CONSULTING
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1901 Pennsylvania Drive
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March 4, 2014

Mr. Larry Hubbard
Director of Campus Facilities
Plan, Design & Construction
E111 General Services Building
Columbia, MO 65211

Re: University Village Apartments Partial Walkway Collapse
Cause of Failure Report

***THHinc** #7429*

Mr. Hubbard,

The purpose of this correspondence is to describe the physical conditions that resulted in the walkway collapse as well as activities contributing to those final conditions. The following narrative is based solely on the conditions witnessed during the February 22, 2014 onsite observation. The resulting conclusions have been established taking into account these observations along with engineering judgment gained from previous experience with similar conditions.

Walkway Framing

The elevated walkway framing consists of a 1½" painted metal deck with 2½" of concrete (4" total) supported on a steel ledge angle at the building and a 9" painted steel channel beam along the outer edge. The exact method of the steel deck attachment was not able to be verified at the time of this report. Although the ledger angle is bolted to the building wood framing the walkway gravity loads are actually supported by the veneer below because the brick is mortared tight to the underside of the horizontal leg of the ledger. The outer 9" channel is supported by steel pipe columns spaced at 12ft centers.

The edge of the walkway is protected by a steel guardrail with vertical posts that are attached to the face of the 9" channel and an angle which is embedded into the top edge of the concrete slab. The top angle has ½" smooth "J" dowels spaced at approximately 2ft centers that were cast into the 4" walkway slab.

Observed General Conditions

In general, the walkway support beams, metal deck and concrete slab, were all found to be significantly deteriorated. The 9" channels and metal deck were

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heavily corroded and portions of the concrete slab were delaminated and showed signs of sever weathering. In addition to the deterioration at the outer edge a few longitudinal cracks in the steel deck were observed that extended nearly the full width of the walkway.

Likely Cause and Mode of Collapse

The resting geometry of the walkway deck was mostly upside down. This allowed for a very thorough observation of the steel deck but precluded any meaningful evaluation of the top of the concrete slab. However, although there were some longitudinal discontinuities in the metal deck and concrete, the alignment of the framing seems to show that the original failure did not occur somewhere in the middle of the span or at one of the ends, but rather at the front or back edge. The final position, markings and collateral damage, also indicate that the front (or outside) edge was the first section to drop. Therefor we have determined that the original failure occurred somewhere near, or within some component of, the outer structural system.

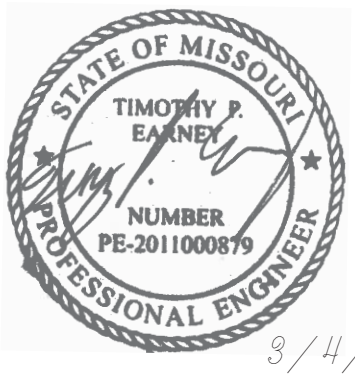
The attachment of the metal deck to the channel provides lateral top-flange support of the edge beam helping to prevent localized buckling, rolling and sweep. Evidence that the integrity of the metal deck has been compromised due to corrosion is prominent through the length of the remaining walkway. However, the channel remained in place and appeared to be mostly intact. Therefore it appears likely that the lack of lateral support of the edge beam was not a major contributing factor.

As described above all of these components were severely deteriorated which makes it very difficult to pinpoint precisely what happened based solely on the observed debris. Additionally, surveillance video or reliable firsthand reports have not been made available. However, we are confident that the collapse was a result of a concrete shear failure along the outer edge. It is likely that water and chlorides, and expansion from freeze-thaw action, combined to deteriorate the concrete to the point where its shear strength could no longer support even only the self-weight of the walkway. The loud “bang” reported by the residents was probably the sound from the shear failure itself. The walkway then likely sagged but remained suspended due to membrane action of the slab supported at the ends and along the face of the building. Once the load surpassed the bond and tension strength of the mesh reinforcing then the slab broke free from the ends and the front edge dropped.

The attached sketches and photos have been included as documentation of the observed items that were considered as a basis of this report.

Please feel free to let us know if anything additional is required.

Sincerely,



Patrick Earney, PE
Structural Engineer

Attached: Documentation Photos 1-5