

Correctness Benchmark Report

Beam forces, main reinforcement and two-legged stirrups

Benchmarked 06 October 2026, 17:37:44 ICT (UTC+7)
Benchmark result timestamp: 2026-10-06T10:37:44.716Z

PASS

27,134 assertions passed; zero final failures.

27,060 expanded checks plus 74 existing regression checks. The actual Windows 1.0.1 executable also passed its packaged-app verification.

Outcome

One real reinforcement-layout defect was reproduced and corrected: the calculator checked horizontal bar spacing but could accept a bar that did not fit vertically inside the stirrup. Version 1.0.1 adds the missing enclosure check. No force-analysis discrepancy was found within the tested cases and tolerances.

Test group	Coverage	Result
Analytical beam formulas	5 closed-form cases	PASS
Independent finite elements	120 cases; 2,520 nodal deflections	PASS
Published numeric references	7 force / section-strength values	PASS
Reinforcement scenarios	600 cases; 116 with arrangements	PASS
Vertical-fit regressions	8 cases	PASS
High-shear spacing branch	1 targeted case	PASS
Existing regression suite	74 assertions	PASS

Reading the result

A passed benchmark supports the implemented calculations in the tested domain. It does not establish construction readiness, Thai-code compliance or complete ACI compliance. Case counts and assertion counts describe different measures: each beam case produces many numerical comparisons.

Beam-force verification

Closed-form references

Five cases verify reactions, support/root moment, peak bending moment and elastic deflection using standard beam equations [1]. The section is 200 × 400 mm, L = 4 m, E = 25 GPa and full gross I; beam self-weight is off.

Case	Applied load	Deflection reference / outcome
Simply supported UDL	w = 500 kgf/m	$5wL^4 / (384EI)$; PASS
Cantilever UDL	w = 500 kgf/m	$wL^4 / (8EI)$; PASS
Simply supported midspan point	P = 800 kgf	$PL^3 / (48EI)$; PASS
Cantilever tip point	P = 500 kgf	$PL^3 / (3EI)$; PASS
Simply supported eccentric point	P = 700 kgf at x = 1.2 m	Piecewise point-load formula; PASS

Largest closed-form normalized difference: 1.58×10^{-16} . For these comparisons the error scale is $\max(1, |\text{reference value}|)$. Loads are converted using 1 kgf = 9.80665 N.

Independent finite-element model

A separately written matrix-stiffness model assembles Euler-Bernoulli elements, consistent distributed-load forces and nodal point loads, then solves the constrained system using pivoted Gaussian elimination. Element end forces recover shear and moment. Hermite interpolation plus the exact UDL bubble term recovers displacement; golden-section search locates peak deflection.

The reference does not call the app solver or copy its integration/extrema algorithm. The 120 deterministic cases include 60 simply supported beams and 60 cantilevers, spans 0.1-100 m, mixed/zero/endpoint/coincident loads, load factors including zero, self-weight, and varied E, geometry and effective I.

Quantity	Maximum normalized error	Acceptance tolerance
Reaction	2.972e-11	2.0e-7
Moment	2.104e-11	2.0e-7
Shear	2.984e-11	2.0e-7
Deflection	6.224e-12	2.0e-7

Normalization: total force (minimum 1 N); total force × span (minimum 1 N·m); and total force × span³ / EI for displacement (minimum 1e-8 mm). Peak-deflection position tolerance is 3e-6 × span. Seed: 0xB3A62026. Mathematical force tests outside the rebar slenderness limits do not establish reinforcement suitability.

Published reference comparisons

Seven reference values agreed within the declared rounding tolerances. The comparison distinguishes section-equation checks from complete reinforcement design.

Reference quantity	Published	Beam Studio	Unit	Tolerance
flexural strength	84.13	84.12987	kN·m	±0.015
concrete shear ϕV_c	58.32	58.32348	kN	±0.015
stirrup shear ϕV_s	102.88	102.88237	kN	±0.015
total shear ϕV_n	161.21	161.20585	kN	±0.015
shear ceiling	284.76	284.75579	kN	±0.015
support shear	32.30	32.30000	kip	±0.005
peak moment	201.88	201.87500	kip·ft	±0.006

Mento ACI 318-19 section-strength example [2]

Inputs: $b = 200$ mm, $h = 500$ mm, $f'_c = 25$ MPa, $f_y = f_{yr} = 420$ MPa, 25 mm cover, mixed 2Ø16 + 1Ø12 bottom bars, and two-legged Ø10 stirrups at 220 mm. Effective depth is recovered from the exact bar-area-weighted centroid.

The flexural strength, concrete shear, stirrup shear, total shear and shear ceiling are checked through the actual production section-strength functions, which are also used by the layout search. This is not a reproduction of the reference's mixed-bar or moment-reversal design; those features and 25 mm cover remain outside the webpage's offered layout inputs.

StructurePoint simply supported example [3]

Inputs: $L = 25$ ft, $D = 0.82$ kip/ft, live load = 1 kip/ft, and factors 1.2 / 1.6. The stated analyzed loads are used with automatic self-weight off. The exact factored UDL is 2.584 kip/ft.

Calculated support shear is 32.30 kip; calculated peak moment is 201.875 kip·ft, matching the published 201.88 within rounding. This comparison covers forces, not the reference's cracked-section or long-term deflection and complete reinforcement detailing.

SCOPE

The published examples confirm selected numerical quantities. Matching these quantities is not a claim of equivalence to the full capabilities or certification of the reference software.

Reinforcement verification

600 reinforcement scenarios

116 returned an arrangement

484 returned no acceptable arrangement

Returned arrangements and rejected layouts are both valid test outcomes. A rejection means that the implemented strength and fit search returned no acceptable arrangement; it is not a failed benchmark. The tests do not prove that every possible layout has been searched.

Independent section check

For every accepted alternative, a separate neutral-axis force-equilibrium root includes elastic/yielding steel stress and checks flexural capacity and tension strain. An additional bisection in steel area checks required moment steel. The largest flexural-capacity relative difference was 6.30×10^{-16} .

Check	Verified criterion
Flexure and ductility	Capacity $\geq$ demand; tension-controlled strain
Main reinforcement	Required moment area and minimum steel area
Horizontal fit	Clear gap $\geq$ max(bar diameter, 25 mm, 4/3 aggregate)
Vertical fit	Internal stirrup clear height $\geq$ main-bar diameter
Stirrup strength / minimums	Yield capacity; minimum shear reinforcement
Stirrup spacing	Longitudinal spacing; transverse leg separation
Concrete shear ceiling	Demand below the implemented compression limit

The 600 scenarios vary beam type, geometry, dead/live loads, self-weight, cover, aggregate size, strengths, main-bar preference (including DB12.5), and stirrup sizes. The smaller-load half improves coverage of accepted layouts; the broader-load half also exercises rejection handling.

Targeted high-shear branch

A 400 × 700 mm section over 3.5 m, $f'_c = 17$ MPa, $f_y = f_{yr} = 420$ MPa and live load 14,500 kgf/m exercises the tighter d/4 spacing branch. Self-weight is off; cover is 40 mm; aggregate is 20 mm.

PASS

Mu = 348.381 kN·m; Vu = 398.150 kN.
Selection: **2 DB32; Ø12 @ 150 mm.**
Maximum longitudinal spacing = 158 mm; selected spacing rounds down to 150 mm.

The starting 20 × 40 cm, 4 m example remains 3 DB12 with Ø8 @ 150 mm. Recommendations use the separate 1.4D / 1.2D + 1.6L gravity strength envelope.

Defect found and corrected

The previous source revision accepted 2 DB12 bars in a 261 × 215 mm section with 100 mm cover and Ø6 stirrups. The horizontal gap was 25 mm, but only 3 mm existed vertically inside the stirrup. A 12 mm bar cannot fit.

Vertical enclosure check

$$215 - 2 \times (100 + 6) = 3 \text{ mm available}$$

3 mm < 12 mm bar diameter: REJECT

Clear cover is measured to the stirrup exterior; dimensions are in mm.

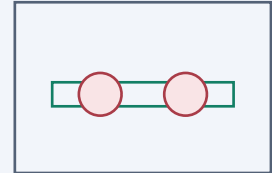


Illustration only; not to scale

Before

The previous Git revision returned **ok: true** and selected 2 DB12. The original result was reproduced directly from that committed source.

After

Version 1.0.1 returns **ok: false**, hides the recommendation and explains the 3 mm / 12 mm mismatch. It checks each candidate bar diameter against the full vertical enclosure.

Regression coverage

Eight checks cover the original case, both beam types, automatic selection, the exact fit boundary, just below that boundary, negative internal height and the unchanged starting example.

This checks geometric enclosure only. Stirrup hooks, bend radii and opposite-face integrity bars still require separate detailing.

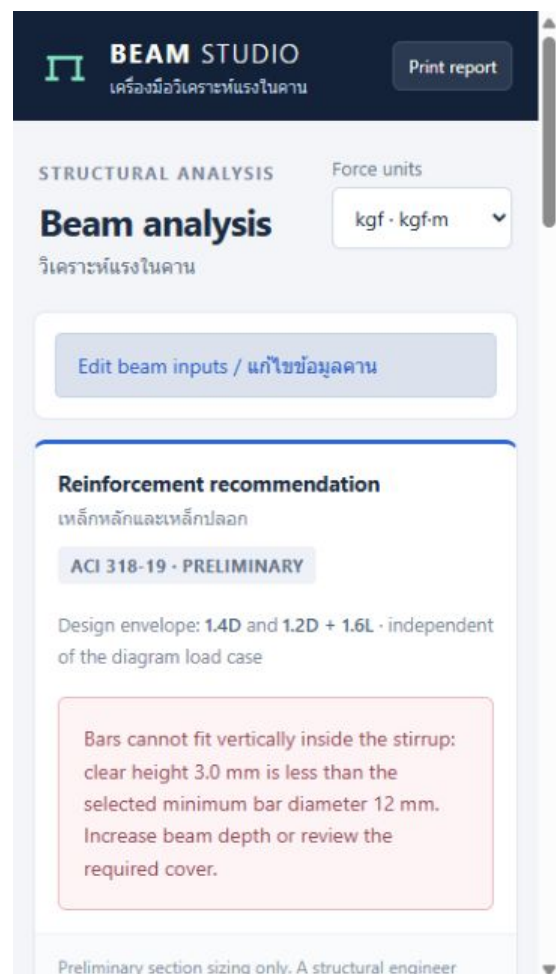


Figure 1. Local webpage verification: the invalid layout now displays a vertical-fit explanation. Full before/after values are saved in vertical-fit-before-after.json.

Release verification and reproducibility

Windows and webpage

The actual portable Windows executable was launched in hidden verification mode and exited with code 0. It reported packaged = true and appVersion = 1.0.1, rendered six diagrams, and confirmed both the default arrangement and the corrected vertical-fit rejection.

Packaged-app check	Observed result
Starting main bars / stirrups	3 DB12 / Ø8 @ 150 mm
Default reaction A	1,384.00 kgf
Vertical-fit regression	Rejected as required
UDL closed-form deflection	Passed
Initial analysis / design errors	Both hidden

The web, desktop and supplied test bundle use identical solver and rebar modules. The corrected public webpage was deployed successfully and retains public access without login.

Repeat the benchmark

With Node.js available, open the supplied Beam-Studio-Benchmark folder and run:

```
node verify.cjs
node benchmark.cjs ../Beam-Studio-Benchmark-Results.json
```

The bundle contains the tests, calculation modules, before/after evidence and packaged-app verification. Test outcomes are deterministic except for the recorded timestamp. Source revision: **30e3e1002aa455989e959c816893e81fa9acf148**.

Calculation limits

Single-span elastic analysis assumes constant E and effective I, ideal supports and vertical gravity loads. Reinforcement checks cover selected strength and spacing equations for normal-weight slender rectangular beams with one tension layer, no axial force and no torsion. Cracked stiffness, long-term deflection, crack control, anchorage/development, hooks/bends, support zones, integrity bars, seismic detailing and multi-layer reinforcement remain outside this benchmark's design scope.

References and evidence

[1] [MIT Deflections due to Bending](#)
[2] [Mento ACI 318-19 beam design example](#)
[3] [StructurePoint simply supported beam example ACI 318-14](#)

Evidence files: Beam-Studio-Benchmark-Results.json; benchmark.cjs; verify.cjs; vertical-fit-before-after.json; desktop-verification.json.

Windows executable SHA-256:
531A3A300F37FDA8A6FB30B25A3D7E4C8B407825256468A192783603C779A024