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HIGH-PRECISION CONSTRUCTION TECHNOLOGY FOR LARGE-AREA SANDWICH-TYPE LIGHTWEIGHT AND HEAVY-LOAD FLOORING

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Abstract: In view of the shortcomings of traditional large-area floors in terms of bearing capacity, deadweight, cost and crack control, this paper proposes a sandwich-type lightweight and heavy-load flooring construction technology. This technology combines solid waste slag concrete cushion layer, film sliding layer, steel fiber concrete and diamond wear-resistant surface layer to ensure that the bearing capacity reaches 5 t/m², effectively solving the problems of high bearing capacity, heavy deadweight and crack prevention. At the same time, the structure saves costs, improves the utilization of solid waste materials, meets the requirements of green buildings, and provides an important reference for the construction of lightweight and heavy-load wear-resistant floors in China.
Keywords: Sandwich type; Light and heavy load; Solid waste slag; Green and low carbon

INTRODUCTION

With the rapid development of global industry, the construction demand of factories and exhibition halls is increasing. As an important component, the floor has put forward higher requirements on construction area, bearing capacity, flatness, crack control and use environment [1-3]. In order to meet the social needs of energy saving, environmental protection and high precision, the floor construction process needs to be optimized and innovated. Traditional large-area floors are usually composed of concrete cushion layers and reinforced concrete surface layers, but when meeting heavy load requirements, there are problems such as heavy weight, high construction cost, high crack risk and difficulty in flatness control [4]. To solve these problems, this paper proposes a sandwich type lightweight heavy load floor construction technology based on the design concept of high load and low bulk density to achieve the advantages of light weight, high flatness, high crack resistance, low cost and green and low carbon.

1 PROCESS PRINCIPLE

Based on the design concept of high load and low bulk density, solid waste slag concrete cushion layer, film sliding layer, steel fiber concrete and corundum wear-resistant surface layer are used (Figure 1). By optimizing the mix ratio of lightweight slag concrete, it replaces traditional plain concrete as cushion backfill; pouring steel fiber concrete to reduce the use of steel bars, and using the excellent properties of steel fibers to improve tensile strength. A double-layer sliding film is added between the slag cushion layer and the steel fiber concrete to reduce shrinkage cracks. At the same time, a leveling robot is used to ensure the high-precision flatness of the large-area surface layer.

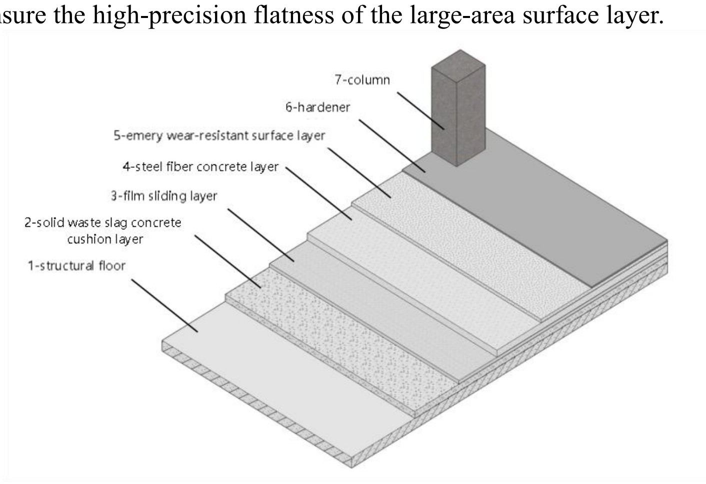

Figure 1 Lightweight and Heavy-Load Floor Structure of the Exhibition Hall

2 PROCESS FLOW AND KEY POINTS OF OPERATION

2.1 Process Flow

Technical preparation → Construction of lightweight slag cushion layer → Laying of film sliding layer → Setting of trench Z-shaped steel, isolation around columns, etc. → Casting of steel fiber concrete → Spreading and finishing of corundum wear-resistant aggregate → Cutting seams → Spraying of hardener → Grinding (Figure 2).

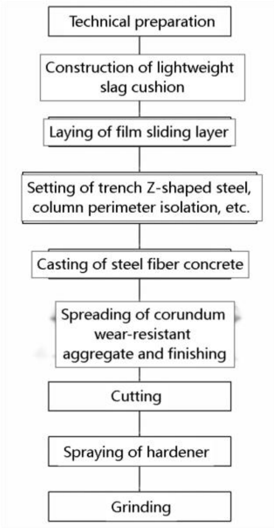

Figure 2 Construction Process Flow Chart

2.2 Technical Preparation

Based on the green building design concept, the lightweight slag cushion layer is optimized in mix ratio design. To ensure that the strength of lightweight aggregate concrete meets the design requirements, 13 groups of standard concrete test blocks are prepared according to different mix ratios, 3 blocks in each group, with specifications of 100mm×100mm×100mm. The mix ratio of lightweight aggregate slag concrete is shown in the table below.

Table 1 Slag Concrete Mix Ratio (0.003m3)

Group Cement	cement（g）	Slag（g）	quicklime（g）	Yellow sand（g）	Stone powder（g）	Crushed stone（g）	Water（g）
1#	471	3000	366	441	-	-	1050
2#	501	3000	366	441	-	-	1050
3#	531	3000	366	441	-	-	1050
4#	561	3000	366	441	-	-	1050
5#	471	3000	366	-	441	-	1050
6#	501	3000	366	-	441	-	1050
7#	531	3000	366	-	441	-	1050
8#	561	3000	366	-	441	-	1050
9#	471	3000	366	-	-	441	1050
10#	501	3000	366	-	-	441	1050
11#	531	3000	366	-	-	441	1050
12#	561	3000	366	-	-	441	1050
13#	621	3000	366	-	-	-	1050

After the test block reaches 28d curing age, the compressive strength test is carried out. The compressive strength of the 8#, 11#, 12#, and 13# test blocks meets the design requirements (≥7.5MPa), as shown in the following table. Finally, considering the low bulk density requirement, on-site construction conditions, and the influence of workers' operation deviation on the strength of slag concrete, the 13# mix ratio was determined as the optimal mix ratio of slag concrete.

Table 2 Comparison of Bulk Density of Slag Concrete with Different Proportions (1m3)

Serial number	42.5Cement（kg）	Slag（kg）	Quicklime（kg）	Stone powder（kg）	Crushed stone（kg）	Water（kg）	Density（kg/m^3）	Compressive strength（MPa）
8#	187	1000	122	147	-	350	1800	7.7
11#	177	1000	122	-	147	350	1800	7.6
12#	187	1000	122	-	147	350	1800	8
13#	207	1000	122	-	-	350	1680	8.2

Figure 3 Optimization of Lightweight Slag Concrete Mix Ratio

2.3 Construction of Lightweight Slag Cushion

The design thickness of the lightweight slag concrete cushion is 250mm, and it is laid in layers, with a ratio of virtual laying to compacted thickness of 1.3:1. Before laying, the surface of the base layer needs to be sprinkled with water to moisten it, and 1:0.5 cement slurry is evenly applied to form a bonding layer. The mixing, laying and compaction of the slag cushion layer must be closely combined to ensure that all operations are completed within 2 hours. For construction joints, a cement slurry bonding layer is applied at the interface when joining to ensure good bonding between different slag cushions and ensure the stability of the overall structure. As shown in Figure 4.

Figure 4 Construction of Slag Concrete Cushion Layer

Figure 5 Laying of Sliding Layer

2.4 Laying of Film Sliding Layer

The sliding layer is set between the cushion layer and the upper concrete. After the slag cushion layer reaches the design strength, two layers of 0.3mm thick PE film are laid perpendicular to each other on it. The PE film must be laid with overlap, and the overlap width is not less than 200mm. As shown in Figure 5.

2.5 Z-Shaped Steel in Trenches, Isolation around Columns, etc.

During trench construction, Z-shaped steel should be welded and fixed on the reserved steel bars on the anti-slope on both sides as the side formwork and finished surface control line of the floor surface. A single-layer bidirectional steel mesh of Φ6@150 is arranged on the surface of the slip layer. The thickness of the protective layer must meet the design requirements to enhance the crack resistance of the upper steel fiber concrete. At the same time, anti-crack reinforcement steel bars are arranged at a 45° angle at the stress concentration parts of the floor (such as the positive corners of the columns), and isolation measures are set around the columns to prevent cracks caused by the restraint of the columns. As shown in Figure 6.

Figure 6 Anti-Crack Reinforcement Setting around Trench and Column

2.6 Steel Fiber Concrete Pouring

Add 10-15 kg of steel fiber into the concrete, with about 4,600 fibers per kg, to enhance the bonding and bite force between the concrete and the aggregate, improve the anti-cracking ability of the floor, and ensure integrity. In addition, a trench is set every 6 meters to realize the compartment pouring of steel fiber concrete. After the concrete is poured, it is first leveled with a vibrating beam, and then leveled with a robot to ensure uniform density of the concrete, and the surface flatness is controlled within the range of 3mm/2m. As shown in Figure 7-8.

Figure 7 Steel Fiber Concrete

Figure 8 Robot Leveling

2.7 Spreading and Finishing of Diamond Wear-Resistant Surface Layer

Before the initial setting of the concrete, mechanical spreading is used instead of manual work to ensure uniform spreading of aggregates. Spread 2/3 of the diamond wear-resistant surface layer on the concrete surface for the first time. After it absorbs water and shows a damp color, use a disc polisher to compact and rub it. The operation should be performed at least 3 times. Then, spread the remaining 1/3 of the diamond sand, with the spreading direction perpendicular to the first time, and smooth it immediately after spreading. Work at least 3 times, and the polishing machine should be operated in a crisscross manner to ensure uniformity and order. As shown in Figure 9-10.

Figure 9 Mechanical Spreading

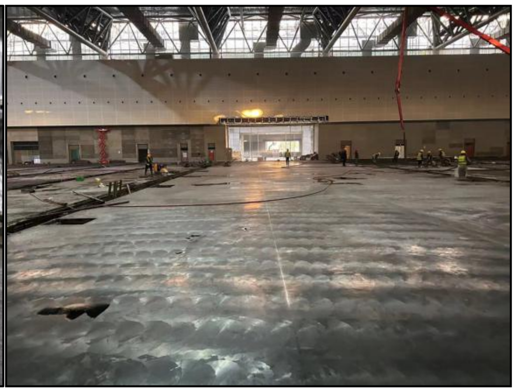

Figure 10 Surface Finishing

2.8 Cutting

Within 48 hours after the floor surface is finished, the cutting should be done with a spacing of 6 meters, a width of 3-5 mm, a depth of 1/2, and staggered arrangement. Before filling the joints, it is necessary to clean up the debris in the joints to ensure that the gaps are clean, and then fill the joints according to the design requirements.

2.9 Hardener Spraying

After the floor has been maintained for 21 days, the surface hardener should be sprayed, and the surface dust should be removed before spraying. On the premise of ensuring that the ground is dry, use a low-pressure spray pot to evenly spray the hardener on the floor surface according to the design dosage of 0.3 kg/m², and keep it wet for at least 40 minutes to penetrate, so as to improve the strength and hardness of the concrete surface and meet the requirements of heavy-duty use.

2.10 Grinding

After the hardener penetration construction is completed, 400# grinding disc should be used for water grinding to remove the residual hardener. After the ground is dry, 800# and 1500# resin sheets are used in combination with grinding equipment for fine grinding to further improve the surface density and ensure that the floor has stronger impact resistance, anti-fouling and anti-seepage capabilities. As shown in Figure 11.

Figure 11 Grinding

3 BENEFIT ANALYSIS

3.1 Economic Benefit

Compared with traditional floor construction methods, this technology uses lightweight slag concrete instead of ordinary plain concrete for cushion backfill; a sliding layer is added between the cushion and the upper surface layer; steel fibers are used instead of the upper steel mesh in the floor surface concrete, which reduces the project cost and saves project costs. The cost comparison between this method and traditional construction is shown in the following table.

Table 3 Cost Comparison (yuan/m^2)

Traditional method (price per square meter)				
Item	Material	Unit price	Quantity	Unit cost (yuan)

1	Plain concrete cushion	580yuan/ m³	0.25m³	145
2	φ6@150steel mesh	5500yuan/ton	12.4kg	68.2
Total				213.2
This process (price per square meter)				
1	Lightweight slag concrete	229.4yuan/ m³	0.25m³	57.3
2	PE film	3yuan/㎡	2 ㎡	6
3	φ6 steel bar	5500yuan/ton	6.2kg	34.1
4	Steel fiber	12000yuan/ton	2.5kg	30
Total				127.4
Comparison results: Compared with the traditional floor method, this process can save about 86 yuan/m^2 (corresponding to the thickness of the cushion layer 250mm).				

3.2 Environmental Benefits

Based on the concept of green building, this method uses industrial solid waste slag, and optimizes the slag concrete ratio to make its corresponding strength reach 8.2MPa (design strength 7.5MPa), and the density is only 1680kg/m3, which effectively solves the problem of solid waste utilization and has good environmental benefits.

4 CONCLUSION

Lightweight and heavy-load floor is an important part of factory and exhibition hall buildings. According to the requirements of construction area, bearing capacity, flatness, crack control, etc., an effective technical solution is proposed. Based on the design concept of high load and low bulk density, this technology adopts solid waste slag concrete cushion layer, sliding layer, steel fiber concrete and diamond wear-resistant surface layer to achieve a bearing capacity of 5 t/m², effectively solving the high load, heavy weight and crack prevention problems of large-area floor. In addition, compared with traditional construction technology, this method saves costs, improves the utilization of solid waste materials, meets the requirements of green and low-carbon buildings, and provides a useful reference for the construction of lightweight and heavy-load wear-resistant floor in China.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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