DESIGN

chapter 2

urban and rural examples

"For two centuries, common knowledge governed American spatial design. Common knowledge is neither folk nor literate but a complex mixture of both the "little tradition" transmitted by half-literate peasants and the "great tradition" of the literate, innovative minority of scholars, rulers, merchants, and of professional designers such as surveyors or architects."

John Stilgoe, *The Common Landscape of America*

Architectural design concerns the arrangement of spaces for human habitation. The space defined by traditional houses is both interior and exterior, private and public. The houses people build are as much a cultural expression as are their music, food or dance. Traditional houses spring from a centuries-deep well of shared experience, knowledge and values. This current of tradition running through society is still felt, although much weakened over the 20th century by the widespread advent of industrialized housing production methods and suburban consumerism --- which can be seen as a new culture, supplanting the old.

Following is a series of case studies of housing from the predominate southwestern cultural traditions, including both rural and urban examples. Among the most developed examples of urban architecture are the Native American Pueblos of Casa Grande, Arizona, and Acoma, New Mexico. These were followed by Spanish and Mexican towns, as evidenced by the courtyards and row-houses of Barrio Viejo in Tucson, Arizona. The Anglo tradition found expression in the isolated ranch houses of the Southwest, such as the Empire and the Gray. All of these traditions hold profound lessons for today's designers and builders.

Historical periods of the U.S. Southwest

Native American	4000 B.C. -- 1609 A.D.	(Settlement of Santa Fe)
Spanish	1609 A.D. -- 1820 A.D.	(Mexican Independence)
Mexican	1820 A.D. -- 1848 A.D.	(Mexican-American War)
Anglo American	1854 A.D. -- present	(Gadsden Purchase -- Present)

Coolidge, Arizona **CASA GRANDE**

Among the earliest works of architecture in the desert southwest is the Hohokam Native American compound known as Casa Grande, Arizona. This imaginative name (Big House) was given by the Jesuit explorer-priest Fr. Francisco Eusebio Kino in 1693. Kino, a German-speaking cartographer from Trento in north Italy, was the first European to see Casa Grande. He found the ancient Hohokam site abandoned, yet with its earthen walls still standing. The central structure stood three stories tall, within the confines of a large walled compound containing numerous single-story room blocks joined together to form a dense townscape.

Hohokam culture flourished from A.D. 700 to A.D. 1450. Archeologists have charted the ascent and decline of this prehistoric civilization, identifying pre-classic, classic, and post-classic periods of development. The Casa Grande complex dates to the late classic period, as the culture was peaking and beginning to experience the stress of long-term drought that lead to its abandonment.

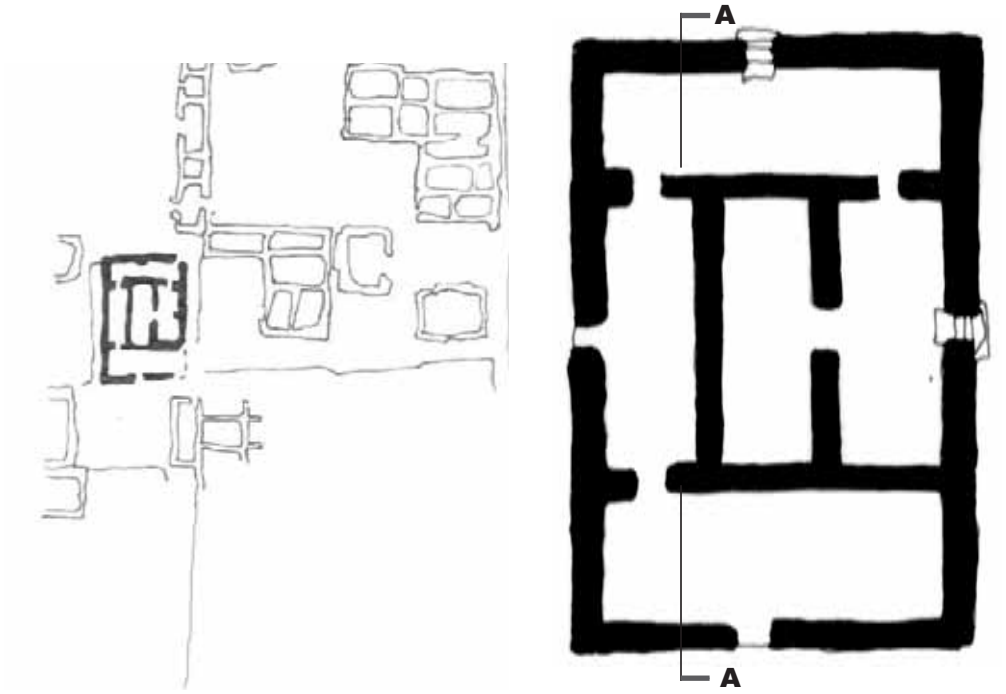
Hohokam society was based on a sophisticated network of irrigation canals, some of which are still in use today by contemporary farmers. Irrigated crops supported dozens of city-states across the broad Gila River basin. Classic-period Hohokam settlements were walled towns, expressing the need to defend their sedentary agricultural civilization against competing nomadic peoples, including the Chichimecs (ancestors of the Apache and Aztecs). Early agricultural civilizations required a high level of social organization to permit cooperative labor in the planning and digging of canals, the planting and irrigating of fields, and the building of towns. The architectural legacy of these early desert dwellers is impressive to this day.

TRADITIONAL PRINCIPLES

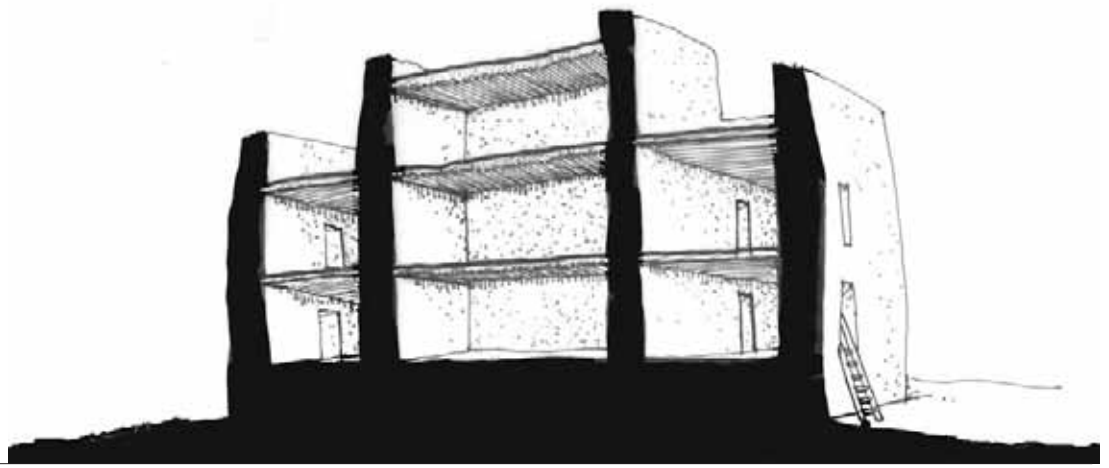
Casa Grande stands as a reminder of a vanished civilization, which endured for over 700 years before collapsing from environmental pressures. After centuries of cultural development, this early agricultural society could not resist the stress of a long drought. While it is impossible to compare the Casa Grande with contemporary conventional housing, it nonetheless demonstrates fundamental principles of how to build in the desert.

- Thick earthen walls for shelter and thermal mass.
- Simple rectangular building forms for ease of construction and structural stability.
- Compact shapes that minimize exposure to the elements.
- Small openings to reduce heat gain.

Today's society will not build another Casa Grande. Yet we can learn much by looking closely at how Native Americans built here seven centuries ago.



Site plan (l.) showing remnants of adjacent buildings & plan (r.)



Section perspective A-A

MATERIALS

The Casa Grande complex was built with earthen walls and a timber roof and floor structure. The walls were built by placing damp earth in layers, raising the walls gradually, layer upon layer, until the desired height was attained. This technique is called puddled adobe and resembles today's rammed earth, in that it produces a monolithic earth wall. That is, the earth is not molded into bricks which are then laid in mortar: rather, the entire wall is formed of earth heaped upon earth and compacted so that it fuses into one mass. It is analogous to the coil method of building clay pots, which was also practiced by the Hohokam. In this case, the vessel created was not a water jug but a building – a container of space for human habitation.

One factor in the longevity of these structures is that they were built with caliche, a naturally occurring soil in the southwest that is rich in calcium carbonate, or lime. The Hohokam thus selected a building material containing a natural stabilizer, that helped the mud walls resist dissolving with centuries of rain that have fallen since the building was erected. Even in a desert which receives less than 12 inches of rain annually, over the centuries this adds up: in 700 years, nearly 700 feet of water have poured over Casa Grande.

Water damages earthen structures both upon entering the walls (water acts as a solvent, turning adobe or rammed earth back into mud) and as it exits (carrying soluble salts in solution to the wall surface, which crystallize as the water evaporates thereby causing "salt erosion" – as salt crystals form in the pores of the wall, they crush the surrounding material by their expansion). Cycles of wetting and drying are the agents of adobe deterioration. Suffice it to say, had the Hohokam built the Casa Grande with unamended mud, it is unlikely that it would have lasted so many hundreds of years.

"The sun's rays touch the edge of one of the openings in the wall of the Casa Grande at summer solstice." Photo courtesy of Western National Parks Assoc.

Casa Grande ca. 1890. Photo courtesy of the National Park Service

The floors and roofs of Casa Grande were structured of timber beams with brush lathing spanning between them, and earth fill over this. Spanish and Mexican immigrants to the Sonoran Desert used the same system centuries later. It is analogous to modern reinforced concrete construction, with the wooden elements providing the tensile strength (like reinforcing steel), and earth the compressive strength (like concrete).
Ironically, Mexican and Anglo farmers and ranchers hastened the deterioration of Casa Grande in the 19th century. These early pioneers took the beams out of Casa Grande to use in the construction of their own houses. Once the roof was removed the earth walls were of course more exposed to the elements, and began to erode more quickly, in spite of which the 700 year old ruin still stands. The Casa Grande complex is a demonstration of the durability of earth construction, if sound design principles are followed.

Labyrinth etched in earth at interior of Casa Grande.
Photo courtesy of the National Park Service

DESIGN FEATURES

The Casa Grande may have been a ceremonial or sacerdotal structure, and may have contained a granary (the community's store of grain being its treasury). The structure may also have served a defensive purpose, as the tallest building in central Arizona providing a suitable vantage point to survey the surrounding broad, flat floodplain of the Gila River. As is typical of early agrarian societies, it is likely that the leadership was priestly and that their religion was based on bringing rain, knowing when to plant, and so on. There are indications that astronomical observations were built into the structure. A spiral shaped maze is inscribed in the earth surface, being possibly a religious symbol or calendar. Small apertures in the Casa Grande have been found by archeoastronomers to align with sunrise at the winter and summer solstices, and other openings that align with the equinox. The building itself may have served as a sort of calendar, letting the priests know when to predict the rainy season, and order planting of the fields.

Casa Grande is evidence of a sophisticated society with knowledge of the abstract calculations necessary for its construction. The plan form is reminiscent of early Greek temples in its simplicity and balanced proportions. It is made up of five elongated rectangular rooms per floor, grouped so that a three-part division is achieved either north to south or east to west. That is, three long rectangles are placed side by side forming a center section, with the remaining rectangles placed one across each end. This resolves into a single large rectangle. The plan resembles a Chinese ideogram or symbol, it has such a strong visual arrangement. The center room rises to three stories in height The surrounding rooms are two stories in height. There are eleven rooms all together, five each on the first two floors plus a single upper room in the center bay.

This building measures 42 feet in width by 64 feet in length, and is from 30 to 45 feet high at the center. The earth walls are battered (tapered in section) and nearly four feet thick at their base, diminishing in thickness as they rise. This makes great sense from both the practical construction point of view (reducing the amount of material handled, and making it easier to raise the walls using the puddle adobe method) as well as from the structural viewpoint (walls should be thicker at their base as the greatest load is accumulated there). Battered walls also have a low center of gravity, making them more stable in resisting overturning forces such as earthquakes.

The simple rectangular plan creates an extremely stable shape for a rammed earth structure: every corner and cross wall serves as a buttress to resist lateral forces. The massive walls themselves have a stable proportion, as their height-to-thickness ratio is less than 10:1 -- thereby conforming to today's earth building codes. Without a doubt the Casa Grande is a major work of architecture, worthy of careful consideration for the lessons it holds in earthen construction. It is, after all, one of the oldest structures in all of North America.

THERMAL PERFORMANCE

Given the great thickness of the bearing walls, Casa Grande has an enormous amount of thermal mass as a proportion of its interior space. More than one third of the gross floor area is solid earth, in addition to the earthen roof and floors. Openings in the massive walls are few and small. Given its two and three story configuration, the inner rooms are extremely well sheltered from the harsh desert climate. When the structure was intact and inhabited, it would have functioned much like a cave – with so much mass to stabilize the ambient air temperature, it would have remained a comfortable shelter year round. Limitations of the structure are that cross ventilation is restricted, and natural light and air are inadequate by today's expectations.

New Mexico **ACOMA PUEBLO**

Sited on a mesa top in northern New Mexico, Acoma is a powerful expression of Native American culture and community. High above the desert floor, in one of the most dramatically sited cities on earth, row upon row of terraced dwellings face south toward the winter sun. The arrangement of the housing blocks leaves open space between for circulation, processions and ceremonial plazas. Crops were grown below on the valley floor. Access was by hidden trails along the cliff face, with hand and foot holds sculpted into the rock. For at least 600 years the Acoman people lived in splendid isolation, developing and refining their culture of architecture, pottery, dress, customs and religion.

Spanish explorers encountered Acoma in the early 1600s as they pushed north in search of wealth and power. The legend of the fabled "Seven Cities of Cibola" was based on fanciful accounts of early travelers, who had seen Acoma's skyline rising above the desert plain and imagined they saw a city of gold. The micaceous soil used for plaster may have created this illusion, as flecks of mica in the wall finish would catch the sun and glint like gold.

The Spanish soon enough discovered that Acoma and other Native American settlements of New Mexico were built merely of stone and mud. They nonetheless represent an advanced civilization based on the cultivation of food crops, and a pattern of dense urban living. There was no concept of private property: the land was of the Creator, belonging to everyone and to no one. People worked cooperatively for the good of the whole.

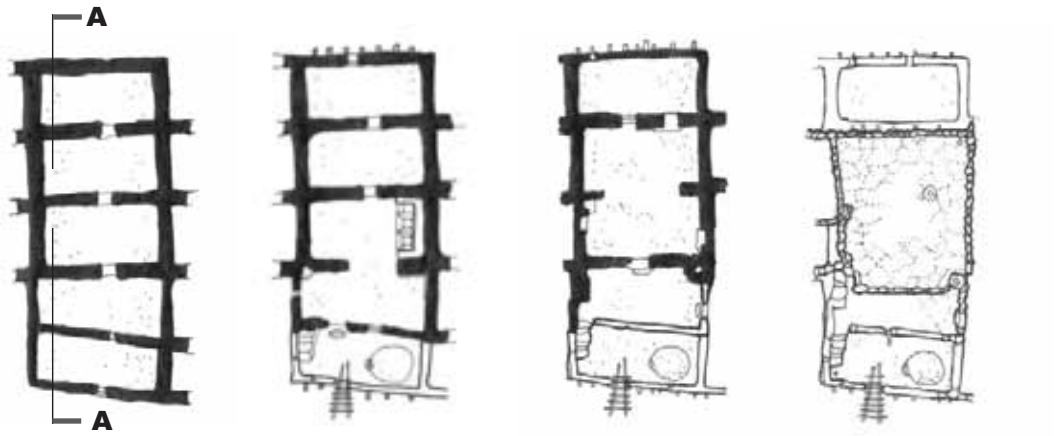
Such sedentary agricultural settlements are the basis of all culture, for they permit the contemplation of the cycle of life, of the stars and the seasons, which is the beginning of abstract thought. The Spanish described the New Mexican Indian villages as pueblos, or towns: they spoke of Acoma Pueblo, Zuni Pueblo and Taos Pueblo. Four centuries later Anglo immigrants applied the term "pueblo" to the people themselves, who are colloquially known as Pueblo Indians.

Acoma Pueblo remains largely intact to the present day. Acomans welcome visitors to their pueblo, which they call "Sky City" with good reason. Although located more than 150 miles from the U.S./Mexico border (HUD's definition of the border region), it is included here as a relevant example of high density, low rise housing. The principles of Acoma are directly applicable to the design of new affordable housing in the desert southwest.

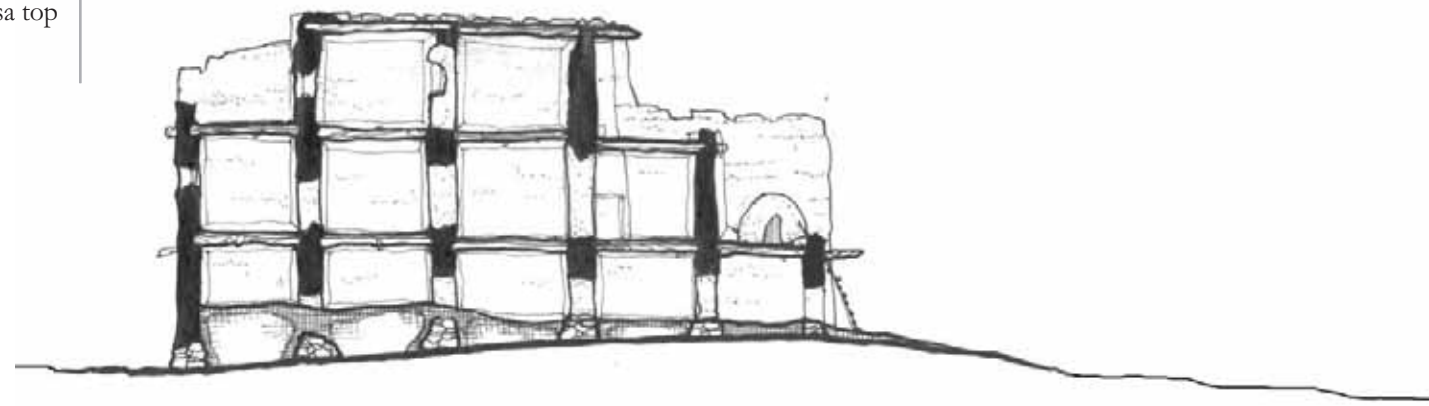
TRADITIONAL PRINCIPLES

Perhaps the most important lesson of Acoma is density and community form.

- High thermal mass walls (stone & mud).
- Houses face south to receive winter sunlight.
- Two & three story housing achieves high density and efficient use of land.
- Roof terraces on south to provide private outdoor space for each family.
- Row houses share walls along the length of the dwellings, reducing amount of exterior walls and exposure to the elements.
- Groups of row houses are placed to create public space between the blocks of dwellings, for gathering and ceremonies.
- A balance of community and privacy.
- Rainwater harvesting occurs on the mesa top in hollows dug into the stone surface.



Acoma Pueblo, Block 1 Unit 3 Plans



Acoma Pueblo, Block 1 Unit 3 Section AA

MATERIALS

The walls of Acoma Pueblo are built of stone laid in mud mortar, and plastered with mud to protect the mortar from weathering. The rock of the mesas provided the building material. Earth for mortar and plaster had to be brought from the valley below, as did timbers to support the floor and roof structures. Piñon poles and branches used for beams span across the short dimension of each room. Lighter poles, cane and brush were laid perpendicular to the primary beams, and mud plaster was spread over this. The floors were finished with smooth paving stones laid in mud mortar. The flagstones of the terraces provide a durable surface as well as an effective thermal mass to absorb the warmth of the winter sun, re-radiating this passively stored solar energy into the interior over night.

Water for mixing mortar and plaster was harvested in hollows in the stone mesa top. This source of water continued to serve the pueblo as a renewable source of domestic water, although it had to be supplemented in the dry season of the year with water brought in clay pots up from springs at the base of the mesa.

Access to individual dwellings is via the south terraces by means of tapering pole ladders designed for stability. Originally small, high doorways the size of today's windows gave access to the interiors. The original windows of Acoma were sheets of translucent mica set in the stone walls, providing diffuse natural light to the interior while maintaining privacy. Only one original mica window remains. Since the arrival of the Spanish and later under the influence of Anglo culture, larger and more conventional wooden doors and wood-frames, double-hung windows were introduced to Acoma. This altered the original architecture significantly, affecting not only the appearance but also the functioning of the spaces.

DESIGN FEATURES

Acoma is urban architecture of the highest order. The urban form is an expression of both environmental and social concerns. Blocks of two and three story high houses are aligned to face south to receive the winter sun. On the south side of each dwelling is a roof terrace accessible from the exterior by means of ladders. These terraces were used

View across roof terraces of Acoma Pueblo ca. 1930. Photo: A. C. Vroman by permission of UCR California Museum of Photography University Print Collection [79.42.225]

South facing roof terraces at Acoma Pueblo ca. 1935.
Photo: F. Hannah by permission of Arizona State Museum

historically as work spaces: here the women of Acoma would sheave and grind corn, weave cloth and make pottery. They could also tend their children in these semi-private spaces, and visit with neighbors on nearby terraces. Thus the architecture of the pueblo provided a supportive environment for a civilized way of life. The whole ensemble creates a balance of community and privacy.

Characteristic features of Acoma pueblo include corner fireplaces, capped with decorated ceramic pots to protect the chimney tops from erosion, and built-in stone benches (*bancos*) at the interiors. The sculptural shapes of the pueblos have captured the imagination of artists and writers from around the world. Among these are counted Georgia O'Keefe, Aldous Huxley and D. H. Lawrence.

Ironically, the forms of Acoma and other pueblos have been popularized as images of southwestern architecture. A stepping parapet with a ladder leaning against it can be found as a decorative feature of suburban houses -- but there are no roof terraces, no shared walls, and no use of natural materials. Stylistic revivalism uses form without substance. It is hoped that the present study will contribute to a greater understanding of the environmental and cultural meanings behind the forms.

THERMAL PERFORMANCE

Because Acoma is located in the high desert of northern New Mexico at an elevation of 6,000 feet above sea level, winter is the harshest season to address architecturally. Where the architecture of Casa Grande responds primarily to the heat of summer, with small openings, thick walls and a compact shape, Acoma steps toward the south to maximize winter insolation over the stone roof terraces. At the roof level, the builders of Acoma carried the beams over the top of the wall to provide a cantilevered overhang. This protects the wall from the high summer sun, yet allows the lower winter sun to strike the wall, warming it as a thermal mass. The cross section of a typical dwelling illustrates these attributes.

Among the most effective energy-conserving strategies at Acoma pueblo is the sharing of walls, reducing exterior exposure and the accompanying heat loss and gain. If we consider the efficiency of an enclosure as a ratio of the interior floor area to the exterior surface area, Acoma compares very favorably to a detached house. The typical single-family detached house as illustrated by the base case house at *Ch. 5*, requires 2.3 square feet of exterior surface area to enclose 1.0 sf of interior floor area. A high-density structure such as Acoma requires only 1.0 sf of exterior surface per 1.0 sf enclosed area. This means that the Acoma model is 230% more efficient at enclosing space than detached housing. This greater efficiency translates into construction cost savings and energy savings over the life cycle of the dwelling. Dramatic benefits can be realized from applying this principle.

Women of Acoma periodically renew the earthen plaster of the mud and stone walls.
Photo: P. Nabokov, by courtesy of the photographer

Tucson, Arizona **ROW HOUSE**

Europeans settled what is now the U.S./Mexico border region during the latter part of the 17th century. Following the Pueblo Revolt of 1680, settlers from the Santa Fe area retreated down toward El Paso, and built settlements and ranches along the Rio Grande in Texas and New Mexico. By the early 18th century other settlers began following the Spanish missions and presidios along the Santa Cruz and San Pedro rivers in what is now southern Arizona. As towns such as Tucson and El Paso grew, an urban type of dwelling, common throughout Mexico, was built to house these frontier families.

The row house began as a one-room adobe structure, with a front door and one or two small windows. There might have been another doorway opposite on the rear wall, opening to a back yard with a small garden and a few chickens or goats. A corner fireplace would have been the only interior feature. This was the basic dwelling type of the Hispanic settlers of northwest New Spain, now northern Mexico and the American Southwest.

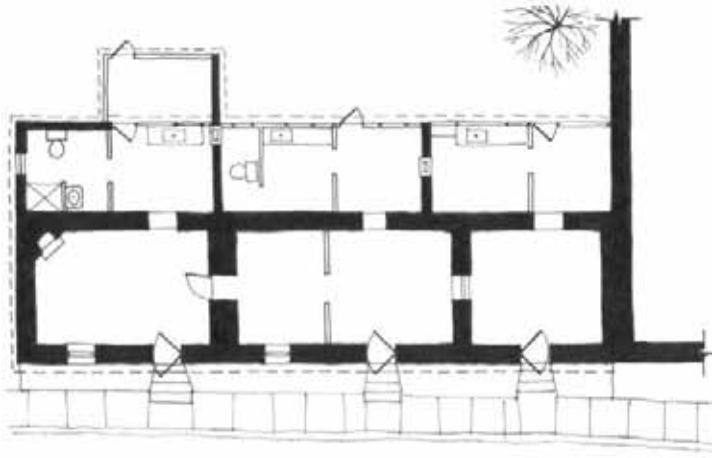
As a family grew and needed more space, additional rooms were built as resources became available. Rooms were added in a linear fashion, eventually forming a row of cellular spaces. Rooms would connect directly to one another without hallways. This is known as an enfilade arrangement. Other families would build houses adjacent to an earlier family's complex, often with shared end-walls. In keeping with Hispanic planning principles, these buildings were built to the front property line forming a continuous wall at the street. Originally, kitchens and bathrooms were treated as out buildings. Gradually these functions moved into the house by enclosing rear porches to accommodate them.

Adobe bricks were made on site or nearby. Rooms were spanned with timber *vigas* (beams) and *latillas* (lathing). In the Sonoran desert the lathing for roofs was traditionally saguaro cactus ribs, while in New Mexico *carrizo* (cane) was used. The latillas were then covered with up to one foot of earth, the most available material, and drained by *canales* (scuppers). Earthen roofs were not very effective at keeping water out, so a ceiling cloth (a *manta* in Spanish) was attached to the under side of the vigas to prevent mud from falling on furniture and occupants. With the arrival of the railroad in the late 19th century, imported materials such as milled lumber and sheet metal became available. Waterproof pitched roofs were then added above the original earthen ones.

TRADITIONAL PRINCIPLES

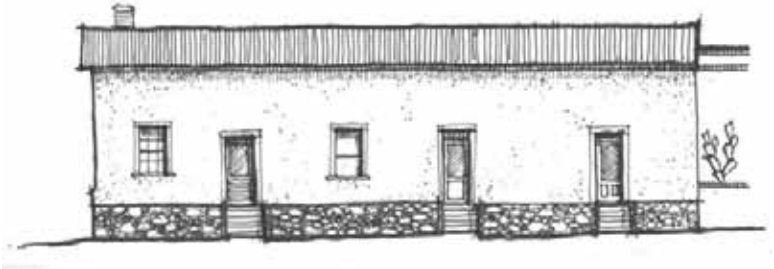
The row house demonstrates the following principles of southwestern vernacular architecture:

- High-density low-rise construction for efficient use of land.
- Pedestrian scale and density of development produces walkable neighborhoods.
- Passive cooling by cross ventilation.
- Proper orientation of row house facing south will assist passive heating and cooling.
- Potential for shared walls to reduce exposure to elements and reduce construction costs.
- High thermal mass construction (adobe).



Plan, Court Avenue row house, Tucson, AZ

North elevation



West elevation

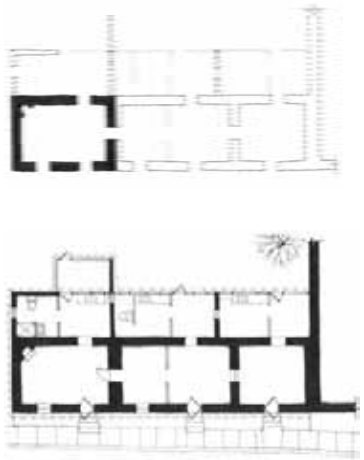
Northwest corner: window and door trim color differentiates individual dwelling units. Photo: P. Briggs

Adobe row house undergoing stabilization. With plaster removed, large joint in adobe wall is evidence how the building evolved over its 130 year history. Photo: C. Neumann

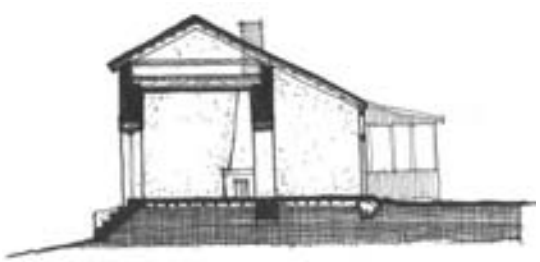
DESIGN FEATURES

The row house is a simple yet adequate dwelling type. Thick adobe walls from eighteen to twenty-four inches thick resting on stone foundations form the exterior walls. Openings are relatively small and have timber lintels, usually of mesquite in Arizona, New Mexico and Texas. Once milled lumber became available, wood casings were placed around doors and windows.

To protect the adobe from erosion, exterior walls were plastered with either mud or lime and sand. During the 20th century many adobe structures were plastered with cement, with the intention of reducing the required maintenance of the softer mud or lime plasters. This has proven to be a mistake because the cement plaster, with its hardness and low porosity, is incompatible with adobe. Cement does not allow adobe walls to transpire moisture, or "breathe". In recent years, adobe bricks have been stabilized by the addition of asphalt emulsion or Portland cement, varying from 6 percent to 10 percent by volume. Structures built with this type of adobe do not require the usual plaster coating for erosion protection because the material is water resistant and stronger than unamended mud adobe.



Plan diagram of growth over time. North unit (top plan) ca. 1870.



Adobe row house cross section

Some new adobe row houses are built with flat roofs with surrounding parapets but rather than soil, they are covered with contemporary roofing materials. They require drains or scuppers to allow rainwater to escape. Pitched roofs, often with sheet metal covering, also are utilized. Rear porches (*portales*) were often added, providing additional shaded outdoor living space. Floors were originally of compacted earth, and later of wood planks on wood "sleepers" (bearing blocks set in the earth). Today, concrete slabs are common.

Tucson, AZ: adobe row house with earthen plaster. Photo: C. Neumann

Tucson, AZ: thermal performance of individual units of row house is improved by sharing interior walls and receiving shade from adjacent vegetation. Photo: B. Vint

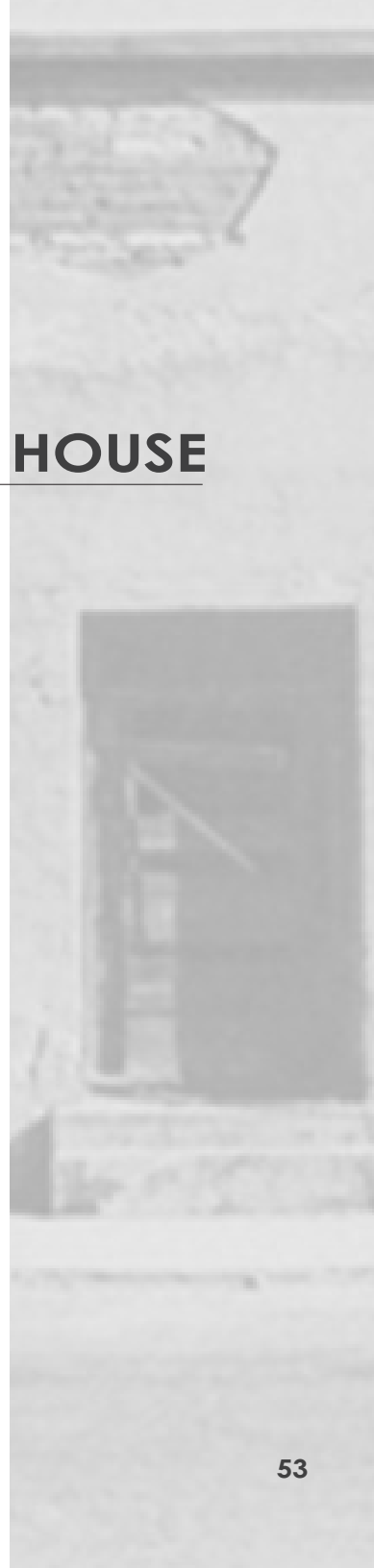
THERMAL PERFORMANCE

The adobe row house type offers excellent energy performance characteristics. The adobe walls provide thermal mass, and the pitched roof models provide the possibility of a ventilated attic space with high insulation. If the east and west walls are shaded by porches or trees, or insulated with rigid insulation between two wythes of adobe, the energy performance will be even better. The one-room thick floor plans allow for excellent cross-ventilation, reducing the dependence on energy driven fans and air conditioning. This aspect of the row house type is diminished with the enclosure of rear porches.

Compass orientation is a significant factor in the energy performance of all dwelling types, but especially in this case. The classic row house is an elongated rectangle in plan. Ideally the long axis would run east-west, so that the greatest exposure is southerly. In this way each room can receive direct solar gain in the winter, when it is desirable for passive heating. The narrowest exposures are east and west, thereby reducing heat gain in the summer.

In practice, however, row houses were built to follow street patterns without regard for solar orientation. Many historic examples face west, the least desirable orientation. This illustrates the predominance of culture in building, in which it was considered most important to follow the street pattern, rather than to orient the house to receive favorable sun.

Tucson, Arizona **ZAGUÁN HOUSE**



The zaguán house represents a progression in the evolution of the Hispanic dwelling on the northern frontier of New Spain, today's Arizona, New Mexico, Sonora and Chihuahua. As settlements grew into towns, neighborhoods became more dense and contiguous row houses lined the streets. Access to the rear yards of properties became limited. Thus a dwelling type common in other urban areas of Mexico began to be utilized. This type of house has a wide central hall that connects the front entrance with a rear courtyard or patio. Major rooms open from this hallway, which is known in Spanish as the zaguán.

Often the zaguán is wide enough for the passage of a carriage or wagon, and in some urban locations this is the only access from the street to rear accessory structures such as stables. The French porte-cochere, a covered entrance leading to a courtyard, common in Louisiana Creole architecture has a similar function. The main difference is that the French version is usually on the side of the dwelling and is not used as the principal entrance.

The zaguán house also has a counterpart in the 19th century central hall house common in the American South, especially in the former plantation regions. However, these examples are usually cottage type dwellings that are raised off of the ground, thus the center hall, being at a higher elevation than the exterior grade, is only accessible for foot traffic.

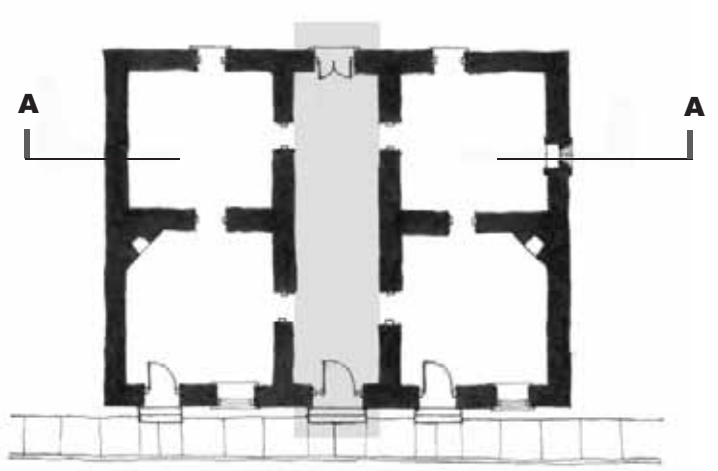
Research by the authors in southern rural New Mexico revealed a similar house type with a wide central hall that is referred to by the ranching families who built and dwell in them as a "dog-run." The dog-run is in many respects the equivalent of the zaguán: it is a matter of speculation as to whether the homonyms "dog-run" and "zaguán" are a matter of coincidence, or whether the similarity betrays an Anglicization of the Spanish term.

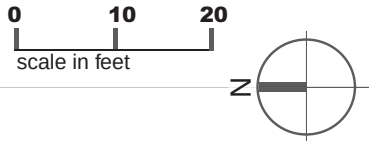
In the north of Mexico the zaguán house is found more often in urban rather than rural areas, and normally in dwellings close to or facing a plaza.

TRADITIONAL PRINCIPLES

The zaguán house demonstrates the following principles of southwestern vernacular architecture:

- Compact form minimizes exposure to the elements.
- Pedestrian scale and density of development produces walkable neighborhoods.
- Passive ventilation by means of central zaguán.
- High ceilings permit stratification of air by temperature.
- High thermal mass construction (adobe).





Plan, Casa Carrillo, Tucson, AZ. zaguan highlighted at center

West elevation

Section A-A

DESIGN FEATURES

With few exceptions the zaguán houses of northern Mexico and the American southwest are built of adobe. The front elevation of the zaguán house is plain, usually finished with stucco, and with little ornamentation. Openings are tall and narrow, and placed symmetrically on both sides of the entrance. The front entrance door is usually reached by steps if the floor level has been raised to accommodate wood flooring placed over an original earthen floor. Occasionally transom windows are placed above door openings for light and ventilation.

The zaguán house has rooms with ceilings of twelve to fourteen feet in height, resulting in parapets sixteen to eighteen feet above grade. The scale of this dwelling type is prominent, and this free-standing plan type was used by the leading citizens of a town.

Vigas span the roof from bearing wall to bearing wall: the length of available timbers determined the sizes of rooms. Originally these dwellings had cactus ribs and soil on top of the vigas. Gradually, the exposed sod roof gave way to standard built-up-roof applications. Rear elevations are either flush or have attached porches with sloped roofs. Rooms are at least two deep and are accessed from the zaguán and from each other. Generally, fireplaces are located in corners in order to spare wall space for connecting doors and windows.

Tucson, AZ: Zaguán used as sitting room ca. 1890 E.N.Fish House.
Photo courtesy of Tucson Museum of Art

THERMAL PERFORMANCE

Traditionally cooling in the zaguán house was provided by natural cross ventilation. By opening the house at night and allowing the day's heat to escape into the cool night sky, one can store the night's coolness in the thermal mass of the interior adobe walls. By taking advantage of the dramatic diurnal temperature swings of the hot, high, arid desert, vernacular houses achieved livability.

Heat for the winter was provided by fireplaces located at interior walls to conserve heat and, again, to store the heat energy in the adobe thermal mass.

Because the zaguán house is detached or freestanding, it has relatively more exposed surface area than the row house, which shares walls with neighboring houses. There is thus

Barrio Viejo, Tucson, AZ: West facade of Casa Carillo.
Photo: B. Vint

Ures, Sonora: Facade of zaguán house from street. Photo: B. Vint

View through zaguán to internal courtyard beyond. Photo: B. Vint

greater heat loss and gain. Further, with the zaguán house being two or more rooms in depth, natural cross ventilation is somewhat limited.

Nonetheless, this type of house is a simple rectangular volume, and is more efficient in terms of the enclosure of space in comparison with the more extended courtyard-type house. The zaguán itself serves as an air distribution device, because it connects each interior space and the patio. Traditionally, cool air was drawn from the back garden or patio through the house via the zaguán: the passive ventilation is augmented by heated air rising from the street, creating a convective cycle of air movement.

Zaguán dwellings tend to have darker interiors than row houses due to their greater depth, which is a passive cooling strategy. Direct sunlight contributes to heat gain and in hot months heat reduction is a crucial function of vernacular desert architecture.

Interior of zaguán, which functions as a breezeway. Photo: B. Vint

Tucson, Arizona **COURTYARD HOUSE**

The idea of building a house around a *patio*, or open courtyard, originated with the ancient Mediterranean civilizations. Early examples are found from 2,000 to 3,000 years ago in Egypt, Greece and Rome. The concept is to capture a portion of outdoor space by the placement of rooms to define an open-air courtyard. This can be transformed into a micro-climate or oasis, providing both privacy and shelter from the elements. In a hot-arid climate these houses make sense climatically, urbanistically and economically because of their shared walls, self-shading configuration, and efficient land use.

The Romans developed the centralized atrium house as a group of rooms surrounding a small open-air court, often with a central fountain. A loggia, or porch, bordered the court on three to four sides, providing shade. The courtyard functioned as a comfortable outdoor living space, with the sound of water trickling in a fountain. In Roman architecture, these spaces are known as peristyle courts, named for the type of surrounding columns. Within the bustling cities of the Roman Empire, the congestion and noise of the street were shut off from the occupants of the peristyle house.

The Arabs developed the courtyard house in response to the deserts of Arabia and North Africa. Their courtyards were oases of flowering and aromatic plants, together with fountains and pools. Spain received the patio as the legacy of both the Latin and the Islamic cultures. From Spain the courtyard was brought to central Mexico in the 1500s, and then north to the area that is now the U.S./Mexico border region in the late 17th century. In northern Mexico, the courtyard house was employed with great flexibility. There are examples of central courtyards completely surrounded by living spaces, as well as offset courtyards defined by L-shaped houses. There are U-shaped houses, with rooms on three sides of a courtyard.

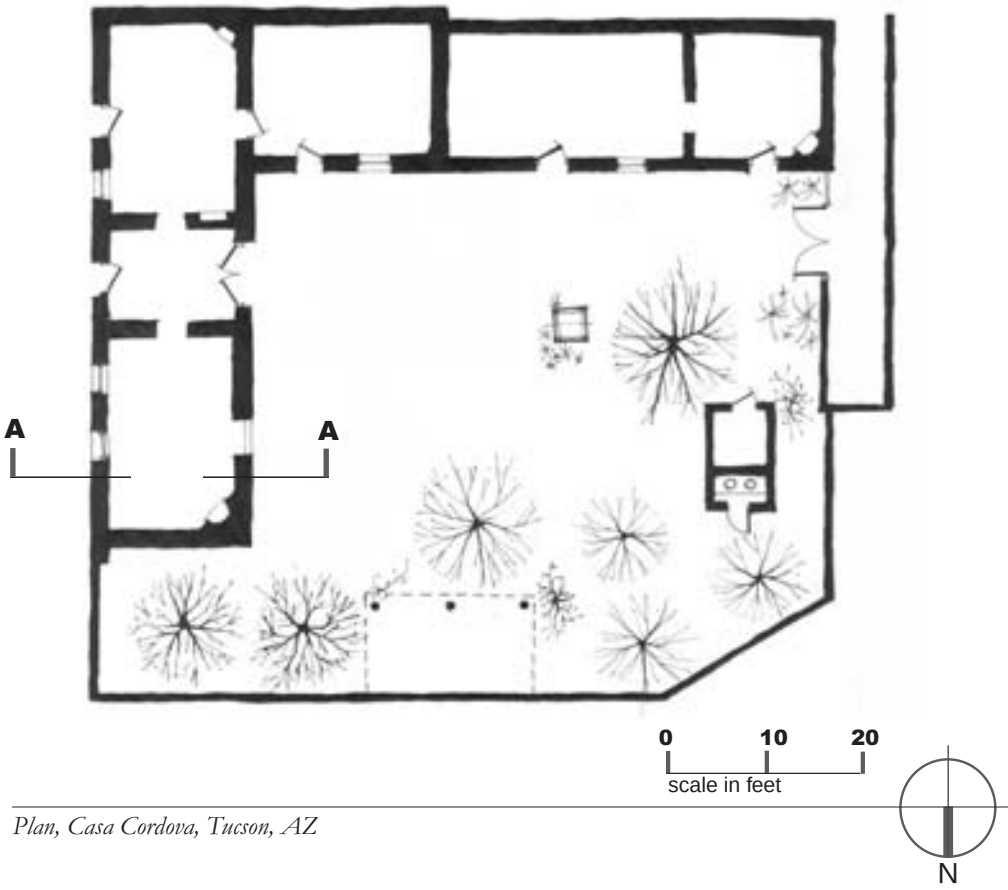
Historically, the courtyard serves various functions. First and foremost it provides privacy within an urban context, in which the inhabitants can relax, prepare food, keep a few small animals or tend a vegetable garden. The courtyard is in essence a large outdoor room, often the largest room in the house. Being open to the sky, it provides ventilation, bringing fresh air into the interior of the house. The plants and shade serve both to cool and filter the air, as it sinks into the space and flows through the rooms.

Contemporary courtyards tend to be smaller than the historic examples, and are used primarily for outdoor living. They are planted with shrubs, flowers, and small trees, and often have a fountain or pool as the centerpiece of the space. A small house can feel more spacious if each room opens onto a courtyard.

TRADITIONAL PRINCIPLES

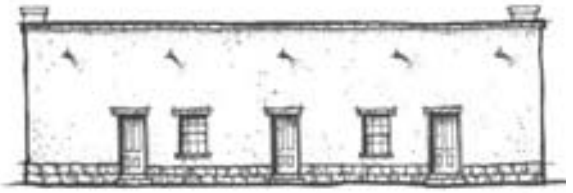
The courtyard house demonstrates the following principles of southwestern vernacular architecture:

- High-density, low-rise construction creates efficient land use, while maintaining private outdoor space in courtyards.
- Pedestrian scale and density of development produces walkable neighborhoods.
- Passive evaporative cooling by creation of oasis micro climate.
- Proper orientation of courtyard facing south or east will assist passive heating and cooling.
- Potential for shared walls to reduce exposure to elements and reduce construction costs.
- High thermal mass construction (adobe).
- Rainwater harvesting for irrigation of courtyard planting.



Plan, Casa Cordova, Tucson, AZ

Section A-A



East elevation

DESIGN FEATURES

The exterior of the courtyard house is austere, and the house is placed close to the street, much like the row house or zaguán house. The historic courtyard houses of northern Mexico and the American southwest are built with adobe walls, typically having a stone base to protect the adobe from moisture. Although resembling a foundation, the base is often only a layer of stone applied to the wall: often the adobe bricks were laid directly on the ground, or in a shallow trench.

The façade is plain, often plastered with lime and sand, and typically devoid of applied ornamentation. Openings are generally tall and narrow expressing the limits of adobe construction and placed symmetrically about the entrance. Wood lintels of locally available timber, such as mesquite or cottonwood, are sometimes left exposed. Transoms were occasionally used to provide cross ventilation through the entry hall or zaguán. If the floor level has been raised to accommodate wood planks over an original dirt floor, the front entrance door is accessed from the sidewalk by set of steps.

The principal rooms of the courtyard dwelling have high ceilings, often from 10 to 12 feet above floor level, permitting air to stratify within the space. Roofs are traditionally heavy timber-framed, with wood planks or lathing supporting a layer of earth approximately one-foot thick. The roofs are surrounded by parapets, and slope gently to drain through the parapets via *canales* or drain scuppers. Secondary rooms or additions often have lower ceiling heights than the principal rooms, such that roof and parapet heights may be lower over these spaces. Kitchens were traditionally located on the courtyard to allow the heat from cooking to dissipate. Prior to indoor plumbing, latrines were logically located at the far end of the patio.

The courtyard dwelling is typically accessed from the street via a zaguán, which connects to a covered exterior *portal*, or porch, along one side of the courtyard. It can be seen as a hybrid or an evolutionary house form, combining the adobe row-house with a zaguán leading to a patio behind the house.

Typically the house surrounding the patio is only one room in depth, so that all spaces open directly onto the courtyard. Some rooms are accessed only from the courtyard, usually via the portal.

When grouped together, such houses create a continuous wall along the street, providing shade for pedestrians. Examples of this type of dense, humane urbanism are found throughout Mexico, and in many of the towns of Sonora, Arizona, and New Mexico. Arizpe, Aconchi, Huepac and Ures are Sonoran towns which typify this approach. The oldest barrio in Tucson, Arizona, and the town of La Mesilla, New Mexico, are examples on the U.S. side of the line.

THERMAL PERFORMANCE

In the deserts of the U.S./Mexico borderland, the summer's heat is intense, while winters are mild. Hence vernacular houses were adapted primarily to address the hot months of the year, May through October. Traditionally, cooling was achieved by passive methods,

East facade of Cordova House. Photo: C. Neumann

Cordova House, Tucson, AZ: View of inner courtyard. Photo: C. Neumann

including night time through-ventilation, thermal mass storage, and evaporative cooling by means of the oasis effect. Heating was provided by fireplaces distributed throughout the house.

The courtyard house is built on the oasis principle, creating a garden at the heart of the house. As the dry desert air absorbs moisture from the plants and fountain of a courtyard, it is cooled by evaporation. The sensible heat of the air is reduced, as its latent heat, in the form of water evaporated, increases. The humidified air feels cooler to the senses.

The zaguán, or breezeway, complements this passive cooling strategy. As cooled air sinks into the patio, it is drawn through the house by passive cross ventilation. For this to function, the rooms must open to one another. The adobe walls provide high thermal mass which tempers the interior environment throughout the day. People inside the house will feel comfortable even if the air temperature is higher than customary comfort levels, because the body can lose heat by radiation to the cool mass of the wall, as demonstrated by the research in the thermal section of *Ch. 4, Performance.*

Guadalajara, Jalisco: Courtyard provides evaporative cooling with central fountain and vegetation. Photo: B. Vint

Traditional flat earthen roofs provide little insulation and leak notoriously in the summer rainy season. With a pitched wood-frame roof added above the original earth roof, it is possible to create a ventilated attic with space for high insulation. This allows air to move through and carry away heat build-up, with a blanket of insulation laid over the ceiling to reduce heat gain and loss through the roof.

Because courtyard houses have relatively more perimeter wall than simple rectangular houses, there is greater exterior wall are subject to heat loss and gain. This can be mitigated by joining courtyard houses with shared walls, which has the added advantage of reducing construction costs as well.

In the harsh desert summer environment, west facing adobe walls can experience excessive heat gain. This can be addressed within the courtyard by porches or portales to shade the walls. At exterior west-facing walls, rigid insulation can be installed between the wythes of adobe in a double-thick wall.

The benefits of the elongated floor plan include increased natural light and cross ventilation, due to the number of windows and doors and the narrow room layout. The courtyard allows for outdoor living and dining, thus reducing the need for larger interior rooms that would require mechanical heating and cooling.

Tucson, Arizona **CELLULAR HOUSE**

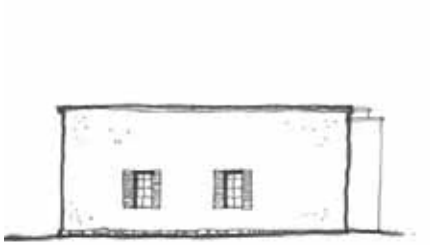
This is one of the greatest buildings in Tucson, Arizona, located at 140 North Main Avenue, and now part of the Tucson Museum of Art. It represents an evolution of traditional architecture in the southwest. It began as a single room adobe house which was joined to a zaguán house, and then continued to grow, room by room, until it formed a U-shaped courtyard house. It can be described as a hybrid house, embodying three distinct vernacular house forms combined into a multi-cell structure.

A cellular house of this nature creates a continuous, dense urbanism. It fills an entire city block from end to end. The buildings are brought to the street front, with private courtyards behind. This is the traditional architecture of Sonora, as witnessed in the towns of the Rio Sonora Valley. It makes a lot of sense for the climate and the culture of the southwest.

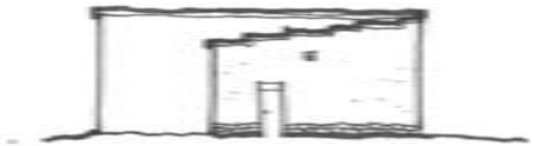
When the Fish/Stevens house was built, southern Arizona had only recently become part of the United States via the Gadsden Purchase of 1854. The earliest record of property ownership concerns the purchase of the house in 1862, indicating that it existed prior to that time. Although known by the name of its owners, Mssrs. Fish & Stevens, the house was undoubtedly designed and built by Mexicans. It incorporates the principles of desert architecture as practiced in the mid 19th century, and demonstrates that when the first Anglo immigrants arrived in the southwest they looked to Hispanic builders for housing.

TRADITIONAL PRINCIPLES

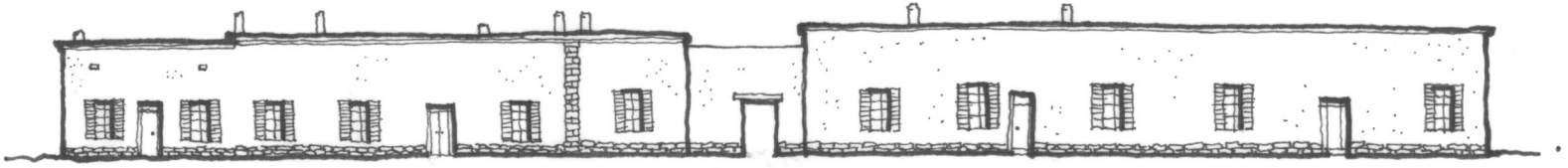
- Thick earthen walls for shelter and thermal mass.
- Simple rectangular building forms for ease of construction and structural stability.
- Compact shapes that minimize exposure to the elements.
- Small openings to reduce heat gain.
- Continuous dense urbanism creates high density housing environment.
- Private courtyards provided away from the street.



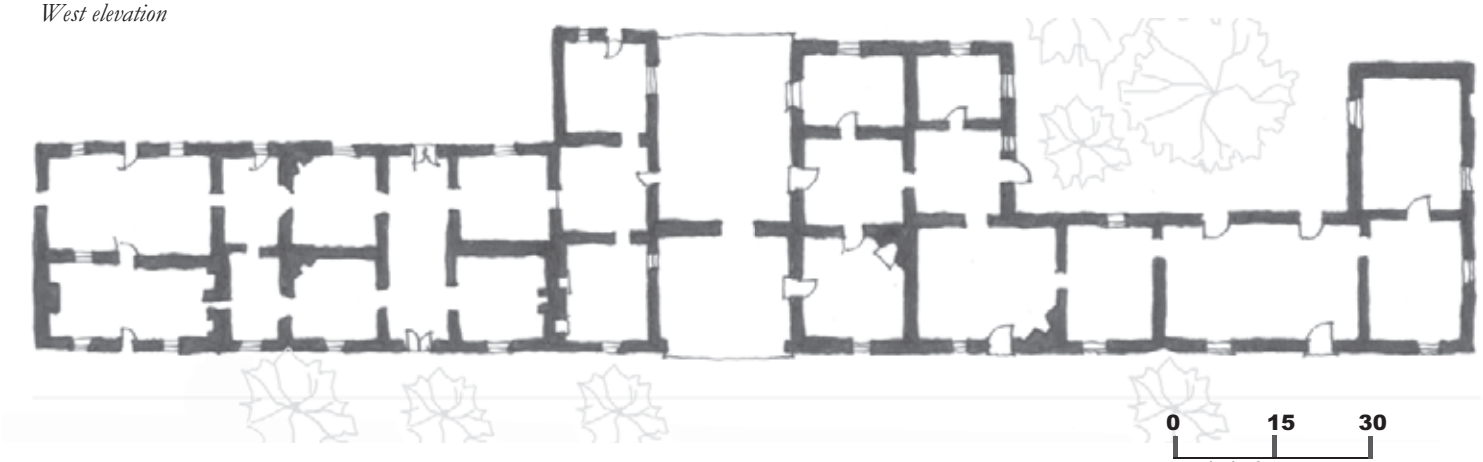
South elevation



North elevation

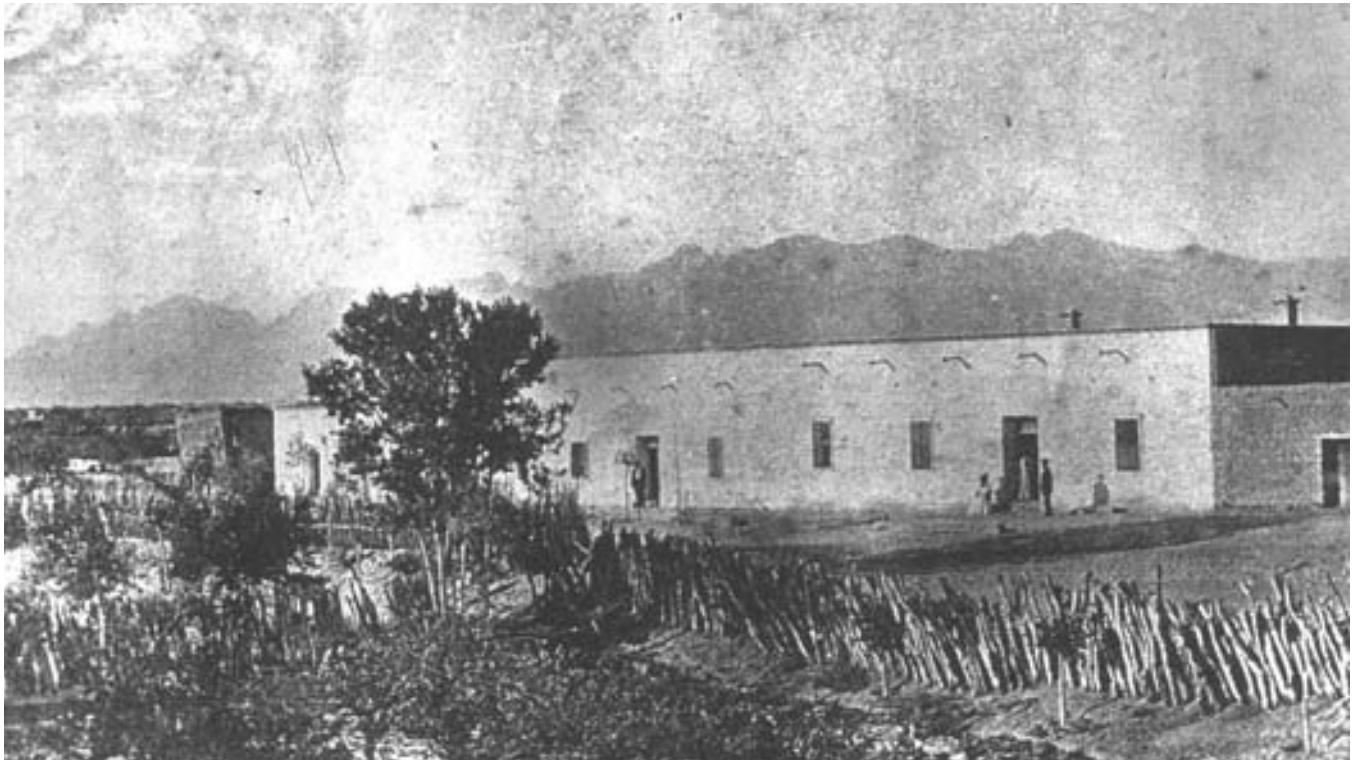


West elevation



Plan at present showing Duffield, Steven, and Fish Houses, Tucson, AZ

Fish Stevens house, ca. 1870. Photo courtesy of Tucson Museum of Art



Shutters and Pepper trees provide shade at west facing wall. Photo: C.Neumann

MATERIALS

The walls of the Fish/Stevens house are 24" thick mud adobe, finished inside and out with lime and sand plaster. Foundations are of rubble stone masonry set in lime mortar, in shallow trenches. The roof is framed with squared mesquite wood timbers and wood lathing spanning between. The type of lathing includes both traditional saguaro cactus ribs, and wood slats from packing crates stamped "Edward Nye Fish & Co." – recycled from the family store for the construction of additions and repairs. Above the lathing is a traditional earth roof, varying from 9" to 12" thick. In the early 20th century a milled 2x4 roof was propped over the original, as was typical in the evolution of Sonoran houses following the arrival of the railroad. This creates a ventilated attic space between the earth ceiling and the sloped modern roof, which is waterproofed with built-up asphalt roofing. Floors were originally tamped earth, later wood, and later still colored concrete slabs. In the northern rooms wood floors remain.

DESIGN FEATURES

Fish/Stevens exhibits all the characteristics of traditional Sonoran architecture: massive adobe walls for shelter from the extreme desert heat, dramatically high ceilings to permit the stratification of air within the interior (allowing heated air to rise and relatively cooler air to sink to the ground level where people were), small window and door openings to the street, and a garden court behind where the family maintained its privacy. These are all natural responses to the desert.

Fortress-like west wall of Fish House provides an excellent thermal barrier against the desert's heat. Photo: C. Neumann

The resulting building is a massive, simple, rectangular volume, extending continuously along the east side of Main Avenue from Alameda Street to Paseo Redondo. The adobe walls are 18 feet in height at the exterior, and ceilings are 14 feet high. The proportion of the openings is tall and narrow, consistent with the nature of adobe construction. The percentage of solid wall far exceeds the percentage of openings (doors and windows), which speaks of the desire of Tucson's early builders to seek shelter from the sun. Overall, the Fish/Stevens house has a great presence on the street, and a powerful beauty resulting from its unpretentious design.

THERMAL PERFORMANCE

Since this example includes all the forms of the Hispanic vernacular, it was selected for engineering analysis in the thermal modeling section of this study (see *Ch.4, Thermal Performance.)*. While the house has the benefit of massive walls and high ceilings, the orientation is a drawback. The house runs north to south on its long axis, meaning that the east and west elevations are exposed to maximum solar gain. This orientation is a disadvantage over the summer months. The house would perform better climatically if it were rotated 90º to run east-west with a long southern exposure. This would be ideal for passive solar gain in the winter months, and present the narrow sides of the house to the most intense sun over the summer. Climate was not the main determinate in the design of this house. as it was built to follow the alignment of the principal street in Tucson, known in the Spanish period as the *Camino Real* (the Royal Road, oriented towards the seat of power in Mexico City). Political organization shaped the urban form, which in turn shaped the architecture.

Tucson, Arizona **HYBRID HOUSE**

The hybrid house combines the row house, zaguán house, and courtyard house of the Hispanic vernacular with traditional design concepts brought from the eastern U.S. by Anglo immigrants. It is a unique expression of cultural integration in the U.S./Mexico borderland that is not found elsewhere.

With the building of the Southern Pacific Railroad in the 1880s, connecting major settlements between west Texas and southern California, Anglos from the east began arriving in large numbers. They brought with them ideas about building that were combined with Hispanic patterns of house and town making.

Late 19th century Anglo immigrants to Tucson, Las Cruces, or San Diego found an architectural culture in place: the Hispanic tradition of adobe construction, row houses, zaguán entry ways, and courtyards. The established builders of the region were Mexican, building in the common language of the vernacular. The new arrivals wished to include in their dwellings familiar features from "back east," such as porches with decorative columns, bay windows, and French doors. These combined preferences, along with availability of materials and skilled labor, led to the development of the hybrid house.

The C. O. Brown house in Tucson, Arizona, is a complete example of this house type. It extends full depth in the middle of a city block, fronting on Jackson Street to the south and Camp Street (now Broadway) to the north. Originally it was flanked on each side by similar adobe houses, which have since been demolished. C.O. Brown remains a clue to the vernacular hybrid architecture of central Tucson.

The southernmost section was built in the 1840s, and is a classic three room adobe row house. This portion is the oldest surviving building in the city of Tucson proper (although ten miles south of the city center is the San Xavier Mission and adjoining convento, dating to 1783). The C.O. Brown house grew and evolved over a period of 60 years, through the end of the 19th century when Anglo elements were incorporated.

TRADITIONAL PRINCIPLES

- Thick earthen walls for shelter and thermal mass.
- Glazed south-facing porch for passive solar gain.
- Passive cross ventilation via zaguán and operable transoms.
- High density, low rise housing environment.
- Private courtyard /oasis provided away from the street.

Section A-A looking north towards sun space

Site plan featuring large interior courtyard

The bearing walls of the C. O. Brown house are of unstabilized adobe. Some sections of adobe were laid on stone rubble foundations, others directly in shallow trenches. That they have endured for over a century demonstrates the durability of adobe when properly built and maintained. The walls are finished with lime & sand plaster, which at the south six-room block has been scored to resemble cut stone blocks with stylized quoins at the corners, a pretension toward elegance in the vernacular.

The floors were originally of compacted earth, then wood strip flooring was laid over sleepers, and later concrete was used to replace rotted or termite-damaged wood. Several rooms at C. O. Brown retain wood floors dating to the historic period. Windows, doors, and frames are of wood. Some panes of glass display the ripples characteristic of 19th century float glass.

The roof is framed with heavy timbers, including a mix of mesquite and pine and both rough and milled lumber. Above this is propped a lighter framed roof of full 2" by 4" lumber with 1" by 8" planks and corrugated sheet metal roofing. The roof slopes inward to the patio, directing rain water to courtyard planting.

North elevation (above) and South elevation (below)

Views through north building zaguán.
Photos: C. Neumann

DESIGN FEATURES

Similar to its Spanish antecedents, the Hybrid Hispanic/Anglo House fronts the street while accomodating a private courtyard. The moderately pitched roof is concealed by a parapet, and drains to the interior patio.

The original three rooms on Jackson Street were replicated with a second rank added behind them. This created a six room block, two rooms deep by three rooms long. The street wall of this portion is classically balanced: a set of three doors, each centered in the space it serves, with pairs of tall, narrow casement windows placed symmetrically about each door. The exteriors of the windows are trimmed with classical revival elements, the suggestions of flat pediments or cornices.

Attached to this compact adobe box is a continuous wood-framed porch facing an open patio or courtyard. The east and north sides of the patio are defined by an "L" shaped house, which grew from the north to create a generous central compound. The north building is where the fusion of Anglo expectations with Hispanic building practices takes place.

At the north, the C.O. Brown house is held back from the street to provide space for a front porch, an element of the Anglo vernacular. The porch displays Victorian features, such as lathe-turned posts, decorative brackets, and rows of turned spindles under the eaves, indicative of the 1890s time period.

South facing sun space in north building. Photo: C. Neumann

After crossing the wood framed porch, one enters a traditional Hispanic zaguán that passes through the depth of the house into a glazed south porch, another Anglo idea. The south porch is enclosed with double-hung windows placed side by side in the upper two thirds of the space, and vertical bead-board wainscot in the lower one third. The glazed porch acts as a sun room in the winter, when the low sun streams in to warm the space.

Principal rooms have very high ceilings (fourteen feet) and operable transom windows above connecting doors. The long leg of the "L" plan runs along the east, and is one room in depth. This row of rooms has a continuous porch, partly open, partly enclosed with adobe, and partly glazed with wood sash windows. The interior has bead-board wainscoting, another Victorian touch. In this house, one sees architectural ideas and concepts of space from different traditions, such as the courtyard and the porch, joined seamlessly together.

THERMAL PERFORMANCE

The adobe walls of the Hybrid House provide excellent thermal mass. The linear floor plan allows for cross ventilation. Attic spaces should be highly insulated to reduce heat loss and gain through the roof. A south facing porch will shade the high summer sun, and also allow the lower winter sun to warm adjacent rooms. The porches and courtyard encourage outdoor living, reducing the need for conditioned interior space. There is space in the courtyard for a vegetable or flower garden.

One of the truly great vernacular buildings of southern Arizona, the Empire Ranch, dates from the second half of the 19th century. The ranch, appropriately named to reflect its enormous size, was originally owned by Tucsonan Edward Nye Fish and included a gold mine called "The Total Wreck." The cattle ranching and mining operations carried out from this headquarters are emblematic of Arizona's history over the last three decades of the 19th century. The Empire even found its way into the legendary cinema of the American west, when John Wayne filmed Red River there in 1949.

The earliest part of the ranch house is the north quadrant where four square rooms surround a central zaguán. This is the purist form of the Sonoran vernacular, and was built in 1871. As the cross-section demonstrates, the building originally had an earth roof over timber beams, above which a gabled roof of milled lumber and wood shingles was added in the early 20th century. The original house served as the bunkhouse for the cowboys, as well as kitchen, mess hall, and meat locker. Early history tells of bringing cattle through the zaguán into a closed corral for protection from Apaches. The compact gathering of rooms, which make up the Empire compound, reflects the need for defensive architecture.

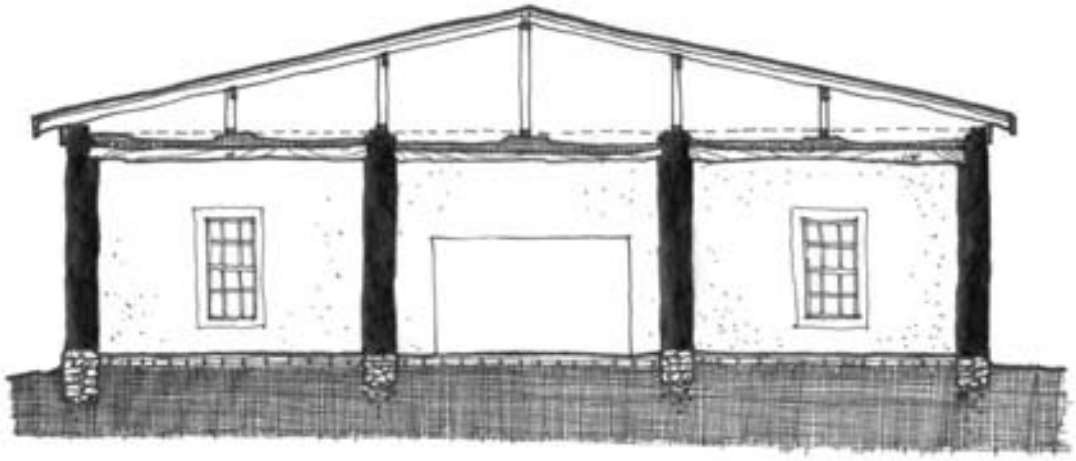
The house grew, as did the size of the ranch, with the addition of a wing for offices, a kitchen and cook's quarters, taking the form of a row-house that extends from the southwest corner of the original house. This was supplemented in 1881 with the T-shaped Victorian addition to the southwest, built by new ranch owner Walter Vail for his bride, Margaret, who traveled west from New England to join her husband. This elaborate addition with its steeply pitched roof was intended to make the western ranch feel homelike for an eastern woman. It is thus a hybrid work combining an imported eastern style with native adobe construction.

Finally, a wood-framed children's wing was added after 1884 on the southeast corner, adjacent to a covered corral for the family's horses. The ranch children could open the door from their bedroom, and literally step into the corral to choose a horse to ride for the day.

The walls of the Empire compound are adobe, with the exception of the Children's Wing, which is wood, framed with shiplap wood siding. This reflects post-railroad construction, and perhaps expresses Mrs. Vail's desire to create an eastern-style home for her children. The complex follows the pattern of Sonoran earth-roofed dwellings being transformed by the addition of pitched framing lumber roofs above. The upper roofs are finished with a mix of corrugated galvanized iron sheets (known colloquially as "tin roofing"), built-up asphalt roofing (rolled roofing felts impregnated with asphalt emulsion for water repellency), and wood shingles (historically red cedar). Of these materials, the most durable has proven to be the metal.

TRADITIONAL PRINCIPLES

- Use of building volumes to create sheltered outdoor spaces.
- Porches to shade west side.
- Interior partitions of adobe or similar high-mass walls.
- Combination of heavy and lightweight construction in different areas of house.
- Fireplaces or wood-burning stoves for heating.
- Passive cooling by natural cross-ventilation and high thermal mass.



Section A-A

Tightly grouped buildings constitute the Empire Ranch headquarters in the rolling grasslands of Sonoita. Photo courtesy of Laura Vail Ingram, Empire Ranch Foundation

Plan, Empire Ranch, Sonoita, AZ

Walls are coarsely plastered inside and out, although historic photos show that the exterior plaster was added late, around the turn of the 20th century. Windows and doors are wood framed and painted white. Floors are concrete slabs in the oldest north section (replacing the original earth floors) and 1x4 wood planks in the southern sections. Overall, the buildings follow the Sonoran adobe tradition, with tall ceilings, high parapets, and simple rectangular forms. Unlike urban examples, however, which have the discipline of street alignments to follow, the Empire grew organically in an irregular pattern. By its form the house creates various outdoor spaces around it. The west side, north of the T-shaped addition, was Mrs. Vail's rose garden. The southeast corner held the horse corral. The central area was the cowboy's domain, where saddles were stored and the cook served meals. The Victorian Addition and Children's Wing each have porches on the west side. This of course makes a lot of sense to protect the house from the summer afternoon sun. The west orientation is the harshest of all in the desert, and it is an excellent practice to provide shade at the west.

Sheltered outdoor space of the Empire Ranch. Note gabled roof framing in progress over original adobe parapets. Photo courtesy of Laura Vail Ingram, Empire Ranch Foundation

THERMAL PERFORMANCE

The Empire Ranch house has stood in the high Sonoran desert for over 130 years without the benefit of, and without a need for, artificial cooling. Given the elevation of 4,700 feet above sea level, summer temperatures are approximately 5° to 10° cooler than on the desert floor in Tucson. This makes a great deal of difference in terms of human comfort and people's willingness to endure. With outdoor temperatures seldom exceeding 100°F , interior ambient air temperatures are seldom more than 80°, which is tolerable for most people, especially when an additional cooling effect is achieved by radiation (heat loss) to the cool mass of the adobe walls. To make this effect possible, the interior partitions should be adobe as well as the exterior walls. The combined effect of thermal mass and natural ventilation more easily keeps summer interior temperatures comfortable in rural areas which are naturally cooler due to higher elevation and increased wind speeds. As with most rural vernacular houses, winter interior temperatures at the Empire Ranch are typically below occupant comfort levels, and heating is supplemented with fireplaces distributed throughout the complex.

Animas Valley, New Mexico **GRAY RANCH**

In the far southwest corner of New Mexico, in the area know as the "boot heel," which juts down beside Arizona, Sonora and Chihuahua, is found the Gray Ranch. In the 1880s a former Texas Ranger and cattle rustler named Michael Gray staked a claim to nearly 500 sections (500 square miles) of open range in the high semi-arid grasslands of the Animas Valley. Gray and his sons ran tens of thousands of cattle (of dubious origin) on this spread, until they were killed by Chiricahua Apaches in the Guadalupe Pass through the Peloncillo Mountains into Arizona.

In the early 20th Century, the former Gray Ranch was again homesteaded, this time by several ranching families who built their houses and cowboy camps in remote areas around the ranch. The camps are named for the families that ranched them, or for local landmarks or brands. They have names like Lynch Camp, the OK-Bar, Fitzpatrick's, Godfrey Camp, Culberson's (where General Blackjack Pershing set up headquarters in his futile chase of Pancho Villa during the Mexican Revolution), Double Adobes, the Howe, and Upshaw.

The houses were built from 1910 to 1920, and represent a true western vernacular. They were built in extremely remote places by their owners and cowboys, on limited budgets, and with as many local or scrounged materials as possible. To this day, the Gray Ranch is one of the least populated places in the U.S.

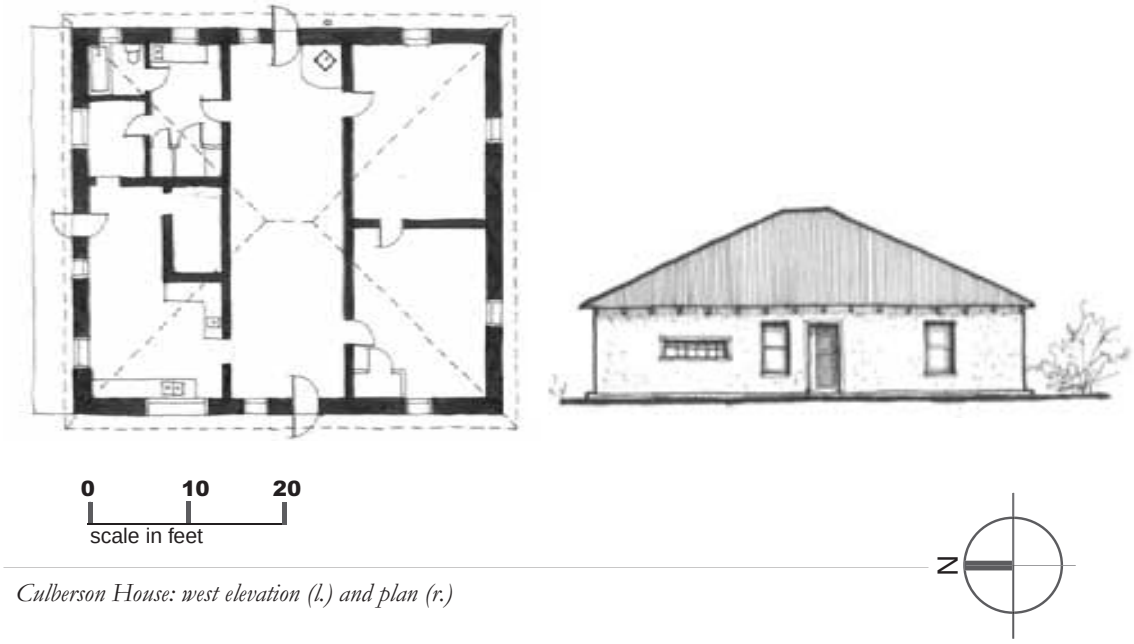
To visit the Gray is to travel back in time a hundred years and witness the ingenuity of country people getting by with the absolute minimum of resources. They built simple yet effective houses that yet contain lessons on housing for their environment.

All the houses on the Gray are built primarily with adobe walls, with the bricks made from the building site. This is the most traditional way of making adobes and it is seldom followed today, when most builders import adobes made by machines in an adobe yard. At the Gray, it is evident from the variety of colors and textures that the adobes are as varied as the sites on which the houses stand.

Unlike the Mexican examples, the ranch houses at the Gray have low ceilings. The interiors are typically eight feet to nine feet in height, with gypsum plaster over wood lath ceilings. The motivation for the low ceilings was clearly economy: the builders erected an eight foot high adobe wall, then put a hipped or gabled wood-frame roof directly on the top. The roofs are all framed with milled 2x4's brought from the railroad to the north. Typical roofing is corrugated galvanized iron. Floors are concrete slab on grade. Doors and windows are wood framed, and of an economical grade. Windows are double-hung single-glazed, sometimes employed lying sideways and operating as sliding windows above kitchen sinks. The architecture is humble and unpretentious, and it works.

TRADITIONAL PRINCIPLES

- Adobe interior walls for interior thermal mass.
- Porches along one or more sides of the house.
- Ventilated attic space above ceiling, with steeply pitched roof.
- Passive cooling through shaded walls and cross ventilation.
- Wood burning stove for heat.
- Compact rectangular plan shapes.
- Corrugated metal roofing.



Culberson House: west elevation (l.) and plan (r.)

Lynch Camp, Gray Ranch. Photo: B. Vint

1. hay barn

2. meat cooler

3. machine shop

4. salt room

5. bunk house

Culberson Camp, Gray Ranch, Animas Valley NM

Adobe outbuilding with weathered corrugated metal roofing at the Upshaw Camp. Propane is currently used for heating necessities . Photo: B. Vint

DESIGN FEATURES

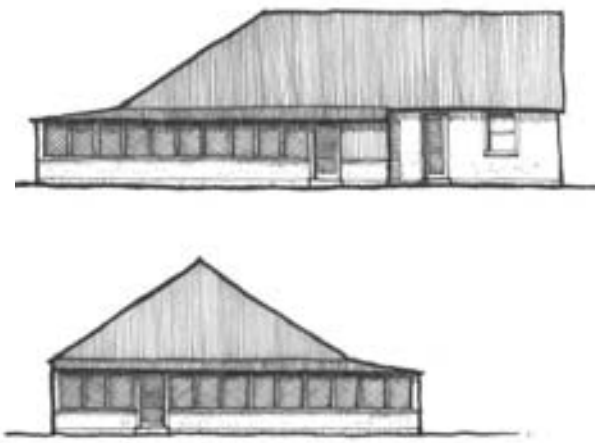
The houses on the Gray began as simple square or rectangular structures of from two to four rooms. The pattern of their growth can be read in the plans. For example, at the Upshaw camp, the original adobe structure was square in plan, and composed of two square rooms beside a long rectangular room that completed the square. The house originally had a pyramidal hipped roof fitting the square plan. Later, low-sloped porches were added along the south and west sides, giving protection to the exterior and creating screened, shaded living space.

As the family grew, a two-bedroom addition was made with cement block walls to the east. As part of this expansion, half of the east adobe wall was removed to permit an indoor bathroom and utility room (prior to which time an outhouse and pump in the yard provided the plumbing necessities). With the addition, the roof was expanded east as a gable, giving the Upshaw an asymmetrical overall roof form. The Upshaw house in its evolution represents several variations on the ranch house.

THERMAL PERFORMANCE

No houses on the Gray Ranch have mechanical cooling. They remain comfortable through the summer months with passive cooling. This is possible at the elevation of 5,000 feet above sea level, where summer temperatures are in the high 80°s F and rarely break 100°F. Because of the wide-open spaces of the ranch, all rooms can have windows on two sides, allowing cross ventilation without compromising privacy. Winters are another story: in the high dry savannah of New Mexico's boot heel, temperatures often drop to the low teens in °F. Ranching families used fireplaces and wood burning cast-iron stoves as their heat sources. The Upshaw house is analyzed in its various stages of growth in *Ch.4, Thermal Performance.*

Upshaw House plan



Upshaw House South (above) and West (below) elevations

Tucson, Arizona **BUNGALOW**

The American bungalow was a popular housing type from the 1890s to the 1930s. Its origins are in India where the British adapted the *bangala*, a low-slung cottage found in the Bengal countryside. It became popular as a style with the English Arts and Crafts Movement, and was transported to the United States by proponents of this freestanding and rustic dwelling type. Examples of the bungalow can be found throughout the United States; however, it was in California and Arizona where the majority were constructed. The individual building type was most often placed on its own lot and surrounded by extensive landscaping, but it also lent itself to grouping in the form of U-shaped courts with plentiful shrubs, hedges, flowering trees, and narrow walkways. Once the automobile became prolific, many landscaped courtyards gave way to motor courts. The first motels in America were based on the bungalow court model.

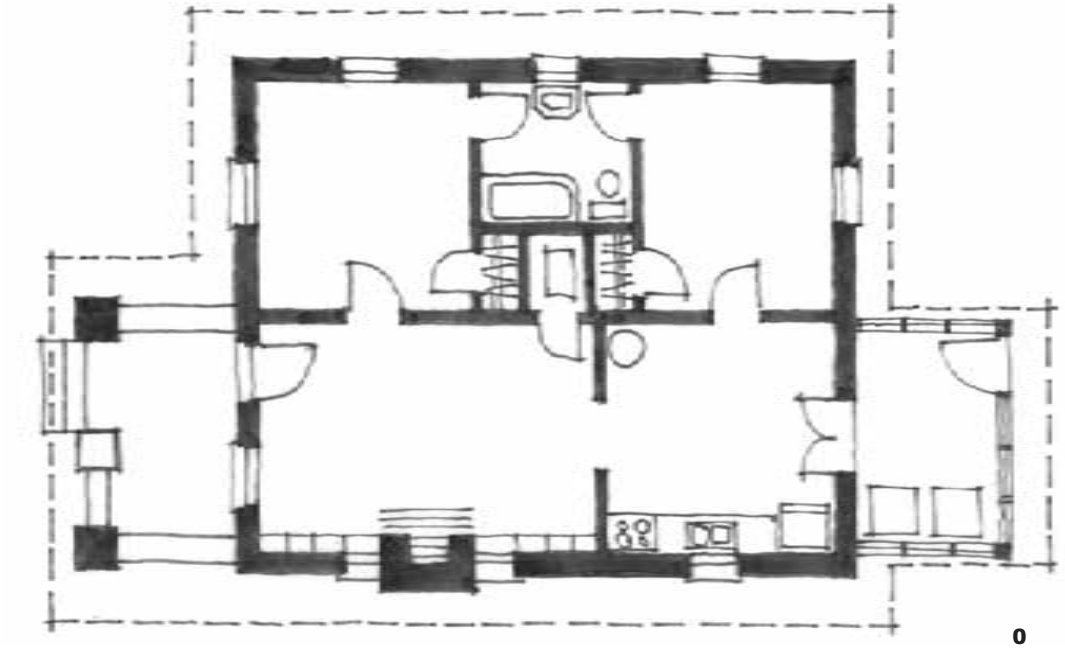
As is typical of vernacular houses, which pre-date the automobile era, there is no provision in the bungalow plan for a carport or garage. Typically, the garage, treated more like a stable, was a separate structure placed behind the house.

TRADITIONAL PRINCIPLES

The bungalow demonstrates the following principles of southwestern vernacular architecture:

- Deep roof overhangs (akin to the brim of a cowboy hat) shade walls from solar gain.
- Compact plan form minimizes exterior wall area.
- Passive cross ventilation.
- Deep porches provide outdoor living space.

North elevation



Plan

DESIGN FEATURES

The bungalow is characterized by a low-to-medium pitched gable roof (occasionally hipped and sometimes with a dormer), wide overhangs, exposed rafter tails, and a deep-set front porch. Roofs are framed with milled lumber and roofed with wood or asphalt shingles. At the porch, massive tapered columns typically flank the entrance steps and support the front gable. In California, most bungalows have wood frame and plaster walls, while in Arizona, New Mexico and Texas, walls are constructed of brick and adobe; both materials usually covered with stucco. Rubble stone was often used for foundation, as well as for the porch columns. The floor plans tend to be one level and more open than their popular predecessor, the Queen Anne cottage. Living and dining rooms are separated by wide openings, some with pocket sliding doors, thus providing a feeling of larger space. Interiors feature the decorative use of wood trim and built-in shelving.

There are examples of two-story bungalows, and, occasionally, a central hall type plan was used. Professional architects designed some bungalows, but the majority were copied from pattern books, and many times these popular and versatile houses were constructed from mail order kits. Many bungalows are very modest homes, typical of the expectations of the time period in which they were built.

During the first half of the 20th Century, the bungalow dwelling type was promoted in various magazines, such as *Western Architect, House Beautiful, Good Housekeeping, Architectural Record and Ladies' Home Journal.* The style fell from popularity in the post-World War II housing boom, when the ranch home dominated the field. However, the bungalow has continued to be in demand by house restorers up to today, and there is a magazine devoted to this dwelling type, *American Bungalow.* A recently planned energy-efficient housing subdivision on Tucson's far east side, called "Civano," has used the bungalow type in several of its house models.

West University, Tucson, AZ: Set of early 20th century bungalows. Photo: B. Vint

Deep porch makes a shady inviting alcove. Photo: B. Vint

Yuma, AZ: a duplex bungalow. Photo: B. Vint

THERMAL PERFORMANCE

The bungalow, with its wide roof overhangs, deep porch, and ventilated attic and crawl space, has architectural features with excellent energy performance for the border regions of the American Southwest. Once again, we see a house type well suited to the desert that is primarily designed to respond to the summer months. This is due to the fact that when these houses were first built there was no electricity available to run mechanical heating or cooling hence the house had to provide shelter and comfort without assistance. The abundance of shade is the greatest single feature of the bungalow in weathering the desert summers, to shelter the building from heat gain. A fireplace was used as the heat source for the winter months.

Windows placed on all sides of the dwelling allow for plentiful natural light, although excessive heat gain from west-facing windows can be a drawback. Wide roof overhangs mitigate this problem. The two to three room deep floor plan limits cross-ventilation, which can only be provided at the expense of privacy.

The bungalow provides an excellent example for today's affordable housing in the southwest border region, when a low-density detached house type is deemed appropriate. The bungalow can be readily adapted to the three principal construction technologies studied in this report: adobe, rammed earth, and straw bale.