FORENSIX

CONSULTING

Condominium Complex
Civil and Structural Evaluation
and Scope of Repair

PROJECT NO.
00018.00

CAUSE NO.
DC-18-09536

IDENTIFICATION OF STRUCTURES
The Vine Condominiums
3210 Carlisle Street
Dallas, Texas 75204

PREPARED FOR
Chris Rhody
McKenzie Rhody, LLP
222 Las Colinas Boulevard West
Suite 1955N
Irving, Texas 75039

EXHIBIT 4

FORENSIX

CONSULTING

July 8, 2019

Chris Rhody
222 Las Colinas Boulevard West
Suite 1955N
Irving, Texas 75039

File: The Vine Condominums
3210 Carlisle Street
Dallas, Texas 75204

Forensix Project No.:	00018.00
Cause No.:	DC-18-09536

Dear Mr. Rhody:

Forensix Consulting, LLC is pleased to submit this report for the above-referenced file. By signature below, this report was authored by and prepared under the direct supervision of the undersigned professional.

Please contact us if you have any questions regarding this report.

With kindest regards,

FORENSIX CONSULTING, LLC
Texas Certificate of Registration F-20771

Kerry S. Lee, M.B.A., P.E.
President



08-JUL-2019

Forensix: Report 1-00018.00.doc.

1: INTRODUCTION

AUTHORIZATION AND PURPOSE

Forensix Consulting, LLC (Forensix) was authorized by the The Vine Condominium Association through its counsel, Mr. Chris Rhody with McKenzie Rhody, LLP (client), to review received information; evaluate the site grading and drainage at the referenced property (subject site); evaluate the structural conditions at the subject structures at the referenced property; determine the cause(s) of any structural distress and/or deficiencies, if any; and provide a scope of repairs for civil and structural defects and/or distress where applicable. Kerry S. Lee, M.B.A., P.E. of Forensix was the project engineer for the civil and structural investigation while at Nelson Forensics, LLC (Nelson), and the structural investigative data and observations collected by Nelson are incorporated into the Forensix project file and this report.

Kerry S. Lee, P.E., previously issued a *Preliminary Report of Findings,* dated October 23, 2017 while at Nelson, and has issued safety letters dated May 28, 2019, and June 17, 2019, related to the garage lintel and masonry installations at the subject property. This report supplements this previous report and the safety letters.

SCOPE OF INVESTIGATION

Forensix visited the site on July 24, 2017, May 21, 2019, and May 22, 2019. Forensix reviewed received information and conducted a visual evaluation of the site grading and drainage and the exteriors at the subject structures. Forensix photographically documented general site conditions and observed distress. Destructive testing (DT) was performed by Reconstuction Experts (RE) under the direction of Diehl Group Architects (DGA), Nelson, and Forensix. The DT investigative and removal activities performed as part of this investigation were reasonable and necessary to accomplish the evaluation of the structural distress and the resultant structural damage related to the deficiencies identified in the building envelope.

The architectural portion of this investigation was performed by DGA. The DGA findings are presented in its reports dated September 6, 2017, and July 2, 2019. Refer to the DGA reports for additional information on the locations of and the conditions identified at the destructive testing.

This report was not prepared for use in a real estate transaction. It was prepared for the purpose and for the client as indicated above. Any and all usage or reliance upon this report by parties other than the client is expressly prohibited.

DESCRIPTION OF SITE

The subject property consisted of 5 multi-family buildings (identified at buildings C, D, E, F, and G) with 27 three-story units (identified as units 17 through 44) contained within Phase III of the development, herein described as "The Vine." Based on available documentation and observations, the exterior finishes consisted of brick and pre-cast stone. Each building was constructed of conventional wood framing and was supported on a concrete slab-on-grade foundation. A partial site plan for the development is provided in **Figure 1-1** which includes the subject buildings and units in Phase III.

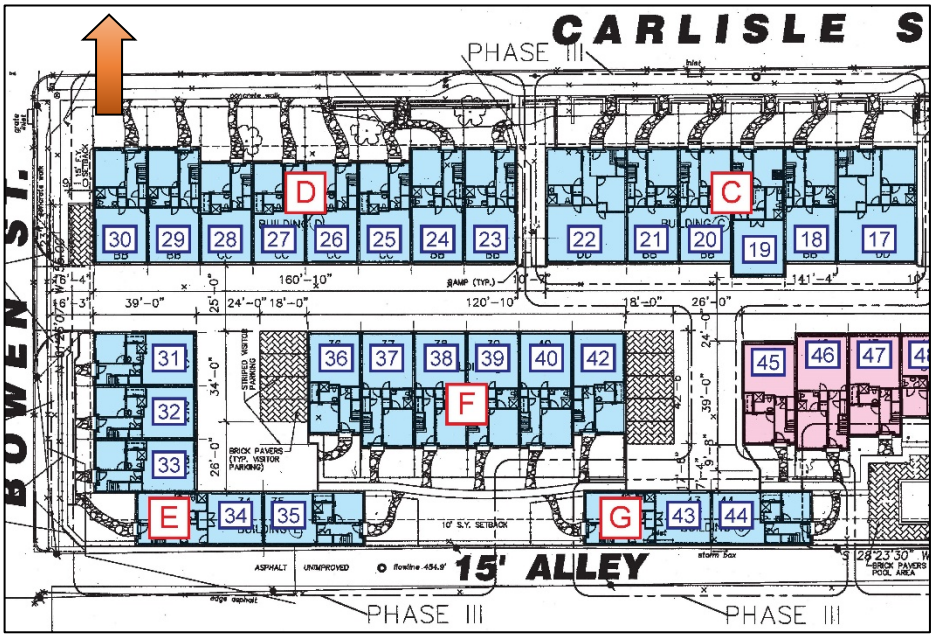


Figure 1-1: Partial site plan showing the subject buildings and units in Phase III

RECEIVED INFORMATION

In addition to on-site observations, the opinions presented in this report may be based on the following information received by our office:

Construction documents including Architectural, Civil, Landscaping, and Structural, prepared by Merriman Associates/Architects, Inc. (maa), various versions and dates.

Geotechnical Engineering Report, prepared by Terracon, bates KWA – 002843 through KWA – 002867, dated August 17, 2005.

Construction documents including Architectural, Civil, Landscaping, and Structural, prepared by Merriman Associates/Architects, Inc. (maa), Phase III documents, produced by KWA, received on June 7, 2019.

Various documents and plans produced by KWA, received June 7, 2019.

Site Plan for The Vine, #17027, provided by the client.

APPLICABLE BUILDING CODES

A review of the received construction plans was performed to determine the applicable building code governing the design and construction of the subject structure. The received architectural drawings indicated that the site and structures had been designed in accordance with the 2000 International Residential Code (IRC) and the 2003 International Building Code (IBC). Based on review of available documents, **Forensix is of the opinion that the 2000 IRC and the 2003 IBC were the applicable building codes governing the design and construction of the subject structures**.

2: GARAGE LINTELS AND MASONRY VENEER

INTRODUCTION AND SUMMARY OF CONCLUSIONS

Forensix observed and evaluated the masonry veneer at the garage lintels and at areas of destructive testing at the subject property. The following construction deficiencies and poor performance were noted:

- Deficient and potentially unsafe conditions at the two-car wide garage lintels. The brick veneer serving as the structural support for the bearing ends of the steel lintels were failed at one or both ends of every two-car wide garage opening.
- Deficient and potentially unsafe anchorage conditions at the corbelled pre-cast stone veneer above the entries.
- Corrugated metal anchors improperly used with a wide air gap between the wood structural framing and the back of the masonry veneer at destructive testing locations.
- Corrugated metal anchors which were not fastened into the stud framing.
- Corrugated metal anchors which were not properly embedded into the mortar beds.
- Mortar blockage and corrosion of corrugated metal anchors within the masonry drainage plane at destructive testing locations.
- Additional masonry and water management deficiencies are outlined in Section 3.0 of the July 2, 2019 DGA report which will require repair in conjunction with the repairs outlined herein.

Forensix is of the opinion that the brick and pre-cast stone masonry veneer assemblies are distressed at the structures; were improperly installed and supported; and that the general contractor and/or developer of the project violated its standard of care for construction by failing to install the masonry veneer to meet the minimum requirements of the building code. Additionally, the installed condition of the masonry veneer has created potentially unsafe conditions.

OBSERVATIONS AND TESTING

Photographic documentation and other field-obtained data of the structures are being maintained in the Forensix project file. Select photographs are included within the body of this report and may be presented for information only or for a general representation of the condition of the structures. All of the Forensix photographic and graphic documentation forms a basis for the opinions presented herein and is incorporated by reference.

Refer to **Section 3.00 of the July 2, 2019 DGA report** for additional information on observations and destructive testing performed at the masonry veneer.

Forensix observed failed end bearing conditions at the bearing brick for the two-car wide garage lintels (**Figure 3-1** and **Figure 3-2**), separation between the garage lintels and the brick supported above (**Figure 3-3** and **Figure 3-4**), and brick veneer fractures and mortar joint separations above a portion of the garage lintels (**Figure 3-5**).

The brick assembly at the bearing ends of the garage lintels was commonly installed using cut/broken bricks which were shifted out to provide an accent band, providing uneven, partial, or lacking bearing area for the lintel ends, in combination with face bricks to cover the lintel ends. The as-installed bricks had failed at and below the garage lintel bearing conditions, causing displacement of the garage lintels and the brick veneer above the garage lintels, creating potentially unsafe conditions (**Figure 3-6** through **Figure 3-9**). One or both ends of the two-car wide garage lintels exhibited evidence of bearing failures. Additionally, the full height of brick veneer between the garage lintel bearing level at units 31 and 32 was failed out of plane and had a lack of veneer anchorage (**Figure 3-10**).

During destructive testing at the brick veneer, the air space cavity was measured to be 2" wide or greater at the brick veneer, and corrugated metal anchors were used for anchorage (**Figure 3-11** and **Figure 3-12**). The air space cavity was measured to range between 3/4" and 4 3/4" wide at the tested locations in the pre-cast stone veneer, and corrugated metal anchors were used for anchorage, with minimal to no embedment of the anchors in the mortar bed at the wide wall cavities (**Figure 3-13** and **Figure 3-14**). The lack of anchorage or other mechanical attachment for the pre-cast stones with wide wall cavities created unsafe conditions at the entry of unit 43 for falling stone which was addressed on-site and in a safety letter dated May 28, 2019.

The air space cavity drainage plane was blocked with mortar resulting in the retention of moisture in the both the brick and pre-cast stone veneer systems. The retention of moisture had corroded the corrugated metal veneer anchors exposed at destructive testing locations in both brick veneer and pre-cast stone veneer (**Figure 3-15** and **Figure 3-16**). Forensix was able to remove a portion of the corrugated metal anchors with light hand pressure since the anchors were attached to the wood sheathing only and not into the structural wood stud framing.

Separations were observed at precast stone veneer mortar joints (**Figure 3-17**).

Destructive testing at the garage lintels was performed at the locations indicated in **Table 1** below:

Table 1: Destructive Testing Locations at Garage Lintels

Unit Number	Bearing End Tested	Observations
18	Left	Failed bearing brick, voids below steel lintel, approximate 6" lintel bearing, 1 7/8" wall cavity width, no through-wall flashing, corrosion at lintel and lag bolts, mortar blockage in air space cavity. **Figure 3-18** through **Figure 3-20**
29	Left	Failed bearing brick, cut brick at lintel bearing, voids in lintel bearing and gap between bearing brick and lintel, no through-wall flashing, approximate 7" lintel bearing. **Figure 3-21** through **Figure 3-24**
31	Right	Failed bearing brick, separation between lintel and brick, brick above lintel displaced outward, cut brick at lintel bearing, face brick over bearing end, voids in bearing brick below lintel, no through-wall flashing, approximate 6" lintel bearing, lag bolt corroded and not fully tightened. **Figure 3-25** through **Figure 3-27**
38	Left	Failed bearing brick with exposed void below lintel, face brick over bearing end, approximate 7" lintel bearing, cut bricks below lintel bearing, voids below lintel bearing, corrosion at lintel, no through-wall flashing, missing lag screw at the steel lintel. **Figure 3-28** through **Figure 3-30**
44	Left	Failed bearing brick, loose face brick over bearing end, corrosion at steel lintel, missing lag screw from bolt hole in lintel, mortar blockage in air space cavity, no bearing material (void) below bearing end, no through-wall flashing. **Figure 3-31** through **Figure 3-34**



Figure 3-1: Failed garage lintel bearing and DT location at unit 38. Failed bricks and exposed void below lintel



Figure 3-2: Failed garage lintel bearing and DT location at unit 44. Separation between lintel and brick above and displaced brick at lintel end



Figure 3-3: Separation between lintel and brick at unit 26 garage



Figure 3-4: Separation between lintel and brick at unit 35 garage



Figure 3-5: Vertical mortar joint separation and brick veneer fracture above unit 21 garage door



Figure 3-6: Brick above unit 25 garage shifted out of plane above lintel



Figure 3-7: Brick above unit 32 garage shifted out of plane above lintel



Figure 3-8: Brick above unit 36 garage shifted out of plane above lintel



Figure 3-9: Brick above unit 43 garage shifted out of plane above lintel



Figure 3-10: Brick veneer supporting garage lintels failed between units 31 and 32



Figure 3-11: Air space approximately 2 1/4" wide at unit 17 window DT



Figure 3-12: Air space approximately 2 1/4" at parapet DT unit 35



Figure 3-13: Air space at pre-cast stone approximately 4 3/4", minimal embedment of anchor in mortar bed above unit 43 entry



Figure 3-14: Minimal anchor embedment and lack of mechanical attachment for pre-cast stones above unit 43 entry. Unsafe condition



Figure 3-15: Mortar blocking air space at unit 17 window DT



Figure 3-16: Corroded wall tie at unit 17 window DT



Figure 3-17: Mortar joint separations at pre-cast stone adjacent to Juliette balcony at unit 37



Figure 3-18: Unit 18 garage lintel DT



Figure 3-19: Voids at bearing for steel garage lintel, corrosion of lintel and lag screws at unit 18



Figure 3-20: Mortar blockage at drainage plane at unit 18 garage lintel, no through-wall flashing



Figure 3-21: Unit 29 garage lintel DT



Figure 3-22: Cut brick below and at face for lintel bearing at unit 29



Figure 3-23: Voids and lack of contact at bearing for unit 29 garage lintel



Figure 3-24: Probe of voids below garage lintel at unit 29



Figure 3-25: Unit 31 garage lintel DT



Figure 3-26 Cut brick and voids below bearing end at unit 31 DT, approximate 6" bearing



Figure 3-27: Full depth voids below garage lintel bearing at unit 31



Figure 3-28: Unit 38 garage lintel DT, cut brick with voids



Figure 3-29: Probe of void below garage lintel at unit 38, corrosion of lintel, no though-wall flashing



Figure 3-30: Lag screw missing at hole in steel garage lintel, unit 38



Figure 3-31: Unit 44 garage lintel DT, missing lag screw from bolt hole



Figure 3-32: Loose face brick at unit 44 garage lintel bearing end, mortar blockage in air space



Figure 3-33: Void with no bearing material below bearing end of lintel at unit 44



Figure 3-34: Probe full depth at void below bearing end of lintel at unit 44

REVIEW OF BUILDING CODE

The 2000 IRC specifies the anchorage and support requirements for stone and masonry veneer as follows:

> ***R703.7.4 Anchorage.*** *Masonry veneer shall be anchored to the supporting wall with corrosion-resistant metal ties. Where veneer is anchored to wood backings through the use of corrugated sheet metal ties, the distance separating the veneer from the sheathing material shall be a maximum of 1 inch (25 mm). Where the veneer is anchored to wood backings through the use of metal strand wire ties, the distance separating the veneer from the sheathing material shall be a maximum of 4 ½ inches (114 mm).. . .*
>
> ***R703.4.1 Size and spacing.*** *Veneer ties, . . . if sheet metal, shall be not less than No. 22 U.S. gage by 7/8 inch (22.3 mm) corrugated. Each tie shall be spaced not more than 24 inches (610 mm) on center horizontally and shall support not more than 3 1/4 square feet (0.302 m^2) of wall area.*
>
> ***R703.7.4.1.1 Veneer ties around openings.*** *Additional metal ties shall be provided around all wall openings greater than 16 inches (406 mm) in either dimension. Metal ties around the perimeter of openings shall be spaced not more than 3 feet (9144 mm) on center and placed within 12 inches (305 mm) of the wall opening.*
>
> ***R703.7.4.2 Air space.*** *The veneer shall be separated from the sheathing by an air space of a minimum of 1 inch (25.4 mm) but not more than 4.5 inches (114 mm).. . .*

> ***R703.7.3 Lintels.*** *Masonry veneer shall not support any vertical load other than the dead load of the veneer above. Veneer above openings shall be supported on lintels of non-combustible materials and the allowable span shall not exceed the values set forth in Table R703.7.3. The lintels shall have a length of bearing of not less than 4 inches (102 mm).*

The 2003 IBC references the *Building Code Requirements for Masonry Structures, TMS 402-02/ACI 530-02/ASCE 5-02,* and the *Specification for Masonry Structures, TMS 602-02/ACI 530.1-02/ASCE 6-02)* for the design and installation of stone and brick masonry veneer. These referenced codes require that masonry anchors by installed to provide structural capacity for the veneer. The specifications for the type and spacing for the veneer anchors depends on the structural substrate and the width of the air space between the wall sheathing and the back side of the masonry veneer.

For corrugated metal anchors, the width of the air space between the wall sheathing and the back of the masonry is required to be a maximum of 1", and each anchor is required to be attached to wood studs or wood framing with a corrosion-resistant 8d common nail or equivalent fastener (ACI 530-02, Section 6.2.2.6, Masonry veneer anchored to wood backing). Further, the spacing for corrugated metal anchors is limited to a maximum wall area of 2.67 square feet per anchor with a maximum vertical spacing of 18" and a maximum horizontal spacing of 32" (ACI 530-02, Section 6.2.2.5.6 Anchor spacing; ACI 530.1-02, Section 3.4D. Veneer anchors).

ANALYSIS AND CONCLUSIONS

Based on the observed conditions, applicable codes and standards, and engineering experience, Forensix is of the opinion that the brick and pre-cast stone masonry veneer at the structures is not installed to meet the minimum requirements of the construction documents and the building code and will require repair to address deficiencies in combination with the repairs outlined in the DGA report.

Corrugated metal ties (anchors) were used throughout the veneer installations with measured wall cavities in excess of 1", and up to as wide as 4 3/4". The use of corrugated metal ties throughout the masonry veneer installation is improper and is in direct conflict with the requirements of the building code. The usage of improper corrugated anchors has resulted in the lack of sufficient embedment of the anchors into the mortar bed at isolated areas of the pre-cast stone masonry units. In addition, there was mortar accumulation in the air space which was restricting the migration of moisture through the drainage plane and out of the veneer system. This blockage and retention of moisture in the veneer system has caused corrosion of the corrugated metal ties which reduces the life-span and structural capacity of the ties and masonry veneer installation.

Mortar joint separations, loose or displaced masonry units, fracturing of masonry units, and out-of-plane displacement of the masonry veneer was observed at multiple locations throughout the site, with a high concentration of distress at the garage areas, which is distress resulting from the anchorage and support deficiencies identified herein. The loose, displaced, and improperly anchored and supported masonry units present a potential life-safety issue for falling masonry.

Forensix is of the opinion that the brick and pre-cast stone masonry veneer assemblies are distressed at the structures; were improperly installed and supported; and that the general contractor and/or developer of the project violated its standard of care for construction by failing to install the masonry veneer to meet the minimum requirements of the building code. Additionally, the installed condition of the masonry veneer has created potentially unsafe conditions.

SCOPE OF REPAIR

Due to the noted deficient conditions at the masonry veneer, Forensix recommends the following remedial actions:

- **Garage Lintels:** In conjunction with the repairs outlined in the DGA report to address water management issues, 100% of the two-car wide garage lintels will require structural repair at the improper/failed bearing conditions.
    - Remove the gravity load of the brick veneer from the lintels by shoring the brick veneer at a height a minimum of 30" above the garage opening.
    - After shoring, remove a minimum of 4 courses of brick for a length of approximately 8" to 12" of the brick veneer (to match the running bond) below each end of the steel lintel or as needed to remove any fractured and/or displaced brick units. Replace the removed brick veneer with full height solid bricks (uncut) and fill the remaining gap with steel shims to provide complete bearing for the ends of the steel lintels. Cut bricks shall not be used below the lintel bearing conditions.
    - After shoring, remove the brick above the lintels as required to access the top of each steel lintel. Install any missing lag screws and install the through-wall flashing and water management repairs outlined in the DGA report. Clean the exposed adjacent air space of mortar droppings and bridging. Replace the brick veneer in kind using code-compliant anchors (do not used corrugated metal anchors) spaced vertically and horizontally to comply with the requirements of the building code. The air space cavity and wall anchors are to be kept clear of mortar droppings.

- **Brick Veneer at Windows and Doors:** The repairs outlined in the DGA report to address water management issues at door and window openings will require removal of brick veneer. These repairs will require the following:
  - Remove the gravity load of the brick veneer from the lintels by shoring the brick veneer above the opening.
  - After shoring, remove the brick above the lintels as required to access the top of each steel lintel. Clean the exposed adjacent air space of mortar droppings and bridging. Perform the scope of repair outlined in the DGA report.
  - Replace the brick veneer in kind using code-compliant anchors (do not used corrugated metal anchors) spaced vertically and horizontally to comply with the requirements of the building code. The air space cavity and wall anchors are to be kept clear of mortar droppings.

- **Pre-cast Stone Veneer:** In conjunction with the repairs outlined in the DGA report to address water management issues, the deficient anchorage for the pre-cast stone veneer will require removal and replacement of the pre-cast stone elements at/surrounding the entries, windows, and Juliette balconies.
  - Remove the gravity load of the veneer above as required by shoring the veneer above the work area outlined in the DGA report.
  - After shoring, remove the pre-cast stone veneer as outlined in the DGA report. Clean the exposed adjacent air space of mortar droppings and bridging. Perform the scope of repair outlined in the DGA report.
  - The replacement precast stones shall be designed with anchorage provisions cast into the stones which can be tied back to the wood framing. Additionally, code-compliant anchors will be required for use with the installed air space width with proper embedment into the mortar beds to meet the requirements of the building code (corrugated metal anchors are not to be used).
  - The pre-cast repairs are to be performed to meet the requirements of the building code and based on a design prepared by, and performed under the supervision of, a civil/structural engineer licensed in the State of Texas. The air space cavity and wall anchors are to be kept clear of mortar droppings.

All repairs shall be performed in accordance with the applicable building codes, industry standards, manufacturers' instructions, and the design documents. Recommended repairs are provided as a basis for an opinion of probable construction cost of repair (cost estimate). Each repair item may require unique design/construction expertise, and some items may require construction documents prepared by a design professional.

3: RESULTANT STRUCTURAL DAMAGE

INTRODUCTION AND SUMMARY OF CONCLUSIONS

Resultant structural damage was exposed during destructive testing. Refer to Section 2.00, Roof Issues, Section 3.00 Exterior Issues, Section 4.00 Interior Issues, and Section 5.00 Window & Exterior Door Issues, in the July 2, 2019 DGA report for information on the identified deficiently installed conditions which are resulting in water intrusion and damage to structural wall sheathing and framing and the interior floor decking. Forensix has reviewed and concurs with the repair procedures outlined in the DGA report for the water damage to roof parapets, structural wood sheathing, framing, and floor and balcony decking due to defects in the building envelope.

Forensix is of the opinion that water intrusion through the building envelope as identified in the DGA reports has resulted in damage to roof parapets, structural wall sheathing, balcony decking, floor decking, and framing, and that the general contractor and/or developer of the project violated its standard of care for construction by failing to design and construct the building envelope to protect the structural sheathing, framing, and decking from water damage.

OBSERVATIONS AND TESTING

Photographic documentation and other field-obtained data of the structures are being maintained in the Forensix project file. Select photographs are included within the body of this report and may be presented for information only or for a general representation of the condition of the structures. All of the Forensix photographic and graphic documentation forms a basis for the opinions presented herein and is incorporated by reference.

The weatherproofing and flashing conditions at the building envelope were evaluated by DGA. The report by DGA discusses the identified weatherproofing/flashing deficiencies resulting in moisture intrusion and resultant damage to roof parapets, structural wall sheathing, floor and balcony decking, and framing. The observed moisture distress at the wood sheathing, framing, and decking correlated to building envelope deficiencies addressed by DGA and is consistent with resultant damage from moisture intrusion through the building envelope.

ANALYSIS

The observed wood staining and deterioration at the framing, wall sheathing, and floor and balcony decking is consistent with long-term and on-going exposure to moisture. Forensix is of the opinion that this moisture-related damage to the wood framing, wall sheathing, and floor decking has resulted from deficiencies in the building envelope, as identified in the reports by DGA. Refer to the DGA reports for additional information on the locations of destructive testing and defective building envelope installation.

CONCLUSIONS AND SCOPE OF REPAIR

Forensix is of the opinion that all resultant water damage and deterioration to structural wall sheathing, framing, and floor decking requires repair as follows:

- At all water damaged sheathing and decking without loss of structural integrity, the sheathing shall be treated as outlined in the DGA report.
- At all water damaged sheathing and decking with loss of structural integrity, the damaged sheathing will require removal and replacement at the areas identified in the DGA report. Forensix is of the opinion that sheathing repairs should be performed using as outlined in the DGA report using a single piece of sheathing to replace the damaged sheathing/decking, or use minimum increments of half- or full sheets of sheathing/decking for larger repair areas. At balcony deck and floor deck repair locations, the length of the repair decking shall be a minimum of 2' wide with a length to span over at least two joist spacings (supported by at least three joists).
    - When the damaged sheathing/decking is removed, the exposed wood framing shall be evaluated for water damage and deterioration. If water damage is identified without loss of structural capacity, the wood framing shall be treated as outlined in the DGA report. If deterioration and loss of structural capacity is identified, the damaged framing element shall be structurally repaired. An allowance for sistering or other similar structural replacement/repair should be estimated for the isolated areas of framing damage identified in the DGA report. Forensix has reviewed and concurs with the repair procedure outlined in the DGA reports.

Forensix is of the opinion that water intrusion through the building envelope as identified in the DGA reports has resulted in damage to roof parapets, structural wall sheathing, balcony decking, floor decking, and framing, and that the general contractor and/or developer of the project violated its standard of care for construction by failing to design and construct the building envelope to protect the structural sheathing, framing, and decking from water damage.

All repairs shall be performed in accordance with the applicable building codes, industry standards, manufacturers' instructions, and the design documents.

Recommended repairs are provided as a basis for an opinion of probable construction cost of repair (cost estimate). Each repair item may require unique design/construction expertise, and some items may require construction documents prepared by a design professional.

4: CIVIL GRADING AND DRAINAGE

INTRODUCTION AND SUMMARY OF CONCLUSIONS

Forensix evaluated the grading and drainage at the site and around the perimeter of the structures. The following construction deficiencies were noted:

- The subject site has inadequate drainage adjacent to the foundation systems at isolated locations.
- Sections of concrete flatwork or pavers were installed at an elevation with prevents the installation of proper slope away from the foundation systems or which results in ponding of surface water.
- The stone retaining walls along Carlisle Street are not performing properly and exhibit loose stones and mortar joint separations.

Forensix is of the opinion that the grading and drainage at the subject property violates provisions of the 2000 IRC and/or 2003 IBC, and that the general contractor and/or developer of the project violated its standard of care for construction by failing to construct the site grading and drainage in accordance with the building code and construction documents.

OBSERVATIONS AND TESTING

Photographic documentation and other field-obtained data of the site are being maintained in the Forensix project file. Select photographs are included within the body of this report and may be presented for information only or for a general representation of the condition of the site. All of the Forensix photographic and graphic documentation forms a basis for the opinions presented herein and is incorporated by reference.

Forensix observed the following representative conditions at Phase III of the subject property:

- Standing water and poor drainage at the sidewalk along Bowen Street (**Figure 4-1**).
- Areas of negative or improper drainage slopes adjacent to structures (**Figure 4-2** and **Figure 4-3**).
- Loose stone walkways and erosion creating potential tripping hazards at locations throughout the property.

- Drainage areas retained within enclosed planter areas or by sidewalks and/or depressed grading areas (**Figure 4-4**).
- Parking space negatively sloped towards unit 30 (**Figure 4-5**).
- Rock retaining walls exhibiting mortar joint separations, loose and displaced rocks, and previous repairs (**Figure 4-6**).
- Deteriorated metal railing conditions.



Figure 4-1: Standing water and poor drainage along Bowen Street



Figure 4-2: Neutral to slightly positive grading slopes adjacent to west elevation of building E



Figure 4-3: Negative drainage slopes adjacent to units 36 and 37, east elevation of building F

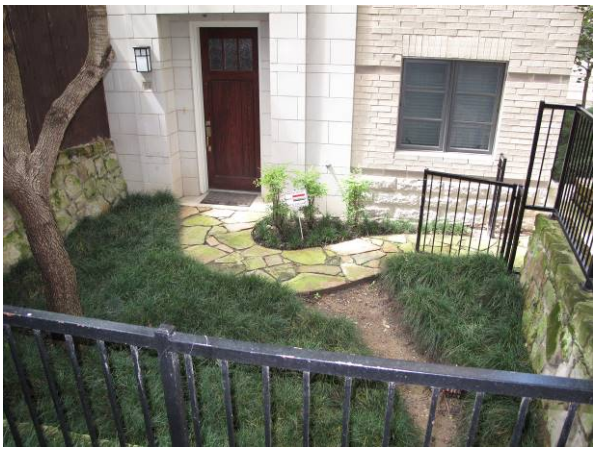


Figure 4-4: Depressed area and drainage blocked by sidewalk at enclosed drainage area adjacent to unit 44, building G



Figure 4-5: 1.7% slope towards building at unit 30



Figure 4-6: Mortar joint separations and loose stones at retaining walls

ANALYSIS

The 2000 IRC and the 2003 IBC both require that the site grading divert water away from the foundation as presented below:

> ***2000 IRC, Section R401.3 Drainage.*** *Surface drainage shall be diverted to a storm sewer conveyance or other approved point of collection so as to not create a hazard. Lots shall be graded so as to drain surface water away from foundation walls. The grade away from foundation walls shall fall a minimum of 6 inches (152 mm) within the first 10 feet (3048 mm).*
>
> > ***Exception:*** *Where lot lines, walls, slopes or other physical barriers prohibit 6 inches (152 mm) of fall within 10 feet (3048 mm), drains or swales shall be provided to ensure drainage away from the structure.*
>
> ***2003 IBC, Section 1803.3 Site grading.*** *The ground immediately adjacent to the foundation shall be sloped away from the building at a slope of not less than one unit vertical in 20 units horizontal (5-percent slope) for a minimum distance of 10 feet (3048 mm) measured perpendicular to the face of the wall or an approved alternate method of diverting water away from the foundation shall be used.*
>
> > ***Exception:*** *Where climatic or soil conditions warrant, the slope of the ground away from the building foundation shall be permitted to be reduced to not less than one unit vertical in 48 units horizontal (2-percent slope).*

> *The procedure used to establish the final ground level adjacent to the foundation shall account for additional settlement of the backfill.*

Perimeter grading and drainage can influence the performance of a structure by affecting the amount of water that is available to saturate the subgrade and pond at the perimeter. The neutral or negative drainage adjacent to the subject structures allows rainwater and irrigation water to collect near the structures and influence the surface and underlying soils. The slope measurements taken indicated that isolated areas of the grading and drainage do not meet the requirements of the 2000 IRC and/or 2003 IBC. Inadequate drainage affects the efficiency with which storm water is removed from the site and can therefore affect the amount of moisture available to influence the subgrade, as well as create nuisance conditions and potentially unsafe conditions at the surface.

The Terracon geotechnical report for the project also presented the importance of positive drainage away from the structures. The report indicates the following:

> *All grades must be adjusted to provide positive drainage away from the structures. Open ground should preferably be sloped at a minimum of 3 percent grade for at least 10 feet beyond the perimeter of the structures. Where paving or flatwork abuts the structures, care should be taken that the joints are properly sealed and maintained to prevent the infiltration of surface water.*

While Terracon does require positive slope away from the foundation systems, it is unclear to Forensix why its recommendation would not meet the minimum requirements of the building code. Forensix is of the opinion that the drainage recommendations in the Terracon report are in direct conflict with the minimum requirements of the building code. However, the minimum requirements of the building code would govern the work performed by the construction team.

Isolated areas of the site grading and concrete flatwork are sloped towards the structures or are insufficiently sloped to convey water away from the foundation systems and off the site. These conditions are in conflict with the construction documents and the minimum requirements of the building codes.

RESULTANT DAMAGE

The installed conditions at the grading and drainage have resulted in areas of the property which retain and/or do not properly convey drainage water away from the foundation systems. Water retained adjacent to shallow-bearing foundation systems can result in differential foundation movement and distress to the superstructure. Additionally, ponding water is a nuisance and creates a hazard to the public.

Loose stones and mortar joint separations at the stone retaining walls along Carlisle Street indicate that the walls are not providing proper long-term performance.

Interior distress such as gypsum board wall and ceiling separations were documented in the July 2, 2019 DGA report. This damage is consistent with differential foundation movement caused by the influence of improper drainage.

CONCLUSIONS

Based on the observed conditions and with reference to the applicable building codes and construction documents, Forensix is of the following opinions regarding the grading and drainage and sitework at the subject site:

- The subject site has inadequate drainage adjacent to the foundation systems at isolated locations.
- Sections of concrete flatwork or pavers were installed at an elevation which prevents the installation of proper slope away from the foundation systems or results in ponding of surface water.
- The stone retaining walls along Carlisle Street are not performing properly and exhibit loose stones and mortar joint separations.

These as-built conditions violate provisions of the 2000 IRC and/or 2003 IBC for the site grading and drainage. Refer to **Figure 4-7** below for the areas of defective grading and drainage and concrete flatwork.

Forensix is of the opinion that the grading and drainage at the subject property violates provisions of the 2000 IRC and/or 2003 IBC, and that the general contractor and/or developer of the project violated its standard of care for construction by failing to construct the site grading and drainage in accordance with the building code and construction documents.

SCOPE OF REPAIR

Due to the deficient conditions, Forensix is of the opinion that the following repairs are required at the site grading and drainage in Phase III:

- Re-grading at isolated areas adjacent to the perimeter of the structures to correct areas of grading not meeting the minimum slope requirements of the 2000 IRC and/or 2003 IBC.
- Remove and replace the concrete flatwork and/or pavers where indicated to provide sufficient elevation change to allow for proper slope away from the foundation systems to facilitate drainage away from the foundation systems or to eliminate ponding conditions on the concrete flatwork.
- Reset loose stones and tuck-point mortar joint separations as required at the retaining walls along Carlisle street.

Remove and replace landscaping and fencing as needed to accomplish re-grading. Refer to **Figure 4-7** on the next page for the locations which require re-grading and concrete flatwork rework. The site grading areas highlighted in **orange** require re-grading to provide the code required slope away from the foundation systems. The concrete flatwork and/or paver areas highlighted in **lime green** require removal and replacement to provide the minimum code required slope away from the foundation systems or to eliminate ponding of water. In conjunction with re-grading the identified areas, a subgrade drainage system, routed to existing drainage inlets or to positively sloped grading or concrete flatwork at least 10' from the structures, may be required in order to properly convey drainage water away from the structures.

Design of the grading and drainage systems should be prepared by a Civil/Structural Engineer licensed in the State of Texas. Recommended repairs are provided as a basis for an opinion of probable construction cost of repair (cost estimate). Each repair item may require unique design/construction expertise, and some items may require construction documents prepared by a design professional.

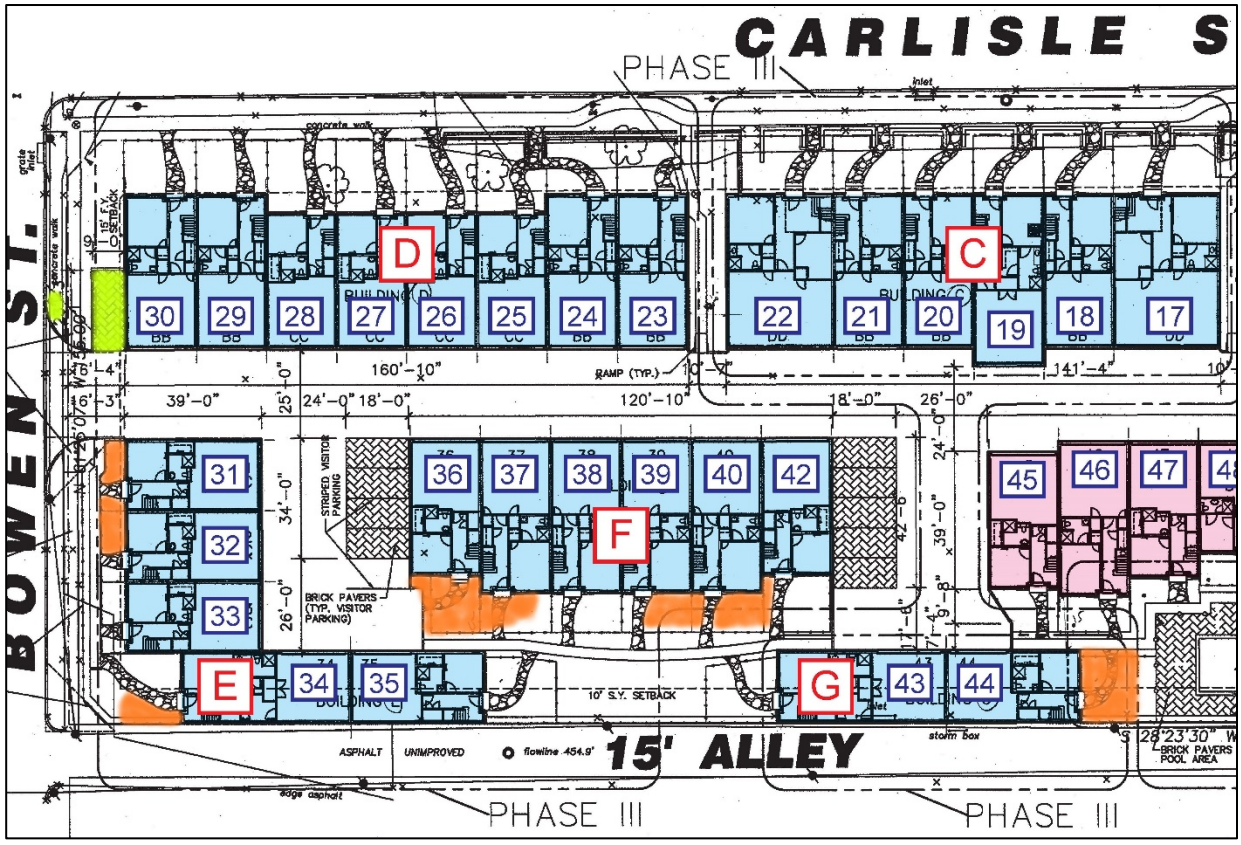


Figure 4-7: Scope of Repair for Civil Grading and Concrete Flatwork at Phase III

LIMITATIONS

This document is the rendering of a professional service, the essence of which is the provision of advice, judgment, opinion, or professional skill. In the event that additional information becomes available that could affect the conclusions reached in this investigation, this office reserves the right to review, and, if required, change some or all of the opinions presented herein.

This report should not be construed as an assessment of total damages to the structures and site at the time of site observation. In addition to the observed and documented items of distress, hidden defects may exist that were not readily visible. Also, some damaged areas may have been previously repaired and, unless otherwise noted, were not visible at the time of observation. However, these areas may experience future distress. No representation, guarantee, or warranty as to the future performance of this structure is made, intended, or implied.

The items observed and documented in this report are intended to be representative of the conditions at the site grading and drainage, and exterior finishes of the subject structures. No attempt has been made to document the condition of each and every structural and nonstructural element. Only visible items were observed and documented.

This report was prepared in order to document distress observed at the site and structures. The opinions presented herein are based on site observations, field information and measurements taken, written and verbal information, and experience, where applicable. No complete review of the site's and structures' conformance to current or previously applicable building codes was performed. However, specific items that may be at issue with the applicable building code requirements may be noted.

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REFERENCES

International Code Council, Inc. (ICC). 2000. *International Residential Code* (IRC).

International Code Council, Inc. (ICC). 2003. *International Building Code* (IBC).

The Masonry Society (TMS) / American Concrete Institute (ACI) / American Society of Civil Engineers (ASCE). 2002. *Building Code Requirements for Masonry Structures, TMS 402-02/ACI 530-02/ASCE 5-02.*

The Masonry Society (TMS) / American Concrete Institute (ACI) / American Society of Civil Engineers (ASCE). 2002. *Specification for Masonry Structures, TMS 602-02/ACI 530.1-02/ASCE 6-02.*