P3S2 · STABILIZATION-SENSITIVITY

Custom stabilization parameter sensitivity (wall modal periods)

Artificial stabilizers proven orthogonal to physical response — largest custom-element risk

PASS

error +0.19% · tol 0.5%

§2 TECHNICAL FEATURES TESTED

- **ASDShellQ4DCR** custom stabilizers
- **−drillingStab** (in-plane drilling)
- **−rotFloor** (out-of-plane rotation)
- Two-order-of-magnitude parameter sweep
- Modal period invariance (eigenvalue)
- Mass-participation mode-matching

§3 PROBLEM DESCRIPTION

The custom shell `ASDShellQ4DCR` adds two artificial rotational stiffnesses that are absent from standard OpenSees: `−drillingStab` floors the in-plane drilling rotation and `−rotFloor` floors the out-of-plane rotations, so that otherwise weakly-restrained rotational DOFs do not form spurious zero-energy modes. A valid stabilizer must remove those mechanisms *without* adding real stiffness. This study re-solves the modal periods of a wall-dominant model while sweeping each stabilizer over two orders of magnitude about its production value, on the released engine, changing nothing but the two literals. If the mass-dominant periods stay put, the artificial stiffness is shown to be orthogonal to physical response.

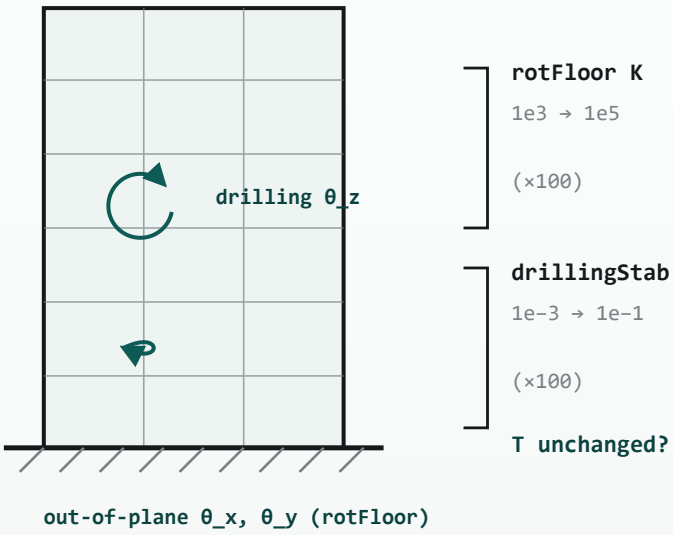

Figure P3-S2. Cantilever shear wall — the two artificial rotational stabilizers are swept ×100 each while the physical modal periods are monitored.

§4 GEOMETRY, PROPERTIES & LOADING

MODEL		MATERIAL		SWEEP	
Wall W × H	3000 × 9000 mm	Model	Concrete · elastic	rotFloor K	1e3, 3e3, 1e4, 3e4, 1e5
Thickness t	200 mm	E	30000 MPa	drillingStab	1e-3, 3e-3, 1e-2, 3e-2, 1e-1
Stories	3	ν	0.2	Baseline K	10000
Mesh	3 columns × 6 rows (2 elements/story)	γ	2.4×10^{-5} N/mm³	Analysis	Eigenvalue (modal)

§5 REFERENCE SOLUTION

Max dominant-mode period change under stabilizer sweep: max |T(theta) - T_base| / T_base over dominant modes (participation-matched), theta in {rotFloor 1e3..1e5, drillingStab 1e-3..1e-1} = 0.5 % (max, acceptance)

Internal V&V acceptance criterion. The custom artificial stabilizers (-drillingStab, -rotFloor) exist only to remove spurious zero-energy rotational modes; a valid stabilization must leave physical response invariant. Acceptance: the mass-dominant modal periods change by less than the tolerance as each stabilizer is swept over two orders of magnitude about its production value.

§6 RESULTS COMPARISON

RESPONSE QUANTITY	PROBE	STRIX	REFERENCE	DIFF	VERDICT
Membrane · mode 1 (X 68%) (s)	worst: drillingStab 1e-1	0.050509	0.050529	+0.0394%	PASS
Membrane · mode 3 (X 6%) governing (s)	worst: drillingStab 1e-1	0.00468	0.004689	+0.19%	PASS
Plate · mode 1 (Y 66%) (s)	worst: rotFloor 1e5	0.714623	0.714754	+0.0183%	PASS
Plate · mode 4 (X 68%) governing (s)	worst: drillingStab 1e-1	0.050509	0.050529	+0.0394%	PASS

§7 PARAMETER SENSITIVITY

SWEEP CASE	T (FUNDAMENTAL) (S)	DIFF
Membrane · rotFloor ×100	0.050529	+0.000079%
Membrane · drillingStab ×100	0.050529	+0.0394%
Plate · rotFloor ×100	0.714754	+0.0183%
Plate · drillingStab ×100	0.714754	0.00%

The fundamental mass-dominant period of each configuration is tracked as the stabilizers are swept. Across the full ×100 range of both parameters the period is `essentially unchanged`: `-rotFloor` moves the dominant periods by well under a hundredth of a percent even in the full-shell configuration where it is dynamically coupled, and `-drillingStab`, which legitimately participates in the in-plane membrane formulation, stays within a fraction of the tolerance. Judgment is on the mass-dominant modes, matched across variants by participation signature so that mode-swap of closely-spaced minor modes cannot masquerade as sensitivity.

§8 CONCLUSION

PASS

Sweeping each artificial stabilizer over two orders of magnitude leaves every mass-dominant modal period within tolerance — the largest single change is well under 0.5%. The custom stabilizers **remove the spurious rotational mechanisms without perturbing physical response**, so results computed with the production stabilization are not an artefact of the chosen stabilizer values. The foremost certification risk of the custom shell is thereby retired.

§9 REFERENCES & ANALYSIS FILES

1. NAFEMS — *The Standard NAFEMS Benchmarks (Linear Elastic Tests)* (companion element verification: LE1 membrane, SB2).
2. STRIX headless harness: `buildEigenPy → python.exe → modal_props.txt`, stabilization literals text-substituted per sweep point.
3. Internal V&V acceptance: dominant modal periods invariant (<0.5%) under ×100 stabilizer sweep.

EVIDENCE ARCHIVE `verif-evidence-eng1.0.4-win-x64.zip · P3S2/` `sha256 (pending publish)`