The Effect of Topping on Hollow Core Slab Floor Plates on Comfort Criteria Due to Vibration by Human Activities

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ABSTRACT
Experimental testing was carried out in a two-story parking building with variations of floor plate finishing without toppings, reinforced concrete toppings, and ceramic toppings. In addition, a drop impact test and a heel drop test were carried out to get the vibration value in the form of a natural frequency. The test results showed that the natural frequency value on the floor slab with topping has a higher natural frequency than without topping, with an average increase of 29.8% for reinforced concrete topping, and 14.2% for ceramic topping. All test results meet the minimum natural frequency limits based on the SCI P354, JGJ 3, PCI MNL-126-15E, and GB50010 standards. As for the AISC DG11, the S4 plate has a frequency that sensitive to the human body.

Keywords: *Prestressed Concrete, Hollow Core Slab, Floor vibration, Drop impact test, Heel drop test.*

1. INTRODUCTION

Recently, the development of material technology and building structural components has made these components lighter in weight so that the floor area supported by beams can be larger.[1–7]. The popularity of open-plan designs and lightweight walls leads to a lower structure's stiffness and damping ratio [7,8]. As a result of the structure's low mass, stiffness, and damping ratio, the vibration caused by human activities on the floor slab becomes large and causes discomfort to the user. [7,9,10]. The low of these three parameters also causes the structure's natural frequency to be lower [11]. According to Campista et al. [12–15], the most sensitive frequency to vibration in humans is in the range of 4-8 Hz, where if the floor slab is at that frequency and human activities have the same frequency, then a resonance phenomenon will occur and cause a higher vibration response.

2. BACKGROUND

Vibration caused by human activities is one problem that needs to be considered in designing a building. These activities include walking, running, aerobic activities, dancing, and jumping [16,17]. In the last few decades, various standards have been developed that regulate vibrations caused by human activities, such as ISO 10137 - *Bases for design of structures Serviceability of buildings and walkways against vibrations* [18], AISC DG11 - *Floor vibrations due to Human activity* [12], *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 2: Vibration in buildings (1 Hz to 80 Hz)* [19], SCI P354 - *Design of Floors for Vibration: A New4 Approach* [20], PCI MNL-126-15E: *Manual for the Design of Hollow Core Slabs and Walls* [21], BS 6472-1 - *Guide to Evaluation of Human Exposure to Vibration in Buildings* [22], and various other standards. Research on vibrations from laboratory testing, field testing, and simulations using finite element software has also been carried out, such as on conventional reinforced concrete floor slabs by Campista et al. [13], Da Silva et al. [23], Chen et al. [24] Pavelchak [25], Chik et al. [26], wooden floor plates Homb et al. [27], Hamm et al. [28] *Prestressed* floor plates by Zhou et al. [6,29], Li et al. [30], Cao et al. [31], Liu et al. [32], composite concrete floor plates by Silva et al. [33], GFRP composite concrete plates by Junges et al. [34], and various other types of plates.

3. RESEARCH METHOD

This paper investigates the Hollow Core Slab (HCS) floor slab in a parking building for frequency values using the impact test method. This research's objectives are as follows:

- Analyze the measurement data from the impact test.
- Comparing the natural frequency values for HCS slabs without toppings, HCS slabs with 5 cm thick reinforced concrete topping, and HCS plates with 5 cm thick ceramic toppings.
- Verify the natural frequency value against the standard AISC DG11 [12], SCI P35 [20], PCI-MNL126-15E [21], JGJ3[35], GB50010 [36].

A test was carried out on a two-story parking building to determine vibration value. The structure uses steel on the column and beam and HCS on the floor plate. This building has a length of 26 m and a width of 8.3 m with a floor plan as shown in Figure 1. The details of the cross-section of the structure are as shown in Figure 2. The drop impact test method is carried out using a sack filled with sand and a heel drop test. To get the natural frequency value of the plate [28].

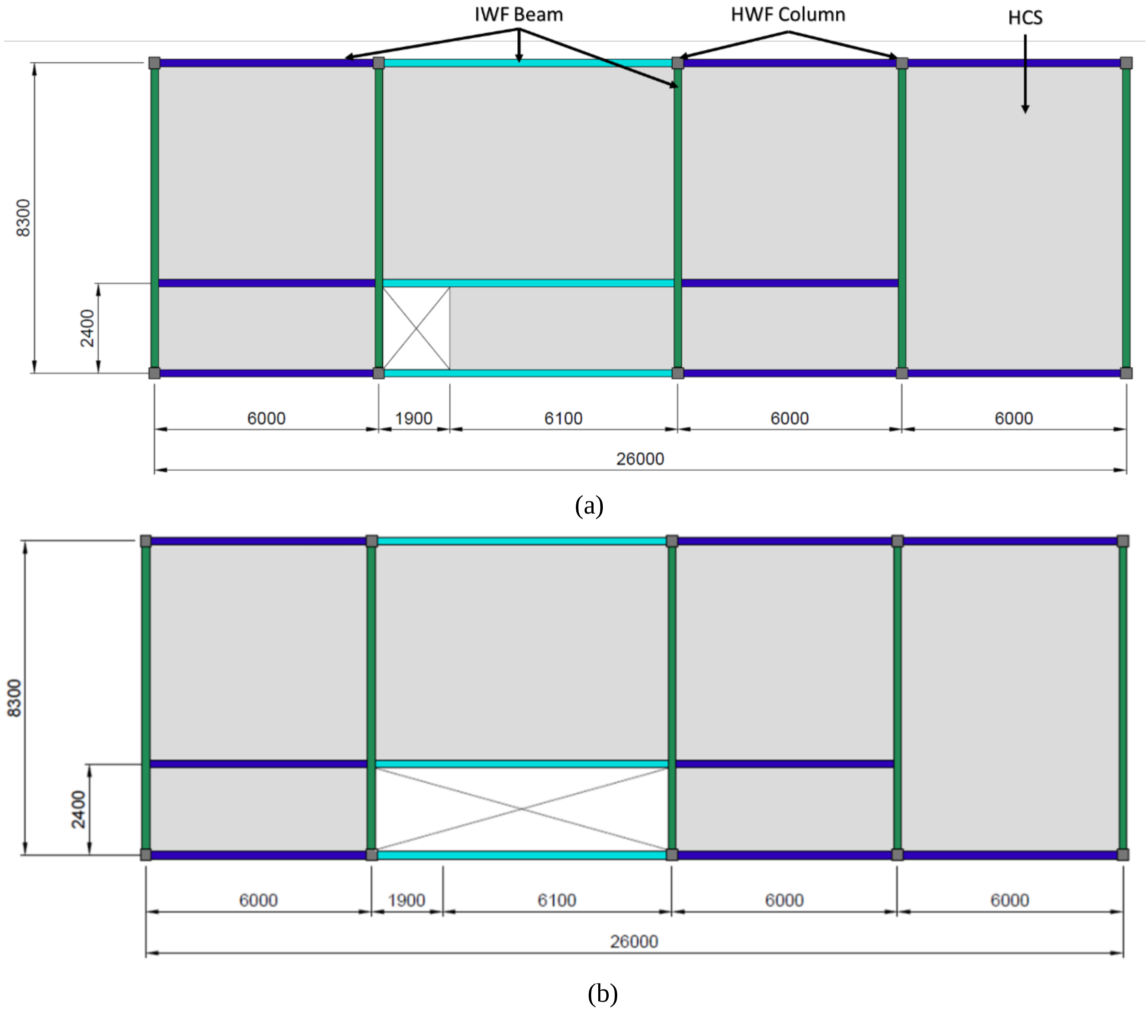

Figure 1 Parking Building Structure Plan (a) 1st Floor, and (b) 2nd Floor.

3.1. Test Specimen

The use of HCS floor slabs in the field is often added with another layer called a topping layer. This layer not only makes the plate's thickness match the design, but it is also a finishing layer on the floor slab. Therefore, in this study, tests were also carried out with these variations. There are three variations tested, namely:

- HCS floor slabs
- HCS floor slab + Topping reinforced concrete quality fc' 29.05 Mpa, thickness 5 cm
- HCS floor plate + Ceramic topping, total thickness 5 cm.

Details of the cross-sectional variations of the floor slabs can be seen in Figure 3. There are five variations in the size of the slab on the HCS (S) floor slab, the HCS + reinforced concrete (TS) floor slab, and two size variations for the HCS + ceramic slab (CS), as can be seen in Figure 3.

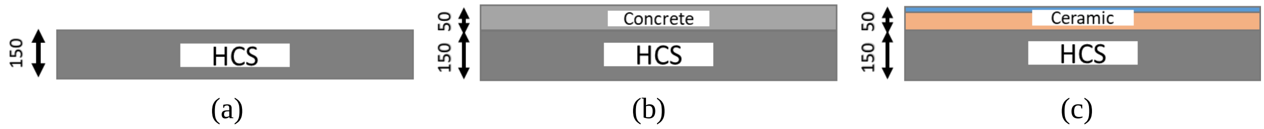

Figure 2 Details of HCS Floor Slab Section Variation, (a) HCS without Topping, (b) HCS with Reinforced Concrete Topping, (c) HCS with Ceramic Topping (mm).

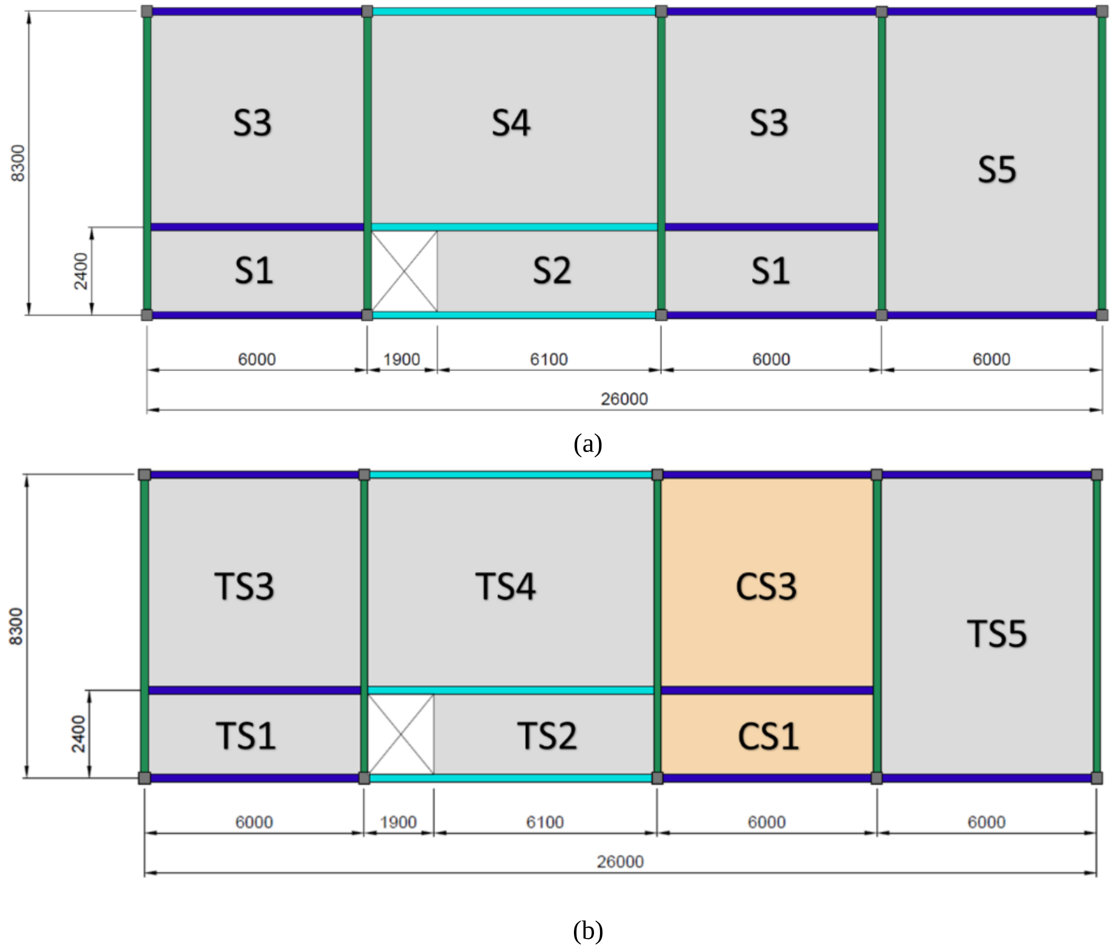

Figure 3 Variation of HCS Plate Size on Variation of (a) HCS Plate, (b) HCS Plate + Reinforced Concrete Topping, and HCS Plate + Ceramic Topping.

3.2. Test Method

To determine the vibration performance on the floor slab, Impact Test and Heel Drop Test was carried out. Impact Test was carried out by dropping sandbags on the surface of the floor slab with a predetermined weight and drop height. The Heel Drop Test relies on a falling load from a person's heels, where the accelerometer reads the resulting impact.

The test points were carried out at ¼, ½, ¾ on longitudinal and transverse directions of the slab. At each test point, the test was repeated three times, which values are then averaged. Repeated testing was done to get better results. The illustration of the test point and the sensor placement for each segment is as shown in Figure 4.

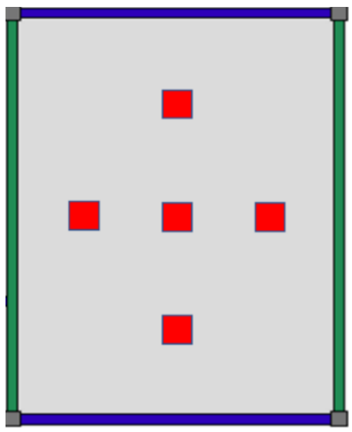

Figure 4 Location of Sensors and Test Points on One Segment of the Floor Plate.

4. CONCLUSION

Vibration testing in a two-story parking building using two test methods in the form of a drop impact test and a heel drop test was carried out to determine the natural frequency value on the floor slab. Based on these tests and analysis, it can be concluded that:

- The natural frequency of HCS floor slabs is 7.95 Hz – 14.9 Hz, HCS floor slabs + reinforced concrete topping have a range of 10.47 Hz – 19.14 Hz, and HCS floor slabs + ceramic toppings have a range of 10.46 Hz – 17.01 Hz.
- The addition of reinforced concrete topping has a better effect than ceramic topping, where the natural frequency value for reinforced concrete slabs is 29.8% on average and 14.2% for ceramics.
- The natural frequency of the floor slabs meets the minimum limits according to the standards of SCI P354 [20], JGJ 3 [35], dan PCI MNL-126-15E [21]. Meanwhile, according to the AISC DG11 [12], a one-floor plate (S4) has a frequency that sensitive to the human body.

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