Desert Mass

A Prototype ADU for Tempe’s Hot-Arid Climate

Proposal Submitted by Studio Zhan

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Tempe ADU Design Competition

Desert Mass reduces reliance on mechanical conditioning and provides a more comfortable indoor environment in the Sonoran climate

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A Prototype ADU for Tempe's Hot-Arid Climate

Desert Mass is a prototype accessory dwelling unit (ADU) designed to leverage the environmental patterns of Tempe's hot-arid climate. Instead of resisting the intense heat and dramatic temperature swings with mechanical systems, the project employs mass walls to moderate thermal comfort.

The design uses three L-shaped cores constructed from concrete masonry units (CMU). These cores, in combination with a concrete floor slab and roof, surround the ADU with a dense layer of thermal mass. These mass elements help counteract temperature fluctuations by absorbing solar heat during the day and delaying its transmission to the indoor spaces until nighttime. The lower evening temperatures of the Sonoran Desert balance out the released heat, reducing the dependency on active cooling systems.

This thermal exchange also works in reverse during cooler months. Solar energy collected during the day is stored in the thermal mass and slowly released after sunset, helping maintain warmth through the night. In both summer and winter, Desert Mass reduces reliance on mechanical conditioning and provides a more stable and comfortable indoor environment.

Floor Plan Showing Three L-Shaped Cores providing thermal mass

Project Narrative

Desert Mass is a prototype ADU designed specifically for Tempe's hot-arid climate. Rather than depending on mechanical systems to resist the extremes of the desert, the project adapts to the environment through the use of mass walls to provide indoor comfort.

SUSTAINABILITY
The design strategy begins with three L-shaped cores made of concrete masonry units (CMU). These cores, along with a concrete floor slab and roof, form a thermal envelope that manages heat transfer and reduces mechanical oads across the seasons.

- During Tempe's **summer months** (May–Sept) , the CMU walls absorb solar heat during the day, delaying its transfer indoors. This thermal lag keeps interiors more stable, especially when combined with nighttime ventilation to purge stored heat.
- During **shoulder seasons** (March–April, Oct–Nov), passive solar gain helps warm the unit gently in the evenings, with the mass walls radiating stored heat after sunset.
- **In winter**, (Dec–Feb) the low sun angle allows direct light to penetrate the glazing, warming interior mass surfaces that slowly release heat through the night.

In addition to thermal mass, shading is carefully calibrated. Deep 5-foot overhangs reduce solar heat gain and glare during summer, while roof cutouts around the CMU cores ensure that the walls receive full sun during winter when passive heat is most beneficial. Insulated glazing and solar-reflective curtains give residents further control, allowing them to regulate indoor light and temperatures.

ACCESSIBILITY
The spatial strategy breaks out of the confinement often experienced in standard ADUs.

- The open plan flows around the three cores. The layout maximizes both visual and physical access. Sightlines extend through and beyond each program zone, allowing ease of movement and quick orientation.
- The lack of thresholds, steps, or abrupt material transitions enhances maneuverability, especially for those using mobility aids.
- Curtains offer adjustable levels of privacy, daylight, and views, allowing residents to modify their environment to personal preferences.

These features support key Universal Design Principles:
2. Accommodate a wide range of individual preferences
3a. Eliminate unnecessary complexity
4a. Maximize legibility of essential information

CONTEXT & VERSATILITY
Desert Mass is designed to be flexible across site conditions, occupant types, and programmatic needs.

- Each indoor space connects directly to an adjacent outdoor space, providing airflow, daylight, and opportunities for gathering and social activity.
- The modular nature of the plan allows it to function as a large, one-bedroom unit or as a two-bedroom layout with rooms of approximately 150 square feet each.
- The ADU can accommodate the main entry on any of three facades, allowing a variety of lot types and relationships to existing structures.
- Each core has a different orientation which allows the design to maintain solar exposer regardless of how the unit is sited. In addition, they protrude above the roofline, making the orientation of the overall unit more flexible.

AFFORDABILITY

Desert Mass addresses affordability by reducing both upfront construction costs and long-term maintenance.

- Concrete masonry is a familiar construction method in the Southwest,which helps limit construction inefficiencies and reduces labor costs.
- CMU walls require minimal finishing, they can remain exposed indoors and need only a sealer on the exterior.
- Their durability eliminates the need for frequent repainting or repairs, and their resistance to rot, termites, and fire makes them ideal for long-term ownership.
- Labor savings are also achieved by consolidating plumbing and mechanical runs within the three utility cores, reducing coordination and complexity on-site.
- Flat, concrete roofs require fewer framing components and shorter construction periods. With proper waterproofing, they require less maintenance than pitched/shingled roofs.

By pairing cost efficiency with durable materials and construction methods, Desert Mass offers a resilient housing solution that's affordable to own and maintain.

AESTHETICS & ARCHITECTURE

Beyond environmental performance, the mass-wall cores are essential to supporting the ADU's living functions. Their layout and orientation organizes the home into three main zones: sleeping, eating, gathering with clear legibility between form and program. These spaces are united with a combination of concrete and natural wood finishes that offer durability while adding warmth and material contrast.

The facade is defined by the balance of solid wall segments and glass to create a rhythm of opaque and transparent planes. A low, flat roofline keeps the massing minimal and grounded in the desert landscape. Roof openings create dynamic shadow patterns that change throughout the day, animating the solid planes.

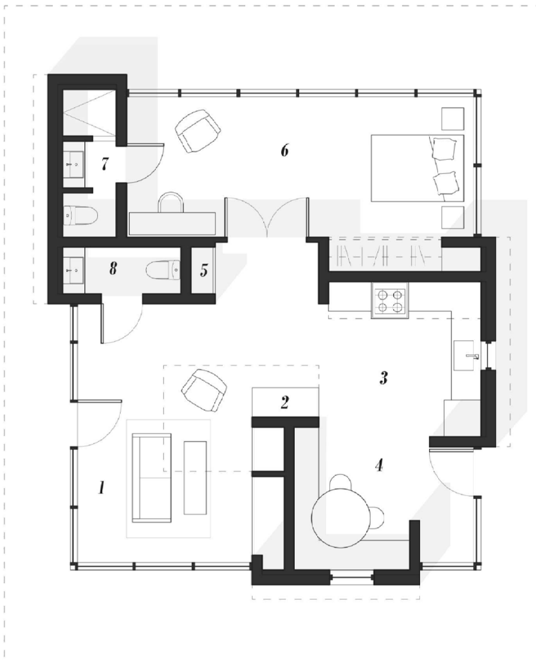
Living Room with View of Kitchen

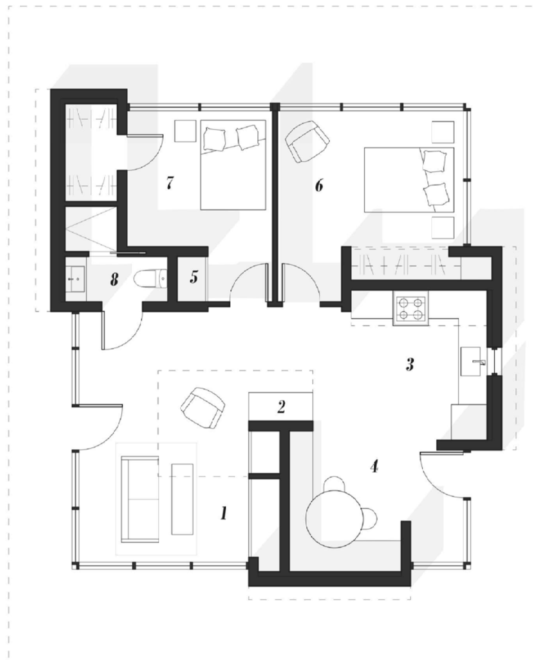
Cost Estimate

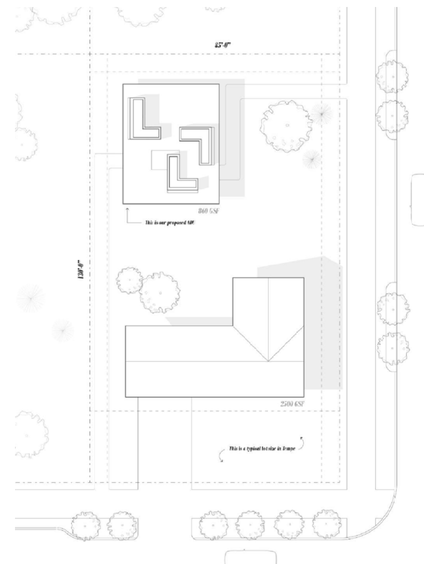
Division		Item	Qty	Unit	Unit Cost	Line Total
Div 01	General Requirements	General Conditions & permits	1	LS	$8,000	$8,000
		Allowance - minor contingencies	1	LS	$100	$100
Div 02	Existing Conditions	Site prep & grading	850	SF	$4	$2,975
Div 03	Concrete	6" insulated slab on grade	900	SF	$15	$13,500
		Thickened edges/footings	180	LF	$30	$5,400
		6" structural concrete roof pour	1,550	SF	$15	$23,250
Div 04	Masonry	8" CMU walls (materials+labor)	1,617	SF	$22	$35,574
		CMU grout/rebar	1,617	SF	$4	$6,468
Div 05	Metals	Metal deck (roof)	1,550	SF	$4	$6,200
Div 06	Wood, Plastics	Birch ply millwork (base/uppers)	42	LF	$380	$15,960
		Interior trim & blocking	850	SF	$3	$2,125
Div 07	Thermal & Moisture	4" XPS rigid insulation	506	SF	$5	$2,530
		Roofing waterproofing membrane	1,550	SF	$7	$10,850
		Flashing & sheet metal	220	LF	$11	$2,420
		Air/vapor barrier for walls	1,617	SF	$3	$4,850
Div 08	Openings	Window wall (IGU incl frames)	684	SF	$80	$54,720
		Exterior doors (insulated)	2	EA	$1,500	$3,000
		Interior doors (solid core)	3	EA	$400	$1,200
		Skylight (curb & install)	1	EA	$1,200	$1,200
		Operable window	1	EA	$800	$800
Div 09	Finishes	Gypsum board & finishing	3,000	SF	$2	$5,400
		Interior paint (3-coat)	3,000	SF	$1	$3,000
		Tile in bath (floor/wet walls)	150	SF	$12	$1,800
Div 10	Specialties	Bath accessories & mirrors	1	LS	$800	$800
Div 22	Plumbing	Plumbing rough-in & piping	850	SF	$10	$8,500
		Water heater (tankless or 50 gal)	1	EA	$1,600	$1,600
		Fixtures – toilets	2	EA	$850	$1,700
		Fixtures – bathroom sinks	2	EA	$650	$1,300
		Fixture – kitchen sink & faucet	1	EA	$1,000	$1,000
Div 23	Hvac	HVAC ductless heat pump (1.5–2 ton)	1	LS	$6,500	$6,500
Div 26	Electrical	Electrical rough-in & devices	850	SF	$11	$9,350
		Lighting fixtures & switches	1	LS	$3,500	$3,500
Div 31	Earthwork	Trenching & utility connections	1	LS	$3,500	$3,500

Total Construction Cost:	**$249,070**
Licensing Fee For Residents:	$3,500
Hourly Rate for Future Work:	$200/Hour

Floor Plans







Floor Plan 1 Bed Option

Scale: 1/4"=1'-0"

1 Living Room
2 Fireplace
3 Kitchen
4 Dining
5 Linen Closet
6 Bedroom
7 Bath
8 Half Bath

Floor Plan 2 Bed Option

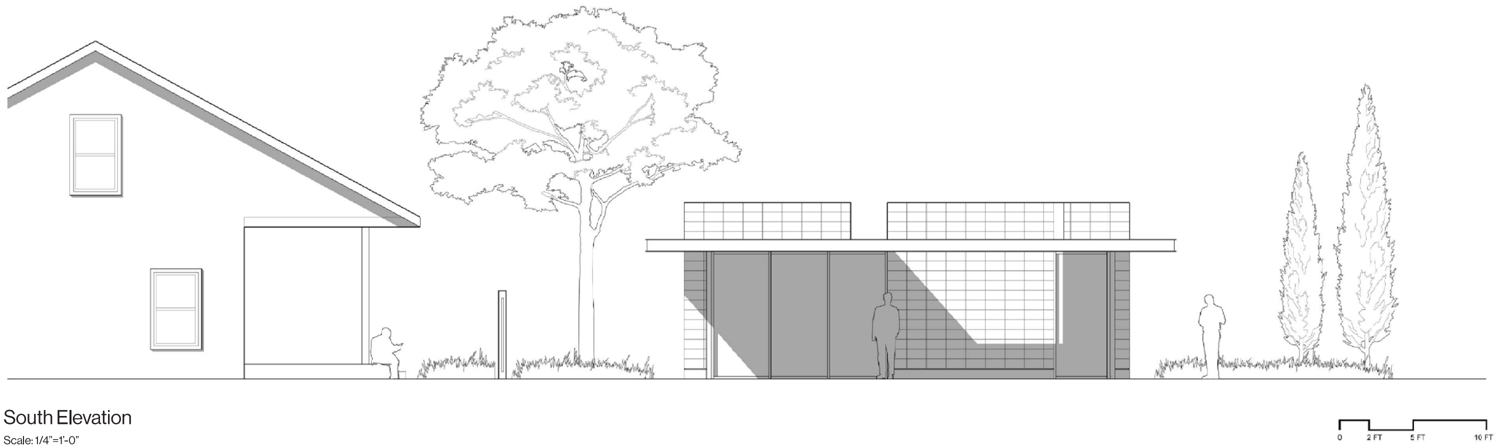
Scale: 1/4"=1'-0"

1 Living Room
2 Fireplace
3 Kitchen
4 Dining
5 Linen Closet
6 Bedroom
7 Bedroom
8 Full Bath

Site Plan

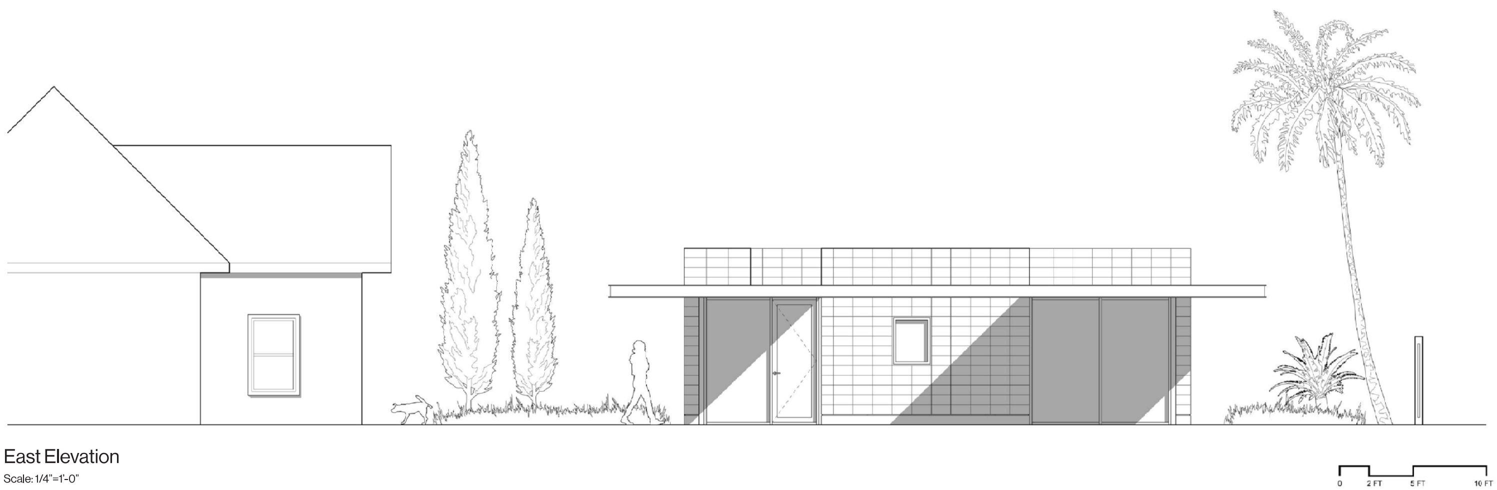
NTS

Blackline Elevations



South Elevation

Scale: 1/4"=1'-0"



East Elevation

Scale: 1/4"=1'-0"

Colored Elevations

South Elevation

Scale: 1/4"=1'-0"

East Elevation

Scale: 1/4"=1'-0"

Exterior View - Mass wall core separating living room (left) from kitchen/dining area (right)

During Tempe's summer months (May–Sept) , the CMU walls absorb solar heat during the day, delaying its transfer indoors. This thermal lag keeps interiors more stable, especially when combined with nighttime ventilation to purge stored heat.

Shading is carefully calibrated. Deep 5-foot overhangs reduce solar heat gain and glare during summer, while roof cutouts around the CMU cores ensure that the walls receive full sun during winter when passive heat is most beneficial. Throughout the day, the cutouts also create dynamic shadow patterns that animate the solid planes.

Living Room with View of Kitchen

The layout and orientation of the CMU cores organizes the home into three main zones: sleeping, eating, and gathering.These spaces are united with a combination of concrete and natural wood finishes that offer durability while adding warmth and material contrast. Sightlines extend through and beyond each program zone, allowing visibility and quick orientation.

Bedroom with Ensuite Bathroom

In winter, (Dec–Feb) the low sun angle allows direct light to penetrate the glazing, warming interior mass surfaces that slowly release heat through the night.
Insulated glazing and solar-reflective curtains give residents further control, allowing them to regulate indoor light and temperatures.
The plan also allows a two-bedroom layout with rooms of approximately 150 square feet each.

Dining Room & Fireplace

Each core contains a different utility zone such as a bathroom, kitchen, and dining/fireplace.
CMU walls require minimal finishing, they can remain exposed indoors and require only a sealer on the exterior.

Material Sample Board

List of Recommended Materials and Mechanical Systems

Material Category	Item	Location/Use	Spec / Notes
Structure/Envelope	CMU stacked-bond walls	Primary interior & exterior walls (3 L-shaped cores + perimeter)	8" CMU, stacked bond; grout/rebar per shear requirements; interior faces sealed; exterior breathable silane/siloxane sealer; integrates thermal mass.
Structure/Envelope	Concrete roof slab (large overhangs)	Primary roof	Cast-in-place concrete with tapered insulation and membrane waterproofing; high-SRI cap sheet; integrate roof cutouts over cores.
Structure/Envelope	Roof insulation & waterproofing	Above roof slab	Polyiso or XPS continuous insulation (target R-30+); cover board; 2-ply SBS or single-ply membrane; light color.
Structure/Envelope	Concrete floor slab (exposed)	Interior floor finish	Polished/sealed concrete; integral low-emitting sealer; slab edges thermally broken at exterior; flush transitions (barrier-free).
Openings	Exterior glazing systems	Full-height sliders/clerestory windows	Thermally broken aluminum or fiberglass; low-e, argon IGUs; SHGC tuned for hot-arid climate; operable units for night flush; insect screens.
Interior	Birch plywood casework	Kitchen, storage, built-ins	FSC veneer, UV-cured clear finish; soft-close hardware; accessible heights and pulls.
Interior	Birch paneling/trim	Selective interior surfaces	Clear finished birch panels for warmth against concrete/CMU; low-VOC finishes.
Envelope	Air/vapor control layers	Roof and around openings	Continuous air barrier; seal penetrations; target ≤3.0 ACH50.
Site	Concrete walks & patio	Shaded outdoor rooms under overhangs	Light, high-albedo finish; sawcut joints; slope to landscape swales.
Site	Desert-adapted planting & DG	Yard & microclimate	Low-water natives, stabilized decomposed granite for accessible paths; drip irrigation-ready.

Mechanical System	Function	Sustainability Benefit	Design Notes
Variable-speed heat pump	Space cooling/heating	All-electric, high SEER2/HSPF2; minimized runtime due to thermal mass and shading.	Shade outdoor unit; consider two zones (living/sleeping); provide transfer grilles for closed-door operation.
Energy Recovery Ventilator (ERV)	Balanced fresh air	Exchanges heat and moderates indoor humidity in arid climate; MERV-13+ filtration.	Supply to living/bedrooms; exhaust from bath/kitchen; boost by CO2/PM2.5 sensors.
Night-flush ventilation (automated)	Purge stored heat via cool night air	Leverages diurnal swing with CMU/Concrete mass to cut cooling energy.	Motorized clerestory/courtyard windows with lockout based on outdoor temp/air quality; secure screens.
Ceiling fans (high-efficiency DC)	Air movement for comfort	Raises effective comfort temperature, reducing AC use.	Place in living and bedrooms; integrate with smart controls.
Heat Pump Water Heater (HPWH)	Domestic hot water	3–4x more efficient than resistance; all-electric.	Ducted to exterior or semi-conditioned mech closet; route condensate to landscape.
Induction cooktop & electric oven	Cooking	No combustion; high efficiency and better IAQ.	Dedicated circuits; compatible cookware.
Ducted range hood (exhausted)	Source capture of cooking pollutants	Improves IAQ and reduces general ventilation demand.	250–400 cfm, quiet operation; backdraft damper.
Exterior/interior shading & glazing controls	Solar control/daylight tuning	Reduces cooling load; glare control; occupant comfort.	Deep 5' overhangs, selective exterior shades, solar-reflective curtains on large glass.
Solar PV–ready electrical	Renewable integration	Offsets operational carbon; supports all-electric strategy.	Conduit to roof; plan for 4–6 kW array on flat roof with ballasted racks; battery-ready subpanel optional.
Smart thermostats/IAQ monitoring	Controls	Optimizes setpoints and ventilation; reduces energy use.	CO2/PM sensors; auto-boost ERV; occupancy-based set-back.