324 N. Main Street, Davenport IA – Partial Collapse
Preliminary Investigative Report

LF232566 / WBG202306
August 15, 2023

Prepared for

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EXECUTIVE SUMMARY

Just prior to 5:00 pm CDT on Sunday, May 28, 2023, a partial collapse occurred at the property located at 324 North Main Street in Davenport, Iowa (the Building).

Concurrent with ongoing Rescue and Recovery operations, the City of Davenport engaged White Birch Group, LLC (WBG) and SOCOTEC Engineering, Inc. (SEI) to investigate and provide opinions regarding the cause and origin of the collapse.

This report presents a summary of the engineering investigation to-date based on available on-site observations and documentation, evaluation of electronic documents produced, and communications with City officials.

Based on the investigation performed to date, WBG and SEI have reached the following conclusions:

1. **Root causes of collapse:**

1.1 Inadequate Capacity of Wall System

The removal of multiple wythes of masonry during the repair work in the three days preceding the collapse severely compromised the western bearing wall and caused it as well as the areas it supported to collapse on May 28, 2023. The temporary shoring that had been installed was grossly inadequate. Had a proper shoring and construction phasing plan been implemented during these repairs, the Building would not have partially collapsed on May 28, 2023.

1.2 Inadequate Shoring

The temporary stabilization methods specified by the Design Professionals during various repair projects for the Building do not appear to have considered that the western wall served as a critical structural load bearing element. Additionally, the shoring implemented by the most recent masonry repair contractor at the subject Building does not conform to usual and customary practices for masonry wall shoring or stabilization. The attempted installation was severely lacking in multiple aspects:

- The shoring did not engage any masonry other than limited portions of the exterior wythe.
- The spacing of the shoring was inadequate given the extent of the brick removal.
- The shoring members were severely undersized.
- The shoring was inadequately restrained at both the top interface with the wall and the bottom interface with the pavement.

While there are multiple proximate and interrelated causes as noted below, the resultant condition of the wall created by the improper implementation of the late May 2023 repairs resulted in the May 28, 2023, collapse incident.

2. **Proximate causes of collapse:**

2.1 Improper Understanding of Original Building Construction

The engineers and masonry contractors responsible for repairs to the Building repeatedly misidentified the structural bearing wall as a nonstructural system. As such, they underestimated the significance of the observable signs of distress in the wall, delayed necessary repair work, designed and installed a weaker replacement system, and removed significant portions of the wall without first installing adequate temporary shoring.

2.2 Inadequate Construction Documents

The available Construction Documents for repair work conducted between 2020 and 2023 do not provide adequate details and specifications for a contractor to implement the repair work necessary at the subject Building. This resulted in the implementation of many incomplete and inadequate repairs. Furthermore, this lack of documentation limited the City Inspectors' ability to easily verify that the work being performed was consistent with the engineer's intent.

2.3 Neglect of Composite Wall

The Design Professionals and masonry repair contractors replaced portions of the original 5 wythe thick bearing wall with a substantially weaker non-composite cavity wall system.

2.4 Inadequate Oversight of Repairs

The deficiencies with the design and implementation of repairs noted herein were exacerbated by the lack of on-site presence by a qualified Design Professional during the repair work. This lack of professional oversight allowed the work by the most recent repair contractor to proceed in an unsafe, incomplete, and improper manner.

2.5 Inherent Weakness of West Wall

Several conditions inherent to the construction and age of the west elevation wall allowed for reduced cross section of the wall, and resulting weaknesses in the wall, especially at Pier E. Although these construction practices were usual and customary for buildings of the subject Building's age, when Piers B, C and D failed, Pier E's inherent weaknesses caused it to fail as well.

2.6 Inadequate Repair Techniques

The improperly repaired brick masonry wall sections were poorly integrated with the original construction and increased the inherent weakness of the west elevation wall.

2.7 Inadequate Frequency and Type of Maintenance

The subject Building exhibited many signs of improper and inadequate exterior envelope maintenance, resulting in excessive water infiltration. Improperly maintained composite clay brick masonry walls will degrade over time due to water infiltration and the effects thereof, resulting in a structurally weakened wall system. Based on the photographic evidence of pre-collapse condition, in addition to on-site observations after the incident, it is apparent that building ownership/management did not adequately address exterior (and other) maintenance requirements, thereby resulting in the compromised integrity of the west elevation wall.

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1. INTRODUCTION

The City of Davenport (City) engaged White Birch Group, LLC (WBG) and SOCOTEC Engineering, Inc. (SEI) to investigate and provide opinions regarding the cause and origin of the partial collapse that occurred on May 28, 2023, at the building located at 324 N. Main Street in Davenport, IA (Building). The collapsed portion at the west elevation includes an area approximately 56-ft wide by 22-ft deep, towards the southern half of the Building. In the three days preceding the collapse, contractors removed brick from the exterior masonry bearing wall in preparation for its repair. A photograph of the aftermath of the collapse is provided in **Fig. 1**.

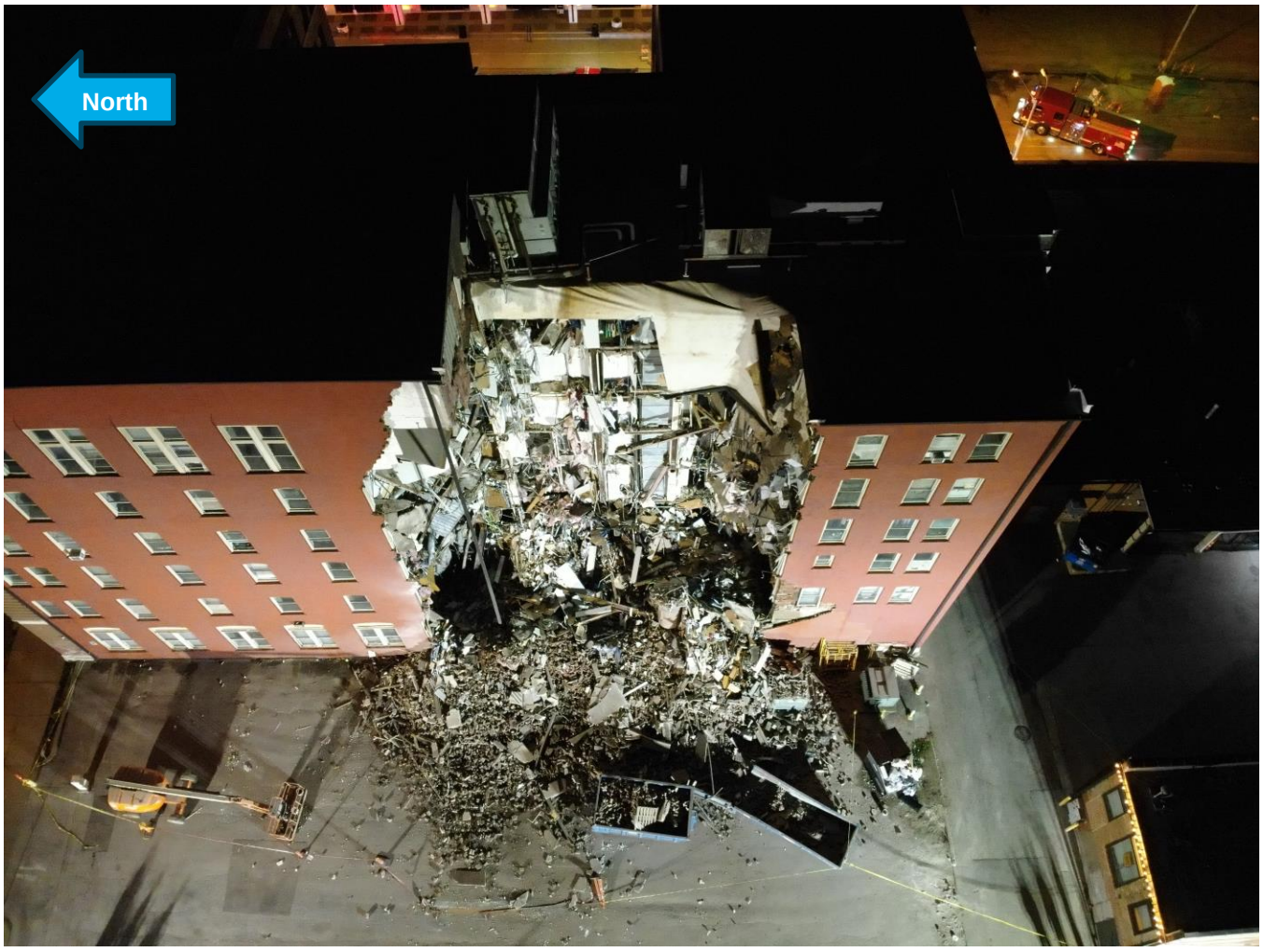

Fig. 1. Overall aerial view of the partial collapse of the Building (Image from City of Davenport)

This study is limited to the Building design, construction, and repair-related causation of the partial building collapse. The scope of the investigation consisted of an assessment of the impact of the repair work and its sequencing on the stability of the exterior wall. Evaluation of municipal procedural and policy related implications, and any contributory factors thereof is beyond the scope of the WBG and SEI investigation.

Further, the scope and breadth of this report is limited to the information and documents available to date. The structural modeling and analytics include the results of a standard linear static analysis based on the limited available information at the time of the reporting.

2. SITE PRESENCE

Representatives of WBG arrived on site June 3, 2023, and were joined by representatives of SEI on June 4, 2023. WBG personnel left the site at approximately 9:00 pm on June 4; SEI representatives remained on site until approximately 5:00 pm on June 5.

While on site, WBG and SEI developed a protocol to provide the City with suggested steps for selective demolition and evidentiary materials recovery. Selected elements of the building, the identified materials, and construction equipment used by contractors for the repairs underway at the time of collapse, were secured offsite as evidentiary material.

Other parties were also on site during this time, including members of municipal and state fire and law enforcement agencies, Iowa Urban Search & Rescue (US&R) Task Force, personnel and equipment from DW Zinser Demolition, and staff from Shive-Hattery Architecture+Engineering who were performing various building monitoring and remote sensing image collection activities on the remaining portions of the building.

3. KEY DOCUMENTS REVIEWED

Table 1 provides a list of key documents reviewed that form the basis for the conclusions presented in this report.

Table 1 – Key Documents Reviewed

Date	Type	Document Description
Drawings and Sketches		
February 24, 1906	Drawings	Original Drawings for the "McManus Building" – Sheets 1 to 31
February 9, 2023	Sketch	Select Structural Sketch for wall bracing
Permits		
September 11, 2020	Permit	Permit for Roof Repair work at the Property
December 17, 2020	Permit	Permit for Masonry Repairs at the Property
February 22, 2023	Permit	Permit for Masonry Repairs at the Property
May 24, 2023	Permit	Permit for Brick Replacement at the Property
Reports		
February 2, 2023	Report	Select Structural Report – Emergency Site Visit
February 8, 2023	Report	Select Structural Report
February 28, 2023	Report	Select Structural Report
May 24, 2023	Report	Select Structural Report
Letters/Code Violation Notices		
August 26, 2020	Letter	Notice of Code Violations at Property by Davenport Neighborhood Services (Task ID: 20-7839)
October 23, 2020	Letter	Final Official Notice of Code Violations at Property by Davenport Neighborhood Services (Task ID: 20-58268)
February 16, 2021	Letter	Notice of Extension for Code Violations at Property by Davenport Neighborhood Services (Task ID: 20-72033)
May 26, 2021	Letter	Final Official Notice of Code Violations at Property by Davenport Neighborhood Services (Task ID: 21-9198)
July 19, 2021	Letter	Complaint Notice and Order for Code Violations at Property by Davenport Neighborhood Services (Task ID: 21-42476)
September 7, 2021	Letter	Final Official Notice of Code Violations at Property by Davenport Neighborhood Services (Task ID: 21-44403)
October 21, 2021	Letter	Failure to Provide Access for Inspection of Code Violations at Property by Davenport Neighborhood Services (Task ID: 21-54633)
December 9, 2021	Letter	Notice to Vacate by Davenport Neighborhood Services (Task ID: 21-64101)
February 2, 2023	Letter	Notice of Public Hazard at Property by Davenport Neighborhood Services (Task ID: 23-6454)

Date	Type	Document Description
March 9, 2023	Letter	Notice of Inappropriate building material being used for exterior of Project by Davenport Neighborhood Services
Emails		
August 18, 2020	Email	Email from Townsend Engineering regarding falling brick at the Project
March 1, 2023	Email	Email from Select Structural stating they were on site February 23, 2023, to observe work in progress at the Project.
Photographs and Videos		
Various	Photos	Photos of the condition of the Property taken by Davenport Neighborhood Services
May 2023	Photos	Miscellaneous photos taken in the days leading up to the collapse.
May 2023	Videos	Miscellaneous Security Camera footage taken in the days leading up to the collapse.

4. BUILDING DESCRIPTION

The building at 324 N. Main Street in Davenport, IA, was constructed in 1907 as The Davenport Hotel. According to the original building design drawings made available to WBG and SEI, the firm of Temple, Burrows, and McLane, Architects designed the building in 1906. The building consisted of six above-ground stories and a basement; at the northwest quadrant of the sixth floor, a double story height Convention Hall extended above the general roofline.

Five steel trusses between the second and third floors provided column-free space in the First Floor Dining Room in the northwest quadrant of the building. Steel columns embedded in the west exterior wall supported the western ends of these five trusses.

The east, or front elevation, in addition to the north elevation of the building consisted of a façade comprised of brick, with stone ashlar elements at the first story, stone accents, terra cotta ornaments, and stone windowsills.

The west wall, or rear elevation of the building was constructed of brick masonry with brick arched window openings and brick sills. The west elevation is the focus of this investigation. **Fig. 2** shows the west elevation with added annotation indicating the approximate location of the structural steel framing behind. Piers A through F, as assigned by WBG and SEI, have been identified in this image and will be referenced throughout the report. Areas of note include:

- Prior to the 2020 repair work discussed herein, several windows on the first floor were infilled and bricked over at some point in the building's history.
- Between Piers B and C, the previous window opening was converted to a door. The door served as an access point to Unit 105 which is referenced later in this report.
- A boiler stack was located behind Pier E. This was a hollow chase constructed of clay masonry, extending the height of the building.
- A smaller chase was located within Pier F and reduced the number of wythes of masonry at this Pier.
- No steel beam framed into Pier C at the second floor; however, a beam framed into Pier B, with a second beam framing into the spandrel location above the door into Unit 105 between Piers B and C.
- A steel lintel was provided above the window between Piers B and C at the second floor to support the second steel beam at this location. Further steel lintels were located between Piers E and F at the second, fourth, fifth, and sixth floors as well as the roof.

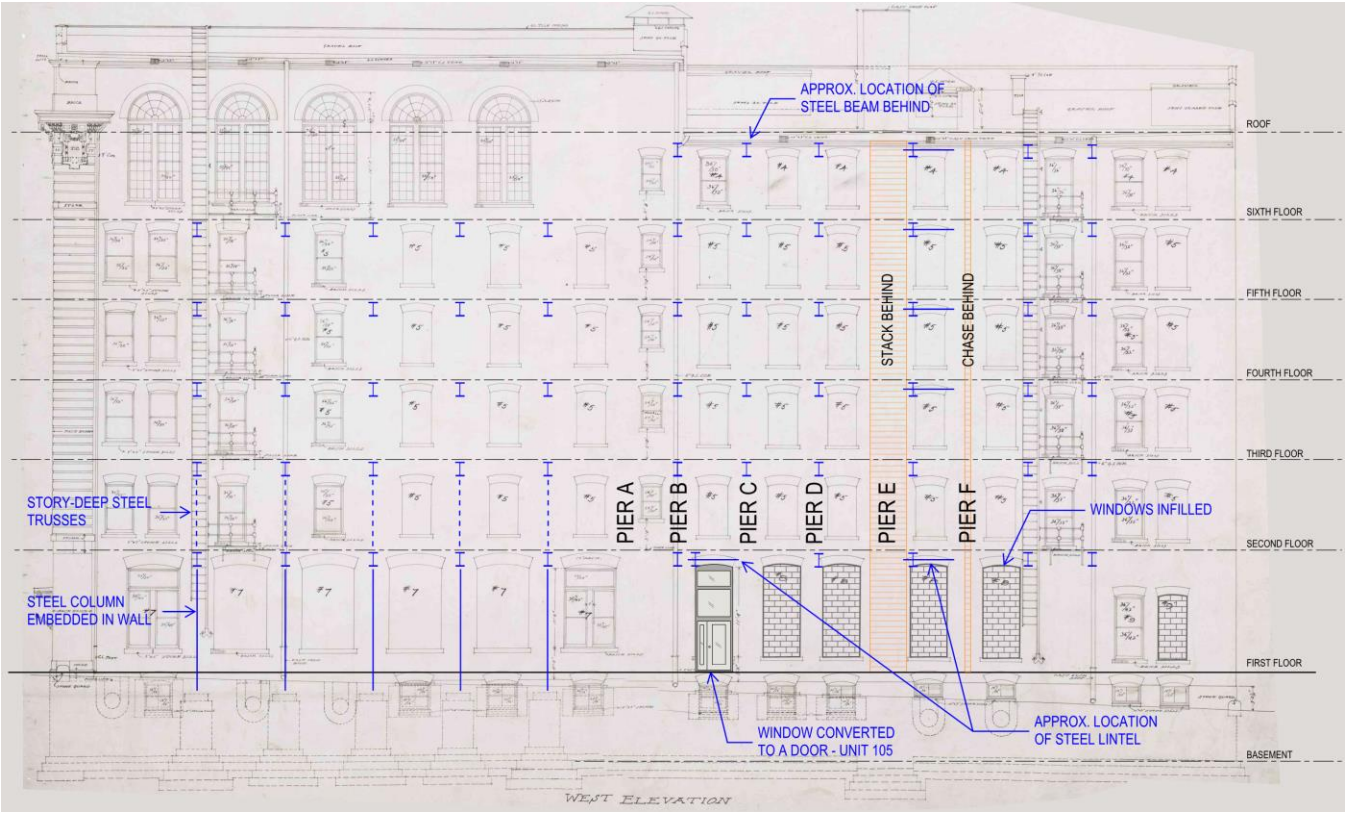

Fig. 2. West elevation of the Building (Ref. Drawing 16, Temple, Burrows, and McLane, Architects). Annotation by WBG and SEI.

All exterior walls were comprised of unreinforced multi-wythe clay brick masonry. A wythe is a vertical section of masonry, one unit thick. Apart from the first story steel columns noted above, and two locations at the east side of the second story, none of the exterior walls contained steel columns. The original design drawings indicate the following dimensions for the exterior wall thicknesses:

- Basement: 2'-2" (six wythes)
- First and Second Floor: 1'-9" (five wythes)
- Third through Fifth Floor: 1'-5" (four wythes)
- Sixth Floor: 1'-1" (three wythes)

Field observation and photographs confirm the wall compositions listed above. Hollow structural clay tile comprised the interior-facing wythe, and solid brick typically comprised the other wythes of the wall.

While the north, east, and south elevations utilized a face brick at the outward-most wythe, the west elevation consisted of common brick. Headers every six courses, visible on the exterior of the Building, served to interlock the original masonry wythes to act as a composite, structural wall system. Structural brick arches span above window openings of the west elevation.

Interior framing consisted of rolled steel beam and girder members bearing on columns generally comprised of built-up riveted plate and angle components. Steel beams framing perpendicular to the exterior walls were pocketed into the multi-wythe masonry walls, generally bearing on cast iron plates embedded within the wall. These beams were keyed into the masonry wall with deformed pins extending through the beam webs (**Fig. 3**). The design

drawings specify steel lintels where beams frame into the wall directly above an opening. At the second floor, a lintel spans over the door between Pier B and Pier C, and another lintel spans over the window between Pier E and Pier F.

Fig. 3. Image taken by SEI on June 4, 2023, indicating beam pin (yellow arrow).

According to the permits on file, the building was converted to apartments in 1985. Other modifications to the west elevation subsequent to the original construction included infill of many of the 1st floor windows, and creation of a doorway by extending one of the existing window openings down to grade. This doorway served as the entrance to Unit 105 referenced later in this report. The fire ladders on the west elevation were also removed. At the infilled windows, concrete masonry units (CMU) or light gauge steel studs were used as backup for the new brick veneer (**Fig. 4**).

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Fig. 4. Overall view of the west elevation of the Building (Ref. Google Streetview, dated June 2021). Annotation by WBG/SEI.

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5. REPAIR HISTORY SINCE 2020

WBG and SEI have evaluated a range of documents pertaining to the condition of the west elevation of the building, as well as the various repair campaigns that were implemented since mid-2020. These documents include:

- Numerous code violation notices issued by the Davenport Neighborhood Services Department and associated inspection report photographs.
- City of Davenport permits and associated photographs and narratives from follow-up inspections.
- Correspondence and reports from Townsend Engineering and Select Structural Engineering, LLC (SSE).

The City of Davenport building permit portal includes various types of permits issued for the subject property dated as early as 1928. Some of these permits involved exterior wall repairs, including tuckpointing and sandblasting the walls, filling in the cellar windows, and removing fire escapes.

Fig. 5 summarizes the sequence of events since 2020 based on the documents reviewed at the time of writing this report.

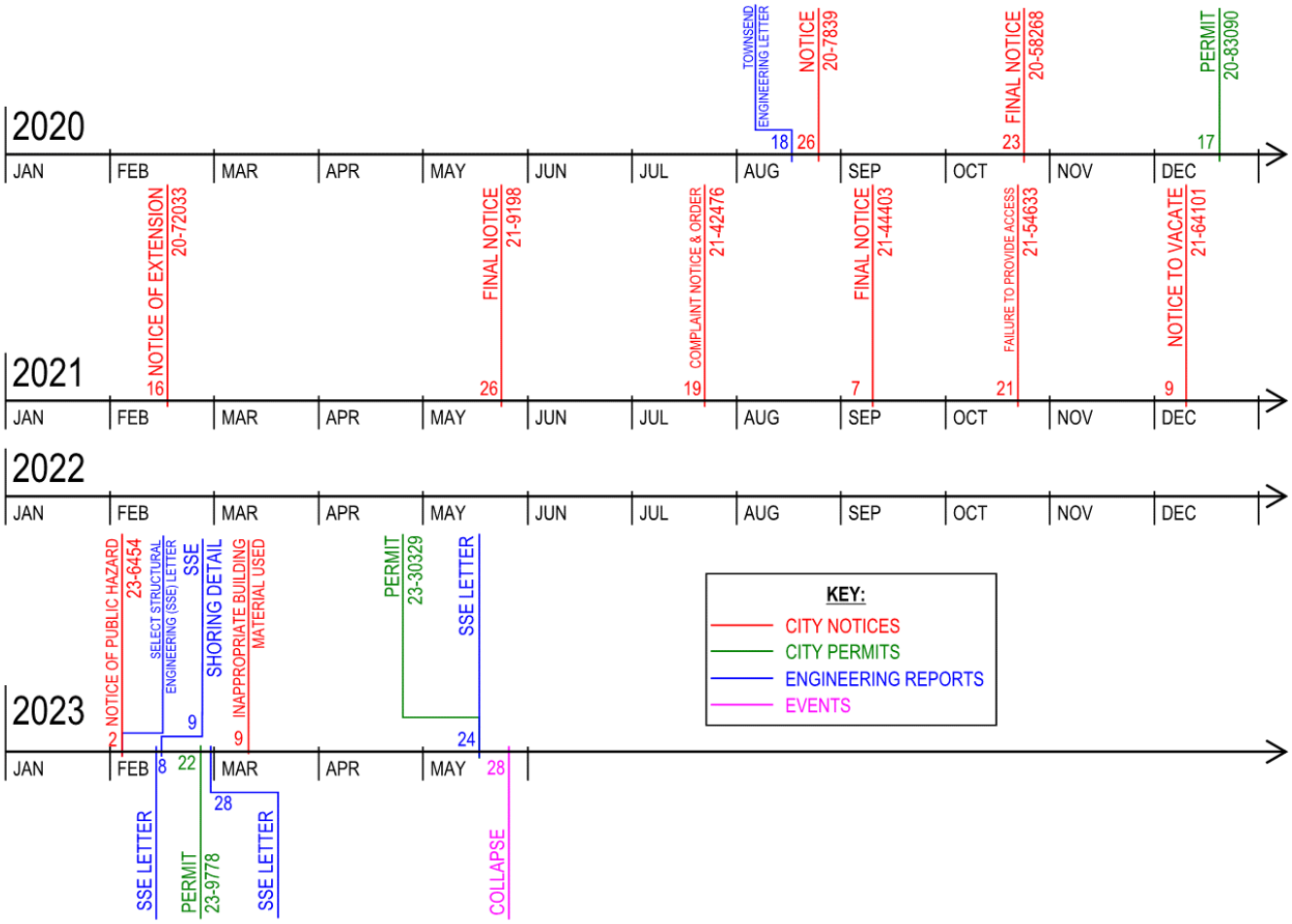

Fig. 5. Timeline of documents for the Building relevant to the west elevation. Note lack of 2022 activity.

Note, the timeline above only delineates the documentation reviewed related to the west elevation. During this same period, the City issued a multitude of other code violation notices for various deficient conditions its inspectors observed throughout the Building.

Appendix A provides a detailed summary of key documents reviewed, in addition to photographs and images that form the basis of WBG and SEI's understanding of the work being implemented at the west elevation of the building since 2020. The information in this section provides a concise summary based on the documents referenced in the Appendix.

5.1 2020 Repair Campaign

In mid-August 2020 Townsend Engineering performed a site visit at the Building due to an incident of falling brick from the 6th floor. Townsend Engineering then issued a follow-up email directed to City officials, dated August 18, 2020, addressing the north, south and east elevations of the building. The email did not discuss the need for any repairs to the west elevation.

Photographs from City inspections and site visits indicate the condition of the west elevation at the time. The exterior exhibited large areas of delaminated paint, with numerous deferred maintenance conditions evident throughout. However, Townsend Engineering's email did not express any concern with the condition of the west wall.

The City notices at this time generally refers to the exterior of the building as containing *"structurally unsound brick"* and requiring a "*certified report"* from a "*professional structural engineer registered with the State of Iowa*". However, no specific reference is made to the west elevation.

Photographs from late 2020 and early 2021 indicate that two relatively small areas of brick replacement were completed towards the southern end of the west elevation. However, there are no engineering reports or related documents on file that designate the scope or methodology for these repairs. In addition, by May 2021 photographs indicate that the entire west elevation was painted red. **Fig. 6** below provides an excerpt from the original 1906 elevation drawings, annotated with areas of brick replaced during the 2020 and 2021 repair campaigns.

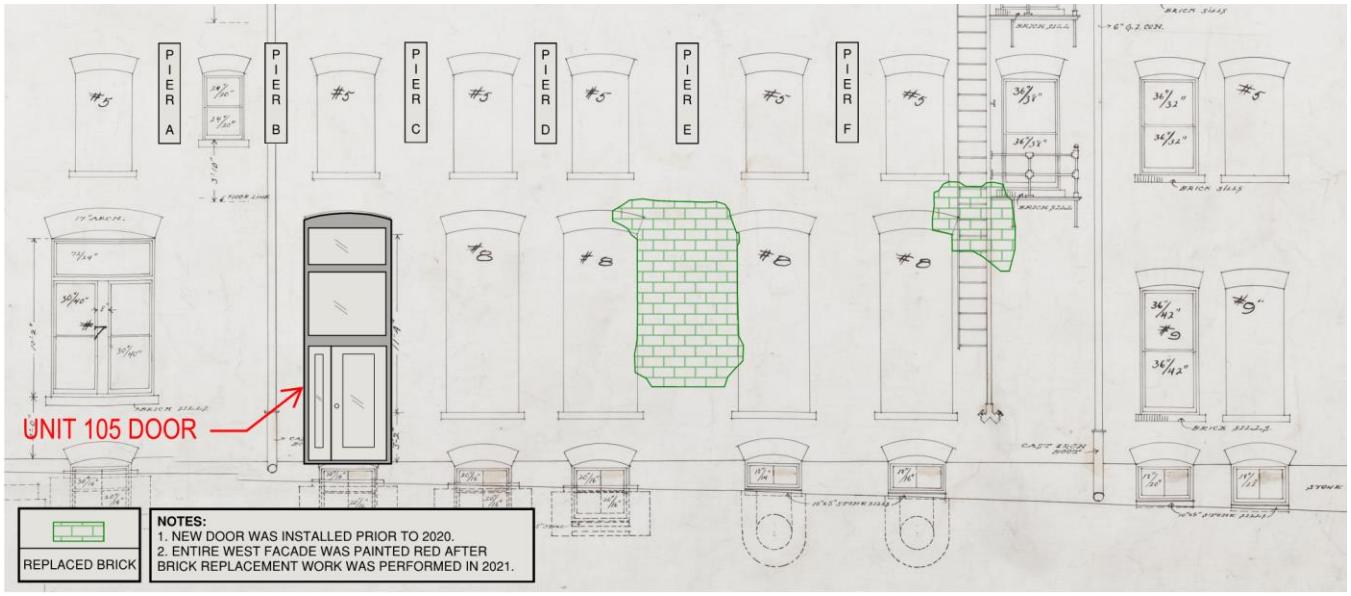

Fig. 6. Original 1906 west elevation drawing indicating 2021 repair locations (Annotations by WBG/SEI)

The City continued to issue Code Violation Notices through the end of 2021 that focus on deterioration and deficiencies noted around the entrance door to Unit 105 on the west elevation (indicated in **Fig. 6**). The City ordered the building owner to submit an engineering report regarding the observed deficiencies, but it appears no reports were received. As a result, the City ordered the unit to be vacated via a notice issued on December 9, 2021. The City did not issue any further citations after this date until 2023.

5.2 Early 2023 Repair Campaign

On February 2, 2023, the City issued a "Notice of Public Hazard" in which it stated the west elevation of the building had been *"gradually failing".* David Valliere, PE, from Select Structural Engineering, LLC (SSE) performed an emergency site visit and issued a letter summarizing his findings the same day. SSE ultimately concluded that the *"damaged area is not an imminent danger to the entire building and its residents".*

SSE followed up with a second letter dated February 8, 2023, specifying repairs on a 12-foot-wide section of wall to the north of a "boarded-up window" (assumed to be located as noted in **Fig. 7**). The repairs specified the installation of needle beams and steel angles at the second floor to temporarily support the façade during brick replacement in the story below. The full height of wall below the second floor would be replaced with a CMU wall in 4-ft segments. SSE issued an addendum to these repairs on February 28, 2020. The addendum highlighted an unspecified additional segment of wall that would also require replacement due to conditions discovered during the demolition of the originally specified section.

Separately, and with no apparent accompanying narrative, SSE issued a temporary façade shoring sketch on February 9, 2023 (**Appendix A**: **Fig. 37**). There are no photographs of this shoring being installed at the Building. However, this sketch was referenced in later SSE correspondence, and similar shoring attempts were implemented during the late May 2023 repair work.

Shortly after the permit was issued and construction was underway in late February 2023, the City halted construction for failure to construct the exposed exterior wythe using solid clay masonry in conformance with the requirements for the preservation of the historic district. This was reported to have caused a delay to the project, while a new mason was found to complete the work. Photographs from April and May 2023 indicate the work resumed and ultimately completed with the masonry painted on May 12, 2023 (**Appendix A**: **Fig. 39**).

Fig. 7 indicates the apparent area of completed repairs. Note, this area of work is far more extensive than that specified in SSE's letters. No specifications or details regarding the additional work areas have been made available to WBG and SEI to date.

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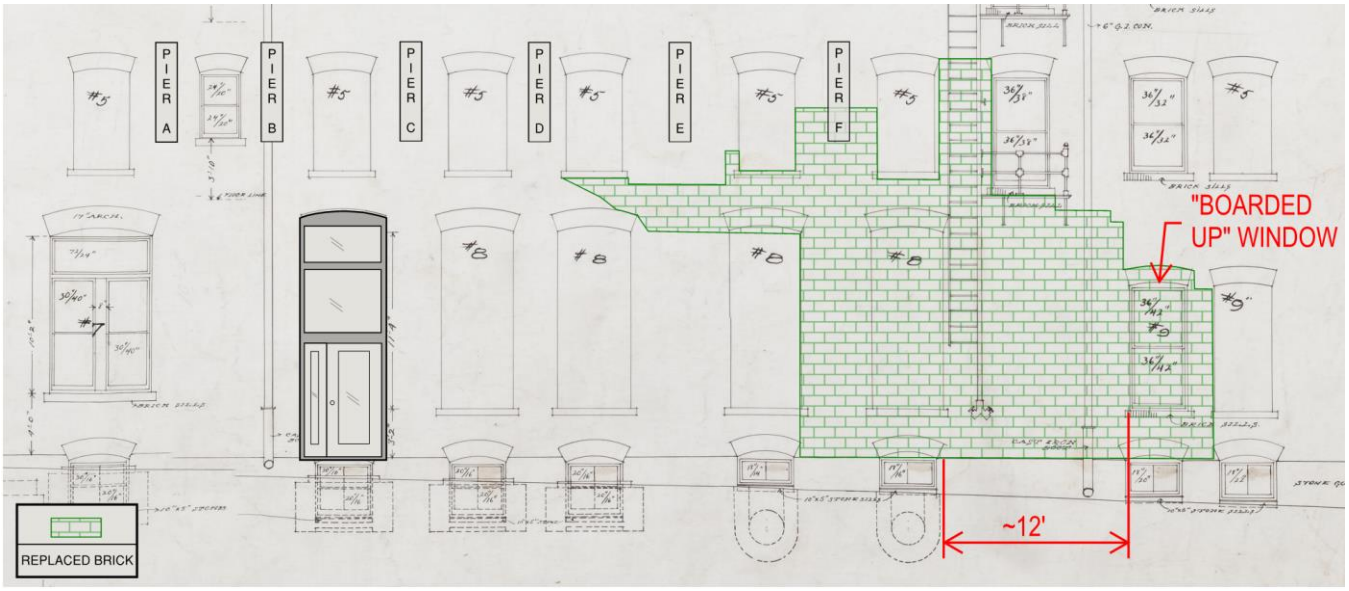

Fig. 7. Original 1906 west elevation drawing annotated with the location of the original "12 Feet" of brick replacement specified by SSE, and the apparent areas of repair completed through May 1, 2023 (Annotations by WBG/SEI)

5.3 Late May 2023 Repair Project

SSE visited the site again on May 23, 2023, and issued a follow-up letter the next day. The letter listed several deficiencies with the west elevation of the building that warranted immediate repair. SSE required existing window openings, that were previously infilled with a single wythe of brick masonry, to be infilled with CMU. In a location south of the Unit 105 door, SSE also required removal and replacement of a large portion of the masonry that was detached and bowed away from the plane of the wall. SSE recommended shoring be implemented per the methodology referenced in their February 9, 2023, correspondence.

The City issued a permit for these repairs on May 24, 2023 (the same day as the SSE letter). Photographs and images captured from security video of the proceeding days' work are included in **Section 6.1** of this report.

On May 28, 2023, at approximately 5 pm a large portion of the west elevation of the building collapsed. The area of collapse included the portion of building undergoing repairs per the May 24, 2023, SSE letter.

Fig. 8 shows the locations of each of the various repairs completed and discussed in this report, in addition to the area of ongoing repair just prior to the collapse on May 28, 2023.

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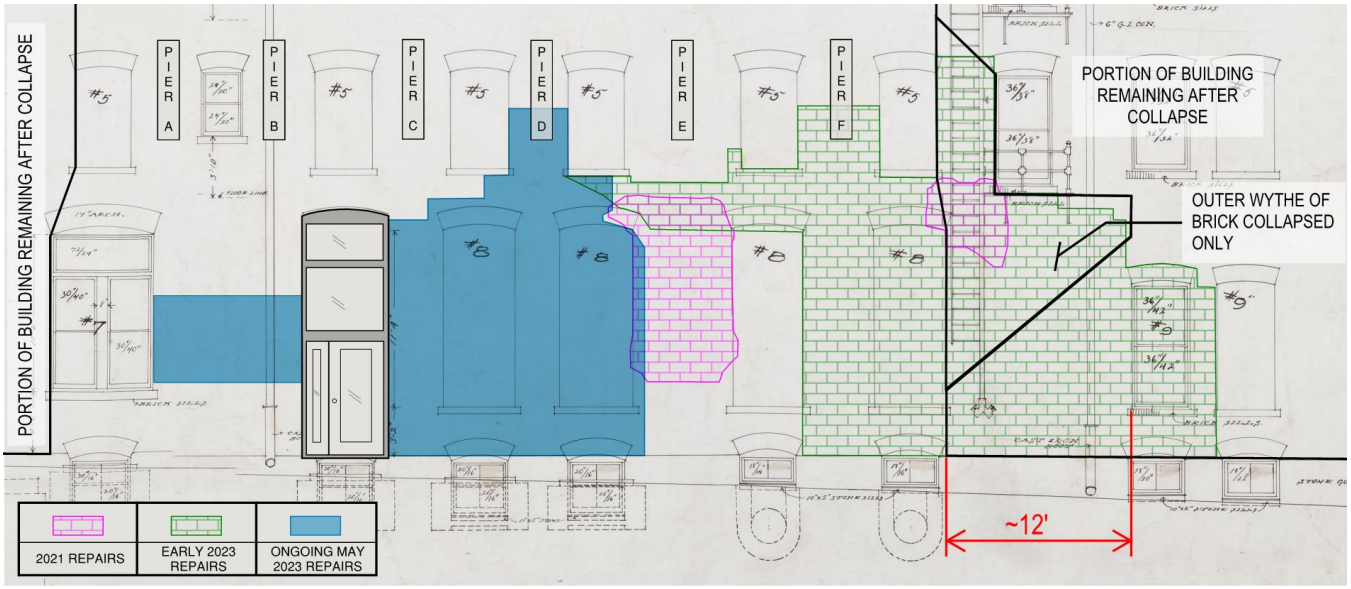

Fig. 8. Original 1906 west elevation drawing annotated with the various repair programs discussed in this report, in addition to the area of the Building that did not collapse (Annotations by WBG/SEI)

6. SEQUENCE OF MAY 2023 REPAIR WORK

WBG and SEI have not received any written documentation pertaining to the repair work completed on or after May 26, 2023. However, WBG and SEI were provided with near-continuous security camera footage from approximately 6.30 pm on May 26, 2023, through the time of collapse at approximately 5pm on May 28, 2023, in addition to other publicly available photographs of the work being performed. The following section of this report summarizes the various activities that were occurring during the May 26 through May 28 period that may be pertinent to the cause of collapse.

6.1 Security Camera Footage

As noted above, WBG and SEI evaluated security camera footage of the work area at the west elevation. This footage provides insight regarding the work being completed by the masonry contractor, as well as the events immediately prior to the partial collapse of the west wall. WBG and SEI compiled available relevant photographic and videographic imagery for the time period from May 26 through May 28, 2023, into **Fig. 9** through **Fig. 14** below.

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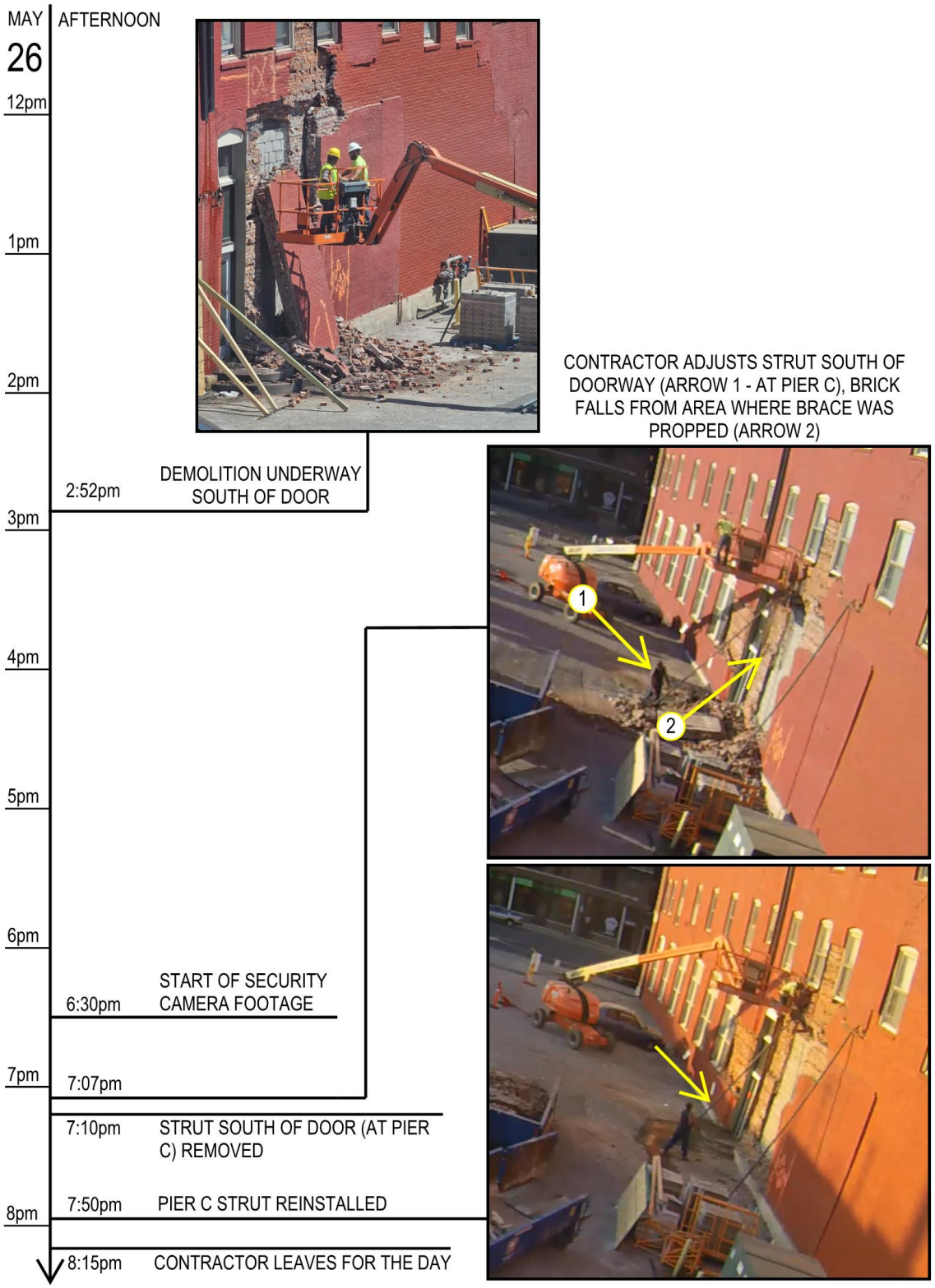

Fig. 9. Timeline of events – Afternoon of May 26, 2023.

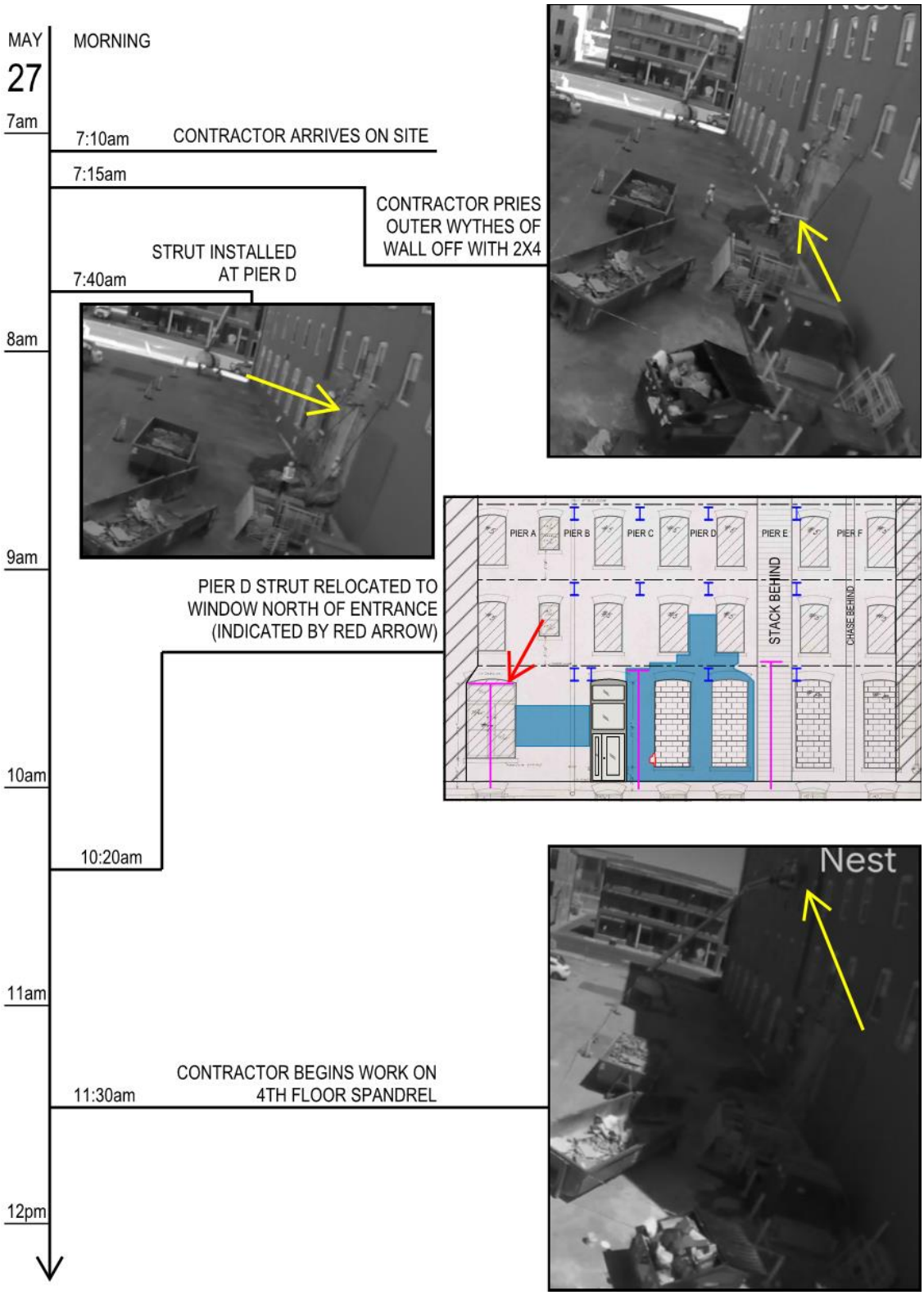

Fig. 10. Timeline of events – Morning of May 27, 2023.

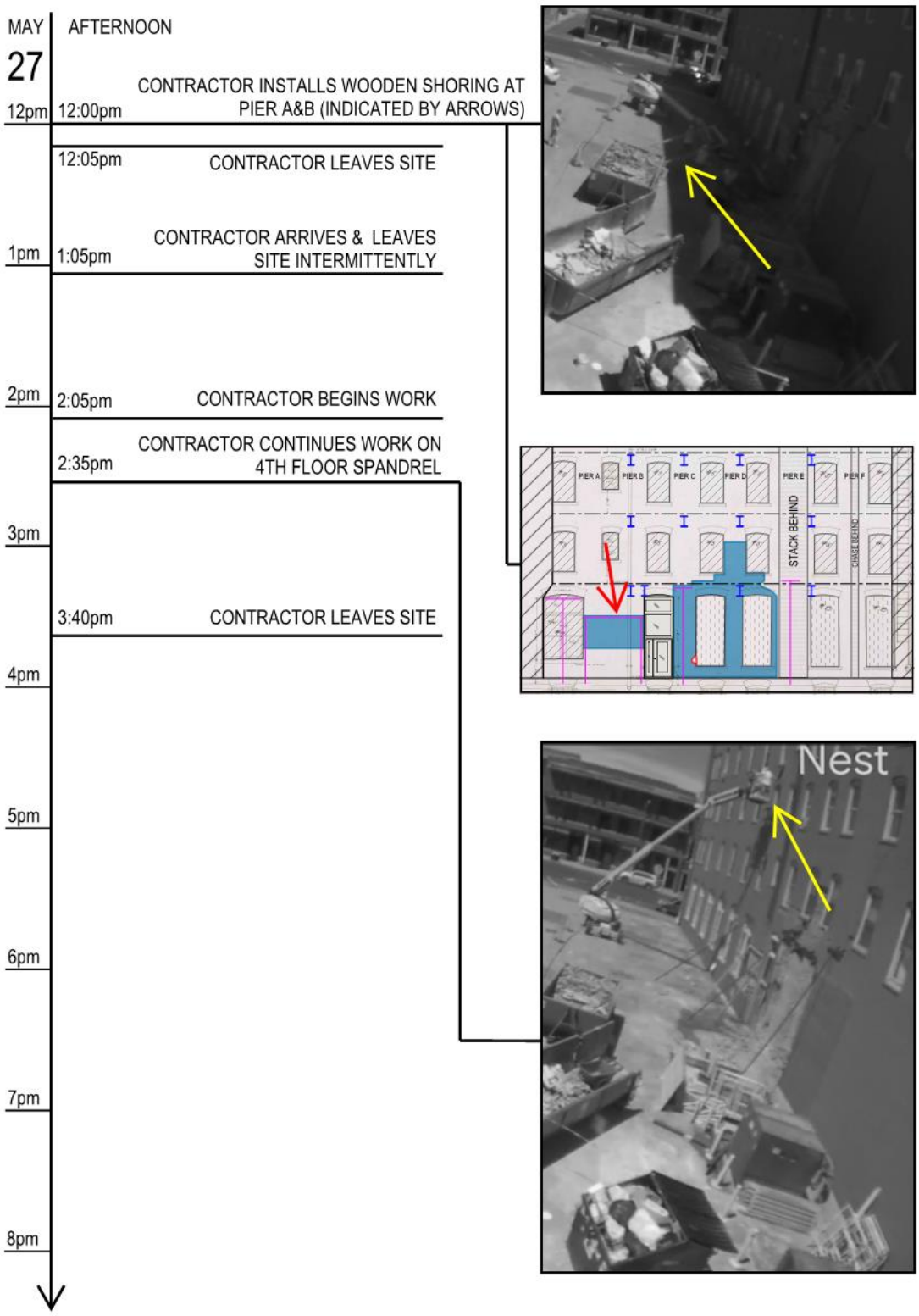

Fig. 11. Timeline of events – Afternoon of May 27, 2023.

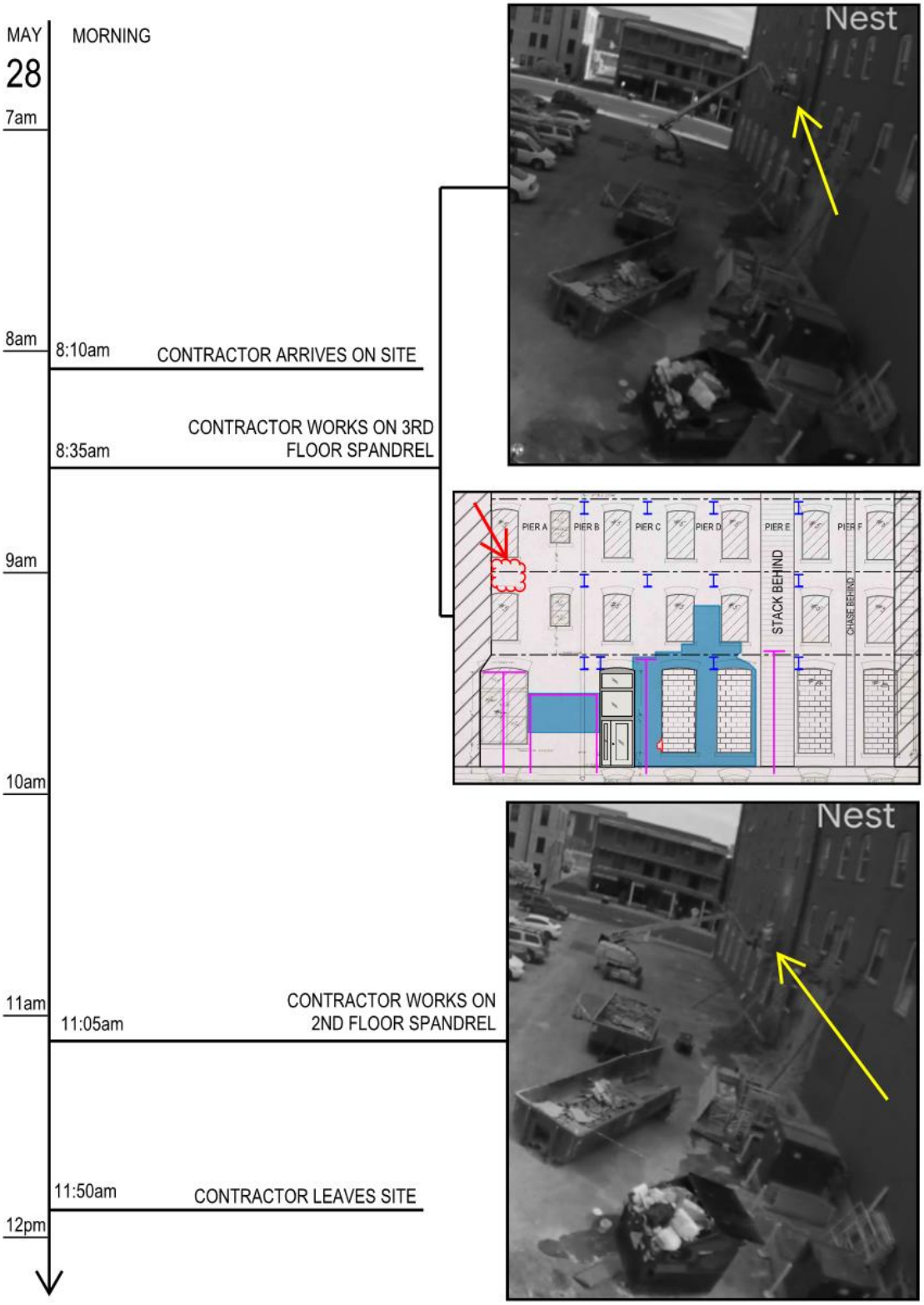

Fig. 12. Timeline of events – Morning of May 28, 2023.

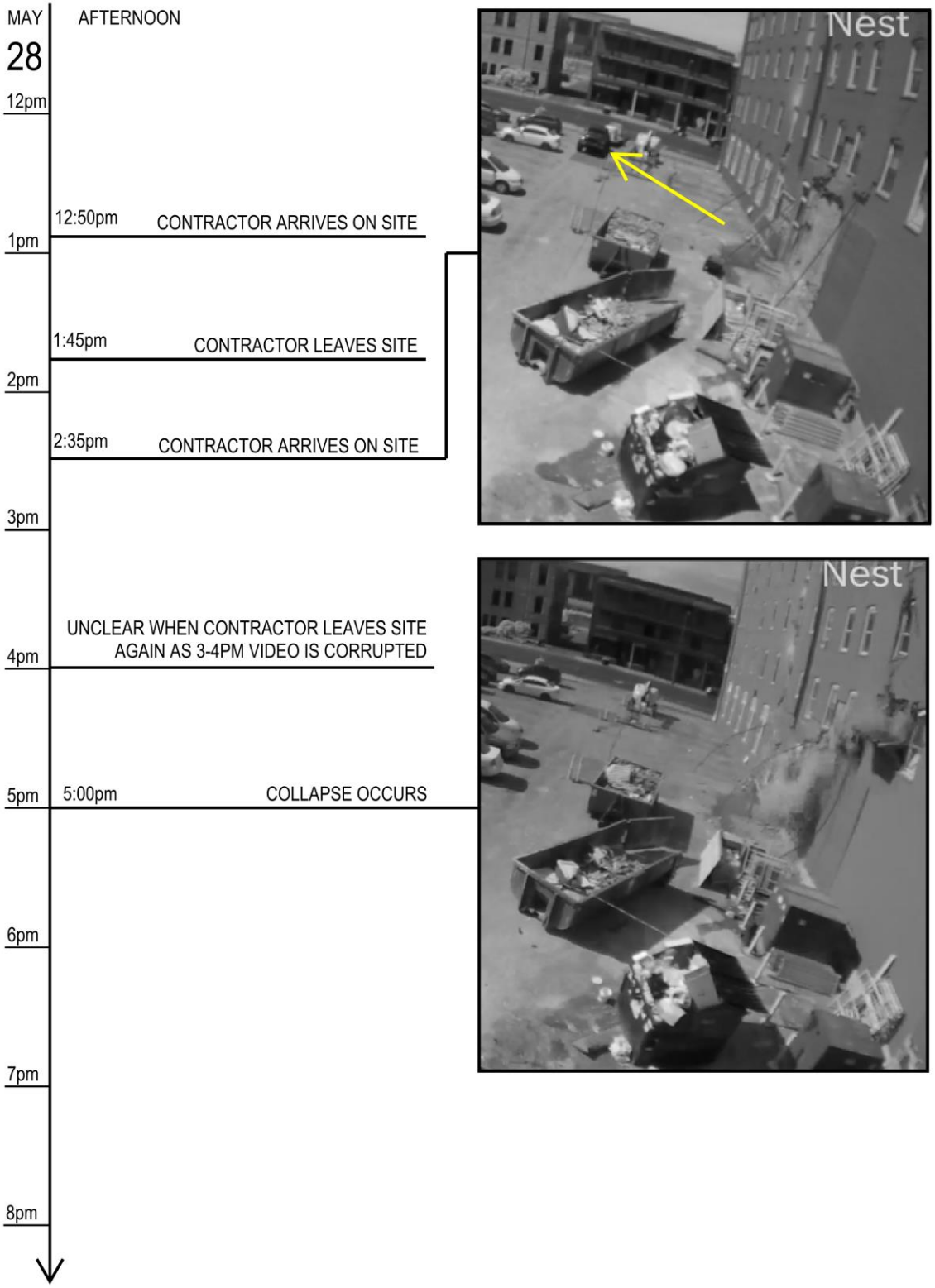

Fig. 13. Timeline of Events – Afternoon of May 28, 2023.

The security camera footage reveals some increased signs of distress at the west elevation occurring in the minutes prior to the partial collapse of the building. This sequence of events is summarized in **Fig. 14**.

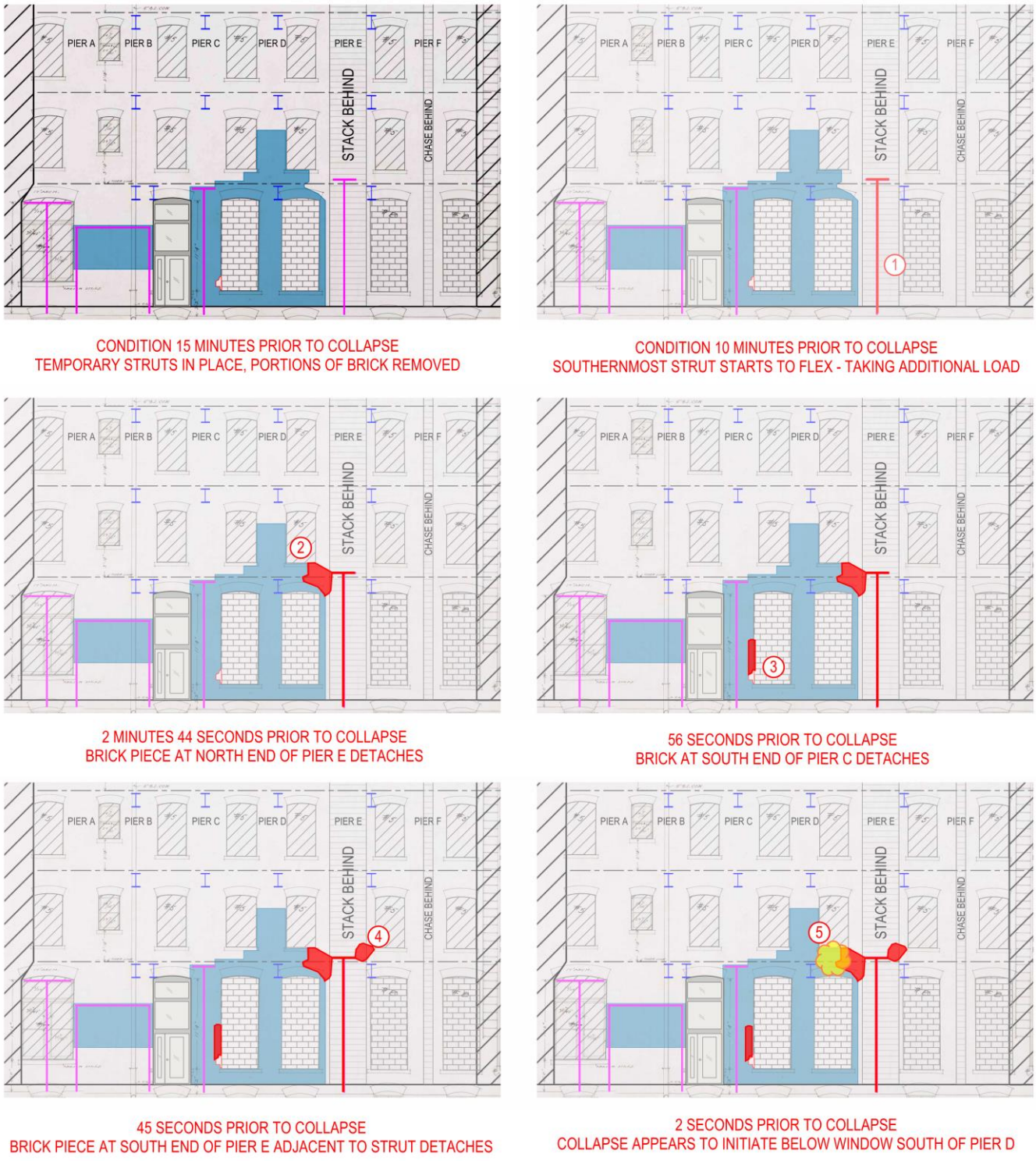

Fig. 14. Timeline of events – Immediately prior to collapse at 5 PM on May 28, 2023.

6.2 Other Imagery

On May 26, 2023 (two days prior to collapse), a photograph was taken of the ongoing repair work at the building. An annotated version of this image is provided in **Fig. 15**. The image indicates several areas of nonconformance with the repair specifications issued by SSE, in addition to other deficient conditions.

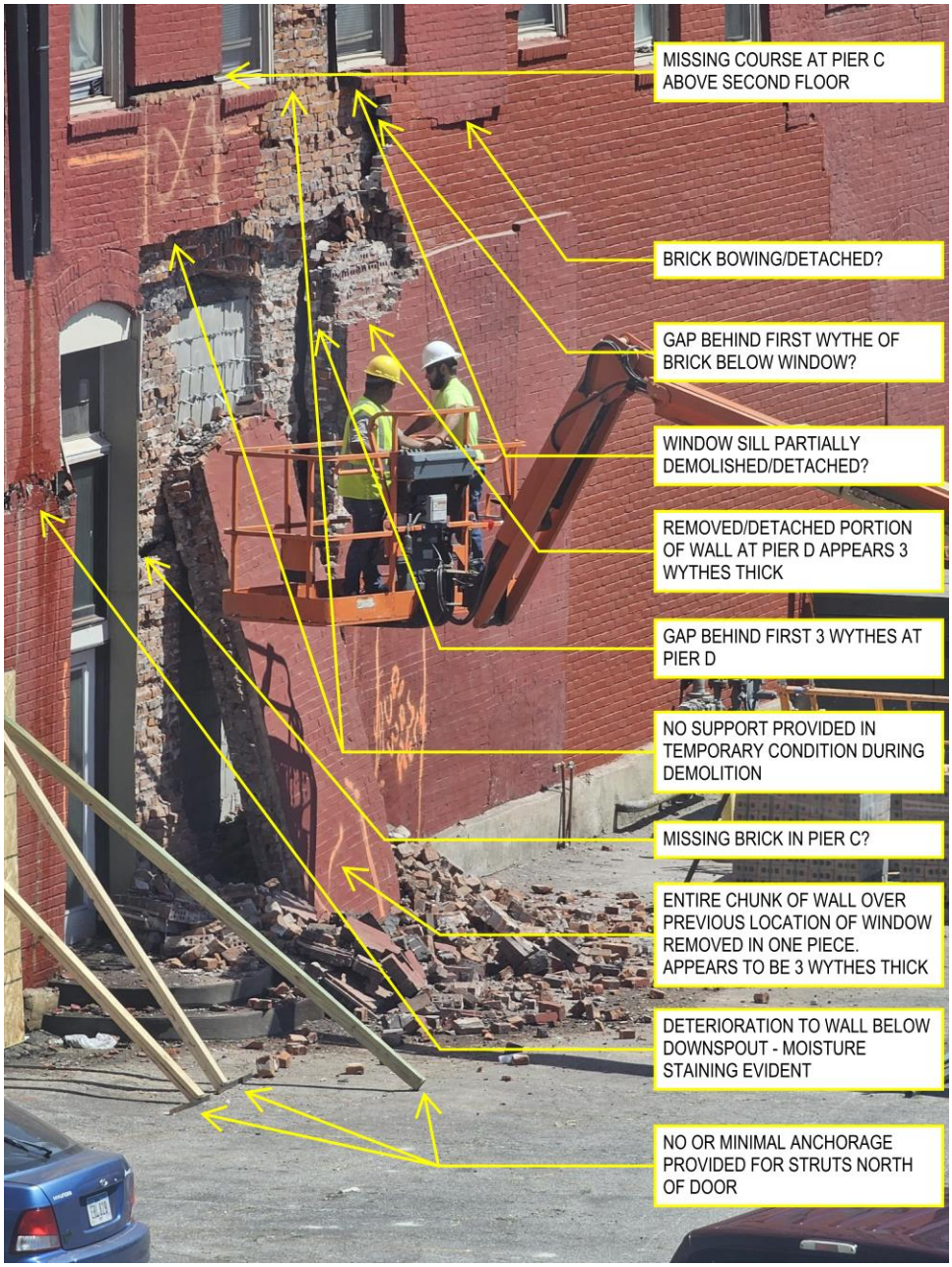

Fig. 15. Photograph from May 26, 2023 at approximately 3pm. Annotation by WBG and SEI.

On May 27, 2023 (one day prior to the collapse), four photographs were taken of the ongoing repair work. One such image is included in **Fig. 16**.

Fig. 16. Photograph from May 27, 2023, at approximately 3pm.

Based on a review of security camera footage, no further work was performed within the area displayed in **Fig. 16** after May 27, 2023. **Fig. 17** delineates the extent of the brick removal as evidenced in the May 27, 2023, photographs, and understood to be unchanged prior to the collapse at approximately 5:00 pm on May 28, 2023.

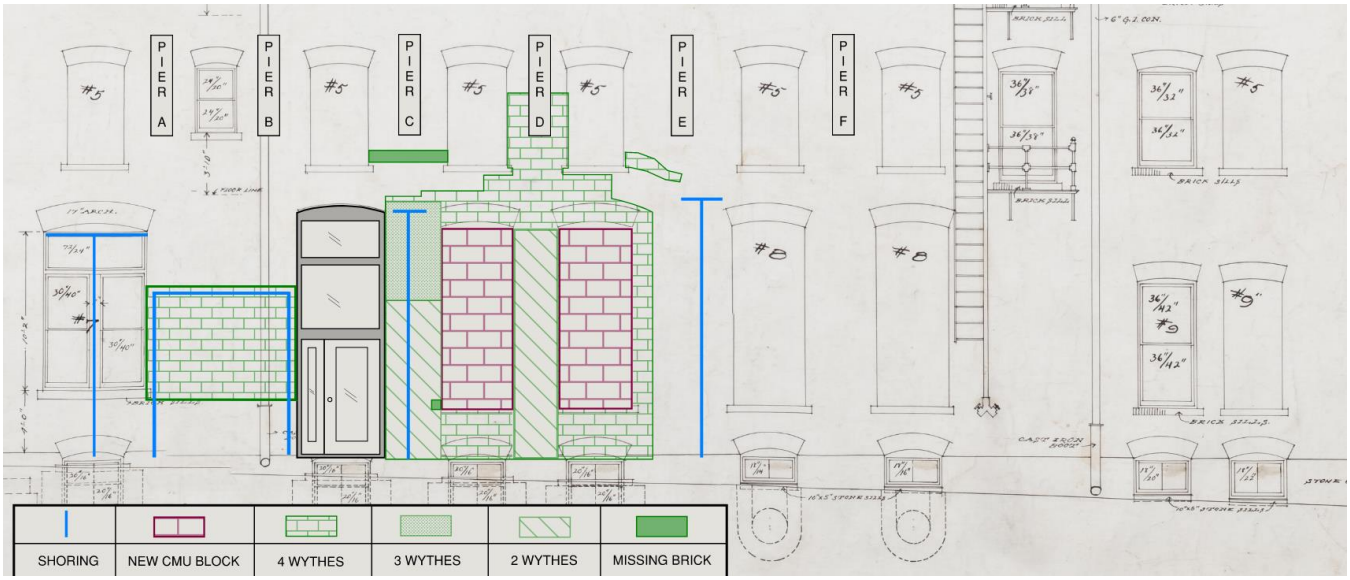

Fig. 17. West elevation markup indicating assumed amounts of remaining brick after brick removal prior to collapse on May 28, 2023.

7. THE COLLAPSE INCIDENT

At approximately 5:00 pm on May 28, 2023, a portion of the west elevation and interior floor structure collapsed. **Fig. 18** and **Fig. 19** indicate an overall elevation and plan view delineating the approximate portion of the building that collapsed.

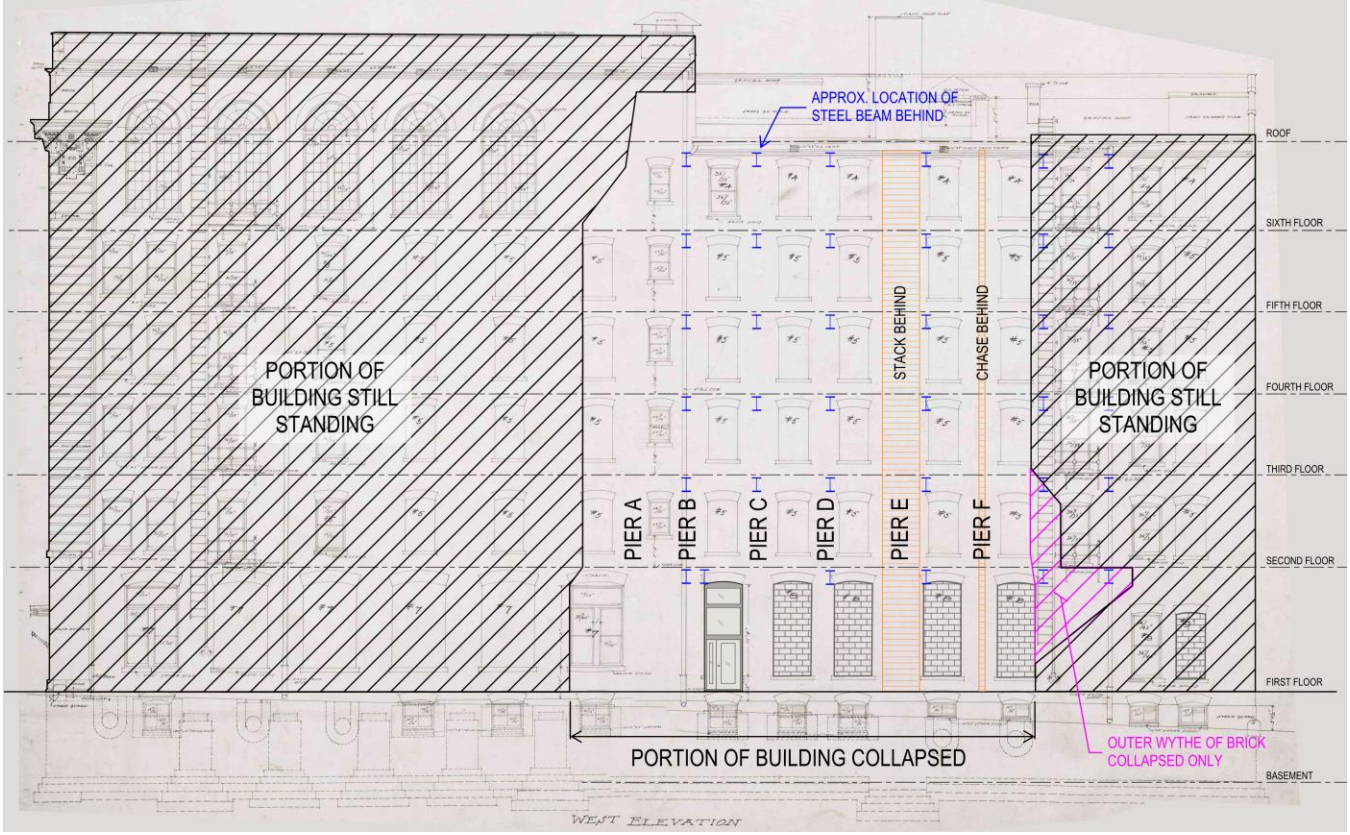

Fig. 18. West elevation view Indicating the portion of the elevation that collapsed on May 28, 2023.

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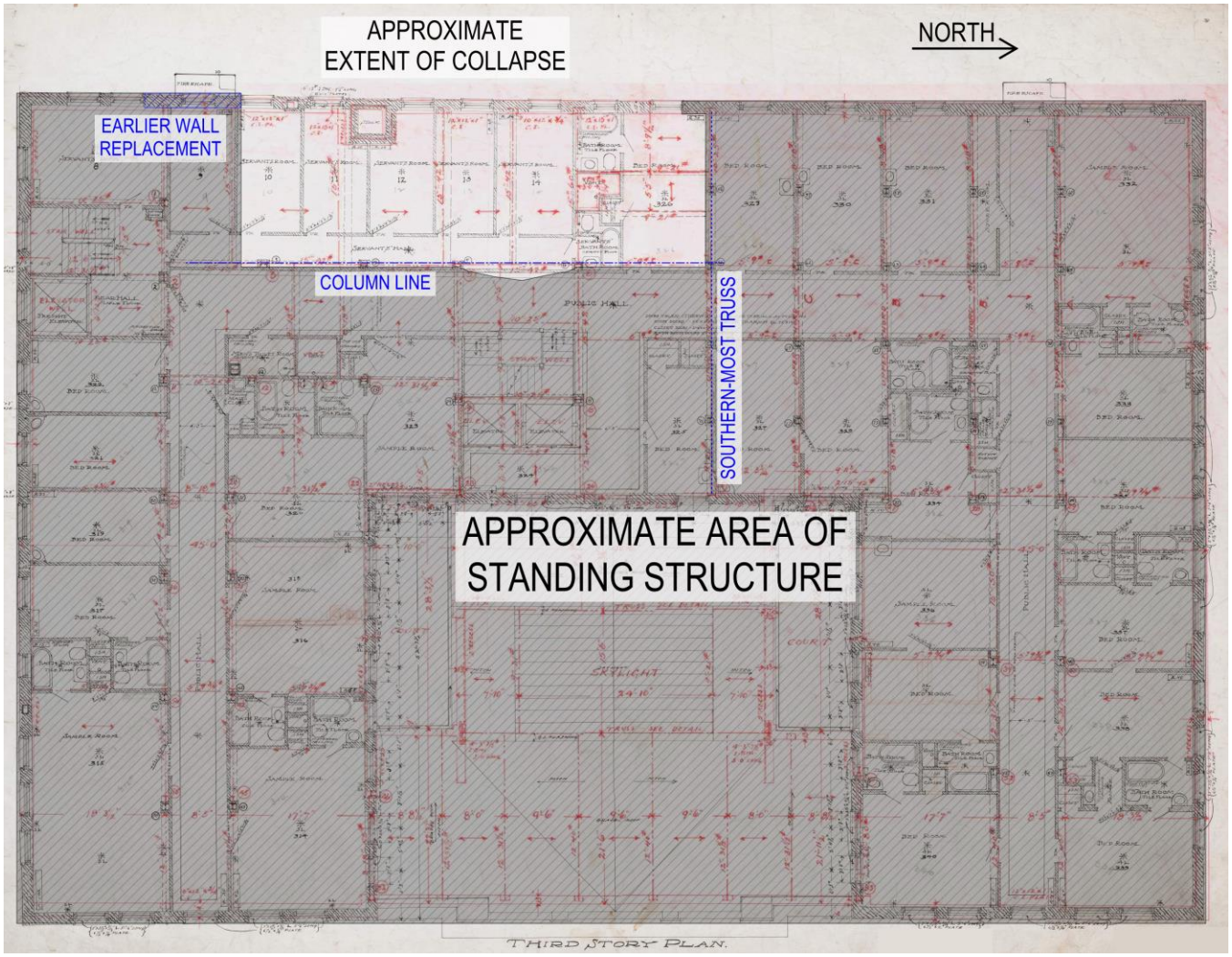

Fig. 19. Third story plan view indicating the portion of the Building that collapsed on May 28, 2023.

The collapse was arrested at the north extent by the southernmost one-story deep 2nd floor truss and supporting steel column (See **Fig. 20**). Note that a cross-section through the brick is visible in **Fig. 20** indicating 5 wythes of masonry, with the innermost wythe consisting of hollow clay tile and the outer wythes solid brick. At the south extent, the collapse was arrested at the column line coinciding with the construction joint in the CMU wall backup that was mentioned in the repair documents issued by SSE in February of 2023, and discussed in **Section 5.2** above. This CMU joint is delineated by a yellow arrow in **Fig. 21**.

Fig. 20. Photograph of the northern extent of the collapsed portion of the Building taken June 4, 2023. Arrows indicate steel column (left) and truss (right).

Fig. 21. Photograph of the southern extent of the collapsed portion of the Building taken June 4, 2023. Arrow indicates construction joint of new CMU wall construction.

Climactic conditions on the day of the collapse consisted of easterly winds with a maximum sustained speed of approximately 14 mph at 4:00 pm. Ambient temperatures reached a maximum of approximately 85°F in the afternoon, increasing from a low of 55°F in the morning. It is noted that at the time of the collapse, the west elevation would be experiencing direct exposure to solar radiation (see **Fig. 22**). Note that weather data is based on archived reporting from the Moline Quad-City Airport weather station (KMLI). Local weather conditions at the Building likely varied slightly from that recorded 6 miles away.

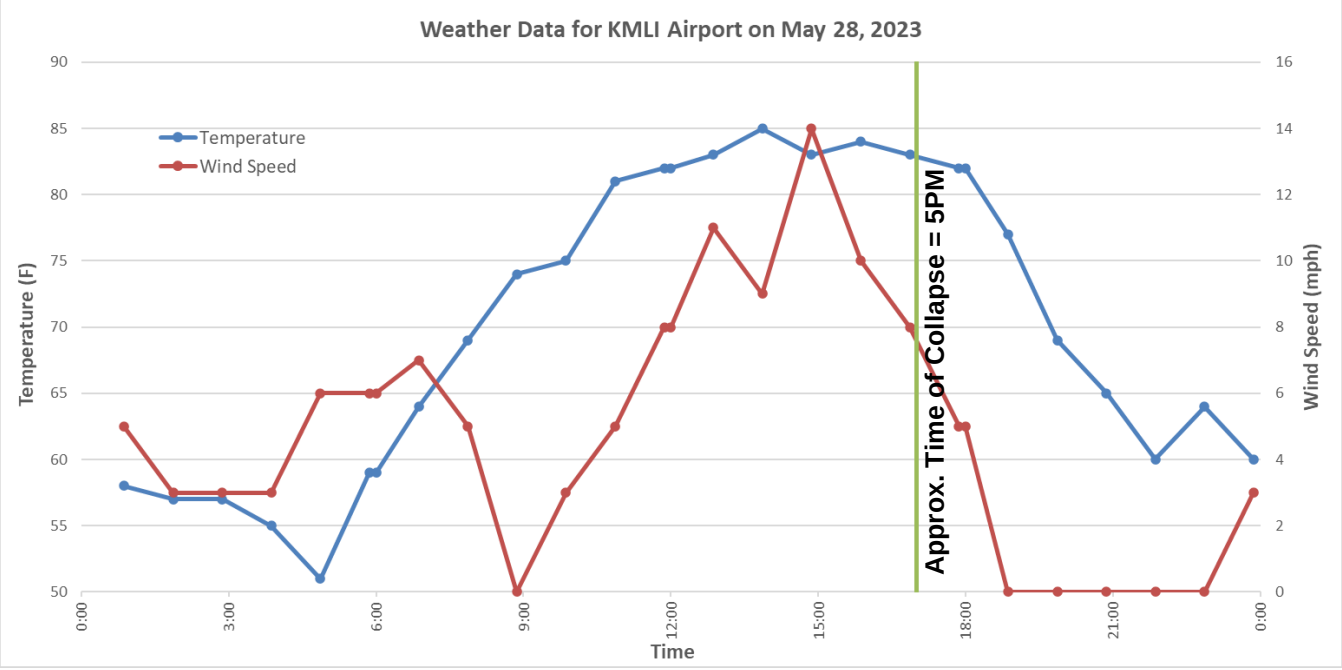

Fig. 22. Weather data for Quad Cities International Airport weather station (Ref. NOAA - KMLI)

8. STRUCTURAL ANALYSIS

The structural analysis summarized in this section is based upon the assumed condition of the west wall developed from the review of documents described in **Section 6**. **Fig. 23** summarizes the condition of the west wall, as understood by WBG and SEI, that was utilized to develop this analysis.

The analysis focuses on Piers C and D due to the removal of masonry, photographic evidence of wall distress, and proximity of these piers to the location of failure initiation indicated on the security video. No calculations were performed for Piers E and F due to the unknown composition of the wall in those locations subsequent to the various masonry repair projects.

The analysis only includes the dead loads and minimal live load assumed to have been in place at the time of the collapse. No consideration was given to other loads such as wind or thermal. However, it is noted that while minimal, the 14 mph wind recorded would have exerted pressure on the façade and further exacerbated the overstress condition of the wall. In addition, the thermally induced expansion of components resulting from the 30°F increase in temperature throughout the day may also have contributed some nominal additional stress.

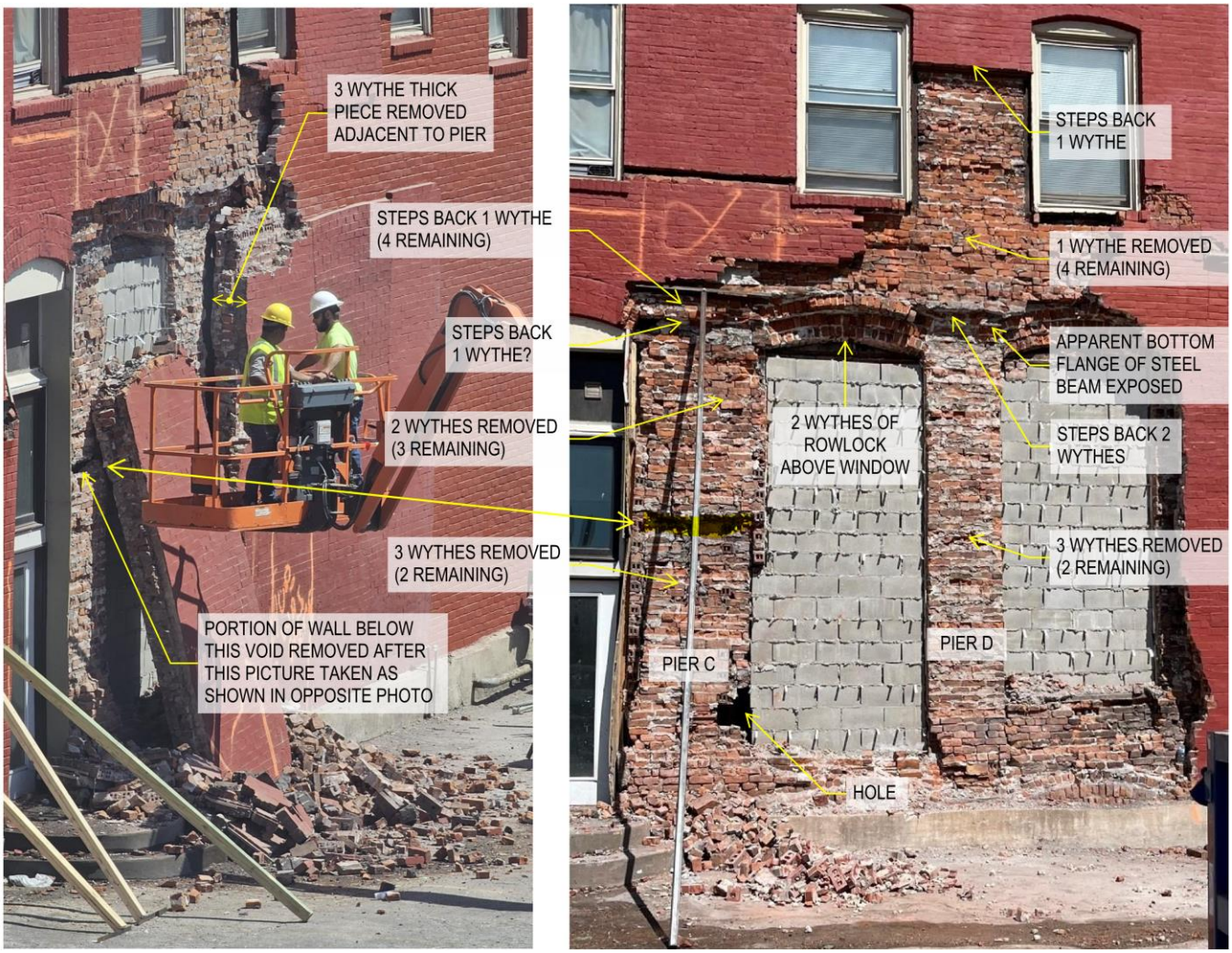

Fig. 23. Basis of pre-collapse condition utilized for analysis of Piers C and D.

In the days prior to the collapse, portions of the exterior wythes of masonry wall were removed in large sections. This activity created an eccentric loading condition where the masonry wall reduced from five wythes down to two to three wythes in thickness. This condition induced bending moment (rotation) that the wall was never intended to resist. Furthermore, these eccentricities would require new load paths to be established (either through redistribution of loads within the wall, and/or supplemental shoring) to resist the forces necessary to stabilize the wall at each beam support location.

Calculations by WBG and SEI indicate that the removal of the outer wythes of brick demonstrably compromised the wall's ability to resist the loads on it at the time of collapse, particularly at Piers C and D, such that collapse was imminent. Pier D at the 1st floor was the most significantly overstressed (where this tall and narrow pier appears to have been reduced to only two wythes thick (see **Fig. 23**). Pier D at the 2nd floor was also marginally compromised. Pier C was similarly overstressed (note that the wall at this location also featured voids that would have significantly reduced the capacity beyond that assumed in this analysis).

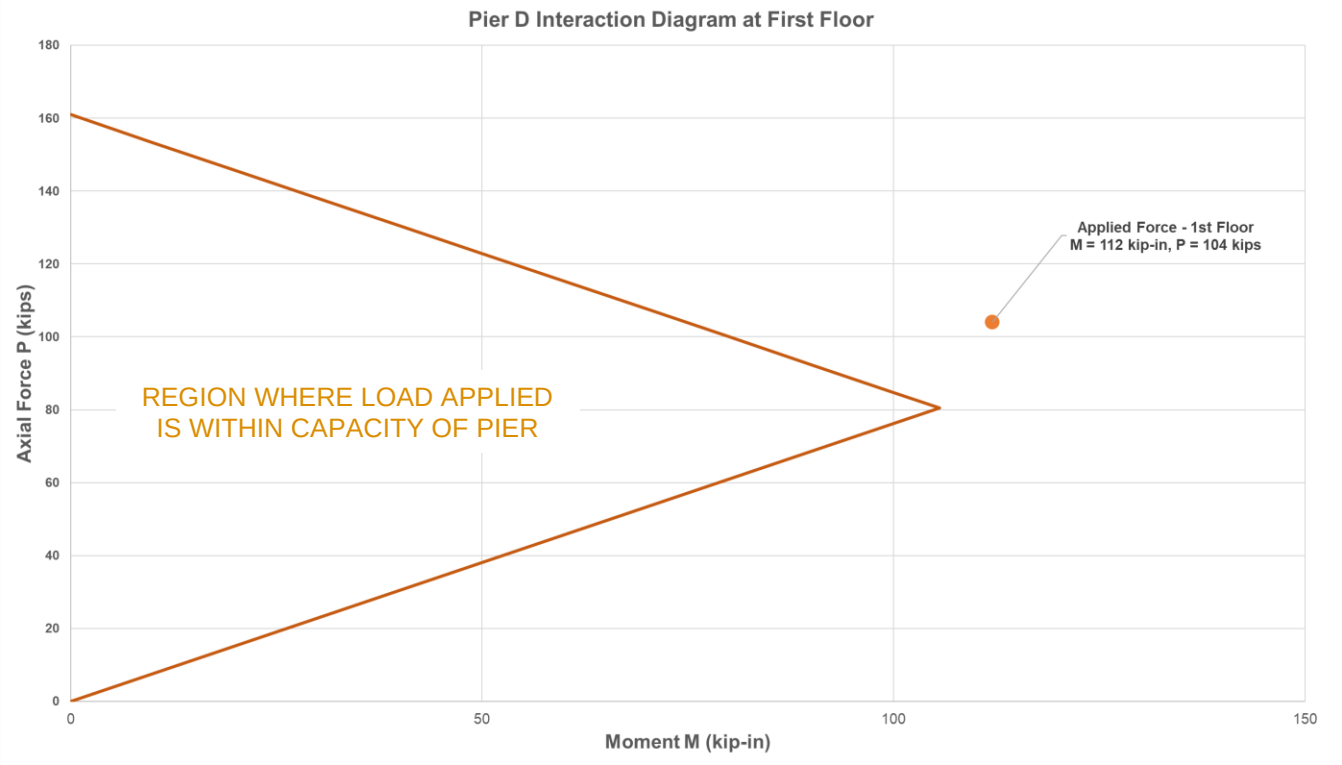

Fig. 24. Interaction Diagram for Pier D at the First Floor

It should be noted that due to the inadequate construction and configuration of the temporary shoring, this analysis does not attribute any capacity to those components. Regardless, no shoring was provided at Pier D, where the analysis and video evidence indicates collapse initiation to have occurred.

Overall, the analysis indicates that removing the outer wythes of brick without providing adequate shoring compromised the structural integrity of the wall sufficiently to precipitate collapse.

See **Appendix B** for further detail regarding the calculations performed.

9. DISCUSSION

The following narrative contains a critical evaluation of the information presented in the earlier sections of this report. The associated commentary establishes the root and proximate causes of the failure and forms the basis of the Summarized Conclusions presented in **Section 10**. Additional photographs are referenced and included in **Appendix C** of this report.

As noted in **Section 8**, the driving force of the partial collapse is the overstress that developed in Piers C and D, which resulted in their inability to support the loads imposed from the floors above. This can be considered the triggering event. However, as is typical to structural collapses of this nature, numerous proximate causes and other interrelated factors contributed to the failure. These factors can be traced back throughout the history of the Building and are summarized below:

- Improper Understanding of the Original Building Construction
- Inadequate Construction Documents
- Inadequacy of Repairs – Neglect of Composite Wall
- Inadequacy of Repairs – Improper Shoring
- Inadequate Oversight of Repairs
- Discontinuity of West Elevation Exterior Wall - Inherent Weakness in Wall System
- Discontinuity of West Elevation Exterior Wall – Poor Integration of Repairs
- Long Term Inadequate and Deferred Maintenance

A successful repair project for an existing, historic building needs to include a holistic review of all the available information pertaining to that structure. This includes a review of available drawings, a review of historic information (including repairs) relating to the structure, and a visual (and sometimes invasive/destructive) investigation of the present condition of the building.

WBG and SEI did not find any evidence in available documentation that indicated the repair projects reviewed and investigated within this report were performed with the due diligence noted above.

Subsequent to the work of the Design Professionals, the repair Contractor, failed to implement appropriate means and methods to allow for the safety and stability of the building during the repair work.

9.1 Improper Understanding of the Original Building Construction

In the August 18, 2020, memorandum discussed in **Section 5.1**, Townsend Engineering expressed an apparent knowledge of the materials utilized in the original design/construction of the Building. While the memo does not address the west wall, which was also not included in the scope of Townsend's remedial efforts, the memo accurately described the wall composition of the area under investigation. Significantly, the Townsend memo indicates original building plans were available and accessible for review through the Public Library. These original drawings clearly delineate a multi-wythe, load-bearing masonry exterior wall system at the subject Building.

The various documents, including the above-referenced Townsend memo, subsequent SSE letters and reports, and City documents, generally refer to the exterior wall system as a "veneer". In actuality, the exterior wythe of the multi-wythe composite exterior wall system of the building serves as an integral and critical portion of the building's gravity and lateral load resisting structural systems – it is not a "veneer" system. Repairs and/or modifications to such wall systems need to be completed in a manner that restores the capacity and integrity of the composite wall system. As noted in the subsequent discussion below, such integrity was not adequately achieved during the various repair projects at the Building.

The SSE documentation available to WBG and SEI does not mention a review of the original construction drawings. Further, the reports and letters produced by SSE contain multiple contradictions, questions, and improper assumptions regarding the composition of the subject Building's structural system:

- February 2, 2023: *"It is unclear whether it bears on the brick wall directly or rather on a steel column encased in brick."*
- February 8, 2023: *"The clay brick wall appears to be three or four wythes thick."*
- February 8, 2023: *"It is unknown if there is a north south steel beam inside the wall at the second floor level, or if there is a steel post encased in the brick…"*
- February 8, 2023: *"It will therefore be conservatively assumed that the east-west beams bear directly on the brick wall to be replaced."*
- February 28, 2023: *"This will soon cause a large panel of façade to also collapse, creating a safety problem and potentially destabilizing the upper areas of brick façade."*
- May 24, 2023: *"…several large patches of clay brick façade which are separating from the substrate. These large patches appear ready to fall imminently, which may create a safety hazard to cars or passersby….the brick façade above the windows should be secured. This is to keep the entire face of the building from falling away when the bottom area(s) come loose."*

Further, SSE's "*Figure 8*" contained within the February 8, 2023 (**Appendix A**: **Fig. 36**), letter delineates a 3-wythe masonry wall, instead of the 5-wythe wall that existed. Although no scale is indicated, the dimensions assigned to the shoring elements contained in the drawing suggest a total wall thickness of approximately 12 in. and the original SSE replacement design only specified a single wythe of CMU replacement to support the 5-wythe wall.

This would result in over 12 in. (3-wythes) of unsupported brick masonry above the new CMU. The February 28, 2023, "Addendum" letter from SSE references a site observation by the masonry contractor that resulted in a modification of the original inadequate scope, changing the original installation of a single wythe of CMU to two wythes of CMU. However, the modified scope (**Appendix A: Fig. 38**) still results in more than 5 in. of unsupported wall thickness, and an overall weaker non-composite system.

Of note, the February 2, 2023, City *Official Notice and Order* addressed to Davenport Hotel LLC, correctly references "*There is visible crumbling of this exterior load bearing wall* [emphasis added] *under the support beam."*

Lastly, pre-incident photographs of the west elevation wall between 2020 and 2023 indicate masonry distress, differential movement/settlement, shear (diagonal) cracks at both the exterior and interior masonry, displaced window frames, and other indications of differential wall movement (**Photograph 1** to **Photograph 13**). These types of damage to a masonry wall indicate overstress conditions where the masonry or its mortar is subjected to forces exceeding its capacity. These overstress conditions should have raised significant concerns because failure of a masonry bearing wall would not be limited to a localized failure of just the exterior wall but would result in the catastrophic collapse of the slabs and beams the wall supports at all levels. Such conditions require immediate investigation, and typically the implementation of shoring, or other stabilization and mitigation methods. The apparent lack of immediate action by the various stakeholders is indicative of an improper understanding of the wall construction, and the severity of the observed distress.

SSE violated the standard of care by misidentifying the composition, thickness, and load-bearing nature of the wall throughout its nearly four months of intermittent engineering assessment and brick replacement projects at the Building.

9.2 Inadequate Construction Documents

Based on documentation made available for this investigation, the Construction Documents prepared for the various stabilization and repair projects for the Building did not comply with the standard of care utilized by design professionals for projects of a similar nature. While hand sketches and field diagrams are often utilized to expedite conditions uncovered during initial or emergency inspections, detailed directions regarding the scope of repairs need to follow in a timely manner.

The extent of Construction Documents evaluated by WBG and SEI consists of incomplete sketches that fail to properly delineate the location and extent of required repairs. In addition, the specific configuration of permanent and temporary measures (shoring) to be implemented are not explained in sufficient detail. The Construction Documents rely heavily on narratives and written attempts to provide direction to the repair contractor/mason, as well as City officials responsible for reviewing and approving permits and completed work. Typically, the repair scope for projects of this nature would contain significantly more plans, elevations, cross-sections, and details of the required scope.

Furthermore, the extent of work performed during each of the repair projects appears to exceed the amount of wall area and locations that was originally contemplated by the Design Professional in their Construction Documents.

Available photographs of the Building from 2020 through 2023 indicate numerous areas of distress visible at the west elevation of the building; however, repairs specified by the various Design Professionals engaged by building ownership/management do not address many of these areas.

Where masonry work was performed, the attempted repairs do not appear to have contemplated the discontinuity of the original wall construction from embedded plumbing and mechanical chases, nor the modifications caused to the wall by dissimilar materials used for previous masonry repair work. In addition, the masonry work seemingly ignores that some portions of the wall have reduced thickness, and modified bearing conditions caused by previous brick replacement projects.

Further, the 2020 repair work failed to comprehensively address the distress in the masonry bearing wall and inappropriately deferred repairs of the visibly distressed west wall. Townsend Engineering's email from August 2020 does not include areas requiring repair at the west elevation, despite photographs available from the time indicating clear and imminently hazardous conditions (**Photograph 1** to **Photograph 6**). While minimal west elevation repairs were ultimately carried out in early 2021, many other visibly distressed areas of the wall did not undergo any remedial work.

In 2023, SSE also specified a limited repair scope and did not address other areas of distress that appear to warrant repair. Examples of apparent deficiencies include, but are not limited to:

- Photographs dated May 1, 2023, exhibit cracks and displacement at Pier C and between Piers E and F (**Photograph 13**) that indicate differential vertical movement of the masonry.
- Photographs dated May 24, 2023, of the masonry north of Pier A exhibits diagonal cracks at spandrel locations below the windows (**Photograph 14**). This suggests differential downward movement of the wall to the south of this pier.
- Photographs of the interior finishes in Unit 105 contained in SSE's May 24, 2023, letter indicated significant downward deformation and deflection (**Photograph 15**), indicating movement of the masonry substrate that the finishes were anchored to.

Moreover, SSE's repair documents issued within the May 24, 2023, letter specified the removal of several wythes of brick south of the Unit 105 doorway on the west elevation of the building. These exterior wythes had delaminated from the interior wythes of masonry and were visibly bowed (**Appendix A**: **Fig. 41** and **Fig. 43**). However, the limited Construction Documents available do not address these conditions. Despite the imminent hazards that were

visible on site (as exhibited in photographs contained in the SSE May 24, 2023, letter report), the scope of work specified by SSE fails to contemplate the severity and extent of distress in the west elevation wall system.

9.3 Inadequacy of Repairs – Neglect of Composite Wall

As noted above, the various repair projects specified CMU construction in several areas of the west elevation wall. Photographs indicate that CMU was installed as infill at window openings, in addition to replacement of clay brick masonry at large portions of the exterior load bearing wall at the first floor.

The new wall construction generally consisted of two wythes of CMU, a cavity, and a single wythe brick masonry veneer (see **Fig. 25**). Unlike the composite multi-wythe masonry of the floors above, the wythes in the new construction were not laterally tied together with headers or other shear ties to form a composite wall construction. Although corrugated steel veneer anchors were installed in some of the new CMU, these ties are typically designed only to provide lateral support for a veneer, not to engage the backup wall compositely through shear. Regardless, these ties were not engaging the exterior wythe of brick masonry (**Photograph 20**).

The lack of composite connection resulted in the single exterior wythe of brick masonry veneer of this configuration supporting approximately a third of the load from the composite masonry wall above, with the remaining two-thirds supported by the 12 in. of hollow CMU. This condition yields a bearing stress increase of approximately 67%, compared to a single wythe of the original construction above. The result of this increase in bearing was the visible large lateral displacement (bowing) of the brick masonry at the outer wythe.

Further, since the new CMU wall construction did not provide continuous bearing support for all 5 wythes of the masonry bearing wall above, and left one of the intermediate wythes vastly unsupported (**Photograph 18** and **Photograph 19**) some of the unsupported brick masonry above became disengaged, and the loose brick fell and collected at the base of the first-floor wall cavity between the CMU backup and the outer brick veneer. This condition exacerbated the wall distress by exerting additional forces on the brick veneer. The accumulation of loose masonry was reported by SSE in their Addendum letter dated February 28, 2023 (**Photograph 21**).

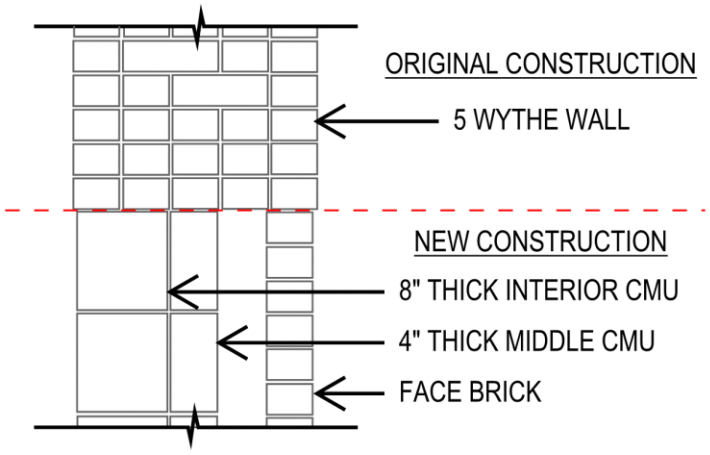

Fig. 25. Configuration of wall resulting from early 2023 repair project

In addition, the unbraced height and load-bearing requirements of the exterior wall require that the CMU wall construction include steel reinforcing bars (rebar). However, based on evaluation of the debris at the site (**Photograph 16** and **Photograph 17**), the CMU wall that was constructed north of Pier F prior to 2023 (**Photograph 26**), did not include any rebar or grout-filled cells. Note, based on City reports, and limited on site evaluation, the 2023 CMU construction south of Pier F did apparently contain reinforcing steel and grouted cells.

9.4 Inadequacy of Repairs – Improper Shoring

As previously stated in **Section 9.2**, the provided details for the repairs at the Building did not meet the standard of care expected of a Design Professional. In the absence of adequate directions contained in the Construction Documents, the contractor is expected to request further information from the Design Professional to ensure that the repairs can be completed in a safe and effective manner. One area where the lack of adequate direction is evident is in the temporary shoring implemented for the repairs carried out in the days prior to the collapse.

SSE provided various incomplete and inadequate directions for the wall stabilization:

- The February 2, 2023, letter indicates that *"…beams need to be shored with heavy posts so that permanent repairs can be applied*." However, the methodology for the shoring, and how to achieve adequate load path to the foundation level, is not indicated or described in the document.
- The February 8, 2023, letter contains incomplete shoring and stabilization information. Although SSE appropriately recommends the use of "needle beams" to support the exterior wall at staggered intervals, the delineation of *"6 x 6 Timber Post To Support Brick Shoring"* on Page 6 fails to achieve a positive connection between the horizontal steel needle beam and the timber posts, nor any lateral support for the proposed shoring.
- The February 9, 2023, sketch (**Appendix A**: **Fig. 37**) delineates an attempt to stabilize only the exterior wythe using OSB plywood and 2x4 cleats supported by *"4x4 Diagonal Braces"*, as well as a steel angle cut into the bed joint of the outer wythe of brick. It is unclear how the steel angle is supported, or how the 4 x 4 braces are to be adequately anchored.
- The February 28, 2023, letter from SSE again only indicates the support of the outer wythe of the multi-wythe wall with the use of a "*Steel Lintel*". How this lintel is intended to be supported is not indicated. Moreover, there is no description of how the load bearing wall is to be supported while the 1st story masonry is removed in its entirety.
- The May 24, 2023, letter report indicates the need for interior reinforcement/shoring of the steel *"E-W Beams",* presumably to transfer load from the existing masonry wall to the new proposed steel column. The only member that is sized in SSE's documents is the vertical column (W6x15). Further, the sizing and configuration of the components and "pilaster" appear to be inadequate to properly transfer the loads resisted by the exterior wall into the existing foundation system. The only shoring referenced in this document is the February 9, 2023, shoring sketch discussed above, which is not appropriate for the proposed scope of work.
- The May 24, 2023, letter report continues to state, "*If the* [East-West spanning] *beam has dropped slightly, then it should be jacked back upward to its proper level position".* Jacking of a member temporarily alters its load path affecting the jacked member, members supporting the jack, and elements supported by the jacked member. Because of this, a jacking plan should be reviewed and approved by a licensed engineer and the process should be carefully monitored. No such evaluation or monitoring is referenced in the letter.

Given these inadequate specifications, the contractor should have either submitted a request for additional information from the engineer of record or hired its own Design Professional to prepare calculations and drawings for the shoring and temporary supports. However, the reviewed documents do not indicate that the contractor took either approach.

The pre-collapse photographic and videographic evidence of the most recent repair attempts of the west exterior wall indicate that the shoring does not comply with SSE's minimal specifications, nor with standard practices for shoring procedures. Further, the installed shoring does not seem to have been subject to any engineering review.

- May 25, 2023, city inspection photographs from task 23-30329 display 4x4 timbers installed to brace the exterior wall (**Photograph 22**). These elements have no positive anchorage, and do not provide any substantial support to the wall or the masonry.
- In the forthcoming days, other locations of the wall are "supported" by slender steel HSS members with steel angles bolted to the top (**Photograph 23**)**.** These elements lack the stiffness and capacity to support the masonry wall, and only engage a single wythe of the 5-wythe wall system.

Furthermore, as is evidenced in video footage of days prior to the collapse, shoring was periodically removed to clean the work area or relocate around the site. Shoring for this type of masonry stabilization work is required to remain in place until the work is completed, and the wall has regained its ability to support the required loads.

9.5 Inadequate Oversight of Repairs

In situations where the construction documents do not adequately detail or specify the extent and type of repairs required for the anticipated conditions, the Design Professional should be retained by building ownership/management to periodically visit the site to ensure that the repair work is proceeding in accordance with the Design Professional's intent. This is particularly important for repairs involving existing structures where unforeseen conditions typically arise. Even when the repair scope is well defined at the outset, changes in conditions often require modifications to the repair approach as the work progresses.

Based on available documentation, it is WBG and SEI's understanding that SSE provided minimal oversight during both repair projects in early 2023, and in the days prior to collapse. Had members of SSE visited the site in late May 2023, they may have observed that the temporary shoring protocol indicated in their February 9, 2023, sketch was not being implemented in the field, and required the contractor to make the necessary modifications.

As another example, video in the days immediately prior to the collapse on May 28, 2023, displays the contractor "prying" large sections of masonry off the wall. More frequent oversight may have allowed SSE to be alerted to this condition and adjust the repair protocol accordingly.

9.6 Discontinuity of West Elevation Exterior Wall - Inherent Weakness in Wall System

The construction drawings, in addition to pre- and post-incident imagery, indicate the presence of utility chases within the west elevation wall. The number of wythes of masonry reduces at each of these chase locations (**Photograph 23**). Some of these locations are not indicated in the drawings but were visible only through review of photographs and on-site observation (**Photograph 25**).

The largest of these utility chases is delineated in the original drawings and was located at Pier F (**Photograph 26**). At these locations the wall thickness was reduced to only a single wythe at both the interior and exterior face of the wall. Beginning at the 3rd floor, the chase also required an offset in the interior wythe of masonry. These conditions all present further discontinuity and weaknesses in the wall system at floors two through six, and an unknown integration with the later constructed CMU modifications of the wall at the 1st floor.

In addition, the original construction drawings, as well as on site investigation indicate the presence of a boiler stack at the inside face of the west elevation masonry wall at Pier E. At this location, the five wythe masonry wall at the first floor reduced to two wythes in thickness. Although some lateral rigidity is provided by the perpendicular walls of the stack enclosure, this location presents another discontinuity and weakness in the vertical capacity of the west elevation wall. This location was also modified over time with the installation of a stack lining (a welded steel lining was observed in the rubble – welding was not a common construction procedure until the late 1920's.

Lastly, pre-incident photographs and post-incident evaluation indicate the presence of sheared and/or fractured header bricks in the wall. The settlement and other overstress within the wall over time apparently resulted in the failure of a number of these header bricks that served to tie the various wythes of masonry together.

Note, while the above-listed conditions did not cause the collapse of the west elevation wall, the inherent original weakness at Pier E explains why it collapsed though it did not undergo any major brick removal during the repair work at the end of May 2023. When Pier E collapsed, Pier F, which has no steel beams framing into it, was left unbraced as the floors bracing it collapsed, and Pier F collapsed as well. Pier F, however, is not of structural significance as it does not support any floor framing.

9.7 Discontinuity of West Elevation Exterior Wall – Poor Integration of Repairs

Although photographic documentation available to WBG and SEI does not pre-date the 2020 modification work, the various types and ages of masonry observed at the west elevation suggest that the subject Building has undergone multiple repair attempts over the life of the structure. Unfortunately, many of these repair projects and modifications have not been implemented in a manner which provides the continuity of load path as intended by the original building design and construction.

Composite multi-wythe load bearing masonry walls require that the various wythes of the wall be tied together using interlocking courses of masonry. These “header” courses allow for load sharing between wythes, in addition to providing out-of-plane (perpendicular) lateral stability for the wythes of masonry. On-site investigation and evaluation of pre-incident photographs of the west elevation indicate a lack of visible headers in many of the areas where brick replacement had occurred. In many locations, exterior wythes of masonry were replaced, without apparent adequate (or any) integration with the interior wythes of the masonry wall.

Further, many of the areas comprising previous repairs are not aligned/in-plane with the parent (existing) masonry wall (**Photograph 27**). This creates a lack of continuity, eccentric load path, and reduced capacity to support and transfer loads through the wall system.

Replacement masonry from most of the repair attempts, including the early May 2023 project, are also not keyed into the existing adjacent brick. There are straight vertical joints between the replacement areas (**Photograph 27** and **Photograph 28**) and the adjacent masonry. While this is technically permissible at the window infill locations, the condition exists in the piers and spandrels as well. To establish an integrated wall assembly, the masonry should be interlaced with the staggered brick joint bond of the adjacent masonry (like interlocking fingers). By not interlocking the brick coursing, each area of masonry acts independently. Thus, the narrow piers at the Building lack the ability to effectively distribute loads at the piers.

Additionally, as noted above, photographs obtained from City reports (**Photograph 7**, **Photograph 8**, **Photograph 11**, and **Photograph 12)** and SSE February 2023 documentation indicate masonry distress at the *interior* face of the west elevation wall. These damaged and missing brick masonry and clay tile units reduce the overall thickness of the wall cross-section, thereby reducing the capacity of the wall assembly even more so than contemplated in the structural analysis delineated in **Section 8** of this report.

In addition, at least two of the repair projects implemented the use of CMU construction in lieu of clay brick masonry. Although not inherently problematic, the use of CMU in an otherwise composite brick masonry wall requires proper detailing and installation techniques to achieve adequate performance of the ‘modern’ materials. As noted in **Section 9.4**, evidence of proper installation was not observed in materials contained in the post-incident debris.

The poor integration of the earlier repair work at Pier E combined with Pier E’s inherent weaknesses caused it to collapse along with Piers B, C, and D, though unlike those piers, Pier E had not undergone any major brick removal in the days preceding the collapse.

9.8 Long Term Inadequate and Deferred Maintenance

Photographic evidence of pre-collapse conditions indicates spalled and deteriorated clay brick masonry and mortar joints throughout the west elevation. Post collapse investigation supports the observation of this deteriorated common brick masonry. These conditions indicate a lack of adequate maintenance to the west elevation wall.

To better understand the ramifications of required maintenance of masonry walls, one must understand the inherent characteristics of this type of wall construction. In the early 20th century, load bearing masonry walls were typically designed using prescriptive methods, that is, for a given height of building, type of use, and story height, a specified thickness of wall would be required. These multi-wythe composite walls were considered “mass walls” and are early versions of “barrier walls” with regard to moisture infiltration and insulation. These walls are designed to allow some amount of water to be able to enter the wall in driving rain through cracks in the mortar joints and bricks. The water could be contained within the mass of the wall system and eventually evaporate before being able to infiltrate the interior of the building. This is opposed to “veneer” systems that include a void space or “cavity” between the outer layer of brick and the inner structural layer(s), to collect and drain water away from crucial structural elements utilizing weep holes or vents.

At the subject Building the areas beneath windows are particularly susceptible to water intrusion due to the brick rowlock detail for the windowsills that leave horizontally orientated mortar joints exposed directly to rain. Water can easily enter the brick wall through the upward facing mortar joints at these sills and other elements.

Therefore, brick masonry walls require regular maintenance of the mortar joints (i.e., tuckpointing) to minimize the amount of water that can enter the wall system. Similarly, rooftop components such as roofing membranes, and coping and parapet masonry, need to be adequately maintained to prevent water infiltration from rain and snow accumulation.

However, the available documentation provided in City records indicates a prolonged history of water infiltration at the subject Building. Reports of ongoing water infiltration at both ceilings and walls at the Building indicate that water from rain and snow melt was able to penetrate the exterior envelope of the Building and migrate to the interior finishes of the apartment units (**Photograph 29** and **Photograph 30**). Moreover, the August 2020 masonry distress at the north elevation sixth floor lintels is representative of the effects of improper exterior wall maintenance resulting in inadequate water management and drainage. As water penetrates the wall system and has prolonged exposure to ferrous elements such as the steel lintels over the north elevation windows, it causes corrosion of the ferrous materials. As the steel corrodes, it expands in volume, imparting forces on the masonry, in addition to forcibly displacing the masonry units. As the masonry units are loaded and displaced, they will fracture and/or be ejected from the wall.

Further, moisture trapped within clay masonry wall systems is problematic, and usually results in degradation of the wall system. Although mass wall barrier systems are designed to absorb (and release) some moisture, excessive voids in the wall system due to failed mortar joints and cracked bricks allow the volume of water that is absorbed by the wall exceeds the capacity that the wall can safely and rapidly dry through evaporation. As such, liquid water is permitted to travel through the wall system.

This condition is more problematic in older buildings such as 324 N. Main Street that utilized lime-based mortars. Until the 1920’s, the use of lime-based mortar was commonplace in brick masonry construction. Lime mortars are far more susceptible to water-induced damage than modern Portland cement-based mortars. When lime-based mortar is exposed to moisture, it allows for the dissolution and re-precipitation of the lime binder. The binder is the ‘glue’ that provides cohesion within the mortar. This results in friability and poor uniformity within the mortar (loss of cohesion) as well as a lack of adhesion to the clay brick masonry. This mechanism ultimately results in a significant weakening of the wall structure over time. Further, this dissolution and degradation of the mortar causes an increase in erosion of the mortar from the wall system, thereby creating larger voids, and in turn allowing greater volumes of water to enter. This cycle repeats at an exponential rate, causing degradation of the wall’s integrity if not maintained through tuckpointing and other customary masonry repairs.

Water infiltration of wall systems employing lime-based mortars are even more problematic in cold weather climates where the wall is subject to freeze-thaw cycles. When water entrapped within the wall (and mortar) freezes, it expands in volume. This volumetric expansion results in imposition of additional forces within the mortar at a micro-level, in addition to the wall system at a larger scale. The expanding water ultimately weakens the strength of the wall by causing fractures between the mortar and brick, as well as within the clay brick masonry units (**Photograph 6** to **Photograph 9**). Note, the porous "common bricks" utilized for the outer wythes of the west elevation at the subject Building are particularly susceptible to the effects of expansive damage due to entrapped water.

It should also be noted that the entire west elevation at the Building was painted in mid-2021 as part of the repair program implemented at that time. The painting covered many of the previously identified areas of distress. There is no evidence that these damaged locations were properly addressed prior to painting. Furthermore, while painting would temporarily protect the wall from water intrusion at some locations, water would still enter the wall system at imperfections. Lastly, unless the paint utilized was a vapor-permeable coating, the presence of paint would then actively prevent water from being able to evaporate from the wall system as required.

There were also numerous indications of ongoing deterioration of the original structural members observed during evaluation of the Building and evaluation of photographic records. Numerous photographs indicate the presence of supplemental steel shoring posts at the interior of the subject Building (**Photograph 31** and **Photograph 32**). **Photograph 32** (extracted from SSE's February 2, 2022, letter) exhibits a supplemental steel beam as well. It is unclear exactly when and why these components were installed at the Building; however, these types of components would generally be required to mitigate structural deficiencies in the building. Due to the location of these elements at the exterior wall of the building, it is probable that water-induced corrosion weakened the existing structural members and/or their connections, and thus required reinforcement.

Lastly, several basement columns exhibited reinforcement at the connection to the beams framing into said column (**Photograph 33** and **Photograph 34**). The column cover plating and supplemental steel angles suggest a deficiency at this connection location. It is unknown if this condition was due to ongoing water infiltration and resultant corrosion, or some other overstress condition.

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10. SUMMARIZED CONCLUSIONS

10.1 Root Causes:

10.1.1 Inadequate Capacity of Wall System

The removal of multiple wythes of masonry during the repair work in the three days preceding the collapse severely compromised the western bearing wall and caused it as well as the areas it supported to collapse on May 28, 2023. The temporary shoring that had been installed was grossly inadequate. Had a proper shoring and construction phasing plan been implemented during these repairs, the Building would not have partially collapsed on May 28, 2023.

10.1.2 Inadequate Shoring

The temporary stabilization methods specified by the Design Professionals during various repair projects for the Building do not appear to have considered that the western wall served as a critical structural load bearing element. Additionally, the shoring implemented by the most recent masonry repair contractor at the subject Building does not conform to usual and customary practices for masonry wall shoring or stabilization. The attempted installation was severely lacking in multiple aspects:

- The shoring did not engage any masonry other than limited portions of the exterior wythe.
- The spacing of the shoring was inadequate given the extent of the brick removal.
- The shoring members were severely undersized.
- The shoring was inadequately restrained at both the top interface with the wall and the bottom interface with the pavement.

While there are multiple proximate and interrelated causes as noted below, the resultant condition of the wall created by the improper implementation of the late May 2023 repairs resulted in the May 28, 2023, collapse incident.

10.2 Proximate Causes:

10.2.1 Improper Understanding of Original Building Construction

The engineers and masonry contractors responsible for repairs to the Building repeatedly misidentified the structural bearing wall as a nonstructural veneer system. As such, they underestimated the significance of the observable signs of distress in the wall, delayed necessary repair work, designed and installed a weaker replacement system, and removed significant portions of the wall without first installing adequate temporary shoring.

10.2.2 Inadequate Construction Documents

The available Construction Documents for repair work conducted between 2020 and 2023 do not provide adequate details and specifications for a contractor to implement the repair work necessary at the subject Building. This resulted in the implementation of many incomplete and inadequate repairs. Furthermore, this lack of documentation limited the City Inspectors' ability to easily verify that the work being performed was consistent with the engineer's intent.

10.2.3 Neglect of Composite Wall

The Design Professionals and masonry repair contractors replaced portions of the original 5 wythe thick bearing wall with a substantially weaker non-composite cavity wall system.

10.2.4 Inadequate Oversight of Repairs

The deficiencies with the design and implementation of repairs noted herein were exacerbated by the lack of on-site presence by a qualified Design Professional during the repair work. This lack of professional oversight allowed the work by the most recent repair contractor to proceed in an unsafe, incomplete, and improper manner.

10.2.5 Inherent Weakness of West Wall

Several conditions inherent to the construction and age of the west elevation wall allowed for weaknesses in the wall, especially at Pier E. Although these construction practices were usual and customary for buildings of the subject Building's age, when Piers B, C and D failed, Pier E's inherent weaknesses caused it to fail as well.

10.2.6 Inadequate Repair Techniques

The improperly repaired brick masonry wall sections were poorly integrated with the original construction and increased the inherent weakness of Pier E. As a result, Pier E collapsed along with Piers B, C, and D, and the collapse zone extended an additional bay.

10.2.7 Inadequate Frequency and Type of Maintenance

The subject Building exhibited many signs of improper and inadequate exterior envelope maintenance resulting in excessive water infiltration. Improperly maintained composite clay brick masonry walls will degrade over time due to water infiltration and the effects thereof, resulting in a structurally weakened wall system. Based on the photographic evidence of pre-collapse condition, in addition to on-site observations after the incident, it is apparent that building ownership/management did not adequately address exterior (and other) maintenance requirements, thereby resulting in the compromised integrity of the west elevation wall.

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11. LIMITATIONS

WBG's and SEI's professional services have been performed in accordance with the standards of skill and care generally exercised by other professional consultants acting under similar circumstances and conditions at the time and in the jurisdiction in which the services were performed.

WBG's and SEI's findings, conclusions and opinions are based on their visual observations, professional experience, interviews with those knowledgeable with the conditions pertinent to the subject investigation, evaluation of documentation and sound investigation practices.

While our findings are summarized as of the date of issuance, should new information or additional documentation become available, WBG and SEI may amend or revise their opinions accordingly.

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APPENDIX A CHRONOLOGY OF REPAIRS

Based on the review of available documentation, a detailed summary of WBG and SEI's understanding of the various repair projects at the Building since 2020 is provided below.

PRE-2023 REPAIR ACTIVITY

On August 18, 2020 Townsend Engineering performed an inspection at the building due to *"some brick falling from the exterior of the 6th Floor onto the sidewalk below".* Townsend Engineering stated that they reviewed the original drawings for the building as part of their investigation, noting that:

- *"…the floor systems for all six floors are comprised of poured on-site concrete floors, approximately nine inches in overall thickness…"*
- *"The concrete floors are supported … by intermediate steel beams with columns at the interior of the building."*
- *"The exterior walls are constructed of two layers of brick and an inside layer of clay tile."*

The majority of Townsend's inspections focused on the north, south, and east exterior walls (not the west wall). At that time, cracks within piers, and loose brick at window heads were observed. The report states:

> *"It is my professional opinion that the structural components of the exterior walls have not moved over the last three years but the brick façade has separated in some locations causing the brick ties to come loose which allows the bricks to fall. It was my recommendation that Bi-State Masonry either remove or stabilize all the loose brick and limestone immediately to prevent more brick from falling to the ground. The brick and limestone around the area where the brick fell will be removed and any other areas that appear to have bowed our will be covered with plywood that is anchored to the interior clay block to hold the brick in place until the permanent repair is made."*

Further:

> *"It is my professional opinion that the damage to the building is not structural and the building is safe to occupy. After the brick face is temporarily secured we will develop a plan to permanently repair the exterior brick to prevent further damage."*

Despite making no mention of deterioration or work required at the west elevation, photograph evidence from city inspections indicates repair work was performed at the west elevation.

On August 26, 2020, the City issued a "Official Notice and Order", which cited numerous code violations throughout the Building, including several instances of deteriorated interior walls and *"structurally unsound brick"* exterior walls. With respect to the exterior walls the notice stated: *"you must provide this office with a certified report from a professional structural engineer registered with the State of Iowa that will attest to the building's structural stability or list the building's structural deficiencies".* An image of the western façade was provided in documentation associated with the notice (included as **Fig. 26**).

Fig. 26. Images of the west elevation (Ref: City Reinspection Reports, Task ID: 20-7839 and 20-58268). Yellow arrow points to area of apparent previous repair.

On October 23, 2020, Davenport Neighborhood Services Department issued a follow-up notice headed "Final Official Notice". This notice cited many of the same issues as the previous notice from August 26, 2020, and included the same requirement for a structural engineer's report regarding the condition of the exterior walls. WBG and SEI were unable to locate any photographs associated with October, 2020 (the date of the notice). Another reinspection was scheduled for the Building on December 1, 2020.

On December 17, 2020 the City issued a permit for repairs to the *"east, north and south sides of brick façade per engineer Chris Townsend's report. All per city code"*. An inspection was performed on January 11, 2021. Photographs of the west elevation were attached to the January 11, 2021 inspection report despite the fact that the permit does not include any work to be completed at the west elevation. It is interpreted that the note *"Deteriorated bricks in the lower South-West portion has [sic] been removed and replaced"* refers to work completed as indicated with yellow arrows in **Fig. 27**. The report also states *"There were some masonry joints/spalled bricks above this area that would be addresses [sic] once the temperatures rise".*

Fig. 27. West elevation photographs. (Ref: City Inspection Report, Task ID: 20-83090). Yellow arrows point to areas of apparent repair.

On February 16, 2021 Davenport Neighborhood Services Department again issued a follow-up notice titled “Notice of Extension”. The letter granted additional time for the Building owner to correct code violations. The notice stated that work at the exterior wall “*must be permitted and scheduled as specified by the structural engineer’s report. Work must have started prior* [to] *May 14, 2021 re-inspection date*”. Additional photographs attached to the notice exhibit some scaffolding erected on the west elevation of the building at the location of a crack in the exterior brick (dated previous to the date of the letter). Other photographs indicate numerous incidents of missing, loose, and delaminated brick on the west elevation.

Fig. 28. West elevation photographs (Ref: City Reinspection Report, Task ID: 20-72033). Yellow arrow indicates crack in wall.

On May 26, 2021 another “Final Official Notice” was issued by the Davenport Neighborhood Services. The report again cited that the exterior wall repair work was in violation. **Fig. 29** is an image associated with this report that indicates the west elevation was painted over by this time.

Fig. 29. Image of the west elevation indicating brick painting completed on May 14, 2021 (Ref: City Reinspection Report, Task ID: 21-9198).

On July 19, 2021 a "Complaint Notice and Order" was issued which cited further deficiencies with the western elevation, specifically around the entrance door to Unit 105. The report stated, "*structural engineer's report required on west wall structural integrity with scope of work required to make proper repairs*". An email attached to the report also stated the drywall around the door to the parking lot was not stable and the door was very difficult to open. Images from the report exhibiting the exterior door and a crack in the drywall behind the brick to the south of the door are displayed in **Fig. 30**.

Fig. 30. Image of the west elevation adjacent the rear door, taken in July, 2021 (Ref: City Reinspection Report, Task ID: 21-42476). Yellow arrow points to apparent location of drywall crack at interior and exterior.

On September 7, 2021, another "Final Official Notice" was issued by Davenport Neighborhood Services Department. This notice again cited deficiencies with the west elevation wall and stated "*structural engineer's report required on west wall structural integrity, report's scope of work required to make proper repairs will be required. Discussed with Trishna Pradhan/Bldg Dept – scope of damage warrants an engineer's report*". The photographs associated with this report display the inside of the west wall doorway (assumed to be inside Unit 105) where the drywall appears to have been repaired. There are no photographs of the exterior of the wall.

On October 21, 2021, a letter was issued stating that the owner had failed to provide access to the property for inspection and that a follow-up inspection would be performed on November 1, 2021.

On December 9, 2021, the Davenport Neighborhood Services Department issued an "Official Notice to Vacate" for Unit 105 due to the deadline for code violation corrections not being met. Photographs associated with the associated inspection report indicate the exterior door at the west elevation which was cited in earlier reports.

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Fig. 31. Image of the west elevation adjacent to Unit 105 door taken on November 1, 2021 (Ref: City Report, Task ID: 21-64101).

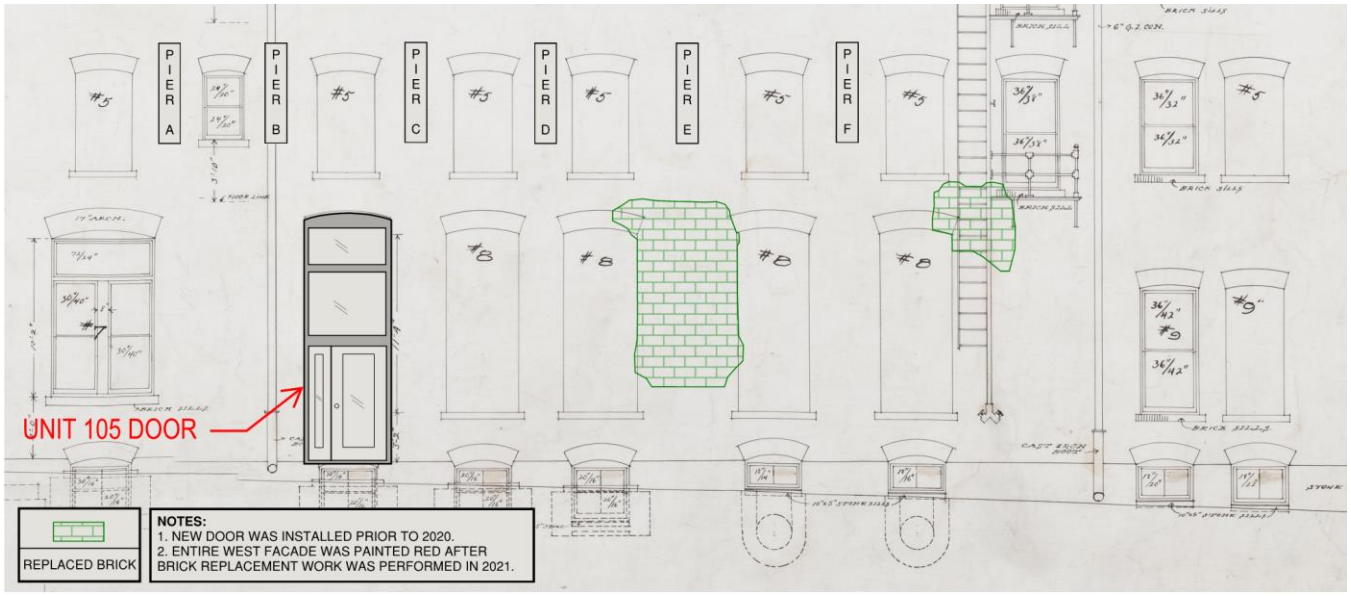

Fig. 32. West elevation markup indicating areas of repair completed in 2021.

Based on WBG and SEI's review of the available photographs, **Fig. 32** indicates the extents of repair work completed in 2021.

The areas in **Fig. 32** that are noted as "Replaced Brick" appear in the reinspection photographs taken by the City Inspector on January 11, 2021. It is not clear from the documents reviewed how the repairs were executed.

Upon completion of the repairs in 2021 (for which no record of any specific direction from an engineer are available) no further citations pertaining to the west elevation of the building were issued until 2023.

2023 REPAIR ACTIVITY

After a period of inactivity with respect to deficiencies at the exterior walls of the building, concerns were again raised in early 2023. Several structural inspection reports were provided by the consulting engineering firm Select Structural Engineering, LLC (SSE) and signed and sealed by David Valliere, PE (Iowa).

FEBRUARY 2023 TO MAY 1, 2023

On February 2, 2023 the City issued a "Notice of Public Hazard" letter regarding the condition of the exterior wall. The letter stated:

- *"Part of the south-west wall has been gradually failing. This failure is seen to continue on the inside wythes of brick masonry as well. There is visible crumbling of this exterior load bearing wall under the support beam".*
- *"The exterior brick veneer has separated allowing rain/ice to build up causing further damage".*
- *"Provide engineer's letter stating this is not an imminent danger".*
- *"Engineer's report to be provided within 48 hours for remediation & repair. Immediately secure the exterior veneer".*
- *"Within 24 hours of receipt of this letter (via email) protect the infrastructure on the exterior with a scaffolding so utility companies can continue to maintain it without any danger of masonry failure".*

Select photographs from the report are included in **Fig. 33**. The photographs indicate areas of distress observable in the wall in early February. Later in the month a scaffold was erected and some brick removal was underway.

Fig. 33. Image of the west elevation adjacent to the rear door taken in February, 2023 (Ref: City Reinspection Report, Task ID: 21-6454). Yellow arrow points to apparent location of deterioration of the brick and later replacement in progress.

An emergency site visit was performed by Select Structural Engineering, LLC (SSE) on February 2, 2023, and a summary letter was issued on the same day. The February 2 letter states that the emergency site visit was performed because *"There is a concern on the west exterior wall where a localized area of brick is cracked and crumbling. An engineer was requested to determine whether this is an imminent threat to the building or a smaller concern."* The letter states:

- *"The main area of brick damage is roughly eight feet wide by four feet high, and occurs directly below a beam which supports the second level. The beam is approximately 16 inches wide and is likely steel encased in concrete. It is unclear whether it bears on the brick wall directly or rather on a steel column encased in brick."*
- *"Both beams [in the maintenance room] need to be shored with heavy posts so that permanent repairs [to the exterior masonry wall] can be applied."*
- *"The main takeaway from the inspection is that this damaged area is not an imminent danger to the entire building and its residents."*

Two photographs were attached to the end of the report. Neither photograph displayed the exterior of the building. No plans or drawings were provided to locate the beams, and no specification was provided for the shoring to be installed.

SSE then issued a follow-up letter dated February 8, 2023. This letter states:

- *"There is a concern on the west exterior wall where a localized area of brick is cracked and crumbling. This engineer determined that this is not an imminent threat to the building or its residents, but structural repairs will be necessary."*
- *"The clay brick wall appears to be three or four wythes thick. The damaged area is roughly eight feet long by four feet high, mainly under the larger east-west beam. The full height of the wall in this area should be replaced. A suitable replacement would be a concrete masonry unit (CMU) wall."*
- *"The new CMU wall need not replace the entire west side of the building, but rather only the approximately twelve foot wide area from a window opening (currently boarded up) to an adjacent wall area of CMU… The CMU shall be 16"x8" standard blocks, full-height grouted in vertical cells at 24 inch spacing (minimum). #5 rebar shall anchor the wall to the existing footing in the grouted cells… A new clay brick façade may be installed against the outer face of the CMU to match the rest of the building. The window opening, currently boarded shut, shall also be infilled with CMU."*
- *"For each four-foot segment of wall, two holes shall be cut/drilled through the wall just below the beam line. Steel W8 needle beams shall be passed through these holes and shall be supported by 6x6 timber posts (or steel posts) to grade on the exterior side and the floor slab on the interior side. On top of the needle beams, parallel to the face of wall, there is to be shoring consisting of two 4"x4"x3/8" angles (one on each side). Horizontal cuts shall be made into the opposing faces of the brick wall to insert the horizontal legs of the angles. Their purpose is to support the brick wall above during demolition of their respective wall segment, and they shall remain in place until their respective segment is rebuilt."*
- *"It is further emphasized that the full 12'-0" length of wall to be replaced is not demolished all at once. There are many unknown factors in the construction and stability of a 100 year old masonry structure. As always, there is inherent risk to altering an existing masonry structure which is showing signs of deterioration."*

Figure 1 from the letter (included as **Fig. 34** in this report) indicates the extents of the observed distress (and therefore area of repair) as viewed from inside the building.

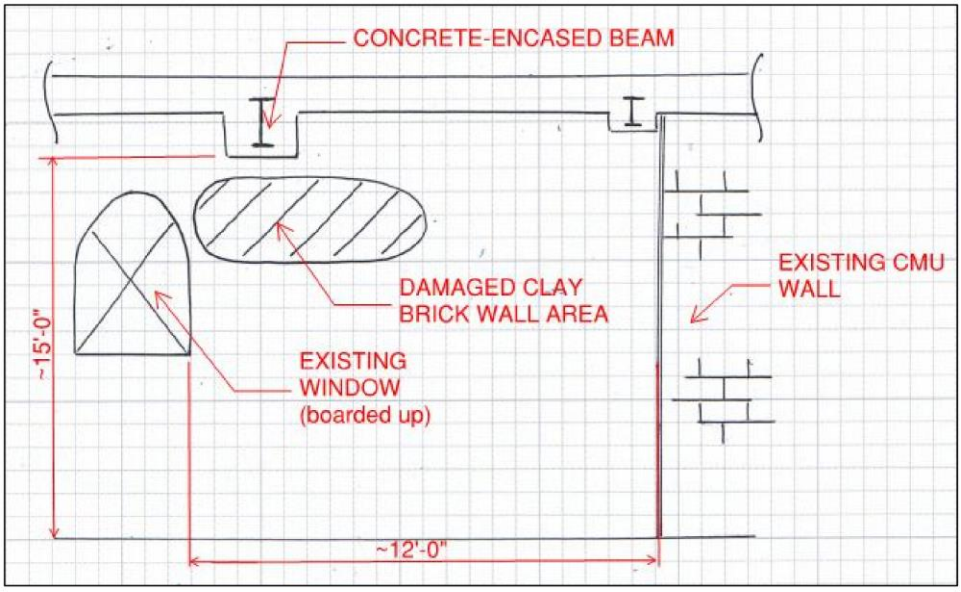

Figure 1 – Current Wall Condition

Fig. 34. Figure 1 from SSE's February 8, 2023 letter indicating the area of specified repair.

The repair specifically calls for a replacement of a wall in only a 12 ft wide segment to the north of a boarded up window. No overall elevation of the building was provided by SSE but it is interpreted that this window was the one included in an image produced by the City, and included as **Fig. 35** in this report.

Fig. 35. View of assumed area of specified repair by SSE's February 8, 2023 letter (Ref. City Report Task ID: 23-6454). Annotation by WBG and SEI.

Figure 8 of SSE's February 8, 2023 letter (included as **Fig. 36** in this report) shows a section through the wall. The wall was drawn as 3 wythes thick (rather than the 5 indicated on the original drawings), with steel angles supporting only the innermost and outermost wythes.

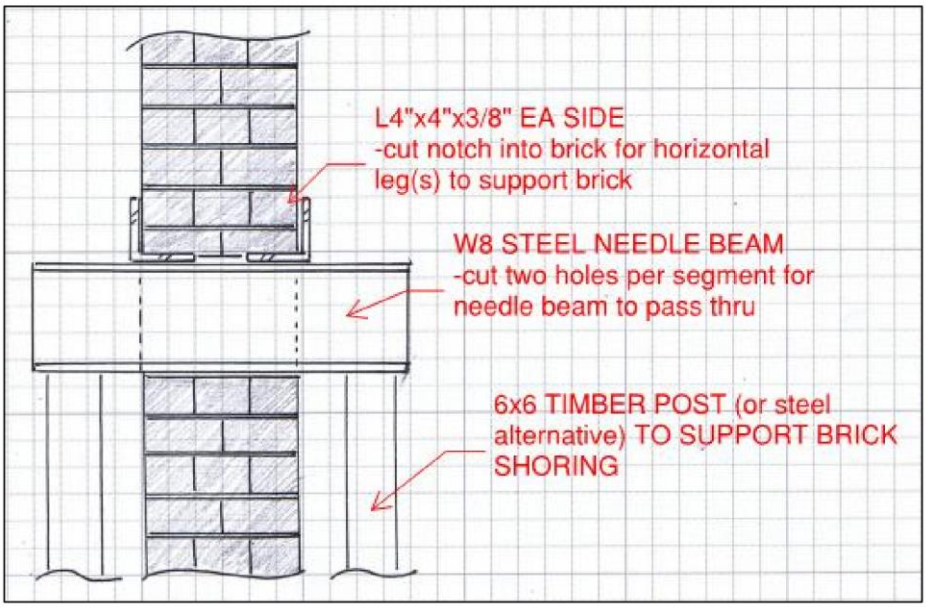

Figure 8 – Brick Wall Shoring Detail

Fig. 36. Figure 8 from SSE's February 8, 2023 showing needle beams and angles.

On February 9, 2023, SSE issued a sketch for the shoring of the exterior of the building. See **Fig. 37**. WBG and SEI have not been provided with any additional accompanying report or sketch that indicates the extents of where this shoring was required. It is our understanding that further construction directives do not exist. There are no images available in the record from reports at the time that indicate this shoring method being implemented at the western elevation of the building.

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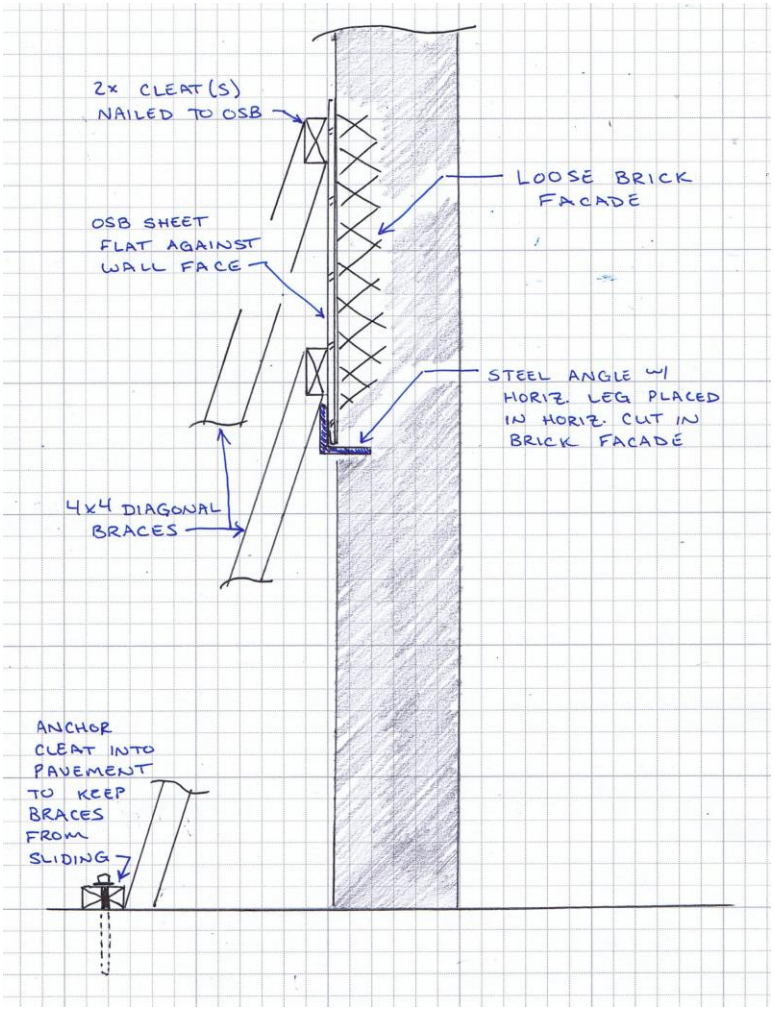

Fig. 37. SSE shoring sketch dated February 9, 2023.

The City issued a permit for the work on February 22, 2023 for repairs characterized as *"structural masonry repairs to west elevation specified in engineers report by IA P.E. D. Valliere #22444 all per city code."*

On February 28, 2023, SSE issued another letter as an addendum to the repairs specified in their February 8, 2023, letter. The letter states a follow-up site visit was performed on February 23, 2023, and that there was a *"large and potentially dangerous void beneath the façade wythe of clay brick".* The letter also states:

> *"The repairs … appear to be going according to plan. One deviation from the plan is that two layers/wythes of CMU are being installed to replace the clay brick wall segments rather than a single layer with an outer, façade layer of clay brick. This modification is acceptable and will add structural strength to the replaced areas. The original repair area is roughly twelve feet wide, and will abut to an existing wythe of CMU (which is likely a previous repair). What has recently come the attention of the team is that this area has a large void space, roughly 12"-14" wide, between the clay brick façade and CMU layer. This void appears to have been caused by the collapse of some mass of clay brick between the façade and CMU. This collapsed mass is now settled and piling up against the inside face of the façade, pushing it outward. This will soon cause a large panel of façade to also collapse, creating a safety problem and potentially destabilizing the upper areas of brick façade. This condition was not visible*

in the early inspection(s) and did not become apparent until repairs were under way and an opening was made by a smaller area of failing façade."

> *"The Mason and Engineer agree that the most direct solution is to remove the brick façade in this area in a safe, controlled manner, and then to construct a second, outer layer of CMU from the ground level up to the top of the void (roughly 15 to 18 feet). This would allow the safe removal of unstable clay brick and add solid structure to the compromised wall. The repairs to the original twelve-foot-wide area of wall would proceed as it is now."*

Diagrams were attached to the end of the report indicating how to execute this repair, but no sketch was produced indicating the extent of the required repairs (see **Fig. 38**). The repairs noted the use of a steel lintel to secure the upper façade however no size was provided for the lintel and no detail was provided for how to support it at each end.

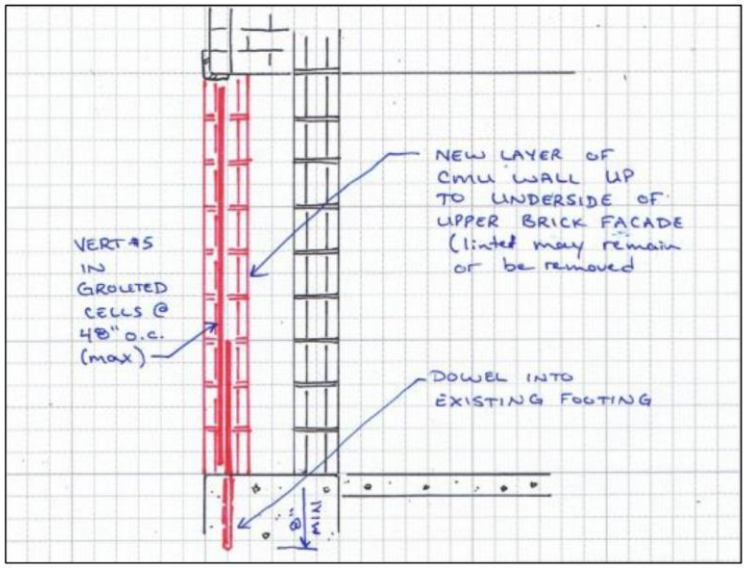

Figure 3 – New CMU Wall

Fig. 38. SSE repair addendum sketch from February 28, 2023 letter.

A City Inspector visited the site on March 1, 2023, and reported that the shoring had been placed and was secure; however, no photographs of the shoring were included in the report. The inspector noted that *"the exterior/finish wythe is also being completed as CMU & I instructed the GC that the exterior wall has to be brick masonry; brick size has to match existing brick"*. The inspector also noted that *"The repair work is being completed in line with structural engineer's report".*

Also on March 1, 2023, an email response from David Valliere at SSE stated: *"I am not on-site regularly, but I was there last week on Feb. 23 and saw that the work is being done per my design. I was able to meet with Justin, and Bi-State Masonry is doing a good job from what I can see".*

On March 9, 2023, a notice with the subject line "Inappropriate exterior building material used" was issued. The notice followed up on the inspector's observation that CMU rather than clay brick masonry was being used for the exterior of the building. The CMU is not permitted at the exterior wythe due to the historic nature of the structure. The letter states that work was stopped and that it could not continue until the issue was resolved as the interior and exterior wythes of brick must be built concurrently.

Another inspection was completed on April 12, 2023. The report from this inspection states: "*work in progress per engineer's drawings. Brick to be installed on the exterior with CMU interior structural wall*". Another inspection took place on April 21, 2023. Documentation from this inspection states: "*on-site work in progress*". A final inspection was completed on May 1, 2023. The May 1 inspection reports states: "*Repair work has been completed per Engineer's Report. Exterior wall has to be painted to close permit. Wall Painted (TRP on site on 5/12/2023)*".

No further citations were issued by the city regarding the exterior walls of the building. However, further photographs were produced of repairs underway that are included in **Fig. 39**.

Photograph indicates repairs underway with use of needling beams evident.

Overall view of repairs underway at southern end of west façade.

Photograph indicates area of repaired (unpainted) brick from outside building.

Photograph indicates area of replaced CMU from inside. Note mechanical opening in floor.

Fig. 39. Images of the Western Elevation taken in April and May, 2023 (Ref. City Document 23-9778).

The photographs above clearly indicate the extents of repair far greater than the 12-foot portion of wall north of the *"boarded up window"* originally specified in SSE's February 8, 2023 letter. The repaired area of brick appears to have extended three bays of windows to the north. It is unclear how these repairs were implemented (e.g. how many wythes of brick were removed and the exact configuration of CMU behind the outer wythe) or whether any

licensed Design Professional provided input regarding how these repairs were to be performed. **Fig. 40** indicates the extent of the actual work area based on photographs reviewed by WBG and SEI.

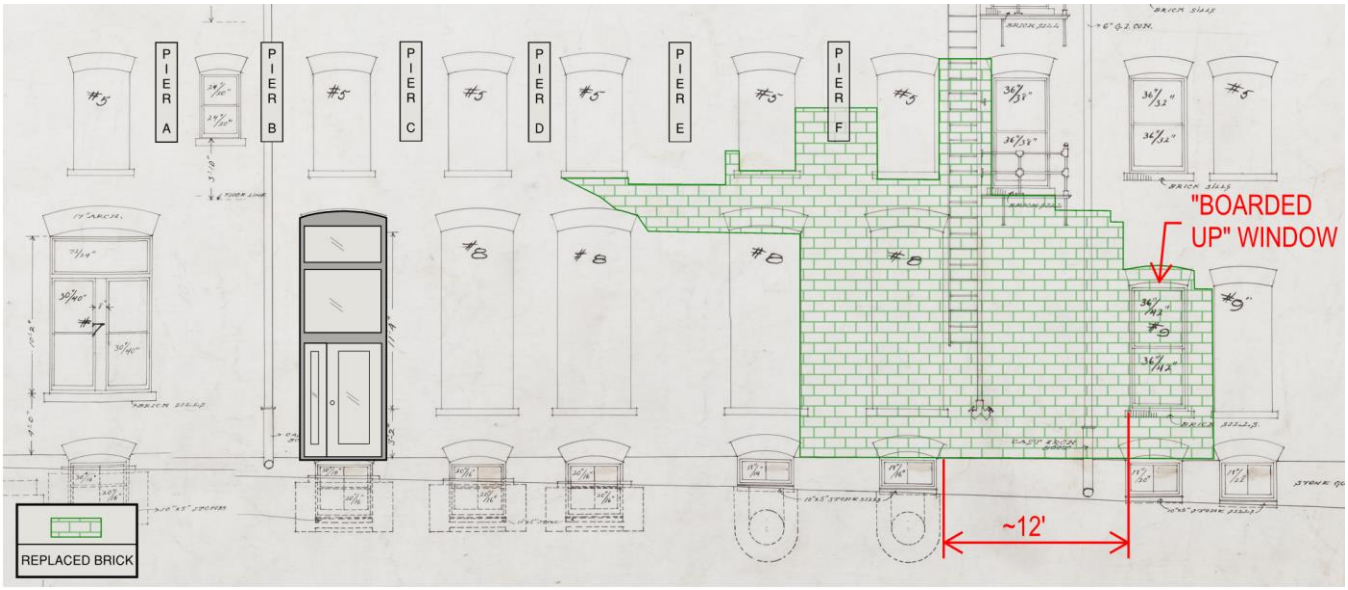

Fig. 40. West elevation markup indicating actual apparent areas of work completed through May 1, 2023.

LATE MAY, 2023

SSE visited the site again on May 23, 2023, and issued a letter summarizing their findings the next day. Key excerpts from the letter are included below:

- *"On the west face of the building, there are several large patches of clay brick façade which are separating from the substrate. These large patches appear ready to fall imminently, which may create a safety hazard to cars or passersby."*
- *"As viewed from the west exterior, there are two former window openings, roughly 12 feet tall by six feet wide, which appear to have been bricked over some years ago. The clay brick façade on and between these openings is bulging outward by several inches and looks poised to fall. In anticipation of these areas falling, the brick façade above the windows should be secured. This is to keep the entire face of the building from falling away when the bottom area(s) come loose. The same temporary façade support as was recommended on February 9th, 2023, may be used here too. Note that the elevation of the steel angle in the detail shall be at or above the top of the window openings."*
- *"…the window openings were never filled with brick or block. Rather, the clay brick façade was just run right over the openings, unsupported. This lack of bracing helps explain why the façade is currently about to topple outward."*
- *"The brick façade is unlikely to be preserved in place, but it can be brought down in a safe, controlled manner. The stable sections above will be secured as mentioned previously. With the loose façade removed, the window openings can be filled in with 12" wide, reinforced concrete masonry units (CMU)… the top shall be capped with either solid block or a grouted bond beam such that the wall above the CMU can bear on the infill like a solid wall. After the window openings are infilled with reinforced CMU, the clay brick façade to the outside may be replaced. This time, the new façade shall be braced back against the face of the structural wall with brick pintels* [sic] *to keep it plumb and secure."*

> *"To the north of the two window openings in question, there is another issue. The wall appears to be loosing [sic] some stability and is causing deformation. This is evidenced by the bowing of the interior light gauge steel furring and drywall; they bulge as if a large downward force is acting upon them… adding a steel column to support the east-west beam would alleviate much of the load from the exterior wall while the façade is rebuilt. This column may be a W6x15 positioned as near the inside face of the structural wall as possible... the brick façade outside this area may be secured and rebuilt as described for the other area".*

Photographs were attached to the end of the report indicating the areas of observed distress. The exterior image (**Fig. 41**) identified the two *"bricked-over"* window openings that are discussed in the letter.

Photo 1 – Clay Brick Façade pulling away from Substrate

Fig. 41. View of the exterior of the building from SSE's May 24, 2023 letter. Annotation by SSE.

SSE also included an image of the interior of the building at the location of these window openings. WBG and SEI have previously identified this Pier as "Pier D" in **Section 4** of this report. The image appears to indicate a steel shoring post contained within the interior finishes. Note this shoring post and the structural beam it is supporting , are located eccentric to the centerline of the Pier. See **Fig. 42**.

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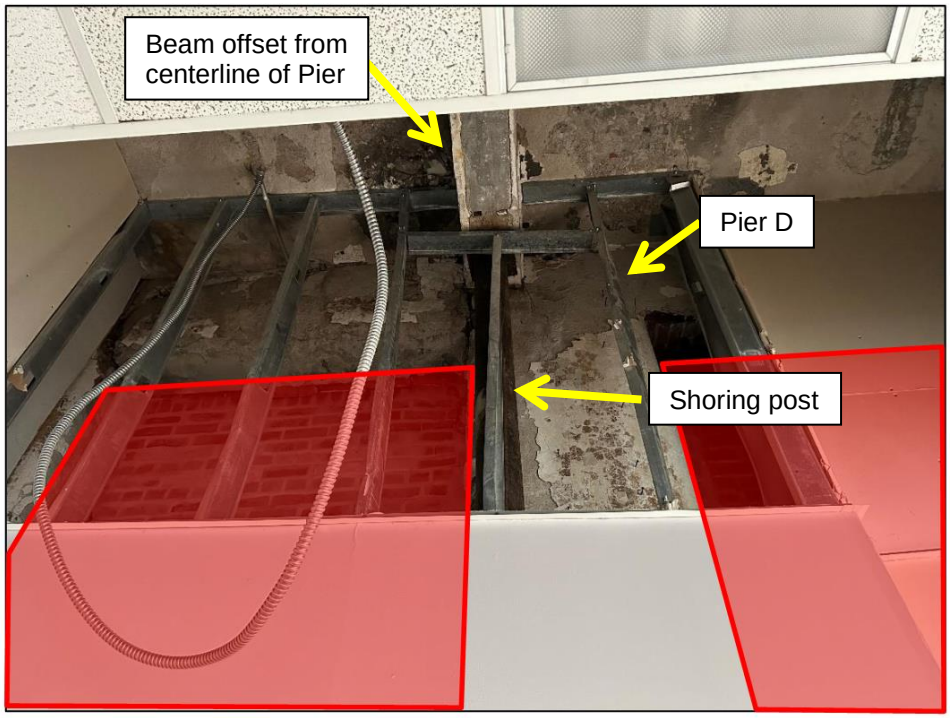

Photo 2 – Window Openings to Infill

Fig. 42. View of the interior of the building from SSE's May 24, 2023 letter. Red annotation by SSE. Yellow arrows by WBG and SEI.

The City issued Building Permit #23-30329 May 24, 2023 (the same day as the SSE letter) and the work to be performed was noted to be *"replace in kind 100 linear feet of brick exterior all per city code".*

An inspection was performed by the City on May 25, 2023. The narrative noted the following:

- *"CMU is being completed per engineer's report with rebar and grout. One opening has been completed and other is being filled with CMU".*
- *"Brick work will start today in sections".*
- *"Wall bracing will be installed per engineer's design".*
- *"Engineer will stop over on-site periodically to make sure work is being done per his design".*
- *"City inspector will stop over periodically to see progress".*

Select photographs taken by the City Inspectors on May 25, 2023 are included in **Fig. 43**. The photographs indicate the initial stages of the work.

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Photograph indicates inside of building with CMU installed inside window opening. Note shore previously identified at Pier D (yellow arrow).

Photograph indicates area of bowing brick south of doorway. Note “shores” in place that do not appear to conform with SSE’s design.

Overall view of portion of west elevation south of door. Note numerous areas of deterioration to wall.

Detail view of bowing brick at south jamb of doorway. Note bricks accumulated in gap between wythes.

Fig. 43. Photographs of ongoing repair work dated May 25, 2023 (Ref. City Document 23-30329). Yellow arrows by WBG and SEI.

Subsequent to the May 25 documentation noted above, SEI and WBG have not received any further notices or other City documentation regarding the repairs at the building.

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APPENDIX B STRUCTURAL ANALYSIS

The following analysis includes numerous assumptions based on the information available at the time of writing this report. Should any further information be made available in the future, the analysis may need to be adjusted to account for any substantive changes to the assumptions listed below:

- Material strength properties:
  - Masonry compressive stress capacity (f'm) = 1,000 pounds per square inch (psi), a reasonable estimate of the masonry strength given the date and type of construction.
  - Masonry modulus of elasticity (E_m) = 700 f'm = 700,000 psi (700 factor provided in the Masonry Code ACI 530).
  - Allowable tension stress = 0 psi.
- Assume solid clay tile brick. Actual brick was noted to be a combination of solid original masonry, hollow clay tile interior wythe, and extruded/cored replacement brick.
- Assume typical geometry of bricks at 3.75 in. wide with mortar joints 0.375 (3/8 in.) in. thick.
- Assume full composite action of masonry brick wythes. Headers were noted throughout the original wall area, but broken headers may reduce the ability for multiple wythes to act together compositely.
- Assume weight of brick = 39 pounds per square foot (psf) per wythe of elevation.
- Assume live load at the time of collapse = 5 psf per floor (for floor finishes, furniture, and ceiling construction).
- Assume dead load includes the 9" thick normal weight concrete slabs (typ.), steel floor framing, and floor and ceiling finishes. Assume density of concrete of 140 pounds per cubic foot.
- Assume the steel beams framing into the exterior wall provide lateral restraint. Assume restraints act as a pin (i.e. no moment transferred). Assume no contribution from the concrete floor to the stability of the wall. Assume beams extend 12 inches into the thickness of the wall.
- Neglect stability and strength provided by wall spandrels either side of pier.
- Neglect effect of pre-existing bowing (or out-of-plumbness) of the wall prior to collapse.
- Neglect other pre-existing deterioration to the wall.
- Building geometry assumed to match with February 24, 1906 drawings, including:
  - Floor-to-floor heights.
  - Interior structural steel beam and column layout.
  - Brick pier widths.
- Neglect support provided by temporary support struts.
- Neglect effect of eccentric beam support on Pier (causing in-plane bending of wall). Assume wall in uniaxial bending only. Ignore effect of Pier location offset between first and second floor (which would also cause in-plane bending of the wall).
- All applied load assumed to act at centroid of wall.
- Assume the outer two or three wythes of brick removed at locations indicated in **Fig. 23** at the time of collapse.
- Neglect loads from wind and temperature recorded in proximity to site at the time of collapse.

PIER ANALYSIS

As discussed previously in this report, prior to the collapse, the west exterior wall had been partially demolished at the lower levels as part of the specified repairs. Up to three of the outer wythes of brick were removed at differing elevations along the length of the wall. Where this condition existed, the resulting eccentricity (offset from center line) would cause significant bending stresses to be induced into the wall. See **Fig. 44**.

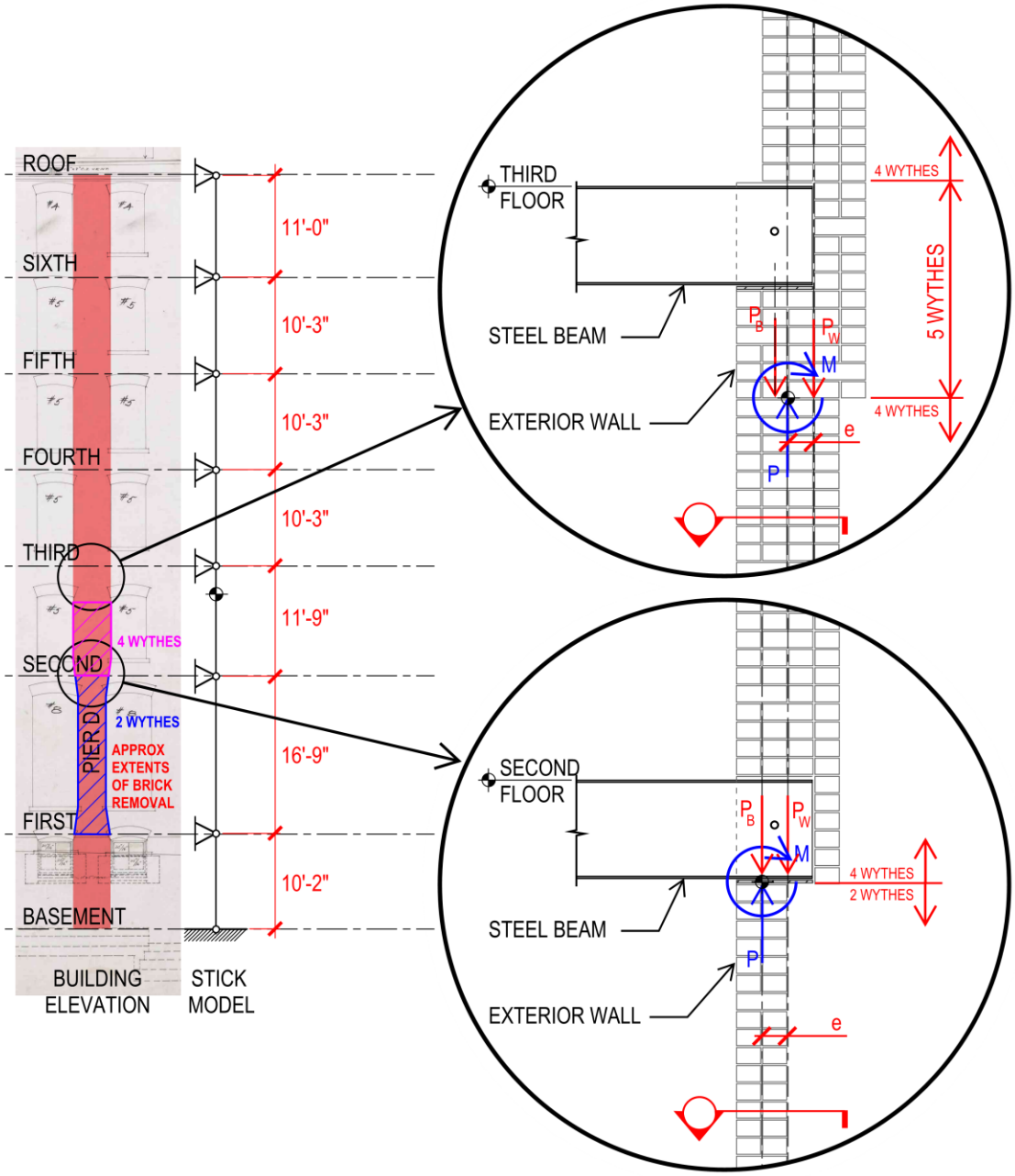

Fig. 44. Wall sections at areas of removed brick at Pier D

To determine the capacity of the masonry wall, the “Building Code Requirements and Specification for Masonry Structures (ACI 530)” code was referenced. The following equations are derived and used in this code.

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \leq 1.0$$

$$P \leq \frac{1}{4} P_e$$

Where:

$$F_a = \frac{1}{4} f'_m \left[1 - \left(\frac{h}{140\, r}\right)^2\right] \text{ for } \frac{h}{r} \leq 99$$

$$F_a = \frac{1}{4} f'_m \left[\left(\frac{70r}{h}\right)^2\right] \text{ for } \frac{h}{r} > 99$$

$$F_b = \frac{1}{3} f'_m$$

$$P_e = \frac{\pi^2 E_m I_n}{h^2} \left(1 - 0.577 \frac{e}{r}\right)^3$$

Since the code equations are derived for design purposes to produce safe structures with significant factors of safety (typically a factor of safety of 4), first principles of stress distribution have been used to determine the actual capacity of the wall more accurately at the time of collapse, see **Fig. 45**.

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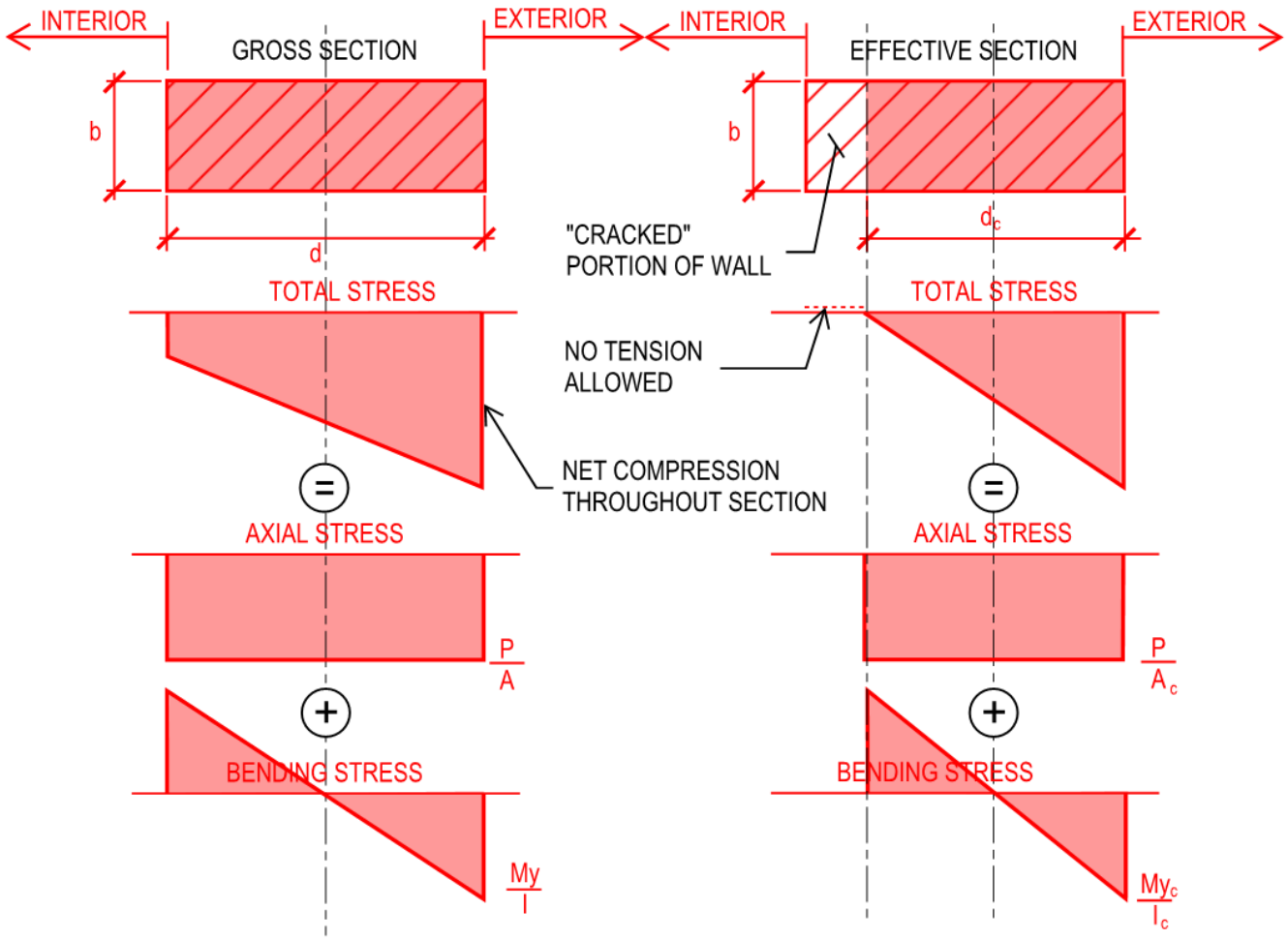
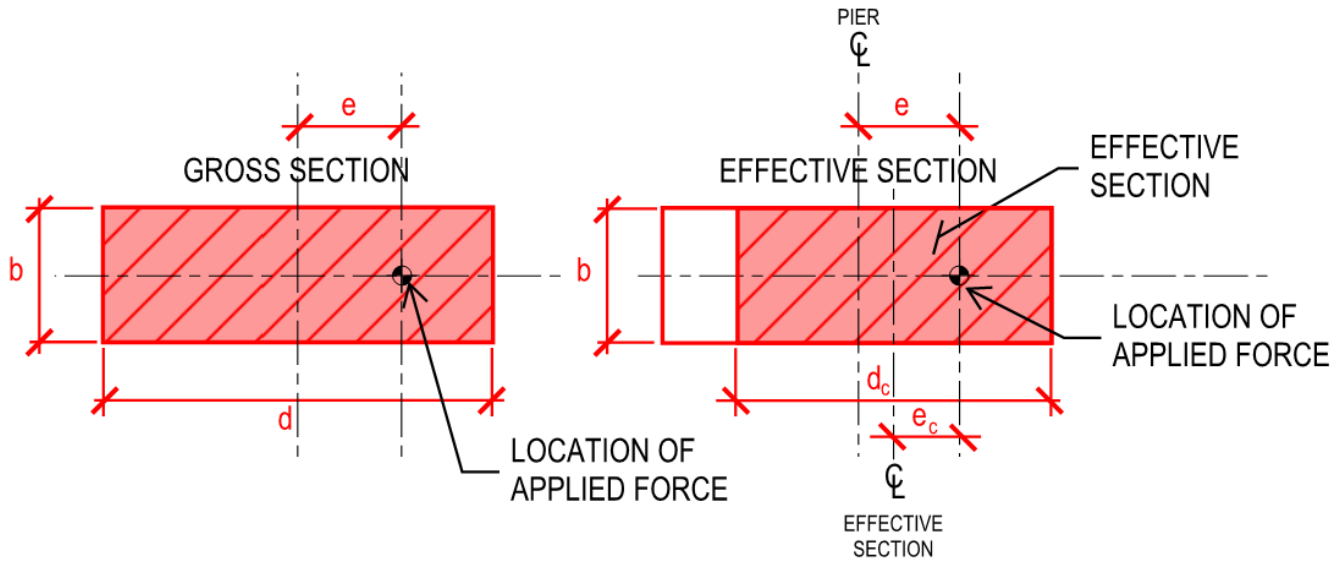


Fig. 45. Assumed stress distribution in wall section

When the axial force is applied at an eccentricity beyond the “kern” of the member (outside the middle third of the section), the member goes into net tension on its outer fibers. Based on the observed condition of the wall at the time of collapse, the known limited tensile capacity of brick masonry, as well as the age of the structure, it has been assumed that no tension is allowed to develop in the section. Thus, a reduced “effective” section must be considered for stress balancing for load applied at an eccentricity beyond the kern of the member. The following equations and derivations form the basis for the analysis of the wall.



	Property for Gross Section	Property for Effective Section
Area	$A = bd$	$A_c = bd_c$
Radius of Gyration	$r = \frac{1}{\sqrt{12}}\, d$	$r_c = \frac{1}{\sqrt{12}}\, d_c$
Section Modulus	$S = \frac{bd^2}{6}$	$S_c = \frac{bd_c{}^2}{6}$
Eccentricity of Load	e	$e_c = e - \left(\frac{d}{2} - \frac{d_c}{2}\right)$
Axial Stress	$f_a = \frac{P}{A}$	$f_{a1} = \frac{P}{A_c}$
Bending Stress	$f_b = \frac{M}{S}$	$f_{b1} = \frac{M_c}{S_c}$
Balanced Stress Equation	$f_a = f_b$	$f_{a1} = f_{b1}$
Limiting Axial Stress $\frac{h}{r} \leq 99$	$f_a + f_b \leq f'_m \left[1 - \left(\frac{h}{140\, r}\right)^2\right]$	$f_{a1} + f_{b1} \leq f'_m \left[1 - \left(\frac{h}{140\, r_c}\right)^2\right]$
Limiting Axial Stress $\frac{h}{r} > 99$	$f_a + f_b \leq f'_m \left[\left(\frac{70r}{h}\right)^2\right]$	$f_{a1} + f_{b1} \leq f'_m \left[\left(\frac{70r_c}{h}\right)^2\right]$

The Euler Buckling equation (P_e) provided in the code assumes the most conservative condition of a fully cantilevered wall (fixed at the base, with the top of the column free to translate – i.e., a 'flagpole' with a load, P, applied at an eccentricity, e) with uniform moment and zero allowable tension. For the purposes of this assessment see **Fig. 46** the actual moment (M) was calculated based on the actual force distribution and assumed restraint conditions of each pier.

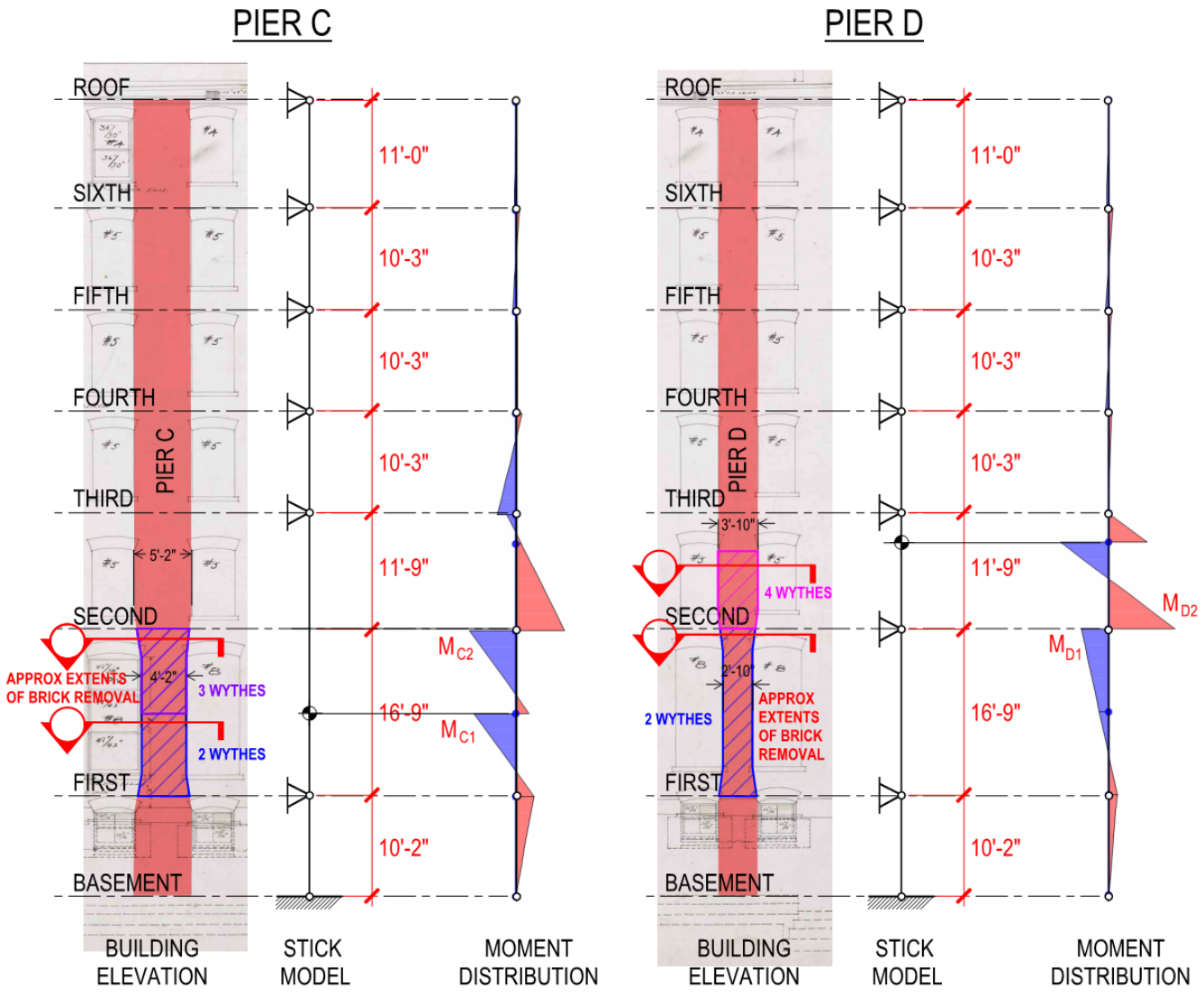


Fig. 46. Wall Pier Moment Distribution Analysis

Based on the above, an “Interaction Diagram” can be plotted for each Pier. This diagram plots axial load (P) against moment (M) for each of the Pier conditions. As the moment increases, and portions of the wall are put into tension, the wall is assumed to “crack” and the effective section is therefore reduced. This is only slightly negated by the slight reduction in effective eccentricity of the load (which has been neglected in this analysis). The actual calculated applied axial force and moment can then be plotted on the graph. If this falls outside the line of the Interaction Diagram, the member section capacity has been exceeded and the Pier is predicted to fail.

Table 2 – Pier Loading

Pier	Floor	Axial Load	Moment
Pier D	2-3	104 kips	268 kip-in (M_{D2})
Pier D	1-2	104 kips	112 kip-in (M_{D1})
Pier C	Upper 1-2	93 kips	186 kip-in (M_{C2})
Pier C	Lower 1-2	99 kips	160 kip-in (M_{C1})

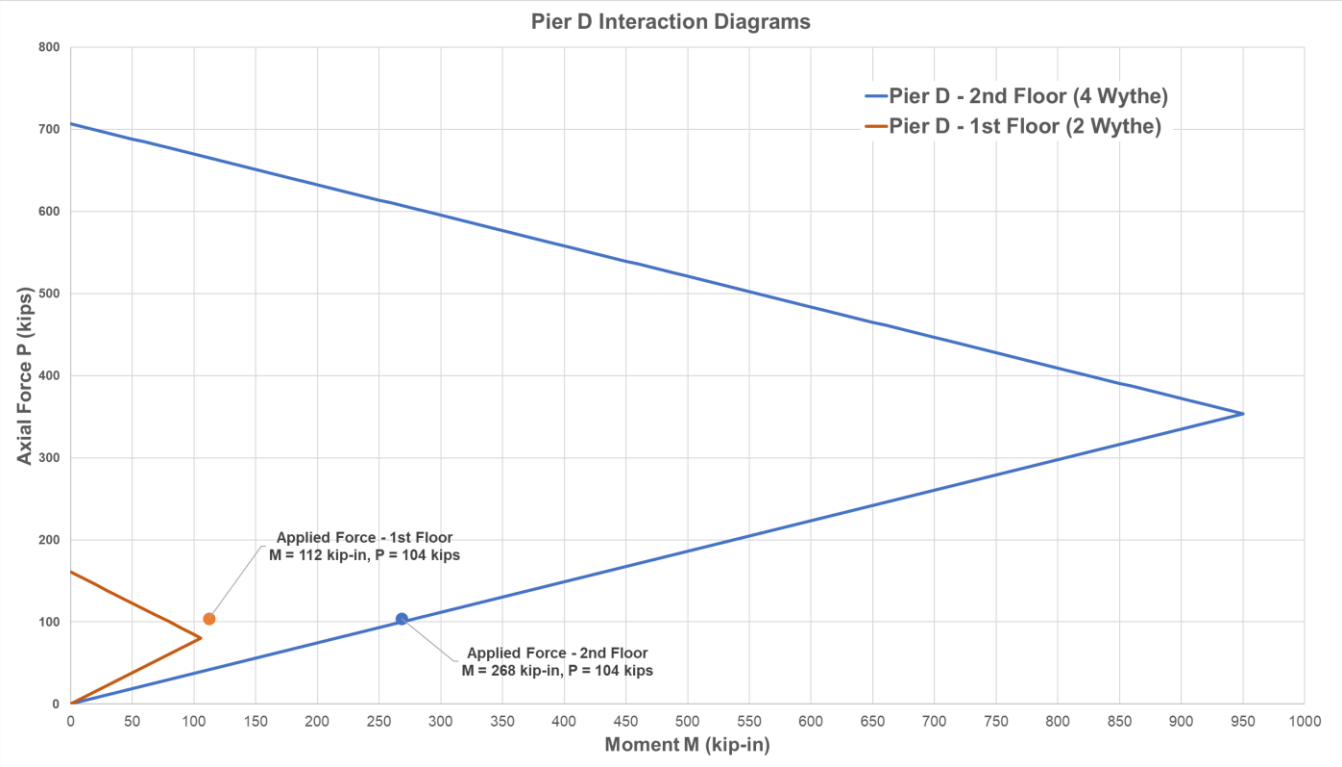


Fig. 47. Interaction Diagrams for Pier D.

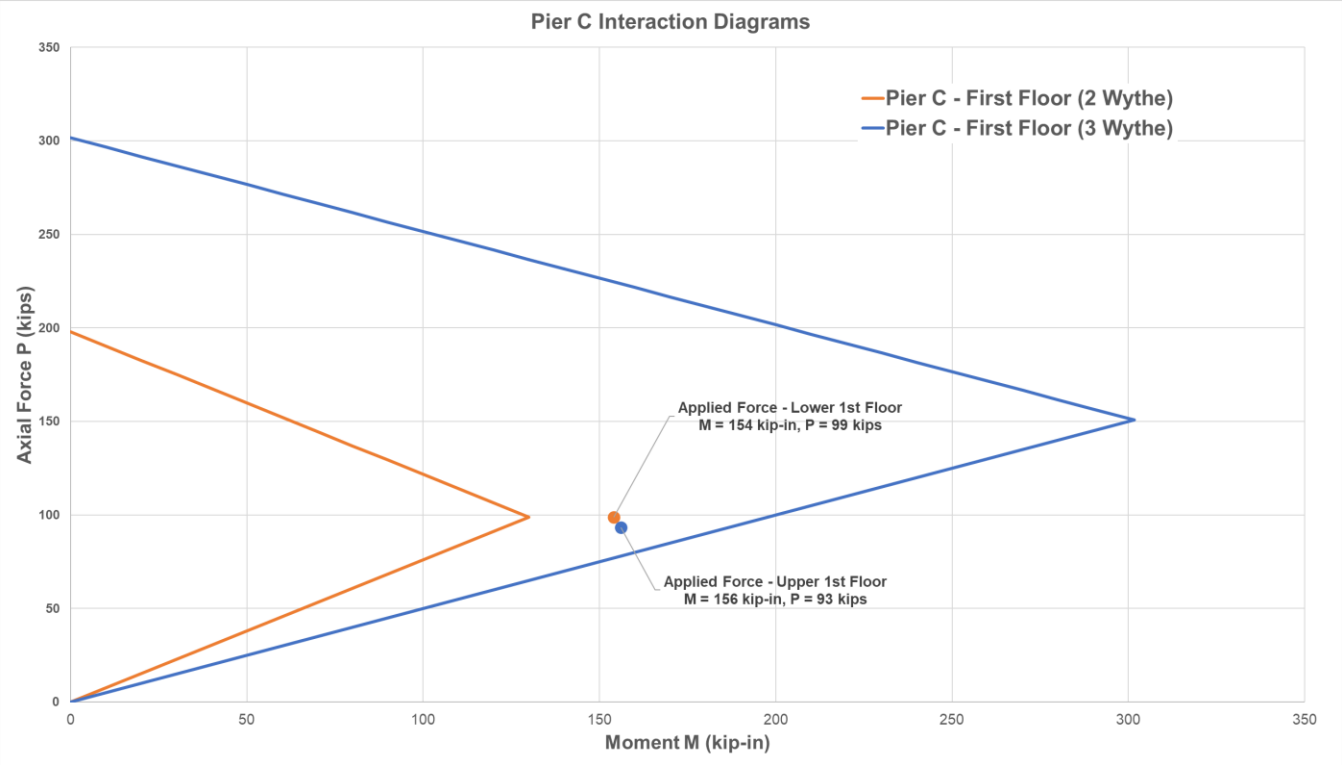


Fig. 48. Interaction Diagrams for Pier C.

This analysis indicates that the wall was very close to or beyond its theoretical ultimate capacity at the time of its collapse at both Piers C and D. It should be noted that while this analysis represents an upper bound on the assumed capacity of the wall (with the assumptions summarized at the start of this section of the report), some idealized behavior has been assumed in order to perform these calculations at this time.

PIER RESTRAINT ANALYSIS

In order to provide stability to the Pier(s), axial forces would be transferred from the exterior wall to the interior beam framing and ultimately to the overall lateral stability system for the building. These forces would have been significantly increased as a result of the bending moment introduced as a result of the eccentricity caused by the removal of the outer wythes of brick. For example, at the second floor connection to Pier D, the wall would exert an outward force that would then be translated to tension in the beam. The mechanism to transfer this load would be through friction at the beam-to-wall interface as well as a contribution from the pin embedded within the wall (included in **Fig. 3** earlier in the report). Due to removal of the outer wythes of brick the effectiveness of the pin would have been compromised and due to the noted location of the shoring post at Pier D (reducing the load transferred from the beam to the wall), the friction load transfer between the beam and the wall may have also been reduced. The combination of these effects would be significant enough to have also contributed to the collapse. The effect of the beam pulling of pushing through the wall would effectively create localized distress in the wall which would further weaken the wall.

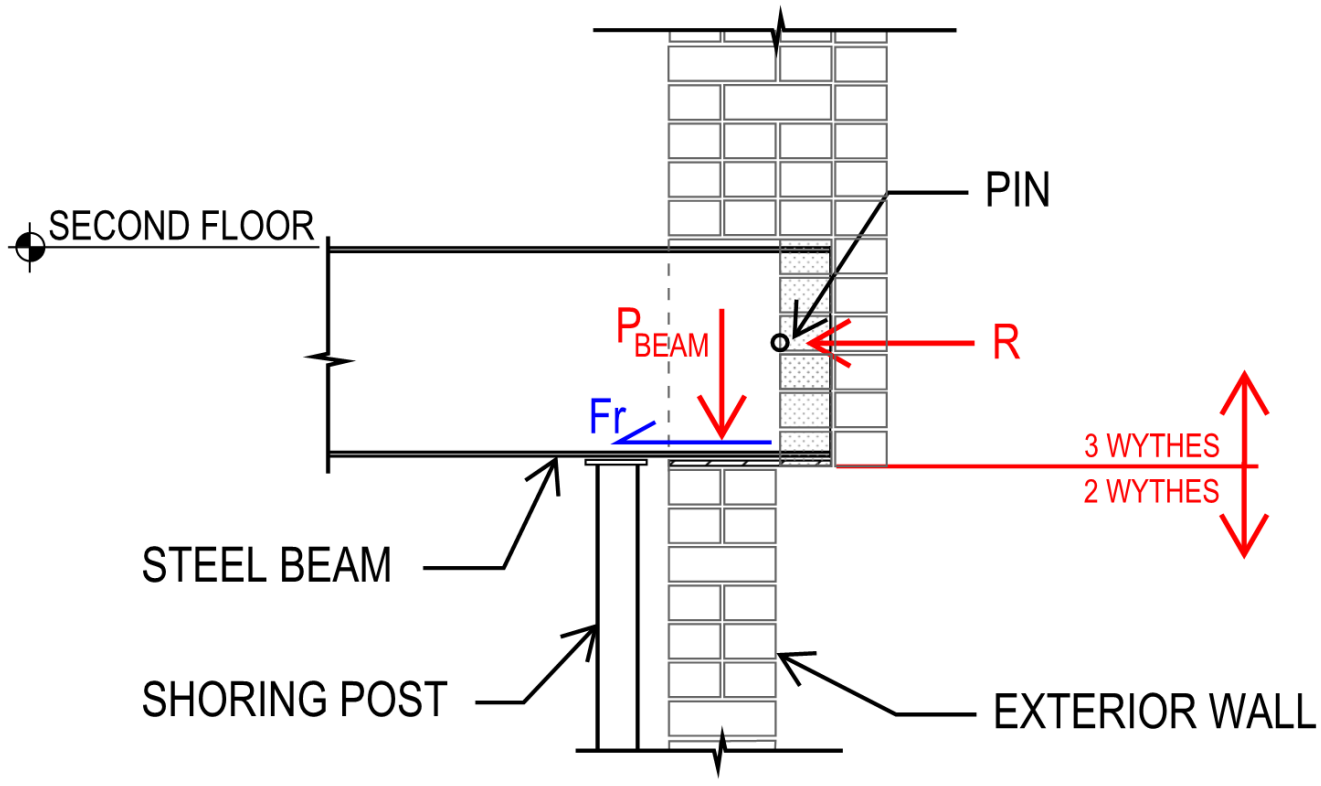


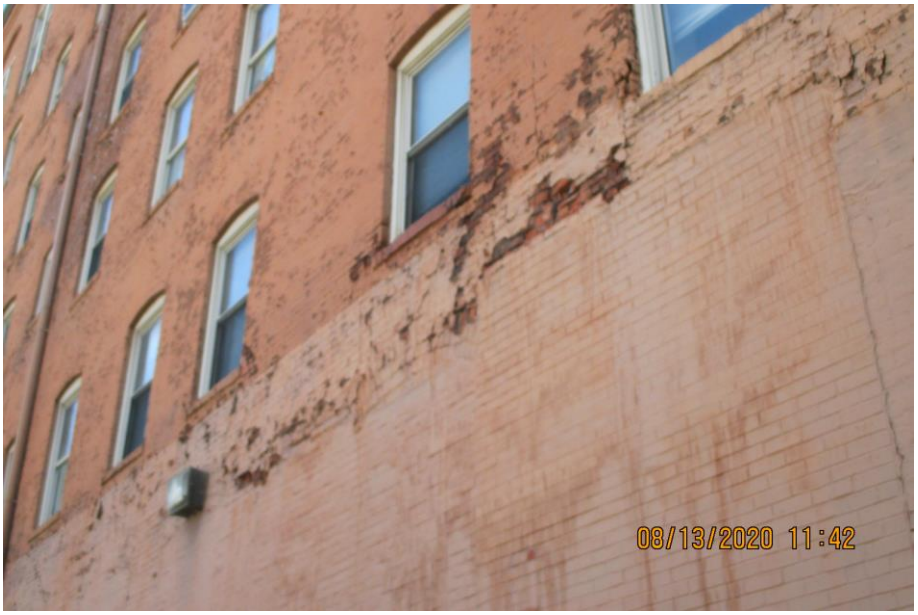
Fig. 49. Reaction at beam connection to Pier D at the second floor.

Many factors regarding the condition of the west wall described elsewhere in this report would also reduce the capacity of the wall considerably. Therefore, the above listed results are a conservative “best case” scenario regarding capacities and performance of the wall components.

APPENDIX C REPRESENTATIVE PHOTOGRAPHS

Photograph 1: August 2020 Image of west elevation from City report.

Photograph 2: August 2020 image of west elevation from City report.
Note open mortar joints and masonry distress.



Photograph 3: August 2020 image of west elevation from City report.
Note open mortar joints and masonry distress.

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Photograph 4: August 2020 image of west elevation from City report.
Note open mortar joints, spalling brick faces, and other masonry distress.

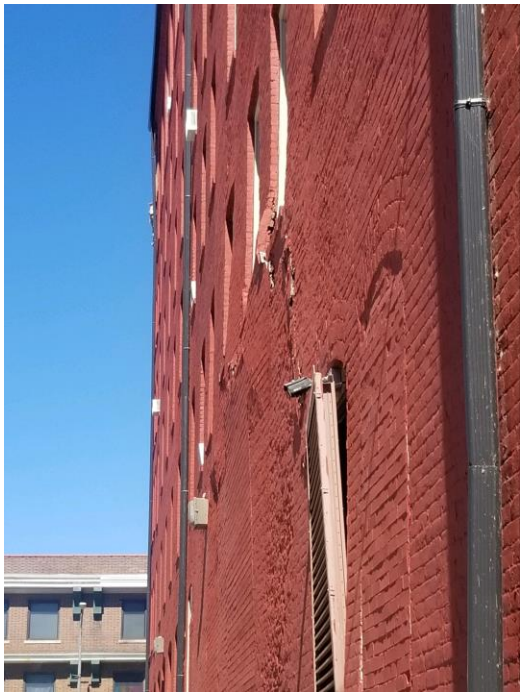
Photograph 5: 2021 image from City report.
Note masonry deterioration throughout west elevation.

Photograph 6: 2021 image from City report.
Note in progress limited repair work.

Photograph 7: August 2020 Image from City report.
Note deterioration of brick masonry at interior wythes.

Photograph 8: August 2020 Image from City report.
Note deterioration of brick masonry at interior wythes

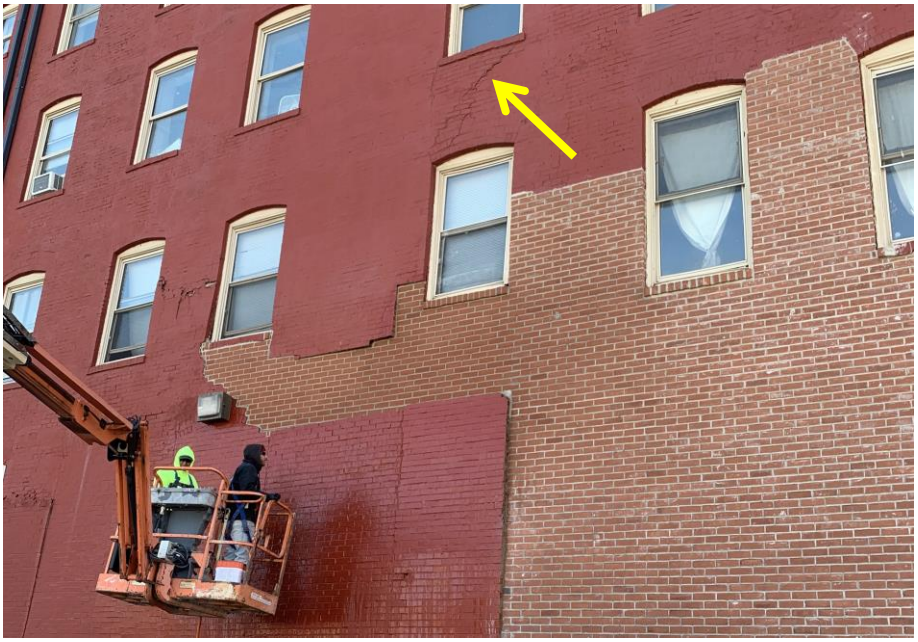
Photograph 9: February 2023 image from City file 23-6454.
Note shear cracks and displaced masonry.



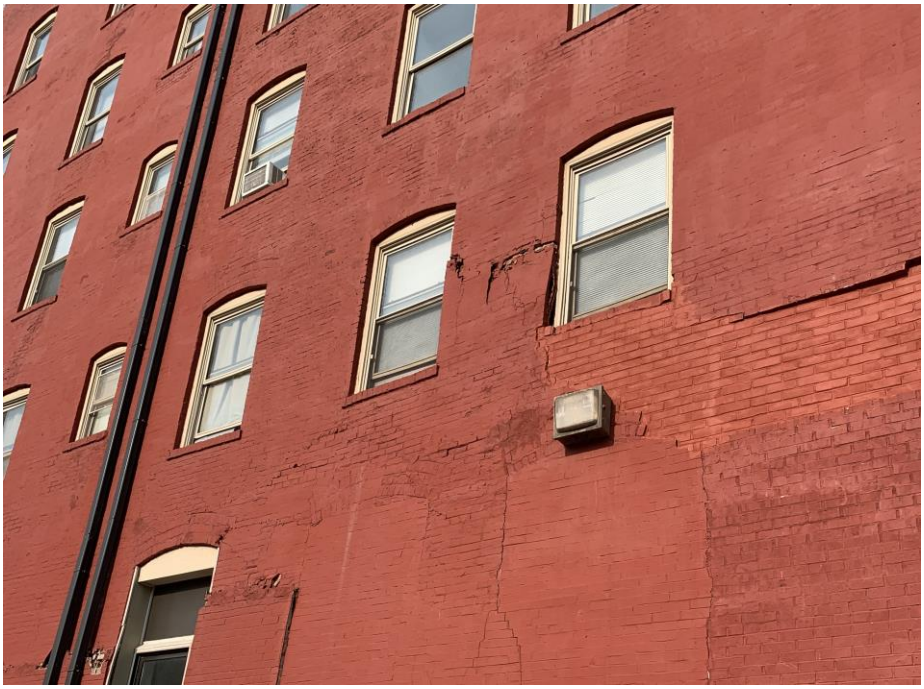
Photograph 10: February 2023 image from City file 23-6454.
Note displaced masonry and louvers.

Photograph 11: February 2023 image from City file 23-6454.
Note distress and damage at interior masonry.

Photograph 12: February 2023 image from City file 23-6454.
Note shear cracks and distress at interior masonry.



Photograph 13: May 2023 brick replacement.
Note shear crack at spandrels.



Photograph 14: May 2023 image of west elevation.
Note masonry distress at Piers C and D.

Photo 3 – Excessive Downward Pressure on Finishes

Photograph 15: Image contained in May 24, 2023 SSE letter.
Note deformation at window jamb and sill, indicative of exterior wall movement.

Photograph 16: Post-collapse photo of west elevation wall.
Note lack of reinforcing steel or grouted cells in CMU wall component debris.

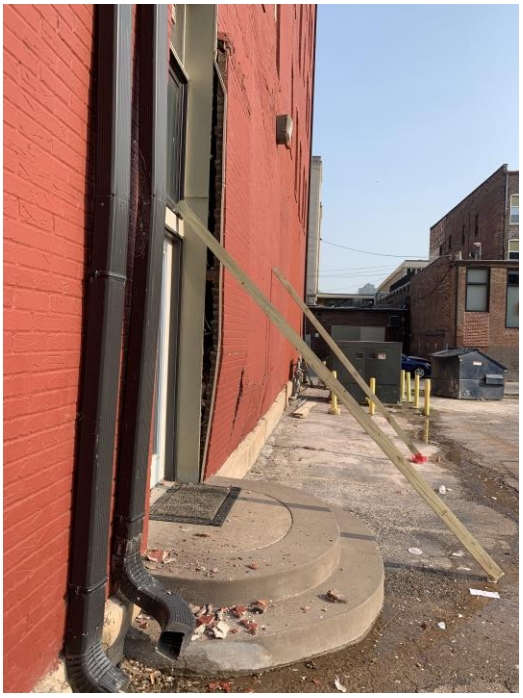
Photograph 17: Post-collapse photo of west elevation wall debris.
Note lack of reinforcing steel or grouted cells in CMU wall component debris

Photograph 18: Post-collapse view at wall cross section.
Note outer 2 wythes of brick masonry not bearing on CMU replacement wall.

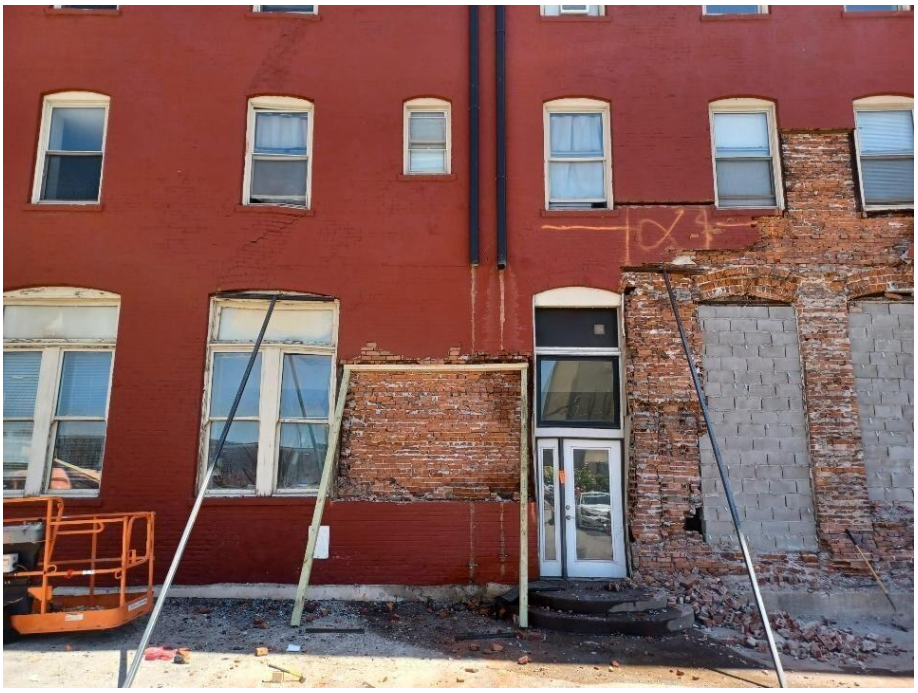
Photograph 19: Post-collapse view at wall cross section.
Note outer 2 wythes of brick masonry not bearing on CMU replacement wall.

Photograph 20: Post-collapse image of CMU wall constructed in May 2023.
Note corrugated brick ties not engaging outer wythe of brick masonry.

Photograph 21: Image from SSE February 28 Addendum letter.
Note cavity between CMU wall and exterior wythes, and unsupported upper wythes of masonry.



Photograph 22: May 25, 2023 image from City file 32-30329.
Note bowing masonry wall and inadequate shoring attempt.



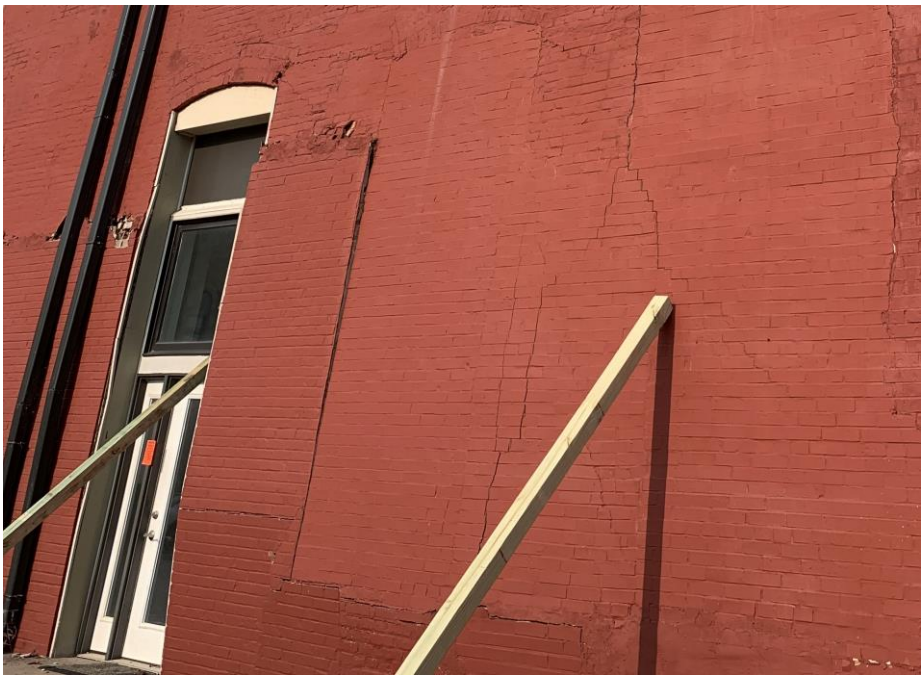
Photograph 23: Image from June 1, 2023 Quad City Times article, taken by R.A. Masonry.
Note improper and inadequate shoring components.

Photograph 24: Interior photo of west elevation wall from City file 23-6454.
Note reduced wall thickness at location of plumbing embedded within wall.

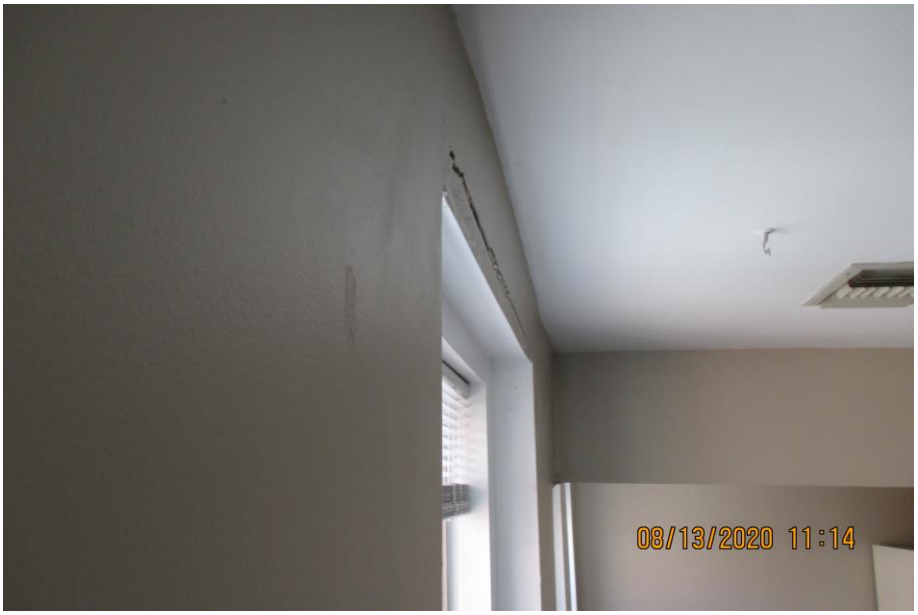
Photograph 25: Post-collapse image of cross section of wall.
Note reduced wall thickness at location of plumbing embedded within wall at Pier G.

Photograph 26: Image from City file 23-9778 exhibiting April 2023 repair work.
Note large vertical chase embedded within wall at Pier F.

Photograph 27: Image from City file 23-30329.
Note mis-aligned masonry at Pier E brick replacement locations.



Photograph 28: Image from City file 23-30329.
Note mis-aligned masonry at brick Piers C and D.



Photograph 29: Image from City file 20-7839.
Note indications of water infiltration and distress at ceiling and window head.

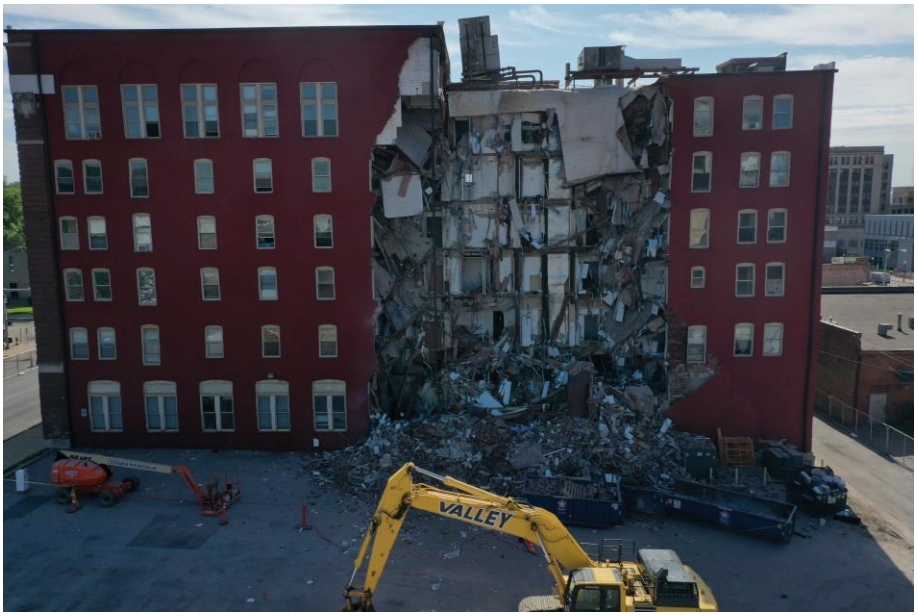
Photograph 30: Image from City file 20-7839.
Note separation of gypsum board at beam to wall interface.

Photograph 31: Image from City file 23-30329.
Note previously installed supplemental steel post.

Photograph 32: Image and annotation from SSE February 2, 2023 letter.
Yellow annotation (by WBG/SEI) denotes supplemental steel post and modern steel beam.

Photograph 33: Image and annotation by WBG/SEI of basement column.
Note cover plate and vertical stiffener.

Photograph 34: Image and annotation by WBG/SEI of basement column.
Note cover plates and steel angle beam seat reinforcement.



Photograph 35: Post collapse overview of west elevation from City sUAS.

Photograph 36: Post collapse aerial image of subject Building from Shive Hattery sUAS.

APPENDIX D EVIDENTIARY PROTOCOL AND SAMPLE IMAGERY

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PROTOCOL
SELECTIVE DEMOLITION / EVIDENTIARY MATERIALS RECOVERY

CLIENT/AGENCY: City of Davenport
INCIDENT LOCATION: 324 N. Main Street, Davenport, IA
TYPE OF INCIDENT: Collapse
DATE OF INCIDENT: May 28, 2023
INCIDENT NO: XXXXXXXXX
WBG FILE NO: 2023006

DATE: June 3, 2023

I. SCOPE AND BACKGROUND

Selected components from the above-referenced incident need to be removed to permit additional evaluation, inspection, investigation and the repair of the affected structure.

Unless noted otherwise, all demolition material from this process shall be disposed of unless defined below. Materials Testing Protocols will be developed for any evidentiary materials as required. These protocols shall be provided to all Interested Parties cooperating in the investigation.

In the event that the direction contained in any relevant City of Davenport standard operating Policies, Procedures, Standards, or Protocols are contradicted by the contents herein, the direction of City of Davenport documents shall supersede and be controlling.

II. NOTIFICATION / AHJ

All notifications and any questions thereof shall be transmitted to/from:

Assistant Chief / Fire Marshal James Morris
City of Davenport Fire Department
Jim.morris@davenportiowa.com

Notifications shall be in conformance with ASTM E860 – 07(2013)e1: *Standard Practice for Examining And Preparing Items That Are Or May Become Involved In Criminal or Civil Litigation.*

SOCOTEC Engineering, Inc.
35 East Wacker Drive, Suite 670, Chicago, IL 60601
Tel.: +1 773 943 7355
www.socotec.us

White Birch Group, LLC
Chicago, IL 60630
Tel.: +1 312 561 3141
www.WhiteBirchGroupLLC.com

III. CHAIN OF CUSTODY

All materials shall be secured, documented, and processed in accordance with City of Davenport Chain of Custody procedures and protocols.

IV. EVIDENTIARY COMPONENTS TO BE REMOVED

The following components shall be deconstructed and removed from the subject structure in conjunction with this Protocol:

A. Representative Steel Framing Members
   a. Girder element (min 2)
   b. Intermediate beam element (min 2)
   c. Shear tab element (min 2)
   d. Any non-typical framing elements identified
B. Representative Masonry Materials
   a. Exterior face brick (painted) (min 3)
   b. Solid clay intermediate wythes (min 3)
   c. Cored clay brick intermediate wythes (min 3)
   d. Cored clay tile (min 3)
C. Representative Concrete Elements
   a. Floor slab and embedded wire reinforcing (min 2)
   b. Floor slab and wire mesh reinforcing (min 2)
D. Representative Concrete Masonry Units (CMU, "cinderblocks")
   a. CMU from exterior wall - South end of West Elevation (min 3)
   b. Reinforcing steel contained in CMU cores (min 3 pieces, two (2) feet in length
   c. Mortar/grout from CMU cores (min 4 cells – can be contained within CMU)
E. Construction Equipment and Materials
   a. Any visible construction tools located within the debris field during recovery phase debris removal operations.
   b. Any visible shoring posts, columns, timbers, etc. located within the debris field during recovery phase debris removal operations.
   c. Any wheelbarrows, concrete mixing tubs/buckets, etc. that are visible in the debris field during recovery phase debris removal operations.
   d. Representative samples (2 each of 0.25 CF min) of mass concrete/grout/mortar (recently cured) visibly located within the debris field during recovery phase debris removal operations.

SOCOTEC Engineering, Inc.
35 East Wacker Drive, Suite 670, Chicago, IL 60601
Tel.: +1 773 943 7355
www.socotec.us

White Birch Group, LLC
Chicago, IL 60630
Tel.: +1 312 561 3141
www.WhiteBirchGroupLLC.com

V. SPECIMEN SELECTION

WBG Personnel, in conjunction with the AHJ, shall identify the members from which the required samples/coupons shall be extracted. If site conditions warrant modification of the proposed location/methodology, said discrepancies shall be recorded. The location of each source location shall be documented via photographic and/or other relevant media prior to, and after extraction.

VI. METHODOLOGY

The selective demolition shall follow the methodology as described below. Should any of the steps listed be determined to be impractical, unsafe or otherwise problematic by the Demolition Contractor, please contact WBG for additional information immediately.

This methodology is intended to provide guidance for the actual demolition process; however, OSHA and local general requirements for site safety and operations are not included in this document. Contractor shall implement their own OSHA and local-compliant access and site safety protocol (including conventional and respiratory PPE) in conjunction with the work described in this protocol. The above notwithstanding, the contractor shall have a minimum of two (2) 10-pound ABC dry chemical fire extinguishers present within the work area at all times.

A. Steel material extraction

The size and configuration of the specimen shall be determined based on the Standard to which the specimen shall be tested. All extraction shall be performed with the use of pneumatic, electric or hand-operated cutting tools with new, clean blades, or approved thermal cutting devices. Any thermal cutting devices (i.e torch cutting) or other extreme heat inducing extraction methods will require that all cutting work is performed twelve (12) inches beyond the specified sample demarcation line, and a minimum of twelve (12) inches from any bolted, riveted, or welded connections.

Steel beam, girder, and column elements shall be extracted twelve (12) inches from the end of the member (unless larger sections are required as noted above).

Shear tab elements can be extracted intact/connected to their parent element.

B. Masonry material extraction

Due to the nature of the collapse, loose masonry material may be collected from the debris field. Masonry selected should be a combination of loose elements, and masonry units bonded to other masonry units with mortar.

C. Concrete slab elements

Concrete slab materials may be selected from loose slab components measuring a minimum of two (2) feet by two (2) feet in plan size. If no elements of this size are

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observed, saw cutting can be utilized to extract the required slabs from larger concrete elements.

D. Concrete Masonry Units (CMU)
CMU shall be extracted as individual units, as well as units with mortar intact. Where grout-filled cells are present, a minimum of 2 CMUs shall be sawcut, keeping grout and reinforcing steel intact.
Where areas of multiple contiguous reinforced CMUs are removed, wall sections shall be photo documented, and representative face shells of CMU shall be mechanically removed to expose extent of grout and reinforcing steel and then photo documented prior to disposal.

VII. SPECIMEN IDENTIFICATION

All specimens (and/or their containers) shall be marked in conformance with ASTM E 1188: Standard Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator and ASTM E 1459: Standard Guide for Physical Evidence Labeling and Related Documentation.

A medium such as permanent ink shall be utilized to label the specimens and/or their containers in conformance with the above-listed requirements.

VIII. SPECIMEN STORAGE

WBG and/or their sub-consultant shall prepare and package all samples for shipping to the evidence storage facility and/or testing laboratory. The type and material of the packaging shall be appropriate to preserve the integrity of the specimen. The testing laboratory shall be responsible for the controlled storage of the specimen until disposition is approved by the individual identified in *Section II - Notification*.

END OF PROTOCOL

Appendix D - Photograph 1:
Evidentiary materials storage location.

Appendix D - Photograph 2:
Exemplar steel beam components.

Appendix D - Photograph 3:
Exemplar masonry components.

Appendix D – Photograph 4:
Exemplar concrete floor slab material.

APPENDIX E KEY DOCUMENTS REFERENCED

Document Continues on Next page

Haut, Tony

From: Chris Townsend <chris@townsendengineering.net>
Sent: Tuesday, August 18, 2020 3:29 PM
To: Morris, Jim
Cc: Haut, Tony; Mark Roemer
Subject: [EXT] 324 Main Street Davenport

Chief Morris and Tony,

Today Cory Voelkers and myself inspected the structure located at 324 Main Street in Davenport, Iowa due to some brick falling from the exterior of the 6th floor onto the sidewalk below. Photos were taken at the time of the inspection and have been included with this email.

This evaluation is limited in scope, focusing only on observations made from visible evidence. No additional destructive or invasive testing was performed.

The six-story structure located at 324 Main Street was reportedly constructed in 1906 and is a total of 83,850 square feet. Original building design plans were obtained at the Davenport Public Library and were reviewed and photographed for a comprehensive knowledge of the construction components. Assumptions have been made that the building was actually built as shown. The plans indicate that the floor systems for all six floors are comprised of poured on-site concrete floors, approximately nine inches in overall thickness, which run primarily in a north to south direction. The concrete floors are supported by a 2-inch deep lip along the north and south exterior building walls and by intermediate steel beams with columns at the interior of the building. The north and south portions of the building, where the majority of our inspection took place, has two rows of beams which run in an east to west direction, spaced approximately 17 feet in from the north and south exterior walls. This beam spacing leaves approximately 9 feet of floor through the middle of each section of the building. A row of beams and columns also run in a north to south direction approximately 25 feet west of the east exterior walls. The exterior walls are constructed of two layers of brick and an inside layer of clay tile equaling to approximately 13 inches in overall thickness. According to the original plans, the main floor of the building has 16-foot tall ceilings, floors 2 through 5 are indicated to have 9 foot 6 inch ceilings, and the sixth floor ceiling height varies from east to west. The plan set indicates that the west side of the sixth floor has ceiling heights of approximately 11 feet, and due to the sloping roofline, the east end of the building ceiling was measured during the inspection to be approximately 15 feet tall.

During the inspection, the primary focus was directed at the exterior brick façade on the east and north sides of the 6th floor. At the time of the inspection several bricks had fallen from the east side of the northeast corner of the building onto the sidewalk. We inspected the interior of three of the units on the 6th floor. We looked at units 601 and 602 at the northeast corner of the building and unit 615 at the southeast corner of the building. We have inspected these three units in the past three years and we could not find any noticeable cracking of the drywall or other movement when comparing today's photos with the previous inspection photos. The roof of the building was also inspected. Damage to the parapet cap was found near the southwest corner and several areas of the roofing had also been damaged during last week's storm. We did not find any recent movement of the parapet on the east side of the north or south sections of the roof and we did not find any separation of the roofing from the brick façade that would indicate any recent movement.

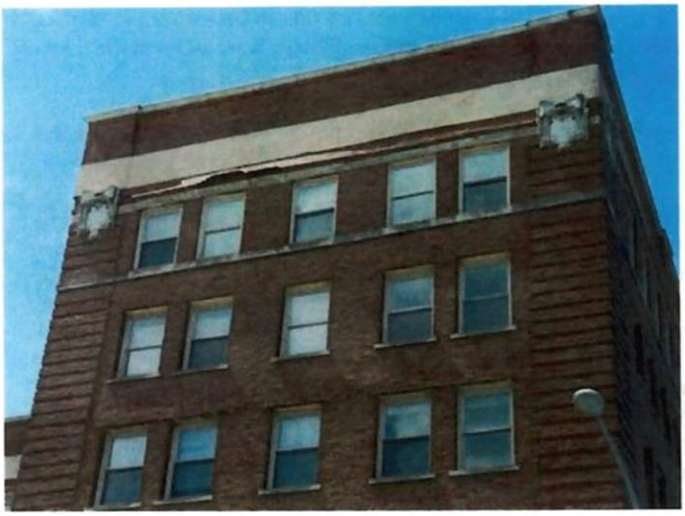
It is my professional opinion that the structural components of the exterior walls have not moved over the last three years but the brick façade has separated in some locations causing the brick ties to come loose which allows the bricks to fall. It was my recommendation that Bi-State Masonry either remove or stabilize all of the

1

loose brick and limestone immediately to prevent more brick from falling to the ground. The brick and limestone around the area where the brick fell will be removed and any other areas that appear to have bowed out will be covered with plywood that is anchored to the interior clay block to hold the brick in place until the permanent repair is made.

It is my professional opinion that the damage to the building is not structural and the building is safe to occupy. After the brick façade is temporarily secured we will develop a plan to permanently repair the exterior brick to prevent further damage.

1. East side of the northeast corner. Notice fallen brick above windows.



Thank you,

Chris Townsend, P.E.

Townsend Engineering
2224 E. 12th Street
Davenport, Iowa 52803
Ph: (563) 386-4236
Fax: (563) 386-4231
Cell: (563) 529-4236
Email: chris@townsendengineering.net

SELECT STRUCTURAL

February 2, 2023

RE: Brick Wall Inspection
324 N. Main St.
Davenport, IA

To Whom It May Concern:

An emergency site visit was performed at the property above on February 2nd. The building is a six-story, brick and steel structure. There is commercial space at street level and residential units above. There is a concern on the west exterior wall where a localized area of brick is cracked and crumbling. An engineer was requested to determine whether this is an imminent threat to the building or a smaller concern.

There is a storage and maintenance room on the west side of the building in which the damaged brick wall can be seen. The main area of brick damage is roughly eight feet wide by four feet high, and occurs directly below a beam which supports the second level. The beam is approximately 16 inches wide and is likely steel encased in concrete. It is unclear whether it bears on the brick wall directly or rather on a steel column encased in brick. Another, smaller, encased beam is parallel, roughly eight feet to the north. The bottom faces of the beams are roughly 15'-0" high. Both beams need to be shored with heavy posts so that permanent repairs can be applied. The permanent repairs will likely involve the replacement of the wall in this area. The on-site building maintenance team confirmed that the ductwork in this workspace along the west wall is abandoned and therefore may be removed. This will allow better access to the wall and beams above.

The main takeaway from the inspection is that this damaged area is not an imminent danger to the entire building and its residents. An evacuation or lockout of the building is not necessary at this time. The damage will still be addressed and repaired. The two beams mentioned shall be shored soon, out of an abundance of caution, but with this shoring in place the structure will be secure for the permanent, long-term repairs to take place. Another report detailing these repairs will follow at a later date.

The opinions and recommendations in this report are based on field measurements and observable conditions. It is not an assessment of the non-structural elements of the local building code or an in-depth analysis of every member of the full structure. Should conditions change or new information become available, the Engineer reserves the right to amend his recommendations and this report. Select Structural Engineering assumes no liability on construction or demolition means and methods. If you have any questions about the findings or recommendations, please contact me.

Thank you,

David Valliere

David Valliere, PE

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Photo 1 – Damaged Brick & Beam to Support

Photo 2 – Second Beam to Support

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February 8, 2023

RE: Brick Wall Repair
324 N. Main St.
Davenport, IA

To Whom It May Concern:

An emergency site visit was performed at the property above on February 2nd. The building is a six-story, brick and steel structure. There is commercial space at street level and residential units above. There is a concern on the west exterior wall where a localized area of brick is cracked and crumbling. This engineer determined that this is not an imminent threat to the building or its residents, but structural repairs will be necessary.

As described in the previous letter (2/2/2023), there are two east-west beams in the vicinity of the west wall which need to be shored. With these secured, reconstruction of the wall can commence. The clay brick wall appears to be three or four wythes thick. The damaged area is roughly eight feet long by four feet high, mainly under the larger east-west beam. The full height of the wall in this area should be replaced. A suitable replacement would be a concrete masonry unit (CMU) wall.

The new CMU wall need not replace the entire west side of the building, but rather only the approximately twelve foot wide area from a window opening (currently boarded up) to an adjacent wall area of CMU. The joint between existing and new CMU could serve as a construction joint. It is also recommended to replace the brick wall in segments, and to shore/support the wall above in said segments. This will help minimize the amount of time which the west side of the building would be unsupported by a wall (even though the beam shoring will remain in place throughout the process). The twelve-foot length of wall may be demolished and shored in three four-foot-wide segments, then it can be replaced in similar increments so the new wall can alleviate the weight of the exterior walls above.

It is unknown if there is a north-south steel beam inside the wall at the second floor level, or if there is a steel post encased in the brick which supports the encased east-west beam. It will therefore be conservatively assumed that the east-west beams bear directly on the brick wall to be replaced. This is further reason to replace the wall in smaller segments to minimize the area and duration of unsupported walls above. If, however, steel members are encountered during demolition, they are to be preserved and undamaged. Notify the Engineer of their presence. These members are not to be removed or damaged so that they can be reused and incorporated into the repairs. The new CMU wall will be built around any such members, encasing them as before.

For each four-foot segment of wall, two holes shall be cut/drilled through the wall just below the beam line. Steel W8 needle beams shall be passed through these holes and shall be supported by 6x6 timber posts (or steel posts) to grade on the exterior side and the floor slab on the interior side. On top of the needle beams, parallel to the face of wall, there is to be shoring consisting of two 4"x4"x3/8" angles (one on each side). Horizontal cuts shall be made into the opposing faces of the brick wall to insert the horizontal legs of the angles. Their purpose is to support the brick wall above during demolition of their respective wall segment, and they shall remain in place until their respective segment is rebuilt.

The CMU shall be 16"x8" standard blocks, full-height grouted in vertical cells at 24 inch spacing (minimum). #5 rebar shall anchor the wall to the existing footing in the grouted cells. The rebar shall be drilled to a minimum embedment of nine inches and an epoxy adhesive such as Hilti HIT-RE 500 V3 (or

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equivalent) used. These anchoring bars need only extend 24 inches above the surface because they shall lap with full-height #5 rebar. Reinforced cells shall be fully grouted, as shall the cells directly below the east-west beams. Horizontal #3 ladder bars shall be placed in the mortar beds every other course. These ladder bars may be permitted to hang free temporarily as each wall segment is constructed so they can be lapped into the next wall segment. The intent is to tie the three wall segments together with continuous horizontal reinforcement. A bond beam shall be placed in the top course continuous across the new wall. If the wall is installed segmentally, as recommended, the horizontal reinforcement in the bond beam may be lapped to the adjacent segments, similar to the ladder bars. Smaller, solid blocks may be needed to fill gap(s) at the top of the wall for the existing upper wall to bear. A new clay brick façade may be installed against the outer face of the CMU to match the rest of the building. The window opening, currently boarded shut, shall also be infilled with CMU.

It is further emphasized that the full 12'-0" length of wall to be replaced is not demolished all at once. There are many unknown factors in the construction and stability of a 100 year old masonry structure. As always, there is inherent risk to altering an existing masonry structure which is showing signs of deterioration. The purpose of the staged and incremental demolition and reconstruction of wall segments is to minimize the risk of local structural failures.

The opinions and recommendations in this report are based on field measurements and observable conditions. It is not an assessment of the non-structural elements of the local building code or an in-depth analysis of every member of the full structure. Should conditions change or new information become available, the Engineer reserves the right to amend his recommendations and this report. Select Structural Engineering assumes no liability on construction or demolition means and methods. Notify the Engineer immediately should field conditions vary from expectations, as a new course of action may be needed. If you have any questions about the findings or recommendations, please contact me.

Thank you,

David Valliere

David Valliere, PE

LICENSED PROFESSIONAL ENGINEER
DAVID VALLIERE
22444
IOWA

2/8/2023

David Valliere

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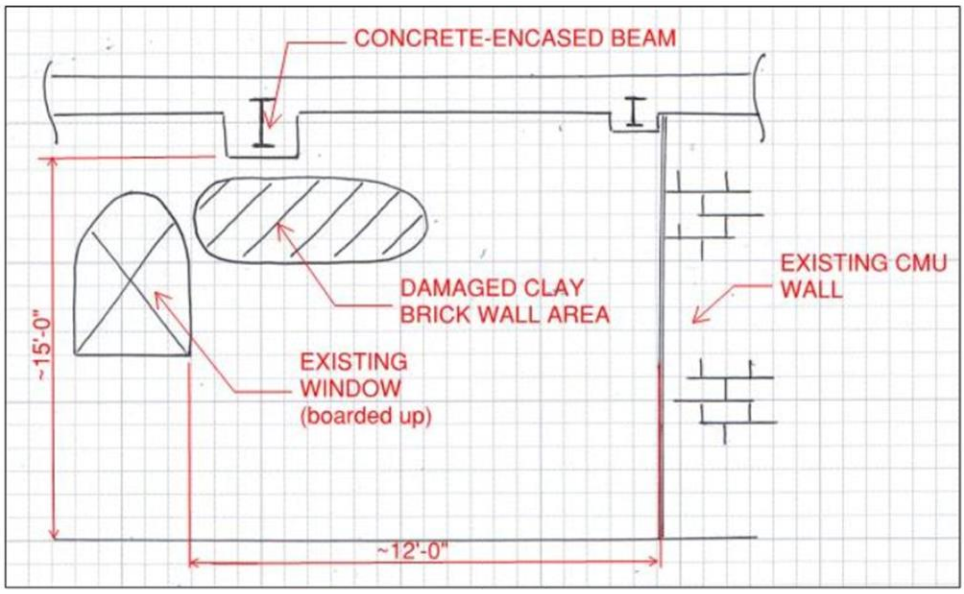

Figure 1 – Current Wall Condition

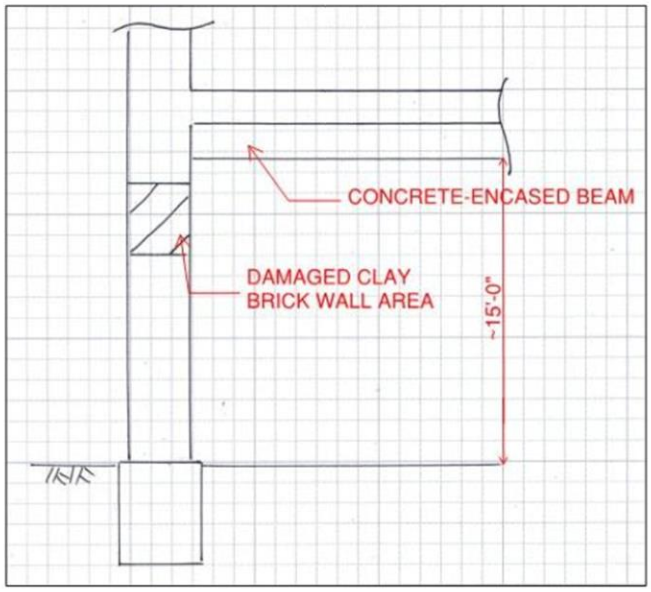

Figure 2 – Current Wall Condition (Section View)

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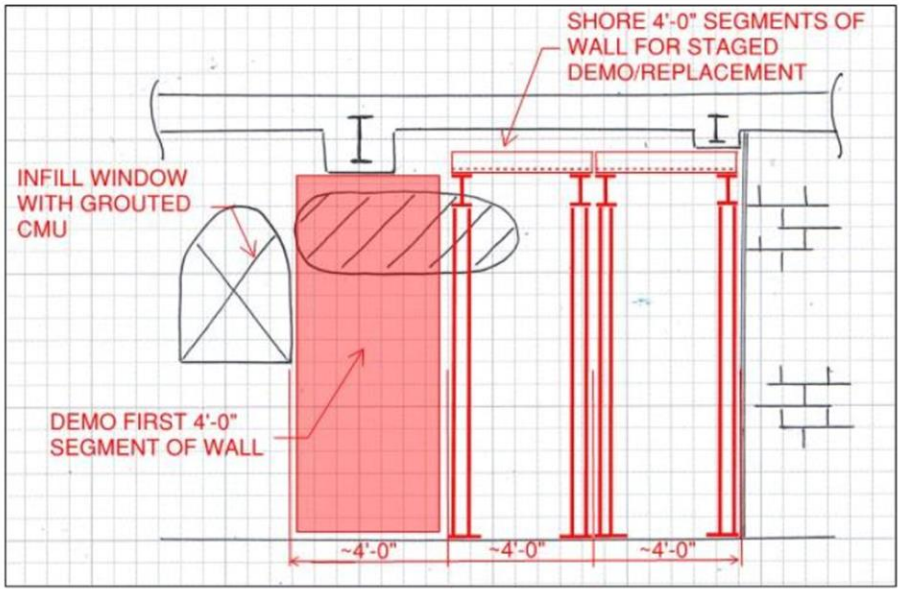

Figure 3 – Step 1 Repairs

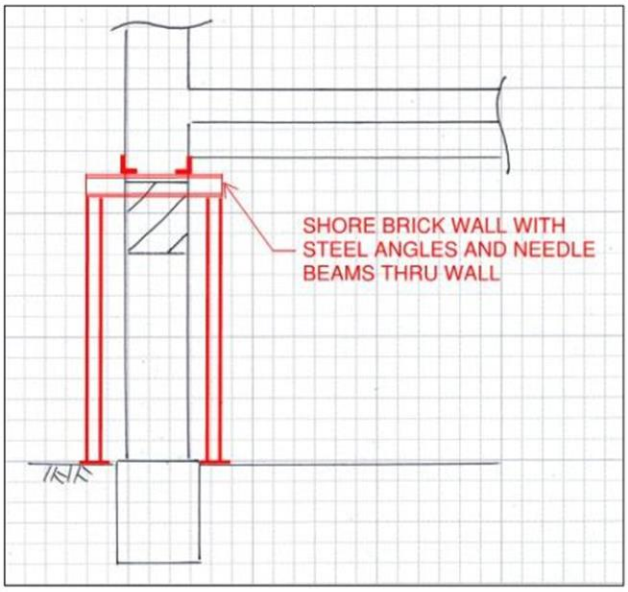

Figure 4 – Step 1 Repairs (Section View)

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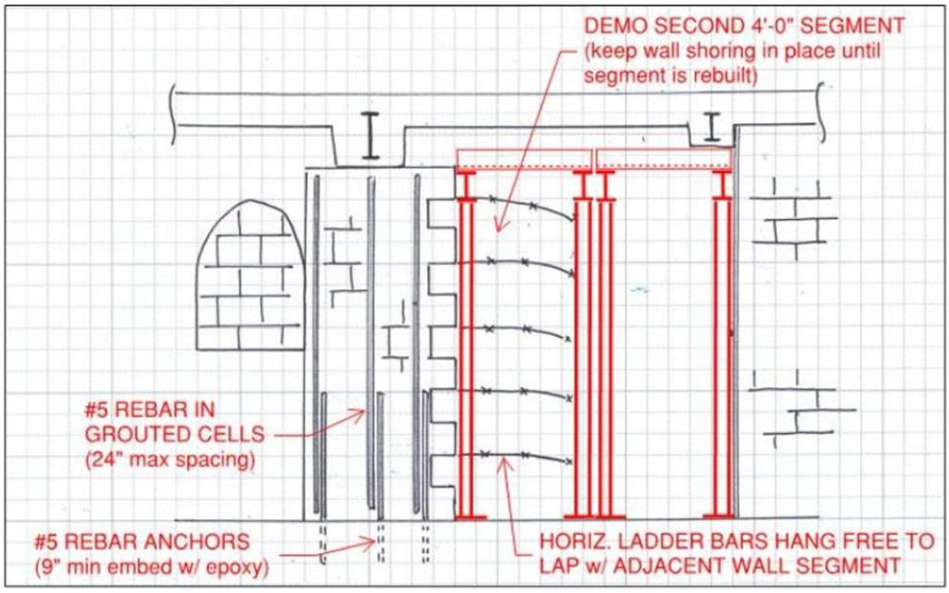

Figure 5 – Step 2 Repairs

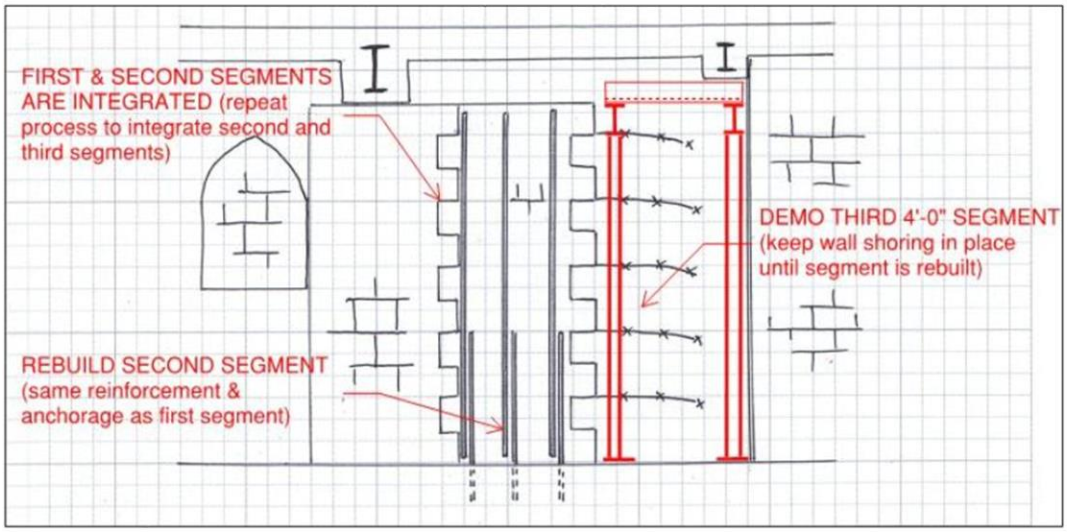

Figure 6 – Step 3 Repairs

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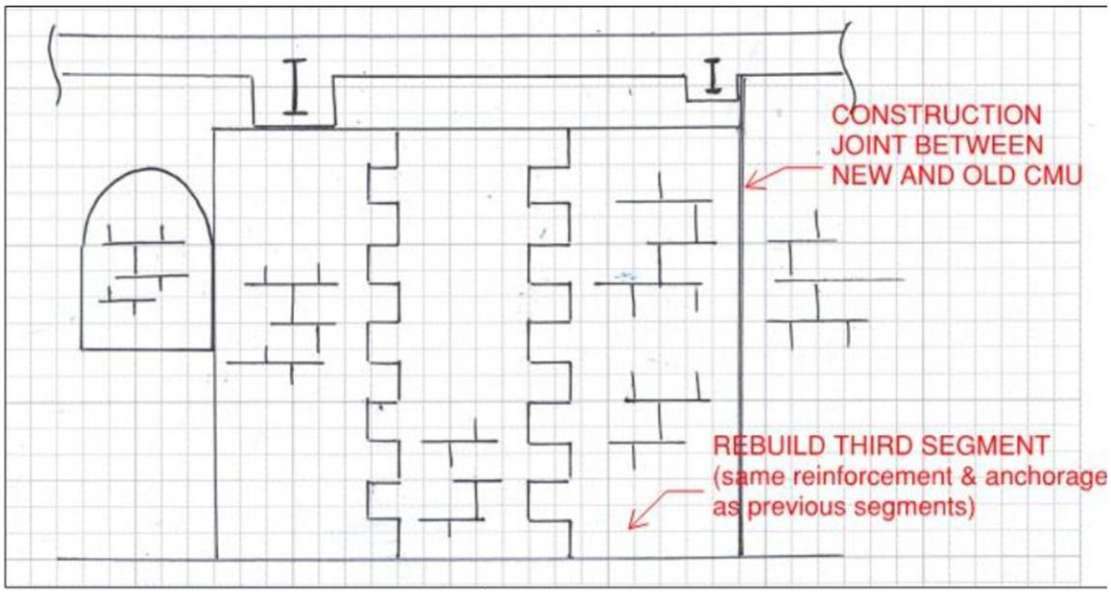

Figure 7 – Final Wall Condition

Figure 8 – Brick Wall Shoring Detail

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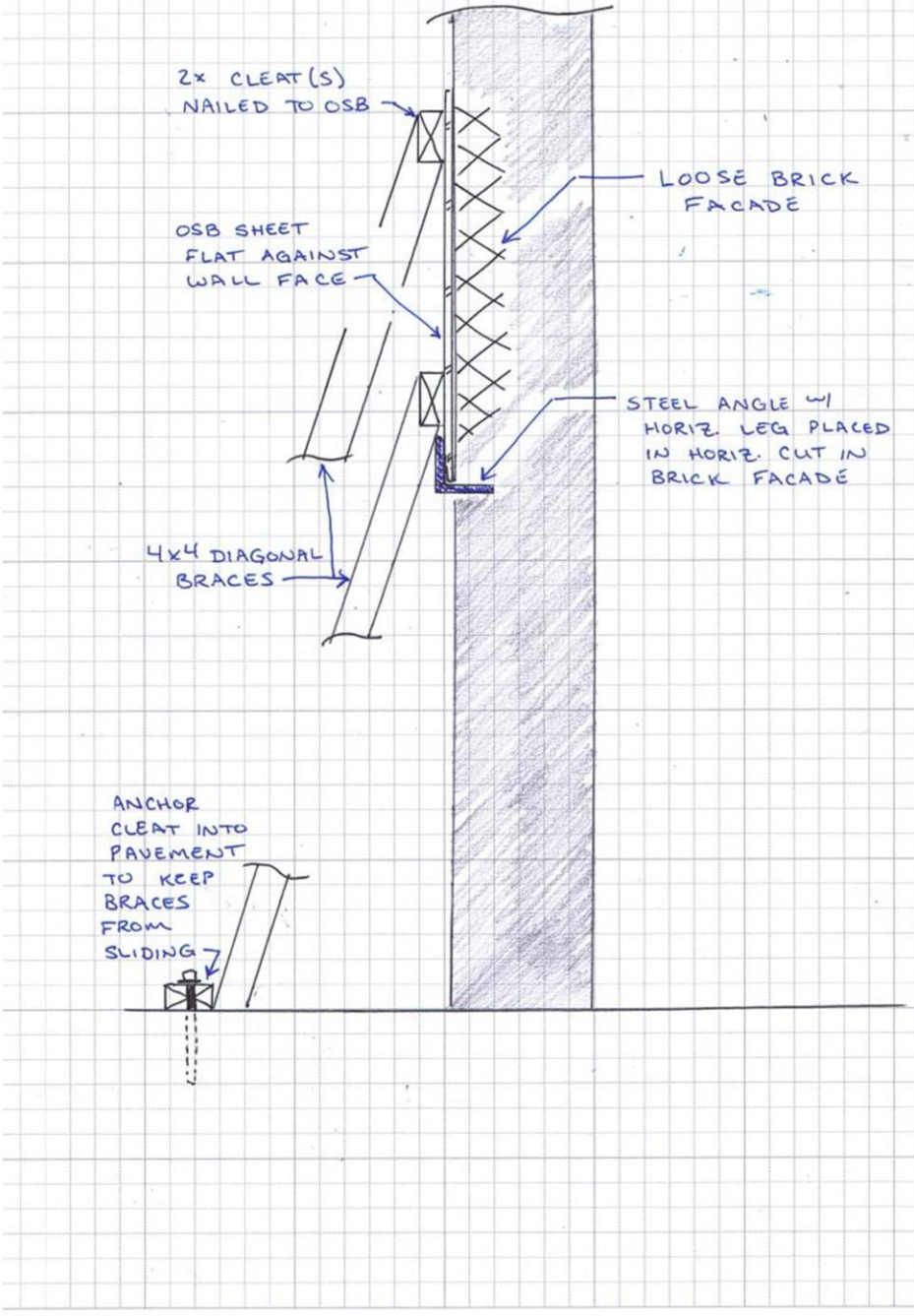
Project WOLD: Davenport No.

Subject

Sheet of Date 2-9-2023

Prepared by Scale



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February 28, 2023

RE: Brick Wall Repair – Addendum
324 N. Main St.
Davenport, IA

To Whom It May Concern:

A follow-up site visit was performed at the property above on February 23rd. At the meeting, the mason pointed out that the area immediately to the north of the work area has a large and potentially dangerous void beneath the façade wythe of clay brick.

The repairs recommended in the report issued February 8th are being performed by Bi-State Masonry; they appear to be going according to plan. One deviation from the plan is that two layers/wythes of CMU are bring installed to replace the clay brick wall segments rather than a single layer with an outer, façade layer of clay brick. This modification is acceptable and will add structural strength to the replaced areas. The original repair area is roughly twelve feet wide, and will abut to an existing wythe of CMU (which is likely a previous repair). What has recently come the attention of the team is that this area has a large void space, roughly 12"-14" wide, between the clay brick façade and CMU layer. This void appears to have been caused by the collapse of some mass of clay brick between the façade and CMU. This collapsed mass is now settled and piling up against the inside face of the façade, pushing it outward. This will soon cause a large panel of façade to also collapse, creating a safety problem and potentially destabilizing the upper areas of brick façade. This condition was not visible in the early inspection(s) and did not become apparent until repairs were under way and an opening was made by a smaller area of failing façade.

The Mason and Engineer agree that the most direct solution is to remove the brick façade in this area in a safe, controlled manner, and then to construct a second, outer layer of CMU from the ground level up to the top of the void (roughly 15 to 18 feet). This would allow the safe removal of unstable clay brick and add solid structure to the compromised wall. The repairs to the original twelve-foot-wide area of wall would proceed as it is now.

The opinions and recommendations in this report are based on field measurements and observable conditions. It is not an assessment of the non-structural elements of the local building code or an in-depth analysis of every member of the full structure. Should conditions change or new information become available, the Engineer reserves the right to amend his recommendations and this report. Select Structural Engineering assumes no liability on construction or demolition means and methods. Notify the Engineer immediately should field conditions vary from expectations, as a new course of action may be needed. If you have any questions about the findings or recommendations, please contact me.

Thank you,

David Valliere

David Valliere, PE

LICENSED PROFESSIONAL ENGINEER
DAVID VALLIERE
22444
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2/28/2023
David Valliere

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Photo 1 – Void between CMU and Clay Brick Façade

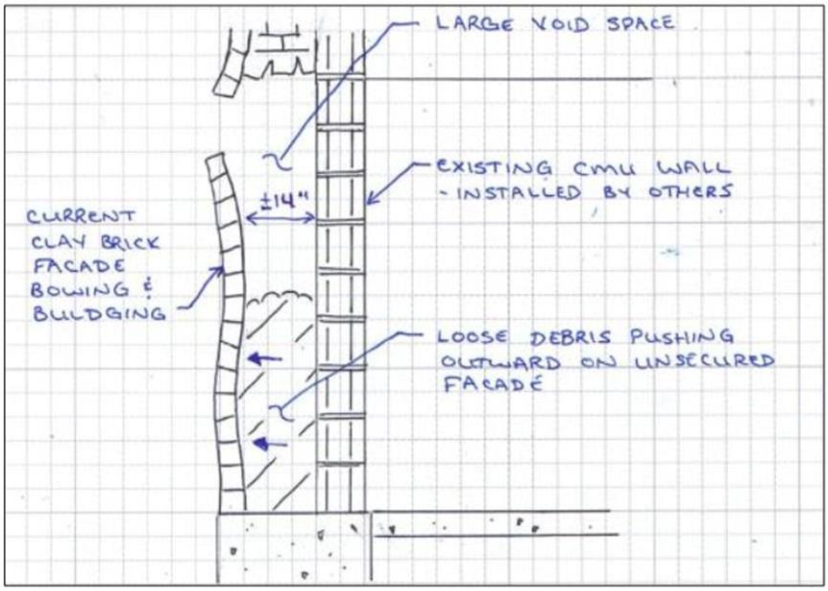

Figure 1 – Current Condition

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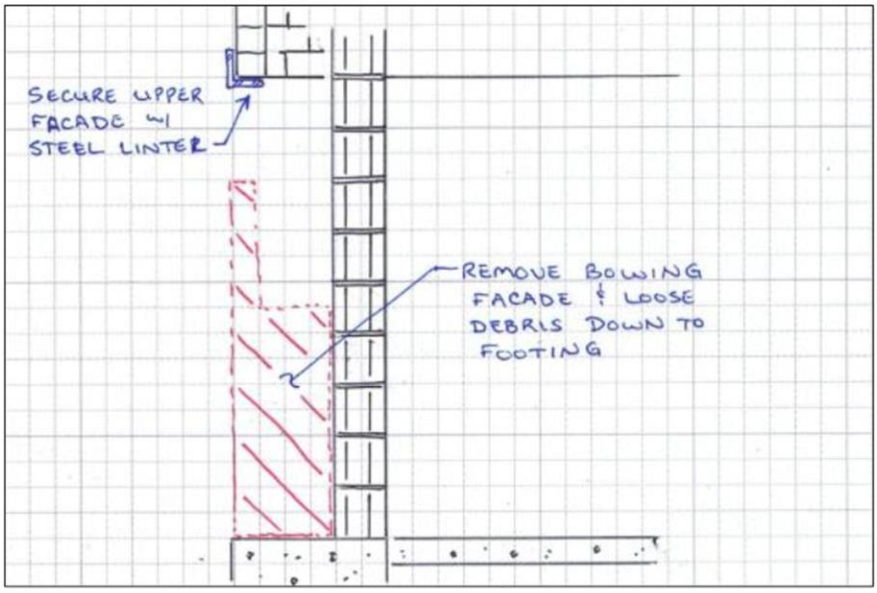

Figure 2 – Brick Demo

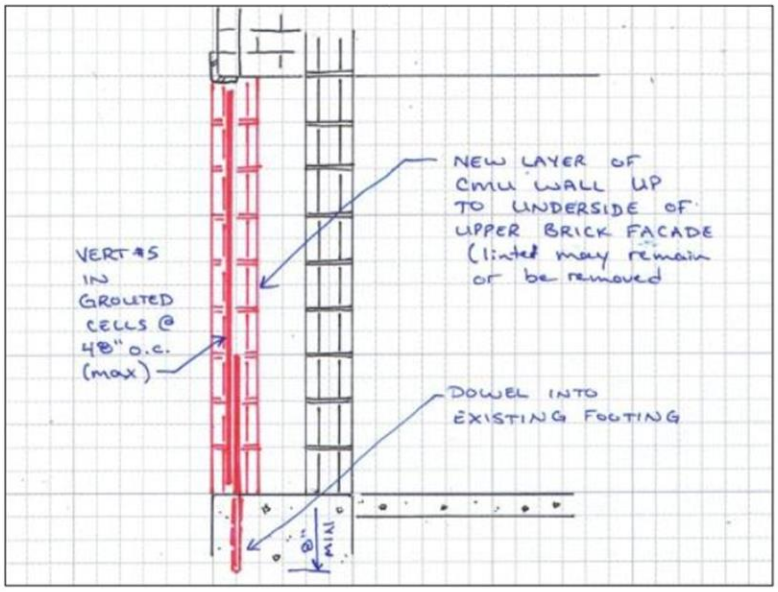

Figure 3 – New CMU Wall

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Pradhan, Trishna

From: David Valliere <dvalliere@select-structural.com>
Sent: Wednesday, March 1, 2023 9:26 AM
To: Pradhan, Trishna; Justin Smith; Chris Belser
Subject: RE: [EXT] RE: CONTRACTOR REGISTRATION

Trishna-
I am not on-site regularly, but I was there last week on Feb. 23 and saw that the work is being done per my design. I was able to meet with Justin, and Bi-State Masonry is doing a good job from what I can see.
Thanks,

David Valliere, P.E.
Structural Engineer
SELECT STRUCTURAL
Select Structural
O: 563.359.3117 D: 563.526.1174
www.select-structural.com

From: Pradhan, Trishna <Trishna.Pradhan@davenportiowa.com>
Sent: Wednesday, March 1, 2023 9:21 AM
To: Justin Smith <justin@bsmqc.com>; Chris Belser <chris@bsmqc.com>
Cc: David Valliere <dvalliere@select-structural.com>
Subject: RE: [EXT] RE: CONTRACTOR REGISTRATION

Good morning,
I will be on-site between 12:30 -1 pm to inspect work in progress. David, have you been on-site yet to ensure work's being done per your design ?

Thank you,

Trishna R. Pradhan (AIA, NCARB)
Chief Building Official | Building Division
City of Davenport

O 563-888-2264
1200 E 46th St, Davenport, IA 52807

Davenportiowa.com

From: Justin Smith <justin@bsmqc.com>
Sent: Friday, February 17, 2023 8:12 AM
To: Chris Belser <chris@bsmqc.com>; Pradhan, Trishna <Trishna.Pradhan@davenportiowa.com>
Subject: [EXT] RE: CONTRACTOR REGISTRATION

ATTENTION: This is an external email.

1

SELECT STRUCTURAL

May 24, 2023

RE: Brick Wall Repairs
324 N. Main St.
Davenport, IA

To Whom It May Concern:

A follow-up site visit was performed at the property above on May 23rd. On the west face of the building, there are several large patches of clay brick façade which are separating from the substrate. These large patches appear ready to fall imminently, which may create a safety hazard to cars or passersby. The owner has already blocked off the area with cones and has begun removing drywall from the inside of the wall to get a view of what might be happening.

As viewed from the west exterior, there are two former window openings, roughly 12 feet tall by six feet wide, which appear to have been bricked over some years ago. The clay brick façade on and between these openings is bulging outward by several inches and looks poised to fall. In anticipation of these areas falling, the brick façade above the windows should be secured. This is to keep the entire face of the building from falling away when the bottom area(s) come loose. The same temporary façade support as was recommended on February 9th, 2023, may be used here too. Note that the elevation of the steel angle in the detail shall be at or above the top of the window openings.

Inside the first floor, the drywall is being stripped away. This reveals that the window openings were never filled with brick or block. Rather, the clay brick façade was just run right over the openings, unsupported. This lack of bracing helps explain why the façade is currently about to topple outward. The brick façade is unlikely to be preserved in place, but it can be brought down in a safe, controlled manner. The stable sections above will be secured as mentioned previously. With the loose façade removed, the window openings can be filled in with 12" wide, reinforced concrete masonry units (CMU). #5 dowels shall be drilled and epoxied into the sill of each window opening to secure the base of the infill. Four vertical #5 bars in grouted cells shall reinforce the infill wall. The top shall be capped with either solid block or a grouted bond beam such that the wall above the CMU can bear on the infill like a solid wall. After the window openings are infilled with reinforced CMU, the clay brick façade to the outside may be replaced. This time, the new façade shall be braced back against the face of the structural wall with brick pintels to keep it plumb and secure. A continuous, rigid insulation can also be installed between the CMU and clay brick façade, leaving a small air gap.

To the north of the two window openings in question, there is another issue. The wall appears to be loosing some stability and is causing deformation. This is evidenced by the bowing of the interior light gauge steel furring and drywall; they bulge as if a large downward force is acting upon them. This downward force may be due to the reaction of an east-west beam which bears on the west exterior wall. Adding a steel column to support the east-west beam would alleviate much of the load from the exterior wall while the façade is rebuilt. This column may be a W6x15 positioned as near the inside face of the structural wall as possible. The cold form and drywall may be re-shaped around it to incorporate it into the re-finished wall. The brick façade outside this area may be secured and rebuilt as described for the other area.

The steel column must rest on a footing. This may be either the wall footing for the exterior wall, if it is wide enough to fit the column, or a new pilaster. The pilaster, if needed, would be a 12"x12" concrete addition to the exterior foundation wall in the lower level. This would allow the existing foundation to

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support the load from the east-west beam above, which is what it should already be doing. Before fitting the steel column into position, the east-west beam should be checked to make sure it is level and has not dropped. If it remains level, then the column shall be fit to its exact height. If the beam has dropped slightly, then it should be jacked back upward to its proper level position and the column fit to that elevation. This will require field measurement and possible field cutting and/or shimming.

The opinions and recommendations in this report are based on field measurements and observable conditions. It is not an assessment of the non-structural elements of the local building code or an in-depth analysis of the full structure. Should conditions change or new information become available, the Engineer reserves the right to amend his recommendations and this report. Select Structural Engineering assumes no liability on construction or demolition means and methods. Notify the Engineer immediately should field conditions vary from expectations, as a new course of action may be needed. If you have any questions about the findings or recommendations, please contact me.

Thank you,

David Valliere

David Valliere, PE

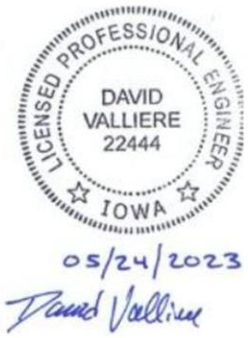

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Photo 1 – Clay Brick Façade pulling away from Substrate

Photo 2 – Window Openings to Infill

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Photo 3 – Excessive Downward Pressure on Finishes

Photo 4 – Existing Beam to Support

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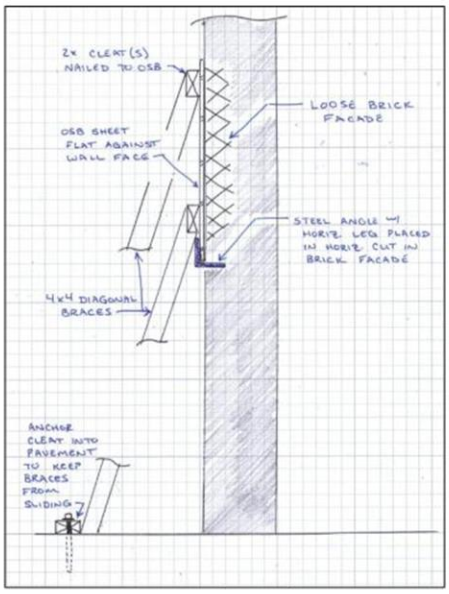

Figure 1 – Temporary Brick Façade Detail (from 02/09/2023)

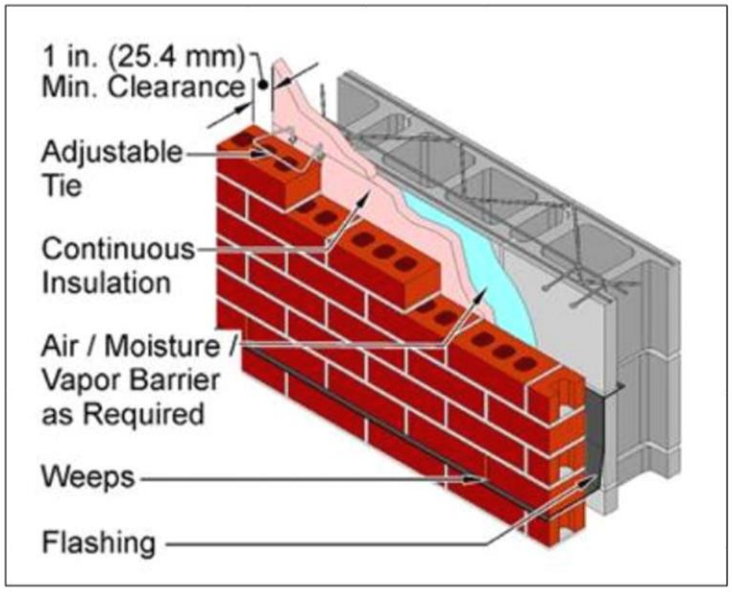

Figure 2 – Typical Brick Façade with CMU Backing

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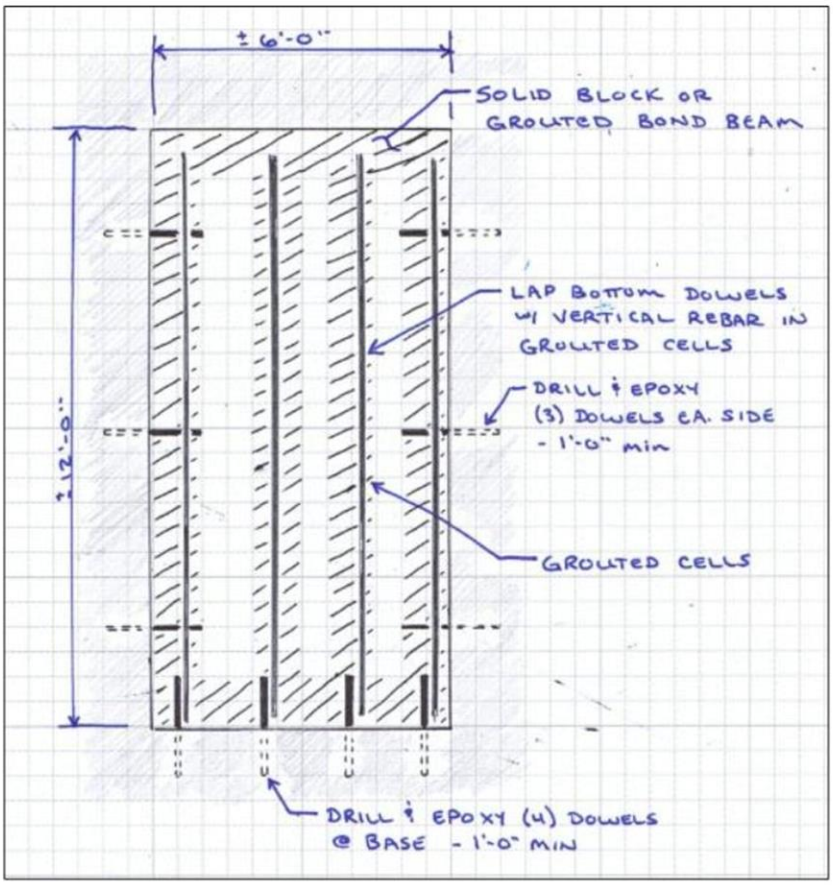

Figure 3 – CMU Infill Detail for Window Opening(s)

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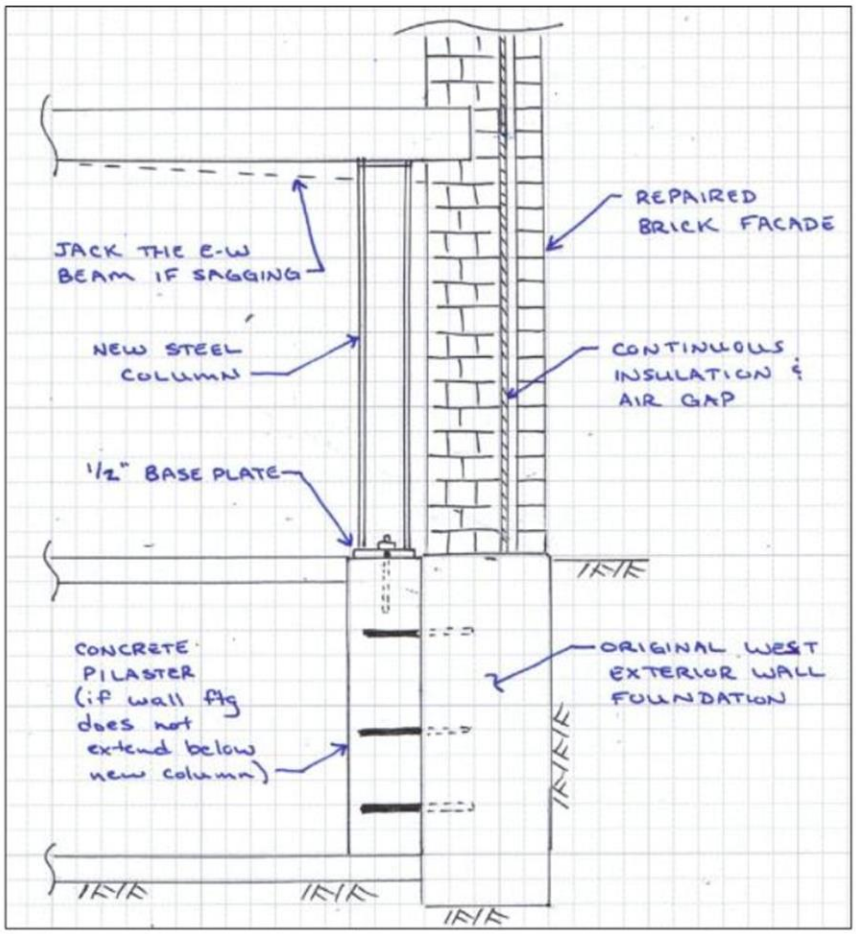

Figure 4 – East-West Beam Support Detail

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