**Old Bridges Made Safer**

(1) About half of the road and rail bridges in the U.S.A. will have celebrated their 50th birthdays by 2020, and according to a recent estimate by the U.S. Society of Civil Engineers, more than one in four US bridges are either structurally deficient or functionally obsolete. Replacing old bridges is not an option because of the capital costs needed and, in a lot of cases, shutting them down even temporarily would significantly disrupt traffic and have a big impact on the economy. The best choice is to develop technologies to monitor emergence of problems that could compromise the ***integrity*** of the bridge.

(2) The big wake-up call came with the collapse of a bridge carrying the I-35W highway over the Mississippi river in Minneapolis, Minnesota, in August 2007. It failed during rush hour, killing 13 people and injuring nearly 150. An investigation by the National Transportation Safety Board put the blame on design flaws, but the collapse also highlighted the need for more stringent inspections. In the US, human inspectors certify bridges every two years, but they can miss small cracks, problems in hard-to-access locations and internal damage. So in 2008 the National Institute of Standards and Technology launched the Technology Innovation Program in order to address “areas of critical national need.” Hundreds of millions of dollars were invested in developing sensors to monitor bridges.

(3) Many of the systems being tested in the framework of this program are based on piezoelectric sensors. These devices can take on a dual role. As well as generating a small current when they vibrate, to passively monitor vibrations in the structure, ***they*** can also actively probe for faults. Just as a medical ultrasound scanner uses an acoustic signal to image internal organs, so an active piezoelectric sensor can send an acoustic signal into a bridge’s interior. By listening to the returned signal, it can detect structural anomalies such as hairline cracks or areas of unusual strain. Such sensors could be placed along the roadway, girders and trusses. Each sensor would be fit into a router that would pick up data sent wirelessly by the sensor, which is then fed into a central computer.

(4) One type of such wireless sensors was developed by University of Maryland electrical engineering researcher Mehdi Kalantari. They measure all the variables reflecting the structural integrity of bridges that conventional wired systems do, such as strain, vibration, tilt, acceleration, deformation and cracking. The sensors themselves are less than five millimeters thick and are comprised of four thin, flexible layers. The first senses and measures structural parameters; the second stores energy; the third transmits data to central computer for analysis; and the outer layer harvests energy from ambient light and radio waves. While serious problems would quickly trigger an alarm, more subtle early-stage problems may take up to a few days until the system is confident enough to report a structural integrity issue.

(5) Kalantari says the sensors are rugged and, because they are self-adhesive, require no potentially damaging drilling into the bridge structure. They should last at least a decade with practically no maintenance required. As they harvest energy from ambient light and radio waves, they don't require any wires, batteries or dedicated external power source. With each unit costing about US $20, the total cost for an average-sized highway bridge needing about 500 sensors would be between $10,000 to $15,000, depending on the design and the overall condition of the bridge. ***This*** is affordable even in the period of strained budgets. By comparison, the cost of replacing a bridge like the one that collapsed in Minnesota is $250 million.

(6) In conjunction with the Maryland Department of Transportation, Kalantari has been testing the sensors by measuring the structural parameters of highway bridges in a real setting for almost a year. He says this has allowed him to optimize the device's performance and energy consumption with the updated model smaller and 10 times more energy efficient than its predecessor. The field testing has also allowed him to track the bridges' response to changes in weather conditions and traffic.

 (7) Jerome Lynch, director of the Laboratory for Intelligent Structural Technology at the University of Michigan in Ann Arbor, has created a sensor of a different sort: a “skin” made of polymers and carbon nanotubes that changes its electrical resistance when deformed, and that can be painted onto a bridge or other structure. He is going to test it out on ***wear***-prone portions of a bridge near the Ann Arbor campus. For the tests, Lynch will apply the skin to a patch of the bridge and line the area with electrodes. Two of ***these*** will transmit an electrical signal while the rest measure how the signal changes as it passes through the skin. The results will allow a computer to generate a two-dimensional image that, like an X-ray, will reveal details of the inside of the structure, providing a map of any damage ***it*** may have sustained.

(8) None of the sensors being developed now will renovate obsolete bridges, but they will make old structures considerably safer by monitoring their condition and giving early warnings about problems.

**Exercise 1: Referents**

What do the following words highlighted in the text refer to?

1. **they**, line 19 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. **this**, line 42 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. **these,** line 56 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. **it,** line 59  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Exercise 2: Vocabulary**

1. Study the chart below and use the dictionary to check the meanings of unfamiliar words.

**Verb Noun Adjective Adverb**

adhere adhesion adhesive

adhesive

adherence adherent

certify certification certified

certificate

deform deformation deformed

deformity

 disrupt disruption disruptive disruptively

 obsoleteness obsolete

 obsolescence obsolescent

precede precedence unprecedented

precedent preceding

set set set

 setting

stringency stringent stringently

sustain sustenance sustainable

transmit transmission transmitted

 transmitter

 **B.** Complete the following sentences using the appropriate words from the chart.

1. The accident in the city center caused widespread \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ for drivers in the whole town.
2. If the rules used to isolate the sick are applied less \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, the spread of the Ebola virus will be difficult to contain.
3. This anti-virus program is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and cannot protect your computer effectively.
4. Risky investments prevented the company from maintaining a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ level of growth.
5. Research methods mentioned in the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ section will be discussed in detail now.
6. High-speed data between different parts of the campus is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ through fiber optic cables.
7. These plastics \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ at temperatures of over 85˚ C.
8. After she obtained a nursing \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ she applied for a job in the local hospital.
9. He speaks French at home but he never uses it in professional \_\_\_\_\_\_\_\_\_\_\_\_\_ .
10. Companies which fail to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to waste disposal regulations will be fined.

**Exercise 3: Similar or different?**

In each line, circle the word or phrase that does not belong. Look for contextual clues in the passage.

**Deficient** (l. 3) partial – intact – fragmentary – defective – faulty

**Disrupt** (l. 5) disentangle – derange – make a mess – disturb - upset

**Flaw** (l. 11) drawback – shortcoming – limitation – fault – label

**Stringent** (l.12) strict – lenient – tough – demanding – severe – rigorous

**Trigger** (l. 33) activate – initiate – set off – provoke – halt

**Rugged** (l. 36) fragile – strong – durable – robust – sturdy

**Predecessor** (l. 49) precursor – forerunner – successor

**Exercise 4: Words often confused**

**Complete the following sentences choosing appropriate words in italics.**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ technologies often trigger exaggerated expectations.

*Emergency – Emergent – Emergence - Emerged*

1. Hundreds of people were left homeless after a hurricane and a state of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*emergency – emergent – emergence*

1. Metal fatigue is a weakness which develops in a metal structure subjected to many repeated cycles of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*strain - strains – stress - stresses*

1. Professional gymnasts often complain about \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ muscles caused by excessive stretching.

*straining – strained – stressing – stressed*

1. A metal-and-glass extension has ruined the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the 19thcentury stone building of the university.

*integration – integral – integrity*

1. Cyclists and builders are required to wear helmets to reduce the risk of head \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

*damage - injury*

1. The \_\_\_\_\_\_\_\_\_\_\_\_\_ caused by fire in our apartment house amounts to $1million and will take months to repair.

 *damage – damages – injury – injuries*

1. The court ordered the company found guilty of river pollution to pay 2 million NIS in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the city.

*damage – damages – injury – injuries*

1. The manager’s answers were \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and failed to explain the reasons for the company’s bankruptcy.

*deficient – deficiency – defective – defectively*

1. A \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ electricity line caused power shortage in the whole area.

 *deficient – deficiency – defective – defectively*

1. Soils \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in minerals need fertilizers to grow good harvests.

*deficient – deficiency – defective – defectively*

**Exercise 5: Comprehension**

**Circle the correct completion of each of the following statements:**

1. It follows from paragraph 1 that

 a. ageing bridges have to be carefully overseen.

 b. the use of structurally deficient bridges is uneconomical.

 c. bridges deteriorate and become unusable 50 years after construction.

 d. bridges that have become technologically outdated must be dismantled.

2. Which of the following did the collapse of the bridge in Minneapolis reveal?

a. bridge inspection was not vigilant enough.

b. semi-annual survey of bridges may be insufficient.

c. internal damage is impossible to discover before it is too late.

d. design of the bridge was impeccable but its maintenance was inadequate.

3. The reader can infer that the fatal accident in Minneapolis

a. was aggravated by the time of the collapse.

b. was triggered by fast propagation of cracks.

c. would not have been so grave if the bridge hadn’t spanned a river.

d. could have been avoided had the National Transportation Safety Board’s

 investigation included hard-to-access locations.

4. Which of the following correctly describes the operation of piezoelectric sensors?

I. They search vulnerable locations.

II. Their primary aim is to recognize fluctuations in vibrations.

III. They are linked into a network to transmit signals to each other.

IV. They communicate with a central computer by means of a router.

V. They can detect structural flaws before they threaten the integrity of the bridge.

VI. The mechanism underlying their probing ability is similar to that of a medical

 ultrasound scanner.

a. I and II

b. III and IV

c. II, V and VI

d. I, IV, V and VI

e. III, IV, V and VI.

5. The sensors developed by M. Kalantari

a. are fed by a single power source.

b. instantly report all emergent problems.

c. consist of four layers with identical functions.

d. measure the same variables as their wired counterparts.

e. are more effective for monitoring early-stage problems than emergency

 situations.

6. Which of the following is **NOT** mentioned among the advantages of sensors developed by Kalantari?

1. They are robust.
2. They are energy efficient.
3. They are relatively inexpensive.
4. They can serve for decades without maintenance.
5. Their installation leaves the structure of the bridge intact.

7. Field tests of the sensors designed by Kalantari

a. are yet to be conducted.

b. were carried out on all types of bridges.

c. enabled the designer to enhance their performance.

d. aimed to check the optimal weather conditions for their operation.

e. helped increase their energy efficiency at the expense of miniaturization.

8. The system designed by J. Lynch will

a. utilize X-rays to monitor damage of the structure.

b. help trace structural problems by means of electrical signals.

c. rely on two electrodes to respond to the polymer deformation.

d. be applied exclusively in the parts prone to wear and structural deterioration.

9. The author of the article seeks to show that

a. sensors cannot extend the use of old bridges.

b. installing sensors is a viable solution to ageing bridges.

c. regular human inspection is sufficient to check bridge safety.

d. the federal government’s attitude to bridge maintenance is negligent.

e. smart sensors can do little when installed in structures prone to sudden collapse.

10. The word ***integrity****,* as it appears on line 7, means

a. honesty b. unimpaired condition c. cohesion

11. The word **wear,** as it appears on line 59, means

a. clothing b. durability c. damage

**Exercise 6: Prepositions**

Complete the following sentences using prepositions where necessary.

1. The engine apparently shut \_\_\_\_\_ 15 minutes after take-off.
2. People are prone \_\_\_\_\_\_\_ illnesses when they are stressed and exhausted.
3. Better medications \_\_\_\_\_\_ conjunction \_\_\_\_\_\_ better sanitations helped health workers reduce the incidence \_\_\_\_\_\_ contagious diseases.
4. The impact of computers \_\_\_\_\_\_ routine office work is hard to overestimate.
5. There is a growing need \_\_\_\_\_\_\_ rented accommodation in large cities.
6. If you drive \_\_\_\_\_ a dirt road after rain, stay \_\_\_\_\_\_ low gear.
7. One \_\_\_\_\_ five children in this area is undernourished and deprived \_\_\_\_\_\_\_ adequate healthcare and education.
8. Before the data is fed \_\_\_\_\_ the system, check whether all the client’s requirements were taken \_\_\_\_\_\_ consideration.