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HMSME 2007

October 16–18, 2007, Southeast University, Nanjing, China

Edited by
Aiqun Li George C.Sih
Herman F.Nied Zhaoxia Li

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Foreword

The October 16 – 18, 2007 conference held at the Southeast University, Nanjing, China can hardly do justice to cover a topic as diversified as the Health Monitoring of Structure, Material and Environment (HMSME). Despite the time limitation, researchers can benefit by meeting and discussing possible areas of collaboration. The impetus was provided by the 2005 US-China seminar that emphasized the mitigation of structural failure. To this end, effectiveness of the overall health monitoring system takes priority, not to mention the appropriate supporting components, both in software and hardware. The former can entail the development of damage models in connection with the monitored signal while the latter can involve sophisticated electronic, optical and infrared devices with varying degree of accuracy. Analytical models need to be identified with the physics of damage depending on the time and size scale. The same holds for the accuracy of the instrumentation that requires an a priori knowledge of the defect type and size, if not the location. The overwhelming complexities of a complete health monitoring system for structures can be of unmanageable proportion unless systematic approaches are carefully thought out to minimize redundant parameters. Lacking in particular is a general framework within which the monitored data can be translated into initiation of local failure in relation to global termination.

Notwithstanding the effort made by the organizing committee, the 223 papers in the proceedings only scratched the field of structural health monitoring. They, however, do show the interest of the contributors, the majority of whom dealt with the computational aspects of bridge design and monitoring methods. Damage analysis applied mostly at the structure scale as they followed the traditional path of leaving out the effect of initial imperfections. Pre-existing flaws were not accounted for in the material. This is analogous to using the classical SN curves for fatigue. It was the advent of fracture mechanics that alerted to the scatter reduction of the SN data when the pre-existing defect size were accounted for. Specifics of the damage with reference to the time and size scale are necessary if health monitoring is intended to provide warning for failure. This is not the same as the gathering of after thought design data that could not be obtained by test without having the structure built. By in large, health monitoring refers to the detection of potential mal function of the system caused by aging or unexpected disturbance. The time span for re-evaluating the remaining life of bridges is about 20 ~ 30 years. The same should be done for buildings or bridges after an earthquake or hurricane. The August 1, 2007 collapse of the I-35W bridge in Minneapolis is a case where health monitoring should have been administered long before the bridge was deemed to be structurally deficient as early as 1990. The time scale for monitoring bridges can be about 20 ~ 30 years and the defect size scale can be 0.5 to 100 or more centimeters. The other extreme is the August 14, 2007 disaster of the Fenghuang bridge in Hunan. It was totally destroyed during construction. Neither the time nor the size scale can even be defined for health monitoring.

Apparently, the real application of structural health monitoring has not even been recognized and/or accepted by the transportation authorities who are responsible for the public safety. In the US alone there are more than 700 000 aging bridges with design similar to the I-35W. The bottom line is that the development of the health monitoring technology is not being directed to areas where failure and disaster can be mitigated. Monitored data need to be able to distinguish the following three conditions of structural damage:

- *structure over designed in contrast to under designed with reference to the selected strength or failure criterion,*
- *structure under designed and later became over designed because of rehabilitation or other factors, and*
- *structure over designed and later became under designed owing to change in loading conditions or otherwise.*

The first pertains to testing of structural design criterion. The cross over points from under design to over design or vice versa in the second and third are the real issues that health monitoring should address. They are intimately associated with validation and cost of the methodology. This is analogous to the fracture control methodology approved by

FFA and currently practiced by the airline industry. Even though the aircrafts experience multiple structural damage types, fracture and fatigue by "cracking" are most dangerous. The collapse of bridges and buildings are similar.

Knowing that all structures are vulnerable to failure, reliability and safety aspects of structural and material evaluation cannot be avoided when discussing health monitoring. They constitute part of the data interpretation process. Costly lessons were learned from the catastrophic disaster of the Comet jet liners and the Titanic in the 1900s that led to the concept of "fail-safe". That is to *extend the time dependent path between local failure initiation and global total destruction.* The aircraft can be ruptured but still land. The passenger can have time to leave the ship before capsize. Portion of the World Trade Center in NY could have remained in tact after impact. The I-35W bridge could have distorted without pan-caking into the Mississippi. Note that a structure can have redundancy but not necessarily fail safe. The capability to exercise fail safe lies in the determination of the time and path of fracture from local to global where the combined effects of material, geometry and loading are accounted for. This methodology has been available and can be readily employed with current computational capability.

Despite the diversification of disciplines associated with health monitoring, much has been gained from the presentations prepared by the contributors. Their efforts are acknowledged. Special thanks are due to Professors Zhaodong Xu, Dr. Tong Guo, and Huifang Ren for their assistance in the editorial work that has made this volume possible.

Nanjing, China
September, 2007

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