

THE UTAH GUIDE FOR THE SEISMIC IMPROVEMENT OF UNREINFORCED MASONRY DWELLINGS



FEMA



**Utah Seismic Safety Commission
Existing Buildings Committee
Second Edition
2016**

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PREFACE

This publication is prepared for information purposes to assist owners of unreinforced masonry (URM) dwellings (homes) in gaining a better understanding of the seismic improvement of their dwellings. It is recommended that owners enlist the expertise of a Utah-licensed contractor or repair specialist prior to the implementation of the fixes illustrated herein. While several generalized dwelling types are addressed in this publication, each home is unique and for greater assurance and reliability, a Utah-licensed Professional Engineer and/or Architect should be retained to design and detail specifically tailored corrective measures. This document is intended for general informational use by homeowners and small residential contractors, and if any non-dwelling building or other non-residential commercial building repair is being considered, the owner should certainly involve a Utah-licensed Structural Engineer. This publication is not to be used as a construction document.

The agencies and businesses involved in the design and preparation of this publication accept no responsibility for rehabilitation work or any action taken based on information found in this publication.

Unreinforced masonry and lightly reinforced masonry dwellings were typically constructed prior to 1975. Beginning in 1973, the building codes began to introduce more significant seismic requirements. Such dwellings were commonly constructed using solid masonry bearing walls without adequate steel reinforcing. As a result, URM dwellings lack the ductility required to absorb seismic energy in a significant earthquake. Often, the dwellings are quite brittle and lack proper attachment between the walls and roof, preventing the roof from stabilizing the wall. In multi-story dwellings, the same concept applies to attachments between the floor and walls. Because of these structural deficiencies, URM dwellings can quickly fail during earthquakes and should not be expected to perform adequately during a large earthquake.

While it is impractical to make any dwelling earthquake proof, the techniques shown in this publication are intended to generally improve the seismic performance of a URM dwelling. Potential earthquakes have a wide range of magnitudes and other characteristics and it should be expected that damage can still occur, even after the upgrading of URM structures. Moderate magnitude earthquakes occur periodically and, although minor damage is usually associated with these events, they have been known to cause major damage. High magnitude earthquakes (such as, above magnitude 6.75) have been known to cause damage to even strengthened or partially-strengthened structures. Generally, the more seismic upgrade measures that are taken to improve any given structure, the greater the potential reduction in damage due to the earthquake. The purpose of this guide is to minimize the possibility of a catastrophic failure of a dwelling by the implementation of seismic upgrades, all in an effort to mitigate the loss of life during a major earthquake.

ACKNOWLEDGMENTS

One important strategy identified in the Utah Seismic Safety Commission's (USSC) 1995 publication *A Strategic Plan for Earthquake Safety in Utah* was the need to provide seismic strengthening of existing dwellings. The USSC partnered with the Structural Engineers Association of Utah (SEAU) in advocating the statewide adoption of existing dwellings building codes and other regulations.

In the 2008 progress report, *Earthquake Safety in Utah*, the USSC describes its action plan and target focuses that include: learning about, building for, and living with earthquakes. Under the building for earthquakes focus, is an initiative for improving vulnerable dwellings. This guide is the outcome for this initiative in that seismically upgraded dwellings will reduce the loss of life and property in the event of an earthquake.

The Utah Guide for the Seismic Improvement of Unreinforced Masonry Dwellings (Utah Guide) has been reviewed, expanded, and updated by the combined efforts of the SEAU, the USSC, the Utah Division of Emergency Management (UDEM), and the Federal Emergency Management Agency (FEMA). A special thanks to the SEAU/USSC Existing Building Committee (EBC) Chairs, Glen Palmer and Barry Welliver, for managing this project, and to the members of the Utah Guide Subcommittee of the EBC: Brian Warner, Zach Hansen, Curtis Earl, Roger Evans, and Bob Carey, who have donated their time and expertise.

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Acknowledgments (Second Edition – 2016)

Contributors

Structural Engineers Association of Utah

Utah Seismic Safety Commission, Existing Buildings Committee

Existing Buildings Subcommittee on the Update of the Utah Guide

Roger Evans, Past USSC Chair

Glen E. Palmer, S.E., EBC Chair

Barry H. Welliver, S.E., Past EBC Chair

Technical Editing Subcommittee Members:

Brian Warner

Zach Hansen

Curtis Earl

Glen E. Palmer

Utah Department of Public Safety, Utah Division of Emergency Management

Robert Carey, Earthquake Program Manager

Sheila Curtis, Operations Planner

Federal Emergency Management Agency

Doug Bausch, FEMA Region 8

Publication Editorial Review, Formatting, and Production (Utah Geological Survey)

Steve D. Bowman, Ph.D., P.E., P.G., Geologic Hazards Program Manager

Vicky Clarke, Publications Manager

Acknowledgments (First Edition – 1996)

Contractor

Reaveley Engineers & Associates Inc.

675 East 500 South, Suite 400

Salt Lake City, Utah 84102

Utah Division of Comprehensive Emergency Management (CEM)

Lorayne Frank, CEM Director

Robert Carey, EPICENTER Manager

Judy Watanabe, Natural Hazards Planner

Brenda Edwards, Natural Hazards Office Technician

Caryn Johnson, Natural Hazards Section

Mikki Easton, Natural Hazards Section

James Tingey, as he was instrumental in initiating this project

Special thanks to:

Lawrence D. Reaveley, Ph.D., S.E.

Mark R. Harris, S.E.

Debra A. Lewis, Structural Technician

David J. Wagner, A.I.A.

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CHAPTER 1

Introduction

Residential dwellings (homes) constructed under the current provisions of the International Building Code (IBC), International Residential Code (IRC) and other subset codes (including amendments adopted in Utah), (<http://le.utah.gov/xcode/Title15A/15A.html>), require that they be designed and built to resist a specified minimum level of forces that might be generated by an earthquake. Dwellings built prior to the adoption and enforcement of these codes almost always do not provide the desired earthquake resistance, (figures 1 and 2), as is common with unreinforced masonry (URM) structures. URM materials consist of stone, brick, block, or rock that is only held together with mortar (no or little reinforcing steel). However, even dwellings designed and constructed today with this minimum level of resistance could still experience considerable structural and non-structural damage due to the fact that minimum code requirements focus only on the safety of the dwelling's occupants without considering the future usability of the dwelling. This is especially true as ground shaking that exceeds the level

anticipated by the building code adopted at the time of design and construction can occur resulting in increased damage to structures.

The concept of upgrading existing dwellings to resist seismic forces from earthquakes is increasingly common in Utah. The majority of this work has been performed on commercial structures, rather than residential dwellings. However, the level of exposure from high profile upgrade projects of complex dwellings has raised the misconception that seismic upgrades are difficult and prohibitively expensive. URM dwellings are usually far simpler than these more prominent projects, but still pose a significant risk due to the quantity of these vulnerable dwellings in Utah that include over 147,000 URM dwellings and other structures in Box Elder, Cache, Davis, Juab, Morgan, Rich, Salt Lake, Summit, Tooele, Utah, Wasatch, and Weber Counties (Earthquake Engineering Research Institute, Utah Chapter, 2015).



Figure 1. Braced exterior wall of a URM dwelling after an earthquake.



Figure 2. Cracks and failure of a Richmond, Utah, home from the 1962 magnitude 5.7 Cache Valley earthquake. The damage was extensive enough that this house was torn down. Photo: Ariel Benson.

Earthquake ground shaking has been found to be very damaging to URM buildings, including dwellings. Seismic forces exerted on a dwelling during an earthquake are a function of the mass, or weight, of the dwelling. The seismic resistance of a dwelling depends on the strength and ductility of the horizontal (lateral) force resisting elements. Due to the relatively high mass and the low ductility of URM materials, these dwellings generally perform poorly in moderate to large earthquakes (generally greater than magnitude 6.75). Previous earthquakes have shown that URM structures are the most vulnerable of all building types to the forces generated by a seismic event. Relatively small levels of ground shaking can cause significant damage to a URM structure. Moderate to large levels of ground shaking have the potential to cause structural collapse to a portion or all of the structure (figures 3 to 12). Additional information on the earthquake hazard, risk, and possible mitigation measures is also available in Appendix A, the USSC publication *Putting Down Roots in Earthquake Country: Your Handbook for Earthquakes in Utah* (<https://ussc.utah.gov/pages/help.php?section=Putting+Down+Roots+in+Earthquake+Country+Handbook>), and from the Utah Seismic Safety Commission (<https://ussc.utah.gov>).

This guide is designed to educate homeowners with respect to the effects of earthquakes on URM dwellings and addresses how individual homeowners can make their own assessment of possible seismic deficiencies and how to improve them. This education process is facilitated by using seven typical model dwellings representative of a wide spectrum of the URM dwellings commonly found



Figure 3. URM structure collapse.



Figure 4. This young woman was in bed during the 1962 magnitude 5.7 Cache Valley, Utah, earthquake when the interior URM wall collapsed. Photo: Ariel Benson

in Utah. A homeowner can examine the architectural features, configuration, and materials of their dwelling and then compare these observations to the model dwellings in this guide. It is usually possible to make some direct correlations between the specific dwelling and one or more of the model dwellings. The seven model dwellings are described in Chapter 5, with photographs and drawings provided to help illustrate the different model dwelling types. Basic seismic deficiencies are noted for each model with suggested corrective measures.

The procedures contained in this guide will not provide the homeowner with a completely earthquake resistant dwelling, but will help improve the seismic performance of the URM dwelling during an earthquake, reducing the risk of collapse. If it is not feasible to make all of the proposed seismic improvements, any work performed will generally be beneficial. The improvements should, as a

minimum, include the anchorage of the exterior walls to the roof and floor structures. Detailed engineering analysis and design by a Utah-licensed Professional Engineer is recommended in order to achieve a greater level of confidence in the strengthened dwelling.

Chapter 2 provides directions for using this guide, including how to select the most important areas for improvement and how to implement the actual fix. A flow chart (figure 11) has been included to aid in the use of this guide.

Chapter 3 provides a basic description of earthquakes and the effects they have on structures, including dwellings. It describes structural elements present in all structures, how these various elements interact during a typical earthquake, and how implementing the improvements in this guide are important.

Chapter 4 illustrates typical features of URM construction and discusses earthquake deficiencies that may exist in URM dwellings. Additional descriptions and illustrations of the many structural elements and connections that are prone to failure are also provided.

Chapter 5 includes descriptions, photos, and illustrations of seven model URM



Figure 5. URM wall (hollow clay units) collapse due to earthquake.



Figure 6. URM wall collapse on a Richmond, Utah, house from the 1962 magnitude 5.7 Cache Valley earthquake. Photo: Ariel Benson



Figure 7. Earthquake damage to an URM wall and displacement of mechanical equipment on roof.



Figure 8. URM wall failure from an earthquake.

dwellings. The intent of this chapter is to identify the type of construction that is most similar to a homeowner's dwelling. This can be performed by making comparisons between the homeowner's dwelling and the photographs and drawings of the typical model dwellings. It may be

that the homeowner's dwelling is a combination of two or more of these models. Included with each model, is a list of its seismic deficiencies and table 1 lists suitable improvement details applicable to each seismic deficiency



Figure 9. URM pier failure of a brick garage in Richmond, Utah, from the 1962 magnitude 5.7 Cache Valley earthquake. Photo: Ariel Benson



Figure 10. URM pier failure on a Richmond, Utah, house from the 1962 magnitude 5.7 Cache Valley earthquake. Photo: Ariel Benson

Chapter 6 provides conceptual details for upgrading the seismic deficiencies described and/or referred to in Chapter 5. These details are generally arranged in rank priority with the most important seismic improvements shown first. These conceptual details are general in nature and have been developed to allow a certain amount of modification to fit the specific deficiency.



Figure 11. Chimney failure due to inadequate reinforcement.



Figure 12. Chimney collapse.



Figure 13. Displacement of wood burning stove.

Where unusual and/or complex conditions are encountered, specific engineering analysis and design by a Utah-licensed Professional Engineer and/or Structural Engineer may be required.

Chapter 7 includes general details for upgrading (bracing, anchoring, etc.) non-structural seismic hazards. These are typically elements and dwelling contents that are not part of or are not anchored to the dwelling structure (figure 13).

Appendix B contains a glossary and list of definitions for the abbreviations used in this document.

CHAPTER 2

How To Use This Guide

This guide was developed on the premise that the wide range of URM dwellings in Utah can be represented by several typical URM models. Previous experience, by engineers in Utah, has determined that the majority of URM, single-family dwellings in Utah can be described by seven different typical models. Each model has distinct architectural styles, variations in construction and materials, and different configurations.

The details in this guide are referenced using a consecutive numbering system with each detail listing the model type referenced and the general purpose of the basic detail shown. These details are included in Chapters 5 and 6.

The process presented in this guide to evaluate and improve the seismic resistance of a dwelling is shown in figure 14 with four major steps:

Step 1

- A. From the seven model dwellings described in Chapter 5, determine which one has the architecture features, configuration, and specific materials most closely resembling the dwelling that is to be improved.
- B. It is possible that several structural details showing wall sections will apply to a single dwelling and each potential similar element should be identified for consideration during the seismic improvement process. A Utah-licensed contractor or repair specialist can assist in determining which wall sections apply to a specific dwelling.

Step 2

Using table 1, select corrective measures that appear to be appropriate for the URM dwelling that is to be improved using the improvement details in Chapter 6. The deficiencies are listed in the order of the approximate overall level of safety related to each deficiency and is recommended that they be corrected in the same sequence. As an example, the first and most important corrective measure for most URM homes is to provide a positive connection between the wood roof structure and the exterior walls.

Step 3

For some deficiencies, there are various seismic improvement details that may be used to achieve the same result with advantages and disadvantages for each. Some methods are much more disruptive and would only be practical if a major renovation is being undertaken. The intended procedure is to select the method that is best suited for the circumstances of the specific dwelling. In most instances, the corrective measures will require some modification from the details as provided. The method selected will be dictated by several factors that include the following:

- A. Should the entire home or just a portion of the dwelling be seismically improved? This may be related to remodeling or other construction projects planned for the dwelling.
- B. Can the architectural and/or historical appearance be altered?
- C. How much money is available for the project? This may require the work to be completed in stages.

Each alternative approach should generally provide the same basic result, however some approaches are based on constraints in the desired appearance or construction methods used. Where multiple seismic improvement details are provided, alternative approaches may show different methods of construction or may show differing ways to achieve a different final appearance. Often, a particular owner may feel the need to minimize the risk of damage that may be possible with the various methods of construction or they may not want to alter the basic appearance (such as, brick exterior) of their dwelling. Because some of the alternatives shown do not always consider the final impact on appearance, owners need to be aware that major alterations in the architectural appearance may result.

Step 4

The cost associated with each seismic deficiency should be estimated for the complete list of corrective measures selected, then summed to determine an overall total. The budget for the project can then be used to determine how

far the seismic improvement process can be taken based on available funds. Each task should ideally be placed in the ranked priority shown in table 1. This priority list can also be readjusted to better meet the homeowners' specific needs considering budget and/or phasing options.

Each corrective measure that is implemented should improve the seismic performance of the dwelling. If a measure is performed out of the suggested order, the desired seismic improvement may not be achieved because of the failure of another structural element. Some measures are much more cost effective than others and this is generally reflected in the suggested order of corrective work. In areas where high levels of ground shaking are probable (IBC

Seismic Design Category C through F), seismic improvements that address the top three deficiencies listed in table 1 are recommended as the minimum level of seismic rehabilitation work. In areas where the level of expected ground shaking is moderate to low (IBC Seismic Design Category A and B), the top two deficiencies listed in table 1 should be addressed as a minimum. Corrective work beyond the minimum recommended levels will improve the seismic performance of the dwelling and should be considered. It is generally assumed most areas in the Salt Lake Valley are Seismic Design Category C or D, therefore it is recommended that the maximum number of seismic deficiencies be addressed.

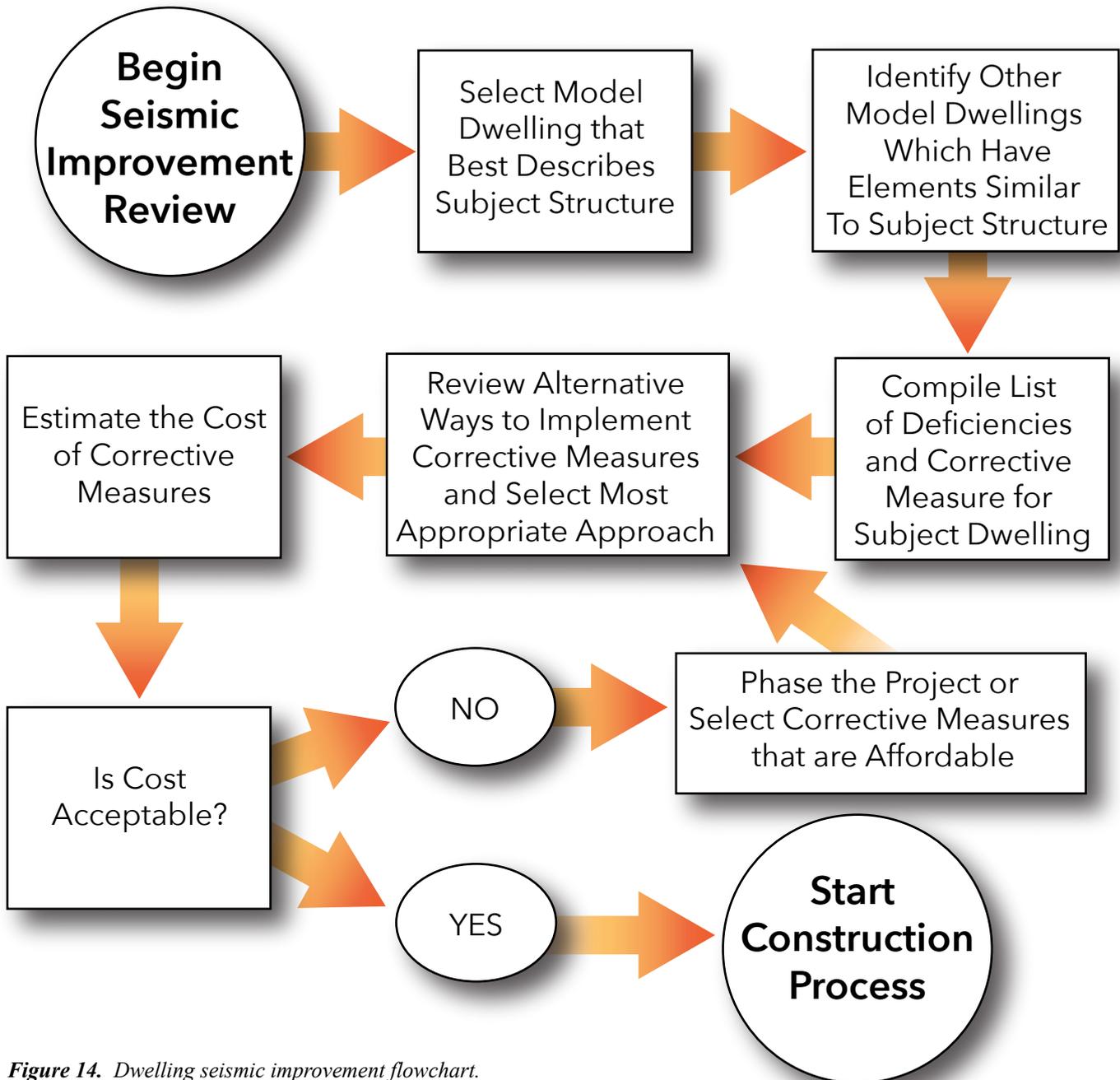


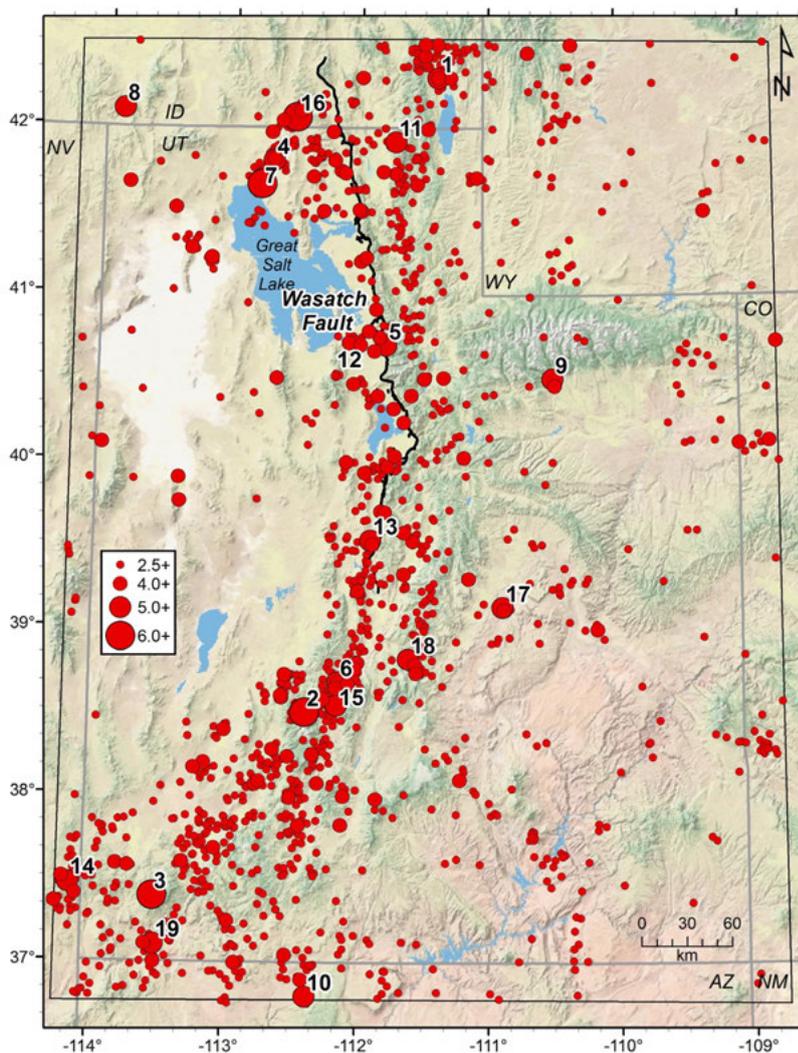
Figure 14. Dwelling seismic improvement flowchart.

CHAPTER 3

Building Dynamics and Earthquake Forces

The ground shakes when an earthquake occurs and sometimes land and structures are damaged or displaced. When a large earthquake takes place along a fault, there will be widespread damage. However, there are steps that can be taken by homeowners to reduce the damage to their individual dwelling and its contents that are explained in this guide and other related information resources. A better understanding of earthquakes and their effect on a dwelling will help homeowners understand the reasons and importance of implementing seismic improvements to protect life safety and their financial investment.

Utah experiences about 700 earthquakes every year (figure 15). Of this number, about eight are magnitude 3.0 or greater. Smaller magnitude earthquakes are rarely felt by people and typically do not cause damage. However, these small earthquakes are important for studying our vulnerability to larger earthquakes. A moderate and potentially damaging earthquake of magnitude 5.0 to 6.0 occur somewhere in Utah about every 5 to 30 years. Earthquakes occur on faults or cracks in the Earth’s crust. Utah has many faults that could produce damaging earthquakes as shown in the *Utah Quaternary Fault and Fold Database* (<http://geology.utah.gov/resources/data-databases/qfaults/>).



Mainshocks of magnitude 4.9 or larger in the Utah Region, 1850–Sept. 2012*			
No.	Year	M	Location
1.	1884	5.6	Paris (Idaho)
2.	1901	6.6	Tushar Mountains
3.	1902	6.3	Pine Valley
4.	1909	5.6	Hansel Valley
5.	1910	5.3	Salt Lake City
6.	1921	5.5	Elsinore
7.	1934	6.6	Hansel Valley
8.	1937	5.4	ID-NV-UT tri-state area
9.	1950	5.3	NW Uinta Basin
10.	1959	5.6	Arizona-Utah border
11.	1962	5.8	Cache Valley
12.	1962	4.9	Magna
13.	1963	5.1	Juab Valley
14.	1966	5.2	Nevada-Utah border
15.	1967	5.1	Marysville
16.	1975	6.0	Pocatello Valley (Idaho)
17.	1988	5.0	San Rafael Swell
18.	1989	5.2	So. Wasatch Plateau
19.	1992	5.5	St. George

*Magnitudes are moment magnitude, **M**.
No further shocks of **M** ≥ 4.9 have occurred through June 2015.

Figure 15. Epicenter map of earthquake mainshocks of moment magnitude, **M**2.5 and larger in the Utah region, 1850 through September 2012; foreshocks, aftershocks, and mining-related seismicity are excluded (Arabasz and others, 2016). Numbered epicenters for shocks of **M** ≥ 4.9 are shown in the accompanying table (USSC, 2008).

The 217-mile long Wasatch fault zone (WFZ; figure 16) is one of the longest and most active normal faults in the world, extending from north of Malad City, Idaho, south to Fayette, Utah. Normal faults move where one block (Wasatch Mountains, etc.) move upward relative to the adjacent downward moving valleys (Salt Lake, Utah, etc.). Based on extensive geologic research, the fault is subdivided into ten segments about 20 to 30 miles long with each segment capable of producing its own earthquake independent of the other segments. At least 22 surface-faulting earthquakes (generally, magnitude 6.5 or greater) have ruptured the five central segments (Brigham City, Weber, Salt Lake City, Provo, and Nephi) of the WFZ since about 6000 years ago (Wong and others, 2016).

The Working Group on Utah Earthquake Probabilities has determined that a large magnitude earthquake will occur somewhere on the five central segments of the WFZ about every 1200 years (Wong and others, 2016). In the Wasatch Front region during the 50 year period of 2014–2063, the probability of a large (magnitude ≥ 6.75) earthquake is 43%, and the probability of a magnitude ≥ 6 earthquake is 57% (Wong and others, 2016).

More information on faults is available from the Utah Geological Survey (<http://geology.utah.gov/hazards/earthquakes-faults/utah-faults/>), on earthquakes from the University of Utah Seismograph Stations (<http://www.seis.utah.edu/>), and seismic risk from the Utah Seismic Safety Commission (<https://ussc.utah.gov>).

Many dwellings built before earthquake construction design standards were adopted, which include those built about pre-1975, have little or no earthquake resistant design.

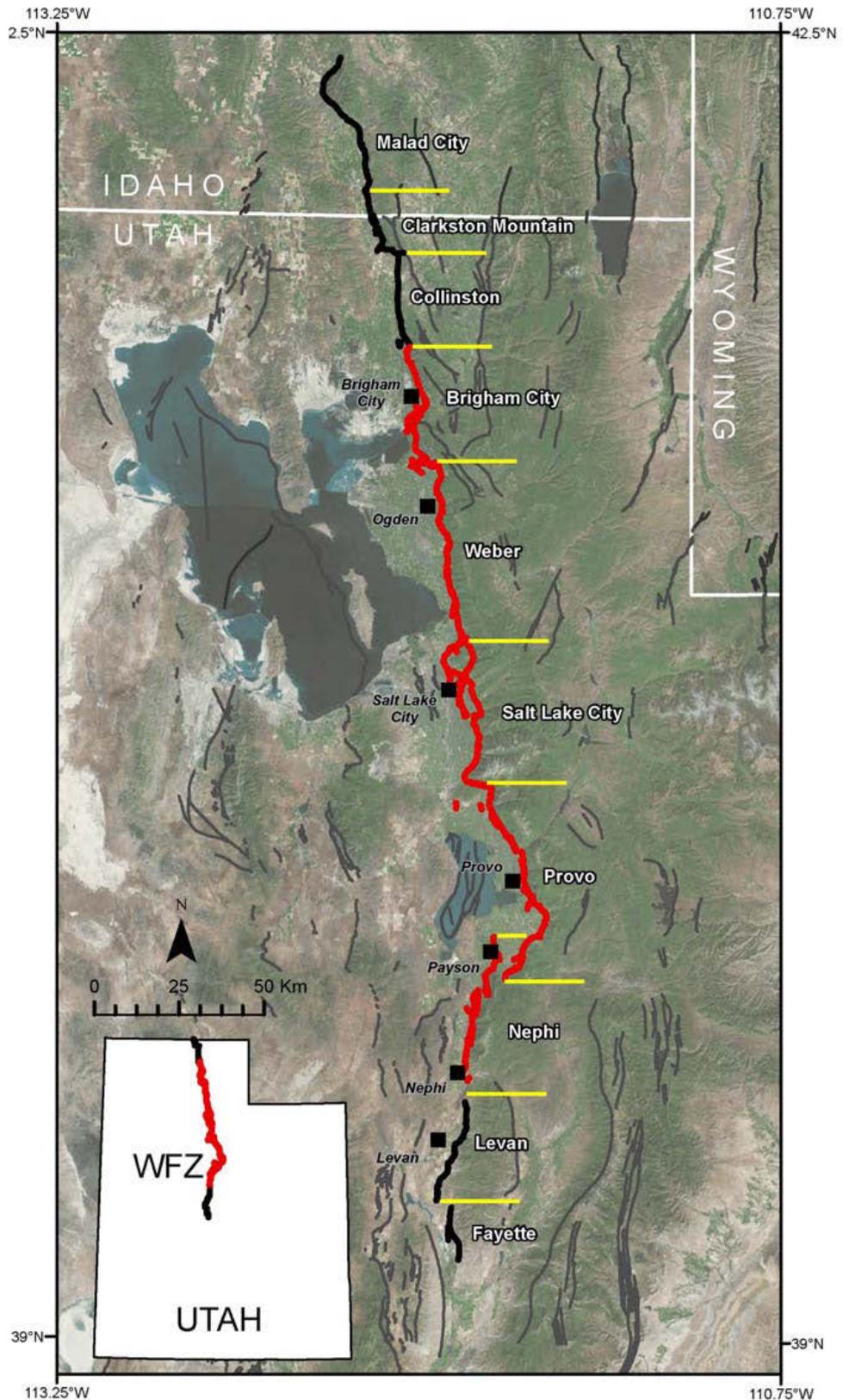


Figure 16. Segments of the Wasatch fault zone (WFZ) in northern Utah and southern Idaho. The central WFZ is shown in red, end segments of the WFZ are shown in black, and other Quaternary faults are shown in dark gray. From Wong and others, 2016.

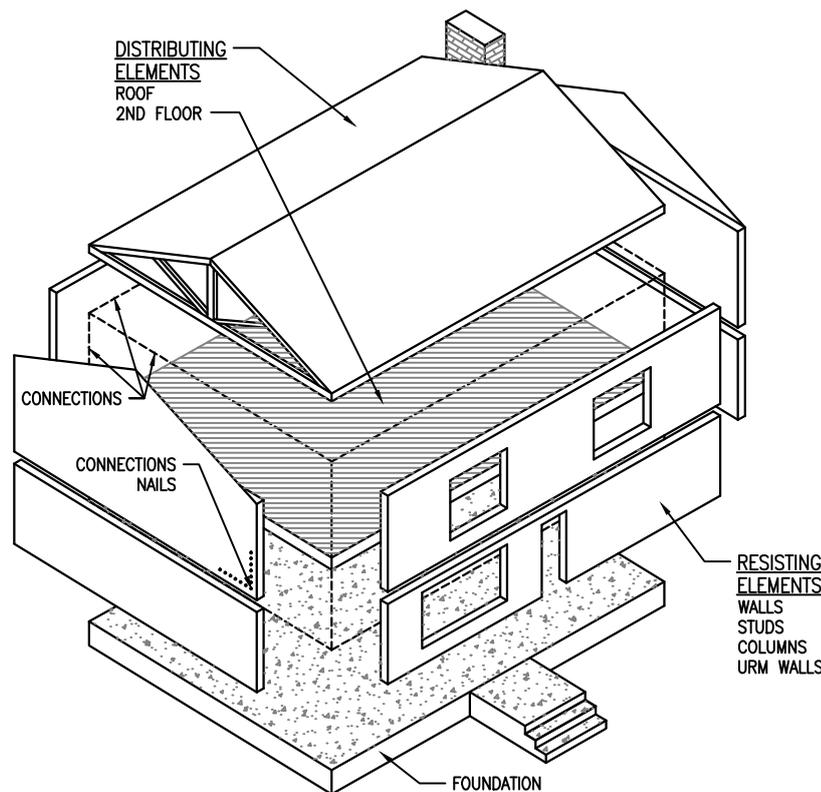


Figure 17. Elements of a typical structure.

Some of these dwellings, such as wood frame, may be fairly flexible and somewhat resistant to ground shaking. A large number of pre-1975 dwellings in Utah were constructed out of unreinforced masonry (URM). Because of the mass and brittle properties of URM construction, these dwellings perform poorly during earthquake ground shaking. The seismic improvement of URM structures in Utah presents a great challenge to the community. It is usually not practical to try to improve these structures to a level consistent with current seismic building code requirements; however careful long-term planning can lead to the improvement and/or replacement of these URM dwellings and should reduce the resultant damage from earthquake events. Knowledge of potential deficiencies that can cause severe damage during an earthquake will guide the homeowner in correcting many of the problems. Although it may not be possible to upgrade the dwelling to current building code requirements, seismic improvement will almost always help reduce the damage and the associated risk to occupants and the contents of these dwellings.

Over the years, much research has been done to understand the reasons for structural failure during earthquakes. By identifying the strengths and weakness of structures that have been subjected to seismic forces, elements required for the seismic stability of most structure types have been identified. Though the size, capacity, and type of materials

vary with each structure, the basic force resisting system must be present in all structures. The basic system to support gravity loads normally includes roof, floor, and wall elements, including solid walls and/or piers, beams, columns, footings, and foundations. A problem found to exist in URM dwellings is that they are intended to carry only vertical gravity loads, but generally have little resistance to the dynamic horizontal forces of earthquakes.

The two main elements in earthquake design are resisting and distributing elements (figure 17). The resisting elements are composed of footings, foundation walls, piers, braced columns, walls, wall bracing, or any other element or combination of elements that helps to transfer earthquake forces back to the foundation wall and footing. Proper connection of these elements to each other and anchorage to the foundation wall and footing is extremely important. If this anchorage is weak or missing, the structure may be displaced, or at worst, it could collapse.

The distributing elements are the floor(s), roof, horizontal bracing, or any other element or combination of elements designed to distribute earthquake forces to the resisting system of the structure. When ground shaking occurs, the resisting and distributing elements must be properly connected to each other in order to allow the structure as a whole to work together to transfer horizontal earthquake forces back to the foundation wall and the footing.

This simple description of the resisting and distributing elements is a very brief overview of what is required for a structure to withstand seismic forces. Chapters 4 and 5 will address many of the construction methods that were common prior to adopting seismic code standards. The adopted building codes in Utah no longer allow structures to be built using URM. There are many dwellings in Utah that are constructed out of URM materials and, although such dwellings have some inherent strength, they have been shown to perform poorly in moderate to large earthquakes. Replacement of the URM dwelling is not normally an economical or historically feasible alternative, as a result, this guide was developed to assist homeowners in identifying and mitigating seismic deficiencies inherent in the most common types of URM construction used in Utah. The following chapters provide an explanation of the weaknesses and the reasonable steps that homeowners can take to improve the performance of their URM dwelling during an earthquake.

CHAPTER 4

Typical Features of Unreinforced Masonry Construction

URM dwellings were designed primarily with structural elements to support only vertical gravity loads with the elements being designed to be strong enough to support the weight of the live loads (people, rain, snow, etc.) and the dead loads (weight of wood, masonry, roofing, contents, etc.) above. Little or no attachment exists from one structural element to the other that works in a static situation where the home is not subject to movement. However, when an earthquake occurs, the elements of a structure are subject to horizontal (lateral) loads, in addition to gravity, live, and dead loads. Structural failure can occur when the elements are overstressed by the additional seismic load and/or by the displacement of adjacent elements.

A typical URM dwelling has many elements where failure could occur. The construction may vary slightly, but they all consist of: (1) a footing and/or foundation wall (concrete, masonry, or rock), (2) load bearing masonry exterior walls, (3) wood frame floor(s), and (4) a roof system. Within the dwelling, there is some type of bearing wall(s) (normally URM or wood) or a beam support system. Each of these major elements could fail individually; however, failure is more likely to occur where one element is adjacent to another.

Foundation Walls

Foundation walls for URM dwellings may be concrete, masonry, or rock. If the foundation wall is URM or rock, it generally breaks apart at the mortar joints during an earthquake with sufficient seismic energy. Many times these walls have significantly deteriorated from moisture penetration over the life of the dwelling. The mortar used in many older dwellings contains very little cement, may be of poor quality, and is normally very soft and weak.

URM Bearing Walls

A bearing wall is defined as a wall that supports any vertical load in a dwelling as well as its own weight (figure 18). In this case, the vertical loads come from the floor and roof systems in a dwelling. The floor(s) and roof are normally composed of wood joists (parallel horizontal wood members) and a diaphragm (plywood or wood

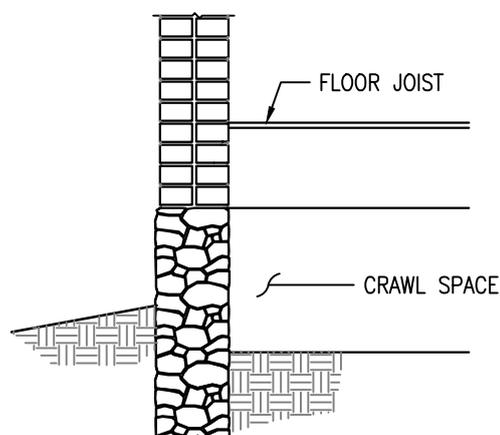


Figure 18. URM bearing wall.

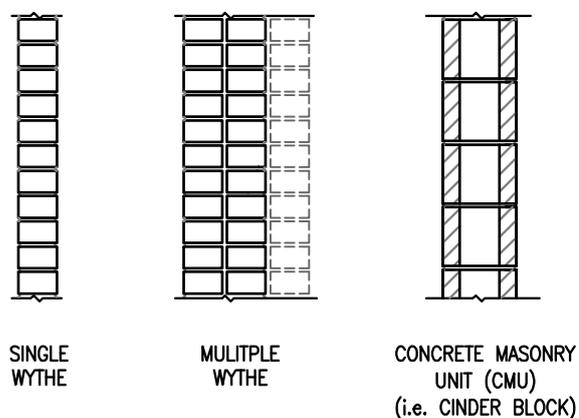


Figure 19. Vertical section through URM walls.

boards that create a flat or sloping surface). The wall may be covered by siding, stucco, or other materials concealing the masonry from view.

Figure 19 illustrates three types of URM walls described in this guide. Failure of these walls can happen in several different ways. In-plane failure occurs when seismic forces from an earthquake are introduced parallel to the wall causing the wall to be displaced horizontally within the plane of the wall (figure 20). Out-of-plane failure occurs when seismic forces are introduced perpendicular to the wall and the wall either falls away from the floor(s) and/or roof, or buckles between the floor(s) and roof (figure

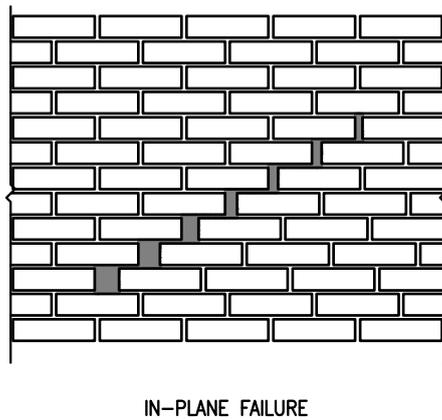


Figure 20. In-plane failure.

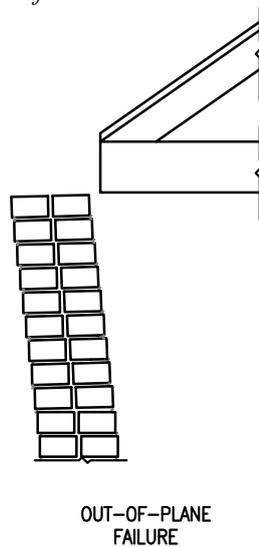


Figure 21. Out-of-plane failure.

21). The floor joists usually pocket into the masonry and the roof joists normally bear on top of wall. In both cases, there may or may not be a wood plate to which these joists are nailed. Failure of these connections can cause the joists to slide off their bearing support, resulting in full or partial collapse of a floor or roof. Another common failure in multiple wythe (or vertical layer) construction where one or more of the outer wythes of brick may fall away from the rest of the wall, as they are not connected together.

Masonry Piers (Columns)

Masonry piers can be located within the dwelling under the main beam line that supports the first floor or at the exterior to support the roof over a porch (figure 22). In both cases, the pier either continues to the floor or roof, or supports a wood post that then continues to the floor or roof. These piers are subject to the same type of failure as the masonry foundation wall. Taller piers will have tendency to topple or buckle during an earthquake.

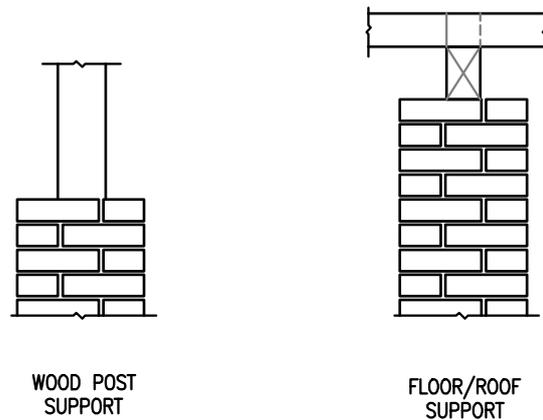


Figure 22. Wood post support and floor/roof support.

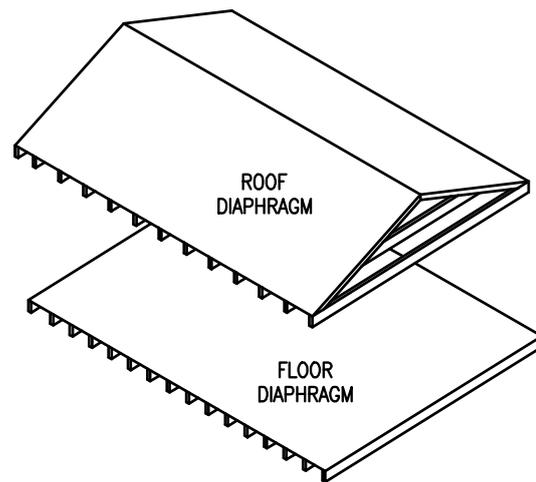


Figure 23. Example of roof and floor diaphragms.

Floor and Roof Diaphragms

The diaphragm is the structural element that consists of sheathing fastened to the underlying joists, creating a flat floor/roof or a sloping roof, which distributes forces throughout a particular level of the dwelling (figure 23). Horizontal forces generated in the masonry walls are transferred to the diaphragms. The diaphragms in URM construction generally fail due to the large forces generated from the weight of the surrounding masonry and/or the poor connections tying the diaphragms and walls together.

Interior Bearing Walls and/or Post and Beam Lines

The interior-bearing element may be an URM wall, a wood stud wall, a post and beam line, or any combination (figure 24). This intermediate support is required because the floor and roof joists generally cannot span between exterior walls. These elements will normally fail from inadequate connections or lack of any connections to each other.

Special Features

Most URM dwellings contain the basic structural elements described in this guide, however there are special features that may not be present in all URM dwellings or may vary from one dwelling to another.

The special features covered in this guide include URM parapets, masonry gable end walls, chimneys, and corner windows (figure 25). There are other special features found on URM dwellings, however these are the most common. A description of each of these items, their deficiencies, and references to the appropriate corrective measures are included at the end of Chapter 5.

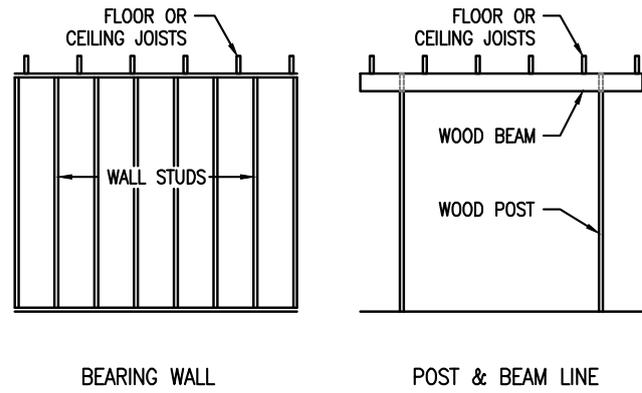


Figure 24. Bearing wall and post and beam line.

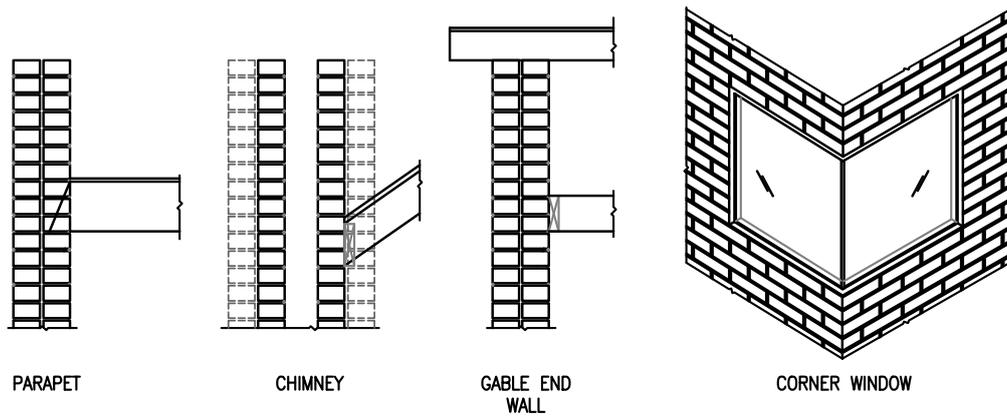


Figure 25. Examples of a parapet, chimney gable end wall, and corner window.

CHAPTER 5

Typical Unreinforced Masonry Dwelling and Seismic Deficiencies

This chapter includes descriptions of seven model dwellings with distinct architectural styles, variations in construction, and different structural configurations typical of URM dwellings found in Utah (figure 26). Photographs of exterior walls and details of typical wall sections are included for each model and can be used to compare the homeowner’s dwelling with the different model dwellings. The objective is to find the typical model dwelling that is most similar to the homeowner’s dwelling. It may be that the homeowner’s dwelling is a combination of two or more of these models. Careful study of the specific conditions at a dwelling will lead to identification of which exterior wall details best match the subject dwelling. Also included with each model dwelling description is a list of its typical seismic deficiencies.

Table 1 lists the deficiencies and corresponding seismic improvement details that may be used to correct the deficiencies. A special features section at the end of this chapter may apply to any of the model dwellings. The details referenced in table 1 are included in Chapters 5 and 6 and follow a consecutive numbering system with each detail listing the model dwelling it is intended to be used with. Not all consecutive numbers are used within the detail numbering system. This is so that future details may be added without modifying the existing numbering and grouping of details used for each model and for each category of seismic improvement.

Table 1. Typical seismic improvement details for model dwelling types A to G for various seismic deficiencies.

Seismic Deficiencies (In order of highest priority to lowest priority)	Model Dwelling Types						
	A	B	C	D	E	F	G
Strengthening and Bracing of Special Features	Details 20, 22, 24, 25, and 26						
Roof to URM Wall Anchorage	Details 30 and 35	Details 31 and 36	Details 32 and 37		Details 33 and 38	Detail 34	Details 32 and 36
Floor to URM Wall and Foundation Wall Anchorage	Details 51, 53, and 54		Details 50, 51, 53, 54, and 56		Details 52 and 55	Detail 51	Details 51 and 54
URM Wall Strengthening	Details 70 and 74					Details 75 and 76	
Roof Diaphragm Strengthening	Details 40 and 43						
Floor Diaphragm Strengthening	Detail 57						
Strengthening of Major Interior Bearing Elements	Details 77 and 82						
Foundation Wall Strengthening	Detail 90						
Non-Structural Bracing and Anchorage	For bracing and anchorage of non-structural items, including water heaters, furnishings, cabinets, equipment, etc., see details 100 and higher.						



Figure 26. Representative model dwelling types.



Figure 27. Model A front view.

Model A Single Story, Double Wythe Brick with Basement

Model A was built in approximately 1906 and is a single-story dwelling with a full basement (figures 27 and 28). The construction consist of double wythe URM exterior walls, concrete foundation walls supporting a wood floor and roof/ceiling joists around the exterior, and wood stud bearing walls within the dwelling. It has two chimneys, one exterior and one interior, and a porch with tall masonry piers supporting the roof.

The seismic deficiencies observed in Model A are:

1. The lack of anchorage of the roof to the URM exterior walls. There may or may not be a wood plate on top of the typical URM wall which this home did not have.
2. The lack of anchorage of the floor to the URM exterior and concrete foundation walls.
3. The chimneys are not braced.
4. The lack of continuous sheathing makes the roof diaphragm weak. There are 1 x 8 inch wood boards spaced at approximately 12 inches on center.
5. The masonry bearing walls are unreinforced.
6. The tall masonry porch piers are not braced or adequately attached to the porch roof.

7. The interior wood stud bearing walls are not anchored to the floor or roof.
8. The water heater is not braced and utility connections are rigid pipe.

Details 1 and 2 show two different existing exterior wall details for a Model A dwelling. Reference circles have been superimposed onto these details showing the area of the wall where seismic deficiencies normally occur. The details for improvements to strengthen these deficiencies are found in Chapter 6. Table 1 and the additional details in Chapters 6 and 7 also recommend other improvements, although not illustrated in these exterior wall details.



Figure 28. Model A rear view.



Figure 29. Model B front view.

Model B
Single Story, Double Wythe Brick
with Basement and Attic

Model B was built in the late 1890s, and is a single-story home with an attic area used for living space, with a concrete shelf type basement (figures 29 and 30). The construction consists of double wythe URM exterior walls, concrete foundation walls supporting a wood floor, roof/ceiling joists around the exterior, wood post and beams inside the dwelling, the front and back porch roofs are supported by wood posts, and it has one exterior chimney. Some of the posts are bearing on masonry piers.

The seismic deficiencies observed in Model B are:

1. The lack of anchorage of the roof to the URM exterior walls. There may or may not be a wood plate on top of the typical URM wall which this home did not have.
2. The lack of anchorage of the floor to the URM and concrete foundation walls.
3. The chimney is not braced.
4. The lack of continuous sheathing makes the roof diaphragm weak. There are 1 x 8 inch wood boards spaced at approximately 12 inches on center.
5. The concrete foundation wall has deteriorated. The vertical concrete walls in the basement of this dwelling do not extend to the floor structure and are walls of the shelf basement. While these interior concrete walls may also be deteriorating, it is typically more important that the actual foundation walls be strengthened first.

6. The interior wood post and beam line is not anchored to the floor and roof.
7. The masonry bearing walls are unreinforced.
8. The wood posts are not braced or adequately attached to the porch roof, there is a weak connection from the posts to the piers below, and the piers have deteriorated. The occupied attic consists of unanchored wood stud walls between the ceiling and roof joists.
9. The water heater is not braced and utility connections are rigid pipe.

Details 3 and 4 show two different existing wall details for Model B. Reference circles have been superimposed onto these details showing the area of the wall where seismic deficiencies normally occur. The details for improvements to strengthen these deficiencies are found in Chapter 6. Table 1 and the additional details in Chapters 6 and 7 also recommend other improvements, although not illustrated in these exterior wall details.



Figure 30. Model B rear view.

Model C
Two Story, Stucco-Covered
Double Wythe Brick with Shelf
Basement

Model C was built in the 1900s, and is a two-story home with a concrete shelf basement (figures 31 and 32). The construction consists of double wythe URM exterior walls covered with stucco, masonry/rock foundation walls supporting a wood floor and roof/ceiling joists around the exterior. A wood beam on masonry piers or wood posts supports the floor, while a wood stud wall supports the roof. It has two exterior chimneys and several small roof areas built into the dwelling.

The seismic deficiencies observed in Model C are:

1. The lack of anchorage of the roof to the URM exterior walls. There may or may not be a wood plate on top of the typical URM wall which this home did not have. The small areas at the front entrances are also not anchored.
2. The lack of anchorage of the floor to the URM exterior and concrete foundation walls.
3. The chimneys are not braced.
4. The lack of continuous sheathing makes the roof diaphragm weak. There are 1 x 8 inch wood boards spaced at approximately 12 inches on center.
5. The masonry/rock foundation walls have deteriorated.
6. The masonry bearing walls are unreinforced.
7. The interior wood stud bearing walls are not anchored to the floor or roof.
8. The water heater is not braced and utility connections are rigid pipe.

Details 5 and 6 show two different existing exterior walls sections for Model C. Reference circles have been superimposed onto the details showing the area of the wall where seismic deficiencies normally occur. The details for improvements to strengthen these deficiencies are found in Chapter 6. Table 1 and the additional details in Chapters 6 and 7 also recommend other improvements, although not illustrated in these exterior wall details.



Figure 31. Model C front view.



Figure 32. Model C rear view.



Figure 33. Model D front view.

Model D

Two Story, Double Wythe Brick with Shelf Basement and Attic

Model D was built in the early 1900s and is a two-story home with living space built into the attic area and a partial shelf basement (figures 33 and 34). The construction consists of double wythe URM exterior walls and masonry/rock foundation walls supporting a wood floor and roof/ceiling joists around the exterior. A wood beam supported by masonry piers support the floor, while an interior wood stud wall supports the ceiling/floor joists. It usually has one exterior chimney and may have low roof areas at any elevated the floor levels.

The seismic deficiencies observed in Model D are:

1. The lack of anchorage of the roof to the URM exterior walls. There may or may not be a wood plate on top of the typical URM wall which this home did not have.
2. The lack of anchorage of the floor to the URM exterior and concrete foundation walls.
3. The chimneys are not braced.
4. The lack of continuous sheathing makes the roof diaphragm weak. There are 1x8 inch wood boards spaced at approximately 12 inches on center.
5. The masonry/rock foundation walls are often deteriorated.
6. The masonry bearing walls are unreinforced.
7. The interior wood stud bearing walls are not anchored

to the floor or roof, the connection of the beam line to the piers is inadequate, and the masonry pier is often deteriorated.

8. The water heater is not braced and utility connections are rigid pipe.

Details 7 and 8 show two different existing exterior wall sections for Model D. Reference circles have been superimposed into these details showing the area of the wall where seismic deficiencies normally occur. The details for improvements to strengthen these deficiencies are found in Chapter 6. Table 1 and the additional details in Chapters 6 and 7 also recommend other improvements, although not illustrated in these exterior wall details.



Figure 34. Model D side view.



Figure 35. Model E front view.

Model E Single Story, Single Wythe Solid Brick with Full Basement

Model E was built in approximately 1966, and is single-story home with a full basement and a low slope roof (figures 35 and 36). The construction consists of single wythe URM exterior walls and concrete foundation walls supporting wood floor joists and roof trusses around the exterior with wood stud bearing walls supporting the interior. The roof structure extends over the carport and changes from trusses to sloped joists supported by wood beams at the ridge and ends. The end beams are carried by steel or wood columns.

The seismic deficiencies observed in Model E are:

1. The lack of anchorage of the roof to the URM exterior walls.
2. The lack of anchorage of the floor to the URM exterior and concrete foundation walls.
3. The masonry bearing walls are unreinforced.
4. The beams and columns for the carport are not anchored or braced to the roof or to the masonry walls of the dwelling.
5. The interior wood stud bearing walls are not anchored to the floor or roof.

6. The water heater is not braced and utility connections are rigid pipe.

Details 9 and 10 show two different existing exterior wall sections for Model E. Reference circles have been superimposed into these details showing the area of the wall where seismic deficiencies normally occur. The details for improvements to strengthen these deficiencies are found in Chapter 6. Table 1 and the additional details in Chapters 6 and 7 also recommend other improvements, although not illustrated in these exterior wall details.



Figure 36. Model E rear view.



Figure 37. Model F front view.

Model F

Single Story, Concrete/Cinder Block with Basement and Flat Roof

Model F was built in 1954, and is a single-story home with a partial basement and flat roof (figure 37). The construction consists of a concrete/cinder block walls, referred as concrete masonry units (CMU), and concrete foundation walls supporting wood floor and roof/ceiling joists around the exterior with wood stud bearing walls supporting the interior. It has one low chimney with a metal flue that extends up. The roof over the front porch is supported by slender wood posts.

The seismic deficiencies observed in Model F are:

1. The lack of anchorage of the roof to the URM exterior walls.
2. The lack of anchorage of the floor to the URM exterior and concrete foundation walls.
3. The masonry bearing walls are unreinforced.
4. The interior wood stud bearing walls are not anchored to the floor or roof.
5. The support for the roof area over the porch is inadequate to transfer the lateral forces.
6. The water heater is not braced and utility connections are rigid pipe.

Detail 11 shows an existing exterior wall section for Model F. Reference circles have been superimposed into this detail showing the area of the wall where seismic deficiencies normally occur. The details for improvements to

strengthen these deficiencies are found in Chapter 6. Table 1 and the additional details in Chapters 6 and 7 also recommend other improvements, although not illustrated in these exterior wall details.

Model G

Single Story, Single Story, Concrete/Cinder Block with Brick Veneer and Full Basement with Flat Roof

Model G is a single-story home with a basement and was a common building type constructed in the 1940s and 1950s (figure 38). The construction consists of CMU walls with exterior brick veneer and concrete foundation walls with the concrete/cinder block portion of the exterior walls supporting wood floor and roof/ceiling joists around the exterior with wood stud bearing walls supporting the interior. The roof is framed with two (2x) members for a sloped roof or later dated dwellings may be constructed with trusses. It usually has a low chimney with a metal flue that extends upward. The roof over the front porch is supported by slender wood posts or masonry piers.

The seismic deficiencies observed in Model G are:

1. The lack of anchorage of the roof to the URM exterior walls.
2. The lack of anchorage of the floor to the URM exterior and concrete foundation walls.
3. The masonry bearing walls are unreinforced.
4. The interior wood stud bearing walls are not anchored to the floor or roof.



Figure 38. Model G front view.

5. The support for the roof area over the porch is inadequate to transfer the lateral forces.
6. The water heater is not braced and utility connections are rigid pipe.

Details 12 and 13 show different existing exterior wall sections for Model G. Reference circles have been superimposed into these details showing the areas of the wall where seismic deficiencies normally occur. The details for improvements to strengthen these deficiencies are found in Chapter 6. Table 1 and the additional details in Chapters 6 and 7 also recommend other improvements, although not illustrated in these exterior wall details

Special Features

Special features are those structural elements that are not typically present in all URM dwellings. This section will address four of the more common special features.

Parapets

A parapet is the portion of a wall that projects above the roofline and the top of a typical parapet is usually not braced (figure 39). When an earthquake occurs, the parapet can break off near the roofline from seismic forces. The bottom of the parapet near the roofline is normally weak zone because roof joists and other framing members are pocketed into the wall at this location. Failure of parapets can create a falling hazard that is a serious life safety concern, especially over doorways and walkways. As a general rule, the higher the parapet, the more serious the



Figure 39. URM parapet walls.

hazard. Details at the end of this chapter show how to help strengthen this deficiency.

Gable End Walls

A gable end wall is the triangle section of an exterior wall under the roof plane and above the eaves line (figure 40). This portion of a typical URM wall is not normally braced and supports the roof ridge. The height of this wall and the unbraced condition make it less stable than other elements to resist out-of-plane forces. Out-of-plane failure of a gable end wall is similar to that described for URM walls. The size of the gable end wall and the intensity and direction of seismic forces will have a direct effect on the stability of the wall. A wide gable generally supports a large portion of the roof. Failure of this type of gable end wall is likely to also result in at least partial collapse of the roof. The roof



Figure 40. URM gable end walls.

rafters adjacent to a tall narrow gable are usually designed to bear on the main walls below. Failure of this type of gable end wall could create a falling hazard similar to parapets, but collapse of the roof is not likely unless the main walls below also fail. See detail 21 to help strengthen this deficiency.

Chimneys

Almost every URM home has one or more chimneys. A chimney can be located on an exterior wall or within the interior of a dwelling (figure 41). The roof joists may be pocketed into the side of the chimney or headered off around it. Often, chimneys are corbelled out of the top of a wall for a flue connection to a stove or furnace. The failure of chimneys is very similar to that of parapets. See details 22 through 25 to help strengthen these deficiencies.

Corner Windows

A corner window usually has a steel pipe at the outside corner of the window under a steel lintel to support the

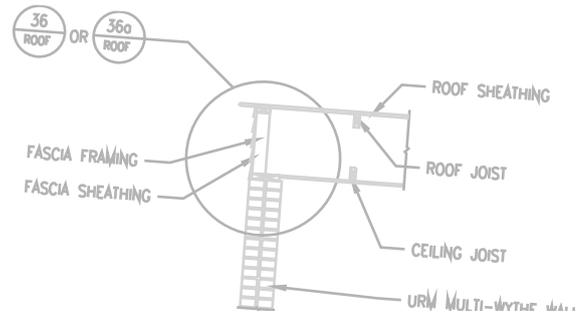
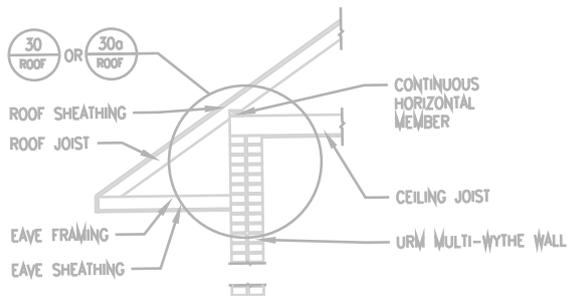


Figure 41. Typical URM chimneys.



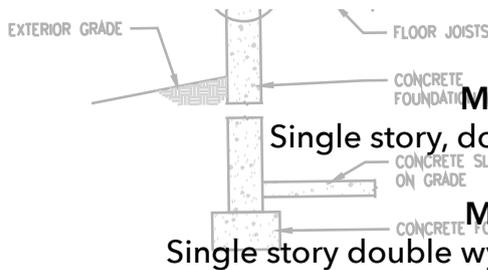
Figure 42. Typical corner window.

masonry wall above or the wall above may be on a cantilevered steel angle to avoid a corner post (figure 42). When used, the steel pipe may or may not be connected to the steel lintel. This feature may create a weakness in the shear wall. If the steel pipe was to become displaced, partial collapse of the dwelling could take place. See details 26 and 26a to help strengthen this deficiency.



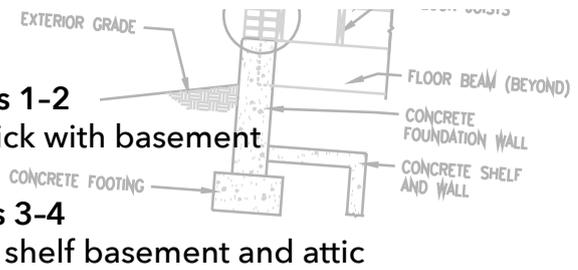
Model Type Description and Wall Details

Wall section details to show areas of potential seismic deficiencies (Details 1-19)*



Model A: Details 1-2

Single story, double wythe brick with basement



Model B: Details 3-4

Single story double wythe brick with shelf basement and attic

1 SECTION W/ JOIST FRAMING PERPENDICULAR TO WALL

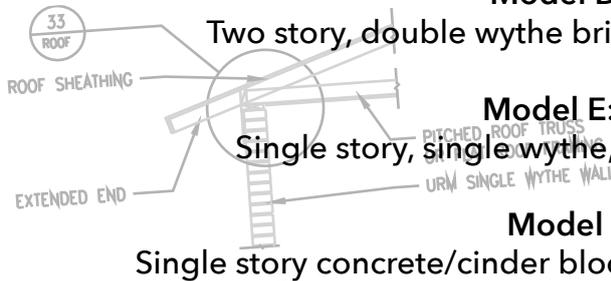
Model C: Details 5-6

Two story, stucco-covered, double wythe brick with shelf basement and attic

Model Home Seismic Deficiencies	MODEL A	Seismic Deficiencies	Exterior Wall Sections	DETAIL: 4
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Model D: Details 7-8

Two story, double wythe brick with shelf basement and attic

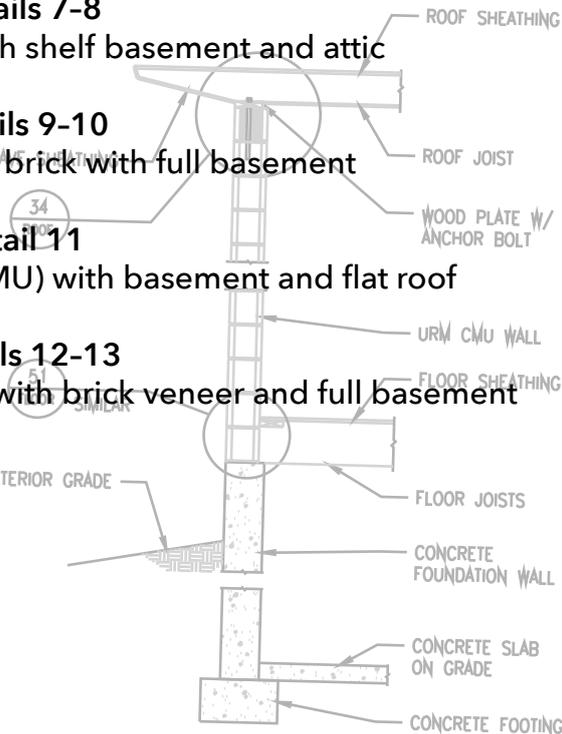


Model E: Details 9-10

Single story, single wythe, solid brick with full basement

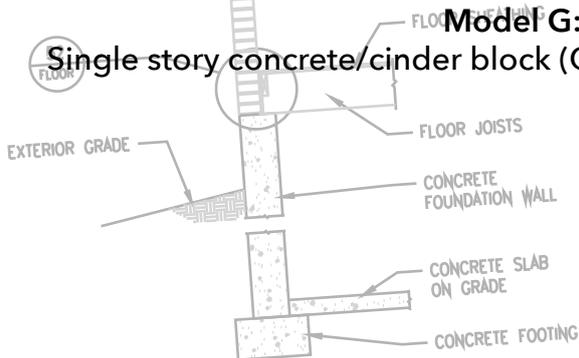
Model F: Detail 11

Single story concrete/cinder block (CMU) with basement and flat roof



Model G: Details 12-13

Single story concrete/cinder block (CMU) with brick veneer and full basement



9 SECTION W/ JOIST FRAMING PERPENDICULAR TO WALL

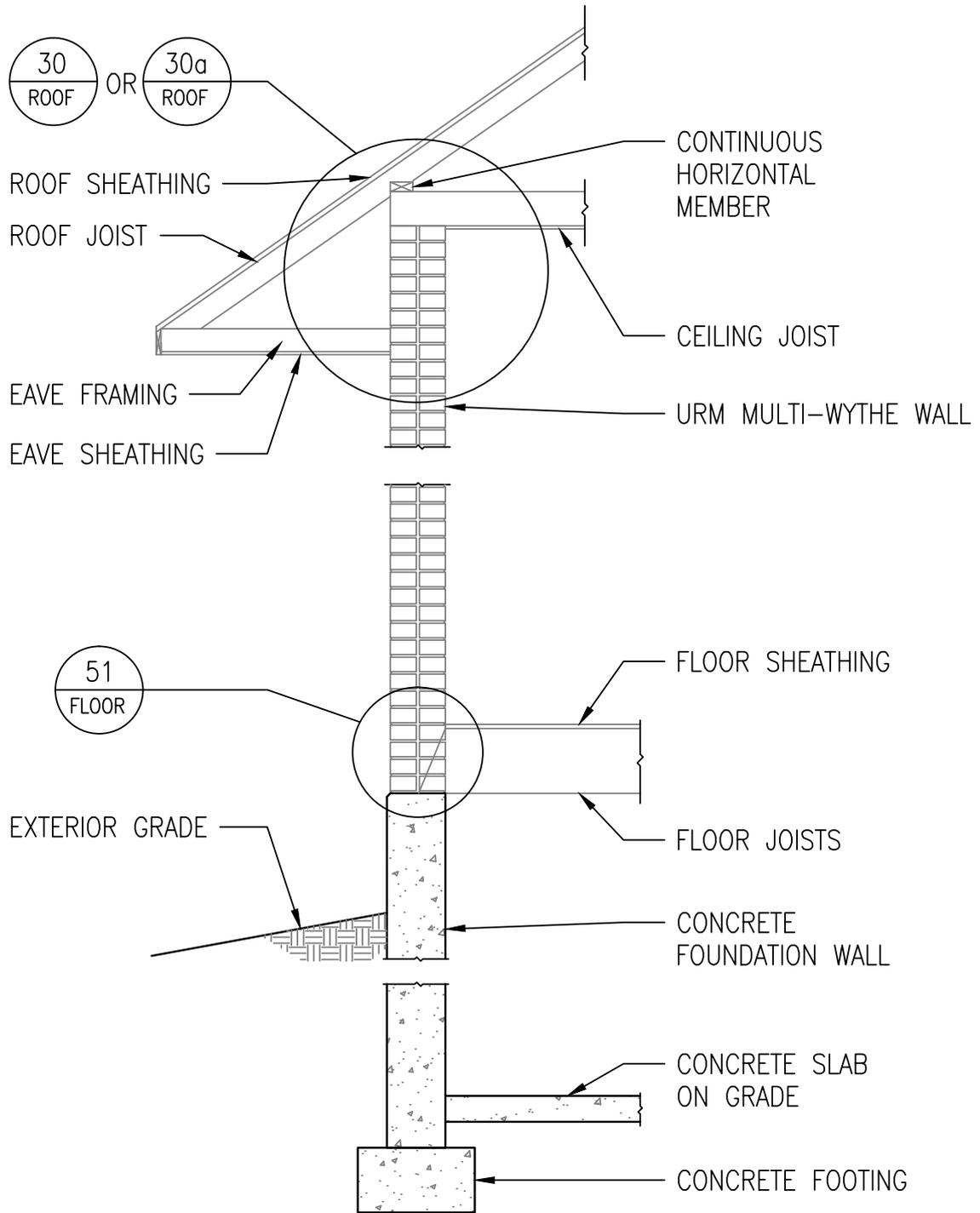
Model Home Seismic Deficiencies	MODEL E	Exterior Wall Sections	DETAIL: 9
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11 SECTION W/ JOIST FRAMING PERPENDICULAR TO WALL

*Unused detail numbers are intentionally left out for future additions.

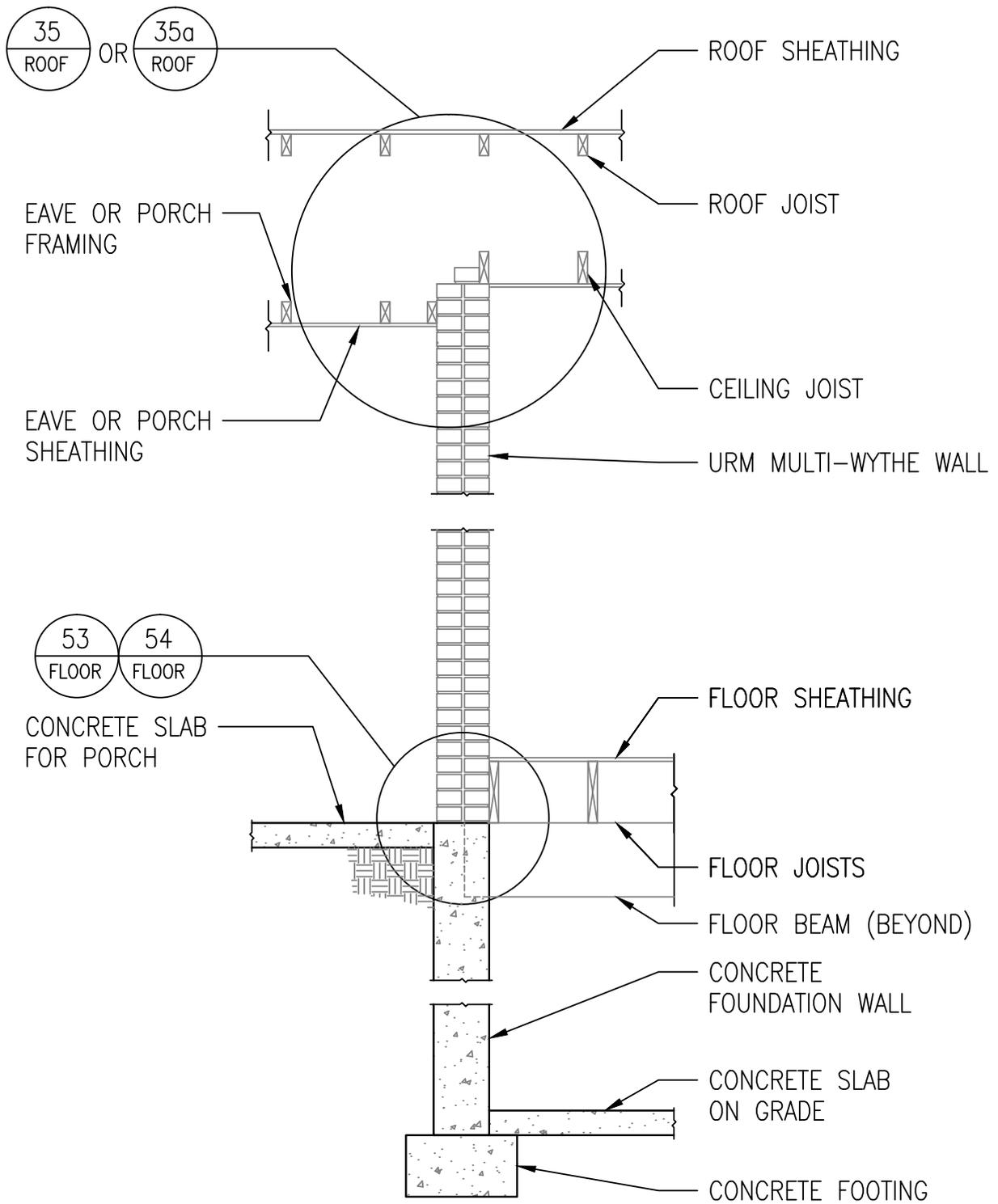
Model A: Details 1-2

Single story, double wythe brick with basement



1 SECTION W/ JOIST FRAMING PERPENDICULAR TO WALL

<p>Model Home Seismic Deficiencies</p>	<p>HOME TYPE: MODEL A</p>	<p>Exterior Wall Sections</p>	<p>DETAIL: 1</p>
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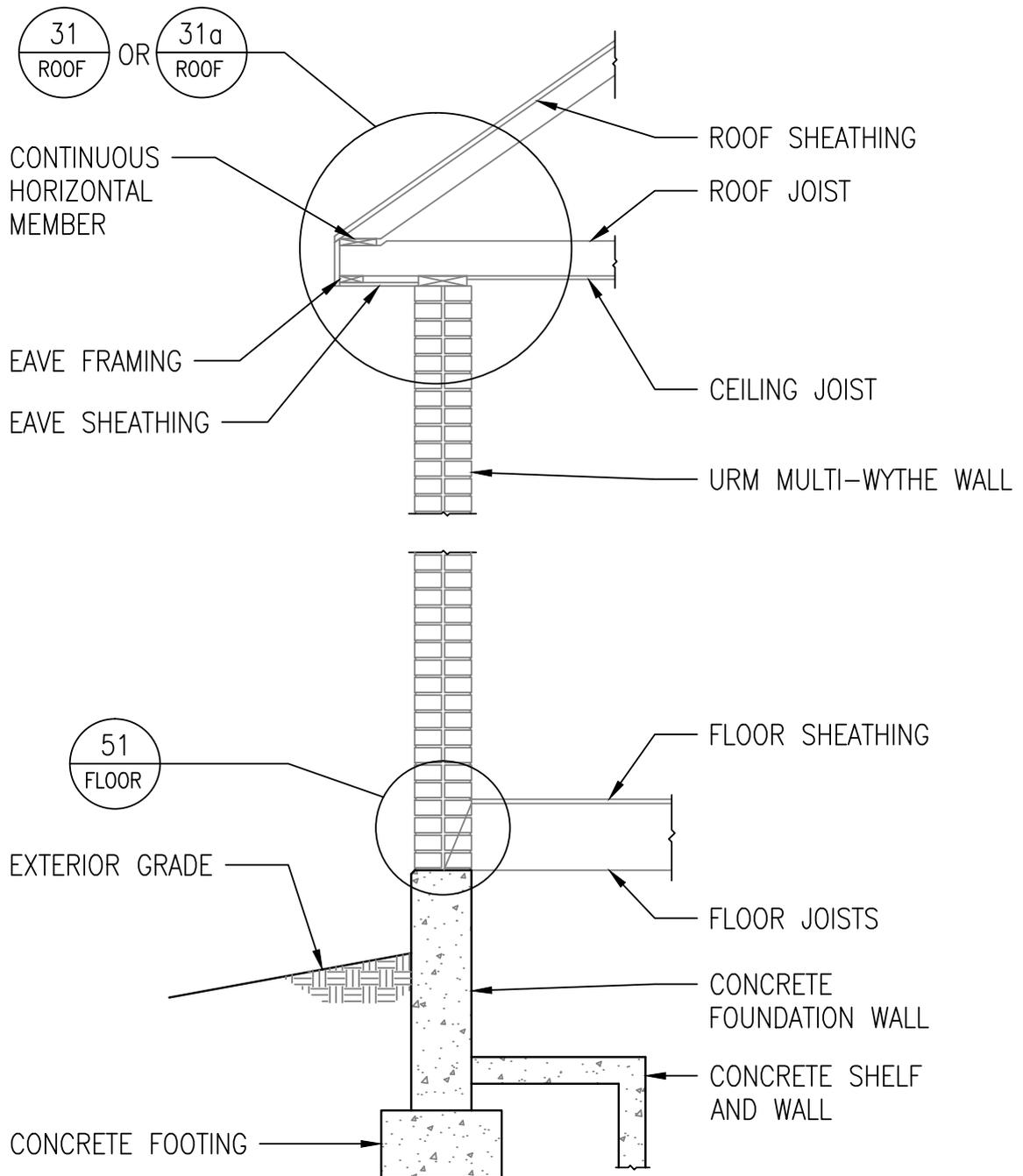


2 SECTION W/ JOIST FRAMING
SECTION PARALLEL TO WALL

<p>Model Home Seismic Deficiencies</p>	<p>HOME TYPE: MODEL A</p>	<p>Exterior Wall Sections</p>	<p>DETAIL: 2</p>
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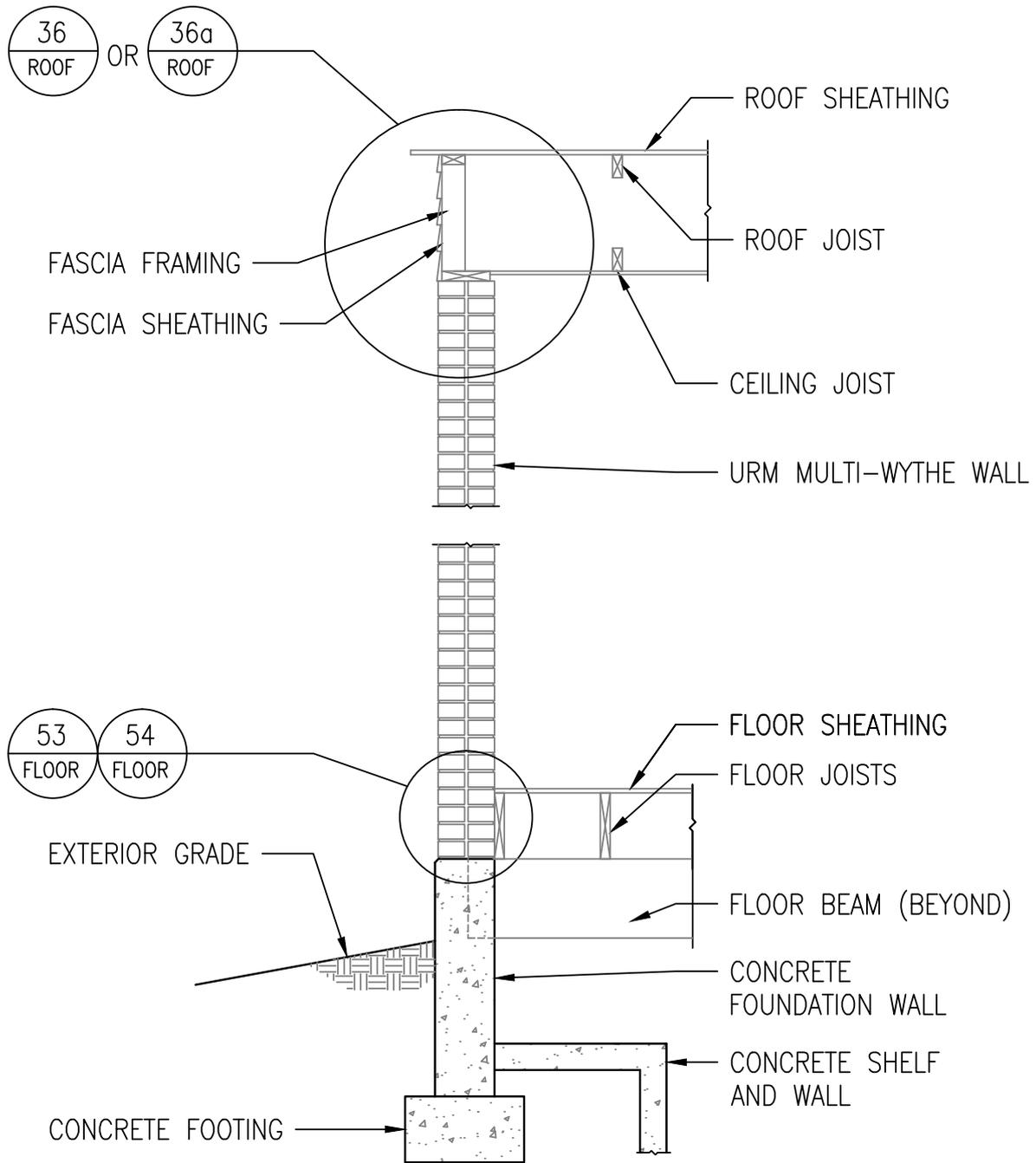
Model B: Details 3-4

Single story double wythe brick with shelf basement and attic



3 SECTION W/ JOIST FRAMING PERPENDICULAR TO WALL

Model Home Seismic Deficiencies	HOME TYPE: MODEL B	Exterior Wall Sections	DETAIL: 3
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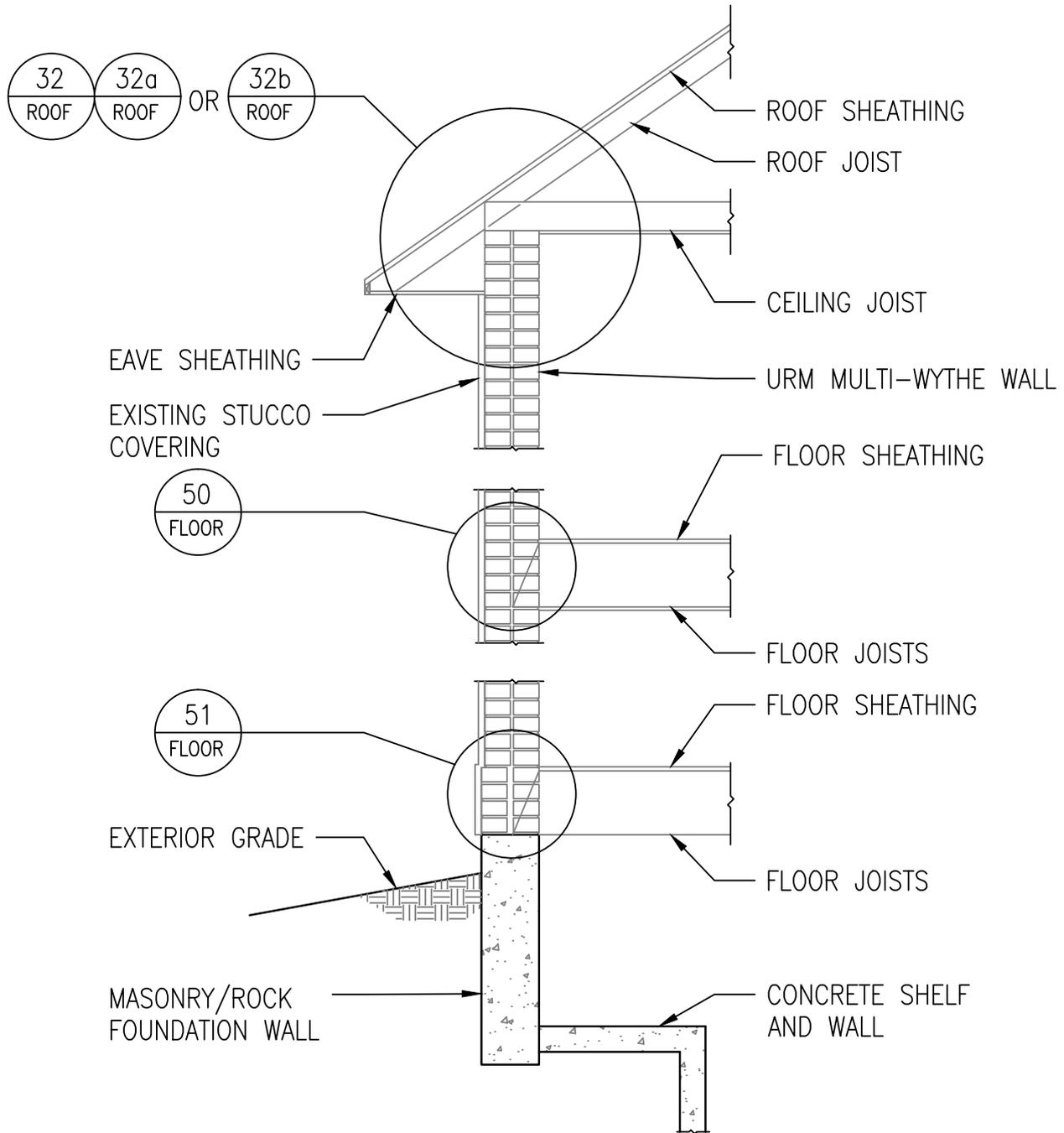


4 SECTION W/ JOIST FRAMING PARALLEL TO WALL

Model Home Seismic Deficiencies	HOME TYPE: MODEL B	Exterior Wall Sections	DETAIL: 4
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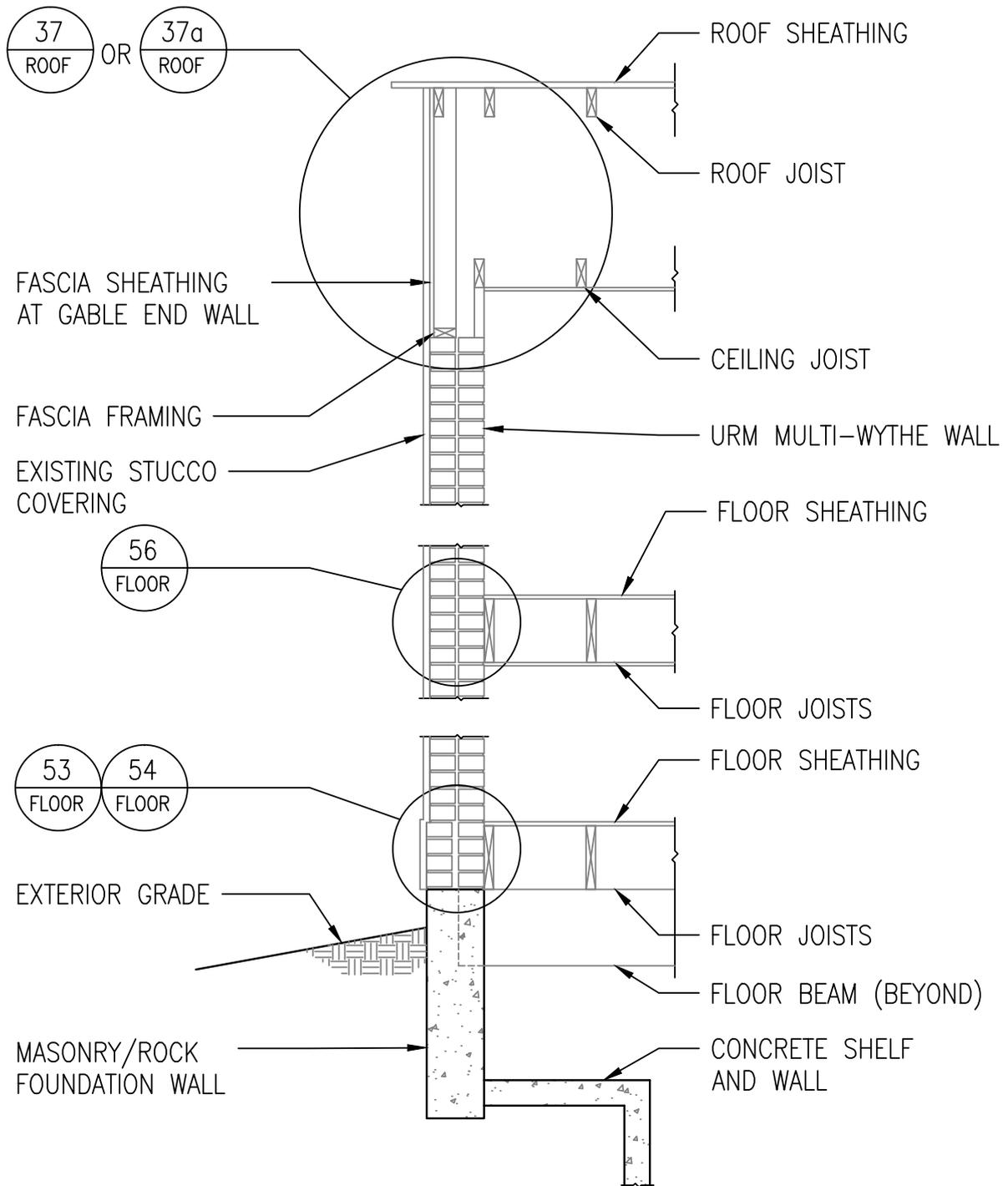
Model C: Details 5-6

Two story, stucco-covered, double wythe brick with shelf basement and attic



5 SECTION W/ JOIST FRAMING PERPENDICULAR TO WALL

Model Home Seismic Deficiencies	HOME TYPE: MODEL C	Exterior Wall Sections	DETAIL: 5
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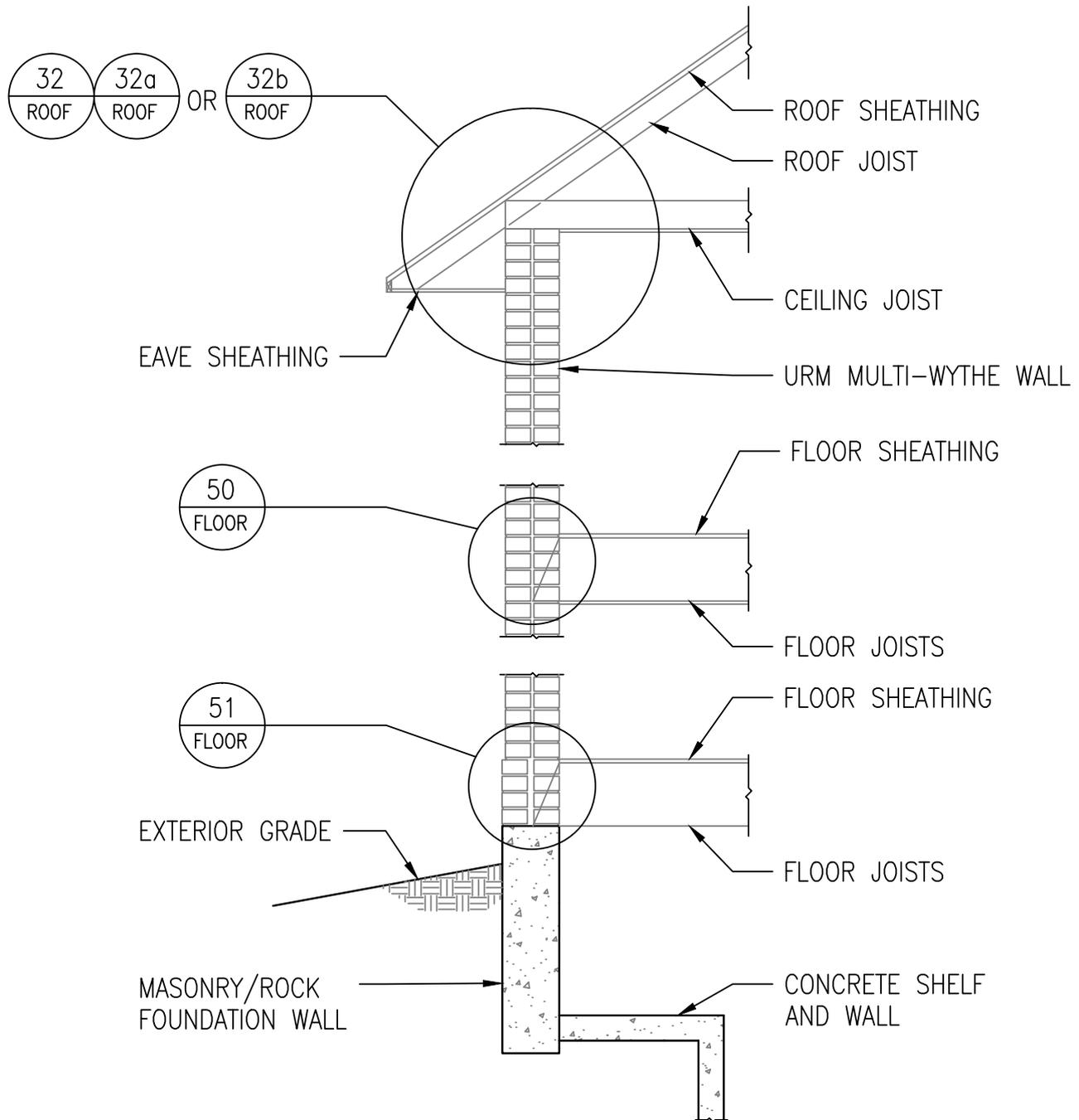


6 SECTION W/ JOIST FRAMING PARALLEL TO WALL

<p>Model Home Seismic Deficiencies</p>	<p>HOME TYPE: MODEL C</p>	<p>Exterior Wall Sections</p>	<p>DETAIL: 6</p>
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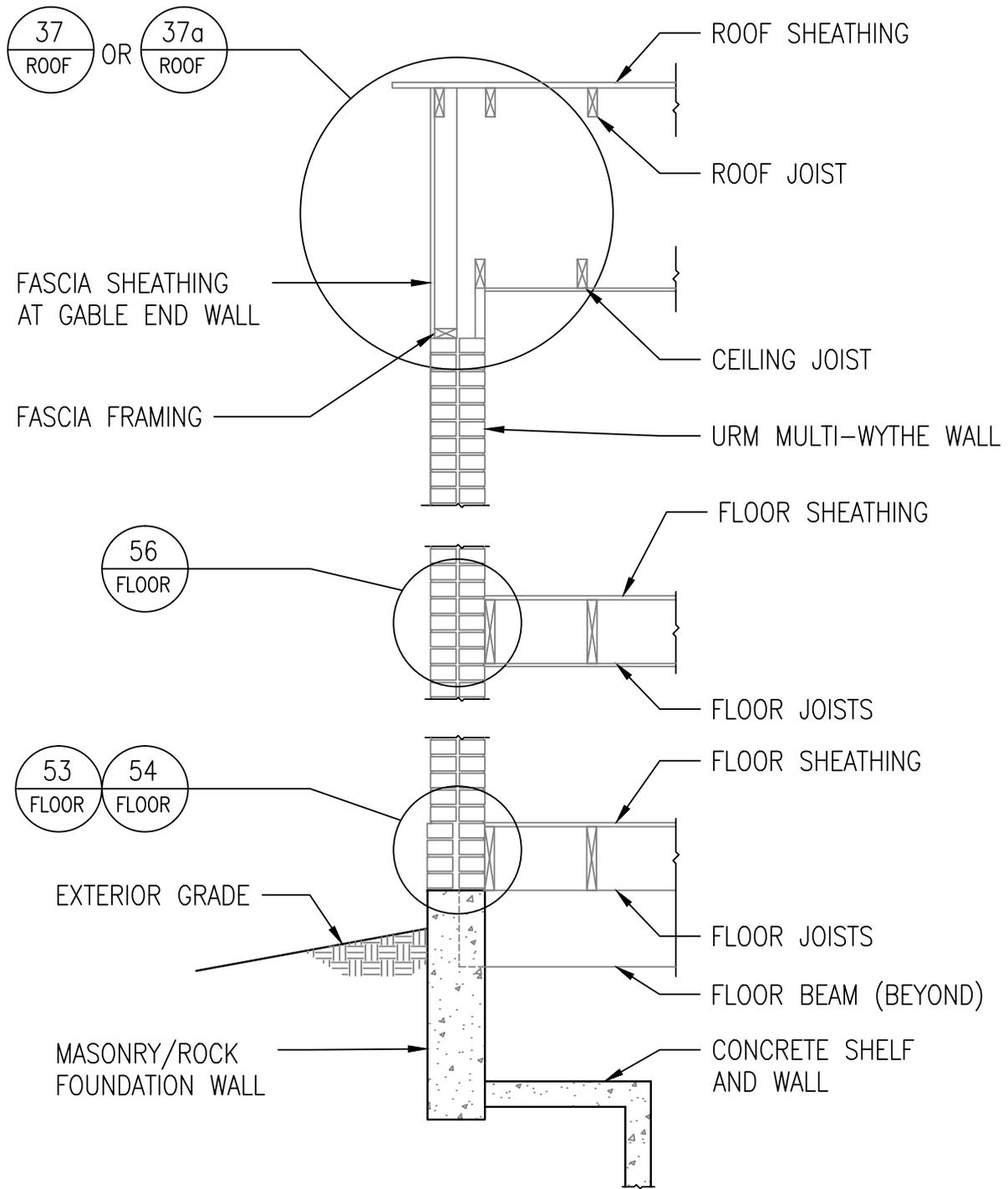
Model D: Details 7-8

Two story, stucco-covered, double wythe brick with shelf basement and attic



7 SECTION W/ JOIST FRAMING PERPENDICULAR TO WALL

Model Home Seismic Deficiencies	HOME TYPE: MODEL D	Exterior Wall Sections	DETAIL: 7
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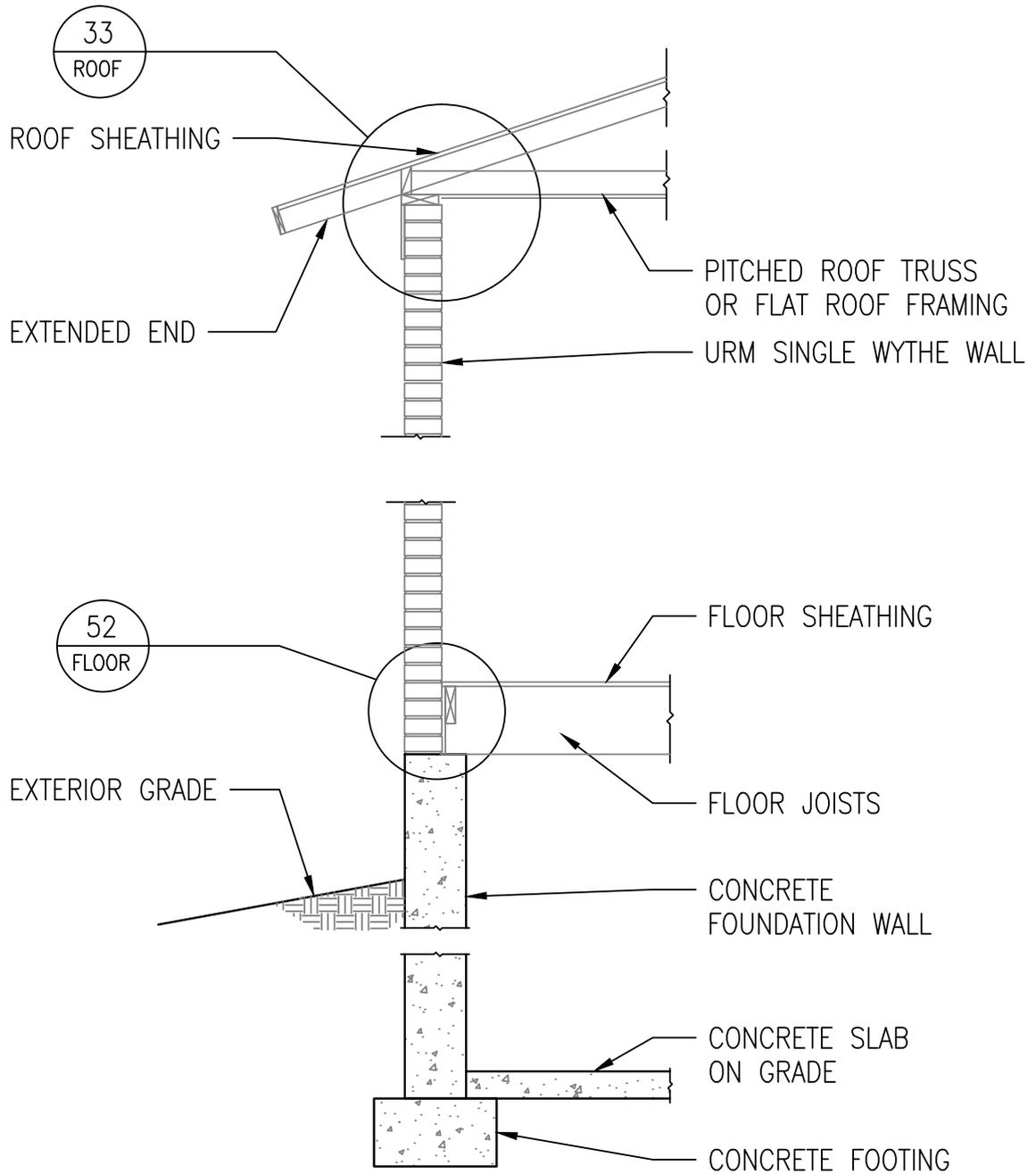


8 SECTION W/ JOIST FRAMING
PARALLEL TO WALL

<p>Model Home Seismic Deficiencies</p>	<p>HOME TYPE: MODEL D</p>	<p>Exterior Wall Sections</p>	<p>DETAIL: 8</p>
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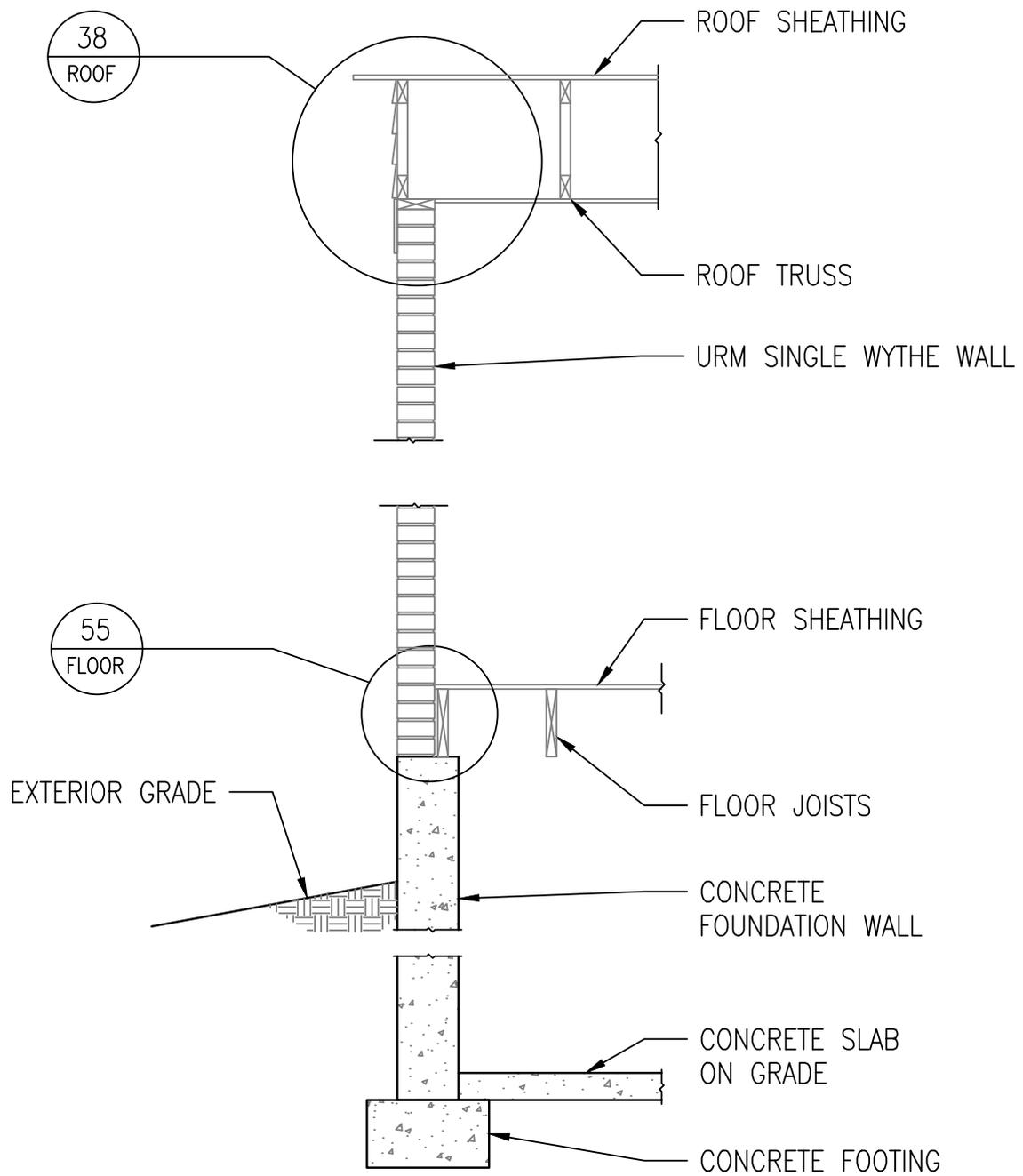
Model E: Details 9-10

Single story, single wythe, solid brick with full basement



9 SECTION W/ JOIST FRAMING
SECTION PERPENDICULAR TO WALL

<p>Model Home Seismic Deficiencies</p>	<p>HOME TYPE: MODEL E</p>	<p>Exterior Wall Sections</p>	<p>DETAIL: 9</p>
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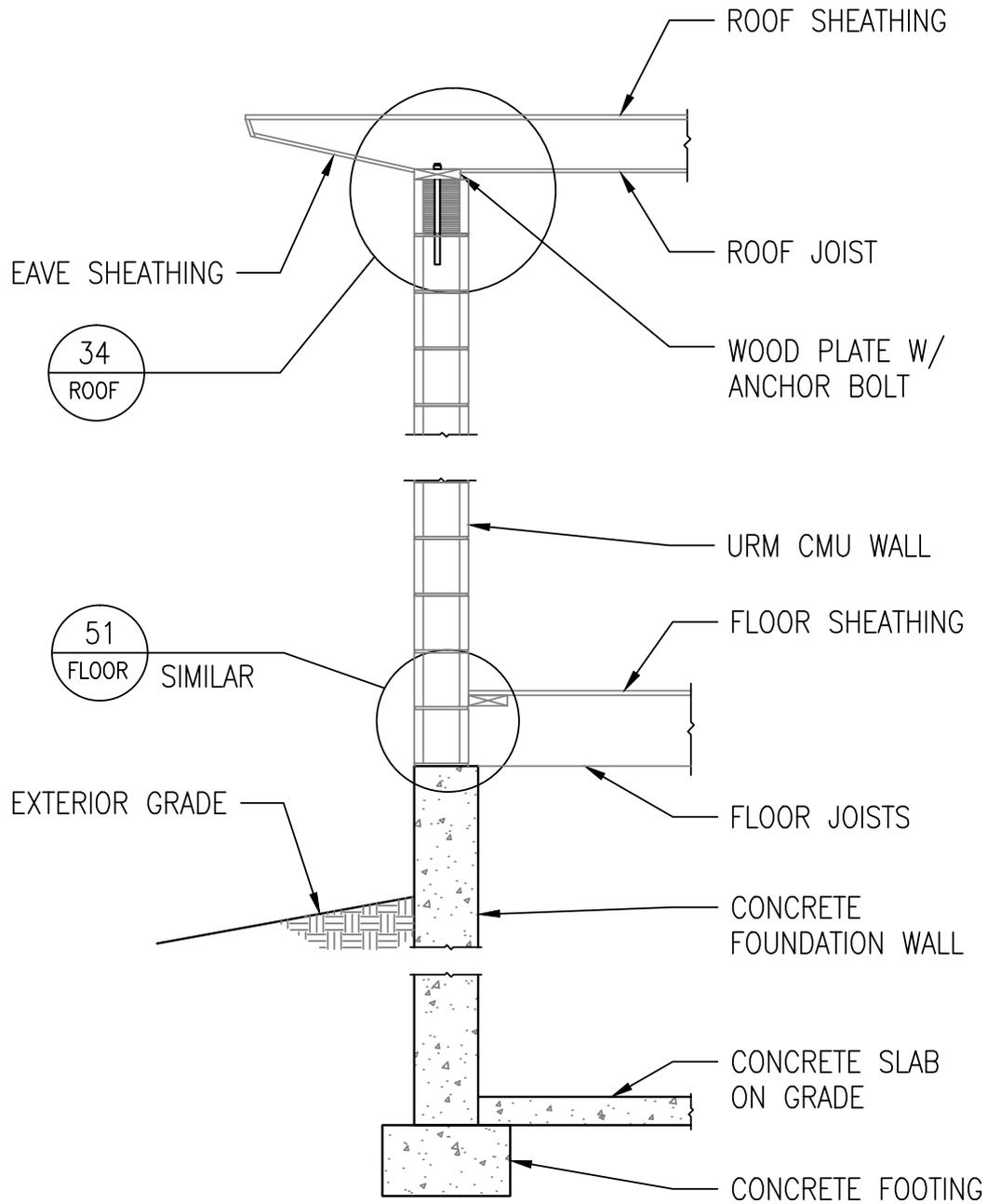


10 SECTION W/ JOIST FRAMING
PARALLEL TO WALL

<p>Model Home Seismic Deficiencies</p>	<p>HOME TYPE: MODEL E</p>	<p>Exterior Wall Sections</p>	<p>DETAIL: 10</p>
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Model F: Detail 11

Single story concrete/cinder block (CMU) with basement and flat roof

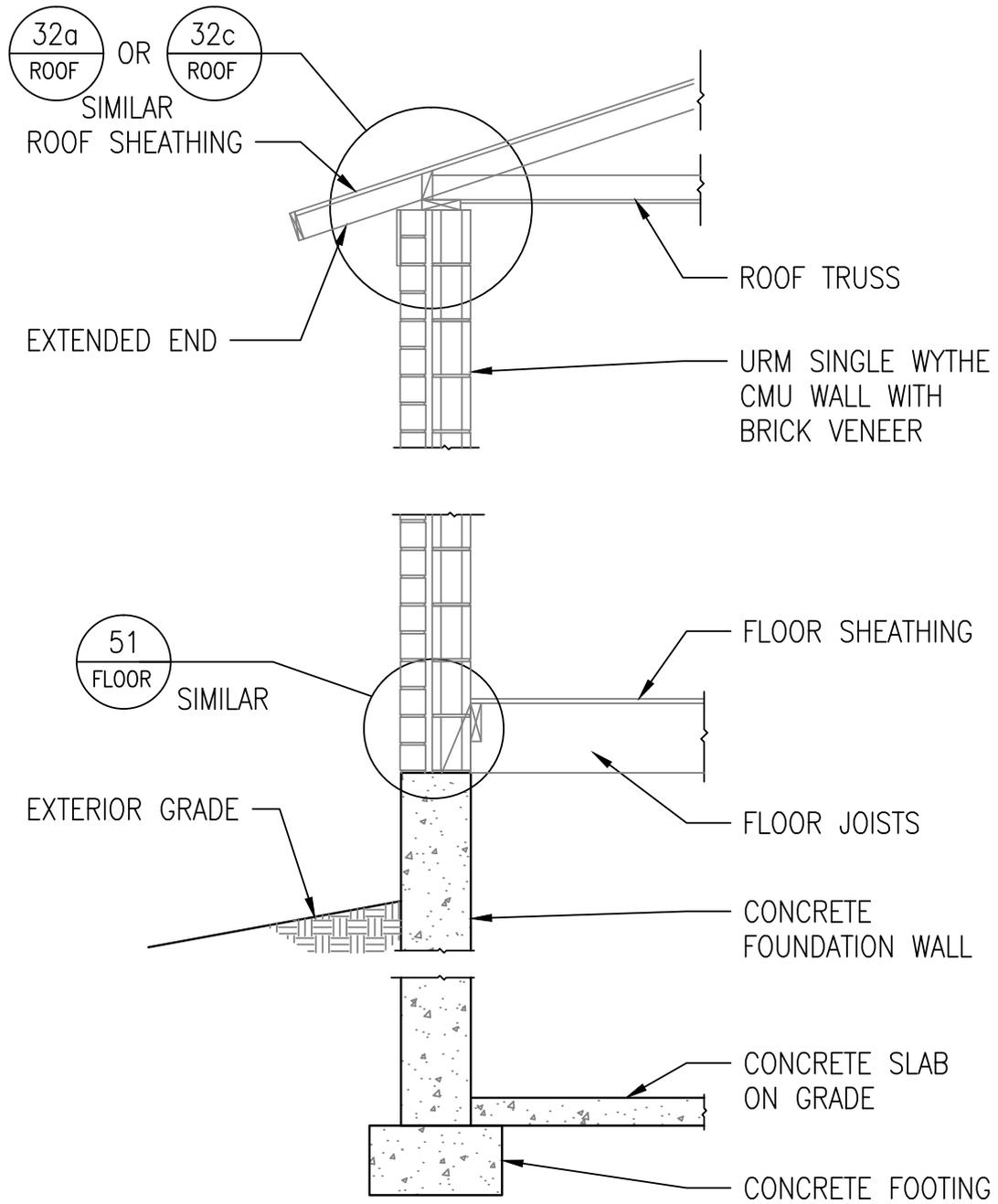


11 SECTION W/ JOIST FRAMING PERPENDICULAR TO WALL

Model Home Seismic Deficiencies	HOME TYPE: MODEL F	Exterior Wall Sections	DETAIL: 11
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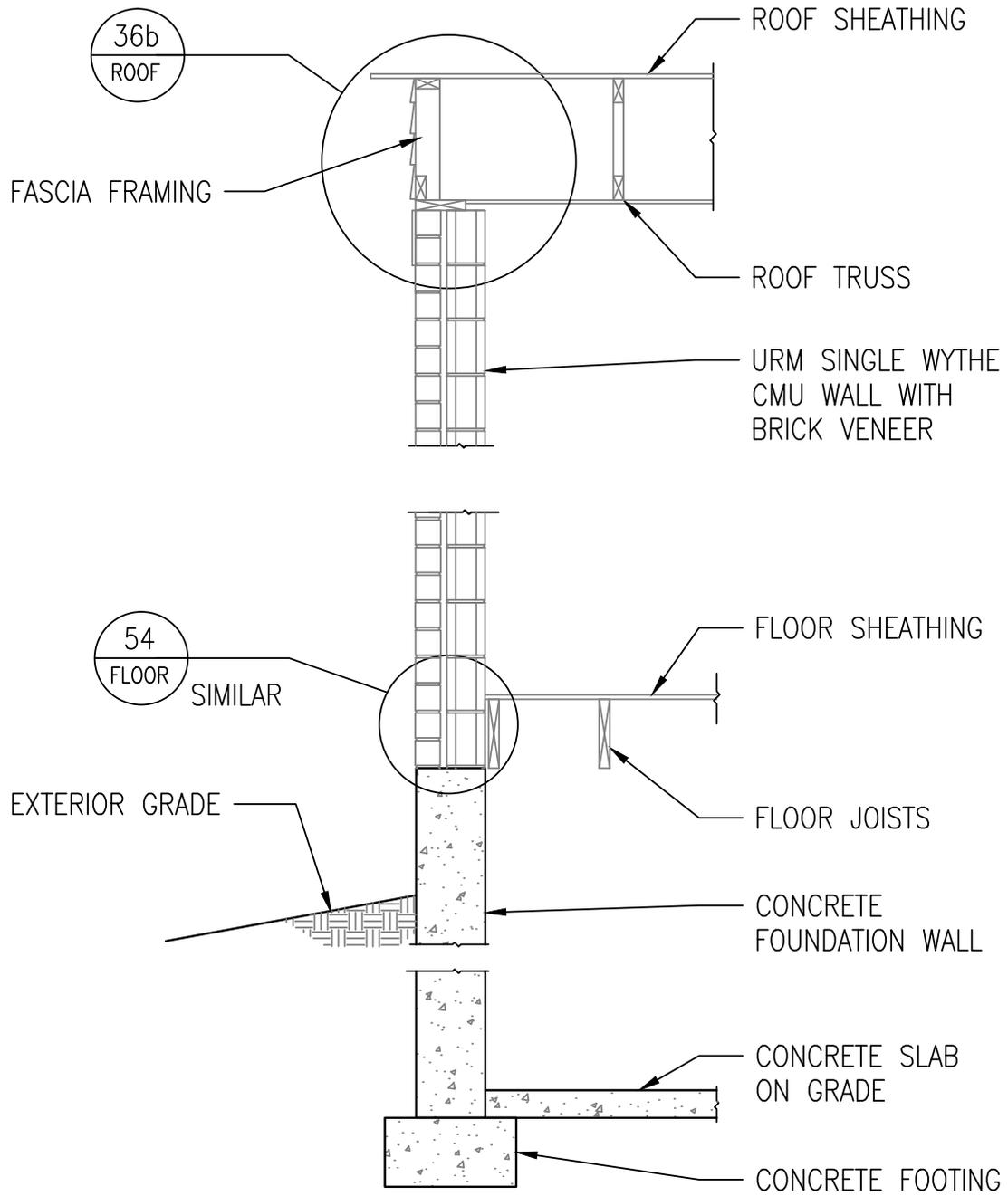
Model G: Details 12-13

Single story concrete/cinder block (CMU) with brick veneer and full basement



12 SECTION W/ JOIST FRAMING PERPENDICULAR TO WALL

Model Home Seismic Deficiencies	HOME TYPE: MODEL G	Exterior Wall Sections	DETAIL: 12
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13 SECTION W/ JOIST FRAMING
PARALLEL TO WALL

<p>Model Home Seismic Deficiencies</p>	<p>HOME TYPE: MODEL G</p>	<p>Exterior Wall Sections</p>	<p>DETAIL: 13</p>
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CHAPTER 6

Seismic Mitigation of URM Structures

Chapter 6 contains conceptual structural details for corrective measures to improve common seismic deficiencies in the typical URM dwelling. The details are intended for general use and may be adapted to similar conditions with some minor modifications. The details have been drawn with continuous lines that are darker for new construction and text and slightly lighter lines to represent existing materials and conditions. Digital files for the details are available at the USSC website (<https://ussc.utah.gov>).

The mitigation details in this guide are designed for use by a homeowner with some construction experience or a small contractor. A homeowner who is comfortable with using power tools and has a general understanding of how their dwelling is built may feel that a contractor is not necessary. This can be a “do-it-yourself” task for homeowners who have a reasonable amount of knowledge in construction methods and materials. We recommend the use of a contractor for that portion of the project that the homeowner determines is beyond their individual capacity, knowledge, and experience. In all cases, we recommend that the homeowner or contractor involved seek additional help and/or consult a Utah-licensed Professional Engineer or Architect if there is any reason for concern. Improper work often creates difficulties or weakness with the dwelling that can be expensive to correct. For each seismic improvement measure selected, there will normally be several potential mitigation details from which to choose, but the specific method chosen will be up to the homeowner. Always check with your local municipality or county for building permit or other requirements that apply to your project.

The details in this chapter are designed to show structural elements and are not intended to provide procedures for product preparation and installation or the removal and replacement of existing materials, such as finishes. Manufacturers normally provide preparation and installation procedures for their products, but seldom cover the removal or replacement of existing materials. The techniques required to removing existing finishes for the purpose of gaining access to the work area and the replacement of these materials after the work is completed will

vary with each specific dwelling. The homeowner will have to develop individual procedures for the removal and replacement of these materials. Explanations of construction procedures are not provided in this guide.

The following items are important considerations for the homeowner when a decision is made to proceed with a seismic improvement project of a dwelling.

Tools

A list of tools required to carry out the project(s) using the selected retrofit details.

- Do you own them?
- Can you borrow them?
- Do you want to purchase or rent them? If purchased or rented, this cost should be added to total project cost.

Cost

- A cost estimate for work contracted will be provided by the contractor performing the work.
- The cost estimate for work performed by the homeowner can be compiled from contacting home improvement stores, lumberyards, suppliers, etc. We recommend adding 20% to 30% of the total project cost for contingency (unexpected) items.

Disruption of Lifestyle

The degree of disruption will differ with each seismic improvement measure. The room(s) surrounding the construction may become unusable for a period of time. Rooms that must remain in use will likely have dust and debris present. Whenever a project is undertaken within an occupied space, it will almost always take longer and cost more than anticipated. The length of time will also vary according to the procedure, experience, and the amount of time the homeowner can devote to the project while still meeting other obligations, such as a job, family, etc.

Construction Considerations

Access to a specific area where seismic improvement measures are to take place can be difficult at times. Some planning should be done prior to proceeding with the project to determine where access to each work area will take place.

Physical work can vary from being stooped over at ground level for a long period of time to standing on a tall ladder working overhead. Work may also include crawling in basements (some with very limited heights) or climbing into cramped attic spaces with loose, dusty insulation. Any area that is not a finished, usable space may contain insects and/or rodents. Anyone with phobias relating to these issues should give strong consideration to hiring a Utah-licensed contractor to perform the job.

Safety

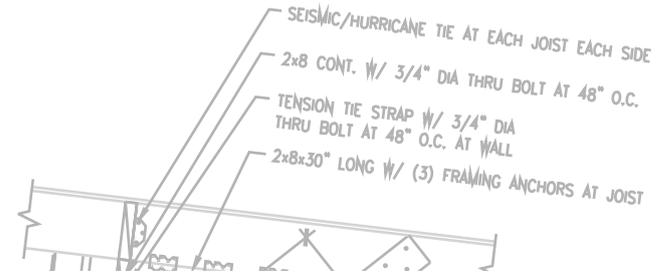
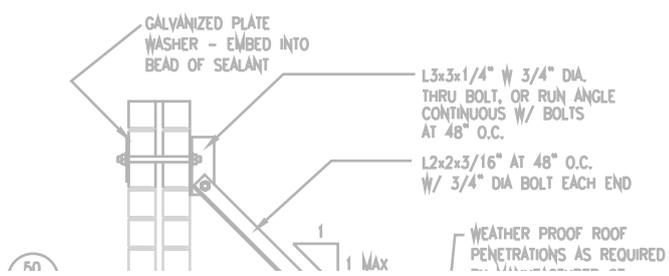
A complete understanding of the work and the ability to operate various tools is mandatory. Improper use of any tool can cause serious injury. Fall hazards and all other real or potential hazards should be investigated and avoided. Personal protective equipment (goggles, respirators, gloves, etc.) should be used at all times. Anytime asbestos or other hazardous materials are suspected, the homeowner should have tests taken immediately by appropriately experienced and Utah-licensed professionals to determine the magnitude of the problem and advise how to proceed. Safety should always be the primary concern, as no improvement

to a dwelling is worth the cost of a debilitating injury or death.

Each seismic improvement measure that is to be implemented must be reviewed and analyzed to determine all of the steps that will be required to complete the work. The homeowners must examine their individual ability and decide whether it is a do-it-yourself job, a hired contractor project, or a combination of both. If a contractor is needed, before selecting: check references, licensing (<http://dopl.utah.gov/licensing/contracting.html>), and the Better Business Bureau (<http://www.bbb.org/utah/>).

The various details within this guide have limited information on fasteners and connectors for the products called out in the details with most noted in a generic method to avoid the appearance of recommending one manufacturer or supplier over another. Many manufacturer and supplier products are available and many of these products are acceptable alternatives. A thorough comparison should always be made to ensure that the materials, strengths, and capacities are equal to or better than the products that are noted in the details.

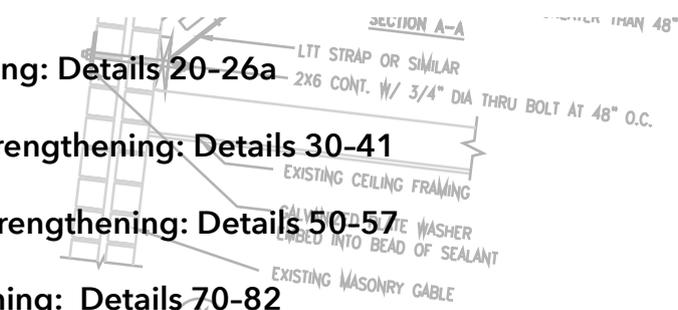
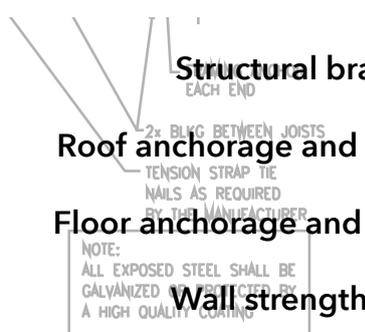
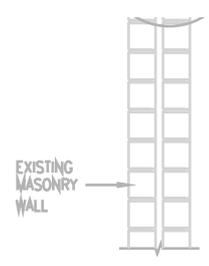
The following details are intended to show basic concepts for generic use with the various model dwelling types and may apply to similar conditions of several model types. If these details do not match the existing conditions of any existing dwelling or if there is any confusion or misunderstanding about how to apply a particular detail, the homeowner is encouraged to contact a Utah-licensed Professional Structural Engineer for consultation.



Individual Structural Repair Details

Details for seismic mitigation of URM structures

(Details 20-99)*



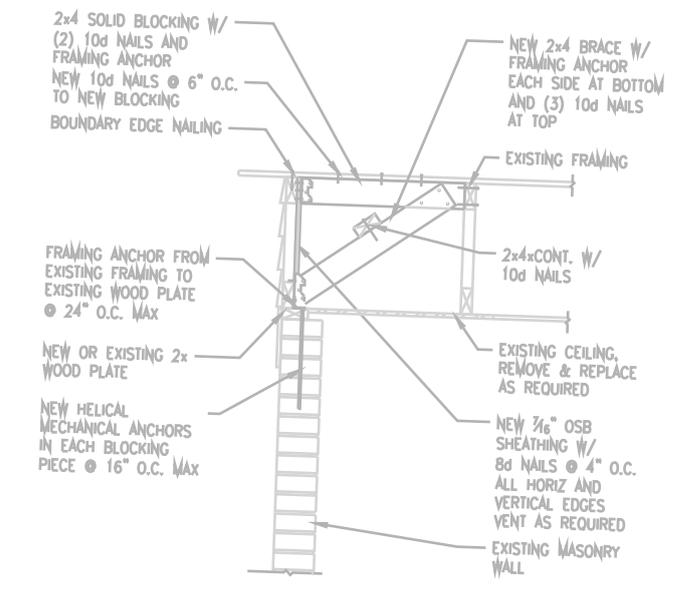
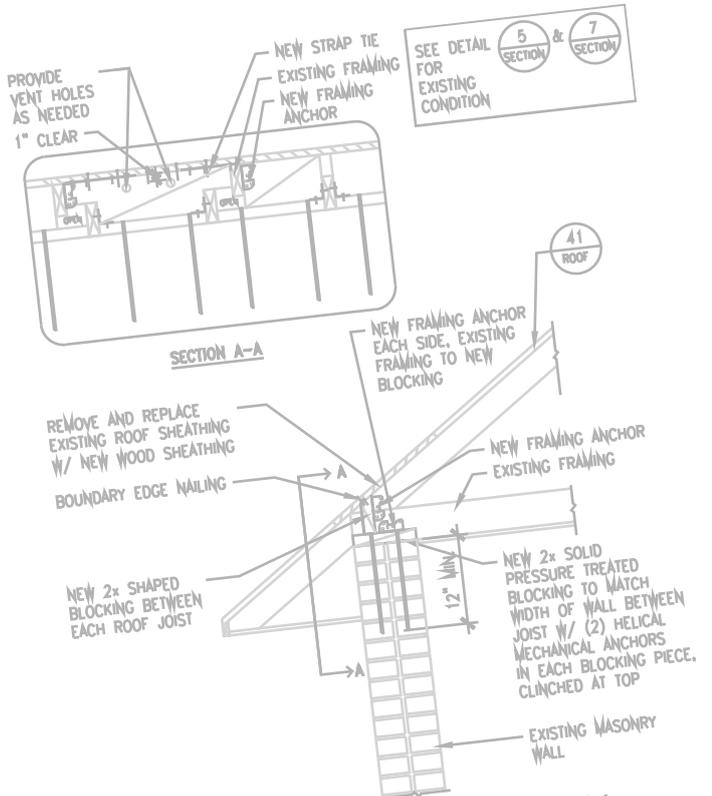
Roof anchorage and strengthening: Details 30-41

Floor anchorage and strengthening: Details 50-57

Wall strengthening: Details 70-82

Foundation anchorage and strengthening: Detail 90

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 20
Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 21

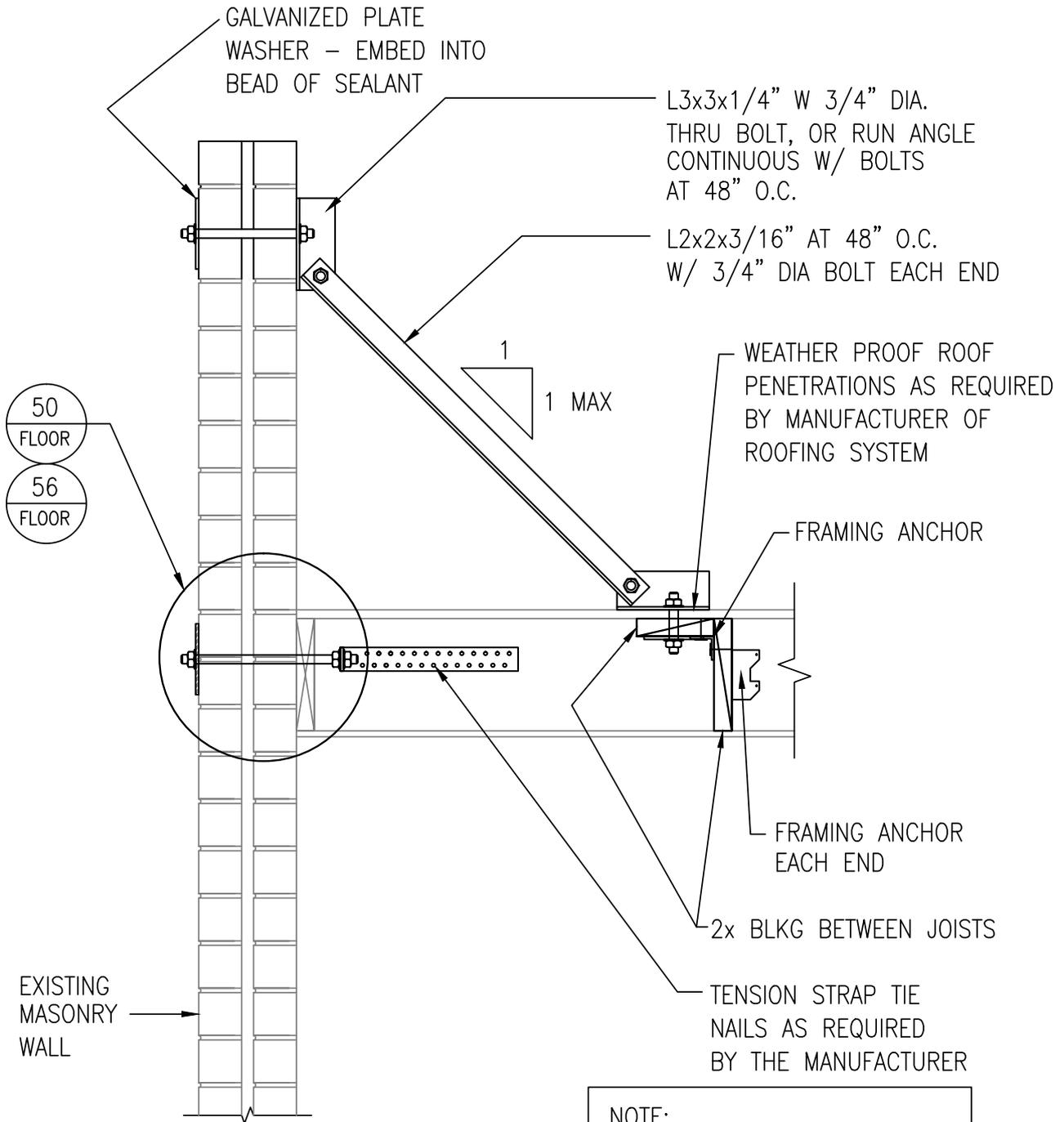


Seismic Improvement Structural Detail	HOME TYPE: MODEL C & D	Roof to URM Wall Anchorage	DETAIL: 32
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Seismic Improvement Structural Detail	HOME TYPE: MODEL E	Roof to URM Wall Anchorage	DETAIL: 38
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*Unused detail numbers are intentionally left out for future additions.

Structural bracing: Details 20–26a

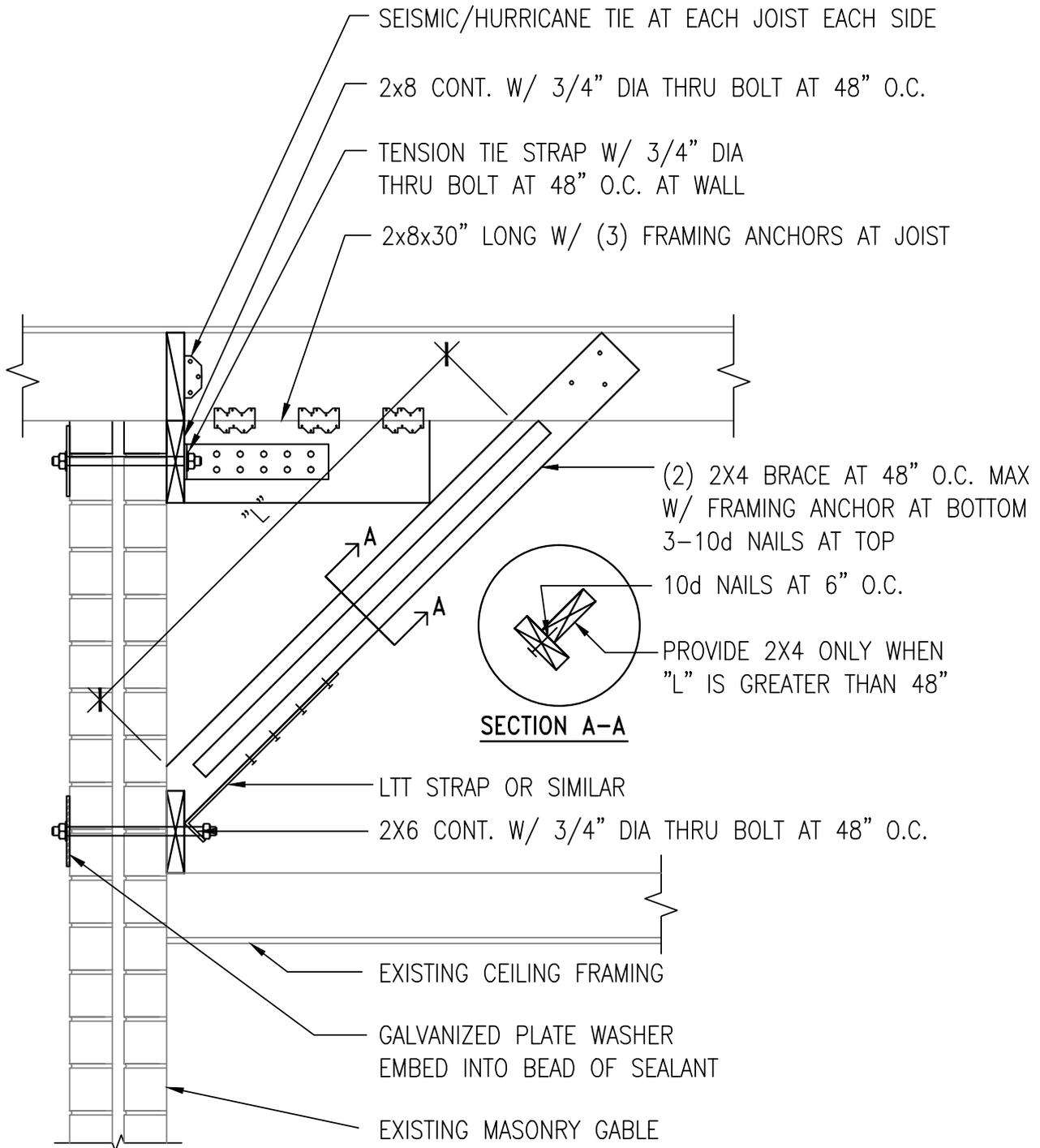


NOTE:
ALL EXPOSED STEEL SHALL BE GALVANIZED OR PROTECTED BY A HIGH QUALITY COATING

20
BRACE

PARAPET BRACING

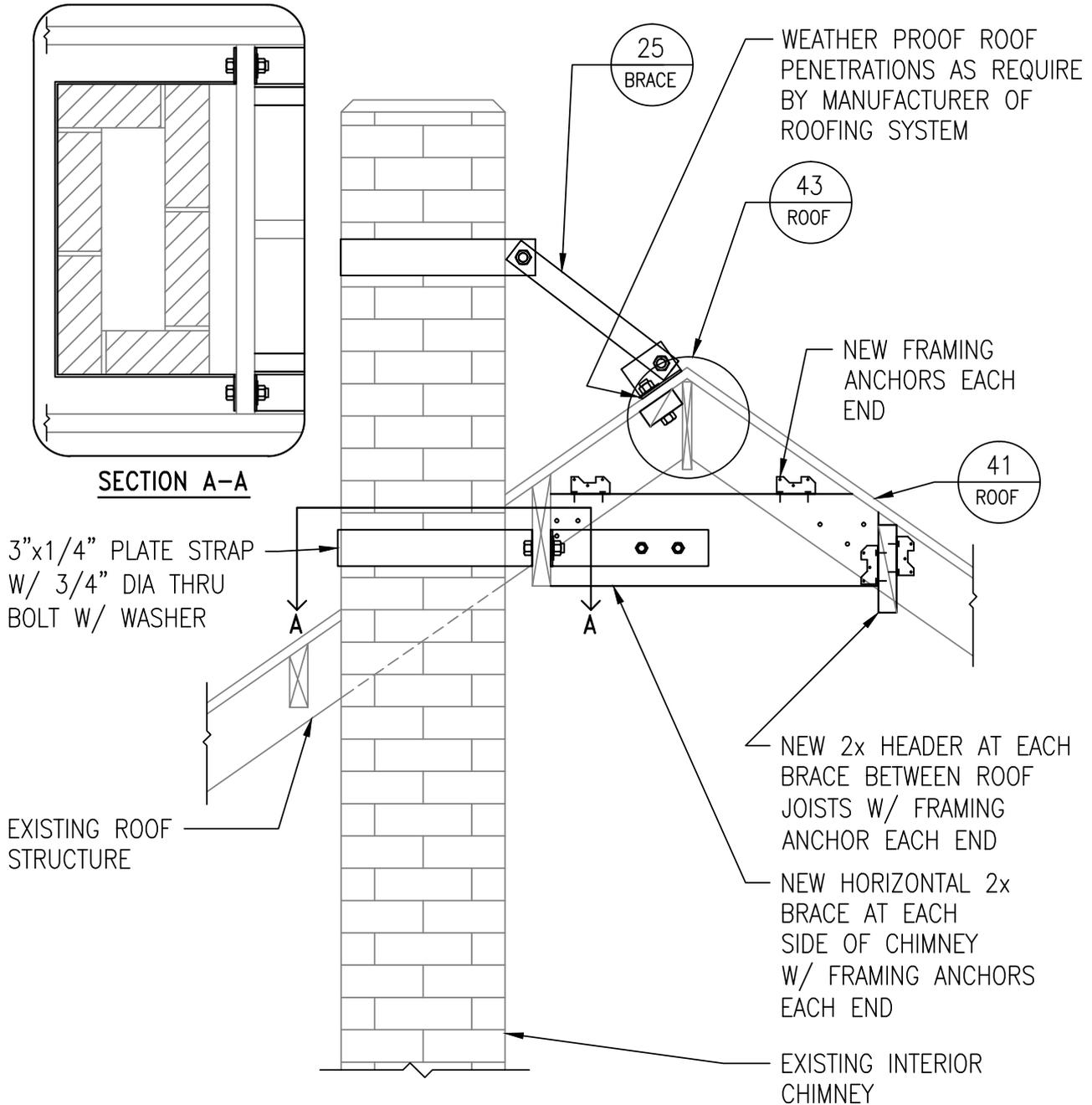
Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 20
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21
BRACE

URM GABLE BRACING

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 21
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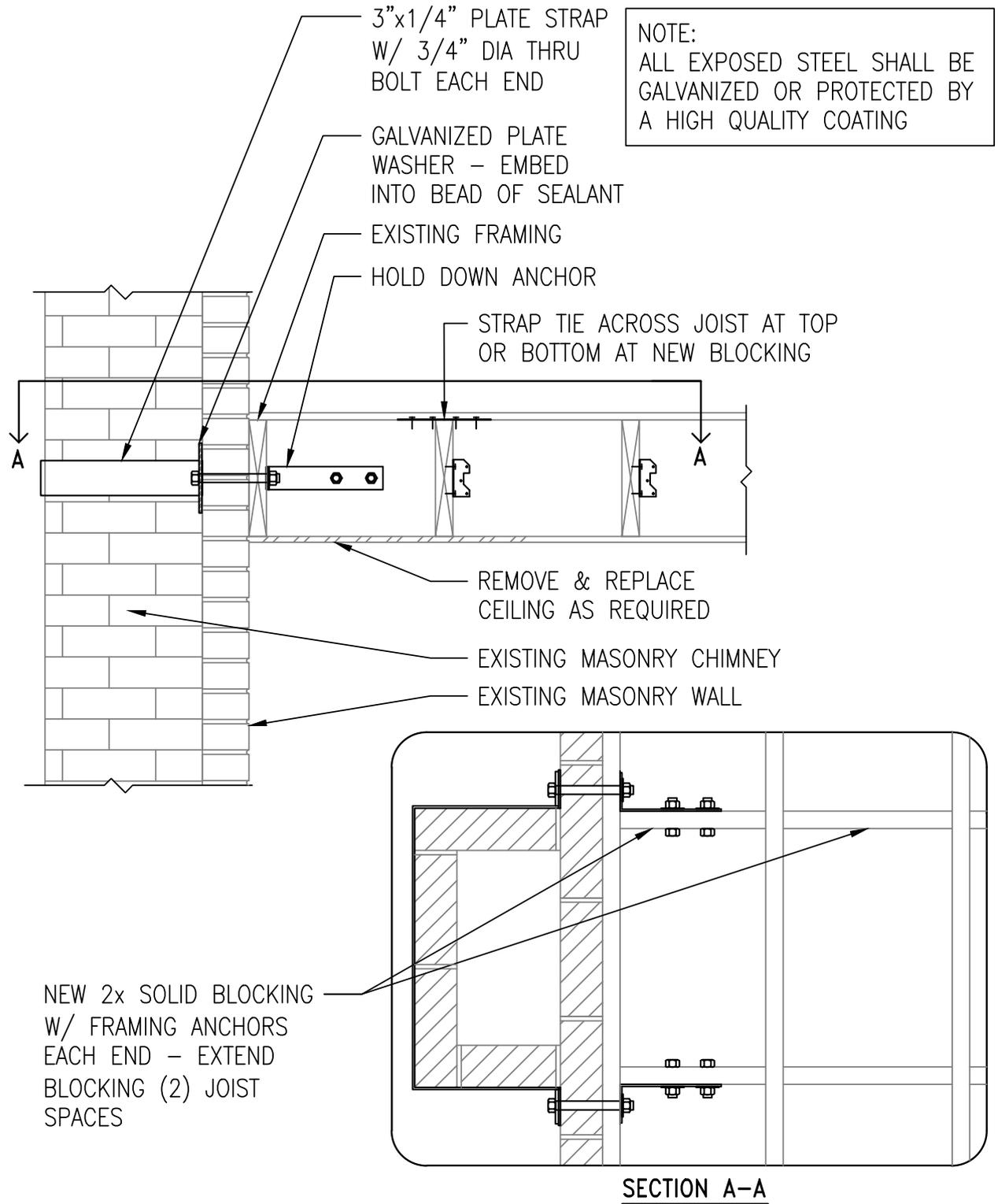


NOTE:
ALL EXPOSED STEEL SHALL BE GALVANIZED OR PROTECTED BY A HIGH QUALITY COATING

22
BRACE

INTERIOR CHIMNEY BRACING
W/ HEADER AT JOIST

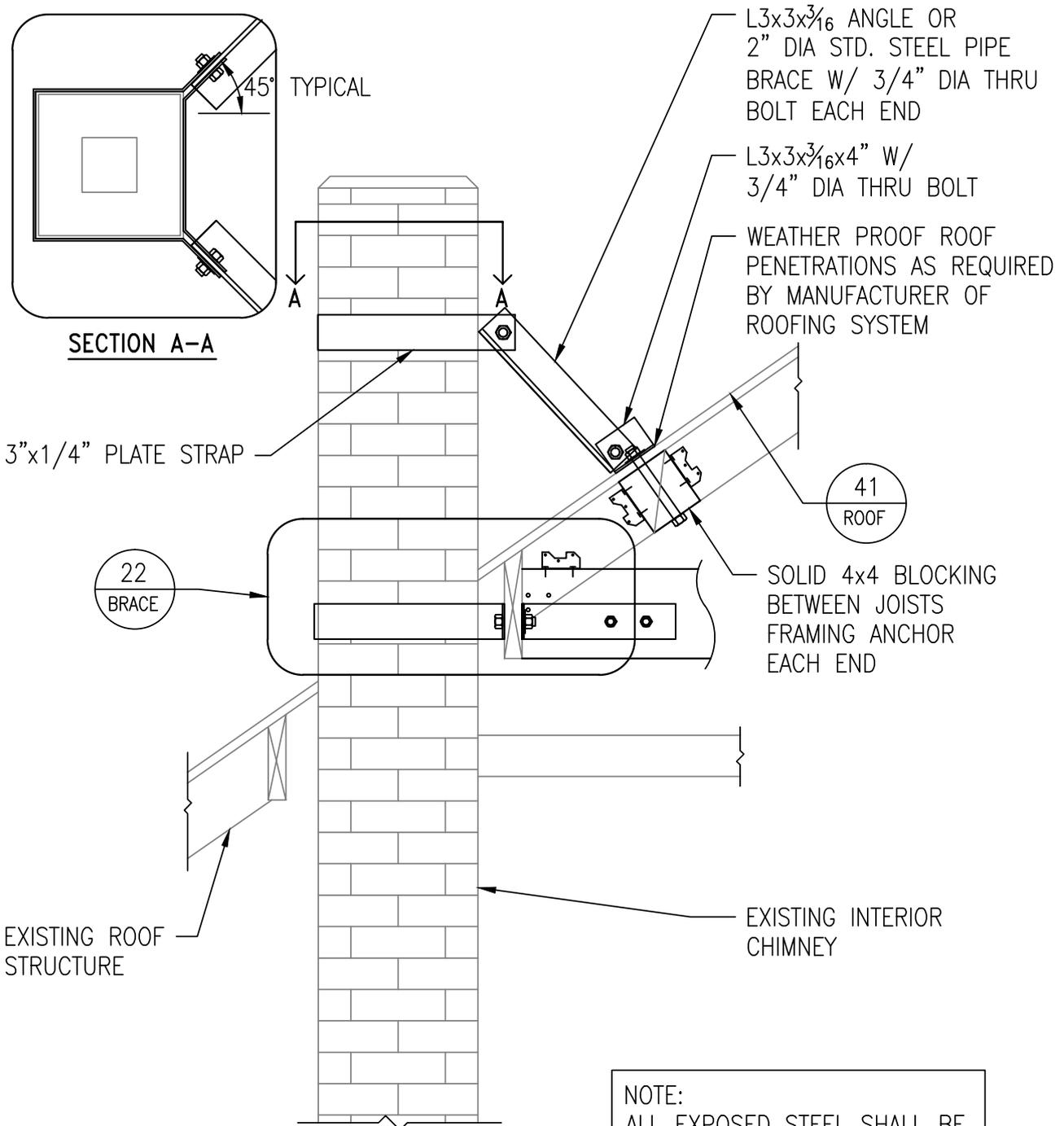
Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 22
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24
BRACE

EXTERIOR CHIMNEY TO FLOOR ANCHORAGE
@ JOISTS PARALLEL TO WALL

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 24
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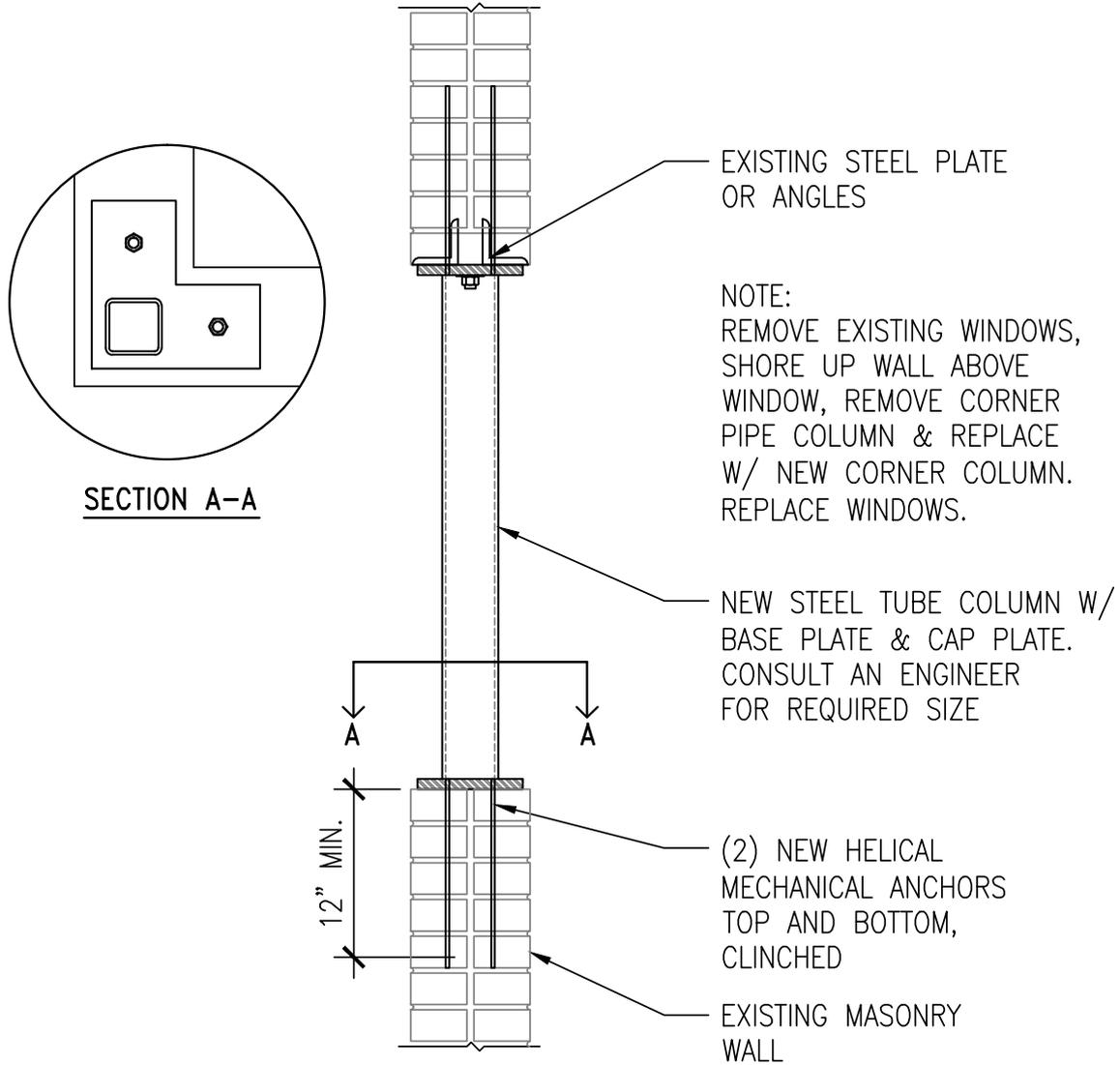
NOTE:
ALL EXPOSED STEEL SHALL BE GALVANIZED OR PROTECTED BY A HIGH QUALITY COATING

25
BRACE

EXTERIOR CHIMNEY TO ROOF ANCHORAGE

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 25
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NOTE:
 DRILLING AND PLACEMENT OF VERTICAL EPOXY BOLTS
 INTO URM WALLS MUST BE DONE WITH EXTREME CAUTION
 TO AVOID FRACTURE OF WALLS AND THE RESULTING
 INCREASED REPAIR EFFORT AND COST.



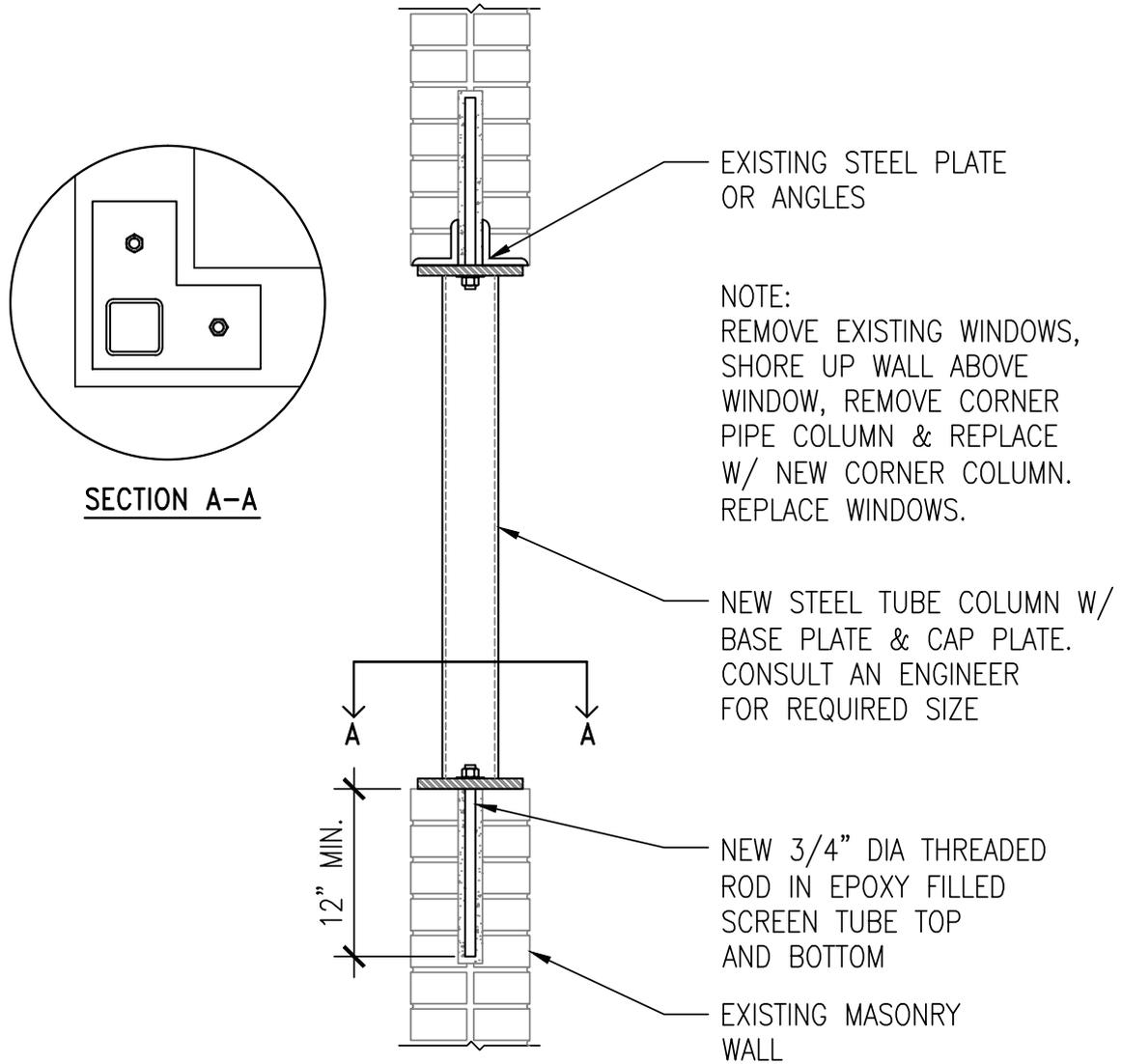
NOTE:
 ALL EXPOSED STEEL SHALL BE
 GALVANIZED OR PROTECTED BY
 A HIGH QUALITY COATING



CORNER WINDOW STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 26
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NOTE:
 DRILLING AND PLACEMENT OF VERTICAL EPOXY BOLTS
 INTO URM WALLS MUST BE DONE WITH EXTREME CAUTION
 TO AVOID FRACTURE OF WALLS AND THE RESULTING
 INCREASED REPAIR EFFORT AND COST.



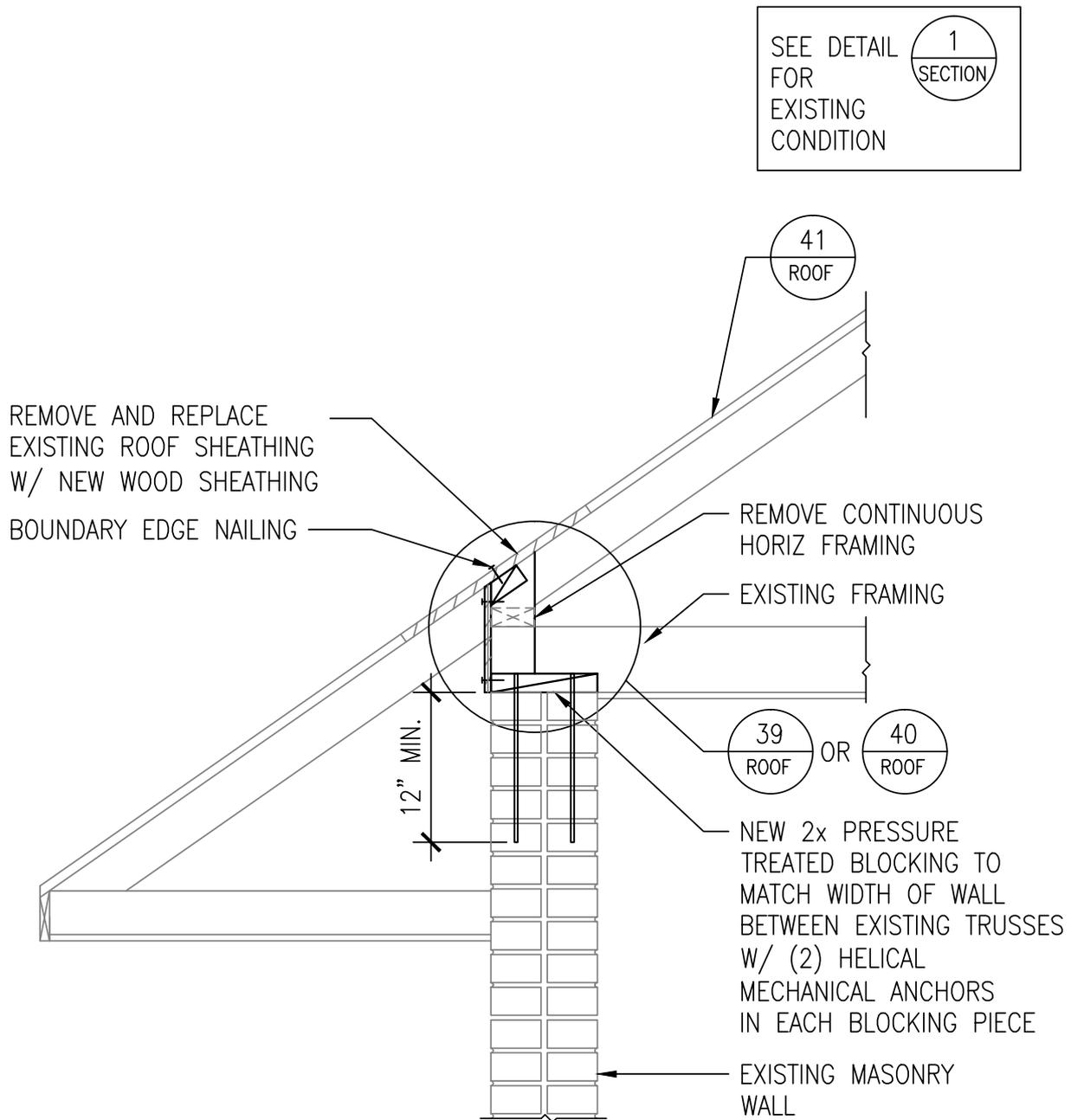
NOTE:
 ALL EXPOSED STEEL SHALL BE
 GALVANIZED OR PROTECTED BY
 A HIGH QUALITY COATING



CORNER WINDOW STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 26a
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Roof anchorage and strengthening: Details 30-41



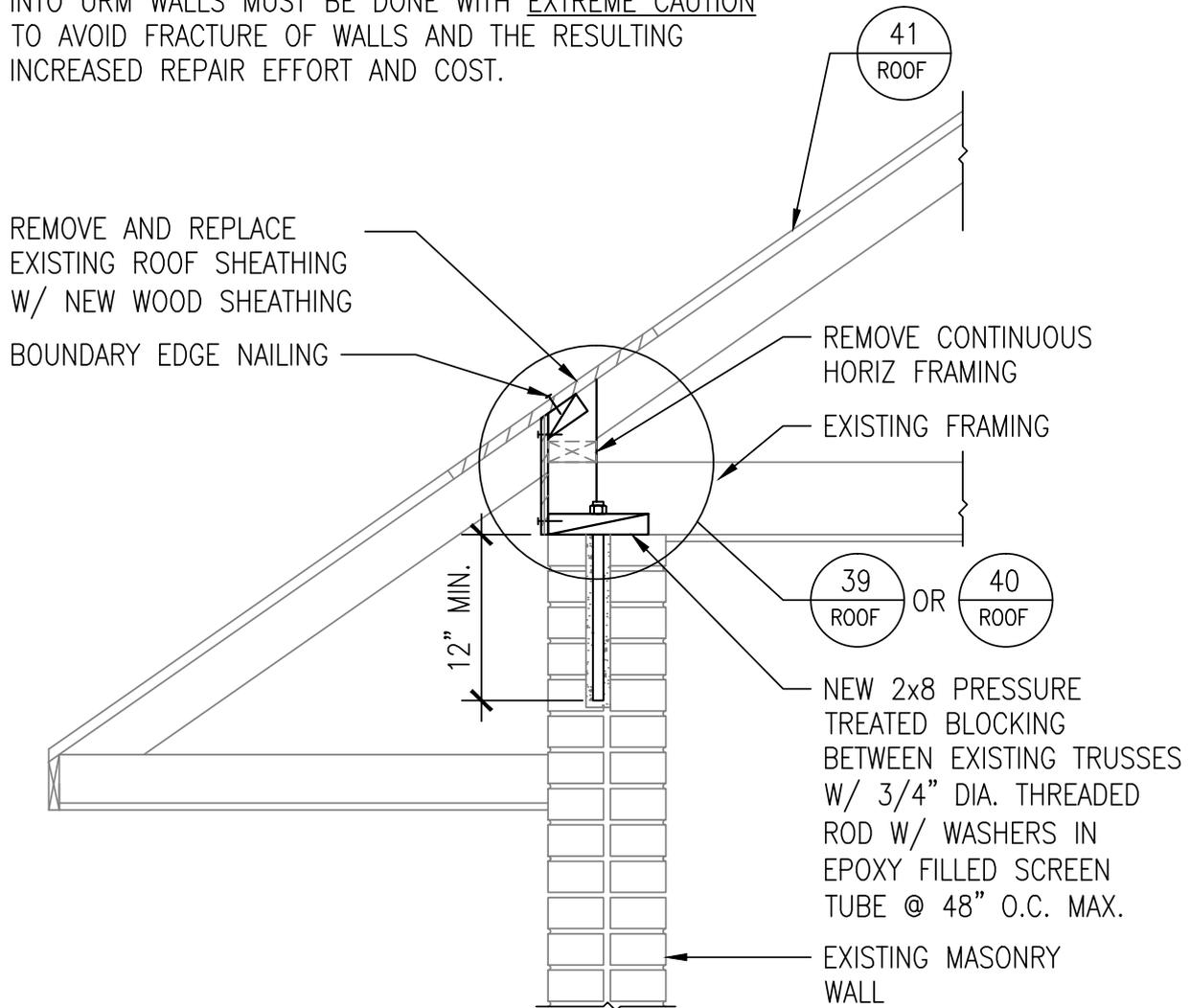
NOTE:
 FOR EASE OF INSTALLATION THE NEW WOOD MEMBERS CAN BE ASSEMBLED ON THE GROUND, LIFTED INTO PLACE AND THEN ATTACHED TO THE EXISTING WALL AND FRAMING.

30 ROOF ROOF TO URM WALL ANCHORAGE W/ JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL A	Roof to URM Wall Anchorage	DETAIL: 30
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NOTE:
 DRILLING AND PLACEMENT OF VERTICAL EPOXY BOLTS INTO URM WALLS MUST BE DONE WITH EXTREME CAUTION TO AVOID FRACTURE OF WALLS AND THE RESULTING INCREASED REPAIR EFFORT AND COST.

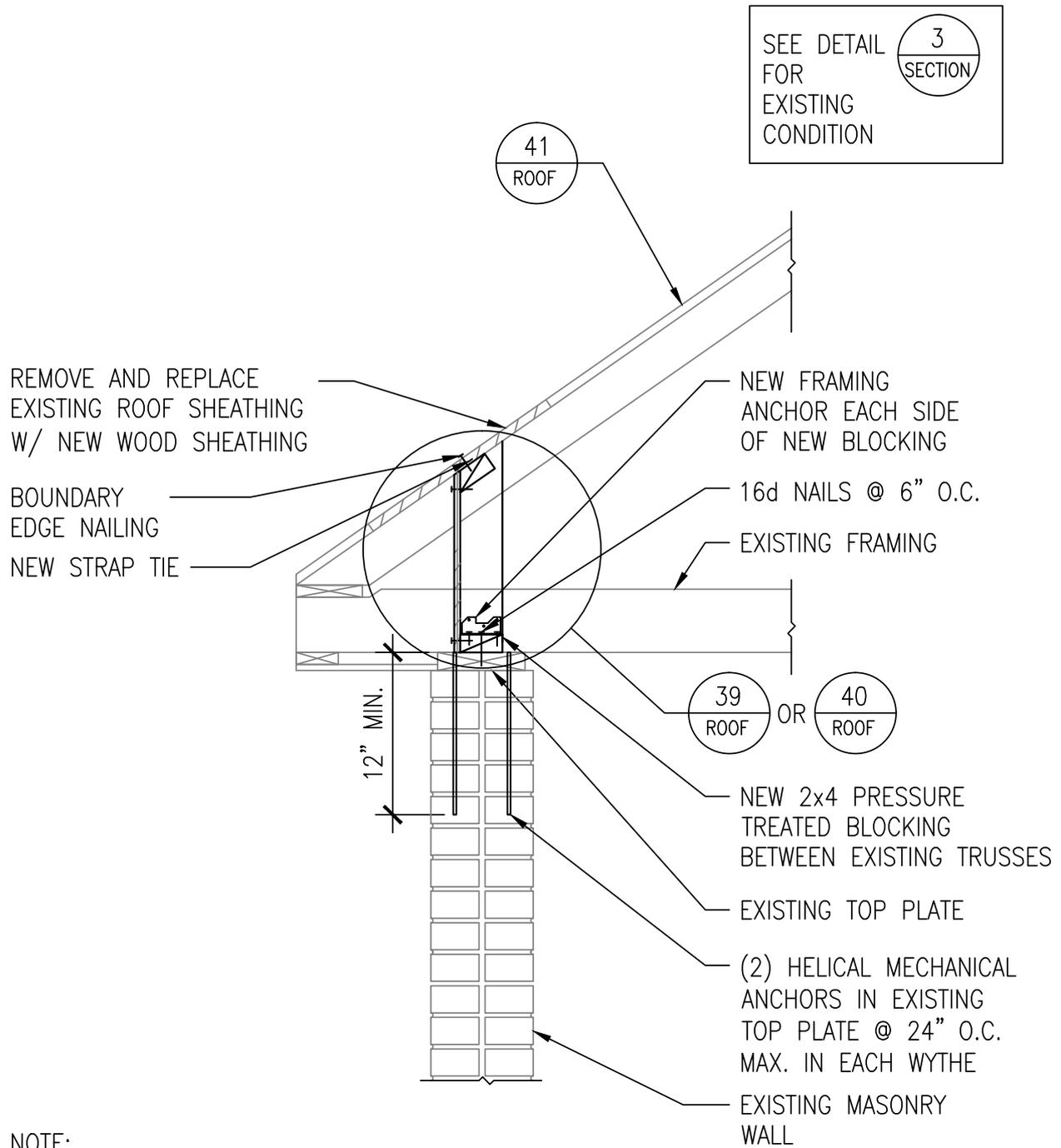
SEE DETAIL 1
SECTION
 FOR
 EXISTING
 CONDITION



NOTE:
 FOR EASE OF INSTALLATION THE NEW WOOD MEMBERS CAN BE ASSEMBLED ON THE GROUND, LIFTED INTO PLACE AND THEN ATTACHED TO THE EXISTING WALL AND FRAMING.

30a
ROOF ROOF TO URM WALL ANCHORAGE W/
 JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL A	Roof to URM Wall Anchorage	DETAIL: 30a
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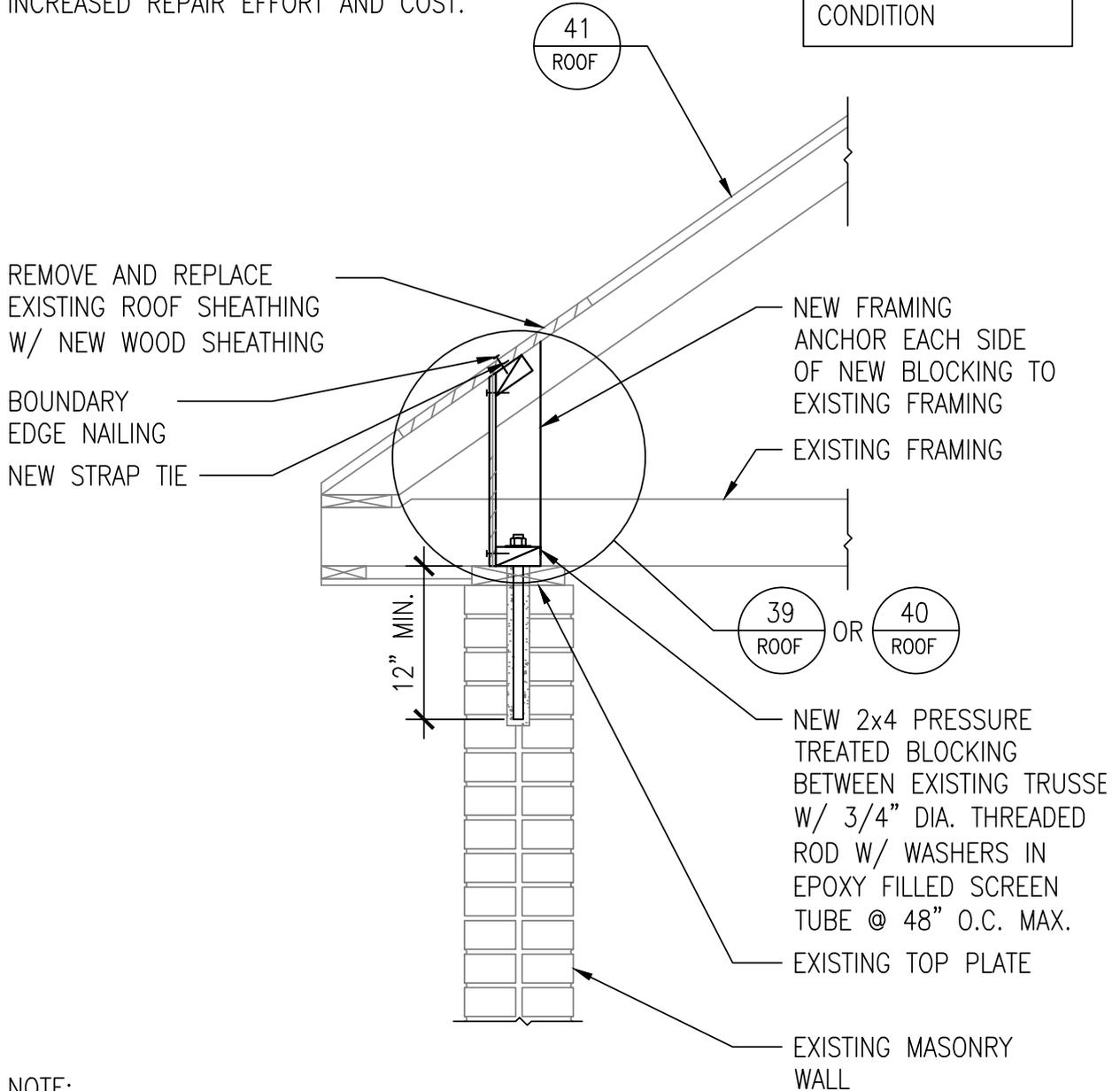
NOTE:
 FOR EASE OF INSTALLATION THE NEW WOOD MEMBERS CAN
 BE ASSEMBLED ON THE GROUND, LIFTED INTO PLACE AND
 THEN ATTACHED TO THE EXISTING WALL AND FRAMING.

31 ROOF TO URM WALL ANCHORAGE W/
 ROOF JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL B	Roof to URM Wall Anchorage	DETAIL: 31
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NOTE:
 DRILLING AND PLACEMENT OF VERTICAL EPOXY BOLTS INTO URM WALLS MUST BE DONE WITH EXTREME CAUTION TO AVOID FRACTURE OF WALLS AND THE RESULTING INCREASED REPAIR EFFORT AND COST.

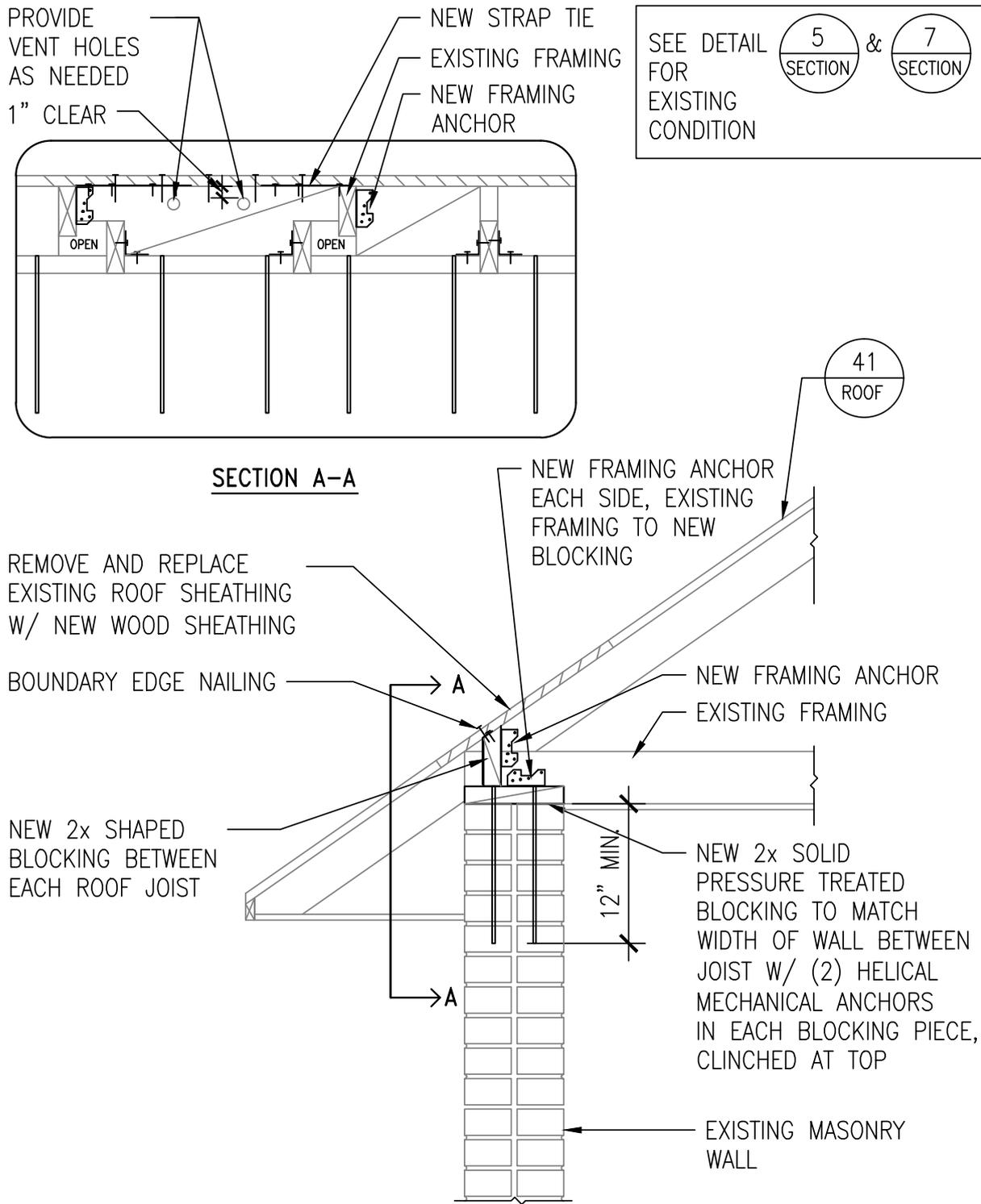
SEE DETAIL 3 SECTION FOR EXISTING CONDITION



NOTE:
 FOR EASE OF INSTALLATION THE NEW WOOD MEMBERS CAN BE ASSEMBLED ON THE GROUND, LIFTED INTO PLACE AND THEN ATTACHED TO THE EXISTING WALL AND FRAMING.

31a ROOF TO URM WALL ANCHORAGE W/ JOISTS PERPENDICULAR TO WALL

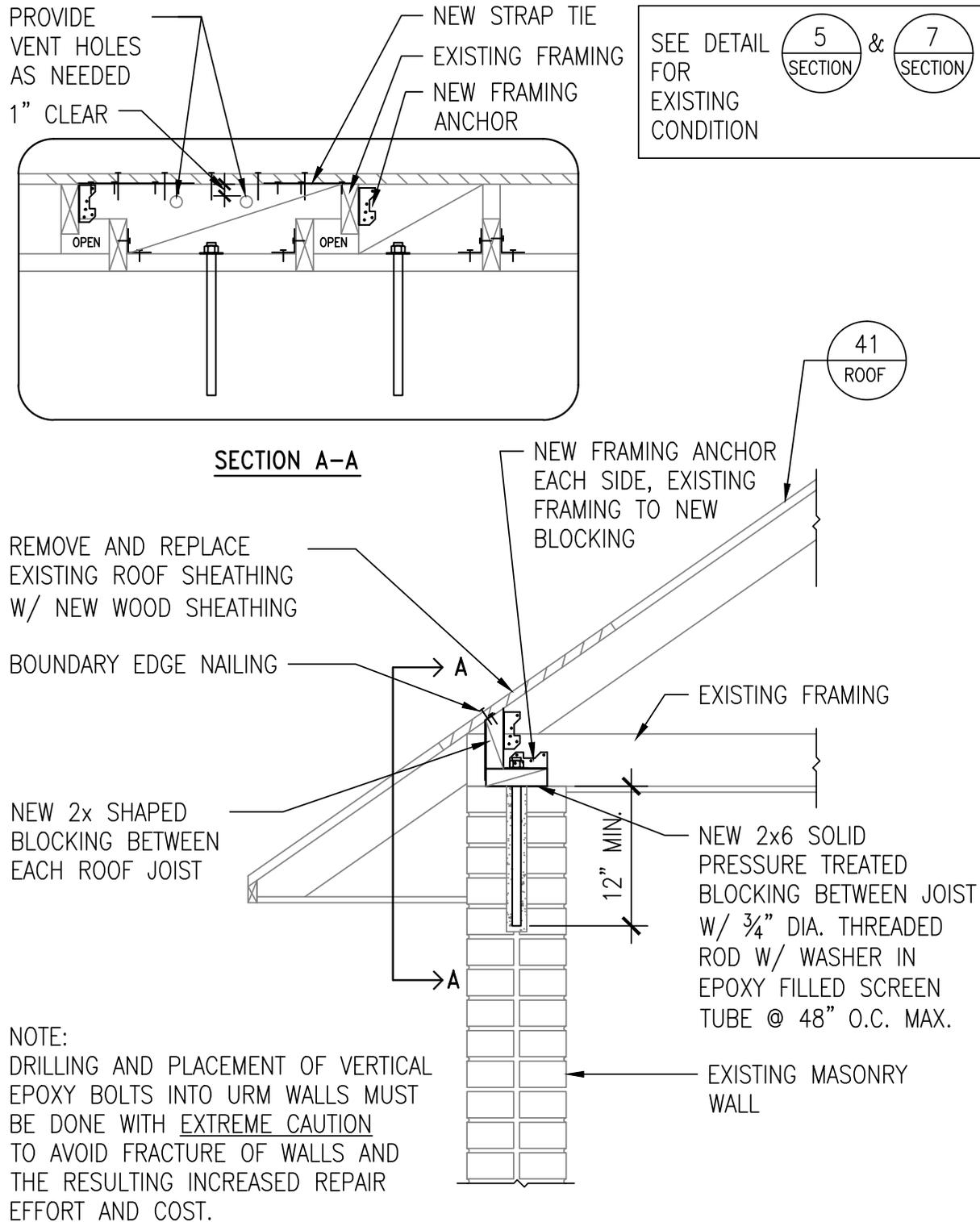
Seismic Improvement Structural Detail	HOME TYPE: MODEL B	Roof to URM Wall Anchorage	DETAIL: 31a
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32 ROOF
ROOF

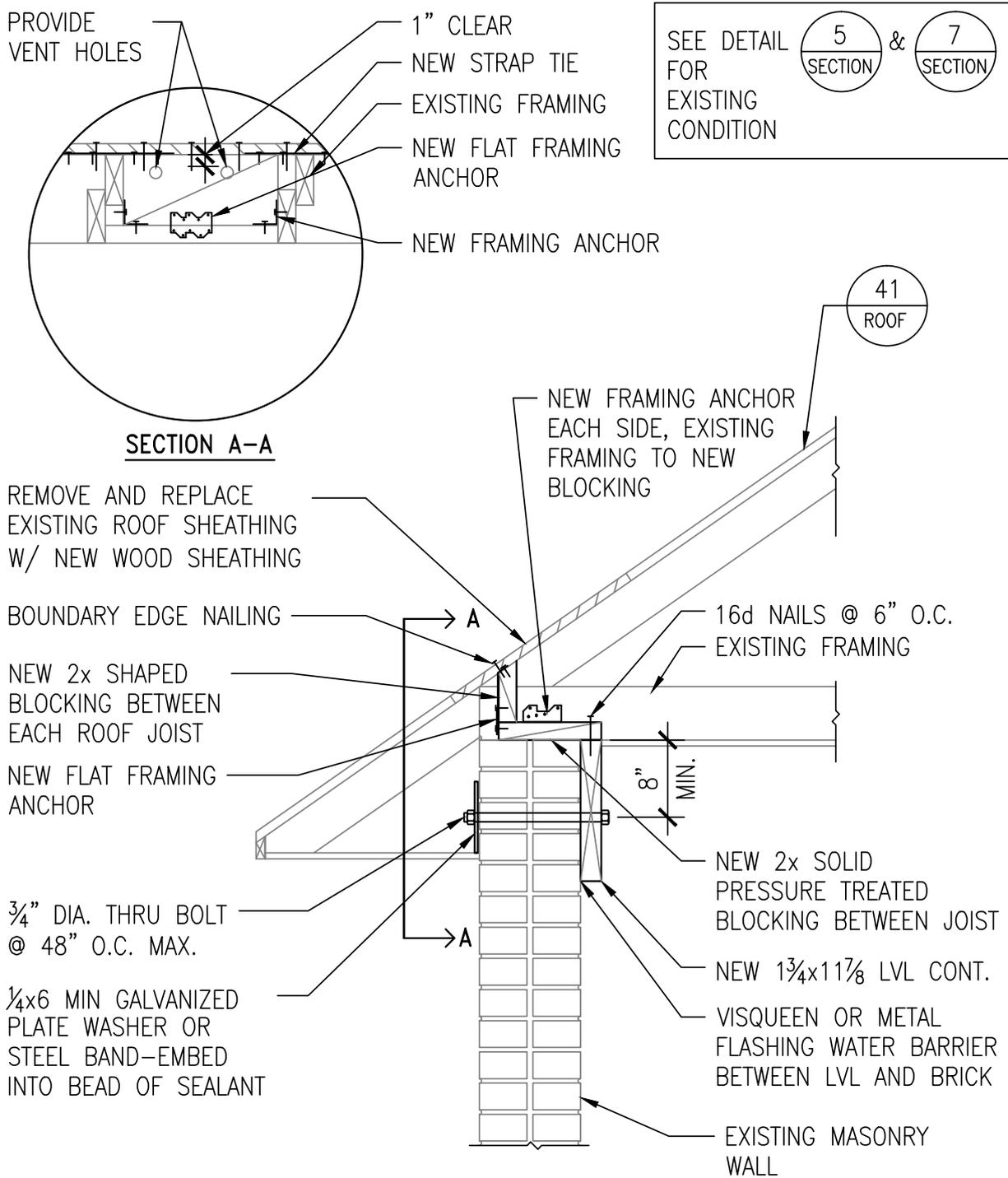
ROOF TO URM WALL ANCHORAGE W/
JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL C & D	Roof to URM Wall Anchorage	DETAIL: 32
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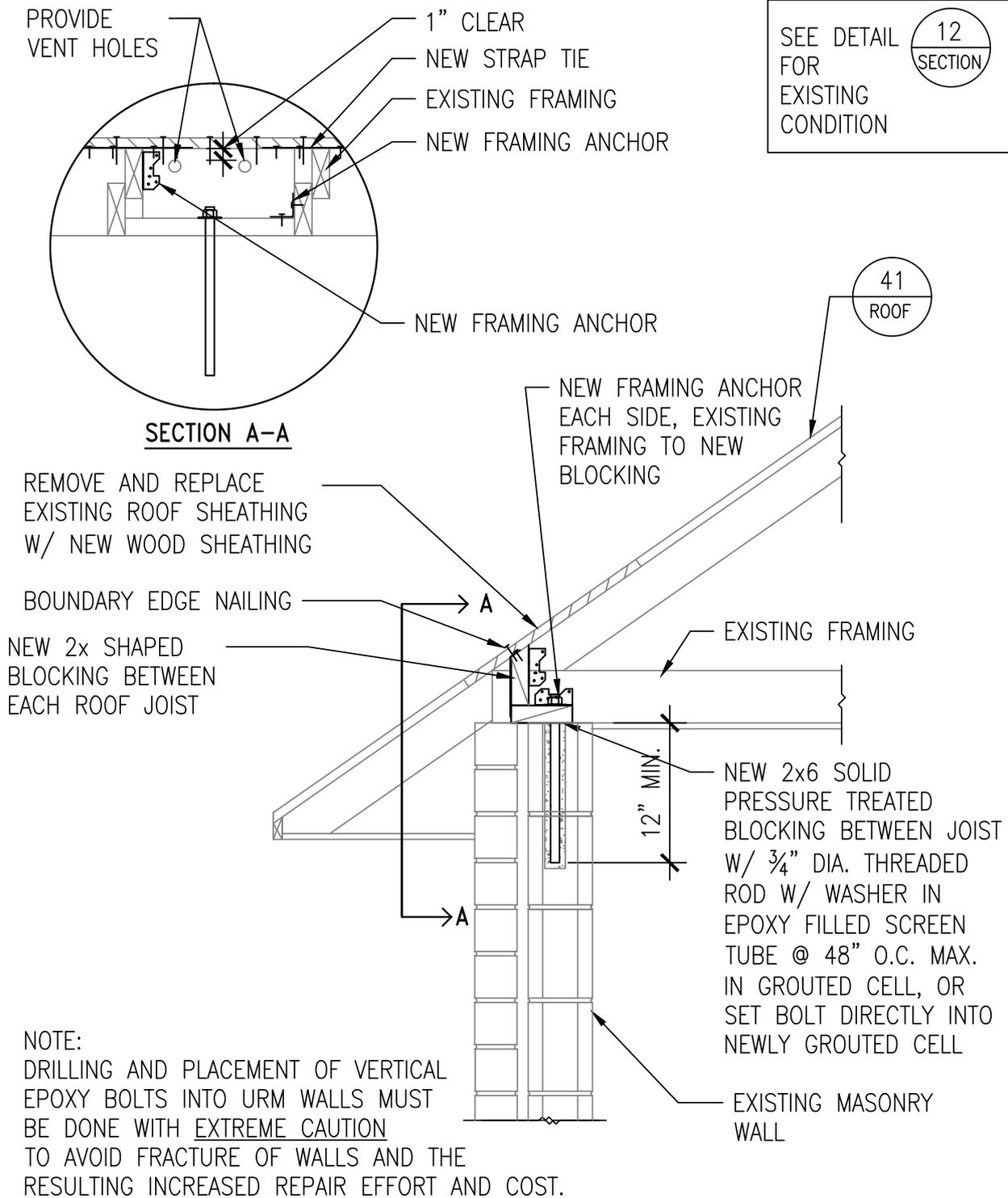
32a ROOF TO URM WALL ANCHORAGE W/ JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL C & D	Roof to URM Wall Anchorage	DETAIL: 32a
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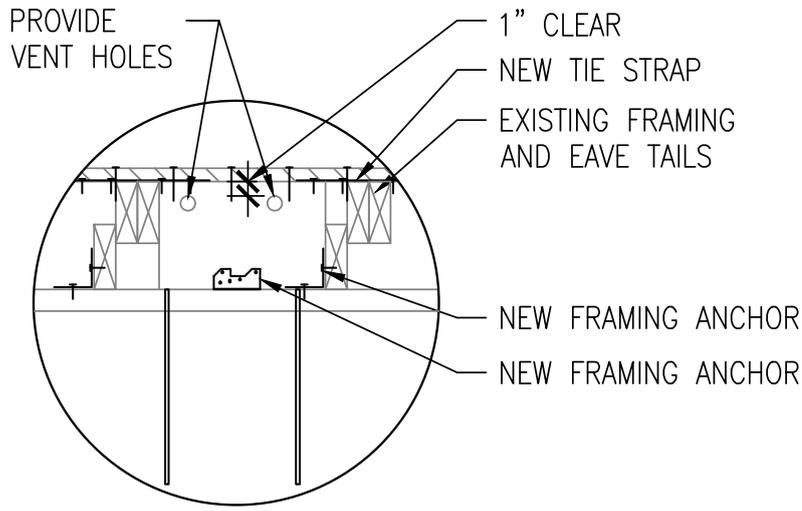
32b ROOF TO URM WALL ANCHORAGE W/
ROOF JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL C & D	Roof to URM Wall Anchorage	DETAIL: 32b
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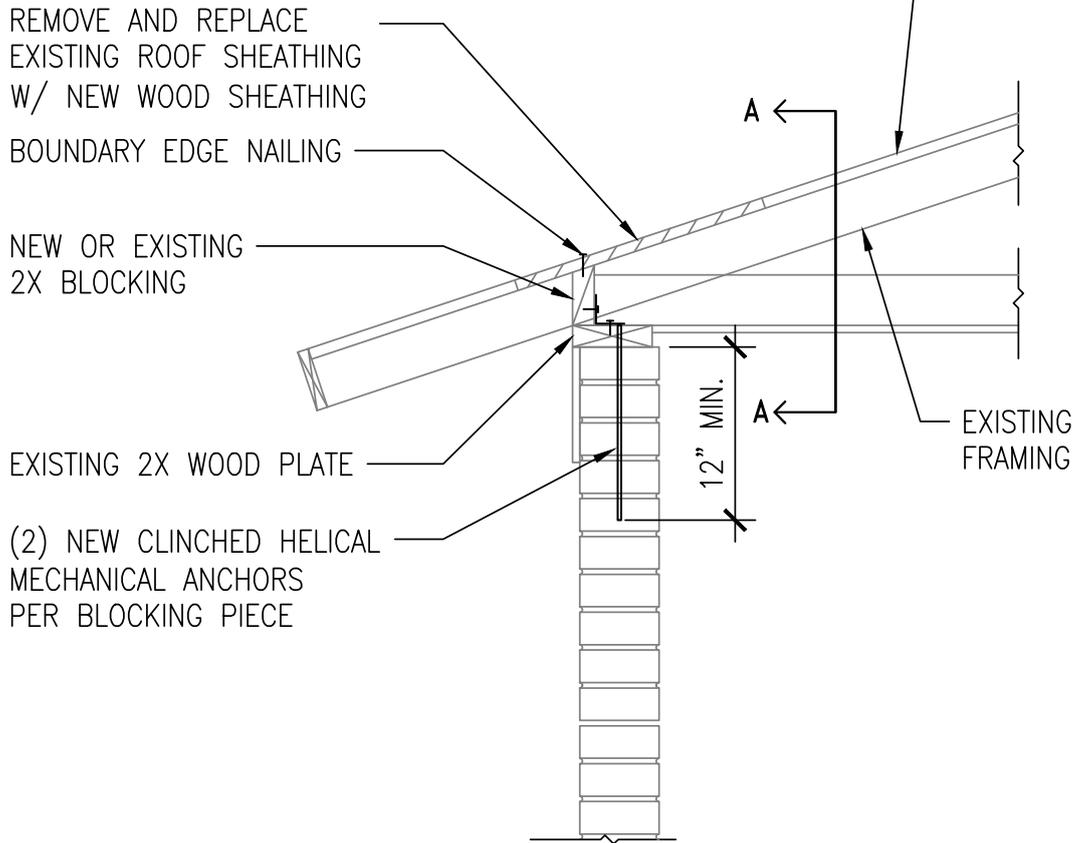
32c ROOF TO URM WALL ANCHORAGE W/ JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL G	Roof to URM Wall Anchorage	DETAIL: 32c
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SEE DETAIL 9
SECTION
FOR
EXISTING
CONDITION

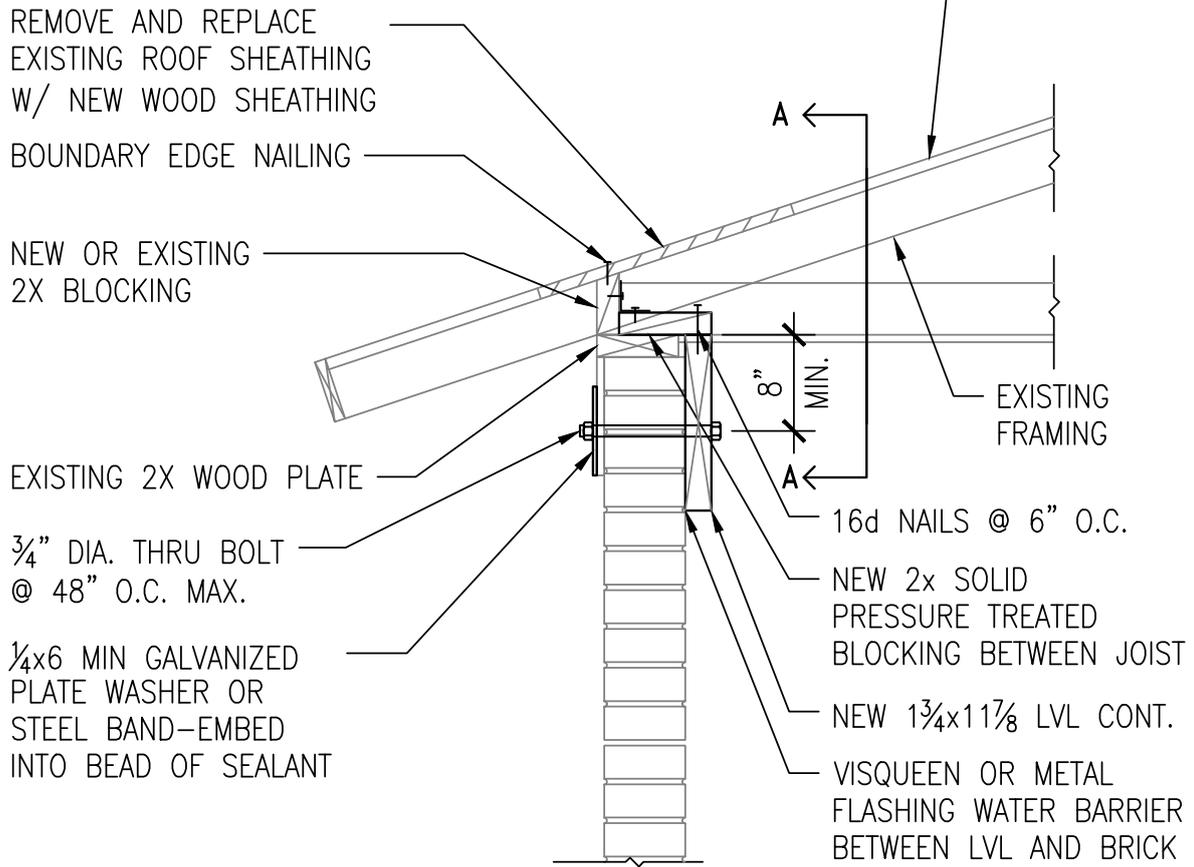
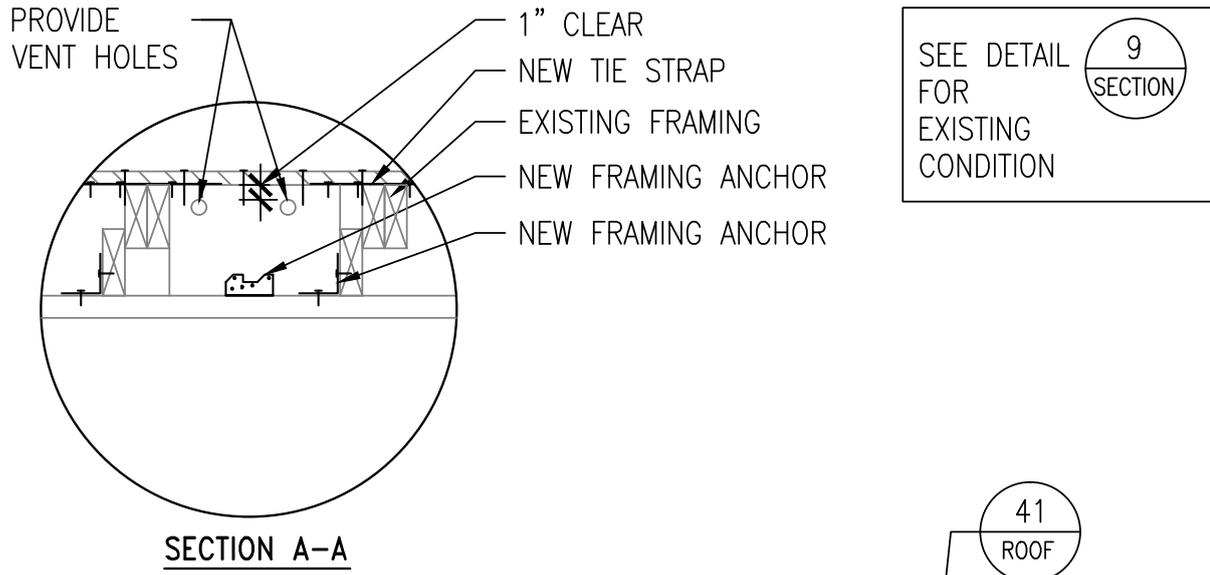
SECTION A-A



33
ROOF

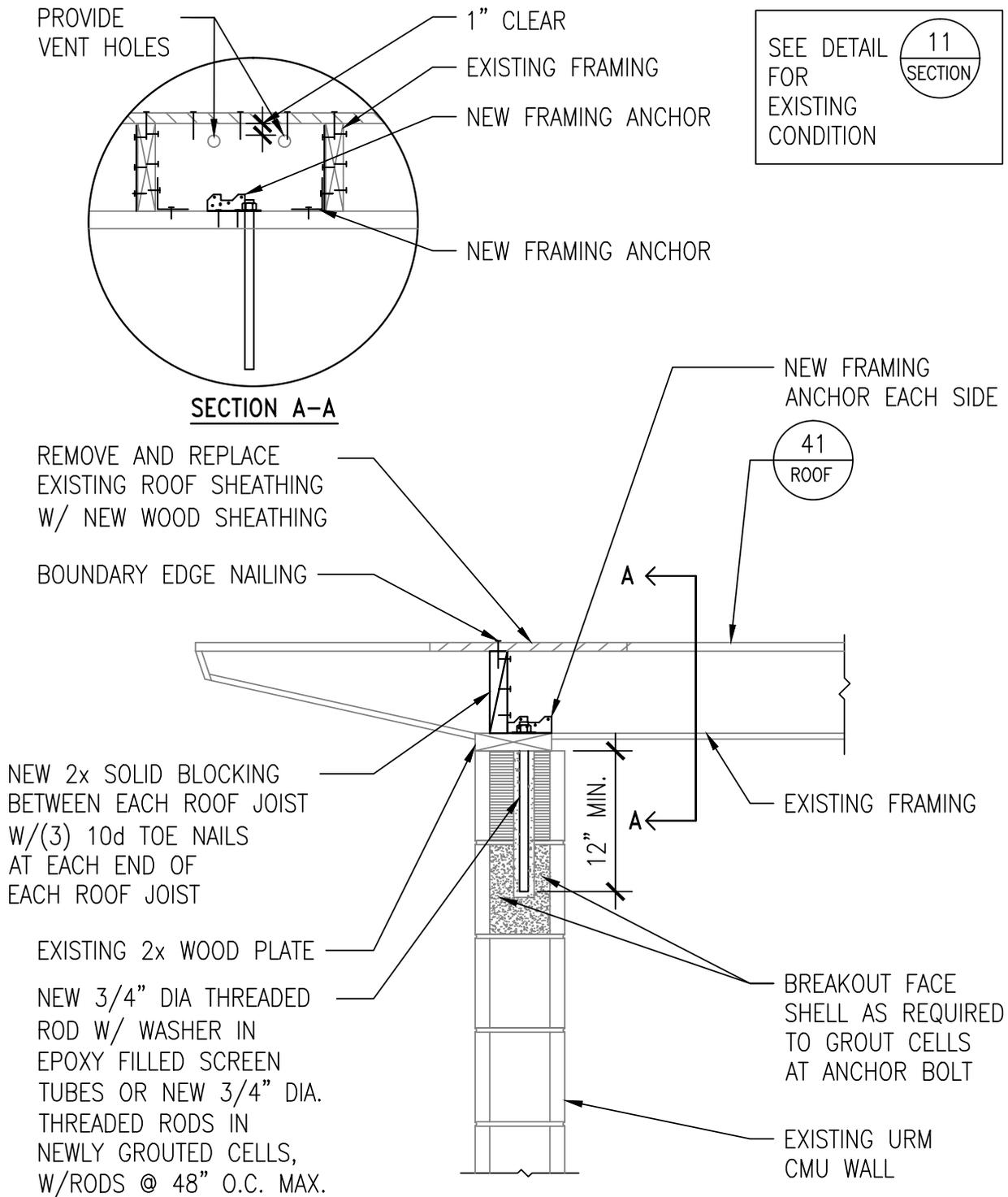
**ROOF TO URM WALL ANCHORAGE W/
JOISTS PERPENDICULAR TO WALL**

Seismic Improvement Structural Detail	HOME TYPE: MODEL E	Roof to URM Wall Anchorage	DETAIL: 33
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33a ROOF TO URM WALL ANCHORAGE W/
ROOF JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL E	Roof to URM Wall Anchorage	DETAIL: 33a
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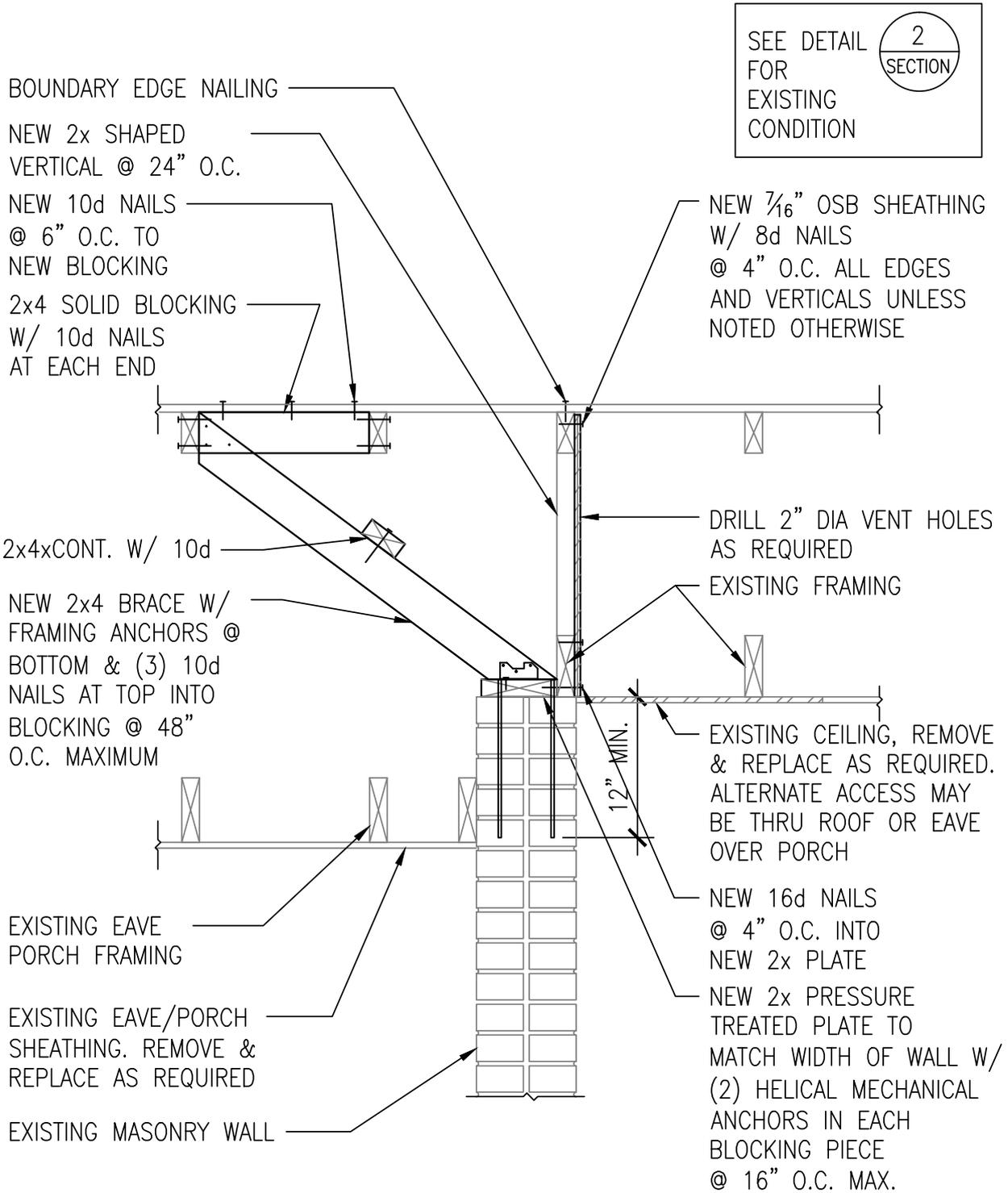
SEE DETAIL FOR EXISTING CONDITION

11 SECTION

34 ROOF

ROOF TO URM WALL ANCHORAGE W/ JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL F	Roof to URM Wall Anchorage	DETAIL: 34
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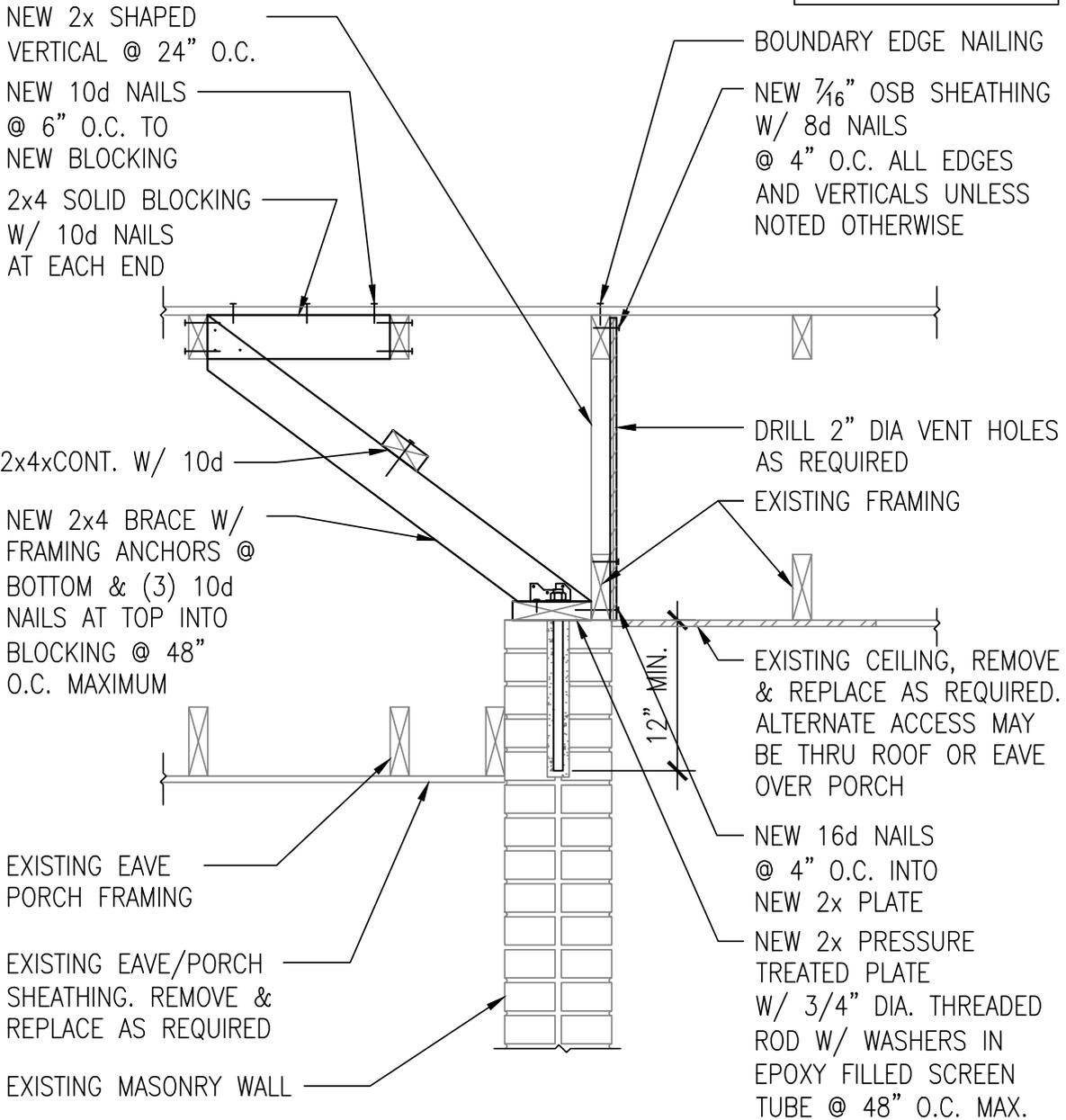


35 ROOF TO URM WALL ANCHORAGE W/ JOISTS PARALLEL TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL A	Roof to URM Wall Anchorage	DETAIL: 35
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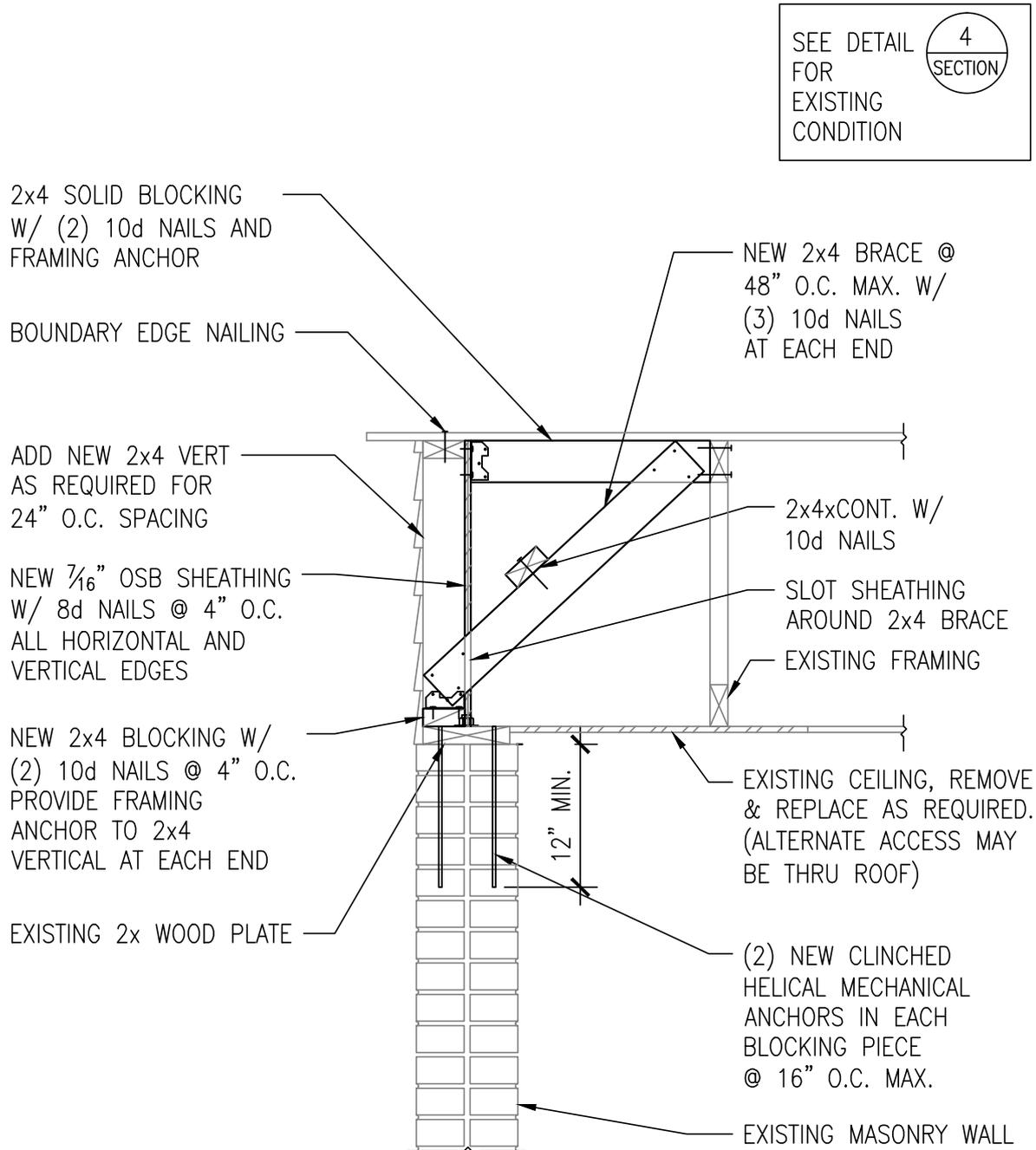
NOTE:
 DRILLING AND PLACEMENT OF VERTICAL EPOXY BOLTS
 INTO URM WALLS MUST BE DONE WITH EXTREME CAUTION
 TO AVOID FRACTURE OF WALLS AND THE RESULTING
 INCREASED REPAIR EFFORT AND COST.

SEE DETAIL 2
 FOR
 EXISTING
 CONDITION



35a ROOF TO URM WALL ANCHORAGE W/
 ROOF JOISTS PARALLEL TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL A	Roof to URM Wall Anchorage	DETAIL: 35a
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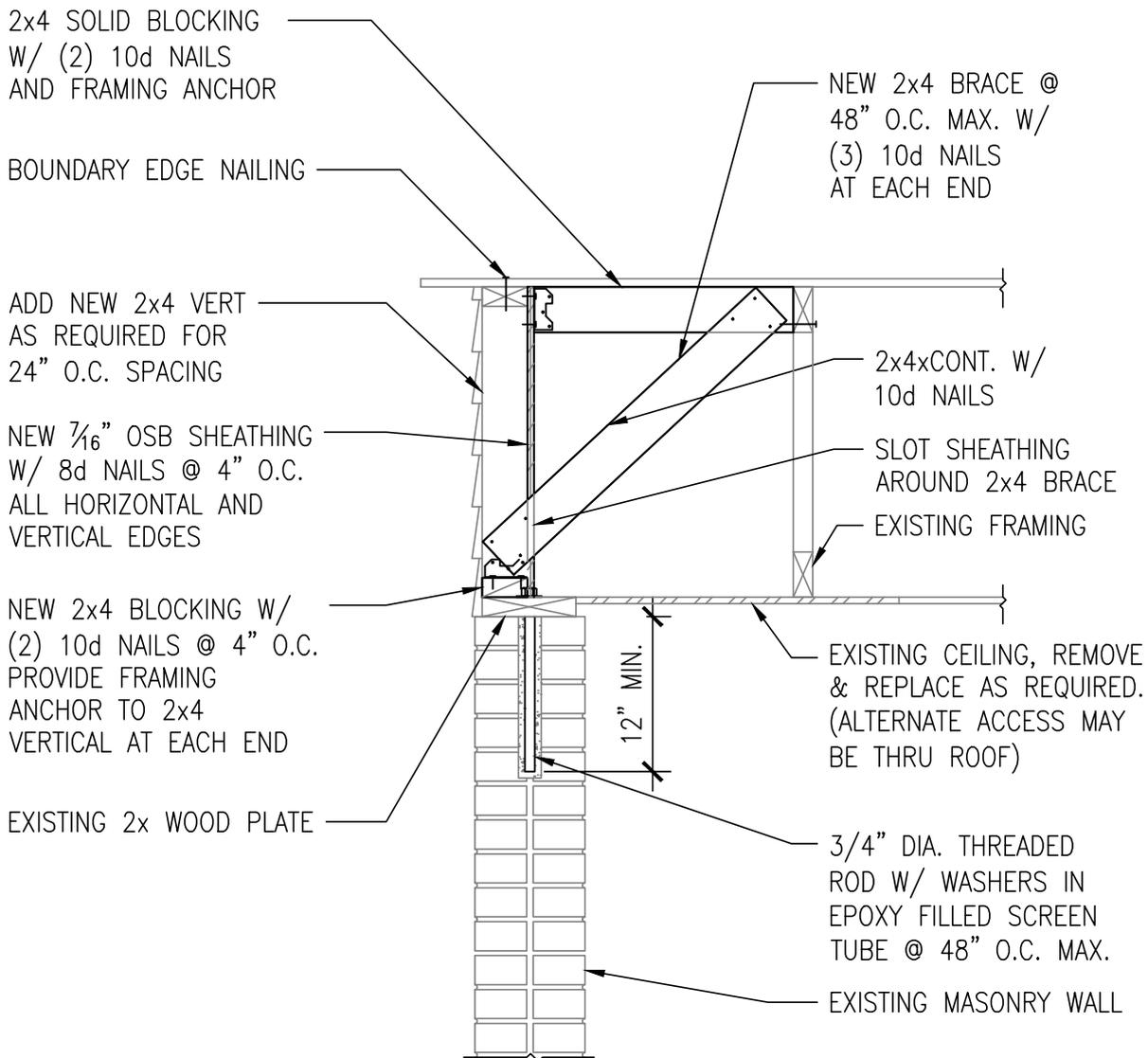


36 ROOF TO URM WALL ANCHORAGE W/ JOISTS PARALLEL TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL B	Roof to URM Wall Anchorage	DETAIL: 36
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NOTE:
 DRILLING AND PLACEMENT OF VERTICAL EPOXY BOLTS
 INTO URM WALLS MUST BE DONE WITH EXTREME CAUTION
 TO AVOID FRACTURE OF WALLS AND THE RESULTING
 INCREASED REPAIR EFFORT AND COST.

SEE DETAIL 4
 FOR
 EXISTING
 CONDITION



36a ROOF TO URM WALL ANCHORAGE W/
ROOF JOISTS PARALLEL TO WALL

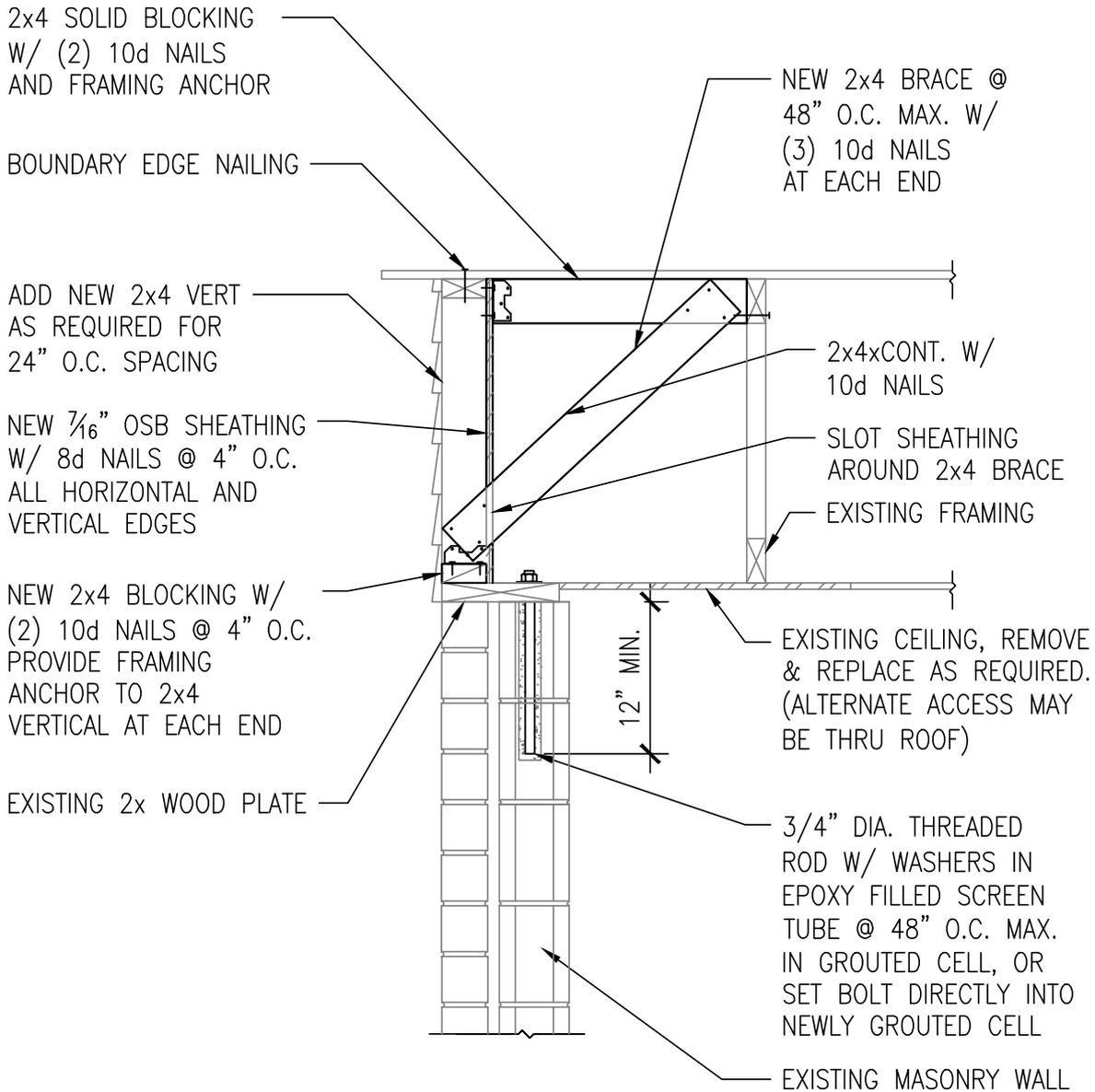
Seismic Improvement Structural Detail	HOME TYPE: MODEL B	Roof to URM Wall Anchorage	DETAIL: 36a
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NOTE:

DRILLING AND PLACEMENT OF VERTICAL EPOXY BOLTS INTO URM WALLS MUST BE DONE WITH EXTREME CAUTION TO AVOID FRACTURE OF WALLS AND THE RESULTING INCREASED REPAIR EFFORT AND COST.

SEE DETAIL FOR EXISTING CONDITION

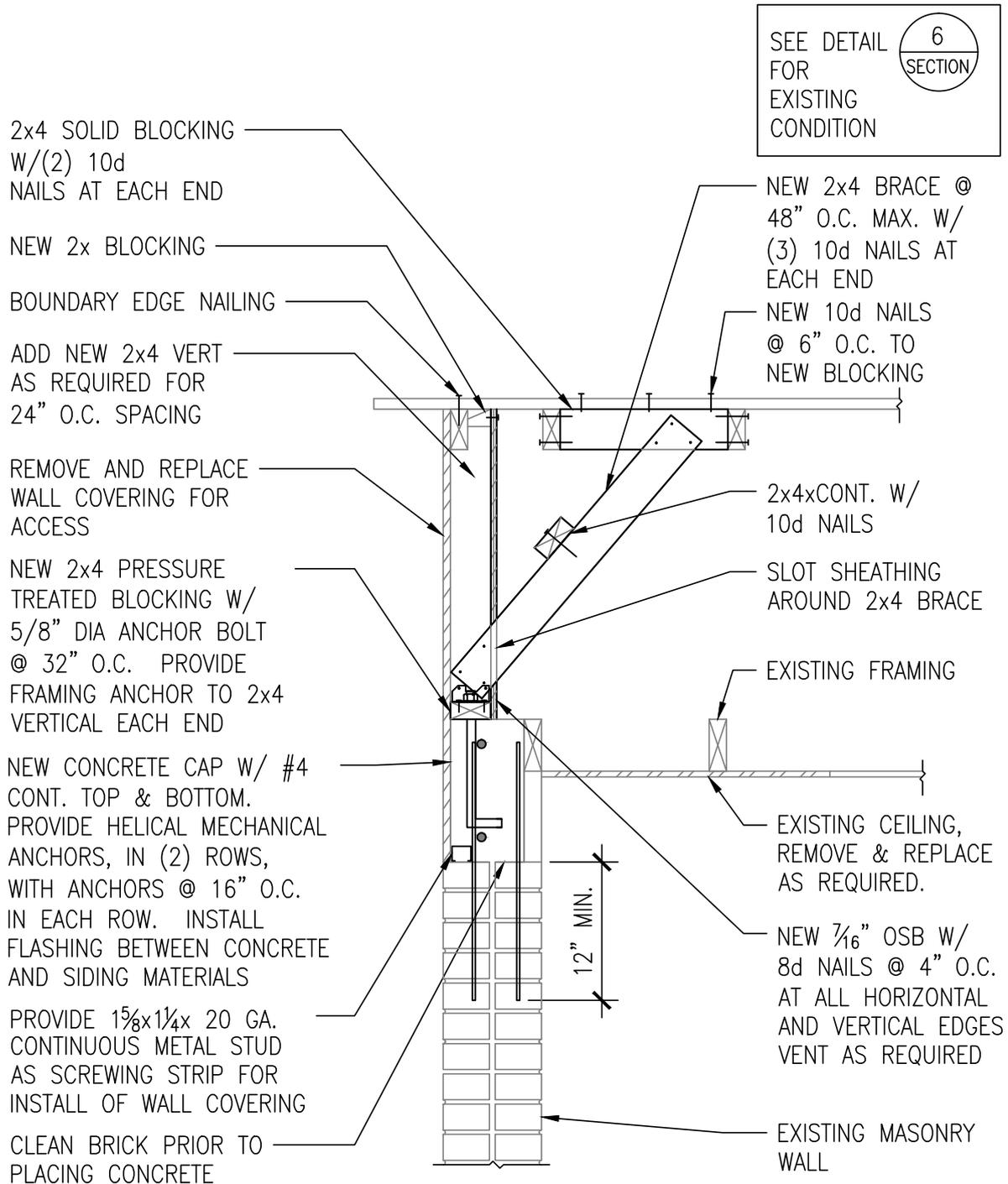
13
SECTION



36b
ROOF

ROOF TO URM WALL ANCHORAGE W/ JOISTS PARALLEL TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL G	Roof to URM Wall Anchorage	DETAIL: 36b
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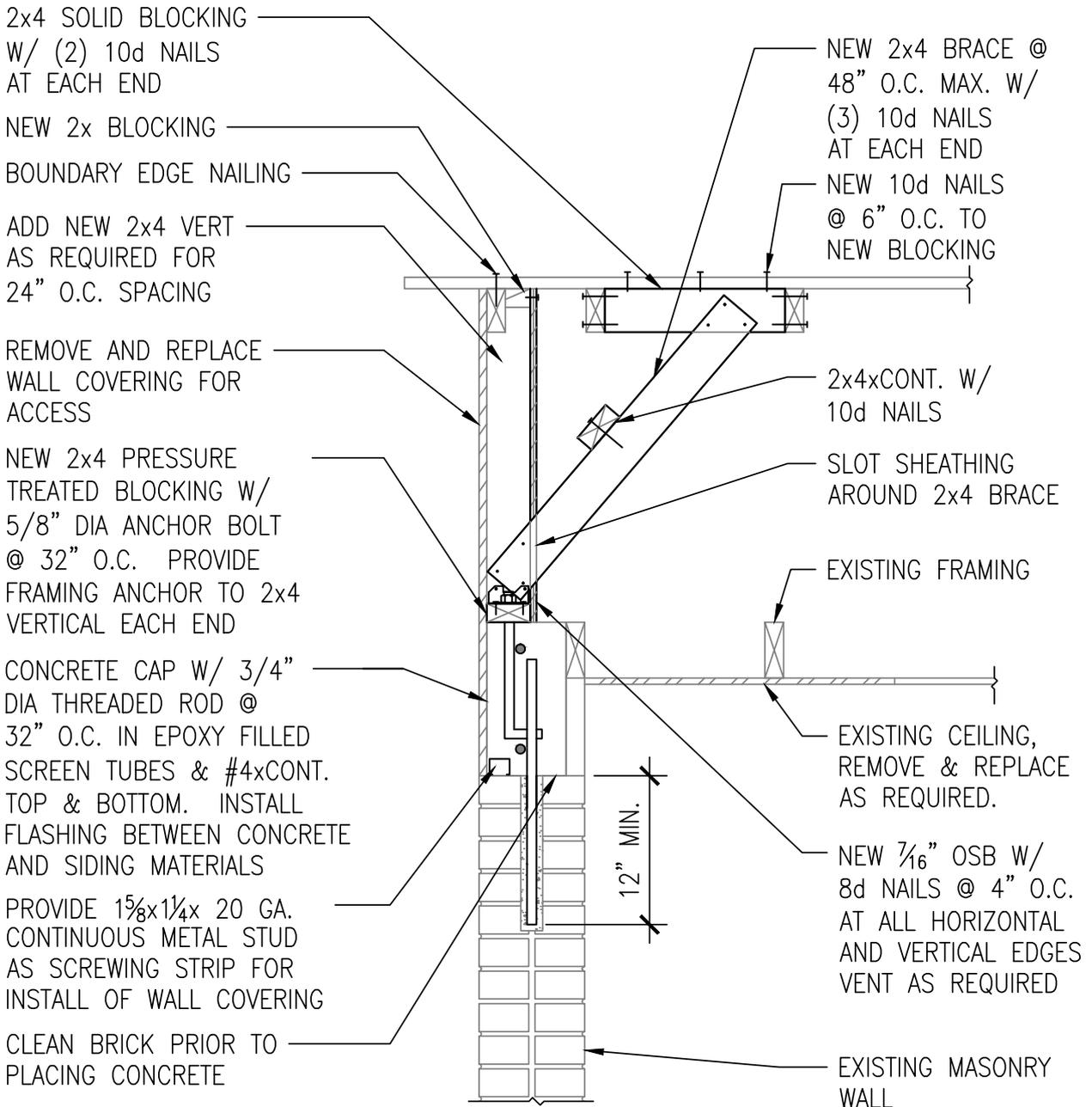
37 ROOF TO URM WALL ANCHORAGE W/ JOISTS PARALLEL TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL C & D	Roof to URM Wall Anchorage	DETAIL: 37
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NOTE:

DRILLING AND PLACEMENT OF VERTICAL EPOXY BOLTS INTO URM WALLS MUST BE DONE WITH EXTREME CAUTION TO AVOID FRACTURE OF WALLS AND THE RESULTING INCREASED REPAIR EFFORT AND COST.

SEE DETAIL 6 SECTION FOR EXISTING CONDITION

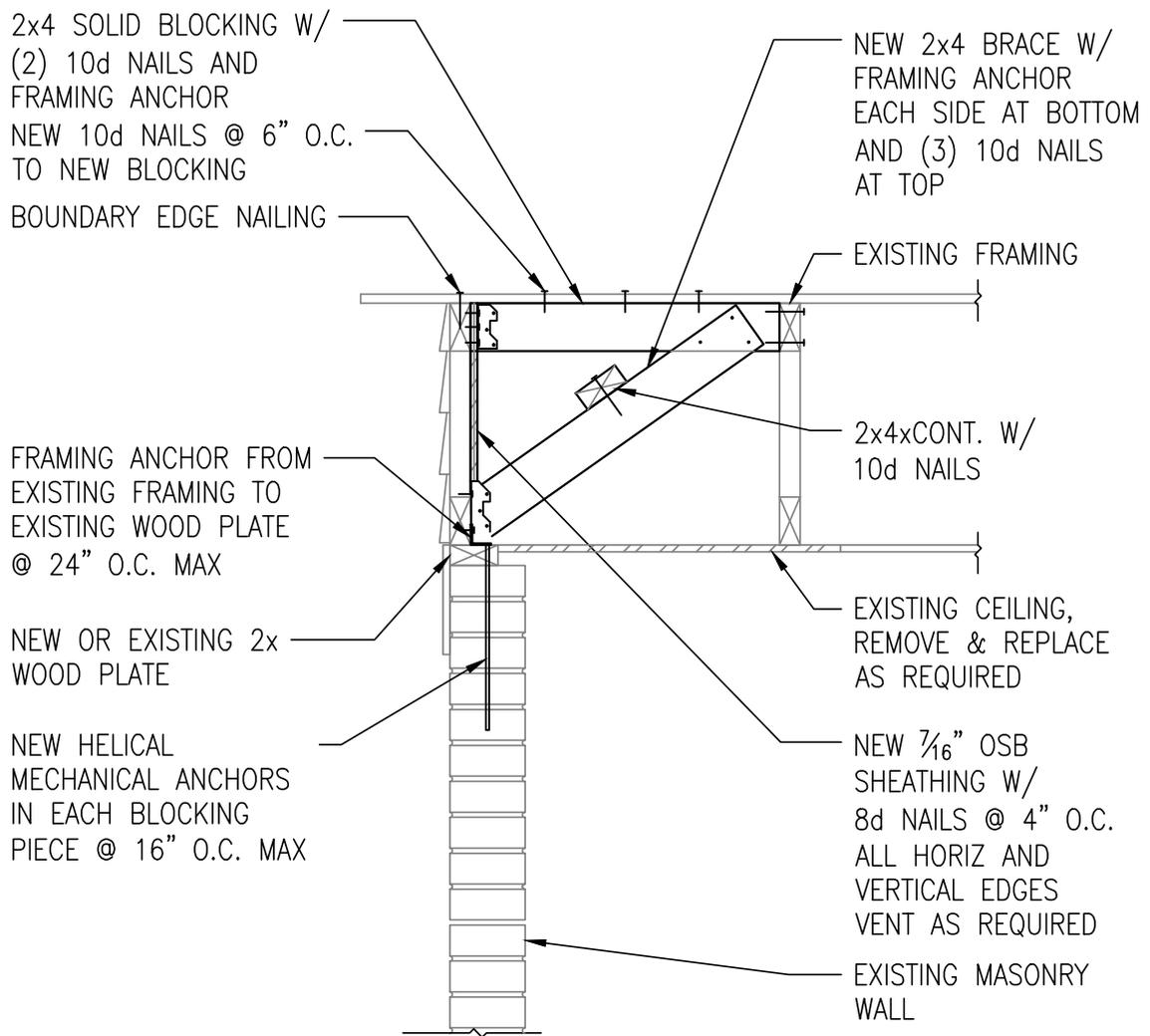


37a ROOF TO URM WALL ANCHORAGE W/ JOISTS PARALLEL TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL C	Roof to URM Wall Anchorage	DETAIL: 37a
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SEE DETAIL FOR EXISTING CONDITION

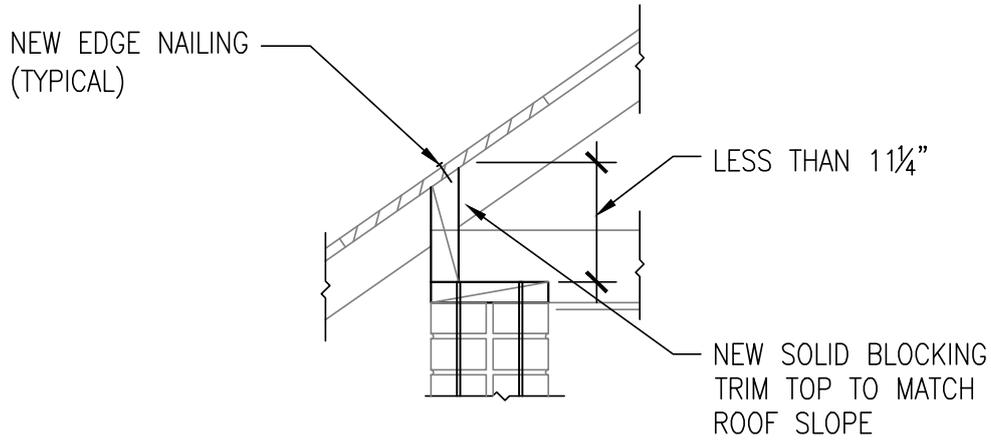
10
SECTION



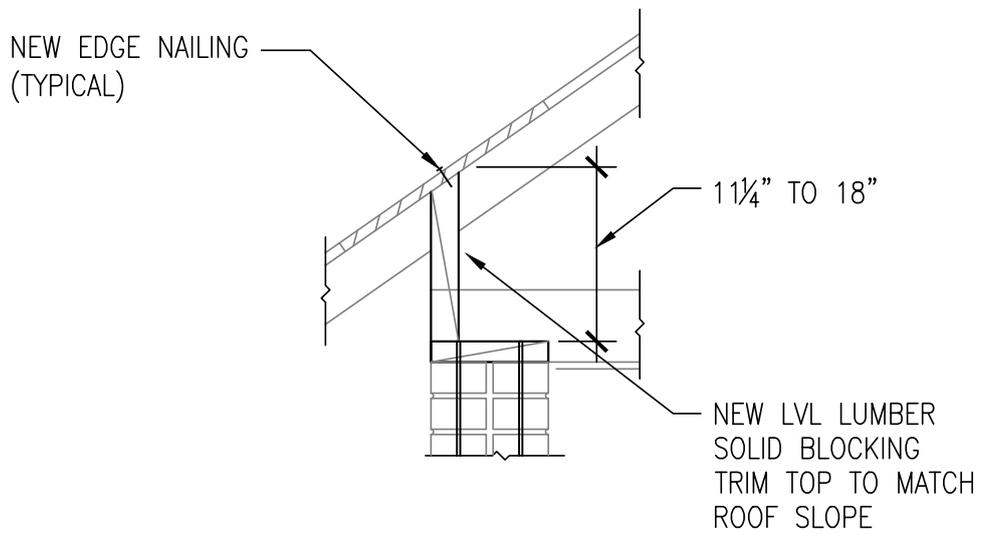
38
ROOF

**ROOF TO URM WALL ANCHORAGE W/
JOISTS PARALLEL TO WALL**

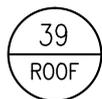
Seismic Improvement Structural Detail	HOME TYPE: MODEL E	Roof to URM Wall Anchorage	DETAIL: 38
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ANCHOR BLOCKING OPTION #1
LESS THAN 1 1/4"



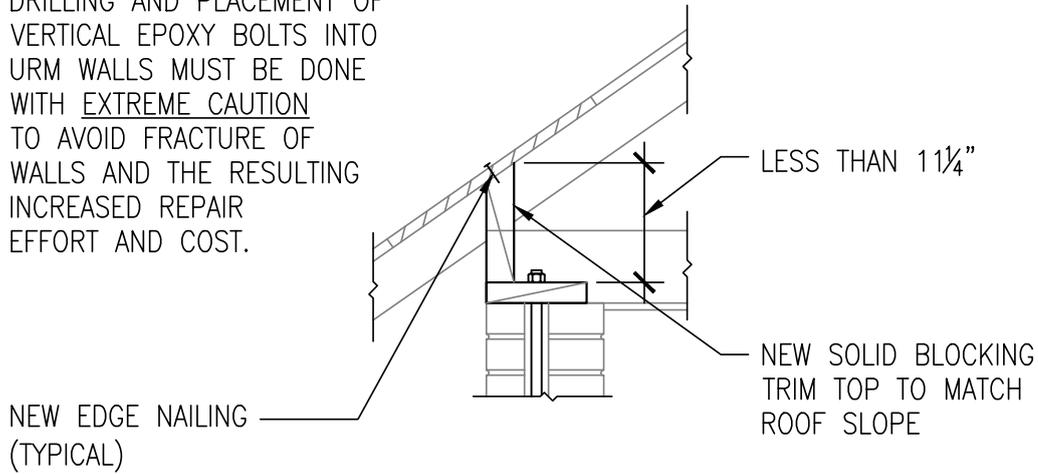
ANCHOR BLOCKING OPTION #2
1 1/4" TO 18"



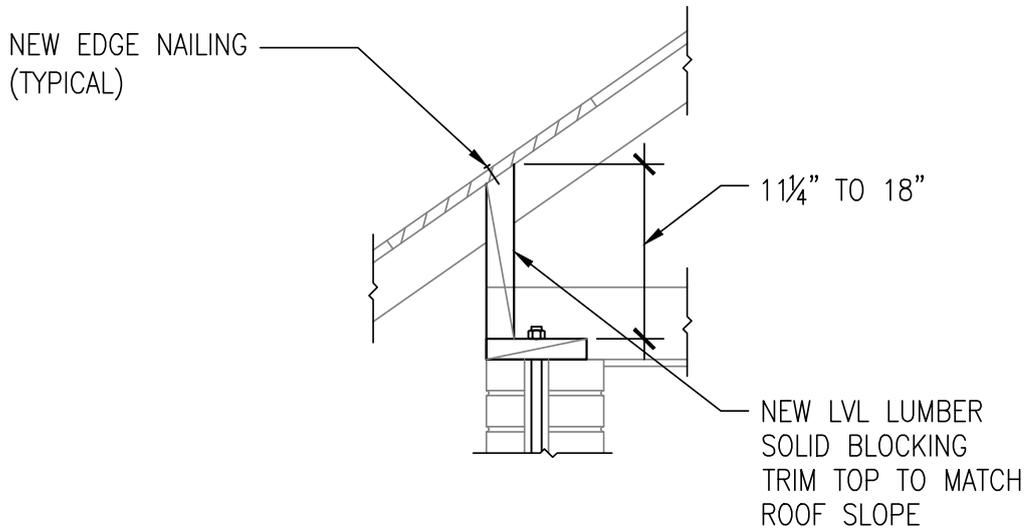
EDGE BLOCKING OPTIONS AT TRUSSED OR STICK FRAME ROOF

<p>Seismic Improvement Structural Detail</p>	<p>HOME TYPE: MODEL A & B</p>	<p>Roof Diaphragm Strengthening</p>	<p>DETAIL: 39</p>
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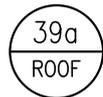
NOTE:
 DRILLING AND PLACEMENT OF
 VERTICAL EPOXY BOLTS INTO
 URM WALLS MUST BE DONE
 WITH EXTREME CAUTION
 TO AVOID FRACTURE OF
 WALLS AND THE RESULTING
 INCREASED REPAIR
 EFFORT AND COST.



ANCHOR BLOCKING OPTION #1
LESS THAN 1 1/4"

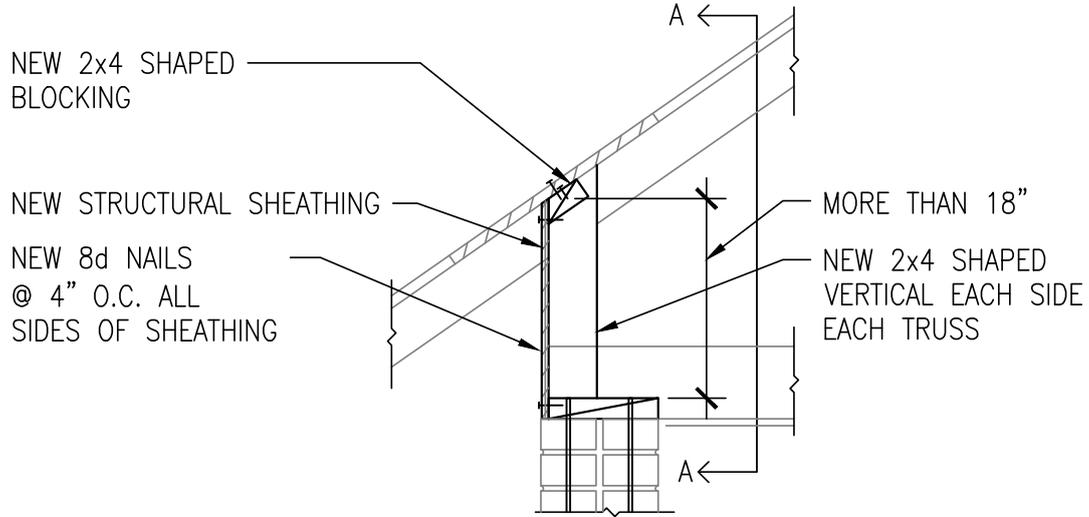


ANCHOR BLOCKING OPTION #2
1 1/4" TO 18"

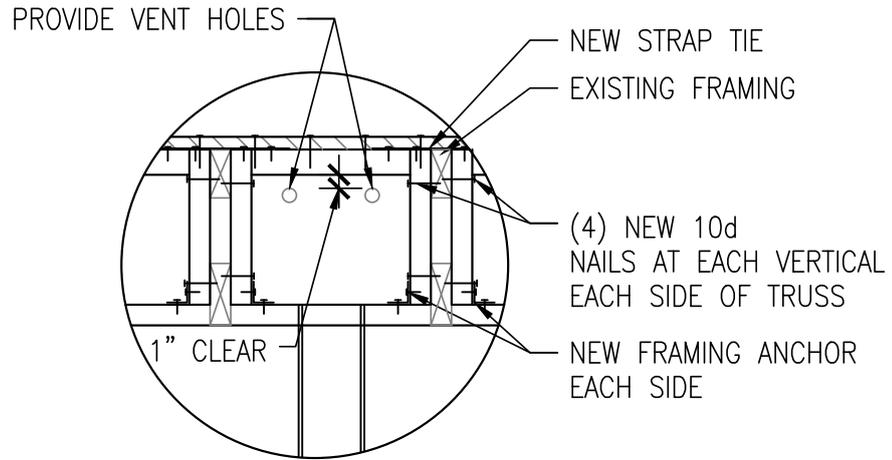


**EDGE BLOCKING OPTIONS AT
 TRUSSED OR STICK FRAME ROOF**

Seismic Improvement Structural Detail	HOME TYPE: MODEL A & B	Roof Diaphragm Strengthening	DETAIL: 39a
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ANCHOR BLOCKING OPTION #3
MORE THAN 18"



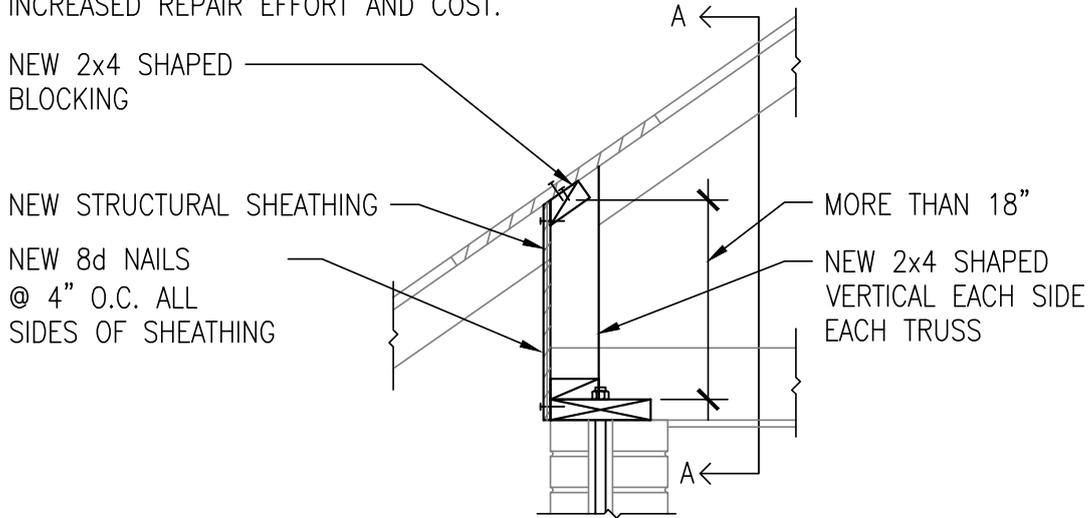
SECTION A-A



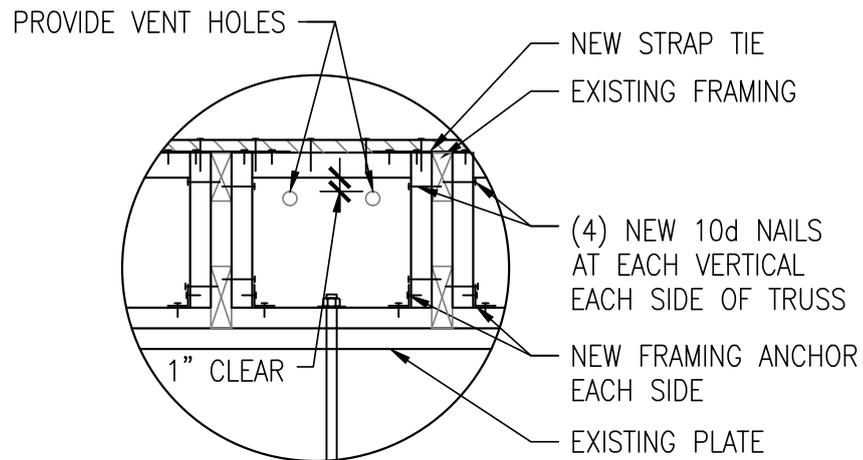
EDGE BLOCKING OPTIONS AT TRUSSED ROOF

Seismic Improvement Structural Detail	HOME TYPE: MODEL A & B	Roof Diaphragm Strengthening	DETAIL: 40
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NOTE:
 DRILLING AND PLACEMENT OF VERTICAL EPOXY BOLTS
 INTO URM WALLS MUST BE DONE WITH EXTREME CAUTION
 TO AVOID FRACTURE OF WALLS AND THE RESULTING
 INCREASED REPAIR EFFORT AND COST.



ANCHOR BLOCKING OPTION #3
MORE THAN 18"

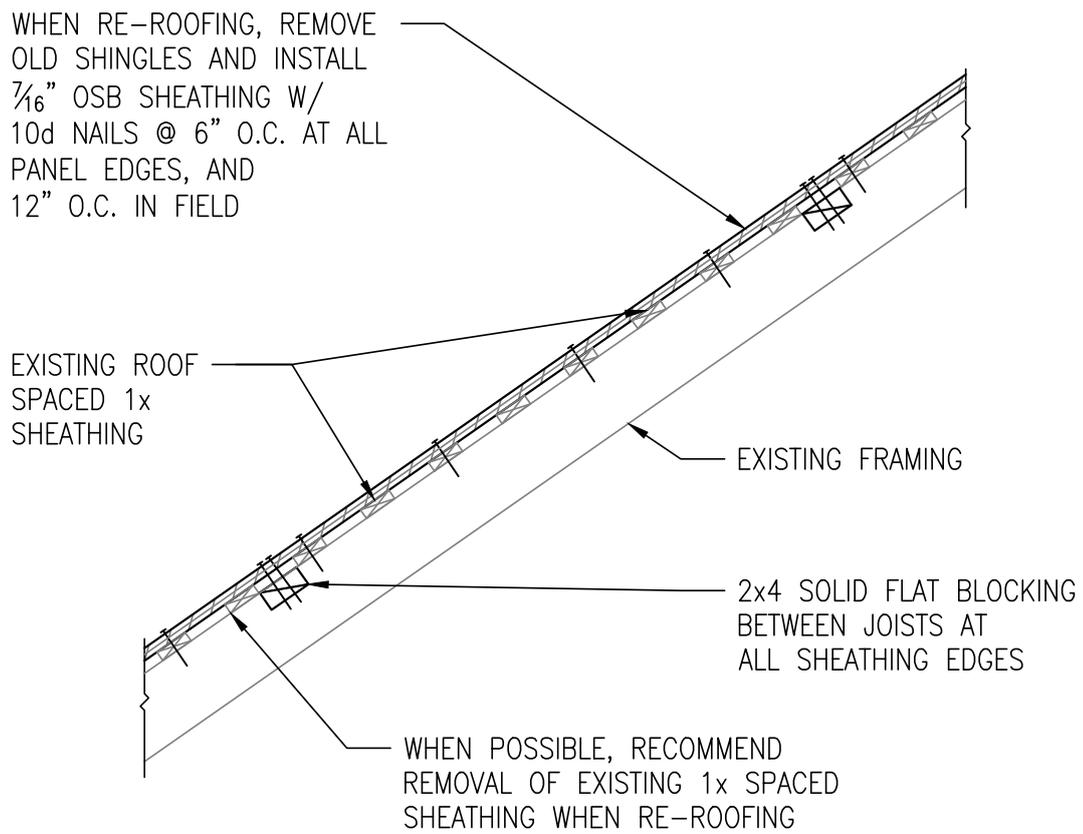


SECTION A-A



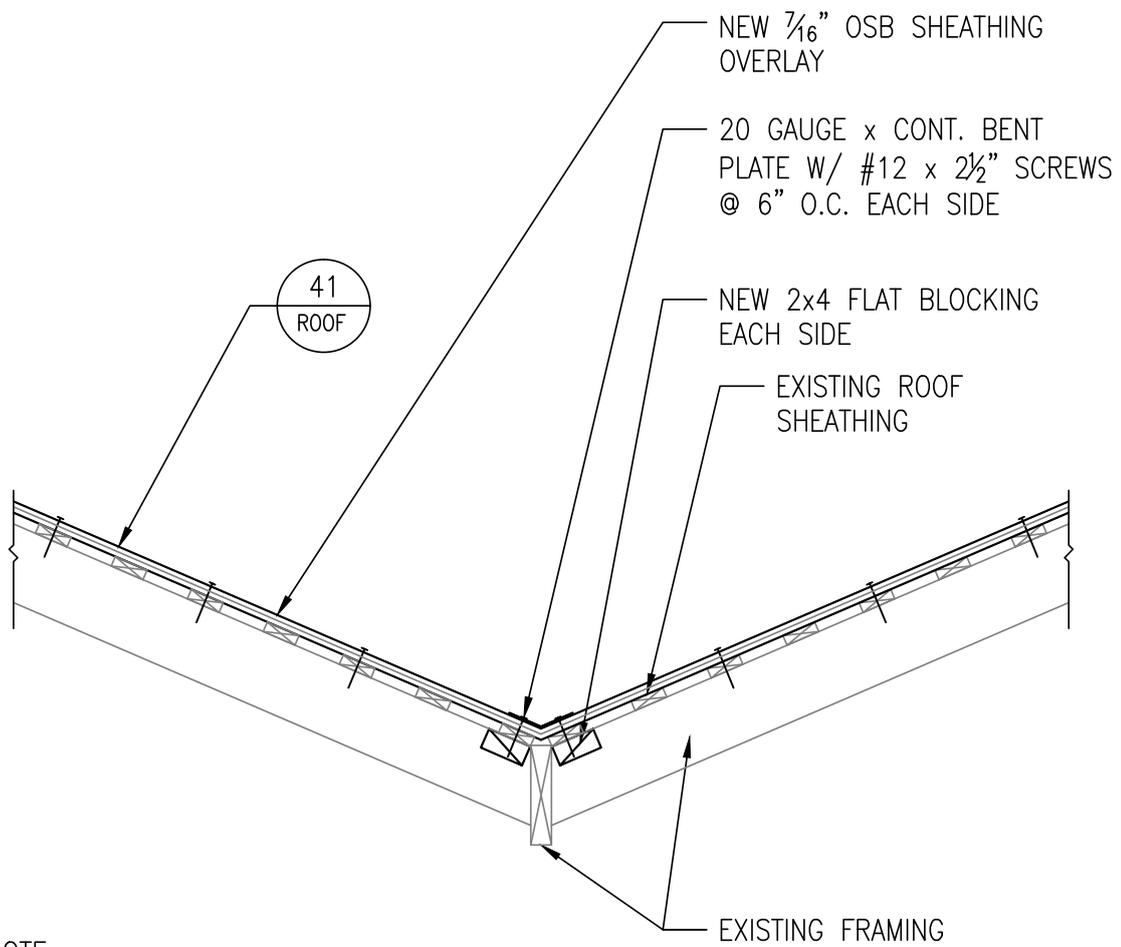
EDGE BLOCKING OPTIONS AT TRUSSED ROOF

Seismic Improvement Structural Detail	HOME TYPE: MODEL A & B	Roof Diaphragm Strengthening	DETAIL: 40a
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ROOF DIAPHRAGM STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: ALL MODELS	Roof Diaphragm Strengthening	DETAIL: 41
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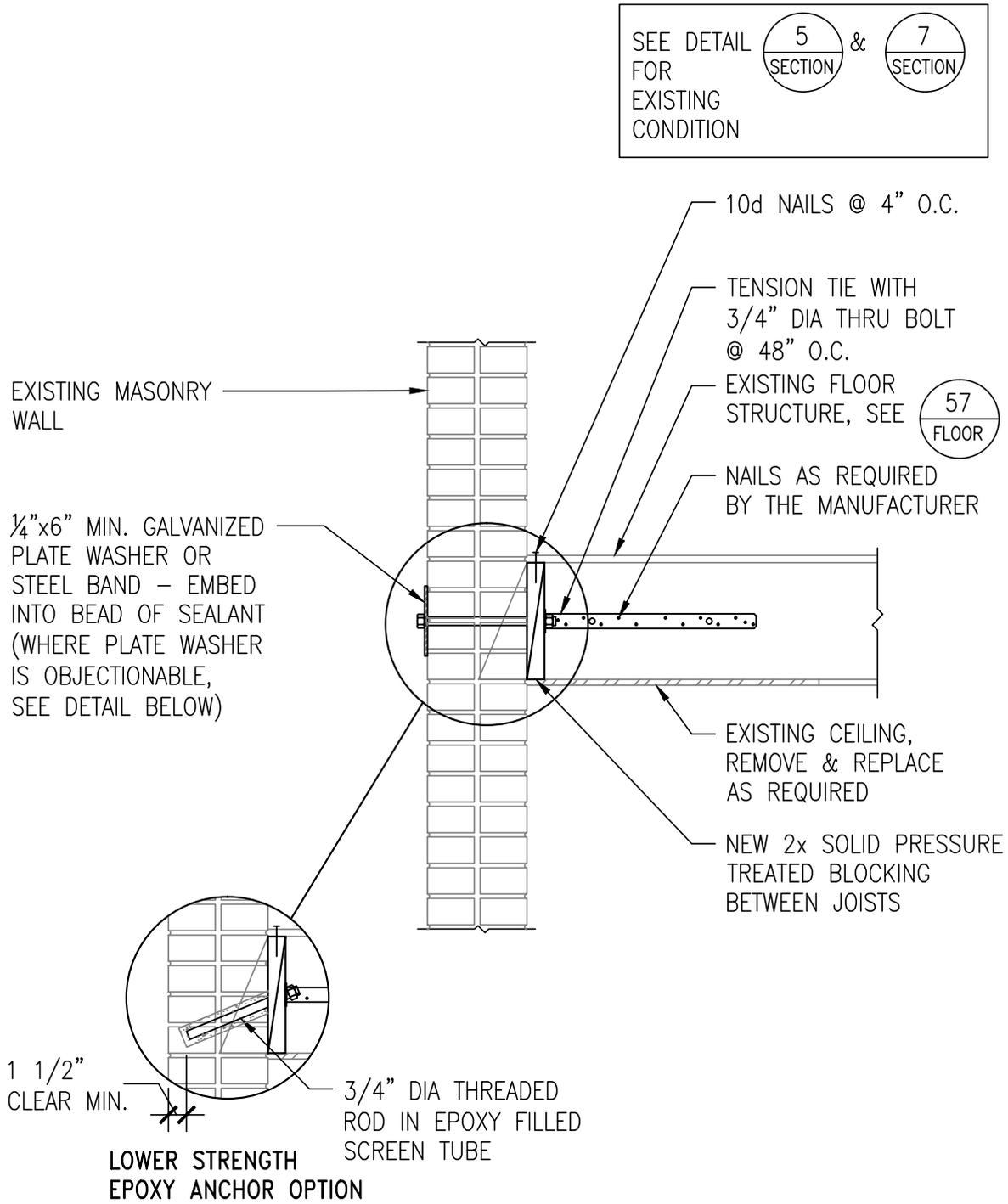
NOTE:
 SHEAR TRANSFER UPGRADE
 AT RIDGE AND HIP RIDGE SIMILAR.

42
 ROOF

SHEAR TRANSFER AT VALLEY

Seismic Improvement Structural Detail	HOME TYPE: ALL MODELS	Roof Diaphragm Strengthening	DETAIL: 42
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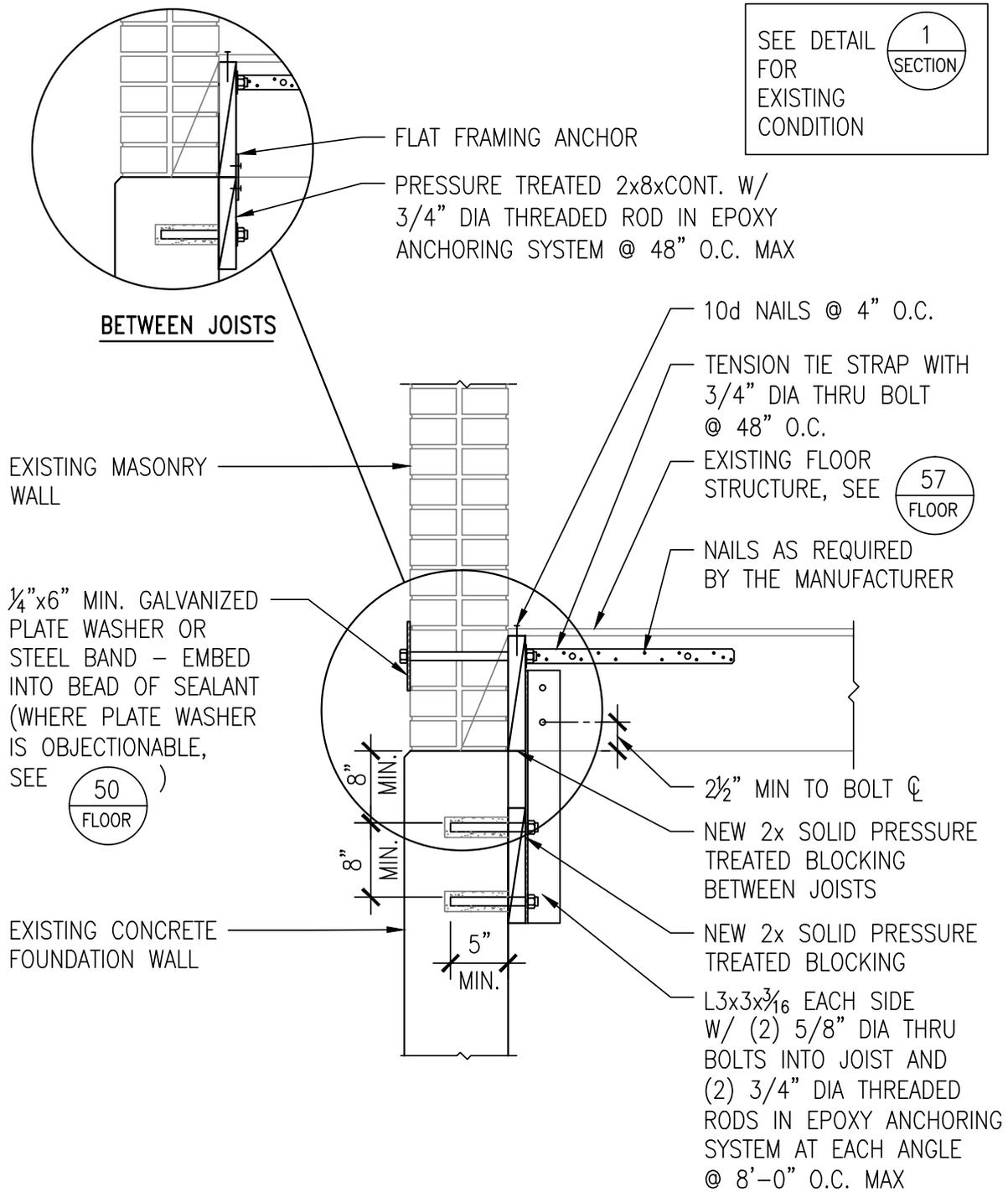
Floor anchorage and strengthening: Details 50–57



50
FLOOR

FLOOR TO URM WALL ANCHORAGE WITH JOISTS PERPENDICULAR TO WALL

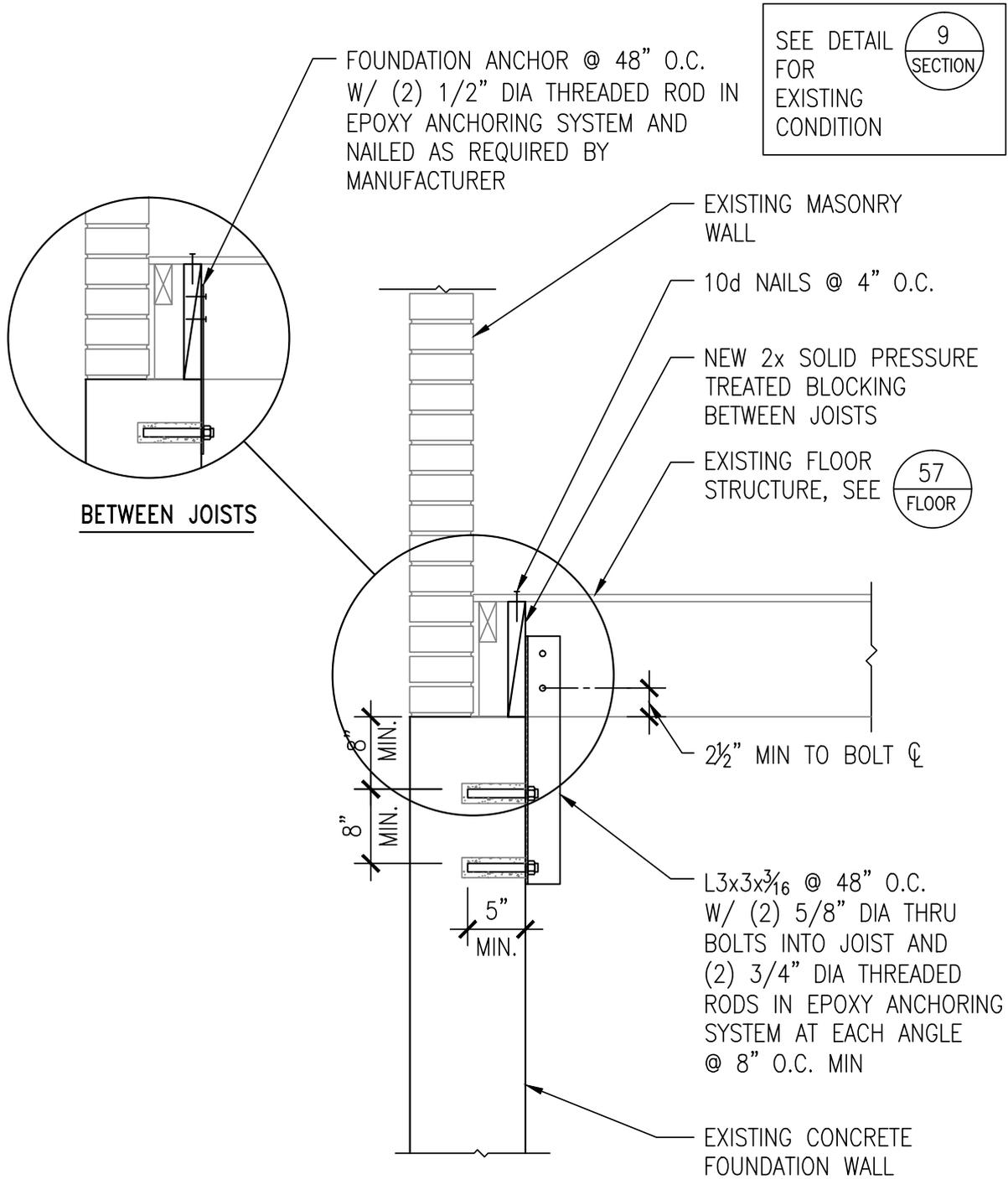
Seismic Improvement Structural Detail	HOME TYPE: MODEL C & D	Floor to URM Wall Anchorage	DETAIL: 50
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51
FLOOR

FLOOR TO URM WALL & FOUNDATION WALL ANCHORAGE W/JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL A,B,C,D,&F	Floor to URM Wall Anchorage	DETAIL: 51
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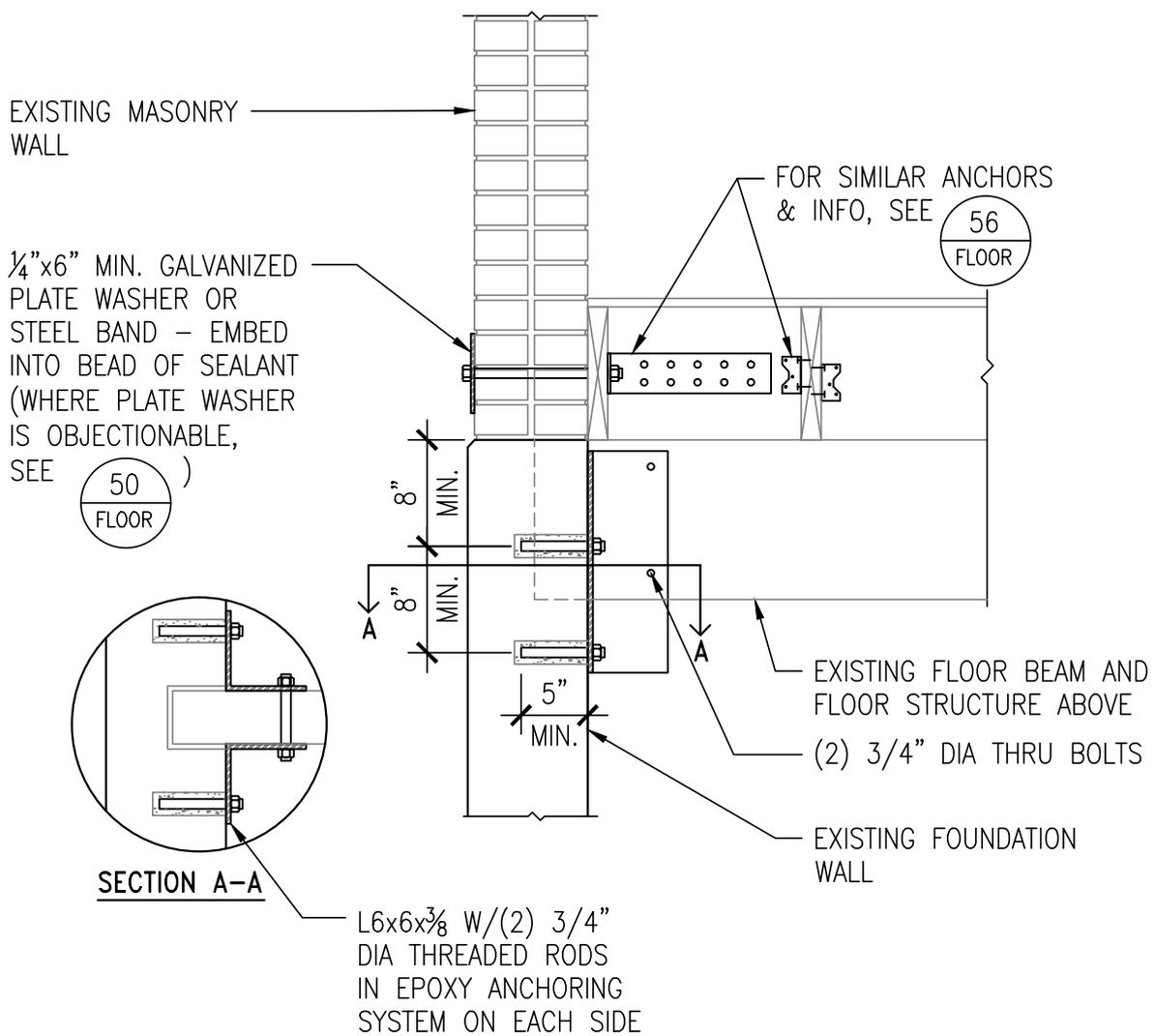


52
FLOOR

FLOOR TO URM WALL & FOUNDATION WALL ANCHORAGE W/JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HOME TYPE: MODEL E	Floor to URM Wall Anchorage	DETAIL: 52
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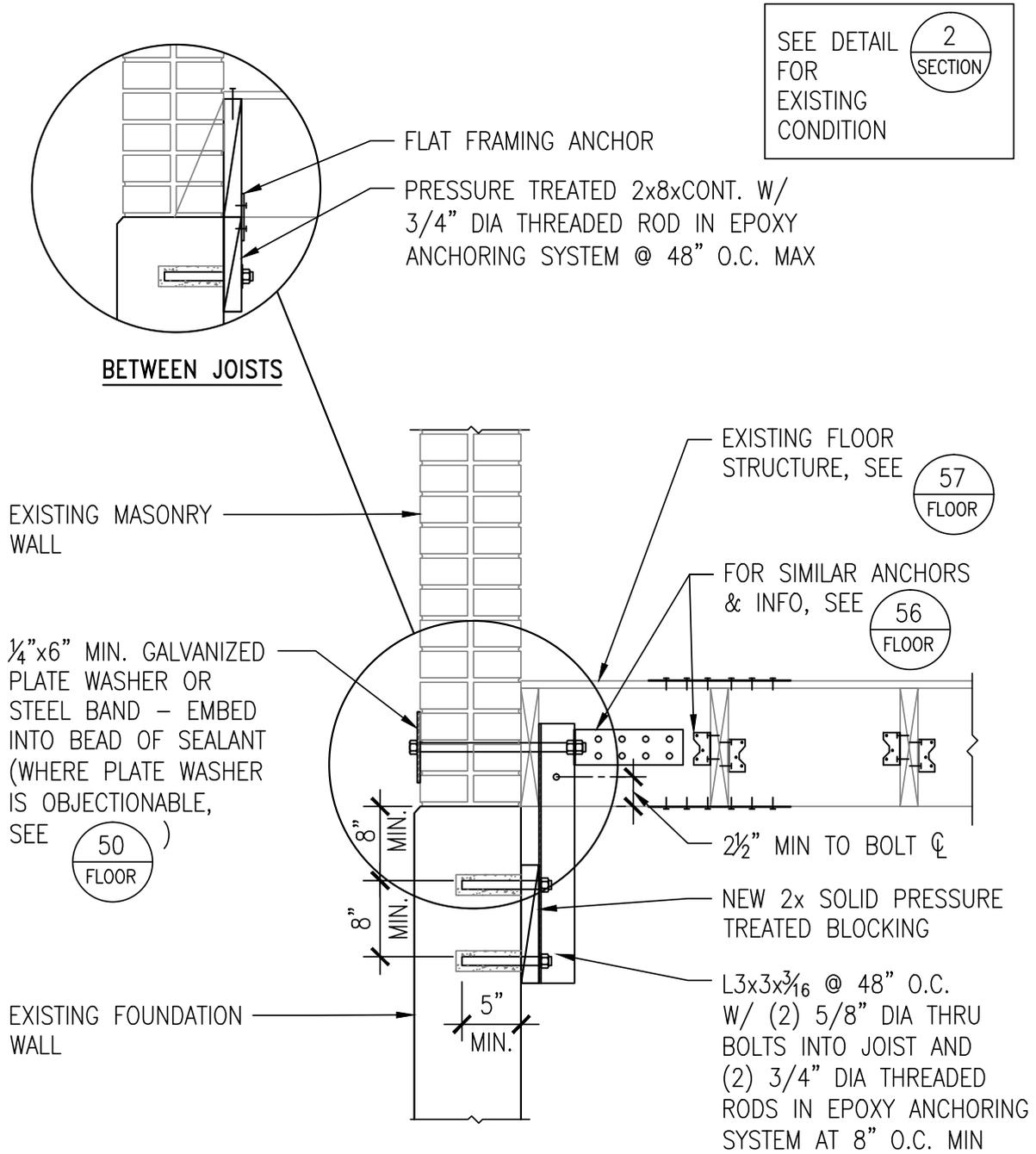
SEE DETAIL 2
FOR
EXISTING
CONDITION



53
FLOOR

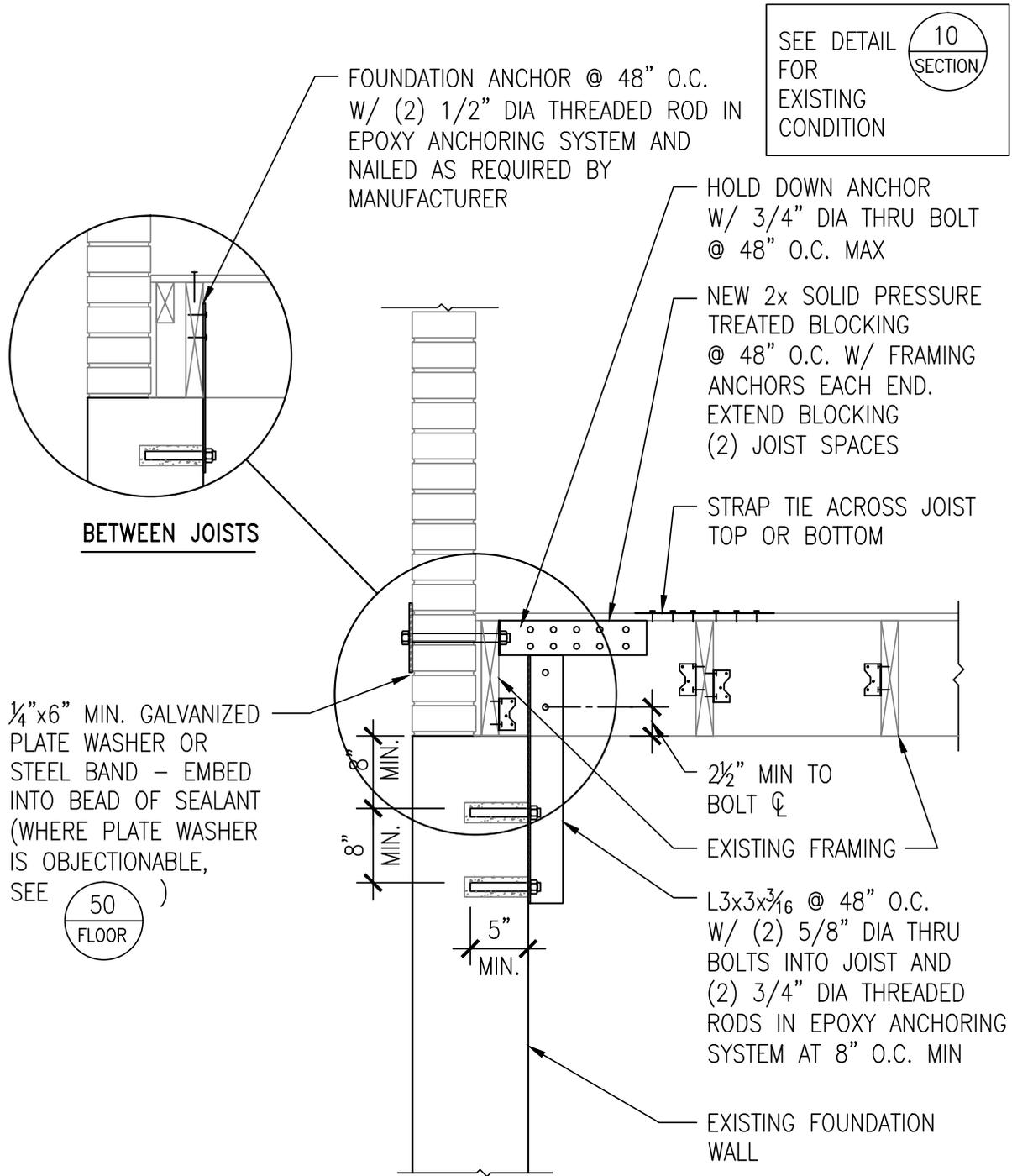
FLOOR BEAM TO FOUNDATION WALL ANCHORAGE

Seismic Improvement Structural Detail	HOME TYPE: MODEL A,B,C,&D	Floor to URM Wall Anchorage	DETAIL: 53
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FLOOR TO URM WALL & FOUNDATION WALL ANCHORAGE W/JOISTS PARALLEL TO WALL FLOOR 54

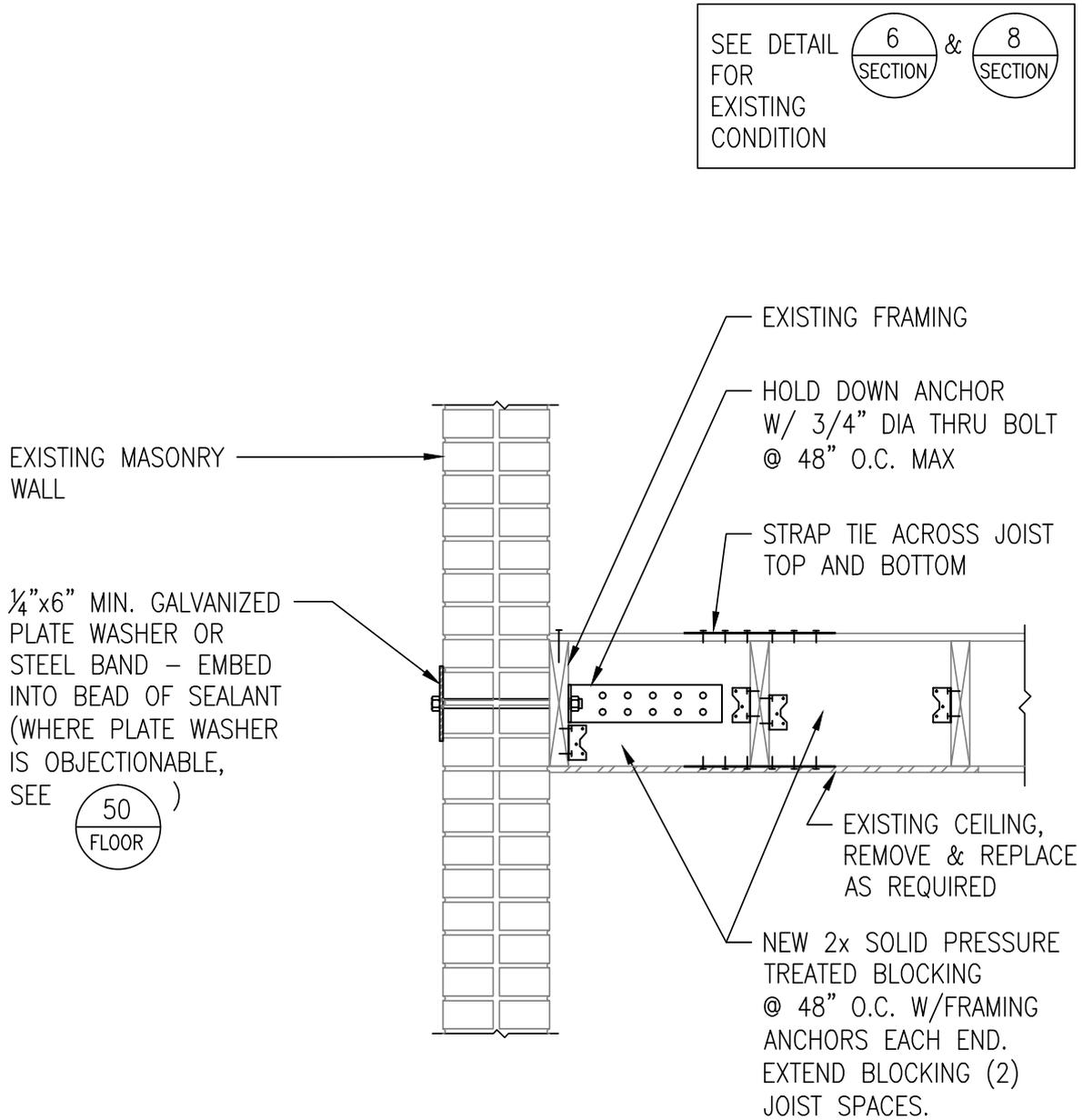
Seismic Improvement Structural Detail	HOME TYPE: MODEL A,B,C,&D	Floor to URM Wall Anchorage	DETAIL: 54
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55 FLOOR

FLOOR TO URM WALL & FOUNDATION WALL ANCHORAGE W/JOISTS PARALLEL TO WALL

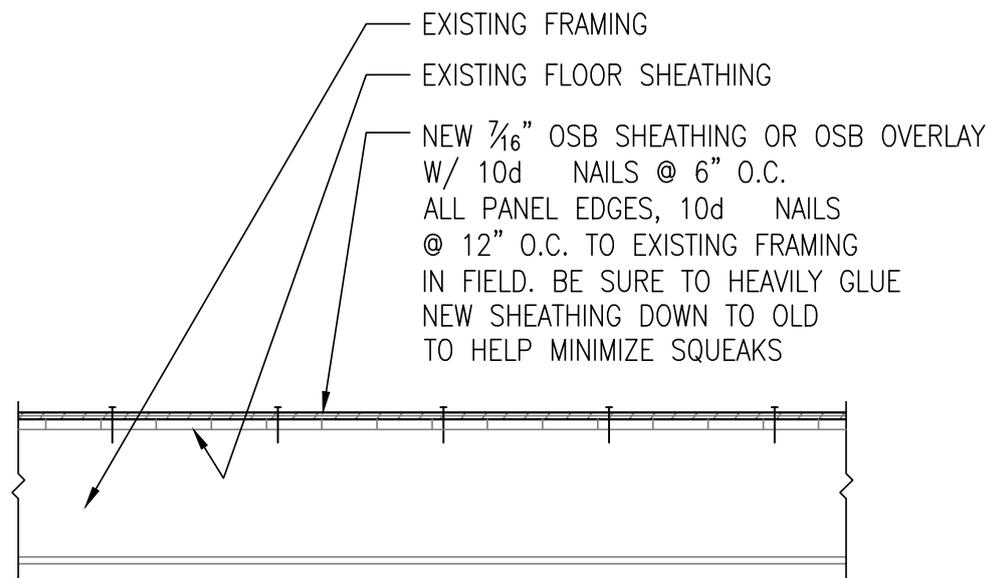
Seismic Improvement Structural Detail	HOME TYPE: MODEL E	Floor to URM Wall Anchorage	DETAIL: 55
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56
FLOOR

FLOOR TO URM WALL ANCHORAGE WITH JOISTS PARALLEL TO WALL

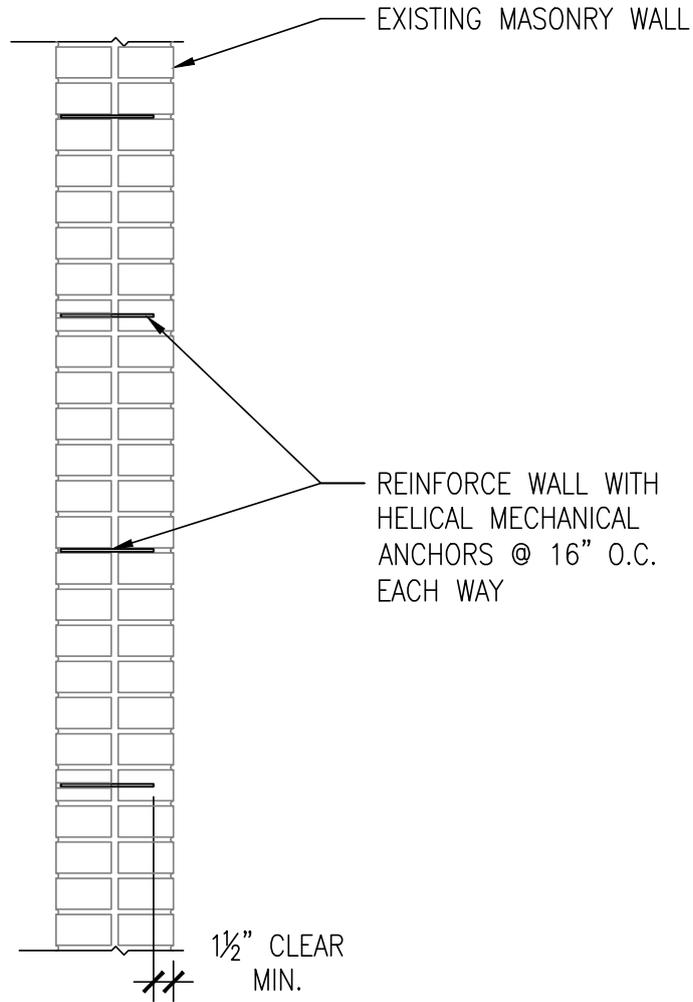
Seismic Improvement Structural Detail	HOME TYPE: MODEL C & D	Floor to URM Wall Anchorage	DETAIL: 56
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FLOOR DIAPHRAGM STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: ALL MODELS	Floor Diaphragm Strengthening	DETAIL: 57
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Wall strengthening: Details 70–82

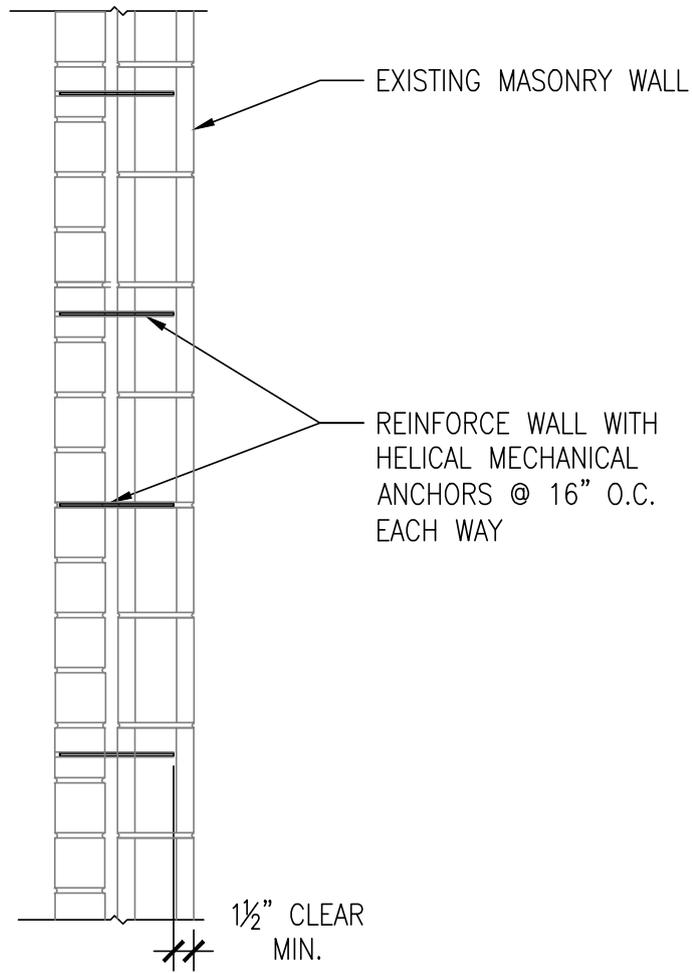


NOTE:
HELICAL TIES MAY BE
INSTALLED IN MULTI-WYTHE
BRICK WALLS IF BENEFICIAL



URM WALL STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: VARIES	URM Wall Strengthening	DETAIL: 70
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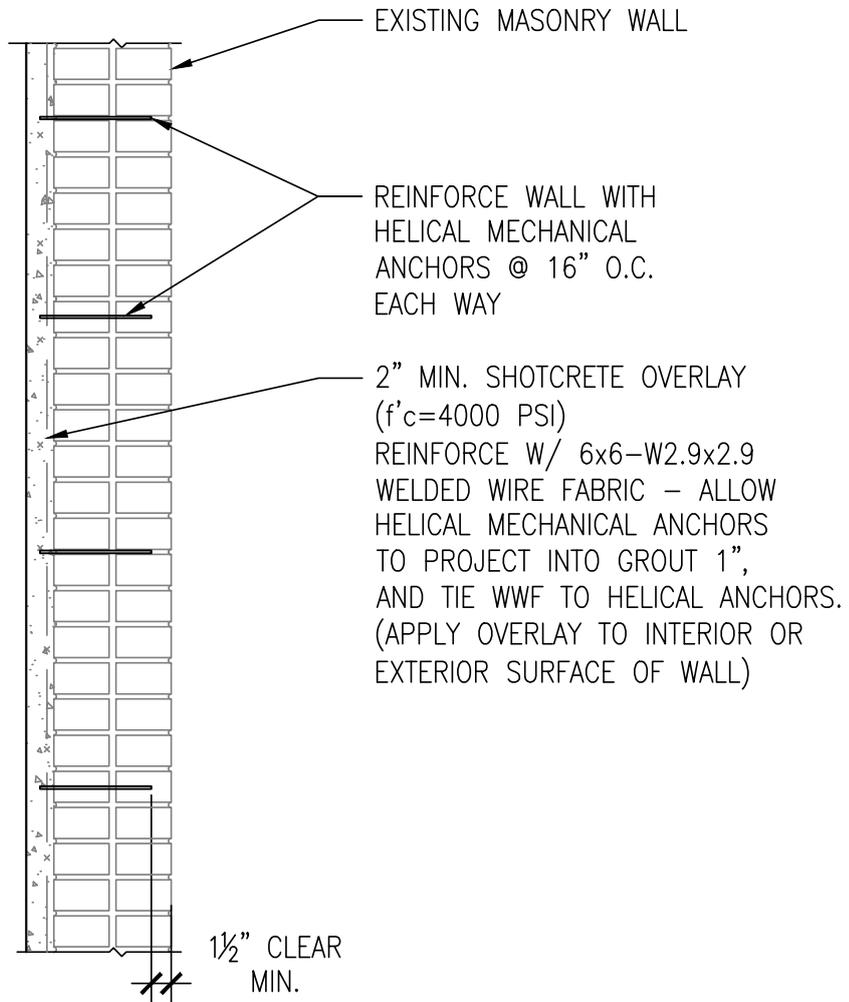


NOTE:
 HELICAL TIES MAY BE
 INSTALLED IN MULTI-WYTHE
 BRICK WALLS IF BENEFICIAL



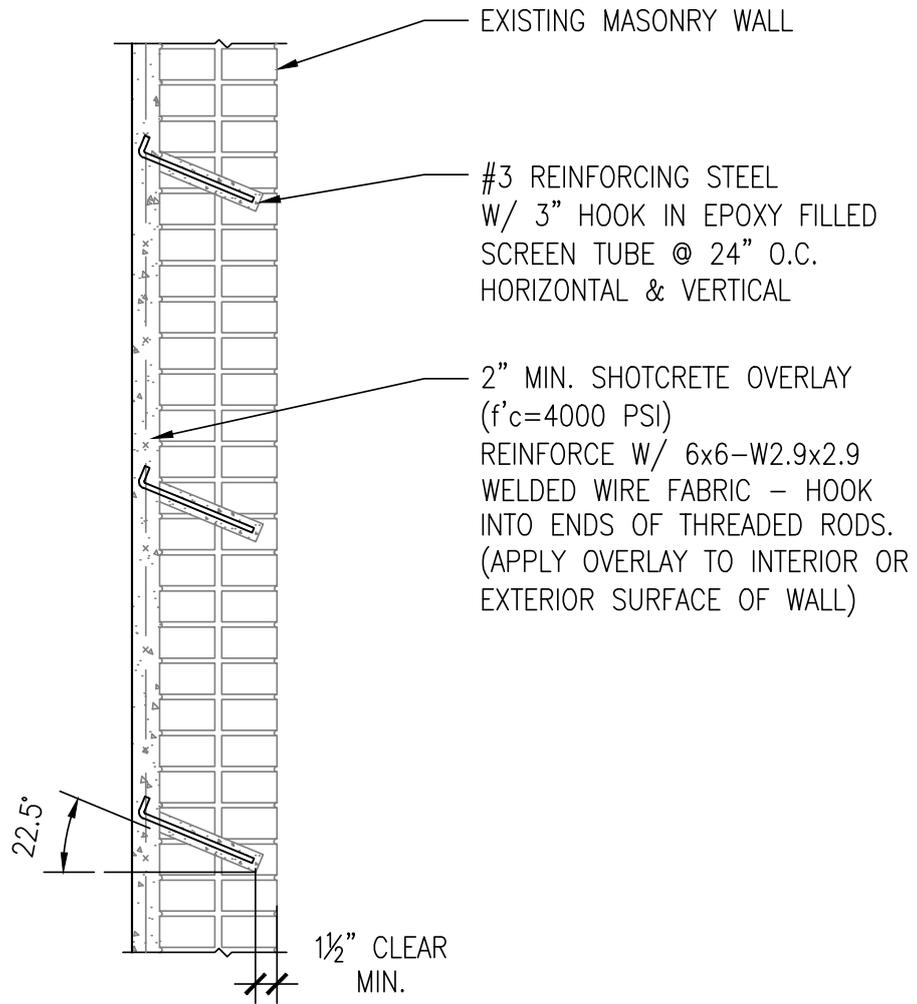
URM WALL STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: VARIES	URM Wall Strengthening	DETAIL: 71
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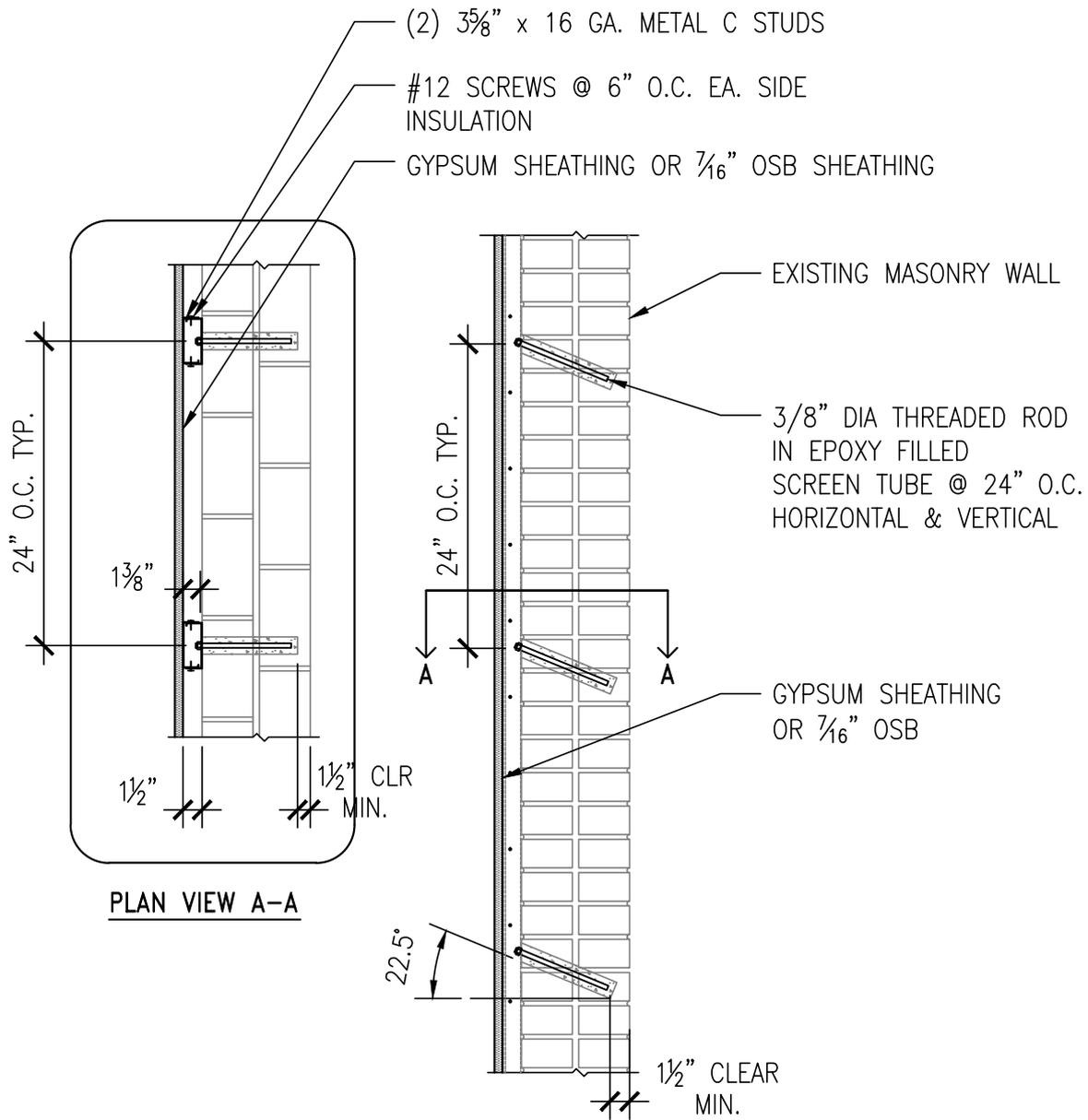
URM WALL STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: VARIES	URM Wall Strengthening	DETAIL: 72
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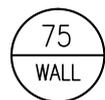
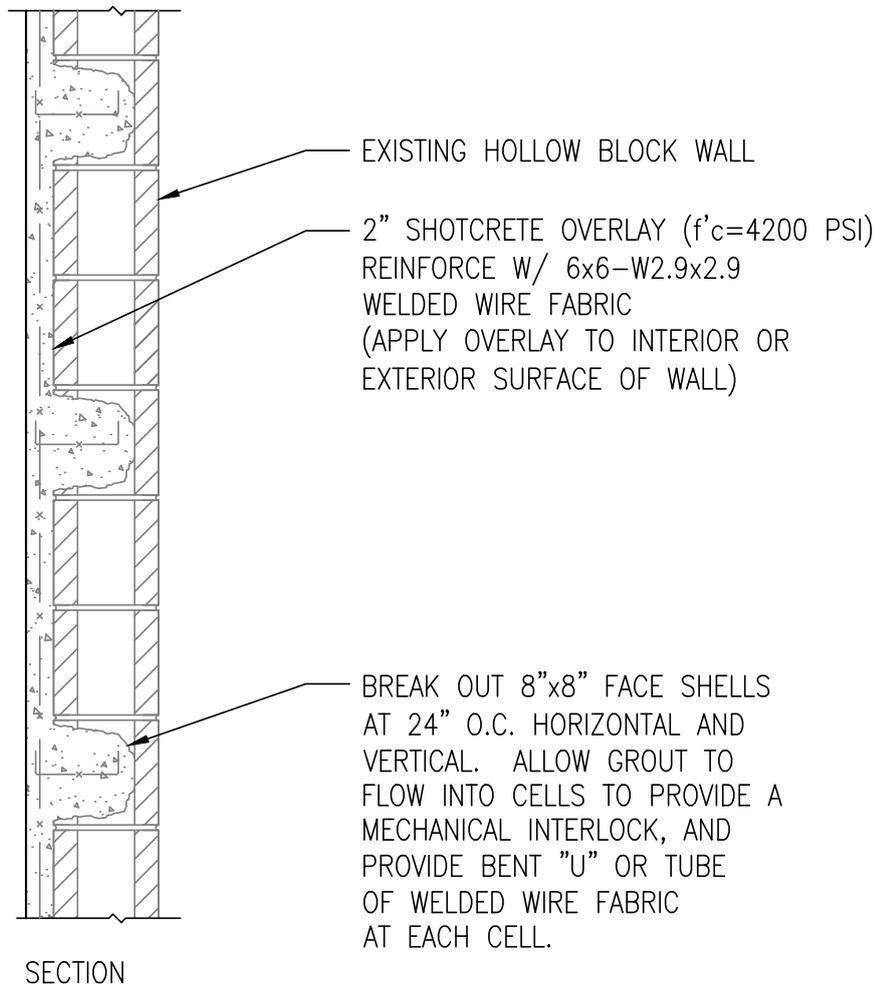
URM WALL STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: VARIES	URM Wall Strengthening	DETAIL: 73
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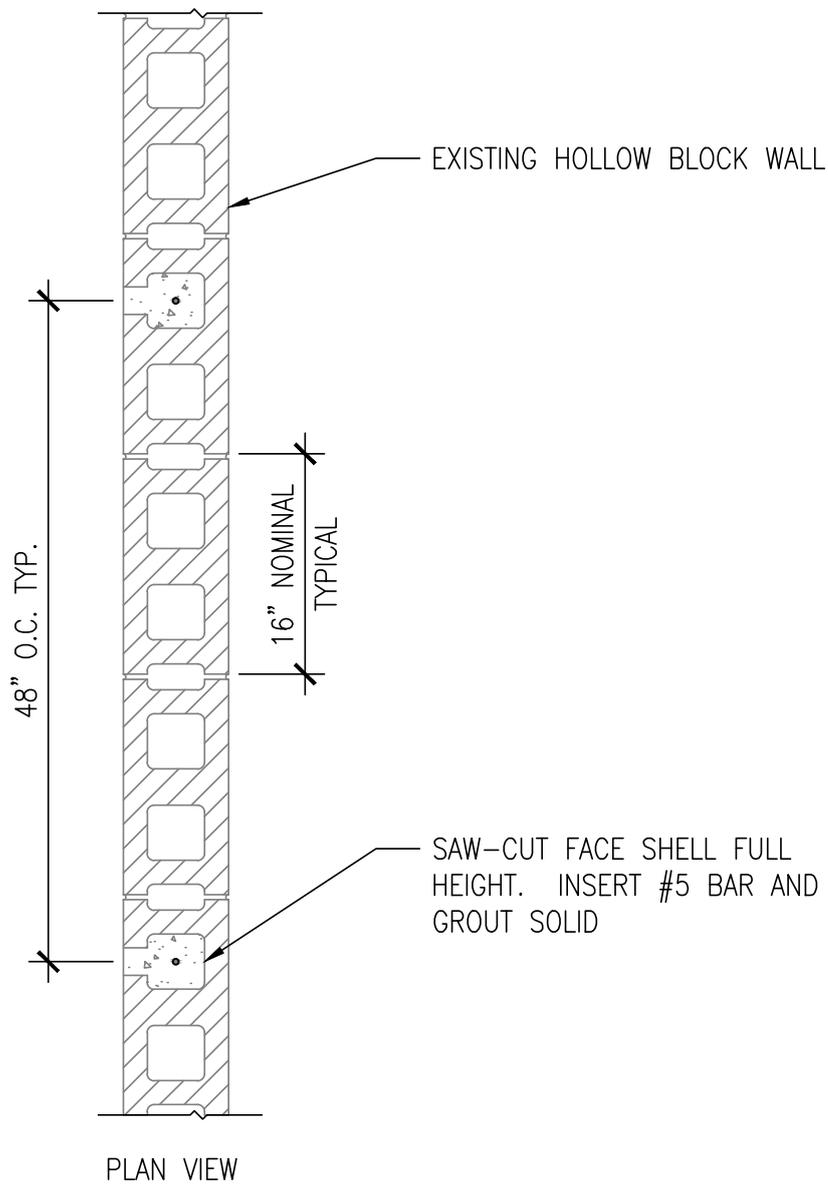
URM WALL STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: VARIES	URM Wall Strengthening	DETAIL: 74
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URM WALL STRENGTHENING

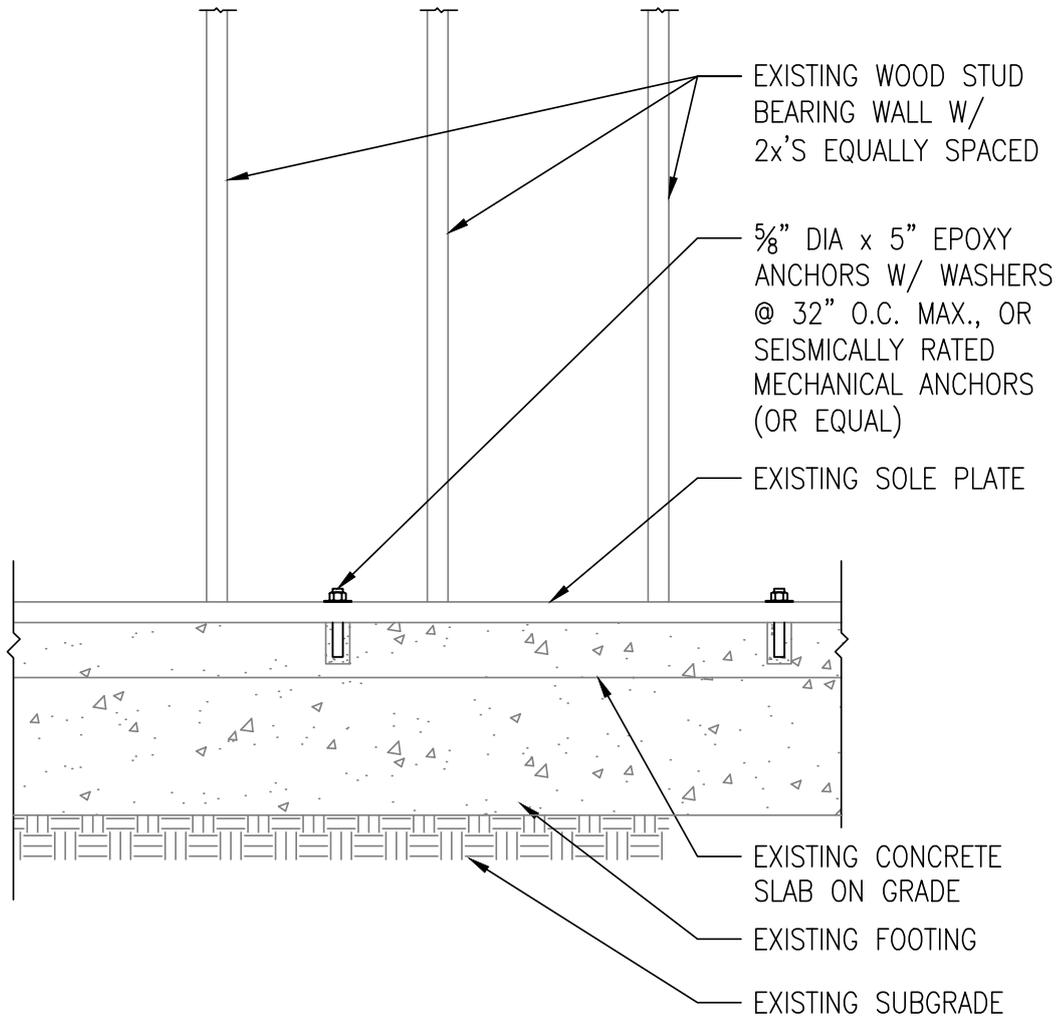
Seismic Improvement Structural Detail	HOME TYPE: MODEL F	URM Wall Strengthening	DETAIL: 75
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76
WALL

URM WALL STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: MODEL F	URM Wall Strengthening	DETAIL: 76
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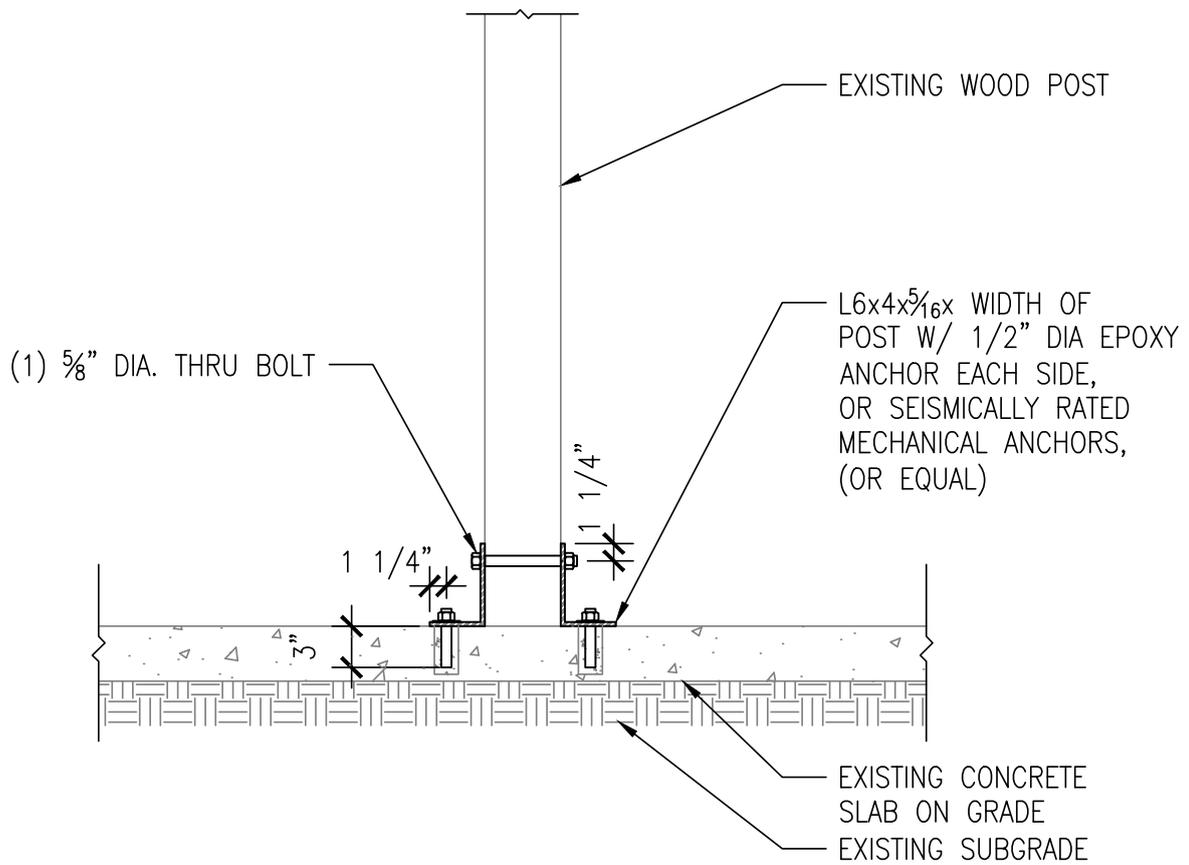


NOTE:
 WALL SHEATHING (USUALLY PLASTER OR GYPSUM BOARD) NOT SHOWN FOR CLARITY. REMOVE AND REPLACE AS REQUIRED FOR CONSTRUCTION.



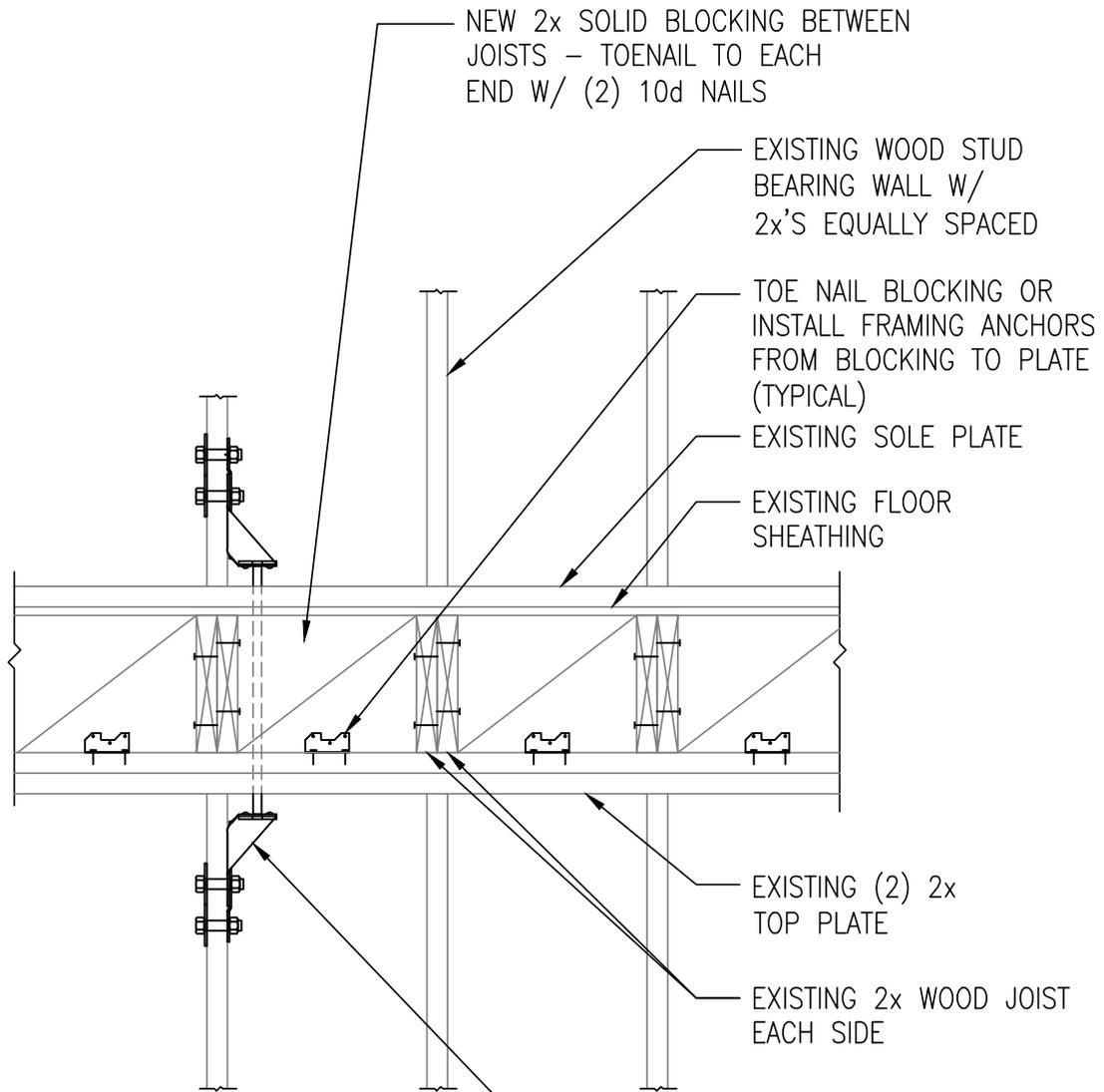
INTERIOR BEARING WALL TO SLAB ANCHORAGE

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Interior Bearing Strengthening	DETAIL: 77
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INTERIOR POST TO SLAB ANCHORAGE

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Interior Bearing Strengthening	DETAIL: 78
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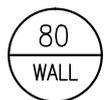
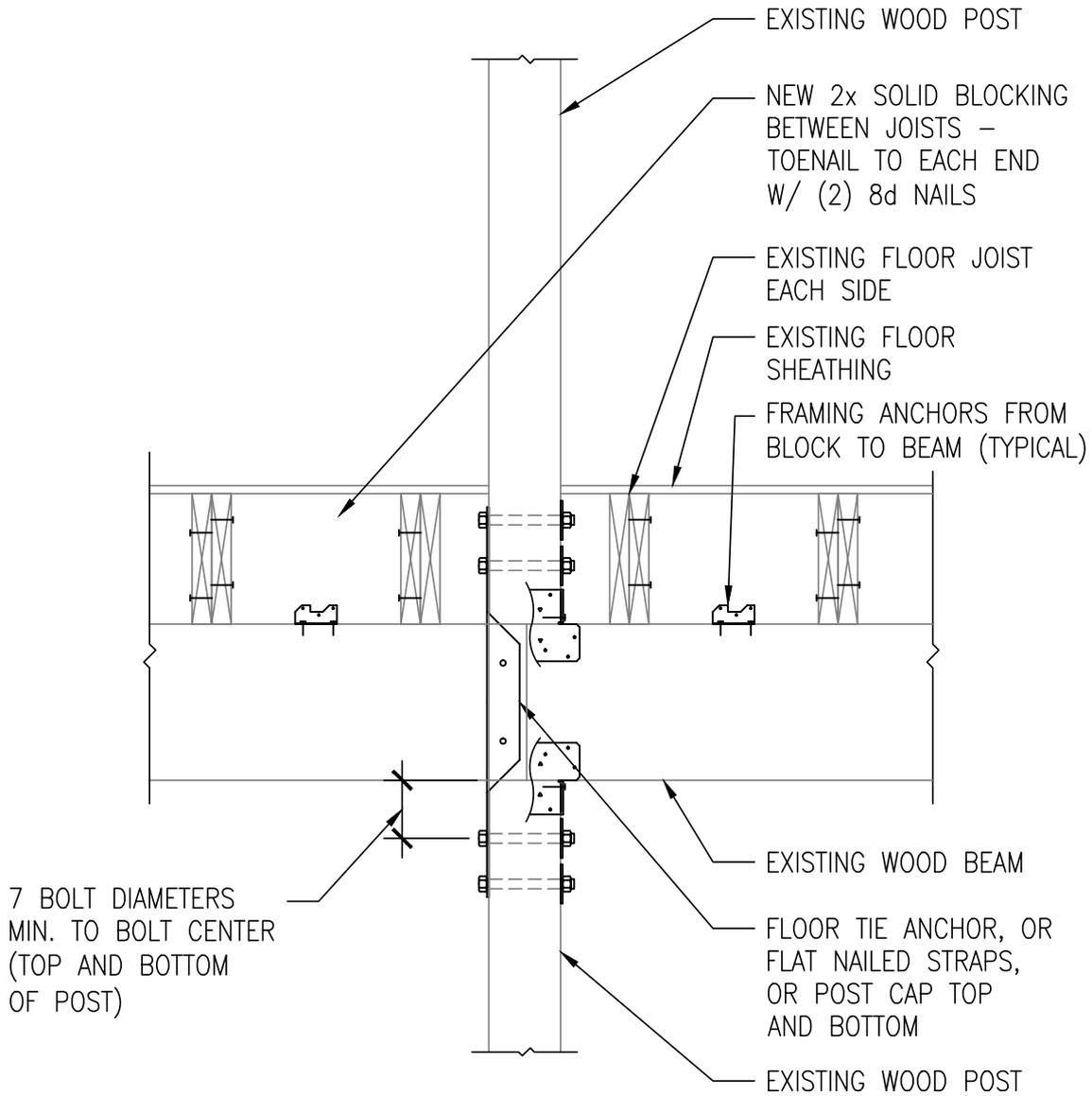


NOTE:
WALL SHEATHING (USUALLY PLASTER OR GYPSUM BOARD) NOT SHOWN FOR CLARITY. REMOVE AND REPLACE AS REQUIRED FOR CONSTRUCTION.



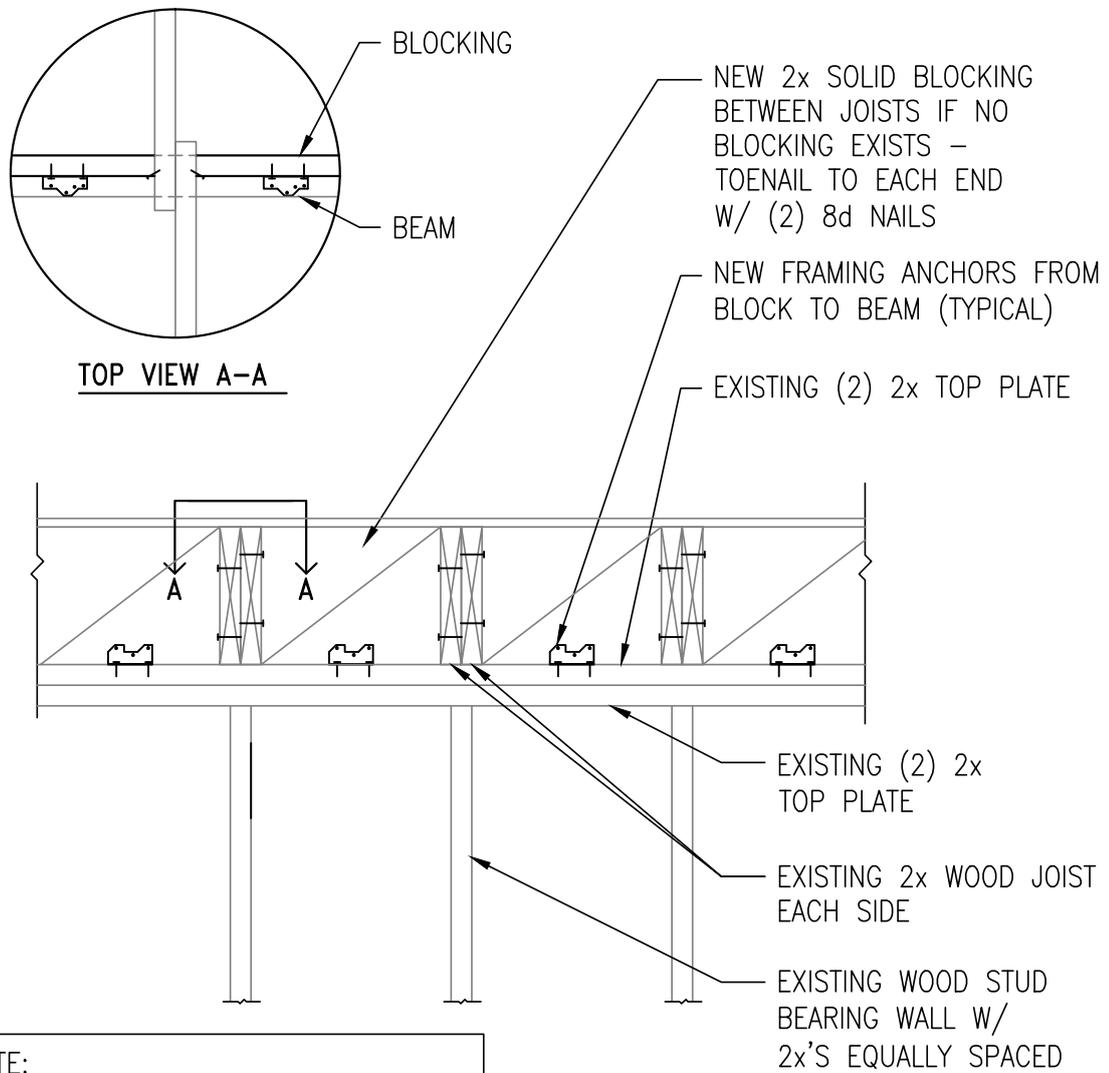
WOOD JOIST TO INTERIOR BEARING WALL AT FLOOR JOISTS

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Interior Bearing Strengthening	DETAIL: 79
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WOOD POST TO INTERIOR BEAM LINE AT FLOOR JOISTS

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Interior Bearing Strengthening	DETAIL: 80
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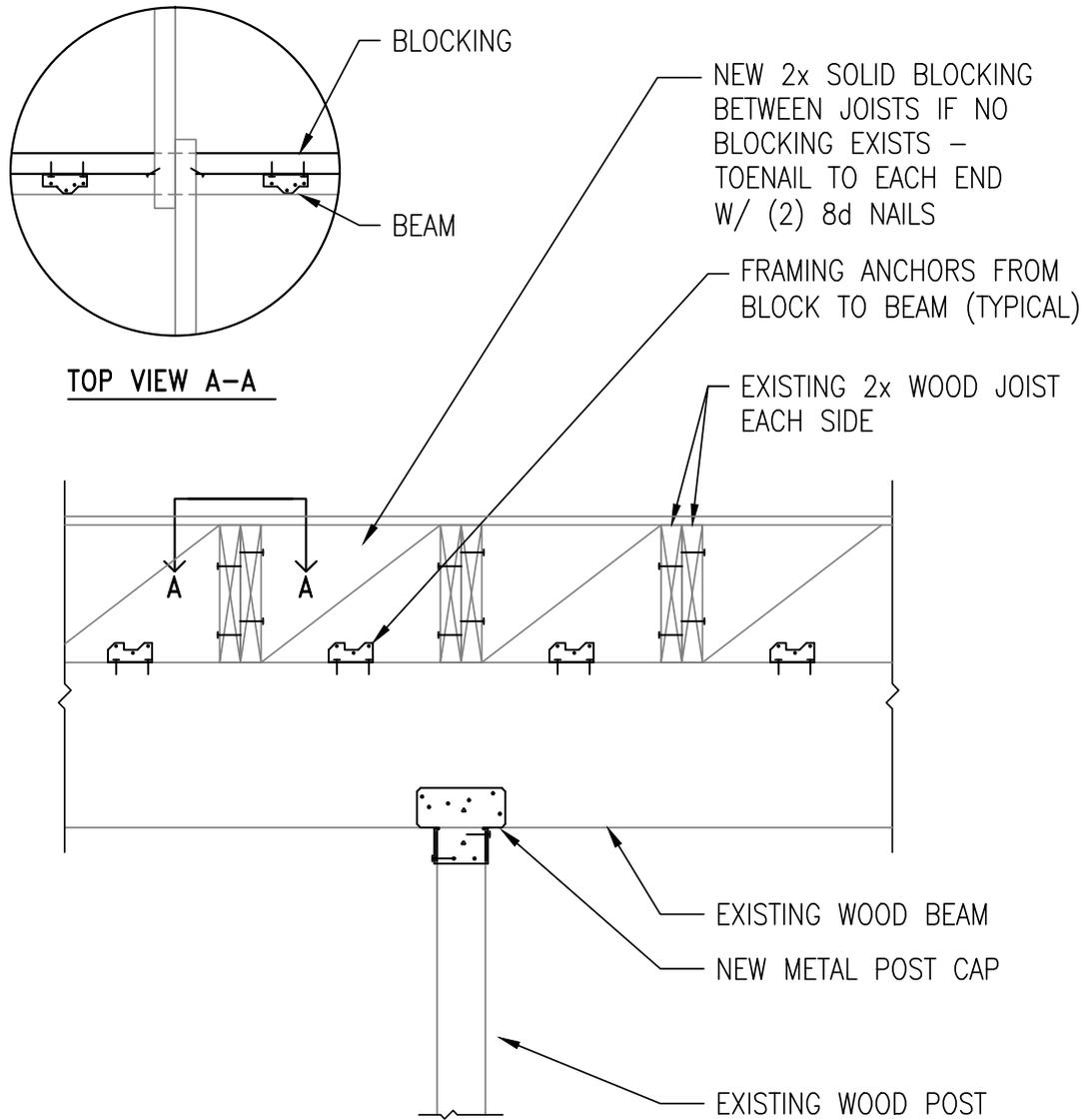


NOTE:
 WALL SHEATHING (USUALLY PLASTER OR GYPSUM BOARD) NOT SHOWN FOR CLARITY. REMOVE AND REPLACE AS REQUIRED FOR CONSTRUCTION.



WOOD JOIST TO INTERIOR BEARING WALL AT CEILING JOISTS

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Interior Bearing Strengthening	DETAIL: 81
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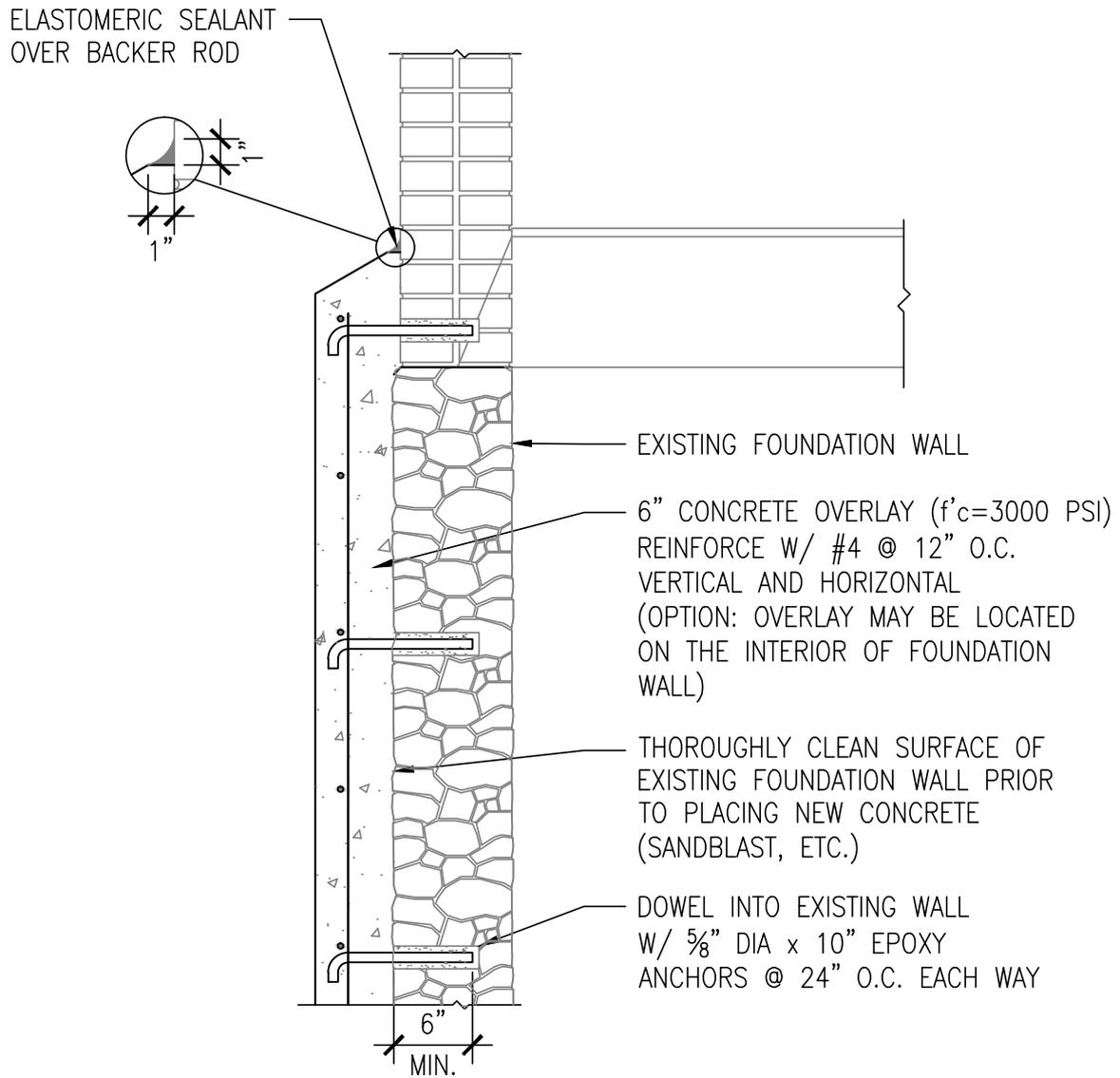


82
WALL

WOOD POST TO INTERIOR
BEAM LINE AT CEILING JOISTS

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Interior Bearing Strengthening	DETAIL: 82
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Foundation anchorage and strengthening: Detail 90



90
FNDN

FOUNDATION WALL STRENGTHENING

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Foundation Wall Strengthening	DETAIL: 90
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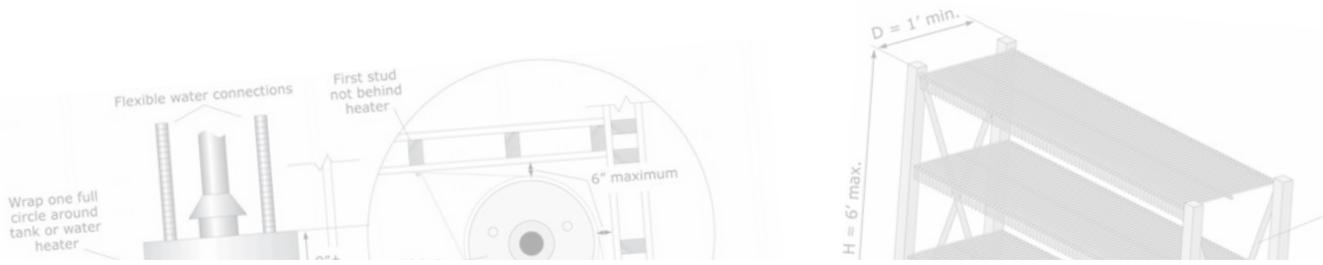
CHAPTER 7

Non-Structural Seismic Hazards: Anchorage and Bracing

Chapter 7 includes details for upgrading non-structural seismic hazards that include, but is not limited to, furnishings, appliances, computers, tall cabinets, machines, mechanical and electrical equipment (water heaters, lights, etc.), and other non-structural elements or building equipment contents which are not directly related to the structural frame, wall, floor(s), and roof of the dwelling structure.

The dislodgment of non-structural elements in a dwelling is a potential life safety hazard during an earthquake. Currently adopted building codes have made a reasonable attempt to address the bracing and anchorage of many non-structural elements, however this is still often overlooked in residential construction. When a dwelling shakes, non-structural elements and building contents,

like heavy equipment, furniture, computers, artwork, and other articles, may slide around violently causing extensive damage both to the object and to the surrounding area. It is not uncommon for a structure to have survived severe ground shaking without serious structural damage while non-structural elements and dwelling contents are almost a total loss. When this involves expensive furnishings, equipment, antiques, artwork, and other personal items, the homeowner can sustain an enormous financial and emotional loss. The displacement of dwelling contents can often be inexpensively reduced. The mitigation details at the end of this chapter are intended to reduce the potential for large dwelling content losses resulting from an earthquake.



Individual Non-Structural Seismic Improvement Details

Details to anchor non-structural items

(Details 100-115)

Water heater bracing: Details 100-101

Floor-mounted equipment: Detail 102

Light-duty shelving: Detail 103

Bookshelves against wall: Detail 104

Anchoring freestanding bookcase: Detail 105

Computers and accessories: Detail 106

Wall-mounted televisions: Detail 107

Desktop/counter equipment restraint: Detail 108

Restraining brackets/straps: Detail 109

Wall-mounted file cabinets: Detail 110

Base-anchored file cabinets: Detail 111

Wall/base-anchored lateral file cabinets: Detail 112

Shelf-mounted items: Detail 113

Fragile artwork restraints: Detail 114

Pendant light anchoring: Detail 115

Monitors

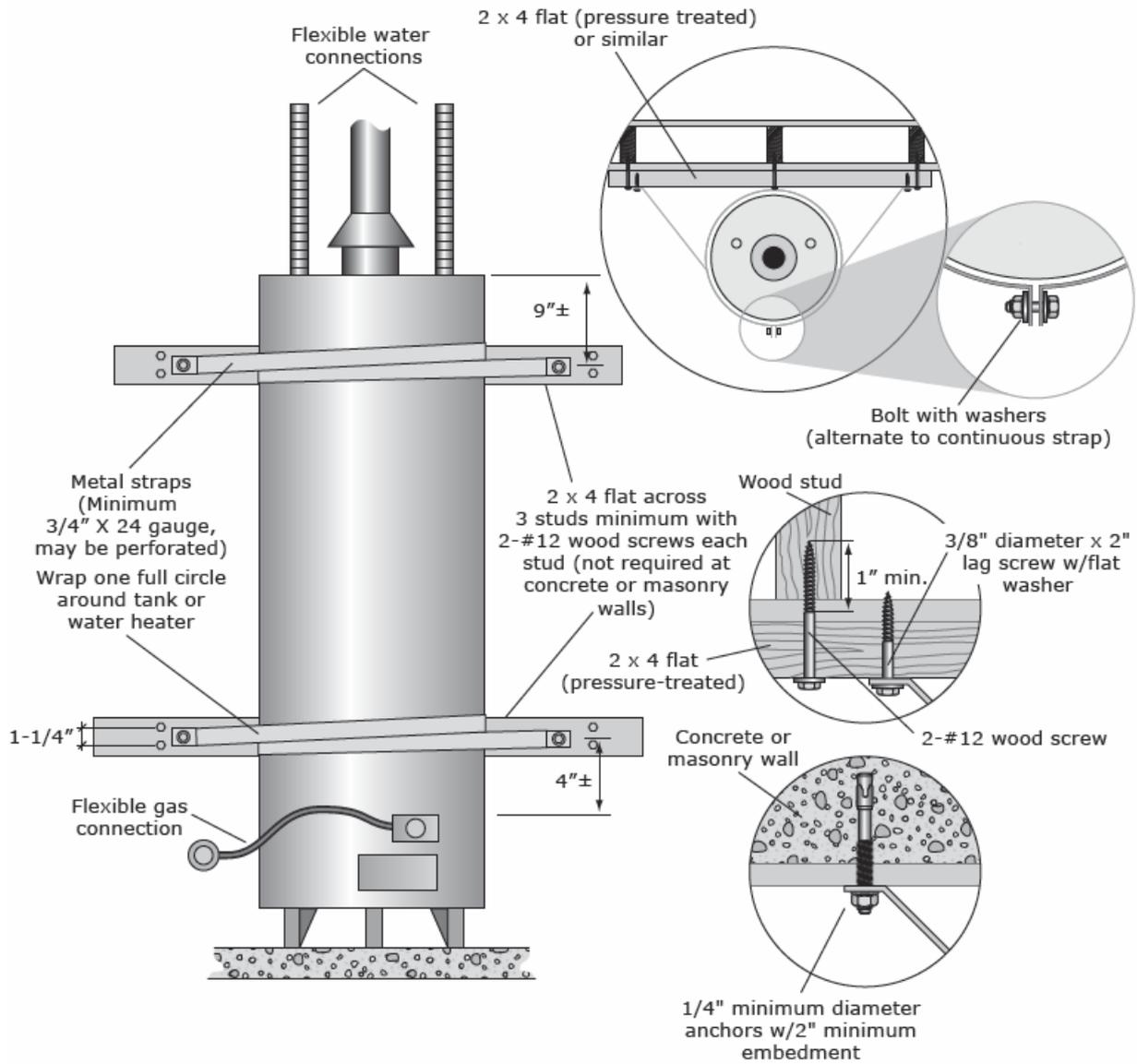
CPU

Labels and Notes:

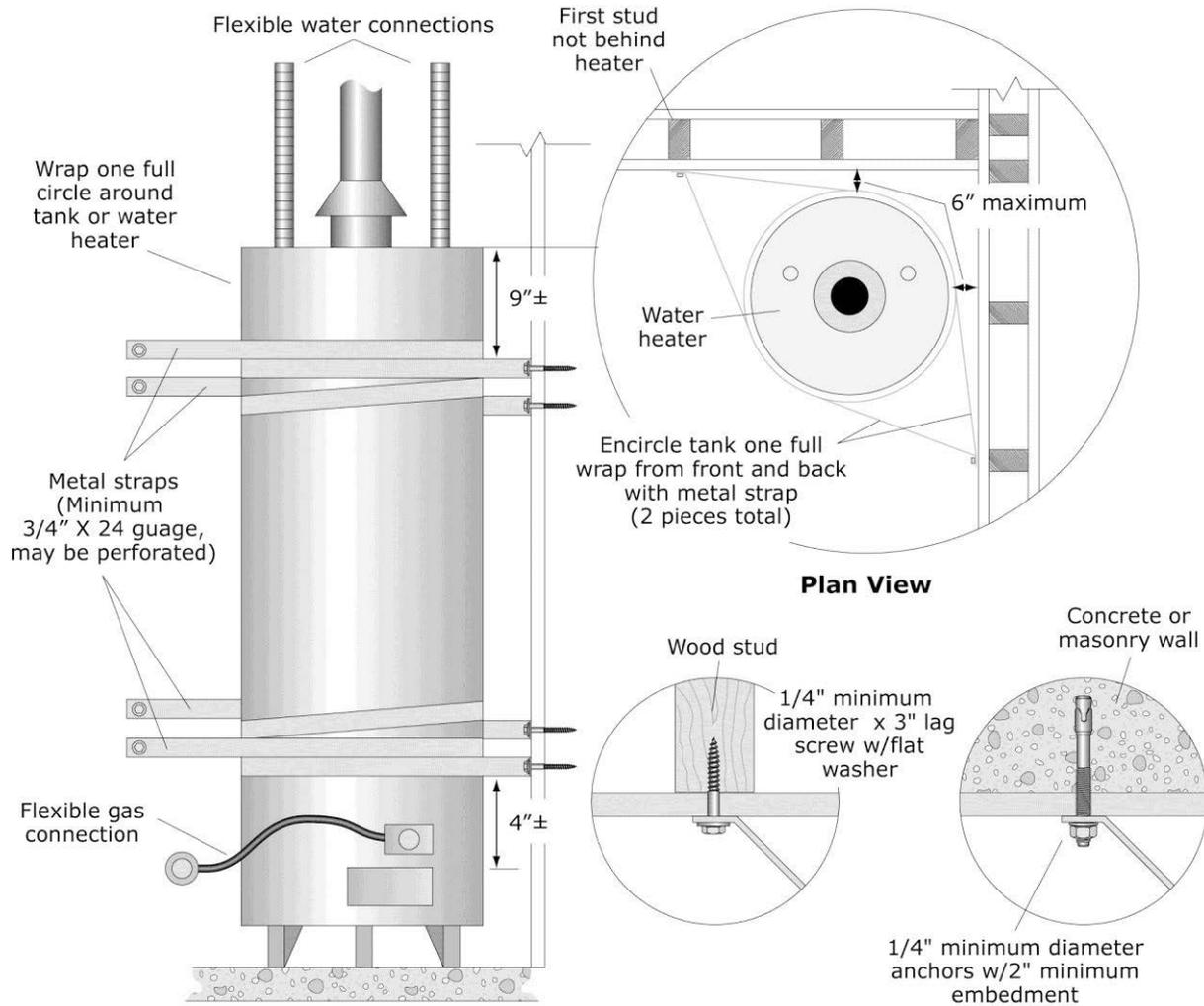
- Flexible water connections
- First stud not behind heater
- 6" maximum
- Wrap one full circle around tank or water heater
- Verify mechanical construction (bolt or screw) between leg and base (if adjustable)
- 1/4" minimum diameter
- 1/4" x 3" lag washer
- 4"
- Flexible gas connection
- Wood stud
- Check for interference
- Alternate: run safety cable to ceiling joist and attach to ceiling joist with a lag screw or concrete slab with expansion anchor
- Ceiling
- Must be free to rotate
- #9 gauge wire support minimum or slack safety cable
- Hollow fixture piping (do not use rigid conduit for attachment)
- Eyebolt (see below)
- Pendant light fixture
- Bolt to fixture
- #9 gauge hanger, minimum
- Eyebolt to housing
- #9 gauge wire, 4 right turns in
- Gang multiple units with steel plates, 1" X 4" X 12 ga. min. with 2-#12 sheet metal screws or 1/4" Ø bolts each end, min.
- If swinging of fixture can cause contact with other items, diagonal brace is required
- Anchor storage shelving to wall studs
- Keep top free of heavy items especially if located near person sitting at desk or lying in bed.
- Screw lip to shelf
- Channel or strut screwed to wall studs or sturdy casework
- Metal wire, elastic strap or solid lip anchored to cabinet
- Elastic strap, strap (high-tension mechanism for example)
- max.
- Alternate: Bolt together through back with 2 - 1/4" Ø bolts top and bottom between, min. Add solid blocking if backs of units are not in contact
- L-2-1/2 X 2-1/2 X 1/8 X 1'-0" min. with 4 #10 sheet metal screws to bookcase, and 2 - 3/8" Ø expansion anchors to slab (each side)

Note: Engineering required for all permanent floor-supported cabinets or shelving over 6 feet tall. Details shown are adequate for typical shelving 6 feet or less in height.

Water heater bracing: Details 100-101

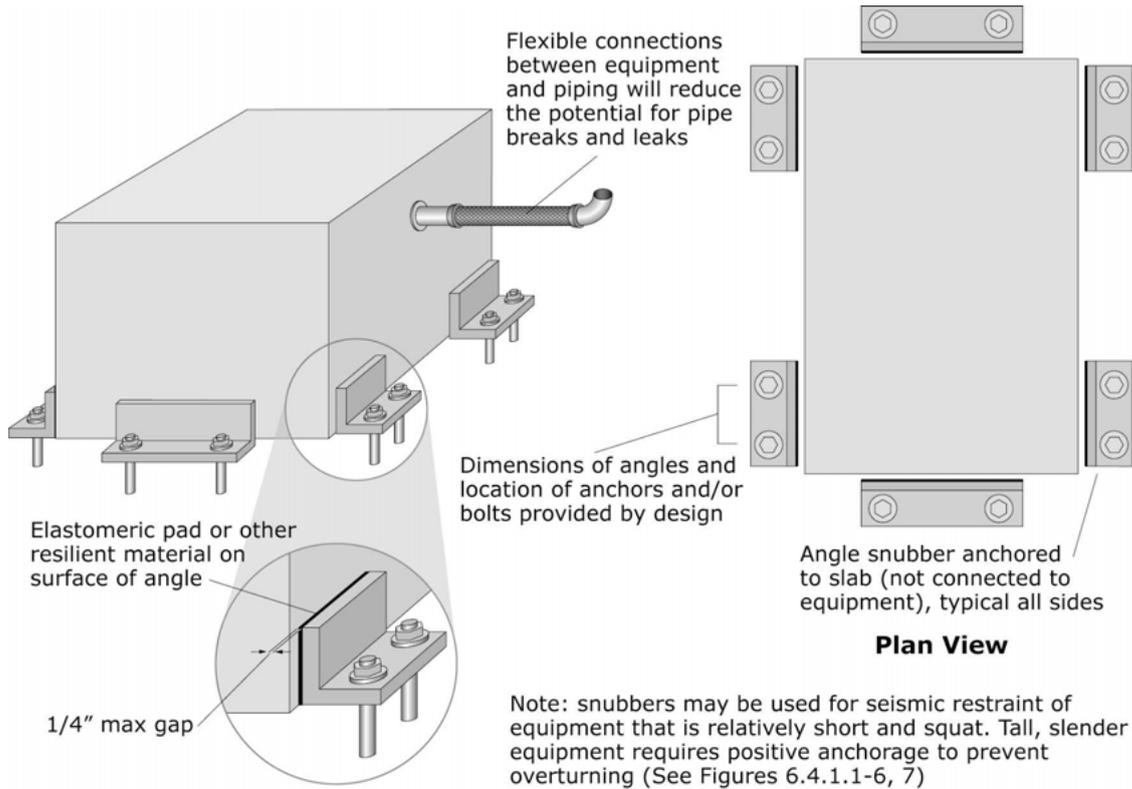


Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Water Heater Bracing	DETAIL: 100
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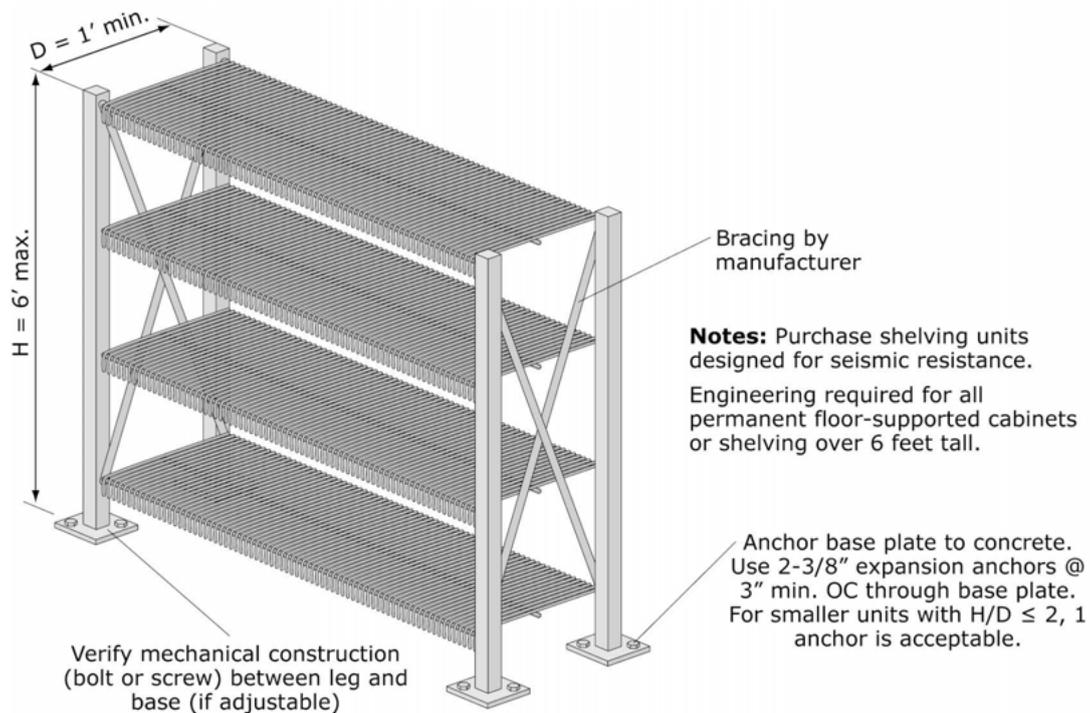
Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Water Heater Bracing	DETAIL: 101
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Floor-mounted equipment: Detail 102



Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Floor Mounted Equipment	DETAIL: 102
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Light-duty shelving: Detail 103



Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Light Duty Shelving	DETAIL: 103
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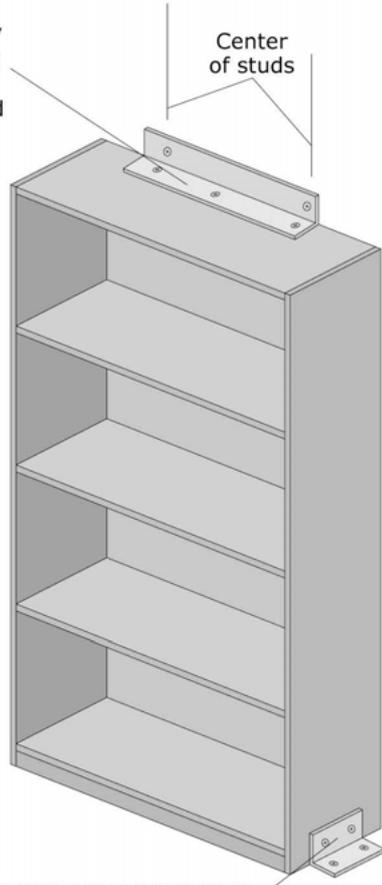
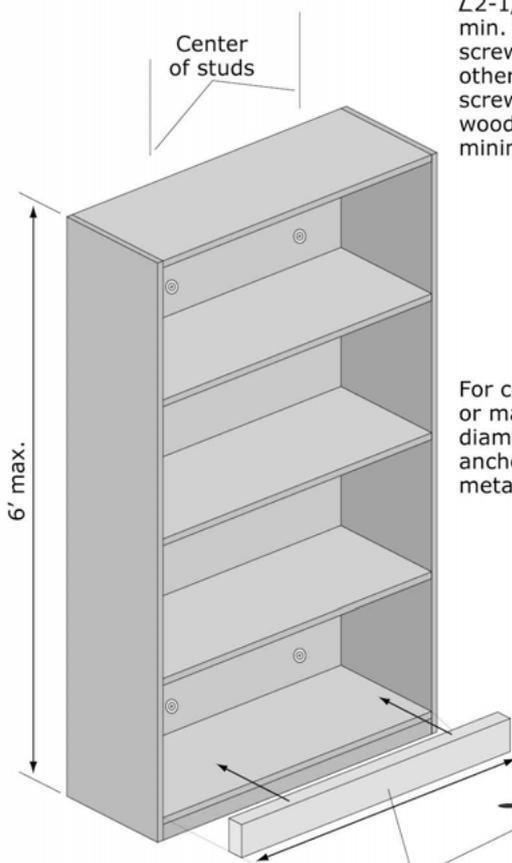
Bookshelves against wall: Detail 104

Where rear wall of bookcase is wood or metal with mechanical connection to bookcase framing, unit may be fastened directly to wall studs with 1/4" sheet metal screw and washer, 2 minimum, top and bottom.

2 X 4 min. wood stud or 20 ga. min. metal stud @ 24" oc max. Verify that studs run full height to floor above or are adequately braced to structural framing

L2-1/2 X 2-1/2 X 1/8 X 1'-6" min. with 1-1/4" sheet metal screw, or 1/4" toggle bolt to other metal studs, 1/4" wood screw with 2" penetration in wood stud. Fasten to a minimum of two studs.

For connection to concrete or masonry walls, use 3/8" diameter expansion anchors in lieu of sheet metal screws.



If back is less than 1/4" thick, add 1 X 4 for full width top and bottom.

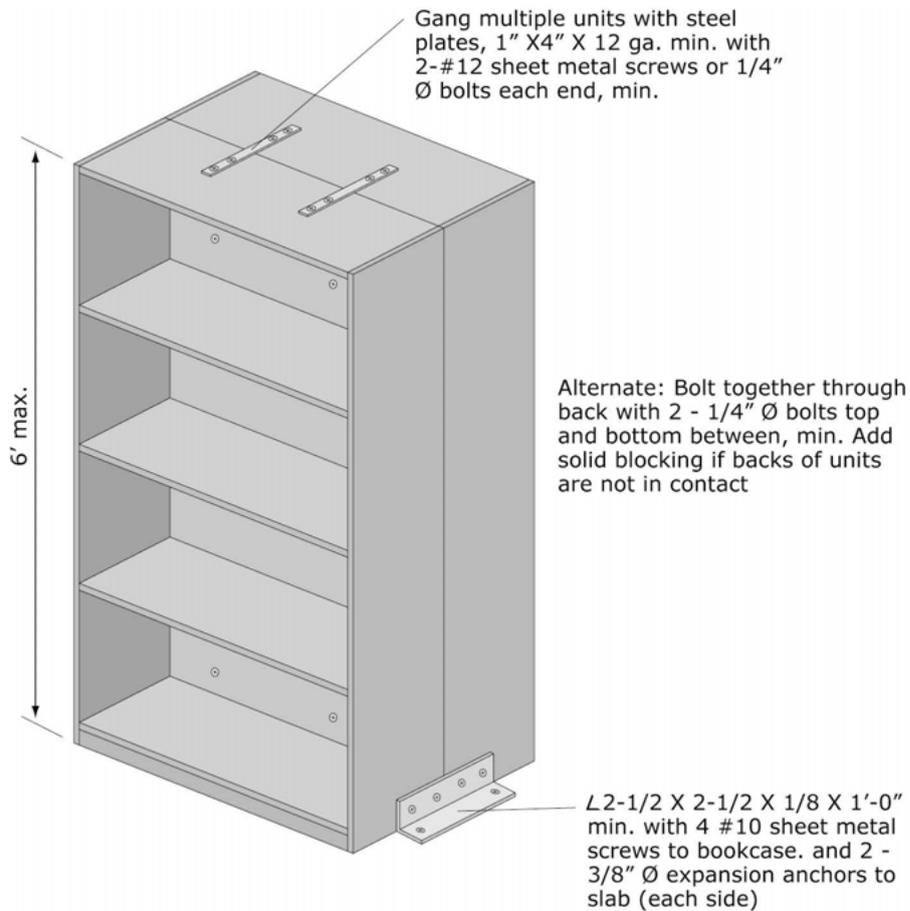
If there is a gap between the back of the unit and the wall. Install a solid mounting strip behind the bookcase (screw to bookcase).

L2-1/2 X 2-1/2 X 1/8 X 0'-7" (min.) each side with 3-#10 sheet metal screws to cabinet and 2-3/8" diameter expansion anchors to floor slab.

Note: Engineering required for all permanent floor-supported cabinets or shelving over 6 feet tall. Details shown are adequate for typical wall-supported shelving up to 6 feet tall.

Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Bookshelves Against Wall	DETAIL: 104
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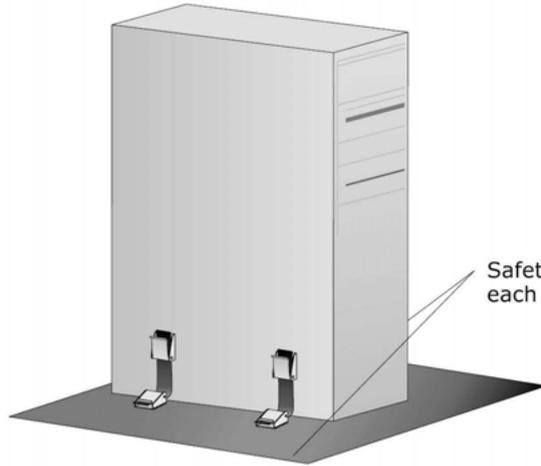
Anchoring freestanding bookcase: Detail 105



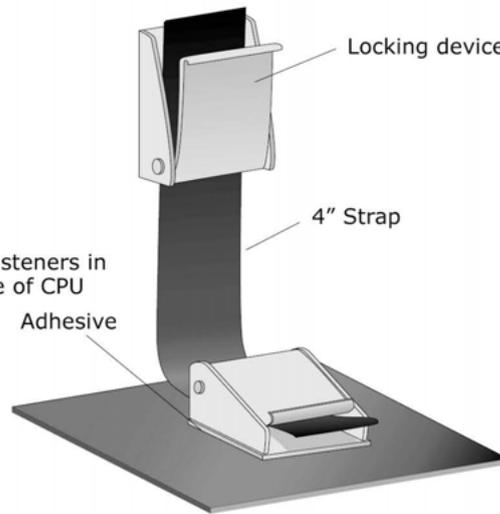
Note: Engineering required for all permanent floor-supported cabinets or shelving over 6 feet tall. Details shown are adequate for typical shelving 6 feet or less in height.

Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Anchoring Free- Standing Bookcase	DETAIL: 105
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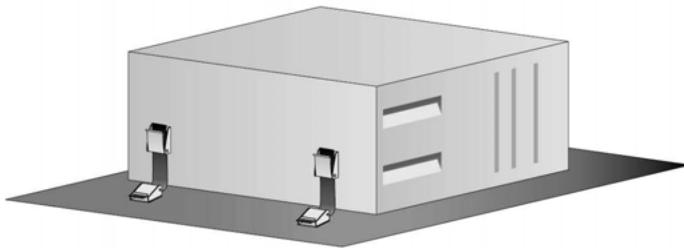
Computers and accessories: Detail 106



CPU Tower
4-Point fastening – use for all CPUs



Safety Fastener



CPU

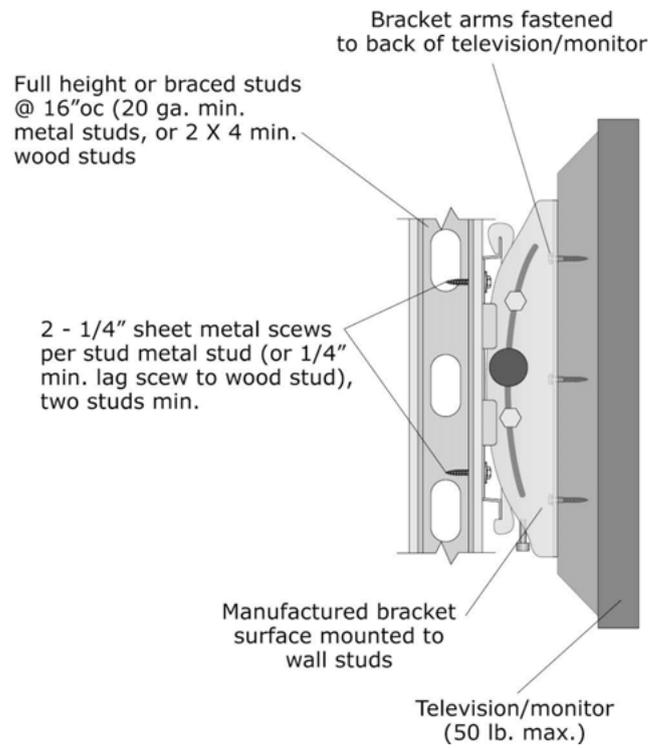
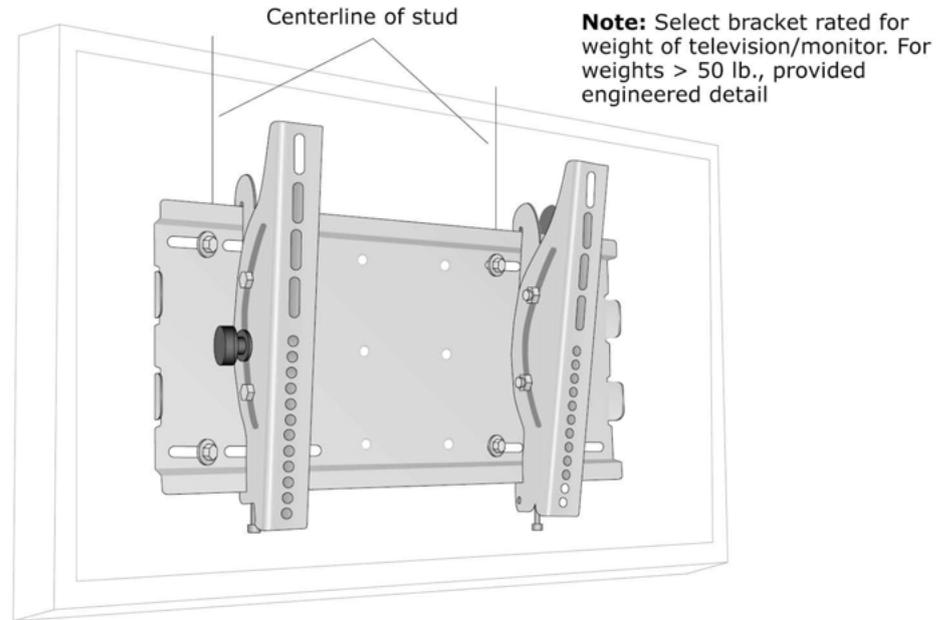
Note: Many proprietary fasteners are available to restrain countertop items. Check the internet for options.



Monitors

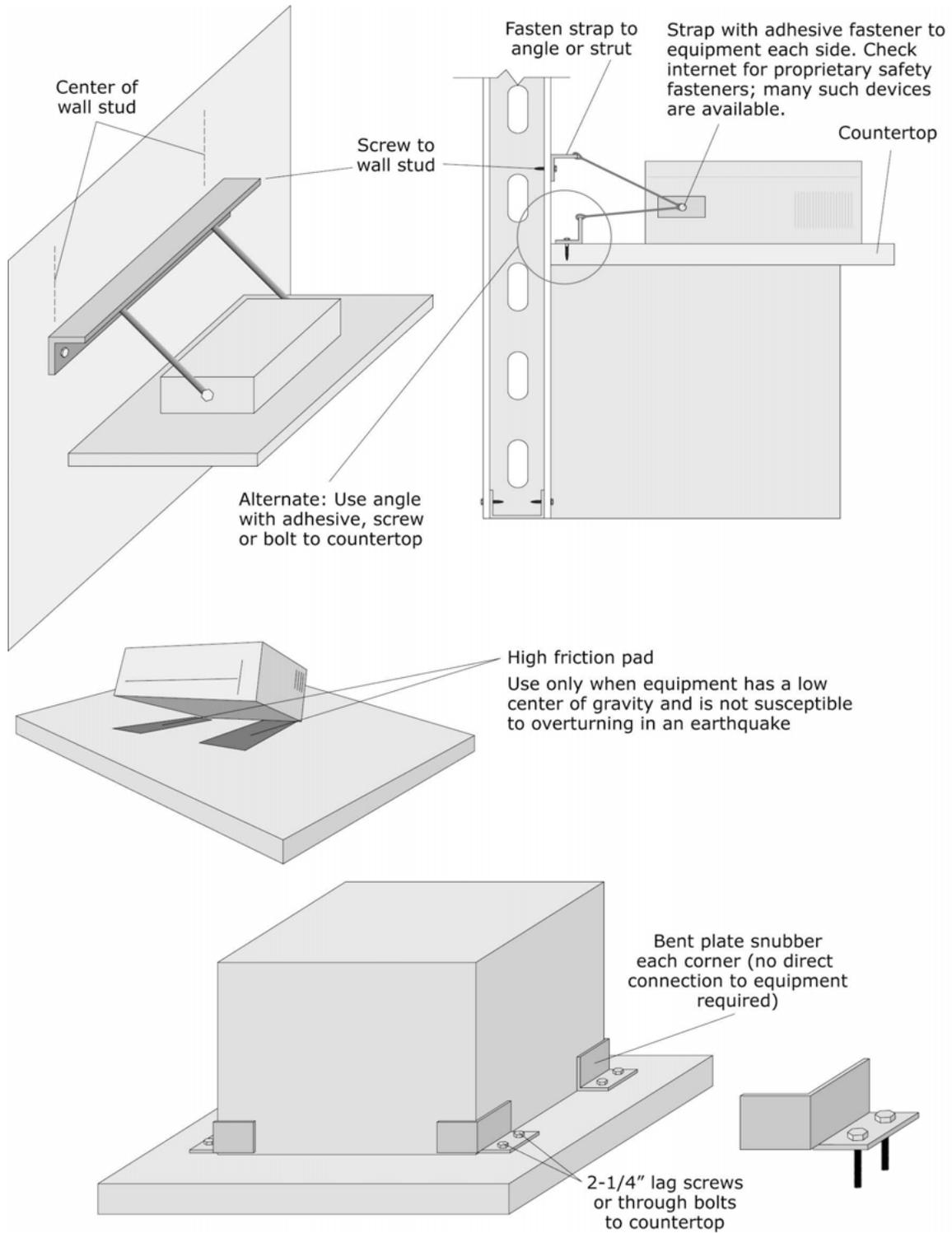
Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Computers and Accessories	DETAIL: 106
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Wall-mounted televisions: Detail 107



Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Wall-mounted Television	DETAIL: 107
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Desktop/counter equipment restraint: Detail 108



Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Desktop/Counter Equipment Restraint	DETAIL: 108
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Restraining brackets/straps: Detail 109

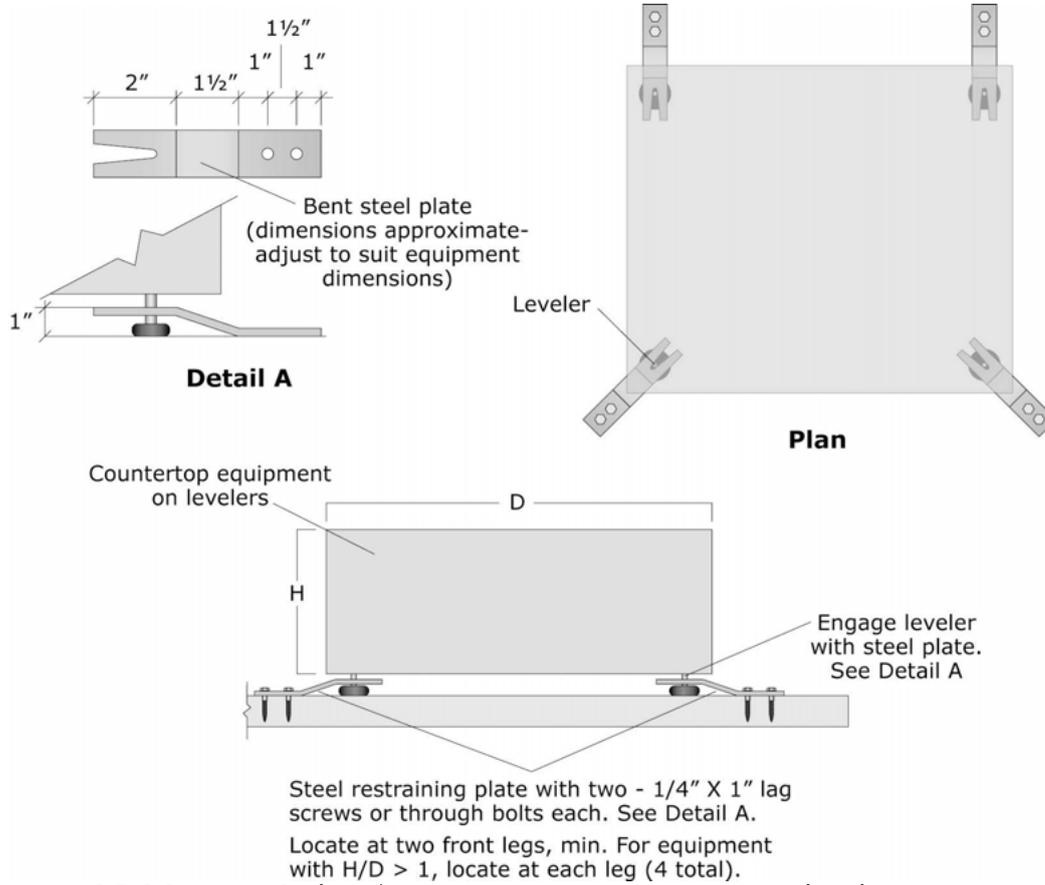
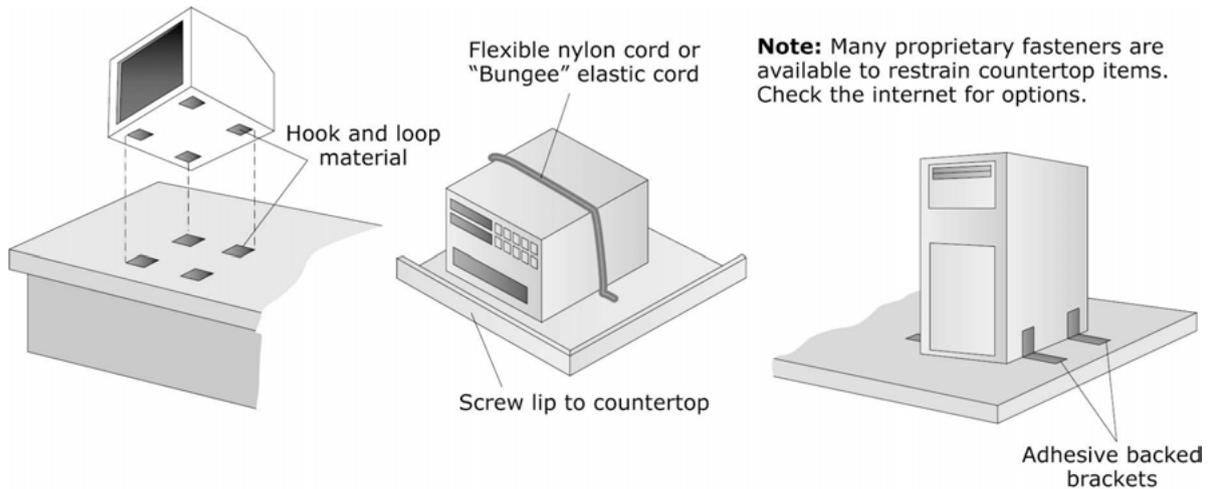


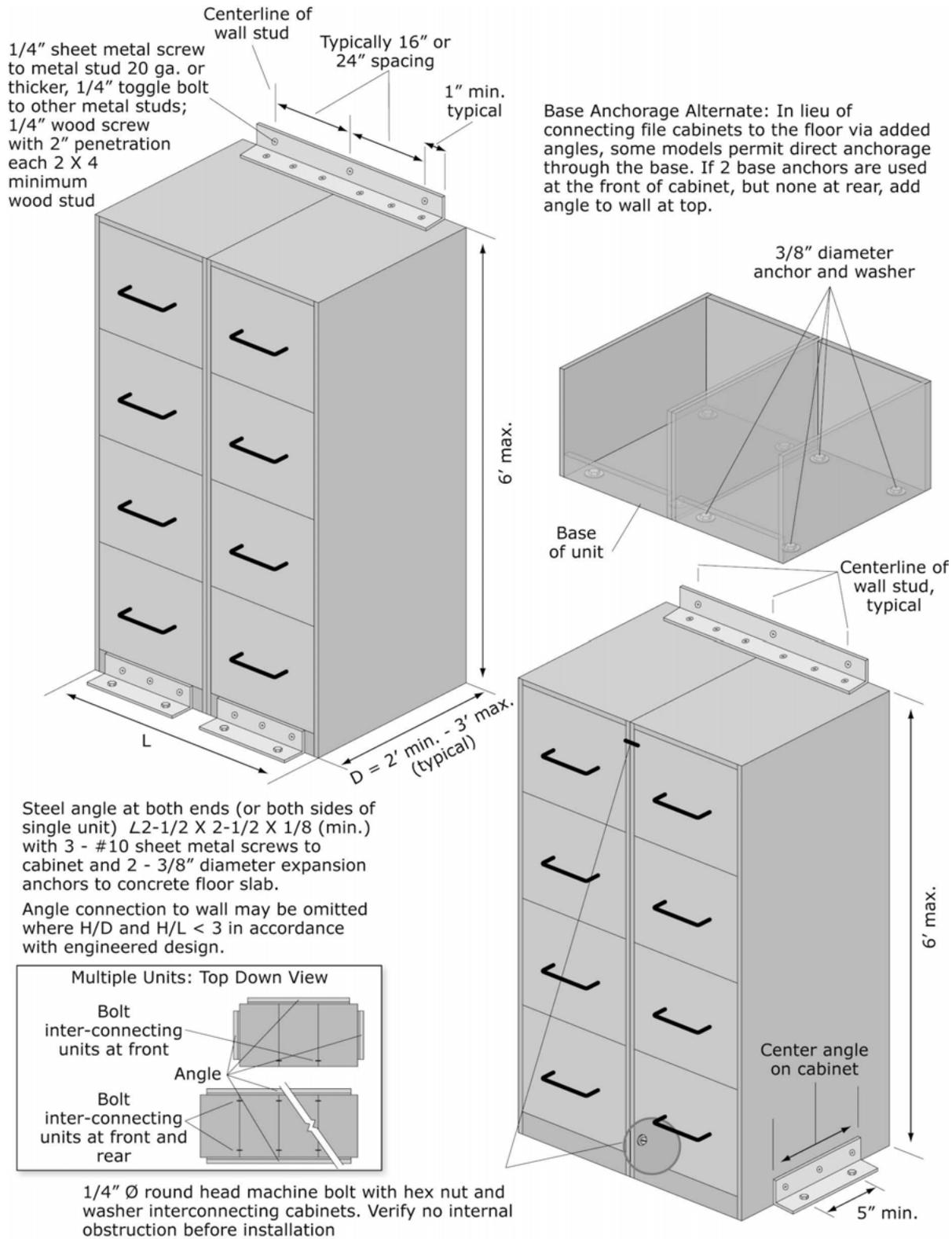
Figure 6.5.6.2-4 Desktop/countertop equipment restraining brackets (NE).



Note: Many proprietary fasteners are available to restrain countertop items. Check the internet for options.

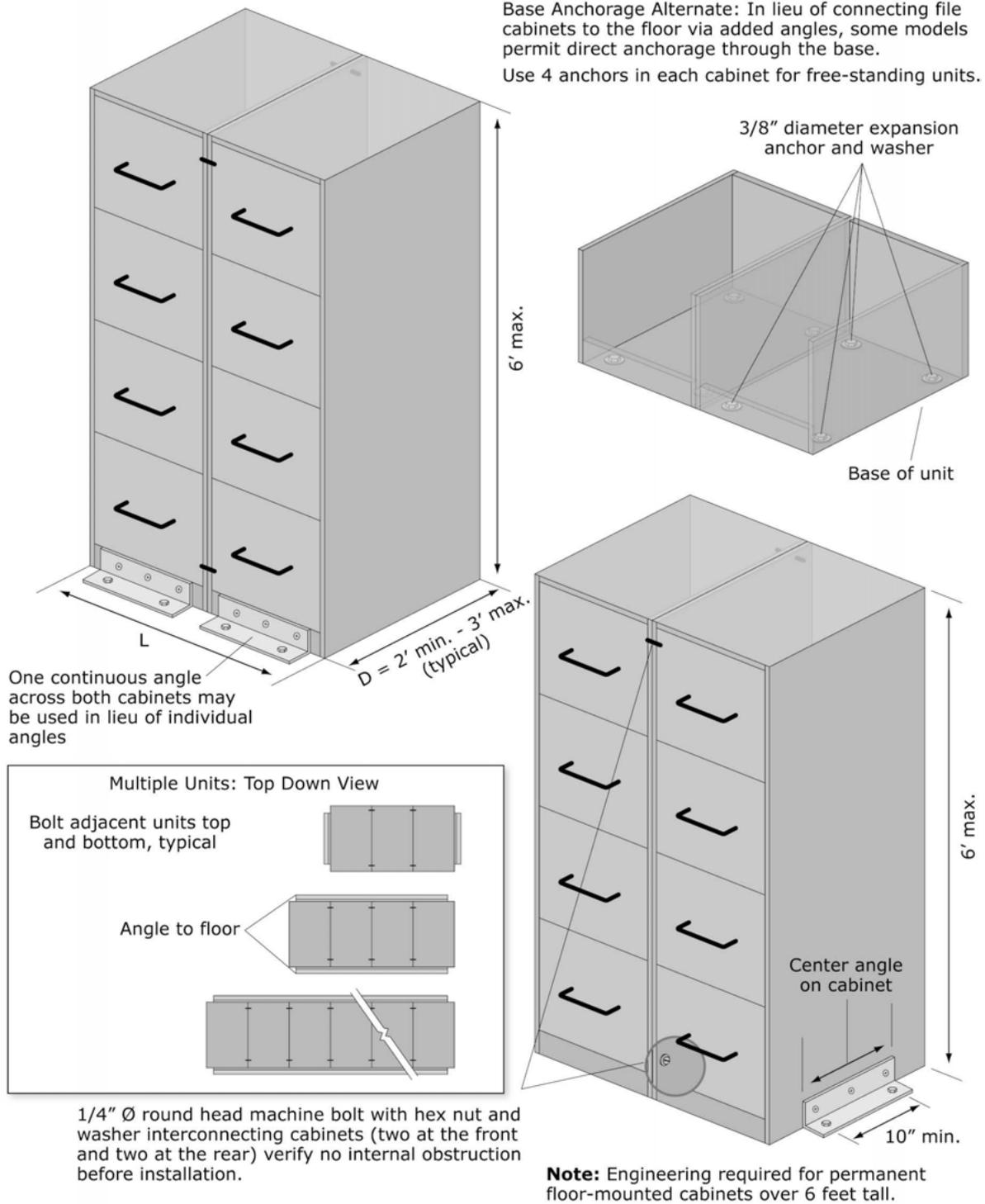
Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Restraining Brackets/Straps	DETAIL: 109
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Wall-mounted file cabinets: Detail 110



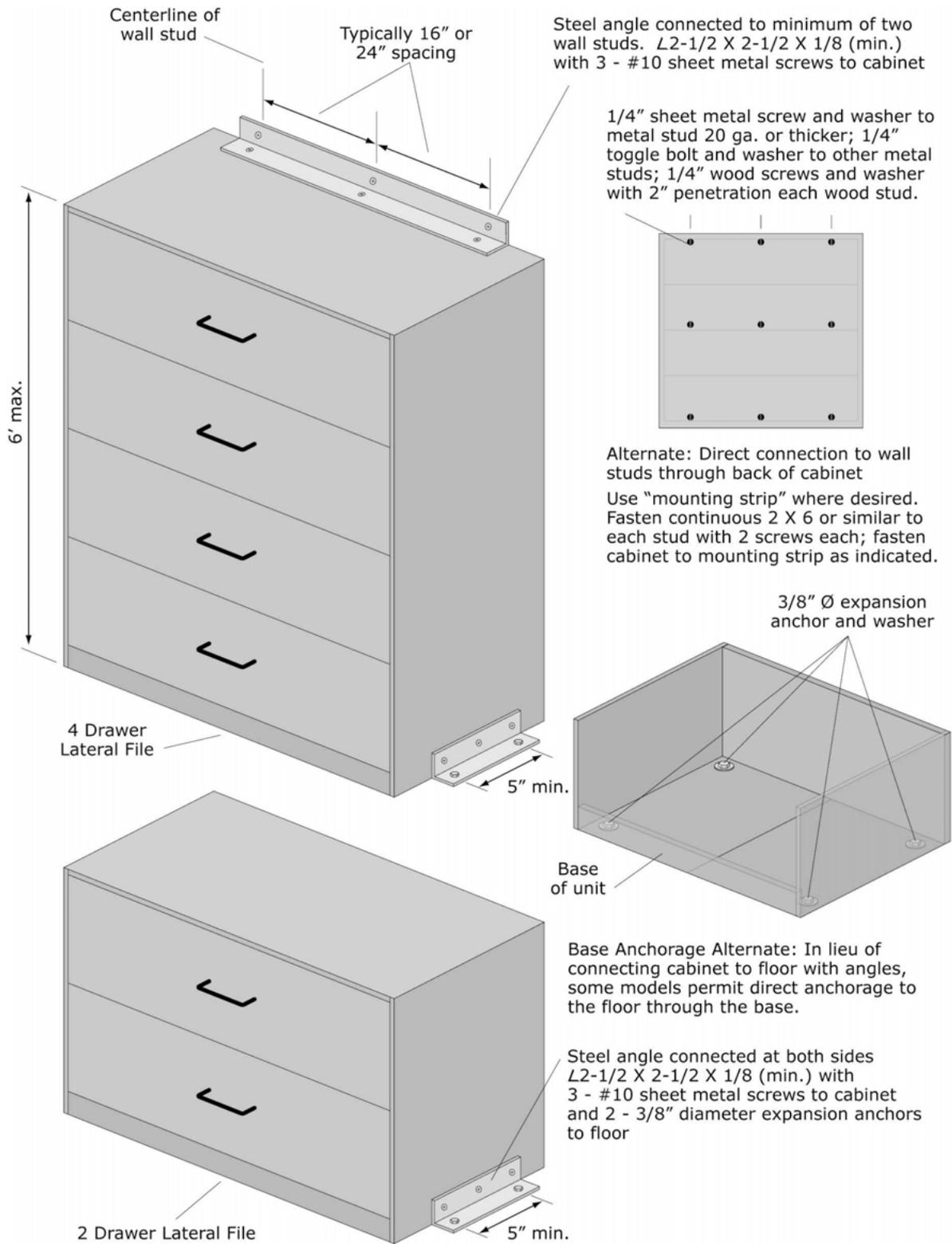
Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Wall-mounted File Cabinets	DETAIL: 110
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Base-anchored file cabinets: Detail 111



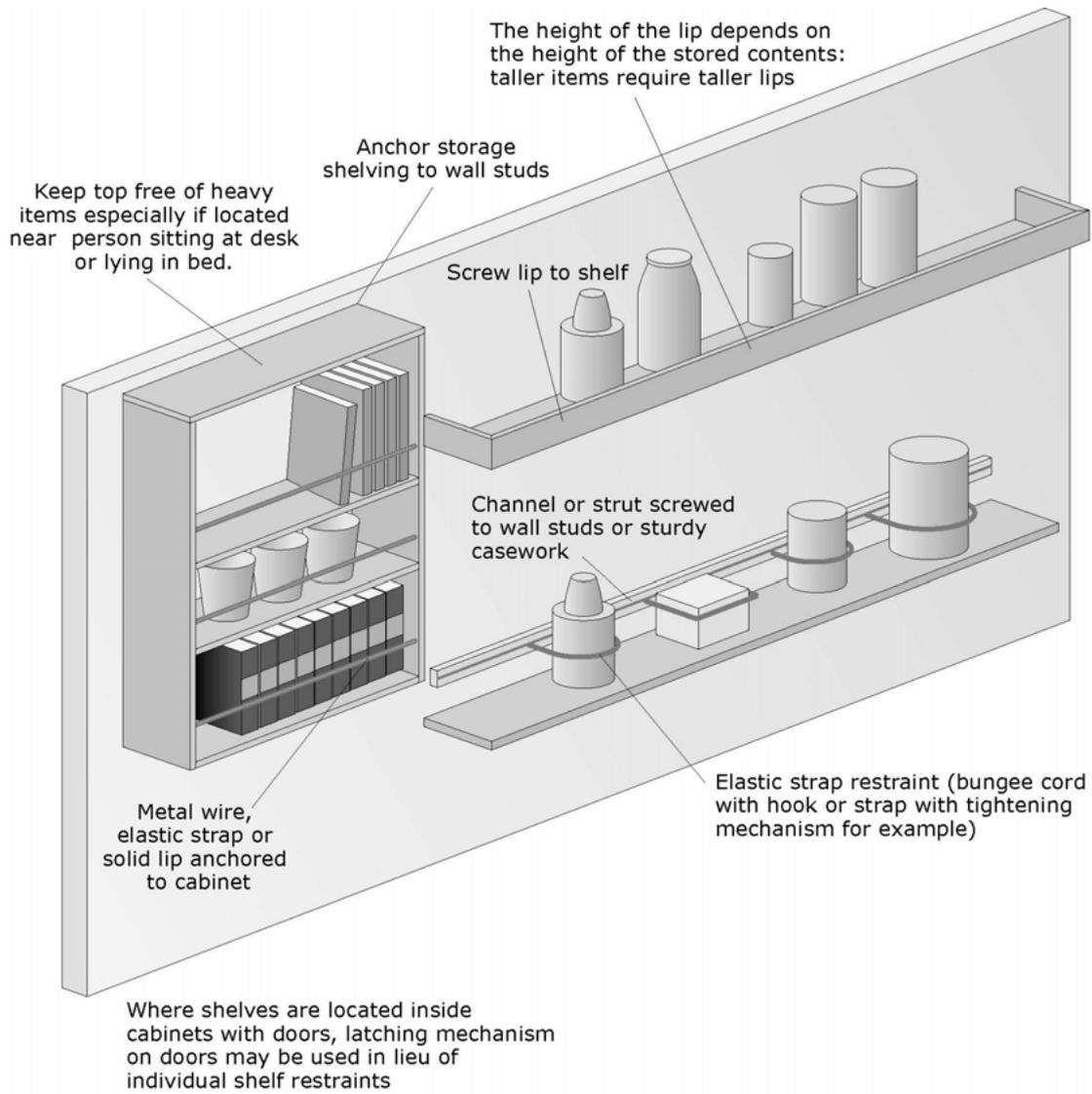
Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Base-anchored File Cabinets	DETAIL: 111
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Wall/base-anchored lateral file cabinets: Detail 112



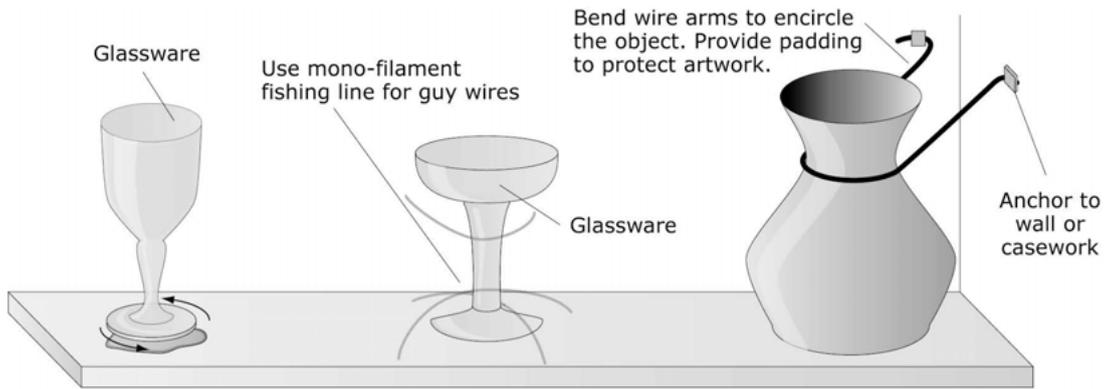
Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Wall/Base-anchored Lateral File Cabinets	DETAIL: 112
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Shelf-mounted items: Detail 113



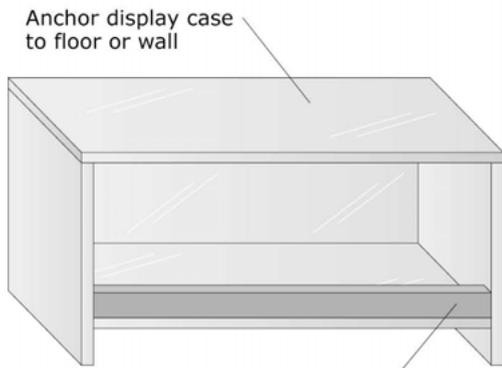
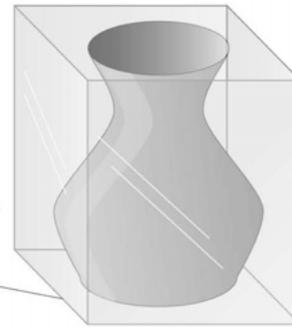
Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Shelf-mounted Items	DETAIL: 113
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Fragile artwork restraints: Detail 114



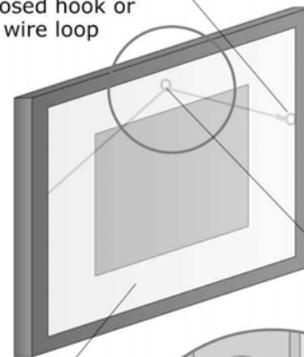
Use museum wax to restrain small lightweight objects. (Remove with care - wax may leave small stain on base of object). Alternative: use patches of hook and loop material. [Caution - glue may affect finish on base of object].

Place object in close-fitting glass or plexiglass display case. Pedestal must be anchored.



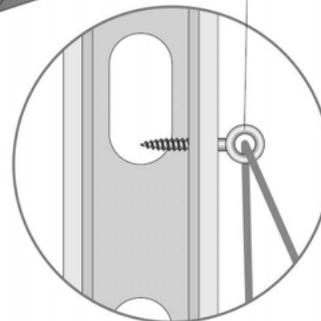
Wood, plastic, or metal lip edge screwed to shelving unit

Wire attached to frame with closed hook or closed wire loop



Eyebolt to wood metal stud

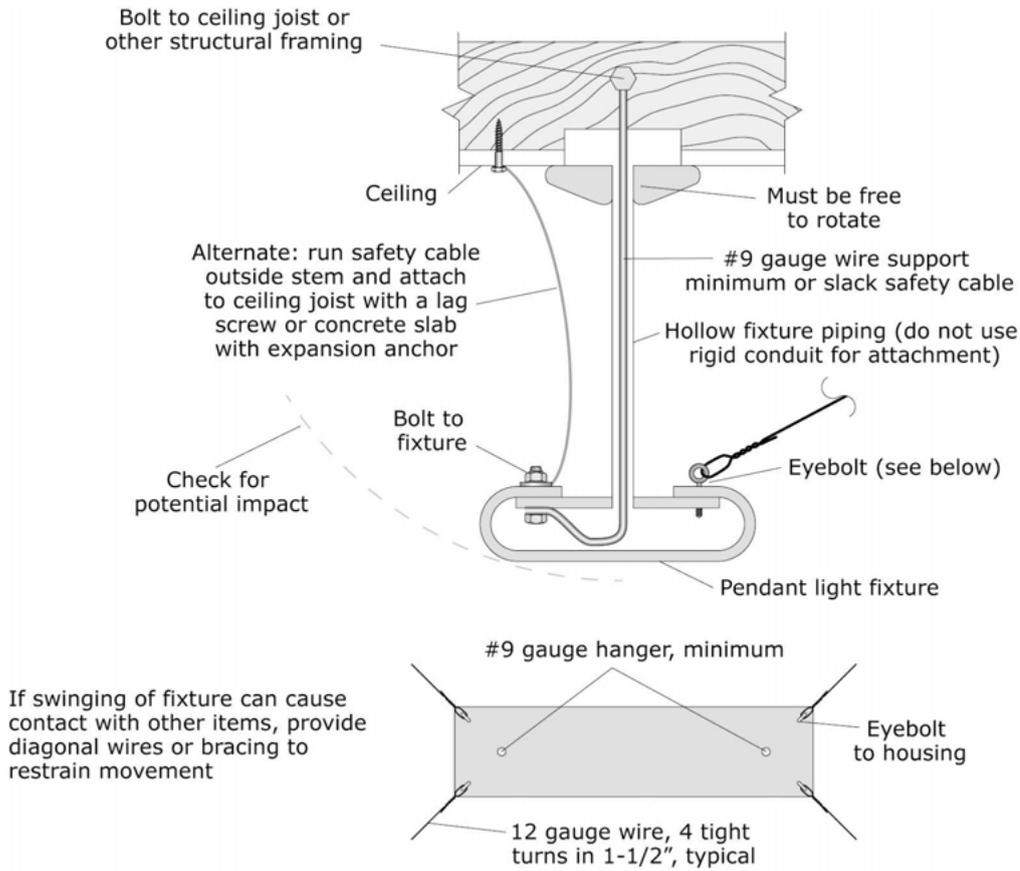
Hanging framed item



Note: Specialty hardware such as base isolated display platforms are available for especially fragile or valuable items. Seek professional guidance for expensive or irreplaceable items.

Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Fragile Artwork Restraints	DETAIL: 114
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Pendant light anchoring: Detail 115



Seismic Improvement Non-Structural Detail	HOME TYPE: VARIES	Pendant Light Anchoring	DETAIL: 115
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APPENDIX A

Supplemental Information Sources

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Other Information

Be Ready Utah, Utah's Official Emergency Preparedness Campaign: <http://www.utah.gov/beready/index.html>

Structural Engineers Association of Utah (SEAU): <http://seau.org/>

University of Utah Seismograph Stations (UUSS): <http://quake.utah.edu>

Utah Division of Emergency Management (UDEM): <http://dem.utah.gov/>

Utah Division of Occupational and Professional Licensing (DOPL): <http://dopl.utah.gov>

Verify a License (Contractors, Engineers, and Architects): <https://secure.utah.gov/llv/search/index.html>

Utah Geological Survey (UGS): <http://geology.utah.gov>

Utah Seismic Safety Commission (USSC): <https://ussc.utah.gov>

APPENDIX B

Glossary

bearing walls: Walls that support any vertical load in a dwelling as well as its own weight.

brick veneer: When brick or masonry is used as a façade, or covering, rather than as a structural element. Many dwellings may appear to have masonry bearing walls when in truth they may consist of wood-frame construction having masonry veneer on the exterior.

cantilever: A projecting beam or member that sticks out from a wall or other structure to support something above it, such as a balcony.

column (or post): A vertical structural element that often supports horizontal girders or beams.

corbel: An architectural member that projects from within a wall and supports a weight.

ductility: The ability of solid material to deform under tensile stress.

dwelling: A house, apartment, or other place of residence.

footing: Horizontal portion of the foundation that transmits load to the soils.

gable end walls: Triangle section of an exterior wall that occurs under the roofline and above the eaves.

in-plane failure: When lateral forces (i.e., earthquake and wind) are introduced parallel to the wall causing the wall to be displaced horizontally within the plane of the wall.

joist: A beam placed repetitively to support a floor or roof.

lateral force resisting elements: Those portions of a building that provide the basic lateral strength and stiffness, and without would cause the building to be unstable (i.e., shear wall, moment frames, braced frames, etc.).

lintel: A structural member placed horizontally over an opening (such as a door or window) to support the load above.

mortar: A mixture of cement, sand, water, and other ingredients used to bond together bricks or concrete blocks.

non-structural seismic hazards: Items such as furnishings, appliances, computers, tall cabinets, machinery, electrical and mechanical equipment, etc.

out-of-plane failure: When lateral forces (i.e., earthquake and wind) are introduced perpendicular to the wall, and the wall either falls away from the floor(s) and/or roof or buckles between the floor(s) and roof.

parapets: Portions of the exterior walls that project above the roof line.

pier: The solid part of a wall between two openings (such as windows) at the same level.

rafter: Repetitive horizontal or sloping structural elements, usually of wood, that supports the roof sheathing.

seismic design category: Classification assigned to a structure based upon the use of the structure and the severity of the expected earthquake ground motion.

sheathing: The individual boards or plywood panels covering a wall, floor, or roof.

stucco: An exterior building finish made by a mixture of cement, sand, and water.

unreinforced masonry (URM): Masonry construction built prior to 1970, before seismic requirements were added to the adopted building codes. This can include masonry construction having minimal steel reinforcement.

veneer: A masonry wall used for finish or surface treatment of a wall, not as a structural wall.

wythe: Multiple layers of bricks or other masonry components that comprise a bearing wall. Many URM dwellings have exterior bearing walls consisting of two to four wythes of brick.

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