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DEVELOPMENT OF A FULL-SCALE DAMAGE INVESTIGATION ON STRUCTURE USING LASER DOPPLER VIBROMETER (LDV)

レーザドップラー計を用いた構造物評価方法の開発

東京大学生産技術研究所 ―― 魚本研究室

1. INTRODUCTION

As civil engineering structures are ageing, it is our responsibility to make the evaluation of the structures about the degree of damage that the structures have generated during their service life. As the matter of fact, many of the structures are not just ageing. Due to some improper methods of working during construction period, each structure is having partial deterioration level in the sense that there are differences in level of deterioration in each part of a structure that some may collapse first and followed by the others in sequence. Then, the impact is on difficulties to detect and localize the damage since we are dealing with a structure that sometimes not just big but also huge in size. This need is added by another requirement to quantify the degree of damage itself. Therefore, as summary we can say that we need to develop a Non-Destructive Testing method that both can capture overall strength information of a structure and also can detect, localize, and quantify the degree of damage. The part-by-part damage evaluation by regular NDT methods is pre-added by a full-scale damage investigation as damage detector, localizer, and initial quantifier.

2. METHOD OF APPLICATION

Just several years back, civil engineers started to consider application of Laser Doppler Vibrometer (LDV) as the answer to their need to have damage detector, localizer and also initial quantifier in a full-scale damage investigation. Some engineers presented their research results in a topic concerning identification of natural frequencies of vibration and mode shapes of several structures they were used as "samples". However, we believe that the identification of natural frequencies of vibration and mode shapes merely is inadequate since we still do not have yet any information about the degree of damage in all aspects (location and quantity).

Therefore, we are developing another branch of LDV utilization that can lead us to the answer of our need. Remembering that structure strength is represented by structure stiffness, the system identification using LDV is performed in such a manner that we can capture stiffness values of the structure. As a result, LDV, as the NDT device, will capture ambient-vibration velocity of a structure and the time-history data is digitized by an Analog-Digital converter and recorded by a personal computer. The recorded data is firstly analyzed by Eigensystem Realization Algorithm (ERA) and followed by Modal Strain Energy (MSE) method of analysis. The former will quantify the strength of the structure,

東京大学生産技術研究所発行 〒153-8505 東京都目黒区駒場4－6－1 TEL. 03－5452－6391
http://www.iis.u-tokyo.ac.jp/

represented by stiffness values. The latter will detect, localize, and quantify the degree of damage hidden inside.

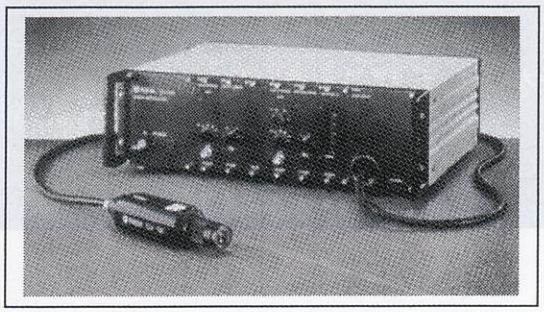

Table 1. Attributes of LDV	
Laser Type	Helium-Neon
Wave Length	633 nm
Laser Output/Class	< 1 mW
Max. Measurement Distance	10 m (concrete surface)
Freq. Range	0-250 kHz
Resolution	0.5-2 μm/s

Figure 1 The Laser Doppler Vibrometer (LDV)

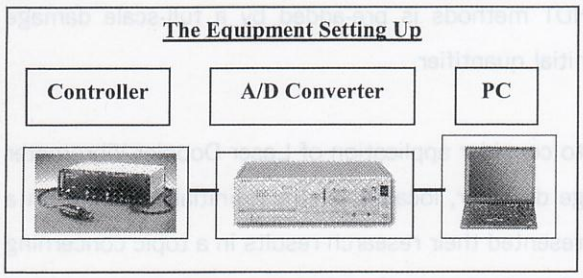

Figure 2 The Equipment Setting up.

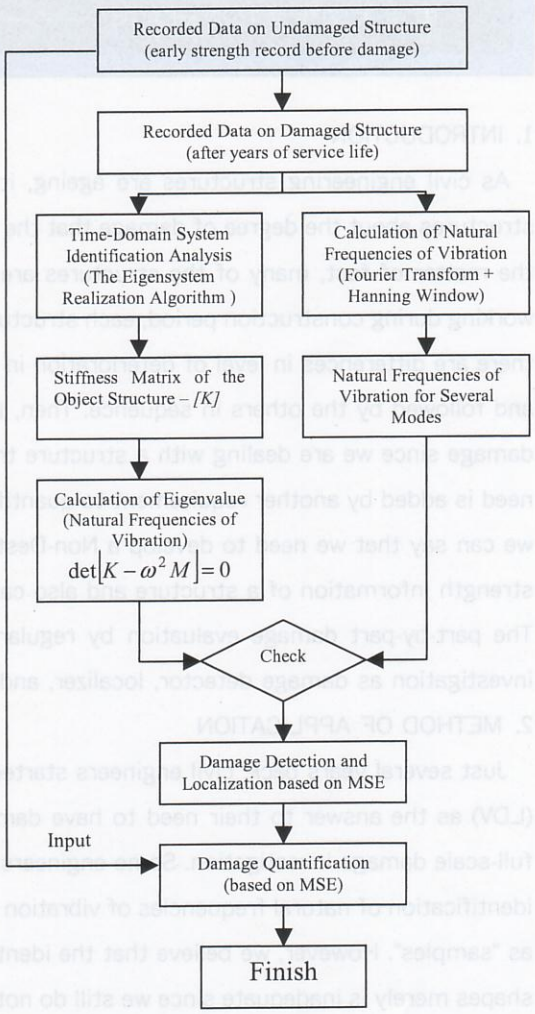

Figure 3 Framework of Damage Investigation-Analysis

3. IMPLEMENTATION

Our recent field investigation was on Kyobashi tunnel in Ginza. We show on Figure 2 the way to set up the equipment. On the tunnel, there are already several deteriorations that could be detected directly by plain eyes, which were cold joint line on the left wall and several crack patterns on the roof. After analyzing the recorded data using our developed application program in Mathematica, we could locate the bare-eye identified deteriorations precisely plus additional information about hidden damage.

(Nathan CHRISTIANTO, Taketo UOMOTO).

Institute of Industrial Science, University of Tokyo Uomoto Laboratory