Wood Beam Design — Validation Report

Independent verification of the Kouzouki calculation engine against closed-form statics, published design-standard values and worked examples

Engine	Kouzouki — Wood Beam Design
Basis	Simple-span statics (M=wL^2/8, V=wL/2) and NDS 2018 Table 4.3.1 adjusted design values. CD is taken from the governing ASCE 7 load combination (D+S -> 1.15, D+L -> 1.0), CL=1.0 (lu=0).
Validation type	Independent validation
Report date	2026-07-11
Result	**PASS** — 14/14 checks within tolerance

1. Validation cases

Each case feeds the tool a defined input set and compares its output against a value derived independently of the engine (cited per row). Tolerance is 1% unless noted.

B1. 4x12 DF-L No.2, 16 ft, snow

w=400 plf UDL (100 D + 300 S). D+S governs, CD=1.15.
Inputs: material_type=Sawn Lumber, species=Douglas Fir-Larch, grade=No.2, plies=1, spacing=16.0, lu=0.0, deflection_limit_live=360, deflection_limit_total=240, load_duration=Ten years / Floor Live (1.0), moisture=Dry (CM=1.0), temperature=T <= 100F (Ct=1.0), incised=False, b=3.5, d=11.25, span=16.0, w_dead=100.0, w_live=0.0, w_snow=300.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Max moment M = wL^2/8 Statics, simple span	12,800.0 lb-ft	12,800.0 lb-ft	0.00%	**PASS**
Max shear V = wL/2 Statics, simple span	3,200.0 lb	3,200.0 lb	0.00%	**PASS**
Bending stress fb = M/S fb = 12 M / S, S = b d^2/6	2,080.5 psi	2,080.5 psi	0.00%	**PASS**
Fb' = Fb*CD*CF (CM=Ct=Ci=Cr=CL=1) NDS Tbl 4.3.1; Fb=900, CD=1.15 (D+S), CF=1.0 (d=12 nom)	1,035.0 psi	1,035.0 psi	0.00%	**PASS**

B2. 4x8 DF-L No.2, 12 ft, floor

w=200 plf (80 D + 120 L). D+L governs, CD=1.0; CF(8)=1.2.
Inputs: material_type=Sawn Lumber, species=Douglas Fir-Larch, grade=No.2, plies=1, spacing=16.0, lu=0.0, deflection_limit_live=360, deflection_limit_total=240, load_duration=Ten years / Floor Live (1.0), moisture=Dry (CM=1.0), temperature=T <= 100F (Ct=1.0), incised=False, b=3.5, d=7.25, span=12.0, w_dead=80.0, w_live=120.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Max moment wL^2/8	3,600.0 lb-ft	3,600.0 lb-ft	0.00%	**PASS**
fb = M/S 12 M / S	1,408.9 psi	1,408.9 psi	0.00%	**PASS**
Fb' = Fb*CD*CF(8)=900*1.0*1.2 NDS Tbl 4.3.1; CD=1.0 (D+L), CF=1.2 (d=8 nom)	1,080.0 psi	1,080.0 psi	0.00%	**PASS**

B3. 6x10 DF-L No.2, 6 ft, heavy

w=1200 plf (400 D + 800 L) short span; D+L, CD=1.0.
Inputs: material_type=Sawn Lumber, species=Douglas Fir-Larch, grade=No.2, plies=1, spacing=16.0, lu=0.0, deflection_limit_live=360, deflection_limit_total=240, load_duration=Ten years / Floor Live (1.0), moisture=Dry (CM=1.0), temperature=T <= 100F (Ct=1.0), incised=False, b=5.5, d=9.25, span=6.0, w_dead=400.0, w_live=800.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Max shear V = wL/2 Statics	3,600.0 lb	3,600.0 lb	0.00%	**PASS**
Shear stress fv = 1.5V/A NDS 3.4.2, fv=1.5V/A	106.1 psi	106.1 psi	0.00%	**PASS**

Fv' = Fv*CD = 180*1.0 NDS Tbl 4.3.1 (D+L)	180.0 psi	180.0 psi	0.00%	**PASS**

B4. 4x12 DF-L No.2, 18 ft — deflection

Live-load deflection vs 5wL^4/384E'I.
Inputs: material_type=Sawn Lumber, species=Douglas Fir-Larch, grade=No.2, plies=1, spacing=16.0, lu=0.0, deflection_limit_live=360, deflection_limit_total=240, load_duration=Ten years / Floor Live (1.0), moisture=Dry (CM=1.0), temperature=T <= 100F (Ct=1.0), incised=False, b=3.5, d=11.25, span=18.0, w_dead=40.0, w_live=80.0

Checked quantity	Independent value	Tool output	Dev.	Verdict
Live deflection 5wL^4/384E'I Beam theory; E'=1.6e6 (dry)	0.284 in	0.284 in	0.00%	**PASS**
Deflection limit L/360 IBC 1604.3	0.6 in	0.6 in	0.00%	**PASS**

B5. 4x12 DF-L No.2, 16 ft — LRFD, snow

w=100 D + 300 S. LRFD 1.2D+1.6S+0.5L governs (lambda=0.8); Fb' = phi_b*K_F*lambda*Fb*CF.
Inputs: material_type=Sawn Lumber, species=Douglas Fir-Larch, grade=No.2, plies=1, spacing=16.0, lu=0.0, deflection_limit_live=360, deflection_limit_total=240, load_duration=Ten years / Floor Live (1.0), moisture=Dry (CM=1.0), temperature=T <= 100F (Ct=1.0), incised=False, b=3.5, d=11.25, span=16.0, w_dead=100.0, w_live=0.0, w_snow=300.0, design_method=LRFD

Checked quantity	Independent value	Tool output	Dev.	Verdict
Factored moment M_u = w_u L^2/8 ASCE 7 2.3.1; w_u = 1.2D+1.6S = 600 plf	19,200.0 lb-ft	19,200.0 lb-ft	0.00%	**PASS**
Fb' = phi_b*K_F*lambda*Fb*CF NDS App. N; phi_b=0.85, K_F=2.54, lambda=0.8 (1.2D+1.6S+0.5L)	1,554.5 psi	1,554.5 psi	0.00%	**PASS**

2. Assumptions

- Simply supported single span, uniform load, ASD combination envelope.
- Sawn dimension lumber; reference values from NDS Supplement Table 4A.
- Dry service (CM=1.0), normal temperature (Ct=1.0), CL=1.0 (lu=0).
- CD follows the shortest-duration load in the governing combination.

3. Limitations

- Single span only; for end fixity, point loads or load classes use the general-analysis mode (validated separately by the cantilever/fixed cases).
- Deflection uses E' (creep factor Kcr not applied to the live case).
- Lateral-torsional CL is exercised by the general beam validation, not here.

4. Sources of the independent values

How the independent values are obtained. Every value in the Independent-value column of Section 1 is computed in a validation harness (validation/cases.py) written and run separately from the calculation engine. Each is an independent re-derivation of the governing closed-form equation, or a value read from a cited published worked example or design-standard table - never copied from the engine's own output. The match therefore confirms the engine reproduces the cited source within tolerance. The source beside each value (Section 1) and the references below identify the governing standard section, equation, or publication.

Basis of the independent values

Simple-span statics (M=wL^2/8, V=wL/2) and NDS 2018 Table 4.3.1 adjusted design values. CD is taken from the governing ASCE 7 load combination (D+S -> 1.15, D+L -> 1.0), CL=1.0 (lu=0).

Governing standards & published sources

- AWC NDS — National Design Specification for Wood Construction (2018 / 2024) and the NDS Supplement (reference design values).
- International Building Code (2018 / 2021 / 2024), ICC — Ch. 18 (soils & foundations, Table 1806.2, Sec. 1807) and Sec. 1604.3 (deflection).
- ASCE/SEI 7 — Minimum Design Loads and Associated Criteria for Buildings and Other Structures (load combinations Sec. 2.3-2.4).
- Classical statics & Euler-Bernoulli beam theory (equilibrium, M=wL^2/8, V=wL/2, deflection=5wL^4/384EI) — independently re-derived in the validation harness.
- Classical statics & Euler-Bernoulli beam theory — independently re-derived in the validation harness.

Per-check citations (Section 1): Statics, simple span; fb = 12 M / S, S = b d^2/6; NDS Tbl 4.3.1; Fb=900, CD=1.15 (D+S), CF=1.0 (d=12 nom); wL^2/8; 12 M / S; NDS Tbl 4.3.1; CD=1.0 (D+L), CF=1.2 (d=8 nom); Statics; NDS 3.4.2, fv=1.5V/A; NDS Tbl 4.3.1 (D+L); Beam theory; E'=1.6e6 (dry); IBC 1604.3; ASCE 7 2.3.1; w_u = 1.2D+1.6S = 600 plf; NDS App. N; phi_b=0.85, K_F=2.54, lambda=0.8 (1.2D+1.6S+0.5L).

5. Conclusion

All 14 independent checks reproduce the reference values within tolerance. The engine correctly implements the governing equations for this tool.

Reproduce: **python scripts/run_tool_validation.py** → **python scripts/make_tool_validation_pdfs.py**. This report is for verification/demonstration; results are for preliminary design and must be confirmed by a licensed engineer against the current adopted code and project-specific conditions.