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STRUCTURAL HEALTH MONITORING FOR EARLY RECOVERY OF BUILDING FUNCTIONALITY AND SERVICEABILITY AFTER EARTHQUAKES
- System verification in large shaking table test of steel high-rise building -

Michihito Shiraishi[1]

[1] *Senior Research Engineer, Institute of Technology, Shimizu Corporation, Tokyo, Japan*
Email: m.shiraishi@shimz.co.jp

ABSTRACT :
Structural health monitoring (SHM) is a technology to assess structural conditions using sensors installed in buildings. In Japan, effectiveness of the SHM was firstly pointed out at the Southern Hyogo prefecture earthquake in 1995, and attracted the widely attentions as one of the solutions, which can be applied efficaciously to the BCP (business continuity planning) at the Mid Niigata Prefecture Earthquake in 2004. Then, under the current circumstances of highly activated seismic activity around Japan after the 2011 off the Pacific coast of Tohoku Earthquake, expectations to the SHM has much more increased.
Based on these backgrounds, as a research activity to realize the SHM, the five-year special research project for urban disaster mitigation (FY2012-FY2016) has been conducted through collaboration between industry, academic and government. In this research project, we have developed two types of SHM prototype systems: Level 1 and Level 2 system. The Level 1 system has already been reached technically at a practical application level, which is mainly aimed for structural damage identification in a building story level using a limited number installed of high-precision conventional servo-type accelerometers. The Level 2 system is still a challenging research stage for the near future, which attempts to detect building damages in structural member level resolution using super high-density deployed new-types of MEMS 6 axis vibration sensors.
To verify the performances of these two types of SHM systems, we applied the systems to the large shaking table test of steel high-rise building, which was conducted as a part of the project in December 2013 at E-defense (3-D full-scale earthquake testing facility, NIED) to clarify the collapsing process of super-high-rise steel building. In the test, the testing specimen was the 1/3 scaled 18-story steel building which was about 25m high and 420t weigh, and input ground motions to the specimen were gradually increased from small earthquake level until the specimen collapsing. 25 sensor of Level 1 system and 152 sensors of Level 2 system were installed to the testing specimen to monitor the changing of structural state at each ground motion levels (Figure 1). In the series of the test, the Level 1 system has verified its performance to identify vibrating response states of the whole building using only a few points of sensors (Figure 2 (a)). The Level 2 system has also shown its capability to detect both of existence and location of very minor and local structural damages, such as fractures of flanges at the end of steel beams in high reliability (Figure 2 (b)).
The Level 1 and Level 2 systems will also be applied to the next E-defense large shaking table test of RC building scheduled in January 2015.

KEYWORDS:
SHM (structural health monitoring), BCP (business continuity planning), Damage detection, MEMS sensors

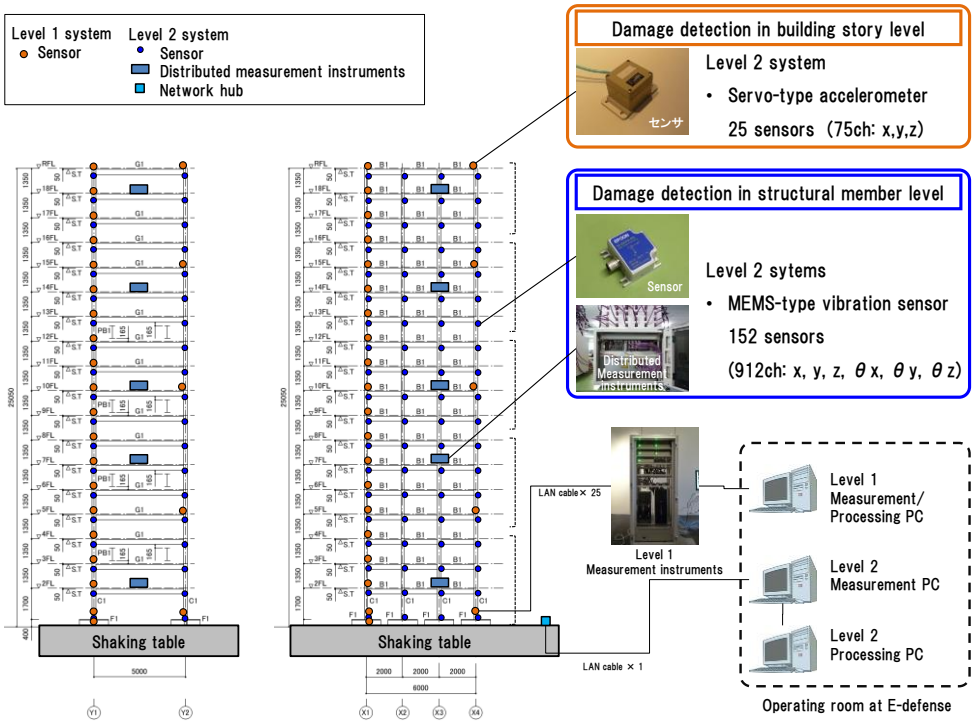
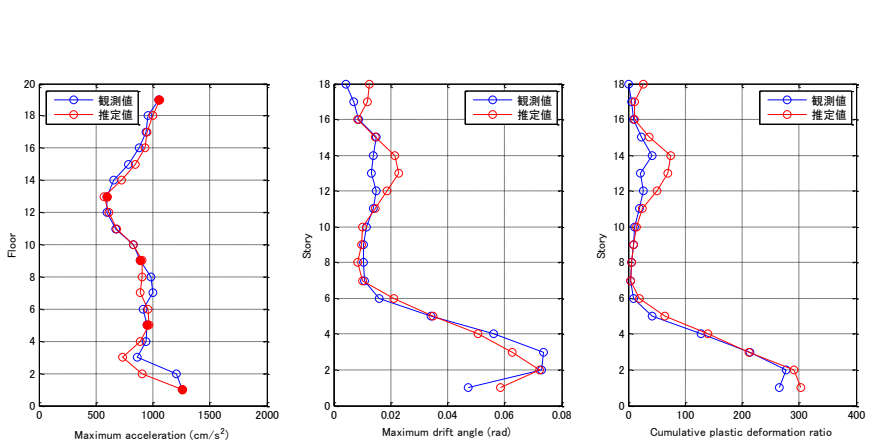


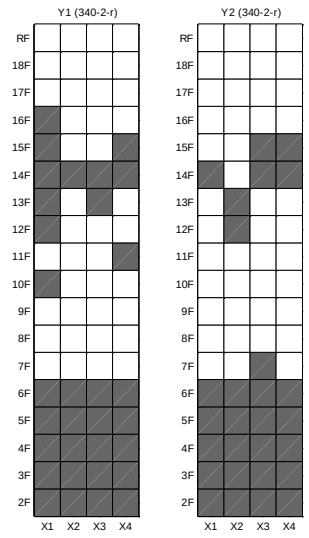
Figure 1 SHM system application to E-defense large shaking table test of steel high-rise building



(1) Max. acceleration (2) Max. story drift angle (3) Cumulative plastic deformation ratio

○: Estimated from all story sensors
○: Estimated from 5 sensors (1, 5, 9, 13 and RF)

(a) Level 1 system
(Estimation results of story response during earthquake)



□: without damage
■: with damage

(b) Level 2 system
(Damage detection results after earthquake)

Figure 2 Example of SHM results at the shaking table test
(input ground motion level: pSv=340cm/s)