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Experimental Study on Dynamic Characteristics of Composite Floor Slab with PSS and ECC Slab under Environmental Excitation

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ABSTRACT: A new type of assembled composite floor was proposed, in which self-tapping bolts were used as shear stud, profiled steel sheet (PSS) and cement fiber board (ECC slab) as tension and compression units respectively. Based on the detailed analysis of the new slab structure, the dynamic characteristics of the new slab were experimentally studied based on the environmental excitation method. The results show that the minimum fundamental frequency of the assembled composite floor slab is 21.68Hz, which can meet the basic requirements of floor comfort. The research results provide a basis for the engineering application of the new floor slab.

KEYWORDS: Profiled steel sheet (PSS), ECC slab, Composite floor, Dynamic characteristics, Environmental excitation.

I. INTRODUCTION

The progress of building materials and technology supports the application of various composite floors in building structures, such as steel-concrete composite floor [1, 2], steel-wood composite floor [3,5], steel-deck composite floor [6,7] cold-formed steel composite floor [8,9] steel-space frame-concrete composite floor [10] and many other mixed composite floors [11,14]. Each type of the floors has different technical characteristics and corresponding application scenarios. Based on the consideration of assembly construction technology, a new type of assembled composite floor structure is proposed in this paper. The existing profiled-steel profile and OSB board or ECC cement fiberboard are used as the tension and pressure components of the floor, respectively. The two components are secured by tapping screws to form a prefabricated composite plate unit. Profile-shaped steel plate, OSB/ECC plate and tapping screw are all industrial products themselves. Through the fastening assembly of tapping screw, the three form a new type of composite floor that can be made industrially. The new composite floor gives full play to the mechanical properties of each basic component (profile-shaped steel plate, OSB/ECC plate, tapping screw). It is a new composite structure with very broad application prospect.

Compared with the traditional floor slab, the new composite floor slab in this paper has very light dead weight, so its foundation frequency is relatively low. In order to promote the application of the composite floor slab in practical engineering structures, it is necessary to understand the dynamic characteristics of the new composite floor slab. In this paper, the PSS-ECC composite slab is taken as the research object, and the dynamic characteristics of the new composite slab are experimentally studied based on the environmental excitation method. The frequency and damping of composite slab are measured, which provides a foundation for the engineering application of composite slab.

II. EXPERIMENTAL STUDY

Specimens design

In view of the test target, two types of four assembled composite floor are designed respectively. The parameters of each specimen are shown in Table 1, in which the type I slab adopts closed profile steel sheet, the type II slab adopts open profile steel sheet, and the bearing component adopts ECC plate. The diameter of tapping screw used for assembly connection is 4.2mm, but the bolt length is 32mm and 45mm respectively. Figure 1 shows the basic

components of the assembled composite floor slab, Figure 2 shows the sectional specifications of the two types of profiled steel plates, The assembling and forming methods of the two types of slabs are shown in Figure 3.

Table 1 Group setting of experimental specimens

Specimen number		Span	Type of profiled steel sheet and thickness (mm)	Type of compression paneland specifications (mm)	Tapping screw specifications	Screw spacing (mm)
Type I	S1	2.4	Closed PSS-0.8	ECC-18x600	M4.2X32	100
	S2	2.4	Closed PSS-0.8	ECC-18x600	M4.2X45	100
	S3	2.4	Closed PSS-0.8	ECC-18x600	M4.2X45	150
Type II	S4	2.4	Open PSS-1.0	ECC-18x1000	M4.2X45	100/150

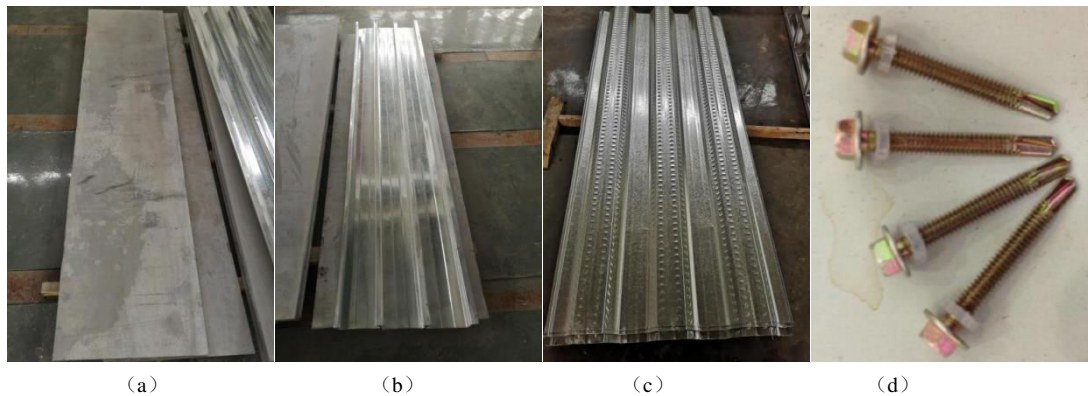


Fig. 1. Basic assembly component of composite floor slab (a) ECC slab (b) Closed profiled steel sheeting (c) Open profiled steel plate (d) Self-tapping bolt

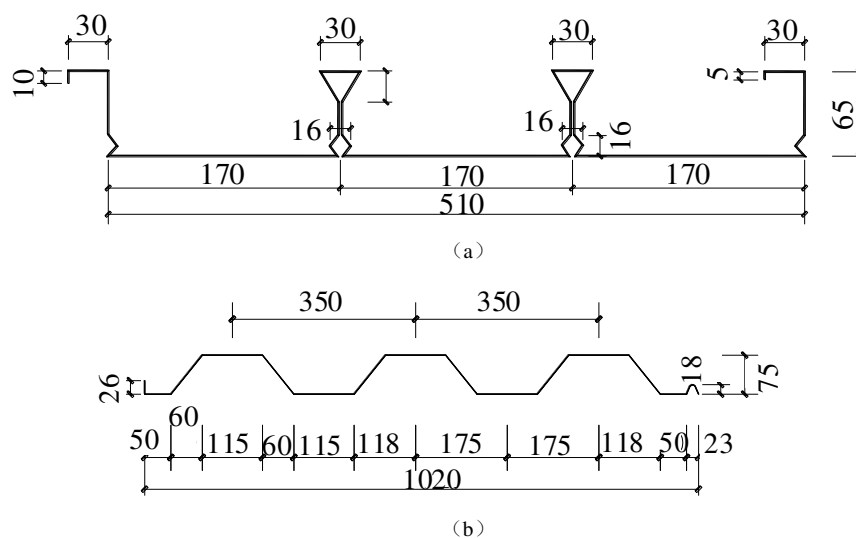


Fig. 2. sectional specifications of two types of profiled steel plates. (a) Section of closed profile steel sheet (b) Section of open profile steel sheet

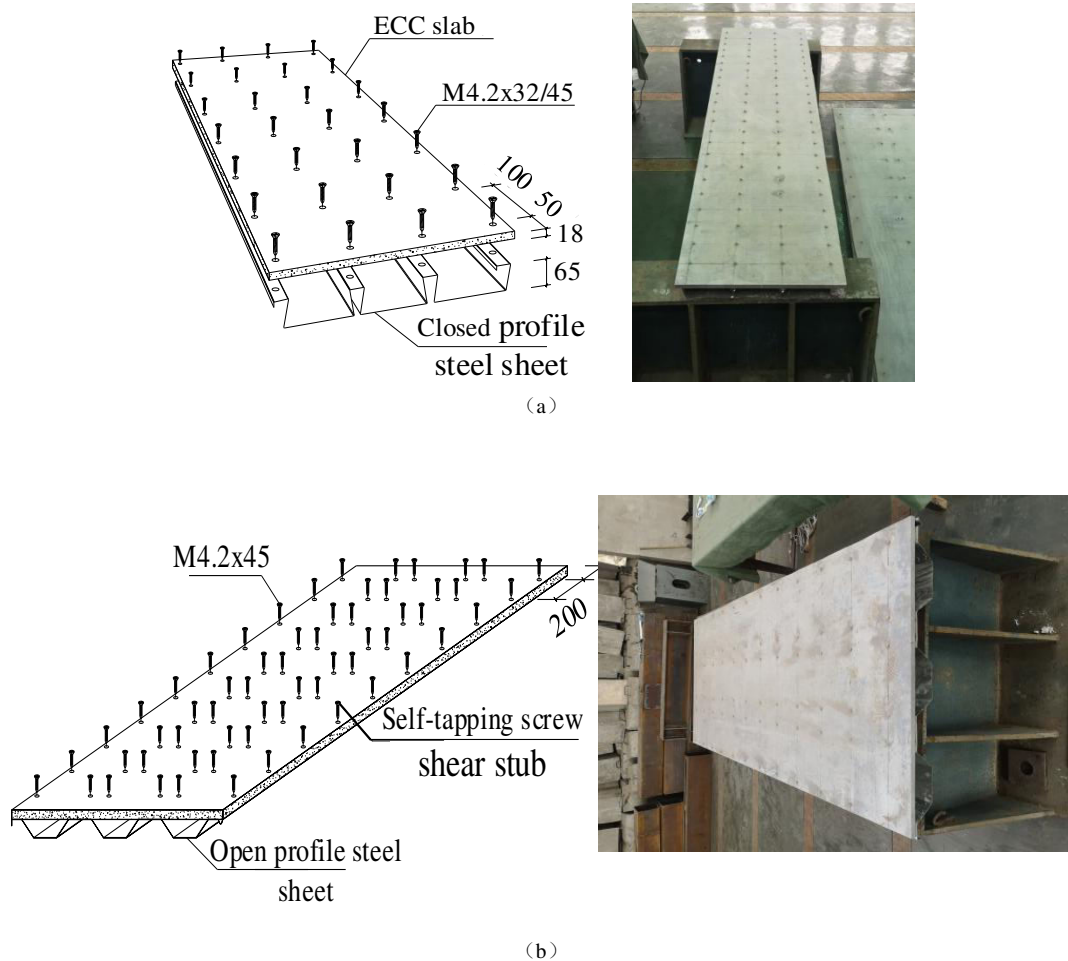


Fig.3. Assembly mode of composite slab. (a) Section of type I (b) Section of type II

Incentive method and test plan

Aiming at the dynamic characteristics test of the floor, the experiment adopts environmental excitation to test its natural frequency and damping ratio. During the experiment, the composite floor was in a simply supported state, and no other external loads were applied to the slab.

The test uses dynamic stress and strain test and analysis system of Donghua Testing Technology Co., Ltd. to test, as shown in Figure 4. The sensor adopts the charge measurement type CA-YD-117 acceleration sensor, and the acquisition system is the DH5920 type dynamic data acquisition system. Figure 5 shows the layout plan of the measuring points in the test.



Fig.4. Acceleration sensor and data acquisition system

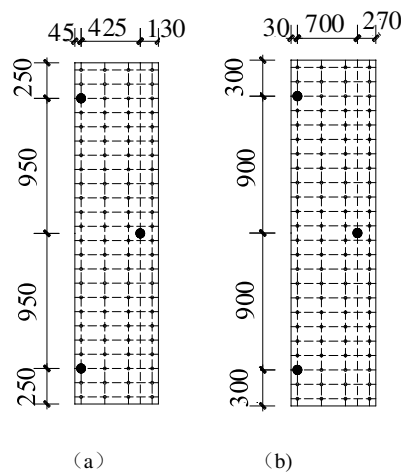
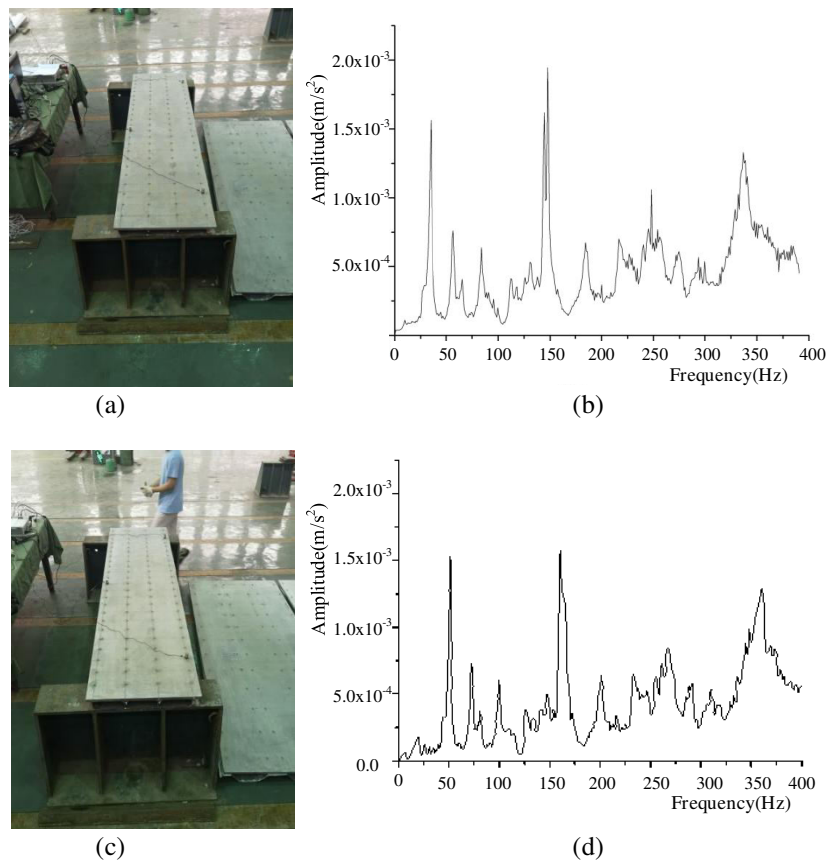


Fig.5. Layout of measuring points.(a) Measuring point arrangement of type I slab (b) Measuring point arrangement of type II slab

III. EXPERIMENTAL PROCESS AND RESULTS

In the case of the composite floor without external additional loads, the frequency of the first few vibration modes of the floor can be accurately measured during the environmental excitation test, and the frequency corresponding to the first mode is the lowest frequency of the composite slab vibration. It is the fundamental frequency, the frequency under the corresponding second mode is the second lowest frequency of the composite plate, and the frequency under the third mode is the third lowest frequency of the composite plate.

Figure 6 shows the acceleration frequency spectrum of specimens S1-S4 under environmental excitation,



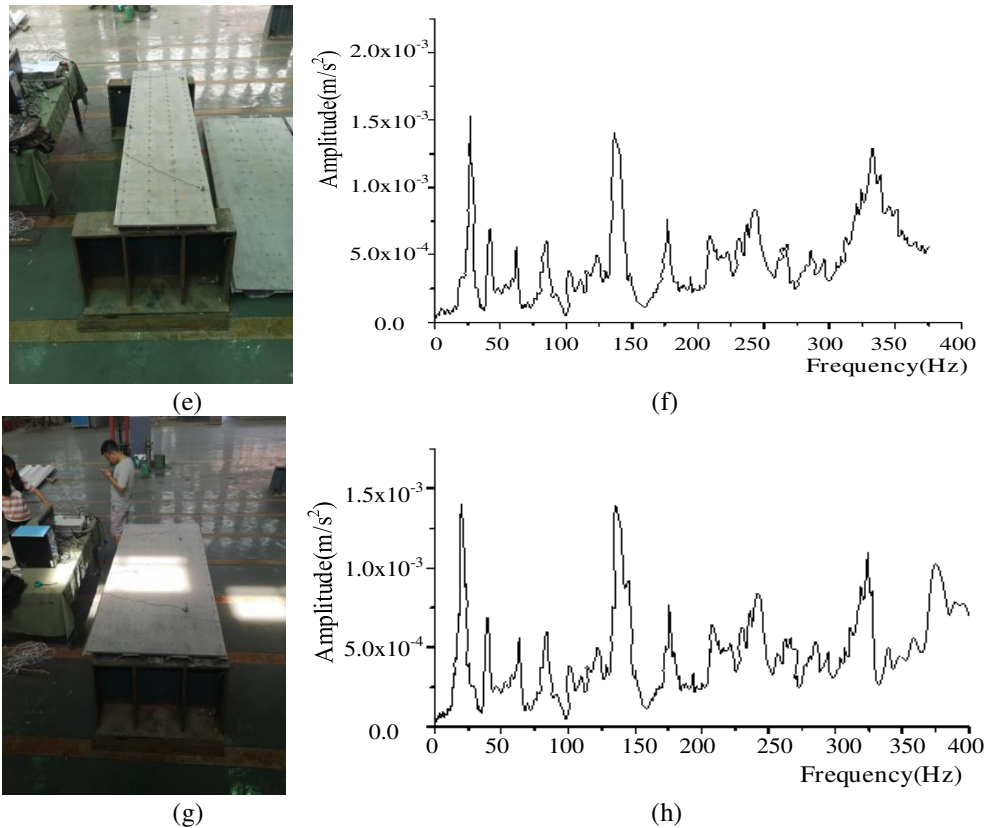


Fig.7 Acceleration frequency spectrum of specimens.(a)S1 environmental excitation test (b)Acceleration frequency spectrum under S1 environmental excitation.(c)S2 environmental excitation test (d)Acceleration frequency spectrum under S2 environmental excitation.(e)S3 environmental excitation test (f)Acceleration frequency spectrum under S3 environmental excitation.(g)S4 environmental excitation test (h)Acceleration frequency spectrum under S4 environmental excitation

Summarizing the above test results, the dynamic characteristics of the new composite floor are summarized in Table 2.

Table 2 Dynamic characteristics of the new composite floor

Specimen Number	environmental incentives					
	first mode		second mode		third mode	
	f1 (Hz)	damping (%)	f1 (Hz)	damping (%)	f1 (Hz)	damping (%)
S1	30.51	4.52	52.86	2.21	80.72	3.06
S2	52.21	4.71	68.43	2.86	98.87	6.12
S3	28.15	3.78	39.21	1.79	64.48	2.84
S4	20.35	3.15	39.56	1.85	64.73	2.97

IV. CONCLUSION

The experimental study on the dynamic characteristics of the new type of composite floor slab shows that the minimum fundamental frequency of the two types of assembly composite floors is 20.35 Hz, greater than 3 Hz, which can meet the standard requirements of floor comfort design. The spacing of tapping screws has a great influence on the fundamental frequency of the floor slab.Reducing the spacing of tapping screwscan effectively increase the fundamental frequency of such kind of slab. Considering that the new composite slab is relatively light and the damping of component is relatively small, appropriate measures can be taken to increase the damping of the new assembled composite slab in practical engineering.

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