

ICS 91.100.01

JC

**BUILDING MATERIALS INDUSTRY STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

JC/T 2850-2024

**Test method for determining interfacial bonding strength of 3D
printed cement-based materials
(English Translation)**

Issued on: October 24, 2024

Implemented on: May 1, 2025

**Issued by: Ministry of Industry and Information Technology of the
People's Republic of China**

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1 Scope

This document specifies the classification for interfacial bond strength tests of 3D printed of cement-based materials, laboratory environmental and curing conditions, interfacial tensile strength test, interfacial shearing strength test, interfacial splitting strength test, and test report.

This document applies to the testing of interfacial bond strength for cement-based materials formed using the extrusion printing process.

2 Normative references

The following referenced documents are indispensable for the application 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/T 50081, Standard for test methods of concrete physical and mechanical properties

JGJ/T 384, Technical Specification for Testing Concrete Strength with Drilled Core

Method

QB/T 2422, BOPP Pressure Sensitive Adhesive Tape for Case Sealing

3 Terms and definitions

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

3.1 3D printed of cement-based materials

Cement-based materials suitable for 3D printing that meet printing process and construction requirements.

3.2

extrusion based 3D printing

A 3D printing manufacturing process in which cement-based materials are extruded through a nozzle and stacked to form a shape.

3.3

cross-printed specimen

A test specimen consisting of two 3D-printed blocks - identical in size and shape and

The thickness of a single thin layer formed by flattening an extruded cement-based material during 3D printing.

4 Classification

Based on the nature of the failure stress, the interfacial bond strength of 3D-printed cement-based materials is classified into.

- a) Interfacial tensile strength σ_{mat} , in megapascals (MPa);
- b) Interfacial shearing strength σ_{mash} , in megapascals (MPa);
- c) Interfacial splitting strength σ_{mast} , in megapascals (MPa).

5 Laboratory environmental conditions and curing conditions

The laboratory ambient temperature shall be $(20 \pm 2)^{\circ}\text{C}$, and the relative humidity shall be no less than 50%.

Curing conditions shall ensure an ambient temperature of $(20 \pm 1)^{\circ}\text{C}$ and a relative humidity of not less than 90%; the temperature of the curing water shall be $(20 \pm 1)^{\circ}\text{C}$.

6.1 Principle

Load is applied to the cross-printed specimen at the specified rate and in the prescribed manner until the interlaminar interface fails. The interfacial tensile strength is then calculated using the tensile fracture load at the moment of interfacial fracture and the area of the bonded interface, as shown in Figure 1.

Keys.

- 1 - Test block x;

2 - Tensile bonding interface;

3 - Test block y;

F1 - Load;

F2 - Reaction force on the fixture support surface.

Figure 1 -- Schematic diagram of the interfacial tensile strength test

6.2 Equipment and instruments

6.2.1 3D printer

An extrusion-based 3D printer for cementitious materials, featuring an automatic control system and the capability for selective-area printing, should be selected. The width of the extrusion nozzle should ideally be 20 mm; however, other sizes may be selected by mutual agreement between the customer and the supplier.

6.2.2 Compression testing machine

It shall comply with the provisions of GB/T 50081.

6.2.3 Dedicated fixtures

It shall comply with the provisions of Annex A.

6.2.4 Measuring instruments

The scale interval shall not exceed 0.01 mm.

6.3.1 Preparation of digital files

First, create a 3D model file of the cross-printed specimen using a computer. Then, use slicing software to convert it into a digital file that the 3D printer can recognize and execute.

6.3.2 Printing of cross-printed specimens

Import the digital file into the 3D printer and uniformly extrude the cement-based material following the printing orientation and path shown in Figure 2.

After printing the first layer, the extrusion nozzle is raised by the thickness of one layer, and the second layer is printed immediately, following the same path as the first. This process is repeated up to the fourth layer, thereby completing the printing of test block x.

Then, place smooth-surfaced, rigid plastic supports of the same height as test block x on both sides of the block. Ensure the distance between the supports and test block x is no greater than 3 mm.

Immediately print test block y on top of test block x, oriented perpendicular to it (at a 90° angle), to form a cross-printed specimen (Figure 3). The time interval between printing test block x and test block y must not exceed 5 min. The number of layers, layer thickness, print path, and dimensions of test block y must be identical to those of test block x.

The length of test blocks x and y should be 160 mm, and the cross-section should be 40 mm x 40 mm. The dimensional deviations shall not exceed ± 3 mm. If other dimensions are required, they may be determined by agreement between the customer and the supplier.

Each set of cross-printed specimens shall consist of no fewer than 6 specimens. The printing time interval between two adjacent cross-printed specimens should not exceed 30 min.

Figure 2 -- Schematic diagram of the printing path

Figure 3 -- Schematic diagram of printing cross-printed specimens

6.3.3 Specimen curing and preparation

After printing, the specimens shall be left undisturbed in the laboratory for at least 12 h, avoiding any vibration or impact during this period. Subsequently, the printed specimens shall be transferred to a curing room and cured for 28 d.

Support the entire cross-printed specimen when moving it, and handle it with care.

When placing the specimens, ensure a minimum separation of 5 cm between them.

Avoid any impact or damage to the cross-printed specimens throughout the entire process.

There should be no excess bonding points around the interface area of the cross-printed specimen. If any such points are present, they may be carefully removed using an angle grinder or a file.

6.3.4 Interfacial tensile fracture load test

Wrap 3~5 layers of adhesive tape - matching the width of the indenter - around the area of the test specimen where it contacts the indenter of the specialized fixture, ensuring full contact between the indenter and the specimen. The material and technical specifications of the adhesive tape shall comply with the requirements of QB/T 2422.

Place the cross-printed specimen into the base of the specialized fixture, as shown in

Figure 4.

Then, place the specialized fixture containing the test specimen at the center of the compression testing machine's bearing plate. Apply the load at a rate of 0.08

MPa/s~0.10 MPa/s until interfacial fracture failure occurs. Record the maximum load value,