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T/CCPA 30—2022

Ultra-high performance concrete (UHPC) panel for exterior wall

超高性能混凝土(UHPC)外墙板



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Foreword

This document is drafted in accordance with the rules given in the GB/T 1.1—2020, ‘*Directives for standardization—Part 1: Structure and drafting of standards*’. China Building Materials Federation, and China Concrete and Cement-based Products Association are in charge of this English translation. In case of any doubt about the contents of this English translation, the Chinese original shall be considered authoritative.

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Ultra-high performance concrete (UHPC) panel for exterior wall

1 Scope

This document specifies the classification and marking, general provisions, raw materials, requirements, test methods, inspection rules, identification, transport, storage and certificate of qualification for ultra-high performance concrete panels for exterior walls.

This document is applicable to non-load bearing ultra-high performance concrete panels for exterior walls.

2 Normative references

The contents of the following documents which, through normative reference in this text, constitute indispensable provisions of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- GB 175 *Common portland cement*
- GB/T 1596 *Fly ash used for cement and concrete*
- GB/T 2015 *White portland cement*
- GB/T 2828.1—2012 *Sampling procedures for Inspection by attributes--part 1: sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*
- GB/T 8076 *Concrete admixtures*
- GB/T 14684 *Sand for construction*
- GB/T 15231 *Test methods for the properties of glassfibre reinforced cement*
- GB/T 18046 *Ground granulated blast furnace slag used for cement, mortar and concrete*
- GB/T 18736 *Mineral admixtures for high strength and high performance concrete*
- GB/T 21120 *Synthetic fibers for cement concrete and mortar*
- GB/T 27690 *Silica fume for cement mortar and concrete*
- GB/T 30100 *Test methods for building wallboard*
- GB/T 39147 *Steel fiber for concrete*
- GB 50016 *Code for fire protection design of buildings (2018 edition)*
- GB/T 50081 *Standard for test methods of concrete physical and mechanical properties*
- JC/T 539 *Pigments for concrete and mortar, and their test methods*
- JC/T 572 *Alkali-resistant glass fiber roving*
- JC/T 841 *Alkali-resistant glass fiber mesh*
- JGJ 63 *Standard of water for concrete*
- JGJ/T 423 *Technical standard for glass fiber reinforced cement (GRC) used on building*
- T/CBMF 96/T/CCPA 20 *Premix for ultra-high performance concrete*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

ultra-high performance concrete (UHPC) panel for exterior wall

a type of concrete panel, prefabricated by casting or spraying process, using raw materials including cement, active powder materials such as mineral admixtures, fine aggregates, chemical admixtures, high-strength micro-steel fibres and/or organic synthetic fibres and/or inorganic fibres, pigments, and water, etc., with ultra-high strength and ultra-high toughness, and applied to non-load bearing exterior walls.

Note: Referred to as UHPC panel for exterior wall.

3.2

ribbed panel

a panel with stiffening ribs on the back along the edge or at other position in need of strengthening.

3.3

stud frame panel

a panel composed of facade panel, embedded fixings and steel frame and prefabricated at one time as a complete unit in the factory according to the design requirements.

4 Classification and marking

4.1 Classification

4.1.1 Classification by structure of the panel

- Flat sheet panel, represented as PB;
- Perforated panel, represented as LKB;
- Ribbed panel, represented as DLB;
- Stud frame panel, represented as GJB.

4.1.2 Classification by manufacturing process

- Panel made by casting process, represented as JZ;
- Panel made by spraying process, represented as PS.

4.1.3 Classification by main reinforcing fibre

- Panel reinforced by steel fibre, represented as SF;
- Panel reinforced by organic synthetic fibre, represented as OF;
- Panel reinforced by inorganic fibre, represented as IF, among which, reinforced by glassfibre is represented as GF.

4.2 Marking

UHPC exterior wall panel is marked in the orders of its structure, manufacturing process, main reinforcing fibre, dimension (length × width × thickness) and compliant standard number.

Example: An UHPC stud frame panel reinforced by steel fibre and manufactured by casting process according to T/CBMF 171—2022/T/CCPA 30—2022, with a dimension of 2000 mm × 1000 mm × 15 mm, is marked as:

UHPC-GJB-JZ-SF-2000 × 1000 × 15-T/CBMF 171—2022/T/CCPA 30—2022

5 General provisions

5.1 The flexural limit of proportionality, ultimate flexural strength and impact strength of UHPC exterior

wall panel are properties of the backing layer.

5.2 The fire resistance rating of UHPC exterior wall panels shall meet the design requirements and the provisions of GB 50016.

5.3 UHPC exterior wall panels and embedded fixings shall be firmly connected and meet the design requirements.

5.4 Steam curing shall not be adopted in the manufacturing process of UHPC exterior wall panels reinforced by glassfibre.

6 Raw materials

6.1 Cement

Portland cement or ordinary Portland cement shall comply with the provisions of GB 175; white Portland cement shall comply with the provisions of GB/T 2015. The strength grade of cement shall not be lower than 52.5.

6.2 Fibres

Steel fibre shall comply with the provisions of GB/T 39147, and the tensile strength shall not be less than 2000 MPa; synthetic fibre shall comply with the provisions of GB/T 21120; alkali resistant glassfibre roving and chopped strand shall comply with the provisions of JC/T 572; alkali resistant glassfibre mesh shall comply with the provisions of JC/T 841. The content of ZrO_2 in alkali resistant glassfibre shall not be less than 16.5%.

6.3 Sand

Sand shall comply with the provisions of GB/T 14684.

6.4 Chemical admixtures

Chemical admixtures shall comply with the provisions of GB/T 8076.

6.5 Mineral admixtures

Fly ash shall comply with the provisions of GB/T 1596; silica fume shall comply with the provisions of GB/T 27690; ground granulated blast furnace slag shall comply with the provisions of GB/T 18046; metakaolin shall comply with the provisions of GB/T 18736.

6.6 Premix

Premix shall comply with the provisions of T/CBMF 96/T/CCPA 20.

6.7 Pigments

Pigments shall comply with the provisions of JC/T 539.

6.8 Water

Water shall comply with the provisions of JGJ 63.

6.9 Metal

Metal materials such as stud frames and embedded fixings shall comply with relevant provisions of

7 Requirements

7.1 Appearance

7.1.1 The edges of UHPC exterior wall panels shall be neat. The appearance surface shall be free of missing edges and corners; there shall be no more than one instance of missing edge or corner within 3 m along the edges, with its size no more than 20 mm.

7.1.2 The surface of joint area of UHPC exterior wall panels shall not bear cavities. The length and depth of cavities on panel surface shall not be more than 3 mm and 2 mm respectively, and the number of cavities shall not be more than one per m^2 .

7.1.3 When special decorative effect is required on the surface of UHPC exterior wall panel, the requirements of appearance shall be agreed between the supplier and the buyer.

7.2 Dimension tolerance

The dimension tolerance shall not exceed the provisions in Table 1.

Table 1 Dimension tolerance

Items	Tolerance
Length	$\pm 2 \text{ mm/m}$, where panel length $\leq 2 \text{ m}$ Overall $\leq 4 \text{ mm}$, where panel length $> 2 \text{ m}$
Width	$\pm 2 \text{ mm/m}$, where panel width $\leq 2 \text{ m}$ Overall $\leq 4 \text{ mm}$, where panel width $> 2 \text{ m}$
Thickness	0mm ~ 2 mm
Planeness	$\leq 3 \text{ mm}$, not including that for panels with special shape or special surface decoration requirements
Difference in Diagonals (applicable to rectangle panel only)	$\leq 3 \text{ mm}$, where panel area $< 2 \text{ m}^2$ $\leq 5 \text{ mm}$, where panel area $\geq 2 \text{ m}^2$
Lateral alignment	1 mm/m, and overall $\leq 8 \text{ mm}$
Torsion-warping	1 mm/m, and overall $\leq 10 \text{ mm}$

7.3 Physical and mechanical properties

7.3.1 The compressive strength of ultra-high performance concrete shall not be less than 120 MPa.

7.3.2 The physical and mechanical properties of UHPC exterior wall panel shall comply with the provisions in Table 2.

Table 2 Physical and mechanical properties

Description	Requirements		
	Casting	Casting	Spraying
	Steel fibre	Organic/inorganic fibre	Glassfibre
Flexural Limit of Proportionality/MPa $\geq$	13.0	12.0	11.0

Table 2 Physical and mechanical properties (Continued)

Description		Requirements		
		Casting	Casting	Spraying
		Steel fibre	Organic/inorganic fibre	Glassfibre
Ultimate flexural strength/MPa	$\geq$	20.0	12.0	22.0
Impact strength/(kJ/m ²)	$\geq$	24.0	9.0	15.0
Bulk density (dry) /(g/cm ³)	$\geq$	2.4	2.2	2.2
Water absorption/%	$\leq$	1.2	1.5	1.5
Frost resistance		No damage such as delamination or peeling occurs after 200 freeze-thaw cycles		
Impermeability		No wet mark or water drop on the back of the test specimens occurs after 48 hours		
Shrinkage/%	$\leq$	0.06		

8 Test methods

8.1 Test age

Test age for naturally cured test specimens shall not be less than 28 days, and that for steam cured test specimens shall not be less than 7 days.

8.2 Appearance

8.2.1 Measuring tool

Steel ruler, with a measuring range 0 mm to 300 mm, accurate to 0.5 mm.

8.2.2 Method

Visually check the panel for any missing section of edges or broken corners and cavities, and measure the size of cavities, if any, with a steel ruler.

8.3 Dimension deviation

8.3.1 Length and width

8.3.1.1 Measuring tool

Steel tape, with a measuring range 0 mm to 10000 mm, accurate to 1 mm.

8.3.1.2 Method

Measure the length of a panel respectively at three locations, i. e. 100 mm away inward from both sides and along the width centerline, accurate to 1 mm. Subtract the nominal length of the panel from the measured length to obtain the deviation, and record the maximum positive and the maximum negative length deviation from the three deviation values. When a panel is less than or equal to 2 m in length, the positive and negative length deviation are obtained through dividing the maximum positive and the maximum negative

deviation by the nominal length of the panel respectively; when a panel is greater than 2 m in length, the maximum positive and maximum negative length deviation are directly taken as the length deviation of the panel.

Measure the width of a panel respectively at three locations, i. e. 100 mm away inward from both sides and along the length centerline, accurate to 1 mm. Subtract the nominal width of the panel from the measured width to obtain the deviation, and record the maximum positive and the maximum negative width deviation from the three deviation values. When a panel is less than or equal to 2 m in width, the positive and negative width deviation are obtained through dividing the maximum positive and the maximum negative deviation by the nominal width of the panel respectively; when a panel is greater than 2 m in width, the maximum positive and maximum negative width deviation are directly taken as the width deviation of the panel.

8.3.2 Thickness

8.3.2.1 Measuring tools

- Vernier callipers, with a measuring range 0 mm to 200 mm, accurate to 0.02 mm;
- Outside callipers, with a measuring range 0 mm to 200 mm.

8.3.2.2 Method

Measure the thickness of the panel, by the outside callipers and Vernier callipers, respectively at the four intersections located 100 mm inward away from each end and each side of the panel, and at the two intersections located 100 mm inward away from each side and the length centerline, excluding the areas with stiffening ribs and other local reinforcements, and take the maximum and minimum values as the test values, and subtract the nominal thickness of the panel from the two test values respectively to obtain the positive and negative deviation of the panel thickness.

8.3.3 Planeness

8.3.3.1 Measuring tools

- Feeler gauge, with a measuring range 0 mm to 10 mm;
- Guiding ruler, with a length 2 m.

8.3.3.2 Method

Measure the planeness, with a guiding ruler and a feeler gauge, along the four lines 200 mm inward from each edge, and along both length centerline and width centerline respectively, record the maximum gap between the guiding ruler and the panel surface of each measurement, and take the maximum of all measured values as the test result, accurate to 0.1 mm.

8.3.4 Difference in diagonals

8.3.4.1 Measuring tool

Steel tape, with a measuring range 0 mm to 10000 mm, accurate to 1 mm.

8.3.4.2 Method

Measure the length of the two diagonals of the panel with a steel tape, accurate to 1 mm. The

difference between the lengths of the two diagonals is the difference in diagonals.

8.3.5 Lateral alignment

8.3.5.1 Measuring tool

Steel ruler, with a measuring range 0 mm to 300 mm, accurate to 0.5 mm.

8.3.5.2 Method

At the edge of the panel length direction, stretch a measuring line along the panel surface connecting the two end points and straighten it tightly. Measure the maximum distance between the straight edge and the measuring line with a steel ruler. Measure both sides respectively, and take the maximum value as the test result, accurate to 0.5 mm.

8.3.6 Warpage

8.3.6.1 Measuring tool

Steel ruler, with a measuring range 0 mm to 300 mm, accurate to 0.5 mm.

8.3.6.2 Method

Stretch two measuring lines at the same time along the two diagonal ends of the panel and straighten it tightly. Use a steel ruler to measure the vertical distance between the intersection of two measuring lines, accurate to 0.5 mm, and double the measured value to obtain the warpage value.

8.4 Physical and mechanical properties

8.4.1 Compressive strength

Prepare threecubic test specimens, at the size of 100 mm × 100 mm × 100 mm each, under the same ambient conditions, mix design (without fibre), manufacturing process and curing method as the product is made, the specimens shall be tested according to the provisions of GB/T 50081, and the loading rate shall be 1.2 MPa/s ~ 1.4 MPa/s. The dimension conversion factor is 1.0.

8.4.2 Flexural limit of proportionality, ultimate flexural strength and impact strength

The test specimens' preparation and test methods shall comply with the provisions of GB/T 15231.

8.4.3 Bulk density, water absorption and frost resistance

The test specimen shall be cut from the product, and the cutting position of the test specimen shall not be less than 100 mm from the edge of the product. The dimension, quantity and test method of the test specimens shall be carried out in accordance with the provisions of GB/T 15231. When measuring the mass of the test specimens in the dry state, the drying time of the test specimens shall be 48 hours; when measuring the mass of the specimens in the saturated state, the immersion time of the specimens shall be 48 hours.

Automatic freeze-thaw test equipment should be used for frost resistance test. The freeze-thaw equipment should meet the requirements of slow free-thaw test equipment specified in JG/T 243—2009. The appearance of frozen and thawed specimens should be inspected every 25 cycles.

8.4.4 Impermeability

Three test specimens shall be cut from the actual product, the cutting position shall not be less than 100 mm from the edges of the product, with a nominal size of 250 mm × 250 mm and a thickness same as the product. The test shall be conducted according to the provisions of GB/T 30100. Test specimens shall be stored indoor with good ventilation for 3 days. The test result is concluded by observing whether wet marks or water droplets occurred on the back of the test specimens after placing for 48 hours.

8.4.5 Shrinkage

8.4.5.1 Apparatus

Apparatus and requirements:

- Outside micrometer, accurate to 0.01 mm;
- Drying oven with a temperature range from 0℃ to 200℃;
- Water tank, water temperature kept at 10℃ ~ 25℃;
- Desiccator.

8.4.5.2 Test specimen preparation

Prepare two test specimens according to the method specified in GB/T 15231, with the dimension of 260 mm × 260 mm × (10 ~ 15) mm.

8.4.5.3 Testing procedure

Place the test specimens indoor with good ventilation for 3 days. Draw and number the marking lines 10mm inward from the four edges of the test specimen, with each line reaching the two ends. Immerse the test specimens in water at 10℃ ~ 25℃ for 24 hours, and the water level shall be at least 20 mm above the test specimens. After removal from the water, wipe the test specimens with a damp cloth to remove any surface water, and measure the length (l_1) of each marking line respectively. Then, put the test specimens into a drying oven with a temperature of $(60 \pm 5)^\circ\text{C}$ for 48 hours, and take them out and put into a desiccator to cool to room temperature. Measure the length (l_2) of each marking line again, accurate to 0.01 mm.

During the immersion and drying of the test specimens, the spacing between the test specimens and the inner wall of the water tank or drying oven shall not be less than 50 mm, and the spacing between adjacent test specimens shall not be less than 20 mm.

8.4.5.4 Calculation of results

Shrinkage is calculated by Equation (1), and the results are presented by the arithmetic mean of eight data obtained from two specimens, accurate to 0.01%:

$$\varepsilon = \frac{l_1 - l_2}{l_1} \times 100 \quad \dots\dots\dots (1)$$

where:

ε —— Shrinkage, %;

l_1 —— Length of test specimens in saturated state, mm;

l_2 —— Length of test specimens after drying at $(60 \pm 5)^\circ\text{C}$, mm.

9 Inspection rules

9.1 Delivery inspection

9.1.1 Inspection items

Delivery inspection items include appearance, dimensional deviation, compressive strength, ultimate flexural strength, bulk density and water absorption.

9.1.2 Batch

Products manufactured with the same raw materials, mix design and manufacturing process form one inspection batch. Each batch comprises 200 pieces of products. Products less than 200 pieces are also regarded as one batch.

9.1.3 Judgement

9.1.3.1 Appearance

Inspect each piece. The appearance of the batch is deemed to be accepted when the inspection results comply with the provisions of 7.1, otherwise, deemed to be rejected.

9.1.3.2 Dimension deviation

Inspect each piece. The dimension deviation of each batch is deemed to be accepted when the inspection results comply with the provisions of 7.1, otherwise deemed to be rejected.

9.1.3.3 Physical and mechanical properties

Inspect each batch according to 8.4. Physical and mechanical properties of each batch are deemed to be accepted when the results comply with the provisions of 7.3, otherwise deemed to be rejected.

9.1.4 Overall judgement

The inspected batch is deemed to be accepted when all delivery inspection items comply with the provisions of this document.

9.2 Type inspection

9.2.1 Inspection condition

Type inspection shall be carried out under any of the following circumstances;

- Trial production and design appraisalment;
- Major change in the product structure, materials and production technology;
- Production resume after suspension for more than 6 months;
- Significant discrepancy between the delivery inspection results and the last type inspection results;
- Once a year under normal production condition.

9.2.2 Inspection items

The type inspection items comprise all the requirements specified in Clause 7.

9.2.3 Batch and inspection sampling

One inspection batch is referred to the products manufactured by the same manufacturing process, raw materials and mix design. Appearance inspection and dimension deviation inspection shall comply with the secondary sampling scheme for normal inspection specified in GB/T 2828.1—2012. The secondary sampling scheme for product inspection is listed in Table 3.

Table 3 Secondary sampling scheme for product inspection

Batch size N	Sample	Sample number		Acceptance criteria		Rejection criteria	
		n_1	n_2	Ac_1	Ac_2	Re_1	Re_2
151 ~ 280	1	8	—	0	—	2	—
	2	—	8	—	1	—	2
281 ~ 500	1	13	—	0	—	3	—
	2	—	13	—	3	—	4
501 ~ 1200	1	20	—	1	—	3	—
	2	—	20	—	4	—	5
1201 ~ 3200	1	32	—	2	—	5	—
	2	—	32	—	6	—	7

9.2.4 Judgment

9.2.4.1 Appearance and dimension deviation

9.2.4.1.1 The appearance and dimension deviation of the product are deemed to be accepted when the appearance and dimension deviation of the inspected product comply with the corresponding provisions in 7.1 and 7.2. The appearance and dimension deviation of the product are rejected if one or more inspection result (s) of the appearance and dimension deviations do not comply with the corresponding provisions in 7.1 and 7.2.

9.2.4.1.2 Based on the sample inspection results, if the number of non-conforming products (μ_1) in the first sample (n_1) is less than or equal to the first acceptance criterion number (Ac_1) listed in Table 3, the appearance and dimension deviation of the batch of products are deemed to be accepted. If the number of non-conforming products (μ_1) in the first sample (n_1) is greater than or equal to the first acceptance criterion number (Re_1) listed in Table 3, the appearance and dimension deviation of the batch of products are deemed to be rejected.

9.2.4.1.3 If the number of non-conforming products (μ_1) in the first sample (n_1) is greater than the first acceptance criterion number (Ac_1) and less than the first rejection criterion number (Re_1), conduct the second sampling (n_2) and inspection. If the sum of the number of non-conforming products in the first and second samples ($\mu_1 + \mu_2$) is less than or equal to the second acceptance criterion number (Ac_2), the appearance and dimensional deviation of the batch are deemed to be accepted. If the sum of the number of non-conforming products in the first and second samples ($\mu_1 + \mu_2$) is greater than or equal to the second rejected criterion number (Re_2), the appearance and dimensional deviation of the batch are deemed to be rejected.

9.2.4.2 Physical and mechanical properties

Inspect each batch according to 8.4. The physical and mechanical properties of each batch are deemed to be accepted when the results comply with the provisions of 7.3, otherwise, deemed to be rejected.

9.2.5 Overall determination

The batch of products is deemed to be accepted when the appearance, dimension deviation and physical and mechanical properties are all accepted. The batch of products is deemed to be rejected if one or more items are rejected.

10 Identification, transport, storage and certificate of qualification

10.1 Identification

The product marking, production date, manufacturer name, etc. shall be identified in a clearly visible position on the back of the panel.

10.2 Transport

During transport, cushioning and protection materials should be used to pack the panels, so as to avoid cracking or unrecoverable deformation caused by structural damage.

10.3 Storage

The storage site shall be firm and flat. The panels should be supported by frames to avoid unexpected loads. Protective measures shall be taken at the positions in contact with the exposed surfaces of the panel, and all cushion blocks, packaging and protective materials shall not cause marks, stains or any other forms of damage to the panel.

10.4 Certificate of qualification

For products passing the inspection, the factory certificate shall be completed, which includes:

- Certificate number;
- Name of the manufacturer;
- Product marking, quantity and production date;
- Delivery inspection results;
- Signature and seal of the quality inspection department of the manufacturer.

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