## EXECUTIVE SUMMARY

This document is a structural evaluation of the St. Matthew Catholic Church Grade School, Gymnasium, Costello Center, and Pastoral Center. As part of the development of a 5 year plan for modernization of these facilities, this structural evaluation identifies the condition of the facilities, their structural weaknesses, and provides recommendations for corrective measures with an engineer's opinion of probable construction costs for those corrective measures.

This assessment report is intended to be used as guidance in development of decisions on the best approach to modernize the facilities. The information presented is intended to be used in a variety of ways: to develop the most critically weak areas of the structure and to identify the impact of modifying the existing structure.

This structural report includes a review of the structural capacity of these buildings to support vertical loading and lateral loading. Vertical loading includes building self-weight, snow, occupant, and content loading. Lateral loading includes seismic and wind effects.

For these structures, the findings in this report indicate weaknesses primarily in the structural capacity to resist code-prescribed seismic forces. As a result, in these areas of weaknesses structural damage is expected to occur during a significant earthquake. The majority of weaknesses in these buildings relate to a lack of adequate connections to heavy concrete walls, a lack of shear walls in key areas, and a weakness in the roof system to resist the seismic forces.

Due to the weaknesses identified in these existing structures, any modifications to the existing structural systems will require strengthening measures in those areas to be undertaken. It is recommended that prudent consideration be given for strengthening areas of these buildings that are impacted by architectural or non-structural changes as a result of modernization efforts. Furthermore, priority should also be given to the areas identified as the highest risk locations.

For modernizations efforts that require building expansions, it is recommended that the existing building be structurally isolated with seismic joints to prevent mandatory seismic retrofits to the existing building from being triggered.

## PURPOSE

The purpose of this evaluation is to review the structural characteristics of the St. Matthew Grade School, Gymnasium/Costello Center, and the Pastoral Center. This evaluation is intended to identify structural deficiencies in the existing buildings so that areas of weakness can be identified and given consideration as a modernization plan is developed. This evaluation is also intended to provide guidance as to the relative hazards for structural deficiencies identified.

## HISTORY

The available documentation provided to us indicates that the St. Matthew Grade School was originally dedicated in 1914 with a total of 45 students. At that time, the original school building was approximately 32 x 66 feet and occupied two levels. In 1949, a major renovation of the school building was performed increasing the size of the school to 245 feet long and 66 feet wide, enrolling over 100 students. This construction expanded the original school building to the south, west, and east. In 1975, the Gymnasium and Costello Center was constructed on the north side of the building adding an additional footprint of 95 feet x 103 feet. Prior to 1980, several other smaller renovations were completed including modifications to the locker/shower rooms, and remodel of the school kitchen/cafeteria. In 1989, additional classrooms at the west end of the lower level were completed. At the time of this report the school has approximately 250 occupants including students and staff.

The Pastoral Center was constructed in 1960 as a convent, constructed with two upper floors and a basement level. The pastoral center occupies a footprint of 88 feet x 57 feet and appears to be largely unchanged from the original construction. This building was originally permitted as a multi-family residential building and is now being used as meeting space. The changes in the use of this building may be considered a change of occupancy and may impact the fire/life safety requirements for the building. For this reason, an architectural review of the fire life safety requirements for this structure may be required.

## EVALUATION STANDARD

The assortment of building structures in this evaluation have been constructed at different times and with different construction standards throughout its history. Since the time of construction the construction standards and related building codes have increased the required force levels and associated material specific detailing requirements.

The provisions and requirements of the current building code are generally intended to address new construction or alterations of existing buildings. Buildings constructed prior to the adoption of the current building code are normally allowed to remain in use and operative as long as there is no change in use, occupancy, or alterations to the existing structural systems. Changes to the building structure require modified portions of the building to be strengthened to the requirements of the current building code.

For this evaluation, the vertical load-carrying capacity of the structure and the horizontal load-carrying capacity of the structure have been reviewed. The vertical load carrying capacity of the structure is the ability of the structure to support its own weight, weight of occupants, and snow loads on the structure, as well as soil loads that may be on the buildings. The vertical load elements have been evaluated based on the *2007 State of Oregon Structural Specialty Code* (OSSC). The 2007 OSSC includes the *2006 International Building Code* (IBC) with amendments by the State of Oregon. These documents contain numerous reference documents for different materials and loading requirements that are also used in the evaluation of the structural components.

In order to evaluate the ability of these structures to resist horizontal forces from seismic loading, the ASCE 31 *Seismic Evaluation of Existing Buildings* was used. ASCE 31 is a nationally recognized guideline that provides procedures to evaluate existing buildings, and the related seismic hazards associated with them. This approach allows the determination of relative seismic hazards and identifies areas of a building that are expected to suffer damage during an expected seismic event. ASCE 31 also provides for the identification of seismic hazards related to construction practices that do not meet modern construction standards.

A review of wind loading on the facility was also performed based on the 2007 OSSC. The results of this evaluation indicate that the seismic design forces were significantly larger than the code-prescribed wind loading. Since the same building elements that resist seismic forces also resist wind forces, the seismic loads were used to determine structural hazards for the lateral force resisting elements of these structures.

### LEVEL OF PERFORMANCE

To identify the structural deficiencies in the lateral force resisting system, a life safety level of performance has been used. The intent of the life safety level of performance assumes that during a design seismic event buildings are expected to be substantially damaged, and may not be usable, but occupants will be able to exit the facility. The life safety level of performance is the expected structural performance of a building designed under the current building code. For evaluation of the vertical force resisting system, provisions of the 2007 OSSC have been used.

The following parameters were used during this evaluation:

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|---|---|
| Wind Loading: | 94.5 MPH (3 second gust), Exposure B |
| Soil Lateral Earth Pressure: | 35 PSF/ft of depth |
| Soil Bearing: | 2000 PSF (Based on existing construction documents) |
| Roof Dead Loading: | 15 PSF (Roof School/Gymnasium/Costello Center)<br>20 PSF (Pastoral Center) |
| Floor Dead Loading: | 20 PSF |
| Floor Live Loading: | 50 PSF (Classrooms)<br>100 PSF (Corridors/Exit ways) |
| Roof Snow Load: | 20 PSF |
| Rain on Snow Load: | 5 PSF for roofs with slopes less than or equal to 1:12 slope |
| Seismic Design: | $S_S$ = 0.916; $S_1$ = 0.354, Site Class = D<br>$S_{DS}$ = 0.692; $S_{D1}$ = 0.400<br>Seismic Design Category = D<br>Seismic Resisting System = Light-framed wood and concrete shear walls<br>Procedure = ASCE 31-03 Seismic Provisions |

## Seismic Force Level

The seismic force parameters are based on a short period acceleration of 0.692g ($S_{DS}$) and one-second period acceleration of 0.0.40g ($S_{D1}$). Due to the nature of these buildings, the short period acceleration controls the design. The accelerations are reduced by a factor of 4 to 6 to represent energy absorption of the existing materials as they become damaged. The resulting value is multiplied by the building weight to arrive at the seismic forces.

The expected earthquake magnitude to generate the design forces depends on the distance from the earthquake epicenter, the type of earthquake, the period of the earthquake, the duration of the earthquake and numerous other factors that are beyond the scope of this report. The question of earthquake damage is often raised and related to Richter magnitude. Richter magnitude is a measure of the energy released, and does not necessarily correlate to the expected damage from a seismic event. Based on information from the United States Geological Survey (USGS) and the Oregon Department of Mineral Industries (DOGAMI), the vicinity of this site is considered a high seismic area. For specific earthquake magnitudes at this facility it is recommended that a Geotechnical consultant be contacted.

## Construction Types

### Main Grade School Building

The main grade school building is constructed with concrete exterior walls with interior wood-framed construction. The roof is sheathed with straight horizontal sheathing, while the floors are sheathed with diagonal sheathing with a hardwood finish. In the long axis of the main grade school building, wood joists for the roof and the floors are supported by two main interior bearing walls at the sides of the main corridor and the exterior concrete walls. At the ground floor, the interior corridor bearing walls above are supported by timber beams, steel columns, and concrete bearing walls. The foundation of the school building is constructed with isolated and continuous concrete footings. The exterior walls of the building act as partial-height retaining walls to support approximately 5 feet of soil.

### Gymnasium and Costello Center

The gymnasium and Costello Center are constructed with concrete tilt walls, manufactured open-web wood joists, and plywood roof sheathing. Tilt-wall construction is a procedure for forming wall panels on the ground, on site, and lifting them into place.

### Pastoral Center

The Pastoral Center is constructed with conventional wood framing. The roof and floors are supported with an interior bearing wall line extending through the long axis of the building. At the south end of the basement an existing steel beam is present supporting the main level framing. The floors and walls are sheathed with diagonal sheathing. The roof is sheathed with straight sheathing. The north stairwell is constructed with masonry walls. The stairs are constructed from reinforced concrete. The lower level is constructed with concrete retaining walls at the building exterior. The building exterior is clad with a masonry veneer. Some of the interior walls at the lower level are constructed from masonry.

## VERTICAL LOAD EVALUATION

As part of this evaluation, a cursory review of the vertical load-carrying members was performed. Vertical load evaluation is a review of the ability of the structural components to support snow load, occupant load, and dead loads of the structure. The evaluation consisted of a spot check review of key elements of the roof framing, floor framing, beams, headers, and foundation elements. The vertical analysis of the main grade school building, the gymnasium, the Costello Center, and the Pastoral Center indicated the structural members are adequate to support the vertical loads as identified in the current building code. No deficiencies were identified in these structural elements.

The vertical load analysis also indicated limited reserve capacity in the existing structural members to support additional loads on the building. Support for new roof top mounted mechanical equipment will likely require additional support members at the roof level. Adding additional floors to the structure would require substantial modifications to the existing foundation, beams, and headers.

### Grade School Building

At the west end of the grade school building cracks in the interior corridor walls were noted. These cracks appear to be related to foundation settlement and isolated to one location in the building. For this type of settlement to occur, it is expected that there is a weakness in the bearing capacity of the soil at this location. The analysis of the foundation indicates that the structure has been designed for 2000 PSF bearing capacity. The construction documents indicate the design of the gymnasium was based on 2000 PSF bearing. Soil bearing is the pressure imparted to the soil from the foundation of a building. The current building code indicates soil bearing above 1500 PSF requires a geotechnical engineering review. Based on past experience with buildings in this area, we would expect soil bearing capacities to range from 1500 PSF to 2000 PSF; therefore, the foundation settlement observed does not appear to be directly caused by undersized footings. The ground level floor appears to have been placed several feet below the original grade. Placing foundations deeper often leads to increased soil bearing. As a result, we would expect higher bearing pressures to be allowed.

The foundation settlement appears to have occurred relatively recently. Therefore, it is expected that the cause of settlement may be related to a change in ground water in the area of the foundation. The exterior grade at the building slopes gently from east to west and from north to south. As a result, the foundation is shallower at the west end of the building, and may be more prone to foundation settlement. During our site inspection, we were notified that work had been done on the waterline in the street west of the building, and that leaks in that system may be a possible cause.

The settlement identified at the corridor walls at the west end of the school appears to be caused by a weakened soil condition. Since this portion of the structure is nearly 60 years old, and the settlement is relatively recent, the settlement is expected to be caused by water penetrating at the foundation. If the cause of the settlement has been identified, and mitigated, then it is our recommendation to wait until the foundation has reached equilibrium before cracks are repaired. Another option is to strengthen the foundation would include installing soil anchors to the foundation at approximately 4 feet on center.

**Gymnasium**
At the southwest corner of the gymnasium cracks in the wall were observed. The direction and size of these cracks indicate that the foundation of the gymnasium has minor settlement. It would appear that the gymnasium foundation had been attached to the existing main school building. The gymnasium foundation has undergone settlement relative to the main school building construction. Buildings placed on soil materials undergo some settlement until the building footings and soil reaches a state of equilibrium. The magnitude and duration of this process is dependent on the soil properties and the load. Since the original 1949 school building had been completed approximately 25 years prior to the construction of the gymnasium, it had undergone settlement prior to the placement of the gymnasium wall. As a result, the cracks at this location indicate the later gymnasium construction had undergone the initial settlement causing damage at the interface of the different construction. Near this area it was also noted that a roof drain was not functioning properly. Excess water in this area could also be a cause of additional settlement. In order to minimize the effects of foundation settlement, it is recommended that roof drains and downspouts be periodically inspected to confirm they are working properly.

## SEISMIC LOAD EVALUATION

The seismic evaluation of this facility has been performed based on ASCE 31.
As part of the ASCE 31 evaluation, a series of checklists with subsequent calculations have been utilized to identify the seismic hazards present in each of the buildings. Parts of the building that have been identified as non-compliant seismic hazards were reviewed further. Non-compliant seismic hazards are deficiencies that have been identified through the checklists as common problems for buildings of these construction types. For each of the non-compliant items, a structural analysis was performed to determine the seismic loads on the element and the structural capacity of the element. For this investigation, the seismic loads on the elements are referred to as “Demand”. To determine the relative seismic hazard for each item, a ratio of the demand divided by the capacity was determined. This is known as a demand capacity ratio (DCR). The DCR is then used to rank relative seismic hazards in terms of the relative risk of failure of structural components. The higher DCR represents a higher probability of failure during an earthquake. A DCR of 1.0 or less indicates items are adequate to resist earthquake forces. A DCR in excess of 1.0 indicates the identified structural capacity for each item is lower than the forces expected during a design level earthquake and are expected to fail.

Since different portions of the building have been constructed at various times with various types of construction, for the seismic load evaluation the facility has been organized into four sections: the original 1914 construction, the main grade school building, the Gymnasium/Costello Center, and the Pastoral Center.

In addition to the structural seismic hazards, the ASCE 31 standard also allows for non-structural hazards. Non-structural seismic hazards relate to portions of the building that are not part of the structural systems, but also have been known to cause loss of life and are also potential hazards to be considered. Non-structural hazards do not contain DCRs.

### SEISMIC HAZARDS FOR THE 1914 CONSTRUCTION

The 1914 construction was originally constructed with concrete exterior walls at the ground level, and wood framed walls at the upper level. In its current condition, upper level offices and conference rooms are present. At the lower level, locker rooms/bathrooms are present.

The original exterior walls of this portion of the construction were found to have inadequate connections between the concrete walls, the wood framed walls and floors above. The lack of connections at these locations is expected to have a high risk of structural damage. The connections in these areas are required to resist in-plane and out-of-plane wall seismic forces. In-plane seismic forces are applied in the plane of the wall. Out-of-plane wall loads are seismic loads perpendicular to the wall plane.

According to the existing documentation, the concrete walls in this area do not have adequate dowels to the foundation, or sufficient reinforcing steel. Foundation dowels are used to transfer seismic forces from the wall to the foundation. As a result, this wall will have limited capacity to resist overturning forces from in-plane seismic loads. Overturning forces are caused by in-plane loads applied from the floors and roof causing shear walls to overturn. These deficiencies are expected to result in damage in this area.

The existing documentation also indicates the reinforcing steel at these concrete walls is less than recommended. Reinforcing steel provides redundancy so that concrete wall elements can remain in place even though they may be substantially damaged and cracked. It should be noted that concrete walls in the 1914 construction have adequate shear capacity to resist the expected seismic loading. Shear refers to in-plane loading on walls. These walls do not meet the minimum recommended reinforcement and still have the potential to suffer damage.

The interior locker room walls were found to be constructed from concrete masonry units (CMU). At the top of these CMU walls no connection is present; as a result, these walls are expected to be a collapse hazard. Since these elements are not part of the main structural system this collapse hazard is considered a non-structural deficiency.

## SUMMARY OF SEISMIC DEFICIENCIES FOR THE 1914 CONSTRUCTION

*Note: The following is a detailed summary of the seismic deficiencies for this portion of the building. For locations of these deficiencies refer to the deficiency plans included in this report. Each deficiency has an associated Demand Capacity Ratio (DCR). The DCR is a measure of seismic risk. DCR greater than 1 indicates structural forces are higher than the calculated capacity. Higher DCRs represent higher risk.*

**Deficiency: TRANSFER TO SHEAR WALLS, DCR = 40.5:** No connection was observed between the concrete walls and the main floor diaphragm to resist in-plane shear forces. The results of this indicate a potential for building collapse as a result of a design seismic event *(Deficiency Item 1).* **Recommended strengthening method:** Install additional connections at the top of the concrete walls at 1914 construction.

**Deficiency: FOUNDATION DOWELS, DCR=2.20:** Wall reinforcement to provide a connection between the walls and foundation elements are required. Foundation dowels are used to provide a load path from concrete and masonry walls to foundation elements *(Deficiency Item 8*). **Recommended strengthening method:** Install vertical strapping to connect foundation to wall to resist overturning forces. Strengthening may also require additional foundation elements to resist the overturning forces, such as increased footings or soil anchors.

**Deficiency: REINFORCING STEEL, DCR=0.37:** The ratio of reinforcing steel area to gross concrete area is less than 0.0015 in the vertical direction, and 0.0025 in the horizontal direction. Reinforcing steel in concrete walls gives them the ability to remain in tact as seismic forces cause cracking and damage. With reinforcing in place, cracks in concrete absorb energy and reduce the overall damage within the structure. The concrete walls in this portion of the structure appear to be unreinforced. It should be noted from the DCR that the calculated strength of the wall to resist in-plane shear forces is greater than the expected design forces; however, this item is still considered a deficiency because it does not meet the detailing requirements of the code and damage to this item may still occur *(Deficiency Item 23).* **Recommended strengthening method:** Install carbon fiber or other fiber reinforced plastic (FRP) to the face of the concrete wall to provide reinforcing.

## SEISMIC HAZARDS FOR THE 1949 MAIN SCHOOL CONSTRUCTION

The main school building is constructed with concrete exterior walls and with wood framed interior walls, floors and roofs. The roof is sheathed with straight lapped boards and the floors are sheathed with diagonal lapped boards. The interior framed walls are constructed with plaster on each side.

There are several significant weaknesses that are expected to result in seismic hazards to the structure. These weaknesses are the result of inadequate connections, inadequate roof framing to resist horizontal loads, and weaknesses in the shear walls of the facility.

At the roof level, the straight sheathing is relatively weak and flexible element. For the size of this roof area seismic forces are expected to cause severe horizontal deflections in the roof. Theses horizontal deflections are expected to put substantial out-of-plane seismic loads into the north and south exterior walls. Large horizontal movement of these walls is expected to result in a collapse hazard. The north and south concrete walls are minimally anchored to the floor and the roof. This limits the capacity of these elements to resist the expected seismic loading in-plane and out-of-plane. The resulting out-of-plane loads at the north and south exterior walls are expected to also result in an increased collapse potential.

At the edges of the roof, there is inadequate anchorage to concrete walls to resist the induced forces that develop as loading is transferred from the roof to the concrete walls.

At east and west walls of the main school construction, the construction documents do not indicate any anchorage connection to the floors. At this location field inspections confirmed no anchorage is present at these walls. As a result, the in-plane and out-of-plane seismic forces create a high potential for collapse. At the north and south concrete wall piers lack connections to the roof, and also require additional connections.

At the basement level, a lack of interior cross walls in the north/south direction in the area of the cafeteria results in seismic loading in the north/south direction has been identified as a seismic hazard. As a result, the seismic loading is expected to load the concrete walls at the 1914 construction, and the exterior east and west walls until failure occurs. Since these concrete walls have a lack of connections, this expected to be a potential collapse hazard.

**SUMMARY OF SEISMIC DEFICIENCIES FOR THE 1949 MAIN SCHOOL CONSTRUCTION**
*Note: The following is a detailed summary of the seismic deficiencies for this portion of the building. For locations of these deficiencies refer to the deficiency plans included in this report. Each deficiency has an associated Demand Capacity Ratio (DCR). The DCR is a measure of seismic risk. DCR greater than 1 indicates structural forces are higher than the calculated capacity. Higher DCRs represent higher risk.*

**Deficiency: WALL ANCHORAGE/TRANSFER TO SHEAR WALLS, DCR=15:** The exterior concrete walls have a lack of connections anchoring the main floor level. At the east and west ends of the main school construction no anchorage was found at these locations. At the north and south walls of the main school construction limited anchorage connections are present. As a result there is inadequate capacity for the connection between the floor and the concrete wall to resist seismic loading in the out-of-plane and in-plane direction *(Deficiency Item 2 and Item 3)*. **Recommended strengthening method:** Install additional anchorage connections at floor of the main school construction.

**Deficiency: ROOF CHORD CONTINUITY, DCR=10.40:** At the edges of the roof, tension and compression forces are developed as a result of seismic loading. To resist the seismic loading, continuous members, or spliced members are normally used. These tension/compression elements located at the edges of roofs are referred to as chords. According to the structural details in the construction documents continuous chord members are not present. A lack of chord members at the roof causes the roof to be too flexible; as a result this deficiency is expected to be a collapse hazard *(Deficiency Item 4).* **Recommended Strengthening method:** Install strapping and blocking at the north and south edges of the main school building roof.

**Deficiency: WALL ANCHORAGE, TRANSFER TO SHEAR WALLS, DCR = 5.50:** The exterior concrete walls have a lack of connections anchoring the roof. At the exterior walls of the main school construction limited anchorage was found. As a result there is inadequate capacity for the connection between the roof and the concrete walls to resist seismic loading in the out-of-plane and in-plane direction *(Deficiency Item 5).* **Recommended strengthening method:** Install additional anchorage connections at the roof of the main school construction.

**Deficiency: WALLS CONNECTED THROUGH FLOORS, DCR = 3.46:** At the upper level cross walls acting to resist seismic loading in the north/south direction there are minimal or no connections to resist seismic loading for in-plane shear and overturning forces *(Deficiency Item 9).* **Recommended strengthening method:** Strengthen key shear walls to resist seismic loading in the north/south direction.

**Deficiency: FOUNDATION DOWELS, DCR=2.90:** According to the construction drawings, steel reinforcement for the exterior concrete walls of the main school do not have reinforcement that penetrates into the footings. Dowels are reinforcing steel elements that provide splices of reinforcement between successive concrete pours. At the interface between successive pours of concrete or the pour joint weaknesses in the concrete strength are typically present. Due to the methods of forming concrete, the footing is often poured separately. The pour joint leads to a weakness in the concrete wall at the top of the footing and can be a source of cracking from a seismic event *(Deficiency Item 7).* **Recommended strengthening method:** At locations of high overturning forces, provide tension connections and if necessary footings and soil anchors. At locations of high shear loading provide an anchorage attachment between the wall and footing.

**Deficiency: SHEAR STRESS CHECK, DCR = 2.0:** The interior framed walls resisting loading from the north/south direction are subject high shear forces. The most critical wall is located at the east and west side of the 1914 construction *(Deficiency Item 13).* **Recommended strengthening method:** Install additional anchorage connections at floor and roof of the main school construction. Strengthen the walls above this area into wood framed shear walls for the full height of the building.

**Deficiency: ROOF DIAPHRAGM SPANS, DCR = 2.0:** The tongue and groove roof sheathing on the 1949 construction is installed perpendicular to the joists. This type of sheathing is referred to as straight sheathing. Straight sheathing has weak structural performance attributes and is flexible. This weakness and flexibility is expected to perform poorly in a seismic event. As a result, the ASCE 31 standard requires that straight sheathing have distances between cross walls not to exceed 24 feet. In the main school building the distances between cross walls acting as seismic resisting elements exceed this requirement. The resulting flexibility and weaknesses in the roof represents a collapse hazard *(Deficiency Item 14).* **Recommended strengthening method:** Strengthening the roof with plywood sheathing at locations where straight sheathing is present.

**Deficiency: UNBLOCKED DIAPHRAGMS, DCR = 2.0:** The roof and floor framing with the sheathing are considered structural diaphragms. The structural diaphragms refer to the sheathing assembly of a floor or roof that transfers horizontal loads to shear walls. Placing wood blocking between joists acts to reduce the flexibility and provides additional strengthening measures. In wood framing, blocking is normally constructed from 2x material placed at edges of sheathing panels. The main floor framing is constructed with diagonal sheathing and has a hardwood finish. The hardwood finish acts as blocking to the diagonal sheathing and is compliant with the ASCE 31 standard. The roof diaphragm has no blocking and exceeds 40 feet between cross walls *(Deficiency Item 15).* **Recommended strengthening method:** Strengthen the roof with plywood sheathing; provide blocking at edges of plywood sheets as required for strength.

**Deficiency: CROSS TIES, DCR = 1.79:** The ASCE 31 standard requires continuous concrete anchorage to resist out-of-plane concrete wall forces. Cross ties are intended to insure the out-of-plane forces from concrete walls are distributed in the roof system *(Deficiency Item 16).* **Recommended strengthening method:** Install strapping and anchorage across sections of roofs and floors where no continuous members are present to distribute seismic forces into the floor and roof system.

**Deficiency: REINFORCING STEEL, DCR=0.88:** The ratio of reinforcing steel area to gross concrete area is less than 0.0025 in the horizontal direction. Reinforcing steel in concrete walls gives them the ability to remain intact even if the force levels exceed the expected capacity. With reinforcing, cracks in a concrete absorb energy and reduce the overall damage within the structure. The concrete walls in this portion of the structure appear to be unreinforced *(Deficiency Item 21).* **Recommended strengthening method:** Since the DCR for this item is less than 1.0, strengthening measures for this item is not required. This deficiency is listed to identify a weakness in structural detailing present in the existing building.

### SEISMIC HAZARDS FOR THE 1974 GYMNASIUM AND COSTELLO CENTER

The gymnasium/Costello Center is constructed with three sides of the building constructed from concrete tilt-wall construction. The south side of the gymnasium is constructed of a wood-framed wall with plywood sheathing. The roof is sheathed with plywood sheathing and has anchorage on the east and west walls through existing manufactured trusses. At the north and south sides of the building, anchorage to the roof is achieved through straps nailed to the plywood sheathing. At the Costello Center, at the east side of the building, a lower roof is present. This roof is supported from manufactured open web joists.

The north side of the building has large holes for windows. The results indicate weaknesses in the anchorage of the north wall to resist out-of-plane seismic forces. Weaknesses at the north shear wall of the gymnasium to resist in-plane loading contributes to the deficiencies at this location. At the wall between the gymnasium and the Costello Center, the lower roof is attached to the concrete wall. The anchorage details at this location indicate splitting will occur causing the connection to fail.

**DEFICIENCY SUMMARY FOR THE 1974 GYMNASIUM AND COSTELLO CENTER**

*Note: The following is a detailed summary of the seismic deficiencies for this portion of the building. For locations of these deficiencies refer to the deficiency plans included in this report. Each deficiency has an associated Demand Capacity Ratio (DCR). The DCR is a measure of seismic risk. DCR greater than 1 indicates structural forces are higher than the calculated capacity. Higher DCRs represent higher risk.*

**Deficiency: WALL ANCHORAGE, DCR=2.9:** Concrete walls that are dependent on the roof to resist out-of-plane seismic forces require anchorage. Strapping to distribute forces from the edges of the roof to the interior portions is required. The connections and strapping are not sufficient to resist the induced seismic loading at the north wall of the gymnasium *(Deficiency 11)*. **Recommended strengthening measure:** Provide additional roof-to-wall connections at the north wall.

**Deficiency: WOOD LEDGERS, DCR = 2.66:** At the lower roof area near the concrete wall above the Costello Center a wood ledger with anchor bolts is present. Out-of-plane tension forces developed in this element are expected to cause splitting (cross grain tension) *(Deficiency 12)*. **Recommended strengthening measure:** Provide tension connections to anchor out-of-plane wall forces to existing trusses.

**Deficiencies: SHEAR STRESS CHECK, DCR = 1.65:** Large windows are present at the upper portion of the north concrete wall. Shear stresses, as a result of in-plane forces, were found to be in excess of the recommended maximums identified in ASCE 31 for the north wall of the gymnasium *(Deficiency 17)*. **Recommended strengthening measure:** Provide additional strength to resist in-plane shear forces by infilling a portion of the windows with reinforced concrete or with steel framing.

**Deficiency: UNBLOCKED DIAPHRAGMS, DCR = 1.17:** The ASCE 31 standard requires that diaphragms with spans in excess of 40 feet between cross walls have blocking at plywood sheet edges. No blocking is present at the gymnasium roof *(Deficiency 18)*. **Recommended strengthening measure:** Provide blocking at the north and south portions of the gymnasium and Costello Center roof to resist induced loading as required to strengthen the roof.

**Deficiency: WALL OPENINGS, DCR = 1.11:** The north wall of the gymnasium has wall openings in excess of 75 percent of wall length *(Deficiency 19)*. **Recommended strengthening measure:** Provide additional strength to resist in-plane shear forces by infilling a portion of the windows with reinforced concrete or with a steel frame.

**Deficiency: CROSS TIES, DCR = 1.04:** To prevent collapse of heavy concrete walls as a result of seismic forces anchorage to interior portions of a roof or floor requires a positive attachment. These positive attachments are referred to as cross ties. The ASCE 31 standard requires cross ties to prevent collapse of heavy concrete walls. At the east wall of the Costello Center cross tie connections are not adequate *(Deficiency Item 20).* **Recommended strengthening measure:** Provide additional anchorage to develop out-of-plane wall forces within the roof system.

**Deficiency: PRECAST WALL PANELS, DCR = 0.79:** Precast wall panels must be connected to the foundation. Based on information provided, no connection is present at these locations *(Deficiency Item 22).* **Recommended strengthening measure:** Since the DCR for this item is less than 1.0, strengthening measures for this item are not required. This deficiency is listed to identify a weakness in structural detailing present in the existing building.

## SEISMIC HAZARD FOR THE 1959 PASTORAL CENTER

The Pastoral center is constructed as a wood framed structure. The floors and exterior walls are sheathed with diagonal sheathing. The roof of this structure is sheathed with straight tongue and grooved sheathing. The stairwells are constructed with concrete masonry walls and concrete stairs. The exterior of the building is finished with a brick veneer.

The primary weaknesses in this structure to resist seismic loads relates to a lack of shear wall capacity and related connections. The largest hazard in this structure is the interior shear walls in the east/west direction at the main and lower levels. These interior walls do not have adequate connections to transfer in-plane loading for shear and overturning forces. The shear walls resisting loading in the north/south direction have also been identified. Narrow wall sections between windows as a result may require strengthening as well.

During the evaluation process we have been notified that removing walls and reconfiguring space in the Pastoral Center are options considered in formulating a modernization plan for this facility. For this reason the seismic considerations of the interior walls used to resist seismic loading were limited. This evaluation assumes an interior wall line in the east/west direction is acting as a shear wall line. No other interior walls are considered resisting seismic forces.

## DEFICIENCY SUMMARY FOR THE 1959 PASTORAL CENTER

*Note: The following is a detailed summary of the seismic deficiencies for this portion of the building. For locations of these deficiencies refer to the deficiency plans included in this report. Each deficiency has an associated Demand Capacity Ratio (DCR). The DCR is a measure of seismic risk. DCR greater than 1 indicates structural forces are higher than the calculated capacity. Higher DCRs represent higher risk.*

**Deficiency: SHEAR STRESS CHECK, DCR = 7.5:** At the main floor level and the ground floor level, the interior walls are constructed from plaster or gypsum wall board. For seismic loads generated in the east/west direction, the roof and floor framing are not capable of transferring seismic loads to the exterior walls. Therefore, an interior wall line located north of the middle stair well was considered as a shear wall. This interior wall was found to be inadequate to resist seismic loads *(Deficiency Item 1)*. **Recommended strengthening method:** Strengthen this interior wall with plywood sheathing.

**Deficiency: GYPSUM WALLBOARD OR PLASTER SHEAR WALLS, DCR = 4.4:** The interior shear walls at the middle of the building are constructed of gypsum wallboard or plaster and are not adequate to support the induced seismic loading *(Deficiency Item 2)*. **Recommended strengthening method:** Strengthen this interior wall with plywood sheathing.

**Deficiency: WALLS CONNECTED THROUGH FLOORS, DCR = 4.4:** Shear wall connections through floors are used to prevent walls from overturning and provide a mechanism to transfer horizontal forces. These connections are not present *(Deficiency Item 3)*. **Recommended strengthening method:** Install the necessary connections through the floors to provide sufficient anchorage to prevent sliding and overturning of the shear walls.

**Deficiency: NARROW WOOD SHEAR WALLS, DCR = 1.38:** Wood sheathed walls with narrow sections between windows or doors are weak in resisting overturning forces *(Deficiency Item 4)*. **Recommended strengthening method:** Provide plywood sheathing and anchorage connections to resist seismic forces.

**Deficiency: ROOF DIAPHRAGM SPANS, DCR = 2.13:** The tongue and groove roof sheathing is installed perpendicular to the joists. This type of sheathing is referred to as straight sheathing. Straight sheathing has weak structural performance attributes and is flexible. This weakness and flexibility is expected to perform poorly in a seismic event. As a result, the ASCE 31 standard requires that straight sheathing have distances between cross walls not to exceed 24 feet. The resulting flexibility and weakness in the roof represents a collapse hazard *(Deficiency Item 5)*. **Recommended strengthening method:** Strengthening the roof with plywood sheathing at locations where straight sheathing is present.

**Deficiency: UNBLOCKED DIAPHRAGMS, DCR = 1.28:** The roof and floor framing with the sheathing are considered structural diaphragms. The structural diaphragms refer to the sheathing assembly of a floor or roof that transfers horizontal loads to shear walls. Placing wood blocking between joists acts to reduce the flexibility and provides additional strengthening measures. The main floor framing is constructed with diagonal sheathing and plywood. The diagonal sheathing acts as blocking to the plywood and is compliant with this requirement. The roof diaphragm has no blocking and exceeds 40 feet between cross walls *(Deficiency Item 6)*. **Recommended strengthening method:** Strengthen the roof with plywood sheathing; provide blocking at edges of plywood sheets as required for strength.

### NON-STRUCTURAL HAZARDS

Non-structural hazards are seismic hazards for items that are not part of the structural system and could result in loss of life, or prevent exiting from buildings following a seismic event. Within all the buildings, we found numerous non-structural hazards present. Tall, unreinforced, unbraced masonry chimneys in the Main school and the Pastoral Center represent a falling hazard. Non-bearing masonry walls at the 1914 original construction area are not anchored at the top and represent a non-structural falling hazard. Hazardous mechanical equipment was observed to be missing anchorage in the boiler room of the Pastoral Center and the school and represent a potential equipment failure hazard.

### DEFICIENCY SUMMARY OF NON-STRUCTURAL SEISMIC HAZARDS

*Note: The following is a detailed summary of the non-structural seismic deficiencies for the Pastoral Center and the school facility. For non-structural deficiencies that have been identified at specific locations, deficiency plans have been included in this report. Non-structural deficiencies have no demand capacity ratio (DCR) determined.*

**Deficiency: UNREINFORCED MASONRY CHIMNEYS:** Masonry chimneys that exceed twice their width in height represent a falling hazard. Unreinforced masonry chimneys are present at the main school building and in the Pastoral Center *(Deficiency Item NS1).* **Recommended Action:** Remove upper portion of chimney to the roof level or reinforce with steel angles.

**Deficiency: HAZARDOUS MATERIALS/HEAVY EQUIPMENT ANCHORAGE:** The main school building and Pastoral Center have boilers present. These boilers were not observed to be anchored. This condition not only represents a falling hazard, it also represents potential due to equipment failure or release of hazardous or explosive materials *(Deficiency Item NS2).* **Recommended Action:** Anchor heavy equipment or remove.

**Deficiency: PARTITION TOPS:** Masonry walls located in the locker room areas were constructed without connections to the top, and represent a potential collapse hazard *(Deficiency Item NS3).* **Recommended Action:** Provide anchorage at the top of the masonry walls to prevent a collapse hazard.

For remaining non-structural hazards refer to Deficiency Plan S1.07.

### MODERNIZATION RECOMMENDATIONS

The findings in this report indicate weaknesses in the performance of these facilities to resist seismic loading. As a result, in its current condition we would expect substantial damage to occur during a design seismic event. Therefore, it would be prudent to take action and strengthen the highest risk weaknesses identified in the building as a minimum.

It should be noted that since the school facility has been permitted and approved by the local building official to be used in its current capacity, the strengthening measures would be voluntary unless the modernization effort requires significant changes to the structural systems. Significant changes to the structural systems are defined by the building code as an increase in the forces on any element of the structure by more than 5 percent or a decrease in the capacity of any structural element by more than 5 percent. Changes of the use of the building to an increased occupancy level or use would also trigger a mandatory seismic retrofit of affected areas.

Although the building code only requires areas impacted by changes in the structural systems or changes in occupancy to be strengthened, it is recommended that modernization plans consider strengthening weaknesses in the portions of the facility that are affected by architectural changes. Furthermore, it is also recommended that as part of a modernization effort, an action plan be formulated eventually in order to mitigate the seismic hazards identified in this facility.

**OPINION OF PROBABLE CONSTRUCTION COSTS**

The engineering estimates of probable construction costs are based on this preliminary engineering study to repair and replace the noted items. The estimate represents the cost in August 2009. The construction cost estimates have a 30 percent contingency to reflect that the final design has not occurred and fluctuation in bids may result in variation of costs. Construction cost data presented within this section is not intended to be the lowest possible cost for completing the work, instead, the median cost that would result from the responsible bids received from competent local contractors given a moderate amount of competition in the vicinity. Actual project costs can vary considerably based on the competition, time of year the project is bid, schedule to complete the work, as well as economic conditions for the local work force.

The cost in the estimate is for construction costs only and do not include financing, pre-design, final engineering, permitting, or construction administration.

The unit costs used in these estimates are derived from suppliers, local specialty contractors, past experience of the engineer on similar types of projects, as well as published cost estimating guides such as the *2008 Construction Cost Guide*.

The construction costs include provisions for removal and repairs to match existing architectural finishes.

The cost estimates identified in this report are intended to address the structural deficiencies only. The modernization efforts would likely encompass other costs in addition to the costs listed. These other costs would be in additional to the costs identified in this report, and would likely include heating/Air Conditioning equipment, electrical system changes, plumbing, architectural including modification for compliance with Americans with Disabilities Act (ADA), or other modifications to meet the needs of the facility.