InterAct

Calibration and verification report

Rectangular reinforced-concrete column N-M section engine

Report date: 2026-07-28

Model basis: first-generation EN 1992-1-1:2004+A1:2014 ULS section assumptions

VERIFICATION STATUS	PRODUCTION RESOLUTION
15 / 15 BENCHMARKS PASSED	**240 concrete fibers** **36 / 120 / 36 strain-domain steps**

Purpose and interpretation

This report documents implementation verification and numerical calibration. It demonstrates agreement between the production engine and independently derived closed-form or high-resolution reference solutions for the cases listed. It is evidence of method implementation, not certification of every possible input or a substitute for project-specific engineering review.

Principal result

For the default 400 x 500 mm, 10D20, C30/37, B500B section at N_{Ed} = 900 kN, the independent closed-form solution gives M_{Rd} = 409.821011 kNm. InterAct gives 409.814975 kNm.

1. Scope and main assumptions

- ULS cross-section resistance under combined axial force and uniaxial bending.
- Plane sections remain plane; perfect bond is assumed.
- Concrete tension is neglected.
- Concrete follows the EN 1992-1-1 parabolic-rectangular design relationship.
- Reinforcement is elastic-perfectly-plastic with a user-visible design tensile strain limit.
- Compression is positive and moments are taken about the gross-section centroid.
- Concrete displaced by reinforcement is deducted from the gross concrete integral.
- The strain path includes tension-controlled, concrete-crushing and full-compression domains.
- The full-compression endpoint is uniform epsilon_c2, correcting the preliminary prototype.
- The interaction envelope is mirrored only because the generated reinforcement is symmetric.
- Entered NEd and MEd are assumed to be already factored design action effects.

Excluded from this verification

Slenderness, imperfections, second-order effects, creep, biaxial bending, confinement, fire, seismic rules, load combinations, anchorage, lap design and complete reinforcement detailing are outside the present section engine.

Normative and implementation references

EN 1992-1-1:2004+A1:2014, particularly material design properties, concrete and steel design diagrams, allowable strain distributions, and ULS bending with axial force. Applicable National Annex values remain the responsibility of the designer.

European Commission / JRC Eurocode 2 overview: https://eurocodes.jrc.ec.europa.eu/EN-Eurocodes/eurocode-2-design-concrete-structures

JRC worked examples: https://publications.jrc.ec.europa.eu/repository/handle/JRC89037

2. Calculation model

Quantity	Implemented relationship
Design concrete strength	fcd = alpha_cc fck / gamma_c
Design steel strength	fyd = fyk / gamma_s
Concrete parabola	sigma_c = fcd [1 - (1 - epsilon_c/epsilon_c2)^n]
Steel law	sigma_s = limit(Es epsilon_s, -fyd, +fyd)
Concrete layer force	Delta_Nc = sigma_c b Delta_y
Net bar force	Fs,i = [sigma_s,i - sigma_c(yi)] As,i
Section equilibrium	NRd = sum(F); MRd = sum[F (h/2 - y)]
Minimum clear spacing	s_clear = center spacing - bar diameter >= 30 mm

Independent analytical reference

For neutral-axis depth x within the section, the concrete parabolic-rectangular stress field is integrated in closed form. Reinforcement forces are evaluated bar-by-bar at their exact strain coordinates. The reference implementation is separate from the production fiber integration and is included in the download package.

3. Verification benchmarks

All tolerances were established before evaluating pass/fail. Small relative percentages near zero axial force can look large; the governing criterion there is the stated absolute tolerance.

ID / quantity	Reference	InterAct	Abs. error	Tolerance	Result
MAT-C30-E2 C30/37 epsilon_c2	0.002000000 -	0.002000000 -	0.0000e+0	1e-12	**PASS**
MAT-C60-ECU2 C60/75 epsilon_cu2	0.002883500 -	0.002883500 -	0.0000e+0	1e-12	**PASS**
GEO-30MM-TOP Maximum bars per 400 mm top/bottom row	6.000000000 bars	6.000000000 bars	0.0000e+0	0	**PASS**
GEO-30MM-SIDE Maximum intermediate bars per 500 mm side	6.000000000 bars	6.000000000 bars	0.0000e+0	0	**PASS**
END-TENSION Default pure-tension resistance	-1365.909849387 kN	-1365.909849387 kN	4.5475e-13	0.000001	**PASS**
END-COMPRESSION Default uniform-compression resistance	5193.805208364 kN	5193.805208364 kN	1.5461e-11	0.000001	**PASS**
C30-X80-N C30 default section N_Rd at x=80.000 mm	-25.490963913 kN	-25.549394984 kN	5.8431e-2	0.1	**PASS**
C30-X80-M C30 default section M_Rd at x=80.000 mm	274.280751731 kNm	274.269419674 kNm	1.1332e-2	0.05	**PASS**
C30-X173-N C30 default section N_Rd at x=173.050 mm	899.999784049 kN	900.027472512 kN	2.7688e-2	0.1	**PASS**
C30-X173-M C30 default section M_Rd at x=173.050 mm	409.820996122 kNm	409.821679159 kNm	6.8304e-4	0.05	**PASS**
C30-X350-N C30 default section N_Rd at x=350.000 mm	2660.349203457 kN	2660.363671050 kN	1.4468e-2	0.1	**PASS**
C30-X350-M C30 default section M_Rd at x=350.000 mm	387.375367990 kNm	387.372474472 kNm	2.8935e-3	0.05	**PASS**
C30-N900-M Default M_Rd at N_Ed=900 kN	409.821010735 kNm	409.814974828 kNm	6.0359e-3	0.15	**PASS**
C60-X200-N C60/75 300x600 section N_Rd at x=200 mm	1439.926365984 kN	1439.958215021 kN	3.1849e-2	0.2	**PASS**
C60-X200-M C60/75 300x600 section M_Rd at x=200 mm	556.736689296 kNm	556.736837302 kNm	1.4801e-4	0.1	**PASS**

4. Numerical calibration

The production resolution was selected by convergence against the independent closed-form solution while retaining immediate browser response.

Concrete fiber convergence

Fibers	Maximum |Delta N| [kN]	Maximum |Delta M| [kNm]	Production
30	2.437893	0.301733	NO
60	0.885132	0.175359	NO
120	0.191018	0.020627	NO
240	0.058431	0.011332	YES
480	0.008259	0.001035	NO

Interaction sampling convergence

Bending-domain steps	|Delta MRd| at NEd = 900 kN [kNm]	Production
30	0.079079	NO
60	0.014352	NO
120	0.006036	YES
240	0.001601	NO
480	0.001480	NO

Selected production values: 240 concrete fibers and 120 bending-domain steps. In the governing default solved example, the capacity difference is 0.006036 kNm, or approximately 0.0015 percent.

5. Traceability and use

Artifact	Purpose
interact-verification-results.csv	All benchmark inputs, references, tolerances and pass/fail results.
interact-calibration-results.csv	Fiber and interaction-sampling convergence study.
interact-reference-calculation.py	Independent closed-form reference implementation.
interact-verification-summary.json	Machine-readable verification summary and limitations.
InterAct source engine	Production strain-domain and section-equilibrium implementation.

Professional-use statement

The benchmarks support the correctness of the implemented section-analysis method within the stated scope. They do not prove correctness for every possible input, establish regulatory approval, or replace independent project calculations. Before professional use, confirm the applicable Eurocode generation and National Annex, and perform all required column and detailing verifications.

Revision record

Revision	Date	Description
1.0	2026-07-28	Corrected full-compression strain domain; added custom strain inputs, safety factors, 30 mm spacing control, and formal benchmarks.