

EDFS Matrix

Analysis Verification

Structural analysis, steel design to SNI 1729:2020 and concrete design to SNI 2847:2019
— comparison with SAP2000®

Application version	1.0.0
Document date	19 October 2026
Reference program	SAP2000® v27.1.0 Plus
Test models	19 models (V1–V14, V14A/B, V16)
Publisher	Edifisia

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1. Summary

Every analysis and design feature of EDFS Matrix used in projects was compared with SAP2000® on 19 small test models. Each model is generated once by a script and run in both programs, so geometry, loads and settings are guaranteed to be the same. Analysis results (reactions, displacements, member forces, envelopes, modal, P-Delta, tension/compression-only non-linearity) are **identical** to SAP2000 within numerical precision (differences 10^{-5} ... 10^{-12}). Differences in design come from different formulas or simplifications in SAP2000. Every difference was traced to its cause and confirmed by an independent hand calculation. EDFS follows SNI: on some items EDFS is more conservative than SAP2000 (e.g. UNP, SHS, SMF Ve), on others more economical (e.g. Cb of the WH400 beams and the column steel area in design mode), and on those items the EDFS figures equal the hand calculation.

Model	Content	Result
V1	Pin-roller beam: point, trapezoidal, triangular, moment, torsion and axial loads; combinations & envelope	Identical (also checked manually)
V2	Inclined member: projected load, full gravity, local 2, global X	Identical (< 0.001)
V3	Frame with pinned beam & brace + truss (end releases)	Identical ($2 \cdot 10^{-10}$)
V4	90° local-axis rotation (cantilever columns & beams)	Identical after the M2 sign fix
V5	3D frame: self weight, diaphragm, mass source, 6-mode modal, envelope	Identical (periods 0.0000 %)
V6	Steel design AISC 360-16: WH, UNP, SHS, pipe, angle, Lb/Cb	Done — differences explained
V7A	Cracked concrete (modifiers) + P-Delta per combination	Identical ($\leq 10^{-7}$)
V7B	Direct analysis method (notional, 0.8 stiffness, P-Delta)	Identical ($\leq 3 \cdot 10^{-6}$)
V8	Tension-only X bracing (non-linear), with/without P-Delta	Identical; differences ≤ 1 % explained
V9	End offsets & insertion points (cardinal, transform)	Identical after the left/right fix
V10	Partial moment releases (springs)	Identical ($3 \cdot 10^{-9}$)
V11	Built-up WH girders F4/F5, E7, shear G2.1(b)	Done — differences explained
V12A/B	Concrete design OMF / SMF: beams, columns, torsion, Ve, joints, 6/5	Done — SMF As,min fixed
V13	Slender non-sway concrete columns (δ_{ns})	Done — ≤ 0.3 %
V14	Secondary beams resting at midspan of undivided girders (nodes joined automatically)	Identical (table rounding)
V14A/B	Load-distributing areas: one/two-way slabs, sloped roofs, walls, arbitrary shapes	Identical ($\leq 3 \cdot 10^{-12}$); 2 shapes explained
V16	Translational & rotational support springs, with diaphragm and modal	Identical ($2 \cdot 10^{-11}$)
Export/import	Models V1–V13 through the application's .s2k file into SAP2000 and SAP2000's .s2k back into the application	Identical (0.0000 %)

2. Method

Verification data.

Item	Description
Verification date	2 October 2026 (V1–V13); 5–14 October 2026 (file exchange, areas, support springs, V14).
EDFS Matrix version	0.1.0 (V1–V13), 0.2–0.4 (V14, V14A/B, V16); results remain valid for 1.0.0
Reference program	SAP2000® v27.1.0 Plus (Computers and Structures, Inc.), run automatically through the OAPI; steel design AISC 360-16 LRFD, concrete design ACI 318-14
Models	19 test models (V1–V14; V7A/B, V12A/B, V14A/B, V16), as EDFS import files (.json) and SAP2000 text files (.s2k), plus a .s2k export/import test on V1–V13
Status	All numerical comparisons on the models above are complete; features not yet compared are listed in Chapter 9

The test models are built by one generator script. The same model is written as an EDFS import file (.json) and as a SAP2000 text model (.s2k). EDFS is run through the same server path as the Run button; steel and concrete design use the same code as the application. SAP2000 is run automatically through the OAPI and all its results are stored as JSON for comparison.

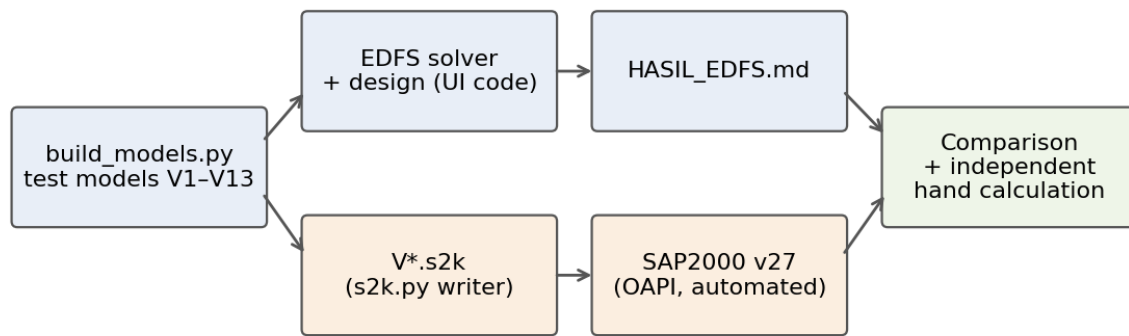


Figure 1. Verification workflow.

Settings for equivalence (written automatically in every .s2k): kN-m units, shear deformation switched off (EDFS is Euler-Bernoulli), 7 output stations, self weight only in the cases ticked in EDFs, $g = 9.80665$, 6-segment auto-mesh for modal/P-Delta. JIS steel sections: analysis stiffness matched through property modifiers from the properties SAP computes itself. Design: same ϕ , SAP default combinations off, SAP pattern live load off (PatLLF = 0).

Tolerance: static $\leq 0.1\%$, modal periods $\leq 0.5\%$. Every difference above numerical rounding is traced to its root cause, usually with a hand calculation written separately from the EDFs code.

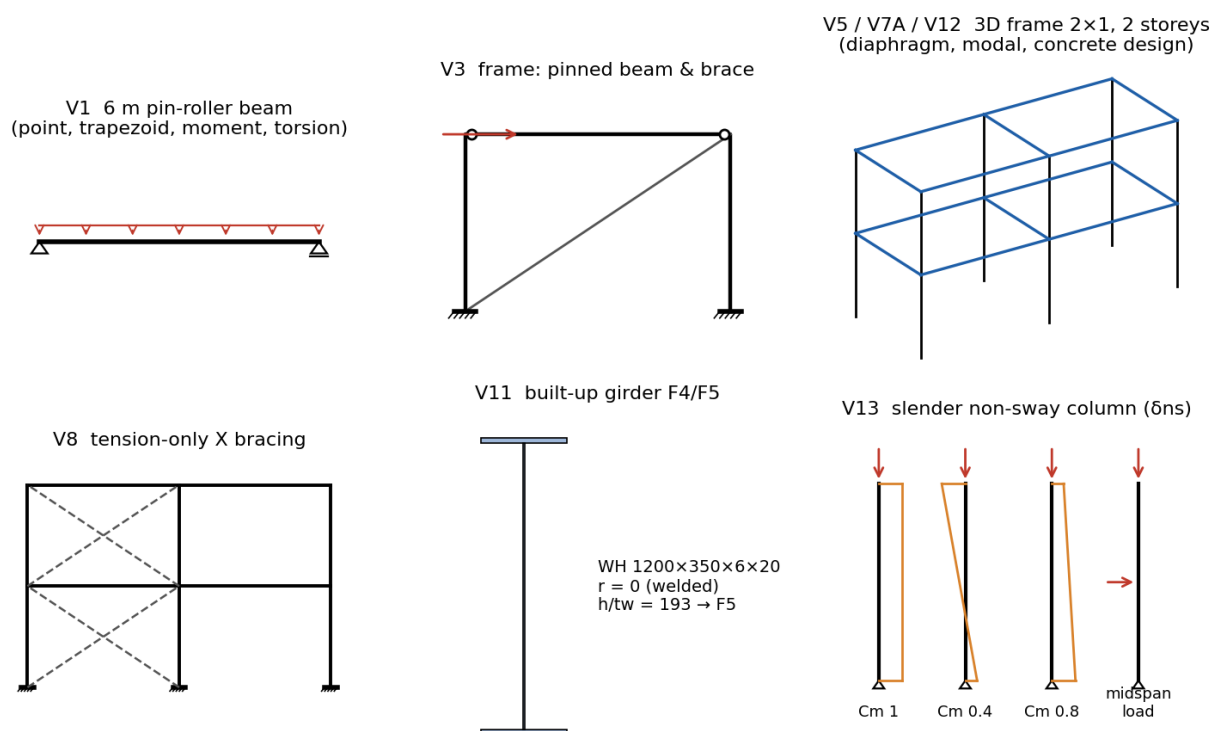


Figure 2. Sketches of some test models.

3. Structural analysis (V1–V10)

Model	Compared	Max. difference	Notes
V1	Reactions, M3/V2 per station, jumps at point loads & moments, torsion, axial, envelope	match	Also checked manually in SAP2000
V2	Reactions, end N/V2, extreme M3, local axes of an inclined member	< 0.001	Projected load = SAP Gravity Projected
V3	63 stations × 3 cases; torsion released at both ends rejected by both programs	$2 \cdot 10^{-10}$	

Model	Compared	Max. difference	Notes
V4	Displacements, 90° local axes, V2, V3, M3, M2	$6 \cdot 10^{-12}$	M2 sign bug fixed (SAP convention: tension on the -3 face)
V5	Reactions, member forces, envelope, mass 133.688 t, periods & mode shapes 1–6	identical	.s2k modal table name fixed
V6	Analysis of the steel frame & single members	10^{-9}	SAP channel shear-centre torsion off (EDFS: load through the shear centre)
V7A	Load cases, combinations, modal, P-Delta per combination	10^{-7} (relative)	
V7B	Replica of the EDFS direct analysis method	$3 \cdot 10^{-6}$ (relative)	Load cases keep full stiffness: $4 \cdot 10^{-10}$
V8	Active/inactive braces, reactions, drift, + P-Delta	$\leq 1\%$ reactions	Only the self weight of slack braces; without it $\rightarrow 10^{-5}$
V9	Column-face offsets, cardinal points with/without transform, global offsets	$4 \cdot 10^{-12}$	Cardinal point left/right bug fixed
V10	Partial-release springs, midspan deflection	$3 \cdot 10^{-9}$	Deflection -2.144681 mm in both programs

4. Steel design (V6, V7B, V11)

4.1 JIS rolled sections and direct analysis method (V6, V7B)

Frame	EDFS	SAP	Difference	Cause
WH300 columns	0.706 / 0.872 / 0.704	0.704 / 0.871 / 0.701	$\leq +0.4\%$	JIS table properties (fillet) vs SAP dimensions
WH250 beam Lb 0.25	0.811	0.809	+0.3 %	same
Pipe 114	0.3444	0.3444	0.0 %	Identical geometry
Angle L75	0.419	0.420	-0.1 %	EDFS E5(a) vs SAP E3/E4
WH400 beams	0.711 / 0.711	0.729 / 0.730	-2.4 %	Cb: EDFS F1-1 per segment (hand calculation), SAP uses H1.3; with the same Cb ϕM_n is the same
UNP150	0.573 / 0.399	0.550 / 0.351	+4 / +14 %	SAP Channel has parallel flanges, JIS UNP tapered flanges
SHS150	0.699	0.674	+3.7 %	SAP Box has sharp corners, JIS has corner radii

V7B (direct analysis method): column ratios +0.2...+0.4 %, beams as in V6.

4.2 Built-up girders (V11)

Five pin-roller plate girders ($r = 0$, treated as welded) and one column with slender web & flanges. $C_b = 1$ in both programs so that only sections F4/F5 are compared.

Quantity	EDFS	SAP	Difference	Cause
ϕV_n shear G2.1(b) (all)	483.2 / 354.2 / 354.8 / 356.6	same	0	—
ϕM_{nx} noncompact flange case 11 (G5)	967.84	967.84	0	—
ϕM_{nx} inelastic LTB (G1 / G3)	1136.93 / 1910.77	1139.16 / 1914.36	-0.2 %	SAP v27 still uses the AISC 360-10 rt formula
ϕM_{nx} elastic LTB (G2 / G4)	449.64 / 561.75	457.14 / 574.02	-1.6 / -2.1 %	rt 360-10 + reduced J in SAP
ϕP_n compression E7 (slender web)	714.6 ... 1402.9	714.3 ... 1402.4	-0.03 %	SAP $c_2 = (1 - \sqrt{1-4c_1})/2c_1$ without rounding
D/C ratio column 6	0.508	0.508	0	—

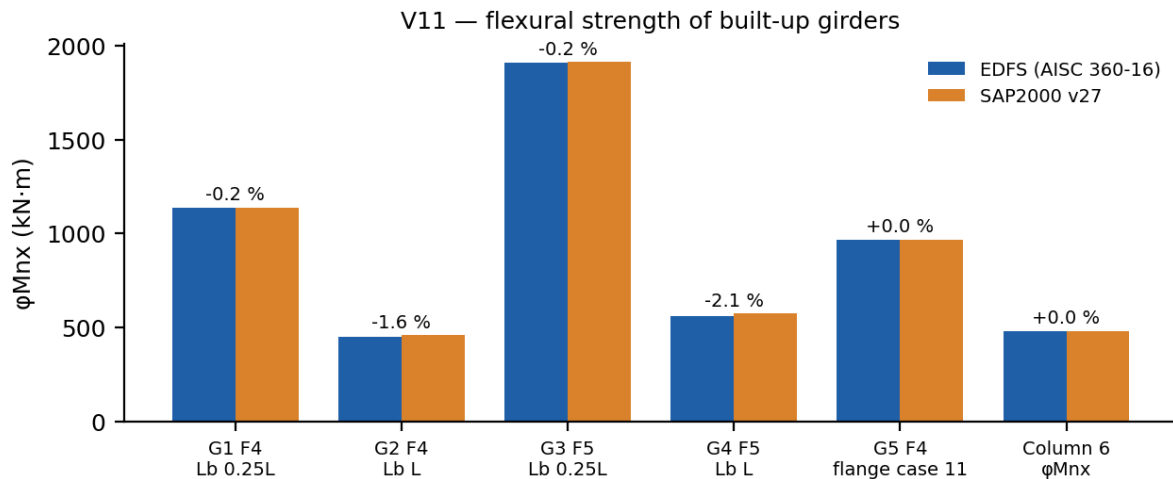


Figure 3. V11 — flexural strength, EDFS vs SAP2000.

An independent hand calculation (plates only) with the AISC 360-16 rt and the exact J gives the EDFS figures exactly; with the 360-10 rt and the reduced J it gives the SAP figures exactly (≤ 0.03 kN.m). EDFS follows SNI 1729:2020 = AISC 360-16.

5. Concrete design (V12, V13)

3D frame V5 with K50x50 columns, B30x50 beams, $f_c' 25$, $f_y 420$, $f_{yt} 280$ MPa, lateral loads $\times 4$ and torsion on the middle beams. V12A = OMF (SRPMB; SAP Sway Ordinary), V12B = SMF (SRPMK; Sway Special). SAP: ACI 318-14 (= SNI 2847:2019).

5.1 OMF (V12A)

Quantity	Difference	Cause
Beam top As (all stations)	0 (identical)	—
Beam bottom As	≤ 1.5 %	As,min: EDFS $1.4/f_y$ (SNI, SI), SAP $200/f_y$ psi = $1.379/f_y$
Av/s beams & columns	≤ 5.1 %	SAP: $V_c = 2\sqrt{f_c'}$ psi = $0.166\sqrt{f_c'}$ (EDFS 0.17); Av,min 50 psi = 0.345 (EDFS 0.35)
At/s, Al torsion	0.8 % / 1.1 %	SAP Aoh equivalent to 44.45 mm (1.75 in) cover vs 45 mm
Column P-M capacity (check mode)	+0.2 ... +1.4 % (SAP)	SAP discrete interaction surface 24x51; EDFS = hand calculation (≤ 0.6 %)
Column required As (design mode)	SAP +9 ... +14 %	SAP area search algorithm — inconsistent with SAP's own check mode

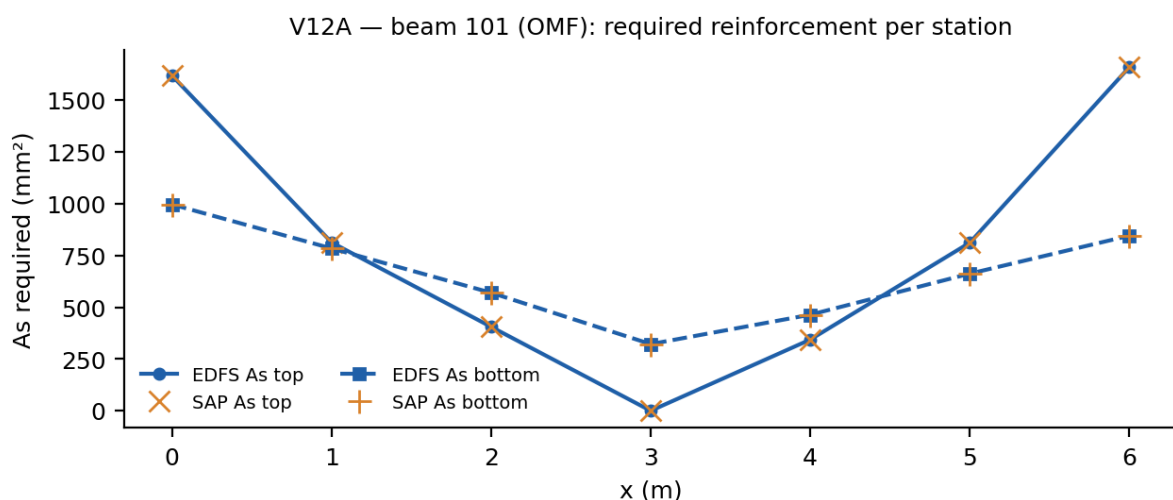


Figure 4. V12A — required reinforcement of beam 101: EDFS and SAP2000 coincide.

Columns were also tested with a single isolated column: required area for $P = 65 \text{ kN}$, $M = 282 \text{ kN}\cdot\text{m}$ by hand calculation 3530 mm^2 , EDFS 3537 mm^2 , SAP design mode 3939 mm^2 . With 12 D19 provided (check mode) the SAP ratio is only 1.2 % above EDFS.

5.2 SMF (V12B)

Quantity	EDFS	SAP2000	Remark
Beam Mpr (1.25fy)	same	same	From the same steel area
Beam Ve	Worst Vp + simple-span gravity shear; earthquake combinations	Vp + gravity shear from the analysis; sway direction per combination	SAP reproduced exactly (1.6203 / 1.6786); EDFS $\geq$ SAP
Vc = 0	within 2h (§ 18.6.5.2)	along the whole beam	SAP more conservative at midspan
Column Ve	each end: min(column Mpr, beam limit)/lu	2·min(Mpr(Pu), beam limit at top joint)/L	SAP reproduced for 12 columns $\times$ 2 directions; EDFS larger at column bases
As,min § 18.6.3.1	min(As,min, 4/3·As) (new)	min(As,min, 4/3·As)	EDFS bug fixed
½ / ¼ rule § 18.6.3.2	area, from As after the minimum	flexural strength, from raw As	EDFS $\geq$ SAP (decision: keep area)
Floor joint shear	—	$\times 1.0036$	SAP Vcol slightly smaller; $\gamma = 1.0$ in both
Roof joint shear	T – Vcol	T	SAP does not subtract the column shear below ($\approx 1.3\times$)
6/5 interior column	Required As of upper column (max)	area at the joint station	–4 %; roof excluded in EDFS (ACI 318-19)

5.3 Slender columns (V13)

K40x40 column, 5 m, pinned-pinned, $k = 1$, $k\cdot l_u/r = 41.7$, $\beta_{dns} = 0.6$, check mode 8 D22. Four moment patterns (single curvature, double curvature, $M1/M2 = -0.5$, midspan load) and one $M2,min$ case.

Column	Pattern	D/C EDFS	D/C SAP	Difference
1	Single curvature, Cm 1	1.0370	1.0367	–0.03 %
2	Double $M1/M2 = 0.5$, Cm 0.4 ($\delta = 1$)	0.8698	0.8723	+0.29 %
3	$M1/M2 = -0.5$, Cm 0.8	0.8838	0.8861	+0.26 %
4	Midspan load, Cm 1	0.9117	0.9121	+0.05 %
5	Small moment, $M2,min$ governs	0.3372	0.3403	+0.93 %

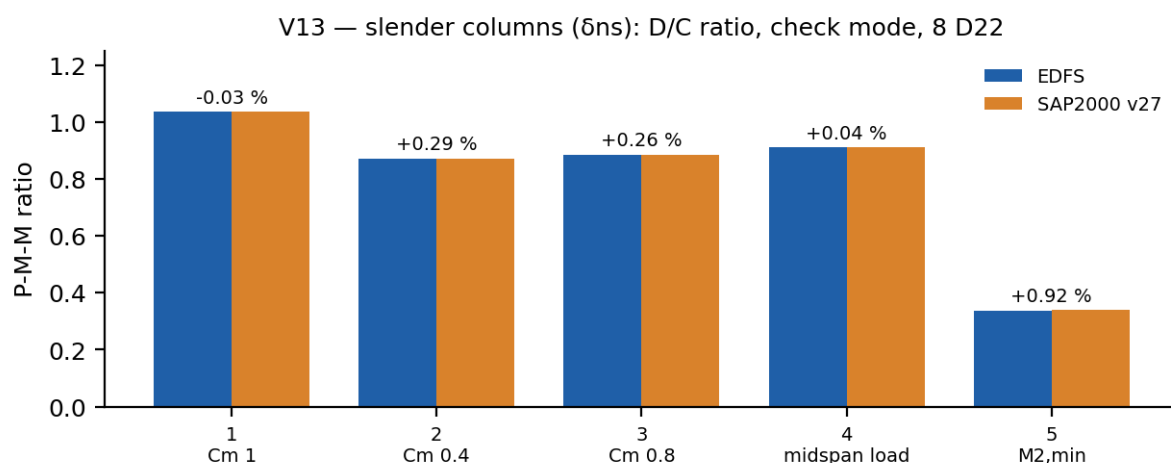


Figure 5. V13 — P-M-M ratio of slender columns.

The non-slender twin columns ($k = 0.3$) give SAP +8...10 % because SAP applies $M2,min$ to every column (MinEccen); with MinEccen off the difference is +0.25 % ($\delta_{ns} \approx 1.02$, which SAP still applies below the slenderness limit).

6. Advanced modelling and file exchange (V14, V14A/B, V16)

The models in this chapter were exported to SAP2000® with the **application's .s2k exporter** (menu File → Exchange), not with the generator script, so both the solver and the exchange file are tested at once.

Model	Compared	Max. difference	Notes
V14	12 × 8 m floor: girders continuous over the middle columns, secondary beams resting at girder midspan without dividing them; 126 displacements, 42 reactions, 3270 member forces	$\leq 6 \cdot 10^{-6}$ (SAP table rounding)	Nodes lying only inside a frame are written as special joints
V14A	One/two-way slabs, diaphragm through area constraints, sloped roofs, walls with normal load, edge without beam	$3 \cdot 10^{-13}$	Modal periods $4.8 \cdot 10^{-4}$: different lumping of mass from linear loads (see below)
V14B	Trapezoid, parallelogram, general quadrilateral, one-way triangle	$3.5 \cdot 10^{-12}$	Two-way triangles and pentagons are distributed differently by SAP (warning on export)
V16	Support springs on all six DOFs, on some DOFs, and on a restrained DOF; diaphragm; 6 modes	$2 \cdot 10^{-11}$ (static), $8 \cdot 10^{-9}$ (periods)	Restraint overrides the spring in both programs
Export V1–V13	Reactions, displacements, member forces, modal periods	0.0000 %	Steel models: 0.5–3.9 % because of SAP's section properties; with SAP properties substituted 0.0000 %
Import .s2k	Files written by SAP2000 itself from 15 models → imported and analysed by EDF5	0.00000 %	Static and modal

Lumping of mass from linear loads (V14A). Mass from line loads transferred by areas to beams is lumped by EDF5 with simple-beam reactions (1/6, 1/3) and by SAP2000® with fixed-end beam shears (3/20, 7/20). The total mass is the same (169.5654 t); checked at one joint: SAP rule → 0.52135 t = SAP, EDF5 rule → 0.5335 t = EDF5. Uniform loads are not affected. EDF5 deliberately keeps the simple-beam rule.

7. Findings and fixes in EDF5

#	Finding	Model	Action
1	M2 sign opposite to the SAP convention (tension on the –3 face)	V4	Fixed in backend & frontend, M2 diagram on the tension side
2	Cardinal point left/right mirrored	V9	Fixed in backend, frontend, Offset dialog
3	SMF As,min on both beam faces not applied (§ 18.6.3.1)	V12B	Applied: $\min(As, \min, 4/3 \cdot As)$
4	SMF Ve also computed for combinations without earthquake	V12B	Limited to earthquake combinations
5	Column p search tolerance 10^{-4} (+25 mm ²)	V12A	Tightened to 10^{-6}
6	.s2k file: nodes lying only inside a frame dropped by SAP2000 on import	V14	Written as special joints
7	Reading .s2k: spelling of the projected direction, mass-source flag, sections with toe radius	Export/import	Fixed in the file reader

8. SAP2000 differences that are not EDF5 errors

- Converted US-unit ACI formulas ($V_c 0.166\sqrt{f'_c}$, $A_v, \min 0.345$, $A_s, \min 1.379/f_y$); EDF5 uses the SI version of SNI 2847.
- SAP v27 still uses the AISC 360-10 r_t in F4/F5 and a reduced J; c2 of Table E7.1 without rounding.
- SAP's C_b and the alternative equation H1.3 for steel beams.
- SAP section shapes: parallel-flange channels, sharp-cornered boxes; user-defined I/Wide Flange treated as built-up ($\phi_v = 0.9$).
- Pattern live load (PatLLF) and minimum eccentricity for all columns — SAP features not modelled by EDF5 (developer decision; see Help → Legal → Batasan Teknis in the application).
- SAP's design-mode column area algorithm is 9–14 % more conservative than SAP's own check mode.

- SAP SMF simplifications: column V_e from the beam limit at the top joint only, roof joint without V_{col} , $V_c = 0$ along the whole beam.
- Distribution of two-way triangular and pentagonal areas, and lumping of mass from linear loads (V14A/B).

9. Items not yet verified

The following features exist in EDFS Matrix 1.0.0 and have passed hand-calculation tests and independent checks by the developer, but **have not yet been compared with another program**.

#	Feature
1	Earthquake loads to SNI 1726:2019: equivalent lateral force and modal response spectrum (CQC)
2	Advanced steel design: transverse stiffeners and tension field (G2.2), slender HSS webs (F7.3), pipe shear (G5), torsion of open sections (H3.3), angles E5(b) and short-leg connection, L_b from model brace points, ASD
3	CT, lipped channel and lipped Z sections, angles/Z on principal axes; RHS in design
4	Concrete design: bar count/diameter, stirrup spacing, P-M diagram with provided bars
5	Diaphragm centre of rigidity
6	Support springs combined with P-Delta and tension-only members
7	Material Take Off
8	STAAD.Pro™ (MEMBER TENSION, MPZ, .std file) and ETABS® (built-in Direct Analysis, building P-Delta)

The EDFS display and user interface (local axes, extrusion, Releases dialog, Detail report) are checked separately and are not part of the numerical comparison.

10. Statements and limitations

Nature of the verification. This report is a self-verification by the developer. The test models, settings and assessment of results were prepared by Edifisia. This report is not a certification, accreditation or endorsement by an independent body, nor an endorsement by Computers and Structures, Inc.

Scope. The results apply to the EDFS Matrix versions, the SAP2000 version (v27.1.0), the test models and the settings stated in this report. Nineteen test models do not represent every possible model. Passing the verification does not guarantee that the program is free of errors in every case.

Professional responsibility. EDFS Matrix is a calculation aid. The correctness of the input, the suitability of the model for the structure, the checking of results and design decisions remain the responsibility of the qualified professional who uses and approves the results. The program's assumptions and limitations are described in the application under Help → Legal → Batasan Teknis (Technical Limitations, in Indonesian).

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