JDH
Structural
Engineering

March 3, 2010

Mr. Thomas Mathison
Tower Pinkster
678 Front Avenue, NW Suite 255
Grand Rapids, MI 49504-5323

RE: Muskegon Community College
Master Plan Review - Floor Structure Cracks
JDH File 0912-015

Dear Tom:

In conjunction with the facility assessment, concrete cracks in the floor structure over the corridor at Rooms 230 to 240 were reviewed. Observations were compared with information contained on the original design drawings and with a report prepared by Fleis and Vandenbrink Engineering, Inc., dated October 21, 2009.

The floor structure consists of a monolithic concrete slab and joist system supported by steel beams. Cracks were observed running parallel to the hallway and steel support beams, perpendicular to the joist span, located approximately three feet from the beams, extending from the slab into the joists. The cracks seem to be limited to this particular area, ending at the ends of the corridor where a steel beam indicates a change in direction. Cracks were not observed in the floor areas adjacent to the hallway, nor in the walls; cracks of comparable magnitude were not apparent in the slab below this level.

After review of the Fleis and Vandenbrink report, our findings generally concur with that report's conclusion that the cracks are the result of internal tension forces generated by negative moment through the joists and slab across the support beam. Reinforcement designations on the design drawings are somewhat unclear in terms of whether continuous reinforcements were required at this location, and the contractor's interpretation of construction is unknown.

It is possible that the cracks occurred shortly after construction and the condition largely unnoticed. It was reported that the concern arose when an uneven top surface was noted after flooring replacement.

We evaluated the joists over the corridor as a single span, using the joist schedule information on the original drawings. That evaluation indicates sufficient capacity to support normal corridor loading. The probability is that the concrete has reached a level of stability such that the cracks will not increase noticeably; in that regard, combined with the result that there is sufficient capacity, it is our opinion that supplemental structure is not required. It is recommended, however, that markings placed by Fleis and Vandenbrink be noted for any potential change. If there is no evidence of change, the recommendation will be that the cracks be cleaned and injected with an epoxy repair material.

Please feel free to call with any questions.

Sincerely,

JDH ENGINEERING, INC.

Larry A. Hulst, PE, SECB

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Copy- Ron Boezwinkle, Tower Pinkster

FLEIS & VANDENBRINK
ENGINEERING, INC.
Offices in Michigan and Indiana

October 21, 2009

Mr. Gerald Nyland, Maintenance Supervisor
Muskegon Community College
221 S Quarterline Road
Muskegon, MI 49442

Re: Structural Investigation of Several Campus Buildings – Updated per Req. #6663

Dear Mr. Nyland:

We have completed our review of the three items identified in our proposal dated April 16, 2009. A summary of our review is as follows:

Item No. 1 – Cracking in T-slab of Main Building

The first area of concern is in the classroom area of the main building. The 3rd floor concrete joists and flooring above the hallway adjoining Room 230 to 240 exhibit severe cracking. The main framing in this area consists of steel beams running parallel with the hallway located in the partition walls separating the hallway from the classroom areas. These beams are supported by steel columns, which carry the loads to the foundation. The steel beams, in turn, support a series of concrete joists and integral concrete floor. The concrete joists are oriented perpendicular to the hallway. We have attached a schematic of the area for your reference. The cracks are primarily located within 3 feet of the steel beams supporting the hallway and oriented parallel to the hallway. The cracks range from hairline cracking at the bottom of the concrete joists to approximately 0.1" or more in the floor slab. There is additional secondary cracking radiating from the main crack with concrete spalling. Based on a limited review of the surrounding area, the cracking observed appears to be concentrated in the hallway location.

We initially considered settlement of the building or parts thereof as a cause for the cracking. During our site visit, we discussed historic periods of sand migration through the drain tile system for the building. Based on the construction drawings we were provided, most of the columns in the area are supported by pile foundations, which would not typically be susceptible to settlement from a loss of soil through the drainage system. Additionally, we did not note cracking in the adjacent partition walls or racking of the doors or windows, which would be expected with building settlement. Also, the joists and flooring between the 1st and 2nd floors show limited cracking, minor in comparison to the area in question and more significant cracking would be expected in the other floors if foundation settlement were a primary cause of the cracking.

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We also considered flexure of the concrete joists under loading as a primary cause of the cracking and feel this to be the likely cause based on several factors. The first factor is the nature of the cracking itself. The cracks are predominantly oriented parallel to the steel support beams, which could indicate flexure. The cracking is generally located near the supports, which would be expected from high stresses due to negative moment bending near the supports in a continuous beam configuration. Cracking has opened to approximately 0.1" at the top of the section but has remained fairly tight at the bottom, which further supports the contention that the cracking is the result of high stresses over the supports.

The second factor considered is the design on the construction plans and possible misinterpretations by contractors. Sheet S13 shows the framing for the area in question. It indicates that the joists spanning the hallway area are to be a "1DJ21", which is a 5"x8" joist with integral 2-1/2" floor slab and a "1DJ20", which is a 6"x14" joist with integral 3" floor slab spanning the adjacent classrooms. For high stresses due to negative moment to be a primary cause of the cracking, the joists and flooring would have to be at least partially continuous at the support. Based on our review of the drawings it is possible that a contractor misunderstood whether the joists were to be constructed continuous over the support beam. First, the notes on sheet S5 indicate "concrete joists shall be spaced for continuous construction from bay to bay unless otherwise shown on the drawing". Under the "Remarks" column of the joist schedule on sheet S13, it indicates that the 1DJ21 joists are not to be continuous with the 1DJ20 joists. However, the construction joints at the support beam were specifically called out on the plans for Part C of the building, but the callout was omitted from the area in question in Part D. Also, the building is fairly symmetric in Part D, and the opposite area appears to be designed for continuous construction. Finally, the joist schedule calls for a #3 dowel bar, 3' long, to be placed across the construction joint at each joist, which would at least partially fix the joint and allow negative moment transmission. Based on these items, it is possible that the contractor misinterpreted the design intent and constructed 1DJ20 and 1DJ21 continuous and did not leave a break in the welded wire fabric reinforcement in the slab. Finally, the joist callouts appear to show the concrete joists parallel to the hallway as opposed to perpendicular, which appears to be the design intent and is how they were constructed. This could have caused further confusion during construction and possibly resulted in improper orientation of the welded wire fabric, which would further reduce the section's ability to resist negative moments.

Based on these two factors, we feel that enough negative moment was transmitted through the joints at the supports of the 1DJ21 joists to cause cracking of the section. Since the reinforcement in the floor slab is nominal welded wire fabric for temperature and shrinkage, the cracking has opened and propagated under loading. We also noted the welded wire fabric exposed in one of the cracks because it was placed with limited cover near the bottom of the floor slab. This lower position would reduce the fabric's effectiveness in resisting moments and allow wider growth of cracking.

Due to the severity of the cracking, we recommend that MCC consider a repair/retrofit to the area to prevent further damage to the structure and increase reliability. A retrofit could take the form of supplemental carbon fiber reinforcement applied to the top of the flooring, a supplemental steel system from the bottom of the section in conjunction with sealing of the cracking or another approach designed to reinforce the section. During our site visit, we marked and recorded crack widths in a number of areas. Because the timeline to budget, plan, design and construct repairs could be a lengthy one, we recommend that the cracking be monitored for further progression. We also recommend reviewing the corresponding area in Part "C" of the building, because it is similar in design.

Item No. 2 – Cracking in the masonry wall adjacent to costume storage

The second area reviewed is located in the art wing. There is a mechanical "penthouse" above the second floor mezzanine behind the theater stage area. The mezzanine area beneath the penthouse is used for storage. A costume rack was installed after construction on the mezzanine level adjacent to the penthouse and is connected to a masonry wall supported by the penthouse framing. The masonry wall exhibits cracking in the masonry joints throughout a significant portion of the costume rack area and several cracked masonry units. The cracking tends to be in a "stepped" configuration above the second course of masonry. During our review, we observed that the cracking was generally in the range of 0.03" to 0.04" in width with the worst cracking in the horizontal joint between the first and second courses of masonry block.

From the construction plans provided, we noted that the wall is supported by a steel beam spanning between steel columns. The beam is encased in concrete, likely for fire protection. The beam also carries roof loading from a series of steel columns. We did not note any deterioration of the concrete surrounding the beam, although it is possible that any deterioration was masked by periodic painting of the area.

Based on our review, we feel it is unlikely that the installation of the costume rack is the primary cause for the cracking. The worst cracking is located below the level of the costume rack connections. If the costume rack connections were exerting significant vertical load on the masonry wall, it would have a tendency to close any cracking between the connection and the beam. Based on the configuration of the racks, it appears that a large portion of the load is being carried by the mezzanine flooring, and the masonry wall connection is carrying the balance and providing lateral support. A more likely scenario is that the beam has deflected after construction of the masonry wall, either from mechanical equipment loading or roof loading above.

Because the area is fairly open and unfinished, a supplemental support option for the beam could be considered. This could entail installation of a column from the beam through the mezzanine level to a new foundation cut through the slab at grade below. Based on the fairly limited severity of the cracking and the apparent lack of cracking of the concrete encasing the steel beam, monitoring the issue for a change in severity is likely a more prudent course of action.

Item No. 3 – Area B Snake Pit and Area D floors sand migration and groundwater undermining

Because much of the lower level of the building was constructed below the water table, a system of drain tiles was installed to control water. The drains collect water and convey it to a pump station, which discharges into the adjacent pond. Based on our conversation, we understand that throughout the life of the building, sand migration has been a problem and that it routinely shows up in the pond near the discharge area. During our site visits, we observed a small amount of sand near the discharge point. We also examined the floor slab of the snake pit area. We understand that this was the location of several of the floor drain failures. We did not note any cracking in the floor slab, which would be a potential indicator of significant undermining. Based on our limited visual review, it appears unlikely that severe undermining has taken place. We recommend that suspect areas be monitored for cracking, at which time specific areas could be evaluated in greater detail. We understand that you are also in the process of potentially eliminating the footing drains in favor of a dewatering well system to use the water for heating and cooling. This would not only help by eliminating the drains, but would also keep sand from entering the pumps, which can cause premature wear of the impellers and other mechanical pump components. If the well system is not constructed, a sand screening system could also be installed upstream of the pump to reduce the amount of sand in the pump chamber and subsequently in the pond.

We have enclosed applicable plan sheets highlighting specific information relating to our findings and are returning the original plans you provided for the drain tiles. We appreciate the opportunity to work with you on this project. Please feel free to call with any questions.

Sincerely,

FLEIS & VANDENBRINK ENGINEERING, INC.

Jonathan W. Moxey, P.E.
Project Manager

Encl.

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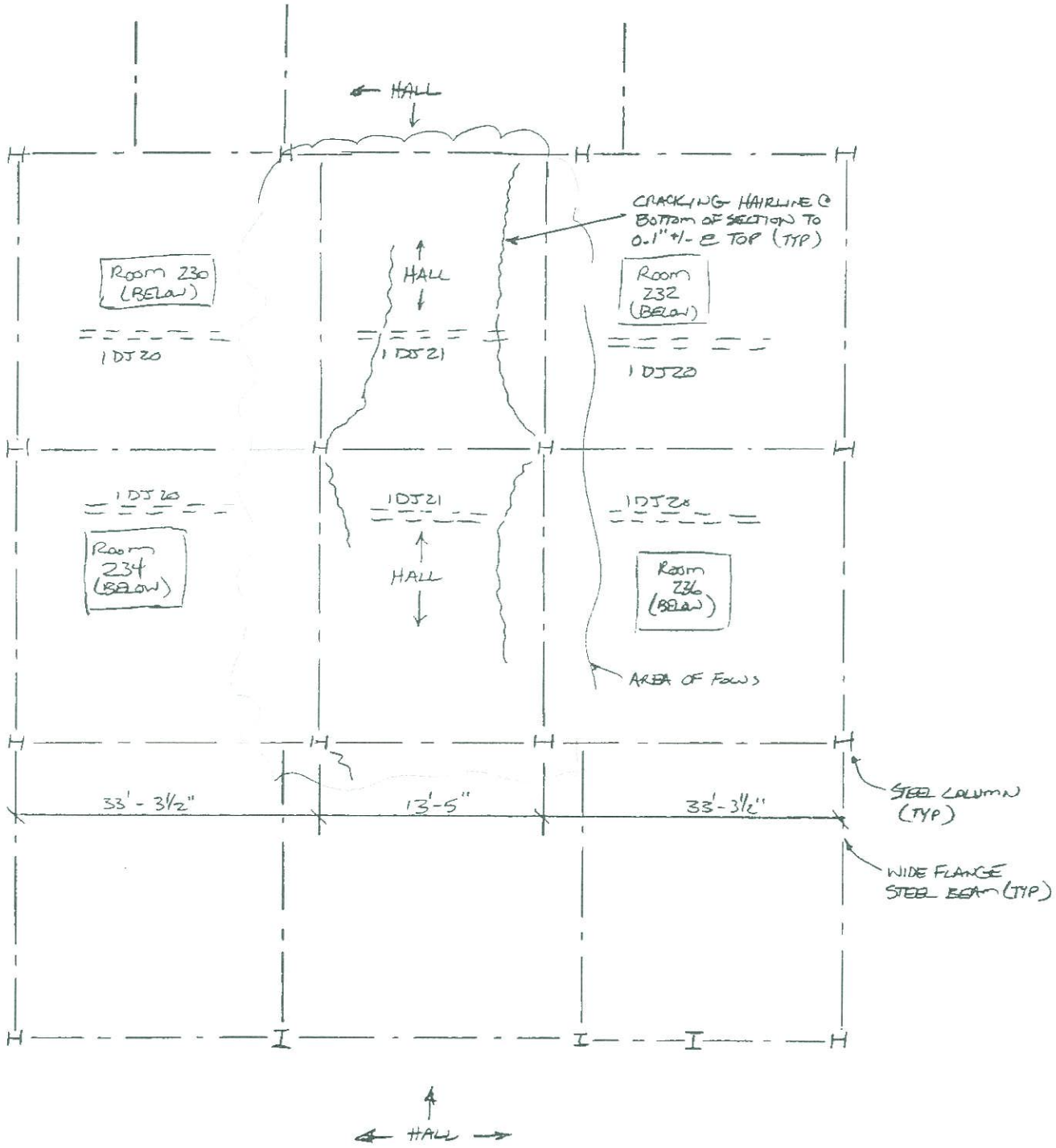
Calculation Sheet

Computed by MOXEY Subject STRUCTURAL REVIEW Sheet 1 of 1
Checked by _____ Client MCC Job No. 802720 Date 10/8/09



SCHEMATIC OF "FIRST FLOOR FRAMING PLAN"
(BETWEEN 2ND & 3RD FLOORS OF BUILDING)