CECS

T/CECS 02-2020

超声回弹综合法
检测混凝土抗压强度技术规程

Technical specification for inspecting compressive strength of concrete by ultrasonic-rebound combined method

中国计划出版社

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5 6

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3 4

5

6

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2.2

e_{r} —

$f_{\mathrm{cu}}^{\mathrm{c}}$ —

$f_{\mathrm{cu},i}^{\mathrm{c}}$ — i

$f_{\mathrm{cu},i}^{0}$ — i

$f_{\mathrm{cu,e}}$ —

$f_{\mathrm{cu,min}}^{\mathrm{c}}$ —

$f_{\mathrm{cor,m}}$ —

$f_{\mathrm{cu,m}}$ —

$f_{\mathrm{cu,m0}}^{\mathrm{c}}$ —

$f_{\mathrm{cor},i}$ — i

$f_{\mathrm{cu},i}$ — i

$f_{\mathrm{cu},i0}^{\mathrm{c}}$ — i

$f_{\mathrm{cu},i1}^{\mathrm{c}}$ — i

l —

l_i — i

l_{1i} l_{2i} — i

$m_{f_{\mathrm{cu}}^{\mathrm{c}}}$ —

n —

R_i — i

R —

R_{a} —

$R_{\mathrm{a}\alpha}$ — α

R_a^t—

R_a^b—

R_{ai}— i

$s_{f_{cu}^c}$—

T_k—

t_i— i

t_0—

v_a—

v_{ai}— i

v_d—

v_j—

v_p—

v_{pp}—

v_k—

v^0—

δ—

α—

β—

λ

$\varDelta_{tot}$—

$\varDelta$— v_k v^o

3

3.1

3.1.1

3.1.2

3.1.3 GB/T 9138

1 2.207J

2

“0”

3 HRC 60±2 80±2

4

1

3.1.4 -4℃ 40℃

3.2

3.2.1 JJG 817

1

2

3

4

5 1

3.2.2

1

2

3.2.3

1 5℃ 35℃

2

3 90°

80±2

3.2.4 80±2 3.3

3.2.5 GB/T 9138

3.3

3.3.1

1 2000

2

3

3.3.2

1 0.5 N 0.8N

2

3

4 3.2.3

3.3.3

4

4.1

4.1.1 JG/T

5004

4.1.2

4.1.3

1

2

3

4

4.1.4

1 0.1 μs~999.9 μs 0.1 μs

±0.5% 1h 5min ±0.2

μs

2 80dB 1dB

3 10kHz~250kHz

4 3 1 50 μV

4.1.5

1 0 40℃

2 80%

3 ±10%

4 4h

4.2

4.2.1 50kHz~100kHz

4.2.2 ±10%

4.3

4.3.1

1

2

3

4

5

4.3.2 A

4.3.3

1 1h

2

3

4

5

5.1

5.1.1

1

2

3

4

5

6

5.1.2

1

10 4.5m 0.3m

5

2 5.1.2

表 5.1.2　随机抽样的最小样本容量

	A	B	C
3-8	2	2	3
9-15	2	3	5
16-25	3	5	8
26-50	5	8	13
51-90	5	13	20
91-150	8	20	32
151-280	13	32	50
281-500	20	50	80
501-1200	32	80	125
1201-3200	50	125	200
3201-10000	80	200	315
10001-35000	125	315	500
35001-150000	200	500	800
150001-500000	315	800	1250

1. A

2. B

3. C

5.1.3

1

2

3

4

5.1.4

1

2

3 2m

4

5 200mm×200mm 400mm×400mm

6

7

5.1.5

5.1.6

5.1.7

5.2

5.2.1

5.2.2

20mm

30 mm

5.2.3

5

10 1

5.2.4 10 1 1

8

$$R = \frac{1}{8}\sum_{i=1}^{8} R_i \qquad 5.2.4$$

R — 0.1

R_i — i

5.2.5

$$R_{\mathrm{a}} = R + R_{\mathrm{a\alpha}} \qquad 5.2.5$$

R_{a} —

$R_{\mathrm{a\alpha}}$ — α B

5.2.6

$$R_{\mathrm{a}} = R + R_{\mathrm{a}}^{\mathrm{t}} \qquad 5.2.6\text{-}1$$

$$R_{\mathrm{a}} = R + R_{\mathrm{a}}^{\mathrm{b}} \qquad 5.2.6\text{-}2$$

$R_{\mathrm{a}}^{\mathrm{t}}$ — C

$R_{\mathrm{a}}^{\mathrm{b}}$ — C

5.2.7

5.3

5.3.1 3

D

5.3.2

1

2

3 t_0 0.1μs

4 1mm ±1%

5 t_0

6 0.01km/s

5.3.3

$$v_d = \frac{1}{3}\sum_{i=1}^{3}\frac{l_i}{t_i - t_0} \qquad 5.3.3$$

v_d — km/s

l_i — i mm

t_i —— i μs

t_0 — μs

5.3.4

$$v_{\mathrm{a}} = \beta \cdot v_d \qquad (5.3.4)$$

v_{a} — km/s

β — 1.034

6

6.1

6.1.1

1

2 7d

3 7d 2000d

4 10MPa 70MPa

6.1.2

6.1.3

6.2

6.2.1

$$f^{c}_{cu,\mathrm{i}} = 0.0286 v_{ai}^{1.999} R_{ai}^{1.155} \qquad 6.2.1$$

$f^{\mathrm{c}}_{\mathrm{cu},i}$— i (MPa) 0.1 MPa

$R_{\mathrm{a}i}$— i

$v_{\mathrm{a}i}$— i

6.2.2 E

F 6.2.1

6.3

6.3.1 G

6.3.2 δ e_r

1 δ 10% e_r 12%

2 δ 11% e_r 14%

3 δ e_r G.0.7-2 G.0.7-3

6.3.3

6.4

6.4.1 i **5.2** **5.3** R_{ai} v_{ai} 6.1.2

6.4.2

6.4.3 6 100mm 1 JGJ/T 384

6.4.5 6 150mm GB/T 50081

6.4.6

1

$$\Delta_{\mathrm{tot}} = f_{\mathrm{cor,m}} - f^{\mathrm{c}}_{\mathrm{cu,m0}} \qquad (6.4.6\text{-}1)$$

$$\Delta_{\mathrm{tot}} = f_{\mathrm{cu,m}} - f^{\mathrm{c}}_{\mathrm{cu,m0}} \qquad 6.4.6\text{-}2$$

$$f_{\mathrm{cor,m}} = \frac{1}{n}\sum_{\mathrm{i}=1}^{n} f_{\mathrm{cor},i} \qquad 6.4.6\text{-}3$$

$$f_{\mathrm{cu,m}} = \frac{1}{n}\sum_{\mathrm{i}=1}^{n} f_{cu,i} \qquad 6.4.6\text{-}4$$

$$f^{\mathrm{c}}_{\mathrm{cu,m0}} = \frac{1}{n}\sum_{\mathrm{i}=1}^{n} f^{\mathrm{c}}_{\mathrm{cu},i} \qquad 6.4.6\text{-}5$$

Δ_{tot} — MPa 0.1MPa

$f_{\mathrm{cor,m}}$ — MPa 0.1MPa

$f_{\mathrm{cu,m}}$ — MPa 0.1MPa

$f^{\mathrm{c}}_{\mathrm{cu,m0}}$ —

MPa 0.1MPa

$f_{\mathrm{cor},i}$ — i

$f_{\mathrm{cu},i}$ — i

$f^{\mathrm{c}}_{\mathrm{cu},i}$ — i

F

n —

2

$$f^{\mathrm{c}}_{\mathrm{cu},i1} = f^{\mathrm{c}}_{\mathrm{cu},i0} + \Delta_{\mathrm{tot}} \qquad 6.4.6\text{-}6$$

$f^{\mathrm{c}}_{\mathrm{cu},i0}$ — i MPa 0.1MPa

$f^{\mathrm{c}}_{\mathrm{cu},i1}$ — i MPa 0.1MPa

6.4.7 $f_{\mathrm{cu,e}}$

1 10.0MPa

$f_{\mathrm{cu,e}}$ 10.0MPa

2 10

$$f_{\mathrm{cu,e}}=f^{\mathrm{c}}_{\mathrm{cu,min}} \qquad 6.4.7\text{-}1$$

$f^{\mathrm{c}}_{\mathrm{cu,min}}$— MPa

0.1MPa

3 10

$$m_{f^{\mathrm{c}}_{\mathrm{cu}}}=\frac{1}{n}\sum_{i=1}^{n}f^{\mathrm{c}}_{\mathrm{cu},i} \qquad 6.4.7\text{-}2$$

$$\mathrm{s}_{f^{\mathrm{c}}_{\mathrm{cu}}}=\sqrt{\frac{\sum_{i=1}^{\mathrm{n}}(f^{\mathrm{c}}_{\mathrm{cu},i})^2-n(m_{f^{\mathrm{c}}_{\mathrm{cu}}})^2}{n-1}} \qquad 6.4.7\text{-}3$$

$$f_{\mathrm{cu,e}}=m_{f^{\mathrm{c}}_{\mathrm{cu}}}\quad 1.645\,s_{f^{\mathrm{c}}_{\mathrm{cu}}} \qquad 6.4.7\text{-}4$$

$f^{\mathrm{c}}_{\mathrm{cu},i}$ — i MPa 0.1 MPa

$m_{f^{\mathrm{c}}_{\mathrm{cu}}}$ — MPa 0.1 MPa

$s_{f^{c}_{cu}}$ — MPa 0.01 MPa

n —

6.4.8

1 $m_{f^{\mathrm{c}}_{\mathrm{cu}}}$ 25.0Mpa

$s_{f^{c}_{cu}}$ 4.50Mpa

2 $m_{f^{\mathrm{c}}_{\mathrm{cu}}}$ 25.0Mpa

50.0Mpa $s_{f^{c}_{cu}}$ 5.50Mpa

3 $m_{f^{\mathrm{c}}_{\mathrm{cu}}}$ 50.0Mpa

$s_{f^{c}_{cu}}$ 6.50Mpa

6.4.9 H I

6.4.10

1

2

3

4

5

6

7

8

9 ( )

10

11

12

A

A.0.1

1 10min

2

l 100mm 125mm 150mm 175mm 200mm 225mm 250mm 275mm 300mm…… t_1 t_2 t_3 ……t_n T_k 0.5℃

A.0.2

1

2 ±0.5% 0.5mm

3

A.0.3

$$l = a + bt \tag{A.0.3}$$

b — v^o

A.0.4 v_k

$$v_k = 0.3314\sqrt{1 + 0.00367T_k} \qquad \text{A.0.4}$$

v_k — km/s

T_k — ℃

A.0.5 v_k v^o Δ

$$\Delta = (v_k - v^o) / v_k \times 100\% \qquad \text{A.0.5}$$

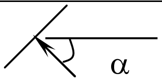
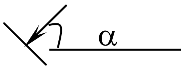
A.0.6 A.0.5 v_k v^o Δ ±0.5%

A.0.7

t_0

t_0

B

								
$R_{a\alpha}$ R	+90	+60	+45	+30	-30	-45	-60	-90
20	-6.0	-5.0	-4.0	-3.0	+2.5	+3.0	+3.5	+4.0
21	-5.9	-4.9	-4.0	-3.0	+2.5	+3.0	+3.5	+4.0
22	-5.8	-4.8	-3.9	-2.9	+2.4	+2.9	+3.4	+3.9
23	-5.7	-4.7	-3.9	-2.9	+2.4	+2.9	+3.4	+3.9
24	-5.6	-4.6	-3.8	-2.8	+2.3	+2.8	+3.3	+3.8
25	-5.5	-4.5	-3.8	-2.8	+2.3	+2.8	+3.3	+3.8
26	-5.4	-4.4	-3.7	-2.7	+2.2	+2.7	+3.2	+3.7
27	-5.3	-4.3	-3.7	-2.7	+2.2	+2.7	+3.2	+3.7
28	-5.2	-4.2	-3.6	-2.6	+2.1	+2.6	+3.1	+3.6
29	-5.1	-4.1	-3.6	-2.6	+2.1	+2.6	+3.1	+3.6
30	-5.0	-4.0	-3.5	-2.5	+2.0	+2.5	+3.0	+3.5
31	-4.9	-4.0	-3.5	-2.5	+2.0	+2.5	+3.0	+3.5
32	-4.8	-3.9	-3.4	-2.4	+1.9	+2.4	+2.9	+3.4
33	-4.7	-3.9	-3.4	-2.4	+1.9	+2.4	+2.9	+3.4
34	-4.6	-3.8	-3.3	-2.3	+1.8	+2.3	+2.8	+3.3
35	-4.5	-3.8	-3.3	-2.3	+1.8	+2.3	+2.8	+3.3
36	-4.4	-3.7	-3.2	-2.2	+1.7	+2.2	+2.7	+3.2
37	-4.3	-3.7	-3.2	-2.2	+1.7	+2.2	+2.7	+3.2
38	-4.2	-3.6	-3.1	-2.1	+1.6	+2.1	+2.6	+3.1
39	-4.1	-3.6	-3.1	-2.1	+1.6	+2.1	+2.6	+3.1
40	-4.0	-3.5	-3.0	-2.0	+1.5	+2.0	+2.5	+3.0
41	-4.0	-3.5	-3.0	-2.0	+1.5	+2.0	+2.5	+3.0
42	-3.9	-3.4	-2.9	-1.9	+1.4	+1.9	+2.4	+2.9
43	-3.9	-3.4	-2.9	-1.9	+1.4	+1.9	+2.4	+2.9
44	-3.8	-3.3	-2.8	-1.8	+1.3	+1.8	+2.3	+2.8
45	-3.8	-3.3	-2.8	-1.8	+1.3	+1.8	+2.3	+2.8
46	-3.7	-3.2	-2.7	-1.7	+1.2	+1.7	+2.2	+2.7
47	-3.7	-3.2	-2.7	-1.7	+1.2	+1.7	+2.2	+2.7
48	-3.6	-3.1	-2.6	-1.6	+1.1	+1.6	+2.1	+2.6
49	-3.6	-3.1	-2.6	-1.6	+1.1	+1.6	+2.1	+2.6
50	-3.5	-3.0	-2.5	-1.5	+1.0	+1.5	+2.0	+2.5

1 0 0 R 20 50 20 50

2 0.1

C

R R_a	R_a^t	R_a^b
20	+2.5	-3.0
21	+2.4	-2.9
22	+2.3	-2.8
23	+2.2	-2.7
24	+2.1	-2.6
25	+2.0	-2.5
26	+1.9	-2.4
27	+1.8	-2.3
28	+1.7	-2.2
29	+1.6	-2.1
30	+1.5	-2.0
31	+1.4	-1.9
32	+1.3	-1.8
33	+1.2	-1.7
34	+1.1	-1.6
35	+1.0	-1.5
36	+0.9	-1.4
37	+0.8	-1.3
38	+0.7	-1.2
39	+0.6	-1.1
40	+0.5	-1.0
41	+0.4	-0.9
42	+0.3	-0.8
43	+0.2	-0.7
44	+0.1	-0.6
45	0	-0.5
46	0	-0.4
47	0	-0.3
48	0	-0.2
49	0	-0.1
50	0	0

1. 0 R 20 50 20 50
2. R_a
3. 0.1

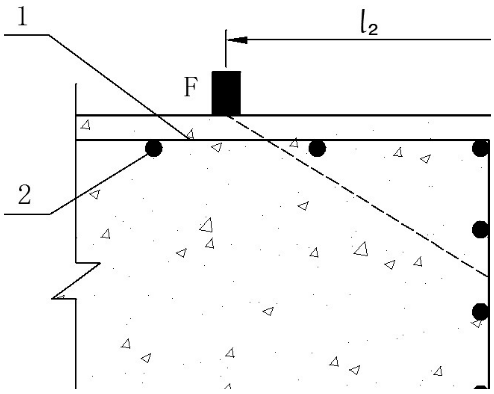
D

D.1

D.1.1

D.1.1 3

3



D.1.1

1- 2- F- S-

D.1.2 l_{1i} l_{2i}

300mm

D.1.3

$$l_i = \sqrt{l_{1i}^2 + l_{2i}^2} \tag{D.1.3}$$

l_i — i (mm)

l_{1i} l_{2i} — i mm

D.1.4

$$v_j = \frac{1}{3}\sum_{i=1}^{3}\frac{l_i}{t_i - t_0} \tag{D.1.4}$$

v_j — km/s

t_i — i μs

t_0 — μs

D.2

D.2.1

D.2.2

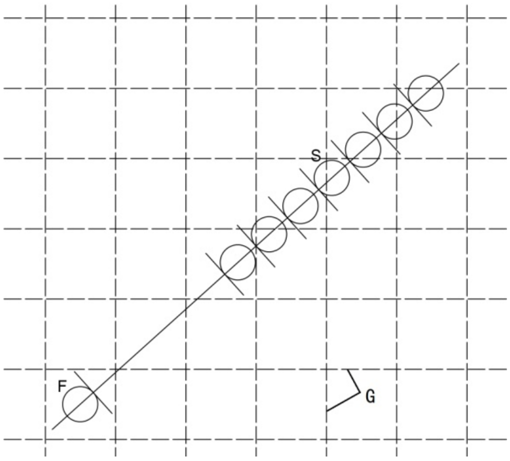
40º 50º D.2.2

200mm 250mm 300mm 350mm 400mm 450mm 500mm

t

$$l = a + ct \qquad \text{(D.2.2)}$$

c— v_{p}



D.2.2

F- S- G-

D.2.3

v_{p} v_{d}

v_{d}

v_{pp}

$$\lambda = v_{\mathrm{d}} / v_{\mathrm{pp}} \qquad \text{(D.2.3)}$$

v_d − (km/s)

v_{pp}— (km/s)

λ—

D.2.4

$$v_{\mathrm{a}} = \lambda\ v_{\mathrm{p}} \qquad \text{(D.2.4)}$$

v_{a} — (km/s)

v_{p} — (km/s)

λ —

E

E.0.1

E.0.2

1

C15 C20 C30 C40 C50 C60 150mm

3

2 3 4

3 28d 60d 90d

4 F

5

G.0.7-2 G.0.7-3 δ 12%

e_r 15%

F

v_a f_{cu}^c R_a	3.80	3.82	3.84	3.86	3.88	3.90	3.92	3.94	3.96	3.98	4.00	4.02	4.04
15.0	—	—	—	—	—	—	10.0	10.1	10.2	10.3	10.4	10.5	10.6
16.0	10.1	10.2	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.5
17.0	10.9	11.0	11.1	11.2	11.3	11.5	11.6	11.7	11.8	11.9	12.1	12.2	12.3
18.0	11.6	11.7	11.9	12.0	12.1	12.2	12.4	12.5	12.6	12.7	12.9	13.0	13.1
19.0	12.4	12.5	12.6	12.8	12.9	13.0	13.2	13.3	13.4	13.6	13.7	13.8	14.0
20.0	13.1	13.3	13.4	13.5	13.7	13.8	14.0	14.1	14.3	14.4	14.5	14.7	14.8
21.0	13.9	14.0	14.2	14.3	14.5	14.6	14.8	14.9	15.1	15.2	15.4	15.5	15.7
22.0	14.7	14.8	15.0	15.1	15.3	15.4	15.6	15.7	15.9	16.1	16.2	16.4	16.6
23.0	15.4	15.6	15.7	15.9	16.1	16.2	16.4	16.6	16.7	16.9	17.1	17.3	17.4
24.0	16.2	16.4	16.5	16.7	16.9	17.1	17.2	17.4	17.6	17.8	17.9	18.1	18.3
25.0	17.0	17.2	17.3	17.5	17.7	17.9	18.1	18.3	18.4	18.6	18.8	19.0	19.2
26.0	17.8	18.0	18.1	18.3	18.5	18.7	18.9	19.1	19.3	19.5	19.7	19.9	20.1
27.0	18.6	18.8	19.0	19.2	19.3	19.5	19.8	20.0	20.2	20.4	20.6	20.8	21.0
28.0	19.4	19.6	19.8	20.0	20.2	20.4	20.6	20.8	21.0	21.2	21.4	21.7	21.9
29.0	20.2	20.4	20.6	20.8	21.0	21.2	21.4	21.7	21.9	22.1	22.3	22.6	22.8
30.0	21.0	21.2	21.4	21.6	21.9	22.1	22.3	22.5	22.8	23.0	23.2	23.5	23.7
31.0	21.8	22.0	22.2	22.5	22.7	22.9	23.2	23.4	23.6	23.9	24.1	24.4	24.6
32.0	22.6	22.8	23.1	23.3	23.5	23.8	24.0	24.3	24.5	24.8	25.0	25.3	25.5
33.0	23.4	23.6	23.9	24.1	24.4	24.6	24.9	25.2	25.4	25.7	25.9	26.2	26.4
34.0	24.2	24.5	24.7	25.0	25.3	25.5	25.8	26.0	26.3	26.6	26.8	27.1	27.4
35.0	25.0	25.3	25.6	25.8	26.1	26.4	26.7	26.9	27.2	27.5	27.8	28.0	28.3
36.0	25.9	26.1	26.4	26.7	27.0	27.3	27.5	27.8	28.1	28.4	28.7	29.0	29.2
37.0	26.7	27.0	27.3	27.6	27.8	28.1	28.4	28.7	29.0	29.3	29.6	29.9	30.2
38.0	27.5	27.8	28.1	28.4	28.7	29.0	29.3	29.6	29.9	30.2	30.5	30.8	31.1
39.0	28.4	28.7	29.0	29.3	29.6	29.9	30.2	30.5	30.8	31.1	31.4	31.8	32.1
40.0	29.2	29.5	29.8	30.2	30.5	30.8	31.1	31.4	31.7	32.1	32.4	32.7	33.0
41.0	30.1	30.4	30.7	31.0	31.3	31.7	32.0	32.3	32.7	33.0	33.3	33.6	34.0
42.0	30.9	31.2	31.6	31.9	32.2	32.6	32.9	33.2	33.6	33.9	34.3	34.6	34.9
43.0	31.8	32.1	32.4	32.8	33.1	33.5	33.8	34.2	34.5	34.8	35.2	35.6	35.9
44.0	32.6	33.0	33.3	33.7	34.0	34.4	34.7	35.1	35.4	35.8	36.1	36.5	36.9
45.0	33.5	33.8	34.2	34.5	34.9	35.3	35.6	36.0	36.4	36.7	37.1	37.5	37.8
46.0	34.3	34.7	35.1	35.4	35.8	36.2	36.5	36.9	37.3	37.7	38.1	38.4	38.8
47.0	35.2	35.6	36.0	36.3	36.7	37.1	37.5	37.8	38.2	38.6	39.0	39.4	39.8
48.0	36.1	36.5	36.8	37.2	37.6	38.0	38.4	38.8	39.2	39.6	40.0	40.4	40.8
49.0	36.9	37.3	37.7	38.1	38.5	38.9	39.3	39.7	40.1	40.5	40.9	41.3	41.8
50.0	37.8	38.2	38.6	39.0	39.4	39.8	40.2	40.7	41.1	41.5	41.9	42.3	42.7
51.0	38.7	39.1	39.5	39.9	40.3	40.8	41.2	41.6	42.0	42.4	42.9	43.3	43.7
52.0	39.6	40.0	40.4	40.8	41.3	41.7	42.1	42.5	43.0	43.4	43.8	44.3	44.7
53.0	40.4	40.9	41.3	41.7	42.2	42.6	43.0	43.5	43.9	44.4	44.8	45.3	45.7
54.0	41.3	41.8	42.2	42.6	43.1	43.5	44.0	44.4	44.9	45.3	45.8	46.3	46.7
55.0	42.2	42.7	43.1	43.6	44.0	44.5	44.9	45.4	45.8	46.3	46.8	47.2	47.7

续表 F

v_a f_{cu}^c R_a	4.06	4.08	4.10	4.12	4.14	4.16	4.18	4.20	4.22	4.24	4.26	4.28	4.30
15.0	10.7	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.1
16.0	11.6	11.7	11.8	11.9	12.0	12.2	12.3	12.4	12.5	12.6	12.7	12.9	13.0
17.0	12.4	12.5	12.7	12.8	12.9	13.0	13.2	13.3	13.4	13.5	13.7	13.8	13.9
18.0	13.3	13.4	13.5	13.7	13.8	13.9	14.1	14.2	14.3	14.5	14.6	14.7	14.9
19.0	14.1	14.3	14.4	14.5	14.7	14.8	15.0	15.1	15.3	15.4	15.5	15.7	15.8
20.0	15.0	15.1	15.3	15.4	15.6	15.7	15.9	16.0	16.2	16.3	16.5	16.6	16.8
21.0	15.8	16.0	16.2	16.3	16.5	16.6	16.8	17.0	17.1	17.3	17.4	17.6	17.8
22.0	16.7	16.9	17.1	17.2	17.4	17.6	17.7	17.9	18.1	18.2	18.4	18.6	18.8
23.0	17.6	17.8	18.0	18.1	18.3	18.5	18.7	18.8	19.0	19.2	19.4	19.6	19.7
24.0	18.5	18.7	18.9	19.0	19.2	19.4	19.6	19.8	20.0	20.2	20.4	20.5	20.7
25.0	19.4	19.6	19.8	20.0	20.2	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7
26.0	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7	21.9	22.1	22.3	22.5	22.7
27.0	21.2	21.4	21.6	21.8	22.0	22.2	22.5	22.7	22.9	23.1	23.3	23.5	23.8
28.0	22.1	22.3	22.5	22.8	23.0	23.2	23.4	23.6	23.9	24.1	24.3	24.6	24.8
29.0	23.0	23.2	23.5	23.7	23.9	24.2	24.4	24.6	24.9	25.1	25.3	25.6	25.8
30.0	23.9	24.2	24.4	24.6	24.9	25.1	25.4	25.6	25.8	26.1	26.3	26.6	26.8
31.0	24.9	25.1	25.3	25.6	25.8	26.1	26.3	26.6	26.8	27.1	27.4	27.6	27.9
32.0	25.8	26.0	26.3	26.5	26.8	27.1	27.3	27.6	27.8	28.1	28.4	28.6	28.9
33.0	26.7	27.0	27.2	27.5	27.8	28.0	28.3	28.6	28.9	29.1	29.4	29.7	30.0
34.0	27.6	27.9	28.2	28.5	28.7	29.0	29.3	29.6	29.9	30.2	30.4	30.7	31.0
35.0	28.6	28.9	29.2	29.4	29.7	30.0	30.3	30.6	30.9	31.2	31.5	31.8	32.1
36.0	29.5	29.8	30.1	30.4	30.7	31.0	31.3	31.6	31.9	32.2	32.5	32.8	33.1
37.0	30.5	30.8	31.1	31.4	31.7	32.0	32.3	32.6	32.9	33.2	33.6	33.9	34.2
38.0	31.4	31.7	32.1	32.4	32.7	33.0	33.3	33.6	34.0	34.3	34.6	34.9	35.3
39.0	32.4	32.7	33.0	33.4	33.7	34.0	34.3	34.7	35.0	35.3	35.7	36.0	36.3
40.0	33.4	33.7	34.0	34.3	34.7	35.0	35.4	35.7	36.0	36.4	36.7	37.1	37.4
41.0	34.3	34.7	35.0	35.3	35.7	36.0	36.4	36.7	37.1	37.4	37.8	38.1	38.5
42.0	35.3	35.6	36.0	36.3	36.7	37.0	37.4	37.8	38.1	38.5	38.9	39.2	39.6
43.0	36.3	36.6	37.0	37.3	37.7	38.1	38.4	38.8	39.2	39.5	39.9	40.3	40.7
44.0	37.2	37.6	38.0	38.3	38.7	39.1	39.5	39.9	40.2	40.6	41.0	41.4	41.8
45.0	38.2	38.6	39.0	39.4	39.7	40.1	40.5	40.9	41.3	41.7	42.1	42.5	42.9
46.0	39.2	39.6	40.0	40.4	40.8	41.2	41.6	41.9	42.3	42.8	43.2	43.6	44.0
47.0	40.2	40.6	41.0	41.4	41.8	42.2	42.6	43.0	43.4	43.8	44.2	44.7	45.1
48.0	41.2	41.6	42.0	42.4	42.8	43.2	43.6	44.1	44.5	44.9	45.3	45.8	46.2
49.0	42.2	42.6	43.0	43.4	43.8	44.3	44.7	45.1	45.6	46.0	46.4	46.9	47.3
50.0	43.2	43.6	44.0	44.4	44.9	45.3	45.8	46.2	46.6	47.1	47.5	48.0	48.4
51.0	44.2	44.6	45.0	45.5	45.9	46.4	46.8	47.3	47.7	48.2	48.6	49.1	49.5
52.0	45.2	45.6	46.1	46.5	47.0	47.4	47.9	48.3	48.8	49.3	49.7	50.2	50.7
53.0	46.2	46.6	47.1	47.5	48.0	48.5	48.9	49.4	49.9	50.4	50.8	51.3	51.8
54.0	47.2	47.6	48.1	48.6	49.1	49.5	50.0	50.5	51.0	51.4	51.9	52.4	52.9
55.0	48.2	48.7	49.1	49.6	50.1	50.6	51.1	51.6	52.1	52.6	53.0	53.5	54.0

续表 F

v_{a} f_{cu}^{c} R_{a}	4.32	4.34	4.36	4.38	4.40	4.42	4.44	4.46	4.48	4.50	4.52	4.54	4.56
15.0	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.1	13.2	13.3	13.4	13.6
16.0	13.1	13.2	13.3	13.5	13.6	13.7	13.8	14.0	14.1	14.2	14.3	14.5	14.6
17.0	14.1	14.2	14.3	14.4	14.6	14.7	14.8	15.0	15.1	15.3	15.4	15.5	15.7
18.0	15.0	15.2	15.3	15.4	15.6	15.7	15.9	16.0	16.1	16.3	16.4	16.6	16.7
19.0	16.0	16.1	16.3	16.4	16.6	16.7	16.9	17.0	17.2	17.3	17.5	17.7	17.8
20.0	17.0	17.1	17.3	17.4	17.6	17.8	17.9	18.1	18.2	18.4	18.6	18.7	18.9
21.0	17.9	18.1	18.3	18.4	18.6	18.8	19.0	19.1	19.3	19.5	19.6	19.8	20.0
22.0	18.9	19.1	19.3	19.5	19.6	19.8	20.0	20.2	20.4	20.5	20.7	20.9	21.1
23.0	19.9	20.1	20.3	20.5	20.7	20.9	21.1	21.2	21.4	21.6	21.8	22.0	22.2
24.0	20.9	21.1	21.3	21.5	21.7	21.9	22.1	22.3	22.5	22.7	22.9	23.1	23.3
25.0	21.9	22.1	22.4	22.6	22.8	23.0	23.2	23.4	23.6	23.8	24.0	24.2	24.4
26.0	23.0	23.2	23.4	23.6	23.8	24.0	24.3	24.5	24.7	24.9	25.1	25.4	25.6
27.0	24.0	24.2	24.4	24.7	24.9	25.1	25.3	25.6	25.8	26.0	26.3	26.5	26.7
28.0	25.0	25.2	25.5	25.7	25.9	26.2	26.4	26.7	26.9	27.1	27.4	27.6	27.9
29.0	26.0	26.3	26.5	26.8	27.0	27.3	27.5	27.8	28.0	28.3	28.5	28.8	29.0
30.0	27.1	27.3	27.6	27.8	28.1	28.4	28.6	28.9	29.1	29.4	29.7	29.9	30.2
31.0	28.1	28.4	28.7	28.9	29.2	29.5	29.7	30.0	30.3	30.5	30.8	31.1	31.3
32.0	29.2	29.5	29.7	30.0	30.3	30.6	30.8	31.1	31.4	31.7	31.9	32.2	32.5
33.0	30.2	30.5	30.8	31.1	31.4	31.7	31.9	32.2	32.5	32.8	33.1	33.4	33.7
34.0	31.3	31.6	31.9	32.2	32.5	32.8	33.1	33.4	33.7	34.0	34.3	34.6	34.9
35.0	32.4	32.7	33.0	33.3	33.6	33.9	34.2	34.5	34.8	35.1	35.4	35.7	36.1
36.0	33.4	33.7	34.1	34.4	34.7	35.0	35.3	35.6	36.0	36.3	36.6	36.9	37.3
37.0	34.5	34.8	35.2	35.5	35.8	36.1	36.5	36.8	37.1	37.4	37.8	38.1	38.5
38.0	35.6	35.9	36.3	36.6	36.9	37.3	37.6	37.9	38.3	38.6	39.0	39.3	39.7
39.0	36.7	37.0	37.4	37.7	38.0	38.4	38.7	39.1	39.4	39.8	40.1	40.5	40.9
40.0	37.8	38.1	38.5	38.8	39.2	39.5	39.9	40.2	40.6	41.0	41.3	41.7	42.1
41.0	38.9	39.2	39.6	39.9	40.3	40.7	41.0	41.4	41.8	42.2	42.5	42.9	43.3
42.0	40.0	40.3	40.7	41.1	41.4	41.8	42.2	42.6	43.0	43.4	43.7	44.1	44.5
43.0	41.1	41.4	41.8	42.2	42.6	43.0	43.4	43.8	44.1	44.5	44.9	45.3	45.7
44.0	42.2	42.5	42.9	43.3	43.7	44.1	44.5	44.9	45.3	45.7	46.2	46.6	47.0
45.0	43.3	43.7	44.1	44.5	44.9	45.3	45.7	46.1	46.5	46.9	47.4	47.8	48.2
46.0	44.4	44.8	45.2	45.6	46.0	46.5	46.9	47.3	47.7	48.2	48.6	49.0	49.4
47.0	45.5	45.9	46.3	46.8	47.2	47.6	48.1	48.5	48.9	49.4	49.8	50.2	50.7
48.0	46.6	47.0	47.5	47.9	48.4	48.8	49.2	49.7	50.1	50.6	51.0	51.5	51.9
49.0	47.7	48.2	48.6	49.1	49.5	50.0	50.4	50.9	51.3	51.8	52.3	52.7	53.2
50.0	48.9	49.3	49.8	50.2	50.7	51.2	51.6	52.1	52.6	53.0	53.5	54.0	54.4
51.0	50.0	50.5	50.9	51.4	51.9	52.3	52.8	53.3	53.8	54.2	54.7	55.2	55.7
52.0	51.1	51.6	52.1	52.6	53.0	53.5	54.0	54.5	55.0	55.5	56.0	56.5	57.0
53.0	52.3	52.8	53.2	53.7	54.2	54.7	55.2	55.7	56.2	56.7	57.2	57.7	58.2
54.0	53.4	53.9	54.4	54.9	55.4	55.9	56.4	56.9	57.4	57.9	58.5	59.0	59.5
55.0	54.6	55.1	55.6	56.1	56.6	57.1	57.6	58.1	58.7	59.2	59.7	60.2	60.8

续表 F

v_{a} f_{cu}^{c} R_{a}	4.58	4.60	4.62	4.64	4.66	4.68	4.70	4.72	4.74	4.76	4.78	4.80	4.82
15.0	13.7	13.8	13.9	14.0	14.2	14.3	14.4	14.5	14.6	14.8	14.9	15.0	15.1
16.0	14.7	14.9	15.0	15.1	15.2	15.4	15.5	15.6	15.8	15.9	16.0	16.2	16.3
17.0	15.8	15.9	16.1	16.2	16.4	16.5	16.6	16.8	16.9	17.1	17.2	17.4	17.5
18.0	16.9	17.0	17.2	17.3	17.5	17.6	17.8	17.9	18.1	18.2	18.4	18.5	18.7
19.0	18.0	18.1	18.3	18.4	18.6	18.8	18.9	19.1	19.2	19.4	19.6	19.7	19.9
20.0	19.1	19.2	19.4	19.6	19.7	19.9	20.1	20.2	20.4	20.6	20.8	20.9	21.1
21.0	20.2	20.3	20.5	20.7	20.9	21.1	21.2	21.4	21.6	21.8	22.0	22.1	22.3
22.0	21.3	21.5	21.7	21.8	22.0	22.2	22.4	22.6	22.8	23.0	23.2	23.4	23.6
23.0	22.4	22.6	22.8	23.0	23.2	23.4	23.6	23.8	24.0	24.2	24.4	24.6	24.8
24.0	23.5	23.7	23.9	24.1	24.4	24.6	24.8	25.0	25.2	25.4	25.6	25.8	26.1
25.0	24.7	24.9	25.1	25.3	25.5	25.8	26.0	26.2	26.4	26.6	26.9	27.1	27.3
26.0	25.8	26.0	26.3	26.5	26.7	26.9	27.2	27.4	27.6	27.9	28.1	28.3	28.6
27.0	27.0	27.2	27.4	27.7	27.9	28.1	28.4	28.6	28.9	29.1	29.4	29.6	29.9
28.0	28.1	28.4	28.6	28.9	29.1	29.4	29.6	29.9	30.1	30.4	30.6	30.9	31.1
29.0	29.3	29.5	29.8	30.0	30.3	30.6	30.8	31.1	31.4	31.6	31.9	32.2	32.4
30.0	30.4	30.7	31.0	31.2	31.5	31.8	32.1	32.3	32.6	32.9	33.2	33.4	33.7
31.0	31.6	31.9	32.2	32.5	32.7	33.0	33.3	33.6	33.9	34.2	34.4	34.7	35.0
32.0	32.8	33.1	33.4	33.7	34.0	34.2	34.5	34.8	35.1	35.4	35.7	36.0	36.3
33.0	34.0	34.3	34.6	34.9	35.2	35.5	35.8	36.1	36.4	36.7	37.0	37.3	37.6
34.0	35.2	35.5	35.8	36.1	36.4	36.7	37.0	37.4	37.7	38.0	38.3	38.6	39.0
35.0	36.4	36.7	37.0	37.3	37.7	38.0	38.3	38.6	39.0	39.3	39.6	40.0	40.3
36.0	37.6	37.9	38.2	38.6	38.9	39.2	39.6	39.9	40.3	40.6	40.9	41.3	41.6
37.0	38.8	39.1	39.5	39.8	40.2	40.5	40.8	41.2	41.5	41.9	42.2	42.6	43.0
38.0	40.0	40.4	40.7	41.1	41.4	41.8	42.1	42.5	42.8	43.2	43.6	43.9	44.3
39.0	41.2	41.6	41.9	42.3	42.7	43.0	43.4	43.8	44.1	44.5	44.9	45.3	45.7
40.0	42.4	42.8	43.2	43.6	43.9	44.3	44.7	45.1	45.5	45.8	46.2	46.6	47.0
41.0	43.7	44.1	44.4	44.8	45.2	45.6	46.0	46.4	46.8	47.2	47.6	48.0	48.4
42.0	44.9	45.3	45.7	46.1	46.5	46.9	47.3	47.7	48.1	48.5	48.9	49.3	49.7
43.0	46.1	46.5	47.0	47.4	47.8	48.2	48.6	49.0	49.4	49.8	50.3	50.7	51.1
44.0	47.4	47.8	48.2	48.6	49.1	49.5	49.9	50.3	50.7	51.2	51.6	52.0	52.5
45.0	48.6	49.1	49.5	49.9	50.3	50.8	51.2	51.6	52.1	52.5	53.0	53.4	53.9
46.0	49.9	50.3	50.8	51.2	51.6	52.1	52.5	53.0	53.4	53.9	54.3	54.8	55.2
47.0	51.1	51.6	52.0	52.5	52.9	53.4	53.8	54.3	54.8	55.2	55.7	56.2	56.6
48.0	52.4	52.9	53.3	53.8	54.2	54.7	55.2	55.6	56.1	56.6	57.1	57.5	58.0
49.0	53.7	54.1	54.6	55.1	55.5	56.0	56.5	57.0	57.5	58.0	58.4	58.9	59.4
50.0	54.9	55.4	55.9	56.4	56.9	57.3	57.8	58.3	58.8	59.3	59.8	60.3	60.8
51.0	56.2	56.7	57.2	57.7	58.2	58.7	59.2	59.7	60.2	60.7	61.2	61.7	62.2
52.0	57.5	58.0	58.5	59.0	59.5	60.0	60.5	61.0	61.6	62.1	62.6	63.1	63.6
53.0	58.7	59.3	59.8	60.3	60.8	61.3	61.9	62.4	62.9	63.5	64.0	64.5	65.1
54.0	60.0	60.6	61.1	61.6	62.1	62.7	63.2	63.8	64.3	64.8	65.4	65.9	66.5
55.0	61.3	61.8	62.4	62.9	63.5	64.0	64.6	65.1	65.7	66.2	66.8	67.3	67.9

续表 F

v_a f_{cu}^{c} R_a	4.84	4.86	4.88	4.90	4.92	4.94	4.96	4.98	5.00	5.02	5.04	5.06	5.08
15.0	15.3	15.4	15.5	15.6	15.8	15.9	16.0	16.2	16.3	16.4	16.6	16.7	16.8
16.0	16.4	16.6	16.7	16.9	17.0	17.1	17.3	17.4	17.6	17.7	17.8	18.0	18.1
17.0	17.6	17.8	17.9	18.1	18.2	18.4	18.5	18.7	18.8	19.0	19.1	19.3	19.4
18.0	18.8	19.0	19.2	19.3	19.5	19.6	19.8	20.0	20.1	20.3	20.4	20.6	20.8
19.0	20.1	20.2	20.4	20.6	20.7	20.9	21.1	21.2	21.4	21.6	21.8	21.9	22.1
20.0	21.3	21.5	21.6	21.8	22.0	22.2	22.4	22.5	22.7	22.9	23.1	23.3	23.4
21.0	22.5	22.7	22.9	23.1	23.3	23.5	23.6	23.8	24.0	24.2	24.4	24.6	24.8
22.0	23.8	24.0	24.2	24.4	24.6	24.8	25.0	25.2	25.4	25.6	25.8	26.0	26.2
23.0	25.0	25.2	25.4	25.6	25.8	26.1	26.3	26.5	26.7	26.9	27.1	27.3	27.6
24.0	26.3	26.5	26.7	26.9	27.1	27.4	27.6	27.8	28.0	28.3	28.5	28.7	28.9
25.0	27.5	27.8	28.0	28.2	28.5	28.7	28.9	29.2	29.4	29.6	29.9	30.1	30.3
26.0	28.8	29.1	29.3	29.5	29.8	30.0	30.3	30.5	30.8	31.0	31.2	31.5	31.7
27.0	30.1	30.4	30.6	30.9	31.1	31.4	31.6	31.9	32.1	32.4	32.6	32.9	33.2
28.0	31.4	31.7	31.9	32.2	32.4	32.7	33.0	33.2	33.5	33.8	34.0	34.3	34.6
29.0	32.7	33.0	33.2	33.5	33.8	34.1	34.3	34.6	34.9	35.2	35.4	35.7	36.0
30.0	34.0	34.3	34.6	34.8	35.1	35.4	35.7	36.0	36.3	36.6	36.9	37.2	37.5
31.0	35.3	35.6	35.9	36.2	36.5	36.8	37.1	37.4	37.7	38.0	38.3	38.6	38.9
32.0	36.6	36.9	37.2	37.5	37.8	38.2	38.5	38.8	39.1	39.4	39.7	40.0	40.3
33.0	38.0	38.3	38.6	38.9	39.2	39.5	39.9	40.2	40.5	40.8	41.2	41.5	41.8
34.0	39.3	39.6	39.9	40.3	40.6	40.9	41.3	41.6	41.9	42.3	42.6	42.9	43.3
35.0	40.6	41.0	41.3	41.6	42.0	42.3	42.7	43.0	43.4	43.7	44.0	44.4	44.7
36.0	42.0	42.3	42.7	43.0	43.4	43.7	44.1	44.4	44.8	45.1	45.5	45.9	46.2
37.0	43.3	43.7	44.0	44.4	44.8	45.1	45.5	45.9	46.2	46.6	47.0	47.3	47.7
38.0	44.7	45.0	45.4	45.8	46.2	46.5	46.9	47.3	47.7	48.1	48.4	48.8	49.2
39.0	46.0	46.4	46.8	47.2	47.6	48.0	48.3	48.7	49.1	49.5	49.9	50.3	50.7
40.0	47.4	47.8	48.2	48.6	49.0	49.4	49.8	50.2	50.6	51.0	51.4	51.8	52.2
41.0	48.8	49.2	49.6	50.0	50.4	50.8	51.2	51.6	52.0	52.5	52.9	53.3	53.7
42.0	50.1	50.6	51.0	51.4	51.8	52.2	52.7	53.1	53.5	53.9	54.4	54.8	55.2
43.0	51.5	52.0	52.4	52.8	53.2	53.7	54.1	54.5	55.0	55.4	55.9	56.3	56.8
44.0	52.9	53.4	53.8	54.2	54.7	55.1	55.6	56.0	56.5	56.9	57.4	57.8	58.3
45.0	54.3	54.8	55.2	55.7	56.1	56.6	57.0	57.5	58.0	58.4	58.9	59.4	59.8
46.0	55.7	56.2	56.6	57.1	57.6	58.0	58.5	59.0	59.4	59.9	60.4	60.9	61.4
47.0	57.1	57.6	58.0	58.5	59.0	59.5	60.0	60.5	60.9	61.4	61.9	62.4	62.9
48.0	58.5	59.0	59.5	60.0	60.5	60.9	61.4	61.9	62.4	62.9	63.4	63.9	64.4
49.0	59.9	60.4	60.9	61.4	61.9	62.4	62.9	63.4	63.9	64.5	65.0	65.5	66.0
50.0	61.3	61.8	62.3	62.9	63.4	63.9	64.4	64.9	65.5	66.0	66.5	67.0	67.6
51.0	62.8	63.3	63.8	64.3	64.8	65.4	65.9	66.4	67.0	67.5	68.0	68.6	69.1
52.0	64.2	64.7	65.2	65.8	66.3	66.9	67.4	67.9	68.5	69.0	69.6	—	—
53.0	65.6	66.1	66.7	67.2	67.8	68.3	68.9	69.4	70.0	—	—	—	—
54.0	67.0	67.6	68.1	68.7	69.3	69.8	—	—	—	—	—	—	—
55.0	68.5	69.0	69.6	—	—	—	—	—	—	—	—	—	—

续表 F

v_a f_{cu}^{c} R_a	5.10	5.12	5.14	5.16	5.18	5.20	5.22	5.24	5.26	5.28	5.30	5.32	5.34
15.0	17.0	17.1	17.2	17.4	17.5	17.6	17.8	17.9	18.0	18.2	18.3	18.4	18.6
16.0	18.3	18.4	18.5	18.7	18.8	19.0	19.1	19.3	19.4	19.6	19.7	19.9	20.0
17.0	19.6	19.7	19.9	20.1	20.2	20.4	20.5	20.7	20.8	21.0	21.2	21.3	21.5
18.0	20.9	21.1	21.3	21.4	21.6	21.8	21.9	22.1	22.3	22.4	22.6	22.8	22.9
19.0	22.3	22.4	22.6	22.8	23.0	23.2	23.3	23.5	23.7	23.9	24.1	24.2	24.4
20.0	23.6	23.8	24.0	24.2	24.4	24.6	24.8	24.9	25.1	25.3	25.5	25.7	25.9
21.0	25.0	25.2	25.4	25.6	25.8	26.0	26.2	26.4	26.6	26.8	27.0	27.2	27.4
22.0	26.4	26.6	26.8	27.0	27.2	27.4	27.6	27.8	28.1	28.3	28.5	28.7	28.9
23.0	27.8	28.0	28.2	28.4	28.6	28.9	29.1	29.3	29.5	29.8	30.0	30.2	30.4
24.0	29.2	29.4	29.6	29.9	30.1	30.3	30.6	30.8	31.0	31.3	31.5	31.7	32.0
25.0	30.6	30.8	31.1	31.3	31.5	31.8	32.0	32.3	32.5	32.8	33.0	33.3	33.5
26.0	32.0	32.2	32.5	32.8	33.0	33.3	33.5	33.8	34.0	34.3	34.6	34.8	35.1
27.0	33.4	33.7	33.9	34.2	34.5	34.7	35.0	35.3	35.6	35.8	36.1	36.4	36.6
28.0	34.9	35.1	35.4	35.7	36.0	36.2	36.5	36.8	37.1	37.4	37.6	37.9	38.2
29.0	36.3	36.6	36.9	37.2	37.4	37.7	38.0	38.3	38.6	38.9	39.2	39.5	39.8
30.0	37.7	38.0	38.3	38.6	38.9	39.2	39.5	39.8	40.2	40.5	40.8	41.1	41.4
31.0	39.2	39.5	39.8	40.1	40.4	40.8	41.1	41.4	41.7	42.0	42.3	42.7	43.0
32.0	40.7	41.0	41.3	41.6	42.0	42.3	42.6	42.9	43.3	43.6	43.9	44.2	44.6
33.0	42.1	42.5	42.8	43.1	43.5	43.8	44.1	44.5	44.8	45.2	45.5	45.9	46.2
34.0	43.6	44.0	44.3	44.6	45.0	45.3	45.7	46.0	46.4	46.7	47.1	47.5	47.8
35.0	45.1	45.5	45.8	46.2	46.5	46.9	47.2	47.6	48.0	48.3	48.7	49.1	49.4
36.0	46.6	47.0	47.3	47.7	48.1	48.4	48.8	49.2	49.6	49.9	50.3	50.7	51.1
37.0	48.1	48.5	48.8	49.2	49.6	50.0	50.4	50.8	51.2	51.5	51.9	52.3	52.7
38.0	49.6	50.0	50.4	50.8	51.2	51.6	52.0	52.4	52.8	53.2	53.6	54.0	54.4
39.0	51.1	51.5	51.9	52.3	52.7	53.1	53.5	53.9	54.4	54.8	55.2	55.6	56.0
40.0	52.6	53.0	53.5	53.9	54.3	54.7	55.1	55.6	56.0	56.4	56.8	57.3	57.7
41.0	54.1	54.6	55.0	55.4	55.9	56.3	56.7	57.2	57.6	58.0	58.5	58.9	59.4
42.0	55.7	56.1	56.6	57.0	57.4	57.9	58.3	58.8	59.2	59.7	60.1	60.6	61.0
43.0	57.2	57.7	58.1	58.6	59.0	59.5	59.9	60.4	60.9	61.3	61.8	62.2	62.7
44.0	58.7	59.2	59.7	60.1	60.6	61.1	61.5	62.0	62.5	63.0	63.4	63.9	64.4
45.0	60.3	60.8	61.2	61.7	62.2	62.7	63.2	63.6	64.1	64.6	65.1	65.6	66.1
46.0	61.8	62.3	62.8	63.3	63.8	64.3	64.8	65.3	65.8	66.3	66.8	67.3	67.8
47.0	63.4	63.9	64.4	64.9	65.4	65.9	66.4	66.9	67.4	67.9	68.5	69.0	69.5
48.0	65.0	65.5	66.0	66.5	67.0	67.5	68.0	68.6	69.1	69.6	—	—	—
49.0	66.5	67.0	67.6	68.1	68.6	69.2	69.7	—	—	—	—	—	—
50.0	68.1	68.6	69.2	69.7	—	—	—	—	—	—	—	—	—
51.0	69.7	—	—	—	—	—	—	—	—	—	—	—	—
52.0	—	—	—	—	—	—	—	—	—	—	—	—	—
53.0	—	—	—	—	—	—	—	—	—	—	—	—	—
54.0	—	—	—	—	—	—	—	—	—	—	—	—	—
55.0	—	—	—	—	—	—	—	—	—	—	—	—	—

1 0.1MPa

2 v_a R_a

3 v_a v R_a R

4 f_{cu}^{c} 6.2.1

G

G.0.1

1 3.1

2 4.1

3 4.2

G.0.2

G.0.3

G.0.4

C15 C20 C30 C40 C50 C60

G.0.5

1 JG 237

2

150mm×150mm×150mm

3 7d “ ”

4 14d 28d 60d 90d 180d 365d

5

6 G.0.5

G.0.5

G.0.5

	14d	28d	60d	90d	180d	365d	
C15	30	30	30	30	30	30	180
C20	30	30	30	30	30	30	180
C30	30	30	30	30	30	30	180
C40	30	30	30	30	30	30	180
C50	30	30	30	30	30	30	180
C60	30	30	30	30	30	30	180

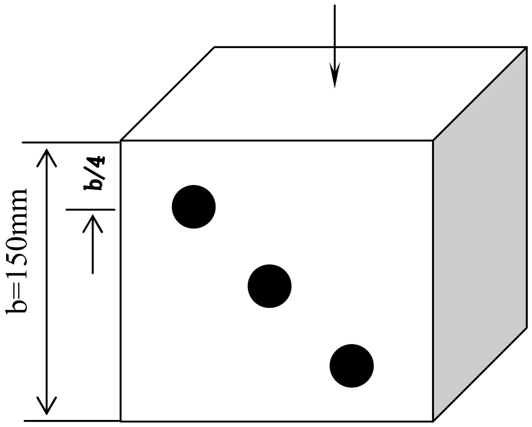
G.0.6

1

3

2 G.0.6

3



G.0.6

3

l_1 l_2 l_3

4

t_1 t_2 t_3 0.1 μs

5 v 3

$$v=\frac{1}{3}\sum_{i=1}^{3}\frac{l_i}{t_i-t_0} \qquad \text{G.0.6}$$

v — km/s 0.01km/s

l_i — i (mm) 1mm

t_i — i μs 0.1 μs

t_0 — μs

6 R

60kN~80kN 5.2.1

5 1 1 1

8 R 0.1

7

GB/T 50081

0.1MPa

G.0.7

1 v

R

2

$$f_{\mathrm{cu}}^{\mathrm{c}} = a v^{b} R^{c} \qquad \text{G.0.7-1}$$

a —

b c —

$f_{\mathrm{cu}}^{\mathrm{c}}$ — MPa

3 δ e_{r}

$$\delta = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{f_{\mathrm{cu},i}^{\mathrm{c}}}{f_{\mathrm{cu},i}^{0}} - 1\right| \times 100\% \qquad \text{G.0.7-2}$$

$$e_{\mathrm{r}} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{f_{\mathrm{cu},i}^{\mathrm{c}}}{f_{\mathrm{cu},i}^{0}} - 1\right)^{2}} \times 100\% \qquad \text{G.0.7-3}$$

δ — % 0.1%

e_{r} — % 0.1%

$f_{\mathrm{cu},i}^{\mathrm{c}}$ — i G.0.7-1

MPa 0.1MPa

$f_{\mathrm{cu},i}^{0}$ — i MPa 0.1MPa

n —

G.0.8 6.3.2

G.0.9

H

______________________________ ______________________________

: ____________ ____________ ____________ ____________kHz t_0 __________ __________℃

__________ ____________ ( ) ( ) ____________

		R_i					R	l_i t_i			v km/s	
		1	2	3	4	5		1	2	3		
	1											
	2											
	3											
	4											
	5											
	6											
	7											
	8											
	9											
	10											

I

		1	2	3	4	5	6	7	8	9	10
km/s											
	β λ										
Δ_{tot} MPa											
MPa											
$n =$ MPa		$m_{f^{c}_{cu}} =$ MPa			$s_{f^{c}_{cu}} =$ MPa			$f_{cu,e} =$ MPa			

1

1

“ ”

“ ”

2

“ ”

“ ” “ ”

3

“ ”

“ ”

4

“ ”

“ ”

2 “ …… ” “ ……
” “ …… ”

1 GB/T 50081

2 GB/T 9138

3 JG 237

4 JGJ/T 384

5 JG/T 5004

6 JJG 817

T/CECS 02-2020

前言

T/CECS 02-2020 XXX

CECS 02 2005

2005

1

1.0.1

1.0.2

$1950kg/m^3$~$2500kg/m^3$

1.0.3

3

3.1

3.1.1

3.1.2

3.1.3

1 E

$$E=\frac{1}{2}KL^2=\frac{1}{2}\times 784.532\times 0.075^2=2.207\mathrm{J}$$

K — (N/m)

L — (m)

2

“0”

0.0615m ( ) 0.075m

“100” “0”

7.82 1.72

3 80±2

2.207J

4

3.1.4 -4℃

40℃

3.2

3.2.1 JJG 817

3.2.2

3.2.3

3.2.4 80±2

80±2

3.3

3.2.5

GB/T 9138

3.3

3.3.1

3.3.2

0.5 N　0.8N

3.3.3

4

4.1

4.1.1

JG/T 5004

4.1.2

JG/T 5004

4.1.3

1

A/D

2

3

4.1.4

1 JG/T 5004

2

1dB

3

50kHz 100kHz

4

3 1

4.1.5

4.2

4.2.1

50kHz 100kHz

50kHz

4.2.2

4.3

4.3.1

4.3.3

5

5.1

5.1.1 1~6

5.1.2

5.1.3 1 4

5.1.4

5.1.5

5.1.6

5.1.7

5.2

5.2.1

5.2.2

5.2.3~5.2.4

10 1 1 8

16 10

5.2.5 5.2.6

5.2.7

5.3

5.3.2

5.3.3～5.3.4

3

1.034

6

6.1

6.1.1

GB 175

GB/T 14684

GB/T 14685 JGJ52

JGJ 63

6.1.2

6.1.3

6.2

6.2.1~6.2.2

F

17713 16887 826

26 17687

2 34%

		a	b	c	r	%	%
17687	16369	0.0286	1.999	1.155	0.92	15.2	12.35

6.3

6.3.2

δ 10% e_{r} 12%

δ 11% e_{r} 14%

6.3.3

6.4 混凝土抗压强度推定

6.4.1

6.4.2

6.4.7

28d

10.0MPa

$f_{\mathrm{cu,e}}$ 10.0MPa 10.0MPa

70.0MPa

“ 10.0MPa” “ 70.0MPa” 10.0MPa

“ 10.0MPa” 70.0MPa

10 6.4.7-1

10 6.4.7-2 ～ 6.4.7-4

6.4.7-2 ～ 6.4.7-4

6.4.8

6.4.8

A

v_k v^o ±0.5%

v_k v^o ±0.5%

D

D.1

D.1.1

D.1.2

l_{1i} l_{2i} 300mm

l_{1i} l_{2i}

1.5

D.1.3 **D.1.4** F S l_{1i}

l_{2i} l_i

D.2

D.2.1

ϕ

40mm ϕ50mm

D.2.2

40° 50°

D.2.2

c v_{p}

v_{p} ~

D.2.3 D.2.4

( )

v_{d}

v_{p} λ

v_{p}

v_{p}

v_{d}

$v_{\mathrm{d}}/v_{\mathrm{p}}$ =1.00 1.03

$v_{\mathrm{d}}/v_{\mathrm{p}}$=1.04 1.15

E

F

10.0MPa 70.0MPa

“ 10.0MPa” “ 70.0MPa”

G

G G.0.7-1

6.3.2