CiviLab 7.1 — Hand verification

Category C tests: each CiviLab result compared with a detailed hand calculation

Bakhti Softwares — 06/11/2026 — supplement to the report “CiviLab-7.1-Validation-All-tests”

For each test without a verifiable published example (category C), the calculation is redone by hand: formula of the standard, data, steps with numerical values, result. The calculation is independent of the CiviLab code and of the formulas of the Excel workbook. The result is compared with the value produced by CiviLab, obtained by running the code of the library (“run”) or by following step by step the code of the input window (“code reviewed”).

Summary

Test	By hand	CiviLab 7.1	
Laboratory			
1. Proctor — wOPT and ρd max	wOPT 12.78 %; ρd max 1.879 g/cm³	12.78 %; 1.879 g/cm³	✔
2. Atterberg limits — Casagrande and cone	wL 45.73 %; PI 23.33; wL cone 44.59 %	45.7 %; 23.3; 44.6 %	✔
3. CBR	22.2	22.2	✔
4. Hydrometer — Stokes diameter	0.0751 mm	0.0751 mm	✔
5. Direct shear — c', φ'	c' 16.6 kPa; φ' 29.9°	16.6 kPa; 29.9°	✔
6. Oedometer — Cc	0.172	0.172	✔
7. Los Angeles, Micro-Deval, sand equivalent	22.6; 13.8; 77.0	22.6; 13.8; 77.0	✔
8. Particle size — FM, Cu, Cc	2.68; 5.26; 0.84	2.68; 5.26; 0.84	✔
In situ			
9. Dynamic penetrometer — qd	3.39 MPa	3.39 MPa	✔
10. Ménard pressuremeter — EM, Vl	EM 8.80 MPa; Vl 914.84 cm³	8.80 MPa; 914.84 cm³	✔
11. Ménard pressuremeter — pl by the inverse curve	2.006 MPa	2.006 MPa	✔
12. CPT — qc, fs	2.10 MPa; 50.0 kPa; 2.38 %	2.100 MPa; 50.000 kPa; 2.381 %	✔
Foundations			
13. Bearing capacity, laboratory (DTU 13.12)	626.6 kPa	626.6 kPa	✔
14. Bearing capacity, pressuremeter (DTU 13.12)	928.3 kPa	928.3 kPa	✔
15. Bearing capacity, CPT (DTU 13.12)	670.6 kPa	670.6 kPa	✔
16. SPT — Meyerhof (1956)	239.1 kPa	239.1 kPa	✔
Settlement			
17. Ménard pressuremeter settlement	sc 0.40; sd 0.85 cm	0.40; 0.85 cm	✔
18. Oedometric (3 layers) and elastic settlement	48.5 cm; 1.28 cm	48.5 cm; 1.28 cm	✔
Concrete			
19. Compression	26.2; 31.9 MPa	26.2; 31.9 MPa	✔
20. Ultrasonic pulse velocity	4 161 m/s	4 161 m/s	✔
21. Rebound hammer	32; 31.33	32; 31.33	✔
22. SonReb — Meynink et al. (1979) correlation	34.5 MPa	34.5 MPa	✔

23. Dreux-Gorisse	YA 46.13 %; water 184.2 L	46.13 %; 184.2 L	✔
24. Bolomey	P(0.08) 15.1 %; water 189.8 L	15.1 %; 189.8 L	✔
25. Faury	60.87 %; 154.5 L	60.87 %; 154.5 L	✔
Roads and asphalt			
26. Kumagawa, paraffin bulk density, degree of compaction	5.63 %; 2.341; 96.6 %	5.63 %; 2.341; 96.6 %	✔

Result: 26 checks, all in agreement. Point to be checked in the original source: coefficient 0.0297 (CiviLab) or 0.0294 (ALCONPAT 2023) of the SonReb correlation of Meynink et al. (1979); difference on the example: 0.09 MPa.

Laboratory

1. Proctor — wOPT and ρd max

Formula: NF P 94-093: w = (mh − ms)/(ms − tare); ρd = (Mh/V)/(1 + w); optimum: 2nd-degree polynomial

Data: V = 944 cm³; mould 4 220 g; 5 points (mould + soil; tare + wet soil; tare + dry soil; tare 40 g)

1. Point 1: w = (152.3 − 143.1)/(143.1 − 40) × 100 = 8.923 %; Mh = 6 100 − 4 220 = 1 880 g; ρd = 1 880/944/(1 + 0.08923) = 1.8284 g/cm³
2. Points 2 to 5: w = 11.24; 13.74; 16.31; 18.54 %; ρd = 1.8759; 1.8777; 1.8325; 1.7739 g/cm³
3. Fit ρd = a·w² + b·w + c (least squares, 5 points): a = -0.003272; b = 0.08361; c = 1.3452
4. wOPT = −b/(2a) = 12.78 %; ρd max = a·w² + b·w + c = 1.8794 g/cm³

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
wOPT 12.78 %; ρd max 1.879 g/cm³	**12.78 %; 1.879 g/cm³**	✔	code reviewed (Proctor.vb, CalculerPolynome)

2. Atterberg limits — Casagrande and cone

Formula: NF P 94-051: w = a + b·log N, wL at N = 25; NF P 94-052-1: w = a + b·penetration, wL at 17 mm

Data: Casagrande: N = 15, 22, 29, 35; w = 48.9; 46.6; 44.8; 43.6 % — Cone: penetration 13.2; 16.1; 19.4; 22.8 mm; w = 41.0; 43.9; 46.8; 49.9 %; wP = 22.4 %

1. log N = 1.1761; 1.3424; 1.4624; 1.5441; means: log N = 1.3812, w = 45.975
2. b = Σ(Δx·Δy)/Σ(Δx²) = -14.4264; a = w̄ − b·x̄ = 65.9014
3. wL = a + b·log 25 = 65.9014 + (-14.4264) × 1.39794 = 45.73 %; PI = wL − wP = 23.33
4. Cone: b = 0.92135; a = 28.9309; wL = a + 17·b = 44.59 %

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
wL 45.73 %; PI 23.33; wL cone 44.59 %	**45.7 %; 23.3; 44.6 %**	✔	code reviewed (Limite.Calculer)

3. CBR

Formula: NF P 94-078: CBR = max(100·F2.5/13.35; 100·F5/19.93)

Data: F(2.5 mm) = 2.71 kN; F(5 mm) = 4.42 kN

1. CBR 2.5 = 100 × 2.71/13.35 = 20.30
2. CBR 5 = 100 × 4.42/19.93 = 22.18
3. CBR index = max = 22.18

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
22.2	**22.2**	✔	code reviewed (CBRClass.CBRValueCalculation)

4. Hydrometer — Stokes diameter

Formula: NF P 94-057: $D = \sqrt{(18 \cdot \eta \cdot Hr/((\rho s - \rho w) \cdot g \cdot t))}$

Data: $\eta = 0.001002$ Pa·s (water at 20 °C); $\rho s = 2\,650$; $\rho w = 998.2$ kg/m³; $g = 9.81$; $t = 30$ s; $Hr = 15.2$ cm

1. $(\rho s - \rho w) \cdot g \cdot t = 1\,651.8 \times 9.81 \times 30 = 486124.7$
2. $18 \cdot \eta \cdot Hr = 18 \times 0.001002 \times 0.152 = 0.0027415$
3. $D = \sqrt{(0.0027415/486124.7)} = 0.00007510$ m = 0.0751 mm
4. Other times (60 s to 86 400 s): D = 0.05380; 0.03852; 0.02474; 0.01454; 0.00742; 0.00156 mm

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
0.0751 mm	**0.0751 mm**	✔	code reviewed (TamisageClass.ParticleDiameter)

5. Direct shear — c', φ'

Formula: NF EN ISO 17892-10: $\tau f = c' + \sigma'n \cdot \tan \varphi'$ (linear regression)

Data: $\sigma'n = 100$; 200; 300 kPa; $\tau max = 74.2$; 131.5; 189.3 kPa

1. Means: $\bar{\sigma} = 200$; $\bar{\tau} = 131.6667$
2. $\tan \varphi' = \Sigma(\Delta\sigma \cdot \Delta\tau)/\Sigma(\Delta\sigma^2) = (-100 \times -57.467 + 100 \times 57.633)/20\,000 = 0.57550$
3. $\varphi' = \arctan(0.57550) = 29.92°$
4. $c' = \bar{\tau} - \bar{\sigma} \cdot \tan \varphi' = 131.6667 - 200 \times 0.57550 = 16.57$ kPa

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
c' 16.6 kPa; φ' 29.9°	**16.6 kPa; 29.9°**	✔	code reviewed (Cisaillement.vb, MoindreCarre)

6. Oedometer — Cc

Formula: NF EN ISO 17892-5: $Hs = Ms/(\rho s \cdot S)$; $e = (H - Hs)/Hs$; $Cc = -\Delta e/\Delta \log \sigma'$

Data: Ø 7 cm; H0 = 2 cm; Ms = 128.4 g; $\rho s = 2.7$; settlements 0.80 mm (200 kPa) and 2.08 mm (800 kPa)

1. $S = \pi \times 3.5^2 = 38.485$ cm²; $Hs = 128.4/(2.7 \times 38.485) = 1.23571$ cm
2. $e(200) = (2 - 0.080 - 1.23571)/1.23571 = 0.55377$; $e(800) = (2 - 0.208 - 1.23571)/1.23571 = 0.45018$
3. $Cc = (0.55377 - 0.45018)/\log(800/200) = 0.10358/0.60206 = 0.1721$

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
0.172	**0.172**	✔	code reviewed (EssaiOdometrique.vb)

7. Los Angeles, Micro-Deval, sand equivalent

Formula: NF EN 1097-2: $LA = 100 \cdot (M - m)/M$; NF EN 1097-1: $MDE = 100 \cdot (500 - m)/500$; NF EN 933-8: $SE = 100 \cdot h2/h1$

Data: LA: 5 000 g, retained on 1.6 mm 3 870 g; MDE: 500 g, retained 431 g; SE: (112; 86) and (110; 85) mm

1. $LA = 100 \times (5\,000 - 3\,870)/5\,000 = 22.6$
2. $MDE = 100 \times (500 - 431)/500 = 13.8$
3. $SE1 = 100 \times 86/112 = 76.79$; $SE2 = 100 \times 85/110 = 77.27$; SE = mean = 77.03

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
22.6; 13.8; 77.0	**22.6; 13.8; 77.0**	✔	code reviewed (EssaiFeuille.LaboRoutesBeton.vb)

8. Particle size — FM, Cu, Cc

Formula: NF EN 12620 annex B: FM = Σ cumulative % retained (4; 2; 1; 0.5; 0.25; 0.125)/100; Cu = D60/D10; Cc = D30²/(D60·D10) (linear interpolation in log d, as TamisageClass.InterpolationDiametre)

Data: Sieves 4; 2; 1; 0.5; 0.25; 0.125; 0.063 mm — passing 98; 86; 69; 48; 24; 7; 3 %

1. FM = (2 + 14 + 31 + 52 + 76 + 93)/100 = 2.68
2. D10 between 0.125 (7 %) and 0.25 (24 %): log D10 = log 0.125 + (log 0.25 − log 0.125) × (10 − 7)/(24 − 7) → D10 = 0.14126 mm
3. D30 = 0.25 × 2^(6/24) = 0.2973 mm; D60 = 0.5 × 2^(12/21) = 0.7430 mm
4. Cu = 0.7430/0.14126 = 5.260; Cc = 0.2973²/(0.7430 × 0.14126) = 0.842

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
2.68; 5.26; 0.84	**2.68; 5.26; 0.84**	✔	code reviewed (TamisageClass)

In situ

9. Dynamic penetrometer — qd

Formula: NF EN ISO 22476-2, Dutch formula: rd = M·g·H/(A·e); qd = rd·M/(M + M'); e = Δz/N

Data: M = 63.5 kg; H = 0.75 m; A = 20 cm²; Δz = 0.20 m; at 0.2 m: N = 4; M' = anvil 18 + 1 rod 6 = 24 kg

1. e = 0.20/4 = 0.05 m
2. rd = 63.5 × 9.81 × 0.75/(0.0020 × 0.05) = 4672013 Pa = 4.672 MPa
3. qd = 4.672 × 63.5/(63.5 + 24) = 3.391 MPa

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
3.39 MPa	**3.39 MPa**	✔	code reviewed (PDLClass)

10. Ménard pressuremeter — EM, Vl

Formula: NF P 94-110-1 § D.2.2: EM = 2(1 + ν)(Vs + Vm)·Δp/ΔV, Vm = (V1 + V2)/2; Vl = Vs + 2V1

Data: Vs = 554.84 cm³; ν = 0.33; p1 = 0.41941 MPa (V1 = 180 cm³); p2 = 0.91875 MPa (V2 = 300 cm³)

1. Vm = (180 + 300)/2 = 240 cm³; Vs + Vm = 794.84 cm³
2. Δp/ΔV = (0.91875 − 0.41941)/(300 − 180) = 0.0041612 MPa/cm³
3. EM = 2 × 1.33 × 794.84 × 0.0041612 = 8.798 MPa
4. Vl = 554.84 + 2 × 180 = 914.84 cm³

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
EM 8.80 MPa; Vl 914.84 cm³	**8.80 MPa; 914.84 cm³**	✔	EM: code reviewed; Vl, pl: run

11. Ménard pressuremeter — pl by the inverse curve

Formula: NF P 94-110-1 annex D: line 1/V = A·p + B for p ≥ p2; pl = p for V = Vl

Data: Points p ≥ p2 of the constructed curve (hyperbolic law); Vl = 914.84 cm³

1. Regression 1/V = A·p + B on the points (0.91875; 1/300), (1.21094; 1/380), (1.47681; 1/470), (1.70088; 1/570): A ≈ −0.00202; B ≈ 0.00514 (rounded values)
2. pl = (1/Vl − B)/A; with the unrounded regression values: pl = 2.006 MPa

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
2.006 MPa	**2.006 MPa**	✔	run (Module.vb, PL)

12. CPT — qc, fs

Formula: NF EN ISO 22476-1: qc = Qc/Ac; fs = Qs/As

Data: Qc = 2.1 kN; Ac = 10 cm²; Qs = 0.75 kN; As = 150 cm²

1. Qc = 2.1 kN = 2 100 N; Ac = 10 cm² = 0.0010 m²; qc = 2 100/0.0010 = 2 100 000 Pa = 2.10 MPa
2. Qs = 750 N; As = 0.0150 m²; fs = 750/0.015 = 50 000 Pa = 50.0 kPa; Rf = 100 × 0.050/2.10 = 2.38 %

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
2.10 MPa; 50.0 kPa; 2.38 %	**2.100 MPa; 50.000 kPa; 2.381 %**	✔	code reviewed (CPTFrm.RecalculerRow; CPTClass.DrawRf)

Foundations

13. Bearing capacity, laboratory (DTU 13.12)

Formula: DTU 13.12 § 3.2.1: qu = sc·ic·c·Nc + ½·sγ·iγ·γ·B·Nγ + sq·iq·γ·D·Nq

Data: B = 1.5; L = 2; D = 1 m; γ = 18 kN/m³; c = 10 kPa; φ = 30° (Nc 30; Nγ 18.1; Nq 18.4); δ = 10°

1. sc = 1 + 0.2·B/L = 1.15; sγ = 1 − 0.2·B/L = 0.85; sq = 1
2. ic = iq = (1 − δ/90)² = (1 − 10/90)² = 0.7901; iγ = (1 − δ/φ)² = (1 − 10/30)² = 0.4444
3. c term: 1.15 × 0.7901 × 10 × 30 = 272.59; γ term: 0.5 × 0.85 × 0.4444 × 18 × 1.5 × 18.1 = 92.31; q term: 0.7901 × 18 × 18.4 = 261.69
4. qu = 626.59 kPa

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
626.6 kPa	**626.6 kPa**	✔	code reviewed (FondationCPhiClass.QnetCalc)

14. Bearing capacity, pressuremeter (DTU 13.12)

Formula: DTU 13.12 § 3.2.2: ple* = mean of pl* capped at 1.5·min; qu = Kp·ple*·iδ + γ·D

Data: pl* = 0.62; 0.95; 1.38 MPa; Kp = 1.1; iδ = 1; γ = 19 kN/m³; D = 1 m

1. 1.5 × min = 1.5 × 0.62 = 0.93 MPa → capped values: 0.62; 0.93; 0.93
2. ple* = (0.62 + 0.93 + 0.93)/3 = 0.82667 MPa
3. qu = 1.1 × 826.67 × 1 + 19 × 1 = 928.33 kPa

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
928.3 kPa	**928.3 kPa**	✔	code reviewed (FondationPREClass.qu)

15. Bearing capacity, CPT (DTU 13.12)

Formula: DTU 13.12 § 3.2.3.1: qce = mean of qc capped at 1.3·qcm; qu = Kc·qce·iδ + γ·D

Data: qc = 4.2; 5.1; 12.8; 4.8; 5.5; 4.9 MPa; Kc = 0.12; γ = 19; D = 1 m

1. qcm = 37.3/6 = 6.2167 MPa; 1.3·qcm = 8.0817 MPa → 12.8 capped at 8.0817
2. qce = 32.5817/6 = 5.43028 MPa
3. qu = 0.12 × 5430.28 + 19 = 670.63 kPa

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
670.6 kPa	**670.6 kPa**	✔	code reviewed (FondationCPTClass.qu)

16. SPT — Meyerhof (1956)

Formula: q = 12·N·Kd (B ≤ 1.2 m); q = 8·N·((B + 0.3)/B)²·Kd (B > 1.2 m); Kd = min(1 + 0.33·D/B; 1.33)

Data: N = 18; B = 1.8 m; D = 1.2 m

1. Kd = 1 + 0.33 × 1.2/1.8 = 1.220
2. ((B + 0.3)/B)² = (2.1/1.8)² = 1.36111
3. q = 8 × 18 × 1.36111 × 1.220 = 239.12 kPa

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
239.1 kPa	**239.1 kPa**	✔	code reviewed (FondationSPTClass.CapaciteSansCharge)

Settlement

17. Ménard pressuremeter settlement

Formula: NF P 94-261 annex H: sc = α·(q' − σ'v0)·λc·B/(9·Ec); sd = 2·(q' − σ'v0)·B0·(λd·B/B0)^α/(9·Ed)

Data: B = 2 m; q' = 300 kPa; σ'v0 = 36 kPa; Ec = Ed = 8 000 kPa; α = 0.5; λc = 1.1; λd = 1.12; B0 = 0.6 m

1. q' − σ'v0 = 264 kPa
2. sc = 0.5 × 264 × 1.1 × 2/(9 × 8 000) = 0.004033 m = 0.403 cm
3. (λd·B/B0)^α = (1.12 × 2/0.6)^0.5 = 1.93218; sd = 2 × 264 × 0.6 × 1.93218/(9 × 8 000) = 0.850 cm
4. s = sc + sd = 1.253 cm

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
sc 0.40; sd 0.85 cm	**0.40; 0.85 cm**	✔	run (TassementPREClass)

18. Oedometric (3 layers) and elastic settlement

Formula: s = Σ H·Cc/(1 + e0)·log((σ'v0 + Δσ)/σ'v0) (NC); s = cf·(1 − ν²)·q·B/E

Data: Layers (H; e0; Cc; σ'v0; Δσ): (2; 0.92; 0.31; 28; 150) (2; 0.88; 0.28; 46; 95) (2; 0.85; 0.26; 64; 60) — elastic: cf 0.88; ν 0.3; q 200 kPa; B 2 m; E 25 MPa

1. layer 1: 2 × 0.31/1.92 × log(178/28) = 25.94 cm
2. layer 2: 2 × 0.28/1.88 × log(141/46) = 14.49 cm
3. layer 3: 2 × 0.26/1.85 × log(124/64) = 8.07 cm; total = 48.50 cm
4. elastic: 0.88 × (1 − 0.09) × 0.200 × 2/25 = 0.01281 m = 1.28 cm

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
48.5 cm; 1.28 cm	**48.5 cm; 1.28 cm**	✔	code reviewed (TassementOedometer.ComputeSc; TassementLinear)

Concrete

19. Compression

Formula: NF EN 12390-3: fc = F/Ac

Data: Cube 10 cm: F = 262.4 kN; cylinder 16 × 32: F = 642.1 kN

1. Cube: Ac = 100 × 100 = 10 000 mm²; fc = 262 400/10 000 = 26.24 MPa
2. Cylinder: Ac = π × 80² = 20106.2 mm²; fc = 642 100/20106.2 = 31.94 MPa

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
26.2; 31.9 MPa	**26.2; 31.9 MPa**	✔	code reviewed (EcrasementBeton.xaml.vb)

20. Ultrasonic pulse velocity

Formula: NF EN 12504-4: V = L/t

Data: P1: L = 30 cm; t = 72.1 µs

1. V = 0.30 m / 72.1 × 10^{-6} s = 4 160.9 m/s

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
4 161 m/s	**4 161 m/s**	✔	code reviewed (UltrasonFrm.xaml.vb)

21. Rebound hammer

Formula: NF EN 12504-2 § 8: median rounded to the integer; ASTM C805: mean, readings more than 6 units away rejected, new mean

Data: Z1: 30; 32; 31; 33; 29; 30; 31; 34; 32; 45

1. Sorted: 29; 30; 30; 31; 31; 32; 32; 33; 34; 45 → median = (31 + 32)/2 = 31.5; only one reading (45) more than 25 % from the median → EN index = 32
2. ASTM: mean = 327/10 = 32.7; 45 deviates by more than 6 → rejected; mean of the other 9 = 282/9 = 31.33

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
32; 31.33	**32; 31.33**	✔	run (Sclerometre.IndiceRebond)

22. SonReb — Meynink et al. (1979) correlation

Formula: CiviLab formula: fc = −24.668 + 1.427·N + 0.0297·V^4 (V in km/s); the ALCONPAT article (2023), table 5, prints 0.0294 instead of 0.0297 (to be checked in the original article, RILEM 1979)

Data: N = 35; V = 4.2 km/s

1. 1.427 × 35 = 49.945
2. V^4 = 4.2^4 = 311.1696; 0.0297 × 311.1696 = 9.2417
3. fc = −24.668 + 49.945 + 9.2417 = 34.52 MPa
4. With 0.0294: fc = 34.43 MPa (difference 0.09 MPa)

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
34.5 MPa	**34.5 MPa**	✔	code reviewed (EssaiCombineeFrm.Resistance, case 1)

23. Dreux-Gorisse

Formula: YA = 50 − √D + K + Ks + Kp; Ks = 6·Mf − 15; XA = D/2; Vabs = 1 000·γ − C/ρc; E = C/(C/E)

Data: D = 20 mm; Mf = 2.6; C = 350 kg/m³; C/E = 1.9; K = 0; Kp = 0; γ = 0.825; ρc = 3.1

1. Ks = 6 × 2.6 − 15 = 0.6; YA = 50 − √20 + 0 + 0.6 + 0 = 46.13 %; XA = 10 mm
2. Vabs = 1 000 × 0.825 − 350/3.1 = 712.10 L/m³
3. E = 350/1.9 = 184.21 L/m³

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
YA 46.13 %; water 184.2 L	**46.13 %; 184.2 L**	✔	code reviewed (BetonFormulation.vb)

24. Bolomey

Formula: P(d) = A + (100 − A)·√(d/D)

Data: D = 25 mm; A = 10; cement 350 + fines 40 kg/m³

1. P(0.08) = 10 + 90 × √(0.08/25) = 10 + 90 × 0.05657 = 15.09 %
2. E1 = 0.23 × (350 + 40) = 89.7 L; E2 (aggregates ≥ 0.16 mm) = 100.11 L; E = 189.8 L

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
P(0.08) 15.1 %; water 189.8 L	**15.1 %; 189.8 L**	✔	code reviewed (BetonFormulation.CalculerPoints)

25. Faury

Formula: y(D/2) = A + 17.8·D^(1/5) + B/(R/(1.25·D) − 0.75); n = K/D^(1/5) + K'/(R/D − 0.75)

Data: D = 20 mm; A = 28; B = 1.5; R = 100 mm; K = 0.28; K' = 0.003

1. D^(1/5) = 20^0.2 = 1.82056; R/(1.25·D) = 4
2. y = 28 + 17.8 × 1.82056 + 1.5/(4 − 0.75) = 60.87 %
3. n = 0.28/1.82056 + 0.003/(5 − 0.75) = 0.15450; water = 1 000·n = 154.5 L/m³

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
60.87 %; 154.5 L	**60.87 %; 154.5 L**	✔	code reviewed (BetonFormulation.BetonFaury)

Roads and asphalt

26. Kumagawa, paraffin bulk density, degree of compaction

Formula: Ext. binder content = 100·(M1 − M2)/M2; NF EN 12697-6 D: ρ = m1/[(m2 − m3)/ρw − (m2 − m1)/ρp]; C = 100·γd/γd max

Data: M1 = 1 250; M2 = 1 183.4 g — m1 = 1 012.5; m2 = 1 036.8; m3 = 578.2 g; ρw 0.9982; ρp 0.9 — γd 1.98; γd max 2.05 t/m³

1. Ext. binder content = 100 × 66.6/1 183.4 = 5.63 %
2. Volume = (1 036.8 − 578.2)/0.9982 − (1 036.8 − 1 012.5)/0.9 = 459.427 − 27.000 = 432.427 cm³; ρ = 1 012.5/432.427 = 2.341 g/cm³
3. C = 100 × 1.98/2.05 = 96.59 %

Hand result	CiviLab 7.1	Agreement	How the CiviLab value was obtained
5.63 %; 2.341; 96.6 %	**5.63 %; 2.341; 96.6 %**	✔	Kumagawa, compaction: code reviewed; ρ: run