KCE STRUCTURAL ENGINEERS, P.C.

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March 13, 2017

River Towers Condominium Association
6621 Wakefield Drive
Alexandria, VA 22307

Attn: Stephen Beach, President, Board of Directors
Nancy Rivers, Board of Directors
Melanie Wallace, Board of Directors
Bill Nichols, Board of Directors
Veronica Brown, General Manager

Whiteford Taylor Preston
3190 Fairview Park Drive, Suite 800
Falls Church, VA 22042

Attn: Marla Diaz, Partner

Pillsbury Winthrop Shaw Pittman, LLP
1200 Seventeenth Street, NW
Washington, DC 20036

Attn: Michael McNamara, Partner

RE: River Towers Condominiums (Buildings 6621, 6631, and 6641) Job No. 2016-18
Alexandria, VA
In-Progress Forensic Investigation Process
Condition of Exposed and Visible Structural Frame Members Post-October 2016 Collapse

Ladies and Gentlemen,

In accordance with your request and pursuant to our agreement, we present herewith an in-progress statement of our professional opinion regarding the above-noted matter.

Our compensation is not related to my opinion.

We reserve the right to modify or amend our opinion as additional information becomes available to us.

KCE was retained on December 2, 2016 to evaluate the condition of the structure of the three buildings at 6621, 6631, and 6641 Wakefield Drive in Alexandria, Virginia, and to develop remediation methods, if any are required.

Attached is a copy of the firm profile and the writer's CV as it relates to this type of investigation and remediation developed.

We have reviewed the following information in regards to this Project:

- Site inspections
- Photographs taken by others
- Various drawings by Thomas Downey, Ltd.
- Various reports by Thomas Downey, Ltd.
- Specifications by Thomas Downey, Ltd.
- Weather records

We have had conversations with:

- River Towers General Manager
- Minkoff Company, Inc.
- Safway Services, LLC
- Thomas Downey, Ltd. (Doug White)
- Fairfax County Building Department Official
- River Towers Board of Directors

I. Event

We understand on October 2, 2016, Building 6631, a tee-shaped building, was reported to have shifted laterally and downward towards the Northeast corner.

Emergency personnel arrived at the site and found issues at the steel columns in the porte cochere area (under the building driveway entrance) of Building 6631.

We understand they removed the architectural column covers and interior board and metal lath and plaster, when existing, to view the columns. They found the perimeter steel columns folded over in two 90° bends just above grade, some actually resting on the concrete walkway, the Southwestern column bent and with a hole through the web, and other columns out of plumb.

Based on the Fairfax County Fire and Rescue Department Collapse Unit's evaluation, the Fairfax County Building Official ordered the residents of the entrance wing tier (aka stem) of Building 6631 to be evacuated. Within several days of the event, temporary scaffolding was installed under the second floor

framing beams and girders in the entirety of the porte cochere (i.e., exterior columns and interior column rows).

In addition, in an abundance of caution (there was no known or reported structural distress evident in Buildings 6621 or 6641), the Fairfax County Building Official directed scaffolding of the same magnitude and orientation as in Building 6631 be installed in the porte cochere areas.

II. History

The Buildings are each 1962-era, 9-story above-grade steel-framed buildings (replicas of each other to suit siting, topography, and roadway alignment) with no full basements.

The buildings were converted to condominiums circa 1981. As part of the conversion, structural, mechanical, and electrical inspections were performed.

The structural systems are as described hereafter for the tee-shaped buildings with no expansion joints at the intersection of the stem and flanges of the tee. (Structural drawings II S1 through II S7 prepared by Donald Hudson Drayer Architects, General Engineering Associates (mechanical, electrical, and plumbing consulting engineers), and SE Sanders Associates (structural engineers).)

The foundation system consists of a minimum 65-foot long steel shell, concrete-filled piles (found to be Raymond Step-Taper Piles®, which were common at the time) with poured-in-place pile caps overlain by 8" framed reinforced concrete slabs (12" at the boiler room), poured on earth but not supported by it after it had cured, and surrounded by perimeter poured-in-place concrete grade beams and pedestals at the first floor/entry level slabs.

The columns were designed as ASTM-A-36-601 (fy 22 ksi) steel shapes varying from W8 to W14 of varying unit weights per foot.

Fourteen porte cochere columns exposed, we understand, were encapsulated with finishes under the second floor, clad with a finish material, wrapped with plaster on metal lath as fireproofing, which, as the finishes were upgraded over time, was replaced or supplemented by Durock™ by USG.

There is a partial second floor (mezzanine) consisting of a portion of the tee portion of the buildings, steel beams, and Dox Plank® (a hollow core precast plank, a widely used system at the time) with 2" concrete topping slab reinforcing with 6"x6" #10/#10 WWF.

The typical floor structural system consists of steel columns as noted above with wide flange wind beams in the 54-foot (short direction of the stem tee of the building) bolted with A325 bolts of the era in moment-type connections to the columns. Framing between the wind beams are then-standard S-series [sic] open web bar joists covered with 9/16" black iron corrugated metal slabform ("steel tex") with and including 2¼" concrete slabs, reinforcing unknown. The joists were to have a minimum 2½" bearing on the steel.

Shop structural steel connections were either welded or riveted. Column splices were bolted with splice plate connections at alternate floors.

There are wide flange spandrel beams around the perimeter with short post-type spacers between columns (due to the different elevations of the steel), supporting continuous shelf angles suspended from the steel spandrel beams. The wind beams were to be fireproofed with concrete where noted on the drawings.

The roof structure consists of similar steel framing with galvanized corroform, but in lieu of the concrete, there is a vermiculite concrete topping (Perlite), a lightweight material used at the time for roofing substrate. There is a portion of the roof that is a roof terrace that is of a similar construction to the typical floor.

The Elevator Machine Room floor consists of steel beam framing and concrete.

The Penthouse roof and Elevator Machine Room roofs consist of steel framing with bar joists and Perlite.

There are balconies, which are ±4'-8" poured-in-place cantilevered slabs with backspans of ±3'-8" with 4½" thickness, sloping to the exterior.

There is a series of integrated, poured-in-place, decorative canopies over the roof terrace supported on pipe columns.

The exterior walls consist of 4" brick and 8" block with relieving angles suspended from the spandrel beams. There are probably no true collar joint cavities, as was the norm at the time. There was to be horizontal joint reinforcing, also standard at the time. Control joints in the brick were cut in after the original construction

Fenestration consists of punched windows.

The Fairfax County Building Official has advised an analysis of the building structure is needed, or a report of the event, which can be performed per the Building Code under which the building was originally designed, which was the Building Officials Conference of America (BOCA) 1960. The structure was also designed, per the drawings, under the then-current American Institute of Steel Construction (AISC) *Specifications for Design, Fabrication, and Erection of a Steel Building* (5th edition) and ACI 318-56, referenced in the BOCA Code.

- Wind loads per Section 714-718 BOCA 1960 (Exterior Forces)
- Earthquake load (aka seismic) - Section 719 BOCA 1960, Appendix K-11, Table 14C, Zone 1
- Floor live load – 40 psf, demising partitions per Table 5 in the BOCA Code.

III. Investigation (In Progress)

Our investigative process is being performed as follows:

- We have measured flanges and webs of exposed steel columns in each porte cochere and determined the thickness of the structural steel with micrometer calipers just under the second floor framing and then just above the ground floor slab in Buildings 6621, 6631, and 6641, comparing results to the original as-designed sizes and material thicknesses per the original drawings.

- We have performed ultrasonic pulse velocity testing to check for thickness of porte cochere column flanges and webs full height to the underside of the second floor framing in Building 6631.

- VIKA, Inc. (a "consultant" to KCE) has performed exterior LiDAR scans of each building to determine plumbness of the stem portion exterior walls of the three buildings, as well as the plumbness of the twelve columns under the porte cochere.

- VIKA has also measured with standard survey equipment the plumbness of the columns within the porte cochere in each building.

- We are running finite element analysis using RAM Structural System® and analyzing the building (each building is the same) based on loading requirements of the Code under which the original building was designed, using the material properties listed on the original structural drawings.

  This process will be followed by using the same procedure using in situ strengths and the physical measured orientation and materials thickness of the existing porte cochere columns.

- We will be taking structural steel and reinforcing steel coupons once the shoring is installed under the column in Building 6631 as described herein, which will be checked for in situ material strength and composition by Metallurgical Technologies, Inc. (another "consultant" to KCE). These coupons will not be taken from the columns in Building 6631 until the shoring we are designing is installed.

- We have taken concrete cores of the "framed" slab on ground and have had them tested by FMC & Associates (another "consultant" to KCE) for compressive strength, which indicates strengths greater than as called for. Additionally, samples will undergo petrographic examinations by The Erlin Company (another "consultant" to KCE).

- VIKA, Inc. has performed levelness evaluations in the main roof structure, as well as in each floor over the porte cochere area in Building 6631. (Note: finishes on floors were partially removed to access the concrete floor. Elevations were based on using the elevator sills at each floor as the control with the true elevation "brought" in from an exterior benchmark.)

- Worcester Eisenbrandt, Inc. (another "consultant" to KCE) has cut test openings into the exterior of the perimeter walls (and then temporarily waterproofed) to provide information regarding the conditions of the walls (i.e., brick and block flashing, relieving angles, etc.).

- We have evaluated the in situ conditions of representative areas of framed slab on ground for "non-structural" voids with GPR devices run by FMC & Associates, LLC and verified through previously cut core holes.

- Clark Foundations (another "consultant" to KCE) has physically located pile caps, grade beams, and piers on perimeter columns and is in the process of locating the top of the base plates in the interior and perimeter columns of the porte cochere in Building 6631.

- Clark Foundations exposed several foundation piles to verify type and condition.

- Superior Iron Works (another "consultant" to KCE) is fabricating the shoring system for the columns of Building 6631 as designed by KCE.

- The plumber on call for the condominium has relocated sanitary stacks at certain columns at our request to allow the installation of the shoring in Building 6631.

- Fairfax County Building Department has been provided preliminary shoring drawings prepared by this office and has advised that work can be accomplished without a new permit, but that a permit for that work and its final remediation will be required at some point.

IV. Ongoing Discussion with Fairfax County

We met with the following Fairfax County officials and others:

- Brian Foley, Building Official/Director, Building Division, Fairfax County DPWES, Land Development Services
- Bill Hicks, Director, Fairfax County DPWES, Land Development Services
- Elizabeth Perry, Property Maintenance Code Official/Senior Deputy Zoning Administrator, Fairfax County Department of Code Compliance
- Jack Weyant, Fairfax County Department of Code Compliance
- Kirsten Munz, PE, Reston Urban Center Coordinator, Fairfax County DPWES, Land Development Services
- Christine Morin, Chief of Staff of Dan Storck, Mount Vernon District Supervisor, Fairfax County Board of Supervisors
- Paul Emerick, Office of Fairfax County Attorney
- Marla Diaz, Whiteford, Taylor, & Preston (Board Attorney)
- Veronica Brown, General Manager, River Towers
- Nancy Rivers, River Towers Condo Board
- Melanie Wallace, River Towers Condo Board
- Bill Nichols, River Towers Condo Board

We were advised by Fairfax County in that meeting that remediation efforts would fall under the Fairfax County Critical Structures Inspection Program. Our sister company, KTLH Engineers, PC, has been providing and will continue to provide those inspections.

V. Discussion

A. Buildings 6621 and 6641

As stated earlier, we understand the temporary scaffolding was installed in an abundance of caution under the second floor framing of the stem portion of Buildings 6621 and 6641 (i.e., similar systems as in Building 6631) in a further abundance of caution.

We see no dramatic plumbness issues of the existing columns or reports of floor unlevelness on the upper floors.

We have preliminarily found a minimum of 90%-100% of the material thickness in the porte cochere columns on Buildings 6621 and 6641 in exposed porte cochere columns remains.

We are in the process of verifying the thickness with ultrasonic equipment.

It is our opinion, based on the information available as of this date and the exposed and visible conditions of the structural frame, we can allow the removal of the scaffolding on Buildings 6621 and 6641 and will issue such comment after such metal thickness test results to Fairfax County.

B. <u>Discussion – Building 6631</u>

To date, we have performed a review of the scaffolding installed by others in October and feel the scaffolding in fact simply supports the second floor framing, with the load of the superstructure (i.e., the roof through and down to including third floor) being supported by the second floor beam to girder and girder to column bolts.

Based on our ongoing review of Building 6631 to date:

- Superior Iron Works will be installing heavy steel ears (channels or HSS sections) on the perimeter exterior columns of the Building 6631 porte cochere and the four interior columns and will install wide flange column sections from those ears on either side of the columns (flange and/or web) to plates bolted to the framed slab over the pile caps, or when the pile caps are not sufficiently large in plan, to a dunnage of rolled steel or heavy timber sections to distribute the load to the pile caps. That shoring (as compared to scaffolding) will be wedged tight and welded, but will not be used to raise or plumb the columns.

- Superior Iron Works will also install similar steel temporary shoring in the interior four columns.

- Superior Iron Works has begun to fabricate and will begin erecting the shoring the week of March 20, 2017.

- Safway Services, LLC is on call if existing scaffold has to be moved, and has installed a heavy duty sidewalk cover around the perimeter of the stem of Building 6631 in an abundance of caution. We will not request that they remove the October scaffolding until our finite element analysis and materials testing are completed, the new shoring of the columns is installed, and the actual column remediation occurs. (Our final column remediation will be accomplished after the temporary shoring is installed and will include cutting out the existing columns at the perimeter of the porte cochere and interior to it and splicing in new steel column sections.)

VI. In Situ Field Investigations To Date

A. In Situ Information Found in Building 6631

- Items that were hidden from view
  - Porte cochere steel columns previously concealed by column covers
    - Original fireproofing consisting of decayed wire mesh and plaster
    - First floor/foundation
      - No original vapor barrier under slab
      - No original under slab drainage
      - The original reinforcing exposed on the soffit of the reinforced slab
      - Original plumbing storm line in webs of some columns hidden from view
      - Cast iron sanitary plumbing running down some column with cleanouts installed
      - Some interior columns have columns resting directly on pile caps and some are resting on a thickened slab not poured tight to the pile cap
      - Two 5/8”-3/4” anchor bolts and no grout under base plates
      - Some perimeter steel columns at the double 90° bend are supported by the sidewalk concrete
- Upper floors in stem of tee
  - Out of level
  - Apparent separation between slab and inside face of CMU walls top floor
- Exterior masonry walls
  - Wall openings
    - Protected 1” cavity
    - Random horizontal joint reinforcing
    - 3x3 angle rusted and swelling
    - Hanging strap rusted
  - Plugged weeps
  - Plastic flashing
  - Control joints in the brick were cut in after the original construction

B. In Situ Investigative Work Completed

1. Buildings 6621 and 6641

- Minor movement (±1/8”) in Buildings 6621 and 6641 was noted (thermal and/or reading error) in exterior masonry walls
- Shelf angles are rusted and some flashing needs repair

2. Building 6631 (work in progress)

- Excavation to evaluate several piles was completed. Water encountered in excavation and ±6” voids were found under the pile caps.
- We are continuing with testing of the core drilled concrete samples
- Excavate on interior columns to find base plates (no pedestal called for on original drawings)

  - Was to have been per detail G7 on Sheet S-2, which would indicate to top of pile cap 1'-0" below top of reinforced slab with a milled column welded to the base plates. Excavation is down ±2'-6" on one column and the plate found was encapsulated by some concrete from the slab and/or some earth)
  - Another column is sitting on the structural slab
- Thickness readings of steel column flanges were taken at approximately top of the existing slab and ±5'-6" above
- Randomly selected temporary access openings were cut in the North and East exterior wall at the stem of the tee to determine conditions in those limited areas
- Monitoring the exterior walls with robotic remote reading devices and conventional surveying equipment is ongoing
- We understand "furring" of the porte cochere steel columns consisted of decayed metal lath and plaster and/or Durock™ (a non-watertight material)
- 4"-6" of asphalt over the framed slab under the porte cochere as a continuation of the exterior driveway surface
- 3"-4" void under the framed slab on ground
- No gravel substrate under slab on grade
- No vapor barrier
- Reinforcing steel - what appears to be #3 laying on the earth and corroded
- Horizontal rods between column flanges in the slab
- Sanitary lines running in column webs and adjacent to the flanges

In addition to the steel temporary **shoring** being installed in Building 6631 described hereinafter, we have installed heavy-duty sidewalk debris covers for a minimum width of 15 feet on East, West, and North sides at the second level.

The LiDAR scans on Building 6631 indicate the Northeast end of the North exterior wall is as much as 2½" out of plumb to the North and East. The wall from the North corner halfway to the South is similarly out of plumb. The out of plumb is not uniform with height; it is more pronounced at the top level but is also evident at the second floor. (Note: an assumed zero "plumb" in the in situ location was used to determine variation roughly mid-height of the North face of the wall.)

The interior floor elevations in the Northeast corner at each floor, both towards the East and North are ±2" out of level.

On the ninth floor in the Northeast corner, there seems to be a separation between the floor concrete and the inside face of the exterior masonry wall where an inserted probe goes down at least four inches into what may be the block cavity or inside of the block.

A plumbness survey of columns in the porte cochere in each of the three buildings and, in summary finds the columns are out of plumb between the first floor and the underside of the second floor framing members as follows.

Building 6631		
Column	**North/South (under existing framing)**	**East/West (under existing framing)**
80	±3" offset ± El 14.00	± ½" ¼"
79	3½" under second floor	3"
78	Measurement being rechecked	6"
77	±7" ±3" offset ± El 14.00	1½"
76	3½"	½"
75	1½"	½"
74	– 2"	½"
73	½" +	2"

Building 6641 In Situ Porte Cochere Column Plumbness Readings to Date

Building 6641		
Column	**North/South (under existing framing)**	**East/West (under existing framing)**
80	¼"	1"
79	1/8"	1/16"
78	1/16"	¼"
77	1/16"	1/16"
76	1/16"	1/16"
75	1/16"	1/16"
74	1/16"	1/16"
73	½"	¼"

Building 6621 In Situ Porte Cochere Column Plumbness Readings to Date

Building 6621		
Column	**North/South (under existing framing)**	**East/West (under existing framing)**
80	±1/8"	±¼"
79	¼"	0
78	1/16"	0
77	0	1/16"
76	0	0
75	1/8"	1/16"
74	0	1/16"
73	1/8"	1/8"

VII. Discussion

We understand in June 2016, prior to the event, a car hit and damaged the finish on one column in the Southwest corner of Building 6631. The structural engineer on call for the condominium was called in and reviewed the limited exposed portion of the newly-exposed steel column and prepared a remediation drawing that was filed for permit by CPR, a contractor that had performed other services at the Project. Comments were received from the Fairfax County Building Department and the drawings were revised in September 2016. We understand, unbeknownst to the Condo Association, the permit was approved days before the event.

VIII. Possible Contributing Causes of Movement in Building 6631

- Trapped moisture causing concealed decay in the structural steel columns
- Steel strength (coupons not yet taken)
- Structural slab not able to span over voids under it
- Deteriorated concealed Durock™
- Deteriorated concealed metal lath and plaster
- Concealed plumbing piping leaks
- The dead and live loads of the building
- Snow that was removed from driving and walking surfaces adjacent to and within the porte cochere was piled up around the column covers, forcing moisture and debris into the enclosure, which became trapped in the enclosure without exterior evidence of it.

IX. Interim Conclusions

A. Building 6631

The shoring in Building 6631 is to be installed and the column sections are to be removed from the foundation to the second floor and spliced out from the base plates to ±11 feet above to the replaced base plate installed with new adhesive anchors bolts set into pile cap. If floor leveling work is to be accomplished, the various possible solutions may require partial or complete vacancy (not due to structural capacity issues).

The out of plumbness remediation work of the masonry and the shelf angle issues in the walls can also be accomplished post-occupancy.

Once the steel columns under the second floor are remediated, the bolts of the second floor beams are replaced, and the porte cochere columns are damp-proofed and fireproofed, it is our professional structural engineering opinion that the structural frame of the building will be in a safe condition vis-à-vis the 1960 BOCA Code.

B. <u>Buildings 6621 and 6641</u>

The column material thicknesses are to be verified and the columns are to be ground to the original material and protected from moisture and fireproofed.

Based on our review of the exposed and visible conditions and our field investigation to date, it is our professional structural engineering opinion that the scaffolding can be removed.

We will continue to keep you advised of the status of the investigation and the remediation work as work progresses and as always, we are available to discuss questions you may have.

If we can be of further service, please contact this office.

Very truly yours,

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Allyn E. Kilsheimer, PE
President

AEK:ms

Enclosures.