. STRUCTURAL SEPARATIONS: Partitions that cross structural separations have seismic or control joints. (Commentary: Sec. A.7.1.3. Tier 2. Sec. 13.6.2)</td>
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<tr>
<td>13.6.2</td>
<td>Ceilings</td>
<td>LS-not required; PR-MH. TOPS: 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. (Commentary: Sec. A.7.1.4. Tier 2. Sec. 13.6.2)</td>
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<td>13.6.4</td>
<td>Ceilings</td>
<td>LS-MH; PR-LMH. SUSPENDED LATH AND PLASTER: Suspended lath and plaster ceilings have attachments that resist seismic forces for every 12 ft² of area. (Commentary: Sec. A.7.2.3. Tier 2: Sec. 13.6.4)</td>
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<tr>
<td>13.6.4</td>
<td>Ceilings</td>
<td>LS-MH; PR-LMH. SUSPENDED GYPSUM BOARD: Suspended gypsum board ceilings have attachments that resist seismic forces for every 12 ft² of area. (Commentary: Sec. A.7.2.3. Tier 2: Sec. 13.6.4)</td>
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<td>13.6.4</td>
<td>Ceilings</td>
<td>LS-not required; PR-MH. INTEGRATED CEILINGS: Integrated suspended ceilings with continuous areas greater than 144 ft², and ceilings of smaller areas that are not surrounded by restraining partitions, are laterally restrained at a spacing no greater than 12 ft 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. (Commentary: Sec. A.7.2.2. Tier 2: Sec. 13.6.4)</td>
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<td>13.6.4</td>
<td>Ceilings</td>
<td>LS-not required; PR-MH. EDGE CLEARANCE: The free edges of integrated suspended ceilings with continuous areas greater than 144 ft² have clearances from the enclosing wall or partition of at least the following: in Moderate Seismicity, 1/2 in.; in High Seismicity, 3/4 in. (Commentary: Sec. A.7.2.4. Tier 2: Sec. 13.6.4)</td>
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<td>13.6.4</td>
<td>Ceilings</td>
<td>LS-not required; PR-MH. CONTINUITY ACROSS STRUCTURE JOINTS: The ceiling system does not cross any seismic joint and is not attached to multiple independent structures. (Commentary: Sec. A.7.2.5. Tier 2: Sec. 13.6.4)</td>
<td></td>
</tr>
<tr>
<td>13.6.4</td>
<td>Ceilings</td>
<td>LS-not required; PR-H. EDGE SUPPORT: The free edges of integrated suspended ceilings with continuous areas greater than 144 ft² are supported by closure angles or channels not less than 2 in. wide. (Commentary: Sec. A.7.2.6. Tier 2: Sec. 13.6.4)</td>
<td></td>
</tr>
<tr>
<td>13.6.4</td>
<td>Ceilings</td>
<td>LS-not required; PR-H. SEISMIC JOINTS: Acoustical tile or lay-in panel ceilings have seismic separation joints such that each continuous portion of the ceiling is no more than 2500 ft² and has a ratio of long-to-short dimension no more than 4-to-1. (Commentary: Sec. A.7.2.7. Tier 2: 13.6.4)</td>
<td></td>
</tr>
<tr>
<td>13.6.4</td>
<td>Light Fixtures</td>
<td>LS-MH; PR-MH. INDEPENDENT SUPPORT: 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. (Commentary: Sec. A.7.3.2. Tier 2: Sec. 13.6.4 and 13.7.9)</td>
<td></td>
</tr>
<tr>
<td>13.6.4</td>
<td>Light Fixtures</td>
<td>LS-not required; PR-H. PENDANT SUPPORTS: Light fixtures on pendant supports are attached at a spacing equal to or less than 6 ft and, if rigidly supported, are free to move with the structure to which they are attached without damaging adjoining components. (Commentary: A.7.3.3. Tier 2: Sec. 13.7.9)</td>
<td></td>
</tr>
<tr>
<td>13.6.4</td>
<td>Light Fixtures</td>
<td>LS-not required; PR-H. LENS COVERS: Lens covers on light fixtures are attached with safety devices. (Commentary: Sec. A.7.3.4. Tier 2: Sec. 13.7.9)</td>
<td></td>
</tr>
<tr>
<td>13.6.4</td>
<td>Cladding and Glazing</td>
<td>LS-MH; PR-MH. CLADDING ANCHORS: Cladding components weighing more than 10 lb/ft² are mechanically anchored to the structure at a spacing equal to or less than the following: for Life Safety in Moderate Seismicity, 6 ft; for Life Safety in High Seismicity and for Position Retention in any seismicity, 4 ft. (Commentary: Sec. A.7.4.1. Tier 2: Sec. 13.6.1)</td>
<td></td>
</tr>
<tr>
<td>13.6.4</td>
<td>Cladding and Glazing</td>
<td>LS-MH; PR-MH. CLADDING ISOLATION: For steel or concrete moment frame buildings, panel connections are detailed to accommodate a story drift ratio 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. (Commentary: Sec. A.7.4.3. Tier 2: Section 13.6.1)</td>
<td></td>
</tr>
</tbody>
</table>
Main Station Seismic Assessment

A. ASCE 41-13 CHECKLIST

MULTI-STORY PANELS: For multi-story panels attached at more than one floor level, panel connections are detailed to accommodate a story drift ratio 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. (Commentary: Sec. A.7.4.4. Tier 2: Sec. 13.6.1)

PANEL CONNECTIONS: 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. (Commentary: Sec. A.7.4.5. Tier 2: Sec. 13.6.1.4)

BEARING CONNECTIONS: Where bearing connections are used, there is a minimum of two bearing connections for each cladding panel. (Commentary: Sec. A.7.4.6. Tier 2: Sec. 13.6.1.4)

INSERTS: Where concrete cladding components use inserts, the inserts have positive anchorage or are anchored to reinforcing steel. (Commentary: Sec. A.7.4.7. Tier 2: Sec. 13.6.1.4)

OVERHEAD GLAZING: Glazing panes of any size in curtain walls and individual interior or exterior panes over 16 ft² in area are laminated annealed or laminated heat-strengthened glass and are detailed to remain in the frame when cracked. (Commentary: Sec. A.7.4.8: Tier 2: Sec. 13.6.1.5)

Masonry Veneer

TIES: Masonry veneer is connected to the backup with corrosion-resistant ties. There is a minimum of one tie for every 2-2/3 ft², and the ties have spacing no greater than the following: for Life Safety in Low or Moderate Seismicity, 36 in.; for Life Safety in High Seismicity and for Position Retention in any seismicity, 24 in. (Commentary: Sec. A.7.5.1. Tier 2: Sec. 13.6.1.2)

SHELF ANGLES: Masonry veneer is supported by shelf angles or other elements at each floor above the ground floor. (Commentary: Sec. A.7.5.2. Tier 2: Sec. 13.6.1.2)

WEAKENED PLANES: Masonry veneer is anchored to the backup adjacent to weakened planes, such as at the locations of flashing. (Commentary: Sec. A.7.5.3. Tier 2: Sec. 13.6.1.2)

UNREINFORCED MASONRY BACKUP: There is no unreinforced masonry backup. (Commentary: Sec. A.7.7.1. Tier 2: Section 13.6.1.1 and 13.6.1.2)

ANCHORAGE: 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. (Commentary: Sec. A.7.7.1. Tier 2: Section 13.6.1.1 and 13.6.1.2)

WEEP HOLES: In veneer anchored to stud walls, the veneer has functioning weep holes and base flashing. (Commentary: Sec. A.7.5.6. Tier 2: Section 13.6.1.2)

OPENINGS: For veneer with metal stud backup, steel studs frame window and door openings. (Commentary: Sec. A.7.6.2. Tier 2: Sec. 13.6.1.1 and 13.6.1.2)

Parapets, Cornices, Ornamentation, and Appendages

URM PARAPETS OR CORNICES: Laterally unsupported unreinforced masonry parapets or cornices have height-to-thickness 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. (Commentary: Sec. A.7.8.1. Tier 2: Sec. 13.6.5)

CANOPIES: 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; for Life Safety in High Seismicity and for Position Retention in any seismicity, 6 ft. (Commentary: Sec. A.7.8.2. Tier 2: Sec. 13.6.6)

CONCRETE PARAPETS: Concrete parapets with height-to-thickness ratios greater than 2.5 have vertical reinforcement. (Commentary: Sec. A.7.8.3. Tier 2: Sec. 13.6.5)

APPENDAGES: 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. This checklist item does not apply to parapets or cornices covered by other checklist items. (Commentary: Sec. A.7.8.4. Tier 2: Sec. 13.6.6)
A. ASCE 41-13 CHECKLIST

Masonry Chimneys
C NC N/A U LS-LMH; PR-LMH. URM CHIMNEYS: 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. (Commentary: Sec. A.7.9.1. Tier 2: 13.6.7)

C NC N/A U LS-LMH; PR-LMH. ANCHORAGE: Masonry chimneys are anchored at each floor level, at the topmost ceiling level, and at the roof. (Commentary: Sec. A.7.9.2. Tier 2: 13.6.7)

Stairs
C NC N/A U LS-LMH; PR-LMH. STAIR ENCLOSURES: 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. (Commentary: Sec. A.7.10.1. Tier 2: Sec. 13.6.2 and 13.6.8)

C NC N/A U LS-LMH; PR-LMH. STAIR DETAILS: In moment frame structures, the connection between the stairs and the structure does not rely on shallow anchors in concrete. Alternatively, the stair details are capable of accommodating the drift calculated using the Quick Check procedure of Section 4.5.3.1 without including any lateral stiffness contribution from the stairs. (Commentary: Sec. A.7.10.2. Tier 2: 13.6.8)

Contents and Furnishings
C NC N/A U LS-MH; PR-MH. INDUSTRIAL STORAGE RACKS: Industrial storage racks or pallet racks more than 12 ft high meet the requirements of ANSI/MH 16.1 as modified by ASCE 7 Chapter 15. (Commentary: Sec. A.7.11.1. Tier 2: Sec. 13.8.1)

C NC N/A U LS-H; PR-MH. TALL NARROW CONTENTS: Contents more than 6 ft 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. (Commentary: Sec. A.7.11.2. Tier 2: Sec. 13.8.2)

C NC N/A U LS-H; PR-H. FALL-PRONE CONTENTS: Equipment, stored items, or other contents weighing more than 20 lb whose center of mass is more than 4 ft above the adjacent floor level are braced or otherwise restrained. (Commentary: Sec. A.7.11.3. Tier 2: Sec. 13.8.2)

C NC N/A U LS-not required; PR-MH. ACCESS FLOORS: Access floors more than 9 in. high are braced. (Commentary: Sec. A.7.11.4. Tier 2: Sec. 13.8.3)

C NC N/A U LS-not required; PR-MH. EQUIPMENT ON ACCESS FLOORS: Equipment and other contents supported by access floor systems are anchored or braced to the structure independent of the access floor. (Commentary: Sec. A.7.11.5. Tier 2: Sec. 13.7.7 and 13.8.3)

C NC N/A U LS-not required; PR-H. SUSPENDED CONTENTS: 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. (Commentary: A.7.11.6. Tier 2: Sec. 13.8.2)

Mechanical and Electrical Equipment
C NC N/A U LS-H; PR-H. FALL-PRONE EQUIPMENT: Equipment weighing more than 20 lb whose center of mass is more than 4 ft above the adjacent floor level, and which is not in-line equipment, is braced. (Commentary: A.7.12.4. Tier 2: 13.7.1 and 13.7.7)

C NC N/A U LS-H; PR-H. IN-LINE EQUIPMENT: Equipment installed in-line with a duct or piping system, with an operating weight more than 75 lb, is supported and laterally braced independent of the duct or piping system. (Commentary: Sec. A.7.12.5. Tier 2: Sec. 13.7.1)

C NC N/A U LS-H; PR-MH. TALL NARROW EQUIPMENT: Equipment more than 6 ft 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. (Commentary: Sec. A.7.12.6. Tier 2: Sec. 13.7.1 and 13.7.7)

C NC N/A U LS-not required; PR-MH. MECHANICAL DOORS: Mechanically operated doors are detailed to operate at a story drift ratio of 0.01. (Commentary: Sec. A.7.12.7. Tier 2: Sec. 13.6.9)
### A. ASCE 41-13 CHECKLIST

<table>
<thead>
<tr>
<th>Component</th>
<th>Compliance</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suspended Equipment</strong></td>
<td>LS-not required; PR-H. SUSPENDED EQUIPMENT: 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. (Commentary: Sec. A.7.12.8. Tier 2: Sec. 13.7.1 and 13.7.7)</td>
<td></td>
</tr>
<tr>
<td><strong>Vibration Isolators</strong></td>
<td>LS-not required; PR-H. VIBRATION ISOLATORS: Equipment mounted on vibration isolators is equipped with horizontal restraints or snubbers and with vertical restraints to resist overturning. (Commentary: Sec. A.7.12.9. Tier 2: Sec. 13.7.1)</td>
<td></td>
</tr>
<tr>
<td><strong>Heavy Equipment</strong></td>
<td>LS-not required; PR-H. HEAVY EQUIPMENT: Floor-supported or platform-supported equipment weighing more than 400 lb is anchored to the structure. (Commentary: Sec. A.7.12.10. Tier 2: 13.7.1 and 13.7.7)</td>
<td></td>
</tr>
<tr>
<td><strong>Electrical Equipment</strong></td>
<td>LS-not required; PR-H. ELECTRICAL EQUIPMENT: Electrical equipment is laterally braced to the structure. (Commentary: Sec. A.7.12.11. Tier 2: 13.7.7)</td>
<td></td>
</tr>
<tr>
<td><strong>Conduit Couplings</strong></td>
<td>LS-not required; PR-H. CONDUIT COUPLINGS: Conduit greater than 2.5 in. trade size that is attached to panels, cabinets, or other equipment and is subject to relative seismic displacement has flexible couplings or connections. (Commentary: Sec. A.7.12.12. Tier 2: 13.7.8)</td>
<td></td>
</tr>
<tr>
<td><strong>Piping</strong></td>
<td>LS-not required; PR-H. FLEXIBLE COUPLINGS: Fluid and gas piping has flexible couplings. (Commentary: Sec. A.7.13.2. Tier 2: Sec. 13.7.3 and 13.7.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Fluid and Gas Piping</strong></td>
<td>LS-not required; PR-H. FLUID AND GAS PIPING: Fluid and gas piping is anchored and braced to the structure to limit spills or leaks. (Commentary: Sec. A.7.13.4. Tier 2: Sec. 13.7.3 and 13.7.5)</td>
<td></td>
</tr>
<tr>
<td><strong>C-Clamps</strong></td>
<td>LS-not required; PR-H. C-CLAMPS: One-sided C-clamps that support piping larger than 2.5 in. in diameter are restrained. (Commentary: Sec. A.7.13.5. Tier 2: Sec. 13.7.3 and 13.7.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Piping Crossing Seismic Joints</strong></td>
<td>LS-not required; PR-H. PIPING CROSSING SEISMIC JOINTS: 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. (Commentary: Sec. A.7.13.6. Tier 2: Sec. 13.7.3 and Sec. 13.7.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Ducts</strong></td>
<td>LS-not required; PR-H. DUCT BRACING: Rectangular ductwork larger than 6 ft² in cross-sectional area and round ducts larger than 28 in. in diameter are braced. The maximum spacing of transverse bracing does not exceed 30 ft. The maximum spacing of longitudinal bracing does not exceed 60 ft. (Commentary: Sec. A.7.14.2. Tier 2: Sec. 13.7.6)</td>
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</tr>
<tr>
<td><strong>Duct Support</strong></td>
<td>LS-not required; PR-H. DUCT SUPPORT: Ducts are not supported by piping or electrical conduit. (Commentary: Sec. A.7.14.3. Tier 2: Sec. 13.7.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Ducts Crossing Seismic Joints</strong></td>
<td>LS-not required; PR-H. DUCTS CROSSING SEISMIC JOINTS: 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. (Commentary: Sec. A.7.14.5. Tier 2: Sec. 13.7.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Elevators</strong></td>
<td>LS-H; PR-H. RETAINER GUARDS: Sheaves and drums have cable retainer guards. (Commentary: Sec. A.7.16.1. Tier 2: 13.8.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Retainer Plate</strong></td>
<td>LS-H; PR-H. RETAINER PLATE: A retainer plate is present at the top and bottom of both car and counterweight. (Commentary: Sec. A.7.16.2. Tier 2: 13.8.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Elevator Equipment</strong></td>
<td>LS-not required; PR-H. ELEVATOR EQUIPMENT: Equipment, piping, and other components that are part of the elevator system are anchored. (Commentary: Sec. A.7.16.3. Tier 2: 13.8.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Seismic Switch</strong></td>
<td>LS-not required; PR-H. SEISMIC SWITCH: 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. (Commentary: Sec. A.7.16.4. Tier 2: 13.8.6)</td>
<td></td>
</tr>
</tbody>
</table>
A. ASCE 41-13 CHECKLIST

C  NC  N/A  U  LS-not required; PR-H. SHAFT WALLS: Elevator shaft walls are anchored and reinforced to prevent toppling into the shaft during strong shaking. (Commentary: Sec. A.7.16.5. Tier 2: 13.8.6)

C  NC  N/A  U  LS-not required; PR-H. COUNTERWEIGHT RAILS: All counterweight rails and divider beams are sized in accordance with ASME A17.1. (Commentary: Sec. A.7.16.6. Tier 2: 13.8.6)

C  NC  N/A  U  LS-not required; PR-H. BRACKETS: The brackets that tie the car rails and the counterweight rail to the structure are sized in accordance with ASME A17.1. (Commentary: Sec. A.7.16.7. Tier 2: 13.8.6)

C  NC  N/A  U  LS-not required; PR-H. SPREADER BRACKET: Spreader brackets are not used to resist seismic forces. (Commentary: Sec. A.7.16.8. Tier 2: 13.8.6)

C  NC  N/A  U  LS-not required; PR-H. GO-SLOW ELEVATORS: The building has a go-slow elevator system. (Commentary: Sec. A.7.16.9. Tier 2: 13.8.6)
B. ASCE 41-13 CALCULATIONS
B. ASCE 41-13 CALCULATIONS

**Design Maps Summary Report**

**User-Specified Input**

**Report Title**  Sandy Fire Station Seismicity  
Thu June 26, 2014 16:01:37 UTC

**Building Code Reference Document**  ASCE 41-13 Retrofit Standard, BSE-2N  
(which utilizes USGS hazard data available in 2008)

**Site Coordinates**  45.39666°N, 122.26397°W

**Site Soil Classification**  Site Class D – "Stiff Soil"

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**USGS-Provided Output**

\[
S_{S,BSE-2N} = 0.769 \text{ g} \quad S_{X,S,BSE-2N} = 0.917 \text{ g} \\
S_{L,BSE-2N} = 0.335 \text{ g} \quad S_{X,L,BSE-2N} = 0.580 \text{ g}
\]

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Although this information is a product of the U.S. Geological Survey, we provide no warranty, expressed or implied, as to the accuracy of the data contained therein. This tool is not a substitute for technical subject-matter knowledge.
Design Maps Detailed Report

ASCE 41-13 Retrofit Standard, BSE-2N (45.39666°N, 122.26397°W)

Site Class D – ”Stiff Soil”

Section 2.4.1 – General Procedure for Hazard Due to Ground Shaking

From Section 2.4.1.1

\[ S_{S, BSE-2N} = 0.769 \text{ g} \]

From Section 2.4.1.1

\[ S_{I, BSE-2N} = 0.335 \text{ g} \]

Section 2.4.1.6 – Adjustment for Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Section 2.4.1.6.1.

<table>
<thead>
<tr>
<th>SITE CLASS</th>
<th>SOIL PROFILE NAME</th>
<th>Soil shear wave velocity, ( \bar{v}_s ) (ft/s)</th>
<th>Standard penetration resistance, ( \bar{N} )</th>
<th>Soil undrained shear strength, ( \bar{s}_u ) (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hard rock</td>
<td>( \bar{v}_s &gt; 5,000 )</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>B</td>
<td>Rock</td>
<td>( 2,500 &lt; \bar{v}_s \leq 5,000 )</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>C</td>
<td>Very dense soil and soft rock</td>
<td>( 1,200 &lt; \bar{v}_s \leq 2,500 )</td>
<td>( \bar{N} &gt; 50 )</td>
<td>&gt;2,000 psf</td>
</tr>
<tr>
<td>D</td>
<td>Stiff soil profile</td>
<td>( 600 \leq \bar{v}_s \leq 1,200 )</td>
<td>( 15 \leq \bar{N} \leq 50 )</td>
<td>1,000 to 2,000 psf</td>
</tr>
<tr>
<td>E</td>
<td>Stiff soil profile</td>
<td>( \bar{v}_s &lt; 600 )</td>
<td>( \bar{N} &lt; 15 )</td>
<td>&lt;1,000 psf</td>
</tr>
<tr>
<td>E</td>
<td>—</td>
<td>Any profile with more than 10 ft of soil having the characteristics:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Plasticity index ( PI &gt; 20 ),</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>2. Moisture content ( w \geq 40% ), and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Undrained shear strength ( \bar{s}_u &lt; 500 \text{ psf} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>—</td>
<td>Any profile containing soils having one or more of the following characteristics:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Peats and/or highly organic clays ((H &gt; 10 \text{ feet of peat and/or highly organic clay where } H = \text{ thickness of soil}) )</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Very high plasticity clays ((H &gt; 25 \text{ feet with plasticity index } PI &gt; 75) )</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Very thick soft/medium stiff clays ((H &gt; 120 \text{ feet}) )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: \( 1 \text{ft/s} = 0.3048 \text{ m/s} \) \( 1 \text{lb/ft}^2 = 0.0479 \text{ kN/m}^2 \)
## B. ASCE 41-13 Calculations

### Table 2–3. Values of $F_v$ as a Function of Site Class and Mapped Short-Period Spectral Response Acceleration $S_v$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$S_v \leq 0.25$</th>
<th>$S_v = 0.50$</th>
<th>$S_v = 0.75$</th>
<th>$S_v = 1.00$</th>
<th>$S_v \geq 1.25$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.2</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>D</td>
<td>1.6</td>
<td>1.4</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>E</td>
<td>2.5</td>
<td>1.7</td>
<td>1.2</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Site-specific geotechnical and dynamic site response analyses shall be performed</td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_v$

**For Site Class = D and $S_v = 0.769$ g, $F_v = 1.192$**

### Table 2–4. Values of $F_v$ as a Function of Site Class and Mapped Spectral Response Acceleration at 1 s Period $S_i$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$S_i \leq 0.10$</th>
<th>$S_i = 0.20$</th>
<th>$S_i = 0.30$</th>
<th>$S_i = 0.40$</th>
<th>$S_i \geq 0.50$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.7</td>
<td>1.6</td>
<td>1.5</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>D</td>
<td>2.4</td>
<td>2.0</td>
<td>1.8</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>E</td>
<td>3.5</td>
<td>3.2</td>
<td>2.8</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Site-specific geotechnical and dynamic site response analyses shall be performed</td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_i$

**For Site Class = D and $S_i = 0.335$ g, $F_v = 1.729$**
**B. ASCE 41-13 CALCULATIONS**

Equation (2–4):

\[ S_{X5,BSE-2N} = F_s S_{S5,BSE-2N} = 1.192 \times 0.769 g = 0.917 g \]

Equation (2–5):

\[ S_{X4,BSE-2N} = F_s S_{S4,BSE-2N} = 1.729 \times 0.335 g = 0.580 g \]

Section 2.4.1.7.1 — General Horizontal Response Spectrum

Figure 2-1. General Horizontal Response Spectrum

- \( S_{X5} / B_1 = 0.917 \)
- \( S_{X4} / B_1 = 0.580 \)
- \( 0.4S_{X3} = 0.367 \)

\[ T_0 = 0.126 \quad T_0 = 0.632 \quad 1.000 \]

**Period, T (sec)**
Section 2.4.1.7.2 — General Vertical Response Spectrum

B. ASCE 41-13 CALCULATIONS

USGS Design Maps Summary Report
User-Specified Input

Report Title  Sandy Fire Station Seismicity
Thu June 26, 2014 16:23:50 UTC

Building Code Reference Document  ASCE 41-13 Retrofit Standard, BSE-1N
(which utilizes USGS hazard data available in 2008)

Site Coordinates  45.39666°N, 122.26397°W
Site Soil Classification  Site Class D – “Stiff Soil”
Risk Category  IV (e.g. essential facilities)

USGS-Provided Output

\[ S_{D5,8SE-1N} = 0.612 \text{ g} \]
\[ S_{D1,8SE-1N} = 0.387 \text{ g} \]

Horizontal Spectrum

Vertical Spectrum

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Design Maps Detailed Report

ASCE 41-13 Retrofit Standard, BSE-1N (45.39666°N, 122.26397°W)

Site Class D – “Stiff Soil”, Risk Category IV (e.g. essential facilities)

Section 2.4.1 – General Procedure for Hazard Due to Ground Shaking

Provided as a reference for Equation (2-4) and Equation (2-5), respectively:

**From Section 2.4.1.1**

\[ S_{S, BSE-1N} = 0.769 \text{ g} \]

**From Section 2.4.1.1**

\[ S_{I, BSE-1N} = 0.335 \text{ g} \]

Section 2.4.1.6 – Adjustment for Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Section 2.4.1.6.1.

<table>
<thead>
<tr>
<th>SITE CLASS</th>
<th>SOIL PROFILE NAME</th>
<th>Soil shear wave velocity, ( \bar{v}_s ) (ft/s)</th>
<th>Standard penetration resistance, ( \bar{N} )</th>
<th>Soil undrained shear strength, ( \bar{s}_u ) (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hard rock</td>
<td>( \bar{v}_s &gt; 5,000 )</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>B</td>
<td>Rock</td>
<td>( 2,500 &lt; \bar{v}_s \leq 5,000 )</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>C</td>
<td>Very dense soil</td>
<td>( 1,200 &lt; \bar{v}_s \leq 2,500 )</td>
<td>( \bar{N} \geq 50 )</td>
<td>&gt;2,000 psf</td>
</tr>
<tr>
<td>D</td>
<td>Stiff soil profile</td>
<td>( 600 \leq \bar{v}_s &lt; 1,200 )</td>
<td>( 15 \leq \bar{N} \leq 50 )</td>
<td>1,000 to 2,000 psf</td>
</tr>
<tr>
<td>E</td>
<td>Stiff soil profile</td>
<td>( \bar{v}_s &lt; 600 )</td>
<td>( \bar{N} &lt; 15 )</td>
<td>&lt;1,000 psf</td>
</tr>
<tr>
<td>E</td>
<td>—</td>
<td>Any profile with more than 10 ft of soil having the characteristics:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Plasticity index ( PI &gt; 20 ),</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Moisture content ( w \geq 40% ), and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Undrained shear strength ( \bar{s}_u &lt; 500 ) psf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>—</td>
<td>Any profile containing soils having one or more of the following characteristics:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Peats and/or highly organic clays (( H &gt; 10 ) feet of peat and/or highly organic clay where ( H ) = thickness of soil)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Very high plasticity clays (( H &gt; 25 ) feet with plasticity index ( PI &gt; 75 ))</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Very thick soft/medium stiff clays (( H &gt; 120 ) feet)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²
Table 2–3. Values of $F_s$ as a Function of Site Class and Mapped Short-Period Spectral Response Acceleration $S_s$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Mapped Spectral Acceleration at Short-Period $S_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_s \leq 0.25$</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.2</td>
</tr>
<tr>
<td>D</td>
<td>1.6</td>
</tr>
<tr>
<td>E</td>
<td>2.5</td>
</tr>
<tr>
<td>F</td>
<td>Site-specific geotechnical and dynamic site response analyses shall be performed</td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_s$

For Site Class = D and $S_s = 0.769$ g, $F_s = 1.192$

Table 2–4. Values of $F_s$ as a Function of Site Class and Mapped Spectral Response Acceleration at 1 s Period $S_i$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Mapped Spectral Acceleration at 1 s Period $S_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_i \leq 0.10$</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.7</td>
</tr>
<tr>
<td>D</td>
<td>2.4</td>
</tr>
<tr>
<td>E</td>
<td>3.5</td>
</tr>
<tr>
<td>F</td>
<td>Site-specific geotechnical and dynamic site response analyses shall be performed</td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_i$

For Site Class = D and $S_i = 0.335$ g, $F_s = 1.729$
B. ASCE 41-13 CALCULATIONS

Provided as a reference for Equation (2-4):

\[ S_{x,5,\text{BSE}-2N} = F_s S_{S,5,\text{BSE}-2N} = 1.192 \times 0.769 \, g = 0.917 \, g \]

Provided as a reference for Equation (2-5):

\[ S_{x,1,\text{BSE}-2N} = F_s S_{1,\text{BSE}-2N} = 1.729 \times 0.335 \, g = 0.580 \, g \]

Equation (2-4):

\[ S_{x,5,\text{BSE}-1N} = \frac{3}{5} \times S_{x,5,\text{BSE}-2N} = \frac{3}{5} \times 0.917 \, g = 0.611 \, g \]

Equation (2-5):

\[ S_{x,1,\text{BSE}-1N} = \frac{3}{5} \times S_{x,1,\text{BSE}-2N} = \frac{3}{5} \times 0.580 \, g = 0.387 \, g \]

Section 2.4.1.7.1 — General Horizontal Response Spectrum

Figure 2-1. General Horizontal Response Spectrum
Section 2.4.1.7.2 — General Vertical Response Spectrum

The General Vertical Response Spectrum is determined by multiplying the General Horizontal Response Spectrum by $\frac{3}{4}$. 

![Graph showing the General Vertical Response Spectrum with key points labeled: $2S_{nt}/3B_1 = 0.408$, $2S_{nt}/3B_1 = 0.258$, $0.8S_{nt}/3 = 0.163$. The horizontal axis represents period, $T$ (sec), with values $T_0 = 0.126$, $T_3 = 0.632$, and $T_9 = 1.000$.]}
**B. ASCE 41-13 CALCULATIONS**

**USGS Design Maps Summary Report**

- **Report Title**: Sandy Fire Seismicity
  - Thu June 26, 2014 15:41:33 UTC
  - (which utilizes USGS hazard data available in 2008)
- **Site Coordinates**: 45.39666°N, 122.26397°W
- **Site Soil Classification**: Site Class D – "Stiff Soil"

**USGS-Provided Output**

- $S_{S_{5,5/50}} = 0.564$ g
- $S_{S_{5,5/50}} = 0.246$ g
- $S_{S_{S_{5,5/50}}} = 0.760$ g
- $S_{S_{5,5/50}} = 0.469$ g

---

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Design Maps Detailed Report
ASCE 41-13 Retrofit Standard, BSE-2E (45.39666°N, 122.26397°W)

Site Class D – “Stiff Soil”

Section 2.4.1 – General Procedure for Hazard Due to Ground Shaking

5%/50-year maximum direction spectral response acceleration for 0.2s and 1.0s periods, respectively:

From Section 2.4.1.3 $S_{5,5/50} = 0.564 \text{ g}$

From Section 2.4.1.3 $S_{1,5/50} = 0.246 \text{ g}$

Section 2.4.1.6 – Adjustment for Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Section 2.4.1.6.1.

<table>
<thead>
<tr>
<th>SITE CLASS</th>
<th>SOIL PROFILE NAME</th>
<th>Soil shear wave velocity, $\bar{v}_s$ (ft/s)</th>
<th>Standard penetration resistance, $\bar{N}$</th>
<th>Soil undrained shear strength, $\bar{s}_{uv}$ (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hard rock</td>
<td>$\bar{v}_s &gt; 5,000$</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>B</td>
<td>Rock</td>
<td>$2,500 &lt; \bar{v}_s \leq 5,000$</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>C</td>
<td>Very dense soil and soft rock</td>
<td>$1,200 &lt; \bar{v}_s \leq 2,500$</td>
<td>$\bar{N} &gt; 50$</td>
<td>$&gt;2,000 \text{ psf}$</td>
</tr>
<tr>
<td>D</td>
<td>Stiff soil profile</td>
<td>$600 \leq \bar{v}_s &lt; 1,200$</td>
<td>$15 \leq \bar{N} \leq 50$</td>
<td>$1,000 \text{ to } 2,000 \text{ psf}$</td>
</tr>
<tr>
<td>E</td>
<td>Stiff soil profile</td>
<td>$\bar{v}_s &lt; 600$</td>
<td>$\bar{N} &lt; 15$</td>
<td>$&lt;1,000 \text{ psf}$</td>
</tr>
<tr>
<td>E</td>
<td>—</td>
<td>Any profile with more than 10 ft of soil having the characteristics:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Plasticity index $PI &gt; 20$,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Moisture content $w \geq 40%$, and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Undrained shear strength $\bar{s}_u &lt; 500 \text{ psf}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>—</td>
<td>Any profile containing soils having one or more of the following characteristics:</td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils.</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Peats and/or highly organic clays ($H &gt; 10 \text{ feet}$ of peat and/or highly organic clay where $H$ = thickness of soil)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Very high plasticity clays ($H &gt; 25 \text{ feet}$ with plasticity index $PI &gt; 75$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Very thick soft/medium stiff clays ($H &gt; 120 \text{ feet}$)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI: $1\text{ ft/s} = 0.3048 \text{ m/s} 1\text{ lb/ft}^2 = 0.0479 \text{ kN/m}^2$
### Table 2–3. Values of $F_s$ as a Function of Site Class and Mapped Short-Period Spectral Response Acceleration $S_s$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Mapped Spectral Acceleration at Short-Period $S_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_s \leq 0.25$</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.2</td>
</tr>
<tr>
<td>D</td>
<td>1.6</td>
</tr>
<tr>
<td>E</td>
<td>2.5</td>
</tr>
<tr>
<td>F</td>
<td>Site-specific geotechnical and dynamic site response analyses shall be performed</td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_s$

**For Site Class = D and $S_s = 0.564$ g, $F_s = 1.349$**

### Table 2–4. Values of $F_s$ as a Function of Site Class and Mapped Spectral Response Acceleration at 1 s Period $S_i$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Mapped Spectral Acceleration at 1 s Period $S_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_i \leq 0.10$</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.7</td>
</tr>
<tr>
<td>D</td>
<td>2.4</td>
</tr>
<tr>
<td>E</td>
<td>3.5</td>
</tr>
<tr>
<td>F</td>
<td>Site-specific geotechnical and dynamic site response analyses shall be performed</td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_i$

**For Site Class = D and $S_i = 0.246$ g, $F_s = 1.909$**
B. ASCE 41-13 CALCULATIONS

Provided as a reference for Equation (2-4):
\[ F_s S_{5,5/50} = 1.349 \times 0.564 \text{ g} = 0.760 \text{ g} \]

Provided as a reference for Equation (2-5):
\[ F_s S_{1,5/50} = 1.909 \times 0.246 \text{ g} = 0.469 \text{ g} \]

Provided as a reference for Equation (2-4):
\[ S_{x5,\text{BSE-2N}} = F_s S_{5,\text{BSE-2N}} = 0.917 \text{ g} \]

Provided as a reference for Equation (2-5):
\[ S_{x1,\text{BSE-2N}} = F_s S_{1,\text{BSE-2N}} = 0.580 \text{ g} \]

Equation (2-4):
\[ S_{x5,\text{BSE-2E}} = \text{MIN}[F_s S_{5,5/50}, S_{x5,\text{BSE-2N}}] = \text{MIN}[0.760\text{g}, 0.917\text{g}] = 0.760\text{g} \]

Equation (2-5):
\[ S_{x1,\text{BSE-2E}} = \text{MIN}[F_s S_{1,5/50}, S_{x1,\text{BSE-2N}}] = \text{MIN}[0.469\text{g}, 0.580\text{g}] = 0.469\text{g} \]

Section 2.4.1.7.1 — General Horizontal Response Spectrum

![General Horizontal Response Spectrum](image.png)

Figure 2-1. General Horizontal Response Spectrum

- \( S_{x5} / B_1 = 0.760 \)
- \( S_{x1} / B_1 = 0.469 \)
- \( 0.4S_{x5} = 0.304 \)

Period, \( T \) (sec)

\( T_0 = 0.123 \)
\( T_5 = 0.617 \)
\( T_8 = 1.000 \)
Section 2.4.1.7.2 — General Vertical Response Spectrum

The General Vertical Response Spectrum is determined by multiplying the General Horizontal Response Spectrum by \( \frac{3}{2} \).
B. ASCE 41-13 CALCULATIONS

Design Maps Summary Report

User-Specified Input

Report Title  Sandy Fire Station Seismicity
Thu June 26, 2014 15:55:09 UTC

(which utilizes USGS hazard data available in 2008)

Site Coordinates  45.39666°N, 122.26397°W

Site Soil Classification  Site Class D – “Stiff Soil”

USGS–Provided Output

\[ S_{S,20/50} = 0.253 \text{ g} \quad S_{S,5, BSE-1E} = 0.404 \text{ g} \]
\[ S_{S,20/50} = 0.096 \text{ g} \quad S_{S,1, BSE-1E} = 0.229 \text{ g} \]

Horizontal Spectrum

Vertical Spectrum

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B. ASCE 41-13 CALCULATIONS

Design Maps Detailed Report
ASCE 41-13 Retrofit Standard, BSE-1E (45.39666°N, 122.26397°W)

Site Class D – “Stiff Soil”

Section 2.4.1 – General Procedure for Hazard Due to Ground Shaking

20%/50-year maximum direction spectral response acceleration for 0.2s and 1.0s periods, respectively:

<table>
<thead>
<tr>
<th>From Section 2.4.1.4</th>
</tr>
</thead>
</table>
| \( S_{s,20/50} = 0.253 \text{ g} \)

<table>
<thead>
<tr>
<th>From Section 2.4.1.4</th>
</tr>
</thead>
</table>
| \( S_{s,10/50} = 0.096 \text{ g} \)

Section 2.4.1.6 – Adjustment for Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class D, based on the site soil properties in accordance with Section 2.4.1.6.1.

<table>
<thead>
<tr>
<th>SITE CLASS</th>
<th>SOIL PROFILE NAME</th>
<th>Soil shear wave velocity, ( \bar{v}_s ) (ft/s)</th>
<th>Standard penetration resistance, ( \bar{N} )</th>
<th>Soil undrained shear strength, ( \bar{s}_u ) (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hard rock</td>
<td>( \bar{v}_s &gt; 5,000 )</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>B</td>
<td>Rock</td>
<td>( 2,500 &lt; \bar{v}_s \leq 5,000 )</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>C</td>
<td>Very dense soil and soft rock</td>
<td>( 1,200 &lt; \bar{v}_s \leq 2,500 )</td>
<td>( \bar{N} &gt; 50 )</td>
<td>( &gt;2,000 \text{ psf} )</td>
</tr>
<tr>
<td>D</td>
<td>Stiff soil profile</td>
<td>( 600 \leq \bar{v}_s &lt; 1,200 )</td>
<td>( 15 \leq \bar{N} \leq 50 )</td>
<td>( 1,000 \text{ to } 2,000 \text{ psf} )</td>
</tr>
<tr>
<td>E</td>
<td>Stiff soil profile</td>
<td>( \bar{v}_s &lt; 600 )</td>
<td>( \bar{N} &lt; 15 )</td>
<td>( &lt;1,000 \text{ psf} )</td>
</tr>
</tbody>
</table>

E — Any profile with more than 10 ft of soil having the characteristics:

1. Plasticity index \( PI > 20 \),
2. Moisture content \( w \geq 40\% \), and
3. Undrained shear strength \( \bar{s}_u < 500 \text{ psf} \)

F — Any profile containing soils having one or more of the following characteristics:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils.
2. Peats and/or highly organic clays \( H > 10 \text{ feet of peat and/or highly organic clay where } H = \text{ thickness of soil} \)
3. Very high plasticity clays \( H > 25 \text{ feet with plasticity index } PI > 75 \)
4. Very thick soft/medium stiff clays \( H > 120 \text{ feet} \)

For SI: \( 1\text{ft/s} = 0.3048 \text{ m/s} \quad 1\text{lb/ft}^2 = 0.0479 \text{ kN/m}^2 \)
## B. ASCE 41-13 Calculations

### Table 2-3. Values of $F_s$ as a Function of Site Class and Mapped Short-Period Spectral Response Acceleration $S_s$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Mapped Spectral Acceleration at Short-Period $S_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_s \leq 0.25$</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.2</td>
</tr>
<tr>
<td>D</td>
<td><strong>1.6</strong></td>
</tr>
<tr>
<td>E</td>
<td>2.5</td>
</tr>
<tr>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_s$

**For Site Class = D and $S_s = 0.253$ g, $F_s = 1.598$**

### Table 2-4. Values of $F_s$ as a Function of Site Class and Mapped Spectral Response Acceleration at 1 s Period $S_i$

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Mapped Spectral Acceleration at 1 s Period $S_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_i \leq 0.10$</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.7</td>
</tr>
<tr>
<td>D</td>
<td><strong>2.4</strong></td>
</tr>
<tr>
<td>E</td>
<td>3.5</td>
</tr>
<tr>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of $S_i$

**For Site Class = D and $S_i = 0.096$ g, $F_s = 2.400$**
B. ASCE 41-13 CALCULATIONS

Provided as a reference for Equation (2-4):

\( F_s S_{5,20/50} = 1.598 \times 0.253 \text{ g} = 0.404 \text{ g} \)

Provided as a reference for Equation (2-5):

\( F_s S_{4,20/50} = 2.400 \times 0.096 \text{ g} = 0.229 \text{ g} \)

Provided as a reference for Equation (2-4):

\( S_{S_{5,\text{BSE-1n}}} = \frac{3}{4} S_{S_{5,\text{BSE-2n}}} = \frac{3}{4} \times F_s S_{5,\text{BSE-2n}} = 0.612 \text{ g} \)

Provided as a reference for Equation (2-5):

\( S_{S_{1,\text{BSE-1n}}} = \frac{3}{4} S_{S_{1,\text{BSE-2n}}} = \frac{3}{4} \times F_s S_{1,\text{BSE-2n}} = 0.387 \text{ g} \)

Equation (2-4):

\( S_{S_{5,\text{BSE-1n}}} = \text{MIN}[F_s S_{5,20/50}, S_{S_{5,\text{BSE-1n}}}] = \text{MIN}[0.404\text{ g}, 0.612\text{ g}] = 0.404\text{ g} \)

Equation (2-5):

\( S_{S_{1,\text{BSE-1n}}} = \text{MIN}[F_s S_{5,20/50}, S_{S_{1,\text{BSE-1n}}}] = \text{MIN}[0.229\text{ g}, 0.387\text{ g}] = 0.229\text{ g} \)

Section 2.4.1.7.1 — General Horizontal Response Spectrum

![Figure 2-1. General Horizontal Response Spectrum](image-url)
Section 2.4.1.7.2 — General Vertical Response Spectrum

The General Vertical Response Spectrum is determined by multiplying the General Horizontal Response Spectrum by ¾.
B. ASCE 41-13 CALCULATIONS

SOURCES

1. ASCE/SEI 41-13
2. ASCE/SEI 7-10

LEVEL OF PERFORMANCE

RISK CATEGORY = IV

⇒ BPOE TIER 1 = IMMEDIATE OCCUPANCY STRUCTURAL PERFORMANCE (1-B)

IMMEDIATE OCCUPANCY

(1) Table 2-1
(2) Table 1.5-1
B. ASCE 41-13 CALCULATIONS

CHECKLISTS REQ

LEL OF SEISMICITY = HIGH
LUL OF PERFORMANCE = IO

⇒ NEED:

BASIC CONFIG. = 16.1.2
IMMEDIATE OCCUPANCY = 16.2.10-16.1.30
POSITION RETENTION NON STRUCTURAL = 16.17
BASIC CONFIG = 16.1.210

VERY LOW SEISMICITY:

LOAD PATH:

- SECONDARY ELEMENT (INDIRECT) LOAD PATH @ WEST WALL LINE \( \Rightarrow \) NEED TIER 3
  \( \overset{1}{1} \) 5.4.1.1

- LOAD PATH B/W EX. & ADD'L
  @ NORTH WALL LINE FOR SOUTH ADD'L
  INDIRECT FOR 2ND FLOOR

- LOAD PATH B/W EX & ADD'L
  @ EAST WALL LINE FOR NORTH ADD'L
  PROBABLY NOT SUFFICIENT
  (REMOVED EX. CMU WALL & REPLACED W/ WOOD STUD WALL W/ OPENINGS)

ADJACENT BLDG:

ADJACENT BLDG HT = \( h_{adj} \)

\( 4 \times h_{adj} = 8'' \)

\( \ll \) CLR & B/W BLDG \( \checkmark \) OK (COMPLIANT)

WEAK STORY:

- REMOVED EX. CMU WALL & REPLACED W/ WOOD STUD WALL W/ OPENINGS
  @ EAST WALL LINE FOR NORTH ADD'L
B. ASCE 41-13 CALCULATIONS

**BASIC CONFIG**

**MODERATE & HIGH:**

OVERTURNING:

\[
\frac{b}{h} = 0.10
\]

\[
27.7' = h
\]

\[
b = 2.67'
\]

\[
S_a = 0.914, USGS DESIGN MAPS
\]

\[
0.6 S_a = 0.55
\]

\[
> \frac{b}{h} \implies \checkmark \text{ NG}
\]

**W/ SEGMENT:**

\[
b = 4' \implies \frac{b}{h} = 0.14 < 0.6 S_a \implies \checkmark \text{ NG}
\]

\[
b = 10' \& \ h = 28.125' \implies \frac{b}{h} = 0.356 \implies \checkmark \text{ NG}
\]

**NEED TIER 2 \checkmark OVERTURN**
B. ASCE 41-13 CALCULATIONS

BASIC CONFIG. = 16.1, 210

VERY LOW:

TORSION:
FLEXIBLE DIAPHRAGM: N/A

LOW:

LIQUEFACTION:
UNKNOWN SOILS

SURFACE FAULT RUPTURE:
LOCATION OF FAULT RUPTURE: UNKNOWN
B. ASCE 41-13 CALCULATIONS

LEVEL OF SEISMICITY

LET SOIL CLASS = D
FROM USGS SEISMIC VALUES:

\( S_{xs} = 0.917, \ BSE = 2N \)

\( S_{ds} = \frac{2}{3} S_{xs} \)

\( = 0.611 \)

\( > 0.50 \) :: LEVEL OF SEISMICITY = HIGH

1) Table 2-5 pg 49

BUILDING PERIOD

\( T = C_t \ h_n^\beta \)

\( C_t = 0.02, \ MASONRY \ FRAMING \ SYS \)

\( h_n = 33.5' \)

\( \beta = 0.75, \ MASONRY \ FRAMING \ SYS \)

\( T = 0.278 \)
W110 STRUCTURAL

VERY LOW SEISMICITY:

SHEAR STRESS CHECK:

\[ A_w = 44' + 12', \text{ MAX SHEAR E-W @ 1ST FLOOR} \]

\[ V_{ew} = 567 \text{ k/l}, \text{ REF RM1 BASEL CONFIG} \]

\[ f_v = \frac{V_{ew}}{A_w} \]

\[ = 5002 \text{ Ib/ft} \]

\[ > 1000 \text{ Ib/ft} \text{ V NG} \]
B. ASCE 41-13 CALCULATIONS

Basic Config - 14.15 x 20

Very Low Seismicity:

Shear Stress Check:

\[ W = \text{Total Seismic WT per } \Delta 4.5.2.1 \]
\[ = W_1 + W_2 + (W_{Ww} \text{ or } W_{Wns}) \]

\[ W_1 = D_L \left( A_1 + A_2 + A_3 + A_u + A_t + A_0 \right) + 0.2 S_L \left( A_1 + A_3 \right) \]
\[ D_L = 15 \text{ psf} \]
\[ S_L = 40 \text{ psf} \]
\[ A_1 = 2028.75 \text{ ft}^2 \]
\[ A_2 = 573.75 \text{ ft}^2 \]
\[ A_3 = 299.7 \text{ ft}^2 \]
\[ A_u = 826.2 \text{ ft}^2 \]
\[ A_t = 97.5 \text{ ft}^2 \]

\[ W_1 = 183.5 \text{ k} \]

\[ W_2 = (D_L + 0.2 S_L) \left( A_1 + A_u + A_5 + A_6 \right) \]

\[ W_2 = 103.9 \text{ k} \]

\[ D_{Lw} = \text{Wood Wall WT} \]
\[ = 1.7 \text{ psf} + 1.5 \text{ psf} + 2.2 \text{ psf} + 0.8 \text{ psf} \]
\[ = 6.2 \text{ psf} \]

\[ D_{Lw} = 75 \text{ psf}, \ 8" \text{ LIGHT WT CMU W/ SOLID GROUT} \]
RMI
BASIC CONFIG

VERY LOW SEISMICITY:

SHEAR STRESS CHECK:

\[ W = W_1 + W_2 + (W_{wew} \text{ or } W_{wns}) \]

1ST FLOOR:

\[ W_{wew} = \frac{[DL_{ww} (10') + DL_{wm} (120' + 10' + 10' + 25' + 11.5' + 99')]}{2} \times h_{1/2} \]

\[ DL_{ww} = 60 \text{ psf} \]
\[ DL_{wm} = 75 \text{ psf} \]

\[ W_{wew1} = 165.8 \text{ k} \]

\[ W_{wns1} = \frac{[DL_{ww} (44') + DL_{wm} (12' + 32' + 16.5' + 52' + 19.5' + 19.5')]}{2} \times h_{2/2} \]

\[ W_{wns1} = 93.1 \text{ k} \]
B. ASCE 41-13 CALCULATIONS

RMI
BASIC CONFIG

VERY LOW SEISMICITY:

SHEAR STRESS CHECK:

\[ W = W_1 + W_2 + (W_{W EW} \text{ OR } W_{W NS}) \]

2ND FLOOR:

\[ W_{W EW2} = \left[ DL_{w} \left( 25' + 99' - 45' + 99' \right) \right] + DL_{w} \left( 45' + 5' + 5' \right) \cdot h_{2} \]
\[ + \left[ DL_{w} \left( 25' + 25' \right) \right] \cdot h_{2} \]

\[ DL_{w} = 62 \text{ psf} \]
\[ DL_{w} = 75 \text{ psf} \]

\[ W_{W EW2} = 159.1 \text{ k} \]

\[ W_{W NS2} = \left[ DL_{w} \left( 52' \right) \right] + DL_{w} \left( 33' - 13.5' + 55' + 19.5' + 19.5' \right) \cdot h_{2} \]
\[ + \left[ DL_{w} \left( 13.5' + 13.5' \right) \right] \cdot h_{2} \]

\[ W_{W NS2} = 171.6 \text{ k} \]

\[ W_{W EW} = W_{W EW1} + W_{W EW2} \]
\[ = 325 \text{ k} \]

\[ W_{W NS} = W_{W NS1} + W_{W NS2} \]
\[ = 265 \text{ k} \]
BASIC CONFIG.

VERY LOW SEISMICITY!

SHEAR STRESS CHECK:

\[ w_{EW} = w_1 + w_c + w_{new} \]
\[ = 612 \text{ k} \]

\[ w_{NS} = w_1 + w_c + w_{new} \]
\[ = 552 \text{ k} \]

\[ V_j = \text{STORY SHEAR} @ \text{LVL} \ j \ \text{PER 4.5.2.2} \]
\[ = \frac{n^2}{x^2} F_x \]

\[ n = \text{TOTAL # STORIES ABOVE GROUND LVL} \]
\[ = 2 \]

\[ j = \text{# OF STORY LVL UNDER CONSIDERATION} \]

\[ F_x = \frac{w_k h_x k}{\sum w_i h_i k} \]

\[ w_k = \text{PORTION OF W @ LVL} \ X \]
\[ h_x = \text{HT @ LVL} \ X \Rightarrow h_1 = 16' \ h_2 = 21' \]

\[ w_i = \text{PORTION OF W @ LVL} \ i \]
\[ h_i = \text{HT @ LVL} \ i \]

\[ k = 1.0, \ T = 0.75 < 0.80 \ \& \ 2 \text{ STORIES < 6 STORIES} \]

\[ V = C S_a W \]
\[ C = 1.0, \ \text{FLEXIBLE DIAPHRAGM \ (Table 4-B)} \]
\[ S_a = 0.972 \]

\[ V_{EW} = 567 \text{ k} \]
\[ V_{NS} = 511 \text{ k} \]
### B. ASCE 41-13 CALCULATIONS

#### Basic Config

**Very Low Seismicity:**

#### Shear Stress Check:

<table>
<thead>
<tr>
<th>DIR`N</th>
<th>( W_1(k) )</th>
<th>( W_2(k) )</th>
<th>( W_{w1}(k) )</th>
<th>( W_{w2}(k) )</th>
<th>( V(k) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-W</td>
<td>183.3</td>
<td>103.9</td>
<td>165.8</td>
<td>159.1</td>
<td>5.67</td>
</tr>
<tr>
<td>N-S</td>
<td>183.3</td>
<td>103.9</td>
<td>93.1</td>
<td>171.6</td>
<td>5.11</td>
</tr>
</tbody>
</table>

\[
F_k = \frac{w_x h_x^k}{\sum_{i=1}^{n} \frac{w_i h_i^k}{k}} \quad h_a = 16' \quad h_L = 31' \quad k = 1.0
\]

\[
F_{V_{EW}} = \frac{(W_{x_{EW}} + W_{w_{x_{EW}}}) h_1}{(W_{x_{EW}} + W_{w_{x_{EW}}}) h_1 + (W_{x_{EW}} + W_{w_{x_{EW}}}) h_2} \quad V_{EW} = 0.41 V_{EW}
\]

\[
F_{V_{EW}} = 231 k
\]

\[
F_{V_{NS}} = \frac{(W_{x_{NS}} + W_{w_{x_{NS}}}) h_1}{(W_{x_{NS}} + W_{w_{x_{NS}}}) h_1 + (W_{x_{NS}} + W_{w_{x_{NS}}}) h_2} \quad V_{NS} = 0.34 V_{NS}
\]

\[
F_{V_{NS}} = 175 k
\]

\[
F_{V_{NS}} = \frac{(W_{x_{NS}} + W_{w_{x_{NS}}}) h_1}{(W_{x_{NS}} + W_{w_{x_{NS}}}) h_1 + (W_{x_{NS}} + W_{w_{x_{NS}}}) h_2} \quad V_{NS} = 0.60 V_{NS}
\]

\[
F_{V_{NS}} = 337 k
\]
RMI
BASIC CONFIG.

VERY LOW SEISMICITY:

SHEAR STRESS CHECK:

\[ V_j = \sum_{x=1}^{n} F_x \]

\[ V_{1EW} = F_{1EW} + F_{2EW} = V_{EW} \]

\[ V_{1EW} = 567 \text{ k} \]

\[ V_{2EW} = F_{2EW} = 337 \text{ k} \]

\[ V_{1NS} = F_{1NS} + F_{2NS} = V_{NS} \]

\[ V_{1NS} = 511 \text{ k} \]

\[ V_{2NS} = F_{2NS} = 337 \text{ k} \]
B. ASCE 41-13 CALCULATIONS

**BASIC CONFIG**

**VERY LOW SEISMICITY**

**SHEAR STRESS CHECK:**

**EAST:**

\[ A_{w1} = 140' \times 16' - (10' \times 4')^2 \]
\[ = 2160 \text{ ft}^2 \]

\[ A_{w2} = 15' \times 45' \]
\[ = 675 \text{ ft}^2 \]

**WEST:**

\[ A_w = [2(275') + 2(4')] 17.625' \text{ ASSUME ONLY PILASTERS} \]
\[ = 1235 \text{ in}^2 \]

\[ f_v = \frac{V_{ew}}{A_w} \]
\[ = 207 \text{ psi} \gg 70 \text{ psi} \]

**N-S SHEAR CONTROLS**

\[ V_{NS} = 511 \text{ k} \]
B. ASCE 41-13 CALCULATIONS

RMI BASIC CONFIG

VERY LOW SEISMICITY:

REINFORCING STEEL:

\[ \text{VERT} = \left( \frac{4'}{16} \right) \text{#4} \]
\[ = \left( \frac{4'}{16} \right) 0.144 \text{ in}^2 \]
\[ = 1.716 \text{ in}^2 \]

\[ A_{\text{V}} = 4' \times 7.625' \]
\[ = 30.6 \text{ in}^2 \]

\[ \frac{\text{VERT}}{A_{\text{V}}} = 0.0048 \]
\[ > 0.002 \therefore \checkmark \text{OK} \]

\[ \text{HORIZ} = \left( \frac{7'}{16} \right) \#4 \text{ @ } 4'-0'' \text{ o.c.} \]
\[ = \left( \frac{7'}{16} \right) \left( 0.20 \text{ in} \right) \]
\[ = 0.10 \text{ in}^2 / \text{ft} \]
\[ \implies \text{HORIZ} = 1.6 \text{ in}^2, \text{ PER 16' TALL} \]

\[ A_{\text{H}} = 16' \times 7.625' \]
\[ = 146.4 \text{ in}^2 \]

\[ \frac{\text{HORIZ}}{A_{\text{H}}} = 0.001 \]
\[ > 0.0007 \therefore \checkmark \text{OK} \]
B. ASCE 41-13 CALCULATIONS

RMI BASIC CONFIG

LOW, MODERATE, & HIGH SEISMICITY:

TRANSFER TO SHEAR WALLS:

DIAPHRAGM SHEATHING:

\[ V_s = 0.80 \times 640 \text{ plf} \]
\[ = 512 \text{ plf} \]
\[ V_s / \eta_d = (640 \text{ plf}) / 2.0 \]
\[ = 320 \text{ plf} \]

SEISMIC WALL SHEATHING:

\[ \phi_d \times V_s = 0.80 \times 680 \text{ plf} \]
\[ = 544 \text{ plf} \]
\[ > \phi_d \times V_s \text{ w/ DIAPHRAGM SHEATHING} \]

\[ \therefore \text{DIAPHRAGM SHEATHING CONTROLS} \]

1/55 ST22:

\[ (V_s / \eta_d) = 320 \text{ plf (1/2" O.C.)} \]
\[ = 427 \text{ lb} \]
\[ < T_a = \text{ALLOW. TENSION OF ST22} \]
\[ = 1420 \text{ lb} \]
\[ \therefore \text{OK} \]

8/55 PA273:

\[ (V_s / \eta_d) = 320 \text{ plf (1" O.C.)} \]
\[ = 1280 \text{ lb} \]
\[ < T_a = \text{ALLOW. TENSION OF PA273 w/ CRACKED CONCRETE} \]
\[ = 1980 \text{ lb} \]
\[ \therefore \text{OK} \]
B. ASCE 41-13 CALCULATIONS

LOW, MODERATE, & HIGH SEISMICITY:

TRANSFER TO SHEAR WALLS:

CMU AB SHEAR STR;

\[ A_{pv} = \frac{\pi \ell_{bc}^2}{2} \]

\[ \ell_{bc} = 3.5'' \]

\[ A_{pv} = 19.2 \text{ in}^2 \]

\[ B_{vb} = 1.25 A_{pv} \sqrt{f_m'} \]

\[ f_m' = 2000 \text{ psi}, \text{ REF 52} \]

\[ B_{vb} = 1076 \text{ lb} \]

\[ B_{vc} = 350 \sqrt[4]{f_m'} A_b \]

\[ A_b = \pi d_b^2/4 \]

\[ d_b = 5/8'' \]

\[ B_{vc} = 1742 \text{ lb} \]

\[ B_{vpy} = 2.0 B_{nb} = 2.5 A_{pl} \sqrt{f_m'} \]

\[ A_{pl} = \frac{\pi l_b^2}{4} \]

\[ l_b = 9'' - d_b \]

\[ B_{vpy} = 2416 \text{ k} \]

\[ B_{vs} = 0.36 A_{vb} f_y \]

\[ f_y = 36 \text{ ksi, A307} \]

\[ B_{vs} = 3976 \text{ lb} \]

\[ B_v = 1076 \text{ lb}, \text{ MIN OF } B_{vb}, B_{vc}, B_{vpy}, \text{ & } B_{vs} \]

\[ (v_s/\ell_{bc})S = 3.20 \text{ plf (4' D.C.)} \]

\[ = 1280 \text{ plf} \]

\[ \Rightarrow B_v = \text{ NG} \]
RMI Basic Config

Very Low Seismicity:

Wall Anchorage:

\[ T_e = \psi S_{ks} w_p A_p \]

\[ \psi = 1.8, \quad I_{0} \]

\[ S_{ks} = 0.917 \quad \text{USGS} \]

\[ w_p = 75 \text{ psf}, \quad 8" \text{ LIGHT WT CMU W/ SOLID GROUT} \]

\[ A_p = \frac{s \cdot h_t}{2} \]

\[ s = \text{ Connection Spacing} \]
\[ h_t = \text{ Wall HT} \]
\[ = 16' \]

\[ T_e = 990.4 \text{ lb} @ 12'' \text{ O.C.} \]
\[ = 1980.8 \text{ lb} @ 24'' \text{ O.C.} \]
\[ = 3961.5 \text{ lb} @ 48'' \text{ O.C.} \]
\[ = 1320.5 \text{ lb} @ 16'' \text{ O.C.} \]

1/85 St22:

\[ T_a = 1420 \text{ lb} \]
\[ > T_e = 1320.5 \text{ lb} @ 16'' \text{ O.C.} \]
\[ \text{ii - OK} \]
RMI BASIC CONFIG

VERY LOW SEISMICITY!

WALL ANCHORAGE:

6/53 CMU AB TENSION STR & PA23:

MSJC 2013 8.1.3.3 => SAME AS SHEAR STR

\[ B_t = \min \left\{ 1.25 \left( \frac{f_{cm}}{2\ell_c \ell_e} \right)^{2/3} \right\} \]

\[ f_{cm} = 2000 \text{ psi} \]

\[ f_{cm} = 2000 \text{ psi} \]

\[ B_t = 1742 \text{ lb} \]

\[ B_t = 1742 \text{ lb} \]

\[ T_a = 1980 \text{ lb}, \text{ PA23} \]

\[ B_t + T_a = 3722 \text{ lb} \]

\[ T_a = 3961 \text{ lb} \text{ at 410.2°C} \]

NG
B. ASCE 41-13 CALCULATIONS

RMI BASIC CONFIG

LOW, MODERATE, & HIGH SEISMICITY:

PROPORTIONS:

\[
\begin{align*}
\text{MAX } h_t &= 30, \quad t = 7.625''\text{, 8'' CMU} \\
\text{MAX } h_t &= 19' \\
\text{TOWER WALL } h_T &= 31' \implies \frac{h_T}{t} = 49 \\
&> \text{MAX } h_T \implies \checkmark \text{ NG} \\
\text{1ST FLOOR WALL } h_T &= 16' \\
&< 19' \implies \checkmark \text{ OK} \\
\text{2ND FLOOR WALL } h_T &= 15' \\
&< 19' \implies \checkmark \text{ OK}
\end{align*}
\]
Main Station Seismic Assessment

B. ASCE 41-13 CALCULATIONS

PILASTER

\[ A_t = 17.5 \times 10' = 175 \text{ ft}^2 \]

\[ DL = 15 \text{ psf, PER FLOOR} \]

\[ SL = 40 \text{ psf} \]

\[ LL = 100 \text{ psf} \]

\[ 16'' \times 16'' \text{ CMU PILASTER} \]

\[ w/ (4) \neq 6 \Rightarrow A_j = (4) 0.044 \text{ m}^2 \]

\[ P_u = 1.2 A_t DL + 1.0 A_t LL + 0.5 A_t SL \]

\[ = 6.3 + 28 + 3.5 \text{ k} \]

\[ P_u = 38.8 \text{ k} \]

\[ a = \frac{A_5 f_y + P_u / \phi}{0.80 f'_{m} b} \]

\[ f_y = 60 \text{ ksf, } \phi = 0.90 \]

\[ f'_{m} = 2000 \text{ psi} \]

\[ b = 16'' \]

\[ a = 5.766'' \]

\[ d = t_{sp} / 2; \text{ CENTERED REINF} \]

\[ t_{sp} = 16'' \]

\[ d = 8'' \]

\[ M_n = (P / \phi + A_5 f_y) (d - \frac{a}{2}) \]

\[ = 63 \text{ k-ft} \]

\[ \phi M_n = 56.7 \text{ k-ft} \]
B. ASCE 41-13 CALCULATIONS

**PILASTER**

\[
\begin{align*}
W_u &= \frac{F_p}{(L_1 + L_2)} \\
V_{\text{max}} &= \frac{W_u(L_1 + L_2)}{2} = 7450 \text{ lb}
\end{align*}
\]

\[
\begin{align*}
F_p &= 0.45S_{\text{L}}L_wW_p > 0.11 \\
S_{\text{L}} &= 0.611 \\
L_w &= 1.50 \\
W_p &= 75 \text{ psf} (L_1 + L_2) 17.1' \\
&= 40.7 \text{ k}
\end{align*}
\]

\[
F_p = 14.9 \text{ k}
\]

\[
W_u = 481 \text{ lb/ft}
\]

\[
M_{\text{max}} = \frac{M_u}{2} = 0.125WL_1, \quad \text{2 SPANS} \\
&= 962 \text{ lb-ft}
\]

\[
M_u = 11.5 \text{ k-ft}
\]

\[
\frac{M_u}{M_{\text{max}}} = \frac{57.8}{57.8} \Rightarrow \text{W/IN 2% OK OK}
\]
B. ASCE 41-13 CALCULATIONS

PILASTER

DCR:

\[ DCR = \frac{Q_{ud}}{Q_{ce}} \]

\[ Q_{ce} = \phi V_n \]

\[ \phi = 0.80 \]

\[ V_n = (V_{nm} + V_{ns}) \gamma_g \]

\[ V_{nm} = \left(4.0 - 1.75 \frac{M_n}{V_u d_v} \right) A_{nv} \sqrt{f_m} + 0.75 P_u \]

\[ M_n = 57.8 \text{ k}-\text{ft} \]

\[ V_u = 63.9 \text{ k} \]

\[ d_v = 2.75' \]

\[ \frac{M_n}{V_u d_v} = 0.33 < 1.0 \]

\[ \Rightarrow V_n \leq \left(2.15 \frac{M_n}{V_u d_v} + 3.3 \right) A_{nv} \sqrt{f_m} \]

\[ A_{nv} = 2.75' \times 7.625'' = 251 \text{ in}^2 \]

\[ f_m = 2000 \text{ psi} \]

\[ P_u = 37.8 \text{ k} \]

\[ V_{nm} = 47.8 \text{ k} \]

\[ V_{ns} = 0.5 (A_{vs} / 5) f_y d_v \]

\[ A_{vs} = (4') 0.44 \text{ ft}^2, = 1.76 \text{ m}^2 \]

\[ s = 4' \]

\[ f_y = 60 \text{ ksi}, = 6 \]

\[ V_{ns} = 36.3 \text{ k} \]

\[ \gamma_g = 0.75; \text{ PARTIAL GROUT} \]

\[ V_n = 63.1 \text{ k} \leq 47.8 \text{ k} \]

\[ V_n = 47.3 \text{ k} \]
**B. ASCE 41-13 CALCULATIONS**

**PILASTER**

**DCR:**

\[ DCR = \frac{Q_{UD}}{Q_{CE}} \]

\[ Q_{UD} = Q_a + Q_e \]

\[ Q_a = \text{GRAVITY LOADS} \]

\[ = \frac{1}{1.1} (Q_d + Q_l + Q_s) \]

\[ Q_d = \text{DEAD LOAD} \Rightarrow DL = 15 \text{ psf} \]

\[ Q_l = \text{LIVE LOAD} \Rightarrow LL = 100 \text{ psf} \]

\[ Q_s = \text{SNOW LOAD} \Rightarrow SL = 40 \text{ psf} \]

\[ Q_e = \text{SEISMIC LOADS} \]

\[ = 511 \text{ k/2 WALL LINES} \]

\[ = 123.9 \text{ k} \]

\[ DCR = \frac{123.9 \text{ k}}{47.2 \text{ k}} \]

\[ = 1.35 \]
C. UPGRADE SCHEME
C. UPGRADE SCHEME

Frame A:

Frame B:

1'-6" x 1'-6" x CONT.

Grade BM

4'-0" x 11'-0" x CONT.
C. UPGRADE SCHEME

[Diagram with instructions and annotations]

Sandy Fire District
August 11, 2014
C. UPGRADE SCHEME
This page intentionally left blank.
## SANDY FIRE DISTRICT 72

**Main Station Seismic Improvements**

**Statement of Probable Cost**

<table>
<thead>
<tr>
<th>LOC</th>
<th>DESCRIPTION</th>
<th>QNTY</th>
<th>UNIT</th>
<th>$/UNIT</th>
<th>TOTAL $</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Add 2nd Floor Drag Struts</td>
<td>6</td>
<td>SF</td>
<td>63,487</td>
<td>8,384</td>
</tr>
<tr>
<td></td>
<td>Ceiling finishes: remove/reinstall</td>
<td>1,048</td>
<td>SF</td>
<td>8.00</td>
<td>8,384</td>
</tr>
<tr>
<td></td>
<td>Drag struts W18x65</td>
<td>17,234</td>
<td>LB</td>
<td>2.53</td>
<td>43,603</td>
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<tr>
<td></td>
<td>Drag strut connections to wood members</td>
<td>1</td>
<td>LS</td>
<td>10,000.00</td>
<td>10,000</td>
</tr>
<tr>
<td></td>
<td>Painting steel columns &amp; beams</td>
<td>1</td>
<td>LS</td>
<td>1,500.00</td>
<td>1,500</td>
</tr>
<tr>
<td>#2</td>
<td>Upgrade Diaphragms</td>
<td>4,000</td>
<td>SF</td>
<td>7.00</td>
<td>28,000</td>
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<tr>
<td></td>
<td>Floor coverings demo &amp; replace</td>
<td>1</td>
<td>LS</td>
<td>2,000.00</td>
<td>2,000</td>
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<tr>
<td></td>
<td>Casework salvage &amp; replace</td>
<td>4,000</td>
<td>SF</td>
<td>1.00</td>
<td>4,000</td>
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<tr>
<td></td>
<td>Re-nail sheathing</td>
<td>6,300</td>
<td>SF</td>
<td>1.00</td>
<td>6,300</td>
</tr>
<tr>
<td></td>
<td>Re-roofing demo &amp; replace</td>
<td>6,300</td>
<td>SF</td>
<td>10.00</td>
<td>63,000</td>
</tr>
<tr>
<td>#3</td>
<td>Seismic Isolation at Hose Tower</td>
<td>112</td>
<td>SF</td>
<td>40.00</td>
<td>4,480</td>
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<tr>
<td></td>
<td>Cut &amp; demo CMU walls</td>
<td>90</td>
<td>SF</td>
<td>34.00</td>
<td>3,060</td>
</tr>
<tr>
<td></td>
<td>Patch at CMU cut</td>
<td>40</td>
<td>SF</td>
<td>24.00</td>
<td>960</td>
</tr>
<tr>
<td></td>
<td>Cut, demo, &amp; patch floor framing</td>
<td>40</td>
<td>SF</td>
<td>9.50</td>
<td>380</td>
</tr>
<tr>
<td></td>
<td>Cut, demo, &amp; patch ceiling</td>
<td>40</td>
<td>SF</td>
<td>9.50</td>
<td>380</td>
</tr>
<tr>
<td></td>
<td>Cut, demo, &amp; patch roof framing</td>
<td>40</td>
<td>SF</td>
<td>24.00</td>
<td>960</td>
</tr>
<tr>
<td></td>
<td>Cut, demo, &amp; patch soffit framing/finish</td>
<td>30</td>
<td>SF</td>
<td>47.00</td>
<td>1,410</td>
</tr>
<tr>
<td></td>
<td>Roofing patch</td>
<td>30</td>
<td>SF</td>
<td>15.00</td>
<td>450</td>
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<tr>
<td></td>
<td>Seismic expansion joint walls/ceil/floor/roof</td>
<td>102</td>
<td>LF</td>
<td>30.00</td>
<td>3,076</td>
</tr>
<tr>
<td></td>
<td>Finishes texture &amp; paint</td>
<td>1</td>
<td>LS</td>
<td>4,000.00</td>
<td>4,000</td>
</tr>
<tr>
<td>#4</td>
<td>Add Moment Frames</td>
<td>5</td>
<td>EA</td>
<td>1,000.00</td>
<td>5,000</td>
</tr>
<tr>
<td></td>
<td>Sectional doors: remove/reinstall</td>
<td>360</td>
<td>SF</td>
<td>16.00</td>
<td>5,760</td>
</tr>
<tr>
<td></td>
<td>Soffit demo &amp; patch</td>
<td>32,655</td>
<td>LB</td>
<td>2.09</td>
<td>66,249</td>
</tr>
<tr>
<td></td>
<td>Steel columns W14x145 &amp; channel</td>
<td>19,330</td>
<td>LB</td>
<td>2.37</td>
<td>45,813</td>
</tr>
<tr>
<td></td>
<td>Steel beams W18x65 &amp; channel</td>
<td>2,400</td>
<td>SF</td>
<td>22.50</td>
<td>54,000</td>
</tr>
<tr>
<td></td>
<td>Wood framing/siding</td>
<td>1</td>
<td>LS</td>
<td>3,100.00</td>
<td>3,100</td>
</tr>
<tr>
<td></td>
<td>Painting steel columns &amp; beams</td>
<td>2</td>
<td>EA</td>
<td>500.00</td>
<td>1,000</td>
</tr>
<tr>
<td>#5</td>
<td>Install BRB Frames</td>
<td>40</td>
<td>SF</td>
<td>9.50</td>
<td>380</td>
</tr>
<tr>
<td></td>
<td>Cut, demo, &amp; patch ceiling</td>
<td>11,772</td>
<td>LB</td>
<td>3.10</td>
<td>36,493</td>
</tr>
<tr>
<td></td>
<td>Steel columns W14 x 90</td>
<td>6,777</td>
<td>LB</td>
<td>3.34</td>
<td>22,636</td>
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<tr>
<td></td>
<td>Steel beams W18x65</td>
<td>6</td>
<td>EA</td>
<td>6,000.00</td>
<td>36,000</td>
</tr>
<tr>
<td></td>
<td>BRB braces</td>
<td>1</td>
<td>LS</td>
<td>4,000.00</td>
<td>4,000</td>
</tr>
<tr>
<td></td>
<td>BRB connections to wood members</td>
<td>1</td>
<td>LS</td>
<td>1,500.00</td>
<td>1,500</td>
</tr>
</tbody>
</table>

**ARCH:** Mackenzie  
**CONSTRUCTION FOCUS, INC.**  
**DESIGN LEVEL:** Study  
**ESTIMATE DATE:** July 21, 2014  
**REVOLUTION #: 0**
# D. COST ESTIMATE

## SANDY FIRE DISTRICT 72
Main Station Seismic Improvements
Statement of Probable Cost

<table>
<thead>
<tr>
<th>LOC</th>
<th>DESCRIPTION</th>
<th>QNTY</th>
<th>UNIT</th>
<th>$/UNIT</th>
<th>TOTAL $</th>
</tr>
</thead>
<tbody>
<tr>
<td>#6: Grade Beam for Frame A</td>
<td>Demo slab</td>
<td>800</td>
<td>SF</td>
<td>6.00</td>
<td>4,800</td>
</tr>
<tr>
<td></td>
<td>Excavation for footing</td>
<td>46</td>
<td>BCY</td>
<td>55.00</td>
<td>2,542</td>
</tr>
<tr>
<td></td>
<td>Grade beam 1'-6&quot;W x 1'-6&quot;D</td>
<td>98</td>
<td>LF</td>
<td>61.36</td>
<td>6,013</td>
</tr>
<tr>
<td></td>
<td>Backfill @ footing</td>
<td>31</td>
<td>TN</td>
<td>45.00</td>
<td>1,394</td>
</tr>
<tr>
<td></td>
<td>Patch slab</td>
<td>800</td>
<td>SF</td>
<td>10.00</td>
<td>8,000</td>
</tr>
<tr>
<td>#7: Spread Footings for BRB Frames</td>
<td>Demo slab</td>
<td>352</td>
<td>SF</td>
<td>6.00</td>
<td>2,112</td>
</tr>
<tr>
<td></td>
<td>Excavation for footing</td>
<td>39</td>
<td>BCY</td>
<td>55.00</td>
<td>2,151</td>
</tr>
<tr>
<td></td>
<td>Spread footing 4'-0&quot;W x 1'-6&quot;D</td>
<td>44</td>
<td>LF</td>
<td>108.02</td>
<td>4,753</td>
</tr>
<tr>
<td></td>
<td>Backfill @ footing</td>
<td>21</td>
<td>TN</td>
<td>45.00</td>
<td>955</td>
</tr>
<tr>
<td></td>
<td>Patch slab</td>
<td>352</td>
<td>SF</td>
<td>10.00</td>
<td>3,520</td>
</tr>
</tbody>
</table>

### Basic Structural Recommendations Hardcost $507,049

### Reinforced Masonry Recommendations

<table>
<thead>
<tr>
<th>2nd Fl</th>
<th>Roof</th>
<th>DESCRIPTION</th>
<th>QNTY</th>
<th>UNIT</th>
<th>$/UNIT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1: Connect CMU walls to the diaphragm</td>
<td>Simpson HTT5 straps</td>
<td>218</td>
<td>EA</td>
<td>37.43</td>
<td>8,160</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Simpson HTT5 straps</td>
<td>58</td>
<td>EA</td>
<td>37.43</td>
<td>2,171</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** roofing and floor coverings are removed and replaced under a different group within this cost estimate.

### Wood Framed Recommendations

<table>
<thead>
<tr>
<th>2nd Fl</th>
<th>Interior</th>
<th>DESCRIPTION</th>
<th>QNTY</th>
<th>UNIT</th>
<th>$/UNIT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1: Reinforce Wooden Shear Walls</td>
<td>Demo window</td>
<td>1</td>
<td>EA</td>
<td>104.56</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Window infill 2x6 framing/insul</td>
<td>45</td>
<td>SF</td>
<td>8.50</td>
<td>383</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marbrecrete patch @ window</td>
<td>45</td>
<td>SF</td>
<td>35.00</td>
<td>1,575</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Simpson HTT5 straps</td>
<td>10</td>
<td>EA</td>
<td>37.43</td>
<td>374</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suspended ceiling: remove &amp; reinstall</td>
<td>504</td>
<td>SF</td>
<td>5.50</td>
<td>2,772</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gypsum board: remove &amp; reinstall</td>
<td>1,260</td>
<td>SF</td>
<td>5.80</td>
<td>7,308</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plywood sheathing-shear</td>
<td>1,260</td>
<td>SF</td>
<td>2.50</td>
<td>3,150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Painting-walls</td>
<td>1,260</td>
<td>SF</td>
<td>0.80</td>
<td>1,008</td>
<td></td>
</tr>
</tbody>
</table>

**ARCH:** Mackenzie  
**DWG DATE:** July 3, 2014  
**DESIGN LEVEL:** Study  
**CONSTRUCTION FOCUS, INC.**  
**ESTIMATE DATE:** July 21, 2014  
**541-686-2031**  
**EUGENE, OREGON**  
**REVISION #: 0**  
**CONST. START: 3 QTR_15**

---

**Sandy Fire District**  
**August 11, 2014**  
**D-2**
#2: Foundation Sill Anchorage
 Lag bolts, 3/8" @ 36" oc

<table>
<thead>
<tr>
<th>LOC</th>
<th>DESCRIPTION</th>
<th>QNTY</th>
<th>UNIT</th>
<th>$/UNIT</th>
<th>TOTAL $</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shear walls</td>
<td>4</td>
<td>EA</td>
<td>10.22</td>
<td>429</td>
</tr>
</tbody>
</table>

Note: wall finishes are removed and replaced under a different group within this cost estimate.

Wood Framed Recommendations Hardcost 17,104

HARDCOST TOTAL 534,483

The above HARDCOST TOTAL does not include typical general contractor markups.
Those plus contingencies are listed below as part of a Low-High Range.
Variables include fluctuations in market conditions, material selections, and design considerations.
The Cost Estimate Range will be consolidated as we move closer to the actual Bid Date.

LOW RANGE

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>@ 3%:</td>
<td>16,034</td>
<td></td>
<td></td>
</tr>
<tr>
<td>@ 15%:</td>
<td>82,578</td>
<td>75,971</td>
<td>56,725</td>
</tr>
<tr>
<td></td>
<td>9,596</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>240,905</td>
</tr>
</tbody>
</table>

Markups:
- Inflation
- Contingency
- Gen Conditions @ 12%
- Profit & Overhead @ 8%
- Performance Bond

Markup Subtotals: 332,537

775,388 BASE BID TOTAL 867,020

NOTES
This estimate assumes competitive bidding by local contractors
Refer to the "Repair Recommendations" for more detailed information.

EXCLUSIONS
Design fees, permit fees, system development fees, utility hookup charges, testing, BOLI fee.
Hazardous materials abatement, moving expenses.
Overexcavation, rock excavation, wet weather sitework.
## D. Cost Estimate

### Sandy Fire Seismic Upgrades

**PRELIMINARY GOVERNMENTAL AND JURISDICTIONAL FEES**

City of Sandy

Please note: This preliminary estimate is provided as a convenience to our clients, and is not intended to duplicate the actual fees assessed by the governing jurisdiction(s). Every effort has been made to accurately estimate the fees that will be associated with this project. However, this information is based solely on information available on the date of the estimate; actual fees may vary at the time of permit application or issuance. If information and/or assumptions about the project change, then we rely on our clients to notify us if a revision to this estimate is needed. In addition, please review the notes below.

### Assumptions

<table>
<thead>
<tr>
<th>Building Area:</th>
<th>Building Size (Per As-Builds)</th>
<th>13,537 SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Area:</td>
<td>Assumes No Change - Area Per Clackamas County Assessor</td>
<td>18,006 SF</td>
</tr>
</tbody>
</table>

| A Construction Cost: | Per Construction Focus Estimate (7/22/14) | $867,020 |

<table>
<thead>
<tr>
<th>Water Meter:</th>
<th>Assumes use of existing water meter</th>
<th>Existing</th>
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</thead>
<tbody>
<tr>
<td>Equivalent Length</td>
<td>New Daily Trip</td>
<td>Assumes no new trips</td>
</tr>
<tr>
<td>Equivalent Dwelling Units:</td>
<td>Assumes no new fixtures</td>
<td>0</td>
</tr>
<tr>
<td>Equivalent Residential Units:</td>
<td>Assumes no new fixtures</td>
<td>0</td>
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</tbody>
</table>

### Fee Estimate

<table>
<thead>
<tr>
<th>B Pre-Application Conference</th>
<th>Required at discretion of Planning Director</th>
<th>$50</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>B Design Review</td>
<td>Type I Design Review for wood framing and siding ($54,000 cost)</td>
<td>$500</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Systems Development Charges

| Transportation SDCs: | $255 per Equivalent Length New Daily Trip | $0 | N/A |
| Water SDC:           | Assumes no new water meter | $0 | N/A |
| Sanitary Sewer SDC:  | $1,834 per ERU (assumes no ERUs) | $0 | N/A |
| Parks SDC:           | Not charged for non-residential buildings | $0 | N/A |

### Building Permit and Related Fees

<table>
<thead>
<tr>
<th>Building Permit:</th>
<th>Permit ($742.00 for 1st $100,000 plus $4.00 per $1,000 thereafter)</th>
<th>$3,810</th>
<th>Paid at bldg permit issuance</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Structural Plan Review @ 65% of Permit fee</td>
<td>$2,477</td>
<td>Paid at bldg permit submittal</td>
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<tr>
<td></td>
<td>Fire &amp; Life Safety Review @ 40% of Permit fee</td>
<td>$1,524</td>
<td>Paid at bldg permit issuance</td>
</tr>
<tr>
<td></td>
<td>Seismic Review @ 1% of Permit fee</td>
<td>$38</td>
<td>Paid at bldg permit issuance</td>
</tr>
<tr>
<td></td>
<td>State Surcharge @ 12% of Permit fee</td>
<td>$457</td>
<td>Paid at bldg permit issuance</td>
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<tr>
<td>C School Construction</td>
<td>$0.58 per SF with a $29,200 maximum (applies to development resulting in new SF)</td>
<td>$0</td>
<td>N/A</td>
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</tbody>
</table>

**Total Fees:** $8,856

### Footnotes:

A. Per the July 21, 2014 construction cost estimate prepared by Construction Focus. This is the High Range estimate.

B. Per City Planning Director Tracy Brown on 7/22/14 and per Municipal Code 17.90.40. Design Review is required for exterior alterations other than general maintenance. A pre-application conference may be required. Design Review fees are based on cost of work; this fee is based on the $54,000 cost of the front exterior work subject to Design Review (wood framing and siding).

C. This tax is imposed on improvements to real property that result in a new structure or additional square footage in an existing structure, to help Oregon school districts pay for a portion of the cost of new or expanded school facilities. Therefore, the tax does not apply to this project.

### General Notes:

1. Special assessments (i.e. sanitary sewer late-comers fees, street improvements, fire sprinkler/alarm, etc.) will need to be identified and are not included here.

2. Permits that are typically the contractor’s responsibility, such as plumbing, mechanical, and electrical permits are not included in this estimate.

3. Any deferred submittal fees are not included in this estimate.

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Sandy Fire District

*August 11, 2014*