ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization   Volume 3, Special Issue 2, April 2014

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

Health Assessment for Structures Using MEMS Technology

[1]Dr.N.Kottiswaran, [2]Mr.K.A.Jayabalaji, [3]S.Deepak, [4]S.Priyadarshini,

[1]Principal, Sengunthar Engineering College, Thiruchengode, India.

[2]Research Scholar, Anna University, Chennai, India.

[3]Department of Civil Engineering, Anna University, Sengunthar Engineering College, Thiruchengode, India.

[4]Department of Electronics and Communication Engineering, Anna University, Tejaa Shakthi Institute of Technology for Women, Coimbatore, India.

ABSTRACT: Industrialized nations have a colossal asset in the ubiquitous civil infrastructure on which our lives rely. To properly manage this infrastructure, its plight or amenity should be loyally appraised. For plight or amenity assessment, Structural Health Monitoring (SHM) has been scrutinizing to furnish information on the ongoing state of structures by grading structural vibration responses and other physical phenomena and circumstances. For quintessential structure the nature of the structure must endure in the domain stated in the design. Although this can be modified by typical aging due to usage, by the response of the environment, and by accidental crisis. So the smart material based pressure sensor using MEMS Technology has been proposed. This could detect the damage in prior and save the huge structure from crash.

KEYWORDS*:* Structural Health Monitoring, Smart materials, MEMS Technology, Pressure sensor.

I. INTRODUCTION

Commercial and industrial structures are omnipresent in whole society, disregard of culture, religion, geographical whereabouts and economical progress. It is arduous to depict a society without buildings, roads, railways, bridges, tunnels, dams and power plants. Therefore good architecture, trait construction, durable and safe exploitation of structures are objective of structural engineering. Malfunctioning of civil structures often has deliberate consequences. The most genuine is mishap involving human victims. The safest and most tenacious structures are those that are well managed.

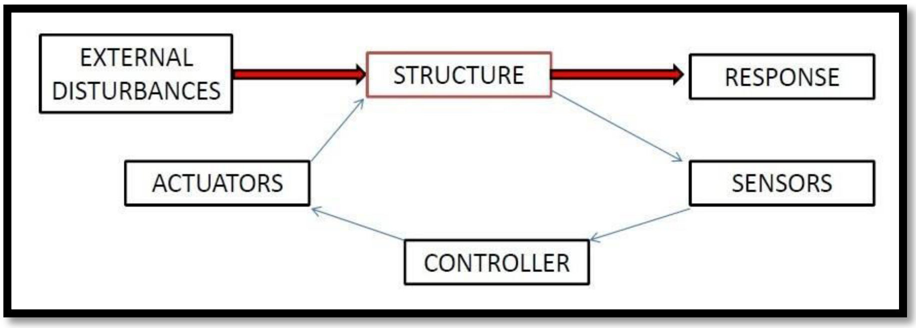

Fig.1: Basic block diagram for SHM

Measurement and monitoring often have crucial roles in management activities. The data culminates from a monitoring programme that are used to intensify the operation, maintenance, repair and replacing of the structure based on predictable and equitable data. Structural Health Monitoring (SHM) gives each moment during the life of a structure and interpret the state of the essential materials of the distinct parts. Assessing the in-service conduct of structures using

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 2, April 2014

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

a array of measurement techniques that margin to the SMART structure. For quintessential structure the state of the structure must persist in the domain itemized in the design. Although this can be altered by typical aging due to usage, by the action of the environment, and by accidental situation. So in order to get rid of this obstacle we need to implement following steps: (1)inspect current condition, (2)evaluate the structure to find load bearing capacity, (3)steady monitoring to audit the condition of the structure. This process may lack the assimilation of sensors, possibly smart materials, data transmission, computational power and processing capability inside the structures. It makes it possible to re-examine the idea of the structure and the full management of the structure itself and finally the structure included as a part of broad system. Knowing the virtue of in-service structures on a continuous real-time support is a very important goal for manufacturers, end-users and maintenance teams. In effect, SHM grant an optimal use of the structure, a minimized downtime, avoidance of catastrophic collapse and gives the constructor advancement in his products.

II. CHALLENGES

Slump of critical infrastructure such as bridges, pipelines, and railways is a usual, yet complex problem. Currently, a mandated bi-annual inspection is the most accepted practice used to monitor the structural virtue of bridges. However, not automatic inspections have proven to be inadequate for ensuring safety. Such inspections do not provide enough data to avert catastrophic failures. So this hikes the demand for monitoring of contemporary designs and materials for exceptional management of present structures. The ongoing development of new sensors, Smart materials, Data acquisition systems (DAS), Wireless and internet technologies, Data transmission, collection, archiving, retrieval systems, data processing and event identification can boost the accuracy and reduce existence of catastrophe with less human effort.

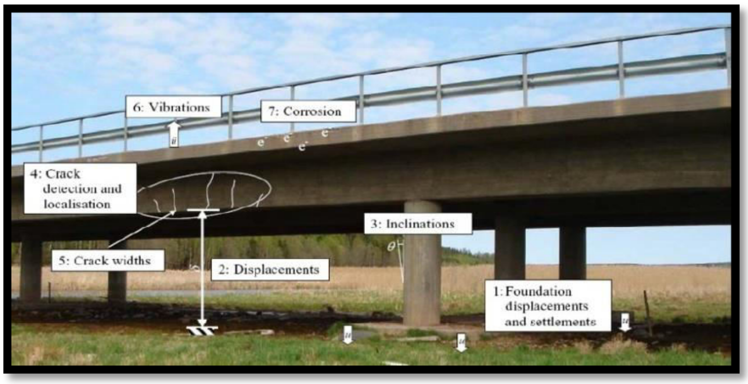

Fig.2: Physical phenomena that affects the structure

The following things should be considered to overcome the challenges as shown in Fig.2,
Load -Measured using load or implied using strain data.
Deformation - Measured using various transducers.
Acceleration - Measured using accelerometers.
Wind Speed and Pressure - Measured using anemometers.
Acoustic Emissions - Measured using microphones.
Video Monitoring- Monitored via emerging internet camera technologies.

III.FACTORS TO BE CONSIDERED

Extremely crucial component incorporate conversion of abstract data signals into valid information about structural response and condition which do not have definitive rules that endure for diagnostics. The next important factor is to monitor unanticipated events and pinpoint location of damage to locate the mark of impact. Image damaged region should be monitored continuously with some sensor network which is non-invasive and has multiple applications to reduce the cost and to enhance sensing speed. So SHM sensors are installed around the damage region to monitor more

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 2, April 2014

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

damage growth. This sensor should be built in such a way that it could able to predict the type of structure, type and location of sensors worn, motivation for monitoring and Structural responses under deliberation.

IV. MATERIALS AND METHODS

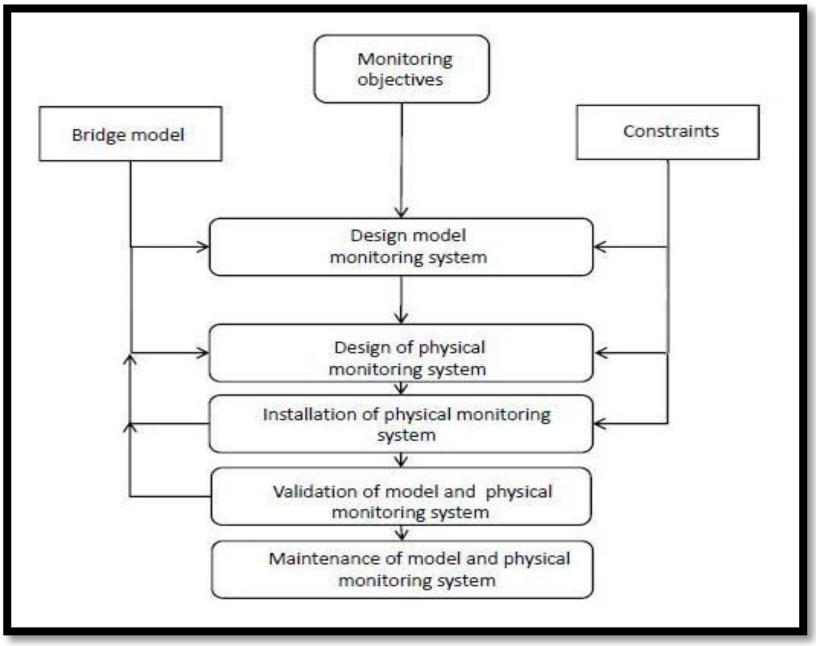

Fig.3: Basic Monitoring Methodology

Ideal SHM system encompasses the Information on demand about the structure's health and warnings respecting any deterioration detected. Evolution of a SHM system associates utilizing information from different engineering disciplines such as Computers, Materials, Communication, Structures, Sensors, Damage Detection, Intelligent Processing and Data Collection. Recently wired and wireless sensors are available that could able to encounter displacement, material specific and corrosion but it could not able to sense the crack. Similarly Laser Interferometers and Deep penetration radar with GPS technology can able to sense crack, corrosion, temperature and displacement but fails to sense humidity materials specific.

A. *Fibre Optic Method*

Fibre-optic sensors are gaining attention in the meadow of structural health monitoring. The operation starts with dispatching of light beam (laser) from optical fibre fronting a gauged length. That light waves measure variations in actual shape (i.e. elongation or contraction) which involves shift in reflected light waves and is correlated to strain reading that demodulates, thus the unit calculates strain from light signals and gives voltage. Therefore, DAS transforms voltage to strain data for processing. So that the damage can be stated as changes imported into a system that adversely influence its current or ultimate performance.

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 2, April 2014

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

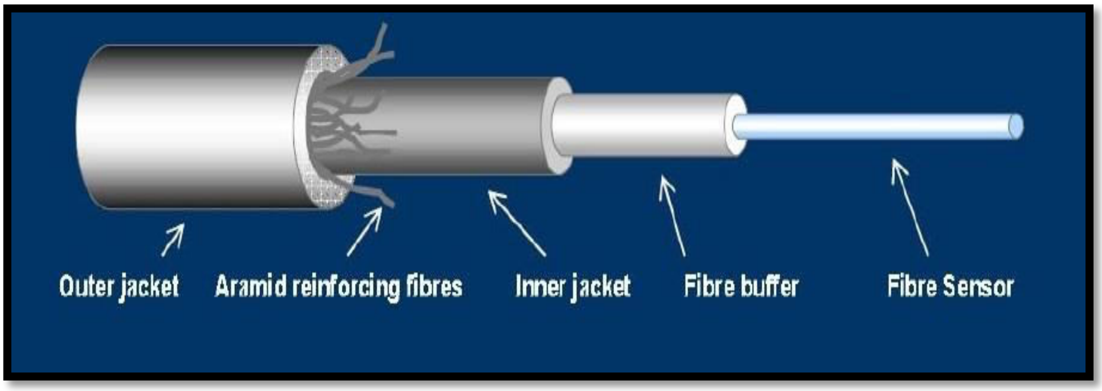

Fig.4: Typical Optic Fibre

This sensor system is recommended for static and dynamic monitoring and it is embeddable, bondable and woundable. Gauge length can range from cm to more than 1 km. Thermal and mechanical strains can be detached. FOC is mainly used to scale the width of cracks, strain transfer in bonded joints and stress concentrations.

Even though the system has many **circumstance**s, it has some issues like design issue, installation issue and usage issue. Other factor like Abrasion occurs during manipulation and installation. Then moisture dwindle the fibre, alkaline environment is inimical to glass fibres that is correlate with building concrete.

B. *Sensor*

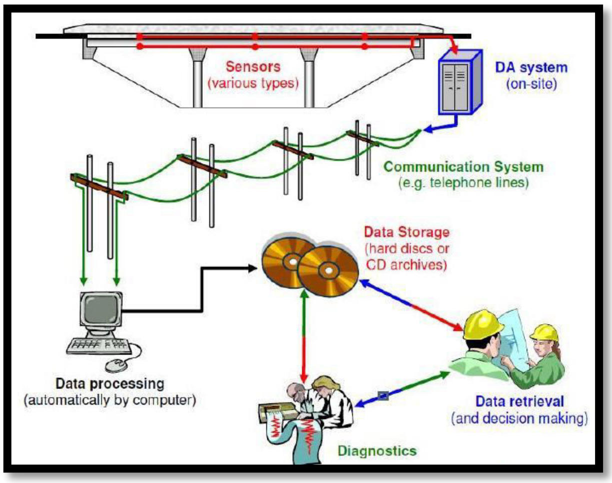

Fig.5: Sensor network in SHM

When more number of sensors is enforced, wireless communication appears to be adorable. The high cost affiliated with the installation of wired sensors and this can be greatly scaled down by employing wireless sensors. Wireless sensors recurrently transform analog signals to digital signals prior to radio frequency (RF) transmission, while numerous wired systems accumulate analog signals at one or more base stations where the signals adaptation takes place. The digital conversion on the wireless sensor node throw out possible signal degradation during analog signal communication buttoned up on long cables. Wireless sensor systems are, thus, auspicious as data acquisition systems with a abundant number of sensors installed on sizable structures.

Smart sensor technology has been under spry development in recent years. A smart sensor is able to convert the physical state of an entity or environment such as temperature, light, sound, and motion into electrical or other types of signals that may be further treated. A single smart sensor node may have infrequent sensors measuring various

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization *Volume 3, Special Issue 2, April 2014*

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

physical quantities. Micro-Electro-Mechanical System (MEMS) devices, which are the assimilation of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through microfabrication technology, are often employed for sensors by virtue of their small size, inexpensive cost (when mass produced), and low power consumption.

The main objective of this sensor is to sense the localized pressure in the highway bridges particularly near the crack tips. Monitoring the crack buildup on the bridges can lead to early discovery and inhibit bridge failures. Pressure sensors can be used as transducers that produce an electrical signal. The Pressure sensor is used due to its benefits like low power consumption, low temperature sensitivity, high dynamic range, high pressure sensitivity and miniature size.

The MEMS based Pressure sensor which is made up of silicon material is capable of sensing pressure by deforming from its original position. This is a U-shaped structure in which it is divided into three domains. Domain one and two are cylindrical in shape that could sense the pressure experienced when load is applied and domain three is a fixed portion that may not vary from its original structure. The geometry of this sensor is shown in Fig.6.

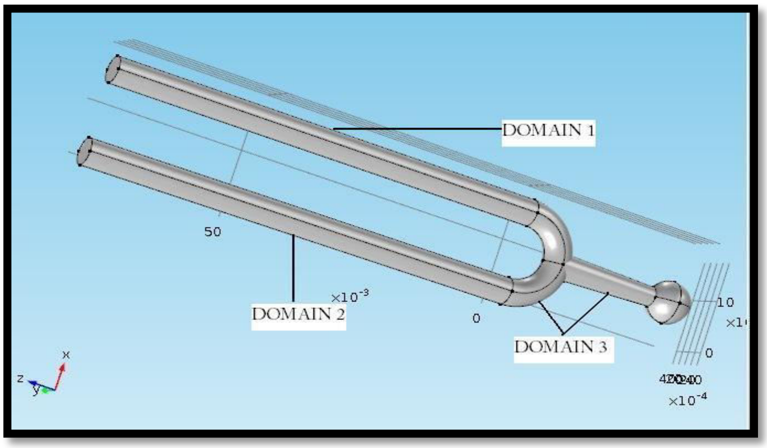

Fig.6: Geometry of Pressure Sensor

The pressure sensor is given Young modulus E = 160 GPa, Poisson ratio ν =0.22. Then the deformation in the pressure sensor occurs due to all the given parametric values as shown in Fig.7. This sensor helps to understand the structural behavior, pinpoint early damage, assure the structural strength and serviceability, and hereby decreases the down time for inspection and repair, develop the rational maintenance/management strategies, and increase the effectiveness in allocation of scarce resources and enables the use of new and innovative materials.

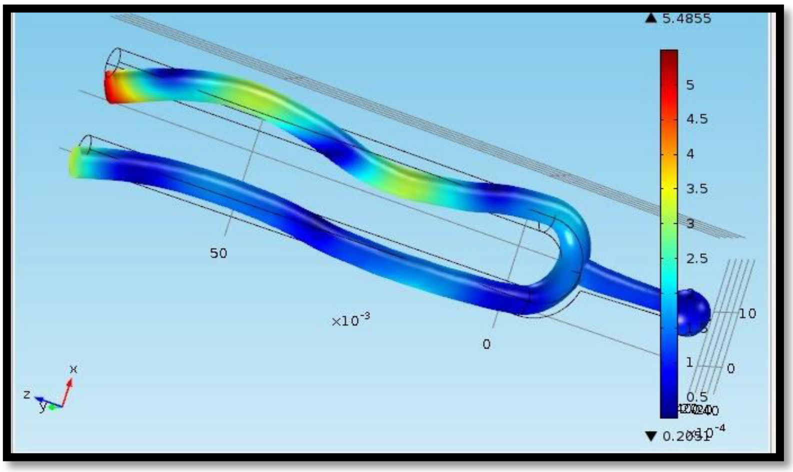

Fig.7: Simulation result after applying pressure to the material

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization *Volume 3, Special Issue 2, April 2014*

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

V. CONCLUSION

Thus the basic definition of MEMS Pressure sensor has been studied and the factors affecting have been discussed. The localized pressures in the highway bridges especially near crack tips have been detected and the solution is given accordingly. Previously Microcontroller based sensors with wired medium have been used which was not so effective and also has high installation cost. So in order to overcome this drawback a smart material based MEMS Pressure sensor has been proposed that has various advantages like low power consumption, temperature independent, and miniature in size and thus do not hinder the life of bridge. The basic design of Pressure sensor using MEMS Technology was presented.

VI. FUTURE WORK

Electromagnetic systems, Fibre Optic sensing system and Microcontroller based sensors network are not suitable for all type of structures. And the initial cost for installation is also high because of using wired medium. So blossoming technology like MEMS Technology sensors are most suitable and can be used for all kind of structures. In order to save many historical buildings and tough structures this type of Pressure sensor is suggested and is able to sense the pressure in different form such as wind, load, deformation in structure, acoustic emissions and acceleration. Replacing MEMS Technology devices will save many structures.

REFERENCES

[1] Aoki, S., Fujino, Y., & Abe, M. (2003).“Intelligent bridge maintenance system usingMEMS and network technology.”*Proceedings of SPIE - Smart Systems and NDE forCivil Infrastructures*, 5057, 37-42.
[2] Basheer, M. R., Rao, V., &Derriso, M. (2003). “Self organizing wireless sensor networksfor structural health monitoring.” *Proceedings of the 4th Int. Workshop on StructuralHealth Monitoring*, Stanford, CA, 1193-1206.
[3] Bernal, D. (2006).“Flexibility-based damage localization from stochastic realization results.”*Journal of Engineering Mechanics*, *132*(6), 651-658.
[4] Biswas, M., Pandey, A. K. &Samman, M. M. (1990).“Diagnostic Experimental Spectral/Modal Analysis of a Highway Bridge.”*Int. Journal of Analytical and ExperimentalModal Analysis*, *5*, 33-42.
[5] Brincker, R., Zhang, L., & Andersen, P. (2001).“Modal identification of output-only systemsusing frequency domain decomposition.”*Smart Materials and Structures*, *10*,441-445.
[6] Casciati, F., Faravelli, L, Borghetti, F., &Fornasari, A. (2003). “Future trends in infrastructuremonitoring.”*Structural Health Monitoring and Intelligent Infrastructure*, 2,997-1002.
[7] Farrar, C. R., Baker, W. E., Bell, T. M., Cone, E. M., Darling, T. W., Duffey, T. A., Eklund,A., &Migliori, A. (1994). “Dynamic characterization and damage detection inthe I-40 bridge over the Rio Grande.” *Los Alamos National Laboratory Report LA-12767-MS*.
[8] Karbhari, V. M., Guan, H. & Sikorsky, C. (2003).“Web-based structural health monitoringof a FRP composite bridge.”*Structural Health Monitoring and Intelligent Infrastructure*,*1*, 217-225.
[9] Li Cao, Tae Song Kim, Susan C. Mantell, Dennis L. Polla, Simulation and fabrication of piezoresistive membrane type MEMS strain sensors, *Sensors and Actuators* 80: 273–279 (2000).
[10] Lynch, J. P., Law, K. H., Kiremidjian, A. S., Carryer, E., Kenny, T. W., Patridge, A., &Sundararajan, A. (2002). “Validation of a wireless modular monitoring system forstructures.”*Proceedings of SPIE - Smart Structures and Materials: Smart Systems forBridges, Structures, and Highways*, San Diego, CA, 4696(2), 17-21.
[11] Mufti, A. A. (2003). “Integration of sensing in civil structures: development of the newdiscipline of civionics.”*Structural Health Monitoring and Intelligent Infrastructure*,*1*, 119-129.
[12] Nagayama, T., Abe, M., Fujino, Y., & Ikeda, K. (2005).“Structural identfication of a nonproportionally damped system and its application to a full-scale suspension bridge.”*Journal of Structural Engineering*, *131*(10), 1536-1545.
[13] Ou, J. P., Li, H. W., Xiao, Y. Q., & Li, Q. S. (2005). “Health dynamic measurement of tall building using wireless sensor network.”*Proceedings of SPIE - Smart Structures andMaterials*, *5765*(1), 205-215.
[14] Ruiz-Sandoval, M. (2004).“Smart sensors” for civil infrastructure systems (Doctoral dissertation,University of Notre Dame, 2004).
[15] Ruiz-Sandoval, M., Nagayama, T., & Spencer, B. F., Jr. (2006).“Sensor development usingBerkeley Mote platform.”*Journal of Earthquake Engineering*, *10*(2), 289-309 .
[16] Smith, Charles S. "PiezpresistanceEfect in Germanium and Silicon." *Physical Review* 94, no. 1, 42-49, (April 1954).
[17] Studer, M. & Peters, K. (2004).“Multi-scale sensing for damage identification”, *SmartMaterials and Structures*, *13*, 283-294.
[18] Sun, C. T. and Lu, Y. P. (1995).*Vibration damping of structural elements*. EnglewoodCliffs, NJ: Prentice Hall.
[19] Tanner, N. A., Wait, J. R., Farrar, C. R., &Sohn, H. (2003). “Structural health monitoringusing modular wireless sensors.”*Journal of Intelligent Material Systems and Structures*,*14*(1), 43-56.