iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: XII Month of publication: December 2021

DOI: https://doi.org/10.22214/ijraset.2021.39337

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XII Dec 2021- Available at www.ijraset.com

Condition Assessment Using None Destructive Tests at Montauk Bridge Deck

Samie Hamad[1], Wajdi Ammar[2], Salah Shaniba[3]
[1] *Missouri University of Science and Technology, Missouri, USA*
[2] *University of Colorado Denver, Colorado, USA*
[3] *Mellitah Oil & Gas B.V, Tripoli, LIBYA*

Abstract: Ground penetrating radar (GPR) and portable seismic property analyzer (PSPA), was used in concrete structures for monitoring, quantifying, and mapping the deterioration of bridge decks. The Montauk Bridge deck was assessed based on PSPA and GPR data. Based on the analysis of the PSPA data, it was determined that over 65% of bridge conditions were rated serious to poor condition with an average compressive strength of less than 2500 psi; less than 35% of bridge deck conditions were rated fair to good with an average compressive strength over 2500 psi. Based on GPR data, it was determined that 72% of the bridge deck was in serious to poor condition, and only 28% of the bridge deck was in fair to good condition. Additionally, the analyses of the ground penetrating radar data indicated possible rebar corrosion in places. For these reasons, it is recommended that the Montauk bridge's deck be completely replaced.
Keywords: Condition assessment, NDT, GPR, PSPA, bridge deck

I. INTRODUCTION

Of states with the highest percentage rates of deficient bridges in the country, Missouri is in the top five. Out of the 10,400 bridges in Missouri, at least 2,000 are structurally deficient, according to the Missouri Department of Transportation. This means that about 20% of the bridges in Missouri are in serious to poor condition, according to the National Bridge Inventory (NBI) Rating Scale [1]. About 50% of these bridges are 50 years or older.

Bridge decks, like any concrete structure, deteriorate over time. For this reason, regular inspections should be performed to detect potential defects [2]. Most internal defects, like the early stages of reinforcement corrosion in the bridge deck, cannot be detected by performing visual inspections or using traditional inspection methods like chain dragging or hammer soundings [3]. These defects can affect the serviceability of the bridge.

Non-destructive testing tools, such as ground penetrating radar (GPR) and the portable seismic property analyzer (PSPA), extensively used in the past two decades for monitoring, quantifying, and mapping the deterioration of bridge decks [4]. Using PSPA and GPR ensures regular monitoring of bridge conditions, leads to the early detection of deterioration, and plays a major role in bridge serviceability. This is important, as not knowing the integrity of bridge decks increases maintenance costs and presents public safety hazards.

PSPA and GPR data were acquired on two bridge decks owned by the Missouri Department of Conservation. The intent of data collection was to determine the condition of the decks (that is, to identify areas where the bridge deck is degraded) [5], and to determine and demonstrate the functionality of using GPR and PSPA together.

II. CONCRETE BRIDGE DECKS

A bridge deck is the surface of the bridge that provides a structural element for overpass traffic. It is a structural element of the superstructure, and it can be built of concrete, steel, open grating, or wood. The primary function of a bridge deck is carrying loads from overpass traffic (compression or tension) over to the columns to the foundation.

A. Montauk bridge deck overview

The bridge is located at Montauk Conservation Area, about 20 miles southwest of Salem, Missouri (Figure 1). The bridge was built in 1954 and is owned by the Missouri Department of Conservation. The deck has a reinforced concrete slab of about 9 inches thick and measures 12 feet wide by 18 feet long. There are no design plans for the bridge and no documents about maintenance of the bridge.

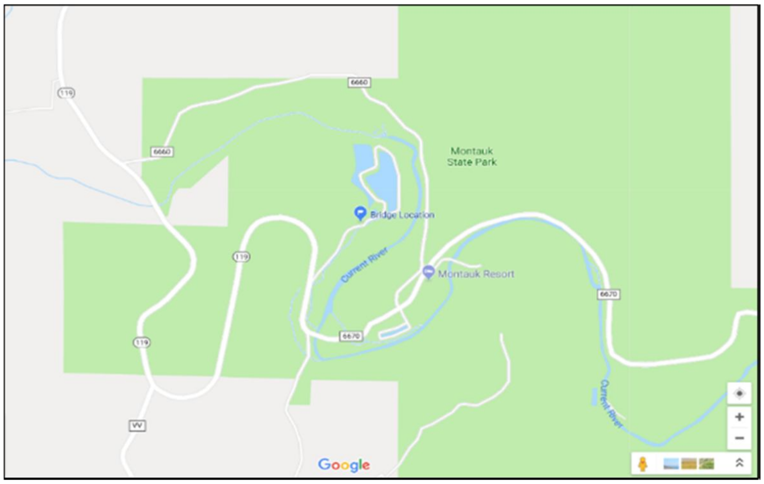


Figure 1. Map shows the location of the bridge.

B. Visual Evidence

Visual inspection was performed on both the top and bottom of the bridge deck. Loose of concrete surface were recorded and marked on the bridge plan on most of the deck area (Figure 2). Grooves about 2-3 inches deep were in a different location on the bridge deck (Figure 3), and exposed steel bars were found in another location, showing evidence of corrosion (Figure 4). The visual data was used to create a map of the defects to compare it with the PSPA data and the GPR data (Figure 5).

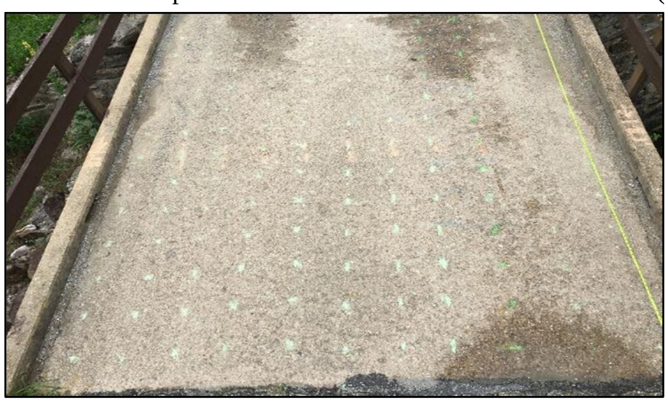


Figure 2. Visual evidence of loss of concrete surface.

Figure 3. Visual evidence shows deep grooves. (Grooves about 3 inches deep cover over half of the bridge deck area)

Figure 4. Visual evidence shows the exposed reinforcement steel bar. (In the picture is a corroded steel bars on the girder.)

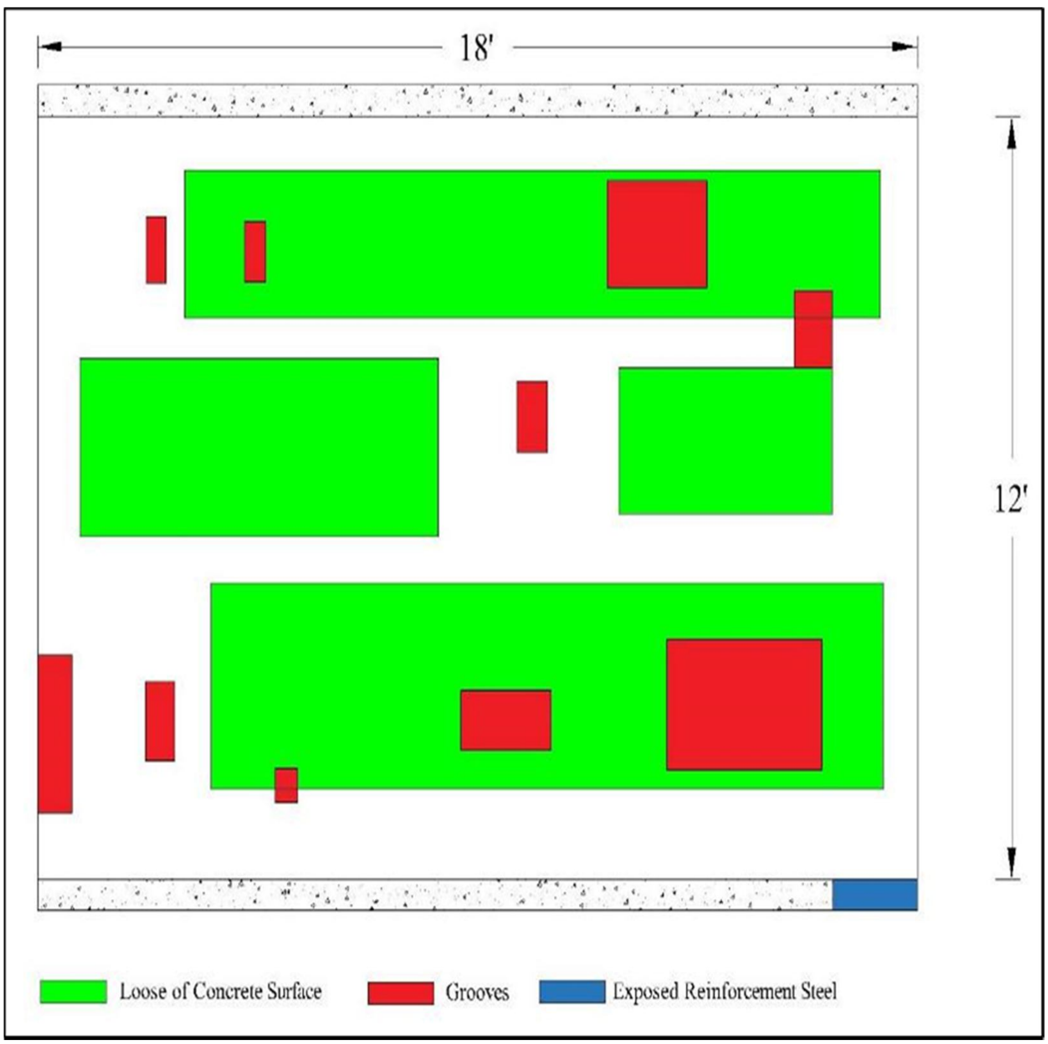


Figure 5. Detail map shows the type of the deterioration and its location on the bridge deck.

C. Portable Seismic Property Analyzer (PSPA)

Field scans were acquired based on point loading. Dense grid was used to provide high resolution data. A total of 88 stations were tested, and at least three repeated samples were taken at each station. The distance between each station was 2 feet in the longitudinal direction and 1 foot in the transverse direction, as shown in Figure 6.

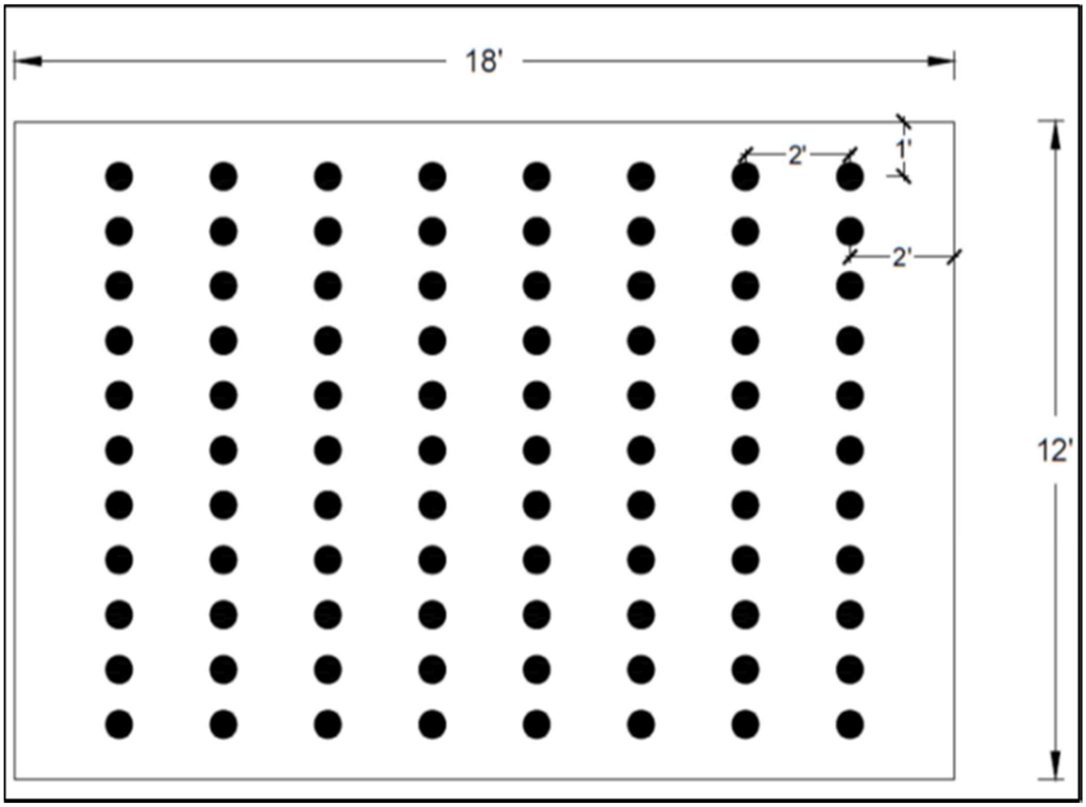


Figure 6. PSPA points location on Montauk bridge deck. layout of the location of the PSPA tests (11 lines total with 8 Stations per Line), total of 88 station.

The American Concrete Institute (ACI) specified the minimum average compressive strength of 2,500 psi for a concrete structure. A concrete deck with average compressive strength of 2,500 psi or less is considered poor condition. Table 1 shows the minimum requirement of the average compressive strength by the type of concrete structure [6].

Table 1. Specified average compressive strength by type of construction.

Type or location of concrete construction	Specified average compressive strength, psi
Concrete fill	Below 2,000
Basement and foundation walls and slabs, walks, patios, steps and stairs	2,500 – 3,500
Driveways, garage and industrial floor slabs	3,000 – 4,000
Reinforced concrete beams, slabs, columns and walls	3,000 –7,000
Precast and pre-stressed concrete	4,000 – 7,000
High-rise buildings (columns)	10,000 – 15,000

Note: For information purposes only; the plans and specifications give actual strength requirements for any job under consideration.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XII Dec 2021- Available at www.ijraset.com

3D map was generated showing the elastic modulus of the bridge deck (Figure 7). Another 3D map was generated showing the average compressive strength of the bridge deck (Figure 8).

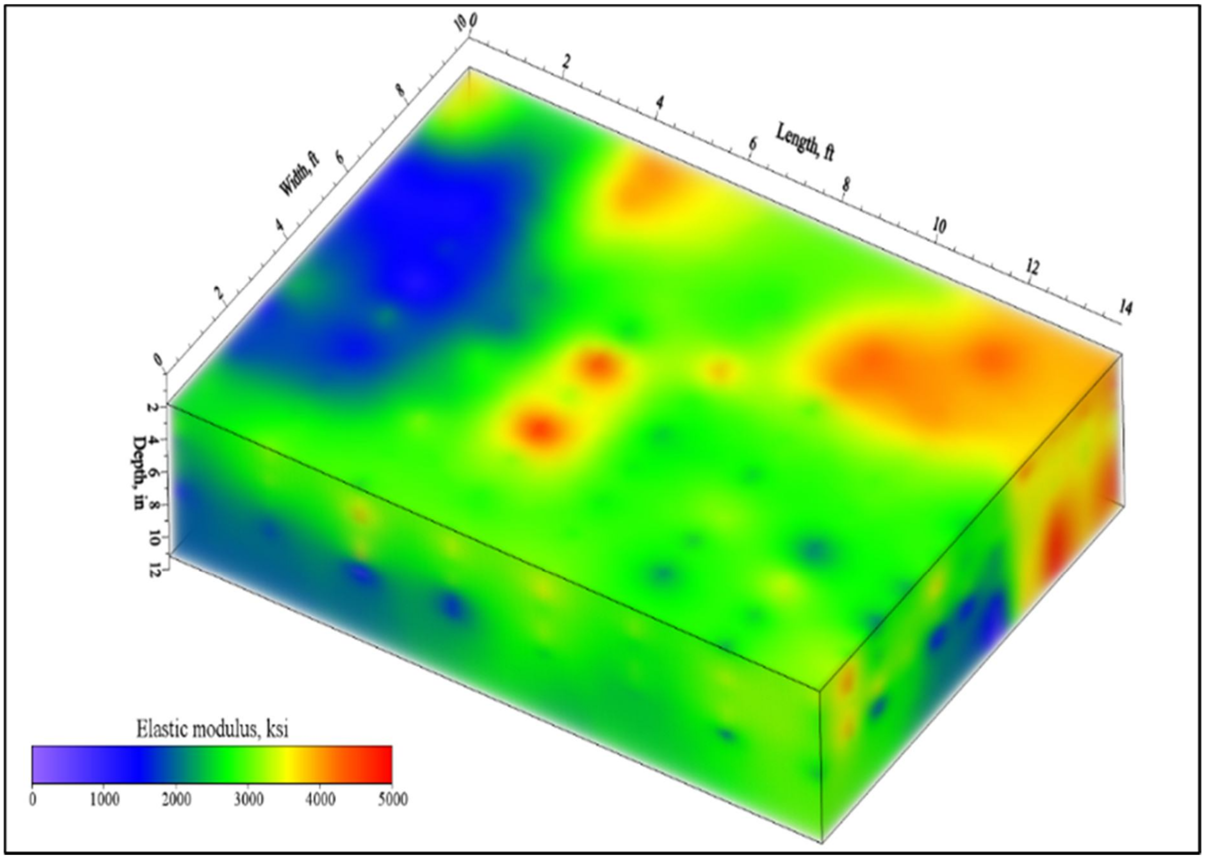


Figure 7. 3D map of the average elastic modulus of Montauk bridge deck.

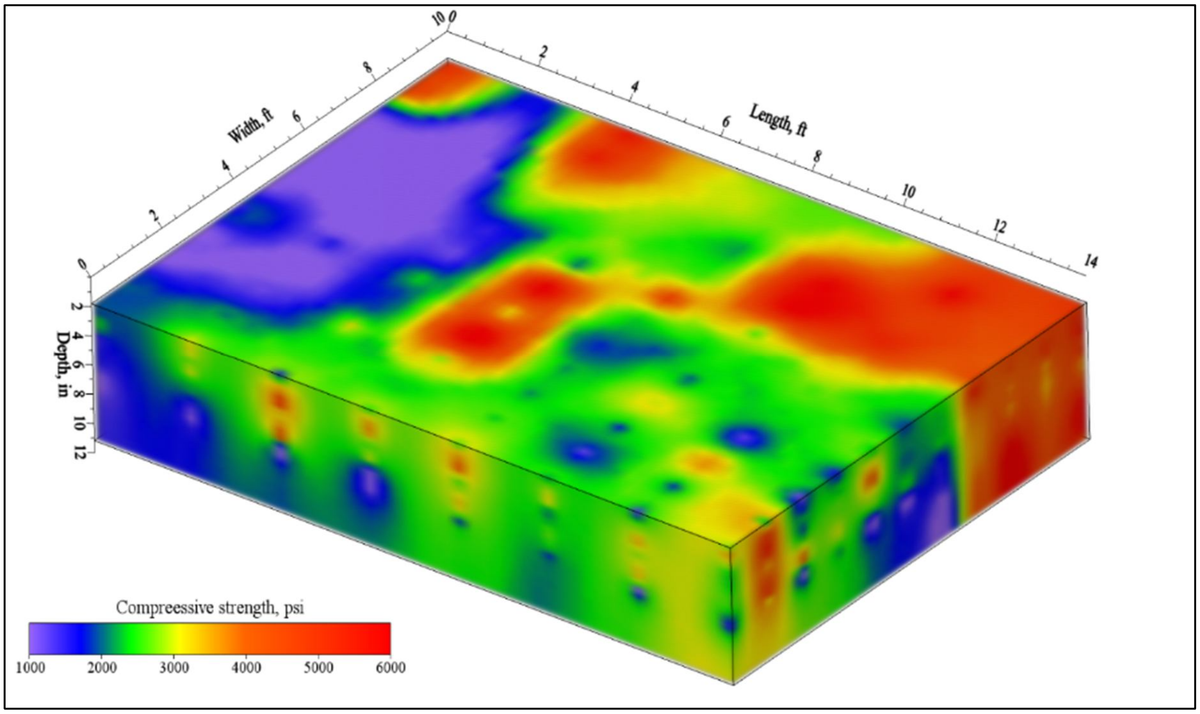


Figure 8. 3D map of the average compressive strength of Montauk bridge deck.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XII Dec 2021- Available at www.ijraset.com

D. Ground Penetrating Radar (GPR)

The GPR data were used to measure the variations in the amplitude reflected of each reinforcement steel bar; to measure the variations in the embedment depth of each reinforcement steel bar; and to generate a map showing amplitude variation across the bridge deck. Starting from the north east corner of the bridge and one foot from the edge, 11 data files were collected in 11 lines, in the same direction as the traffic flow, with 1 ft. spacing between each line (Figure 9).

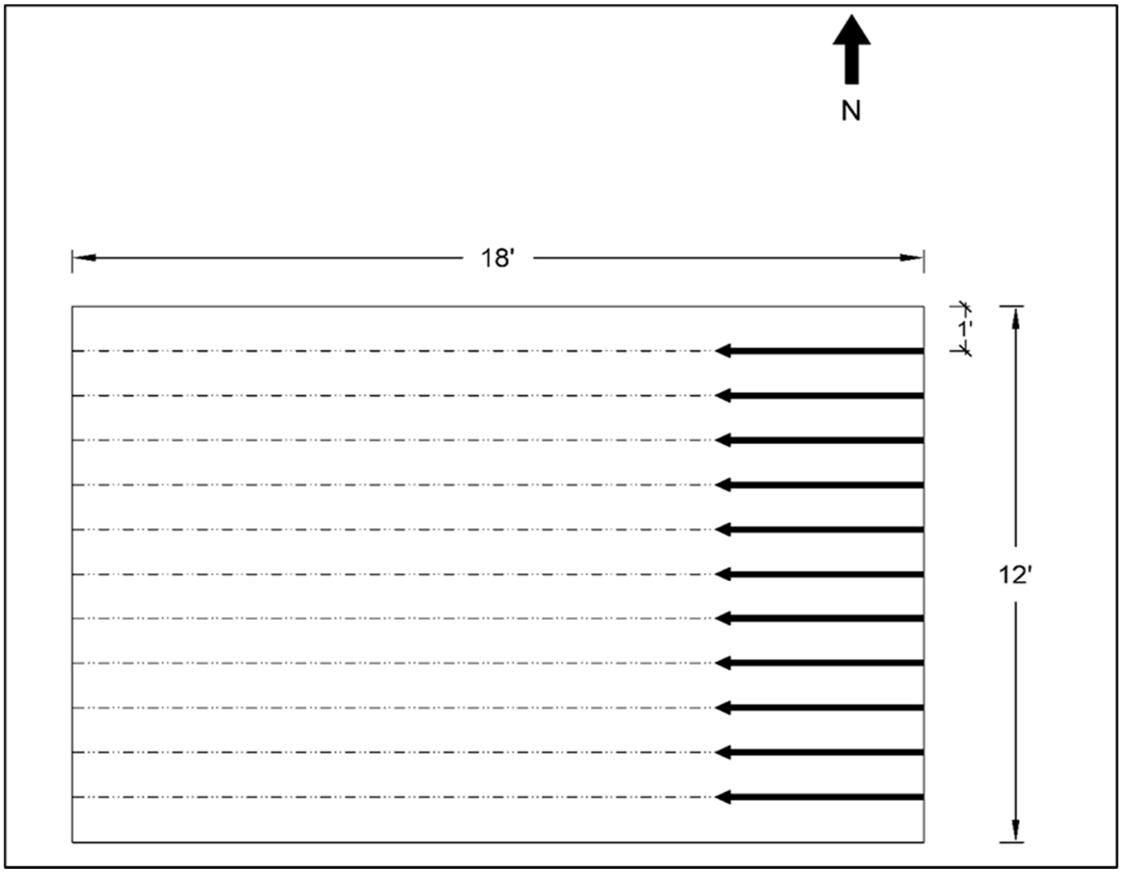


Figure 9. GPR layout.

Table 2. shows the rating scale of the concrete deck based on the magnitude value of the amplitude.

Table 2. GPR amplitude range rating condition scale

Concrete condition	Amplitude range (dB)
Good	28-32
Fair	24-28
Bad	20-24
Serious	16-20

The condition of the bridge deck is a function of the moisture content. The more moisture content in the concrete, the more conductivity. Additionally, the dielectric permittivity increased. As the signal attenuated more rapidly, moisture conductivity increased, and the amplitude of the reflection decreased. As shown in Figure 10, low amplitude was in most of the bridge deck.

Figure 11 is a side-by-side comparison between the 2D map of the average compressive strength and the 2D map of GPR amplitude reflection. The figure shows consistency where the area of the bridge deck was expected to be deteriorated. It is also very consistent where the concrete was expected to be in a good shape.

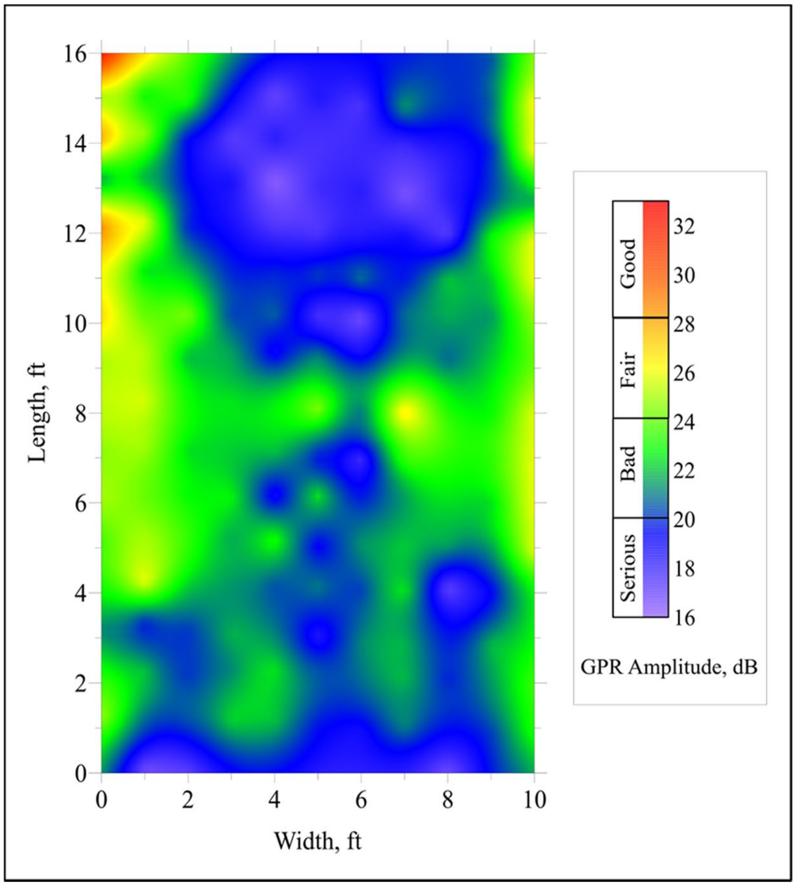


Figure 10. Amplitude reflection (dB) of Montauk bridge deck.

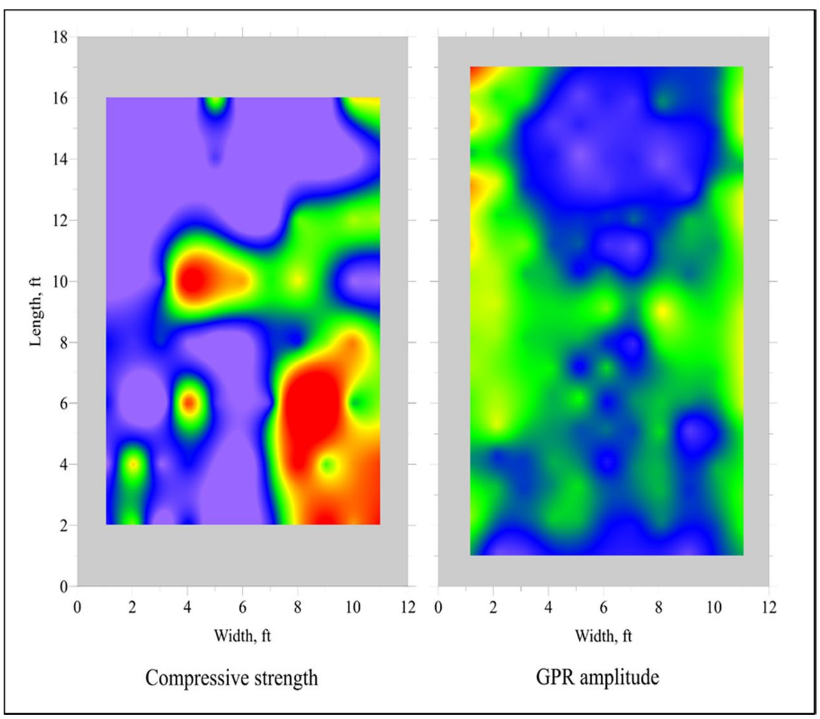


Figure 11. Compressive strength vs. GPR amplitude of the Montauk bridge deck.

III. CONCLUSIONS AND RECOMMENDATIONS

Bridge deck condition assessment were conducted at Montauk bridge deck using portable seismic property analysis (PSPA) and ground penetrating radar (GPR) tools, along with visual inspection. The PSPA tool measured the elastic modulus of the concrete bridge deck. Measuring the elastic modulus of the concrete bridge deck using PSPA tool and relating it to the compressive strength gave a solid condition assessment of the bridge deck (as compressive strength is one of the main factors used in assessing the condition of a concrete deck). The PSPA tool did not give any information about the upper 3 inches of the bridge deck. So, the PSPA assessments of the condition of the bridge deck are based on the condition of the bridge deck from a depth of 3 inches to 11 inches. The GPR tool responded mostly to the presence moisture content of the concrete bridge deck. GPR data were interpreted with the expectation that moisture content is a function of porosity, and that porosity is a function of the integrity. GPR tool was also used to accurately measure the pattern, placement, and density of reinforcing steel.

The interpretations of the data acquired using both tools correlated very well with each other and with visual inspection.

REFERENCES

[1] "Structurally Deficient Bridges | Bridge Infrastructure | ASCE's 2021 Infrastructure Report Card." [Online]. Available: https://infrastructurereportcard.org/cat-item/bridges/. [Accessed: 29-Nov-2021].

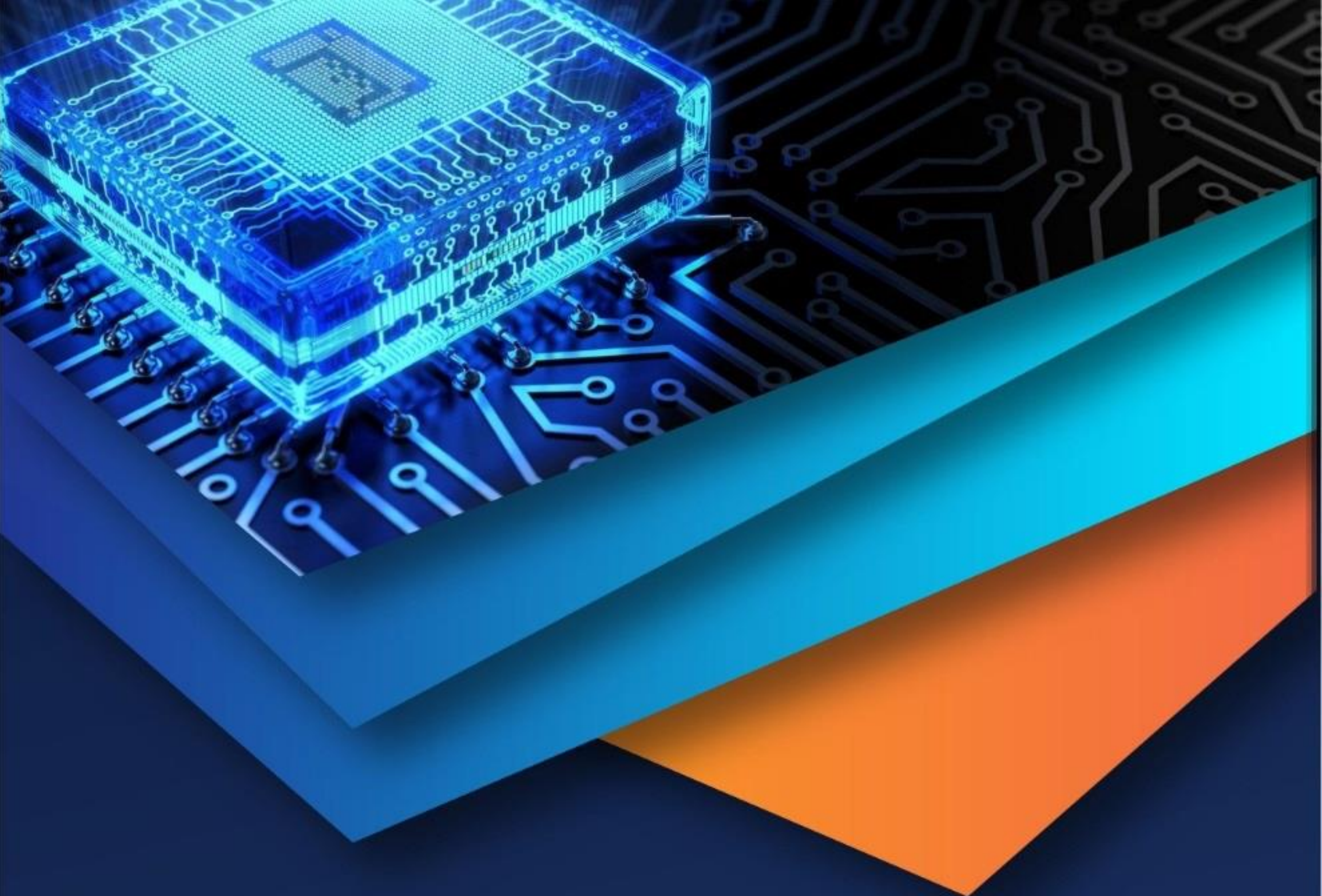
[2] H. Samie, O. Abdurraouf, A. Neil, and A. Wajdi, "Use of portable seismic property analyzer and ground-penetrating radar to assess bridge decks," in Symposium on the Application of Geophysics to Engineering and Environmental Problems 2021, Society of Exploration Geophysicists and Environment and Engineering Geophysical Society, 2021, p. 327.

[3] R. Parrillo and R. Roberts, "Bridge Deck Condition Assessment using Ground Penetrating Radar," Ecndt, vol. Tu.4, no. 2.5, pp. 1–12, 2006.

[4] N. Gucunski et al., "RABIT: implementation, performance validation and integration with other robotic platforms for improved management of bridge decks," Int. J. Intell. Robot. Appl., vol. 1, no. 3, pp. 271–286, Sep. 2017, doi: 10.1007/s41315-017-0027-5.

[5] H. Samie. Use of portable property analyzer and ground penetrating radar to assess bridge decks. Missouri University of Science and Technology, 2021.

[6] ACI Committee 222, "ACI 222R-01 Protection of Metals in Concrete Against Corrosion Reported by ACI Committee 222," Aci Comm. Rep., vol. 01, no. Reapproved, pp. 1–41, 2001.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY