

“Technical Research and Development for Road Policy Quality Improvement” Study Summary

No.	Title	Principal Researcher
No.25 - 5	Non-destructive testing and structural safety evaluation for re-deteriorated RC structures reinforced by steel plates or carbon fiber sheets	Tohoku Univ. Prof. Suzuki

Local vibration testing method by using a portable shaker was proposed to identify the damage location and damage state for RC bridge slab decks and beams which were reinforced by steel plates or carbon fiber sheets. Moreover, load capacity and structural safety evaluation for deteriorated RC structures were examined based on the structural reliability theory.

1. Backgrounds and Objects

It is difficult to identify the re-deterioration for the invisible RC bridge slab decks and beams which are reinforced and covered by steel plates or carbon fiber sheets. In this research, a local vibration testing method by using a portable shaker was examined to apply to a damage identification. Moreover, the relations between the damage states and local resonant frequencies, load capacity, structural safety were investigated based on the experimental tests of fatigue damage, corrosion of steel bars, and freezing and thawing. The calculations of failure probability for the deteriorated RC structures were conducted in considering the uncertainty of non-destructive testing and load capacity evaluation. The field tests of road bridges were carried on to examine the usability of the proposed method for a structural health assessment.

2. Activities in Research Period

- **Non-destructive testing:** Forced vibration testing method was proposed to identify the fatigue damage, corrosion of steel bars, and freezing and thawing for the RC bridge slab decks and beams which were reinforced and covered by steel plates or carbon fiber sheets.
- **Load capacity and structural safety evaluation:** Load capacities of deteriorated RC members were investigated for the fatigue damage, corrosion of steel bars, and freezing and thawing. Moreover, the calculation flow of failure probability was proposed based on a structural reliability theory.
- **Field tests of road bridges:** Field tests of road bridge slab decks reinforced by steel plates or carbon fiber sheets were conducted to examine the usability of the proposed vibration testing method.

3. Study Results

The electric portable shaker was produced (see Fig. 1). By using the portable shaker, the local resonant frequencies were measured for the RC members (see Fig. 2). The inner concrete cracks could be identified based on decrease of resonant frequency. Especially,

- i) The inner concrete cracks were identified by the excitation and measuring on the steel plates, carbon fiber sheets, asphalt pave, even when the local vibration tests were conducted on the upper or lower sides of the RC members.
- ii) The relations between the damage state (fatigue damage, corrosion of steel bars, freezing and thawing) and resonant frequencies, load capacities were obtained.
- iii) In the field bridge tests, the damage maps of the RC slab decks were shown based on the measured local resonant frequencies.



Fig.1 Electric portable shaker

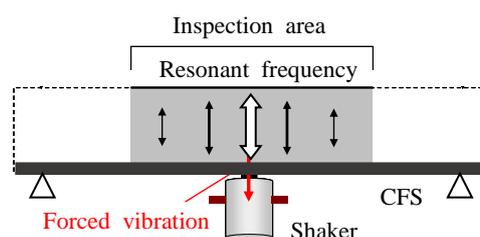


Fig. 2 Outline of local vibration tests

4. Papers for Presentation (Award papers are marked.)

- 1) Hideki NAITO, Shu KOBAYASHI, Yuki TSUCHIYA, Ryosuke SUGIYAMA, Kyohei YAMAGUCHI, Yohei HAYASAKA, Yoshiyuki YASUKAWA and Motoyuki SUZUKI: Damage Identification for RC Bridge Deck Based on Local Vibration Test, *Journal of Japan Society of Civil Engineers*, Ser. E2, Vol. 73, No. 2, pp. 133-149, 2017.
- 2) Eiichiro KON, Hiroyuki YASHIMA, Hideki NAITO, Hiroshi MATSUZAKI, Koichi SANDO and Motoyuki SUZUKI: Safety Assessment of RC Beams Subjected to Freezing and Thawing, *Journal of Structural Engineering*, Japan Society of Civil Engineers, Vol. 63A, pp. 784-794, 2017.
- ③) Eiichiro KON, Hideki NAITO, Aki IGARASHI and Motoyuki SUZUKI: Damage Identification for RC Culvert Based on Forced Vibration Test, *Proceeding of the Japan Concrete Institute*, Vol. 38, No. 2, pp. 967-972, 2016.
- ④) Takuya MAESHIMA, Yasuhiro KODA, Ichiro IWAKI, Hideki NAITO, Ryo KISHIRA, Yasunori SUZUKI, Koji OHTA and Motoyuki SUZUKI: Influence of Alkali Silica Reaction on Fatigue Resistance of RC Bridge Deck, *Journal of Japan Society of Civil Engineers*, Ser. E2, Vol. 72, No. 2, pp. 126-145, 2016.
- 5) Masaki MIYAMURA, Hideki NAITO, Satoshi NAKANO, Masuo KADO, Ichiro IWAKI and Motoyuki SUZUKI: Study on Evaluation of Structural Performance in 15-Years-old PC Road Bridge after Reconstruction under Severe Chloride Environment, *Journal of Japan Society of Civil Engineers*, Ser. E2, Vol. 72, No. 2, pp. 41-55, 2016.
- ⑥) Seiji ABE, Hiroyuki UETA, Takumi MOROHASHI, Hideki NAITO and Motoyuki SUZUKI: Structural Performance Evaluation and Damage Identification of RC Beams Reinforced by Fiber Sheet or Steel Plate, *Proceedings of the Concrete Structure Scenarios*, Japan Society of Material Science, Vol.14, pp.433-438, 2014.

5. Study Development and Future Issues

Apply to field tests for many kind of concrete structures

More field tests are conducted to examine the usability of the proposed method for the damage identification and structural safety assessment for many kind of concrete structures.

Apply to other research topics

- Study on fatigue mechanism of RC slab decks
- Damage identification and structural safety assessment after a large earthquake
- Dynamic analysis of wave diffraction motion around inner voids or cracks in the porous asphalt pave

6. Contribution to Road Policy Quality Improvement

Usability of the proposed method was indicated, especially, for a damage identification of RC slab decks. Some trials are reported that the proposed method is used in highway road maintenance, and structural health assessment for the re-deteriorated road bridges reinforced by steel plates or carbon fiber sheets.

7. References, Websites, etc.

None