Paper 1

Automatic inference of three-dimensional spatial structure in multi-story buildings using the slab area conservation law and Z-axis topological invariance

First edition: November 10, 2026 / Ver. 2.1 finalized: November 12, 2026 / Latest revision (Ver. 2.2, Block Puzzle & machine XYZ carry-in/out integrated edition): November 16, 2026

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Abstract

From the footprint area and number of floors obtained from public data outside the building (GSI, PLATEAU 3D, nationwide building DB), we derive each floor's slab area and subtract the common core (stairs, elevators, corridors, toilets, pipe shafts) sized by reference guidelines of the Building Standards Act, Fire Service Act and JIS to obtain private (room) areas. The Z-axis topological invariance condition—upper floors do not extend beyond lower floors and stairs/elevators run through the same position on all floors—checks the consistency between each floor plan and the total floor area.

1. Area conservation law

The total floor area equals the sum of the slab areas of all floors. On a setback floor, the floor area is the footprint area minus the rooftop portion.

$$A_{\mathrm{total}} = \Sigma_{z=1}^{F} A_{\mathrm{slab}}(z) \qquad (1)$$

$$A_{\mathrm{slab}}(z) = A_{\mathrm{fp}} - A_{\mathrm{roof}}(z) \qquad (2)$$

2. Back-calculating the common core and private areas

The private area of each floor is the slab area minus the common-core areas $k \in K$, whose sizes are reference values bounded below by legal/JIS minimum dimensions.

$$A_{\mathrm{priv}}(z) = A_{\mathrm{slab}}(z) - \Sigma_{k \in K} A_k(z) \qquad (3)$$

3. Z-axis topological invariance

The outline of an upper floor P(z+1) lies within the lower outline P(z) dilated by tolerance ε, and stair/elevator positions c_k coincide on all floors.

$$P(z+1) \subseteq P(z) \oplus B(\varepsilon), \quad c_k(z+1) = c_k(z) \qquad (4)$$

$$r(z) = A_{slab}(z) - \Sigma_j\, a_j(z) - \Sigma_k\, A_k(z) \to 0 \qquad (5)$$

4. Results and scope

Equations (1)–(5) give a consistent skeleton of floor areas, common core and private areas even for buildings without drawings, which becomes the input of the Block Puzzle formula in the 3rd Paper. Values are reference guidelines and do not judge legal conformity.

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(Created: Nov 10, 2026 | Ver. 2.1: Nov 12, 2026 | Latest Revision Ver. 2.2: Nov 16, 2026)

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