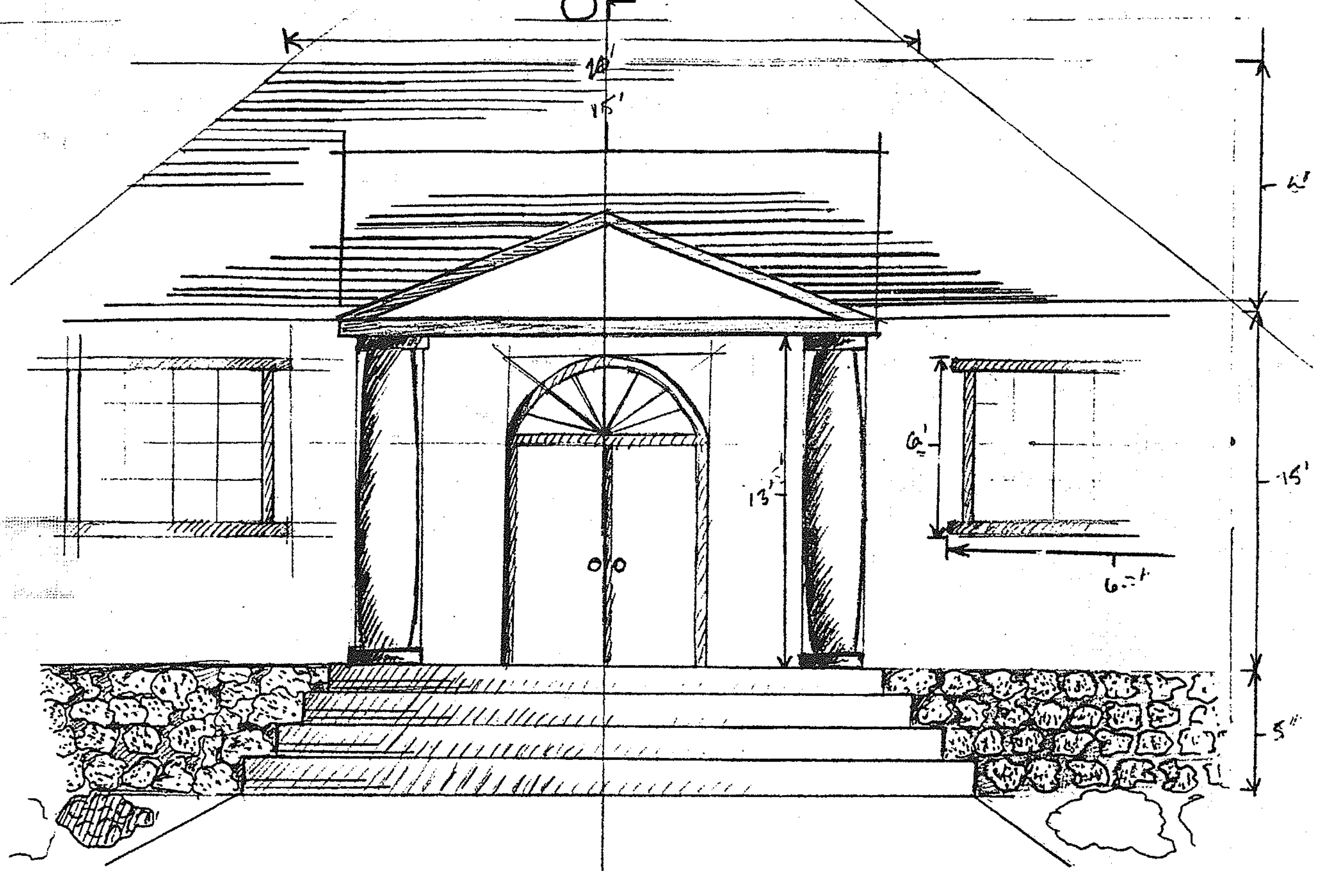
The Utah Guide for the Seismic Improvement of



Unreinforced Masonry Dwellings

UTAH EPICENTER
EARTHQUAKE PREPAREDNESS INFORMATION CENTER

RICHARDS CONSULTING GROUP

SEPTEMBER 1996

PREFACE

This publication is prepared for information purposes only, it is not to be used as a construction document. This document is prepared for the owners of unreinforced masonry structures (URM), to gain a better understanding of the seismic improvement of their dwellings. **Intended for use by contractors, repair specialists, and homeowners that possess construction skills above a typical "handyman" level.**

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.

If the owner of a URM structure has a desire for greater assurance and reliability, a professional engineer and/or architect should be commissioned to design and detail specific corrective measures for their dwelling. Only through individual evaluation, analysis, design and inspection of a dwelling's construction can insure such corrective measures. Nevertheless, we are confident that URM homeowners can be successful in improving the seismic resistance of their dwellings through proper application of the information in this guide.

Unreinforced masonry dwellings were typically constructed prior to 1970, when seismic requirements were added to the Uniform Building Code. They were normally constructed with solid masonry-bearing walls without adequate reinforcement. As a result, URM structures lack the ability to move beyond the elastic limit required to absorb the seismic energy in an earthquake. Often the structures are quite brittle and can quickly fail when seismic activity is present. Thus, such URM structures should not be expected to perform adequately through a large seismic event.

The techniques shown in this document are intended to generally improve the seismic performance of a URM structure, but the **implementation of these techniques cannot make a dwelling "Earthquake proof"**. There are a wide range of potential earthquakes. Moderate magnitude earthquakes occur periodically, and although minor damage is associated with these events, they can cause major destruction. High Magnitude ground shaking from a large quake may cause a strengthened or partially-strengthened structure to fail. It should be expected that damage will still occur; but generally, the more seismic measures taken to improve the structure, the greater the potential reduction in damage.

ACKNOWLEDGMENTS

In 1977 Congress passed the Earthquake Hazards Reduction Act, establishing the National Earthquake Hazard Reduction Program (N.E.H.R.P.) as a long-term, nationwide, earthquake risk reduction program. The 1977 Act was amended and re-authorized in 1990 to meet the changing needs of the dynamic forces in our nation. The purpose of N.E.H.R.P. has been to reduce the risks to life and property in the United States through the establishment and maintenance of the earthquake risk reduction program. With the Act, the aims are: to increase understanding, characterization and prediction of hazards, improve model building codes as it relates to land use, reduce risks through post-earthquake investigation and education, improve design and construction techniques, improve mitigation capacity which all depend on accelerating the application of effective research. The member agencies involved in the program: The Federal Emergency Management Agency (F.E.M.A.), U.S. Geological Survey (U.S.G.S.), National Institute of Standards and Technology (N.I.S.T.), and the National Science Foundation (N.S.F.)

This guide is a result of cooperation between F.E.M.A., and the State of Utah Division of Comprehensive Emergency Management (C.E.M.). The Earthquake Preparedness Information Center (EPICENTER) under contract No. 92-1909 assembled the guide.
We wish to thank...

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Mikki Easton, Natural Hazards Division.
and James Tingey for being instrumental in initiating this project.

Special Thanks to:
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CHAPTER 1.

Introduction

Facilities constructed under the current provisions of the Uniform Building Code require that they be built to resist a specified **minimum** level of force that might be generated by an earthquake. Buildings built prior to the adoption and **enforcement** of these relatively recent requirements almost always do not have the desired earthquake resistance. However, buildings constructed with this minimum level of resistance could still experience considerable structural and non-structural damage. This is especially true considering that ground shaking exceeding the building code anticipated level may occur resulting in increased damage to all structures.

FIGURE 1: Braced wall of URM. home after earthquake.

The concept of upgrading existing buildings to resist seismic forces is relatively new in the State of Utah. Very little of this work has been done on houses. It is not difficult to determine which homes are inherently earthquake resistant and which homes are vulnerable to seismic disturbances.

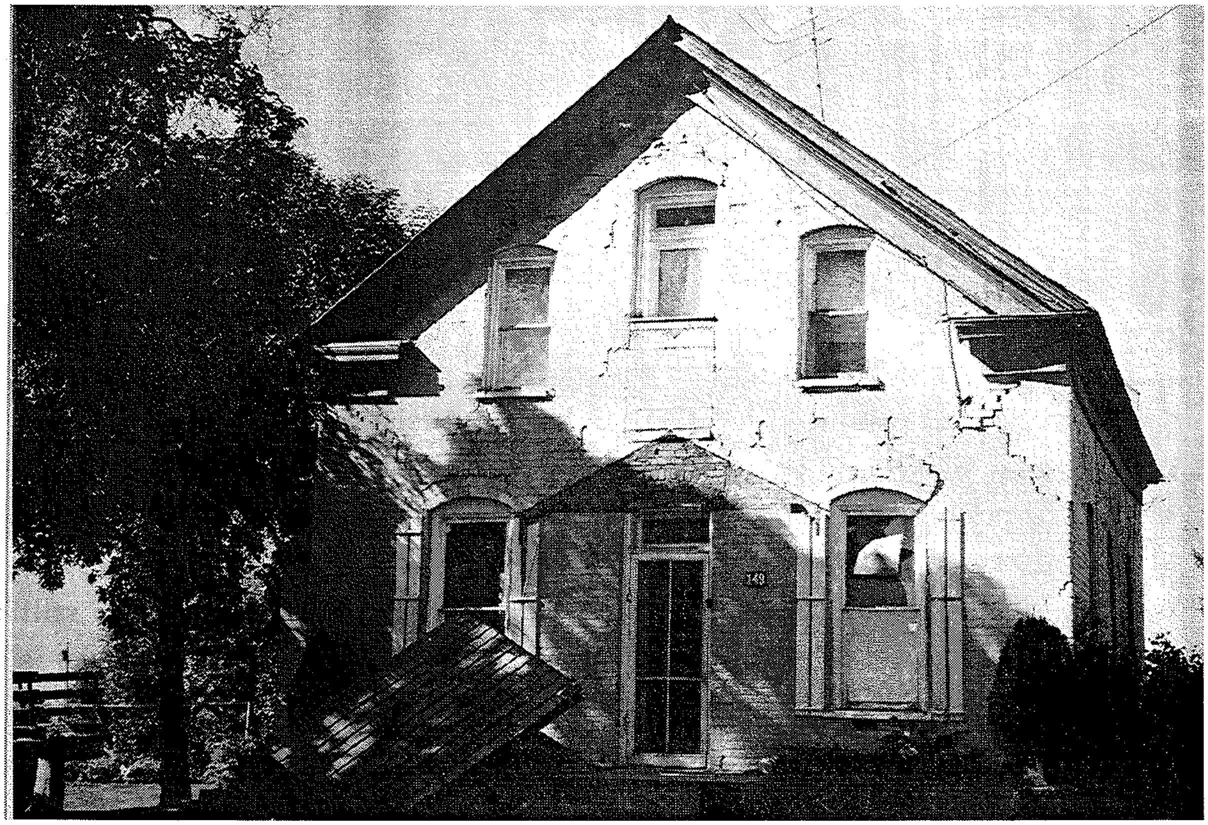


Figure 2: Cracks/failure due to earthquake   Photo: Ariel Benson

Earthquake ground shaking has been found to be very damaging to Unreinforced masonry (URM) dwellings. Previous earthquakes have shown that masonry structures are the most vulnerable of all building types to the forces generated by a seismic occurrence. Relatively small levels of ground shaking can cause significant damage in an URM structure. Moderate to large levels of ground shaking have the potential to cause structural collapse to a portion or all of the building.

Figure 3: Unreinforced masonry collapse

This guide will help answer many of the questions asked by individual homeowners as to their home's vulnerability to seismic (earthquake) forces and how to improve its seismic performance.

Figure 4: Interior URM wall collapse. Photo: Ariel Benson

The material contained in this manual is designed to educate the homeowner with respect to the effects of earthquakes on masonry homes. The material also addresses how individual homeowners can make their own assessment of possible seismic improvements and how to make them, or have them made by a contractor. This educational process is facilitated by using six model homes representative of a wide spectrum of the masonry homes in the Utah area. By examining the architectural features, configuration, and materials of the homeowner's dwelling and then comparing these observations to the model homes, it is usually possible to make some direct correlation between the specific dwelling and one or more of the model homes. The six model homes are described by photographs and drawings in Chapter 5. Basic seismic deficiencies are noted for each model and alternative corrective measures are suggested for many of the seismic deficiencies which are listed.

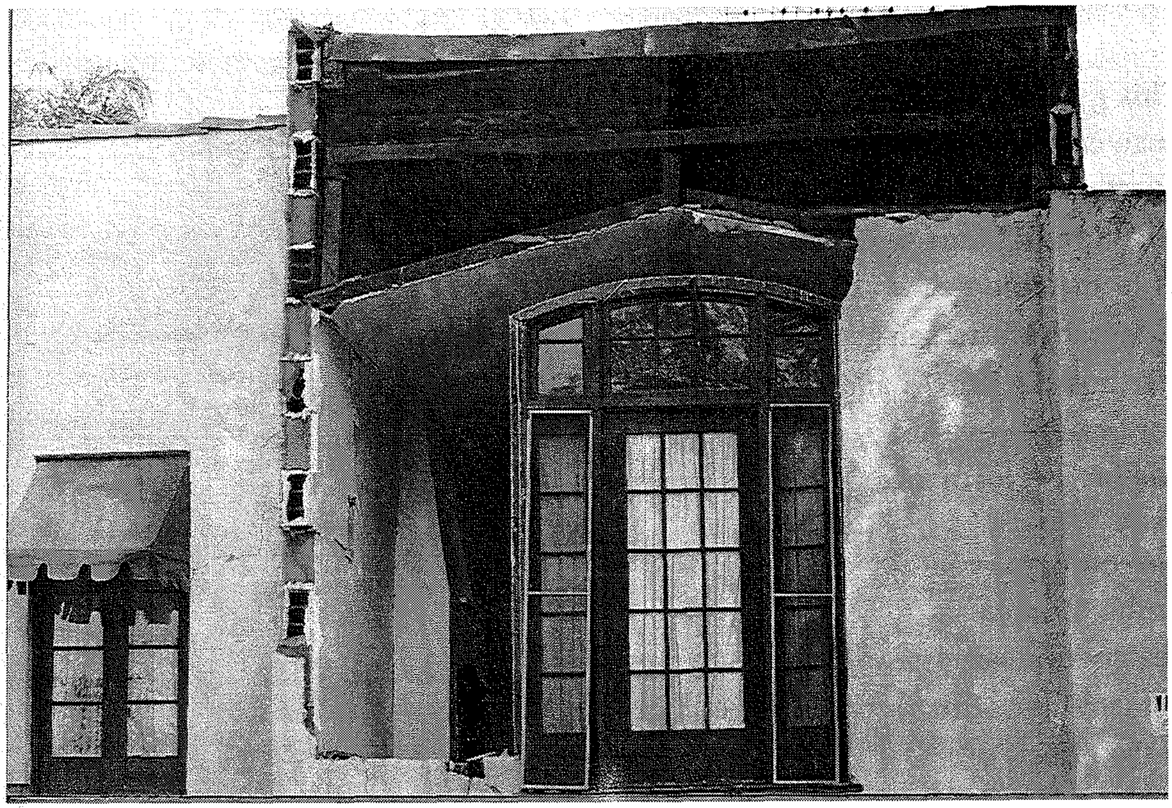


Figure 5: URM wall (hollow Clay Units) collapse due to earthquake

It should be pointed out that the procedures contained in this manual will not provide the homeowner with a completely earthquake resistant dwelling, but will help improve the seismic performance of a URM. home during an earthquake. If it is not feasible to make all of the proposed improvements, any work done will generally be beneficial. The improvements should, as a minimum, include the anchorage of the exterior walls to the roof and floor structure. Detailed engineering analysis and design is recommended in order to achieve a greater level of confidence in the strengthened building.

Chapter 2 provides the reader with directions for the use of this guide. A process is also presented in Chapter 2 which explains how to define a specific set of remedial measures. It also outlines the procedure for implementing these measures, thereby improving the seismic performance of the masonry (URM.) single family dwelling. A flow chart has been included on page 2 to aid the homeowner in their use of this guide.

Figure 6: URM wall collapse from earthquake damage. Photo: Ariel Benson

Chapter 3 provides a basic description of earthquakes and the effect they have on homes. It describes structural elements present in all structures, and how these various elements interact during a typical earthquake. This illustrates the importance of implementing the improvements noted in the following chapters.

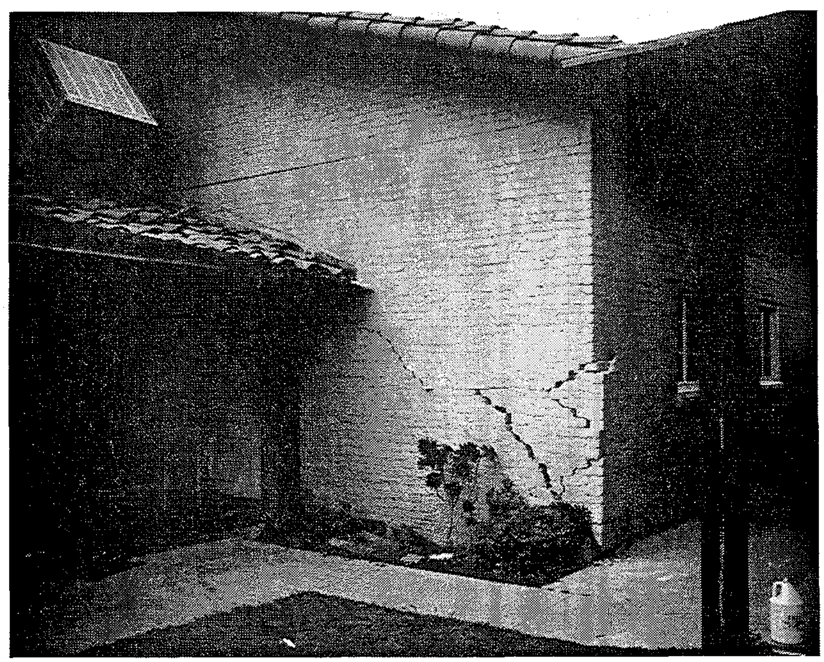


Figure 7: Earthquake damage to URM wall and displacement of mechanical equip. on roof.

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

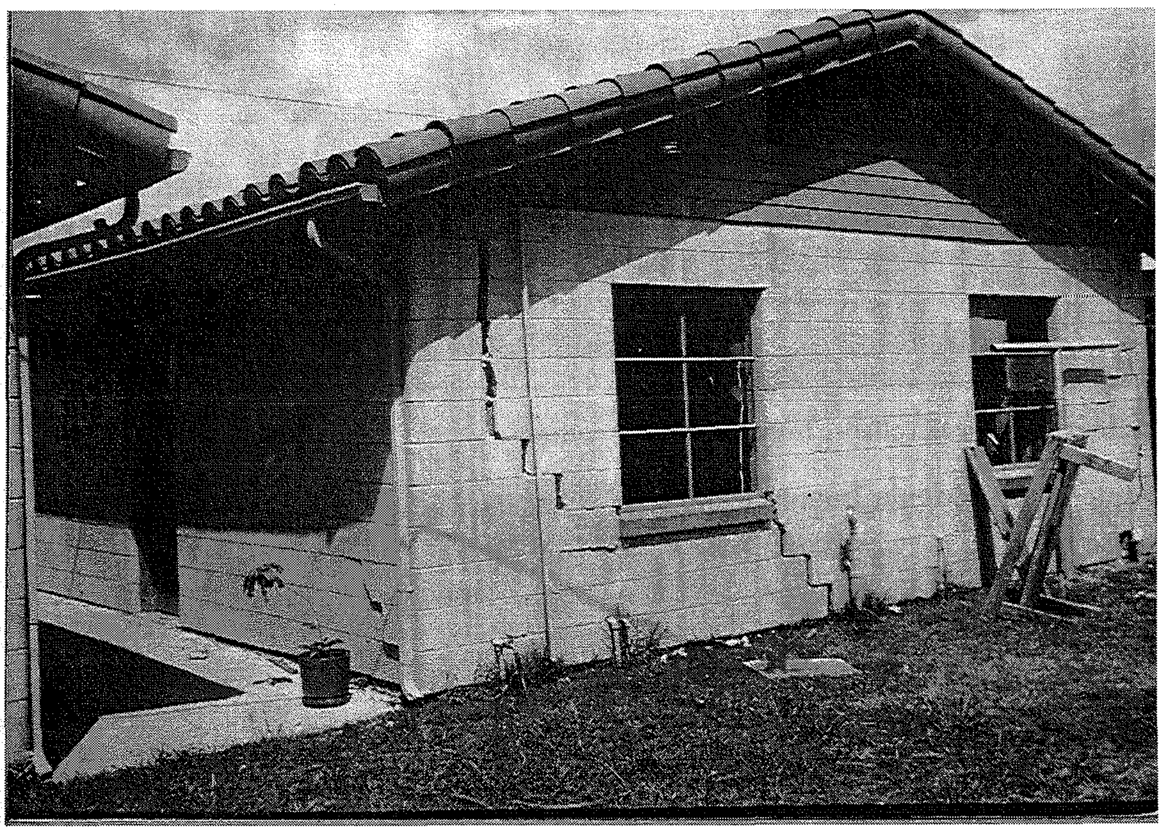


Figure 8: URM wall failure from earthquake.

Chapter 5 includes descriptions, photos, and illustrations of six model URM. homes. The intent of this chapter is to identify the type of construction that is most similar to a homeowner's dwelling. This can be done by making a comparison between the homeowner's dwelling and the photographs and engineering drawings of the typical model homes found in Chapter 5 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 deficiencies. A table has also been included at the beginning of Chapter 5 to assist the homeowner in locating suitable improvement details for noted deficiencies.

Figure 9: URM pier failure. Photo: Ariel Benson

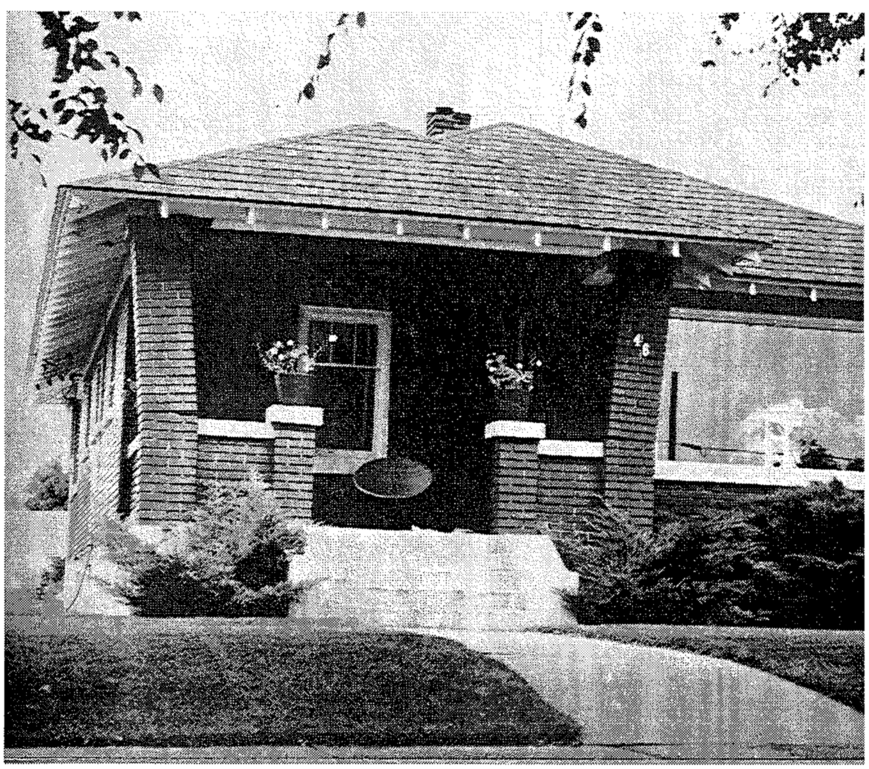


Figure 10: Another URM pier failure. Photo: Ariel Benson

Chapter 6 provides conceptual details for upgrading the deficiencies described and/or referred to in Chapter 5. These details are 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 condition.

Where unusual and

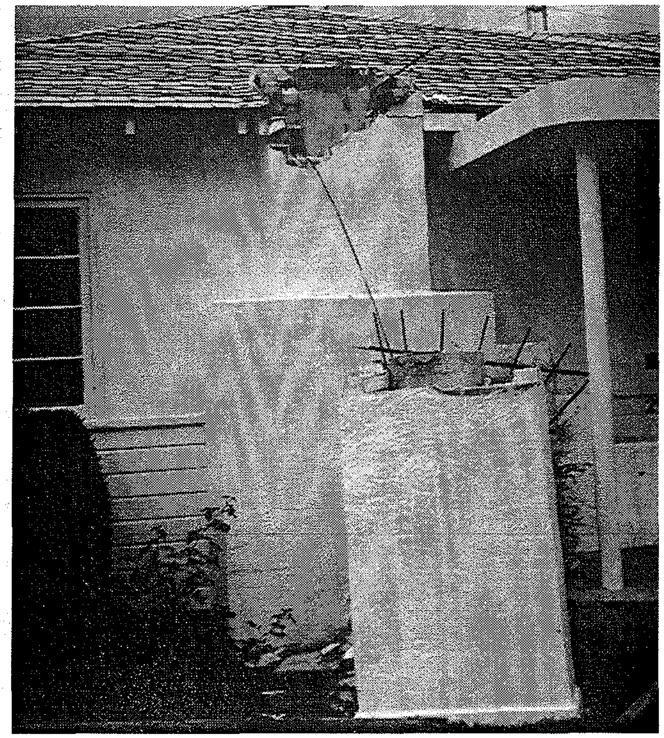


Figure 11: Chimney failure due to inadequate reinforcement.

complex conditions are encountered, specific engineering analysis and design may be required.

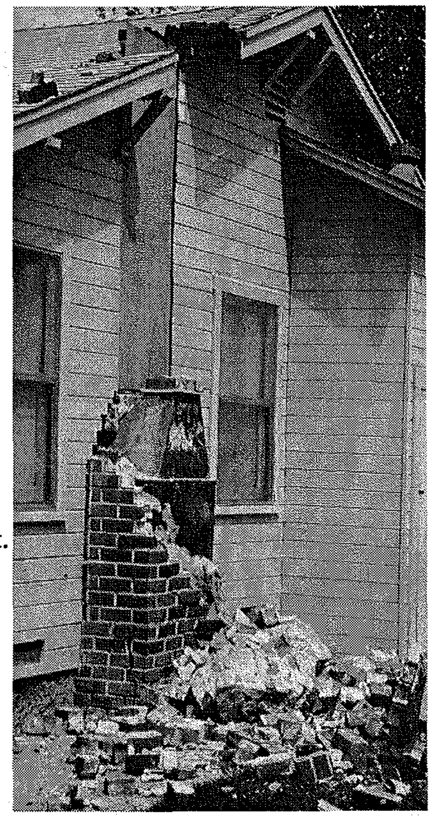


Figure 12: Chimney collapse

Chapter 7 includes general details for upgrading (bracing, anchoring, etc.) non-structural seismic hazards. This typically includes non-structural elements and/or building contents which are not part of the structure or are not anchored to the structure.

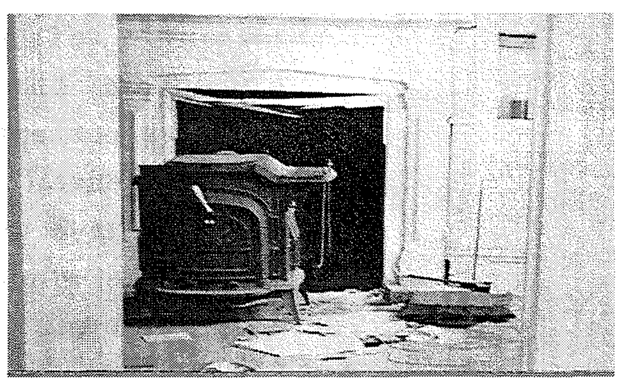


Figure 13: Displacement of wood-burning stove found in fireplace.

The Appendix includes a list of manufacturers and suppliers of the connectors and other products shown in the details. It also contains a list of resources for obtaining additional information and a glossary defining some of the terms and abbreviations in this report.

CHAPTER 2

How to use this guide

This guide was developed on the premise that the wide range of unreinforced masonry (URM) homes in Utah can be represented by a smaller number of URM models. It was determined that the vast majority of unreinforced masonry (URM) single-family homes along the Wasatch Front could be described in terms of six different models. Each model has distinct architectural styles, variations in construction, and different configurations.

The figures in this document are referenced using the following guide:

Chapter — X (X-X) — Model Type or Section Number

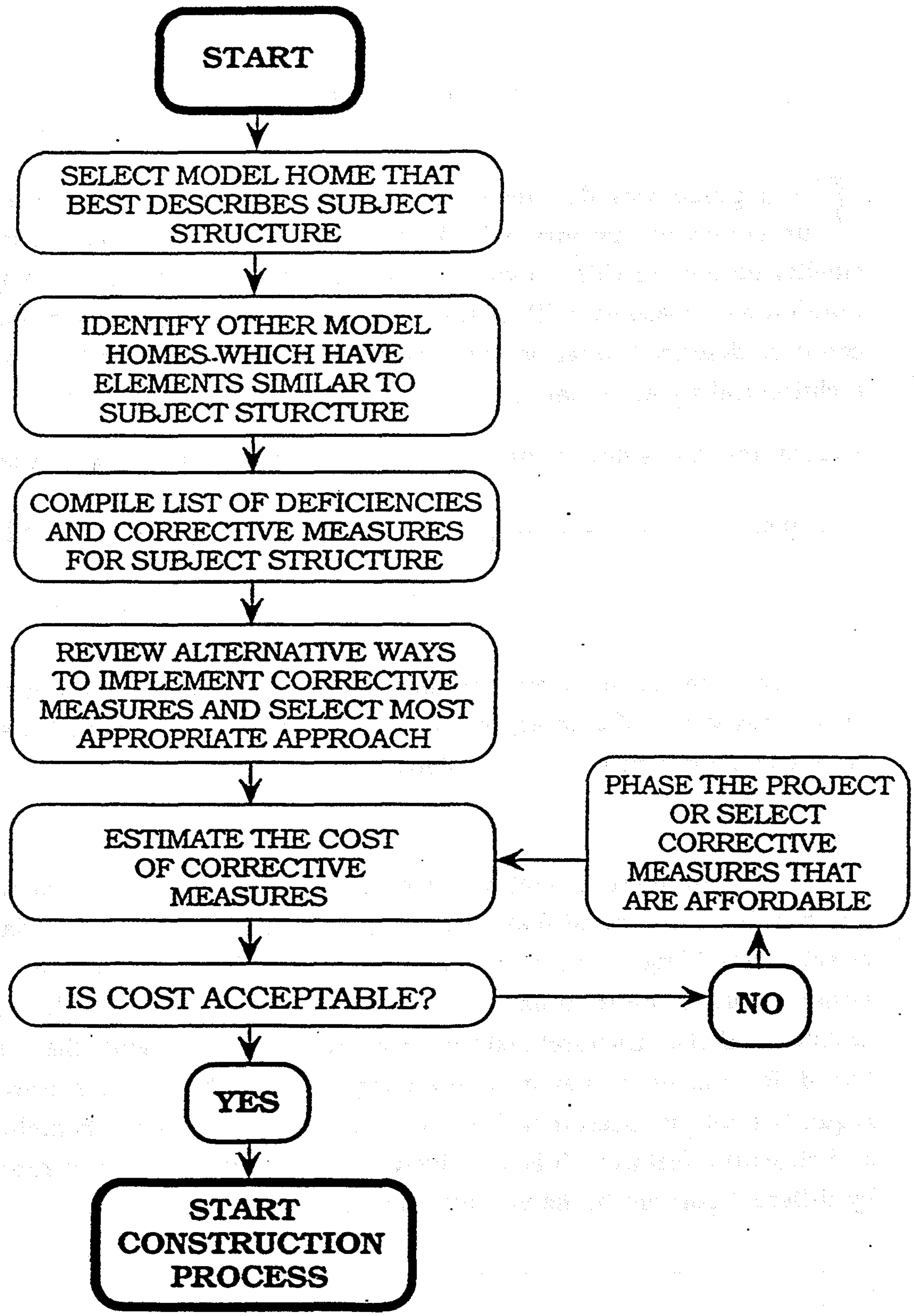
Consecutive Number

The process presented in this guide to evaluate and improve the seismic resistance of a home, is shown in the flow chart on page 10, and will be translated in four consecutive steps:

STEP 1.

From the six model homes described in Chapter 5, determine which one has the architectural features, configuration, and specific materials most closely resembling the home that is to be improved. It may be that a specific home requires more than one model home to properly describe it's architectural and structural features. Chapter 5, best represents the conditions found for the home being investigated. It may be that a specific home requires multiple exterior wall sections to properly describe its architectural and structural features. It is also likely that the home can be best represented by different portions of the various exterior wall sections.

Figure 14: SEISMIC IMPROVEMENT FLOWCHART



STEP 2.

From the list of deficiencies and exterior wall sections in Chapter 5, and seismic improvement details in Chapter 6, select corrective measures which appear to be appropriate for the URM home that is to be improved. The deficiencies are listed according to an order of importance. It is recommended that they be corrected in the same sequence. As an example, the first and most important corrective measure for most unreinforced masonry homes is to provide a positive connection between the wood roof structure and the exterior walls.

STEP 3.

For some deficiencies, there are a number of alternative seismic improvement details which may be used to achieve the same result. There are advantages and disadvantages for each of the alternatives. 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 detail as provided. The method selected will be dictated by several factors which may include the following:

a. Should the entire home or just a portion of the home be seismically improved? This may be related to remodeling or other construction projects planned for the home.

b. Can the architectural and/or historical appearance can 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 are based on constraints in the desired appearance or construction methods. Where multiple seismic improvement details are provided, the first alternative approach shown assumes that no constraints exist. An example of a constraint might be a case where individuals do not want to alter the basic brick look of their home. Since the first alternative shown does not always consider this constraint, major alterations in the architectural appearance could be the result.

STEP 4.

The cost associated with each task should be estimated for the complete list of corrective measures selected. It is recommended that the cost of each task be added to the previous task to create a cumulative total. The budget for the project can then be used to determine how far the seismic improvement process can be taken. Each task should ideally be placed in the ranked priority shown in Table 1, Chapter 5. This priority list can also be readjusted to better meet the homeowners specific needs considering budget or phasing options.

Each corrective measure that is implemented should improve the seismic performance of the home. If a task is done out of the suggested order, the desired improvement may not be achieved because of the failure of another element. Some measures are much more cost effective than others and this is reflected in the suggested order of corrective work. In areas where high levels of ground shaking are probable (U.B.C. Zones 3 & 4), seismic improvements that address deficiencies A., B., & C. are recommended as the minimum amount of seismic rehabilitation work. In areas where the level of expected ground shaking is moderate to low (U.B.C. Zones 2a & 2b), deficiencies A. & B. should be addressed as a minimum. Corrective work beyond these minimum recommended levels will improve the seismic performance of the structure and should be considered.

CHAPTER 3.

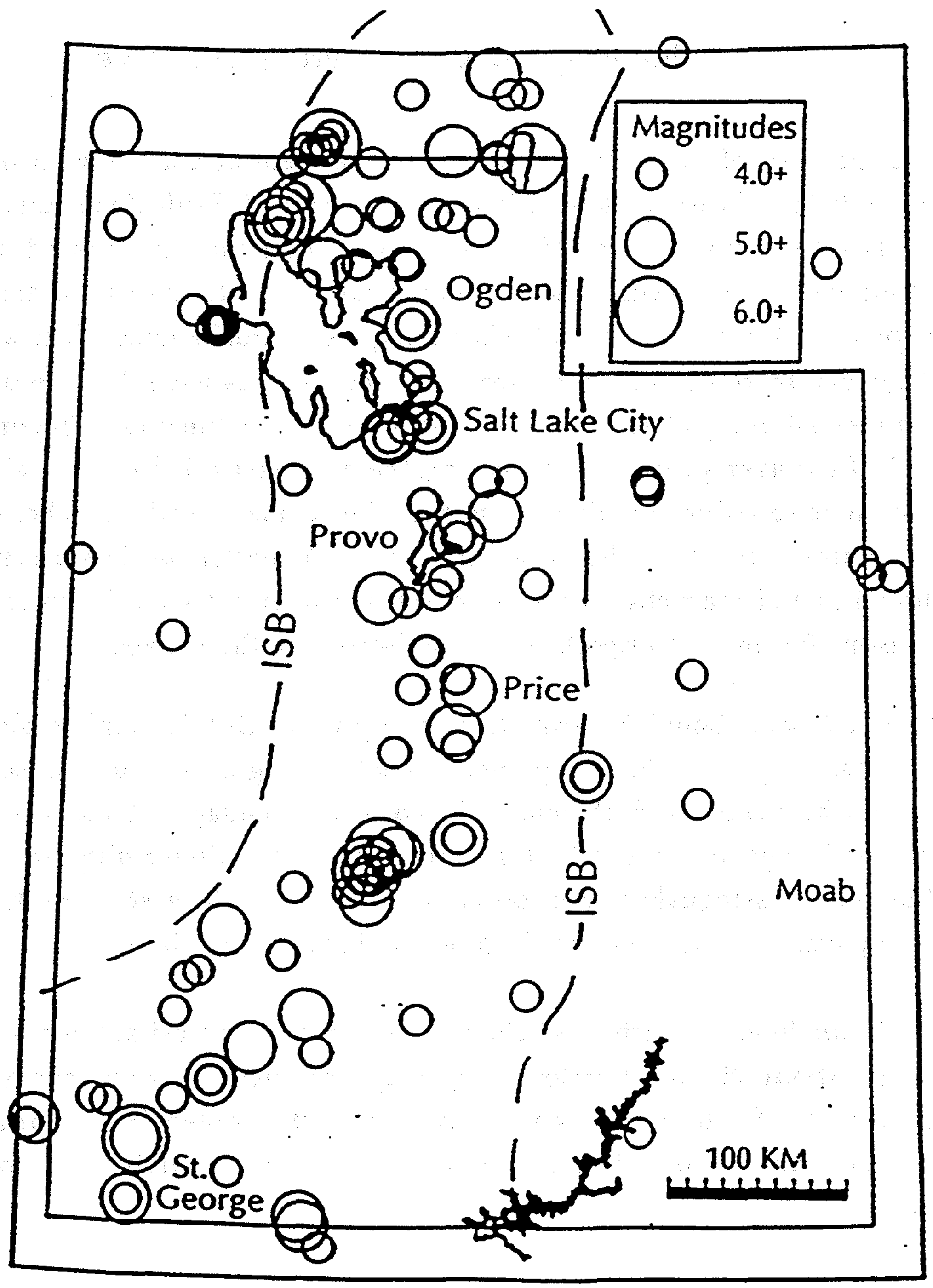
Building Dynamics and Earthquake Forces

The majority of the people who live in the State of Utah have a limited knowledge of earthquakes. We know the Wasatch Fault Zone runs along the west side of the Wasatch Mountains. We know that the ground shakes when an earthquake occurs, and sometimes land and structures are damaged or displaced. We also know that when a large earthquake takes place along a fault system, there will be widespread damage. The damage that could occur to commercial and public structures, and to our infrastructure is beyond the control of the average citizen. However, there are steps that can be taken by homeowners to reduce the damage to their individual dwelling. These steps are explained in the following chapters. A better understanding of earthquakes and their effect on a structure will help individuals understand the reasons for and the importance of implementing these steps.

Utah experiences about 700 earthquakes every year. Of this number, about 13 are Richter magnitude 3.0 or greater. Smaller magnitude earthquakes are rarely felt by people and obviously do not cause damage. However, these small rumblings are important in studying our vulnerability to larger earthquakes. Earthquakes occur on faults or cracks in the earth's crust. Utah has many active faults which could produce damaging earthquakes.

The 180-mile long Wasatch Fault Zone is broken into several segments. Each segment, about 20 to 30 miles long, may produce it's own earthquake independent of other segments. A moderate, potentially damaging earthquake (magnitude 5.5 to 6.5) occurs somewhere in Utah about every 7 years.

Figure 15: INTERMOUNTAIN SEISMIC BELT



General outline of the Intermountain Seismic Belt. Earthquakes of magnitude 4 or greater, in the Utah area from 1850 - 1990.

University of Utah Seismograph Stations catalog: Arabasz and others (1987).

Based on geological studies, large earthquakes (magnitude 6.5 to 7.5) occur along the Wasatch Fault of northern and central Utah about once every 300 to 400 years. The probability of a large earthquake occurring along the Wasatch Fault during the next 50 years is about 1 in 5 or a 20% chance that this will happen.

The Basin and Range province stretches from Reno, Nevada on the west, to the Wasatch Mountains on the east. It includes parts of Utah, Idaho, Oregon, California, Arizona, and New Mexico and is an active part of our drifting continent. This entire area is slowly being uplifted and pulled apart. As the crust of the earth stretches from west to east, cracks and/or faults appear. Portions of the area drop down along these north-south trending faults forming our familiar long narrow valleys, while the mountains have been pushed up and wedged between the dropped valley sections. As the extension and gravitational forces acting on the area overcome the frictional forces holding the valley in place, we experience an earthquake. When this happens, a tremendous amount of stored up energy is released. This energy is in the form of shock waves or vibrations which radiate in all directions from the focus of the earthquake. The point on the ground directly above the focus is the epicenter.

Many houses built before earthquake standards were used (about pre 1970), have little or no earthquake resistant design. Some of these structures, such as wood frame homes, may be fairly flexible and somewhat resistant to ground shaking. A large number of pre-1970 homes in Utah were constructed out of unreinforced masonry (URM). Because of the mass and the brittle properties of masonry construction, these homes have been found to perform poorly during earthquake ground shaking. The seismic improvement of unreinforced masonry 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 code requirements, however, careful long-term planning, leading to the improvement of these URM dwellings, should reduce the resultant damage from earthquake events. Knowledge of potential deficiencies which 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 home to current code requirements, seismic improvement will almost always help reduce the damage and the associated risk to occupants of these dwellings.

Over the years, much research has been done to understand the reasons for failure of certain types of construction. By identifying the strengths and weaknesses of structures that have been subjected to seismic forces, elements required for the seismic stability of most structures have been identified. Though the size, capacity, and type of materials vary with each structure, the basic resisting system must be present in all structures. The basic system to support gravity loads normally includes roof framing, floor framing, wall framing, solid walls and/or piers, beams, columns, footings, and foundations. These systems carry gravity loads, but generally have little resistance to the forces of earthquakes without proper connections between resisting and distributing elements.

The two main elements in earthquake design are resisting elements and distributing elements. The resisting elements are composed of footing, foundation walls, piers, braced columns, walls, wall bracing, or any other element or combination of elements which 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 lateral earthquake forces back to the foundation wall and footing.

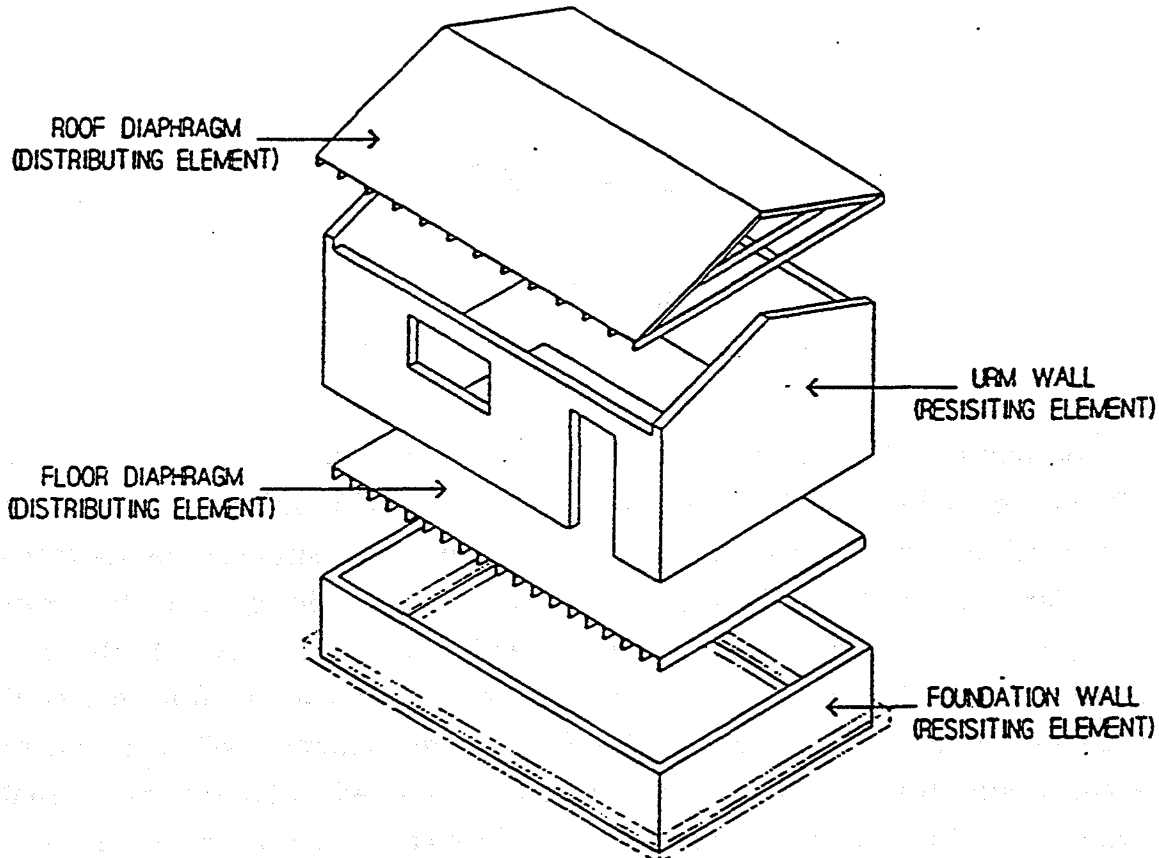


Figure 16 : Isometric view of Typical Structure.

The description of the resisting and distributing elements is an overview of what is required for a structure to withstand seismic forces. Chapter 4 and 5 will address many of the construction methods which were common prior to implementing seismic code standards. The Uniform Building Code no longer allows structures to be built using unreinforced masonry (URM) in seismically active areas. There are many homes in Utah that are constructed out of unreinforced masonry, and although such homes have some inherent strength, they have been shown to perform poorly in moderate to large seismic events. Replacement of the URM dwelling is not normally an economical or historically feasible alternative. This guide was developed to assist the homeowner to identify and mitigate seismic deficiencies inherent in the most common types of URM construction. The following chapters provide explanations of weaknesses and offer the homeowner reasonable steps that can be taken to improve the performance of their URM dwelling during an earthquake.

CHAPTER 4.

Typical *Features* of Unreinforced Masonry (URM) Construction

The focus of this guide is on unreinforced masonry homes built prior to the time when the Uniform Building Code (U.B.C.) prohibited this type of construction. These homes were designed primarily to support gravity loads. The elements used in this type of construction were designed to be strong enough to support the weight of the live and dead loads above. Little or no attachment exists from one element to another. This works fine in a static situation where the home is not subject to movement. When a seismic event occurs, the elements of a structure are subjected to lateral (horizontal) loads in addition to the gravity loads. Failure can occur when the elements are over stressed by the additional loads and/or by the displacement of adjacent elements.

A typical unreinforced masonry dwelling has many elements where failure could occur. The construction may vary slightly, but they all consist of: a footing and/or foundation wall (concrete, masonry, or rock), load bearing masonry exterior walls, wood frame floor(s), and roof system. At the interior, 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, but failure is more likely to occur where one element connects to another.

FOUNDATION WALLS:

Foundation walls for URM homes may be either concrete, masonry, or rock. If the foundation wall is unreinforced masonry or rock, it can break apart at the mortar joints when seismic activity occurs. Many times these walls have been badly deteriorated from moisture penetration over the life of the dwelling. The mortar used in many older homes contains very little cement and is normally very soft and weak.

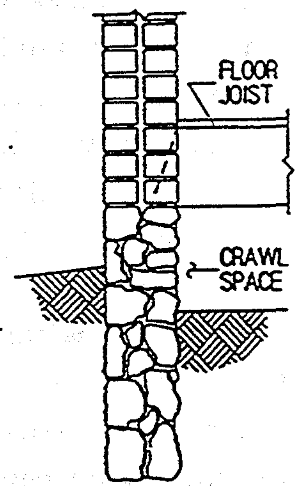


Figure 17

UNREINFORCED MASONRY (URM) BEARING WALL:

A bearing wall is defined as "A wall which supports any vertical load in a building as well as its own weight". In this case, the vertical loads come from the floor and roof systems in the home. The floor(s) and roof are normally composed of wood joists (repetitive horizontal wood members) and a diaphragm (plywood or wood boards). The walls may be covered by siding, stucco, or other materials concealing the masonry from view.

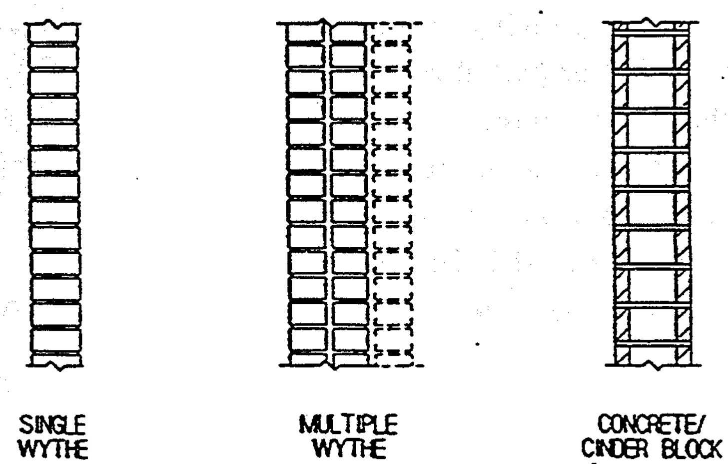


Figure 18: Vertical Section through URM Walls

Figure 18 on the previous page illustrates three types of URM walls in this guide. Failure of these walls can happen in several different ways. In-plane failure occurs when seismic forces are introduced parallel to the wall causing the wall to be displaced horizontally within the plane of the wall. 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. The floor joists usually pocket into the masonry wall and the roof joists normally bear on top of the 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 joist to slide from its bearing support resulting in full or partial collapse of the floor(s) or roof. Another common failure is in multiple wythe construction where the outer wythe(s) of brick fall away from the rest of the wall.

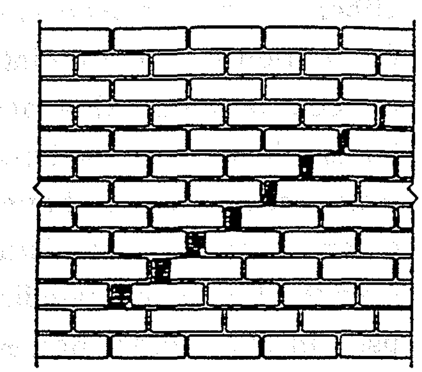


Figure 19

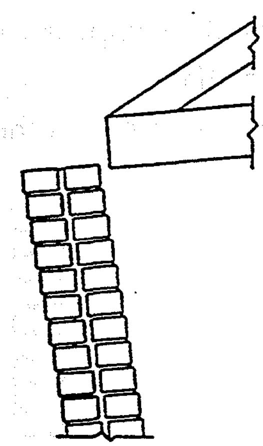


Figure 20

MASONRY PIERS:

There are two typical conditions where masonry piers are likely to occur in this type of dwelling. They can be located at the interior under the main beam line that supports the first floor, or at the exterior to support the roof over a porch. In both cases, the pier either continues to the floor or roof, or supports a wood post which 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 a tendency to topple or buckle during a seismic event.

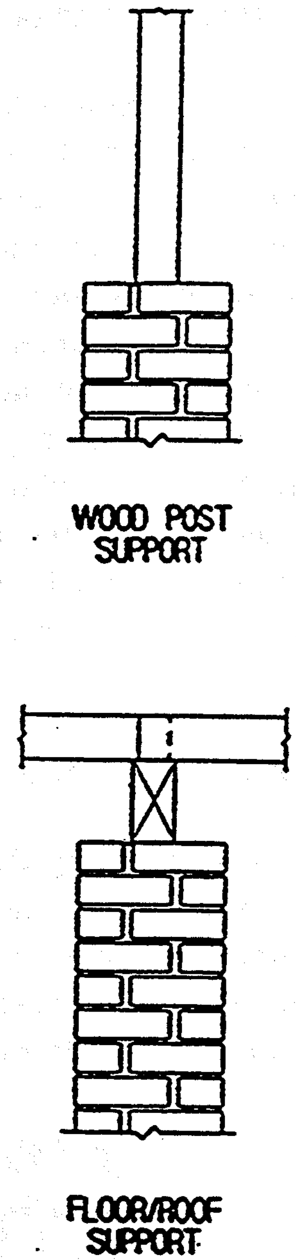


Figure 21

FLOOR AND ROOF DIAPHRAGMS:

The diaphragm is the structural element which consists of sheathing fastened to the underlying joists and distributes forces throughout a particular level. Lateral forces generated in the masonry walls are transferred to the diaphragms. The diaphragms in URM construction generally fail due to the large forces generated form the weight of the surrounding masonry.

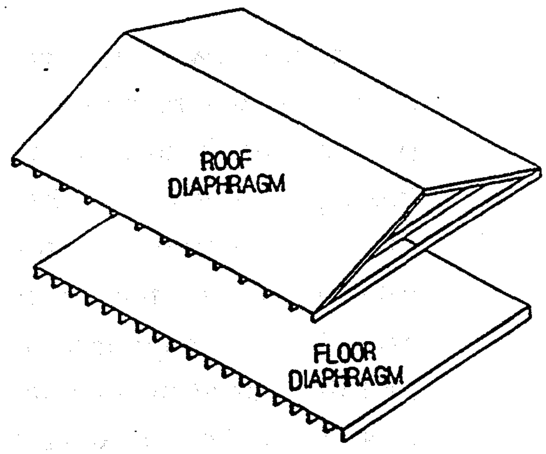


Figure 22

INTERIOR BEARING WALLS AND/OR POST AND BEAM LINES:

The interior bearing element may be an unreinforced masonry wall, a wood stud wall, a post and beam line, or any combination thereof. 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 connection to each other.

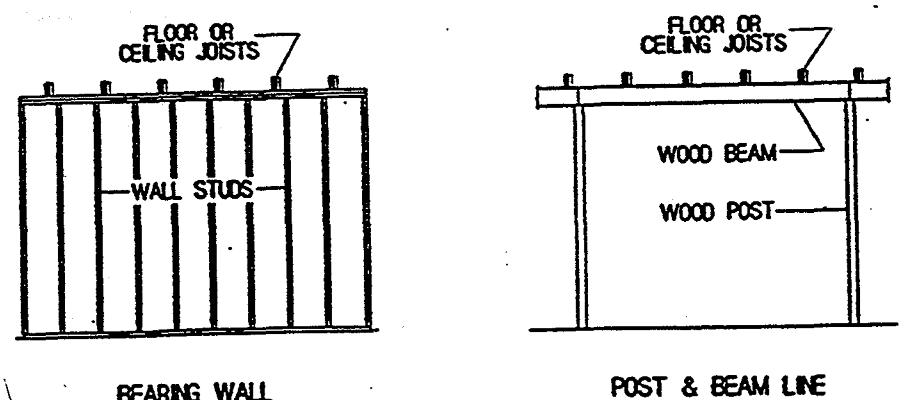


Figure 23

SPECIAL FEATURES:

Most URM homes 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. There are other special features found on URM dwellings; however, these are the most common. A description of these items, their deficiencies, and references to the appropriate corrective measures is included at the end of Chapter 5.

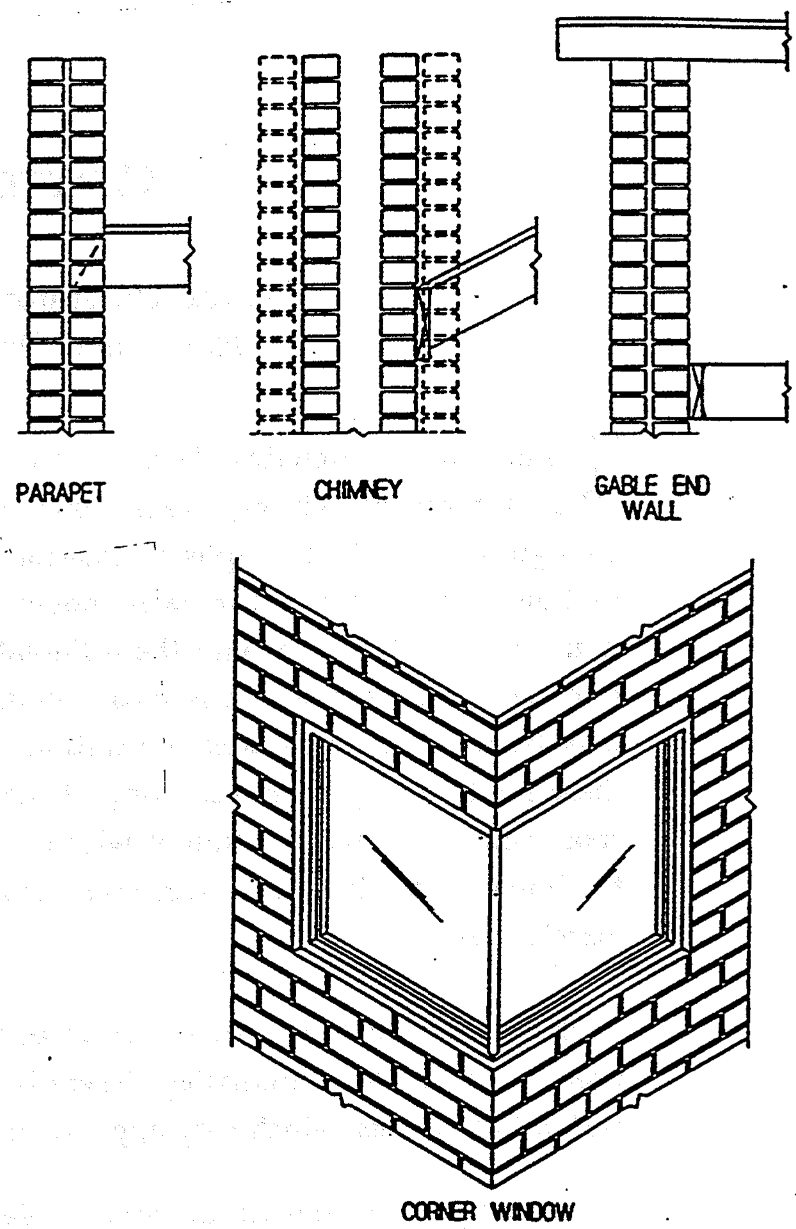


Figure 24

CHAPTER 5.

Typical Unreinforced Masonry *Homes* and Deficiencies

This chapter includes descriptions of six model homes with distinct architectural styles, variations in construction, and different configurations. Photographs of exterior walls and drawings of typical wall sections are included for each model and can be used to compare the homeowner's dwelling with the different model homes. The objective is to find the typical home 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 model types. Careful study of the specific conditions at a home will soon lead to an identification of which exterior wall sections best match with the home. Also included with each model description is a list of its typical deficiencies.

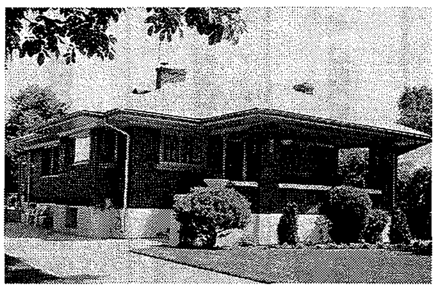
Table 1 lists the deficiencies and corresponding mitigation details that may be used to correct the deficiencies. There is also a special features section at the end of this chapter which may apply to any of the model homes.

The figures in this document are referenced using the following guide:

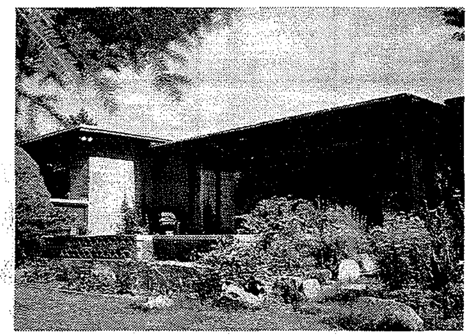
Chapter — X (X-X) — Model Type or Section number.

Consecutive Number

Figure 25: REPRESENTATIVE MODEL HOME TYPES

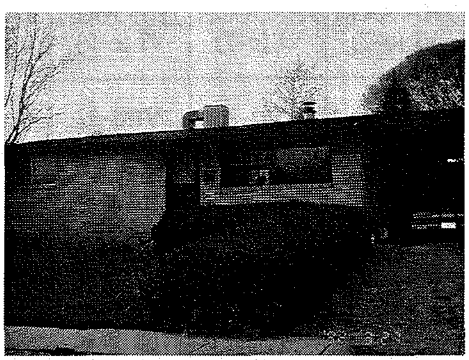


Model A

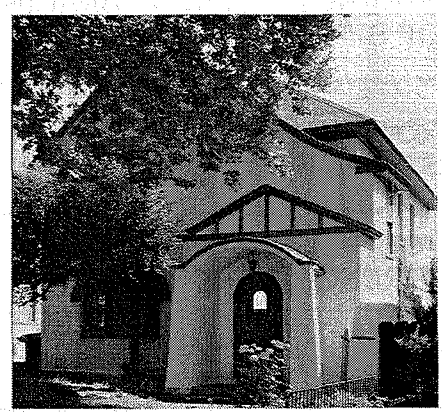


Model F

Model B



Model E



Model C

Model D

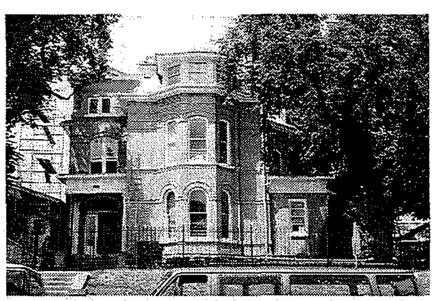


Table 1:
MODEL HOME DEFICIENCIES & UPGRADE DETAILS

SECTION (CHAP. VI)	DEFICIENCIES (In order of highest priority to lowest priority.)	TYPICAL SEISMIC IMPROVEMENT DETAILS					
		MODEL A	MODEL B	MODEL C	MODEL D	MODEL E	MODEL F
a	ROOF TO URM WALL ANCHORAGE	VI (a-1) VI (a-6)	VI (a-2) VI (a-7)	VI (a-3) VI (a-8)	VI (a-3)	VI (a-4) VI (a-9)	VI (a-5)
b	FLOOR TO URM WALL AND FOUND. WALL ANCHORAGE	VI (b-2) VI (b-4) VI (b-5)	VI (b-2) VI (b-4) VI (b-5)	VI (b-1) VI (b-2) VI (b-4) VI (b-5) VI (b-7)	VI (b-1) VI (b-2) VI (b-4) VI (b-5) VI (b-7)	VI (b-3) VI (b-6)	VI (b-2)
c	STRENGTHENING & BRACING OF SPECIAL FEATURES	VI (c-1) THROUGH VI (c-7)	VI (c-1) THROUGH VI (c-7)	VI (c-1) THROUGH VI (c-7)	VI (c-1) THROUGH VI (c-7)	VI (c-1) THROUGH VI (c-7)	VI (c-1) THROUGH VI (c-7)
d	ROOF DIAPRHAGM STRENGTHENING	VI(d-1) THROUGH VI (d-3)	VI(d-1) THROUGH VI (d-3)	VI(d-1) THROUGH VI (d-3)	VI(d-1) THROUGH VI (d-3)	VI(d-1) THROUGH VI (d-3)	VI(d-1) THROUGH VI (d-3)
e	FOUNDATION WALL STRENGHENING	VI (e-1)	VI (e-1)	VI (e-1)	VI (e-1)	VI (e-1)	VI (e-1)
f	FLOOR DIAPHRAGM STRENGTHENING	VI (f-1)	VI (f-1)	VI (f-1)	VI (f-1)	VI (f-1)	VI (f-1)
g	URM WALL STRENGTHENING	VI (g-1) VI (g-2)	VI (g-1) VI (g-2)	VI (g-1) VI (g-2)	VI (g-1) VI (g-2)	VI (g-1) VI (g-2)	VI (g-3) VI (g-4)
h	STENGTHENING OF MAJOR INTERIOR BEARING ELEMENTS	VI (h-1) THROUGH VI (h-6)	VI (h-1) THROUGH VI (h-6)	VI (h-1) THROUGH VI (h-6)	VI (h-1) THROUGH VI (h-6)	VI (h-1) THROUGH VI (h-6)	VI (h-1) THROUGH VI (h-6)
	NON-STRUCTURAL BRACING & ANCHORAGE	FOR BRACING & ANCHORAGE OF NON-STRUCTURAL ITEMS INCLUDING WATER HEATERS, FURNISHINGS, CABINETS, EQUIPMENT, ETC. SEE DETAILS VII-1 THROUGH VII-12.					

MODEL A

Single Story, Double Wythe Brick with Basement

Model Home A was built in approximately 1906. This is a single story home with a full basement. The construction consists of double wythe URM walls and concrete foundation walls supporting wood floor and roof/ceiling joists around the exterior and wood stud bearing walls at the interior. It has two chimneys, one exterior and one interior, and a porch with tall masonry piers supporting the roof.

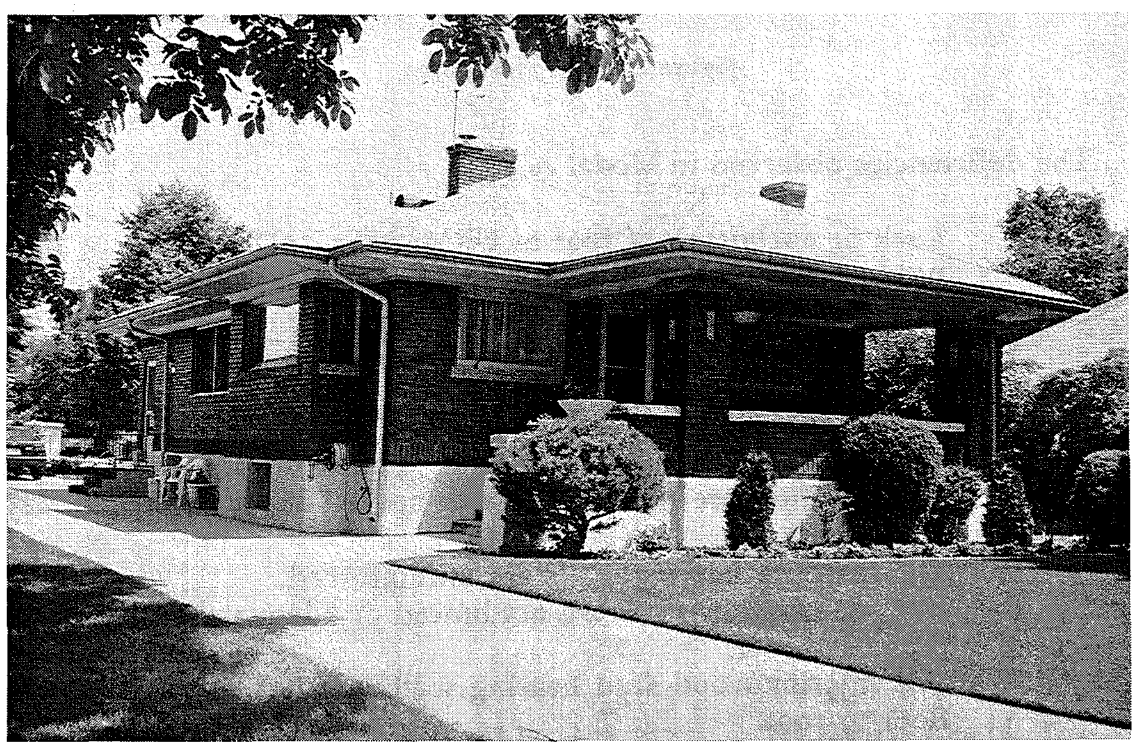


Figure 26: Front Elevation

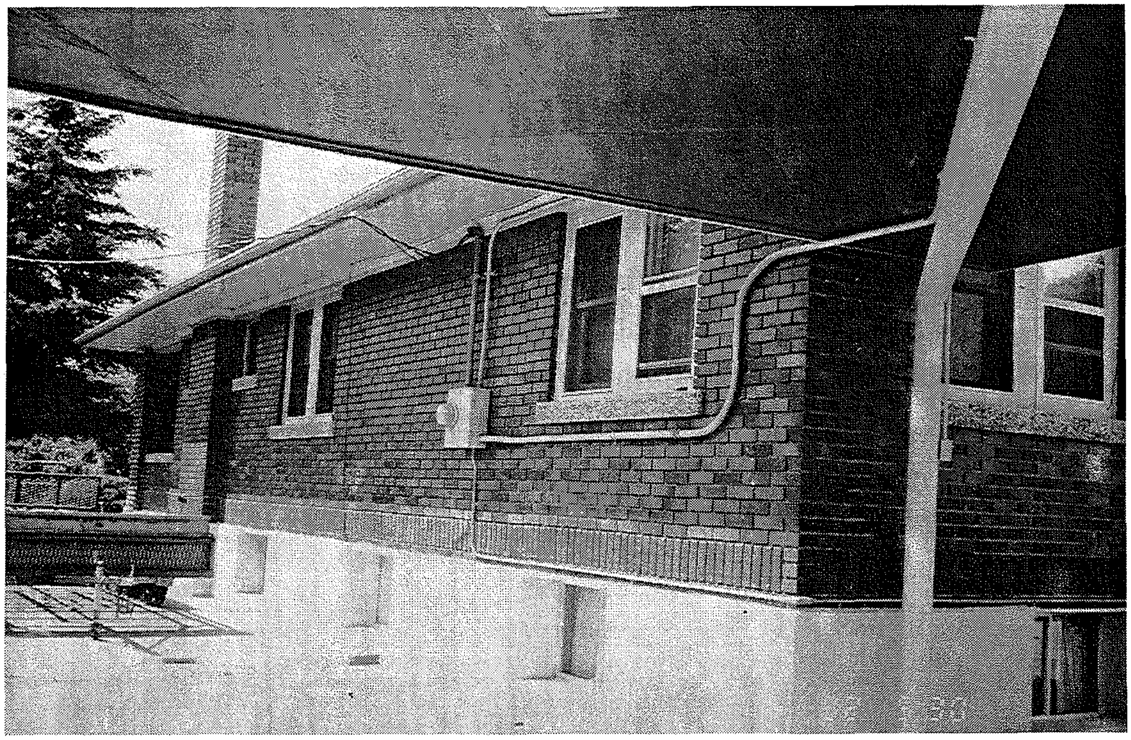
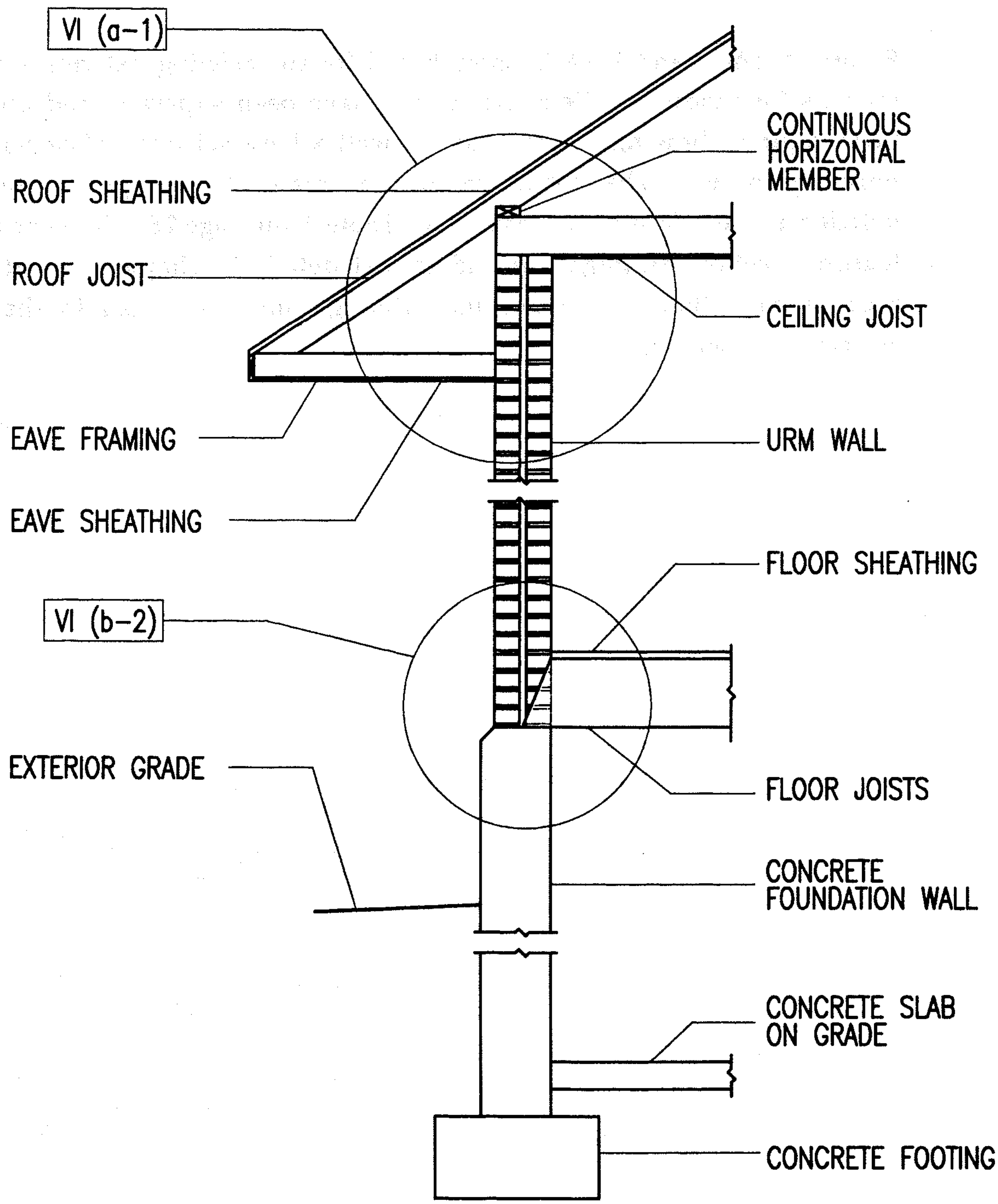


Figure 27: Rear Elevation

The deficiencies observed in Model A are:

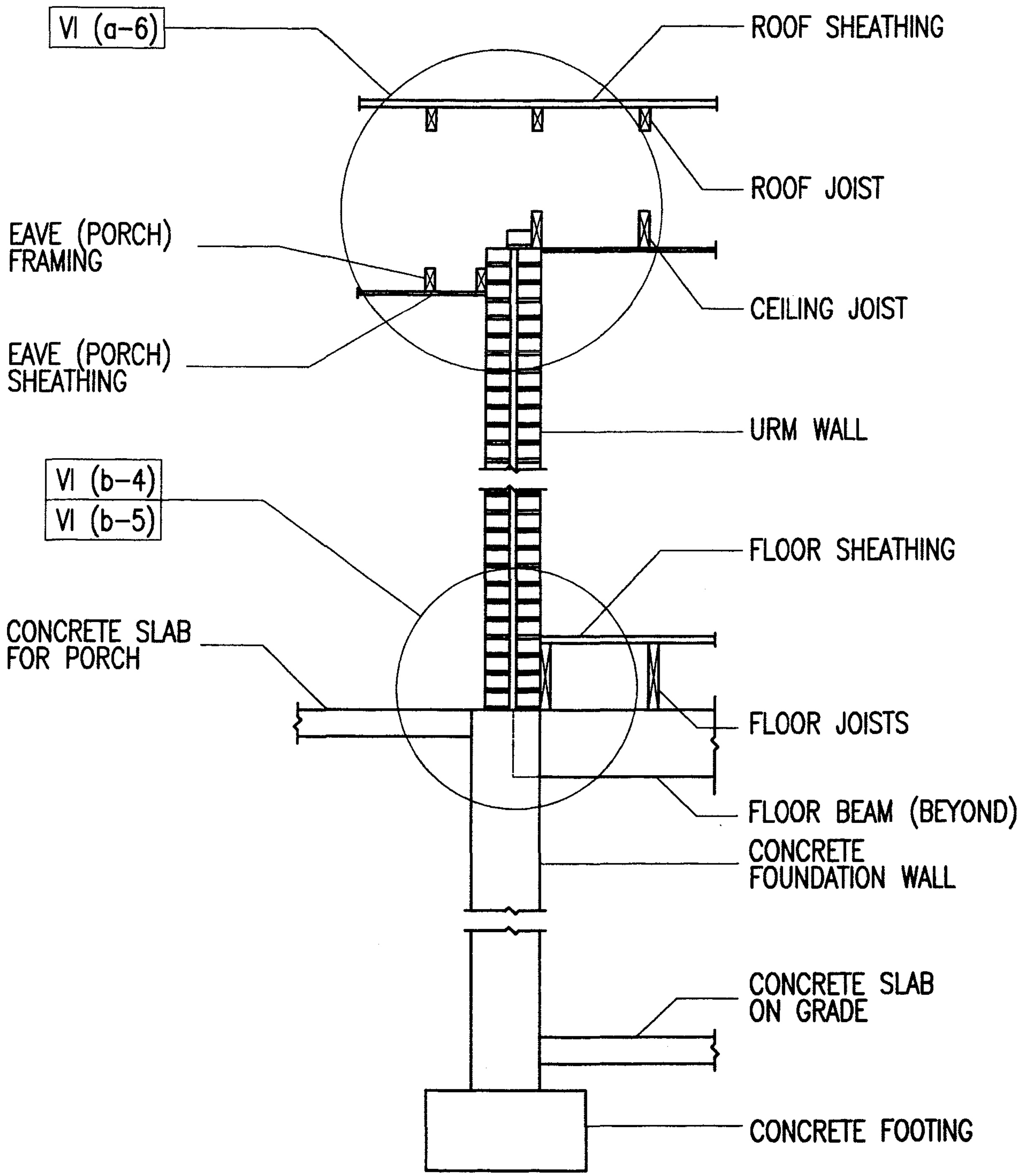
1. Lack of anchorage of roof to URM walls. (There may or may not be a wood plate on top of the typical URM wall. This home did not have one.)
2. Lack of anchorage of floor to URM walls and concrete foundation walls.
3. The chimneys are not braced.
4. The lack of continuous sheathing makes the roof diaphragm weak. (There are 1x6 wood boards spaced at approximately 12" on center.)
5. The masonry bearing walls are unreinforced.
6. The tall masonry 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. Water heater is not braced. Utility connections are rigid.

Figures V (A-1) and V (A-2) show two different existing exterior wall sections for Model A. Reference circles have been superimposed onto these figures 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 on page 26 , the special features section **on page**, and additional details in chapters 6 and 7 recommend other improvements, although not illustrated in these exterior wall sections.



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL A	Figure No.: V (A-1)



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL A	Figure No.: V (A-2)

MODEL B

Single Story, Double Wythe brick with Shelf Basement and Attic

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

Figure 28: Front Elevation.

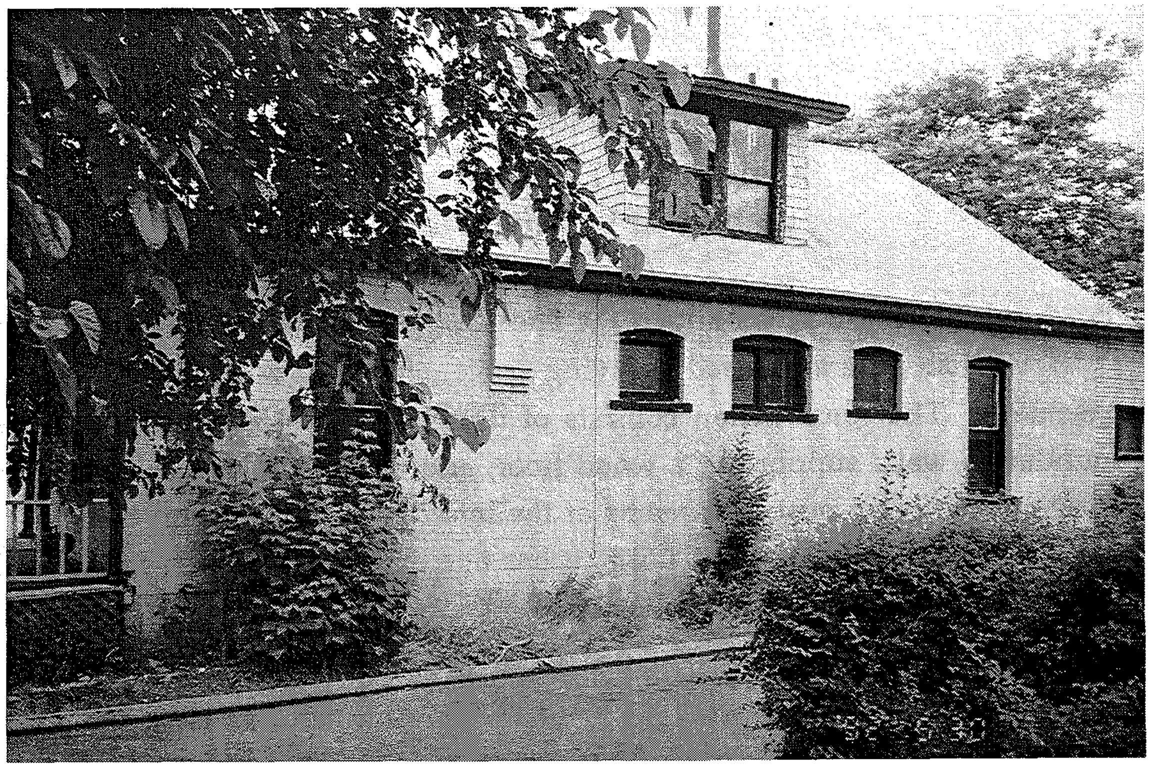


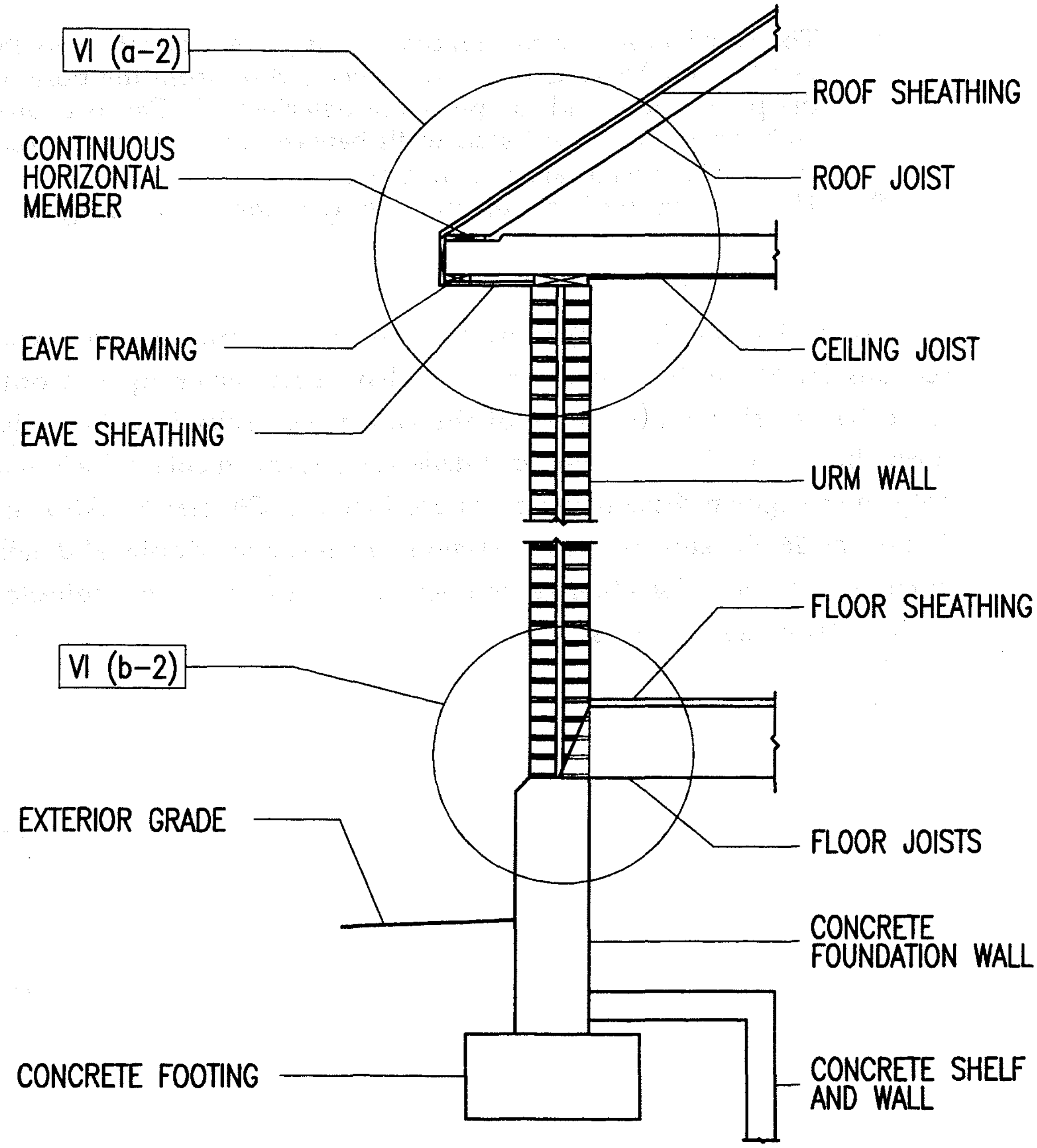
Figure 29: Side Elevation

The deficiencies observed in Model B are:

1. Lack of anchorage of roof to URM walls. (There may or may not be a wood plate on top of the typical URM wall. This home did have one.)
2. Lack of anchorage of floor to URM walls and concrete foundation walls.
3. The chimney is not braced.
4. The lack of continuous sheathing makes the roof diaphragm weak. (There are 1x8 wood boards spaced at approximately 12" on center.)
5. The concrete foundation wall is deteriorated. (The vertical concrete walls in the basement of this house that do not extend to the floor structure 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 or roof.
7. The masonry bearing walls are unreinforced.

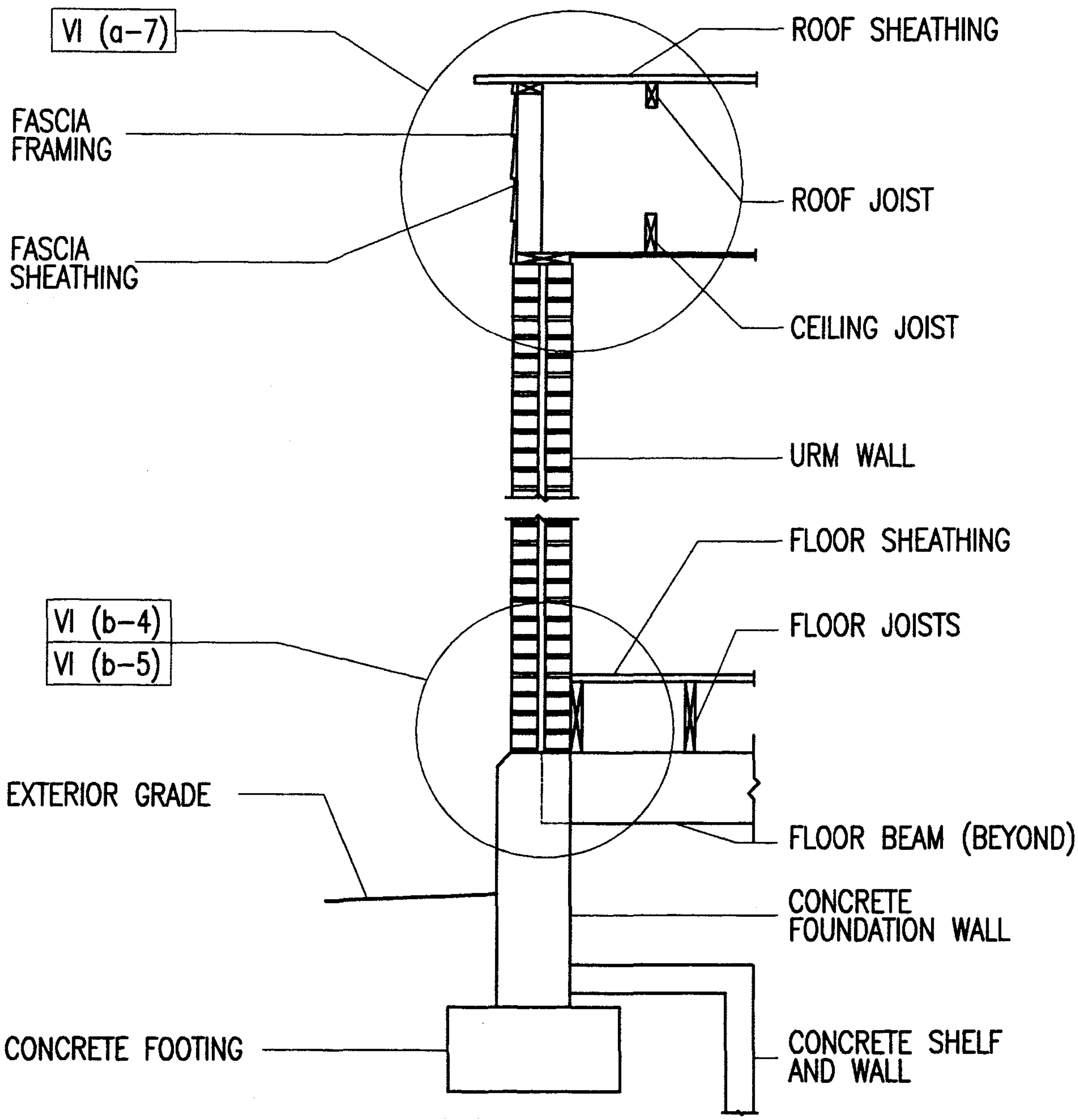
8. The wood posts are not braced or adequately attached to the porch roof. There is also a weak connection from the posts to the piers below and the piers are deteriorated. The occupied attic consists of wood stud walls between the ceiling and roof joists. These walls are not anchored.
9. The water heater is not braced. Utility connections are rigid.

Figures V (B-1) and V (B-2) show two different existing exterior wall sections for Model B. Reference circles have been superimposed onto these figures showing the area of the wall where seismic deficiencies normally occur. The referenced details for improvements which will help to strengthen these deficiencies are found in Chapter 6. Also, see Table 1 on 26, the special features section on page, and additional details in chapters 6 and 7 for other recommended improvements not reflected in the exterior wall sections.



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL B	Figure No.: V (B-1)



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL B	Figure No.: V (B-2)

MODEL C

Two-Story, Stucco-covered Double Wythe Brick with Shelf Basement

Model Home C was built in the 1900's . This is a two story home with a concrete shelf basement. The construction consists of double wythe URM walls covered with stucco and masonry/rock foundation walls supporting 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 home

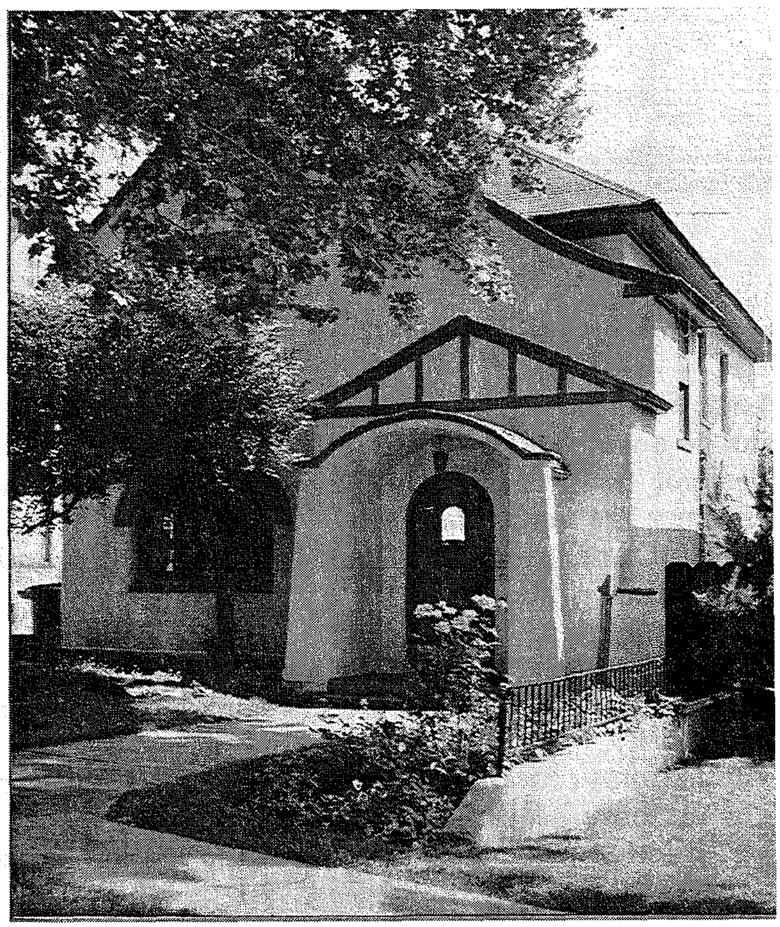


Figure 30: Front Elevation

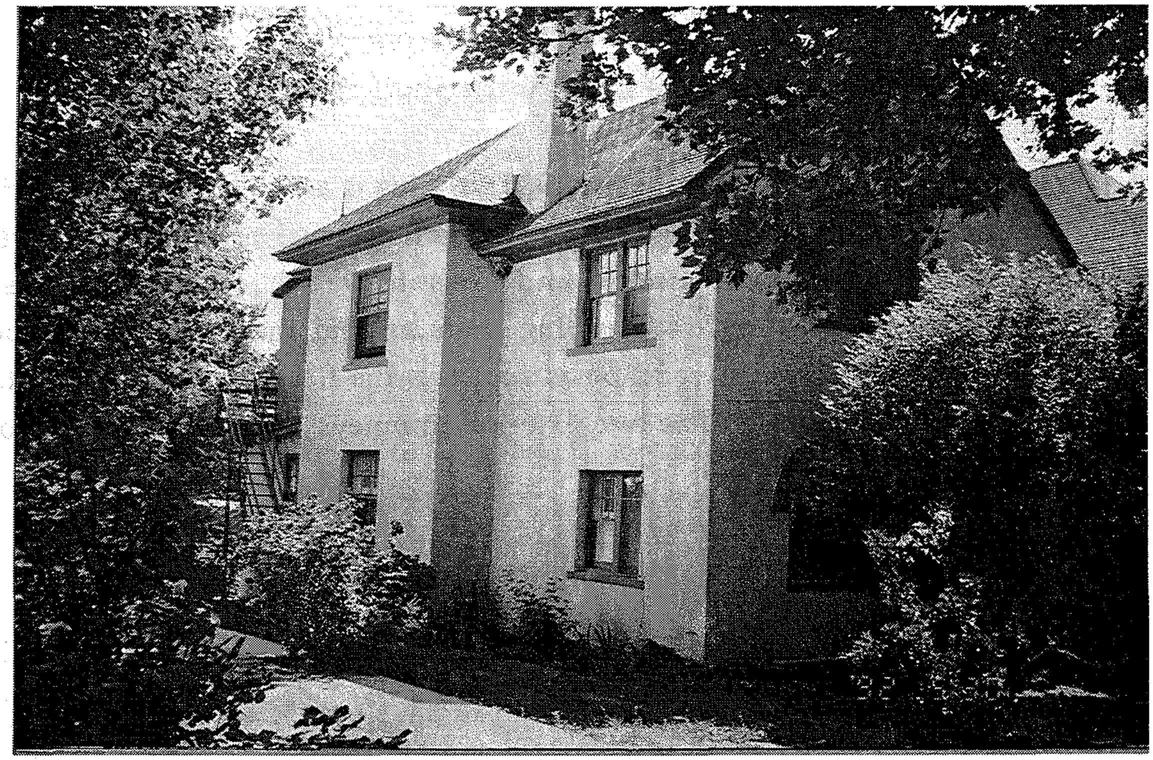
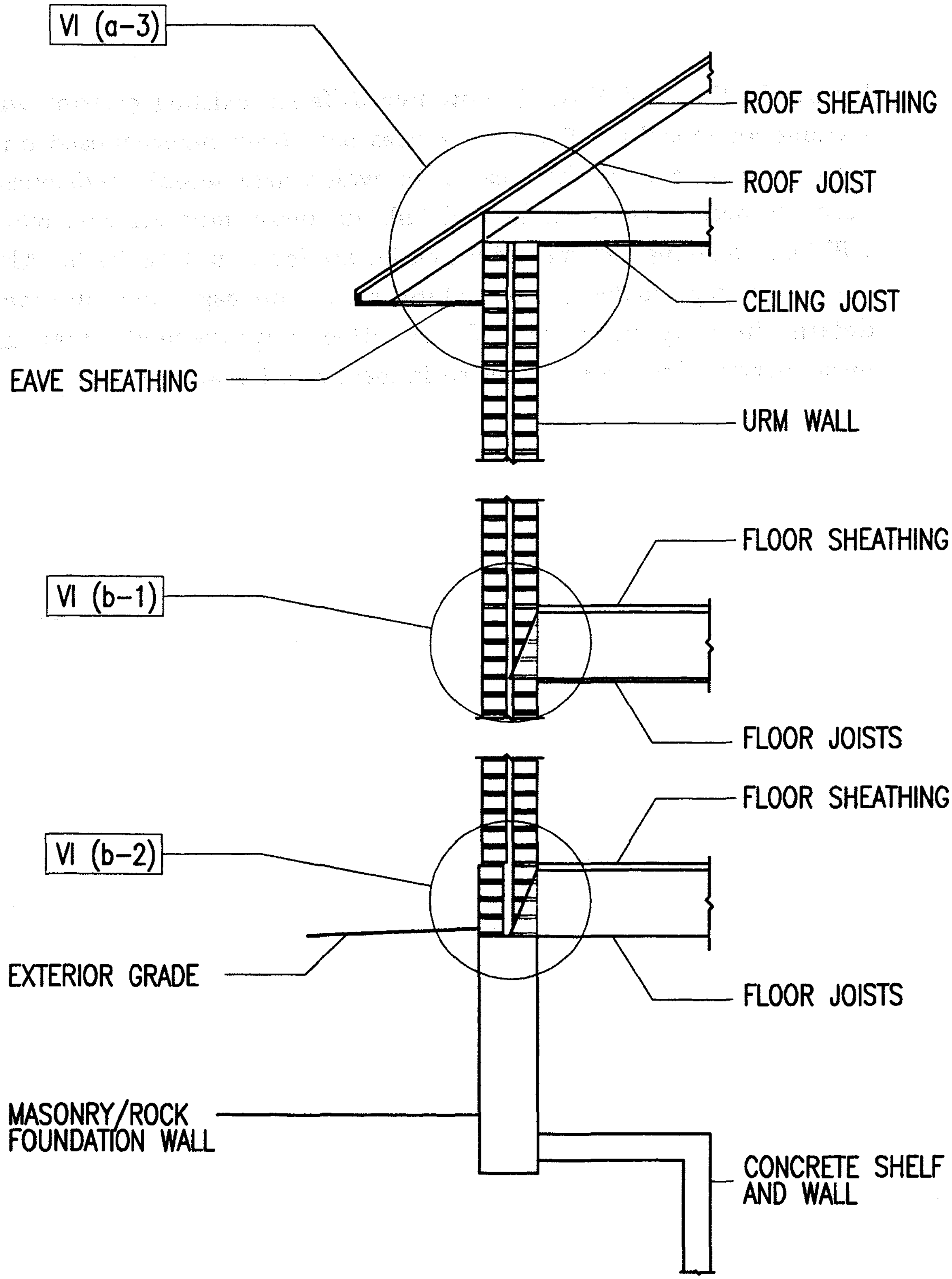


Figure 31: Side Elevation

The deficiencies observed in Model C are:

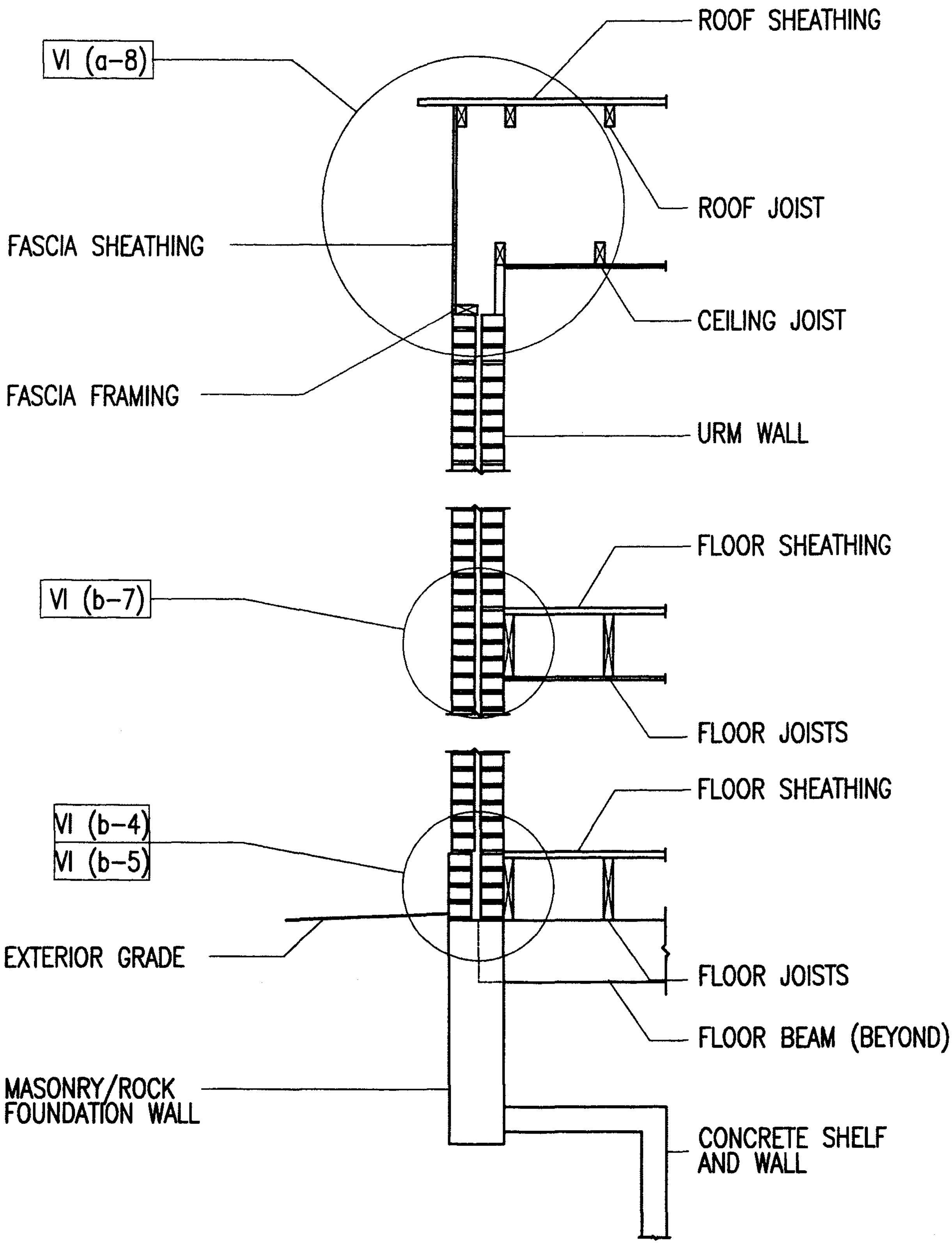
1. Lack of anchorage of roof to URM walls. (There may or may not be a wood plate on top of the typical URM wall. This home did not have one.) Also, the small roof areas at the front entrance are not anchored.
2. Lack of anchorage of floor to URM walls and concrete foundation walls.
3. The chimneys are not braced.
4. The lack of continuous sheathing makes the roof diaphragm weak. (There are 1x8 wood boards spaced at approximately 12" on center.)
5. The masonry/rock foundation walls are deteriorated.
6. The masonry bearing walls are unreinforced.
7. The interior wood stud bearing walls are not anchored to the floor or roof.
8. Water heater is not braced. Utility connections are rigid.

Figures V (C-1) and V (C-2) show two different existing exterior wall sections for Model C. Reference circles have been superimposed onto these figures showing the area of the wall where seismic deficiencies normally occur. The referenced details for these improvements which will help to strengthen these deficiencies are found in Chapter 6. Also, Table 1 on page 26 the special features section on page, and additional details in chapters 6 and 7 for other improvements that are recommended, but are not reflected in these exterior wall sections.



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL C	Figure No.: V (C-1)



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL C	Figure No.: V (C-2)

Model D

Two-Story, Double Wythe Brick with Shelf Basement and Attic

Model Home D was built in the 1900's. This is a two story home with living space built into the attic area and a partial shelf basement. The construction consists of double wythe URM walls and masonry/rock foundation walls supporting wood floor and roof/ceiling joists around the exterior. A wood beam carried by masonry piers support the floor, while a wood stud wall supports the ceiling/floor joists. It has one exterior chimney and a few low roof areas at the floor line.

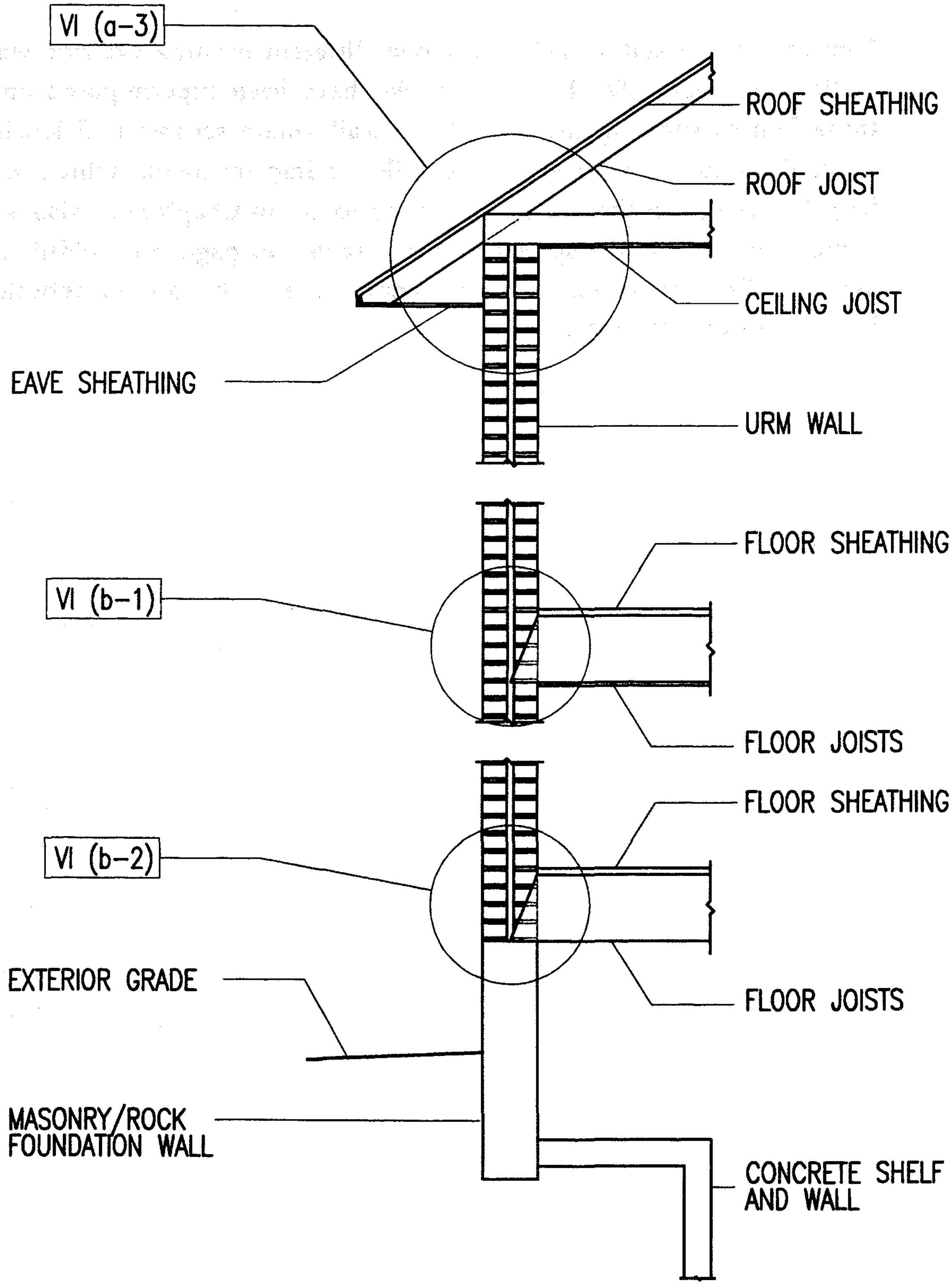
Figure 32: Front Elevation

Figure 33: Side Elevation

The deficiencies observed in Model D are:

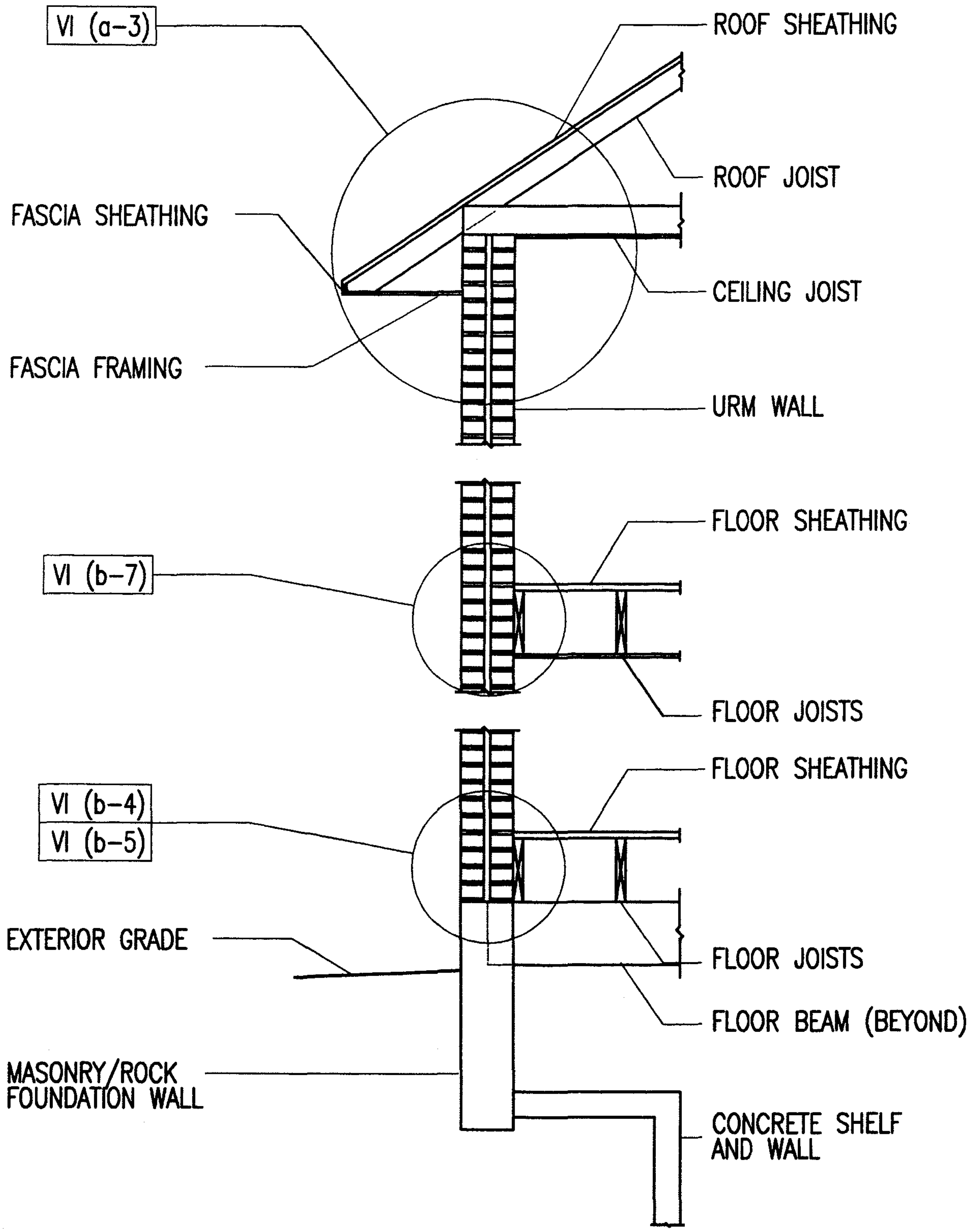
1. Lack of anchorage of roof to URM walls. (There may or may not be a wood plate on top of the typical URM wall. This home did not have one.
2. Lack of anchorage of floor to URM walls and concrete foundation walls.
3. The chimney is not braced.
4. The lack of continuous sheathing makes the roof diaphragm weak. (There are 1x8 wood boards spaced at approximately 12" on center.)
5. The masonry/rock foundation walls are 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. The masonry pier is deteriorated.
8. Water heater is not braced. Utility connections are rigid.

Figures V (D-1) and V (D-2) show two different existing exterior wall sections for Model D. Reference circles have been superimposed onto these figures showing the area of the wall where seismic deficiencies normally occur. The referenced details for improvements which will help to strengthen these deficiencies are found in Chapter 6. Also, see Table 1 on page 26, the special features section on page, and additional details in Chapters 6 and 7 for other improvements that are not reflected in the exterior wall sections.



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL D	Figure No.: V (D-1)



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL D	Figure No.: V (D-2)

MODEL E

Single Story, Single Wythe Solid Brick with Full Basement

Model Home E was built in approximately 1966. This is a single story home with a full basement and a low slope roof. The construction consists of single wythe URM walls and concrete foundation walls supporting wood floor joists and roof trusses around the exterior. Wood stud bearing walls support 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/wood columns.

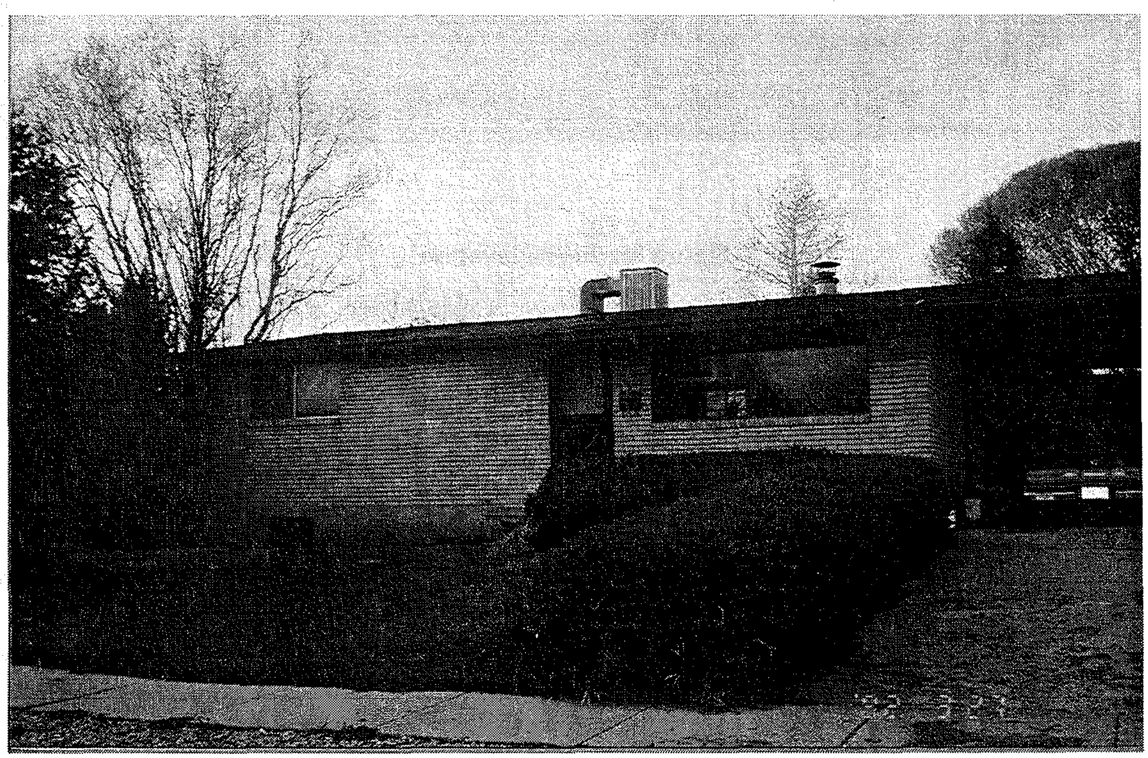


Figure 34: Front Elevation

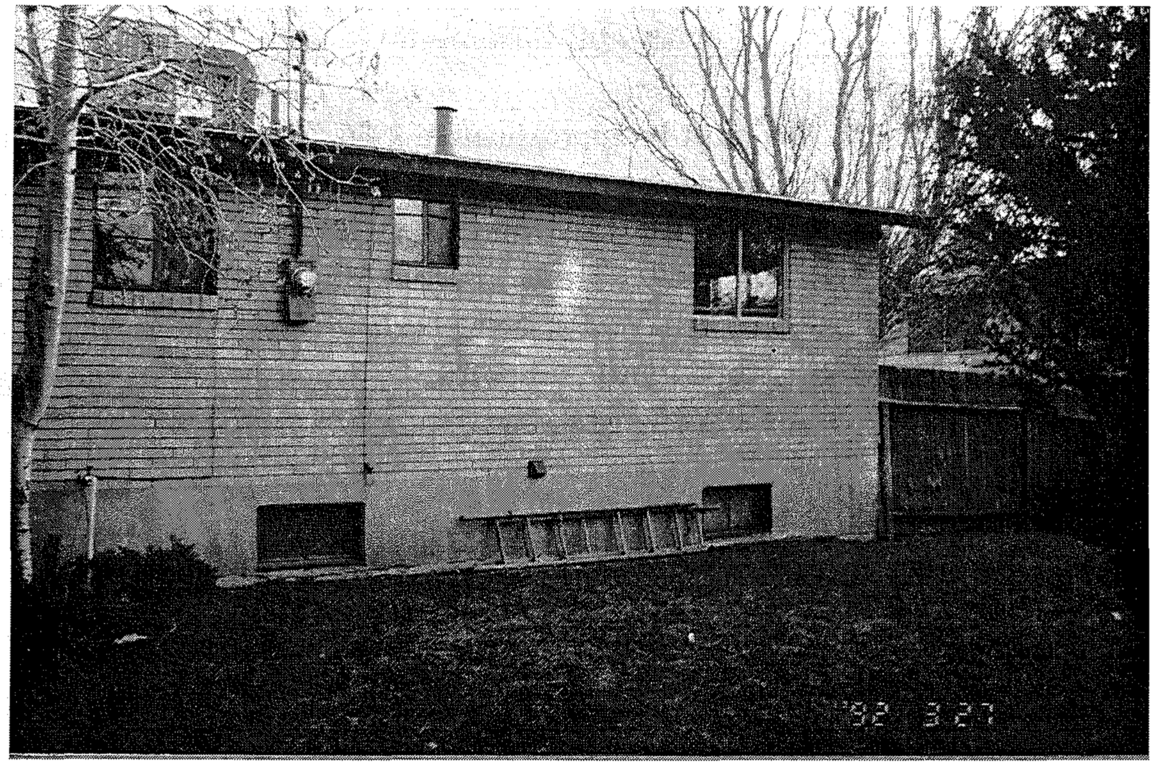
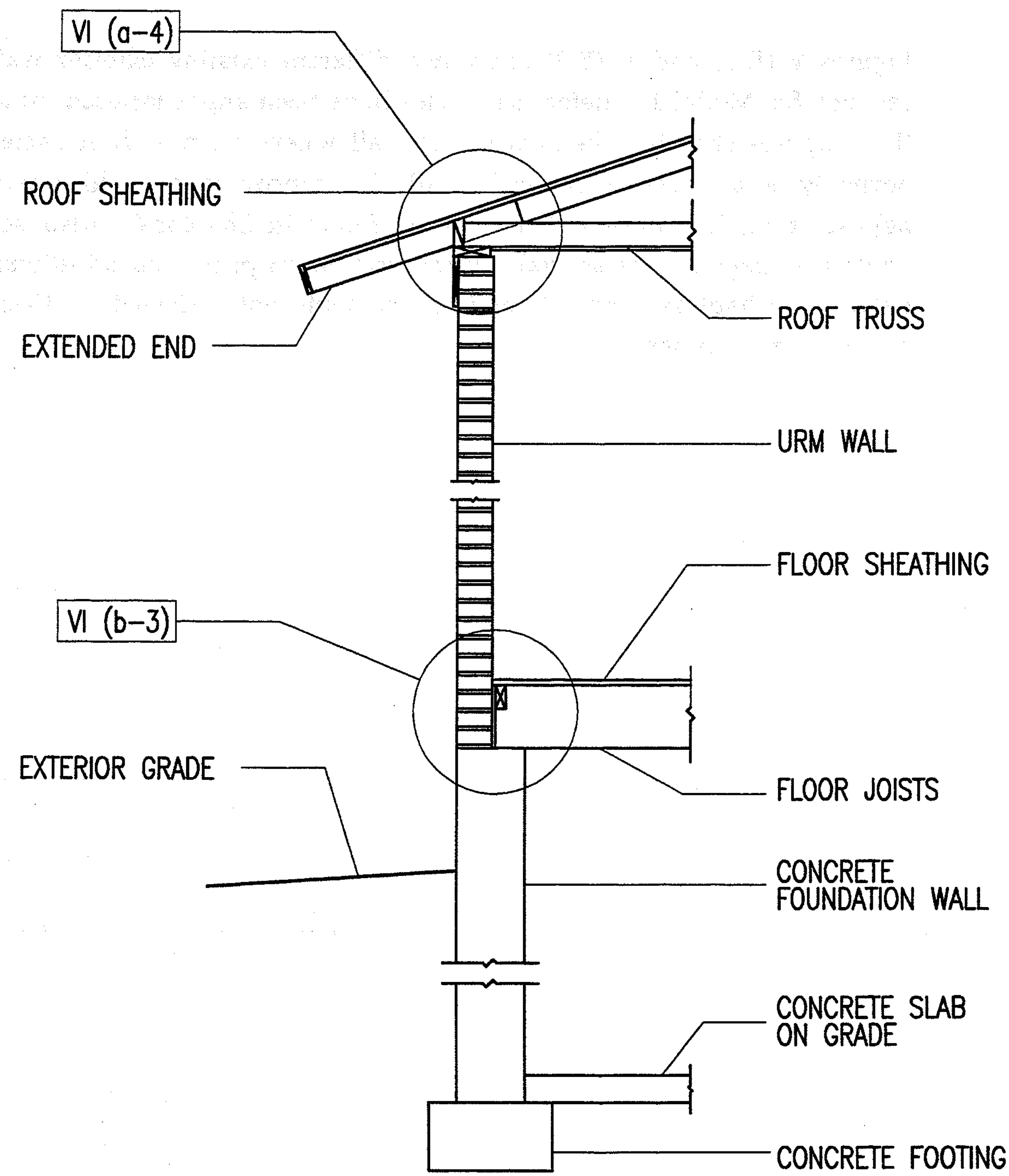


Figure 35: Rear Elevation

The deficiencies observed in Model E are:

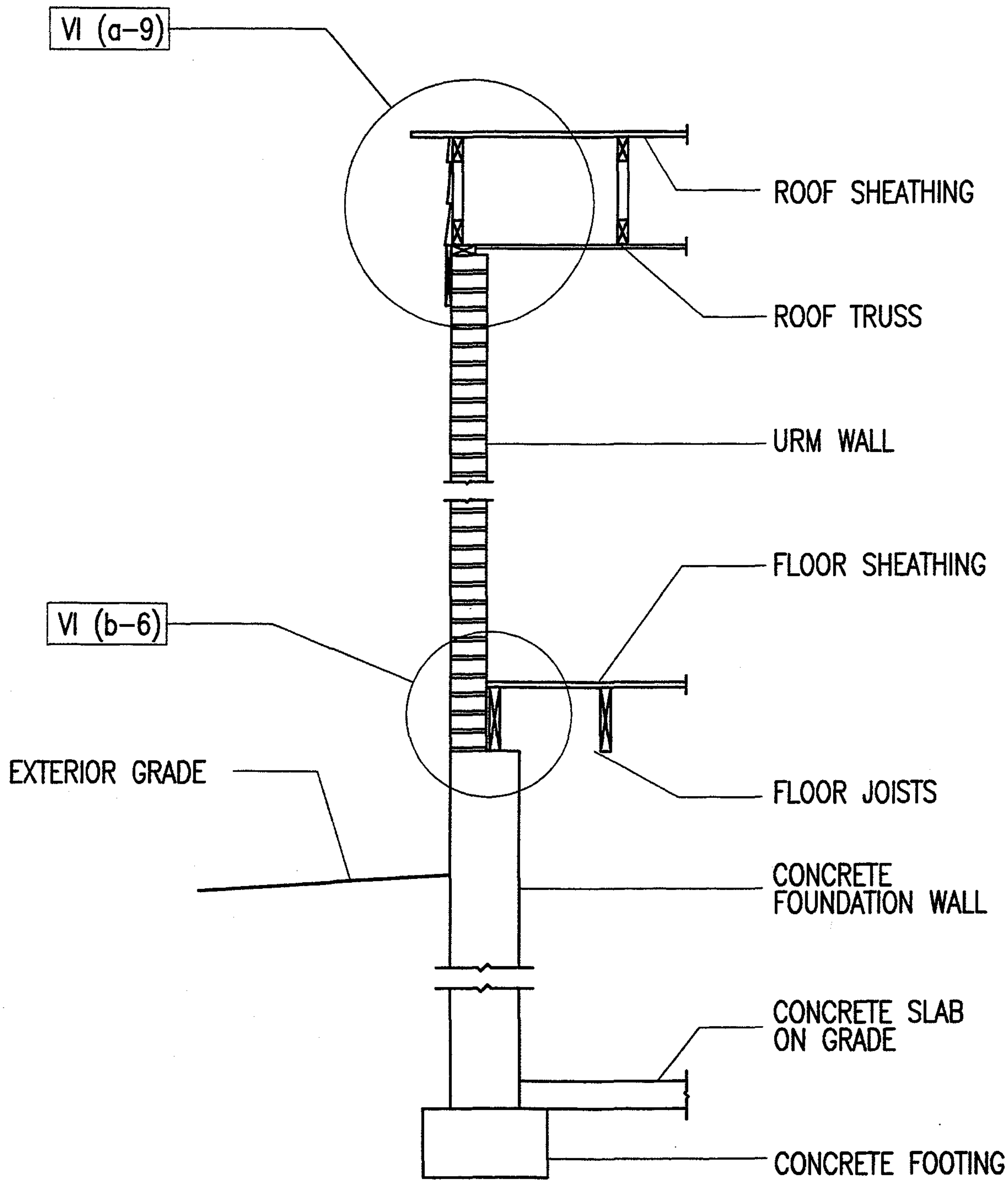
1. Lack of anchorage of roof to URM walls.
2. Lack of anchorage of floor to URM walls and concrete foundation walls.
3. The masonry bearing walls are unreinforced.
4. The beams and columns for the carport are not anchored or braced to the roof or to the masonry walls of the building.
5. The interior wood stud bearing walls are not anchored to the floor or the roof.
6. Water heater is not braced. Utility connections are rigid.

Figures V (E-1) and V (E-2) show two different existing exterior wall sections for Model E. Reference circles have been superimposed onto these figures showing the area of the wall where seismic deficiencies normally occur. The referenced details for improvements which will help to strengthen these deficiencies are found in Chapter 6. Also, see Table 1 on page 26, the special features section on page, and additional details in Chapters 6 and 7 for improvements not reflected in these exterior wall sections.



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL E	Figure No.: V (E-1)



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL E	Figure No.: V (E-2)

MODEL F

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

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

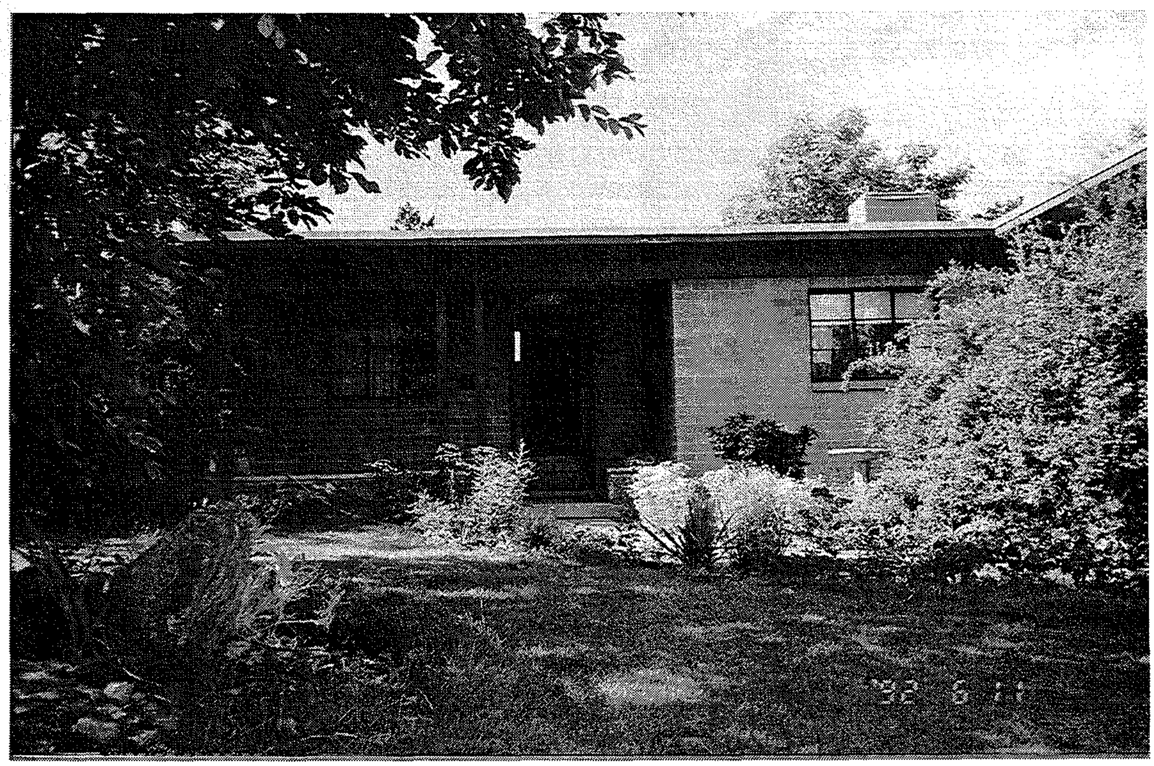


Figure 36: Front Elevation

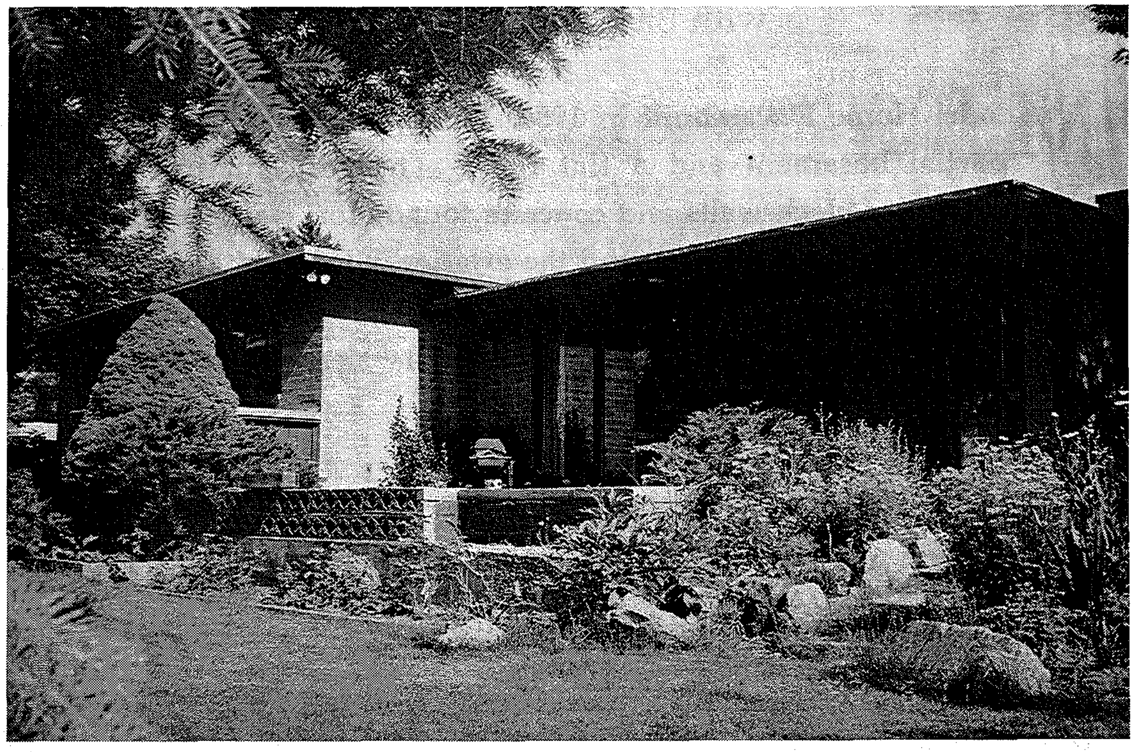
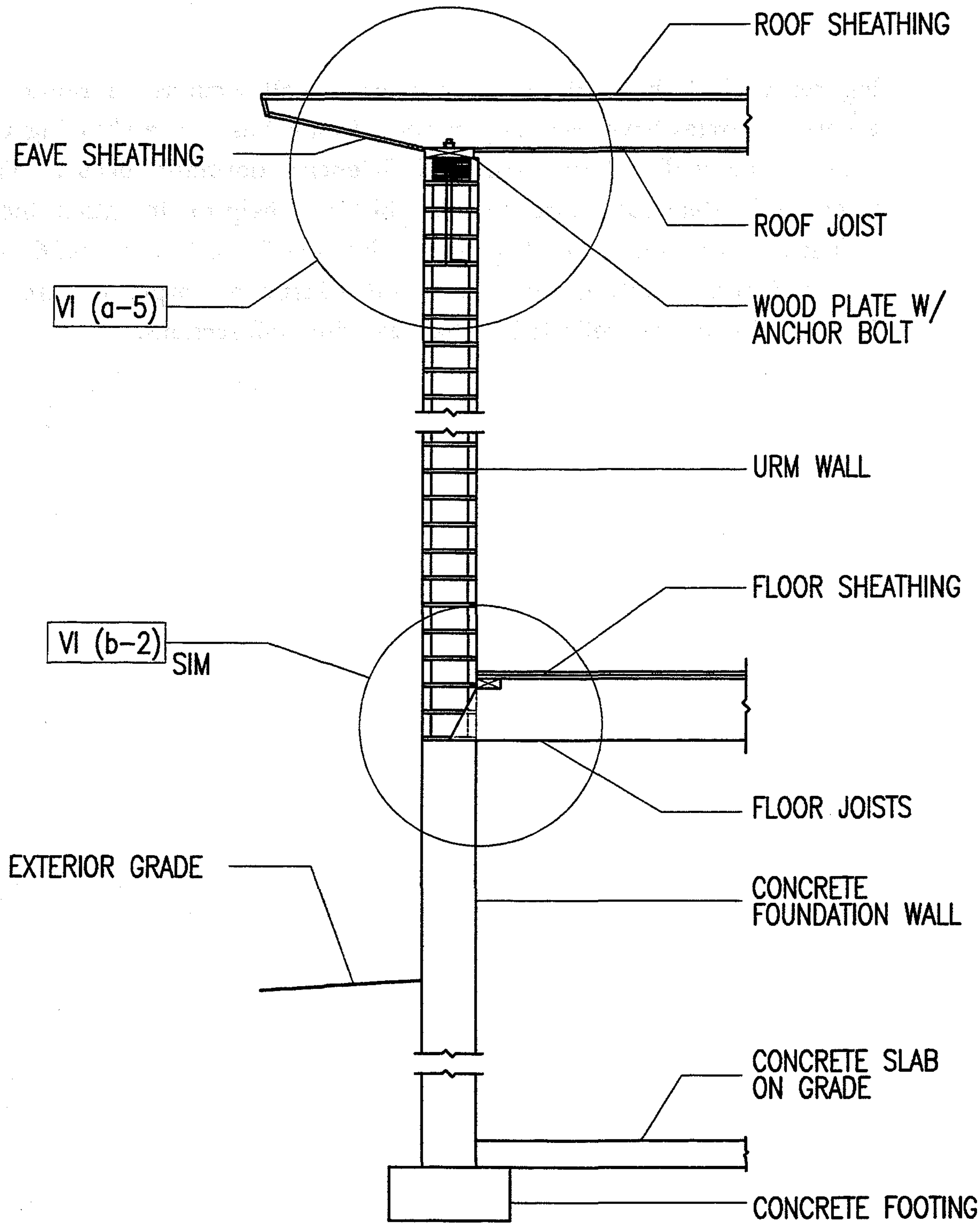


Figure 37: Rear Elevation

The deficiencies observed in Model F are:

1. Lack of adequate anchorage of roof to URM walls.
2. Lack of anchorage of floor to URM walls 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. Water heater is not braced. Utility connections are rigid.

Figures V (F-1) shows the existing exterior wall sections for Model F. Reference circles have been superimposed onto this figure showing the area of the wall where seismic deficiencies normally occur. The referenced details for improvements which will help to strengthen these deficiencies are found in Chapter 6. Also, see Table 1 on page 26, the special features section **on page**, and additional improvements in Chapters 6 and 7 not reflected in these exterior wall sections.



EXTERIOR WALL SECTION

Model Home Seismic Deficiencies	Home Type: MODEL F	Figure No.: V (F-1)

SPECIAL FEATURES

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

PARAPETS

The portion of a wall which projects above the roof line is considered to be a parapet. The top of a typical parapet is usually not braced. When movement occurs, the parapet can break off near the roof line. The bottom of the parapet near the roof line is normally a weak zone because roof joists and other framing members are pocketed into the wall at this level. Failure of parapets can create a falling hazard that is a serious life safety concern, especially over exits and walkways. As a general rule - the higher the parapet, the more serious the hazard. See detail VI (C-1) to help strengthen this deficiency.

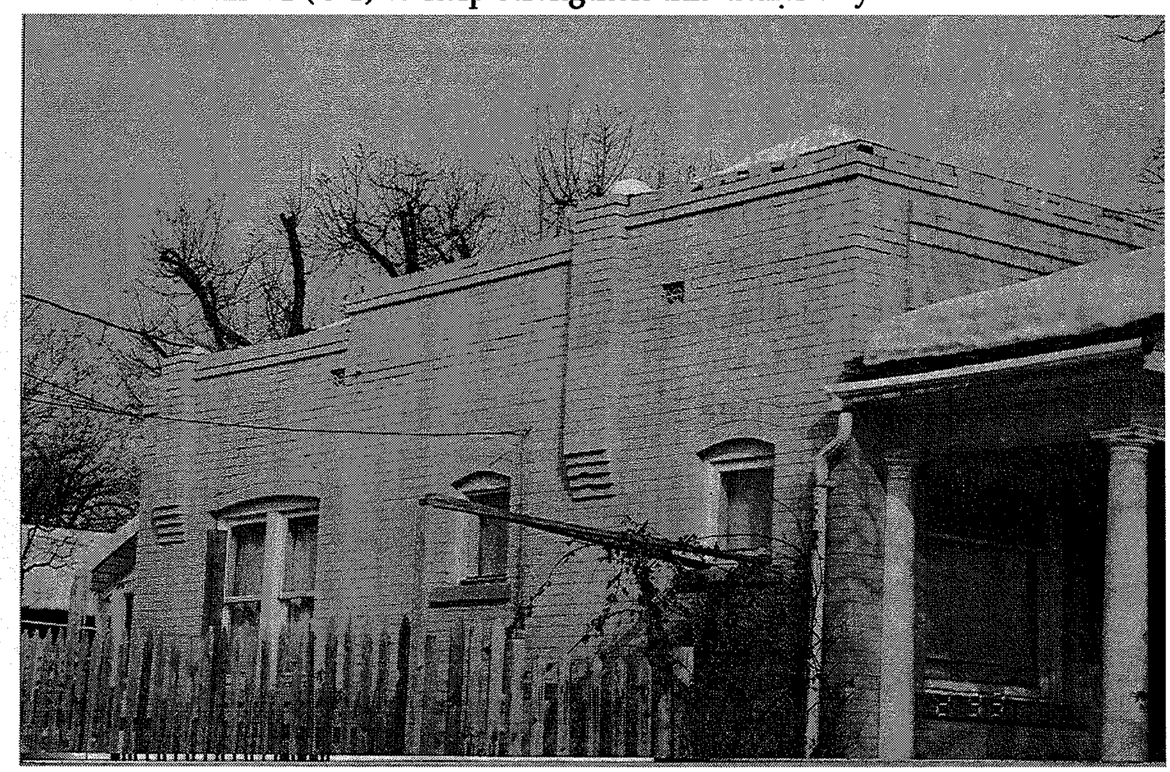


Figure 38: URM Parapet Walls

GABLE END WALLS

The triangular section of an exterior wall under the roof plane and above the eaves line is called a gable end wall. This portion of the typical URM wall is normally not braced and supports the ridge of the roof. The height of this wall and the not braced condition make it less stable than other elements to resist out-of-plane forces. Out-of-plane failure of the gable end wall is similar to that described for unreinforced masonry walls. The size of the gable end wall and the intensity and direction of the seismic event will have a direct effect on the stability of this 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 a partial collapse of the roof. The roof 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 that described for parapets, but collapse of the roof is not likely unless the main walls below also fail. See detail VI (C-2) to help strengthen this deficiency.

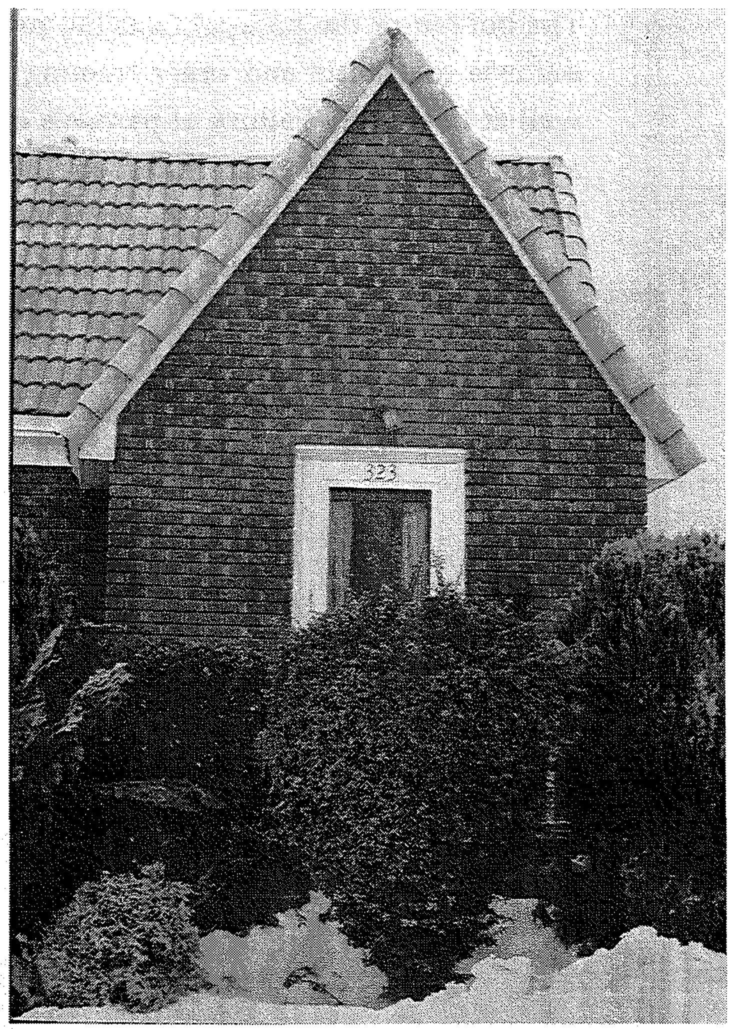


Figure 39: URM gable end wall

CHIMNEYS

Almost every unreinforced masonry home has one or more chimneys. A chimney can be located on an exterior wall or the interior of the home. The roof joists may be pocketed into the side of the chimney or headed off around it. Often times chimneys are corbeled 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 VI (C-3) through VI (C-6) to help strengthen these deficiencies.

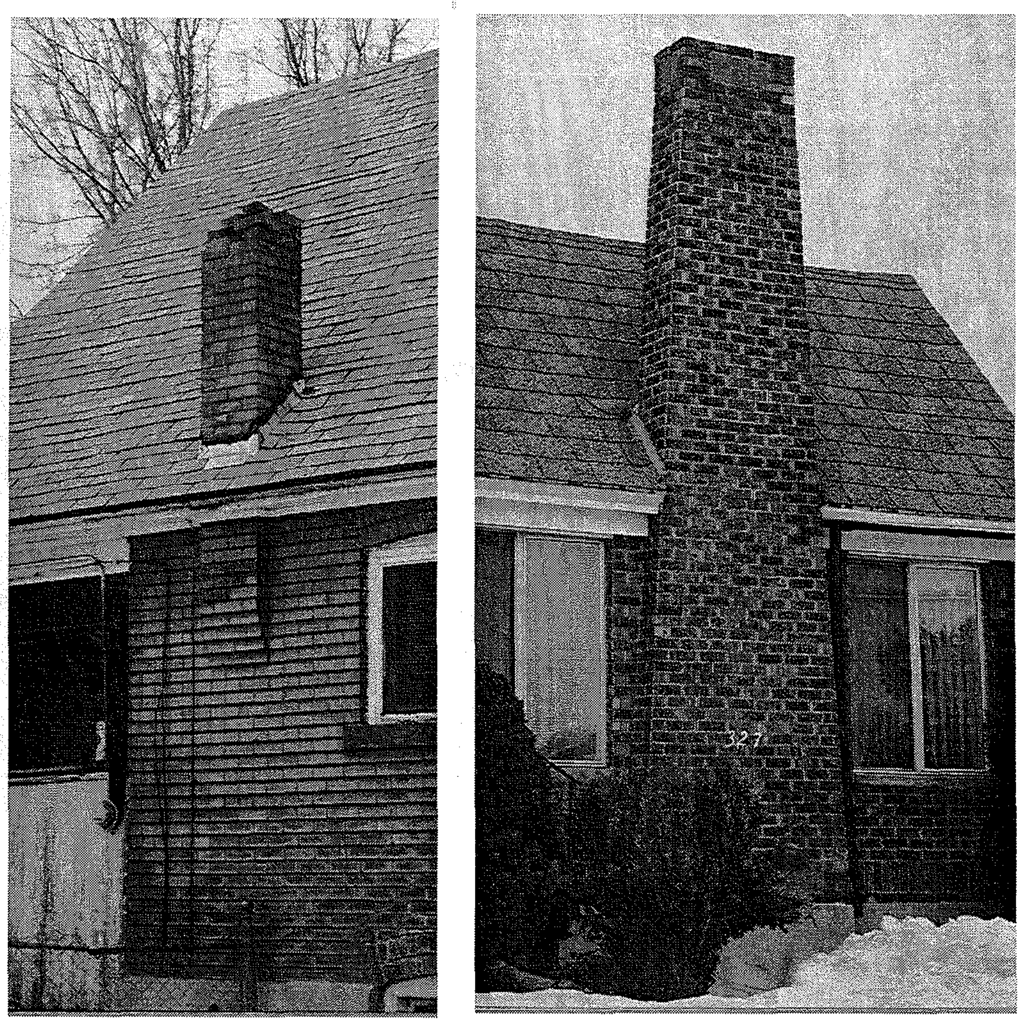


Figure 40: URM Chimneys

CORNER WINDOWS

A corner window usually has a steel pipe at the outside corner of the window under a steel lintel used to support the masonry wall above. This 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 building could take place. See detail VI (C-7) to help strengthen this deficiency.

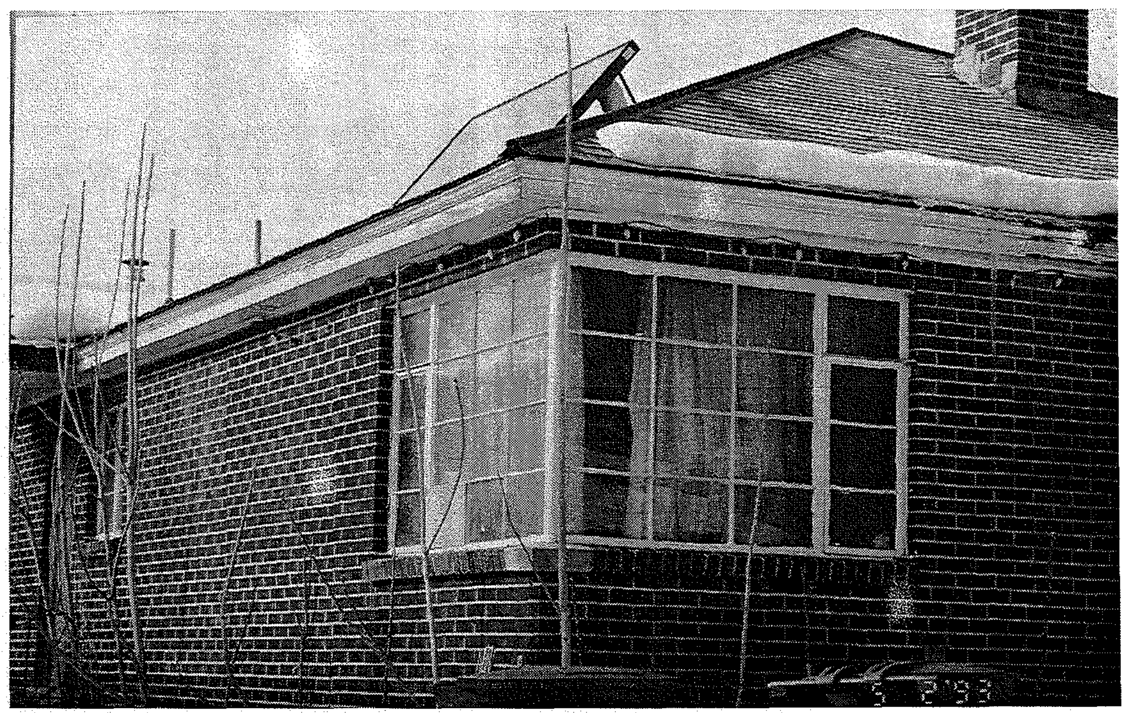


Figure 41: Corner window in URM dwelling

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 home. The details are intended for general use and may be adapted to similar conditions with some minor modifications. The details have been drawn with both continuous lines which are darker and broken or screened lines which are lighter. The darker lines and text represent new construction while the lighter lines and text represent existing materials and conditions.

The mitigation details in this manual 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 home 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 which the homeowner determines is beyond their individual capacity or knowledge. For each corrective 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.

The details in this chapter are designed to show structural elements and are not intended to provide procedures for product preparations and installation, or for the removal and replacement of existing finishes. Manufacturers normally provide preparation and installation procedures for their products but seldom cover the removal or replacement of existing finishes. The techniques required to remove existing finishes for the purpose of gaining access to the work area and the replacement of these finishes after the work is completed will vary with each specific home. 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 go ahead with a seismic upgrade project:

TOOLS:

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

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

COST:

- When requested by homeowner, a cost estimate for work contracted out will be provided by the contractor doing the work.

- The cost estimate for work done by homeowner can be compiled from contacting stores, suppliers, etc. We recommend adding 20% to 30% of the total cost for contingency items.

DISRUPTION OF LIFESTYLE:

The degree of disruption will differ with each corrective measure. The room(s) surrounding the construction may become unusable for a period of time. Rooms which must remain in use, may 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 and the amount of time the homeowner can devote to the project while still meeting other obligations; i.e., job, family, etc.

CONSTRUCTION CONSIDERATIONS:

Access to a specific area where corrective 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 items should give strong consideration to hiring someone else to do the job.

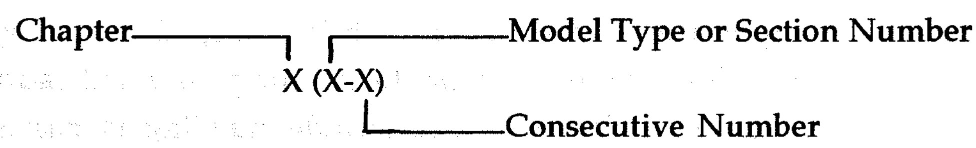
SAFETY:

A complete understanding of the work and the ability to operate the tools is mandatory. Improper use of any tool can cause serious injury. 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 to determine the makeup of the substance.

Each corrective 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, check references, licensing, and local agencies for job record and present status.

The appendix has limited information on fasteners, connectors, and manufacturers of many of the products called out in the details. There are also acceptable products which are not noted in the appendix, but are available. A thorough comparison should always be made to ensure that the materials, strengths, and capacities are equal to or better than the products which are noted.

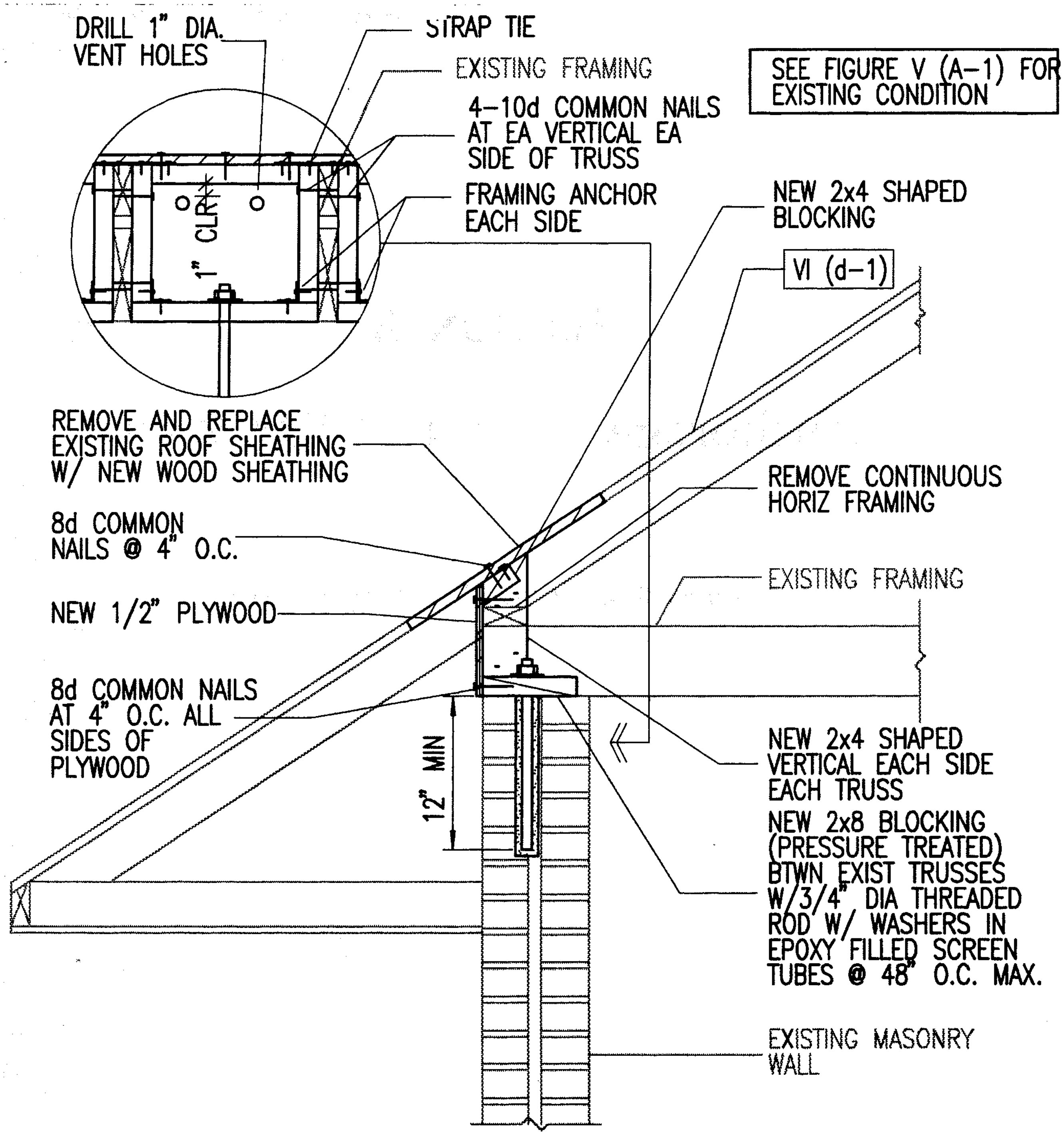
The figures in this document are referenced using the following guide:



SECTION A

Anchorage: Roof to URM Wall

Figures VI (a-1) through VI (a-9) inclusive.

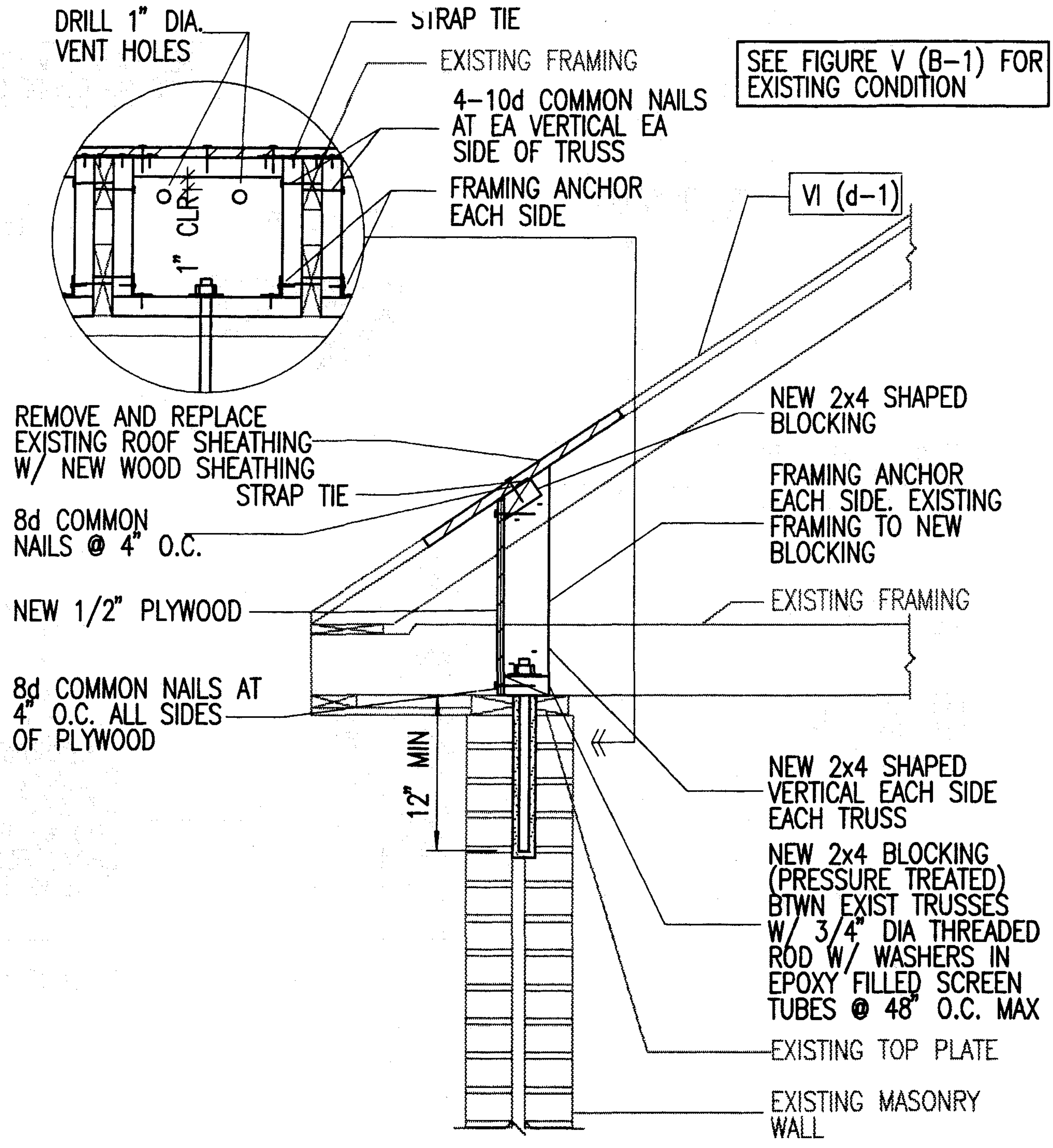


NOTE:

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.

ROOF TO URM WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL A	Figure No.: VI (a-1)

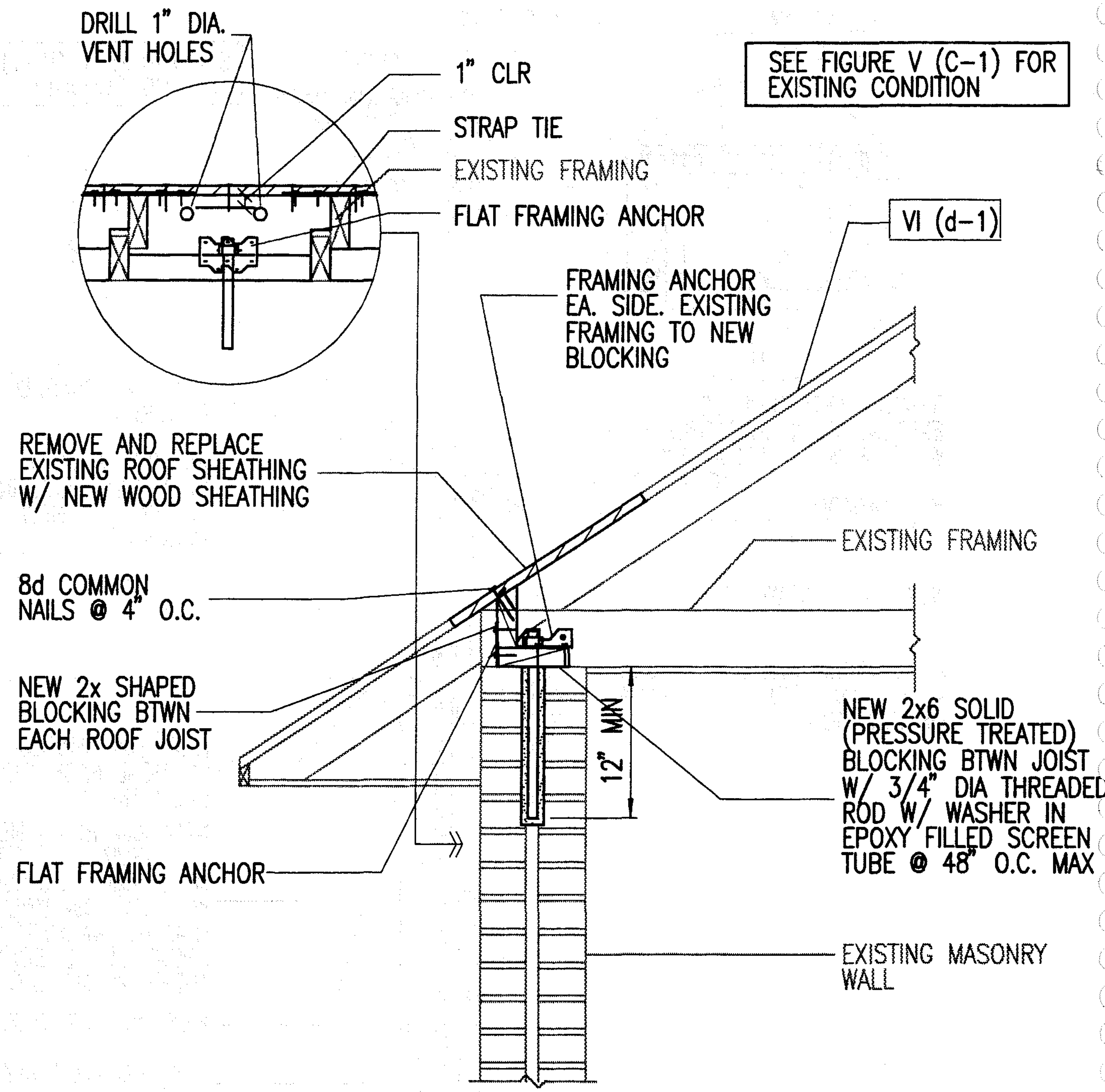


NOTE:

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.

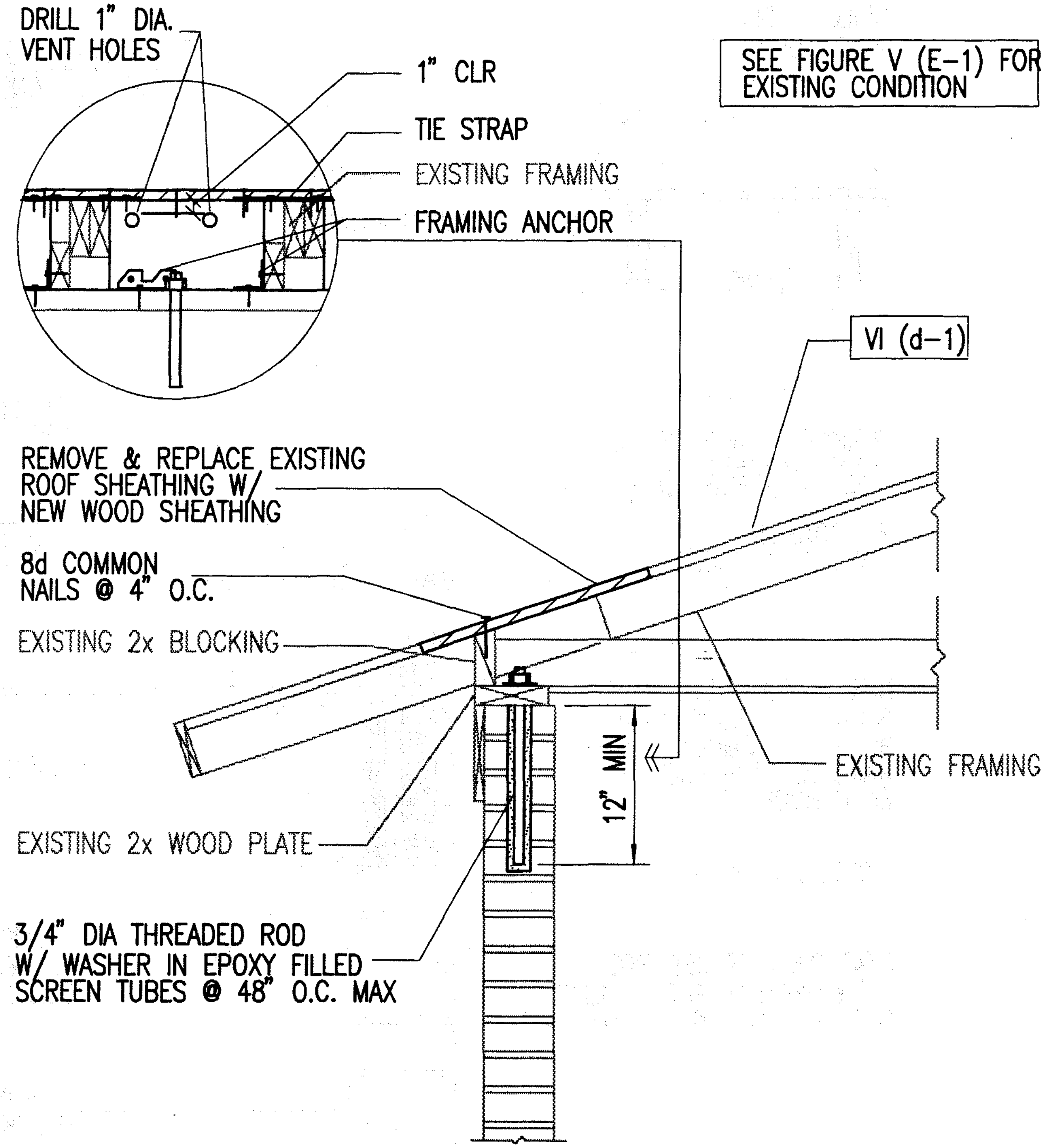
ROOF TO URM WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL B	Figure No.: VI (a-2)



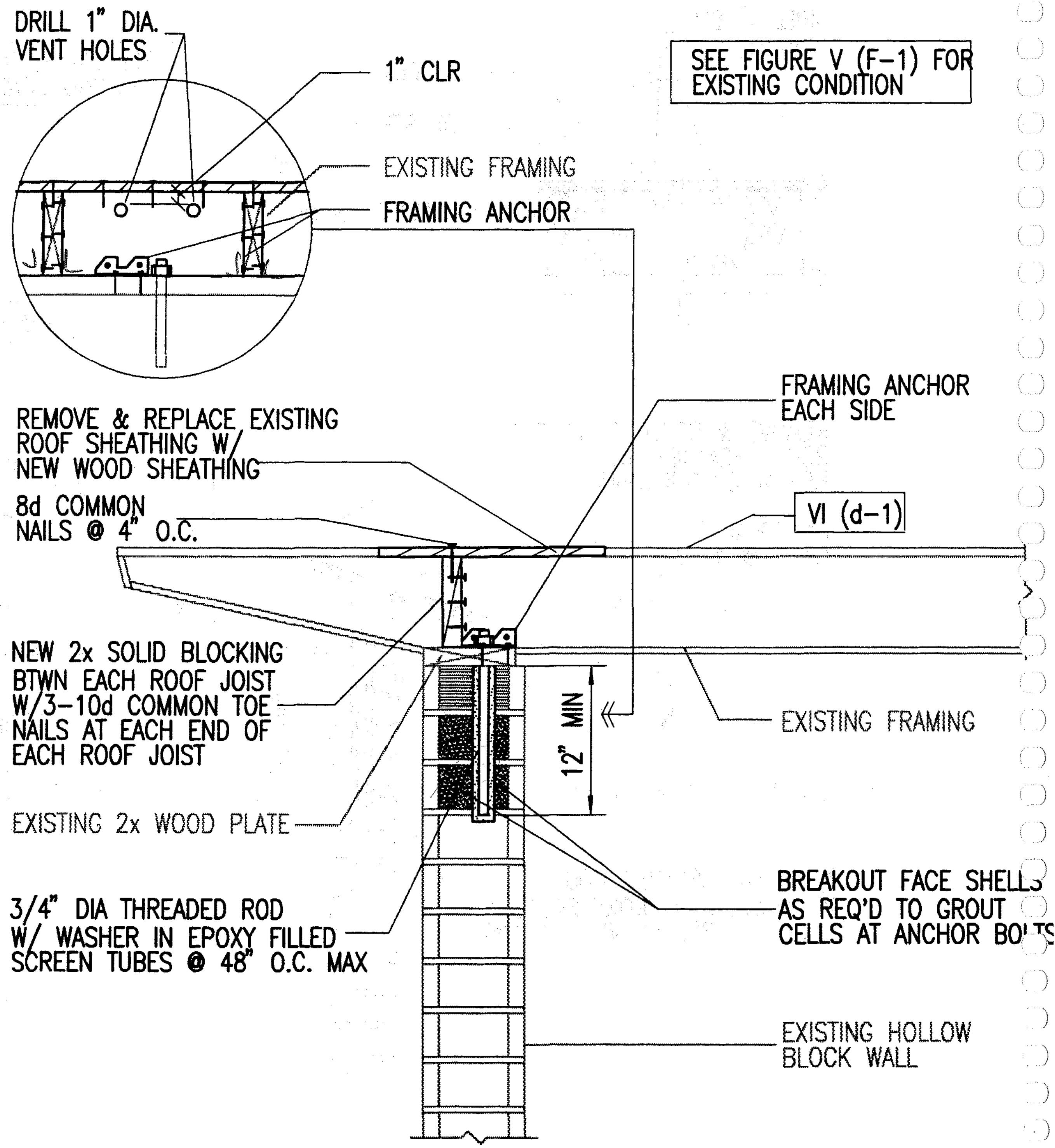
ROOF TO URM WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL C&D	Figure No.: VI (a-3)



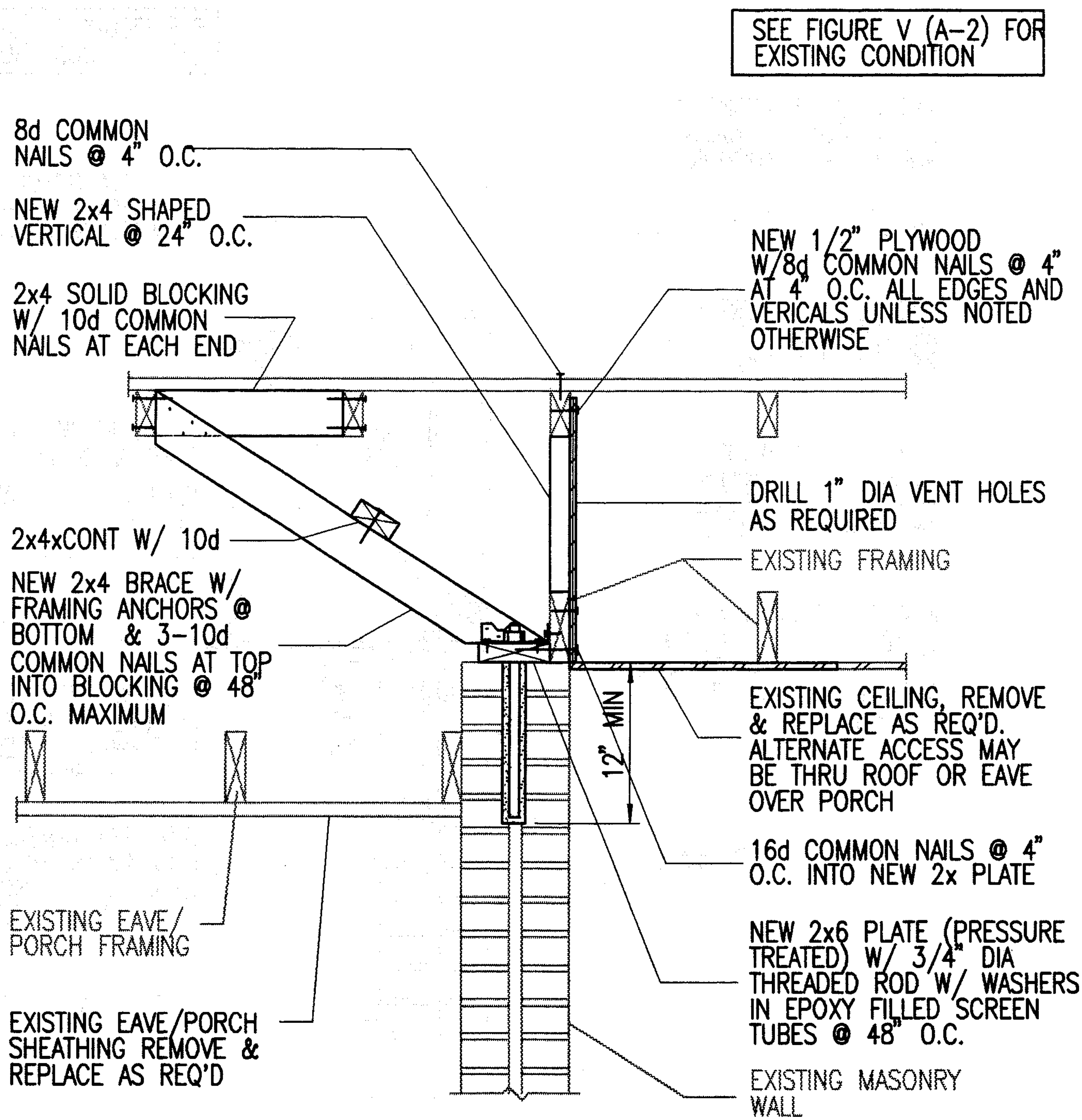
ROOF TO URM WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL E	Figure No.: VI (a-4)



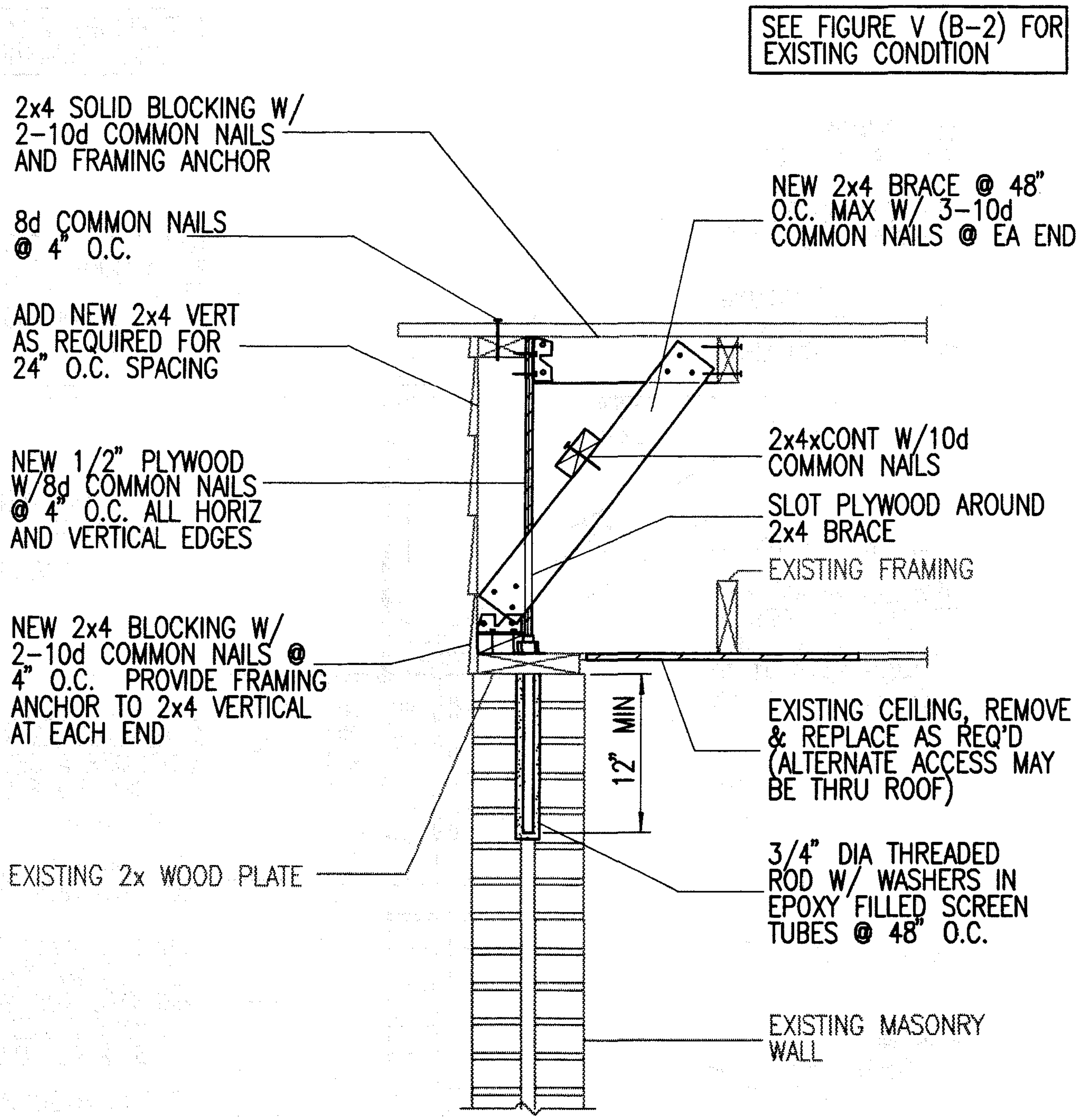
ROOF TO URM WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL F	Figure No.: VI (a-5)



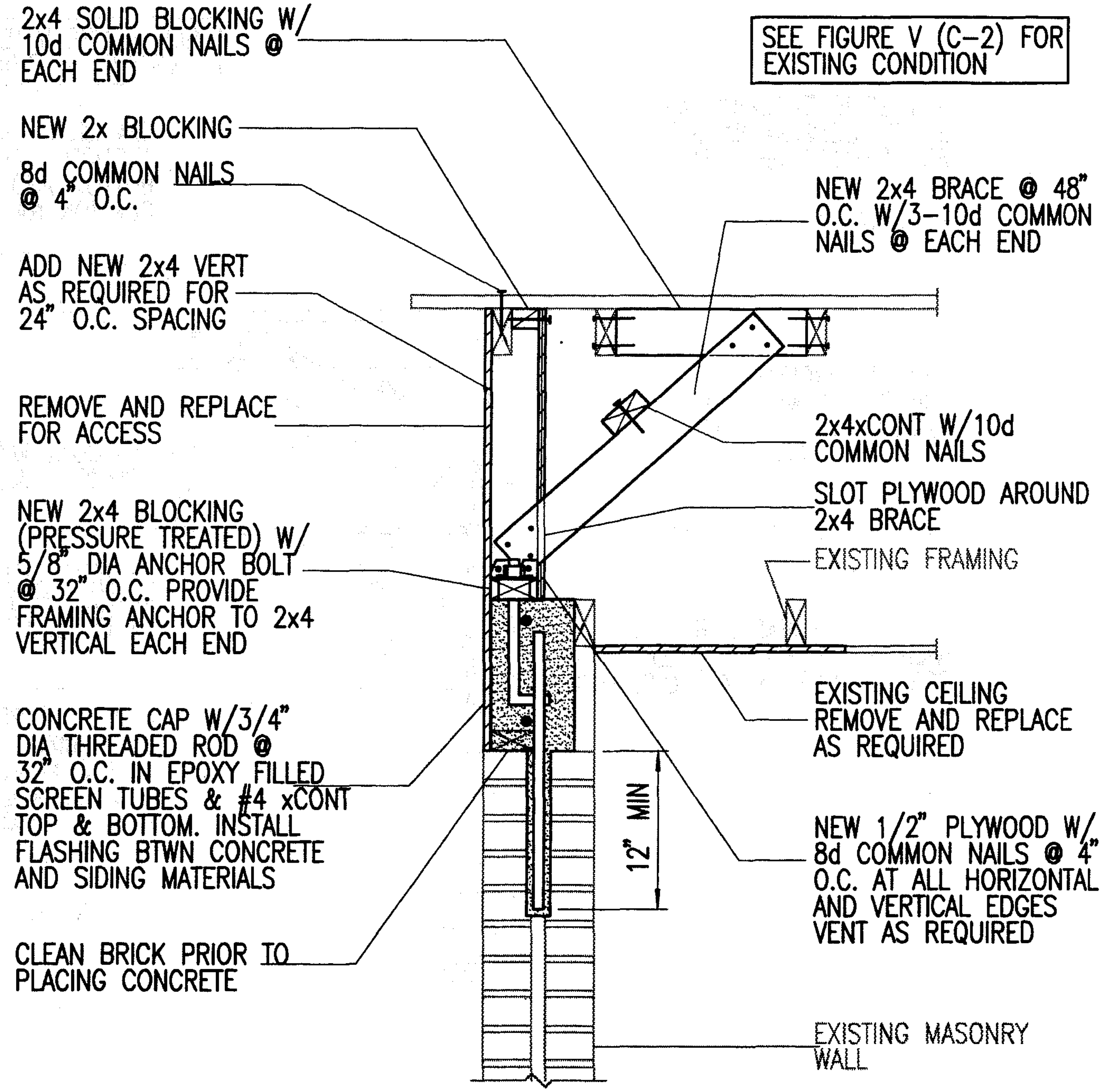
ROOF TO URM WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL A	Figure No.: VI (a–6)



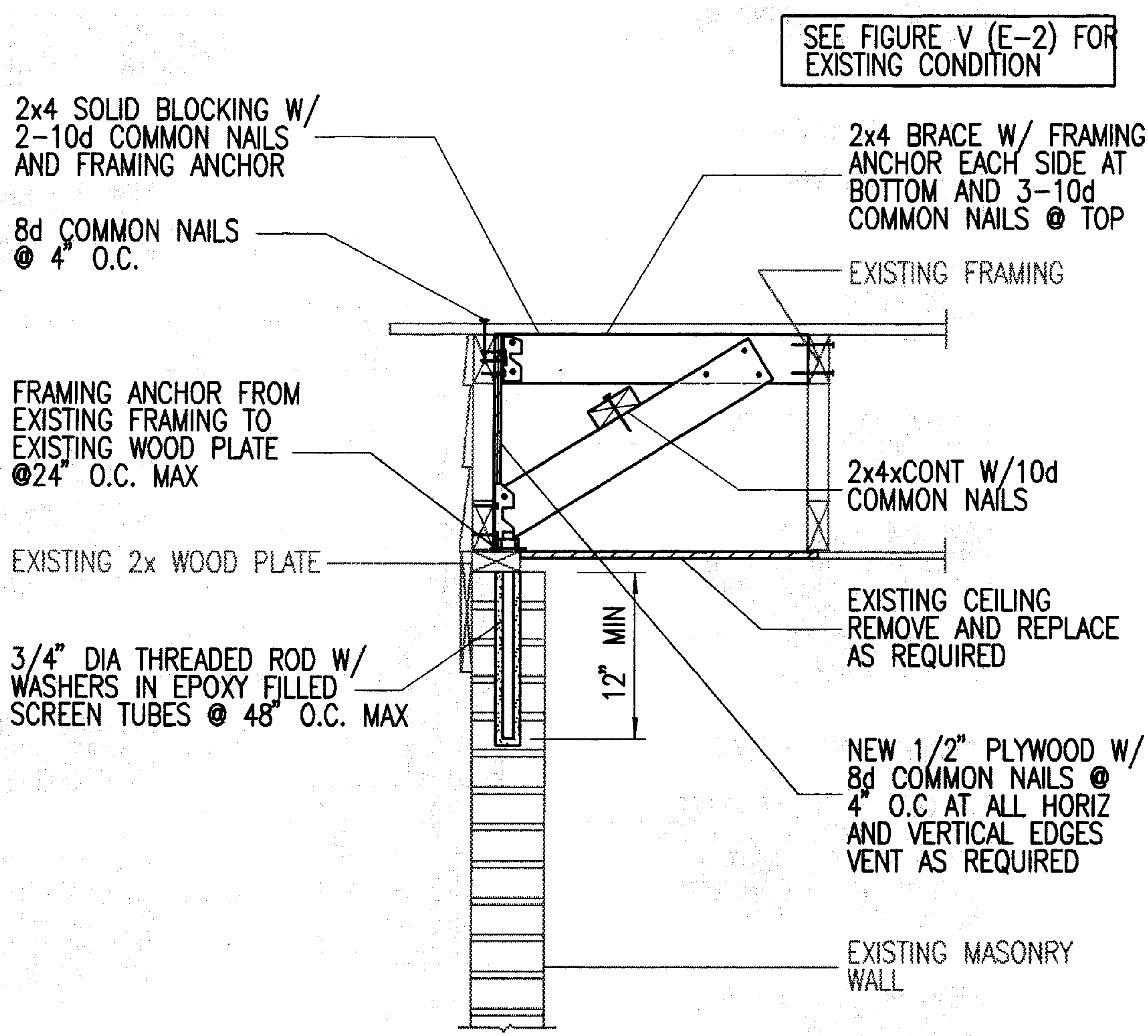
ROOF TO URM WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL B	Figure No.: VI (a-7)



ROOF TO URM WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL C	Figure No.: VI (a-8)



ROOF TO URM WALL ANCHORAGE

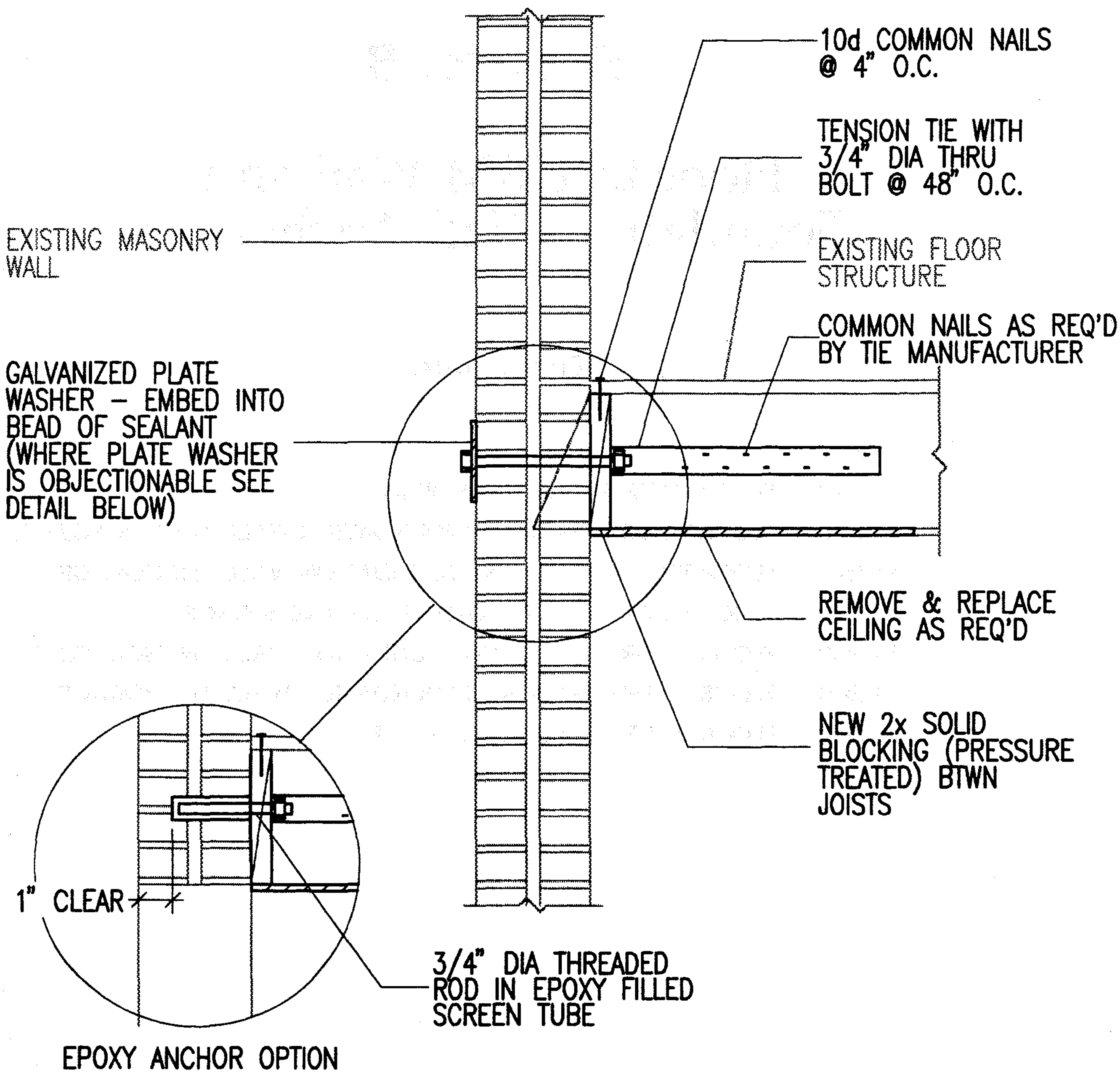
Seismic Improvement Structural Detail	Home Type: MODEL E	Figure No.: VI (a-9)

SECTION B

Floor to URM Wall and Foundation Wall Anchorage

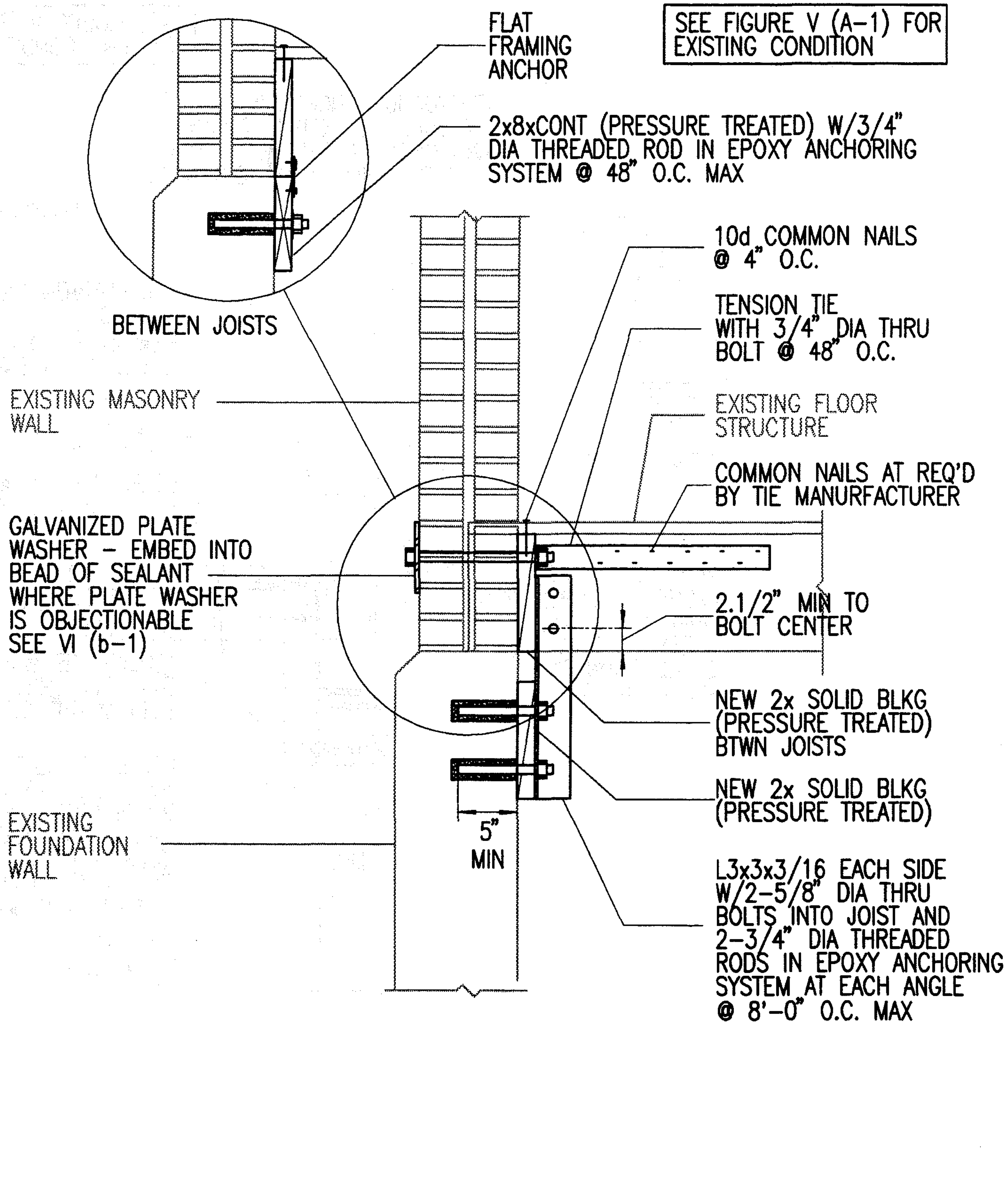
Figure Index

SEE FIGURE V (C-1) FOR EXISTING CONDITION



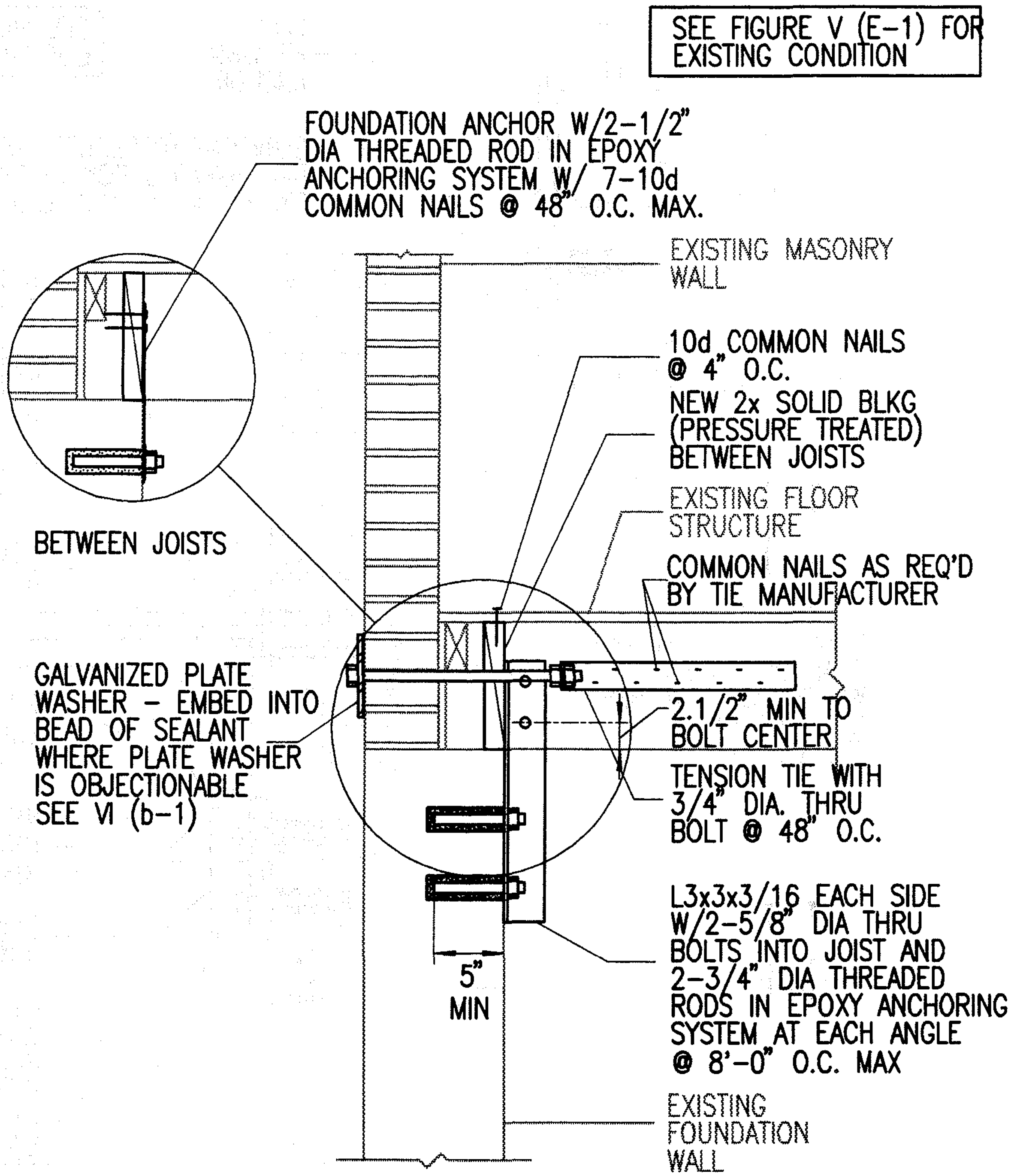
FLOOR TO URM WALL ANCHORAGE

Seismic Improvement Structural Detail	**Home Type:** MODEL C	**Figure No.:** VI (b-1)



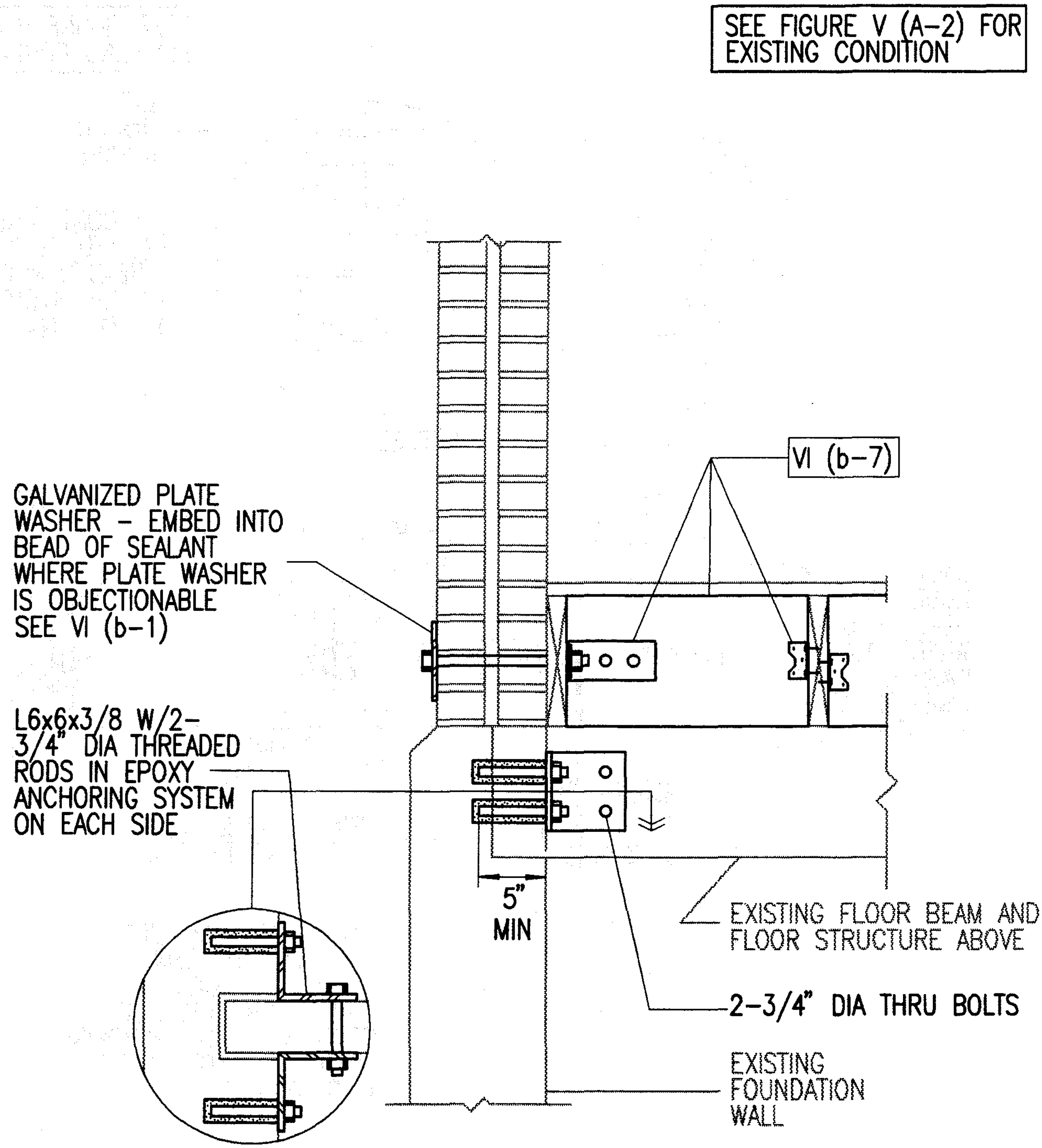
FLOOR TO URM WALL AND FOUNDATION WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL A,B,C,D,&F	Figure No.: VI (b-2)



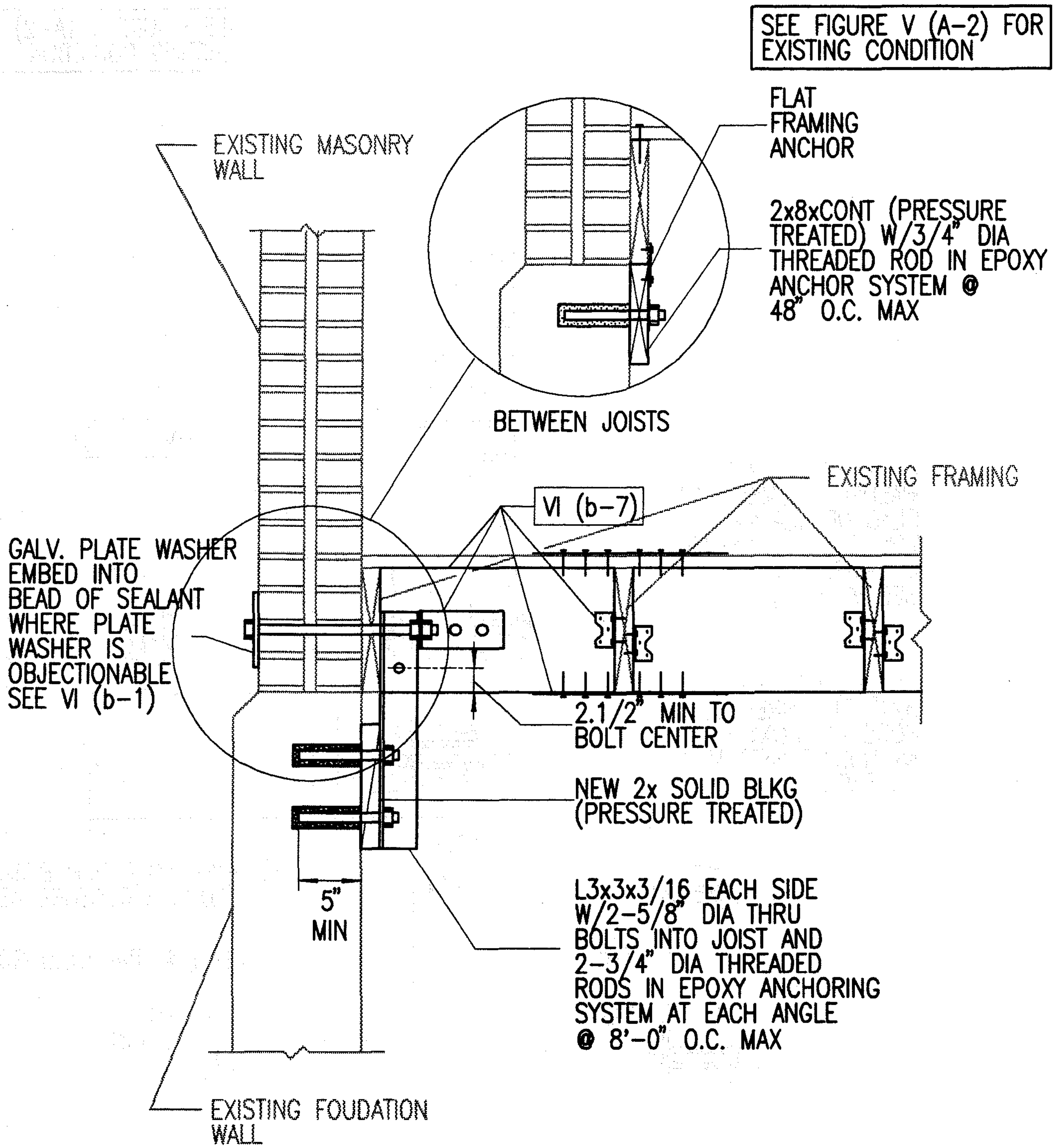
FLOOR TO URM WALL AND FOUNDATION WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL E	Figure No.: VI (b-3)



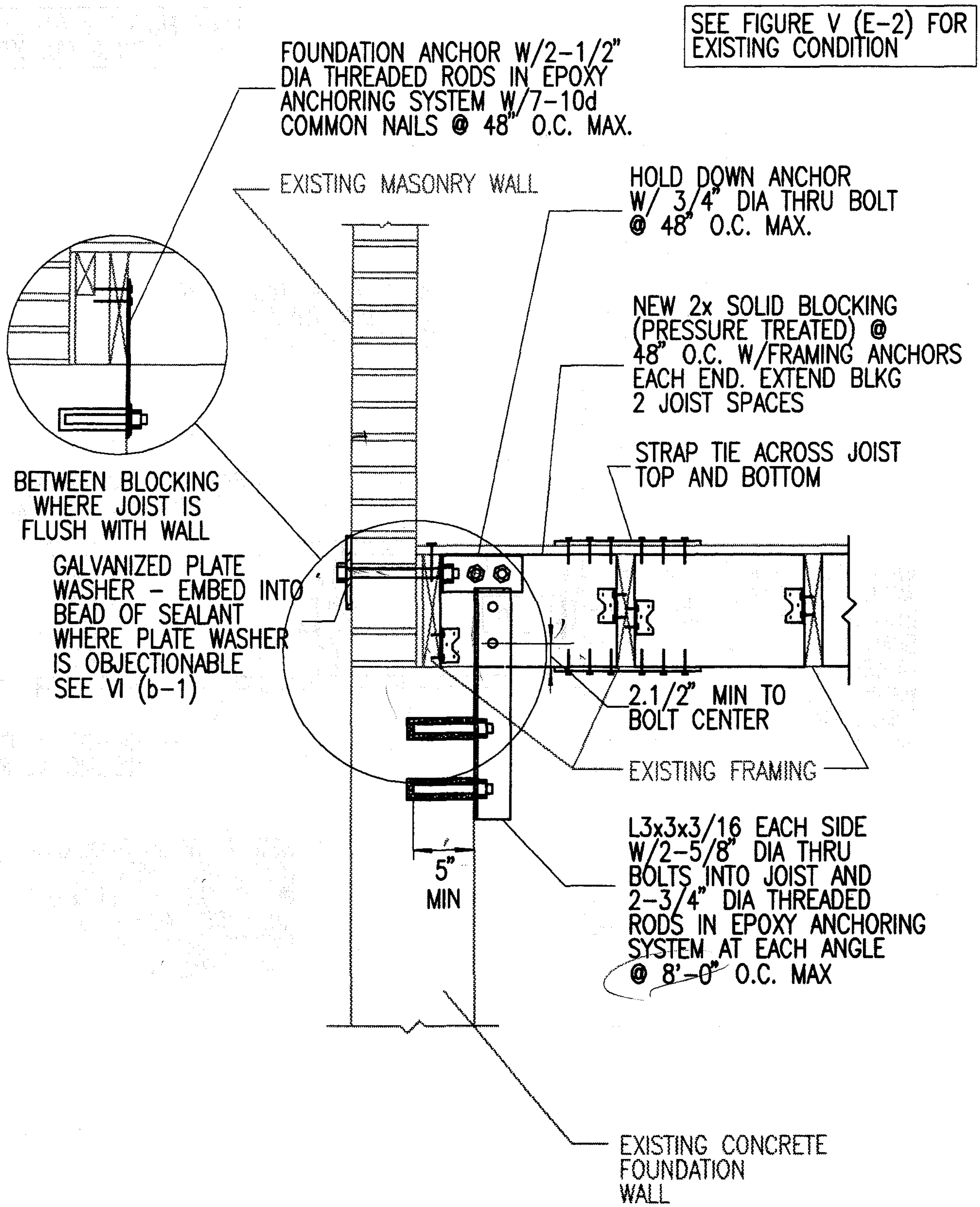
FLOOR BEAM TO FOUNDATION WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL A,B,C,&D	Figure No.: VI (b-4)



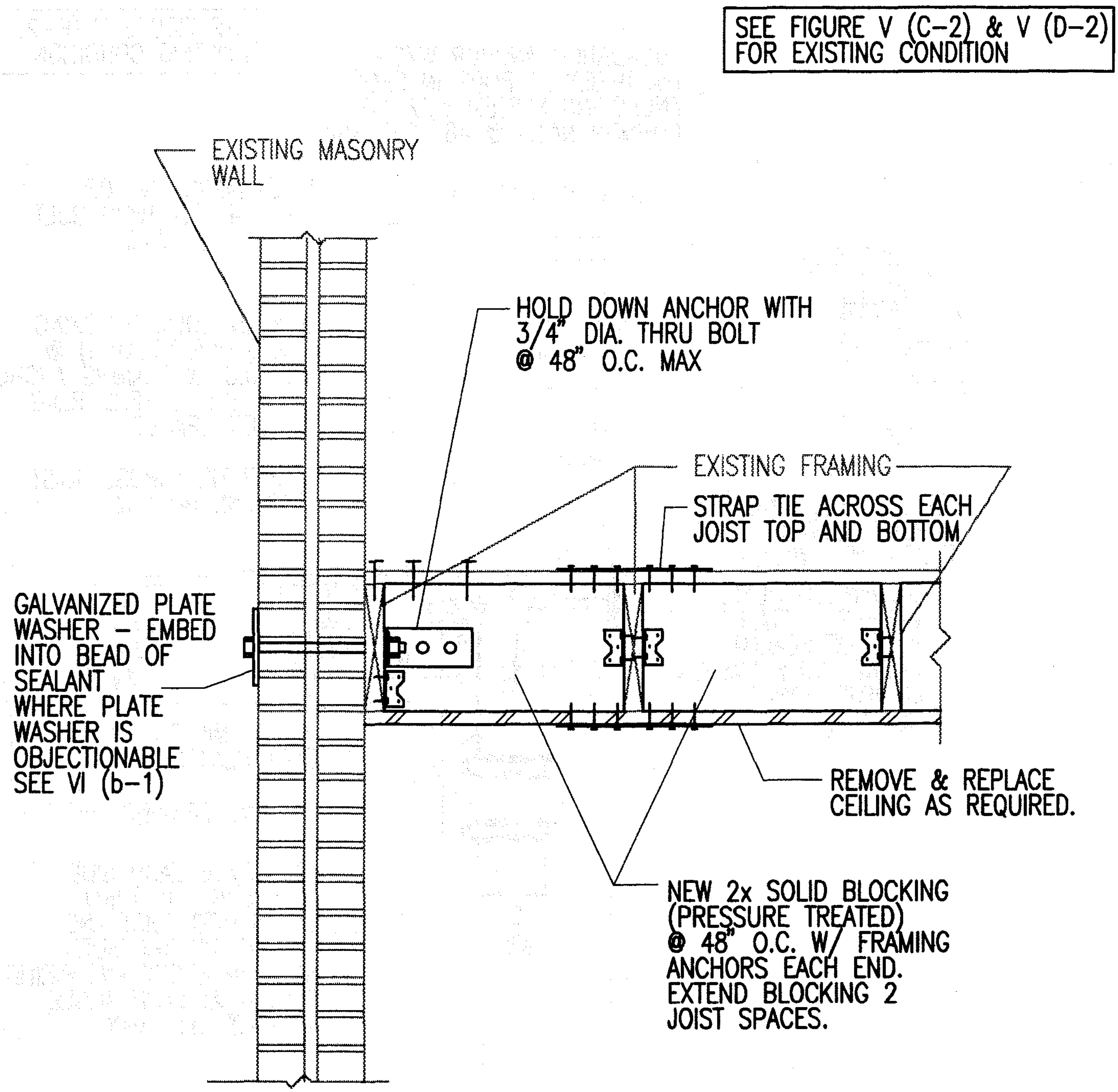
FLOOR TO URM WALL AND FOUNDATION WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL A,B,C,&D	Figure No.: VI (b-5)



FLOOR TO URM WALL AND FOUNDATION WALL ANCHORAGE

Seismic Improvement Structural Detail	Home Type: MODEL E	Figure No.: VI (b-6)



FLOOR TO URM WALL ANCHORAGE

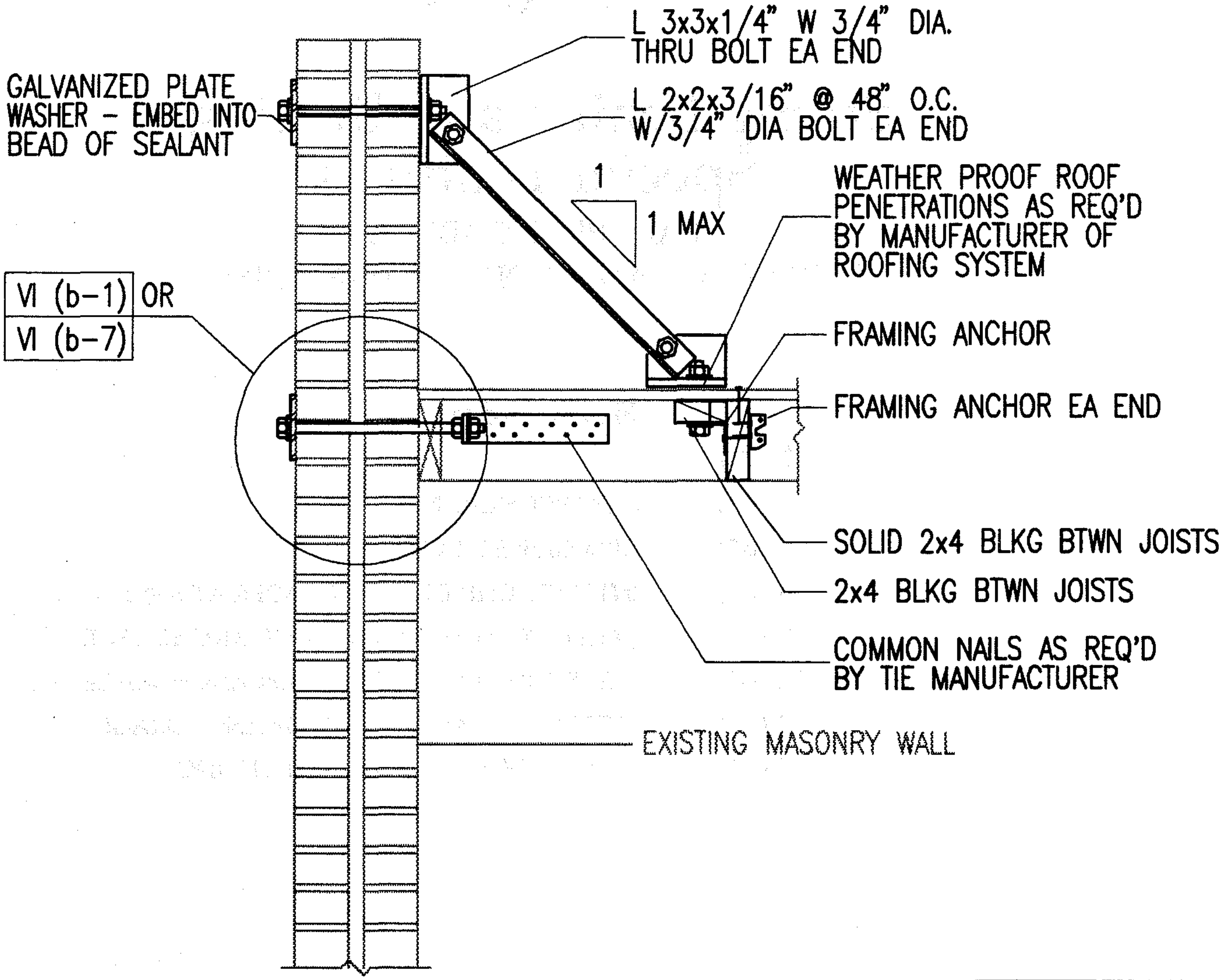
Seismic Improvement Structural Detail	Home Type: MODEL C&D	Figure No.: VI (b-7)

SECTION C

Strengthening and Bracing Special Features

PARAPETS, GABLES, CHIMNEYS, AND CORNER WINDOWS

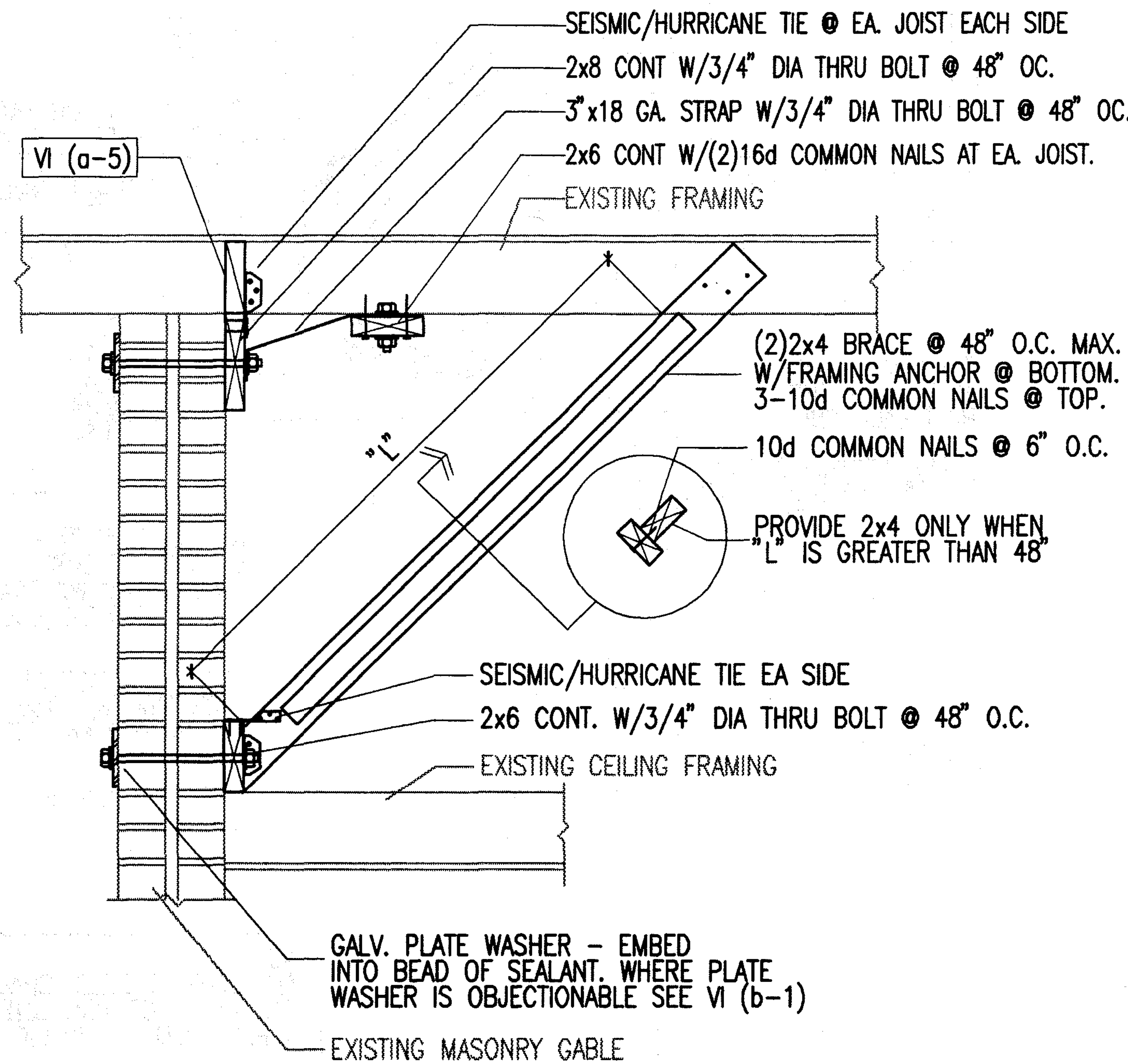
Figure Index



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

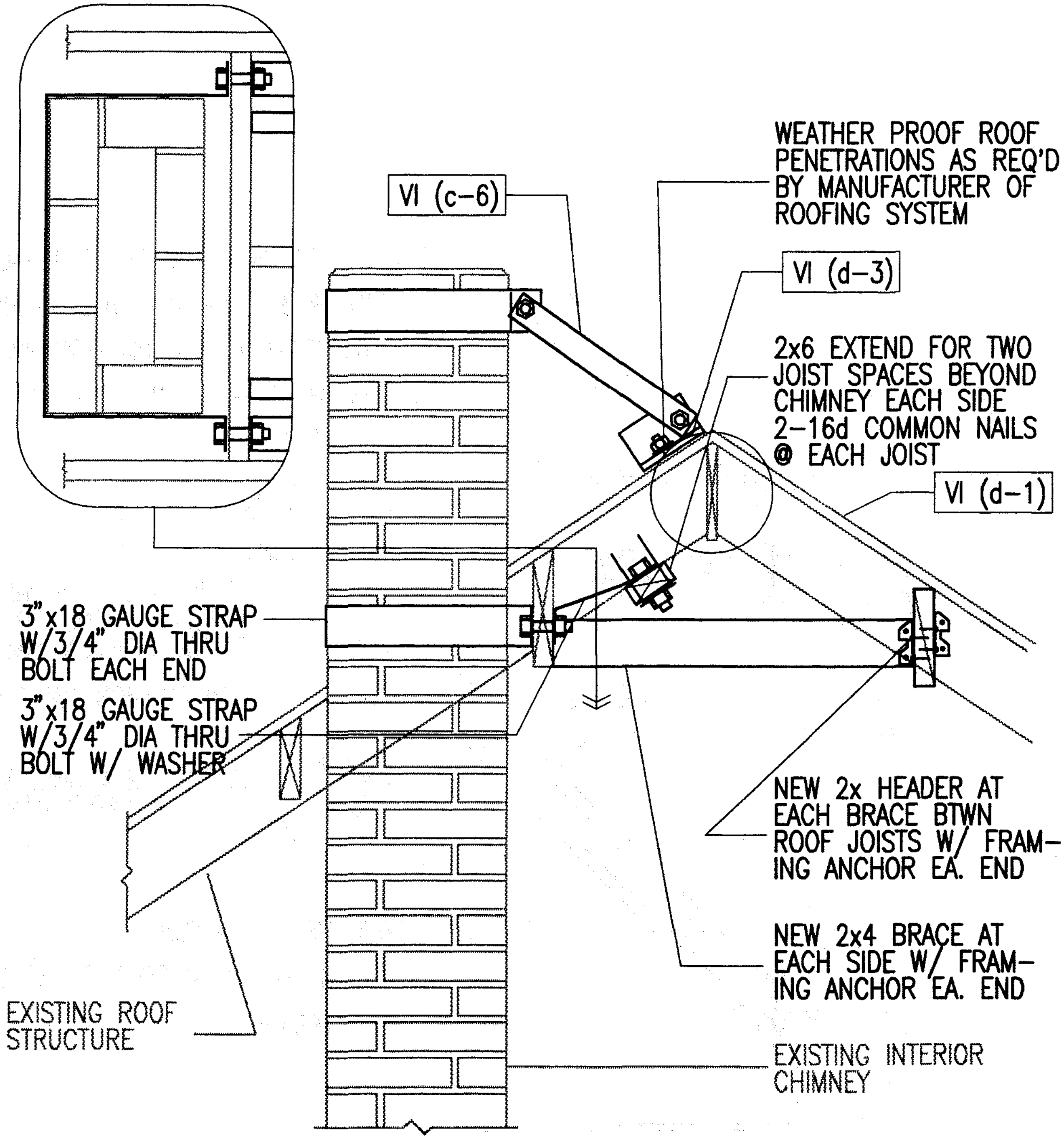
PARAPET BRACING

Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (c-1)



URM GABLE BRACING

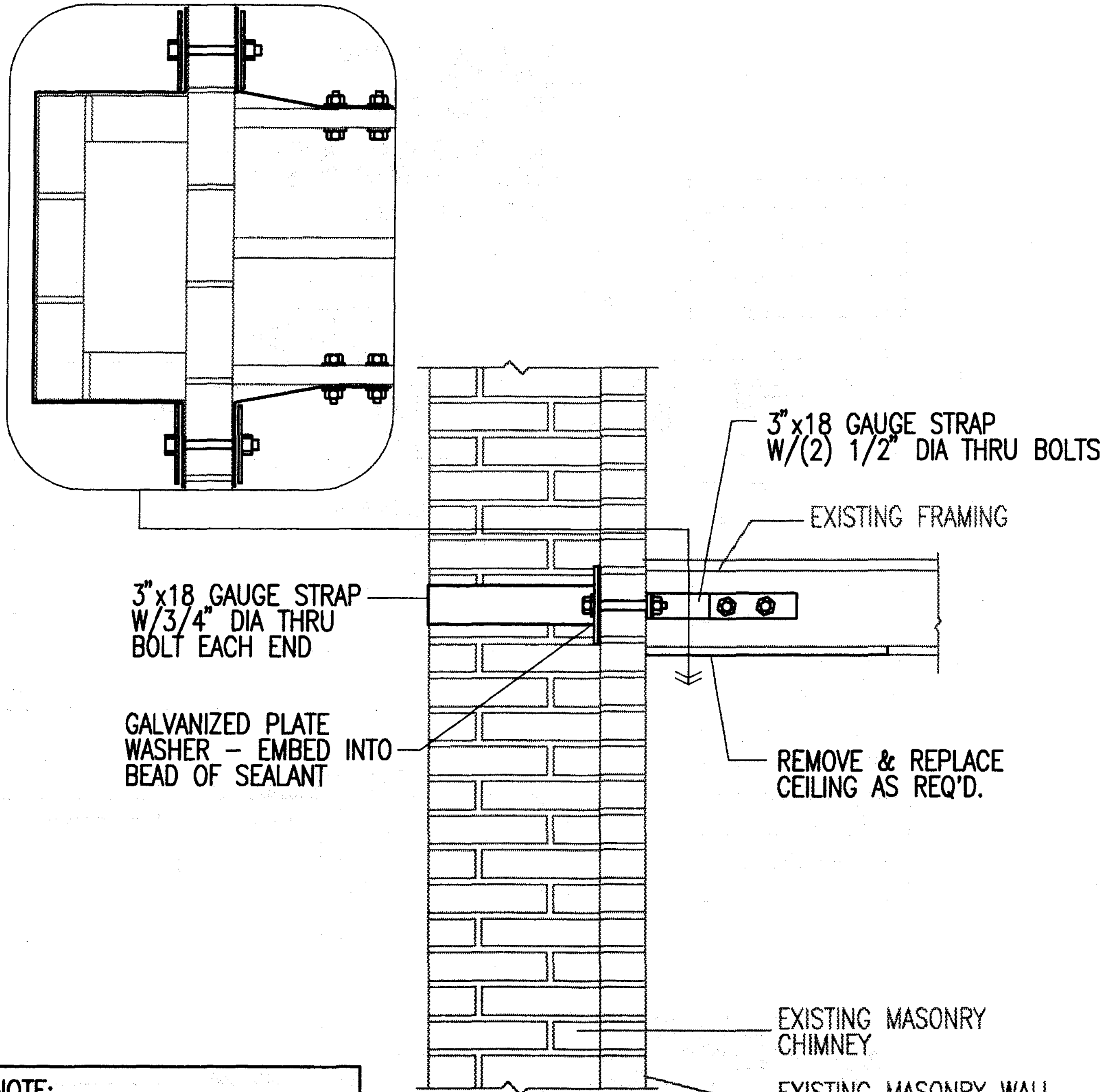
Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (c-2)



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

INTERIOR CHIMNEY W/ HEADER AT JOIST

Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (c-3)

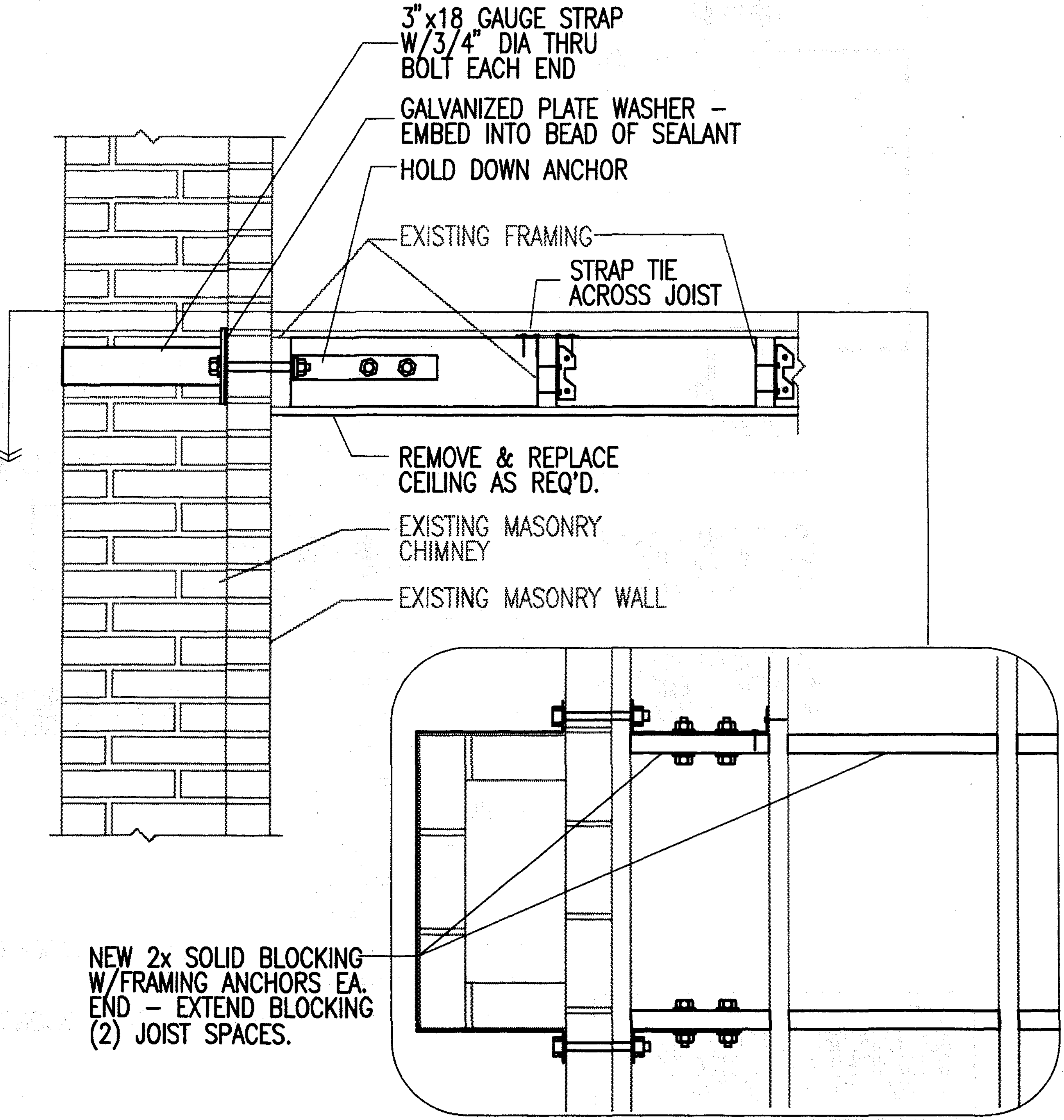


NOTE:
ALL EXPOSED STEEL SHALL BE GALVANIZED OR PROTECTED BY A HIGH QUALITY COATING

EXTERIOR CHIMNEY TO FLOOR ANCHORAGE

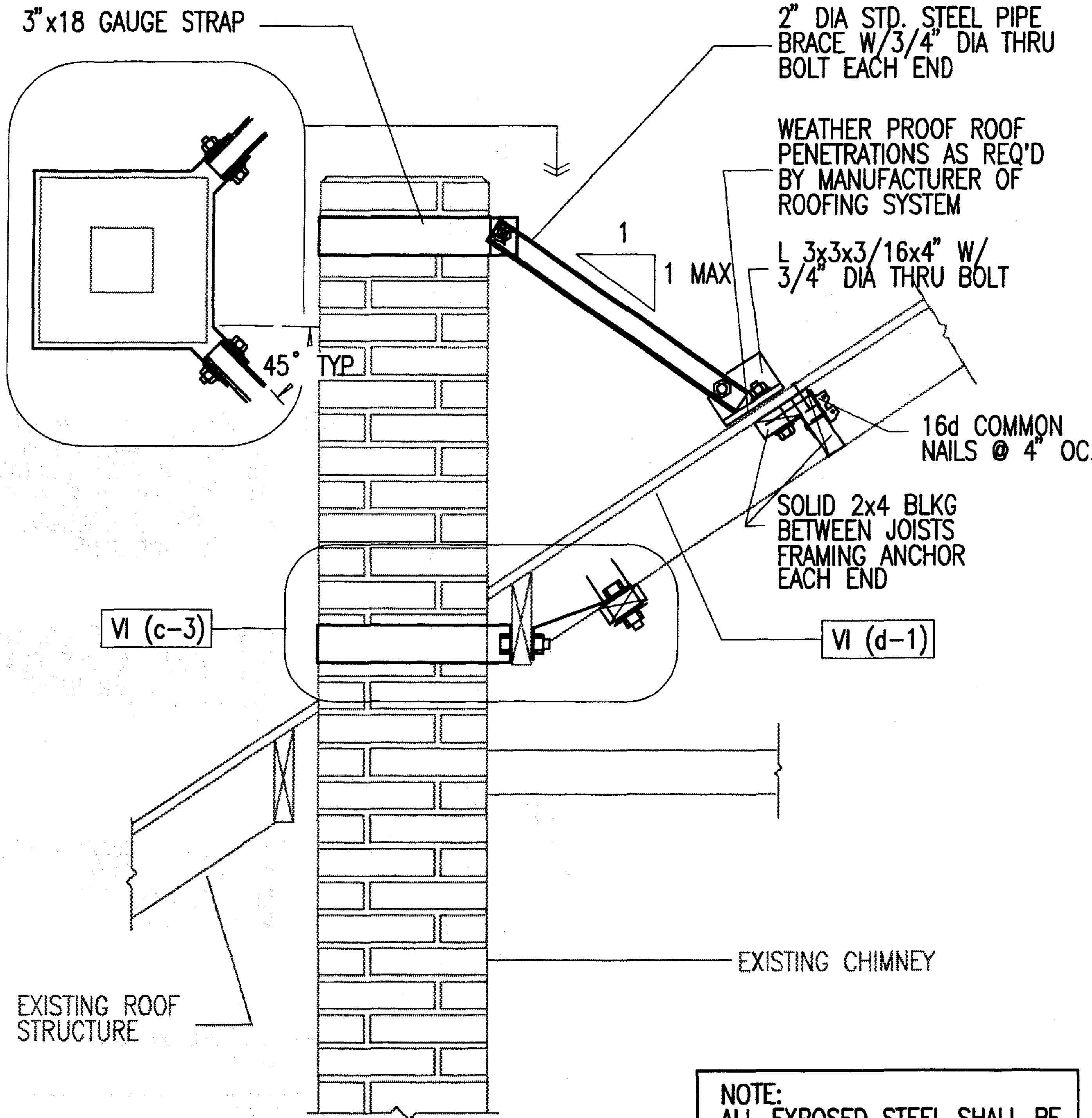
Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (c–4)

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



EXTERIOR CHIMNEY TO FLOOR ANCHORAGE

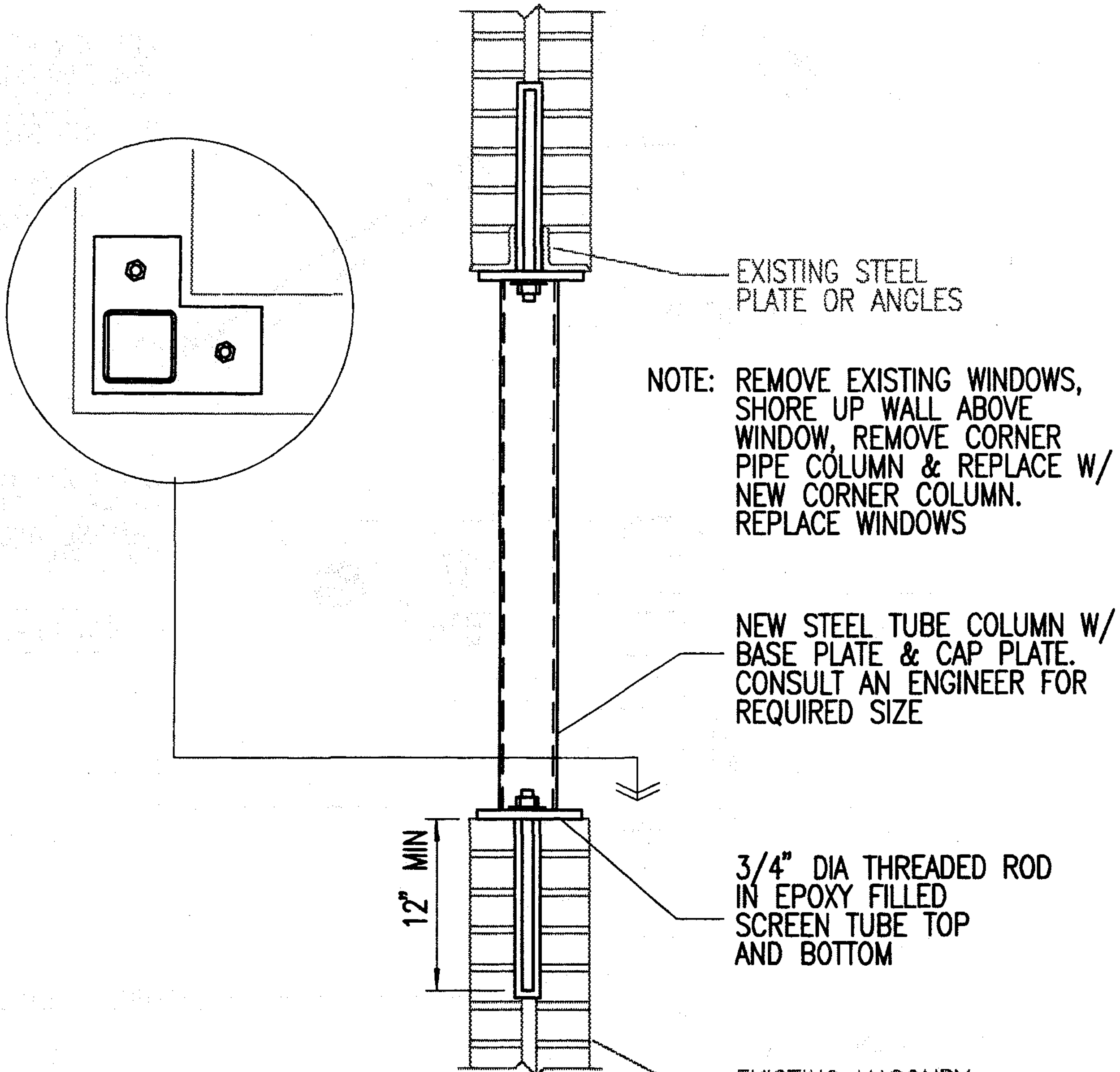
Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (c–5)



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

EXTERIOR CHIMNEY TO ROOF ANCHORAGE

Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (c-6)



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

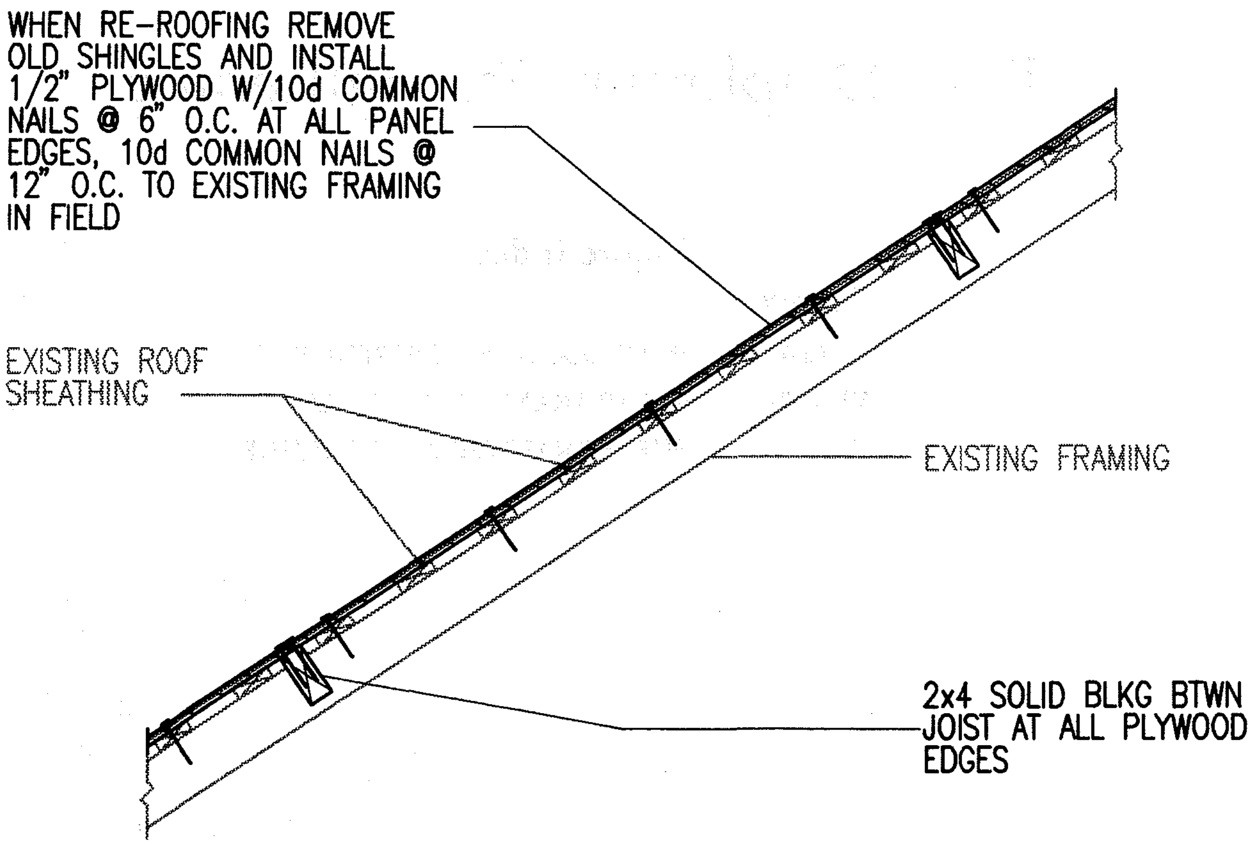
CORNER WINDOW STRENGTHENING

Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (c-7)

SECTION D

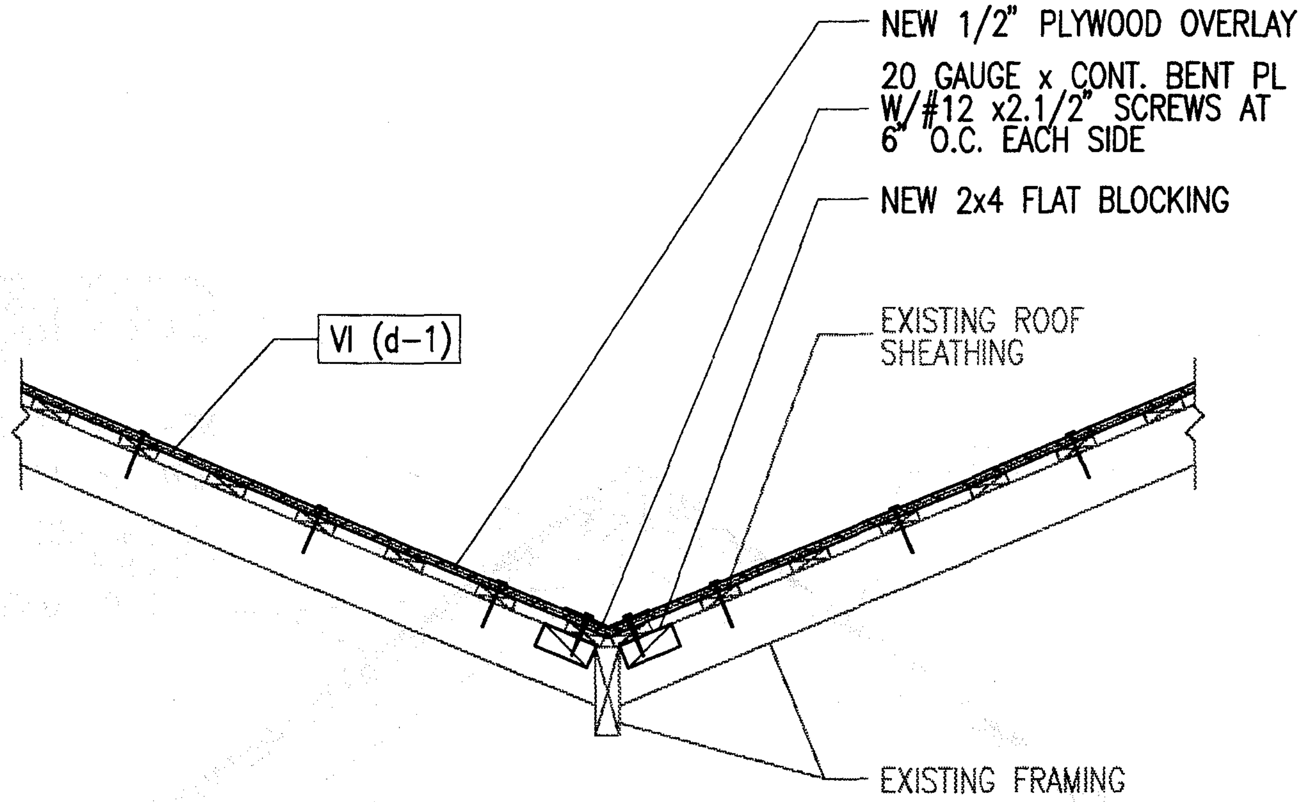
Roof Diaphragm Strengthening

Figure Index



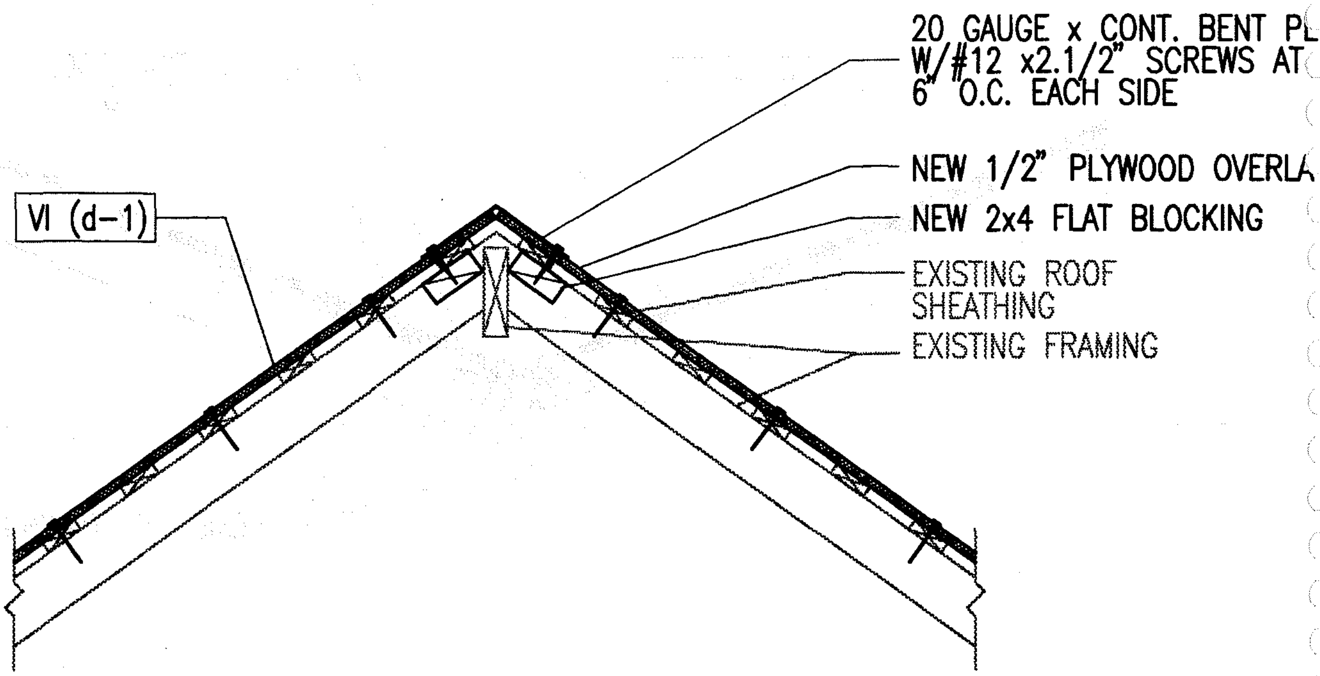
ROOF DIAPHRAGM STRENGTHENING

Seismic Improvement Structural Detail	Home Type: ALL MODELS	Figure No.: VI (d-1)



SHEAR TRANSFER AT VALLEY

Seismic Improvement Structural Detail	Home Type: ALL MODELS	Figure No.: VI (d-2)



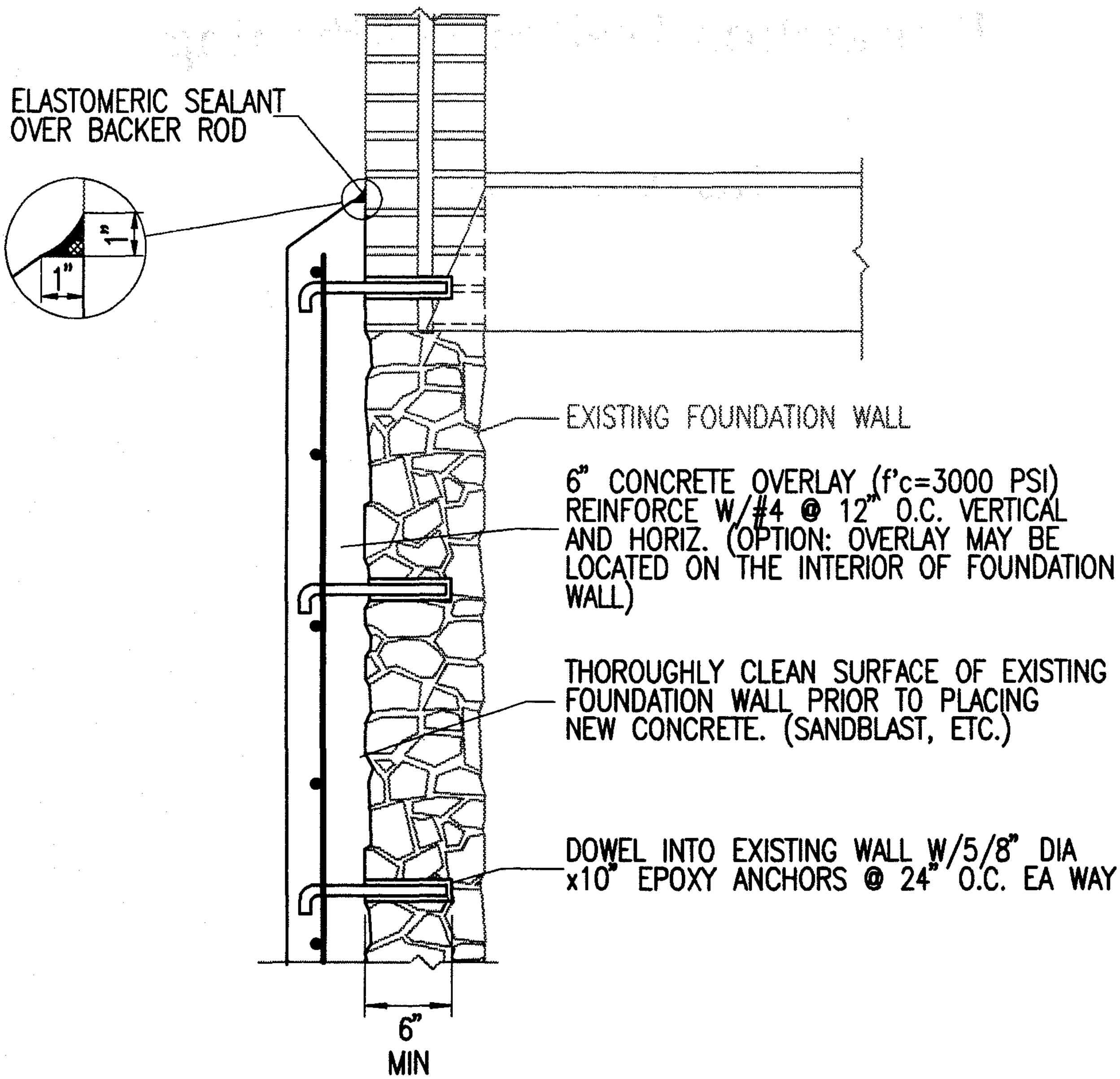
SHEAR TRANSFER AT RIDGE/HIP

Seismic Improvement Structural Detail	**Home Type:** ALL MODELS	**Figure No.:** VI (d-3)

SECTION E

Foundation Wall Strengthening

Figure VI (e-1) inclusive.



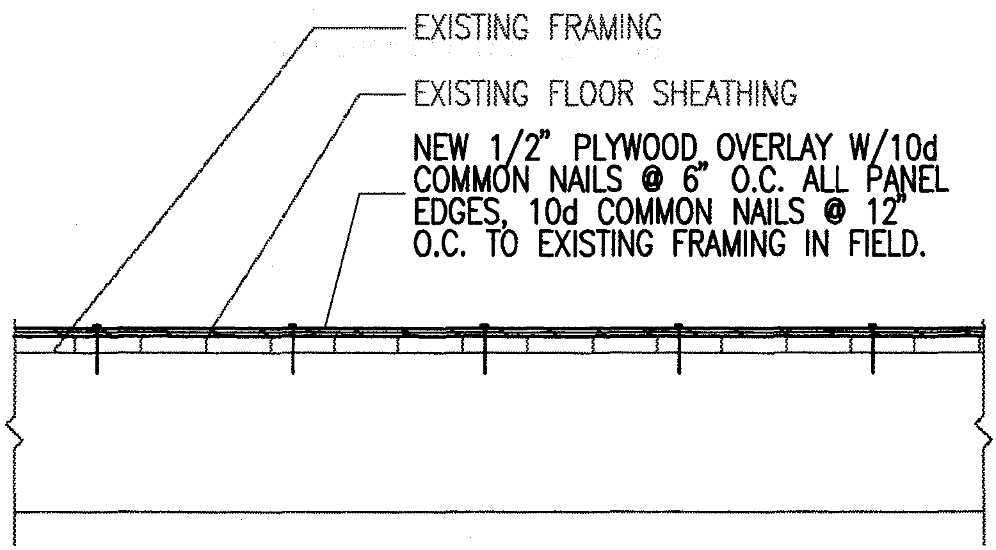
FOUNDATION WALL STRENGTHENING

Seismic Improvement Structural Detail	**Home Type:** VARIES	**Figure No.:** VI (e-1)

SECTION F

Floor Diaphragm Strengthening

Figure VI (f-1) inclusive.



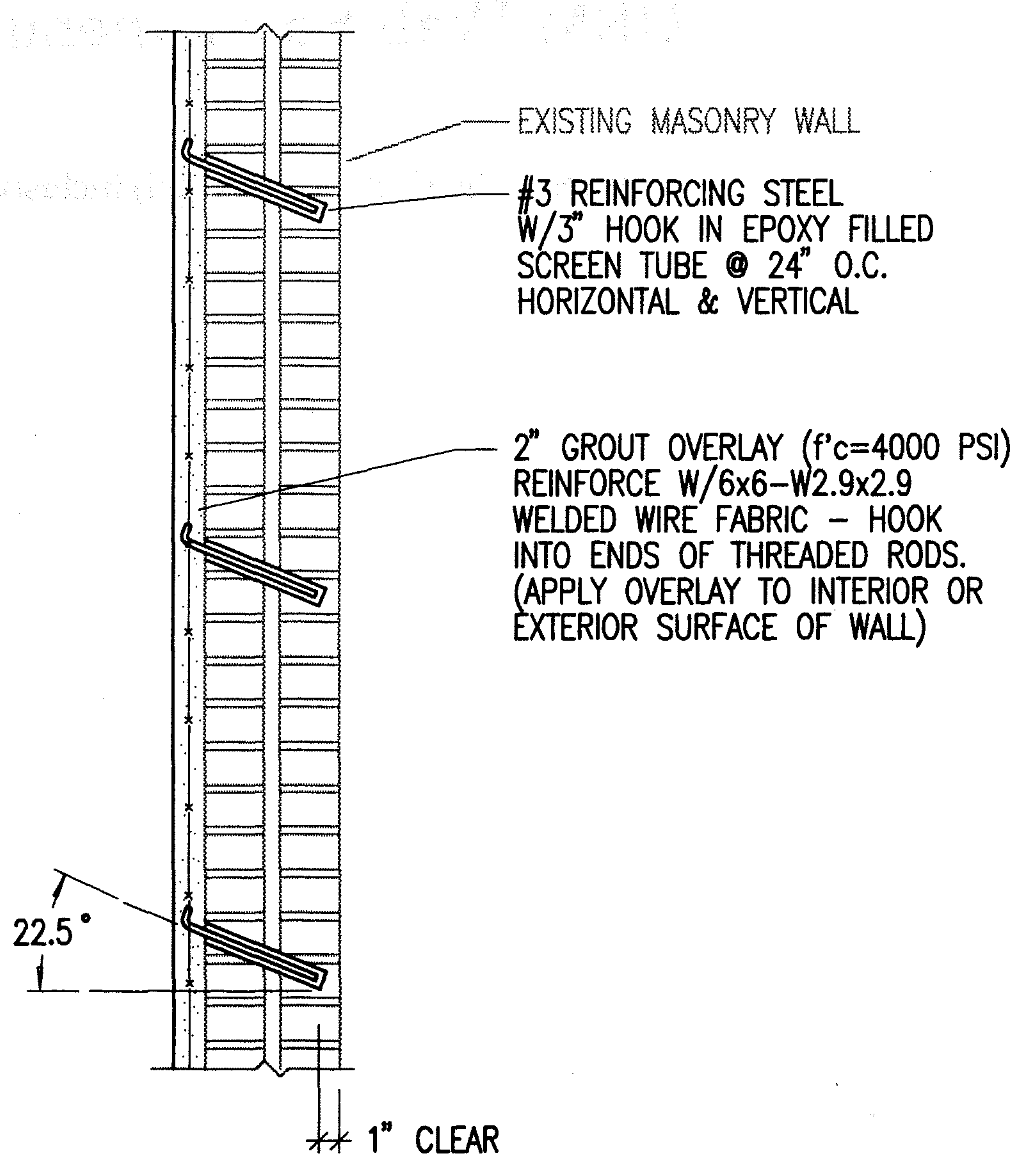
FLOOR DIAPHRAGM STRENGTHENING

Seismic Improvement Structural Detail	Home Type: ALL MODELS	Figure No.: VI (f-1)

SECTION G

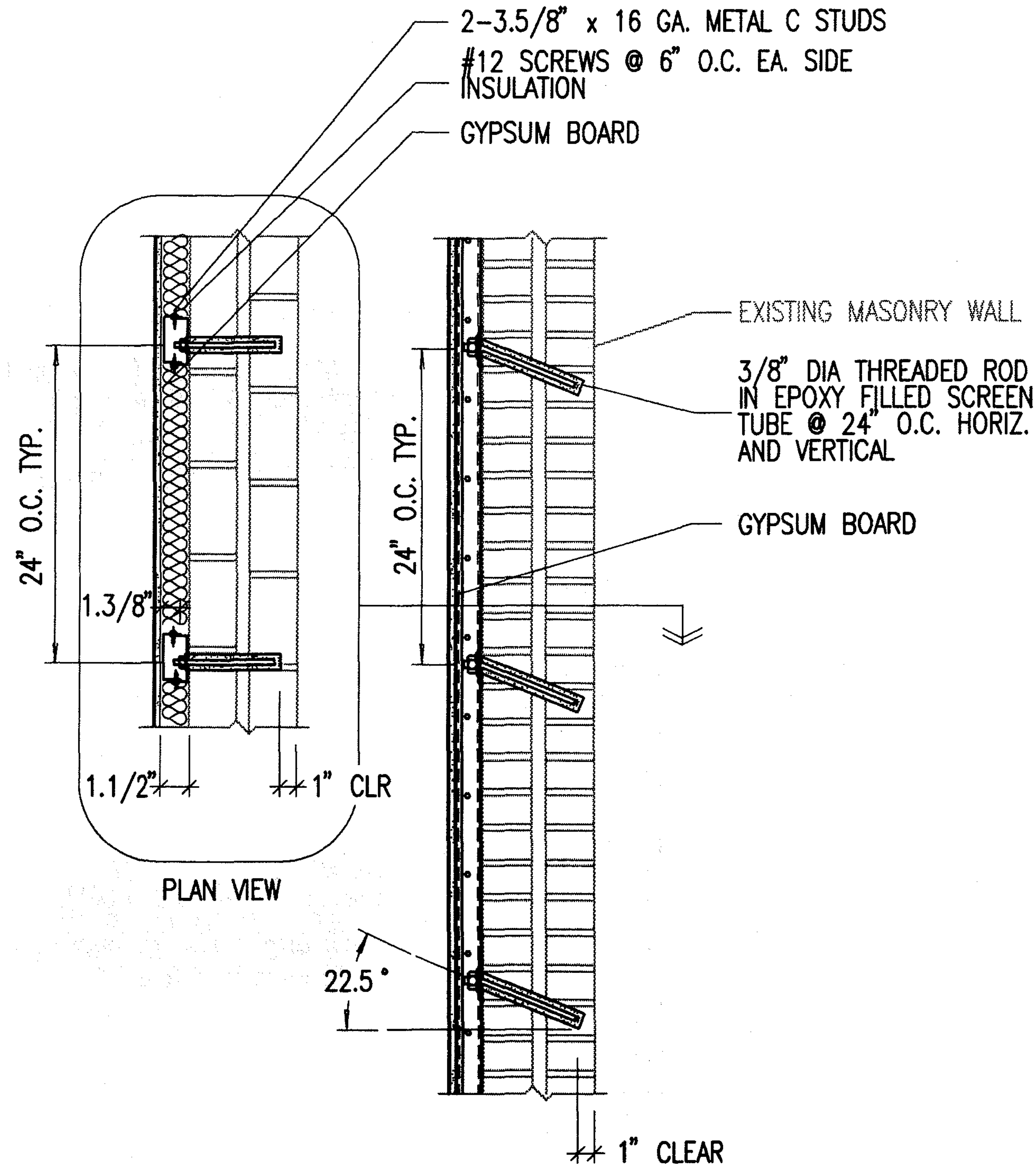
URM Wall Strengthening

Figures VI (g-1) through VI (g-4) inclusive.



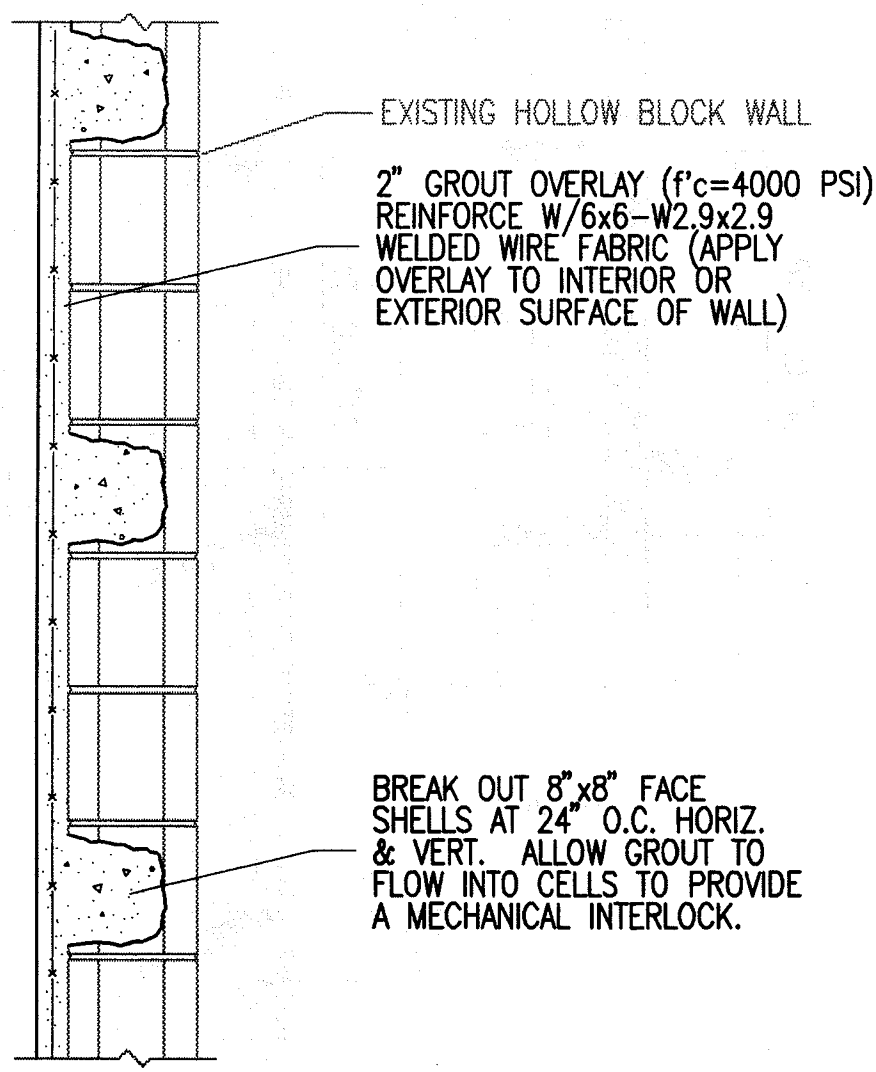
URM WALL STRENGTHENING

Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (g-1)



URM WALL STRENGTHENING

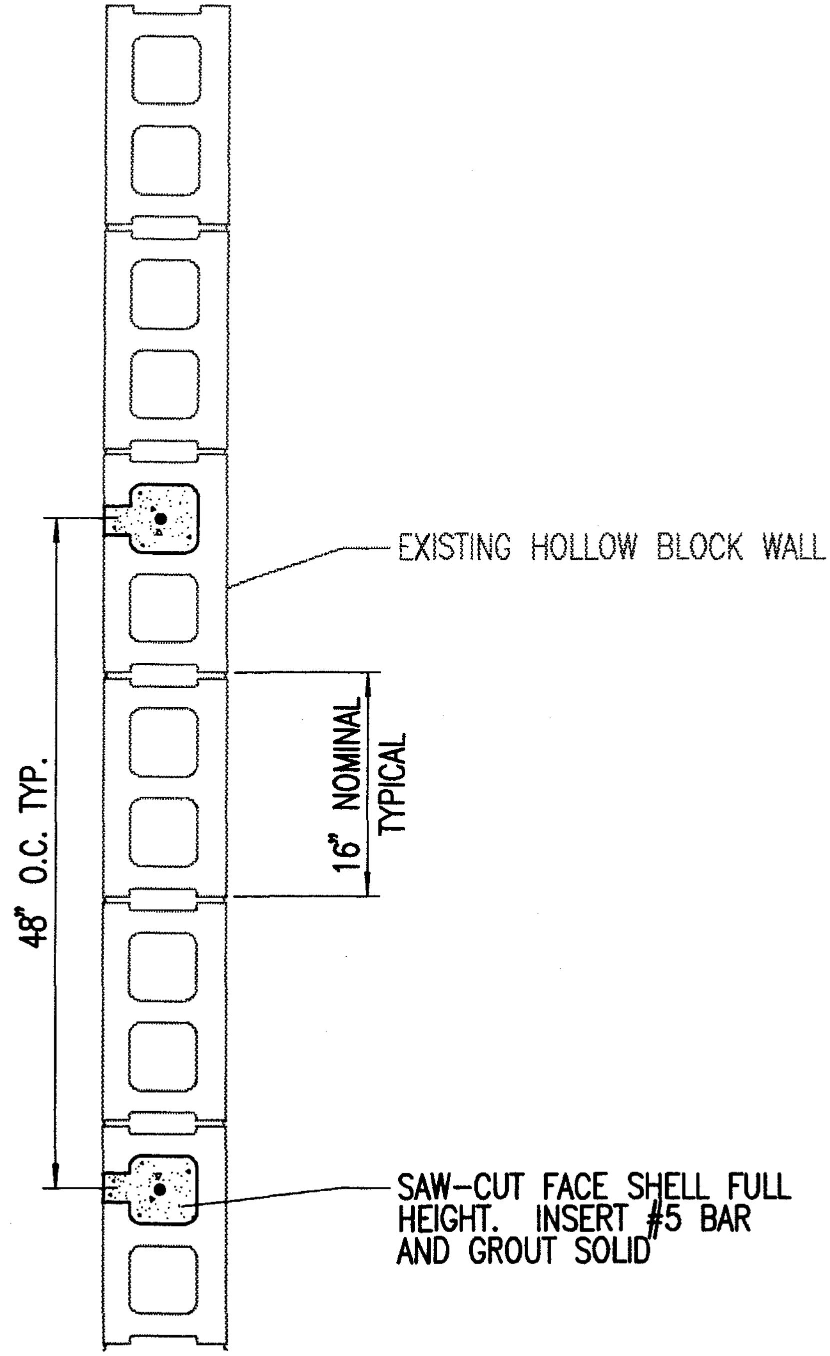
Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (g-2)



SECTION

URM WALL STRENGTHENING

Seismic Improvement Structural Detail	Home Type: MODEL E	Figure No.: VI (g-3)



PLAN VIEW

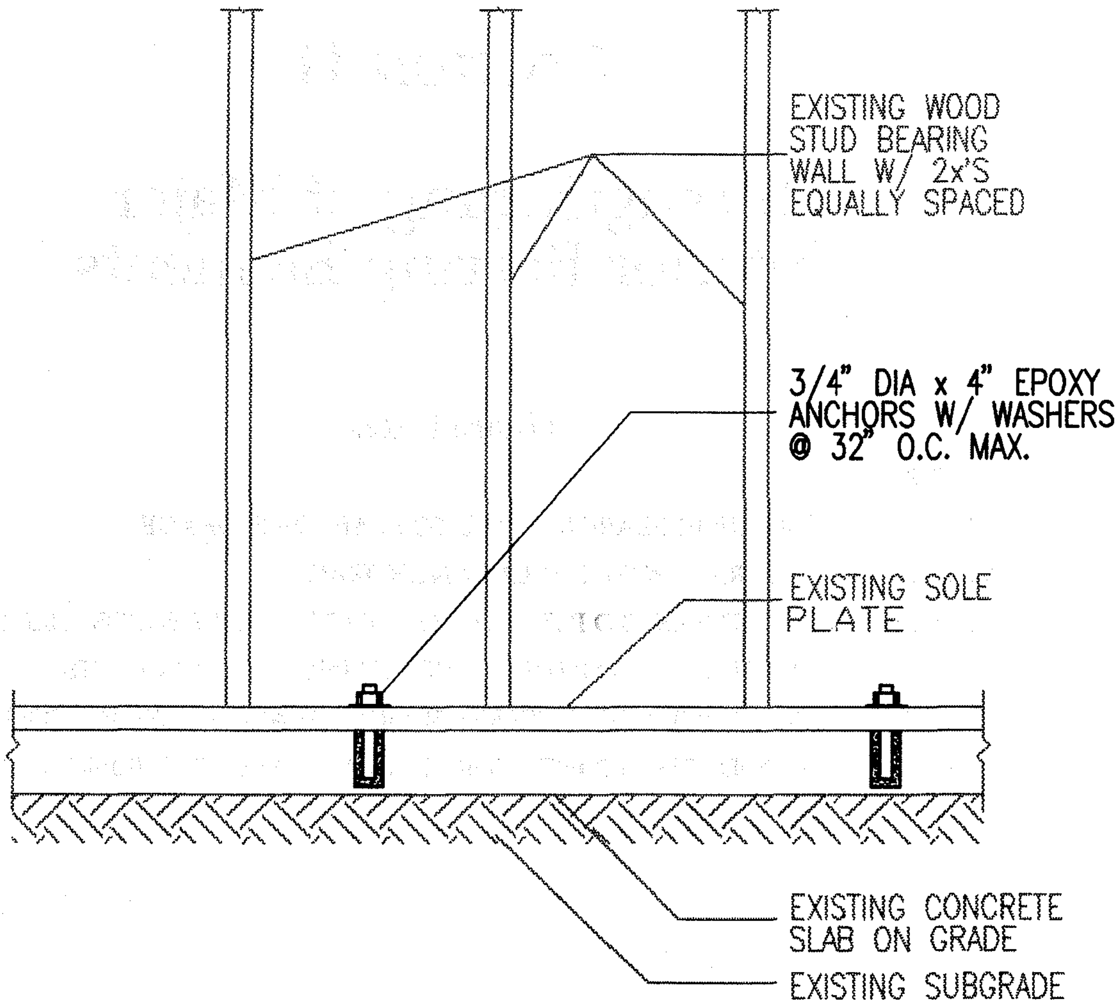
URM WALL STRENGTHENING

Seismic Improvement Structural Detail	**Home Type:** MODEL E	**Figure No.:** VI (g–4)

SECTION H

Strengthening of Major Interior Bearing Elements

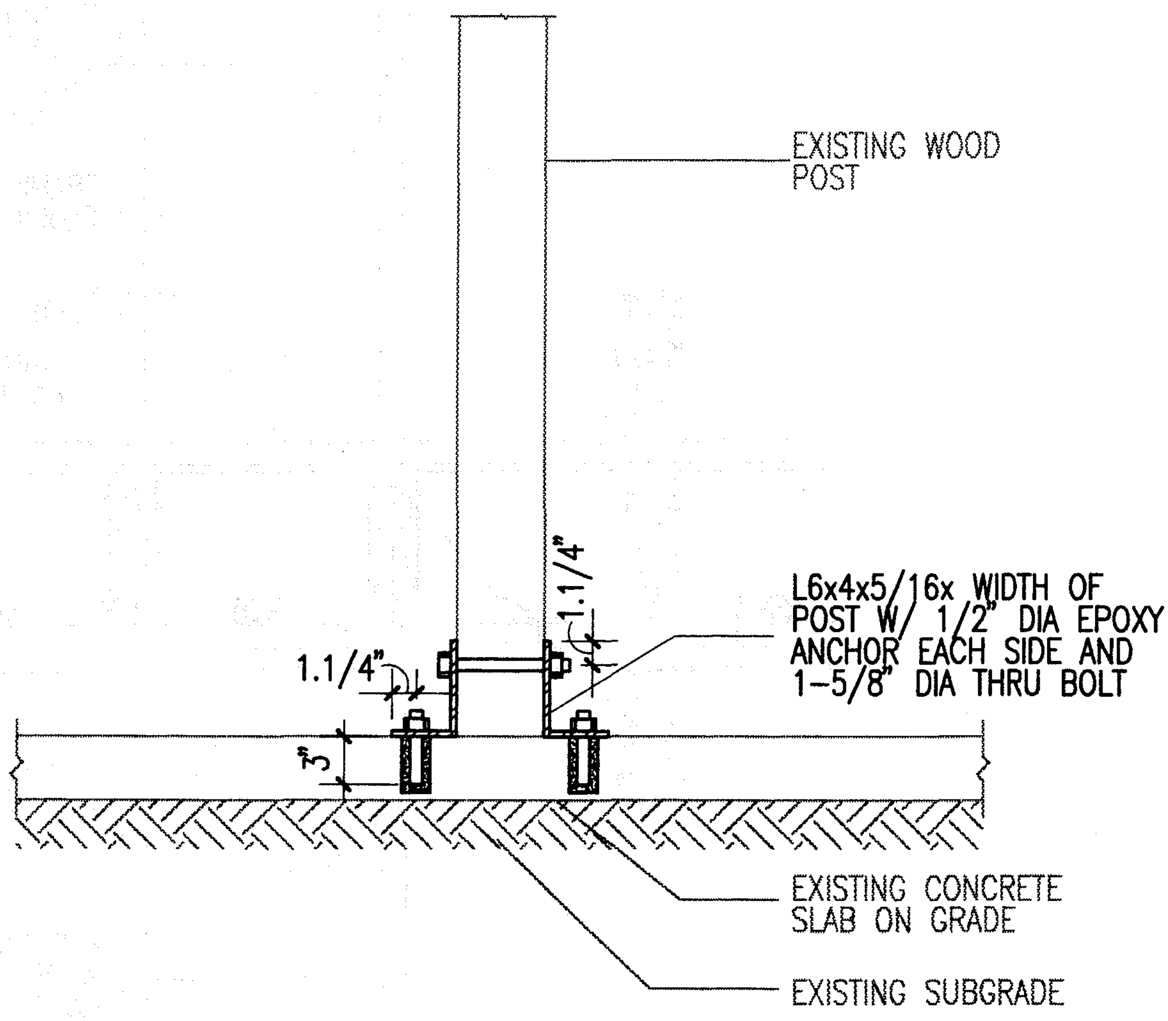
Figure Index



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

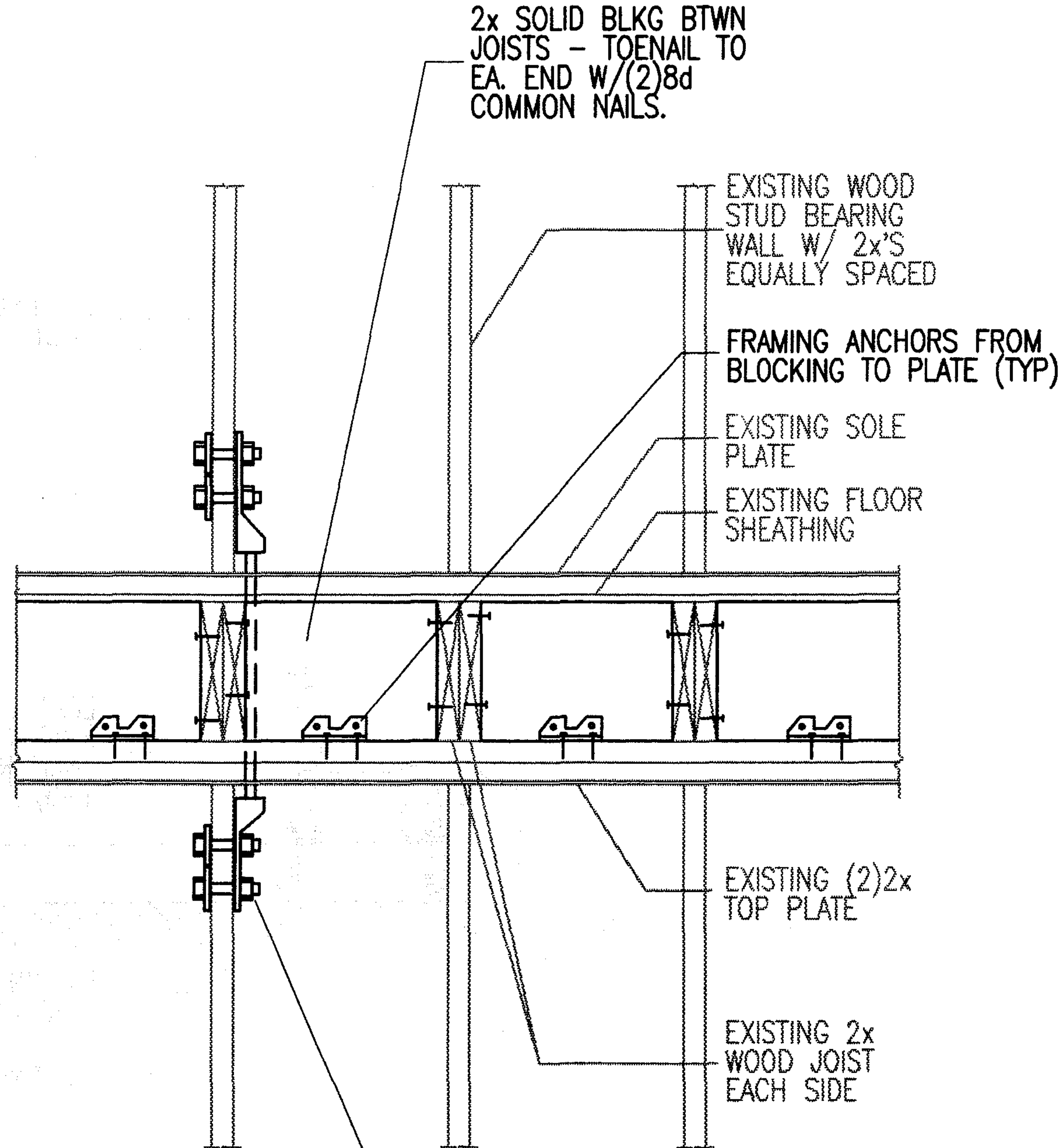
INTERIOR BEARING WALL TO SLAB ANCHORAGE

Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (h-1)



INTERIOR POST TO SLAB ANCHORAGE

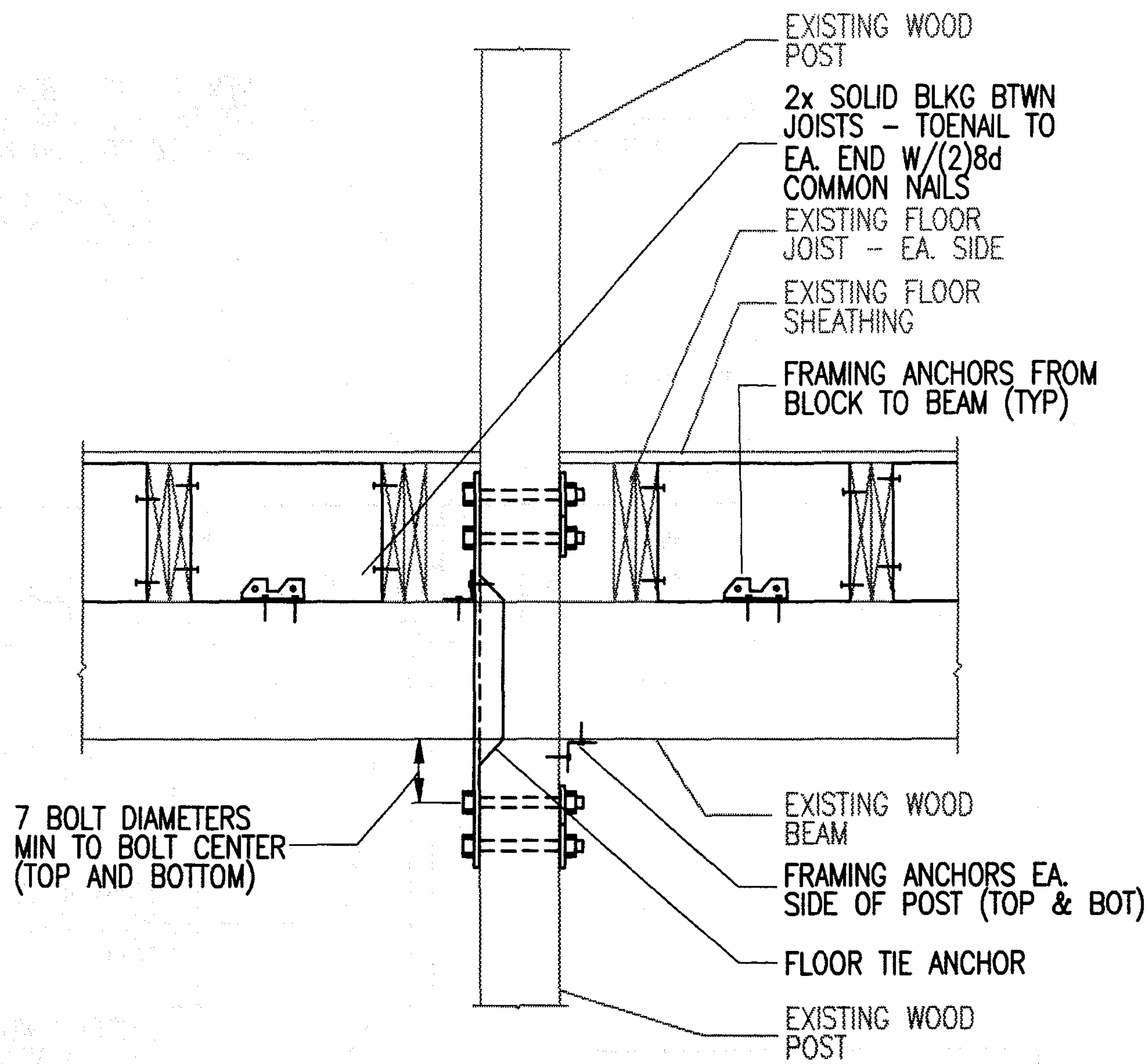
Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (h-2)



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

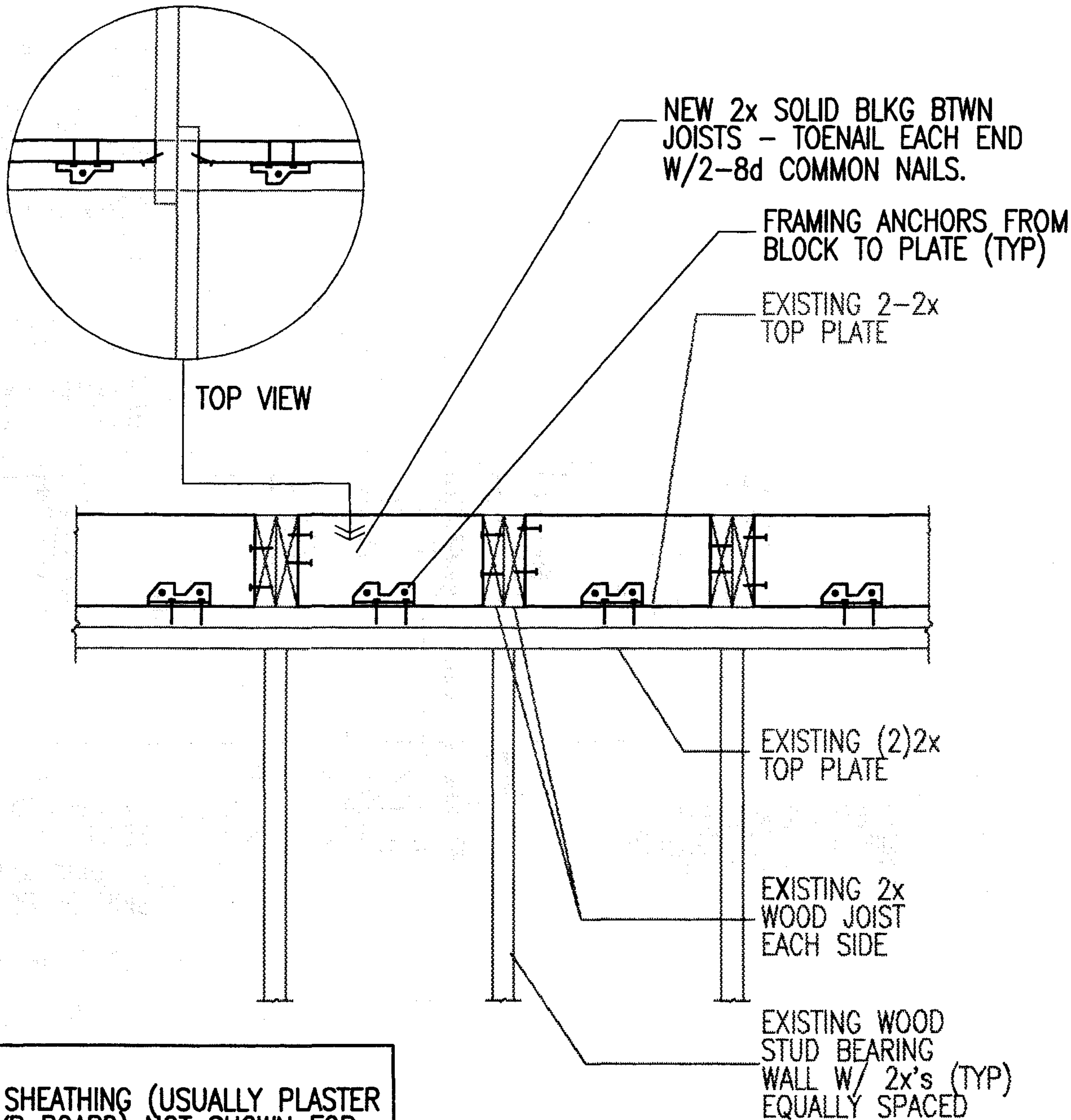
WOOD JOIST TO INTERIOR BEARING WALL AT FLOOR JOISTS

Seismic Improvement Structural Detail	**Home Type:** VARIES	**Figure No.:** VI (h–3)



WOOD POST TO INTERIOR BEAM LINE AT FLOOR JOISTS

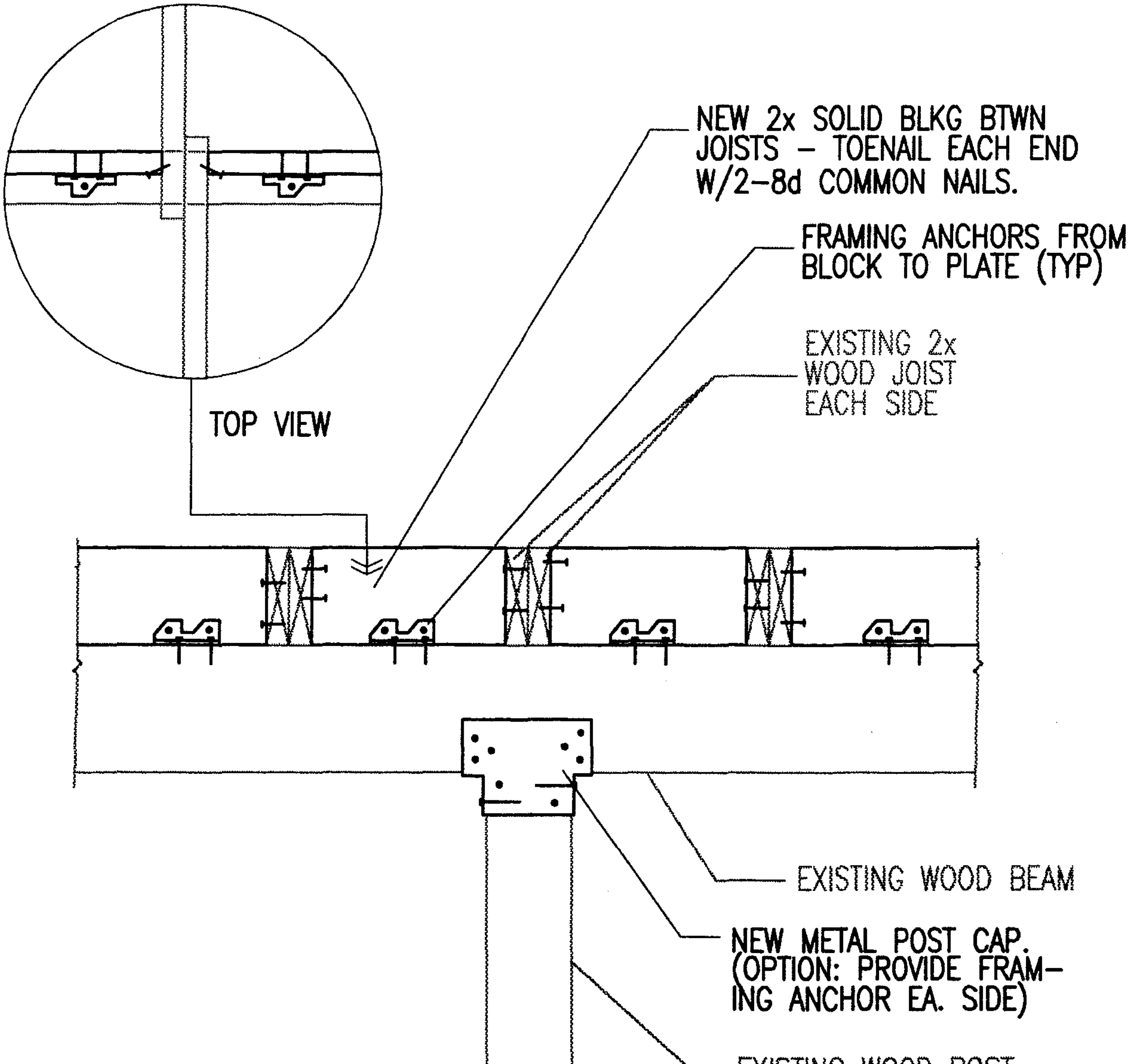
Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (h–4)



NOTE:
WALL SHEATHING (USUALLY PLASTER OR GYP 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	Figure No.: VI (h-5)



WOOD JOIST TO INTERIOR BEARING WALL AT CEILING JOISTS

Seismic Improvement Structural Detail	Home Type: VARIES	Figure No.: VI (h-6)

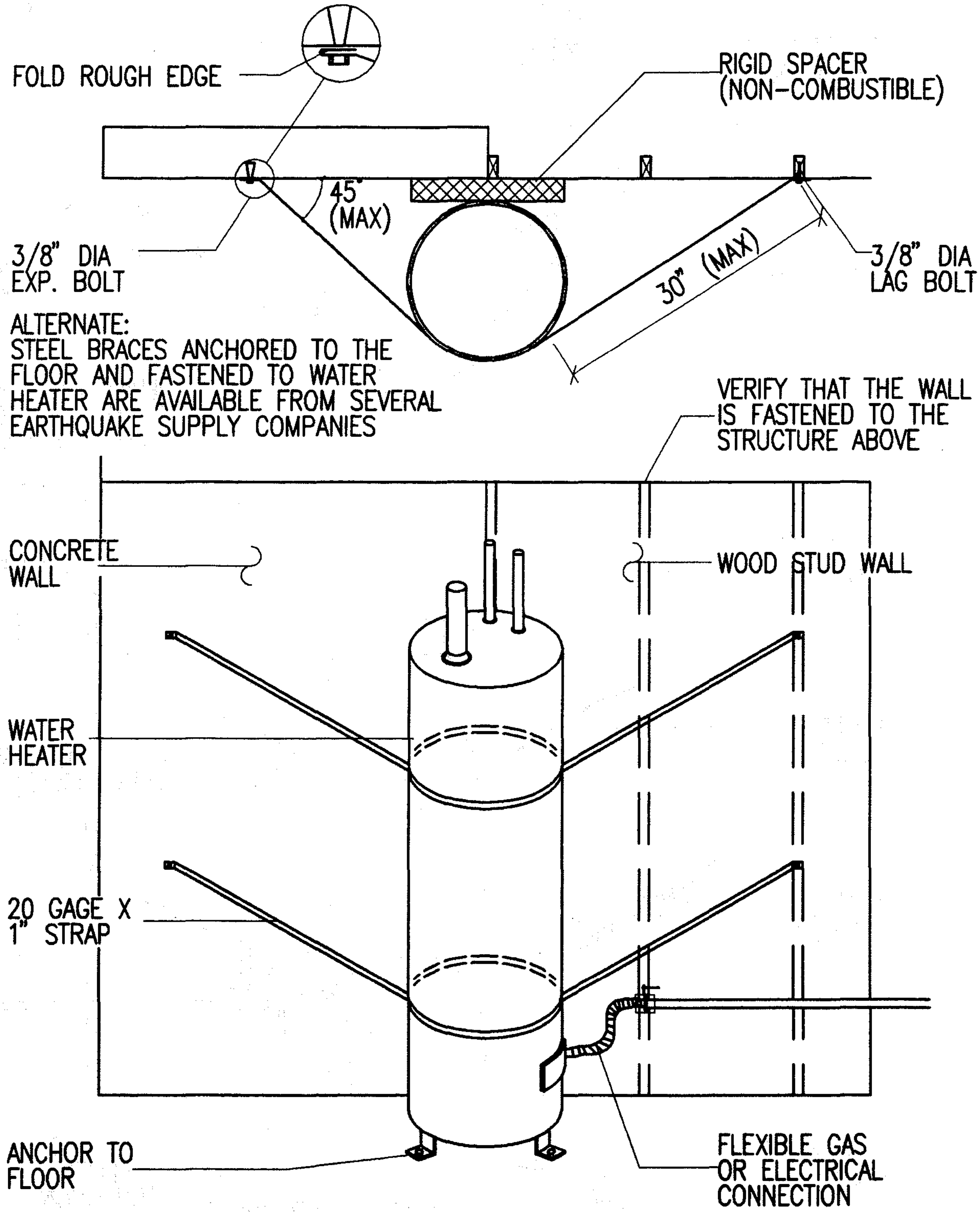
CHAPTER 7.

Non-structural Seismic Hazards: Anchorage and Bracing

Chapter 7 includes details for upgrading non-structural seismic hazards. This includes, 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 contents which are not directly related to the structural frame, walls, floor(s), and roof of the building structure.

The dislodgment of non-structural elements in a dwelling is a potential life safety hazard during an earthquake. Today's 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 building shakes, non-structural elements and building contents like heavy equipment, furniture, computers, art work 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 building contents are almost a total loss. When this involves expensive furnishings, equipment, antiques, art work, etc., the homeowner can sustain an enormous loss. The displacement of building contents can often be inexpensively reduced. The following mitigation details are designed to reduce the potential for large losses resulting from an earthquake.

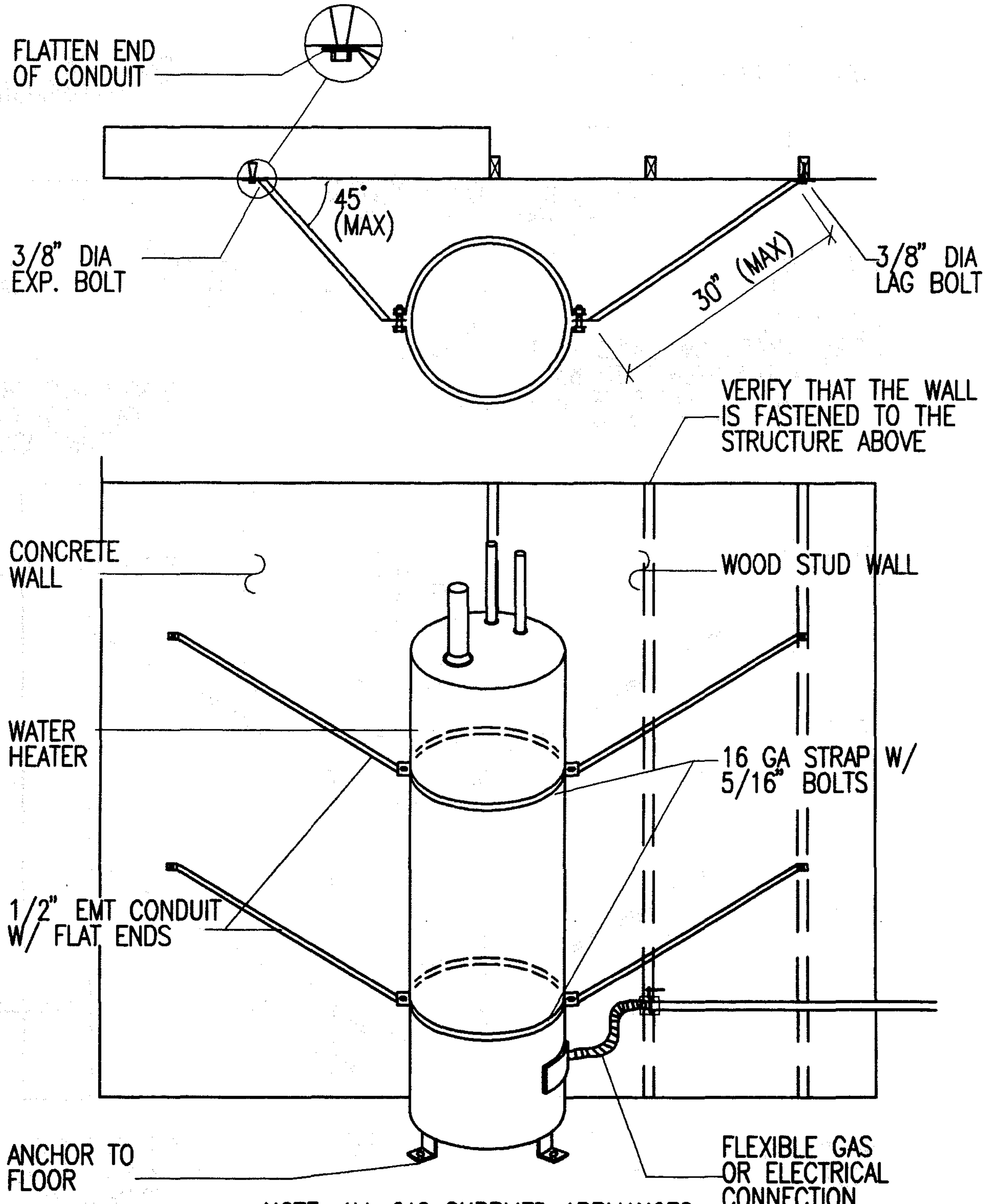
Figure Index



NOTE: ALL GAS SUPPLIED APPLIANCES (FURNACE, STOVE, ETC.) SHOULD HAVE FLEXIBLE CONNECTIONS.

WATER HEATER BRACING

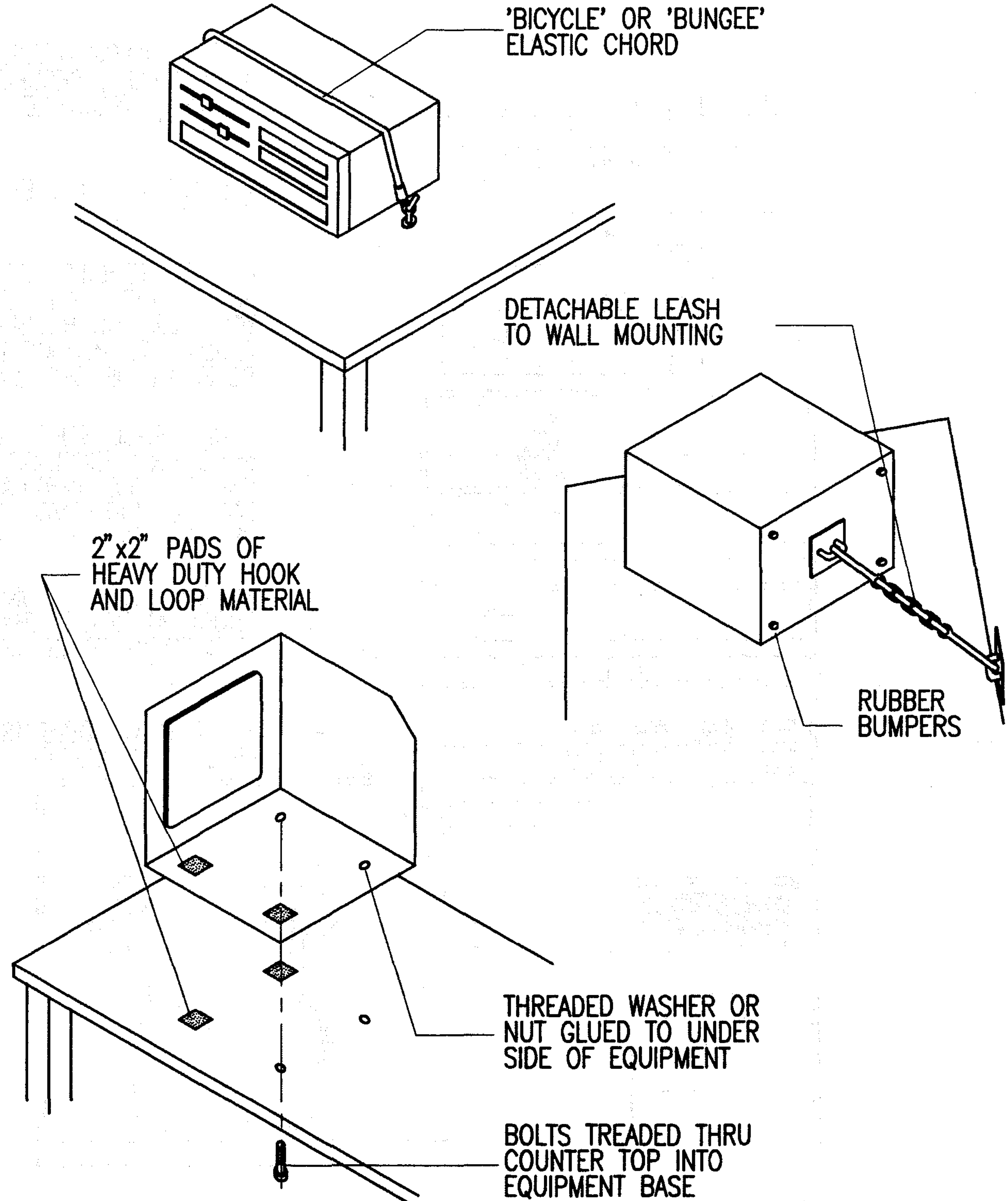
Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-1



NOTE: ALL GAS SUPPLIED APPLIANCES (FURNACE, STOVE, ETC.) SHOULD HAVE FLEXIBLE CONNECTIONS.

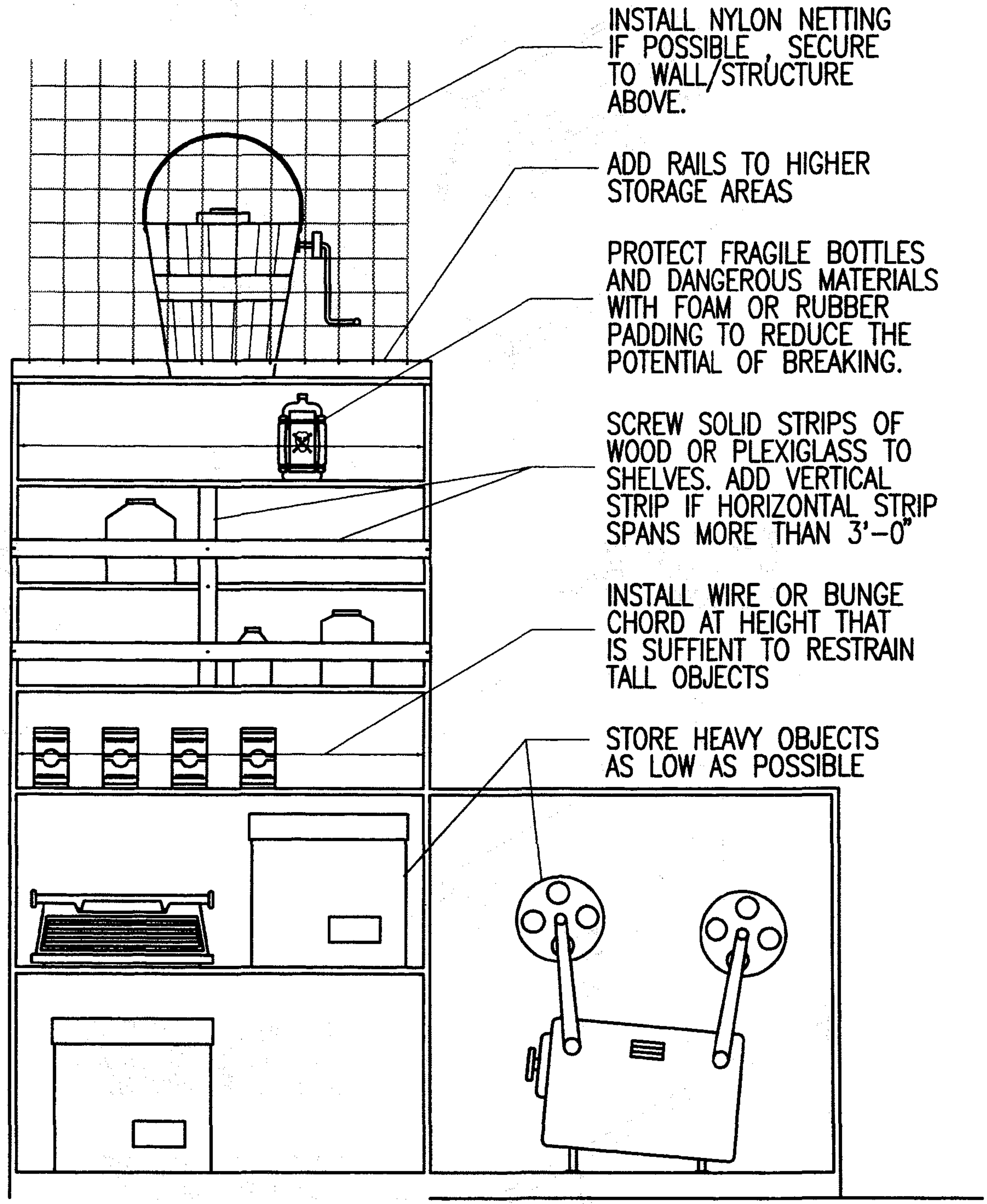
WATER HEATER BRACING

Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-2



RESTRAINT OF COMPUTERS, TYPEWRITERS, ETC.

Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-3

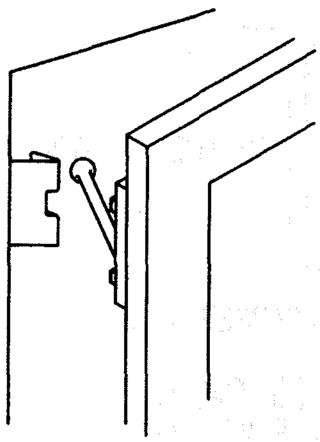


ATTACH SHELVING SECURELY TO WALLS, SEE VII-6

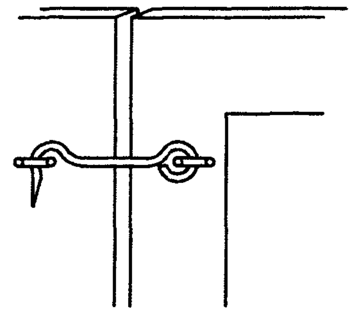
RESTRAINT OF STORAGE ITEMS

Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-4

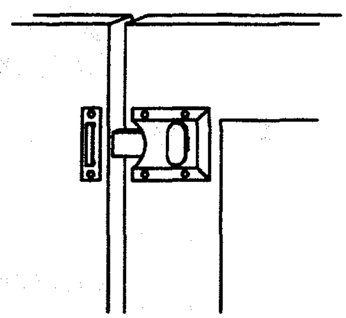
SECURE CABINET DOORS WITH POSITIVE CATCHING LATCHES



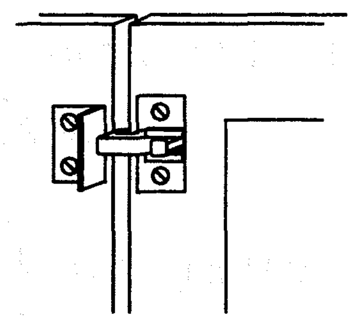
CHILDPROOF LATCH



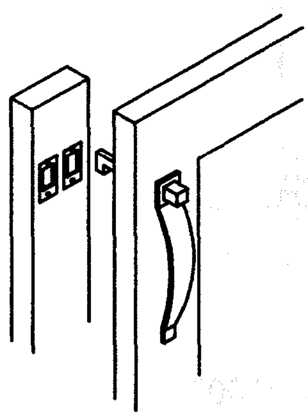
HOOK AND EYE



KNOB LATCH



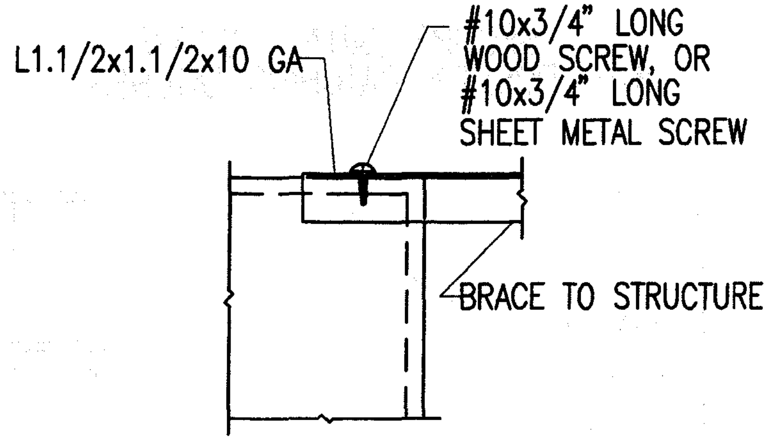
PULL HANDLE LATCH



RELEASE BUTTON LATCH

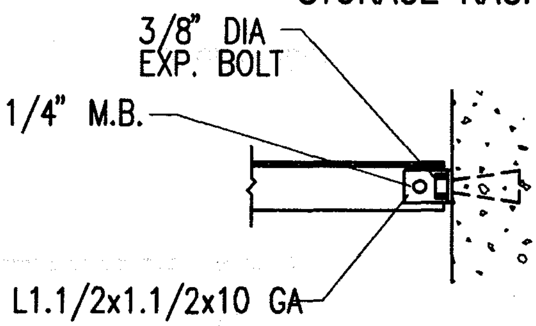
CABINET DOOR LATCHES

Seismic Improvement Non–Structural Detail	Home Type: VARIES	Figure No.: VII–5

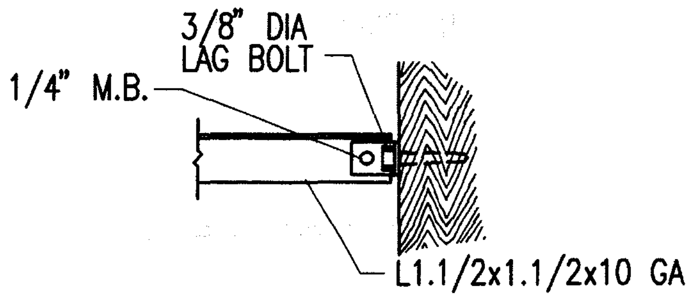


WOOD SHELVING/CABINET/ETC.

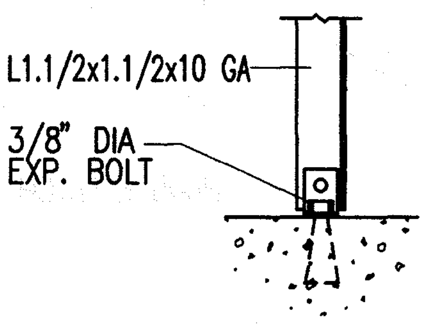
BRACE ATTACHMENT TO CABINETS, STORAGE RACKS, OR EQUIPMENT



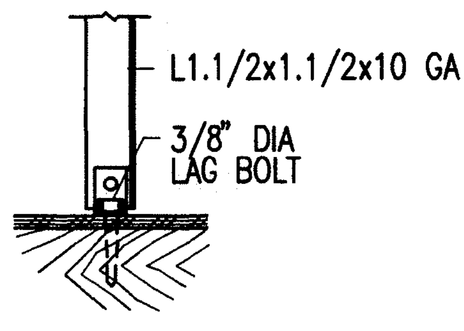
CONRETE OR MASONRY WALL



WOOD WALL



CONRETE FLOOR

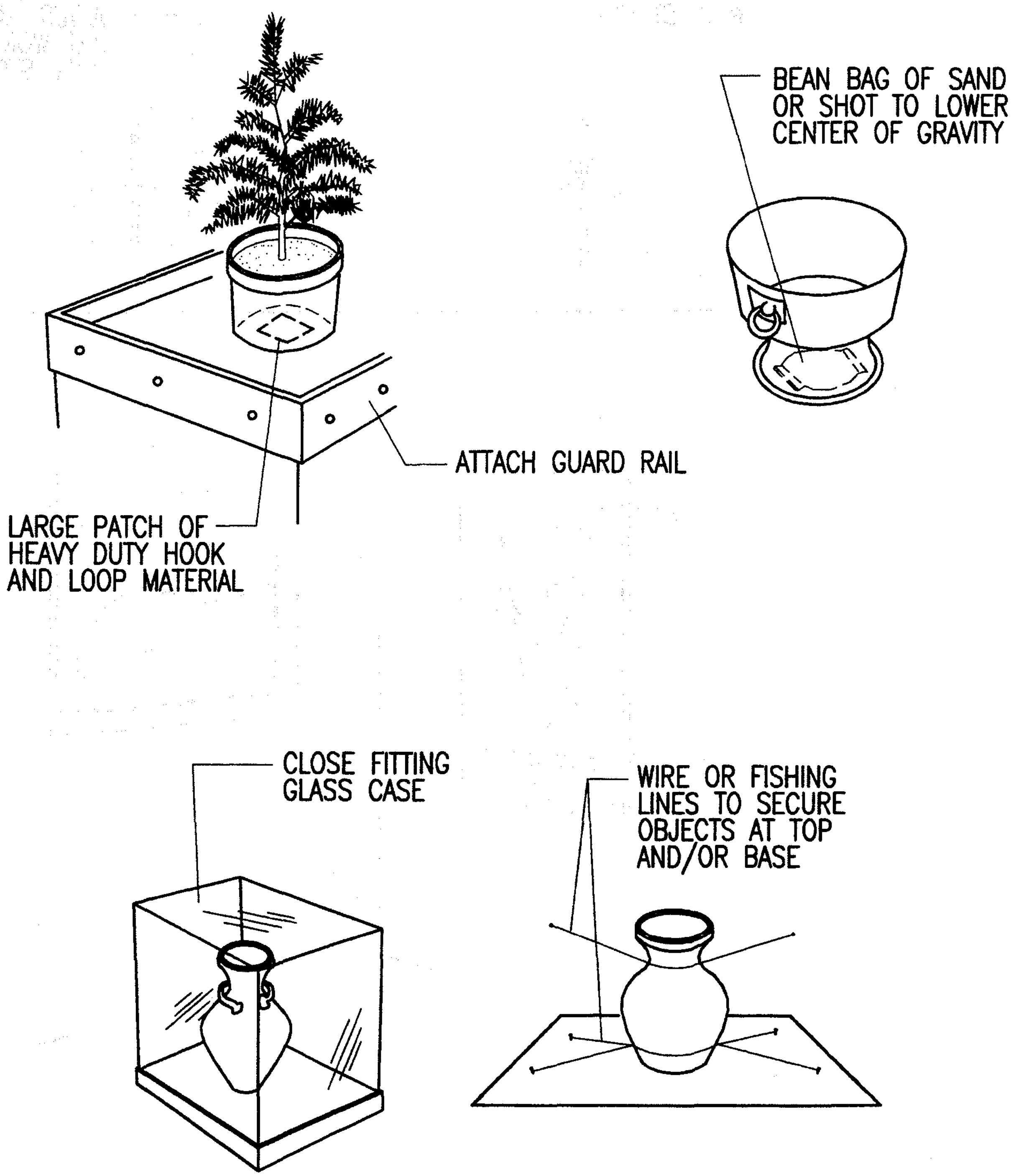


WOOD FLOOR

BRACE ATTACHMENT TO STRUCTURE

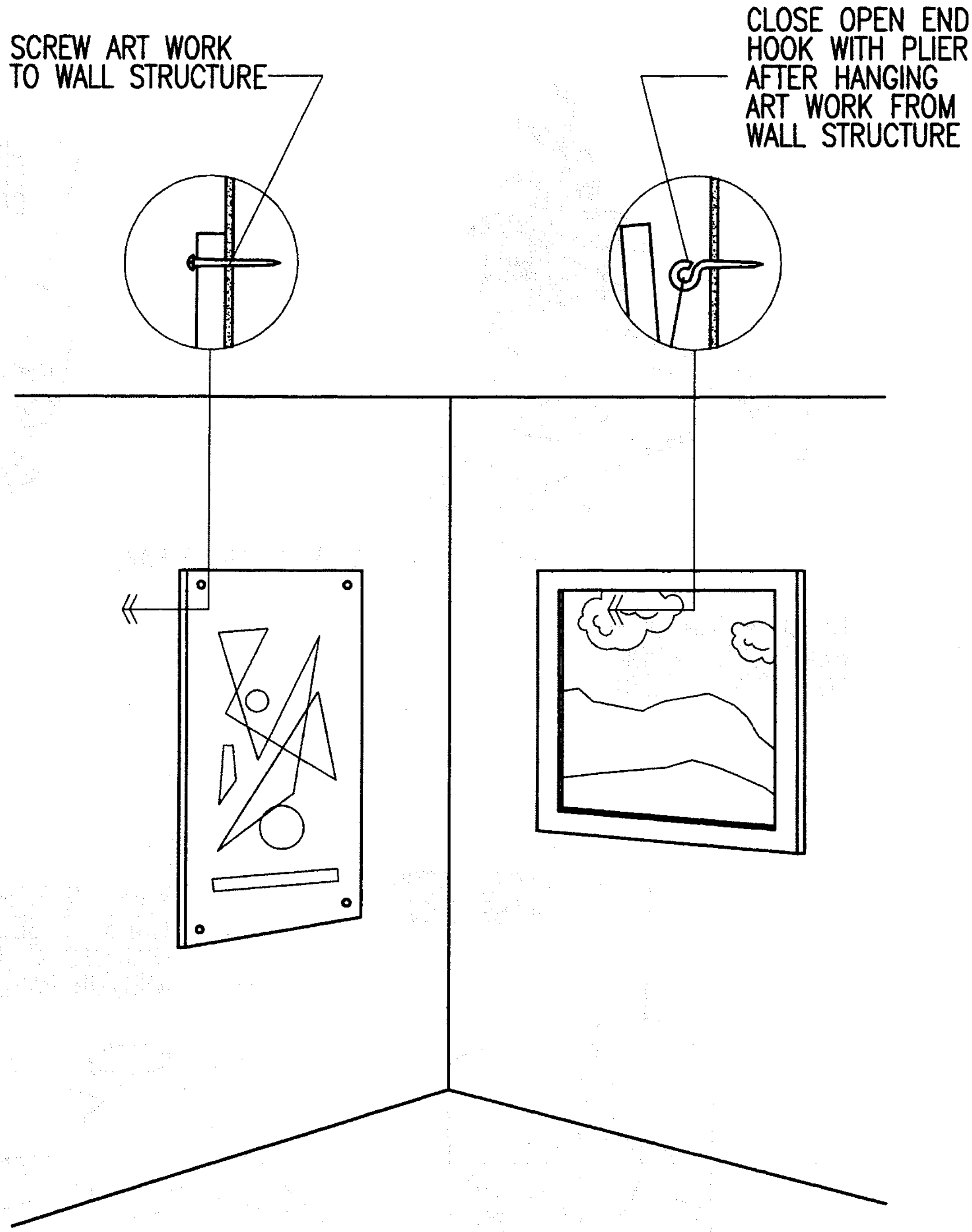
SHELVING AND STORAGE RACKS

Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-6



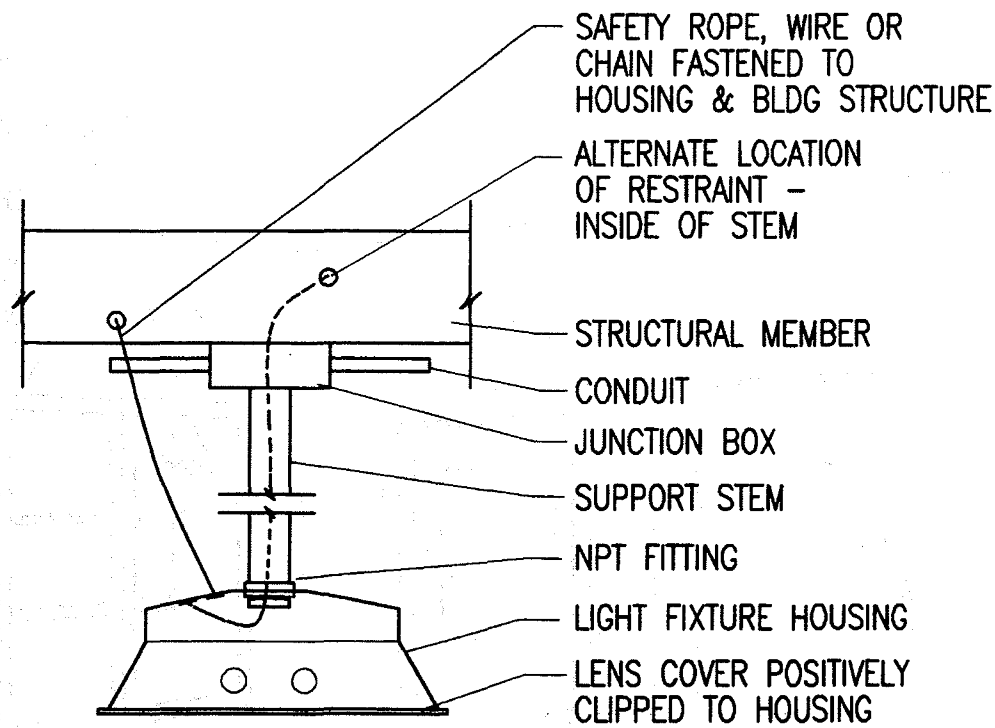
RESTRAINT OF ART OBJECTS, BREAKABLES, ETC.

Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-7



RESTAINT OF ART WORK & OTHER WALL MOUNTED ITEMS

Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-8



STEM-HUNG LIGHT FIXTURE

BRACING AND SUPPORT OF LIGHT FIXTURES, CHANDELIERS AND FANS

Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-9

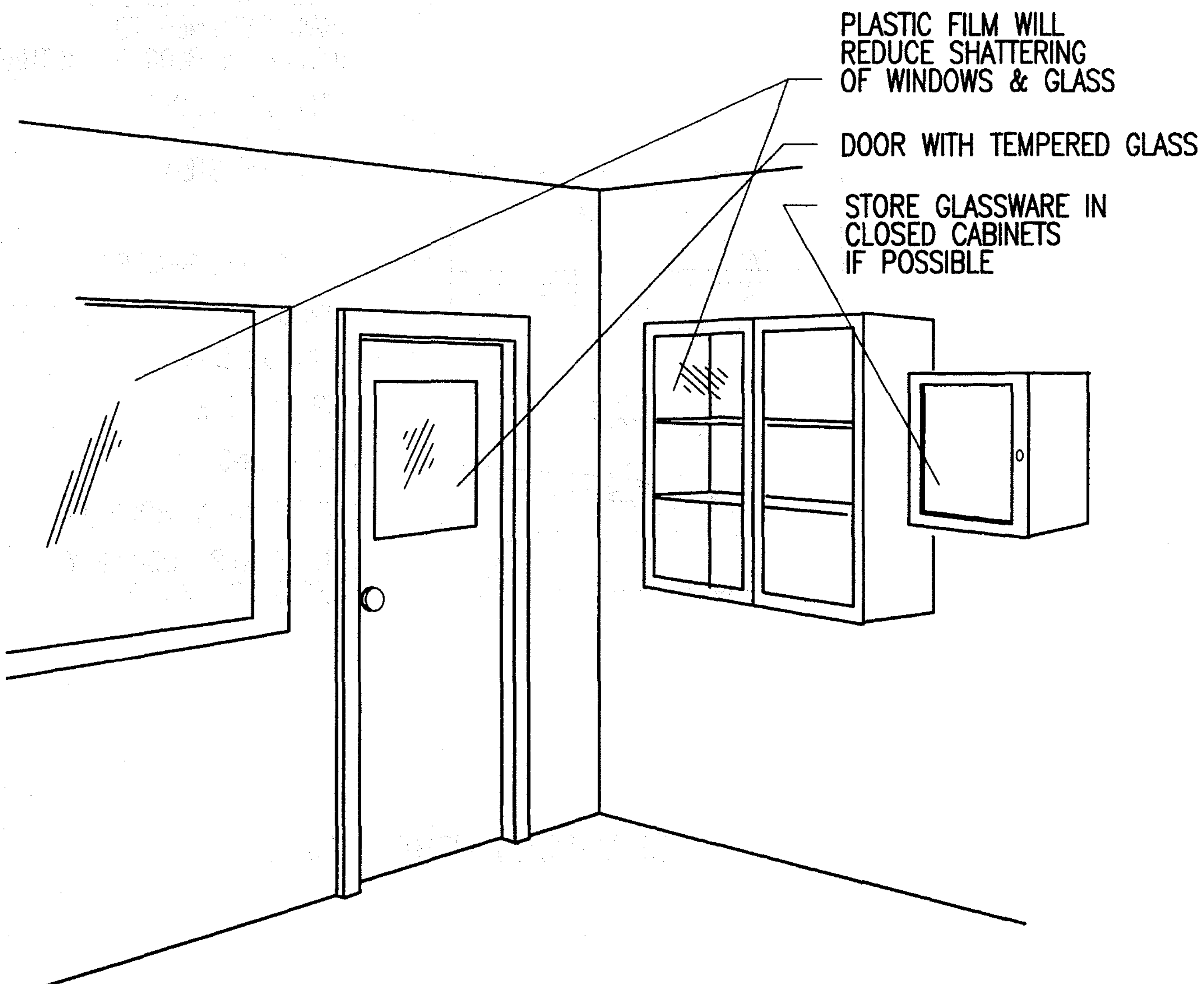
WINDOWS: WINDOWS CAN BE REINFORCED WITH "ARMOR COAT" CLEAR POLYESTER FILM OR MATERIAL WITH SIMILIAR PROPERTIES OR REPLACED W/TEMPERED GLASS. LARGE WINDOWS AND HIGH WINDOWS PRESENT THE GREATEST RISK. LOWER BLINDERS OR DRAW DRAPES ON WINDOWS WHERE THIS IS PRACTICAL AND WILL NOT CREATE LIGHTING PROBLEMS.

DISPLAY CASES: OFTEN HEAVY ITEMS LIKE TROPHIES ARE STORED IN DISPLAY CABINETS. THE GLASS IN THESE AREAS CAN BE COATED WITH "ARMOR COAT" OR REPLACED WITH TEMPERED GLASS OR PLEXIGLASS.

GLASS OBJECTS: GLASSWARE CAN BE STORED IN CLOSED CABINETS OR RESTRAINED ON OPEN SHELVES.

MIRRORS: MIRRORS SHOULD BE FIRMLY ATTACHED TO WALLS.

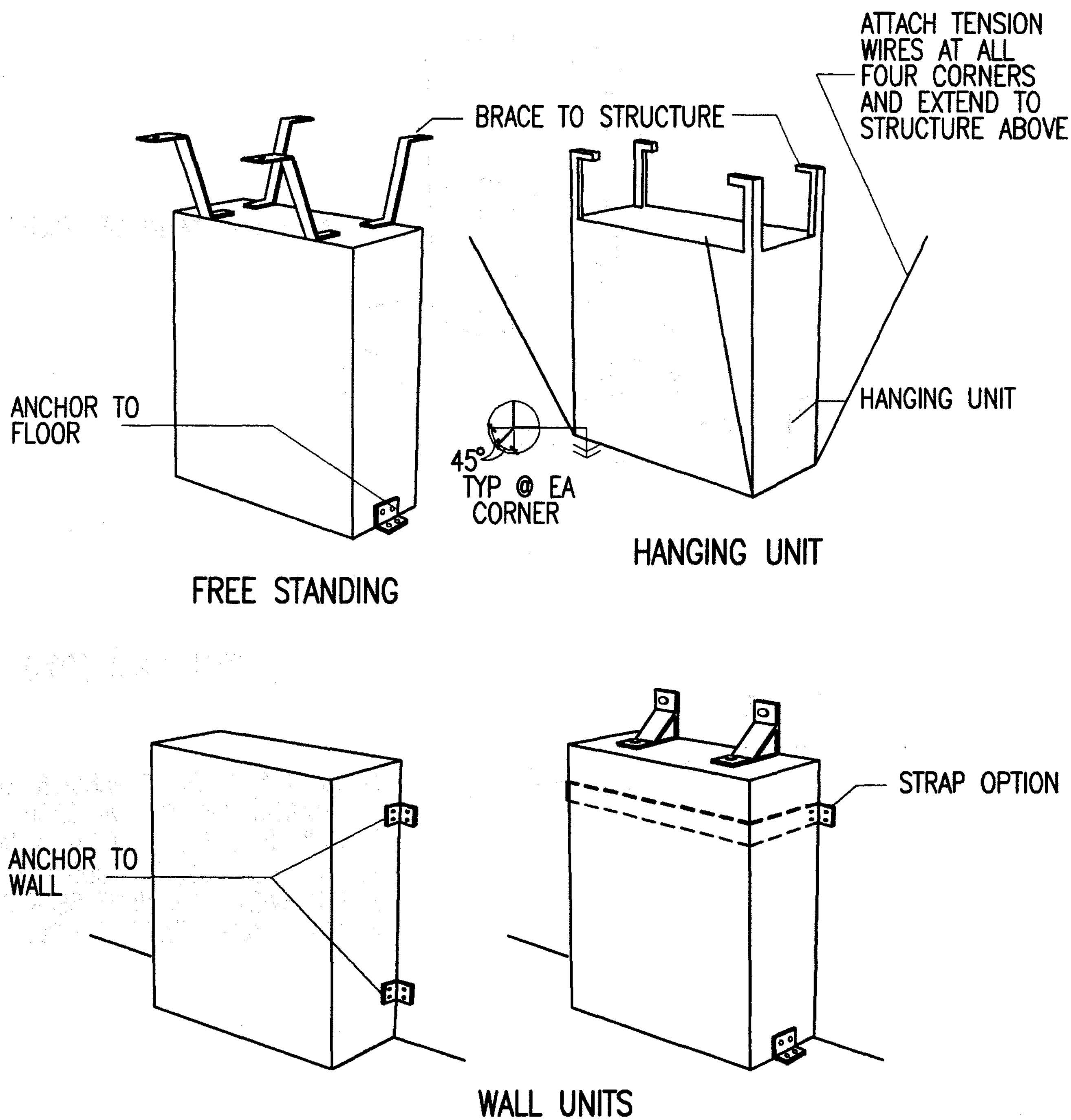
SKYLIGHTS: SKYLIGHTS ARE FREQUENTLY LOCATED ABOVE EXITWAYS. THEY SHOULD BE TREATED SIMILARLY TO WINDOWS UNLESS WIRE OR SAFETY GLASS WAS USED.



SEISMIC CONSIDERATIONS OF GLASS ITEMS

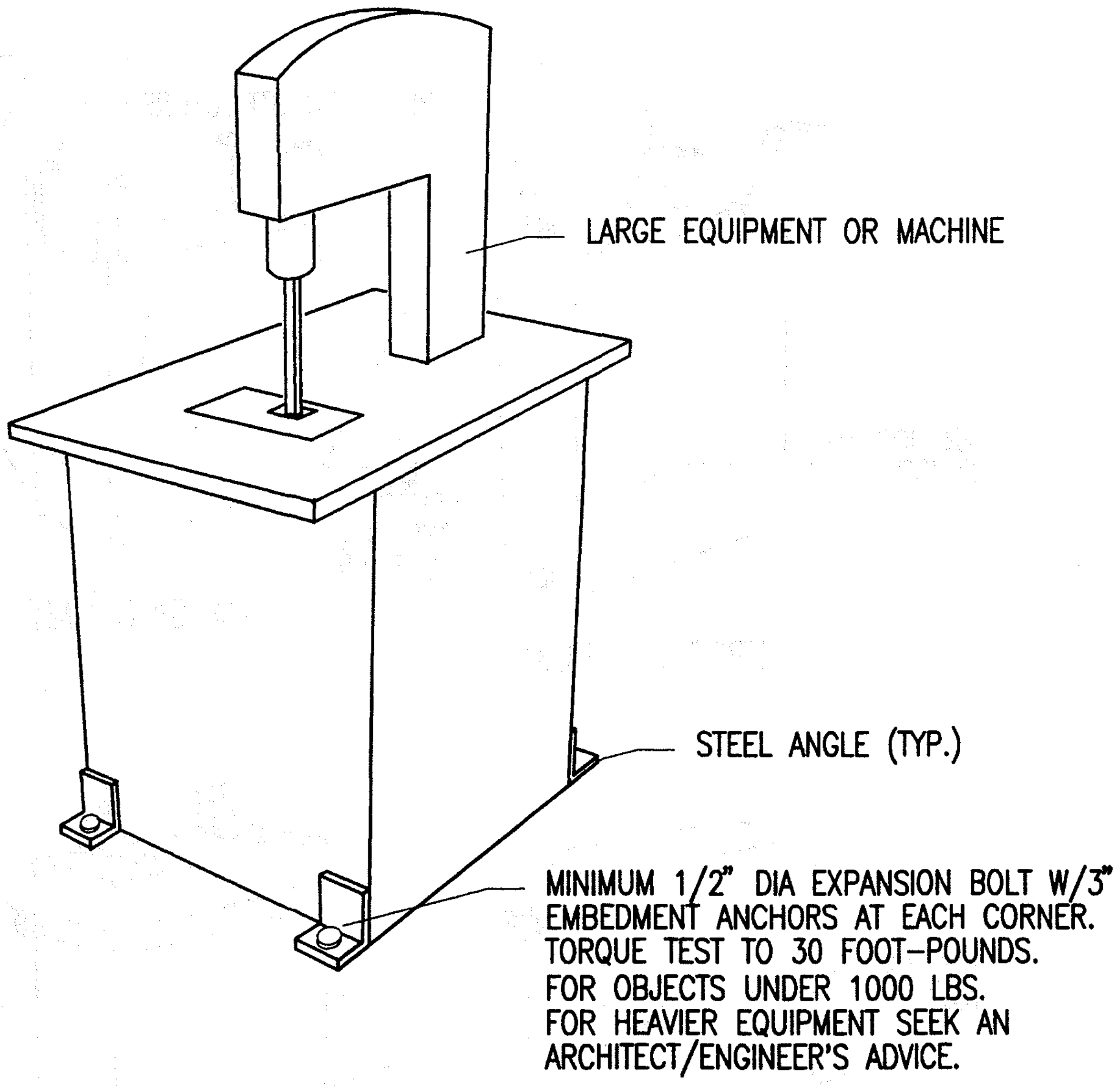
Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-10

EQUIPMENT THAT IS TALL AND NARROW MAY BE SUSCEPTIBLE TO OVERTURNING AND SLIDING, CAUSING DAMAGE TO INTERNAL INSTRUMENTS AND UTILITY CONNECTIONS. THIS TYPE OF EQUIPMENT CAN BE SECURED AGAINST SLIDING OR ROCKING IN MANY WAYS, DEPENDING ON THE LOCATION OF THE UNITS RELATIVE TO ADJACENT WALLS, CEILINGS, AND FLOORS.



TYPICAL OPTIONS FOR ANCHORING EQUIPMENT

Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-11



ANCHORAGE OF SHOP EQUIPMENT TO FLOOR

Seismic Improvement Non-Structural Detail	Home Type: VARIES	Figure No.: VII-12

APPENDIX A

References

Applied Technology Council. (1976). A Methodology for Seismic Design and Construction of Single-Family Dwellings.

Applied Technology Council. (1980). The Home Builder's Guide for Earthquake Design. Author: Berkeley, CA.

Applied Technology Council. (1986). ATC-5: Guidelines for Seismic Design and Construction of Single-Story Masonry Dwellings. Seismic Zone 2. Author: Redwood City, CA.

Author. (1982, March). Getting Ready for a Big Quake. Sunset.

Federal Emergency Management Agency. A Methodology for Seismic Design and Construction of Single-Family Dwellings. The Home Builder's Guide for Earthquake Design-Guideline 6.

Federal Emergency Management Agency. Earthquake Hazards Reductions Series 1. (1985). Reducing the Risks of Non-structural Earthquake Damage: A Practical Guide.

National Trust for Historic Preservation. (1992). Controlling Disaster: Earthquake-Hazard Reduction for Historic Buildings (No. 61).

Robert Lyon Associates. (1991). Construction Data for Existing Wood: Framed Buildings and Foundations. (Seismic Retrofit, DRM-S2) Redwood, Ca: Author.

Smith-Kim, C. & Furukawa, C. (1991). Introduction to Earthquake Retrofitting, Tools & Equipment.

State of California: Seismic Safety Commission. (1992). The Homeowner's Guide to Earthquake Safety (SSC No. 92-02). Sacramento, California.

Structural Concepts and Details for Seismic Design. (1991). Lawrence Livermore National Laboratory for E.Q.E. Engineering and Design

Structural Engineers Association of California. (1991). Reflections On The Loma Prieta Earthquake- October 17, 1989.

APPENDIX B

Glossary

8d An eight penny common wire nail. Shank diameter equals 0.131 inches and the length equals $2^1/_2$ inches.

10d A ten penny common wire nail. Shank diameter equals 0.148 inches and the length equals 3 inches.

16d A sixteen penny common wire nail. Shank diameter equals 0.162 inches and the length equals $3^1/_2$ inches.

anchor bolt A steel rod with one hooked end and threads at the other end for a nut.

beam A horizontal structural element to support joists.

BLKG. *abbr.*. Blocking.

blocking Wood blocks used as filler pieces between framing members.

BTWN. *abbr.*. Between.

CLR. *abbr.*. Clear.

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

compression A force which tends to shorten a member.

concrete block A manufactured building element made of concrete, usually 8″ x 8″ x 16″, with open interior cores.

CONT. *abbr.*. Continuous.

crawl space A low (less than 18") space between the ground and the first floor.

dead load Load due to weight of the members, the supported structure, and permanent attachments to the structure.

deflection Displacement or movement of a structural element from self weight or an applied force downward normally due to gravity.

deterioration The worsening of the structural capacity or appearance of a building element, usually by weathering, "wear and tear".

DIA. *abbr.*. Diameter.

EA. *abbr.*. Each.

earthquake resistance The ability of a structure to resist the motion from an earthquake without collapse or significant damage.

E.M.T. A type of electrical conduit.

epicenter The point on the earth's surface directly above where the earthquake originates.

epoxy A very strong chemical bonding system which normally comes in two parts and must be mixed before using. It is used as a coating, as an adhesive, as a matrix for setting structural anchors, etc.

epoxy anchor A threaded rod inserted into a drilled hole filled with epoxy or another chemical resin designed for this purpose.

EXIST. *abbr.*. Existing.

EXP. *abbr.*. Expansion.

expansion bolt A bolt with a sleeve or bushing that, when set into a hole in masonry or concrete, expands and anchors itself firmly as the bolt is tightened to it.

face shell The side wall of a hollow concrete masonry unit.

f'_c The symbol used to indicate the compressive strength of concrete at 28 days.

footing The horizontal portion of the foundation that transmits load to the soils.

foundation anchor A pre-manufactured sheet metal connector.

foundation joist anchor A pre-manufactured sheet metal connector.

framing anchor A pre-manufactured sheet metal connector.

GA. *abbr.*. Gauge.

GALV. *abbr.*. Galvanized.

gauge The thickness measure of sheet metal.

geo-technical engineer An engineer who specializes in the behavior of soils that support building foundations.

grade The ground level around a building.

grout A mixture of cement, sand, and water that is placed in masonry with reinforcing steel rods to improve the earthquake resistance of masonry walls.

hold-down anchor A pre-manufactured sheet metal connector.

HORIZ. *abbr..* Horizontal.

horizontal forces The forces caused by the side-to-side swaying of buildings during earthquakes.

inertia The tendency of a part of a structure to remain at rest and not be accelerated by earthquake motions.

infill walls The walls built into the rectangular openings formed by the columns and girders of a concrete or steel frame.

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

L-angle A steel angle. The length will normally vary depending on framing and loading conditions. e.g. *L3x3x1/4x(length) is a steel angle with each leg 3 inches long, made of 1/4 inch thick steel.*

lag bolt A large pointed screw installed into wood by turning with a wrench. This type of bolt requires a drilled pilot hole.

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

live load The non-permanent load to which a structure is subjected to in addition to its own weight. e.g. weight of persons occupying the building, free standing materials, partitions, including the building's equipment, machines, etc.

MANUF. *abbr..* Manufacturer.

MAX. *abbr..* Maximum.

M.B. *abbr..* Machine bolt.

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

nails Steel connecting devices for wood members. There are many types of nails sharing the same nominal size (8d, 10d, 16d)- the main difference represented in the diameter of the shank.

non-structural elements The elements of a building that are not a part of the structural frame, walls, floors, or roof.

N.P.T. A connection between a fixture housing and an electrical conduit.

O.C. *abbr..* On center.

parapet That part of a wall which extends above the roof.

partitions Nonstructural walls within a building.

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

PL. *abbr..* Plate.

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

REQ'D. *abbr.*. Required.

running bond A pattern of masonry wall construction where the long face side of the masonry is visible, and the vertical joints are staggered.

screen tubes A tube constructed of screen mesh, normally used when installing epoxy anchors in masonry.

seismic Related to earthquakes.

seismic/hurricane tie A pre-manufactured sheet metal connector.

sheathing Individual boards or plywood panels covering a wall, floor, or roof.

spall To break off a piece of concrete or masonry. Often due to rust on the enclosed reinforcing steel bar or steel structural member, or the freezing of water trapped in cracks.

stack bond A pattern of masonry wall construction where the long face side of the masonry is visible, and the vertical joints are in line.

X-bracing Round steel rods that extend diagonally between rectangular structural elements to brace the structure for earthquake forces.

strap tie Long thin metal plate to connect two elements.

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

tension tie A pre-manufactured sheet metal connector.

terra cotta A fired clay cladding and ornamental material often used on the exteriors of old buildings.

threaded rod Steel rod with threads over its entire length.

thru bolt A bolt passing through a member with both the head and nut exposed.

TYP. *abbr.*. Typical.

unreinforced masonry Brick or hollow concrete block without reinforcing steel.

URM. *abbr.*. Unreinforced masonry

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

VERT. *abbr.*. Vertical.

W/ *abbr.*. With.

wythe The width of one brick in the thickness of a masonry wall.

APPENDIX C

Index of Figures

APPENDIX D

Product Manufacturers and Suppliers

CONCRETE PRODUCTS AND GROUT:

1 A. J. Dean & Sons Ready Mix Concrete Co.
6695 S Wasatch Blvd.
Salt Lake City, UT

2. Geneva Rock Products
748 W 300 S
Salt Lake City, UT

3. Monroc Inc.
1730 N Beck
Salt Lake City, UT

EPOXY ADHESIVES AND SCREEN TUBES:

1. Epcon System- I.T.W. Ramset/Red Head
Wood Dale, IL
800-227-1823

Local Supplier:
Utah Fasteners
3345 S 300 West
Salt Lake City, UT

2. Hilti
   Tulsa OK.
   800-879-8000

   Local Supplier:
   Hilti
   2150 S 300 W
   Salt Lake City, UT.

3. Anchor-It Fastening Systems- Adhesive Technology Corp.
   Kent, WA.
   206-850-2400

   Local Supplier:
   Fastener Engineering & Sales Corp.
   185 W 1700 S
   Salt Lake City, UT.

METAL STUDS:

1. Capitol Building Materials & Tool Supply
   2922 S 300 W
   Salt Lake City, UT.

2. Pacific Supply
   2114 S 400 W
   Salt Lake City, UT.

3. Swanson Building Materials Inc.
   525 W 2890 S
   Salt Lake City, UT

MISCELLANEOUS HARDWARE:

Clear polyester film, bolts, bungee cords, door latches, expansion bolts, foam/rubber padding, flexible gas lines, hook & loop material, lumber, metal conduit and straps, nails, Plexiglas, plywood)

1. Anderson Lumber
   1333 W 9000 S
   West Jordan, UT.

2. Economy Builders Supply
   9150 S 300 W
   Sandy, UT.

3. Standard Builders Supply
   220 W 2700 S
   South Salt Lake, UT.

PRE-MANUFACTURED SHEET METAL CONNECTORS:

Includes: *Framing anchors, foundation anchors, floor tie anchors, foundation joist anchors, hold downs, hurricane/seismic anchors, post caps, strap ties, tension ties.*

1. Simpson Strong-Tie Connectors
San Leandro, CA
800-999-5099

Local Suppliers:

A & T Bolt & Anchoring Systems
379 W 6500 S.
Salt Lake City, UT.

Anderson Lumber
1333 W 9000 S
West Jordan, UT

Standard Building Supply
220 W 2700 S
South Salt Lake, UT

2. Silver Wood Connectors
Livermore, CA
800-972-5295

Local Suppliers:

Economy Builders Supply
9150 S 300 W
Sandy, UT.

Home Base
5585 S Redwood Rd.
Salt Lake City, UT.

SHEET METAL:

Includes:
Continuous bent plates, custom sheet metal straps.

1. Carver Sheet Metal Works
1349 S Jefferson
Salt Lake City, UT.

2. Nielco Inc.
5780 S 300 W
Murray, UT.

3. Western Sheet Metal Inc.
3919 W 1820 S
Salt Lake City, UT.

STRUCTURAL STEEL:

Includes:
Anchor bolts, steel angles, steel pipes, steel tubes, welded wire fabric.

1. D & H Steel
   575 W 3615 S
   Salt Lake City, UT.

2. Mark Steel
   1230 W 200 S
   Salt Lake City, UT.

3. Masco
   462 S 675 W
   Centerville, UT.