

ICS 91.100.40

CCS Q 15

**CBMF**

Standard of China Building Materials Federation

T/CBMF 171-2022

T/CCPA 30-2022

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

## 超高性能混凝土 (UHPC) 外墙板

*(English Translation)*

(征求意见稿)

Issued Date: 2022-03-22

Implementation Date: 2022-07-22

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Issued by China Building Materials Federation & China Concrete &  
Cement-based Products Association

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## Forward

This document is drafted in accordance with the rules given in GB/T 1.1-2020, 'Directives for standardization—Part 1: Structure and drafting of drafting of standards'. China Building Materials Federation & China Concrete & Cement-based Products Association is in charge of this English translation. In case of any doubt about the contents of 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, signs, transport, storage and certificate of qualification of ultra-high performance concrete panel for exterior wall.

This document is applicable to the non-load bearing ultra-high performance concrete panel for exterior wall.

## 2 Normative references

The contents in the following documents constitute essential clauses of this document through normative references. For dated references, only the edition cited applies. For undated references, the latest edition (including all amendments) of the normative document referred to 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 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 fibres 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 fibre for concrete*

GB 50016 *Code for fire protection design of building*

GB/T 50081 *Standard for test methods of concrete physical and mechanical properties*

JC/T 539 *Pigments for concrete and mortar and test methods*

JC/T 572 *Alkali-resistant glass fibre roving*

JC/T 841 *Alkali-resistant glass fibre mesh*

JGJ 63 *Standard of water for concrete*

JG/T 243—2009 *Apparatus for resistance to free-thaw test of concrete*

JGJ/T 423 *Technical standard for glass fibre reinforced cement (grc) used on building*

T/CBMT 96-2020/T/CCPA20-2020 *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 panel for exterior wall**

Non load-bearing ultra-high strength and ultra-high toughness concrete panel for exterior wall, referred to as UHPC panel for exterior wall, is made of active powder materials such as cement and mineral powders, fine aggregates, admixtures, high-strength micro steel fibres and/or organic synthetic fibres and/or inorganic fibres, pigments, water and other raw materials by casting or spraying process.

#### **3.2**

##### **Ribbed panel**

A panel with reinforcing ribs in the back along the edge or at other position to be strengthened.

#### **3.3**

##### **Stud frame panel**

A panel composed of front panel, embedded fixings and steel frame and prefabricated at one time in the factory according to the design requirements.

### **4 Classification and marking**

#### **4.1 Classification**

4.1.1 UHPC exterior wall panels are divided into the following four categories according to the construction of the panel

- a) Flat sheet, represented as PB;
- b) Perforated panel, represented as LKB;
- c) Ribbed Panel, represented as DLB;
- d) Stud frame panel, represented as GJB.

4.1.2 UHPC exterior wall panels are divided into the following two categories according to the manufacturing process

- a) Casting method, represented as JZ;



b) Spraying method, represented as PS.

4.1.3 UHPC exterior wall panels are divided into the following three categories according to the reinforcing fibres,

a) Steel fibre, represented as SF;

b) Organic synthetic fibre, represented as OF;

c) Inorganic fibre, represented as IF, among them, glassfibre is represented as GF.

## 4.2 Marking

UHPC exterior wall panel is marked in turn by construction type, 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 XX-202X/T/CCPA XX-202X with a dimension of 2000mm×1000mm×15mm is marked as:

**UHPC-GJB-JZ-SF-2000×1000×15-T/CBMF XX-202X/T/CCPA XX-202X**

## 5 General provisions

5.1 The flexural limit of proportionality, ultimate flexural strength and impact strength of UHPC exterior wall panel are part of the properties of backing layer.

5.2 The fire resistance limit of UHPC exterior wall panel 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 to 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 2000MPa; 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<sub>2</sub> 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 Admixtures**

Admixtures shall comply with the provisions of GB 8076.

**6.5 Mineral powders**

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 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 96-2020/T/CCPA20-2020.

**6.7 Pigment**

Pigment 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 frame and embedded fixings shall comply with relevant provisions of JGJ/T 423.

**7 Requirements**

**7.1 Appearance**

7.1.1 The edge of UHPC exterior wall panel shall be neat. The appearance surface shall be free of missing edges and corners. In addition, there shall be no more than one missing edge or corner within 3m length along the edge, and its size shall not be more than 20mm.

7.1.2 The edge sides of UHPC exterior wall panel shall not bear cavity. The length and depth of cavities inside panel surface shall not be more than 3mm and 2mm respectively, and the number of cavities shall not be more than 1 per m<sup>2</sup>.

7.1.3 When specified decorative effect is required on the surface of UHPC exterior wall panel, the requirements of appearance can be determined by the supplier and the buyer.

**7.2 Dimension tolerance**

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

**Table 1 Dimension tolerance**

Item	Tolerance
------	-----------

Length	±2mm/m, where length ≤2m Overall tolerances≤4mm, where length >2m
Width	±2mm/m, where width ≤2m Overall tolerances≤4mm, where width >2m
Thickness	0mm ~+2mm
Planeness	≤3mm, not including special-shaped panel or specified surface decoration effect requirements
Difference in Diagonals (rectangle panel only)	≤3mm, where panel area<2m <sup>2</sup> ≤5mm, where panel area≥2m <sup>2</sup>
Lateral alignment	1mm/m, and overall≤8mm
Torsion-warping	1mm/m, and overall≤10mm

### 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**

Properties		Index requirements		
		Casting		Spraying
		Steel fibre	Organic/ inorganic fibre	Glassfibre
Limit of Proportionality/MPa	≥	13.0	12.0	11.0
Ultimate flexural strength/MPa	≥	20.0	12.0	22.0
Impact strength/(kJ/m <sup>2</sup> )	≥	24.0	9.0	15.0
Bulk density(dry)/(g/cm <sup>3</sup> )	≥	2.4	2.2	2.2
Water absorption/%	≤	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 pieces occurs after 48hrs		
Shrinkage/%	≤	0.06		

## 8 Test methods

### 8.1 Test age

Test age of naturally cured pieces shall not be less than 28d, and not less than 7d for steam curing pieces.

### 8.2 Appearance

#### 8.2.1 Measuring tool

Steel ruler, measuring range: 0mm ~ 300mm, scale division: 0.5mm.

### 8.2.2 Method

Visually check any missing edges or corners and cavities, and measure the cavity size with a steel ruler.

## 8.3 Dimension tolerance

### 8.3.1 Length and width

#### 8.3.1.1 Measuring tool

Steel tape, measuring range: 0mm ~ 10000mm, scale division: 1mm.

#### 8.3.1.2 Method

Measure the length at 100mm from the edges on both sides of the panel and the centerline in the width direction, accurate to 1mm. Subtract the nominal length of the panel from the measured value to obtain the deviation value, and take the maximum positive and negative deviation values as the length deviation. When the length of the panel is less than or equal to 2m, the maximum positive and negative deviation divided by the nominal length of the panel is the length deviation; When the length of the panel is greater than 2m, the maximum positive and negative deviation values are directly used as the length deviation.

Measure the width at 100mm from the edges on both ends of the panel and the centerline in the length direction, accurate to 1mm. Subtract the nominal width of the panel from the measured value to obtain the deviation value, and take the maximum positive and negative deviation values as then width deviation. When the width of the panel is less than or equal to 2m, the maximum positive and negative deviation divided by the nominal width of the panel is the width deviation; When the width of the panel is greater than 2m, the maximum positive and negative deviation values are directly used as the width deviation.

### 8.3.2 Thickness

#### 8.3.2.1 Measuring tool

Vernier caliper, measuring range: 0mm ~ 200mm, scale division: 0.02mm.

Outside calipers, measuring range: 0mm ~ 200mm.

#### 8.3.2.2 Method

At the intersection of 100mm from both ends and both sides of the panel (four in total) and the intersection of 100mm from both sides and the symmetric line in the length direction (two in total), use the outside calipers and vernier caliper to measure the thickness of the panel avoiding areas in the reinforcing ribs and other locally reinforced positions, take the maximum and minimum values as the test values, and subtract the nominal thickness of the panel from the two test values to obtain the positive and negative deviation of the panel thickness.

### 8.3.3 Planeness

#### 8.3.3.1 Measuring tool

Feeler gauge, measuring range 0mm~10mm;

Guiding ruler, length 2m.

#### 8.3.3.2 Method

At 200mm from both sides and ends of the panel and the centerline of the length and width direction, measure along the length and width direction with a guiding ruler and a feeler gauge, record the value at the maximum gap between the guiding ruler and the panel surface, and take the maximum of all measured values as the test result, accurate to 0.1mm.

#### 8.3.4 Difference in Diagonals

##### 8.3.4.1 Measuring tool

Steel tape, measuring range: 0mm ~ 10000mm, scale division: 1mm.

##### 8.3.4.2 Method

Measure the length of the two diagonals of the panel with a steel tape, accurate to 1mm. 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, measuring range: 0mm ~ 300mm, scale division: 0.5mm.

##### 8.3.5.2 Method

At the edge of the panel length direction, pull 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 0.5mm.

#### 8.3.6 Torsion-warping

##### 8.3.6.1 Measuring tool

Steel ruler, measuring range: 0mm ~ 300mm, scale division: 0.5mm.

##### 8.3.6.2 Method

Pull 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 0.5mm, and double the measured value to obtain the torsion-warping value.。

### **8.4 Physical and mechanical properties**

#### 8.4.1 Compressive strength

With the same environmental conditions, mix design (excluding fibre), manufacturing process

and curing method as the actual product, make 3 cubic test specimens at the size of 100mm × 100mm × 100mm. Specimens shall be tested according to the provisions of GB/T 50081, and the loading rate shall be 1.2MPa/s ~ 1.4MPa/s. The dimension conversion factor is 1.0.

#### 8.4.2 Limit of Proportionality, Ultimate flexural strength, Impact strength

The test pieces preparation and test methods shall comply with the provisions of GB/T 15231.

#### 8.4.3 Bulk density, Water absorption, Frost resistance

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

Automatic freeze-thaw equipment should be used for frost resistance test. The freeze-thaw equipment should meet the requirements of slow freezing and thawing 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

Test pieces shall be cut from the actual product, the cutting position shall not be less than 100mm from the edge of the product, and the nominal size of the test piece is 250mm × 250mm, the thickness is same as the product, and the quantity is 3. The test method shall be conducted according to the provisions of GB/T 30100. Test pieces shall be stored in a well ventilated chamber for 3 days. The test result concluded by observing whether wet marks or water droplets occurred on the back of the test piece after 48 hours.

#### 8.4.5 Shrinkage

##### 8.4.5.1 Apparatus

Apparatus comprises and their requirement:

- a) Outside micrometer: scale division 0.01mm;
- b) Drying oven: temperature range: 0°C~200°C;
- c) Water tank: water temperature adjusted to 10°C~25°C;
- d) Desiccator

##### 8.4.5.2 Test specimen preparation

Make 2 test pieces according to the method provided in GB/T 15231 and the dimension is 260mm×260mm×(10~15)mm.

##### 8.4.5.3 Testing procedure

Put the test pieces in a well ventilated chamber for 3 days. Draw and number the measuring lines

10mm away from the four edges of the test piece, and each line shall extend to the two ends. Immerse the test pieces in water at 10°C~25°C for 24 hours, and the water level shall not be less than 20mm higher than the test pieces. After removal from the water, wipe the test pieces with a damp cloth to remove any surface water. Measure the length ( $l_1$ ) of each marking line respectively. Then put the test pieces into a drying oven with a temperature of (60 ± 5)°C for 48h. Take them out and put into a desiccator and cool it to room temperature. Measure the length ( $l_2$ ) of each marking line again, accurate to 0.01mm.

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

#### 8.4.5.4 Expression of results

Shrinkage is determined by the equation (1):

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

where :

$\xi$ —Shrinkage, % ;

$l_1$ —Length of test pieces in saturated state, mm;

$l_2$ —Length of test pieces after dried under (60±5)°C, mm.

The results are expressed by the arithmetic mean of eight data obtained from two specimens, accurate to 0.01%.

## 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

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

#### 9.1.3 Determination

##### 9.1.3.1 Appearance

Inspect piece by piece. Appearance of inspected batch is determined to be qualified when results

comply with the provisions of 7.1, otherwise, determined to be unqualified.

#### 9.1.3.2 Dimension deviation

Inspect piece by piece. Dimension deviation of inspected batch is determined to be qualified when results comply with the provisions of 7.1, otherwise, determined to be unqualified.

#### 9.1.3.3 Physical and mechanical properties

Inspect each batch according to 8.4. Physical and mechanical properties of inspected batch are determined to be qualified when results comply with the provisions of 7.1, otherwise, determined to be unqualified.

#### 9.1.4 Overall determination

The inspected batch is determined to be qualified when all 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:

- a) Trial production and design appraisalment;
- b) The product construction, materials and production technology are greatly changed;
- c) Resume production after suspended for more than 6 months;
- d) The delivery inspection result differs from the last type inspection result significantly;
- e) 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

The products manufactured by the same manufacturing process, raw materials and mix design constitute one inspection batch. Appearance inspection and dimensional 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 scale $N$	Sample	Sample number		Qualified criteria		Unqualified 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 Determination

### 9.2.4.1 Appearance and dimension deviation

9.2.4.1.1 The appearance and dimension deviation of the product is determined to be qualified when the appearance and dimension deviation of the inspected product comply with the corresponding provisions in 6.1 and 6.2. The appearance and dimension deviation of the product is determined to be unqualified if one or more result of the appearance and dimension deviations inspection do not comply with the corresponding provisions in 6.1 and 6.2.

9.2.4.1.2 Based on the sample inspection results, if the number of unqualified products ( $\mu_1$ ) in the first sample ( $n_1$ ) is less than or equal to the first qualified criterion number ( $Ac_1$ ) listed in Table 3, it is determined to be qualified. If the number of nonconforming products ( $\mu_1$ ) in the first sample ( $n_1$ ) is greater than or equal to the first qualified criterion number ( $Re_1$ ) listed in Table 3, the appearance and dimensional deviation of this batch of products is determined to be unqualified.

9.2.4.1.3 If the number ( $\mu_1$ ) of nonconforming products in the first sample ( $n_1$ ) is greater than the first qualified criterion number ( $Ac_1$ ) and less than the first unqualified criterion number ( $Re_1$ ), conduct spot check from the second sample ( $n_2$ ). If the sum of the number of nonconforming products in the first and second samples ( $\mu_1+\mu_2$ ) is less than or equal to the second qualified criterion number ( $Ac_2$ ), the appearance and dimensional deviation of this batch is determined to be qualified. If the sum of the number of nonconforming products in the first and second samples ( $\mu_1+\mu_2$ ) is greater than or equal to the second unqualified criterion number ( $Re_2$ ), the appearance and dimensional deviation of this batch is determined to be unqualified.

### 9.2.4.2 Physical and mechanical properties

Inspect each batch according to 8.4. Physical and mechanical properties of inspected batch is determined to be qualified when results comply with the provisions of 7.1, otherwise, determined to be unqualified.

## 9.2.5 Overall determination

The batch of products is determined to be qualified when the appearance, dimensional deviation and physical and mechanical properties are all qualified. The batch of products is determined to be unqualified if one or more items are unqualified.

## 10 Signs, transport, storage and certificate of qualification

### 10.1 Signs

The product sign, production date, manufacturer, etc. shall be marked at the obvious position on the back of the panel.

### 10.2 Transport

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

### **10.3 Storage**

The storage site shall be firm and flat. The panel should be support by frame to avoid unexpected load. Protective measures shall be taken at the position in contact with the exposed surface of the panel, and all cushion blocks, packaging and protective materials shall not cause pollution or damage to the panel.

### **10.4 Certificate of qualification**

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

- a) Certificate number;
  - b) Name of the manufacturer;
  - c) Product mark, quantity and production date;
  - d) Delivery inspection results;
  - e) Signature and seal of the quality inspection department of the manufacturer.
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