Supplementary Information

Spatial relationships guide semantic component extraction from Gaussian splatting of traditional Chinese timber architecture

Table S1 provides the textual component descriptions. Tables S2–S5 report the per-class numerical results underlying the main quantitative figures. Tables S6–S8 provide rendering results across filtering thresholds. Figures S1 and S2 show the exemplars used for initial annotation and spatial relationship-guided review. Figure S3 presents additional category-wise segmentation comparisons.

Table S1 Textual Descriptions of Components

Component	Textual description
Major Architrave	The uppermost and thickest beam of the three-tier lintel system, painted in blue-green and dark-blue Suzhou-style polychrome, positioned directly above the Frieze Board.
Frieze Board	A thin, flat board forming the shallowest tier of the three-tier lintel system, painted a uniform red, sandwiched between the Major and Minor Architraves.
Minor Architrave	The lowest and most slender beam of the three-tier lintel system, painted in blue-green and dark-blue Suzhou-style polychrome, positioned directly above the Hanging Lattice Fascia.
Eave Column	A tall, cylindrical timber column forming the outer ring of the building, its shaft coated in vermilion lacquer with painted bands at the head, standing on the Platform.
Inner Column	A tall, plain cylindrical timber column set back from the Eave Columns, coated in smooth vermilion lacquer without painted decoration, often partly hidden behind them.
Penetrating Tie-beam	A horizontal tie beam running in the depth direction, its exposed end painted in blue-green or dark-blue Suzhou-style patterns, projecting from the shaft of the Eave Column.
Embracing Tie-beam	A short, square-sectioned beam running in the depth direction, its end face bearing a white cartouche painted in a 'bogu' pattern, sitting directly on the eave-column head.
Corbel	A wing-shaped timber bracket with a right-triangular outline, carved in openwork or relief and finished in bright blue-green or dark-blue lacquer, fixed beneath the Hanging Lattice Fascia.
Hanging Lattice Fascia	A slender, openwork rectangular lattice screen painted alternately in blue-green and dark blue, spanning between the Eave Columns directly beneath the Minor Architrave.
Bench-under Lattice Fascia	A low, openwork guard panel of interlaced timber strips painted deep green or blue-green, raised off the ground on lotus-leaf blocks beneath the Bench Seat.
Bench Seat	A long, flat timber board coated in uniform red or green lacquer, resting directly on the Bench-under Lattice Fascia.
Door	A vertical timber door of one or more leaves, its upper half an openwork lattice frame and its lower half carved panels, coated in vermilion lacquer, set between the Inner Columns.
Window	A rectangular timber window with a heavy outer frame, its upper section filled with openwork lattice strips and its lower section glazed, coated in vermilion lacquer, set above the Sill Wall.
Sill Wall	A low masonry wall beneath the window, finished in dark grey/blue-grey brick with a central diamond pattern of diagonally laid blue bricks.
Window Lattice	An openwork lattice panel of crossing timber strips forming a 'gong'- and 'T'-shaped grid, coated in uniform vermilion or blue-green lacquer, set within the Door or Window frame.
Platform	The stepped stone base of the building, its upper surface paved in pale grey/white stone and its sides built from dark grey/blue-grey stone, supporting the entire structure above.
Steps	A stepped stone stairway of alternating treads and risers, finished in coarse, weathered pale grey stone, joining the paved surface of the Platform.
Inclined Side-stone	A diagonally laid stone ramp with a trapezoidal side wall, finished in coarse pale grey stone with ribbed striations, running alongside the Steps.
Gable Wall	A tall enclosure wall built from courses of blue-grey brick or stone, resting on a stone plinth, rising along the Eave Column line to support the roof above.
Baofu Pattern	A painted decorative panel in high-saturation Suzhou-style polychrome depicting flowers or landscapes, distinguished by spanning continuously across all three tiers of the lintel-beam system.
Single Eave	The single-tier roof-eave system at the top of the building, its grey tile edge alternating round eave tiles and drip tiles above a dense row of blue-green rafters.
Frame	A rectangular timber frame enclosing the window or door opening, coated in uniform vermilion lacquer, noticeably thicker than the lattice strips it encloses.

Table S2 Image-Level Component Segmentation IoU

Component	Ours	Heritage-3DGS	Grounded-SAM	SAM3	MaskCLIP
Major Architrave	86.16	51.07	3.43	0.00	0.00
Frieze Board	95.25	64.89	0.00	0.00	5.84
Minor Architrave	95.44	64.15	5.70	0.00	0.02
Eave Column	92.05	86.07	81.99	79.29	0.29
Inner Column	84.97	53.62	0.00	0.00	0.00
Penetrating tie-beam	60.39	49.53	0.46	0.00	0.03
Embracing tie-beam	71.05	34.70	0.00	0.00	0.61
Corbel	66.43	33.66	0.00	0.00	0.00
Hanging lattice fascia	87.17	89.13	49.85	0.22	3.52
Bench-under lattice fascia	92.51	75.14	6.38	0.00	0.01
Bench seat	91.48	81.26	28.32	98.33	16.63
Door	90.24	79.01	52.78	49.53	40.12
Window	82.09	79.42	14.83	18.17	10.47
Sill wall	93.84	75.03	75.64	0.00	19.46
Window latticework	87.74	85.66	25.25	83.89	5.78
Platform	89.37	74.15	56.02	0.00	0.80
Steps	91.23	84.83	29.61	56.12	23.76
Inclined Side-stone	89.49	79.65	48.69	0.00	0.49
Gable wall	74.85	78.19	0.00	0.00	3.42
Baofu pattern	94.51	65.55	97.29	0.00	9.51
Single Eave	93.79	90.34	22.47	0.00	5.89
Frame	75.81	43.58	0.00	0.00	10.33
mIoU	85.72	69.03	27.21	17.53	7.14

Table S3 Gaussian Semantic Field Reconstruction

Component	Heritage-3DGS	Ours("Decoupled Semantic Assignment")	Ours("Artifact and Background Filtering")
Background	87.38	87.65	91.09
Major Architrave	78.09	79.28	79.05
Frieze Board	72.27	76.25	74.83
Minor Architrave	96.67	96.69	97.02
Eave Column	95.38	91.94	94.49
Inner Column	82.58	78.76	81.40
Penetrating Tie-beam	92.22	85.65	91.53
Embracing Tie-beam	91.43	93.86	93.14
Corbel	92.38	93.68	90.11
Hanging Lattice Fascia	97.91	98.23	97.83
Bench-under Lattice Fa.	97.86	94.73	92.49
Bench Seat	95.92	88.31	87.30
Lattice Door	84.54	80.16	77.48
Window	83.31	88.62	92.18
Sill Wall	95.86	95.68	93.49
Window Lattice	97.62	93.07	93.90
Platform	93.58	93.30	93.68
Steps	90.68	93.04	92.66
Inclined Side-stone	92.43	92.52	92.03
Gable Wall	93.19	86.83	89.91
Baofu Pattern	98.19	98.02	98.04
Single Eave	93.51	96.12	95.60
Frame	78.20	79.34	79.55
Overall Metrics	mIoU 90.49 mAcc 95.11	mIoU 89.64 mAcc 94.94	mIoU 89.95 mAcc 94.62

Table S4 Independent Component Extraction IoU

Component	Heritage-3DGS	Ours	Δ
Major Architrave	9.46	65.06	+55.60
Frieze Board	11.17	63.12	+51.95
Minor Architrave	26.38	92.96	+66.58
Eave Column	45.54	88.64	+43.09
Inner Column	34.97	64.45	+29.48
Penetrating Tie-beam	36.62	61.64	+25.02
Embracing Tie-beam	46.13	71.83	+25.70
Corbel	28.11	82.30	+54.19
Hanging Lattice Fascia	31.53	92.71	+61.18
Bench-under Lattice Fa.	51.01	49.04	-1.97
Bench Seat	39.05	59.67	+20.62
Lattice Door	26.26	63.03	+36.77
Window	16.79	52.94	+36.14
Sill Wall	31.33	66.38	+35.04
Window Lattice	21.59	46.86	+25.27
Platform	19.12	77.82	+58.70
Steps	15.61	52.72	+37.11
Inclined Side-stone	36.47	73.69	+37.21
Gable Wall	29.06	82.59	+53.54
Baofu Pattern	23.03	95.20	+72.17
Single Eave	19.52	68.56	+49.03
Frame	17.49	52.12	+34.62
Overall mIoU	28.01	69.24	+41.23

Table S5 Independent Component Rendering Quality

Component	Heritage-3DGS			Ours		
	PSNR↑	SSIM↑	LPIPS↓	PSNR↑	SSIM↑	LPIPS↓
Major Archit.	12.49	0.8955	0.2184	23.11	0.9712	0.0608
Frieze Board	13.96	0.9290	0.1573	26.41	0.9847	0.0363
Minor Archit.	16.74	0.9415	0.1014	25.76	0.9761	0.0452
Eave Column	14.91	0.9139	0.2149	25.69	0.9802	0.0600
Inner Column	16.18	0.9349	0.1478	22.76	0.9734	0.0575
Penetrating Ti.	23.06	0.9783	0.0562	27.95	0.9908	0.0196
Embracing Ti.	22.52	0.9742	0.0709	30.53	0.9914	0.0217
Corbel	22.77	0.9790	0.0439	31.45	0.9938	0.0114
Hanging Lat.	16.03	0.9247	0.1204	24.32	0.9623	0.0454
Bench-und.	20.43	0.9458	0.0778	22.62	0.9556	0.0650
Bench Seat	23.52	0.9760	0.0548	26.98	0.9860	0.0268
Lattice Door	10.80	0.8329	0.3099	18.86	0.9468	0.1028
Window	8.66	0.7890	0.3862	17.52	0.9342	0.1240
Sill Wall	18.12	0.9514	0.1085	25.50	0.9808	0.0431
Window Lattice	8.41	0.7480	0.4403	14.91	0.8404	0.2534
Platform	9.90	0.8069	0.4518	21.34	0.9051	0.1826
Steps	28.94	0.8543	0.2327	31.20	0.8737	0.2188
Inclined Si.	33.28	0.9772	0.0458	33.52	0.9739	0.0466
Gable Wall	19.70	0.9499	0.1053	23.74	0.9652	0.0713
Baofu Pattern	16.18	0.9420	0.1235	28.87	0.9827	0.0268
Single Eave	12.12	0.8784	0.2460	16.97	0.9256	0.1465
Frame	6.37	0.6574	0.5665	14.65	0.8731	0.2506
Overall Mean	17.05	0.8991	0.1946	24.30	0.9530	0.0871

Table S6 Per-Class PSNR across Filtering Thresholds

Component	Baseline	$\phi \geq 0.0$	$\phi \geq 0.1$	$\phi \geq 0.3$	$\phi \geq 0.5$	$\phi \geq 0.7$	$\phi \geq 0.9$
Major Arch.	12.49	12.65	22.60	22.69	22.74	22.82	23.11
Frieze Board	13.96	14.54	25.89	26.19	26.27	26.39	26.41
Minor Arch.	16.74	19.36	24.73	25.11	25.26	25.40	25.76
Eave Col.	14.91	19.40	24.08	25.09	25.24	25.47	25.69
Inner Col.	16.18	11.60	21.65	22.21	22.40	22.63	22.76
Penetrating.	23.06	15.92	26.39	27.90	27.95	27.94	27.95
Embracing.	22.52	19.65	29.61	29.69	29.92	30.12	30.53
Corbel	22.77	23.55	31.46	31.55	31.56	31.54	31.45
Hanging Lat.	16.03	14.65	23.28	23.98	24.11	24.22	24.32
Bench-un.	20.43	11.42	20.70	21.39	22.40	22.50	22.62
Bench Seat	23.52	19.72	27.41	27.12	27.03	26.98	26.98
Lattice Door	10.80	10.09	17.61	18.11	18.66	18.68	18.86
Window	8.66	6.45	15.42	16.74	17.08	17.35	17.52
Sill Wall	18.12	11.53	25.01	25.40	25.42	25.46	25.50
Window Lat.	8.41	4.97	12.70	13.98	14.22	14.52	14.91
Platform	9.90	14.41	20.56	20.92	21.01	21.13	21.34
Steps	28.94	26.24	29.68	30.77	31.08	31.07	31.20
Inclined Si.	33.28	24.09	27.20	27.43	27.47	33.48	33.52
Gable Wall	19.70	17.71	23.06	23.27	23.39	23.47	23.74
Baofu Pat.	16.18	14.66	28.31	28.61	28.77	28.82	28.87
Single Eave	12.12	11.66	16.14	16.47	16.75	16.85	16.97
Frame	6.37	7.29	13.26	13.84	14.16	14.34	14.65
Overall Mean	17.05	15.07	23.03	23.57	23.77	24.15	24.30

Table S7 Per-Class SSIM across Filtering Thresholds

Component	Baseline	$\phi \geq 0.0$	$\phi \geq 0.1$	$\phi \geq 0.3$	$\phi \geq 0.5$	$\phi \geq 0.7$	$\phi \geq 0.9$
Major Arch.	0.8955	0.8977	0.9681	0.9692	0.9695	0.9699	0.9712
Frieze Bo.	0.9290	0.9263	0.9822	0.9832	0.9836	0.9840	0.9847
Minor Arch.	0.9415	0.9496	0.9744	0.9752	0.9756	0.9756	0.9761
Eave Col.	0.9139	0.9590	0.9768	0.9788	0.9792	0.9797	0.9802
Inner Col.	0.9349	0.8867	0.9681	0.9712	0.9717	0.9730	0.9734
Penetrating.	0.9783	0.9337	0.9875	0.9906	0.9907	0.9907	0.9908
Embracing.	0.9742	0.9688	0.9905	0.9906	0.9908	0.9910	0.9914
Corbel	0.9790	0.9785	0.9926	0.9933	0.9935	0.9937	0.9938
Hanging La.	0.9247	0.9022	0.9566	0.9600	0.9606	0.9613	0.9623
Bench-un.	0.9458	0.8495	0.9477	0.9510	0.9540	0.9547	0.9556
Bench Seat	0.9760	0.9604	0.9859	0.9859	0.9859	0.9860	0.9860
Lattice Door	0.8329	0.8328	0.9341	0.9391	0.9435	0.9446	0.9468
Window	0.7890	0.6895	0.9170	0.9269	0.9299	0.9321	0.9342
Sill Wall	0.9514	0.8902	0.9792	0.9802	0.9803	0.9806	0.9808
Window La.	0.7480	0.5840	0.8127	0.8272	0.8311	0.8354	0.8404
Platform	0.8069	0.8528	0.8984	0.9013	0.9026	0.9035	0.9051
Steps	0.8543	0.8604	0.8712	0.8729	0.8732	0.8733	0.8737
Inclined Si.	0.9772	0.9546	0.9695	0.9707	0.9710	0.9733	0.9739
Gable Wall	0.9499	0.9396	0.9634	0.9640	0.9645	0.9647	0.9652
Baofu Pat.	0.9420	0.9364	0.9808	0.9816	0.9820	0.9824	0.9827
Single Eave	0.8784	0.8799	0.9197	0.9214	0.9234	0.9241	0.9256
Frame	0.6574	0.6954	0.8513	0.8601	0.8633	0.8668	0.8731
Overall Mean	0.8991	0.8785	0.9467	0.9498	0.9509	0.9518	0.9530

Table S8 Per-Class LPIPS across Filtering Thresholds

Component	Baseline	ϕ≥0.0	ϕ≥0.1	ϕ ≥≥0.3	ϕ ≥≥0.5	ϕ ≥≥0.7	ϕ ≥≥0.9
Major Arch.	0.2184	0.2145	0.0675	0.0645	0.0637	0.0633	0.0608
Frieze Bo.	0.1573	0.1641	0.0426	0.0399	0.0393	0.0386	0.0363
Minor Arch.	0.1014	0.0996	0.0487	0.0469	0.0461	0.0460	0.0452
Eave Col.	0.2149	0.1220	0.0676	0.0630	0.0623	0.0607	0.0600
Inner Col.	0.1478	0.2506	0.0711	0.0631	0.0616	0.0582	0.0575
Penetrating.	0.0562	0.1407	0.0299	0.0210	0.0207	0.0204	0.0196
Embracing.	0.0709	0.0796	0.0255	0.0251	0.0246	0.0239	0.0217
Corbel	0.0439	0.0383	0.0141	0.0127	0.0119	0.0116	0.0114
Hanging L.	0.1204	0.1644	0.0551	0.0494	0.0483	0.0474	0.0454
Bench-un.	0.0778	0.2905	0.0829	0.0753	0.0672	0.0661	0.0650
Bench Seat	0.0548	0.0930	0.0282	0.0275	0.0271	0.0268	0.0268
Lattice Door	0.3099	0.3475	0.1354	0.1225	0.1127	0.1103	0.1028
Window	0.3862	0.5332	0.1597	0.1387	0.1317	0.1272	0.1240
Sill Wall	0.1085	0.2632	0.0486	0.0452	0.0445	0.0434	0.0431
Window La.	0.4403	0.5968	0.3088	0.2809	0.2731	0.2649	0.2534
Platform	0.4518	0.2781	0.1968	0.1926	0.1900	0.1876	0.1826
Steps	0.2327	0.2526	0.2266	0.2210	0.2196	0.2186	0.2188
Inclined Si.	0.0458	0.1067	0.0596	0.0550	0.0538	0.0475	0.0466
Gable Wall	0.1053	0.1402	0.0765	0.0744	0.0733	0.0725	0.0713
Baofu Pat.	0.1235	0.1319	0.0315	0.0296	0.0284	0.0274	0.0268
Single Eave	0.2460	0.2390	0.1650	0.1581	0.1518	0.1502	0.1465
Frame	0.5665	0.5421	0.2861	0.2727	0.2669	0.2611	0.2506
Overall Mean	0.1946	0.2313	0.1013	0.0945	0.0917	0.0897	0.0871

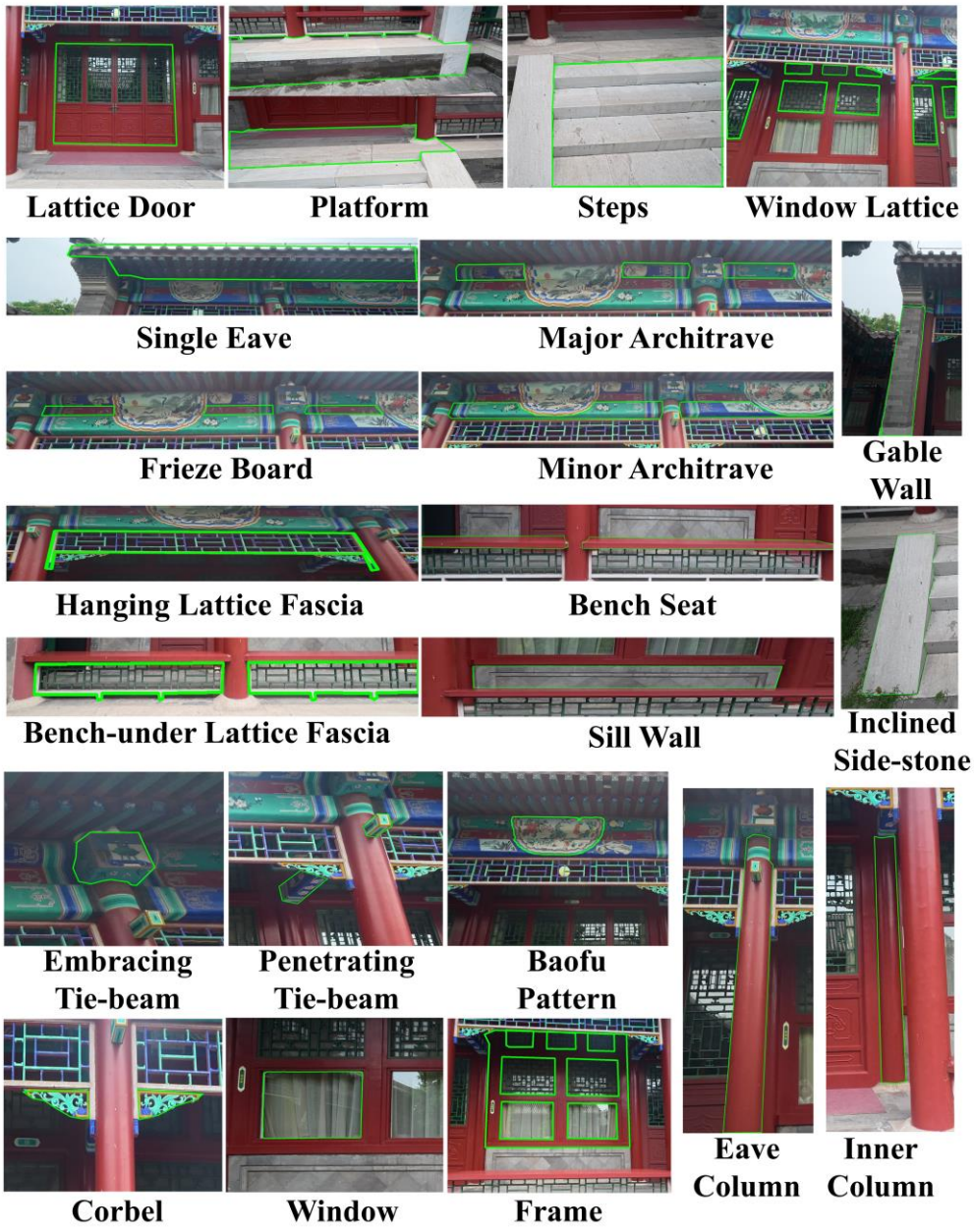


Figure S1. Component image exemplars used for preliminary semantic annotation. Each exemplar shows a target component and its surrounding architectural context. Labels identify the target categories, and colored outlines delineate the target regions. The images retain neighboring structures and local textures.

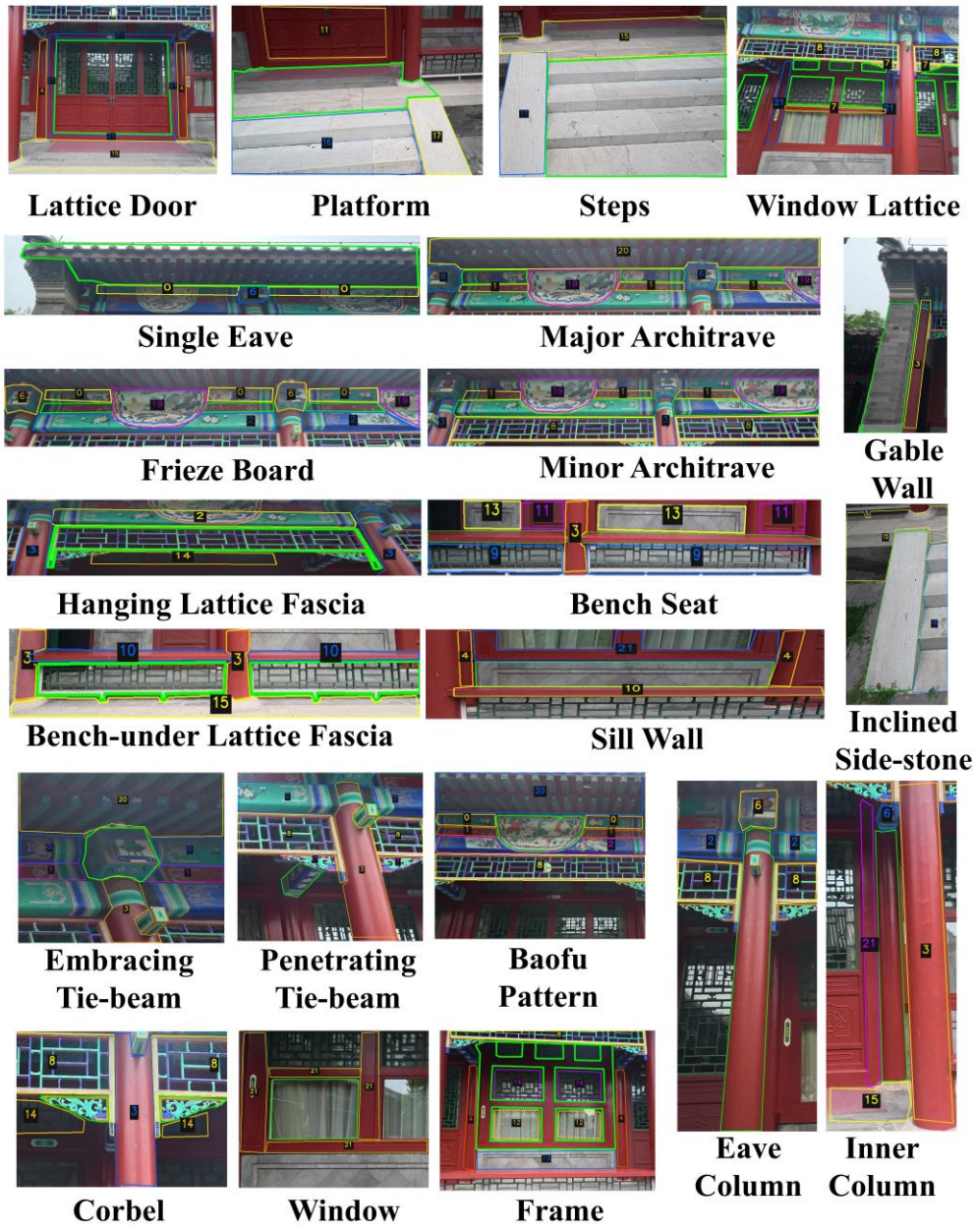


Figure S2. Component image exemplars used for spatial relationship-guided semantic re-verification. Each exemplar shows a target component and neighboring regions, with the target category identified below. Outlines and numerical labels locate regions corresponding to the component and relationship descriptions in the prompts.

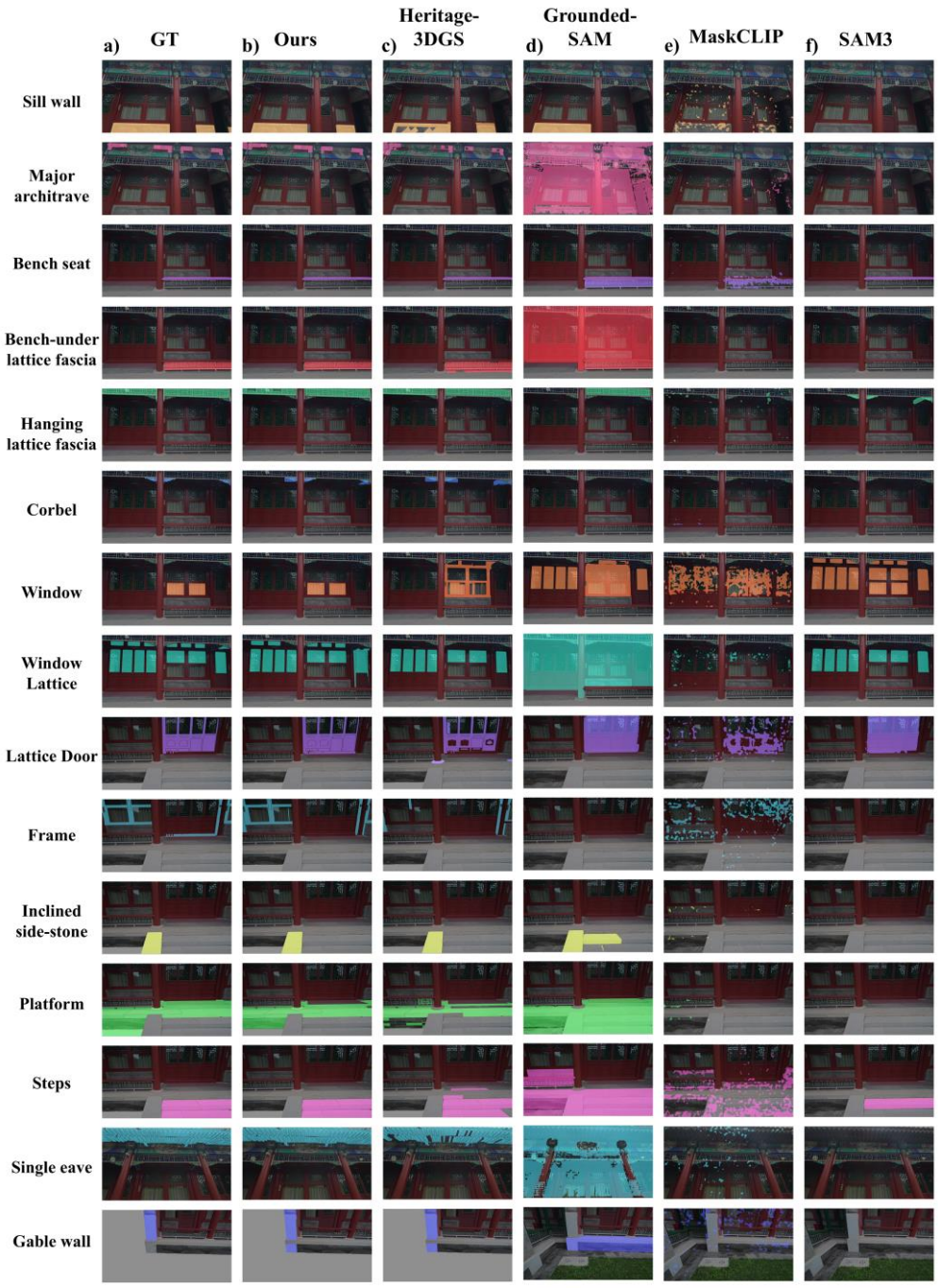


Figure S3. Image-level semantic segmentation of additional component categories. a) Ground truth. b) Our method. c) Heritage-3DGS. d) Grounded-SAM. e) MaskCLIP. f) SAM3. Rows correspond to the component categories labeled on the left. Colored masks overlaid on the photographs show the target regions identified by each method. GT denotes ground truth, SAM denotes Segment Anything Model, and CLIP denotes Contrastive Language–Image Pre-training.