MCPOLIN BARN – STRUCTRUAL STUDY

PROJECT #14359

July 1, 2014

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structural

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1.1 PROJECT SCOPE AND OBJECTIVES

At the request of Park City, BHB Consulting Engineers PC (BHB) conducted an evaluation of the McPolin Barn in an effort to determine the building's ability to withstand the effects of a wind storm, earthquake or heavy snow storm.

McPolin Barn is an historic building and was listed as such on the National Register of Historic Places in 2003. It is a recognizable place and significant to the city of Park City.

The objectives of this evaluation are as follows:

- Assess the condition of the building under current design loads and use.
- Identify areas of concern.
- Provide reasonable options to upgrade the building for different usage.
- Identify the best upgrade solution and usage with the city.

The structural deficiencies and retrofit recommendations contained in this evaluation are based on a "Life Safety" level of analysis as defined by the code ASCE 31-03: Seismic Evaluation of Existing Buildings.

1.2 EXECUTIVE SUMMARY

At the request of the city of Park City BHB Consulting Engineers PC (BHB) conducted an evaluation of the McPolin Barn in an effort to determine the building's ability to withstand code gravity, wind, snow, and seismic forces. BHB also investigated the possibility of removing cross bracing that was installed in the early 1990's. This cross bracing severely impeded accessibility of the building.

The McPolin Barn is in relatively good condition considering the age of the building. There are several issues with the building as described in this report. The deficiencies in the McPolin Barn are consistent with similar buildings of the same age. Many of these issues are exasperated by the location's high snow and seismic loads.

The existing structure is currently inadequate to resist snow loads, wind loads and high seismic loads required by local building codes. We recommend that the building be retrofitted with new braced frames to resist the required lateral loads. These frames could be shaped in a way to minimize the impact on the barn and historic nature of the building. Refer to B/S-301 Appendix. We also recommend that portions of the east and west walls be sheathed to create shear walls.

There are several structural deficiencies with the general framing of the building that should be repaired. The connection of the floor beams to the exterior wood post needs to be strengthened. The gable walls need to be stiffened, and the floor framing at the stairs needs to be strengthened.

Under design snow loads, the roof structure is highly over stressed. The city has the option of not using the building during the winter months or reinforcing the roof. The roof can be reinforced by adding trusses to the center of the building next to each roof joist and bracing the outside joists. The main timbers would also need some minor bracing. Refer to structural drawing in the Appendix.

The additions to the original building are framed with unreinforced masonry walls (URM). These walls present a hazard in an earthquake due to their relatively high weight and potential to tear away from the roof in an earthquake. The connections between these walls and the roof trusses should be retrofitted.

The retrofit of this building is voluntary, which allows many different options for partial upgrades for various uses of the building. A prioritized list is provided for various options. The building would not be considered to meet an ASCE31 Life Safety performance level until all recommended retrofits have been installed.

The retrofit options have been outlined in the report and appendices. These documents may be used for pricing of these options. These documents are intended to assist the city in choosing an acceptable retrofit for the building, consistent with the building uses.

2.1 BUILDING HISTORY

The original portion of McPolin Barn was constructed in 1921. Some of the wood timbers may have been reused from local mines. Many of the connections used are similar to those used in the mining industry. The building's primary function was housing and milking cows on the first floor. The second floor is a large hay loft.

An addition to the west face was made in 1954. It is a single story addition with a crawl space. The floor is a couple of feet lower than the main barn. A milking parlor was added to the north around the same time period. It also has a one story wing.

Currently the building is not in use. The building is closed to the public. The original use of the building was agriculture. This report considered the building as a risk category I building per IBC and ASCE 7. Risk category I structures are, "Buildings that represent a low risk to human life in the event of a failure". Changes in the use of the building could change this categorization and therefore require additional analysis.

2.2 PHYSICAL CHARACTERISTICS

Gravity Systems

The main building is framed with wood timbers and framing. The first floor consists of 2 x 12 framing at 16"o.c. supported by large timbers. The roof is framed like many barns of the era with gambrel shaped, heavy timber frames at ten feet on center. These frames support wood timbers and 2 x 6 roof purlins at 24" o.c. The wall of the building are framed with 4 x 6 timber girts laid flat at approximately 4'-0"o.c. The 1 x 12 wood planks run vertically between these girts to close off the spaces.

The west 1954 addition has a wood roof with stick framed wood trusses at 24" o.c. The wall structure was not visible at the time of the report, but the National Register documents state that these are block walls.

The milking parlor addition has a gambrel shaped roof framed with 2 x 6 members at 24" o.c. This rests on CMU block walls. The floor framing was concealed at the time of this report. It appears to be framed with wood joists

Lateral (wind and seismic) Systems

The barn does not have a dedicated system to resist earthquakes or wind loads. Instead the wood frames have performed both functions of resisting the lateral and gravity loads. The exterior wood planks have also helped stiffen the structure. This system is woefully inadequate. Consequently, diagonal steel cables where added in the 90's to resist lateral loads.

At the newer additions, unreinforced masonry walls (URM) walls provide stuffiness. However, the stiffness provided by the URM walls can be a hazard under cyclic earthquake forces. This is due to the fact that the URM walls are not very ductile and are susceptible to cracking. Additionally, the high weight of the walls increases the seismic forces experienced by the structure. The biggest threat is the potential for the wall to pull away from the roof, resulting in a total collapse.

Soils and Geotechnical

The original footings of the building appear to be a stone foundation. Per the National Register report, it is classified as sandstone. The newer building has a concrete foundation. Little is known of the soil around the building at this time. There are no reports of settlement of the footing that we are aware of at this time. For the seismic assessment we have assumed Site Class D. Soil Site Class D includes relatively stiff soils with a shear wave velocity between 600 and 1200 feet per second, a standard penetration resistance from 15 to 50 blows per foot, and un-drained shear strengths between 1000 and 2000 psf. Soil Site Class D is specified by the IBC to be used as the default soil site class for seismic design in the absence of specific geotechnical data for a given site.

2.3 BUILDING SETTING

McPolin Barn is located in Summit County at an elevation of 6700 ft. The design snow load at this location and elevation is very high. Also the building is classified as an unheated structure per ASCE 07. This results in a 20% increase in the snow load. The resulting snow load in this area is 92psf. This is three times higher than normal structures located in Salt Lake Valley.

McPolin Barn is in proximity to the predicted locations of the Wasatch Fault (See Figure 1). It is about 15 miles from the nearest fault. The Wasatch Fault is a known geologically active, normal fault that trends in a North-South direction along the base of the Wasatch mountains extending from Malad City, Idaho to Fayette, Utah. It is believed that the fault is capable of delivering an earthquake of a Richter magnitude up to 7.5. Earthquakes of this magnitude are capable of causing catastrophic damage to building structures

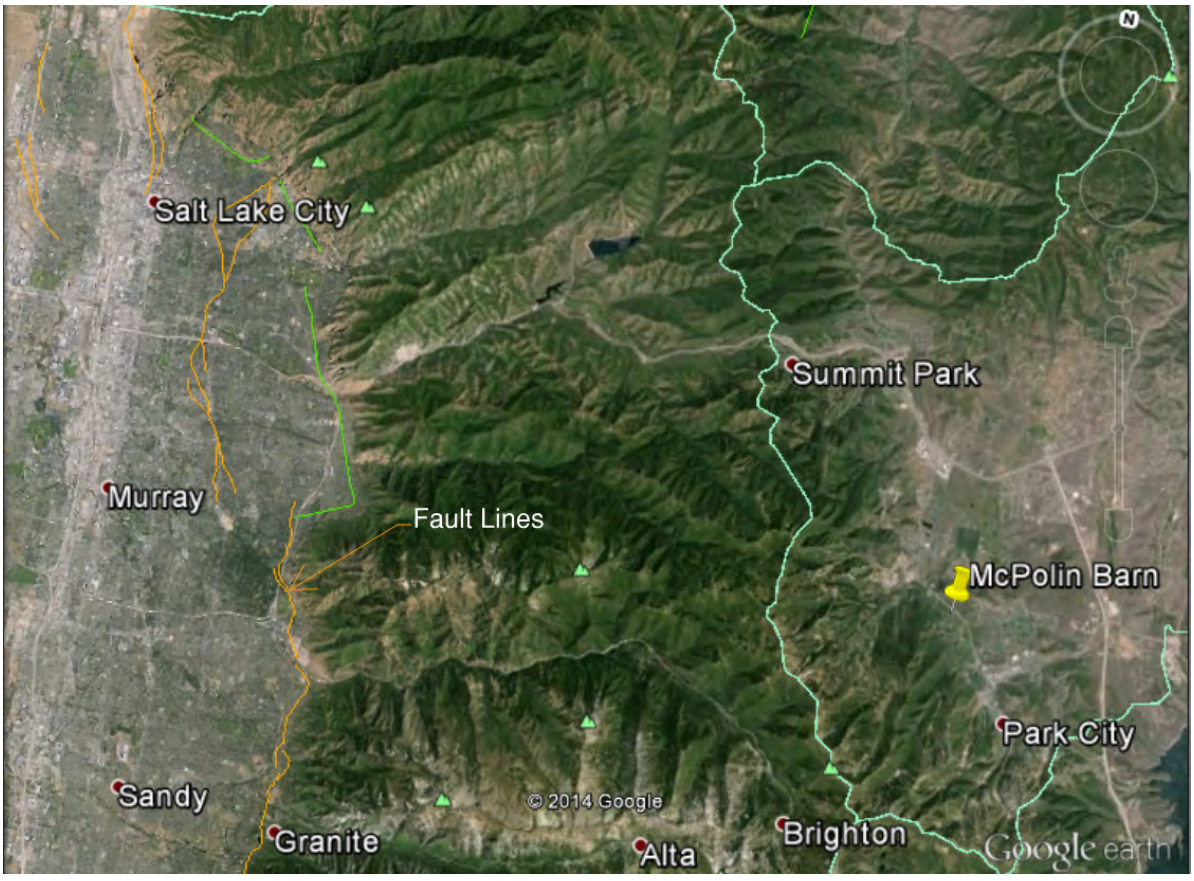


Figure 1. Proximity of the Barn to Active Faults

The average recurrence interval for earthquakes along the Wasatch Fault is estimated to be about every 1200 to 2600 years over the entire length of the fault, and 350 years in any one of its six active segments (See Figure 2).

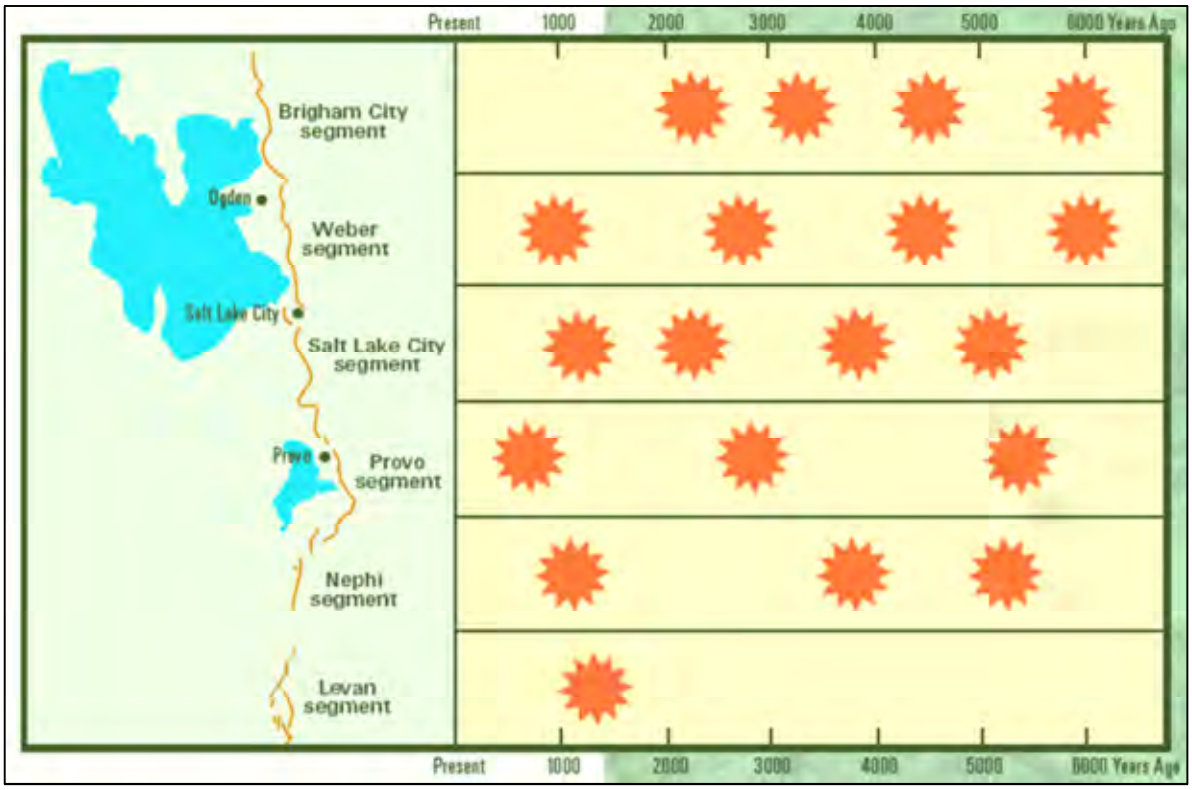


Figure 2. Earthquakes Along the Wasatch Fault. (image from Utah Geologic Survey)

According to geological studies of the Wasatch fault, the last major earthquake on the Salt Lake City segment of the Wasatch fault was approximately 1300 years ago. The last large earthquake in any segment of the Wasatch fault was approximately 400 to 600 years ago. From the data available, the Brigham City and the Salt Lake City fault segments appear likely to be next in line for a large earthquake.

3.1 ANALYSIS

Codes

The building has been analyzed per ASCE 07-10 for snow and wind loads. The original use of the building was agriculture. This report considers the building as a risk category I building per IBC and ASCE 7. Risk Category I structures are, "Buildings that represent a low risk to human life in the event of a failure". Changes in the use of the building could change this categorization and therefore require additional analysis.

ASCE 31-03 was used as the template for the seismic portion of the evaluation of the McPolin Barn. The retrofit recommendations contained in this report are based on code requirements found in the 20012 International Building Code (IBC 20012).

ACSE 07 Evaluation

During our visit to the site, building member sizes and location where established. These are based on visual observation. Available reports, including the National Register report, were also used.

The building was then analyzed using basic engineering principles. The main barn was modeled in three dimensions. It was then analyzed under wind, snow and gravity forces. Areas and components of the structure that are non-compliant with minimum code provisions were identified.

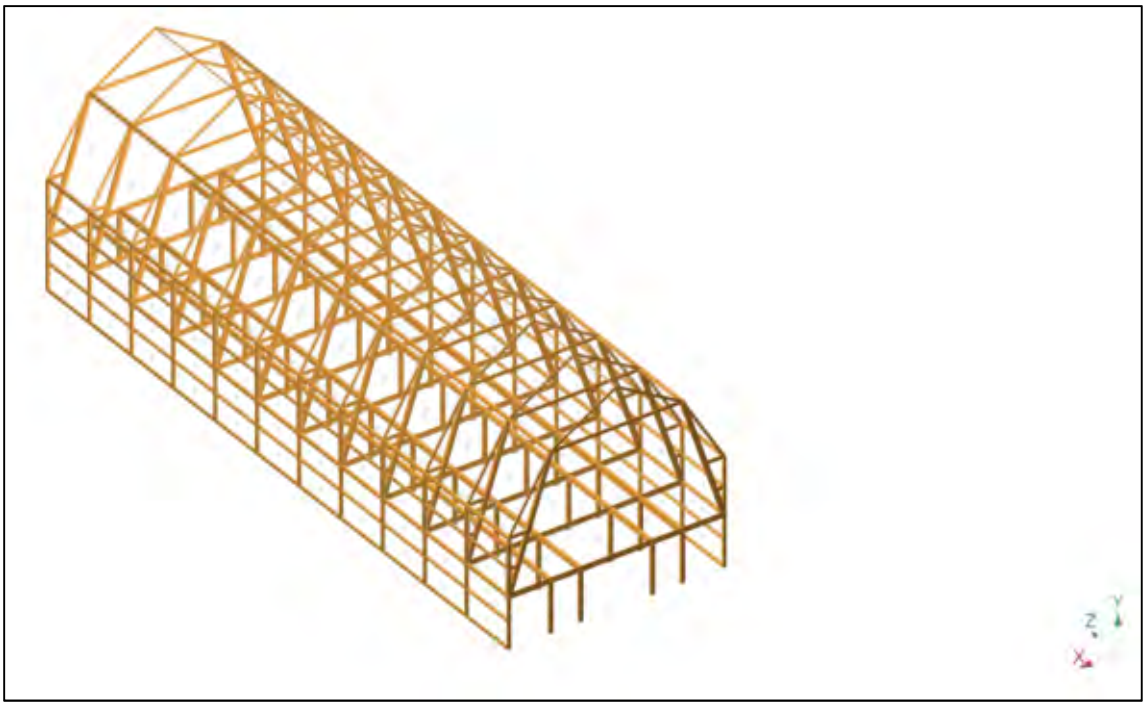


Figure 4. Computer Model of the "as-is" Barn Structure

Seismic Evaluation

A building seismic evaluation typically begins with an ASCE 31-03 Tier 1 evaluation. The Tier 1 evaluation consists of a series of checklists that are meant to quickly document potential building seismic deficiencies. The checklists are typically filled out during one, or possibly multiple, visits to the site. The checklists are general in nature and meant to quickly identify deficiencies common for the building type being investigated

Each Tier 1 checklist identifies building components as either "Compliant", "Non-Compliant", or "Not Applicable". A Tier 1 investigation also determines if non-compliant deficiencies should be retrofitted, or if further investigation is required. If further investigation is required and/or desired, more in depth Tier 2 and Tier 3 investigations can be carried out under ASCE 31-03.

Tier 2 is often called the evaluation phase. A Tier 2 evaluation uses a standard linear analysis to determine the seismic loading on the existing structure. This evaluation is similar to the analysis used in the current code for new buildings.

Tier 3 is often called a detailed evaluation phase. A Tier 3 evaluation uses a non-linear analysis to consider the initial strength plus the residual member strength developed after initial failure, but prior to its complete collapse.

The main objective in performing a Tier 2 and Tier 3 analysis is to discover if a more in-depth analysis will reclassify non-compliant building components as compliant. In short, the goal of a Tier 2 and Tier 3 analysis is to save construction costs by more accurately identifying building components that do not need to be retrofitted. For this reason, our seismic evaluation was limited to a Tier 1 evaluation. A Tier 2 and Tier 3 analysis are usually not performed until the owner is ready to seismically retrofit the building and develop a full seismic upgrade design with construction documents.

The evaluation of McPolin Barn was done using the Tier 1 approach per ASCE 31-03 as previously described. Use of the Tier 1 checklists allows the reviewer to quickly identify most areas and components of the structure that are non-compliant with minimum code provisions. However, for some checklist items, further Tier 2 analysis is required as part of the initial screening process to determine whether the item is seismically compliant or non-compliant. After the initial screening, non-compliant items are identified as areas of concern and a course of action is identified to bring the building into compliance for the selected performance level. The completed Tier 1 checklist for McPolin Barn is shown in Appendix 5.1.

Based on the type of construction and the significant number of structural deficiencies in the barn's structural system, it is our opinion that a Tier 2 analysis would only confirm our findings from the Tier 1 evaluation. Our proposed retrofit solutions are provided per the design requirements of the IBC 2012 building code.

Building Uses

A building's desired use and seismic performance level during an earthquake must be identified in order to determine recommended retrofits for building deficiencies. The building is currently not in use. Park City has indicated various future uses for the building, varying from small tours to use as office space. The use of the building will have significant effects on the level of retrofit selected. There are three retrofit options available: Dangerous Building Use, Code Level Upgrade, and Full Upgrade. The three retrofit options are described below.

Dangerous Building Use

The building is occupied as a dangerous historic building by small groups less than 50 people. The building is not occupied when snow is present on the roof. This allows tours during the summer months. Seismic upgrade is taken to a collapse prevention level.

Code Level Upgrade

The building is occupied with less than 50 people. The building would be available year round. Mechanical and electrical system would not be added. Seismic upgrade is taken to a life safety level.

Full Upgrade

The building is occupied with less than 300 people. Building is fully upgraded including mechanical and electrical systems. Seismic upgrade is taken to a life safety level or higher if desired.

Seismic Performance Levels

Seismic performance levels generally define the expected damage to a structure following a seismic event. Performance levels also help clarify the building's expected utility after an earthquake. The performance objective is determined by the building owner and the design professionals in accordance with performance levels specified in the building code. The building code defines these performance levels as follows:

Operational Level:

Very little damage present following the earthquake. Backup utility services maintain function.

Immediate Occupancy Level:

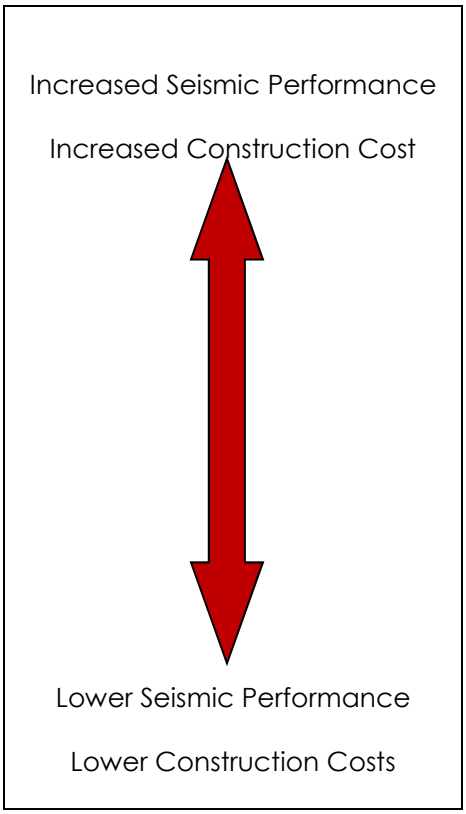
The building remains safe to occupy. Needed structural repairs are usually minor.

Life Safety Level:

Structure remains stable and has significant reserve capacity. Hazardous non-structural damage is controlled. Life safety of the building occupants is priority.

Collapse Prevention Level:

The building remains standing, but may not be structurally sound. All other damage to the facility is acceptable.



A building designed or retrofitted to an Operational Level would be expected to be fully functional with little to no damage following an earthquake. Meanwhile a building designed to a Collapse Prevention Level would only be expected to be stable enough to allow people to exit during a seismic event. The building may be a complete loss with damage beyond reasonable repair costs.

As may be expected, construction costs increase proportionately with increasing seismicity, and as the desired performance level increases towards the Operational Level. ASCE 31-03 requires most buildings to be evaluated for either Life Safety or Immediate Occupancy. Typical construction cost adjustment factors to go from a Life Safety performance level to an

Immediate Occupancy performance level are shown in Figure 3 below. As stated in section 2.3 of this report, McPolin Barn is located in an area of "High" seismicity.

SEISMICITY/PERFORMANCE COST ADJUSTMENT FACTORS		
SEISMICITY (LOCATION)	**LIFE SAFETY**	**IMMEDIATE OCCUPANCY**
Low	0.52	1.03
Moderate	0.59	1.19
High	0.75	1.43
Very High – University of Utah	1.00	1.76

Figure 3. Cost Factors - Seismicity vs. Performance Level (based on FEMA-156)

While code requires most new structures to be designed to a minimum Life Safety Level, existing structures are often retrofitted voluntarily by their owners and therefore may be retrofitted to any desired performance level. Owners should consider many factors when deciding what performance level they would like to achieve. These factors often include cost, expected life of building, current and future uses, etc.

Demand Criteria

Once the desired building performance level is determined, it is necessary to define the seismic demand criteria to be used for that performance level. ASCE 31-03 bases seismic demand on a fraction of the Maximum Considered Earthquake (MCE). The MCE is the largest statistically credible earthquake based on current knowledge of the fault line proximity, expected fault movement, estimated return rate, etc. The MCE along the Salt Lake City portion of the Wasatch Fault has been estimated to be up to a Richter magnitude 7.5. ASCE 31-03 states the seismic force for a Tier 1, Life Safety performance level evaluations should be no less than two-thirds (67%) of the force associated with the MCE. This force level is similar to what is required for new structures designed to the same criteria.

Building Type and Typical Seismic Behavior

McPolin Barn is classified by ASCE 31-03 as a Building Type W2: Wood Frames, Commercial and Industrial. These structures rely on wood diaphragms and exterior wood walls sheathed with strait sheathing. The large timber trusses have contributed to the lateral resisting system regardless of the original design intent. The barn has been modified from its original system to include diagonal cables to resist lateral loads.

The additions to the barn are classified by ASCE 31-03 as building Type URM: Unreinforced masonry bearing walls with flexible diaphragms: These structures rely on the unreinforced masonry to restrain the building during an earthquake. Building codes typically did not recognize the need for seismic design prior to the San Fernando Earthquake in 1973. Because of the age of the structure, it is unlikely that seismic loading was considered in the design. Although the masonry walls were not designed as shear walls, due to the nature and rigidity of the masonry, these walls will receive seismic shear and function as shear walls.

3.2 STRUCTURAL DEFICIENCIES

ASCE-07 DEFICIENCIES

Structural deficiencies under gravity, snow and wind / lateral loads per ASCE-07 Minimum Design Loads for Buildings and other Structures include:

1. Gravity Loads
    a. The beam to column connections at the exterior wall does not have adequate transfer of load from beam to column.

Figure 4. Column to bean connection

    b. There is a column in the south west of the building that has been modified and does not appear to be installed properly.

Figure 5. Modified Column

c. The floor framing at the stair opening is overstressed.

2. Snow Loads
   a. Roof joists are over stressed between 120% and 500% under design snow loads.
   b. The 6 X 6 roof beam is stressed at 300% under design snow loads.
   c. The diagonal 6 x 10 timber is not braced adequately to withstand design snow loads.

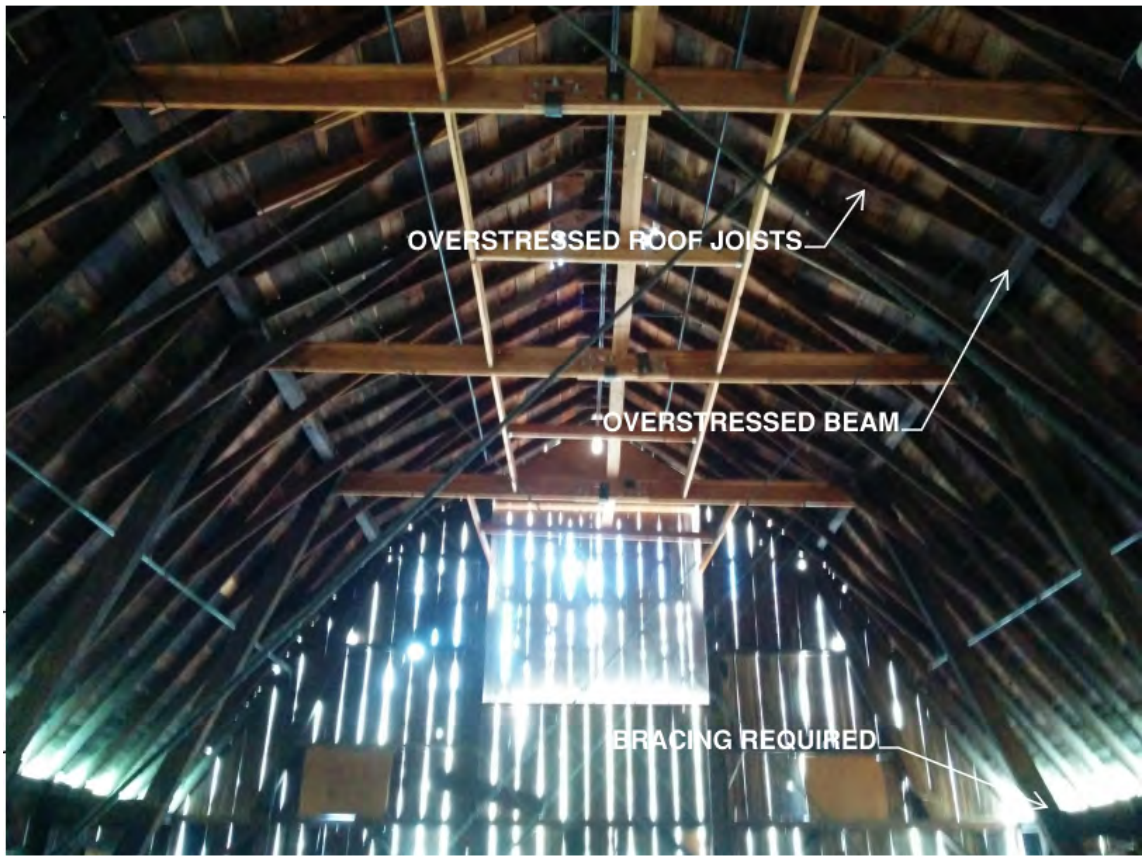


Figure 6. Roof Framing

3. Lateral Loads
    a. Without the diagonal tie rods, the main timbers are stressed above 300%.
    b. The east and west wall 1 x 12 straight sheathing is not adequate to resist wind loads as a shear wall.
    c. The floor 1 x 12 straight sheathing is not adequate to resist wind loads in the floor diaphragm.
    d. The gable end walls are too tall and slender for wind forces.

ASCE 31 SEISIMIC DEFICIENCIES

Structural deficiencies are determined using the ASCE 31-03 Tier 1 checklists. The ASCE-31-03 checklists used for the Biology Building include:

1. 3.7.2 - *Basic Structural Checklist for Building Type W2: Wood Frames, Commercial and Industrial*

2. 3.7.2S - *Supplementary Structural Checklist for Building Type W2: Wood Frames, Commercial and Industrial*

3. 3.7.15 Basic Structural Checklist for Building Type URM: Unreinforced Masonry Bearing Walls with Flexible Diaphragms

4. 3.7.15S Supplemental Structural Checklist for Building Type URM: Unreinforced Masonry Bearing Walls with Flexible Diaphragms

5. 3.8 - *Geological Site Hazards and Foundation Checklist.*

6. 3.9.1 - *Basic Nonstructural Component Checklist.*

7. 3.9.2 – Intermediate Nonstructural Component Checklist

Non-Compliant Items

The structural items found to be Non-Compliant are listed below.

Main Building

1. Lateral Force Resisting System:

   a. SHEAR STRESS CHECK: The shear stress in the shear walls, calculated using the Quick Check procedure of Section 3.5.3.3, shall be less than the following values for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.7.1): Straight sheathing 100 plf

      The east and west wall of the building do not have adequate shear capacity.

   b. WALLS CONNECTED THROUGH FLOORS: Shear walls shall have interconnection between stories to transfer overturning and shear forces through the floor. (Tier 2: Sec. 4.4.2.7.5)

      Walls above and below the floor need to be properly attached to each other.

2. Connections:

   a. WOOD POSTS There shall be a positive connection of wood posts to the foundation. (Tier 2: Sec. 4.6.3.3)

   b. WOOD SILLS: All wood sills shall be bolted to the foundation. (Tier 2: Sec. 4.6.3.4)

c. GIRDER/COLUMN CONNECTION: There shall be a positive connection utilizing plates, connection hardware, or straps between the girder and the column support. (Tier 2: Sec. 4.6.4.1)

Building Additions

1. Building System:

   a. ADJACENT BUILDINGS: The clear distance between the building being evaluated and any adjacent building shall be greater than 4 percent of the height of the shorter building for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.1.2)

   b. MASONRY UNITS: There shall be no visible deterioration of masonry units. (Tier 2: Sec. 4.3.3.7)

2. Connections:

   a. WALL ANCHORAGE: Exterior concrete or masonry walls that are dependent on the diaphragm for lateral support shall be anchored for out-of-plane forces at each diaphragm level with steel anchors, reinforcing dowels, or straps that are developed into the diaphragm. Connections shall have adequate strength to resist the connection force calculated in the Quick Check procedure of Section 3.5.3.7. (Tier 2: Sec. 4.6.1.1)

   b. WOOD LEDGERS: The connection between the wall panels and the diaphragm shall not induce cross-grain bending or tension in the wood ledger. (Tier 2: Sec. 4.6.1.2)

   c. TRANSFER TO SHEAR WALLS: Diaphragms shall be connected for transfer of loads to the shear walls for Life Safety and the connections shall be able to develop the lesser of the shear strength of the walls or diaphragms for Immediate Occupancy. (Tier 2: Sec. 4.6.2.1)

   d. GIRDER/COLUMN CONNECTION: There shall be a positive connection utilizing plates, connection hardware, or straps between the girder and the column support. (Tier2: Sec. 4.6.4.1)

3. Diaphragms

   a. STRAIGHT SHEATHING: All straight sheathed diaphragms shall have aspect ratios less than 2-to-1 for Life Safety and 1-to-1 for Immediate Occupancy in the direction being considered. (Tier 2: Sec. 4.5.2.1)

   b. SPANS: All wood diaphragms with spans greater than 24 feet For Life Safety and 12 feet for Immediate Occupancy shall consist of wood structural panels of diagonal sheathing. (Tier 2: Sec. 4.5.2.2)

3.3 BUILDING UPGRADE RECOMMENDATIONS

Many options are available to address the non-compliant items outlined in Section 3.2. Our team discussed several options with the city. Many of the factors we considered during our discussion included:

- Future building use
- Impacts to the historical nature of the building
- Impacts architectural appearance
- Cost impacts of different retrofit solutions
- Improve the functionality of the building
- Add MEP and other building equipment
- ADA and egress issues

Retrofit solutions deemed to be most in line with the city's stated objectives for the Barn are given below. The retrofit of this building is voluntary, which allows many different options for partial upgrades for various uses of the building. A prioritized list is provided for the various options in sections 3.4.

DEFICIENCIES

Structural deficiencies under gravity, snow and wind loads per ASCE-07 Minimum Design Loads for Buildings and other Structures include:

1. Gravity Loads

   a. The beam to column connections at the exterior wall does not have adequate transfer of load from beam to column.

      An additional 2 x 6 stud can be added to each side of the timber column and nailed properly. This will give the beam something to physically bear on. Lag screws can be added to create a positive connection. Refer to detail 1 in Appendix.

   b. There is a column in the south west of the building that has been modified and does not appear to have been replaced properly.

      The column can be paced back in its original location or a footing could be added and the beam to column connection could be upgraded.

   c. The floor framing at the stair opening is overstressed.

      Additional framing can be added to the opening to reinforce the joists.

   d. Deteriorated masonry / wood

      Deteriorated masonry and wood should be repaired.

e. The exterior 6x6 floor beam is overstressed. The remaining floor framing is adequate for 70 psf.

The beam should be reinforced by adding (2) 2x6 to the bottom of the wood beam.

2. Snow Loads

a. Roof joists are over stressed between 120% and 500% under design snow loads

New prefabricated wood trusses can be added adjacent to each existing roof truss. These would need to be added in the middle bay. The steeper joist on either side can be reinforced by adding a single vertical 2x member at each joist. Refer to A/S-301 in appendix.

b. The 6X6 roof beam is stressed at 300% under design snow loads.

Provide (3) 2 x 6 studs to the bottom of the beam and a 2 x12 to the side. This will reinforce the beam adequately. Refer to S-121 in appendix.

c. The diagonal 6 x 10 timber is not braced adequately to withstand design snow loads

Provide (3) continuous 2 x 6 studs to connect the timbers together. Diagonal members would then brace back to the exterior wall in a few locations. Refer to A/S-301 in appendix. Refer to A/S-301 in appendix.

3. Lateral Loads

a. Without the diagonal tie rods the main timbers are stressed above 300%.
With the existing tie rods the collar ties are overstressed.

Add new steel brace frames at 3 locations in the historic barn. This will allow for the removal of the cable braces. The brace frame would be shaped similar to the existing timber frame. A nailer would be added to the top and the roof diaphragm would be nailed to the frame. On the lower floor a diagonal brace would be added. The frame would be anchored with micro piles and concrete pile cap. The frame could be wrapped in wood to minimize the visual impacts. Refer to structural plans and section B/S-301

b. The east and west wall 1 x12 straight sheathing is not adequate to resist wind loads as a shear wall.

At the east and west walls a section of the wall would need to be upgraded as a shear wall. The existing frame should be infilled with 2 x 6 studs at 24" o.c. The wall would then be sheathed with 7/16" sheathing. The sheathing can be placed on the inside face of the wall. Another option is to remove the exterior 1x lumber and sheath the exterior face off the wall. The exterior 1x lumber could then be reinstalled over the sheathing. Refer to detail 2-5 in appendix.

c. The floor 1 x 12 straight sheathing is not adequate to resist wind loads in the floor diaphragm.

The floor should be overlaid with wood sheathing to strengthen the floor diaphragm. Drag beams need to be added at the new brace frame location to transfer the forces adequately to and from the diaphragm.

d. The gable end walls are too tall and slender for wind forces.

A large wood timber girt should be added at third points of the wall to stiffen it under wind loads. This member needs to be connected to both the floor and the roof.

4. Seismic Loads

a. Unreinforced masonry walls are not properly connected to the roof/ floor diaphragm. The walls should be bolted to the roof/ floor structure. Refer to details 6 -8 in the appendix

b. Beam, girder and truss supports are not positively connected

Column / beam joints should be connected with steel plates/ bolts to prevent slip in an earthquake.

3.4 PRIORITIZED BUILDING RETROFITS OF DIFFERENT USES

The upgrade of McPolin Barn is voluntary and dependent on the buildings use. Often building upgrades cannot be accomplished all at once due to budget limitations, personnel management and relocation issues, construction schedules, or other factors. For this reason we have offered this prioritized list for retrofit. It should be noted, however that all retrofit measures contribute to the overall safety of the building. For this reason the building cannot be considered to meet an ASCE31 Life Safety performance level until all recommended retrofits have been installed.

For the various uses described in 3.1 the deficiencies listed below should be retrofitted.

No Changes

Building should not be occupied when winds over 40mpf are expected. Building should not be occupied when there is snow on the roof.

Dangerous Building Use

Building is occupied as a dangerous historic building by small groups less than 50 people. The building is not occupied when snow is present on the roof. This allows tours during the summer months. Seismic upgrade is taken to a collapse prevention level

Minimum Retrofits

- Gravity load retrofit of deficiency 1a through 1d completed.
- Cable bracing removed.
- Lateral load retrofit of deficiency 3a through 3d completed.
- Unreinforced masonry wall to floor/ roof diaphragm connection. Retrofit of deficiency 4a completed.

Code Level Upgrade

The building is occupied with less than 50 people. The building would be available year round. Mechanical and electrical system would not be added. Seismic upgrade is taken to a life safety level

Minimum Retrofits

- Roof reinforced for snow loads. Retrofit of deficiency 2 completed.
- Gravity load retrofit of deficiency 1a through 1d completed.
- Cable bracing removed.
- Lateral load retrofit of deficiency 3a through 3d completed.
- Unreinforced masonry wall to floor/ roof diaphragm connection. Retrofit of deficiency 4a completed.

- Unreinforced masonry wall to floor/ roof diaphragm connection completed.
- Beam to column connections upgraded.

Full Upgrade

The building is occupied with less than 300 people. Building is fully upgraded including mechanical and electrical systems. Seismic upgrade is taken to a life safety level or higher if desired.

Retrofits

- Interior walls finished and insulated.
- Mechanical and electrical systems installed.
- Roof reinforced for snow loads. Retrofit of deficiency 2 completed.
- Gravity load retrofit of deficiency 1a through 1d completed.
- Cable bracing removed.
- Lateral load retrofit of deficiency 3a through 3d completed.
- Unreinforced masonry wall to floor/ roof diaphragm connection. Retrofit of deficiency 4a completed.
- Unreinforced masonry wall to floor/ roof diaphragm connection completed.
- Beam to column connections upgraded.
- Other upgrade to the seismic system per formed if better performance is requested by the city.

3.5 CONCLUSIONS

At the request of the city of Park City BHB conducted an evaluation of the McPolin Barn in an effort to determine the building's ability to withstand code gravity, wind, and snow forces, along with the effects of an earthquake.

The McPolin Barn is in relatively good condition considering the age of the building; however, the building does contain several liabilities and deficiencies as described in this report. Many of the deficiencies discovered in the McPolin Barn are consistent with similar structures that were constructed during the same time period.

The existing structure is currently inadequate to resist snow loads, wind loads and high seismic loads required by local building codes. The building has cross bracing that was added in the 1990's to stabilize the building. This report provides options that would allow this bracing to be removed. Specifically, we recommend the building's structure be retrofitted with new braced frames. These frames could be shaped in a way to minimize the impact on the look and historic nature of the building. Shear walls should also be added in the north-south direction. Refer to structural drawing in the appendix. Following these recommendations would permit removal of the cable braces.

There are a number of issues with the general framing of the building that should be repaired. The connection of the floor beams to the exterior wood post needs to be strengthened. The gable walls need to be stiffened and the floor framing at the stairs need to be strengthened.

The roof members are highly over stressed under snow loads. This leaves the city with the option of reinforcing the roof or not using the building during the winter months. The roof can be reinforced by adding trusses to the center of the building next to each roof joist and bracing the outside joists. Refer to structural drawing in the appendix. The main timbers would also need some minor bracing.

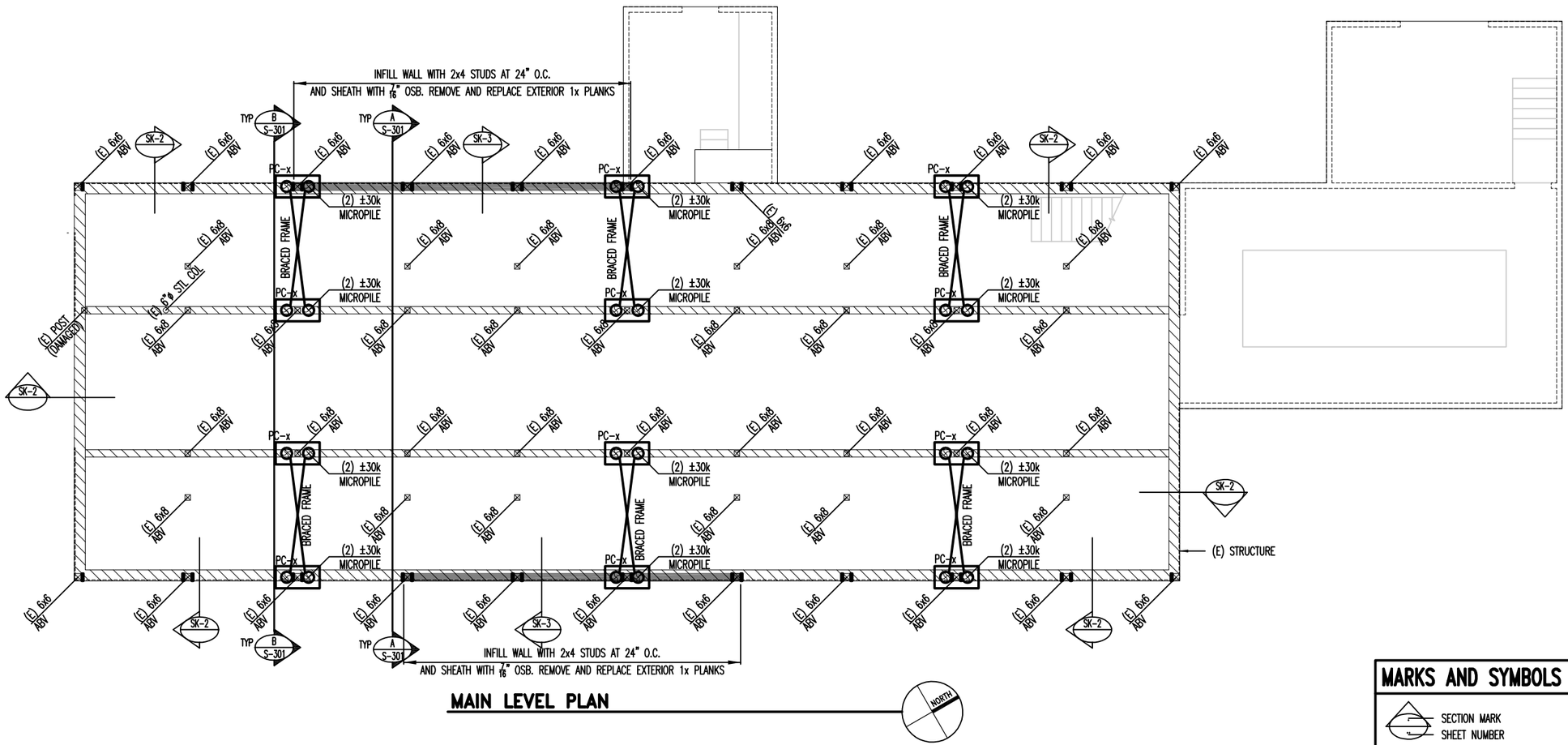
The additions to the original building are framed with URM. These walls present a hazard in an earthquake due to their relatively high weight and potential to tear away from the roof in an earthquake. These walls should be retrofitted to attach properly to the roof trusses.

The retrofit of this building is voluntary. There are many different options for partial upgrades for various uses of the building. A prioritized list is provided within this report for the various options; however, the building would not be considered to meet an ASCE31 Life Safety performance level until all recommended retrofits have been installed.

3.6 LIMITATIONS

This report is to be used for planning purposes for the city of Park City. The evaluation and recommendations presented in this report are limited to structural and seismic issues only. The condition of non-structural components of the building is outside the scope of this evaluation. Although some incidental statements may be included regarding non-structural systems, the focus of the report is on structural issues. No other warranty, either expressed or implied is offered with regard to these services.

Our evaluation is based on visual observations. Assumptions were made in our evaluation when structural conditions could not be verified by visual observations, or by the available documents. Some assumptions include properties of building materials, construction practices, verification of as-built conditions, etc. As a result, the conclusions and recommendations are based upon professional judgment and experience, rather than known conditions. As a result, additional conditions detrimental to the structure may exist which were not visible, not noted in the available documents, or outside the scope of this evaluation.



MAIN LEVEL PLAN

MARKS AND SYMBOLS LEGEND

- SECTION MARK / SHEET NUMBER
- INDICATES EXSITING WALL
- INDICATES WOOD FLOOR SHEATHING OVERLAY, SEE DETAILS.
- INDICATES FLOOR OFFSET, SEE DETAILS.

PLAN NOTES

1. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING CONDITIONS AND DIMENSIONS.

OWNER

PARK CITY CORP.
POB 1480
PARK CITY, UT 84060

MARK	DATE	DESCRIPTION
0	7/3/14	SEISMIC REPORT

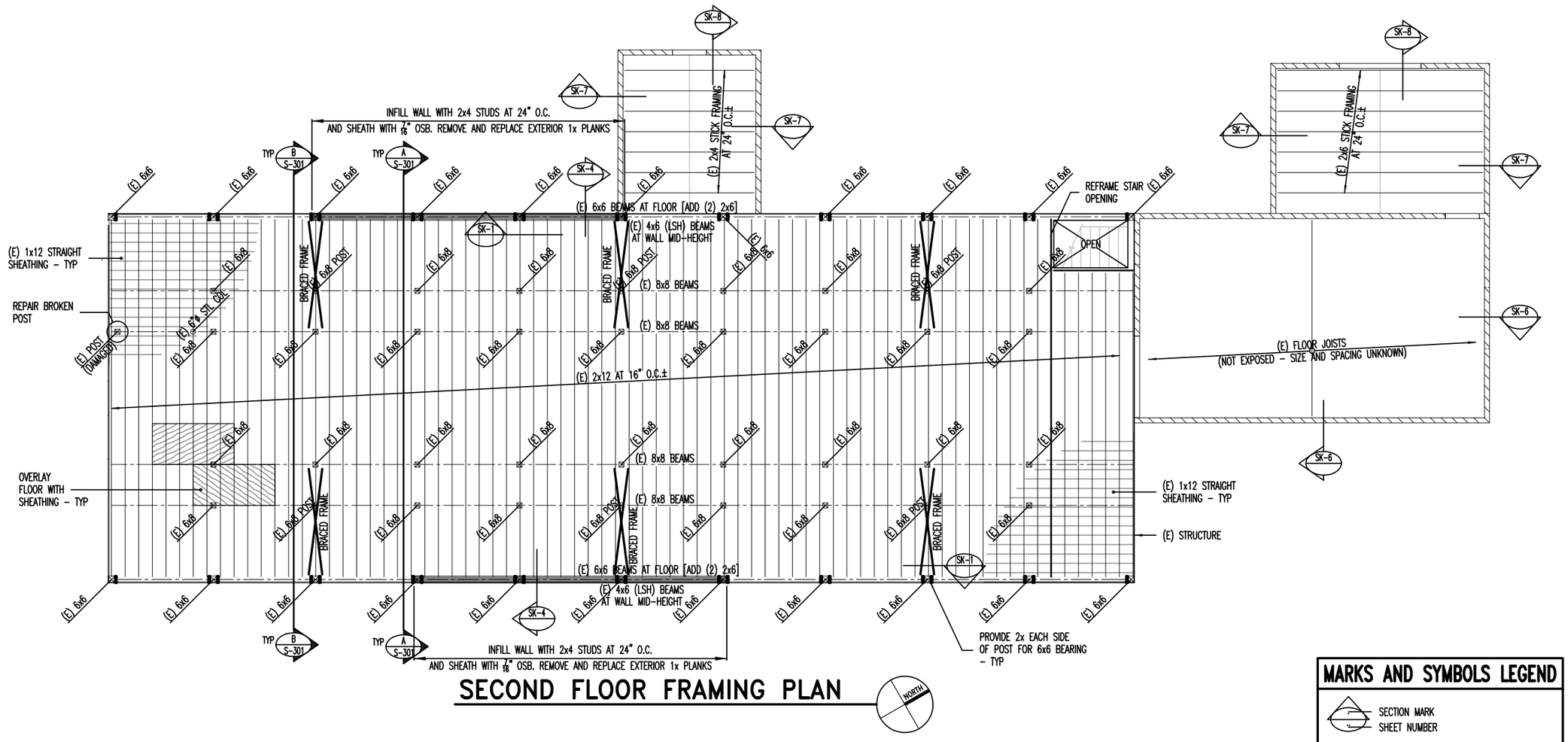
BHB structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224
PARK CITY, UT 84060

PROJECT NO: 14359
DRAWN BY: JBM
CHECKED BY: BKG

SHEET TITLE
MAIN LEVEL PLAN

S-101



SECOND FLOOR FRAMING PLAN

MARKS AND SYMBOLS LEGEND

- SECTION MARK / SHEET NUMBER
- INDICATES EXSITING WALL
- INDICATES WOOD FLOOR SHEATHING OVERLAY, SEE DETAILS.
- INDICATES FLOOR OFFSET, SEE DETAILS.

PLAN NOTES

1. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING CONDITIONS AND DIMENSIONS.

OWNER

PARK CITY CORP.

POB 1480
PARK CITY, UT 84060

MARK	DATE	DESCRIPTION
0	7/3/14	SEISMIC REPORT

BHB structural
2766 S. Main Street
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MCPOLIN/OSGUTHORPE BARN

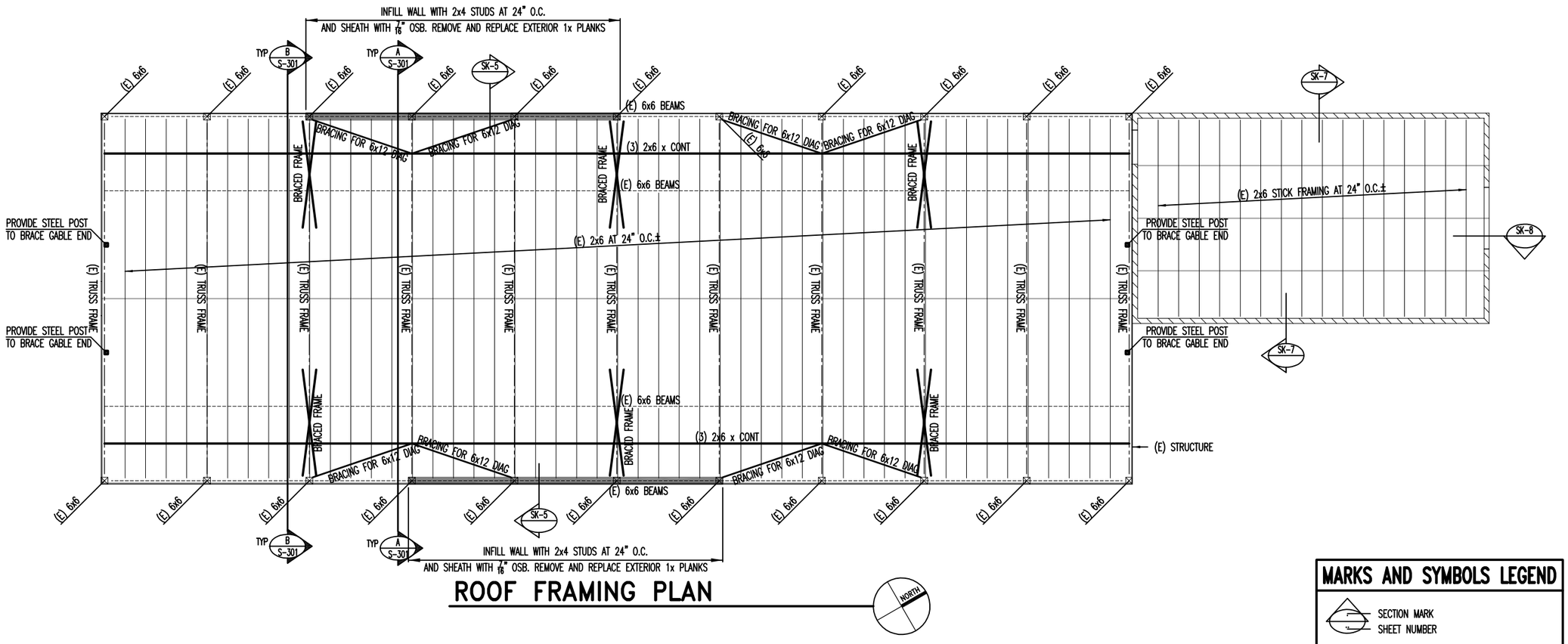
HIGHWAY 224
PARK CITY, UT 84060

PROJECT NO: 14359
DRAWN BY: JBM
CHECKED BY: BKG

SHEET TITLE

LEVEL 2
FRAMING PLAN

S-111



ROOF FRAMING PLAN

NORTH

MARKS AND SYMBOLS LEGEND

- SECTION MARK / SHEET NUMBER
- INDICATES EXSITING WALL
- INDICATES WOOD FLOOR SHEATHING OVERLAY, SEE DETAILS.
- INDICATES FLOOR OFFSET, SEE DETAILS.

PLAN NOTES

1. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING CONDITIONS AND DIMENSIONS.

OWNER

PARK CITY CORP.

POB 1480
PARK CITY, UT 84060

MARK	DATE	DESCRIPTION
0	7/3/14	SEISMIC REPORT

BHB structural
2766 S. Main Street
Salt Lake City, Utah 84115
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bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN

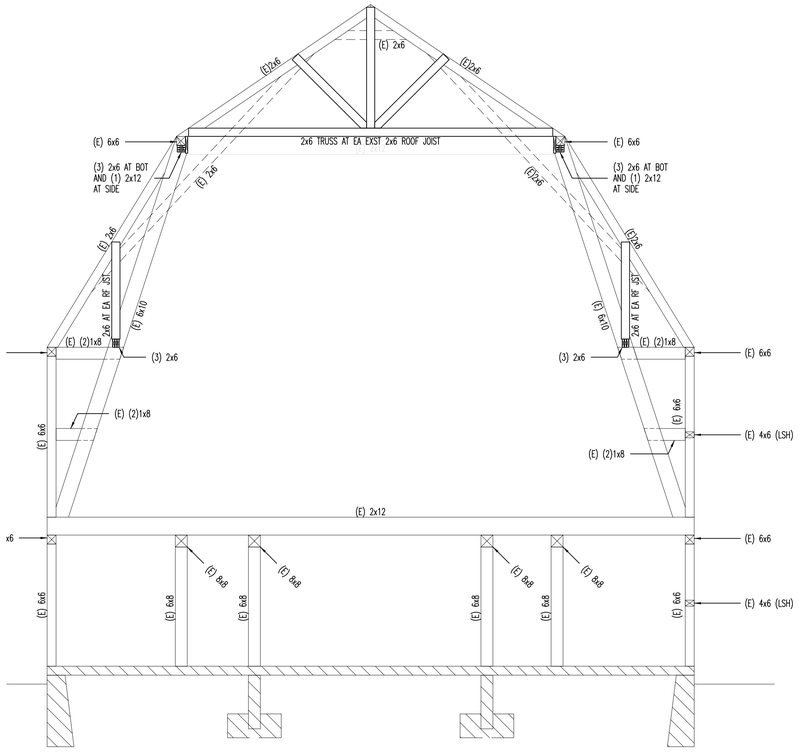
HIGHWAY 224
PARK CITY, UT 84060

PROJECT NO: 14359
DRAWN BY: JBM
CHECKED BY: BKG

SHEET TITLE

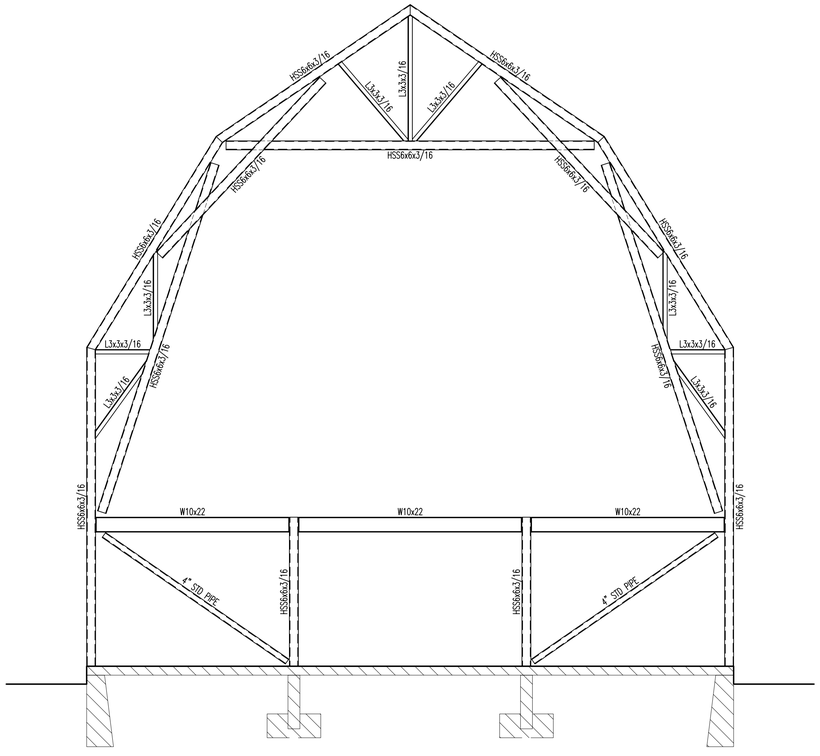
ROOF FRAMING PLAN

S-121



A BARN/TRUSS SECTION ROOF RETROFIT

SCALE: 1/4"=1'-0" 0 4' 8' 16'



B BARN/TRUSS SECTION BRACE FRAME RETROFIT

SCALE: 1/4"=1'-0" 0 4' 8' 16'

OWNER

PARK CITY CORP.

POB 1480
PARK CITY, UT 84060

MARK	DATE	DESCRIPTION
0	7/3/14	SEISMIC REPORT

structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN

HIGHWAY 224
PARK CITY, UT 84060

PROJECT NO: 14359

DRAWN BY: JBM

CHECKED BY: BKG

SHEET TITLE

SECTION

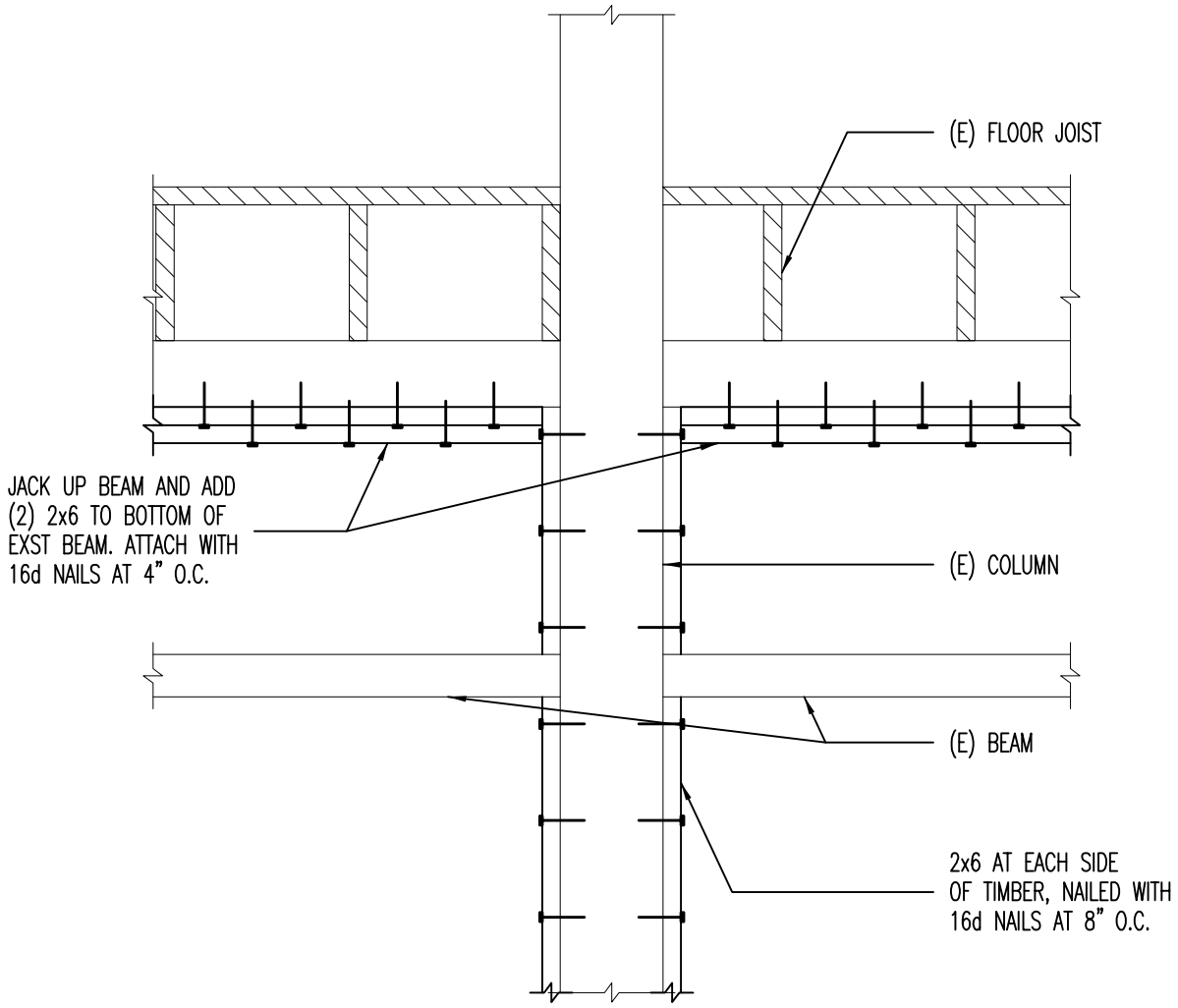
S-301

BHB structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 1a

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
SK-1



1 BEAM TO COLUMN CONDITION (DEFICIENCY 1a)
14359_SK000

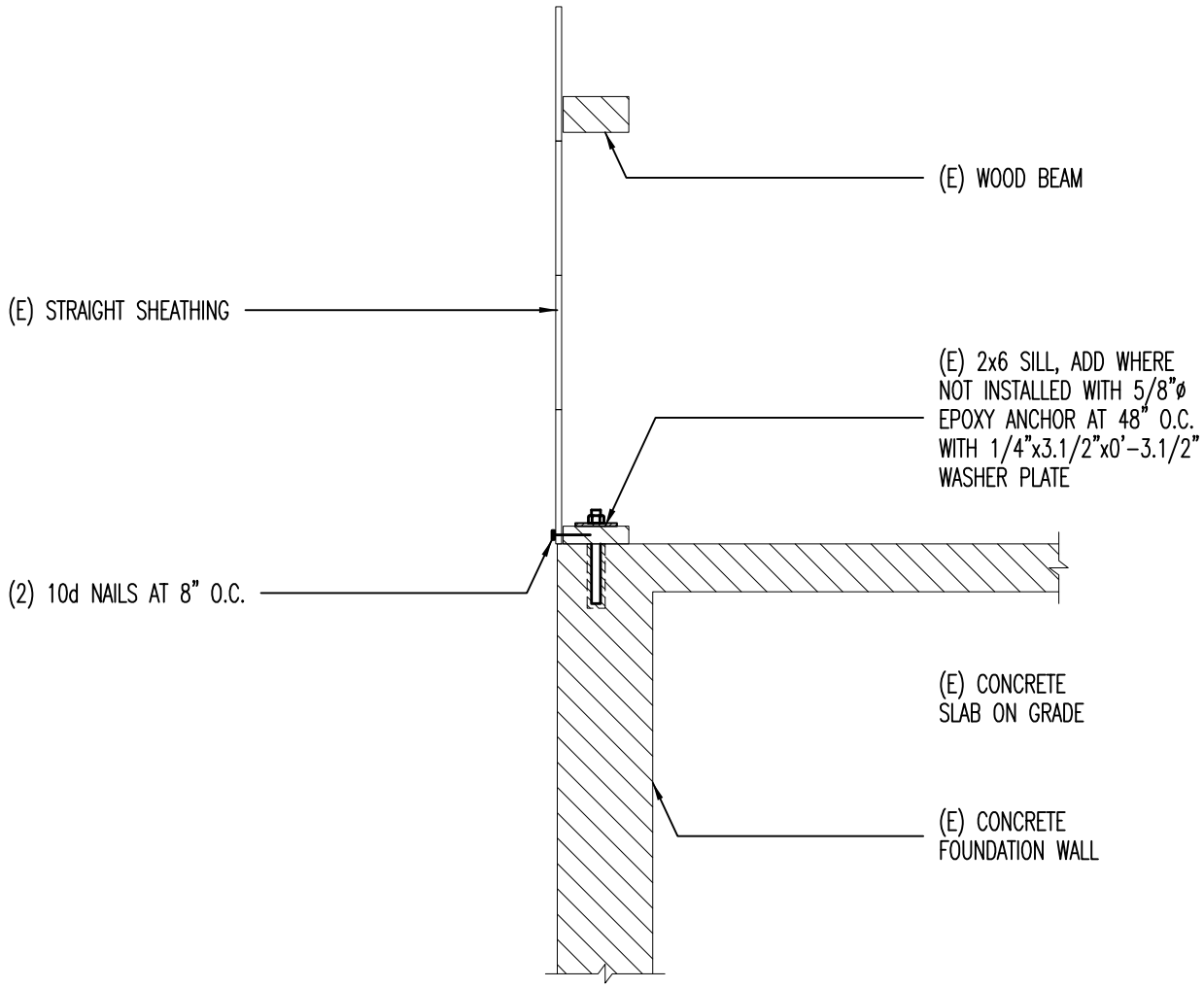
NO SCALE

structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 3c

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
SK-2



2
14359_SK000

TYPICAL WALL TO FOUNDATION DETAIL (DEFICIENCY 3c)

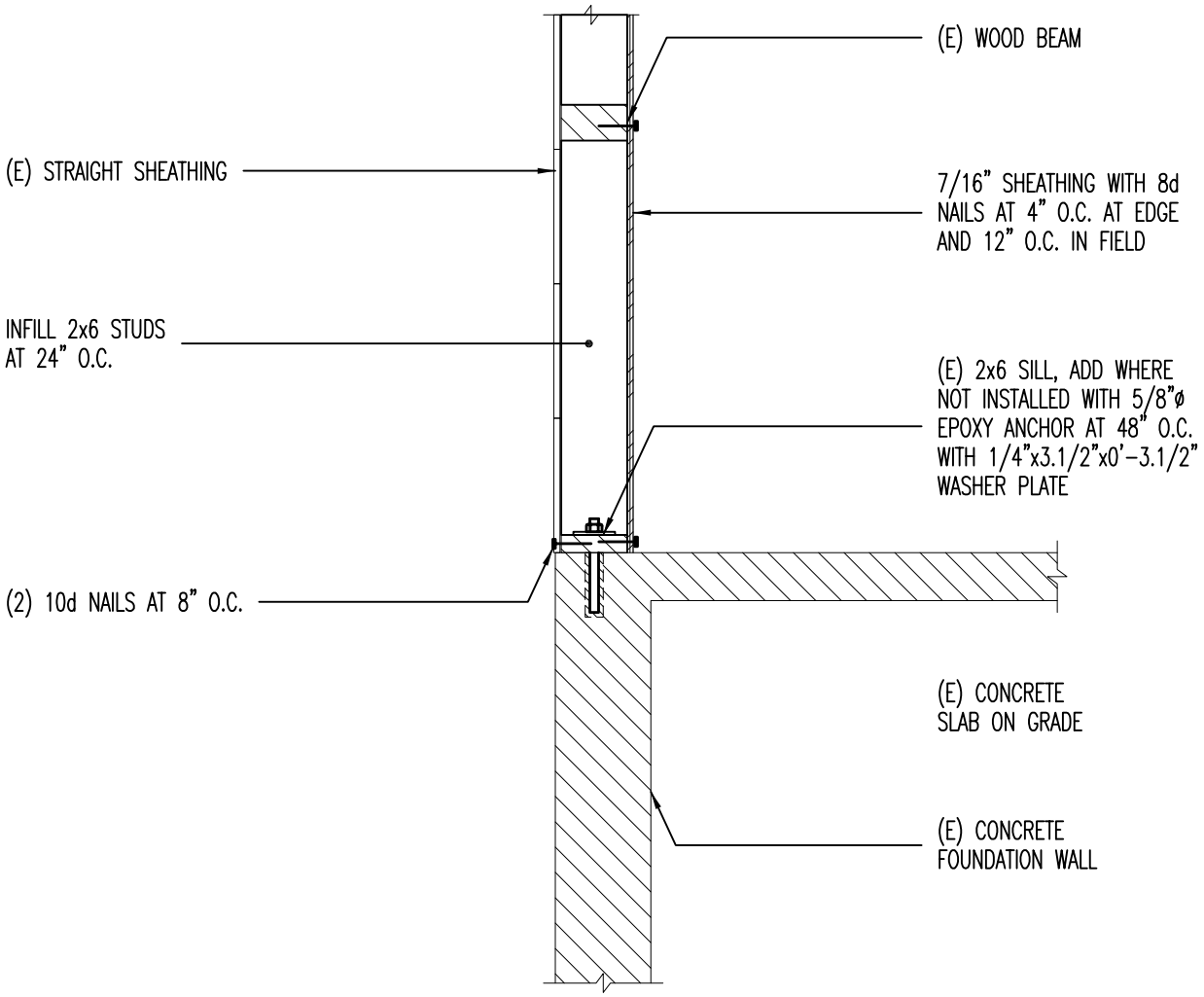
NO SCALE

BHB structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 3c

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
SK-3



3A
14359_SK000

SHEAR WALL TO FOUNDATION DETAIL OPTION A (DEFICIENCY 3c)

NO SCALE

BHB structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 3c

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
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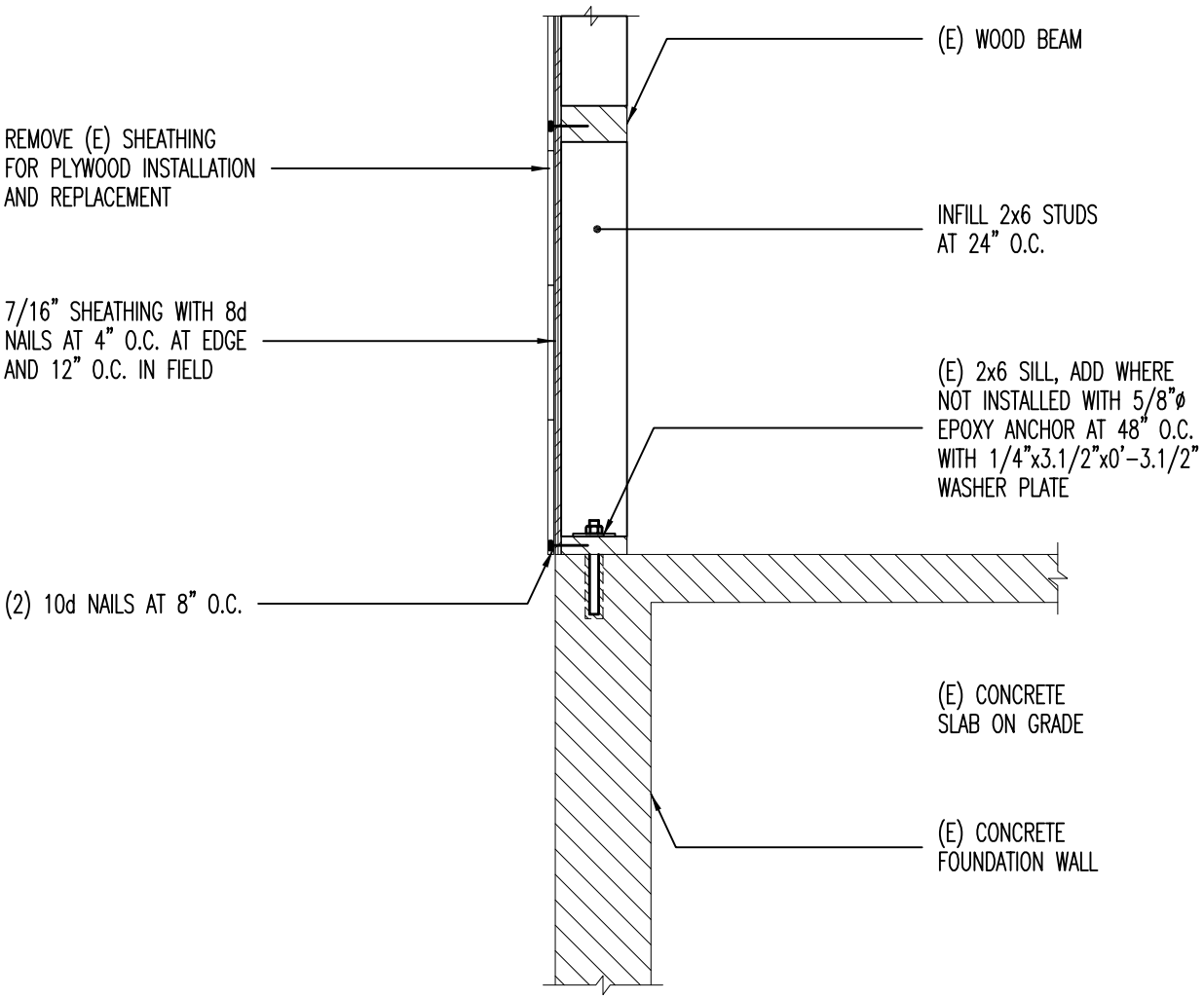


3B
14359_SK000

SHEAR WALL TO FOUNDATION DETAIL OPTION B (DEFICIENCY 3c)

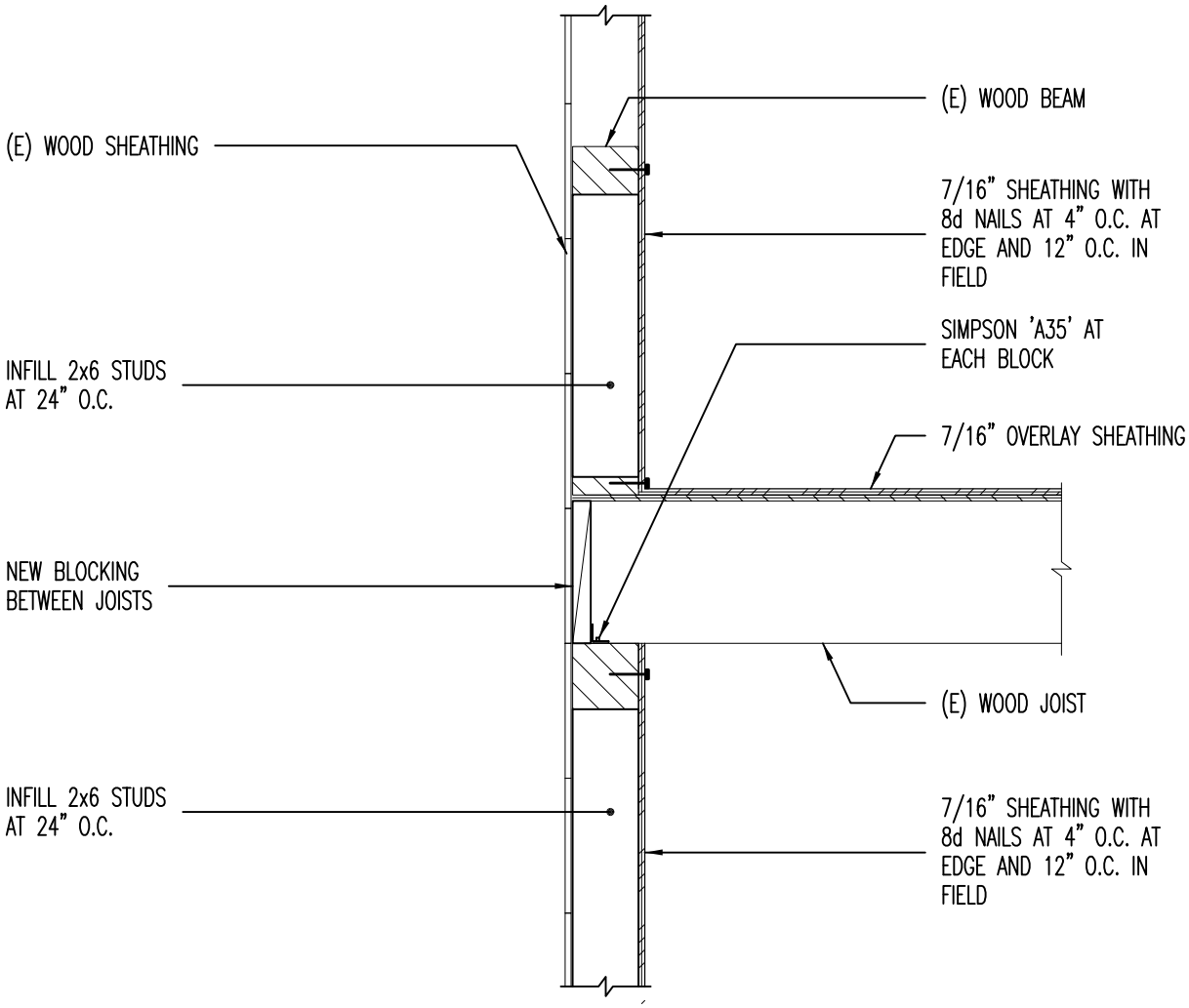
NO SCALE

structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 3c

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
SK-4



4A FLOOR CONNECTION AT SHEAR WALL - OPTION A (DEFICIENCY 3c)

14359_SK000

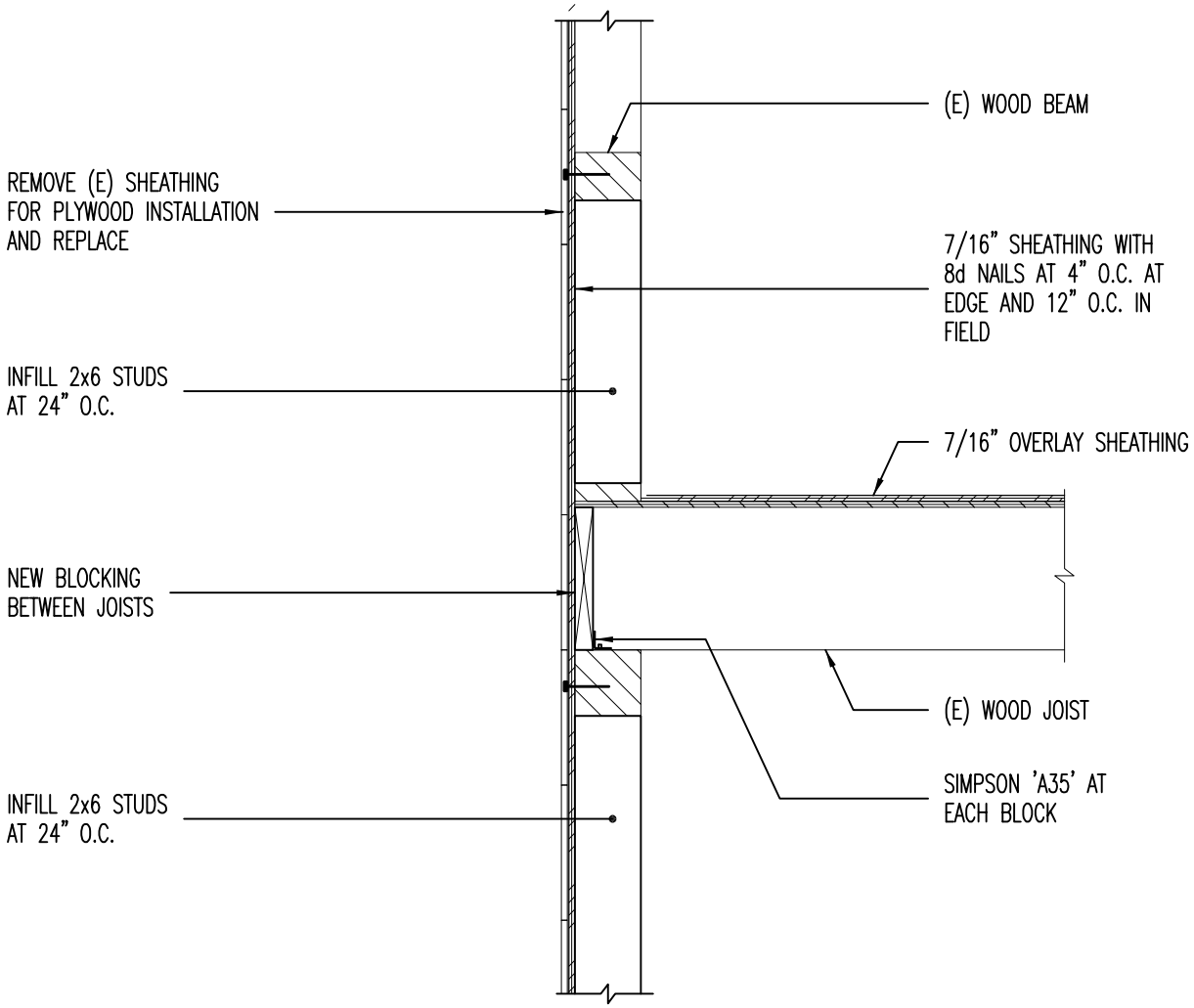
NO SCALE

structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 3c

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
SK-4



4B FLOOR CONNECTION AT SHEAR WALL - OPTION B (DEFICIENCY 3c)

14359_SK000

NO SCALE

BHB structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 3c

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
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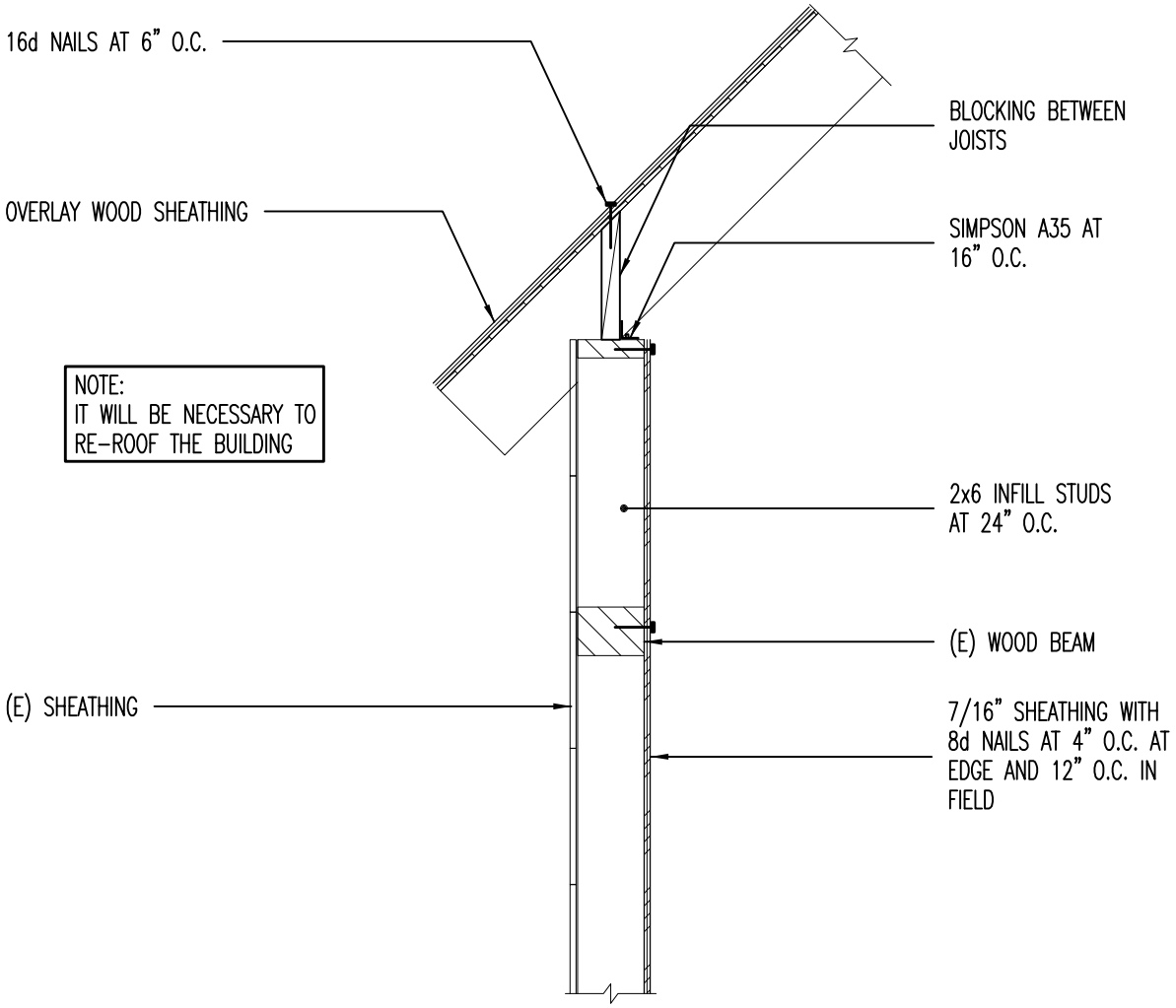

5A SHEAR WALL TO ROOF CONNECTION - OPTION A (DEFICIENCY 3c)

14359_SK000

NO SCALE

structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 3c

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
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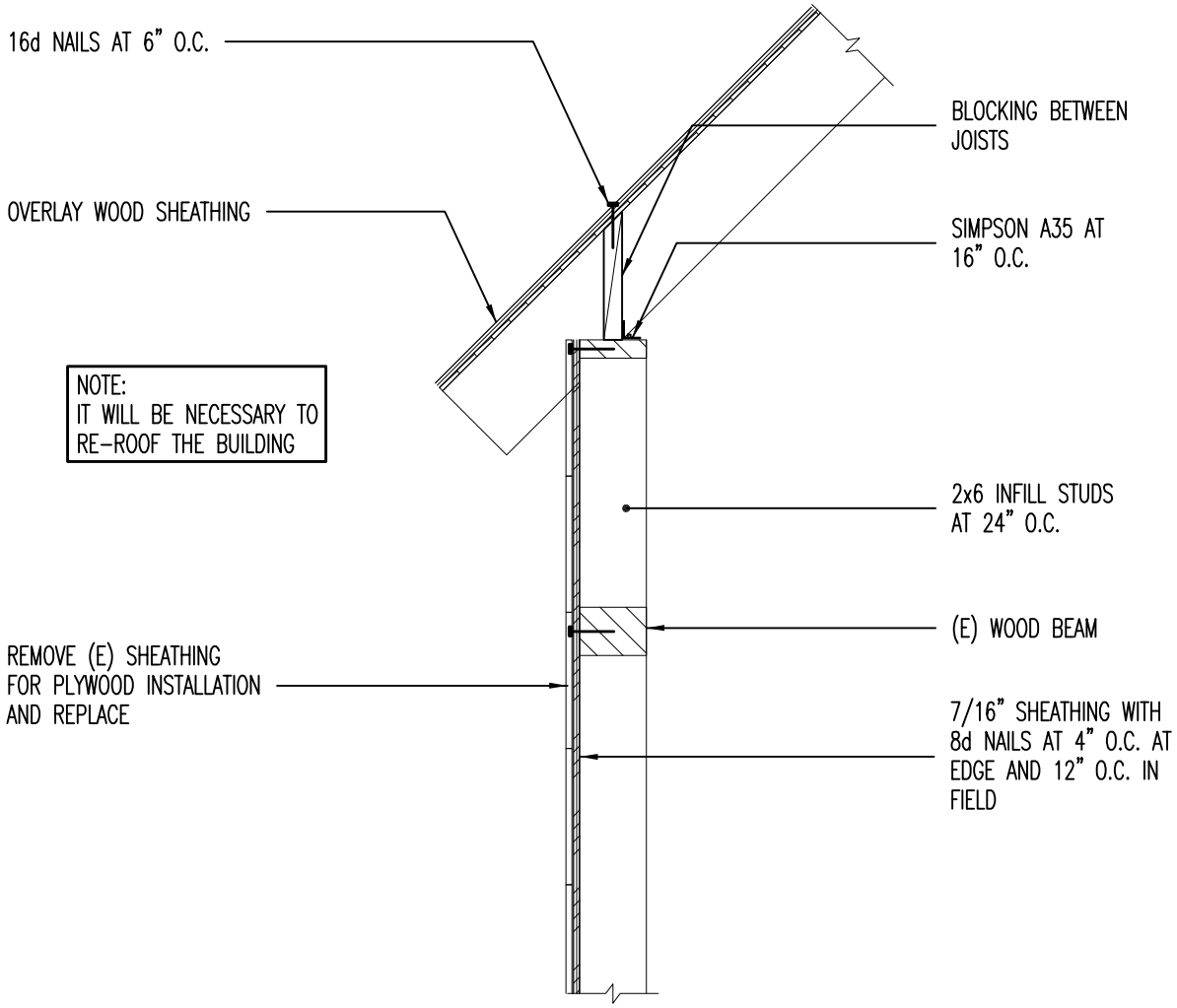

5B SHEAR WALL TO ROOF CONNECTION - OPTION B (DEFICIENCY 3c)

14359_SK000

NO SCALE

BHB structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 4a

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
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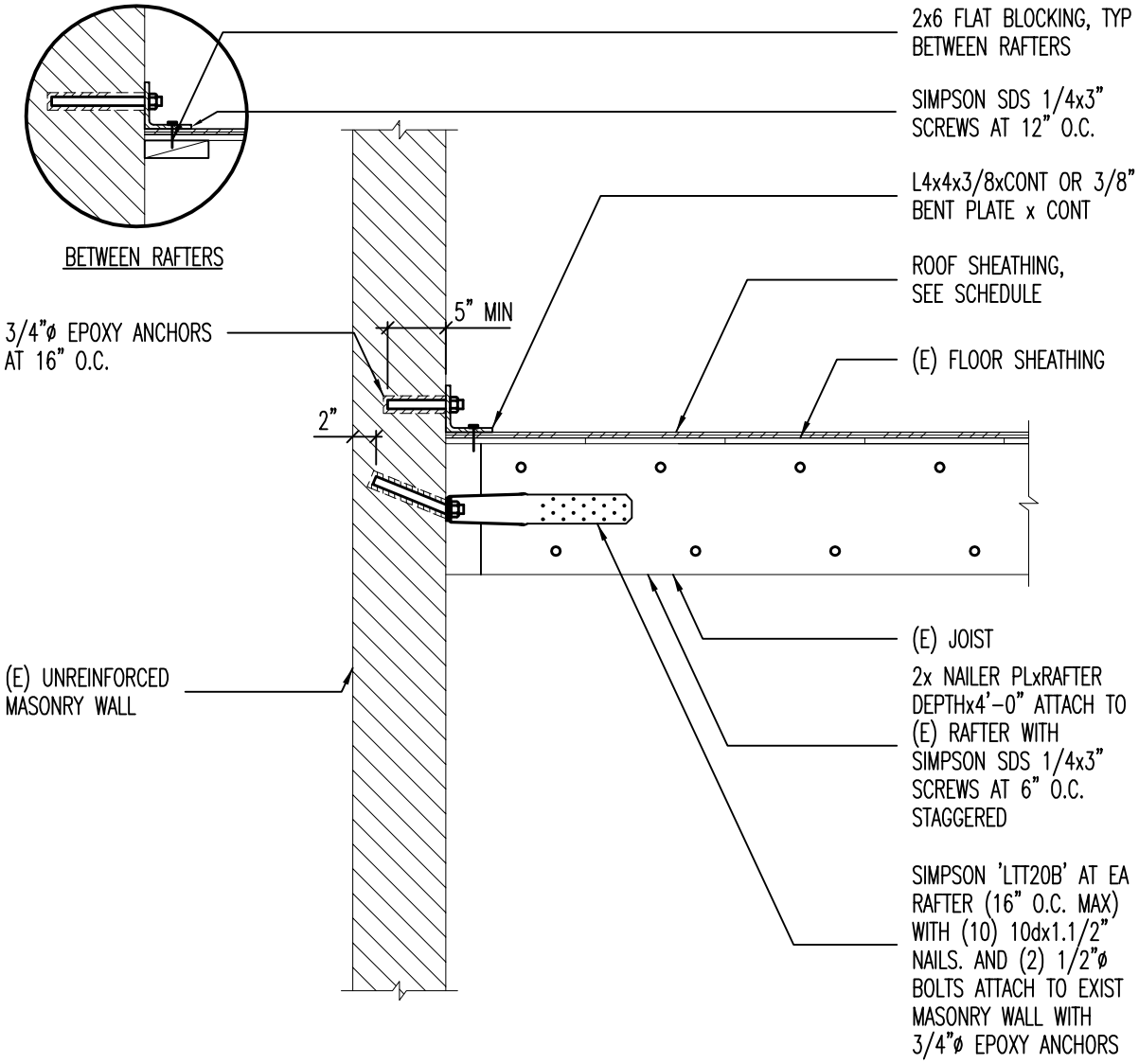

6 TYPICAL FLOOR ANCHORAGE DETAIL AT URM (DEFICIENCY 4a)

10413_S-512

NO SCALE

BHB structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 4a

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
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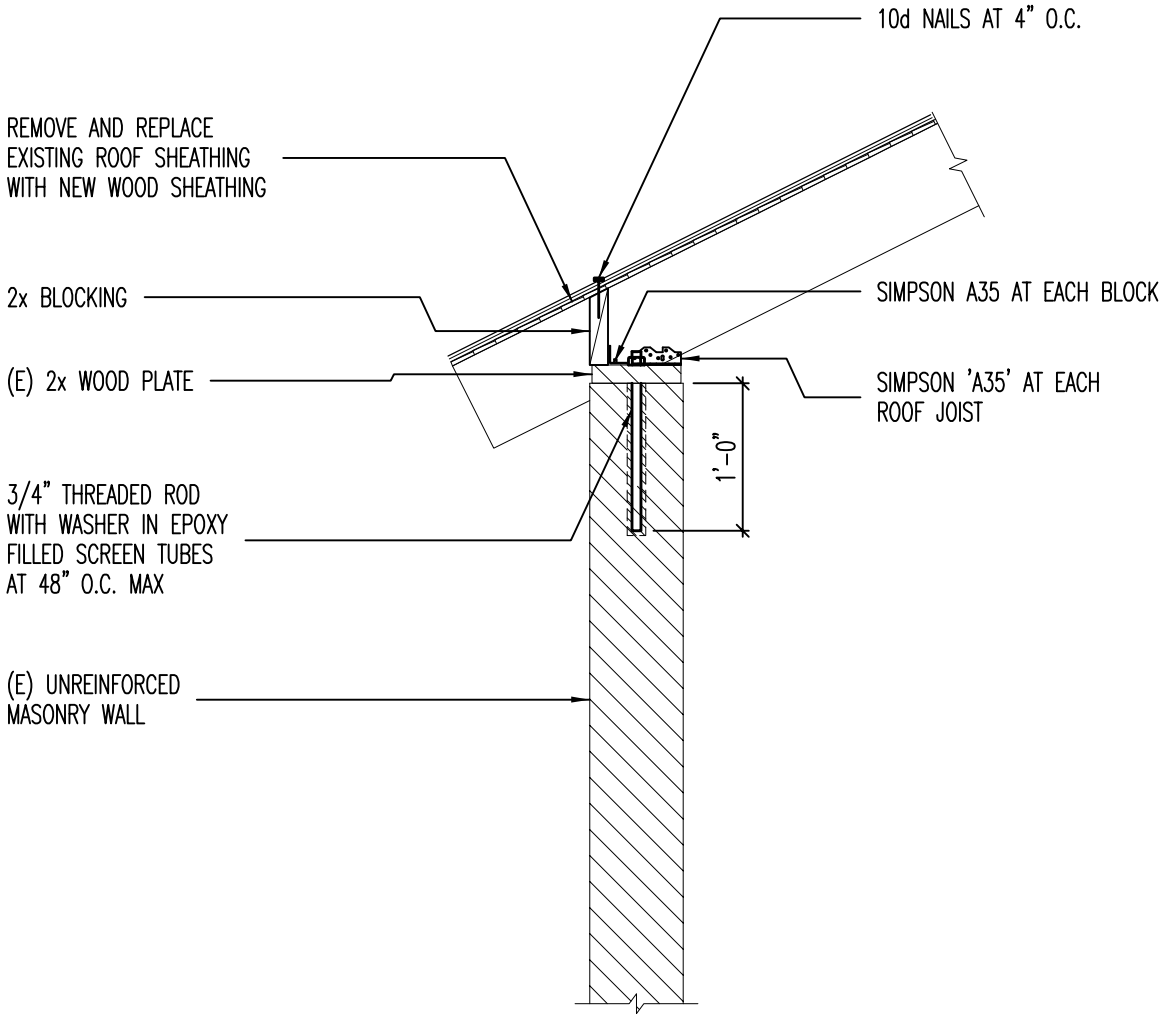

7 TYPICAL URM WALL BRACING AT ROOF (DEFICIENCY 4a)
14359_SK000

NO SCALE

structural
2766 S. Main Street
Salt Lake City, Utah 84115
801.355.5656
bhb@bhbengineers.com

MCPOLIN/OSGUTHORPE BARN
HIGHWAY 224, PARK CITY UT 84060
DEFICIENCY 4a

DRAWN BY: jbm
DATE: 7/3/14
JOB No. 14359

SHEET NUMBER:
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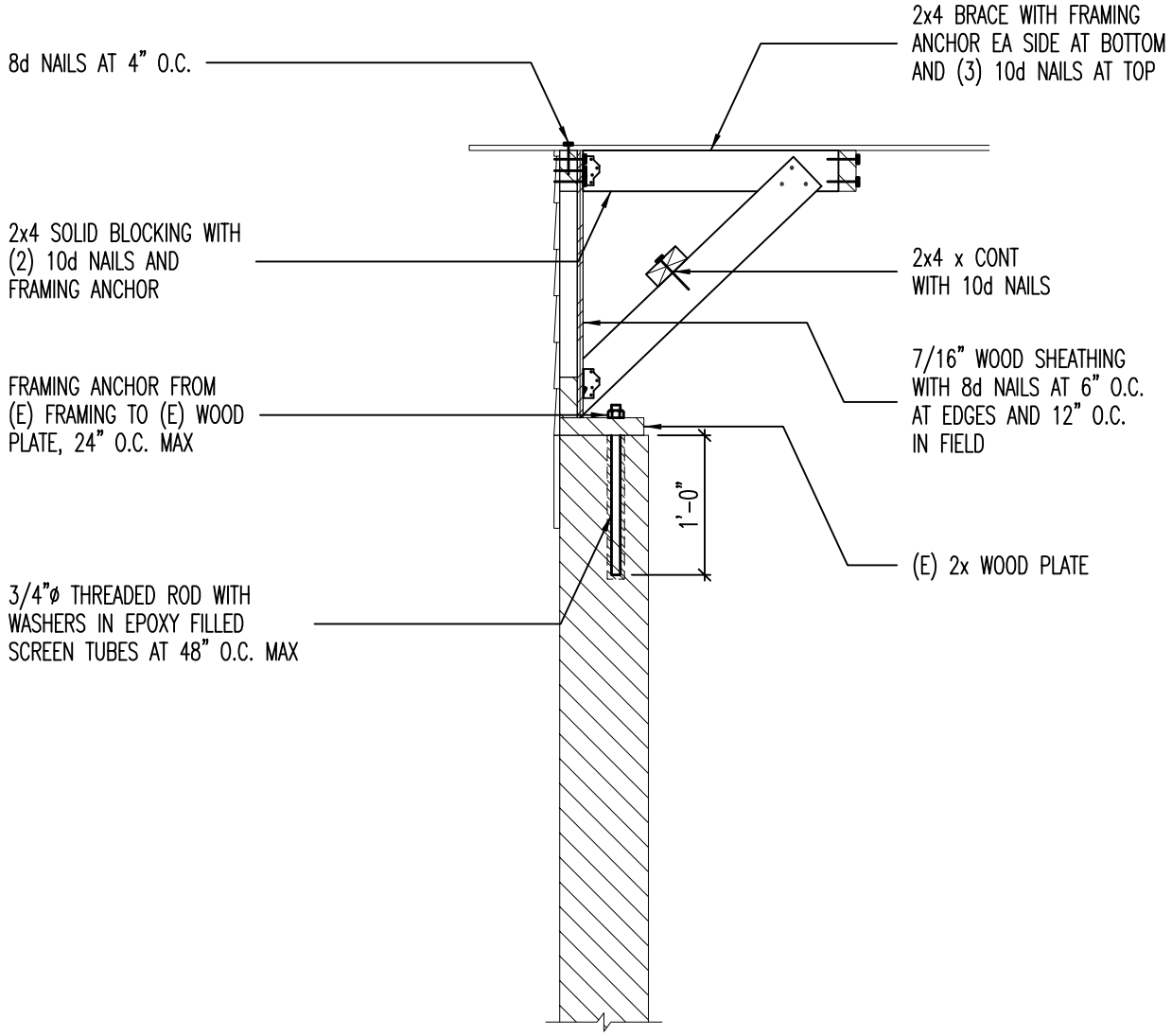

8 TYPICAL URM WALL BRACING AT ROOF (DEFICIENCY 4a)

14359_SK000

NO SCALE

3.7.2 Basic Structural Checklist for Building Type W2: Wood Frames, Commercial and Industrial

Building System

C NC N/A LOAD PATH: The structure shall contain a minimum of one complete load path for Life Safety and Immediate Occupancy for seismic force effects from any horizontal direction that serves to transfer the inertial forces from the mass to the foundation. (Tier 2: Sec. 4.3.1.1)

C NC N/A MEZZANINES: Interior mezzanine levels shall be braced independently from the main structure, or shall be anchored to the lateral-force-resisting elements of the main structure. (Tier 2: Sec. 4.3.1.3)

C NC N/A WEAK STORY: The strength of the lateral-force-resisting system in any story shall not be less than 80 percent of the strength in an adjacent story, above or below, for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.1)

C NC N/A SOFT STORY: The stiffness of the lateral-force-resisting system in any story shall not be less than 70 percent of the lateral-force-resisting stiffness in an adjacent story above or below, or less than 80 percent of the average lateral-force resisting system stiffness of the three stories above or below for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.2)

C NC N/A GEOMETRY: There shall be no changes in horizontal dimension of the lateral-force-resisting system of more than 30 percent in a story relative to adjacent stories for Life Safety and Immediate Occupancy, excluding one-story penthouses and mezzanines. (Tier 2: Sec. 4.3.2.3)

C NC N/A VERTICAL DISCONTINUITIES: All vertical elements in the lateral-force-resisting system shall be continuous to the foundation. (Tier 2: Sec. 4.3.2.4)

C NC N/A MASS: There shall be no change in effective mass more than 50 percent from one story to the next for Life Safety and Immediate Occupancy. Light roofs, penthouses, and mezzanines need not be considered. (Tier 2: Sec. 4.3.2.5)

C NC N/A DETERIORATION OF WOOD: There shall be no signs of decay, shrinkage, splitting, fire damage, or sagging in any of the wood members, and none of the metal connection hardware shall be deteriorated, broken, or loose. (Tier 2: Sec.4.3.3.1)

C NC (N/A) WOOD STRUCTURAL PANEL SHEAR WALL FASTENERS: There shall be no more than 15 percent of inadequate fastening such as overdriven fasteners, omitted blocking, excessive fastening spacing, or inadequate edge distance. This statement shall apply to the Immediate Occupancy Performance Level only.. (Tier 2: Sec. 4.3.3.2)

Lateral-Force-Resisting System

(C) NC N/A REDUNDANCY: The number of lines of shear walls in each principal direction shall be greater than or equal to 2 for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.1.1)

C (NC) N/A SHEAR STRESS CHECK: The shear stress in the shear walls, calculated using the Quick Check procedure of Section 3.5.3.3, shall be less than the following values for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.7.1)

Structural panel sheathing	1,000 plf
Diagonal sheathing	700 plf
Straight sheathing	100 plf
All other conditions	100 plf

C NC (N/A) STUCCO (EXTERIOR PLASTER) SHEAR WALLS: Multi-story buildings shall not rely on exterior stucco walls as the primary lateral-force-resisting system. (Tier 2: Sec. 4.4.2.7.2)

C NC (N/A) GYPSOM WALLBOARD OR PLASTER SHEAR WALLS: Interior plaster or gypsum wallboard shall not be used as shear walls on buildings over one story in height with the exception of the uppermost level of a multi-story building. (Tier 2: Sec. 4.4.2.7.3)

(C) NC N/A NARROW WOOD SHEAR WALLS: Narrow wood shear walls with an aspect ratio greater than 2-to-1 for Life Safety and 1.5-to-1 for Immediate Occupancy shall not be used to resist lateral forces developed in the building on levels of moderate and high seismicity. Narrow wood shear walls with an aspect ratio greater than 2-to-1 for Immediate Occupancy shall not be used to resist lateral forces developed in the building in levels of low seismicity. (Tier 2: Sec. 4.4.2.7.4)

C (NC) N/A WALLS CONNECTED THROUGH FLOORS: Shear walls shall have interconnection between stories to transfer overturning and shear forces through the floor. (Tier 2: Sec. 4.4.2.7.5)

C NC (N/A) HILLSIDE SITE: For structures that are taller on at least one side by

more than one-half story due to a sloping site, all shear walls on the downhill slope shall have an aspect ratio less than 1-to-1 for Life Safety and 1 to 2 for Immediate Occupancy. (Tier 2: Sec. 4.4.2.7.6)

C NC (N/A) CRIPPLE WALLS: Cripple walls below first-floor-level shear walls shall be braced to the foundation with wood structural panels. (Tier 2: Sec. 4.4.2.7.7)

C NC (N/A) OPENINGS: Walls with openings greater than 80 percent of the length shall be braced with wood structural panel shear walls with aspect ratios of not more than 1.5-to-1 or shall be supported by adjacent construction through positive ties capable of transferring the lateral forces. (Tier 2: Sec. 4.4.2.7.8)

Connections

C (NC) N/A WOOD POSTS: There shall be a positive connection of wood posts to the foundation. (Tier 2: Sec. 4.6.3.3)

C (NC) N/A WOOD SILLS: All wood sills shall be bolted to the foundation. (Tier 2: Sec. 4.6.3.4)

C (NC) N/A GIRDER/COLUMN CONNECTION: There shall be a positive connection utilizing plates, connection hardware, or straps between the girder and the column support. (Tier 2: Sec. 4.6.4.1)

3.7.2 Supplemental Structural Checklist for Building Type W2: Wood Frames, Commercial and Industrial

This Supplemental Structural Checklist shall be completed where required by Table 3-2. The Basic Structural Checklist shall be completed prior to completing this Supplemental Structural Checklist.

Lateral-Force-Resisting System

C NC (N/A) HOLD-DOWN ANCHORS: All shear walls shall have hold-down anchors constructed per acceptable construction practices, attaced to the end studs. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.4.2.7.9)

Diaphragms

C NC (N/A) DIAPHRAGM CONTINUITY: The diaphragms shall not be composed of split-level floors and shall not have expansion joints. (Tier 2: Sec. 4.5.1.1)

C NC N/A ROOF CHORD CONTINUITY: All chord elements shall be continuous, regardless of changes in roof elevation. (Tier 2: Sec. 4.5.1.3)

C NC N/A PLAN IRREGULARITIES: There shall be tensile capacity to develop the strength of the diaphragm at re-entrant corners or other locations of plan irregularities. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.5.1.7)

C NC N/A DIAPHRAGM REINFORCEMENT AT OPENINGS: There shall be reinforcing around all diaphragm openings larger than 50 percent of the building width in either major plan dimension. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.5.1.8)

C NC N/A STRAIGHT SHEATHING: All straight sheathed diaphragms shall have aspect ratios less than 2-to-1 for Life Safety and 1-to-1 for Immediate Occupancy in the direction being considered. (Tier 2: Sec. 4.5.2.1)

C NC N/A SPANS: All wood diaphragms with spans greater than 24 feet For Life Safety and 12 feet for Immediate Occupancy shall consist of wood structural panels or diagonal sheathing. (Tier 2: Sec. 4.5.2.2)

C NC N/A UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms shall have horizontal spans less than 40 feet for Life Safety and 30 feet for Immediate Occupancy and shall have aspect ratios less than or equal to 4-to-1 for Life Safety and 3-to-1 for Immediate Occupancy. (Tier 2: Sec. 4.5.2.3)

C NC N/A OTHER DIAPHRAGMS: The diaphragm shall not consist of a system other than wood, metal deck, concrete, or horizontal bracing. (Tier 2: Sec. 4.5.7.1)

Connections

C NC N/A WOOD SILL BOLTS: Sill bolts shall be spaced at 6 feet or less for Life Safety and 4 feet or less for Immediate Occupancy, with proper edge and end distance provided for wood and concrete. (Tier 2: Sec. 4.6.3.9)

3.7.15 Basic Structural Checklist for Building Type URM: Unreinforced Masonry Bearing Walls with Flexible Diaphragms

Building System

(C) NC N/A LOAD PATH: The structure shall contain a minimum of one complete load path for Life Safety and Immediate Occupancy for seismic force effects from any horizontal direction that serves to transfer the inertial forces from the mass to the foundation. (Tier 2: Sec. 4.3.1.1)

C (NC) N/A ADJACENT BUILDINGS: The clear distance between the building being evaluated and any adjacent building shall be greater than 4 percent of the height of the shorter building for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.1.2)

C NC (N/A) MEZZANINES: Interior mezzanine levels shall be braced independently from the main structure, or shall be anchored to the lateral-force-resisting elements of the main structure. (Tier 2: Sec. 4.3.1.3)

(C) NC N/A WEAK STORY: The strength of the lateral-force-resisting system in any story shall not be less than 80 percent of the strength in an adjacent story, above or below, for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.1)

(C) NC N/A SOFT STORY: The stiffness of the lateral-force-resisting system in any story shall not be less than 70 percent of the lateral-force-resisting stiffness in an adjacent story above or below, or less than 80 percent of the average lateral-force resisting system stiffness of the three stories above or below for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.3.2.2)

(C) NC N/A GEOMETRY: There shall be no changes in horizontal dimension of the lateral-force-resisting system of more than 30 percent in a story relative to adjacent stories for Life Safety and Immediate Occupancy, excluding one-story penthouses and mezzanines. (Tier 2: Sec. 4.3.2.3)

(C) NC N/A VERTICAL DISCONTINUITIES: All vertical elements in the lateral-force-resisting system shall be continuous to the foundation. (Tier 2: Sec. 4.3.2.4)

(C) NC N/A MASS: There shall be no change in effective mass more than 50 percent from one story to the next for Life Safety and Immediate Occupancy. Light roofs, penthouses, and mezzanines need not be considered. (Tier 2: Sec. 4.3.2.5)

C NC N/A DETERIORATION OF WOOD: There shall be no signs of decay, shrinkage, splitting, fire damage, or sagging in any of the wood members, and none of the metal connection hardware shall be deteriorated, broken, or loose. (Tier 2: Sec.4.3.3.1)

C NC N/A MASONRY UNITS: There shall be no visible deterioration of masonry units. (Tier 2: Sec. 4.3.3.7)

C NC N/A MASONRY JOINTS: The mortar shall not be easily scraped away from the joints by hand with a metal tool, and there shall be no areas of eroded mortar. (Tier 2: Sec. 4.3.3.8)

C NC N/A UNREINFORCED MASONRY WALL CRACKS: There shall be no existing diagonal cracks in the wall elements greater than 1/8 inch for Life Safety and 1/16 inch for Immediate Occupancy, or out-of-plane offsets in the bed joint greater than 1/8 inch for Life Safety and 1/16 inch for Immediate Occupancy, and shall not form an X pattern. (Tier 2: Sec. 4.3.3.11)

Lateral-Force-Resisting System

C NC N/A REDUNDANCY: The number of lines of shear walls in each principal direction shall be greater than or equal to 2 for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.1.1)

C NC N/A SHEAR STRESS CHECK: The shear stress in the unreinforced masonry shear walls, calculated using the Quick Check procedure of Section 3.5.3.3, shall be less than 30 psi for Life Safety and Immediate Occupancy. (Tier 2: Sec. 4.4.2.2.1)

Connections

C NC N/A WALL ANCHORAGE: Exterior concrete or masonry walls that are dependent on the diaphragm for lateral support shall be anchored for out-of-plane forces at each diaphragm level with steel anchors, reinforcing dowels, or straps that are developed into the diaphragm. Connections shall have adequate strength to resist the connection force calculated in the Quick Check procedure of Section 3.5.3.7. (Tier 2: Sec. 4.6.1.1)

C NC N/A WOOD LEDGERS: The connection between the wall panels and the diaphragm shall not induce cross-grain bending or tension in the wood ledger. (Tier 2: Sec. 4.6.1.2)

C NC N/A TRANSFER TO SHEAR WALLS: Diaphragms shall be connected for transfer of loads to the shear walls for Life Safety and the connections shall be able to develop the lesser of the shear strength of the walls or diaphragms for Immediate Occupancy. (Tier 2: Sec. 4.6.2.1)

C NC N/A GIRDER/COLUMN CONNECTION: There shall be a positive connection utilizing plates, connection hardware, or straps between the girder and the column support. (Tier2: Sec. 4.6.4.1)

3.7.15S Supplemental Structural Checklist for Building Type URM: Unreinforced Masonry Bearing Walls with Flexible Diaphragms

Lateral-Force-Resisting System

(C) NC N/A PROPORTIONS: The height-to-thickness ratio of the shear walls at each story shall be less than the following for Life Safety and Immediate Occupancy (Tier 2: Sec. 4.4.2.5.2).

Top story of multi-story building	9
First story of multi-story building	15
All other conditions	13

Diaphragms

(C) NC N/A CROSS TIES: There shall be continuous cross ties between diaphragm chords. (Tier 2: Sec. 4.5.1.2)

C NC (N/A) OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls shall be less than 25 percent of the wall length for Life Safety and 15 percent of the wall length for Immediate Occupancy. (Tier 2: Sec. 4.5.1.4)

C NC (N/A) OPENINGS AT EXTERIOR MASONRY SHEAR WALLS: Diaphragm openings immediately adjacent to exterior masonry shear walls shall not be greater than 8 feet long for Life Safety and 4 feet long for Immediate Occupancy. (Tier 2: Sec. 4.5.1.6)

C NC (N/A) PLAN IRREGULARITIES: There shall be tensile capacity to develop the strength of the diaphragm at re-entrant corners or other locations of plan irregularities. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.5.1.7)

(C) NC N/A DIAPHRAGM REINFORCEMENT AT OPENINGS: There shall be reinforcing around all diaphragm openings larger than 50 percent of the building width in either major plan dimension. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.5.1.8)

C (NC) N/A STRAIGHT SHEATHING: All straight sheathed diaphragms shall have aspect ratios less than 2-to-1 for Life Safety and 1-to-1 for Immediate Occupancy in the direction being considered. (Tier 2: Sec. 4.5.2.1)

C (NC) N/A SPANS: All wood diaphragms with spans greater than 24 feet

For Life Safety and 12 feet for Immediate Occupancy shall consist of wood structural panels of diagonal sheathing. (Tier 2: Sec. 4.5.2.2)

C NC (N/A) UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms shall have horizontal spans less than 40 feet for Life Safety and 30 feet for Immediate Occupancy and shall have aspect ratios less than or equal to 4-to-1 for Life Safety and 3-to-1 for Immediate Occupancy. (Tier 2: Sec. 4.5.2.3)

C NC (N/A) NON-CONCRETE FILLED DIAPHRAGMS: Un-topped metal deck diaphragms or metal deck diaphragms with fill other than concrete shall consist of horizontal spans of less than 40 feet and shall have span/depth ratios less than 4-to-1. This statement shall apply to the Immediate Occupancy Performance Level only. (Tier 2: Sec. 4.5.3.1)

C NC (N/A) OTHER DIAPHRAGMS: The diaphragm shall not consist of a system other than wood, metal deck, concrete, or horizontal bracing. (Tier 2: Sec. 4.5.7.1)

Connections

C (NC) N/A STIFFNESS OF WALL ANCHORS: Anchors of concrete or masonry Walls to wood structural elements shall be installed taut and shall be stiff enough to limit the relative movement between the wall and the diaphragm to no greater than 1/8 inch prior to engagement of the anchors. (Tier 2: Sec. 4.6.1.4)

C (NC) N/A BEAM, GIRDER, AND TRUSS SUPPORTS: Beams, girders, and Trusses supported by unreinforced masonry walls or pilasters shall have independent secondary columns for support of vertical loads. (Tier 2: Sec. 4.6.4.5)