Engineering
UPDATE©

MEA MARINO ENGINEERING ASSOCIATES, INC. • Issue 11

FROZEN FILL CAUSES BUILDING DAMAGE

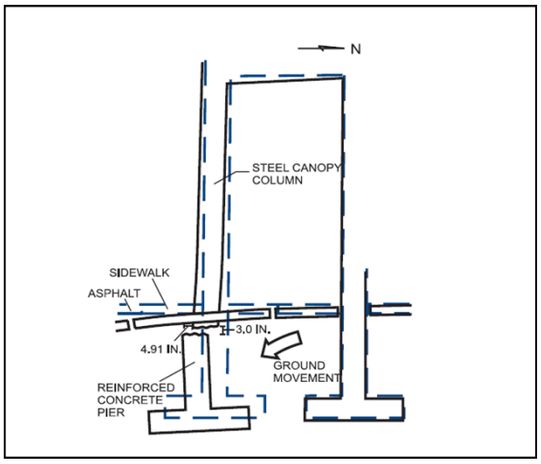

FIGURE 1 DEFORMATION PATTERNS AT THE FRONT OF THE STRUCTURE

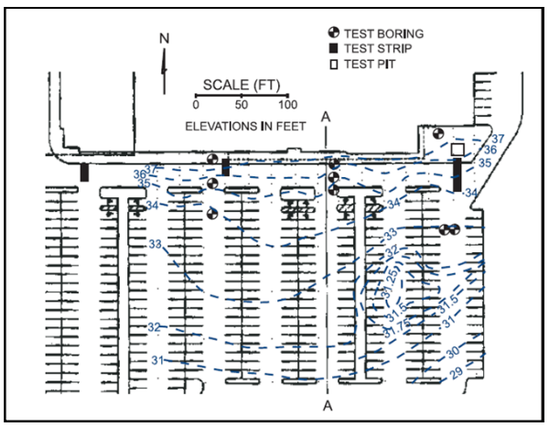

FIGURE 2 SURFACE TOPOGRAPHY OF PARKING LOT SOUTH OF THE BUILDING AND LOCATION OF TEST PITS/STRIP AND EXPLORATORY BORINGS

Shortly after construction the ground beneath the front of a food store in Minnesota settled and moved laterally away from the building. This building behavior is shown in Figure 1. Also, significant movement was experienced in the parking lot in front of the store. The resulting damage mainly consisted of structural distortion of a canopy structure which supports second floor office facilities, significant cracking and separations in the masonry walls, racked store openings, as well as uneven settlement causing significant ponding and adverse grades in the parking lot.

The maximum measured settlement was up to 3.5 ft. and was located in the parking lot. A topographic map prepared across the project site is shown in Figure 2. By analyzing design and post-settlement grades, the building experienced as much as 0.5 ft. of differential settlement. An important feature of the movement was the determination that basically a settlement through had developed adjacent to the store. A section across the trough in the approximate area of maximum settlement is depicted in Figure 3. To determine the source(s) of the ground movement which resulted in the building damage, a total of 4 test pit/strips and 10 borings were drilled (see Figure 2).

Prior to development of the shopping center (which included the food store) there were fairly dramatic topographic and geotechnical conditions north to south across the site with differences in elevation of about 90 ft. This required cuts of up to 40 ft. into hard igneous rock to the north and fills more than 30 ft. to the south over some areas which contain significant amounts of peat and organics to bring the food store 18 ft. into hard rock in back of the store and fill up to about 25 ft. in the front. The fill was to consist of gravel from crushed blast rock sloped down to native soils at a specified 1:1 slope after any organics were removed. In the parking lot to the south, 8-10 ft. of residual cut soils were placed over the lower elevation swamp-like materials.

On top of the residual soil fill shot (blast) rock (mainly boulder and cobble sized from the rock cut)

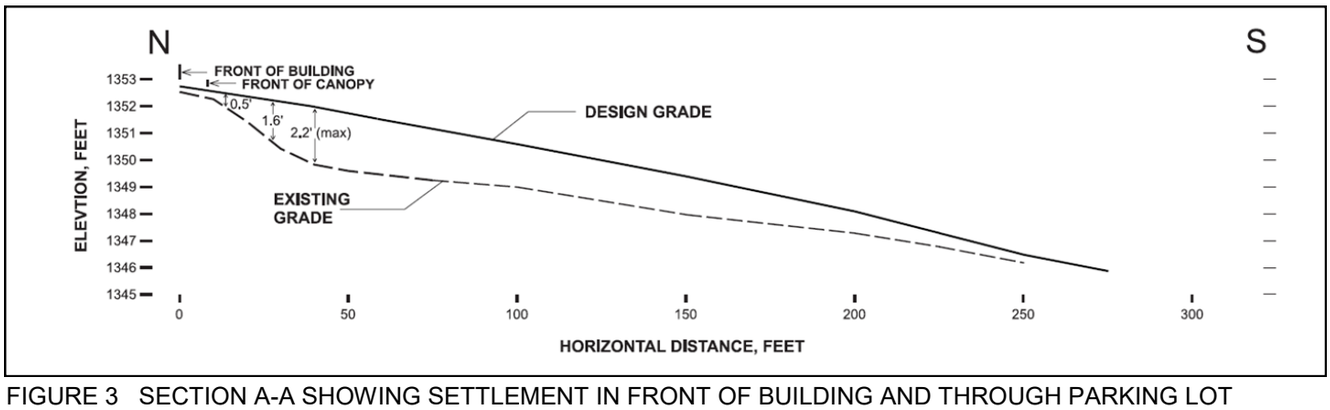

FIGURE 3 SECTION A-A SHOWING SETTLEMENT IN FRONT OF BUILDING AND THROUGH PARKING LOT

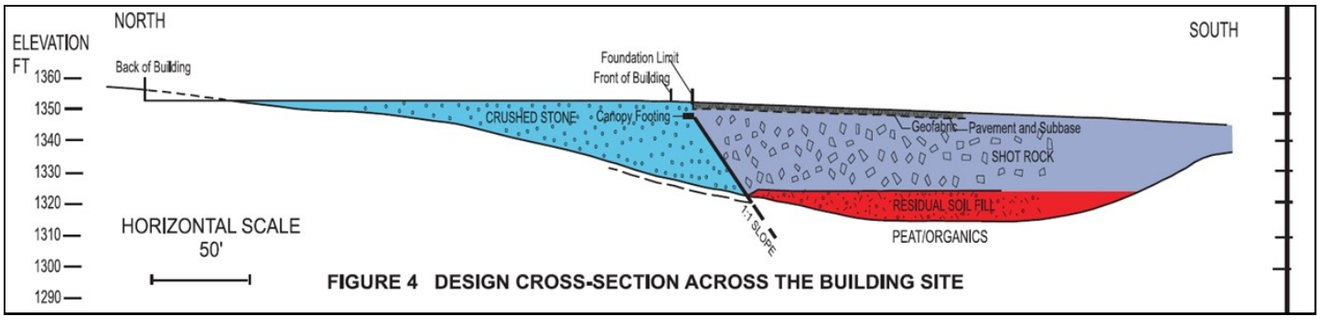

FIGURE 4 DESIGN CROSS-SECTION ACROSS THE BUILDING SITE

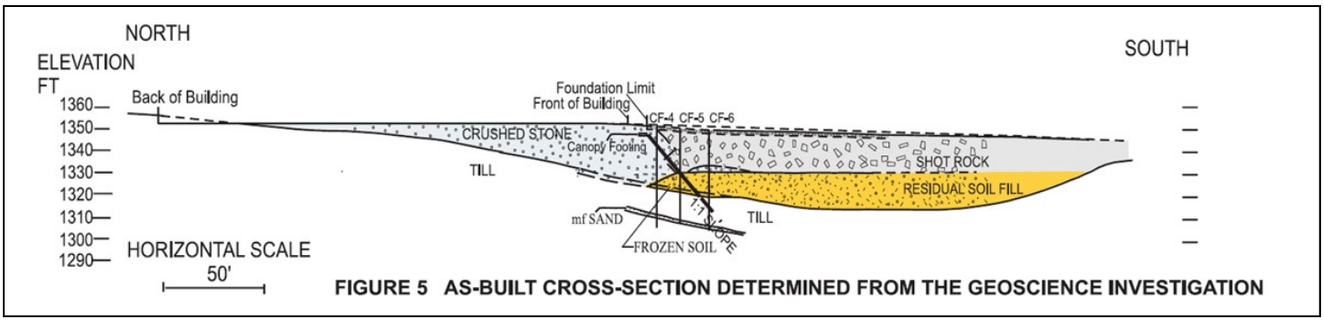

FIGURE 5 AS-BUILT CROSS-SECTION DETERMINED FROM THE GEOSCIENCE INVESTIGATION

was installed to about 1 ft. below top of pavement. The shot rock was covered with geofabric, subbase stone, and then asphalt (see Figure 4).

It was initially thought that the presence of peat to the south was the likely cause of ground movement affecting the building. While it appeared to be mainly the cause for settlement to the south in the parking lot, the exploratory work uncovered the main cause for the resulting damage to the store was thawing of frozen residual soil fill within the influence zone (and building pad) of the structure. The location of this material is shown in the cross-section in Figure 5. Based on our forensic studies this frozen material was left within the building pad and froze when the north construction slope of this fill was exposed to winter conditions because the building pad gravel had not been placed over it in time. This can be seen in the photograph looking along this construction slope in Figure 6. The photograph was taken by a local geotechnical inspection engineer.

FIGURE 6 GRAVEL BEING INSTALLED IN BUILDING PAD AND AGAINST FROZEN FILL SLOPE

Other Engineering UPDATES of Interest:

UPDATE 8: Geotechnical Investigation of Building Damage

UPDATE 7: Soil Provides Poor Road Construction Support

UPDATE 9: Hard Excavation Dispute

ABOUT MEA: Marino Engineering Associates, Inc. focuses on engineering research, practice and expert evaluations and is licensed in 24 states in the U.S. Our projects primarily have an emphasis on Geotechnical Engineering, however, we also have significant experience in projects involving transportation, subsidence engineering, laboratory testing, training, and geophysical exploration. Gennaro G. Marino, Ph.D., P.E., D.GE is president and principal engineer of Marino Engineering Associates, Inc., and has been a licensed professional engineer since 1984. To obtain additional information on MEA, one can also visit our website at www.meacorporation.com.

FOR MORE INFORMATION: There is a significant amount of additional information that is available on the above subject. For more information, please contact Dr. Marino at the address listed below.

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