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Study of mechanical properties of a new type composite slab

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Abstract. The mechanical performance of a new type of composite slabs is experimentally studied. The slab consists of a set of precast ceramsite concrete panels and the thin-walled steel skeleton which is formed with thin-walled steel main beams and secondary ones. The experimental results show that the composite slab has better plastic deformation capacity and greater bearing capacity, and the height of main steel beams and boundary conditions at ends of them have greater effect on bearing capacity of the composite slabs presented here.

1. Introduction

In order to reduce the floor quality, it can be replaced by lightweight aggregate concrete instead of ordinary concrete with gravel as coarse aggregate to form profiled steel plate-lightweight aggregate concrete composite slabs[1-2]. The light steel truss-profiled steel sheet concrete composite floor is presented and the mechanical property of it has been experimentally studied, and the combined action of light steel trusses and the lightweight aggregate concrete has been studied[3], but the lightweight precast concrete panel is not considered. The laminated composite floor is studied[4], in which the occlusal effect between the upper laminated plates and the precast panels is discussed to obtain the effective construction. Based on the existing papers, the mechanical property of thin-walled steel truss-ceramsite concrete composite slabs is researched[5], in which the thin-walled steel truss is considered, but there is still some deficiencies for engineering application.

It follows that the research on lightweight prefabricated composite floor needs to be further studied. Hence, a new type of lightweight composite slab is presented, which consists of the H-type thin-walled steel beams and the lightweight concrete. The composite slab also has advantages of lighter weight, no formwork support and factory prefabrication, et al. For application of the slab in engineering, the mechanical property of it is studied on basis of experiments and analysis, and some valuable suggestions are obtained.

2. Fabrication and Geometrical Dimensions of Specimens

The construction and the geometrical dimensions of the composite slab is shown in Fig.1. It is noted that the slab specimens consist of the thin-walled steel skeleton which is formed with a set of H-type main steel beams and some steel channels, the lightweight precast panels located upon the steel skeleton, the shear keys connected to the main steel beams and the post-pouring concrete layer.

It is especially noted that the geometrical dimensions of the cross-section of thin-walled steel beams, steel channels and dimensions of the precast panels are shown in Fig.2. It is seen that the thickness of steel plates of the main steel beam and steel channel is 0.6mm, and the thickness of the precast panels is 40mm, and the depth of groove of the precast panel is 10mm.
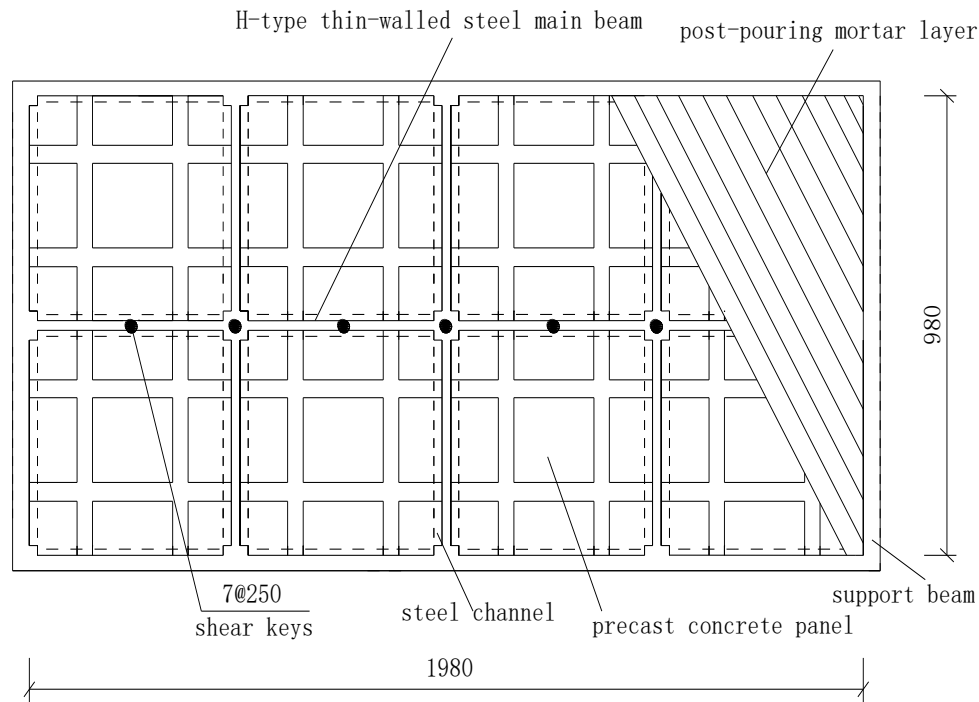
Fig.1 Construction and geometrical dimensions of specimens

(a) Cross section of main beam   (b) Cross section of steel channel   (c) Precast panel
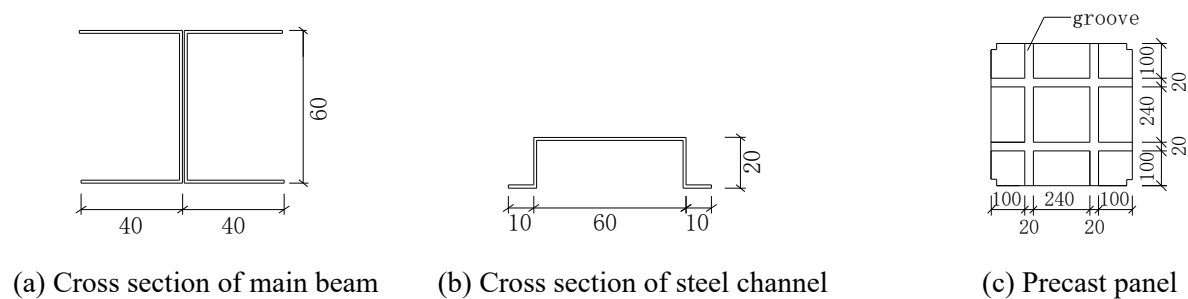
Fig. 2 Geometrical dimensions of elements

It is noted that the main steel beams of three specimens are supported at the support beam as shown in Fig.1. Each secondary beam (steel channel) is connected with the main steel beam and supported at the support beam. The mechanical properties of the materials used are taken as: yield strength and elastic modulus of steel are f_y= 146MPa, E_s=2.06×10^{5}MPa, respectively, and the cube strength standard value and elastic modulus of lightweight concrete are σ_c = 41.2MPa and E_c=2.17×10^{4}MPa, respectively.

3. Experimental Results and Discussions

3.1. Description of specimens
Static loading tests for three composite slab specimens as shown in Fig.1 are finished. Loading point distribution is shown in Fig.3.

The specimens are noted as SJ1, SJ2 and SJ3, for which the constraint conditions for them are different. In particularly, two ends of the main steel beam of specimen SJ1 and SJ2 are all simply supported, and four corners of specimen SJ2 are restrained in vertical direction, however two ends of

the main steel beam of specimen SJ3 are fixed support. All the other parameters of three specimens are the same with each other as shown above. The loading scene of the specimens is shown in Fig.4.
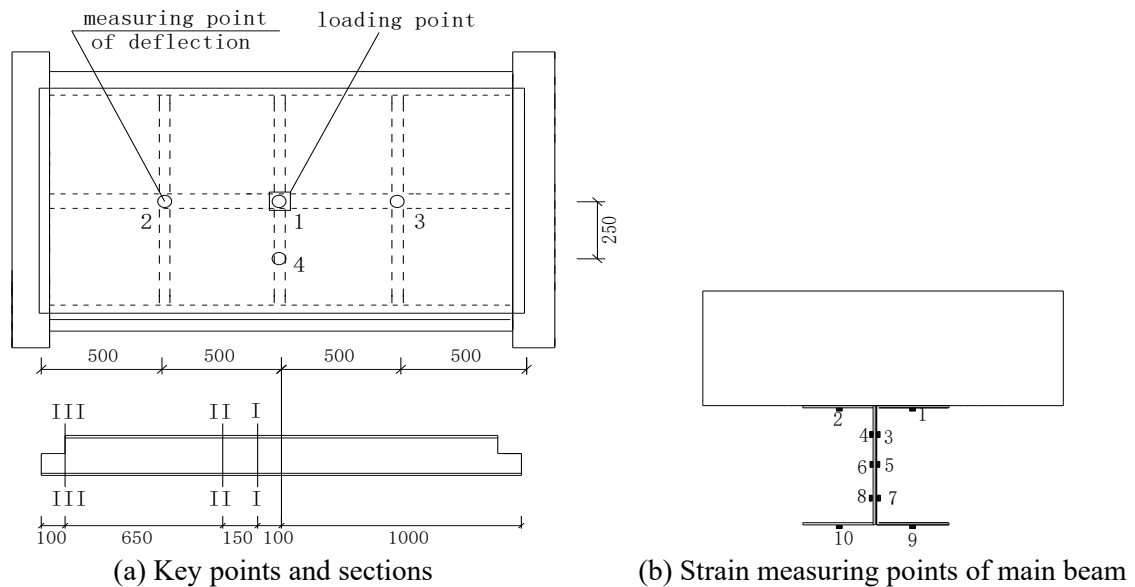

(a) Key points and sections   (b) Strain measuring points of main beam

Fig.3 Distribution of measuring points of specimens

Fig.4 Loading scene of specimens

3.2. Experimental phenomena

As shown in Fig.4, the composite slab specimens is statically loaded in the center of the slab by the jack. It is seen that all the specimens presented here have better entirety and deformation ability, and the local failure of the specimens are shown in Fig.5. It is shown that there are obvious local buckling in upper flange of the main steel beam and evident through transverse crack on top surface of the concrete panel of specimen SJ1.

(a)Local buckling of main beam   (b) Crack on top surface of concrete

Fig.5 Failure characteristics of specimen SJ1

The test results show that there is light nose at load 11.5kN for specimen SJ1, 8.5kN for specimen SJ2 and 15kN for specimen SJ3, respectively. The concrete panels began separation from steel beam at load 17.5kN for both of specimen SJ1 and specimen SJ2 and at 16.5kN for specimen SJ3. Finally, the severe local distortion of steel beam and cracking of concrete panels take place for all specimens.

3.3. Displacements and strains of specimens

The curves of load-vertical displacements of three specimens are shown in Fig.6. It is seen that the relation of load P and vertical displacement of the specimens has evident nonlinearity, but the deflection $\triangle$ varies linearly with load P for the load less than 10kN for all specimens, which means that the composite slabs are elastic when the load P is less than 10kN. It is also seen that the maximum value of deflections of the specimens presented here is much less than L/400 for 5kN/m^2 of equivalent uniform load.
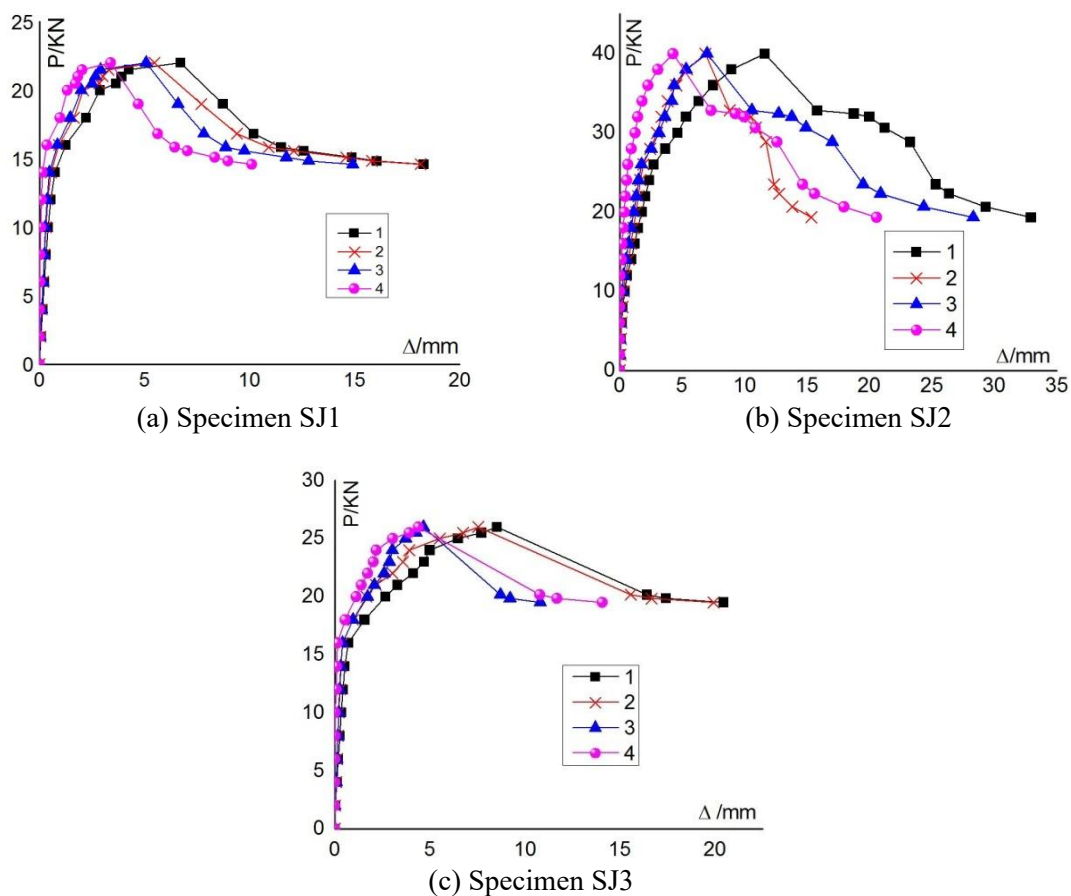

(a) Specimen SJ1   (b) Specimen SJ2

(c) Specimen SJ3

Fig.6 P- $\triangle$ Curves of specimens

It is also seen from the results shown in Fig.6 that the composite slab has better plasticity and ductility. The characteristic values of the specimens are listed in Table 1.

Table 1 Characteristic values of specimens

No.	Crack load/kN	Yield load/kN	Ultimate load/kN
SJ1	18.0	14.0	22.0
SJ2	26.5	14.0	40.0
SJ3	20.5	16.0	25.0

It is seen from the results shown in Table 1 that the specimen SJ2 has the largest ultimate load which means that the vertical restraint to corners of the composite slab is helpful for increasing bearing capacity of the composite slab.

(a) Specimen SJ1   (b) Specimen SJ2
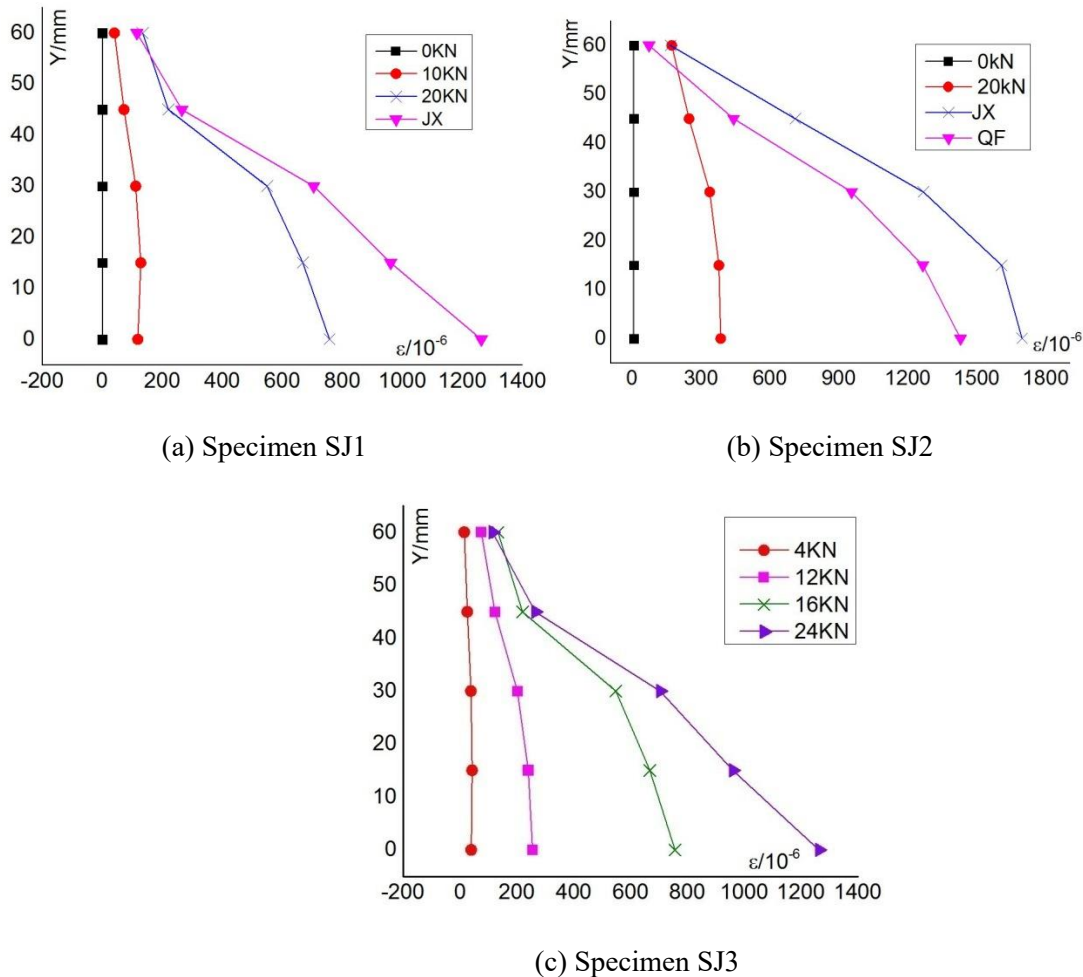

(c) Specimen SJ3

Fig.7 Strain curves of specimens

It is denoted that the symbols QF and JX in Fig.7 represent the yield load and the ultimate load, respectively. It is seen from the curves shown in Fig.7 that the H-type thin-walled steel beams basically accord with the plane section assumption when the applied load P is less than 10kN. However, the strains near the lower flange of the main steel beam increase much faster than that of the upper flange, and the results show that the neutral axis of cross section of the steel beam moves up with load and there is great plastic deformation near the lower flange of the steel beam.

3.4. Discussions
The mechanical performance of three lightweight composite slabs is experimentally studied, the test results show that the composite slabs presented here have better plasticity and larger deformation ability. It is noted that there is no any crack before the applied load is smaller than 3kN/m^2 of the equivalent uniform load, and the composite slab works elastically. It is seen that the boundary conditions of the composite slabs has obvious effect on the mechanical performance of the composite slab specimens shown in Fig.1, and the results show that restraint to four corners of the concrete

panels of the composite slabs has the greatest effect on entirety and bearing capacity of the composite slabs.

4. Conclusion

Based on the results and discussions presented above, the following conclusions are obtained as

(1) It is seen that all the lightweight composite slabs presented here have better entirety and plastic deformation ability, there is no overall collapse whenever the deflection is 12mm which is larger than L/200.

(2) The failure modes of the composite slabs are local buckling of thin-wall steel beams including the main steel beams and the secondary steel channels, and the through cracks in concrete.

(3) It is shown that the H-type thin-walled steel beams of the composite slabs basically accord with the plane section assumption when the equivalent uniform load applied to the specimens is less than $5kN/m^2$, which means that the main steel beam may be analyzed with typical mechanics principle.

References

[1]   ZHEN Yi, Cheng Shuwei, et al. The caculation of shear slippage of light-weight aggregate concrete composite floor slabs[J].Industrial Construction, 2007,37(s1):579-591(in Chinese).

[2]   Zhang Yankun, Liu Yanghua, et al. Experimental study on flexural bearing capacity of profiled steel sheet-light-weight aggregate concrtete floor slabs[J]. Industrial Construction, 2008, 38(8):83-85(in Chinese).

[3]   Kong Weichao. Experimantal study of light steel truss beam-profiled sheet lightweight concrete composite slabs[D]. Chongqing: Chongqing University,2013:6-38(in Chinese).

[4]   Wu Fangbai, Liu Biao,et al. Analysis of the interlocking effect of the combined interface in a new type of composites floor[J]. Journal of Hunan University, 2014,41(2):1-7(in Chinese).

[5]   Wang Xintang, Yang Jin, et al.Experimental study of mechanical property of thin-walled steel truss –ceramsite concrete composite slabs[J]. Journal of Building Structures, 2016,37(s1): 259-266(in Chinese).