**Study on Mechanical Properties of Multi-Cavity Steel–Concrete Composite Floor**

Chunbao Li 1,*, Gaojie Li 1, Rangang Yu 1, Xiaosong Ma 1, Pengju Qin 2 and Xukai Wang 1

1 Department of Civil Engineering, China University of Petroleum (East China), Qingdao 266580, China; S20060028@s.upc.edu.cn (G.L.); 19940040@upc.edu.cn (R.Y.); Z20060043@s.upc.edu.cn (X.M.); Z20060042@s.upc.edu.cn (X.W.)

2 College of Civil Engineering, Taiyuan University of Technology, Taiyuan 030024, China; qinpengju@tyut.edu.cn

* Correspondence: 20070048@upc.edu.cn; Tel.: +86-532-8698-1820

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**Abstract:** This paper proposes a novel multi-cavity steel–concrete composite floor. The mechanical properties of multi-cavity steel–concrete composite floor were studied by static load test. Based on full-scale tests on 2500 × 1000 × 120 mm multi-cavity steel–concrete composite floors, the bearing capacity and failure characteristics of the composite floor were analyzed. Compared with the existing prefabricated floor, the reliability of the test was verified by finite element simulation. The influence of steel plate material thickness, floor thickness, cavity size and span on the mechanical properties of composite floor was analyzed. The results showed that the composite floor had stronger bearing capacity and better ductility and integrity than the existing precast floor. The bearing capacity and stiffness of composite floor were positively correlated with the thickness of steel plate and floor, and negatively correlated with the cavity size and span.

**Keywords:** multi-cavity steel plate; composite floor; mechanical properties; failure characteristics

**1. Introduction**

With the continuous improvement of the degree of industrialization of housing construction, many prefabricated composite floor slabs suitable for construction industrialization have been explored. At present, prefabricated composite floors include profiled steel plate concrete composite floor (Figure 1a), steel truss composite floor (Figure 1b), reinforced truss concrete composite floor (Figure 1c) and precast ribbed floor slab (Figure 1d). Although all kinds of composite floors have certain advantages, under certain conditions, the applications of these composite floors are limited in different aspects due to cost and actual service performance [1–4].
Wu Fangbo [5] carried out full-scale tests on composite slabs simply supported on four sides, and studied their failure characteristics and compressive bearing capacity. The results showed that the composite floor had better bi-directional mechanical characteristics, and its bearing capacity was greatly improved compared with the ordinary floor. Liu Yi [6] studied the bearing capacity and damage characteristics of four steel bar truss composite slabs through a load test, and improved design and calculation method. They pointed out that compared with the ordinary floor, the section stiffness of the steel truss composite slab system was significantly increased, and the deflection of each part was significantly reduced, while its ultimate bearing capacity was the same as that of the traditional cast-in-place concrete floor. Yao Zhong [7,8] conducted a full-scale test on the precast unsupported steel truss floor, and carried out the corresponding numerical simulation. They concluded that the section stiffness of this steel truss floor was large, and the overall bearing capacity of the precast floor can meet the construction requirements. Through the static tests of four groups of open profiled steel sheet concrete composite slabs with different spans, Li Guochang studied the crack distribution, failure characteristics and slip of composite slabs. The test results showed that the failure mode of the composite slab was mainly the longitudinal and horizontal shear-bond failure. The longitudinal shear cracks occurred between the profiled steel sheet and the concrete, and the relative slip at the end was observed. Setting studs and increasing the thickness of the floor improved the bending capacity, and the stud can effectively reduce the relative slip at the end. For the large-span open-ended profiled steel sheet concrete composite floor, the longitudinal tensile reinforcement should be properly equipped to improve its bending performance. Their work showed that the ultimate flexural capacity calculated by the full plastic theory was greater than the experimental results, which indicated that the ultimate bearing capacity of the composite slab was controlled by the horizontal and longitudinal shear capacity. The open composite floor designed according to the ultimate bending capacity was unsafe [9]. Wang Qiuwei made an experimental study on the mechanical properties of four 1:1 closed profiled steel sheets. The load deflection curve method and the ultimate moment method were used to determine the section characteristics. It was found that the results calculated by the load deflection curve method were much larger than the theoretical values. The results calculated by the ultimate moment method agreed well with the theoretical values under positive loading, while their difference under negative loading became large. The reason behind this may be that only part of steel in the compression flange of closed profiled steel played a role under negative loading [10].

A new type of multi-cavity steel plate concrete composite floor has been proposed. Multi-cavity steel–concrete composite floor is composed of a multi-cavity steel plate framework and self-compacting concrete. It has the following advantages:

(1) The bottom steel plate of multi-cavity steel plate framework can be used as the stressed steel bar in use phase, and the porous steel plates can be used as the distribution steel bar and shear steel bar in the floor, so as to enhance the bending resistance and the shear capacity of the floor, make

Figure 1. Pictures of existing precast slabs: (a) steel deck-concrete composite floor; (b) steel bar truss deck; (c) composite floor with steel tubular truss; and (d) precast ribbed slab-composite floor slab.
full use of the material properties of the steel, and the process of binding the steel bars in the field is avoided;

(2) The multi-cavity steel plate framework is produced by factory prefabrication, which can be used as the formwork in the construction stage of composite floor, and can bear the construction load such as concrete dumping load, simplifies the construction process on site and improves the construction efficiency;

(3) The steel plate cavity inside the composite floor can effectively overcome the problems of concrete cracking and crack exposure. The steel plate cavity has a strong lateral restraint effect on the concrete and gives full play to the compressive performance of concrete;

(4) In the composite floor, a steel plate cavity is used instead of the stressed steel bar and stirrup, which can avoid the excessive steel bar in the traditional floor due to the excessive bearing capacity of the floor, so that the internal concrete filling of the floor is not saturated during the concrete pouring, which affects the overall performance of the concrete components.

Through the full-scale indoor static load test of multi-cavity steel plate concrete composite floor, the ultimate bearing capacity and failure mode of composite floor were studied, and compared with other forms of precast composite floor; numerical simulation was carried out by ANSYS software. The mechanical properties of composite floor in the elastic stage were studied and compared with the test results; the influences of different steel plate thickness, composite floor thickness, cavity size and span on the mechanical properties of composite floor were analyzed by numerical simulation [11–15].

2. Structure and Prefabrication

2.1. Structure

Multi-cavity steel–concrete composite floor is composed of a multi-cavity steel plate framework and self-compacting concrete. As shown in Figure 2, the framework consists of the inset porous plates and the nonporous plates at the outside surface as the shell. The inset porous plates communicate with each other and thus form a continuous framework for concreting, which can strengthen the bonding performance of self-compacting concrete and improve the integrity of the composite floor [16–18].

![Figure 2. Structure diagram of multi-cavity steel–concrete composite floor.](image)

2.2. Prefabrication

The fabrication of multi cavity steel–concrete composite floor is mainly divided into three steps: (1) preparation of porous and nonporous steel plates; (2) welding of steel plates to form a multi-cavity steel framework where the porous steel plates create many regular cubic cells and the nonporous steel plates act as shells (as presented in Figures 2 and 3); and (3) concreting. The self-compacting concrete has good rheology properties and can fill the whole multi-cavity steel framework with the help of interconnecting pores on the inset steel plates [19–21].
3. Experimental Details

3.1. Design and Fabrication of Specimens

A 2500 × 1000 × 120 mm multi-cavity steel–concrete composite floor was fabricated for the mechanical test. The inset porous Q235 steel plates with a thickness of 1 mm divided the whole framework into 100 × 100 × 120 mm cuboids. Circular pores with a radius of 4 mm were punched on the inset steel plates with 40% open porosity. The C30 concrete was used in the test. All the welds in the test conform to the welding standards specified in the code for design of steel structures (GB 50017-2003). The structure of the multi-cavity steel plate is shown in Figure 4, and the prefabricated composite floor is shown in Figure 5.
3.2. Materials

The same batch of steel and concrete samples were selected as experimental materials. The cubic concrete pastes were cast for compression test according to GB 50081-2002 [22]. The measured compressive strength was 29.30 Mpa, reaching 97.68% of the design standard value. According to GB/T228-2002 [23], the tensile test was carried out at room temperature. The yield strength of steel plate with thickness of 1.0, 1.5 and 2.0 mm was 235.7, 236.3 and 236.1 MPa, respectively, and the ultimate strength was 291.3, 294.3 and 293.9 MPa, respectively.

3.3. Test Set-Up

The support points were set at the 150 mm from both ends of the composite floor, and the static load test on the net span between the two support points was studied, which was divided into three equal parts. The vertical concentrated loads were applied at diversion points, as shown in Figure 6.

![Figure 6. Loading scheme.](image)

The JAW-2000K multi-channel electrohydraulic servo loading device with maximum capacity of 2000 kN was used for loading. Before loading, sands were evenly laid on the contact part between the floor and the supporting steel pipe to prevent stress concentration during the loading process. The strain gauges were installed at the bottom and side surface of composite floor, as shown in Figure 7.

![Figure 7. Arrangement of strain gauges.](image)
The displacement transducers were, respectively, arranged at the end of the composite floor and 1/2 and 1/3 of the effective length of span to measure the vertical displacement for each loading stage during static loading test.

3.4. Loading Procedure

In the multi-stage loading test, the linear load was applied at the three dividing points of the composite floor. The load was increased by 2 kN at each stage until the failure of composite floor took place. The loading time interval was controlled to allow deformation of the floor to become stable before going to the next loading stage.

4. Results and Analysis

4.1. Failure Process

When the load reached 80 kN, small cracks began to appear between the steel plate and the concrete on the side of the specimen. When the load was 96 kN, the mid span deflection of composite floor was 10.9 mm, which almost reached the deflection limit \([L_0/200] = 11.0 \text{ mm}\) according to the code for design and construction of composite floor (CECS273:2010) [24]. When the load was increased to 146 kN, the buckling of side steel plate occurred and destructive cracks were produced, leading to the cracking of concrete, accompanied by the local buckling of the mid span position of the composite floor. Under this load, the composite floor failed, and the ultimate bearing capacity of the composite floor was determined. The loading test of composite floor is shown in Figure 8, and the failure characteristics of composite floor are shown in Figure 9.

![Figure 8. Loading of composite floor.](image)

![Figure 9. Failure characteristics of composite floor: (a) bending deformation of composite floor; (b) crack between steel plate and concrete on the side of the specimen.](image)
4.2. Load-Deflection Curve

According to the deflection values at the end, 1/3 and 1/2 span of the floor, the load-deflection curve of the composite floor was drawn, as shown in Figure 10.

![Load-deflection curve of composite floor](image)

**Figure 10.** Load-deflection curve of composite floor.

It can be seen from Figure 10 that under a load <96 kN, the deflection increased linearly with the load, and the composite floor was in the elastic deformation stage; when the load reached 96 kN, the deflection of mid span of the composite floor was 10.9 mm; when the load value was greater than 96 kN, plastic deformation occurred and the deflection increased much more rapidly, which was caused by the large deformation of the cavity steel plate on the side of composite floor. As a result, the restraints on concrete were weakened and the stiffness of composite floor was reduced.

When the load reached 146 kN, the stress of the composite floor did not increase, and the ultimate bearing capacity was reached. The load-deflection curve of the composite floor was close to that of the traditional cast-in-place concrete floor, both of which showed the characteristics of bending deflection. This shows that the cavity steel plate and concrete form a whole through the holes in the cavity steel plate, which has good vertical bearing capacity and shear strength. Thus, they can maintain as a whole under load.

As seen from Table 1, in Nie Jianguo’s experimental study on reinforced concrete composite floor, the size of reinforced concrete composite floor was (length) 2500 × (width) 1000 × (thickness) 120 mm, the concrete strength was C30 and the total weight of steel was 30.2 kg [25]. As can be seen from Figure 11, the maximum bearing capacity of reinforced concrete composite floor was 21.6 kN when the mid span deflection reached 11 mm of normal service limit. The total weight of steel for multi-cavity steel–concrete composite floor with the same size was 52.9 kg, which is 1.75 times of that of the composite floor. However, when the same ultimate deflection was reached, the load it could bear was 4.44 times that of the composite floor. For Cheng Long’s precast anchor floor, the size of it was (length) 2500 × (width) 1000 × (thickness) 120 mm, the concrete strength was C30 and the total weight of steel used was 28.19 kg [26]. When the mid span deflection reached the normal service limit of 11 mm, the maximum load it could bear was 13.6 kN. The total weight of steel for the same size of multi-cavity steel–concrete composite floor was 1.88 times that of the precast floor slab anchored at the pier head. However, when the same ultimate deflection was reached, the load that our composite floor could bear was 7.06 times that of the precast anchor floor. This shows that compared with the two existing precast floors, the total weight of steel used in the multi-cavity steel–concrete composite floor is nearly twice as much as that of the two existing precast floors, but the bearing capacity of multi-cavity steel–concrete composite floor increases to more than four times.

| Table 1. Steel consumption of three precast floors. |
| Floor Type                  | Size (mm)   | Maximum Bearing Capacity (kN) | Total Weight of Steel (kg) |
|-----------------------------|-------------|-------------------------------|---------------------------|
| Multi-Cavity Floor          | 2500 × 1000 × 120 | 96.0                          | 52.90                     |
| Reinforced Concrete Composite Floor | 2500 × 1000 × 120 | 21.6                          | 30.20                     |
| Precast Anchor Floor        | 2500 × 1000 × 120 | 13.6                          | 28.19                     |

Figure 11. Load-deflection curve of three precast floors.

4.3. Load Strain Curve of Composite Floor

Except for the strain gauges at the midspan position, other strain gauges were arranged symmetrically, so only one side load strain curve was drawn, as shown in Figure 12.
Figure 12. Load-strain curve of composite floor: (a) no. 1–5 strain gauge; (b) no. 6–10 strain gauge; (c) no. 11–15 strain gauge and (d) no. 26–33 strain gauge.

As can be seen from Figure 12a, at the quarter point of the bottom of composite floor, the cavity steel plate was compressed and the strain increased linearly under the load <126 kN, indicating that the steel plate at the quarter point was basically in the elastic deformation; when the load was greater than 126 kN, the increasing rate of the strain versus load increased, which suggests the change to plastic deformation.

Strain gauge No. 6–10 recorded the variation of strain at the third point of the bottom of composite floor. Before the load reached 106 kN, the strain maintained linear growth, and the steel plate was basically in the elastic deformation stage; when the loading continued to increase, the strain increased rapidly, and the cavity steel plate began to develop plastic deformation. Finally, the strain stopped increasing and the slope of the curve tended to zero. At this stage, the composite floor could no longer bear the load and fails.

The gauge No. 11–15 monitored the strain at the mid span position of the composite floor. The steel plate in the middle of the span was basically in the elastic deformation stage under a load <96 kN. Beyond the critical value (96 kN), the strain increased rapidly, the plastic deformation took place. Finally, the strain stopped increasing and the composite floor failed under greater load.

No. 26, No. 27, No. 30 and No. 31 strain gauges were attached to the upper side of the composite floor. Before the load reached 96 kN, the four strain gauges were in compression state. When the loading continued, the side of the shell steel plate buckled and the shell steel plate stretched outward, making the strain gauge change from compression state to tension state. For the strain gauges attached to the lower part of the composite floor, they are always in the tensile state. When the loading continued to increase, the plastic deformation of the steel plate began to occur, so the strain increased rapidly. Finally, the slope of the load–strain curve tended to zero, which indicated that the composite floor could no longer bear the load and the floor fails. These conclusions conform to the experimental phenomenon.

5. Finite Element Modeling Investigation

5.1. Finite Element Model Description

In order to study the mechanical properties of multi-cavity steel–concrete composite floor, and the influence of steel thickness, composite floor thickness and span on the bearing capacity of composite floor, ANSYS software was used for finite element simulation.
Element selection: In the model, SOLID65 is used as the concrete element, and SHELL181 with large deformation and nonlinear function is used for the multi-cavity steel plate element [27].

Material parameters: It was assumed that the concrete was ideally homogeneous with the strength grade of C30, the elastic modulus of $3 \times 10^4$ MPa and the Poisson’s ratio was 0.2. The steel strength grade was Q235, the elastic modulus was $2.06 \times 10^5$ MPa and the Poisson’s ratio was 0.3. The steel thickness was 1 mm, the specimen thickness was 120 mm, the cavity size was 100 mm, the floor span was 2500 mm and the floor width was 1000 mm. W-W five parameter yield criterion was used for concrete [28,29], and Mises yield criterion was used for the stress–strain relationship of steel.

Constraint conditions: In order to make the simulation results close to the test results, according to the test that the composite floor is directly placed on the bottom adminiculum, no lateral or vertical movement occurred during the loading process, so the displacement constraints in Y direction and Z direction were applied to the model, and the displacement in both directions was zero; the displacement in X direction was set as zero at the longitudinal end of the composite floor.

Load application: According to the test procedure, the concentrated load was converted into linear load in the simulation, which was applied at the third point of the upper surface of the composite floor.

Composite floor model: The composite floor model consists of a multi-cavity steel plate model and a concrete model. The concrete was a solid unit, and the cavity steel plate framework was embedded into the concrete to form the composite floor.

It can be observed that the concrete and the cavity-steel plate were well bonded, and the cavity steel plate was not damaged by the concrete extrusion when the concrete was under compression, so the relative movement of the concrete and the cavity steel plate at the interface was not considered in the model. Because the cavity steel plate opening has no effect on the elastic modulus of steel, in order to simplify the model, there was no hole in the cavity steel plate during the modeling. In order to ensure the unity of the simulation and test, the model size was the same as the test [30,31]. The composite floor model is shown in Figure 13.

![Figure 13. Finite element model of composite floor.](image)

5.2. Finite Element Model Result

The size of the composite floor for the finite element analysis was exactly the same as that in the test. In the test, when 96 kN of load was applied to the floor, the deflection limit of the normal use stage was basically reached. In order to simulate the deformation of the composite floor in the elastic stage, the load applied to the model was set as 96 kN. The shell steel plate was in the tensile state when the floor was under load, and the tensile stress along the X tangent direction of the shell steel plate at the bottom midspan position was the maximum. The vertical deflection nephogram of the composite floor is shown in Figure 14.
It can be seen from Figure 14 that pure bending deformation occurred in the composite floor specimen under load, and the cavity steel plate did not show obvious buckling deformation and stress concentration. The deformation of the midspan position was the largest at the composite floor, and the deflection value reached 9.61 mm. The deformation decreased along the longitudinal direction to both sides. The minimum deflection was at both ends of the composite floor, which was only 3.7 mm. The deformation characteristics were similar to those of ordinary cast-in-place reinforced concrete floor.

It can be seen from Figure 15 that for both simulation and test results, the load-deflection curves are close to straight lines, and the composite floor was basically in elastic deformation stage under the load <96 kN. When the load value was greater than 96 kN, plastic deformation occurred and the deflection increased much more rapidly, which was caused by the large deformation of the cavity steel plate on the side of composite floor. As a result, the restraints on concrete were weakened and the stiffness of composite floor was reduced. Under the same load, the deflections of the floor in the simulated case were smaller than that in the test. For example, under the load of 96 kN, the midspan deflection in the test and simulation condition was 10.9 and 9.6 mm, respectively. The reasons for this deviation are as follows:

1. In the simulation, the constraint condition and load application were ideal. However, in the test, the x-direction displacement at the two simply-supported points was unlikely to be zero under load. Therefore, during the loading process, the two sides of the composite floor moved to the middle, which led to the increase in the mid-span deflection.

2. Insufficient displacement transducers were set up, which made the test data slightly deviate. The displacement transducer might be disturbed if it is fixed at the center of composite floor when the composite floor is damaged. Therefore, only one displacement transducer was set up at the bottom surface of midspan. The upper part of the actuator which applies load on the span is a spherical hinge. Therefore, during the loading process, the composite floor may incline slightly to the side with the displacement transducer. For these reasons, the simulation results are relatively accurate.
Figure 15. Load–deflection curve of composite floor in midspan.

The stress nephogram of composite floor under load is shown in Figure 16.

Figure 16. Stress nephogram of composite floor: (a) concrete stress nephogram of composite floor and (b) steel plate stress nephogram of composite floor along X direction.

It can be seen from Figure 16: (1) when the load was 96 kN, the maximum stress of the cavity steel composite floor was 182.7 N/mm², which did not reach the steel yield strength of 235.7 MPa. Moreover, the compressive stress on the upper edge and the tensile stress on the lower edge of the cavity steel plate were basically symmetrical, and the stress distribution was relatively uniform. The neutral axis of the composite floor is located in the middle position where the stress is basically zero, which indicates that the composite floor has good mechanical performance.

(2) When the load was 96 kN, the concrete stress on the upper part of the composite floor reached 20.3 N/mm², which was less than the ultimate compressive strength of concrete, and the concrete was not fractured. These results are the same with experiment data. The simulation results confirm that the concrete and steel plate framework have compatible deformation under load; thus, the composite floor is able to maintain integrity under load.

(3) The stress of the cavity steel plate at the bottom of the composite floor was well-distributed. The stress at the midspan was the largest, which gradually decreased along the X direction to both
ends of the composite floor. Additionally, no stress concentration was observed at the composite floor, which suggests that the multi-cavity steel plate and concrete bond well with each other.

5.3. Analysis of Influencing Factors

In order to evaluate the influence of steel thickness, floor thickness, cavity size and span length on bearing capacity and section rigidity of composite floor were studied. In the simulation, the composite floor was not concreted, and other parameters were kept constant. The initial steel thickness, floor thickness and span length were 1.0, 120 and 2500 mm, respectively. The midspan deflection of composite floor and the maximum stress of steel were obtained under the load of 96 kN. The deflection nephogram and stress nephogram are shown in Figures 17–24. The results are summarized in Table 2.

![Deflection nephogram of composite floor with different steel thickness](image1)

**Figure 17.** Deflection nephogram of composite floor with different steel thickness: (a) 1.0, (b) 1.5 and (c) 2.0 mm.

![Stress nephogram of composite floor with different steel thickness](image2)

**Figure 18.** Stress nephogram of composite floor with different steel thickness: (a) 1.0, (b) 1.5 and (c) 2.0 mm.
Figure 19. Deflection nephogram of composite floor with different thickness: (a) 120, (b) 110 and (c) 100 mm.

Figure 20. Stress nephogram of composite floor with different thickness: (a) 120, (b) 110 and (c) 100 mm.

Figure 21. Deflection nephogram of composite floor with different cavity size: (a) 100, (b) 125 and (c) 250 mm.
Figure 22. Stress nephogram of composite floor with different cavity size: (a) 100, (b) 125 and (c) 250 mm.

Figure 23. Deflection nephogram of composite floor with different span: (a) 2500, (b) 2000 and (c) 3000 mm.

Figure 24. Stress nephogram of composite floor with different span: (a) 2500, (b) 2000 and (c) 3000 mm.
Table 2. Simulation results of composite floor.

| Number | Steel Thickness (mm) | Floor Thickness (mm) | Cavity Size (mm) | Span Length (mm) | Midspan Deflection (mm) | Maximum Stress of Steel (MPa) |
|--------|----------------------|----------------------|------------------|-----------------|------------------------|-----------------------------|
| 1      | 1.0                  | 120                  | 100              | 2500            | 9.61                   | 182.7                       |
| 2      | 1.5                  | 120                  | 100              | 2500            | 8.98                   | 69.2                        |
| 3      | 2.0                  | 120                  | 100              | 2500            | 8.67                   | 66.8                        |
| 4      | 1.0                  | 110                  | 100              | 2500            | 10.43                  | 207.6                       |
| 5      | 1.0                  | 100                  | 100              | 2500            | 12.26                  | 220.9                       |
| 6      | 1.0                  | 120                  | 100              | 2000            | 3.85                   | 133.5                       |
| 7      | 1.0                  | 120                  | 100              | 3000            | 14.80                  | 221.0                       |
| 8      | 1.0                  | 120                  | 125              | 2500            | 10.43                  | 195.9                       |
| 9      | 1.0                  | 120                  | 250              | 2500            | 12.61                  | 199.5                       |

It can be seen from Table 2 that when the steel thickness increased from 1.0 to 1.5 and 2.0 mm, the midspan deflection decreased by 6.5% and 9.8%, and the maximum stress of steel decreased by 62.1% and 63.4%, respectively. It can be concluded that increasing the thickness of steel can significantly improve the bearing capacity and section rigidity of composite floor.

When the thickness of composite floor was reduced from 120 to 110 and 100 mm, the mid span deflection of composite floor increased by 8.6% and 27.7%, and the maximum stress of steel increased by 13.6% and 20.9%, respectively. This shows that increasing the thickness of composite floor can improve the bearing capacity and section rigidity of composite floor.

When the cavity size increased from 100 to 125 and 250 mm, the mid span deflection of composite slab increased by 8.5% and 31.2%, and the maximum stress of steel increased by 7.2% and 9.2%, respectively. This is because when the size of the cavity steel plate of the composite floor increases, the restraint effect of the cavity steel plate on the concrete is reduced. In this case, the load which was burdened by the deformation of concrete and steel plates was exerted to the steel plate at the bottom of the composite floor. In addition, with the increase in the size of the cavity, the number of steel plates in the cavity was reduced accordingly, which reduced the height of the compression zone of the composite floor, thereby reducing the sectional stiffness of the composite floor as a result.

When the span length of composite floor was reduced from 2500 to 2000 mm, the midspan deflection decreased by 59.9%, and the maximum stress of steel decreased by 26.9%. When the span length was increased from 2500 to 3000 mm, the midspan deflection increased by 54.2%, and the maximum stress of steel increased by 21.0%, which indicates that the bearing capacity and section rigidity of composite floor can be significantly improved by reducing the floor span.

6. Conclusions

This paper puts forward a new type of composite floor—the multi-cavity steel-concrete composite floor. In order to understand its basic mechanical properties, a static load test was carried out to study the bearing capacity and failure of composite floor under the load. Numerical simulation was performed using ANSYS software to understand the mechanical properties of the composite floor. Additionally, the influence of steel thickness, composite floor thickness, cavity size and span length on the bearing capacity of composite floor was investigated. The following conclusions can be drawn from this paper:
(1) The multi-cavity steel–concrete composite floor has relatively large bearing capacity, stiffness and good ductility. Moreover, the multi-cavity steel–concrete composite floor has good crack resistance and integrity. The porous steel plates are well bonded with self-compacting concrete to form an integrated structure. The cavity steel plate provides good shear performance for the composite floor, and effectively restricts the horizontal movement of concrete under load, which can ensure that the cavity steel plate and self-compacting concrete work together under loading.

(2) Compared with certain existing precast floors, the total weight of steel used in the multi-cavity steel–concrete composite floor is nearly twice as much as that of certain existing precast floors, but the bearing capacity of multi-cavity steel–concrete composite floor increases to more than four times.

(3) The multi-cavity steel–concrete composite floor is still in the elastic stage when it reaches the limit deflection.

(4) The steel thickness, composite floor thickness, cavity size and span length have a great influence on its bearing capacity. The bearing capacity and section rigidity of composite floor can be improved by increasing steel thickness and floor thickness and by reducing cavity size and floor span length.

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