

# Reinforced Concrete Beam (Flexure+Shear) — Validation Report

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

<b>Engine</b>	Kouzouki — Reinforced Concrete Beam (Flexure+Shear)
<b>Basis</b>	Flexure $\phi M_n = \phi A_s f_y (d - a/2)$ , $a = A_s f_y / (0.85 f'_c b w)$ ; one-way shear $\phi V_n = \phi (V_c + V_s)$ , $V_c = 2 \sqrt{f'_c} b w d$ , $V_s = A_v f_y d / s$ .
<b>Validation type</b>	Independent validation
<b>Report date</b>	2026-06-20
<b>Result</b>	<b>PASS</b> — 2/2 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.

### CB1. Flexural capacity $\phi M_n$

Inputs: width\_bw=12.0, depth\_h=24.0, fc=4000.0, fy=60000.0, cover=2.5, bar\_size=#8, n\_bars=3, Mu=150.0, Vu=40.0, stirrup\_size=#3, stirrup\_spacing=8.0, stirrup\_legs=2

Checked quantity	Independent value	Tool output	Dev.	Verdict
$\phi A_s f_y (d - a/2)$ ACI 22.3	210.7 kip-ft	210.7 kip-ft	0.01%	<b>PASS</b>

### CB2. Shear capacity $\phi V_n$

Inputs: width\_bw=12.0, depth\_h=24.0, fc=4000.0, fy=60000.0, cover=2.5, bar\_size=#8, n\_bars=3, Mu=150.0, Vu=40.0, stirrup\_size=#3, stirrup\_spacing=8.0, stirrup\_legs=2

Checked quantity	Independent value	Tool output	Dev.	Verdict
$\phi (V_c + V_s)$ ACI 22.5	51.082 kip	51.1 kip	0.03%	<b>PASS</b>

## 2. Assumptions

- Singly reinforced rectangular section; tension-controlled ( $\phi=0.9$ ).
- Normalweight concrete ( $\lambda = 1.0$ ).
- Vertical stirrups;  $A_v = \text{legs} \times \text{bar area}$ .

## 3. Limitations

- No compression-steel or T-beam flange contribution.
- Torsion and deep-beam behavior not covered.

## 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

Flexure  $\phi M_n = \phi A_s f_y (d - a/2)$ ,  $a = A_s f_y / (0.85 f'_c b w)$ ; one-way shear  $\phi V_n = \phi (V_c + V_s)$ ,  $V_c = 2 \sqrt{f'_c} b w d$ ,  $V_s = A_v f_y d / s$ .

### Governing standards & published sources

- ACI 318 — Building Code Requirements for Structural Concrete (318-14 / 318-19), American Concrete Institute (Ch. 7, 8, 13, 20, 22).

Per-check citations (Section 1): ACI 22.3; ACI 22.5.

## 5. Conclusion

All 2 independent checks reproduce the reference values within tolerance. The engine correctly implements the governing equations for this tool.

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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.