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Non-Destructive Assessment of the Historic World War Memorial Baseball Stadium, Greensboro, North Carolina

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Abstract: The World War Memorial Stadium located at 510 Yanceyville St. Greensboro, North Carolina was built in 1926 at the. Currently, the stadium is used as a baseball field for NC A&T State University and University of NC at Greensboro. The stadium was designed by the architect, White, Leonard, Jr. and Barton Harry with architectural style modern classicism. The stadium is maintained by The Parks and Recreation Department of the City of Greensboro who invited the Department of Civil Engineering, College of Engineering at NC A&T State University to assess and evaluate the structural conditions of the stadium. The outcome of the assessment is to provide the city with tools for decision making in terms of repair, replacement or demolishing. The existing conditions by the visual inspection indicate severe environmental deterioration of many areas including seating slabs the towers of the front façade, beams and columns.
The initial evaluation included the following:
1- Review previous evaluation reports prepared by Sutton-Kennerly & Associates, Inc. in 2003 and 2008. The 2003 report was mainly based on the visual test for concrete deterioration and cracks while the 2008 report showed more comprehensive assessment in which core tests were retrieved from various concrete structural members.
2- Perform a site visit to develop assessment scheme and planning for the work schedule.
3 -Perform a visual test for the areas under investigation and reporting the dimensions and all types of deteriorations and cracks in details and its exact locations.
The assessment of the structure was focused on mapping the areas with a concrete reinforcement scanning device using Ground Penetrating Radar (GPR) in X and Y directions on a grid spacing of one yard. The concrete strength test was used to evaluate the in-suite modulus of elasticity using Seismic Property Analyzer (SPA) device on the same grid of one yard spacing. Core tests at deferent locations were

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retrieved to correlate the test data obtained by the above two methods. All the investigation steps with results, graphs and pictures will be presented in this paper. Recommendations were made to retrofit the stadium. Partial replacement of some members was recommended to maintain the structural integrity of the stadium.

Keywords: Non-destructive test, GPR, SPA, World War Memorial Stadium

1 Background and Literature Review

The War Memorial Stadium in Greensboro was built in the year 1926 to host the baseball games. In this time, it was considered one of the largest baseball fields in State of North Carolina. Currently, the stadium is used by North Carolina Agriculture and Technical State University (A&T) and University of North Carolina at Greensboro (UNCG). The stadium is located at 510 Yanceyville St. The stadium is maintained by The Parks and Recreation Department of the City of Greensboro. In 2003; the City of Greensboro hired a professional consulting engineering office "Sutton-Kennerly & Associates, Inc." to evaluate the condition of façade towers and seating slabs, the final report summarizes visual tests for the investigated areas and indicated extensive cracking and delaminating of concrete sables and supporting beams specially around the expansion joints. In 2008; Sutton- Kennerly & Associates made more detailed evaluation and they reported their recommendations based on additional visual examination for some investigated areas and several core tests to check the strength of concrete. The report indicated severely weakened concrete areas. The assessment in the second report was extended to include some chemical and petrographic analyses for some designated areas.

The significance of the structure, being on the register of historic buildings, has spurred the City Council to try to define the extent of the damages. This is by investigating the conditions of the reinforcement and the quality of the concrete surrounding deteriorated areas. On Friday April 27, 2012, a group from City of Greensboro Council members with personnel of the Parks and Recreation Department accompanied by personnel from Sutton-Kennerly & Associates and personnel from NC A&T State University. The group performed a walk through for the purpose of setting up a "pilot" investigation to provide the City Council with enough information to make a decision on the future of the stadium. Also, the purpose of the pilot study is to identify candidate areas that provide true representative of the overall conditions of the stadium. This paper provides the final recommendations as highlighted in the finding of non-destructive evaluation performed in the final assessment report.

2 Test Investigation

The research investigation began with the site visit by the teamwork of NC A&T to define the boundary of the candidate areas for the assessment, to determine the type of devices that fit the nondestructive tests required and to decide on the equipment required to obtain the desired results. The prognosis of the work was divided to four steps, the first step was a visual inspection, and second step was a screening test using Ground Penetrating Radar (GPR), third step was an analytical test using Seismic Property Analyzer (SPA) and the final step was to core preselected areas to insure true calibration with the previous tests.

The visual test was run by the NC A&T team work as a survey of preselected candidate areas by dividing them into four testing areas due to location and the degree of deterioration as well as the dimensions and thicknesses of concrete members. Figure 1. shows the planed area for seating slab and the façade tower.

(a) (b)

Figure 1: The areas under investigation (a) Seating slab, and (b) façade Tower

During the visual inspection, the cracks types and type of deteriorations were identified by design symbols inside organized scheme of work as shown in Figure 2. The investigated areas were divided to grids with a spacing of one yard for easy reading defining the location of concrete delaminating, the figure shows the pictures of several delaminating pictures and its symbols and the symbols were sited on the grid corresponding to the actual location. Figure 3 shows the detailed visual test for the seating slab where Figure 4 shows the detailed visual test for the left façade tower. The two figures show that the most affected areas in seating slab are Area -2 and Area-3 as they are the most exposed reinforced concrete members to environmental factors. The concrete delaminating in the façade tower is more extensive near the top and more cracks concentrated existence around the bottom

window opening, and it was noticed that most cracks in the façade exist in the decorative cover.

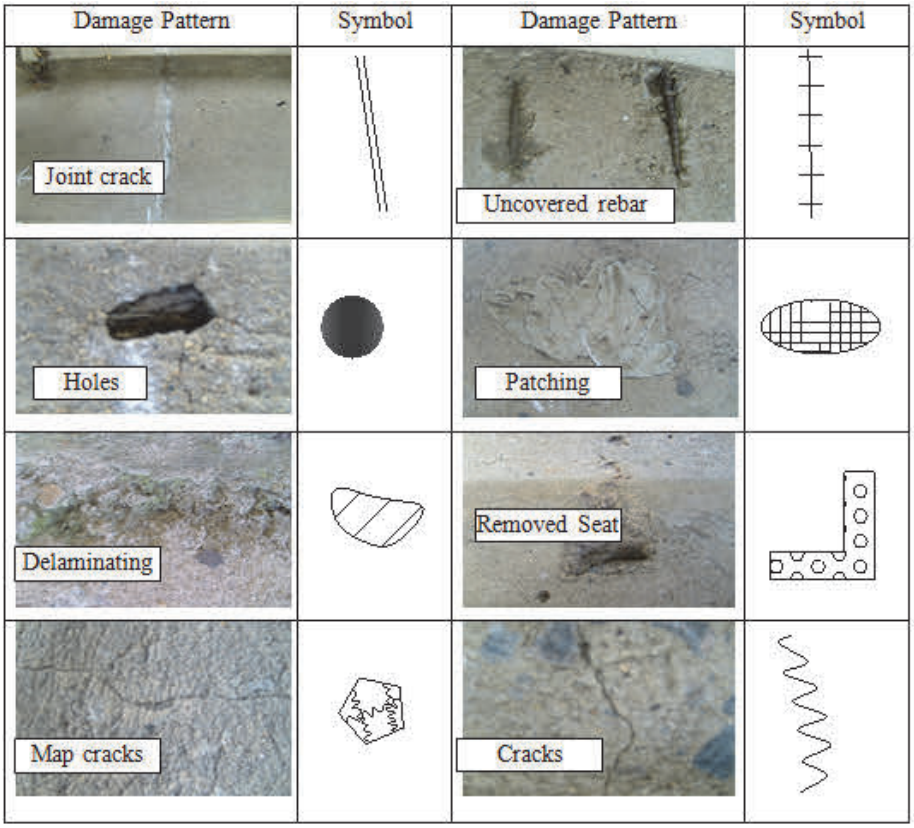


Figure 2: Pictures and Symbols for Delaminating Types.

2.1 GPR Scanning test

The GPR unit used in this test is the StructureScan™ Mini (SSM) as shown in Figure 5. made by Geophysical Survey Systems, Inc. (GSSI) of Salem, New Hampshire. It is a compact, lightweight handheld unit designed expressly for the location of subsurface objects in concrete structures. The SSM works by calculating the relative differences between the dielectric constants in the material being scanned. Continuous records of these readings are collected, allowing for the creation of profile views based on using a wheel encoder to measure distance across a surface. Well documented methods of determining the depth of cover to reinforcing steel and reinforcement spacing will be utilized, the test was done on the longitudinal

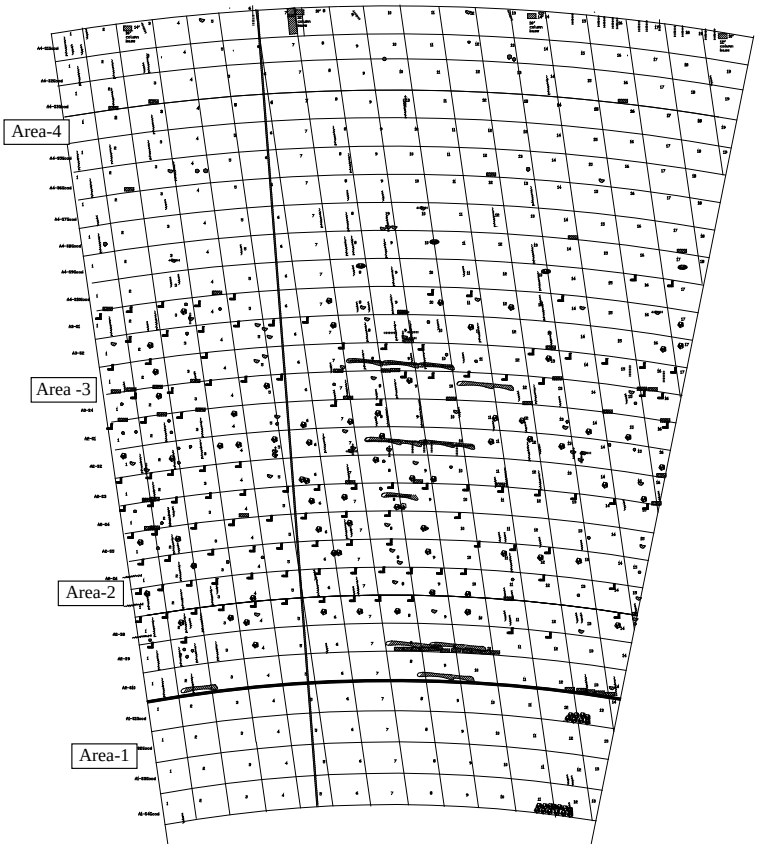


Figure 3: Seating Area Visual test.

axis and every one yard on the perpendicular axis to show the delaminating area inside concrete and the reinforcement bars, as well as the scanning picture shows the concrete cover to reinforcement, in **Figure 6** shows a sample of a slab scanning with details for the left side seating slab of area- 4 of as the red rectangular boxes show the areas that affected by concrete delaminating or deterioration and the chamfered blue rectangular boxes show the areas that contain the reinforcement bars with no enough concrete cover

2.2 SPA Scanning Test

The seismic property analyzer (SPA) shown in Figure 7. does not provide images of a cross section like GPR, but will provide an average moduli for a concrete thickness that may be contoured to show areas of defects and assess overall mod-

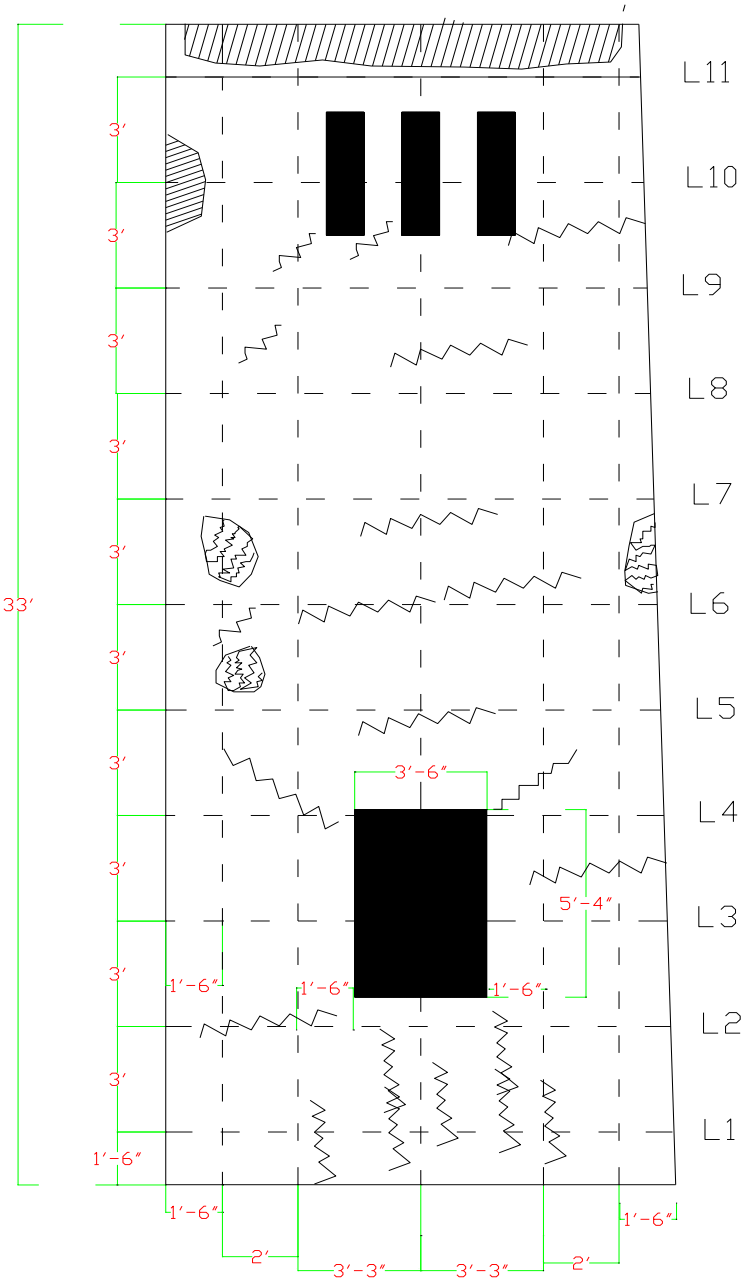


Figure 4: Visual test for façade tower.

Figure 5: GPR Device (SSM).

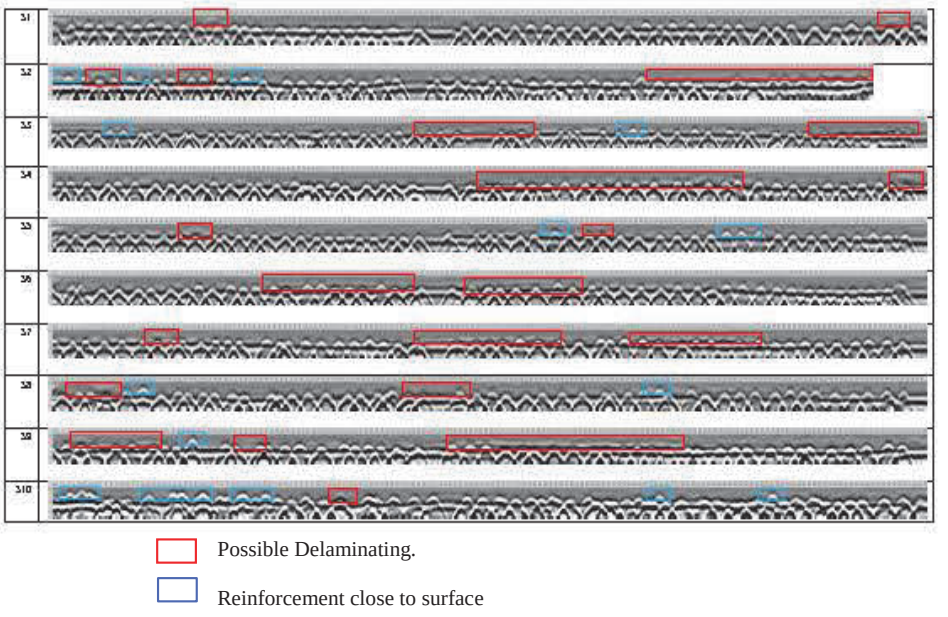


Figure 6: GPR Results for Area 4 Left Side.

uli values, the main advantage of SPA as a seismic method is the similarity of its results with that obtained from the field cut and tested at the laboratory by means of nondestructive way to the member by measuring the material moduli, The seismic method is depending on nondestructive impacting hummer hits the surface of concrete and monitoring the propagation of seismic waves with two receivers. The analysis recommended here will be conducted via the Ultrasonic Surface Waves (USW) method in which the elastic modulus, E, of the concrete is estimated from the seismic wave velocities. The most dominant seismic wave arrivals at the receivers are the surface waves, which travel at a velocity of Vr. Since these waves contain about two-thirds of the imparted seismic energy they are easy to automatically be recognized and recorded with a computer. The elastic modulus E, is related to Vr, through equation (1)

$$E = 2\rho(1+\nu)[Vr(1.13--0.16\nu)]2 \tag{1}$$

where E is the material's modulus and (ν) is Poisson's ratio for concrete which normally falls between 0.15 and 0.20; in the test it was taken 0.18 for this study. Likewise, the density of concrete (ρ) will be assumed to be 150 lb/ft3 (2,402.8 kg/m3). By the software and the site concrete information the computer analyzes the returned waves received by the two receivers to give the average of concrete moduli.

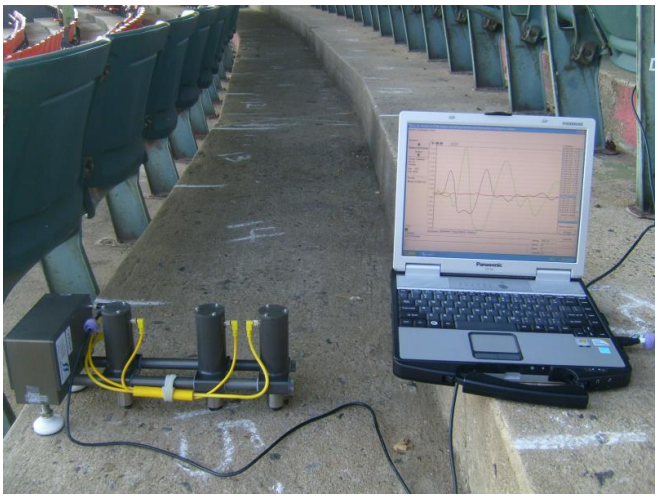
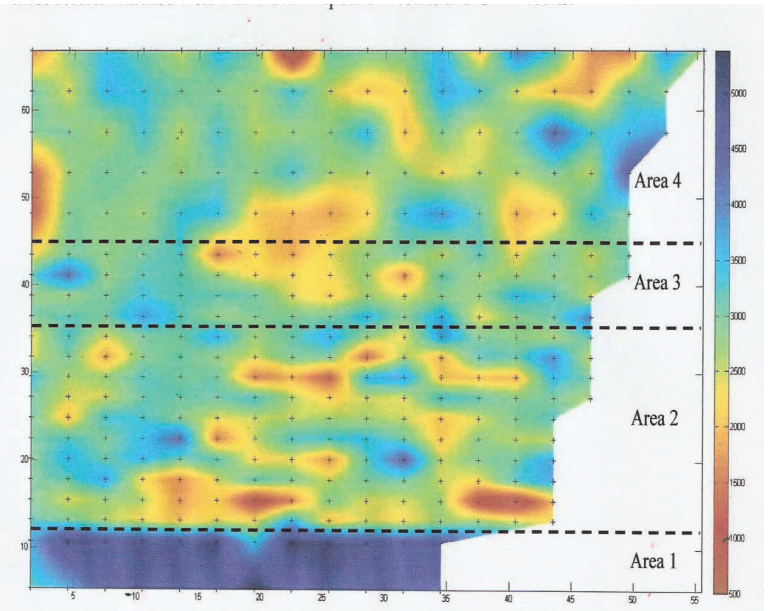


Figure 7: SPA device set.



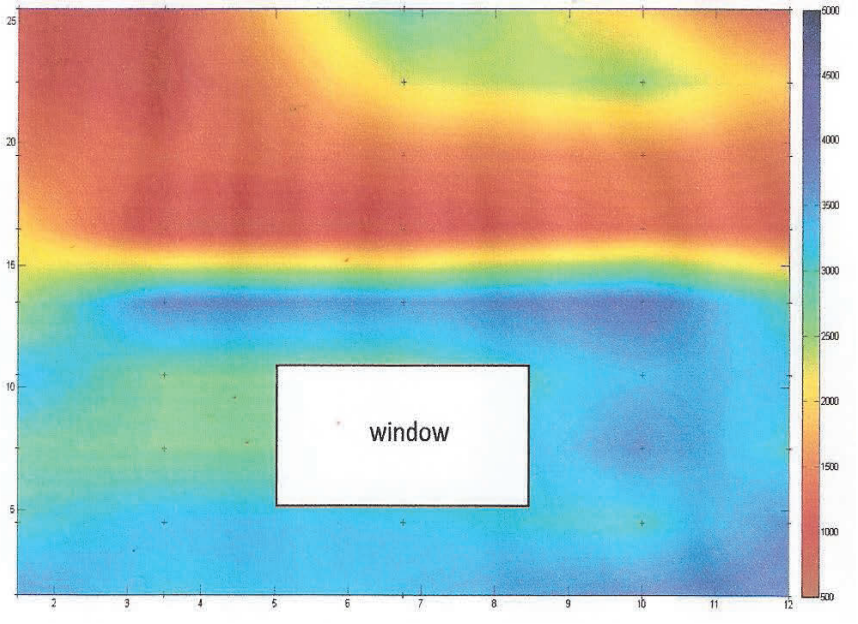
(a)

(b)

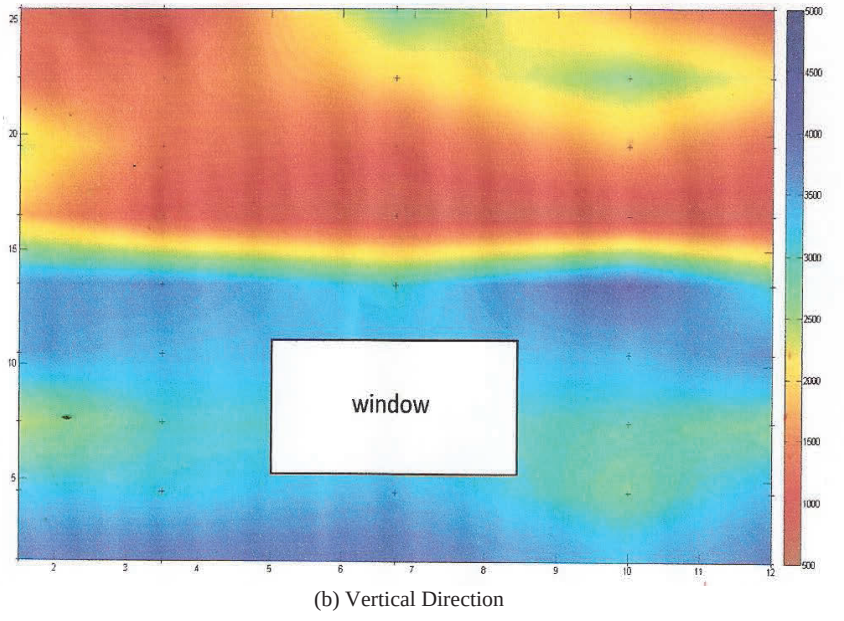
(c)

Figure 8: a- Seating Slab SPA Results Image (Red are Weak Areas) b and c are the damage picture in area 2 and area 4 respectively .

The test was run on a point every one yard for every seating slab step and on a similar grid X and Y on the façade wall. The collected data by SPA and the grid location, the MATLAB software were used to create an image for concrete strength in seating slabs and the façade wall as shown in Fig. (8) With corresponding damage pictures for area 2 and area 4, in Figure 9. and Figure 10. a simulation for SPA test for the tower wall and the corresponding damage pictures respectively. some core samples 3.0” x 6.0” were taken from selected locations and tested in the laboratory to support and calibrate the previous tests.



(a) Horizontal Direction



(b) Vertical Direction

Figure 9: Façade Wall SPA Test.

(a) Tower damage on top (b) tower damage on bottom

Figure 10: The Façade Tower Damage.

3 Conclusion

Based on the limited tests performed and the limited areas assessed, this paper summarizes preliminary conclusions and provides recommendations needed to decide on the future of the stadium. The finding of the inspected area including the surface of left tower and the seating slab and the assessed vertical supports are summarized as follows:

1. Structure in the Section 1 exhibits numerous areas of concrete spalling, delaminating, and cracking as well as the reinforcing steel corrosion especially in area 2 and area 3.

2. As seen in Figure 8 and Figure 9, the condition of the concrete in the stadium can be categorized into three cases:

   Case-a, sound concrete area, can be found in the area indexed by blue color.

   Case-b, minor damaged area, can be found in the area indexed in yellow and green color.

   Case-c, excessive damaged area, can be found in the area indexed in orange and red color.

3. Even there is significant damage in some of surveyed areas so far, it can be concluded that the structure can be repaired.

However, before making the final decision for repair of the structure, it is recommended that a complete nondestructive survey needs to be extended to cover all

the areas expected to be repaired. The purpose of this survey is to provide tools to assess the extent of the damage in order to reduce the cost of unnecessary repairs.

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4 *References

Bell, H. P. (2006): *Operating the Portable Seismic Pavement Analyzer.* US Army Corps of Engineering.

Kennerly, Robert G.; Tepke, David G. (2008): *Condition Assessment and Evaluation World War Memorial Stadium, Greensboro, NC*. Sutton-Kennerly & Associates.

Zanetell, David F. (2009): *Portable Seismic Property Analyzer.* US Department of Transportation.