

CEMENT TESTING

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OUTLINE

- Standard introduction
 - Type, deviation & code

- Cement testing
 - Overview of standard
 - General provisions
 - Standard requirement
 - Testing——Normal consistency, soundness, setting time, strength

TYPE OF STANDARD

- National standard: GB/T 17671-1999
- Industry standard:
 - JGJ—建工局; JC—建材工业局;JTJ-交通部;
 - SD—水电（水利电力部） YB—冶金部;SH—石油部; JJG—计量局;
 - For example: JGJ 53—2006
- Province : DB32/165-1997
- Enterprise standard: Q/32500、 SG5002-1992
- Other: CECS(engineer construction) 21:2000 , CCES(civil engineering) 01-2004

ERROR OF STANDARD

- Average relative error δ , Relative standard deviation S_r :

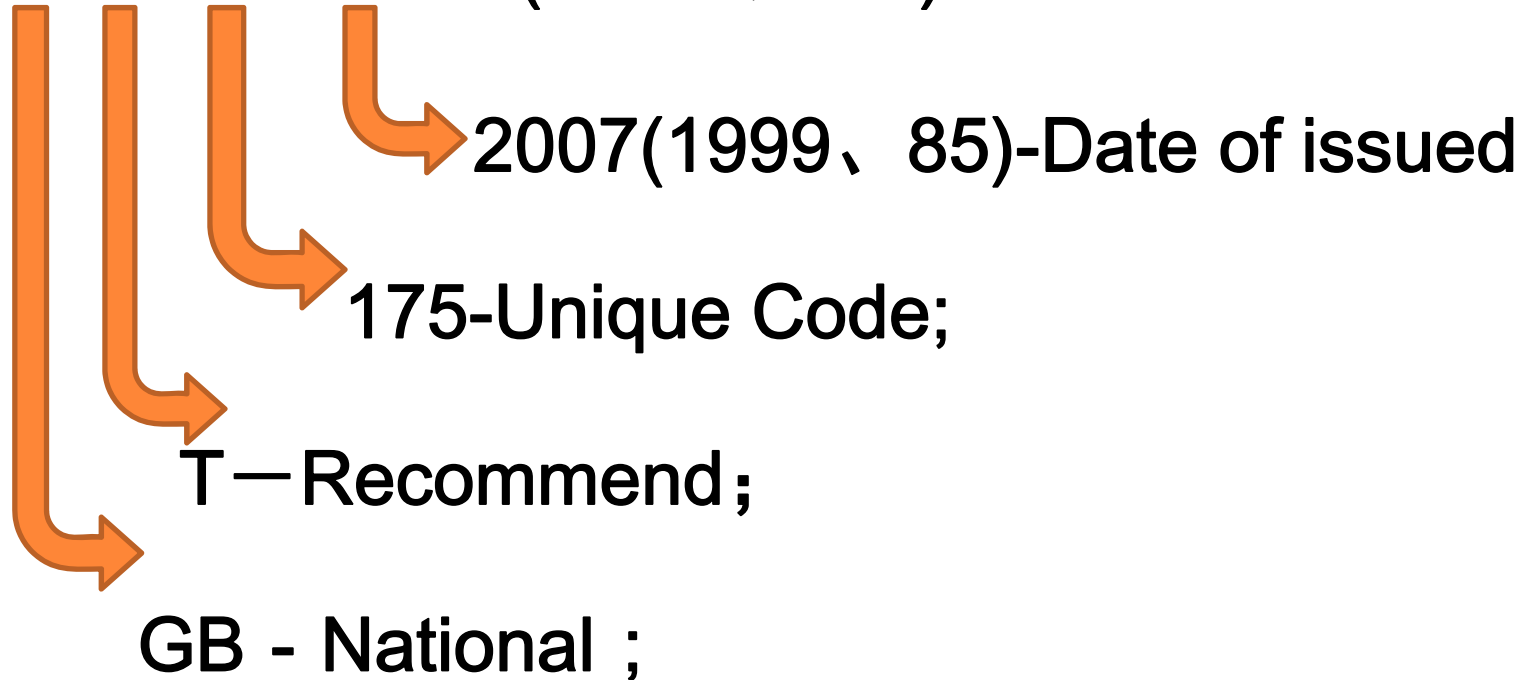
$$\delta = \pm \frac{1}{n} \sum_{i=1}^n \left| \frac{R_{\text{Tested}}}{R_{\text{Cal}}} - 1 \right| \times 100\%$$

$$S_r = \sqrt{\frac{1}{n-1} \sum_{i=1}^n \left(\frac{R_{\text{Tested}}}{R_{\text{Cal}}} - 1 \right)^2} \times 100\%$$

- Province ,enterprise <national or industry
- More wide , more easy to accept;
More narrow, more accuracy

CODE OR NUMBER OF STANDARD

GB/T 175-2007 (1999、 85)



OVERVIEW OF STANDARD FOR CEMENT TESTING

- GB 175-2007 Common Portland cement
- GB/T1346-2001 ...water requirement **of normal consistency**, setting time and **soundness** of the portland cements
- GB/T1345-2005 The test sieving method for **fineness** of cement
- GB/T17671—1999 ... Determination of **strength** (ISO)
- GB/T2419-2005 ... **fluidity** of cement mortar
- GB/T 8074—2008 ... **specific surface** of cement-Blaine method
- GB/T176-2008 ...chemical analysis
- GB/T208-1994 ...density
- JC/T 603—2004 ...dry shrinkage of mortar
- JC/T421—2004 ... wear abrasion for harden mortar
- JTG E30—2005 ... cement and concrete for highway Engineering

CEMENT

➤ Testing method:

- **According** to : GB/T1346 — 2001 ,
GB/T1345—2005, GB/T17671—1999。

➤ Pruduct standard:

- **Results** should be conform
to:GB175—2007

TYPE OF CEMENT-PRODUCT STANDARD (GB175-2007)

Type	Code	Admixture content
Portland cement	P·I/ P·II	<5%
Normal Portland	P·O	6~20%
Portland slag	P·S	>20%&≤50% (P·S·A) >50%&≤70% (P·S·B)
Portland pozzolana	P·P	>20%&≤40% pozzolana
Portland fly ash	P·F	>20%&≤40% FA
Portland composite	P·C	>20%&≤50%, Two admixture

—、GENERAL PROVISIONS

- Sampling method: GB12573-2008 , **representative/typical**, $\geq 12\text{kg}$ 。
- Sample should be uniform mixing, passing the sieve of **0.9mm**。
- **Curing Condition:**
 - Room: $T: 20 \pm 2^{\circ}\text{C}$, $\text{RH} \geq 50\%$;
 - Cabinet: $T = 20 \pm 1^{\circ}\text{C}$, $\text{RH} > 90\%$;
 - Water: $T = 20 \pm 1^{\circ}\text{C}$ 。
- **Same temperature** of material and environmental before testing。

PROPERTIES REQUIREMENT OF CEMENT

➤ Chemical compositions:

Item	Requirements	objects
Insoluble	$\leq 0.75/1.50$	P• I 、 P• II
Ignition Loss	$\leq 3.0/3.5/5.0$	P• I 、 P• II 、 P• 0
SO ₃	$\leq 3.5/4.0/3.5$	All
MgO	$\leq 5.0/6.0$	All
Cl ⁻	≤ 0.06	All
Alkali / Na ₂ O+0.658K ₂ O	0.6%	Optional

➤ Physical properties: Setting time, Soundness, Normal consistency, strength grade, fineness

NORMAL CONSISTENCY

➤ Aim

- Offer to standard paste for testing **soundness & setting time** .
- Indirectly demonstrate the water requirement

- ## ➤ Test methods: **Vicat** & Cone (adjust water content & fixed water content) ;
- Vicat is final decision if any dispute,

VICAT METHOD—STANDARD

- Apparatus : Mixer for cement paste.



Vicat: Sliding fitting
 $m=300g \pm 1g$, testing
bar can free fall.
Molds and others



TEST PROCEDURE

➤ Check the equipment: Bar (free fall), mixer.

➤ Make paste:

• record the time when finished adding cement

• Zero setting
• Screw down 1~2s, release
• after 30s, record the distance away from the bottom plate



➤ Notes: Whole procedure within 1.5min.

RESULTS

- Away from the bottom plate $6\text{mm} \pm 1\text{mm}$ 。
- Calculate: $P = m \times 100\% / 500$ (0.1%)
- Rounding rules
 - Rounding five single and double, round up when not zero, or else single round up, double round down (四舍六入五单双, 五后非零应进一, 五后为零视单双, 单进双不进)。

SETTING TIME

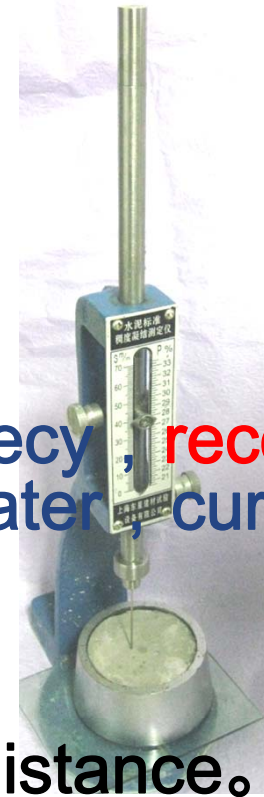
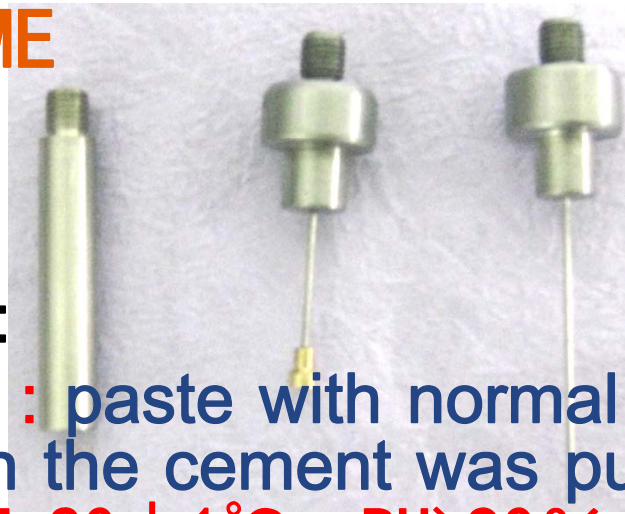
➤ Apparatus :

➤ Test procedure :

- **Making paste** : paste with normal consistency , **record the time** when the cement was put the water , curing cabinet with $T=20 \pm 1^{\circ}\text{C}$, $\text{RH}>90\%$ 。

● **Testing** :

- ① Zero setting, release, 30s, record the distance。
- ② **Initial setting state**: $4\text{mm} \pm 1\text{mm}$ away from the bottom plate ;
- ③ **Initial setting time** : duration from the time when completed the adding cement to the time up to initial setting state, “min” 。
- ④ First test in 30min , test per 5min when close to initial setting state。



FINAL SETTING TIME

- After testing initial setting time , **Overturn 180°** , continue curing ;
- **Final setting state:0.5mm away from surface** , i.e. An slight trace can't be stayed by he ring of needle ;
- **Final setting time : duration from the time when completed the adding cement to** the time up to Final setting state“min” 。
- test per 15min when close to final setting state ;



NOTES WHEN TEST THE SETTING TIME

- **Not less than 10mm** away from the inner surface of mold ;
- Not the same needle pole
- **Vibrate-control during** the whole testing。
- **Standard curing**
- **Immediately repeated** when reach the initial or final setting state。 Only the same results was obtained^

SOUNDNESS

- Aim: assess the influence on soundness of $f-CaO$.
- Two Methods: **Le chatelier test** & Pat test.
- Apparatus:
 - Boiling tank.
 - Le chatelier needle: Made of Calibrated weight of 300g, distance of needle should be
 - Expansion tester of Le Chatelier needles (0.5mm)
 - Glass plate of **75~80g**



LE CHATELIER TEST

- Standard curing 24 ± 2 h;
- Measure the **initial distance** of Le chatelier needle (A) (0.5mm);
- Boiling (Up to boiling within 30 ± 5 min then keep boiling $3\text{h} \pm 5\text{min}$)
- Measure the **final distance** (C) ;



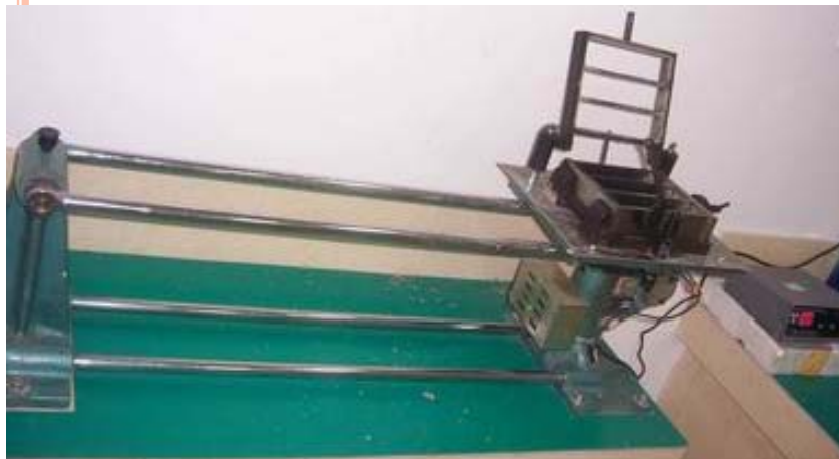
- Calculate the expansion ($C - A$) , Take average of 2 specimens
- Assessment:
 - Accepted if the average is not greater than **5mm**。 Unless the divergence of samples are **greater than 4mm** , repeated test procedure, if the same results, rejected。

PAT TEST

- Two smooth surface pats with $\phi 70\sim 80\text{mm}$, 10mm in thickness in the center and Gradually thin in the edge
- Standard curing $24\pm 2\text{h}$.
- Check, If **no defect**, boiled.
- Measure with eyes : Accepted if **no cracks & no bending by ruler**, and the same results of two specimens .

APPARATUS FOR MORTAR MAKING

- Mixer for mortar: $3 \pm 1 \text{ mm}$ the distance between the blades and bowl.



- Vibration compaction sets: Amplitude $15 \pm 0.3 \text{ mm}$, frequency 60 times / $60 \text{ s} \pm 2 \text{ s}$.

- Molds: $40 \times 40 \times 160 \text{ mm}$,
- Tester: class I accuracy; Force area of compression is $40 \times 40 \text{ mm}$.



PREPARE MORTAR

- **Demand of standard sand** : $\text{SiO}_2 > 98\%$, grade distribution is 0.08 ~ 2.0mm
- **Parameters of mix** : **C/S=1:3** , **W/C=0.50** (Assure the fluidity is $\leq 180\text{mm}$ for PP, or else increment 0.01)。
- **Amount for 3 samples** : C 450g , Sand 1350g , water 225mL(1g)。
- First adding water , then add cement , finally Mix(slow mix 30s Then add sand during the second 30s)
- Vibration & consolidation : Two layer , 60 times per layer。

CURING

- Curing in the cabinet at $T = 20 \pm 1^\circ\text{C}$, $\text{RH} > 90\%$ with mold for 20 ~ 24h。
- Number , 2 ages should be included for 3 samples in a mold , Record the date of prepare and test。
- Demould after 24h, permit to delay when slow hardened, in 2h before the test if the age is 24h。
- Immediately cure in the water , $T = 20 \pm 1^\circ\text{C}$, there is a distance between the samples , Not less than **5mm** from the top of sample。

TESTER FOR BENDING AND COMPRESSION



BENDING TESTER



COMPRESSION TESTER



BENDING TEST

- Age : 24h±15min , 48h±30min ,
72h±45min , 7d±2h , **28d±8h**
- Take out in 15min before the test
- First bending, load rate (50±10N/s)
- Calculate the bending strength :
$$R_f = (3F_f L) / (2bh^2) (0.01\text{MPa})$$

L = 100mm ; b、h为40mm。
- Take the average of 3 specimens ;
 - **Unless >±10% of the average, Excluded** ,
Take the average of the other 2 specimens 。

COMPRESSIVE

- **Six samples** after bending, immediately performing compressive strength **keeping wet** , loading rate: $2.4 \pm 0.2 \text{ kN/s}$ 。
- Directly read of Calculate the compressive strength through maximum load $F_c(\text{N}) : f_c / 0.1 \text{ MPa} : f_c = F_c / A$
 $A = 40 \text{ mm} \times 40 \text{ mm} = 1600 \text{ mm}^2$ 。
- Take the average of 6 specimens ;
 - **Unless $> \pm 10\%$ of the average, Excluded** , Take the average of the retained 5 specimens 。
Unless again $> \pm 10\%$, Invalidate results

NOTES DURING TESTING THE STRENGTH

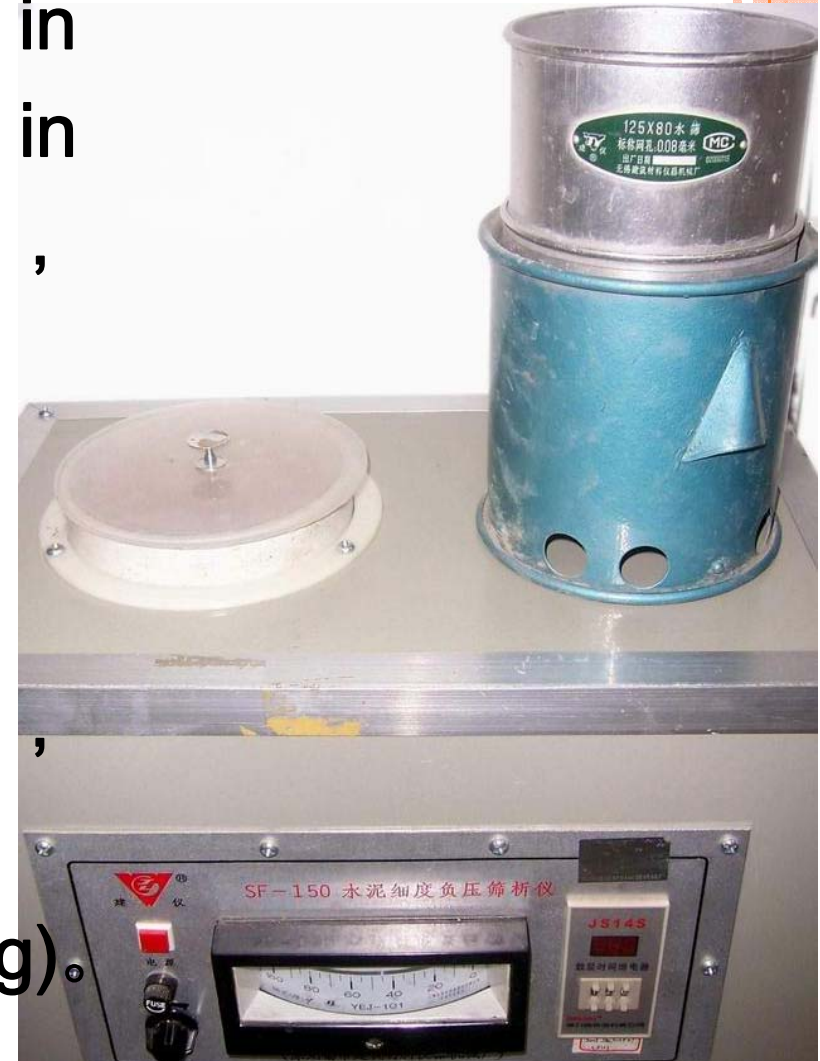
- Demands of T & RH
 - Room, cabinet & water。
- State during test
 - Keep wet
 - The forming surface can't be the load face
- Load rate
- Assessment : Compare with the $\pm 10\%$ average

FINENESS

- P• I , P• II , P•0: specific surface area 。
 - Preparation of powder layer, assessment by different resistance of passing the layer by the air. Correction by standard power 。
- P•P, P•S, P•F, P•C: **Sieving** (80/45 μ m) :
 - Retained percentage
 - 3 methods: **Vacuum sieve**, water sieve, hand sieve
 - Clean with specialized agent after **10 times**, No soak with weak acid!。

VACUUM SCREEN METHODS

- Apparatus: suction sieve(142 in inner diameter , 25mm in height,mesh,made of copper , Vacuum screen analyzer)。
- Test procedure
 - ① Check ;
 - ② Weight W , $80\mu\text{m}$:25.00g , $45\mu\text{m}$:10.00g (0.01g)。
 - ③ Weight the retainer R_t (0.01g)。



CALCULATE

- **Retained percentage** $F = (R_t/W) \times 100\%$,
(0.1%) 。
- If necessary, correct the sieve, multiple the correction factor。
- **Take the average of 2 samples** 。
- When $F \leq 5\%$, Absolute error $< 0.5\%$;
- When $F > 5\%$, Absolute error $< 1.0\%$ 。

CORRECTION OF SIEVE

- Prepare: standard materials, be calibrated sieve(clean, dry, the same temperature of materials and room)。
- Calibration procedure:
 - Put samples into sealed jar, shake 2min, uniform mixed;
 - Weight , then test;
 - Take the average of 2 samples。
 - If the divergence is greater than 0.3%, the third test should be conducted, take the average of two closed tests F_t 。
 - Correction factor: $C = F_s / F_t (0.01)$
- $C = 0.80 \sim 1.20$ 。

BLAINE APPARATUS



BLAINE SPECIFIC SURFACE

- Apparatus : Blaine apparatus , Analytical balance (0.0001g)
- Test procedure:
 - Corrected the apparatus , Check the air sealing;
 - Measure the densit of cement;
 - Calculate the test weight: $m = \rho V(1 - \varepsilon)$
 - Weight, then prepare the power layer.



TEST PROCEDURE

- Passing the air, record the fall time of water level from the second line to the third line, and record the temperature.
- Calculate (10cm²/g or m²/kg) :

$$S = \frac{s_s \rho_s \sqrt{T} (1 - \varepsilon_s) \sqrt{\varepsilon_s^3} \sqrt{\eta_s}}{\rho \sqrt{T_s} (1 - \varepsilon) \sqrt{\varepsilon_s^3} \sqrt{\eta}} (cm^2 / g)$$

Where subscript s is standard data.

- Take the average of 2 samples , but if the divergence is greater than 2%, repeated the test.

ASSESSMENT OF CEMENT

➤ Physical properties

- Initial setting time not earlier than 45min, Final setting time not later than 600min (390min for P-I, P-II) ;
- Soundness should be conformed by boiling methods.
- Fineness (Optional) :
 - ◆ 80 μ m Sieving Residue \nlessgtr 10 % or 45 μ m \nlessgtr 30%
 - ◆ Surface area $>300\text{m}^2/\text{kg}$ for P-I, P-II, P-0;

ASSESSMENT

➤ strength grade

- Bending and compressive strength in each age should be conformed.

◆ P·O、 P·S、 P·P、 P·F、 P·C :

32.5(R),42.5(R),52.5(R)

◆ P·I,P·II: 42.5(R),52.5(R),62.5(R)

OTHER PROPERTIES

➤ P·I、 P·II

- Insolubles: $P·I \leq 0.75\%$; $P·II \leq 1.50\%$

➤ P·I、 P·II、 P·O

- Ignition loss: $P·I \leq 3.0\%$; $P·II \leq 3.5\%$,
 $P·O \leq 5.0\%$

➤ P·I、 P·II、 P·O、 P·S、 P·P、 P·F、 P·C

- MgO: General not less than 5.0%, 6.0% unless qualified of the autoclave soundness

- SO_3 : $P·I、 P·II、 P·O、 P·P、 P·F、 P·C$
 $\leq 3.5\%$;

$P·S \leq 4.0\%$

- Alkali: $Na_2O + 0.658K_2O$, Low alkali $\leq 0.6\%$

REJECTS

Any items can't be conformed to the requirement

- ① Chemical composition
- ② Setting time
- ③ Soundness
- ④ Strength



THE END