STRUCTURAL INVESTIGATION OF MISSOURI AVENUE ELEMENTARY SCHOOL

ROSWELL, NEW MEXICO

BY

ROBERT ALLEN, P.E.
BACKGROUND:

The Missouri Avenue Elementary School consists of three phases. The original school was designed and built around 1950 (as indicated on the design drawings). The second phase is a classroom wing that was added to the north side of the original structure around 1959. The third and final phase is a multipurpose room (which includes a gymnasium/cafeteria) that was added in 1981.

The first two phases were built with similar construction materials and methods. The foundations are spread (shallow) concrete footings and stem walls around the perimeter of the buildings. A mechanical or pipe tunnel runs adjacent to the exterior stem wall. The tunnel is about 4 feet wide and another stem wall (without a footing) forms the inside wall of the tunnel. The majority of the floor is concrete slab-on-grade that is turned down onto the top of the interior stem wall. A structural slab spans between the interior and exterior stem walls and turns down on top of the exterior stem wall. There is no rebar tying the structural slab to the exterior stem wall. The exterior walls are constructed with 8” concrete masonry units (CMUs) and are bearing on the turned-down structural slab. Truss-type Dur-O-Wall joint reinforcement appears to be used in all 8” CMU walls. A brick veneer covers the CMU walls and bears on a brick ledge integral with the footing. The Dur-O-Wall appears to have been used to tie the brick veneer to the 8” CMU walls. The main corridor that runs the length of the building is formed by an 8” CMU load-bearing wall on each side. These walls also bear on shallow spread footings. The roof framing consists of steel open-web joists which bear on the 8” CMU walls. Load-bearing
wood-framed walls bear near the center of the steel joists and on the interior CMU walls. Wood roof rafters bear on the exterior CMU wall, the interior load-bearing CMU/wood-framed wall, and are supported near mid-span by the wood-framed wall bearing on the steel joists. Wood decking is supported by the rafters and provides the substrate for the composition shingle roofing. The original roofing shown on the construction drawings was composed of clay tile.

The multipurpose room was not investigated, but it is constructed with 12” CMU exterior walls and has a steel joist roof with steel roof deck. The foundations could not be seen and no drawings were available to the investigator.

**SCOPE OF THE INVESTIGATION:**

The structural investigation of the Missouri Ave. Elementary School was conducted to determine:

1. The extent of structural damage or degradation associated with the building;
2. Whether any damage or degradation poses an imminent threat to the occupancy of the building;
3. The possible causes of the damage or degradation;
4. Whether the causes still exist and are continuing to act on the building; and
5. Whether it is economically feasible to repair the school as opposed to replacing the school. (See Recommendations.)

**INVESTIGATIVE ACTIVITIES PERFORMED:**

1. Visual observations were made inside and outside the building to establish the different types of distress and the extent of the distress present. The observations were made by a structural engineer who is licensed in the State of New Mexico as a Professional Engineer.

**FINDINGS OF THE INVESTIGATION:**

**Roof Framing:**

The following observations were made:
1. A cursory observation of the roof from outside the building did not indicate any structural problems with the roof framing. However, a more thorough investigation of the roof framing would be required to confirm its condition. No assumptions about the integrity of the roof framing should be made from the observations made during this investigation.

Main Building Walls: (8" CMU with Brick Veneer)

The following observations were made:

1. The 8" CMU walls are covered by the brick veneer on the outside, but are visible on the inside of the building. Very little distress can be seen in the exterior CMU walls. However, the brick veneer shows distress around the entire building. The main types of distress are:
   a. Most corners at the top of window openings show stair-stepped cracks;
   b. Stair-stepped cracks are visible in several locations near building corners near the bottom of the walls;
   c. Large out-of-plane displacements are visible in several areas around the building, but are most obvious on the south side of the building;
   d. Some horizontal cracks are visible in different areas around the building; and
   e. The majority of cracks are limited to the mortar joints, however some cracks extend through the brick as well.

2. There does not appear to be any imminent threat associated with distress seen in the main load-bearing 8" CMU walls. Without more extensive investigation, it is not possible to determine whether the brick veneer may pull away from the wall and fall from various locations around the building.

3. Possible causes for the distress observed in the exterior walls include:
   a. Foundation problems due to poor subgrade, water infiltration, or improper soil preparation;
   b. Inadequate lateral load resisting system to resist wind or seismic loads;
   c. Inadequate lintel and lintel connection design over large opening in CMU walls for windows; and
d. Inadequate shrinkage control joints.

4. It is very likely that the causes listed above are still acting on the walls and may continue to cause further distress.

**Slab-on-Grade and Slab Over the Pipe Tunnel:**

The following observations were made:

1. Direct observations of the concrete slabs were limited to one classroom and one janitor’s closet. In general, the slab-on-grade appears to be in good condition. However, the slab over the pipe tunnel appears to be vertically displaced in many areas, especially in the classrooms along the south side of the original building. For the most part, the slab over the tunnel is sloping down toward the exterior wall. The slope varies but was measured in several places to be approximately ¼” per foot. Since carpet covers most of the concrete slab, potential cracks could not be observed. There are also places in the 1959 addition where the slab has separated from the stem wall.

2. There does not appear to be any imminent threat associated with distress seen in the concrete slabs.

3. Possible causes for the distress observed in the concrete slabs include:
   a. Foundation problems due to poor subgrade, water infiltration, or improper soil preparation; and
   b. Inadequate isolation of the concrete slabs from the stem walls to allow relative movement.

4. It is very likely that the causes listed above could cause further distress in the concrete slabs.

**Stem Walls:**

The following observations were made:

1. Direct observations of the stem walls were limited to the exterior portions visible above grade. Most of the distress observed was actually in the brick veneer covering the concrete stem wall. It is unclear whether the stem wall has experienced the same distress as the brick veneer, or not. In general, the stem walls appear to be in good condition. Most of the distress in the stem
walls appears to be located at vents formed by spacing soldier bricks with gaps between them to allow air into the tunnel. At these locations, cracks are present at some of the corners of the vent, and some of these cracks extend several feet away from the vent. Some of the soldier bricks have been completely displaced from their intended location.

2. There does not appear to be any imminent threat associated with distress seen in the stem walls.

3. Possible causes for the distress observed in the concrete slabs include:
   a. Foundation problems due to poor subgrade, water infiltration, or improper soil preparation; and
   b. Excessive stress due to an inadequate lateral resisting system.

4. It is very likely that the causes listed above could cause further distress in the stem walls.

**Interior 4” CMU Partitions (Non-Structural Walls):**

The following observations were made:

1. The most visible distress is observed in the interior partitions. These partitions are constructed of unreinforced 4” CMU (according to the design drawings). These partitions bear directly on the slab-on-grade and the structural slab which spans over the pipe tunnel. Large cracks are present in many of the partitions that separate the classrooms along the south side of the school. Some of the cracks are more than ½” wide. Most of the cracks have been filled with flexible sealants (“caulk”) of various types. It is obvious that the cracks have continued to grow and shrink over time. It is not obvious when the cracks originated. Most of the cracks appear to start or stop approximately 4 feet from the south exterior wall of the building. This location coincides with the location of the stem wall that forms the interior wall of the pipe tunnel. This is also the location where the concrete slab transitions from a slab supported on soil to a slab that spans over the pipe tunnel.

2. There does not appear to be any imminent threat associated with distress seen in the 4” CMU partition walls, however further investigation should be done to determine how the tops of the walls are supported laterally to prevent
out-of-plane displacement. Sever out-of-plane displacement, though unlikely, could result in the collapse of the partition. This would only occur during a strong seismic event.

3. Possible causes for the distress observed in the 4” CMU partition walls include:
   a. Foundation problems due to poor subgrade, water infiltration, or improper soil preparation;
   b. Inadequate support or differential settlement of support for the partitions; and
   c. Insufficient flexibility, due to lack of steel reinforcing, in the partition walls to accommodate movement and resist shear stresses.

4. It is very likely that the causes listed above could cause further distress in the 4” CMU partition walls.

North Stairs:

The following observations were made:

1. Some cracks were observed in the brick veneer at the stairs. Also, the stairs appear to have displaced from the exterior building wall.
2. There does not appear to be any imminent threat associated with distress seen in the stairs.
3. Possible causes for the distress observed in the concrete slabs include:
   a. Foundation problems due to poor subgrade, water infiltration, or improper soil preparation.
4. It is very likely that the causes listed above could cause further distress in the stairs.

Expansion Joints at Sidewalks and Concrete Aprons:

The following observations were made:

1. Asphalt-impregnated expansion joint material was used around the perimeter of the building to prevent the transfer of loads and stresses between the exterior concrete flat work and the building foundation and to prevent the infiltration of water into the soil immediately adjacent to the building
foundation. Over several years, the concrete aprons and the joint material have separated from the building. In some places, the separation is more than an inch. This displacement and the associated loss of seal has allowed rain or melting snow to run unencumbered directly into the soil next to the building.

EXPLANATION OF CAUSES:

Much of the soil in and around Roswell has high concentrations of moisture-sensitive (i.e. expansive) clay. Moisture-sensitive clay varies in volume depending upon its moisture content. Typically, moisture-sensitive clays are extracted from the immediate vicinity of building foundations through a process called over-excavation. After the clay is removed, it is replaced with engineered soil (soil with desirable properties). The engineered soil is compacted to increase its soil bearing capacity (capacity to carry building loads). The drawings do not indicate that the original soil was modified in this manner. It is possible that much of the distress observed at the school may be attributed to poor soil containing moisture-sensitive clay and the infiltration of surface water into the soil supporting the building foundations and the slab-on-grade. The lack of proper isolation between the concrete slab and the stem wall may preclude a permanent repair to the slab and the partitions bearing on it.

Also, structural engineering and the subsequent building designs to resist loads induced by seismic activity have changed substantially over the past 50 years. CMU walls have been used for many years to resist lateral loads (wind or seismic). Over the last several years, changes in the Building Code have required more ductility to be designed and detailed into the masonry walls for resisting and dissipating loads caused by seismic events. The 8” load-bearing CMU walls may or may not be designed to adequately resist seismic loads, but the 4” unreinforced CMU walls are most definitely not. Although Roswell is in a relatively low seismic risk region, seismic events have occurred in the last 50 years. The 4” CMU walls should be further investigated to determine if they should be modified or replaced with more structurally adequate construction.
The very large openings in the exterior walls, which were originally designed for large windows, leave very little of the wall to resist lateral loads. Lateral loads from the roof and the wall itself must be transferred to the foundation/soil interface through structural elements capable of resisting the stresses induced by those loads. The relatively small portions of full-height walls (piers) adjacent to the large openings may not be adequate to resist the lateral loads that have been placed on the school over the past 60 years. Cracks in the brick veneer indicate excessive stresses in the veneer. The shallow lintels over the window openings may also be overstressed during wind or seismic events due to the weak connections between the lintel and its supporting elements on either side.

For many years, the school had a clay tile roof that would have weighed much more than the current roofing material. The mass of the roof would have induced very large lateral loads during seismic events (even small earthquakes). Also, when the heavy clay tile was replaced with much lighter composite shingles, the reduction in dead load may have allowed the expansive clay to swell. This swelling could cause differential displacement between different building elements which would create cracks or visible separations between walls, floors, and ceilings.

**CONCLUSIONS:**

The school, which was designed and built in the 1950’s, appears to have suffered ongoing structural distress for some time. It is difficult to identify which cause or causes are responsible for each individual area of distress or damage. It is even possible that large portions of the observed damage occurred during large wind or seismic events. It appears that many of the areas of distress are still being affected and are still deteriorating. A substantial amount of remediation must be performed to reduce the future deterioration of the building’s structural integrity. The unreinforced CMU partitions may have to be replaced throughout the school to eliminate the possibility of collapse during a seismic event.
The potentially unstable soils beneath the school could continue to cause various problems including cracks and relatively large movements of various parts of the building. Soil stabilization or foundation stabilization (e.g. helical piers) may be required to reduce further damage to the building.

RECOMMENDATIONS:

Due to the large scope of existing and potential damage to the school building, it is recommended that strong consideration be given to replacing the school building with a building that is designed to meet current codes and standards. It is anticipated that very large amounts of work would be necessary to stabilize the school’s existing foundation to prevent further structural and aesthetic damage and distress. There is also a possibility that no reasonable amount of remedial work will stabilize the building enough to prevent further damage.

It should be noted that certain modifications or additions to the school building may, in turn, require that the entire school building comply with the International Existing Building Code (IEBC). Whether it is required, or not, it would be advisable that the building comply with the IEBC to help ensure the safety and welfare of the students, teachers, and administrative staff.

Our firm cannot determine the associated costs of repairs and modifications that would be required to achieve compliance with the IEBC.

This report was written and submitted by,

Robert Allen, P.E.
Desert Eagle Engineering, LLC
STRUCTURAL INVESTIGATION
MISSOURI AVENUE ELEMENTARY SCHOOL
ROSWELL, NEW MEXICO

APPENDIX
INVESTIGATION PHOTOS
Photo 1: Concrete slab and wall displacement near north entrance.

Photo 2: Ceiling and wall separation near north entrance.
Photo 3: Interior partition crack adjacent to south exterior wall.

Photo 4: Crack with separation where 4” CMU interior partition intersects exterior 8” CMU wall.
Photo 5: Interior partition crack due to exterior wall differential displacement.

Photo 6: Previously sealed crack in interior partition.
Photo 7: Interior partition with previously sealed crack and subsequent movement.

Photo 8: Crack in exterior wall brick veneer at pipe tunnel vent.
Photo 9: Large separation between concrete apron and exterior stem wall.

Photo 10: Large shear crack at exterior wall intersection and window lintel.
Photo 11: Repointed cracks at window lintels.

Photo 12: Repointed mortar crack near repaired/replaced wall pier on west side of building.
Photo 13: Cracks at north stair showing multiple repair attempts.

Photo 14: Large stair-stepped crack at pipe tunnel vent.
Photo 15: Rotated and displaced brick veneer on south side of building.

Photo 16: Large stair-stepped crack below window near southeast corner of 1959 addition.
Photo 17: Large stair-stepped crack on south side of 1959 addition.

Photo 18: Mortar cracks around area where a brick was removed on south wall of 1959 addition.