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August 7, 2023

Charlie Brock
Superintendent
Estill County Schools
253 Main Street
Irvine, KY 40336

Re: Structural Observation at Estill County Middle School

Dear Mr. Brock,

At your request, we visited the above referenced project on August 4, 2023. Said visit was to observe the existing conditions for reported heaving of walls and floor slabs within the building footprint. Specifically, it was said that the exterior walls were in acceptable condition, but the interior of the building has undergone several inches of heaving due to the presence of expansive pyritic shale within the building pad.

You provided us with the original architectural and structural plans, as well as the proposed mitigation/repair plans produced by the original structural engineer. Your staff gave us a quick walk through of the facility, pointing out areas they were specifically concerned about.

Our site observations and professional opinions are summarized below.

Existing Structure

The existing building consisted of wood truss and 2x framed roof bearing on CMU walls. The second floor was framed with a suspended concrete slab on open-web steel joists, supported by CMU interior and exterior walls. The first floor is primarily a slab on grade. A very general overview of the structure: the exterior walls and corridor walls are the primary bearing walls for the building. Floor and roof joists span from exterior wall to corridor wall, corridor wall to corridor wall, and corridor wall to exterior wall. Reference section A on sheet A-43 of the original architectural drawings.

One detail we found to be unlike current construction techniques was the lack of a connection between the second floor slab and continuous CMU walls. The slab appeared to have no mechanical connection between it and the CMU walls that penetrated the floor. We observed a continuous strip of ½"+/- foam expansion joint between the wall and slab and no deck edge angle was observed. Typically, these CMU walls would be used as shearwalls to resist lateral forces from wind and seismic loads. However, there are no notable lateral force system details in the original project drawings. At this time, we are unsure of the original design intent for the transfer of lateral loads into shearwalls.

Issues Encountered

Of course, the primary issue is the presence of expansive pyritic shale. Based on our past experience with pyrite, pyritic shale tends to exist within the New Albany Formation located at this site. Pyritic shale has the potential to swell or heave if disturbed, causing upheave to foundations and floor slabs. The "swelling" is caused by a chemical reaction with oxygen, called "oxidation". Crystals will form shortly after the oxidation process. The formation of these crystals can cause upheave resulting in detrimental effects to slab on grades and conventional shallow footings.

There are many areas of differential heave within the structure; some areas have heaved while other areas have not, resulting in non-uniform movement of the building and subsequent stresses placed on the interior walls and slab on grade. We did not observe much movement in the exterior walls, presumably because their footings extend further down into a less active soil zone than the interior slab.

As stated, there were many problematic areas observed within the facility. The worst of the movements had occurred in the area of the building from the main foyer, down Corridor 102, and the classrooms tied to this corridor. We used a laser auto-level to measure approximately 5 ¼" of heave in this main corridor hallway. The load-bearing corridor walls had not seen this amount of movement, measuring somewhere between 1 ½" – 2" of total heave of these walls. Again, this would be due to the corridor wall footings extending down to a less active soil layer. Other areas of the building have also seen significant heave, but this portion of the building was the most notable.

Cracks were most notable at interior, non-structural partitions that were placed on thickened slab footings (the walls rest more or less directly on the slab on grade). As the shallow slab on grade heaves to larger magnitudes than the CMU walls that rest on deeper continuous footings, substantial differential movements can be seen between the two wall conditions. Many times this occurred at walls that butt against one another.

Some of the CMU classroom walls are continuous from first floor to the bottom of wood roof trusses. As mentioned, these walls are not connected to the second floor slab, which has allowed them to move freely relative to the floor. Considering the affects of wall heaving only, this is a good condition as the second floor would be in worse condition had it been mechanically attached to the CMU walls. However, the lack of a structural connection remains a concern for lateral force resistance of the building.

Some floor slabs within a single classroom have heaved as much as four inches. Many doors "stick" and will not fully open or close. Many interior door frames are warped and notably out of square. With this much slab heave observed, we also question the condition of under-slab plumbing pipes and electrical lines.

Although the functionality of the building is compromised, in our opinion the building is not in danger of collapse or a structural life safety issue to its occupants. The building needs to be placed on a monitoring program, and we recommend a reputable structural engineer perform a structural observation every school semester for the next 3 to 5 years. This would be to observe how much (if any) the building is still moving and to call attention to any life safety issues that may result with further heaving of the shale.

There are some areas of lintels at corridor walls that we consider in need of repair and should be placed on your maintenance plan.

Previous and Future Repairs

It was said that the gymnasium had the slab on grade demolished, approximately 3 feet of soil excavated, treated, and a new suspended slab placed. This was an effort to create a crawlspace and relieve some of the heaving action to the slab on grade. We were not able to observe previous repairs, but the gym floor did appear to be in acceptable condition. We do not believe these repairs were carried out for the entire building's footprint.

Pyritic shale is difficult to mitigate since the main catalyst for its heaving is exposure of the shale to oxygen. When repair work is performed, you assume the risk of simply further exposing the shale to oxygen and having new problematic areas in subsequent years. Remedial methods post construction (once pyrite has been disturbed) as of present date, have not been established. It is recommended to not perform invasive construction techniques within the building area to limit disturbance as much as possible. It is further recommended to monitor the building for additional movement and perform periodic structural inspections, as noted earlier.

Please let us know if there are any further questions.

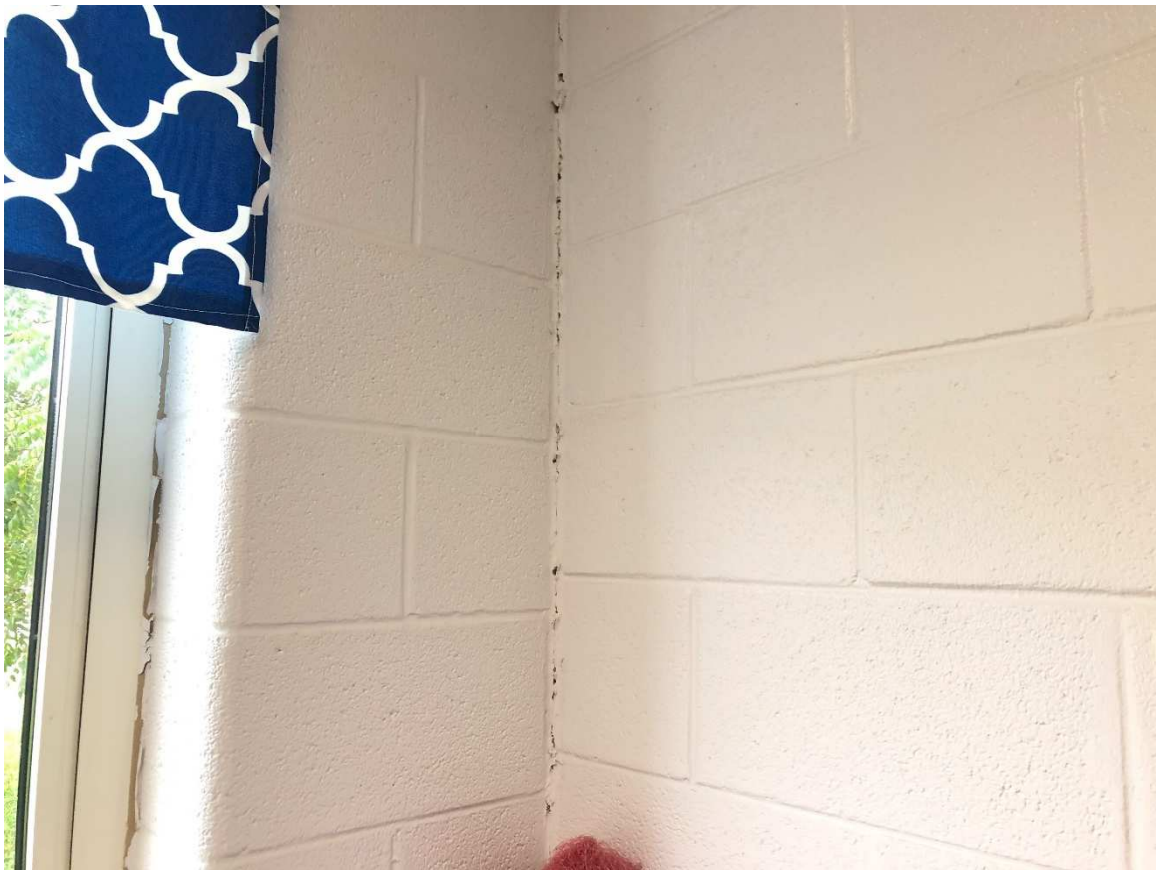
ACKNOWLEDGEMENT

Our site visit consisted of visual observations only, made solely for the purposes as described in this report. Neither the observations nor this report covers any other structural, mechanical, plumbing, electrical, architectural, hydrological or geotechnical features that are not described in this report. This report and recommendations may not reflect variations in conditions that could exist intermediate of the observed locations or in concealed areas of the structure, or information that has not been disclosed to us.

Sincerely,

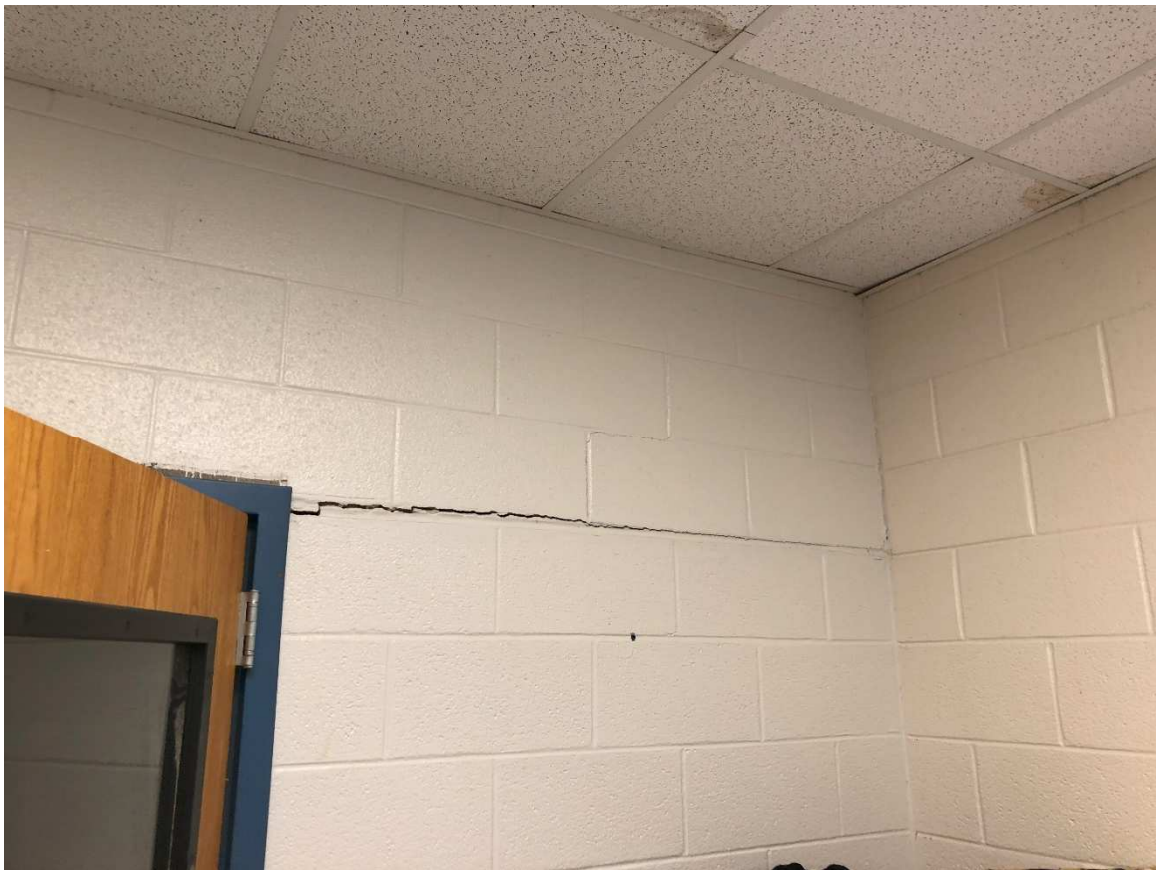
Logan Sams, P.E.

Front entrance of school



Interior partition heave

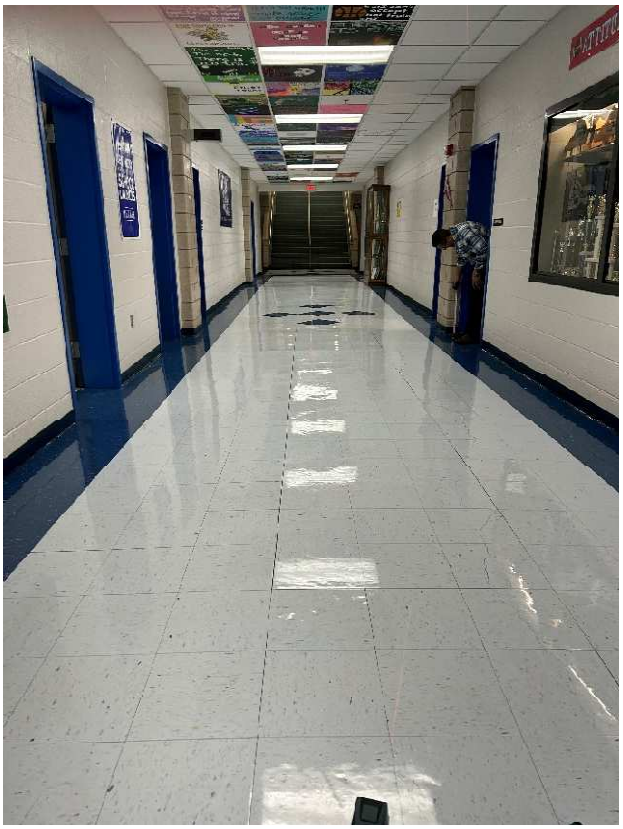
Interior partition heave



Horizontal crack in CMU

Slab heave @ construction joint

Significant crack in partition wall

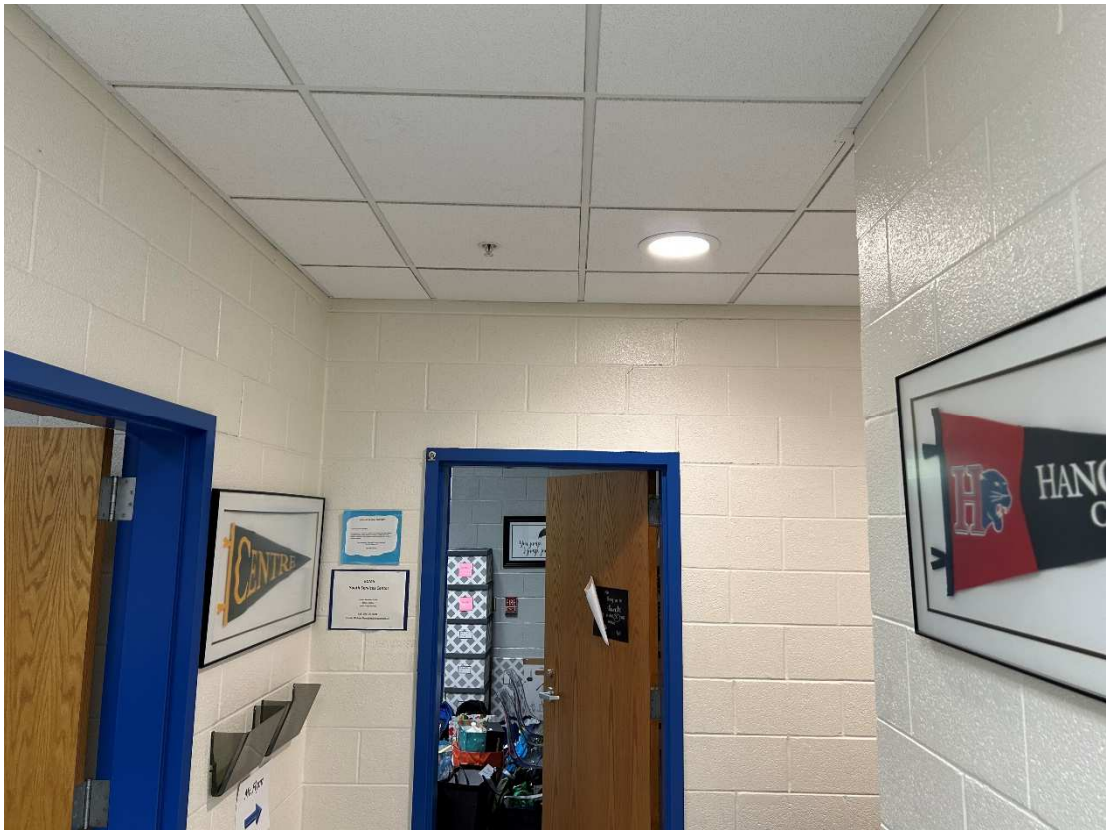


View of hallway w/ slab heave

Laser level establishing reference point at front pilaster mortar joint

Laser level indicating a rise in concrete slab of approx. 2” from exterior door to mid-point in classroom hallway.

Laser level indicating a rise in concrete slab of approx. 5 1/4” from exterior door to most severe heave location in corridor.



Crack in CMU near youth service center room

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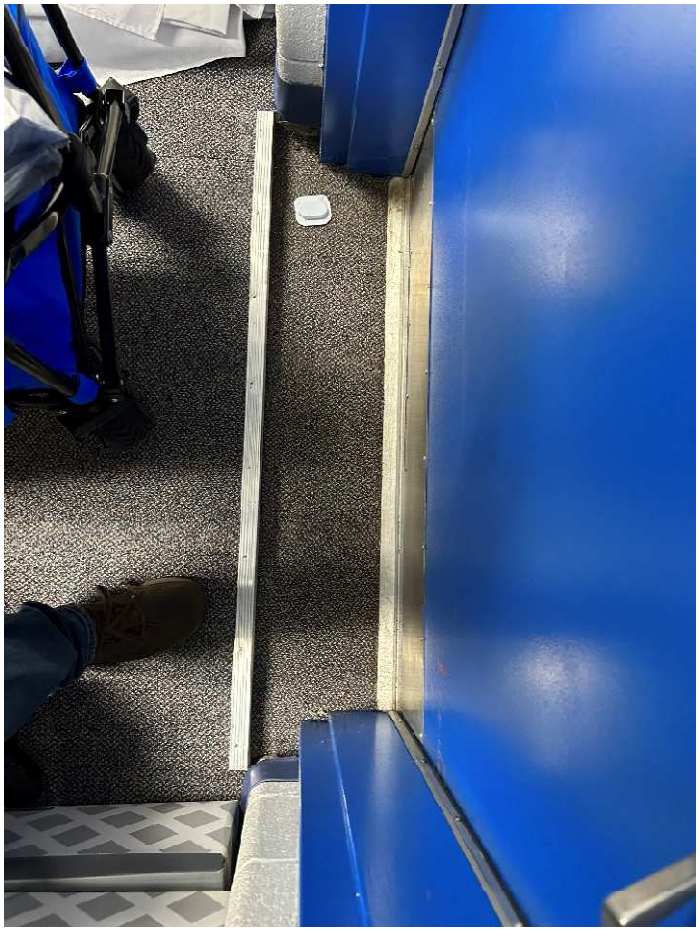
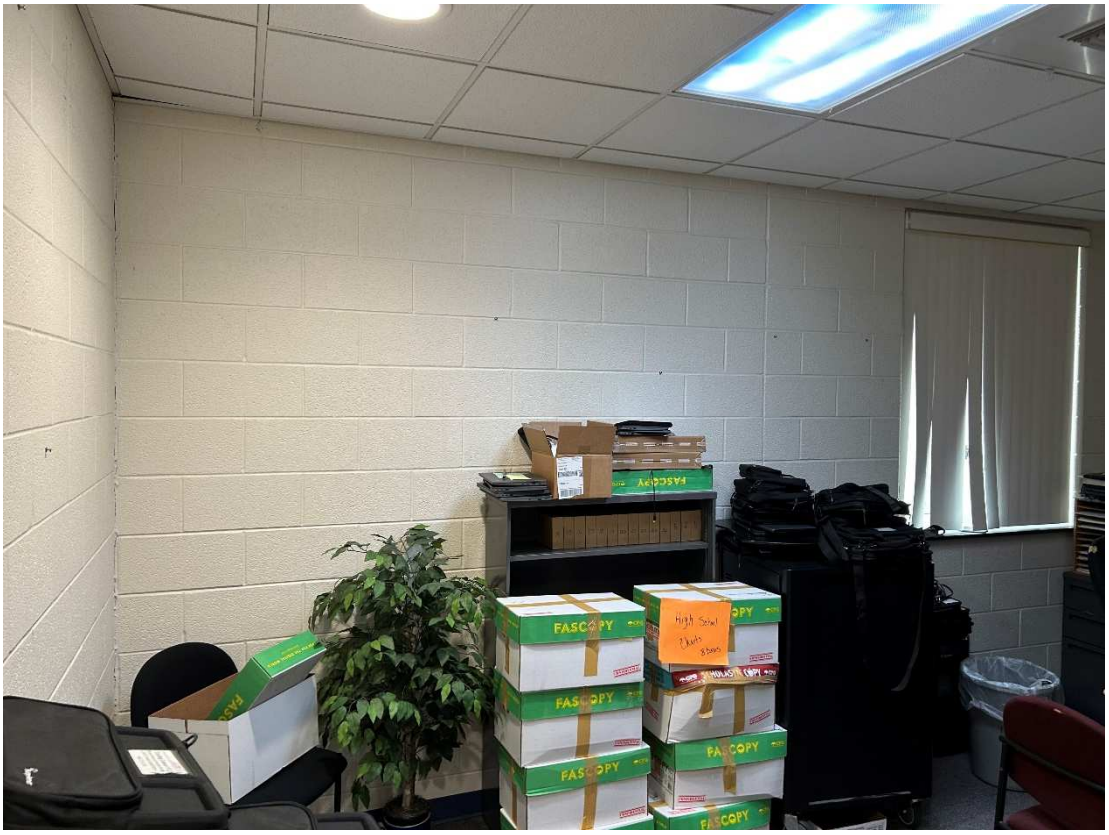
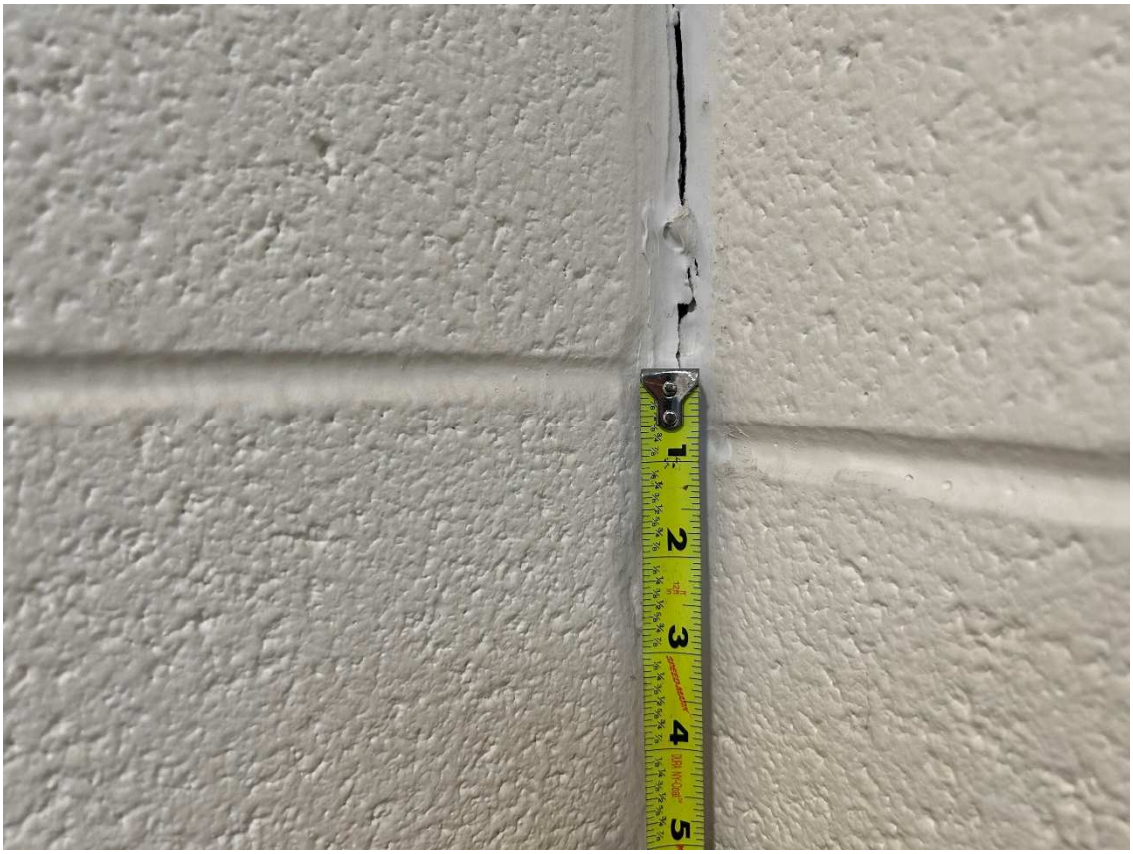


Visible heave in concrete slab near exterior door of youth service center

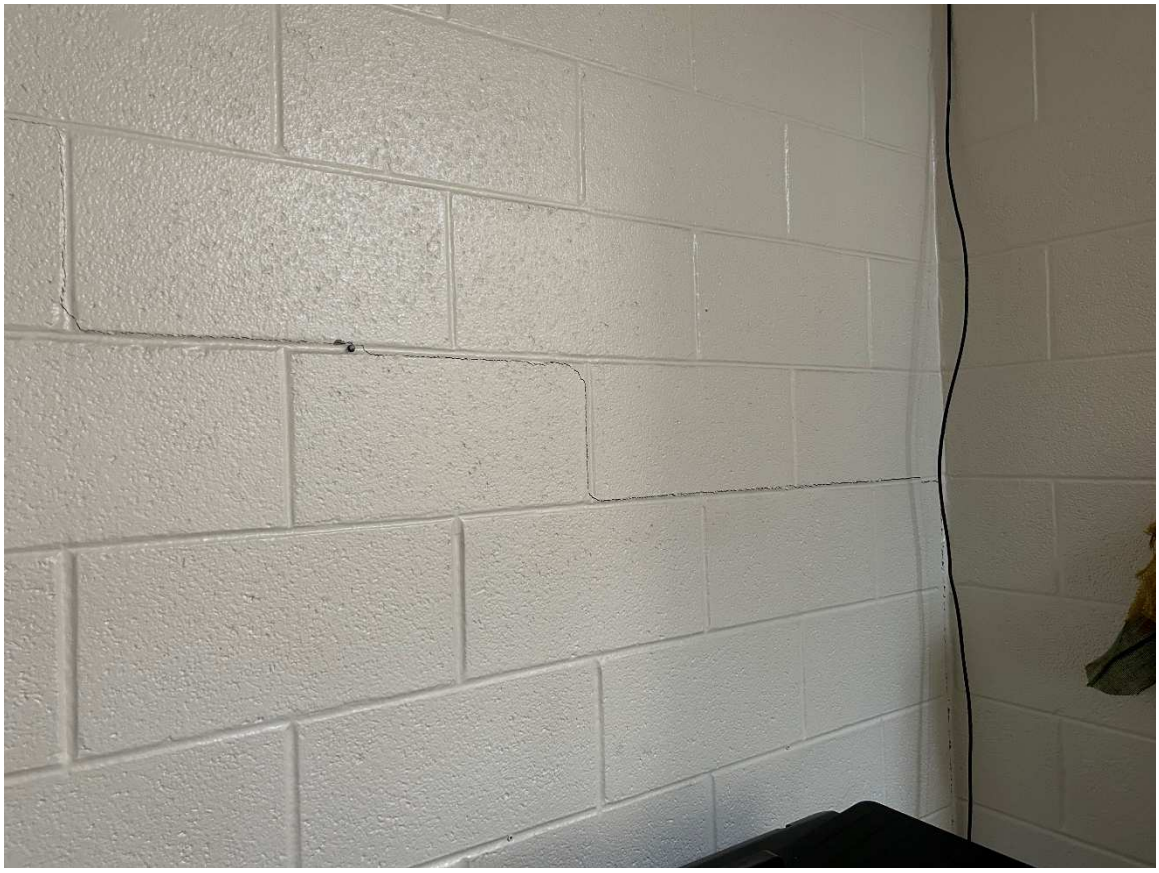
Visible heave in concrete slab near exterior door of youth service center, measuring approx 2”.



CMU coursing in counselor office

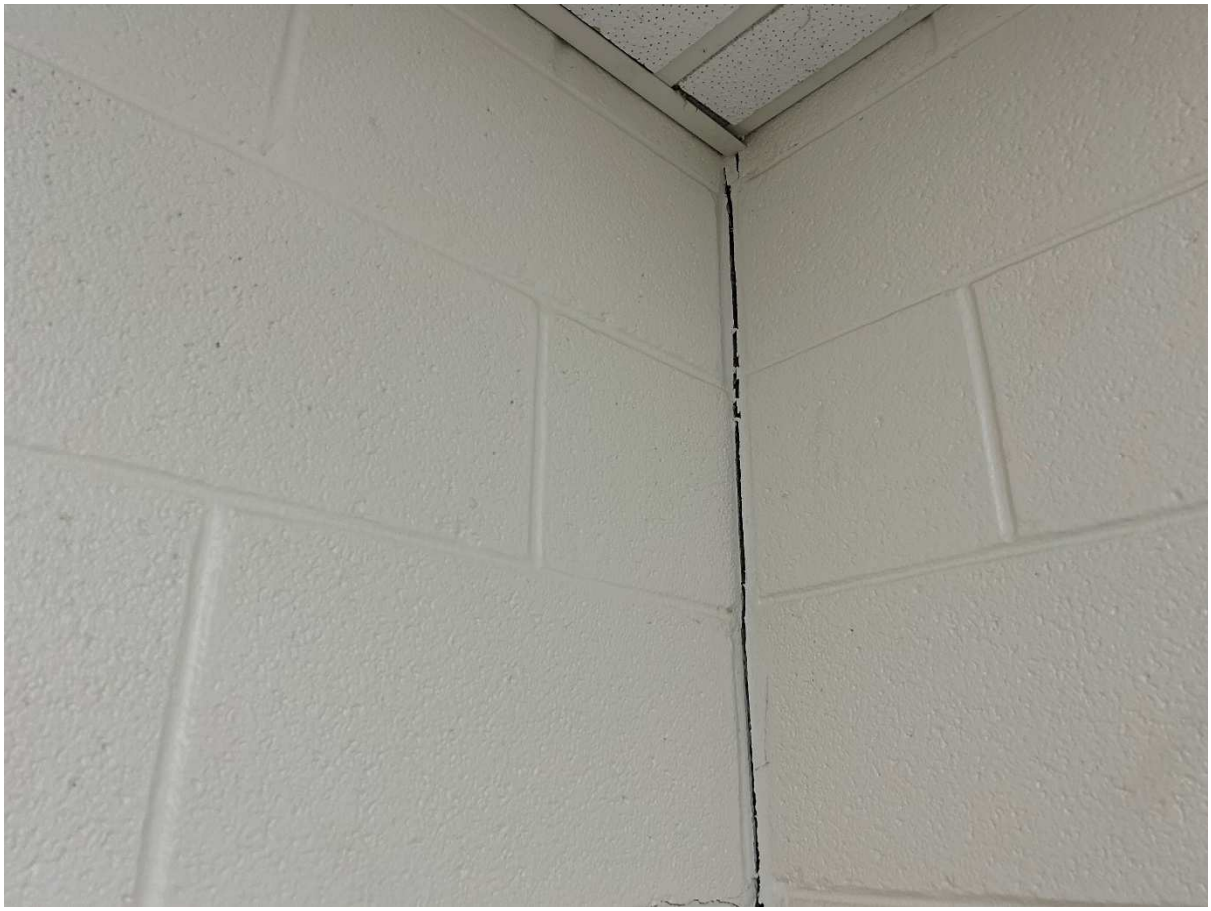


CMU coursing in counselor office measures approx ¾" differential heave in interior wall (exterior wall on right side of photo).

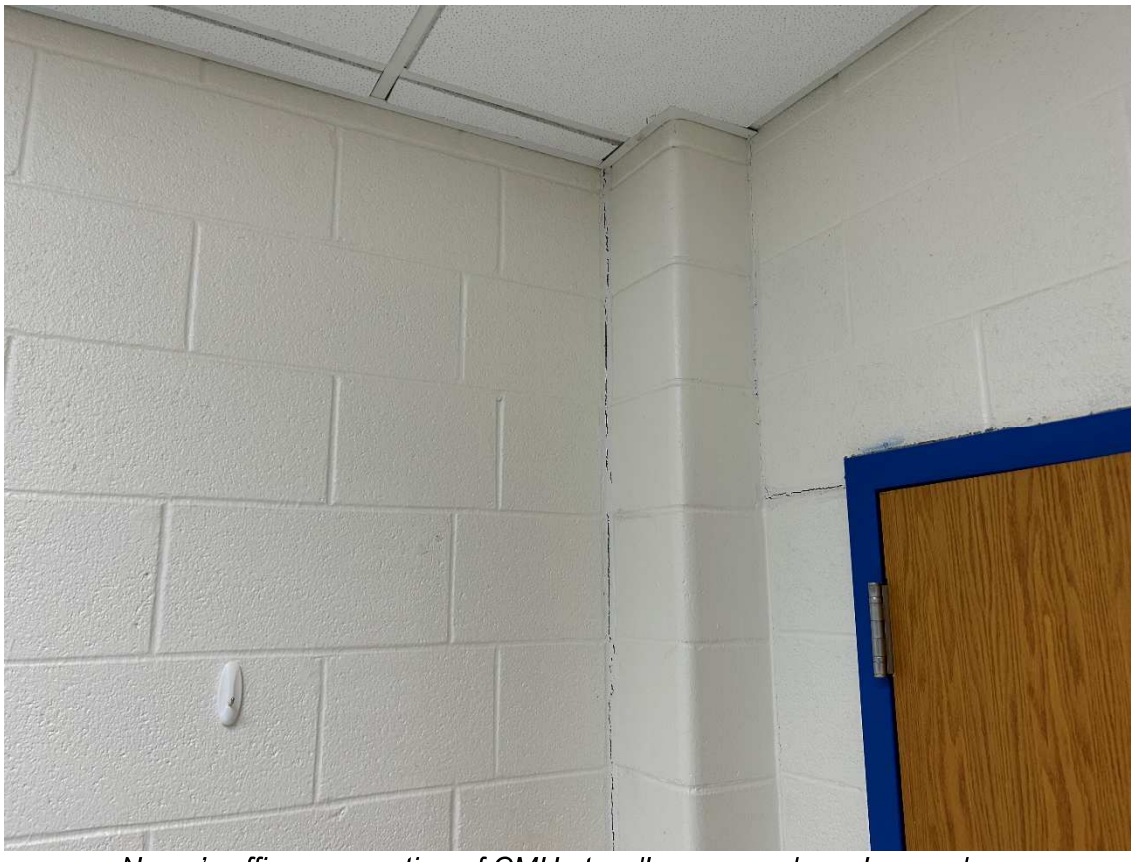


Crack in CMU coursing in counselor office

Nurse's office, separation of CMU at wall corner.



Nurse’s office, separation of CMU at wall corner



Nurse’s office, separation of CMU at wall corner and crack near door.

Room 105, CMU crack at door frame.

Room 105, CMU cracks in closet area.

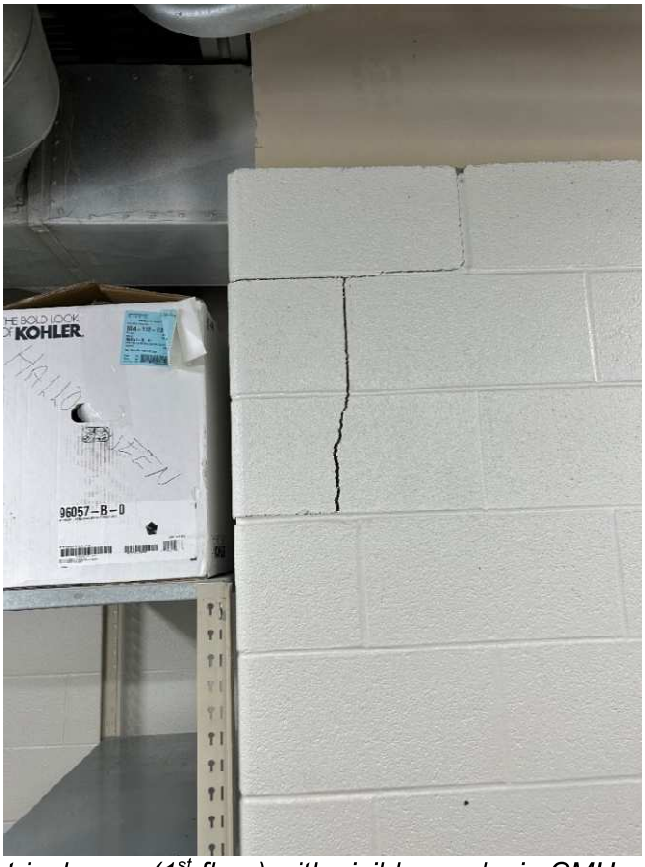
Room 105 slab heaved and showing gap from CMU interior wall.

Room 105 slab showing heave in slab, approx. 3”

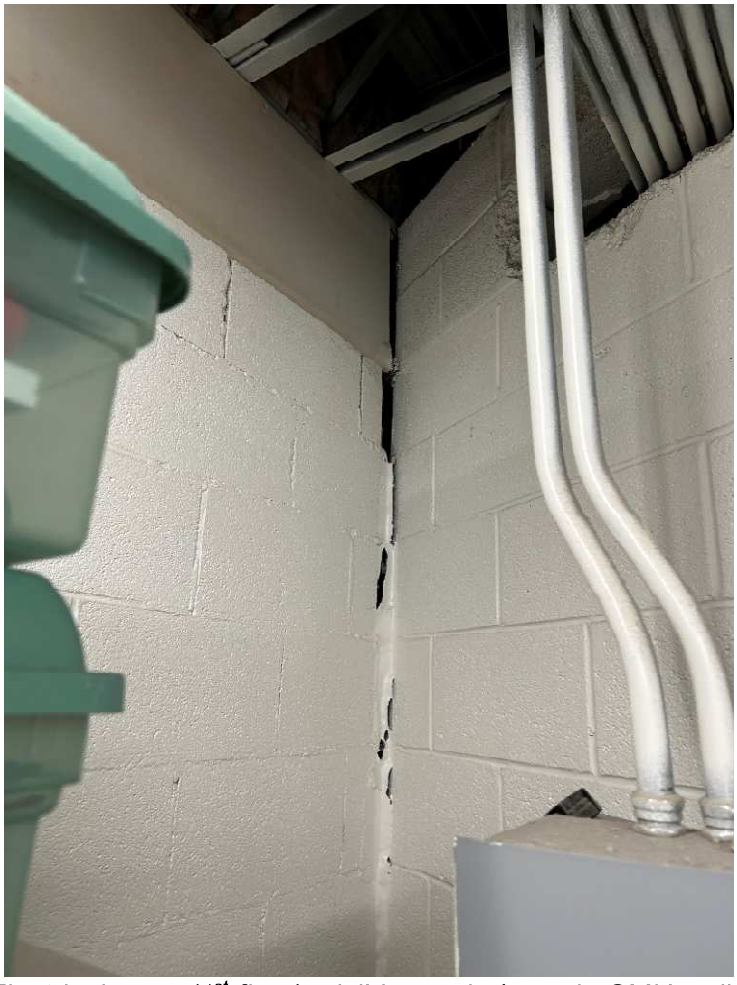
Cracks in slab of hallway

Heaving of slab on grade

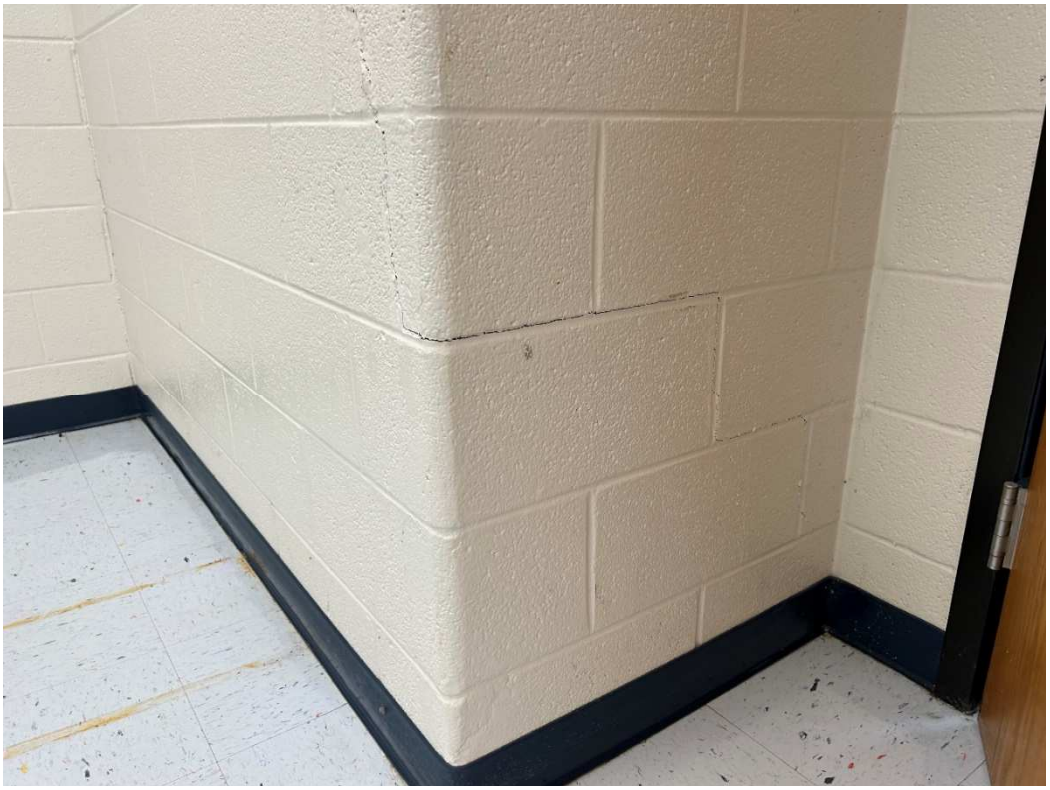
Heaving of slab



Electrical room (1st floor) with visible cracks in CMU walls.

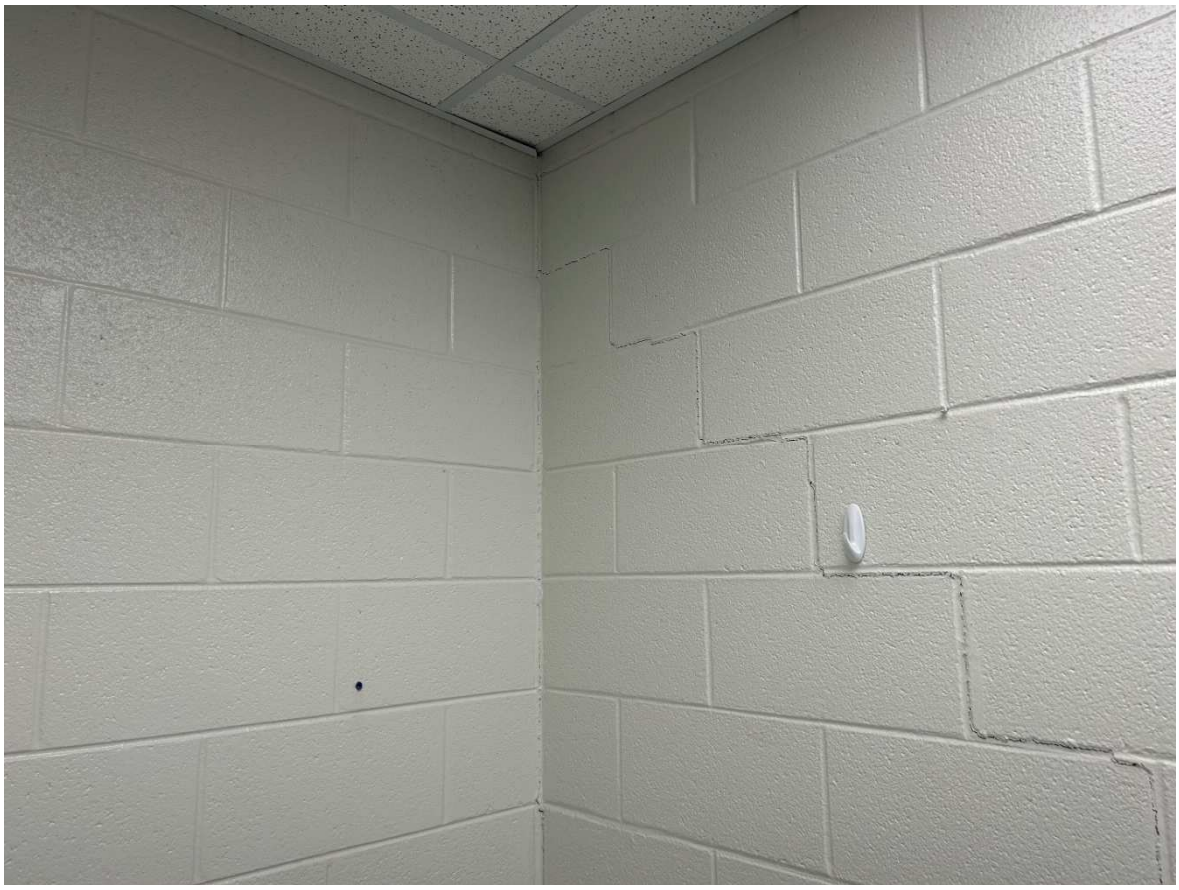


Electrical room (1st floor), visible cracks/gaps in CMU walls.

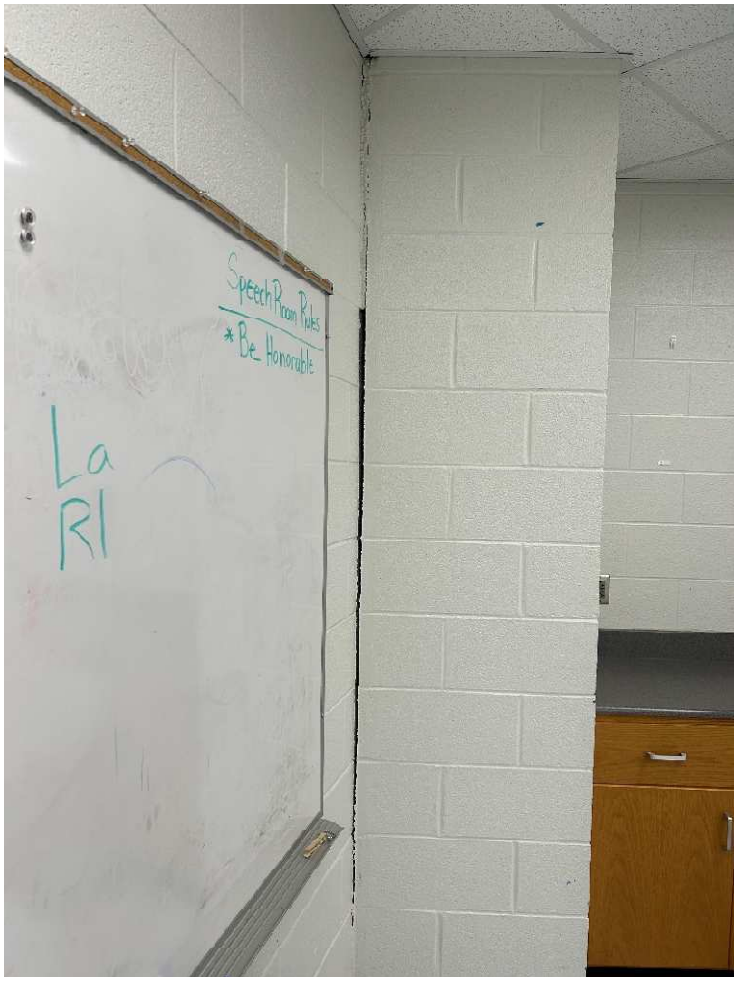


Room 119 with visible cracks in CMU wall.

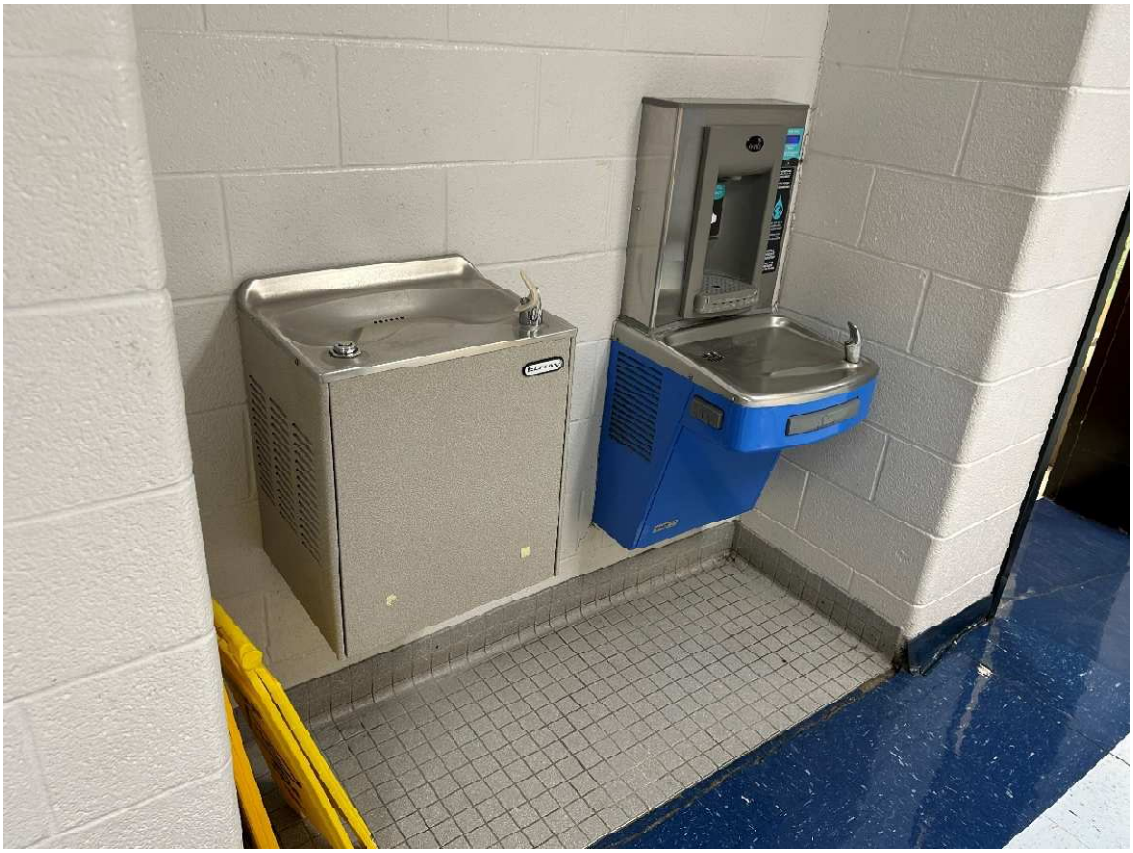
Room 119, with visible cracks in CMU wall.



Room 119, with visible cracks in CMU wall.



Room 119, visible gap in CMU wall (approx ¾”).

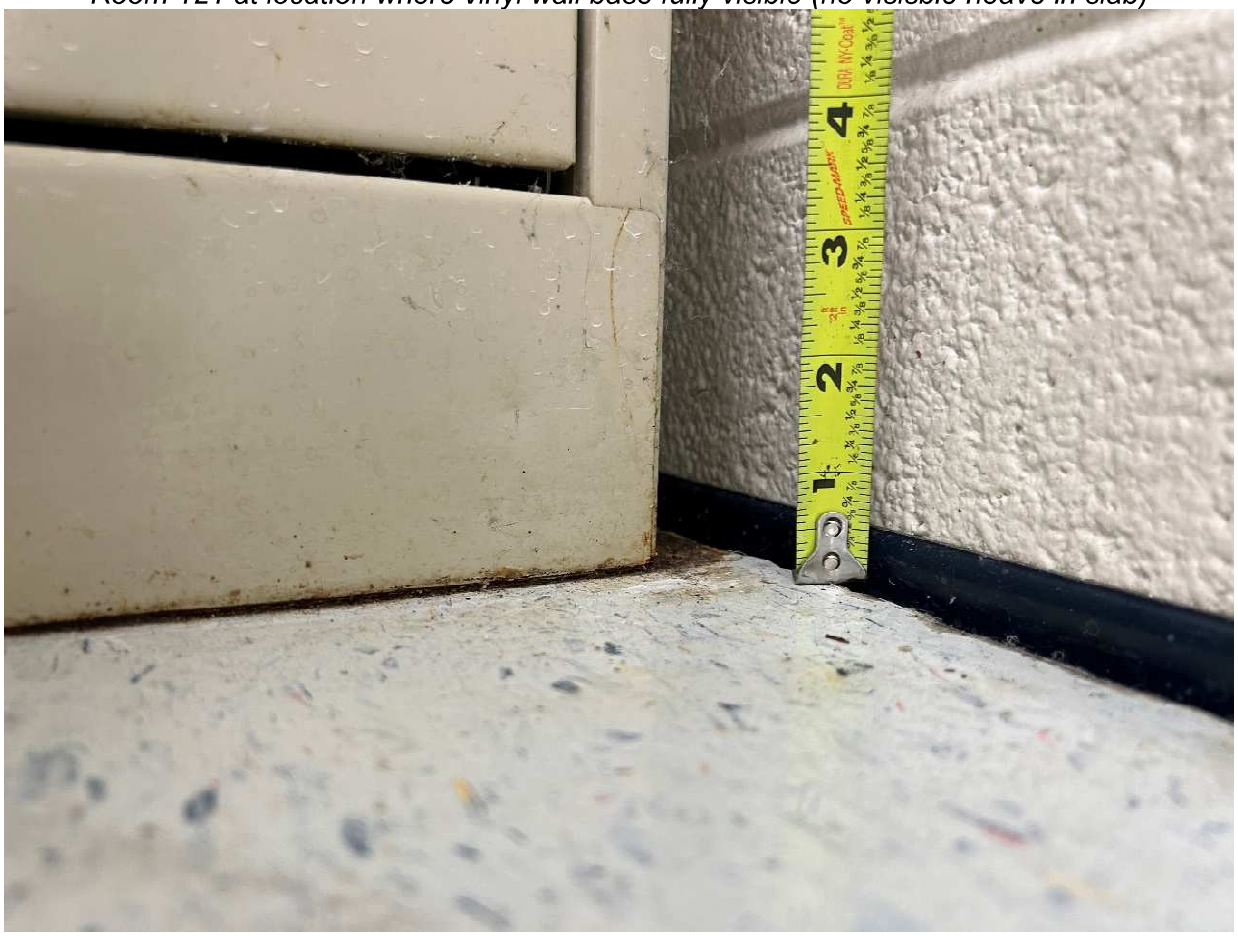


Crack in slab at water fountain (near Room 119)

Slab crack at water fountain showing visible heave (3/4" differential).

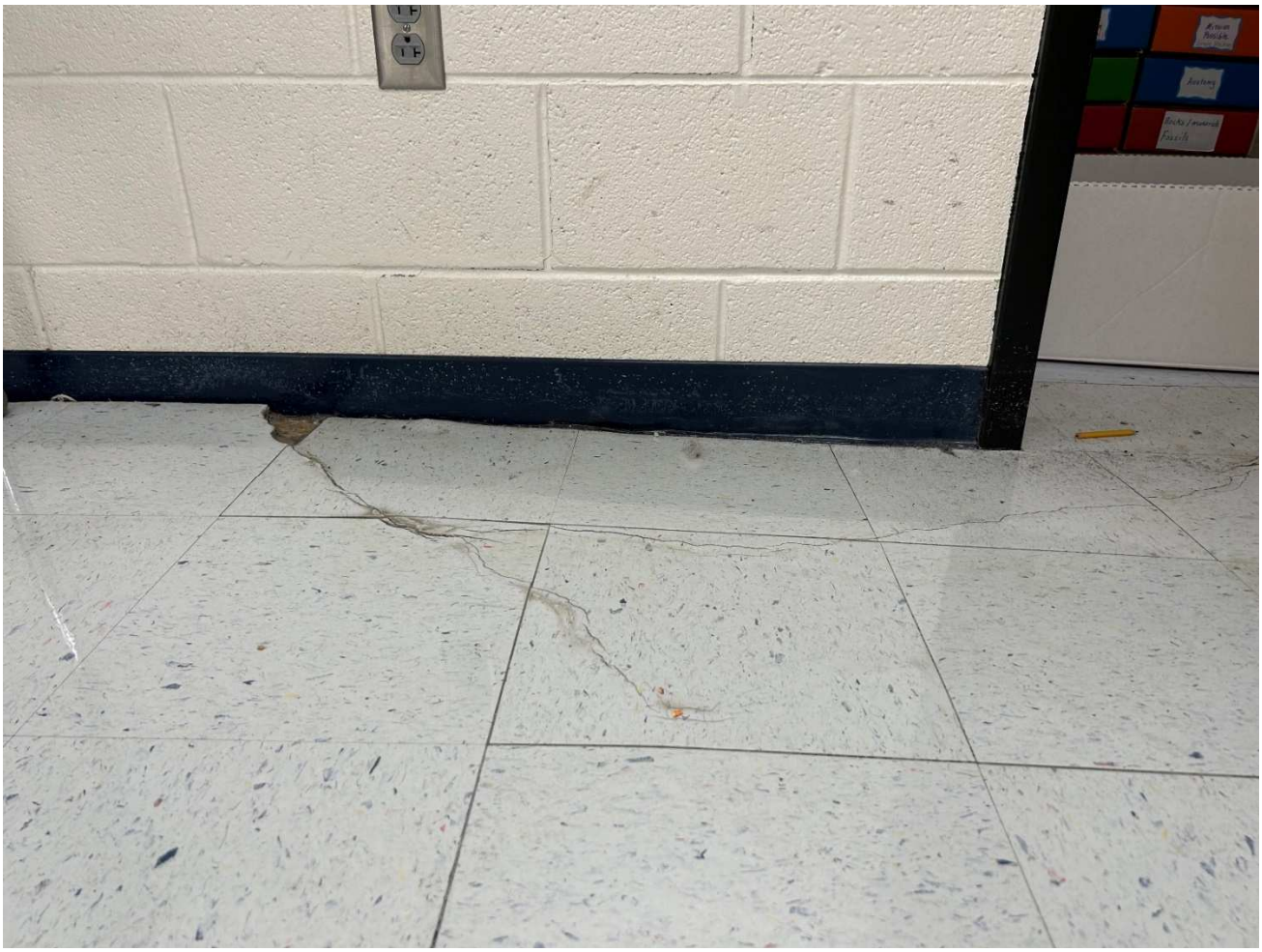
Room 121 showing slab heave. Up to 3 ½" +/- heave.

Room 121 at location where vinyl wall base fully visible (no visisble heave in slab)

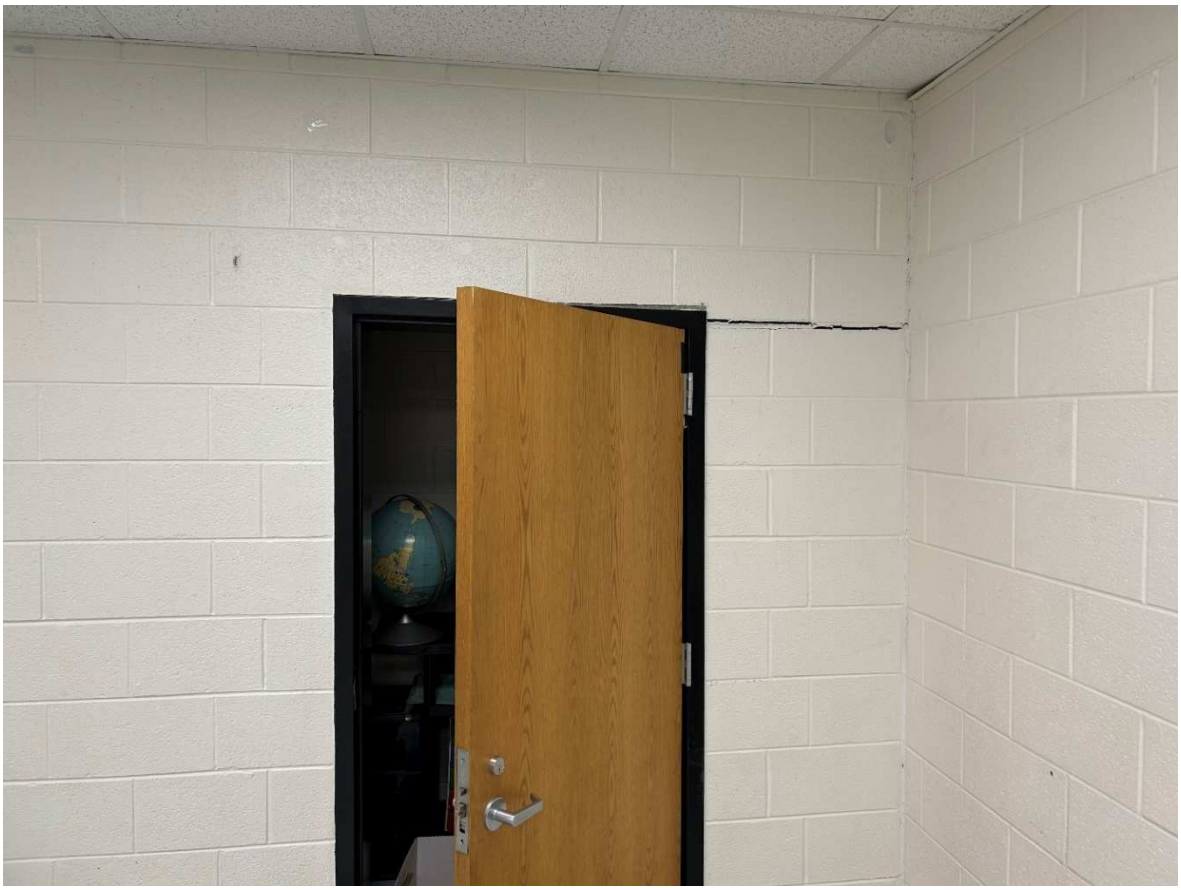


room 121 at slab location where heave is roughly 3 ¼” +/-.

Room 121, visibly different elevations between door area and surrounding slab.

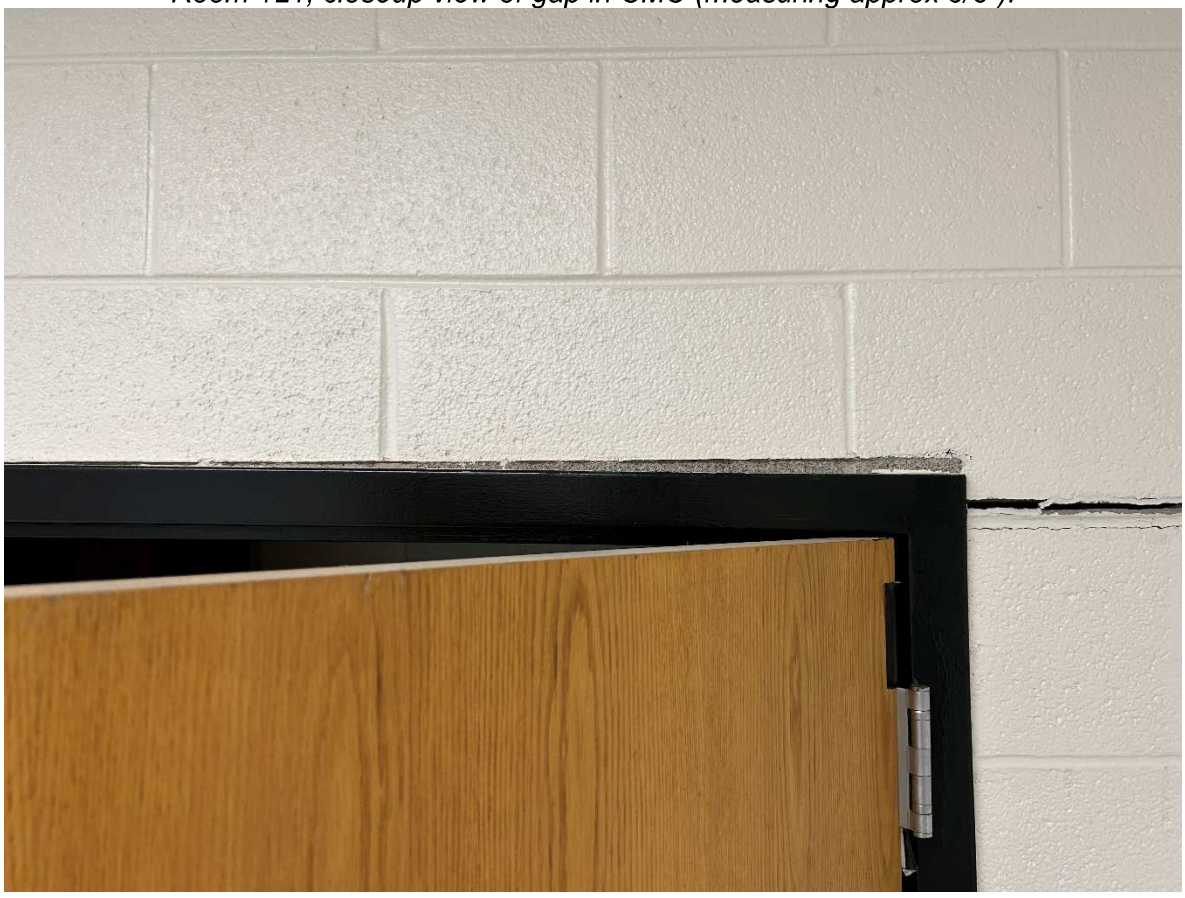


Gap under door displaying slope in floor elevation.



Crack in CMU to the right of closet door. Door frame out of square.

Room 121, closeup view of gap in CMU (measuring approx 3/8”).

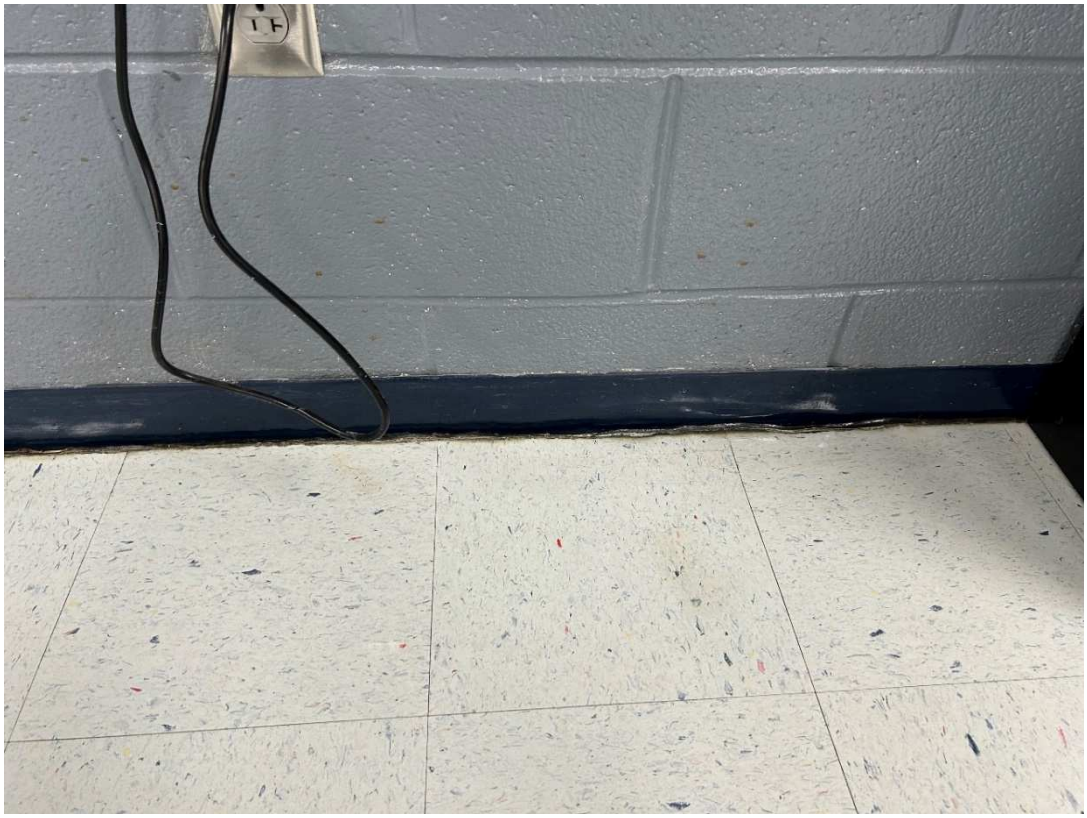


Closet door out of level/square. Closeup view.

Room 121, CMU coursing showing approx ½" heave between exterior and interior walls.

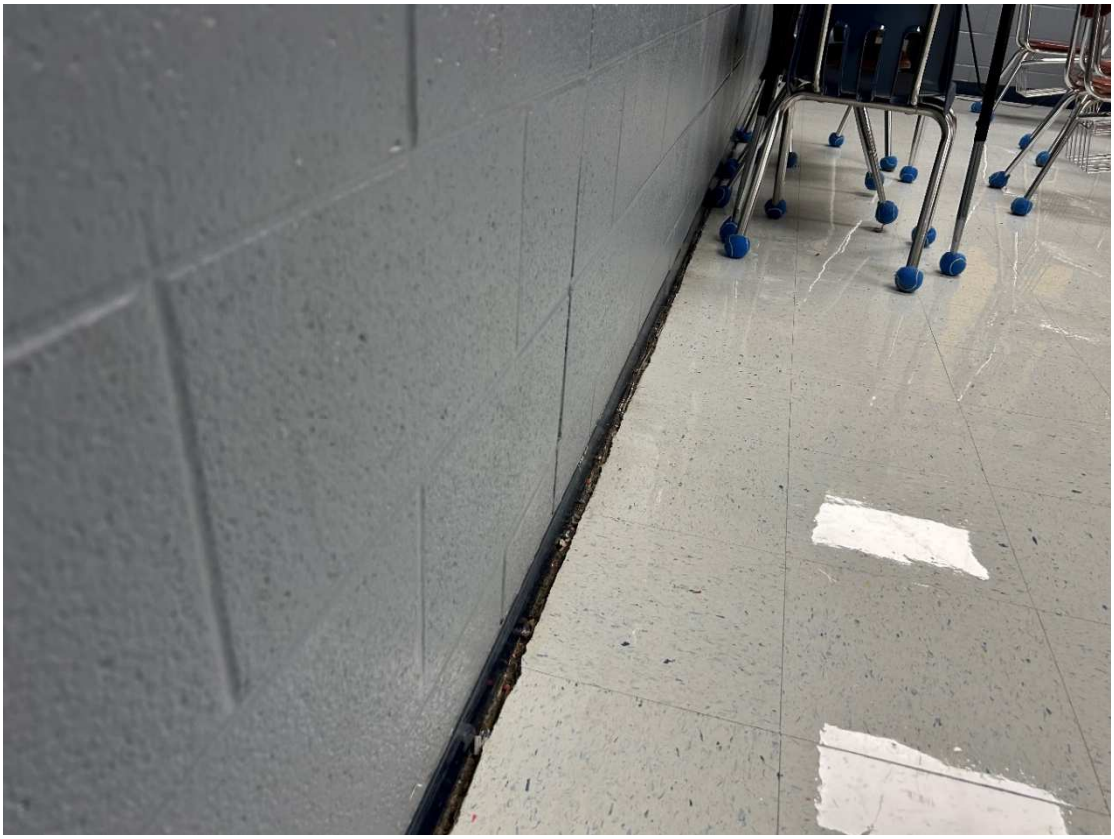
Room 121, cracks in CMU wall near hallway door. Load bearing wall.

Room 123 shows visible heave.



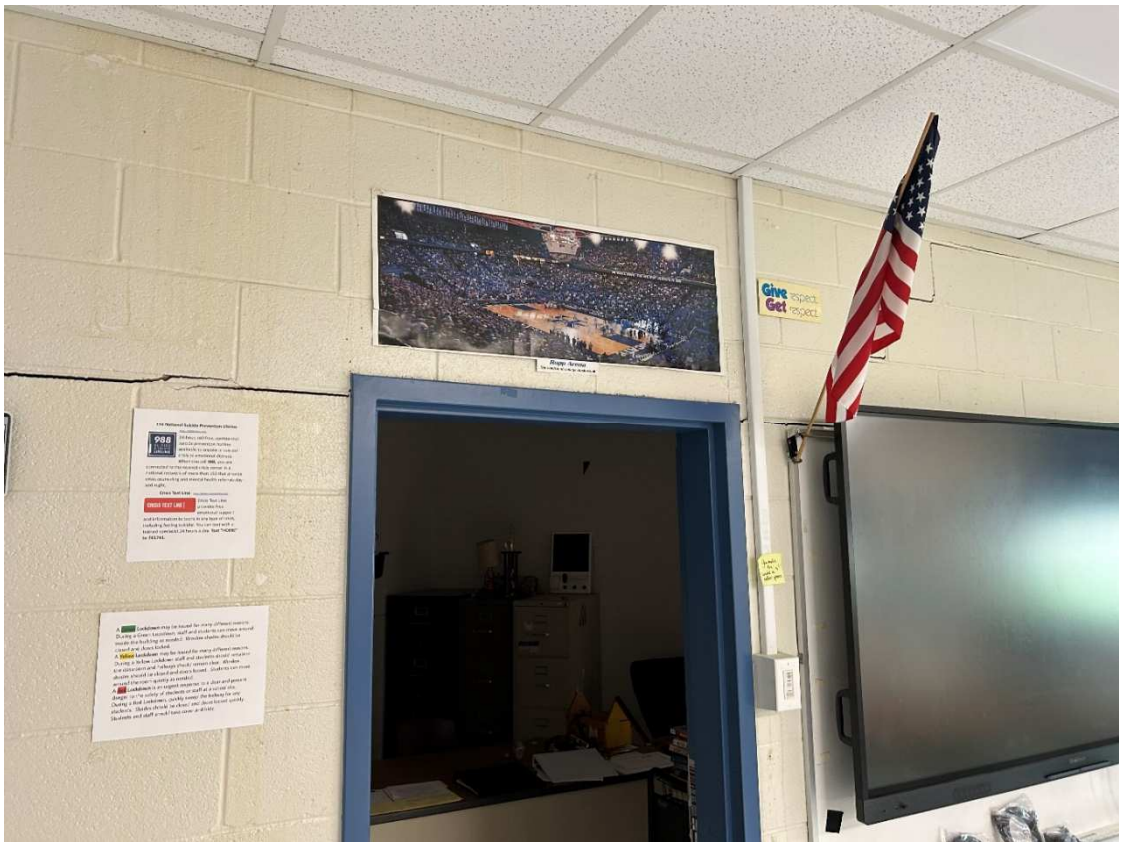
Room 123 showing visible heave in floor slab.

Room 123 showing approx. 2” of heave in areas.



Room 123 slab heave.

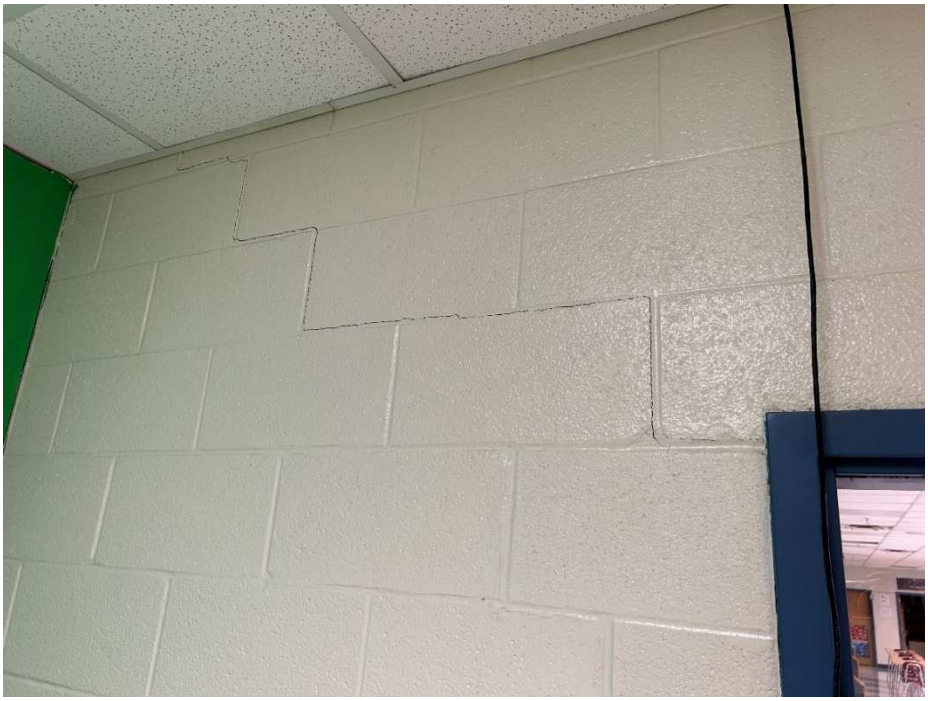
Room 131, cracks in CMU wall.



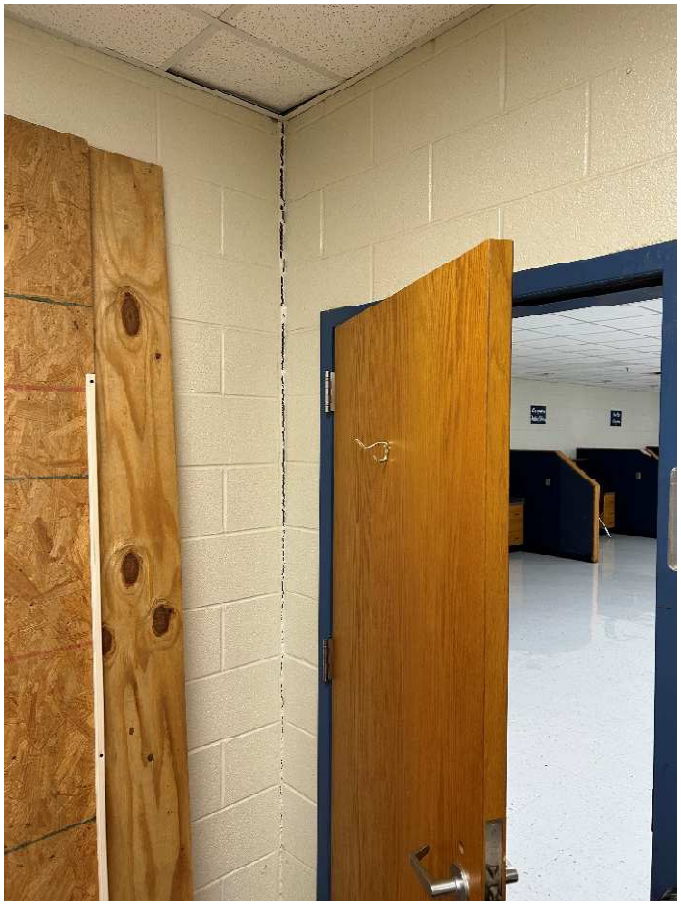
Approx ¼" gap in CMU course, Room 131

Room 131, cracks in CMU wall with heave visible in coursing.

Room 131, showing approx. 1”+ heave between interior and exterior walls.



Room 131, cracks in CMU near door of green screen room.



Room 131, gap in CMU walls in closet

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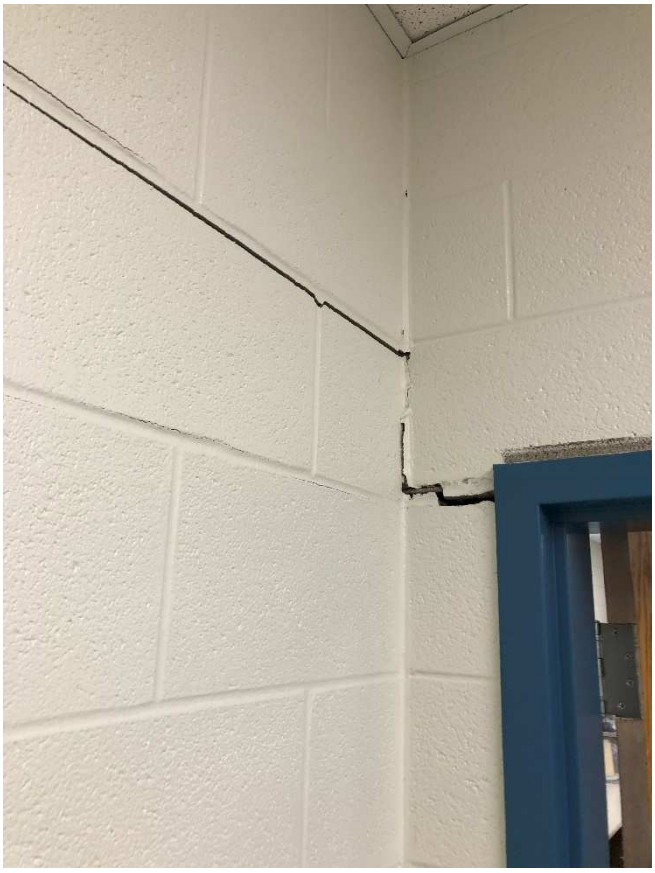
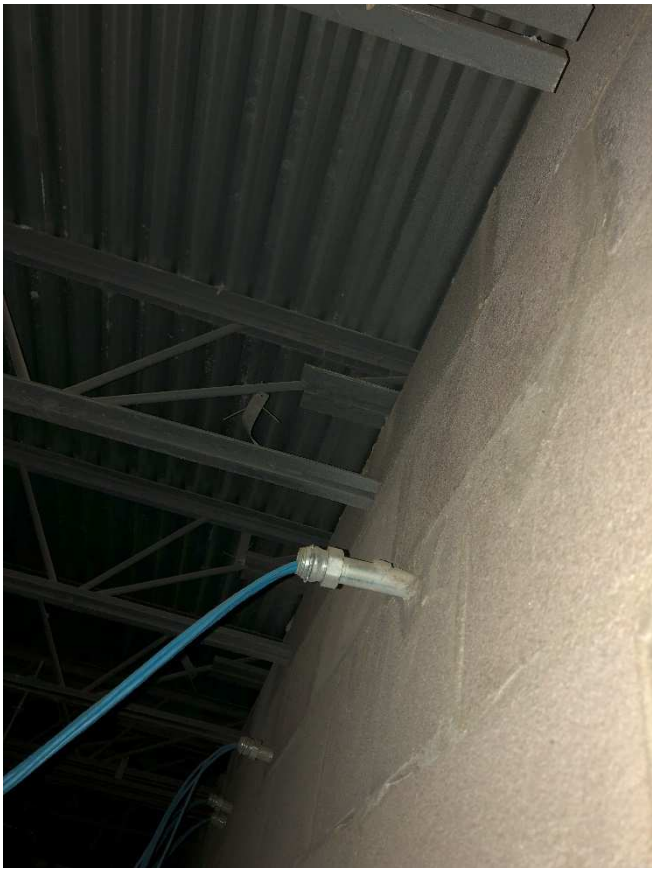
Closeup of Room 131 gap, approx ½" wide.



Significant crack in CMU wall

Cracking in partition wall. Window frame significantly out of level.



Joist bearing. No apparent issues at bearing locations observed.

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Cracking and deflection of lintel at load bearing wall.

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Cracking and deflection of lintel at load bearing wall. Door frame out of square.

Significant cracking at steel lintel

Edge of deck condition at continuous CMU wall (assumed shearwall). No connection to shearwall observed.

Joist bearing at continuous CMU wall. Some uplift on joist observed and cracking of exterior CMU.

Heaving of continuous CMU @ 2nd floor level. Suspended concrete slab has not heaved with wall. Some areas appear to have separation of slab from wall, but upon further inspection slab has not significantly separated from CMU wall.

Heaving between jambs of steel lintel. Distortion of steel lintel and cracking of CMU has occurred.

Stress cracks in CMU over heaving of steel lintel.