

CONCRETE SHRINKAGE THEORY-BASED BUILDING FLOOR CRACK-RESISTANT METHOD

TECHNICAL FIELD

5 The present invention relates to the technical field of concrete structure construction, in particular to a concrete shrinkage theory-based building floor crack-resistant method.

BACKGROUND

10 Fine aggregate concrete floor is one of the main forms of building floors for civil buildings such as residential buildings in China. It has the advantages of low cost, good technical performance, long service life, and convenient construction and maintenance. Traditional fine aggregate concrete floors are constructed as follows.

15 First, treating the base layer if the floor of a building is made from reinforced concrete floor slab or prefabricated slab; then setting up elevation and surface level lines and making leveling marks; coating a layer of cement slurry (with construction adhesive mixed inside), and then coating a layer of 25-thick type-III cement-based inorganic thermal insulation slurry; finally, laying a 40-thick C25 fine aggregate concrete surface layer, vibrating, compacting, troweling and followed by maintenance.

20 However, the traditional fine aggregate concrete floors are prone to cracks during daily use. According to the causes of cracks, they can be classified into cracks caused by load, cracks caused by deformation and cracks caused by combined reasons, among which, cracks caused by concrete deformation account for 80%. In other words, most of the cracks in concrete are caused by the deformation of the concrete itself.

25 Hence, there is a need to develop a concrete shrinkage theory-based building floor crack-resistant method to solve the aforementioned technical problem.

SUMMARY

30 An objective of the present invention is to provide a concrete shrinkage theory-based building floor crack-resistant method. By calculating a shrinkage value of the concrete at a certain time point through relevant theoretical calculation formula combined with the actual

engineering situation, and using a torsion device to apply a certain amount of deformation compensation to the concrete during the concrete curing period, the deformation compensation applied can fully meet the shrinkage conditions of the concrete and reduce the likelihood of concrete cracking from the source.

5 In order to solve the above technical problem, the technical solution of the present invention is as follows:

A concrete shrinkage theory-based building floor crack-resistant method, comprising the following steps:

10 Step S1, forming a base layer composed of a cast-in-place concrete floor slab, a plain cement slurry, and a fine aggregate concrete sloping and leveling layer that are sequentially constructed from bottom to top; reserving a construction operation space for a post-cast strip; laying a rebar mesh on the base layer, where square bars are mounted using connecting screws on the two side surfaces of the rebar mesh away from a wall body and the base layer; each connecting screw is provided with a matching single-thread nut, and the single-thread nut is
15 arranged on the side of the square bar away from a rebar;

Step S2, pouring concrete to form a fine aggregate concrete surface layer after the rebar mesh has been laid in step S1;

20 Step S3, performing shrinkage compensation operation by rotating the single-thread nut after completion of final setting of concrete of the fine aggregate concrete surface layer of step S2.

Further, the shrinkage compensation operation in step S3 includes:

Step S31, calculating a unit concrete shrinkage according to a concrete shrinkage formula, wherein the concrete shrinkage formula is:

$$\varepsilon_y(t) = \varepsilon_y^0 \bullet M_1 \bullet M_2 \cdots M_n (1 - e^{-bt})$$

25 where ε_y is an amount of concrete shrinkage per unit length at time t, unit: mm/mm; t is time, unit: day; b is an empirical coefficient, generally take 0.01, take 0.03 when maintenance is poor; ε_y^0 is an ultimate shrinkage under a standard state, take a value of 3.24×10^{-4} , unit: mm/mm; M1, M2, ... Mn are correction values for actual engineering correction obtained according to a value table in the book "Engineering Structure Crack Control", wherein formula 1 represents a
30 shrinkage of concrete along a shrinkage direction:

$$\varepsilon(t) = D\varepsilon_y(t) \quad \dots \dots \text{formula 1,}$$

where D is a length of concrete along the shrinkage direction, unit: mm; $\varepsilon(t)$ is an amount of concrete shrinkage at time t, unit: mm;

Step S32, providing a torsion device, which includes a transverse torsion member and a longitudinal torsion member fixedly connected to each other, the longitudinal torsion member being an L-shaped member, the transverse torsion member being fixed to an upper end of the longitudinal torsion member, a lower end of the longitudinal torsion member matching with the single-thread nut of step S1, wherein the single-thread nut is rotated by pushing the transverse torsion member;

Step S33, calculating a displacement value of the transverse torsion member to be pushed according to formula 2, so as to realize shrinkage compensation of the concrete:

$$X = L \tan \left(\frac{2\pi\Delta}{P} \right) \quad \dots \dots \text{formula 2,}$$

where X is the displacement value of the transverse torsion member, unit: mm; L is a length of the longitudinal torsion member, unit: mm; Δ is a daily concrete shrinkage increment, which is a difference in concrete shrinkage between two adjacent days; P is a pitch of the single-thread nut, unit: mm;

Step S4, removing and recycling the square bar and the torsion device after concrete curing is completed, and pouring the post-cast strip and maintaining the construction operation space of step S1, so that construction of a thermal insulation fine aggregate concrete floor is completed.

Further, the construction operation space of step S1 is a rectangular area of a surface of the base layer defined by a 20cm extension in each of the transverse and longitudinal directions.

Further, one end of the connecting screw is welded to the rebar, and the other end passes through a reserved hole in the square bar, and the connecting screw is locked and fixed after it is rotated to a predetermined position using the single-thread nut.

Further, in order to prevent trampling interference when laying the rebar mesh, the step of laying the rebar mesh includes first laying rebars in one direction and then laying rebars in another direction.

Further, considering that the dimensions and specifications of the connecting screw and nut should be reasonably adopted according to the size of the rebar, and due to the need for fine adjustment operations, it is best to use a grade A or grade B fine-pitch nut. Here, according to the diameter of the rebar, the single-thread nut is an M8 single-thread grade A fine pitch nut.

5 Compared with the prior art, the beneficial technical effects of the present invention are as follows:

(1) The concrete shrinkage theory-based building floor crack-resistant method provided by the present invention can effectively prevent the expansion of micro-cracks and the formation of macro-cracks in the concrete, improve the crack resistance of the fine aggregate concrete,
10 and significantly improve the performance of the fine aggregate concrete. Excellent construction quality further improves the service life.

(2) The concrete shrinkage theory-based building floor crack-resistant method provided by the present invention starts from the crack theory, calculates the amount of concrete shrinkage in detail, provides accurate data on the control of concrete shrinkage, and amplifies the data
15 through a torsion device into a value that is observable and operable. The method has a guiding significance for similar concrete crack control projects.

(3) In the concrete shrinkage theory-based building floor crack-resistant method provided by the present invention, the square bars and the torsion device can be prefabricated according to the rebar layout on the floor surface and the adopted nut specification, and the device can be
20 recycled and reused after the construction is completed, without causing pollution or waste. The method is green and environmentally friendly, and saves construction costs.

(4) The concrete shrinkage theory-based building floor crack-resistant method provided by the present invention can be used together with other anti-crack measures to further improve the anti-crack performance of concrete.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a structural schematic of a thermal insulation fine aggregate concrete floor according to an embodiment of the present invention.

Fig. 2 is a layout of the rebar mesh in the thermal insulation fine aggregate concrete floor
30 according to an embodiment of the present invention.

Fig. 3 is the front view of the torsion device for the thermal insulation fine aggregate concrete floor according to an embodiment of the present invention.

Fig. 4 is an enlarged view of part A of Fig. 3.

Fig. 5 is a side view of the torsion device for the thermal insulation fine aggregate concrete floor according to an embodiment of the present invention.

In the figures:

1-cast-in-place concrete floor slab; 2-plain cement slurry; 3-fine aggregate concrete sloping and leveling layer; 4-fine aggregate concrete surface layer; 7-rebar; 8-square bar; 9-connecting screw; 10-single-thread nut; 11-transverse torsion member; 12-longitudinal torsion member.

10 DETAILED DESCRIPTION

The concrete shrinkage theory-based building floor crack-resistant method provided by the present invention will be further described in detail below in conjunction with the accompanying drawings and specific embodiments. The advantages and features of the present invention will become clearer from the following description. It should be noted that all the drawings are in a very simplified form and use imprecise scales, and are only used to facilitate and clearly assist the purpose of illustrating the embodiments of the present invention. For the convenience of description, the terms "up" and "down" described below are consistent with the directions of up and down in the drawings, but this should not be a limitation to the technical solution of the present invention.

From the perspective of crack generation theory, cracks in concrete are formed from self-deformation, and the deformation is affected by various external and internal conditions, such as temperature, humidity, and surface air velocity. Concrete shrinkage accounts for the largest deformation during the entire process of concrete pouring, curing and subsequent use. When the design load is not exceeded, the amount of concrete shrinkage is the most important factor determining whether it will crack. Therefore, we can calculate the shrinkage value of concrete at a certain time point through relevant theoretical calculation formulas combined with actual engineering conditions, and use torsion device to apply a certain deformation compensation to the concrete during the concrete curing period, so that the shrinkage conditions can be fully satisfied, and the possibility of concrete cracks can be reduced from the source.

The concrete shrinkage theory-based building floor crack-resistant method of the present invention will be described in detail below in conjunction with FIGs. 1 to 5.

Embodiment 1

This embodiment provides a concrete shrinkage theory-based building floor crack-resistant method, which can be used for construction of thermal insulation fine aggregate concrete floor. The specific implementation steps are as follows:

5 Step 1. Cleaning base layer: Clean and rinse off soils, slurry blocks and other sundries on the surface of the base layer; water and moisten the base layer one day before laying the surface layer; and remove accumulated water on the surface.

10 Step 2. Setting up elevation and surface level lines: Measure position of level lines of the floor surface layer according to existing +500mm horizontal elevation lines on walls, and set up level lines on the surrounding walls, making sure that the level lines are consistent in elevation with the corridors, stair platforms, and steps outside the room.

15 Step 3. Controlling concrete pouring area: form a base layer composed of a cast-in-place concrete floor slab 1, a plain cement slurry 2, and a fine aggregate concrete sloping and leveling layer 3 that are sequentially constructed from bottom to top; then divide a concrete pouring area and a construction operation space reserved for a post-cast strip; at the same time, measure placement positions of square bars 8, and mark all areas by setting up lines. The construction operation space is a rectangular area of a surface of the base layer defined by a 20cm extension in each of the transverse and longitudinal directions.

20 Step 4. Placing square bars 8 and laying rebars 7: each rebar 7 is welded at one end thereof with a connecting screw 9 in advance; fix the other end of the rebar 7 to the wall; pass the end welded with the connecting screw 9 through the square bar 8; and tighten a single-thread nut 10 to a predetermined position. In particular, in order to prevent trampling interference when laying the rebars 7, during laying out a rebar mesh, first laying out rebars in one direction and then laying out rebars in the other direction.

25 Step 5. Pouring concrete: pour concrete after the rebars 7 have been laid in both transverse and longitudinal directions; perform rough leveling, and then evenly sprinkling 1:1 cement and sand on the upper surface of the fine aggregate concrete surface layer 4; after water is absorbed, smooth the surface with a wooden trowel for twice. Finally, 2 to 3 hours after pouring, the surface layer begins to cure. When footprints can be formed on the floor but do not sink down,
30 use an iron trowel for final smearing and sweep with a broom.

Step 6. Calculation: calculate, using corresponding formula, daily concrete shrinkage

increment according to data such as length of the concrete section and concrete pouring conditions; and calculate daily displacement value to be applied to the transverse torsion member 11 according to the relationship between sizes of the single-thread nut 10 and the torsion device. In particular, considering that the dimensions and specifications of the connecting screw 9 and single-thread nut 10 should be reasonably adopted according to the size of the rebars 7, and due to the need for fine adjustment operations, it is best to use a grade A or grade B fine-pitch nut. Here, according to the diameter of the rebar 7, the single-thread nut 10 is selected as an M8 single-thread grade A fine pitch nut.

Step 7. Maintenance and shrinkage control: after the final setting of the upper surface of the fine aggregate concrete surface layer 4, use a torsion device to control the amount of concrete shrinkage. During the period of maintenance, applying a daily displacement operation to the transverse torsion member 11 according to the calculated data to achieve the purpose of controlling the shrinkage of concrete.

Step 8. Removing the device and pouring post-cast strip: after the maintenance is completed, remove and recycle the concrete shrinkage control device; then, pour high-grade micro-expansion concrete in the post-cast strip, and carry out corresponding leveling and maintenance measures, so that the entire construction of a thermal insulation fine aggregate concrete floor is completed.

Step 6 specifically includes:

Calculate a unit concrete shrinkage according to a concrete shrinkage formula, wherein the concrete shrinkage formula is:

$$\varepsilon_y(t) = \varepsilon_y^0 \bullet M_1 \bullet M_2 \cdots M_n (1 - e^{-bt})$$

where ε_y is an amount of concrete shrinkage per unit length at time t, unit: mm/mm; t is time, unit: day; b is an empirical coefficient, generally take 0.01, take 0.03 when maintenance is poor; ε_y^0 is an ultimate shrinkage under a standard state, take a value of 3.24×10^{-4} , unit: mm/mm; $M_1, M_2, \dots, M_n$ are correction values taken from a value table in the book "Engineering Structure Crack Control" according to actual engineering situation. In this embodiment, take 3m in transverse direction and 6m in longitudinal direction as an example, the corresponding values are provided in the M_n value table (Table 1). Further, the shrinkage amounts at the transverse 3m long section in the axial direction can be calculated according to the above formula (see Table 2). Formula 1 below represents a shrinkage amount of concrete along a shrinkage direction:

$$\varepsilon(t) = D\varepsilon_y(t)$$

where D is a length of concrete along the shrinkage direction, unit: mm; $\varepsilon(t)$ is an amount of concrete shrinkage at time t, unit: mm.

Table 1: Mn value table

m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12	ΣM_n
1.00	1.13	1.00	1.21	1.20	1.11	0.88	1.00	1.00	1.00	1.00	1.00	1.60

5 Table 2: Shrinkage of 3m long concrete at time t (mm)

t	1	2	3	4	5	6	7	8	9	10	11	12	13	14
$\varepsilon(t)$	0.015	0.031	0.046	0.061	0.076	0.090	0.105	0.119	0.134	0.148	0.162	0.176	0.189	0.203

It can be seen from the above table that the daily axial shrinkage of a concrete with a length of 3 meters is about 0.015mm, that is, the daily control amount of concrete shrinkage is 0.015mm. According to this data, the square bar 8 should be controlled to move in the direction of the concrete by 0.015mm every day.

10 Step 7 includes:

First, provide a torsion device, which includes a transverse torsion member 11 and a longitudinal torsion member 12 that are fixedly connected to each other. The longitudinal torsion member 12 is an L-shaped member, and the transverse torsion member 11 is fixed to an upper end of the longitudinal torsion member 12. A lower end of the longitudinal torsion member 12 engages the single-thread nut 10 such that the single-thread nut can be rotated by pushing the transverse torsion member 11.

For a single-thread nut, its pitch is equal to the lead, which is 1.25mm, that is, one turn of rotation results in an axial displacement of 1.25mm. From this we can calculate that a radian of daily rotation of the single-thread nut 10 should be 4.32°.

20 Secondly, referring to Fig. 4, since the radian is too small to control, this embodiment uses a torsion device to convert the radian into a transverse displacement. According to the trigonometric function formula, if a length of the longitudinal torsion member 12 is 93mm, then translating the transverse torsion member 11 by about 7mm can result in a rotation of the nut 10 by 4.32°. In this way, radian is converted into displacement, and a tiny rotation is converted

into a visible displacement.

According to the above calculation results, the daily shrinkage of a 3m long concrete in the axial direction is about 0.015mm, and the present invention compensates the concrete compression by tightening the nut 10 to push and displace the square bar 8. The daily tightening degree of the nut 10 is about 4.32°. The tiny rotation is amplified into an operable and visible displacement through the longitudinal torsion member 12 and the transverse torsion member 11. To achieve the corresponding degrees of rotation, it is only necessary to push the transverse torsion member 11 by a corresponding distance. In the above calculation process, formula 2 can be deduced according to the relational formula and trigonometric functions. And the pushing distance of the transverse torsion member 11 can be calculated according to formula 2, so as to realize the compensation of concrete compression. Formula 2 is:

$$X = L \tan \left(\frac{2\pi\Delta}{P} \right)$$

where: X is the displacement value of the transverse torsion member 11, unit: mm; L is a length of the longitudinal torsion member 12, unit: mm; Δ is a daily concrete shrinkage increment, which is a difference in concrete shrinkage between two adjacent days; P is a pitch of the single-thread nut 10, unit: mm.

The above description is only a description of the preferred embodiments of the present invention, and does not limit the scope of the present invention. Any changes and modifications made by those of ordinary skill in the field of the present invention based on the above disclosures shall fall within the protection scope of the claims.

CLAIMS

1. A concrete shrinkage theory-based building floor crack-resistant method, comprising the following steps:

5 step S1, forming a base layer composed of a cast-in-place concrete floor slab, a plain cement slurry, and a fine aggregate concrete sloping and leveling layer that are sequentially constructed from bottom to top; reserving a construction operation space for a post-cast strip; laying a rebar mesh on the base layer with each rebar having one end welded to a connecting screw and the other end secured to a wall, an end of the connecting screw away from the rebar passing through
10 a reserved hole in a square bar; arranging a single-thread nut that matches the connecting screw on a side of the square bar away from the rebar; rotating the connecting screw by the single-thread nut until reaching a predetermined position; and locking and fixing the connecting screw;

 step S2, pouring concrete to form a fine aggregate concrete surface layer after the rebar mesh has been laid in step S1;

15 step S3, performing shrinkage compensation operation by rotating the single-thread nut after completion of final setting of concrete of the fine aggregate concrete surface layer of step S2;

 wherein the shrinkage compensation operation in step S3 comprises:

 step S31, calculating a unit concrete shrinkage according to a concrete shrinkage formula,
20 wherein the concrete shrinkage formula is:

$$\varepsilon_y(t) = \varepsilon_y^0 \bullet M_1 \bullet M_2 \cdots M_n (1 - e^{-bt})$$

 where ε_y is an amount of concrete shrinkage per unit length at time t, unit: mm/mm; t is time, unit: day; b is an empirical coefficient, generally take 0.01, take 0.03 when maintenance is poor;
25 ε_y^0 is an ultimate shrinkage under a standard state, take a value of 3.24×10^{-4} , unit: mm/mm; M1, M2, ... Mn are correction values for actual engineering correction obtained according to a value table in the book "Engineering Structure Crack Control", wherein formula 1 represents a shrinkage of concrete along a shrinkage direction:

$$\varepsilon(t) = D\varepsilon_y(t) \quad \dots \dots \text{formula 1,}$$

 where D is a length of concrete along the shrinkage direction, unit: mm; $\varepsilon(t)$ is an amount of
30 concrete shrinkage at time t, unit: mm;

step S32, providing a torsion device, which includes a transverse torsion member and a longitudinal torsion member fixedly connected to each other, the longitudinal torsion member being an L-shaped member, the transverse torsion member being fixed to an upper end of the longitudinal torsion member, a lower end of the longitudinal torsion member matching with the single-thread nut of step S1, wherein the single-thread nut is rotated by pushing the transverse torsion member;

step S33, calculating a displacement value of the transverse torsion member to be pushed according to formula 2, so as to realize shrinkage compensation of the concrete:

$$X = L \tan \left(\frac{2\pi\Delta}{P} \right) \quad \dots \dots \text{formula 2,}$$

where X is the displacement value of the transverse torsion member, unit: mm; L is a length of the longitudinal torsion member, unit: mm; Δ is a daily concrete shrinkage increment, which is a difference in concrete shrinkage between two adjacent days; P is a pitch of the single-thread nut, unit: mm.

2. The crack-resistant method according to claim 1, further comprising:

step S4, removing and recycling the square bar and the torsion device after concrete curing is completed, and pouring the post-cast strip and maintaining the construction operation space of step S1, so that construction of a thermal insulation fine aggregate concrete floor is completed.

3. The crack-resistant method according to claim 1, wherein the construction operation space of step S1 is a rectangular area of a surface of the base layer defined by a 20cm extension in each of the transverse and longitudinal directions.

4. The crack-resistant method according to claim 1, wherein laying the rebar mesh comprises first laying rebars in one direction and then laying rebars in another direction.

5. The crack-resistant method according to claim 1, wherein the single-thread nut is an M8 single-thread grade A fine pitch nut.