Explaining Residential Density

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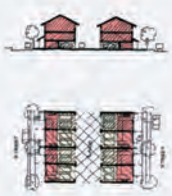
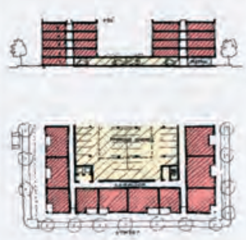
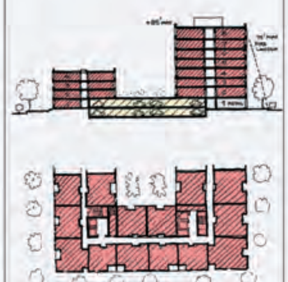
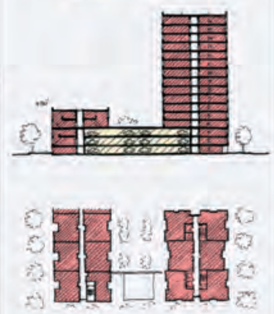
Residential Density Matrix

	Single Family Detached	Semi-Detached w/ In-Law Unit	Front Loaded Row Houses
	(2 Story) Alley Loaded	(2-3 Story) Alley Loaded	(3 Story) Front Loaded
			
			
Density Dwellings/ Net Acre	10 DU/ AC	15 DU/ AC	20-25 DU/ AC
Parking Type	2 Car Garage	1 Car per Dwelling	1 Car per Dwelling
Construction Type	Wood Frame	Wood Frame	Wood Frame
Construction Cost Index	1.00	0.95	0.90

Rear Loaded Row Houses	Stacked Rowhouses	Stacked Flats	Midrise Stacked Flats	Highrise Stacked Flats
(3 Story) Rear Loaded	(4 Story) Rear Loaded	(5 Story) 1 Level Podium	(below 8 Stories) 2 Level Podium Below Life Safety	(above 8 Stories) 3 Level Podium Above Life Safety
				
				
25-30 DU/ AC 2 Cars per Dwelling Wood Frame	30-35 DU/ AC 2 Cars Per Dwelling Wood Frame	35-45 DU/ AC 1 Car per Unit Wood Frame Over Concrete Garage	45-75 DU/ AC 1 Car per Unit Concrete Frame	75-125 DU/ AC 1 Car per Unit Concrete Frame
0.90	1.20	1.60	2.00	2.50
Unstacked	Stacked			
	Tuck Under Parking	Podium Parking		
		Wood Frame Construction	Concrete Construction	

On many occasions when presenting proposals for higher-density housing at community workshops or planning commissions, architects are faced with an emotional type of opposition they find difficult to understand. Behind this opposition, which may have nothing to do with designs actually being proposed, usually lies a misunderstanding of terms. In particular, the words "high-density housing" conjure up images of closely spaced highrise apartment towers, with a consequent lack of daylight, reduced open space, and blocked views. Even at medium and lower densities, there is little public awareness of the different potential configurations of buildings and their impact on streets and neighborhoods.

One reason for this misunderstanding is easy to see. At the planning stage, describing a project in terms of the number of dwelling units per acre is about as revealing to most people as telling them how much the buildings weigh. Without a sense of what "25 dwellings per acre" means in real terms, for example, discussion may get bogged down in abstractions that are difficult to resolve. Worse, without a clear sense of what is being proposed, a simple fear of change may take over. Any new housing means the "wrong" type of people will move in, traffic will increase, property values will decline, etc.

Ultimately, perceptions of residential density are as tied to design quality as actual numbers. But even the numbers may be complicated to explain. One reason is that levels of residential densities cannot be considered in a vacuum; they can only be understood with reference to three related factors: building typologies, parking configurations, and construction types. Thus, housing layouts that require parking for two cars per dwelling can produce a completely different density and typology than those that require parking for only one car. Higher density, therefore, doesn't necessarily mean highrise buildings.

In this article, I would like to provide an illustrated guide to some of these issues. My hope is that this examination of the current building blocks of residential architecture will be of value both to practitioners and citizens as they wrestle with choices for how their communities will meet future housing needs.

The Density/Building Typology Chart

Architects and planners generally use the term "building typology" to refer to a range of typical structures. In the field of housing, at the lower densities, these include such forms as single-family dwellings, semi-detached units (duplexes, etc.), row houses, and secondary in-law units. Middle densities can generally be achieved with stacked walk-up townhouses or flats. At the highest densities, elevator- and corridor-accessed units are necessary.

Parking arrangements generally form a gradient that corresponds to these increases. It progresses from individual garages, to common surface lots, to podiums or basement garages.

The range of application of different construction types is determined by local interpretation of national building codes. But there are common variables, and these may be used to arrive at a common index of construction cost. Generally, as densities increase, building construction changes from wood-framed Type V construction (up to 50 feet) and Type III construction (up to 65 feet), to concrete and steel-framed Type I and II construction for mid- and highrise buildings. For units located more than 75 feet above the ground, the introduction of special life-safety code requirements has an important impact on building design.

Considering the above qualifications, the accompanying chart attempts to show how increases in residential density are related to different building typologies and specific thresholds that trigger different construction types. The chart also attempts to compare the relative cost of each category. This particular study focused primarily on higher-density urban conditions, where smaller dwelling units and lower parking ratios were the norm.

In preparing the chart we measured the density of units per acre in relation to the net area within the property lines, and excluded the public right-of-way. For the purposes of comparison across unit types, certain assumptions were also made: all dwellings were in the range of 1,000–1,200 net sq.ft. in area; a parking ratio of one car per dwelling applied for all off-street parking; and open space of at least 100 sq.ft. per dwelling was required either as a yard, a balcony, or communal open space.

Based on these assumptions, the chart divides building types according to certain categories. These include stacked vs. unstacked units; units with separate individual garages vs. those with communal garage types; wood-frame vs. concrete-frame construction; and units below vs. above the life-safety limit (75 ft. to the floor level of the uppermost unit).

To fully understand the chart, some additional definitions may be required. "Front loaded" means that car access is from the street; "rear loaded" means it is from

Right: Low-density residential typologies.

a rear alley or parking court. "Single aspect" means a unit has windows that face in only one direction; "double aspect" means the unit faces in two directions. Walk-up units have stairs only; elevator- and corridor-access units give residents the choice of stairs and elevators. Flats are dwellings on one level; townhouses have more than one level. Lofts are two-story units with a double-height space. Garages may come in a variety of different types: single car; or tandem (front and back) and side-by-side for two-car garages. Secondary units (carriage-house or in-law units) are smaller units on a single property, and may be located either in the main structure or in a subsidiary building.

Low-Density Residential Development

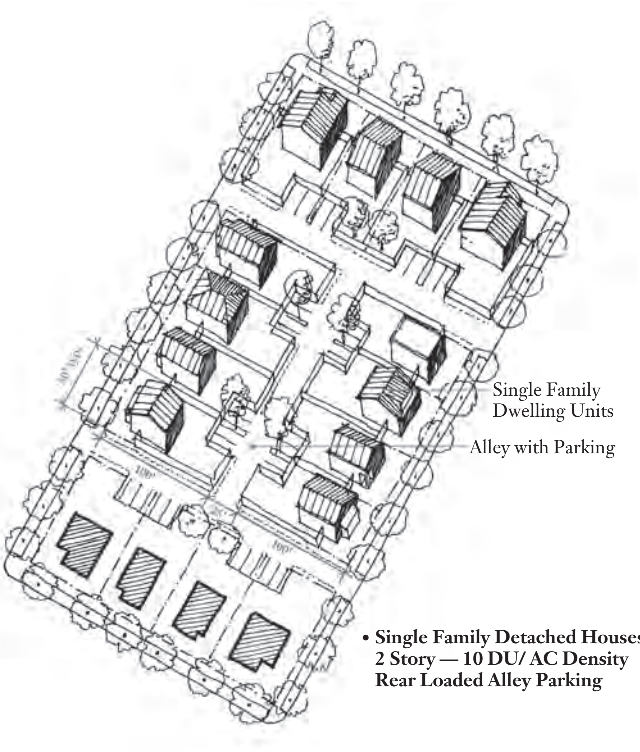
To show what these various levels of residential density mean in physical terms we prepared a series of standard block diagrams. The first pair illustrates low-density development in the range of 10-15 dwellings per acre, on lot sizes that range from 3,000 to 5,000 sq.ft. The building types considered here are either single-family houses on 50 x 100 ft. parcels or semi-detached houses on 30 x 100 ft. parcels.

Buildings at this density can be either front loaded, with parking from the street with a side drive (sometimes shared), or rear loaded from an alley. The presence of alleys offers the opportunity to create street frontages that do not have frequent curb cuts, and so can provide more on-street parking for visitors. Alleys may also be desirable to hide all the service activities, cars, trucks, and the other detritus of everyday life.

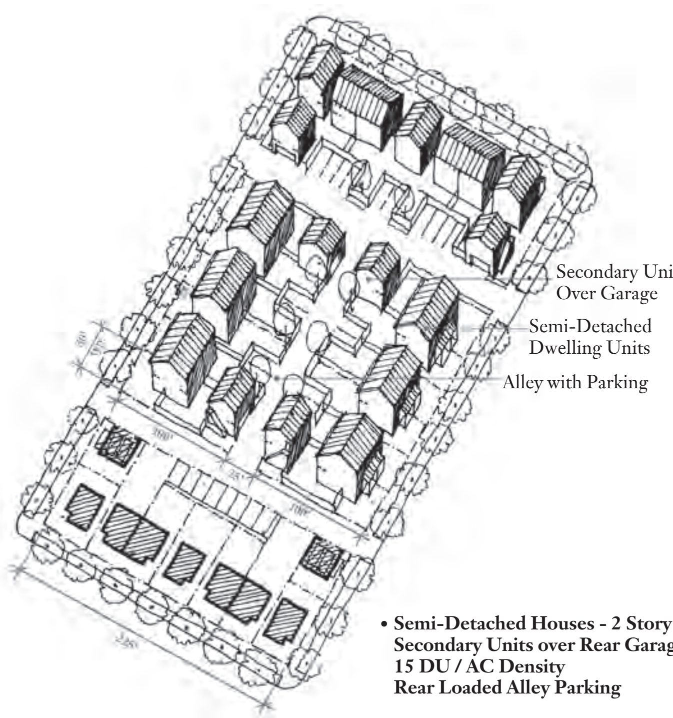
The alley can also provide the setting for secondary "in-law" units above garage spaces. In this way mixed-income housing can be easily created within the same block. Such housing also offers a greater level of security because there are more "eyes on the street," and it serves as a way of increasing density without affecting the appearance of the surrounding streets.

Row Houses

At medium densities of 15-25 dwellings per acre and up, one moves into groups of dwellings arranged as row houses. These are shown in the middle two pairings of block diagrams. Typically, row houses comprise two- or three-story dwellings ranging in width from 16 to 25 feet. They can be front or rear loaded, but parking is preferable at the rear to avoid a street frontage dominated by garage doors. Where front loading is unavoidable, tandem parking is preferable for two-car garages.



• **Single Family Detached Houses**
2 Story — 10 DU/ AC Density
Rear Loaded Alley Parking



• **Semi-Detached Houses - 2 Story**
Secondary Units over Rear Garages
15 DU / AC Density
Rear Loaded Alley Parking

Using the row-house typology, various site configurations can be used to increase densities without creating an overwhelming impact on the street. Two such arrangements were developed by nineteenth-century builders in San Francisco: the tandem house and the mid-block alley. "Tandem housing" consists of a second row of houses located behind the street-facing units and accessed through a garage court or portal. This works well on deeper lots, because from the street the appearance is the same as for ordinary row housing, but at double the density.

Alternatively, using a mid-block alley, a new narrow street lined with single-family two- or three-story row houses can be inserted between two main streets. This allows the same number of units as would be accommodated in a pair of taller buildings facing the main streets.

A popular variant on the tandem-housing model is to place six- or eight-plex row house modules around a common parking court. This permits a greater number of units to be built while minimizing the impact on the street frontage by having a single curb cut on the street. Parking can either be accommodated in an internally located surface court or in individual garages on either side of a drive-in court.

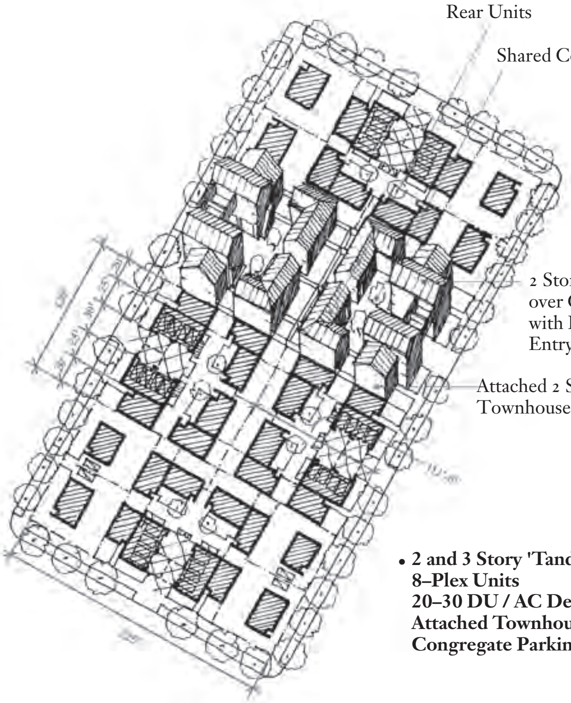
Another type of dwelling, known as a "tuck-under," consists of a two-story house raised half a level above the street with a rear-accessed garage half a level down. This arrangement avoids the arduous building-code requirement of a secondary staircase from a third-floor bedroom. The dwelling is measured as a two-story unit from the street frontage, even though it is three levels high when measured from the garage alley.

Densities of 25-30 dwellings per acre are possible with the tuck-under arrangement. It can also be used to create attractive street frontages, since garages are hidden away at the rear, and the ground-floor rooms are raised half a level above the street, preserving privacy from pedestrians passing by on the sidewalk.

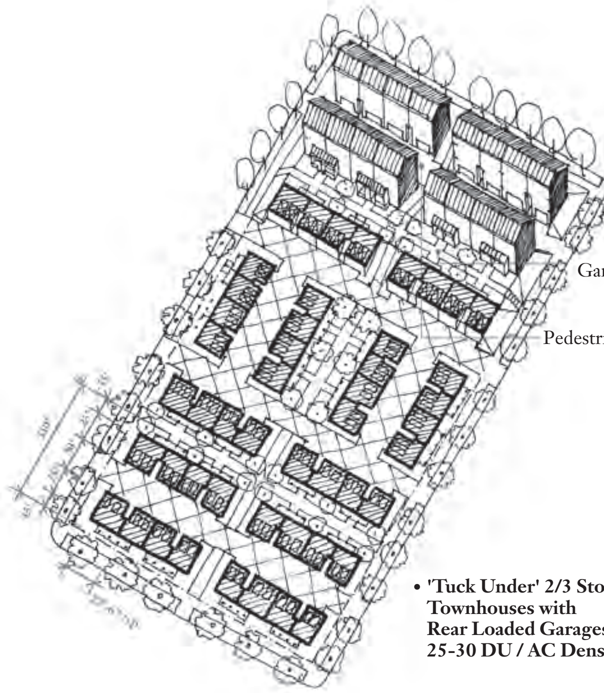
Moving up the density scale, four-story stacked walk-up townhouses over their own garages can be built at a density of up to 40 dwellings per acre. Stacked units above two stories, however, require two means of escape, so stairs need to be provided to give access both from the street and from rear parking areas.

With units built over their own garages, two vertically stacked townhouses can be arranged with a rear-accessed garage on the first level, and a four-story building above with an interlocking section for the separate units. A 50-ft. pairing of stacked 25-ft.-wide units can share a common stair from the garage and require only a total of three stairs for four units.

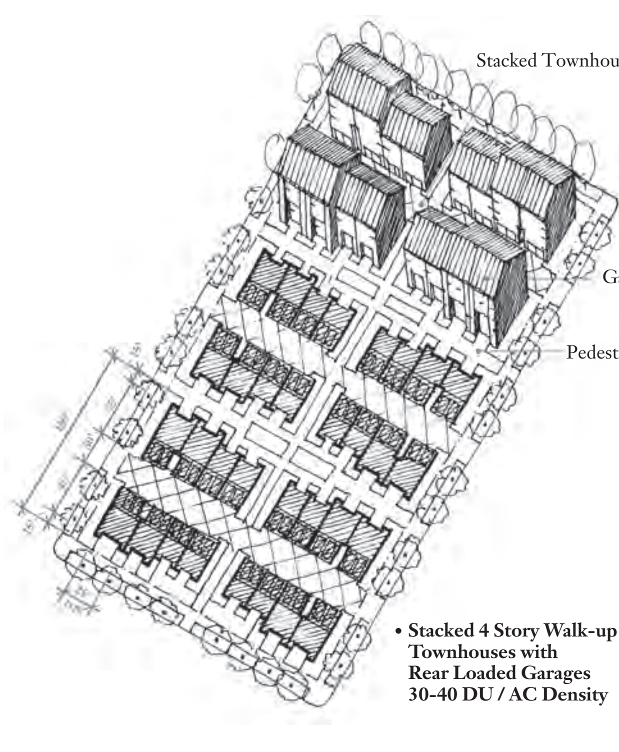
Above: Townhouse typologies can create a variety of urban conditions. Examples from San Jose, California.
Right: Townhouse residential typologies.



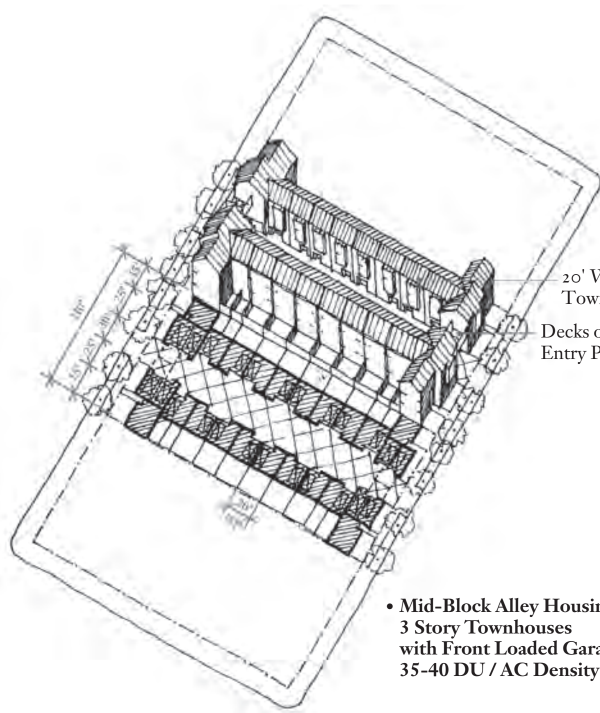
- **2 and 3 Story 'Tandem Housing'**
  8–Plex Units
  20–30 DU / AC Density
  Attached Townhouses over
  Congregate Parking Shared Court



- **'Tuck Under' 2/3 Story**
  Townhouses with
  Rear Loaded Garages
  25-30 DU / AC Density



- **Stacked 4 Story Walk-up**
  Townhouses with
  Rear Loaded Garages
  30-40 DU / AC Density



- **Mid-Block Alley Housing**
  3 Story Townhouses
  with Front Loaded Garages
  35-40 DU / AC Density

A simpler pattern, which achieves the same density but replaces townhouses with flats, involves arranging three stories of stacked walk-up flats around a pair of stairs, one facing the street, the other giving access to surface parking at the rear. Each flat thus has a double aspect, facing both the street and the rear of the site. With a 25-ft.-wide frontage, there is also enough room for each flat to be designed with side-by-side rooms.

Medium Density to High Density

The last two pairs of images show medium to high-density residential arrangements. A great number of configurations are possible at this end of the density scale, but as the chart shows they are more expensive to build, largely because of the need to build common structured parking.

As a general rule, above 45 dwellings per acre one gets into elevator and corridor access, with communal parking garages either below grade or in a separate structure. At a density above 75 dwellings per acre one moves further to multilevel parking arrangements. These can take the form of underground basement parking or internal podium parking on several levels — both of which require mechanical ventilation and fire-separation. Alternatively, independent multilevel parking garages may be designed which can be naturally ventilated and do not require expensive fire separation, but these may require more space.

The simplest and least expensive arrangement is often to build a multistory, concrete-framed garage in the center of a block or parcel with a 20-ft. gap around its perimeter to permit natural ventilation. Surrounding this garage one can build four-story, corridor-accessed, single-aspect units in Type V wood-frame construction.

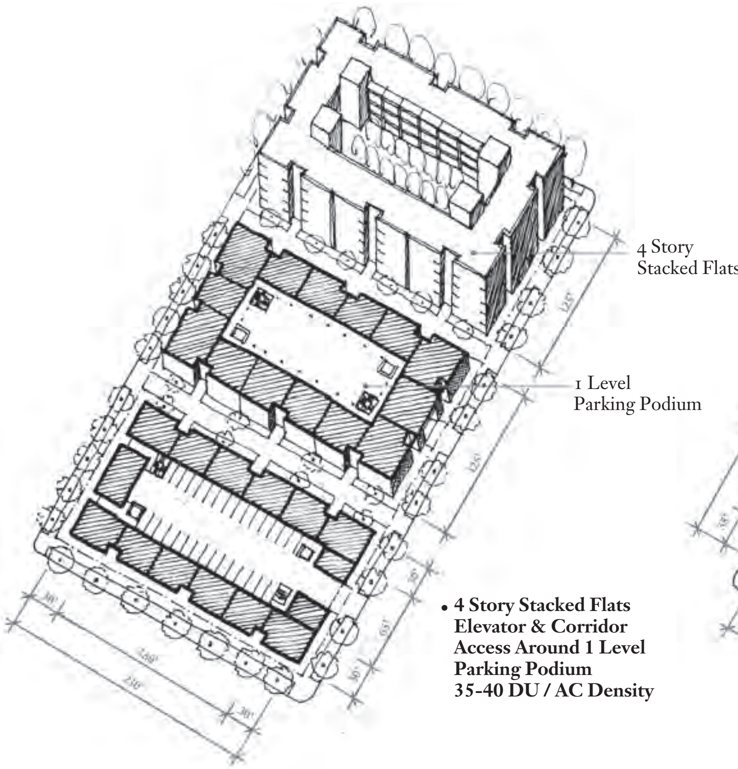
If the surrounding units adjoin the parking garage, the garage needs to be mechanically ventilated and have a four-hour separation between the autos and surrounding residential or commercial/office uses. One alternative is to build above a parking podium, with special "liner" units wrapping the perimeter and facing the street.

Mid- and highrise construction can achieve densities far greater than 75 dwellings per acre. However, life-safety requirements require such special building features as pressurized stair shafts and places of safe refuge in buildings with floors above the reach of a fire-truck ladder (75 feet above the street). Midrise buildings built to just below this life-safety level are typically eight stories high, with a roof level of up to 85 feet.

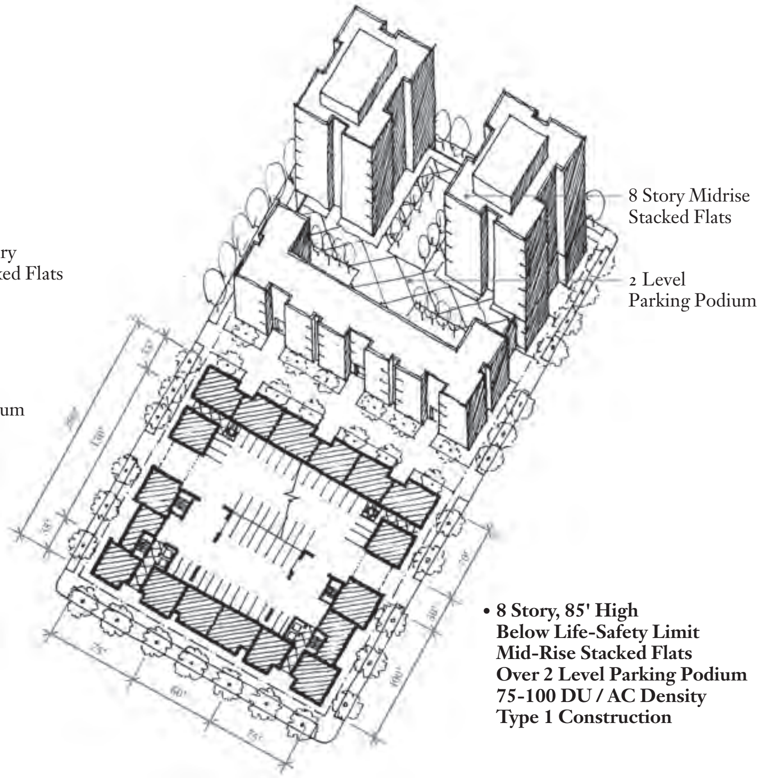
Mid- and highrise construction always requires one or more elevators and two stairs. But building-code requirements vary from city to city in terms of how these may be provided. For example, in New York, Chicago and

Above: Examples of medium-density housing in San Jose, California.

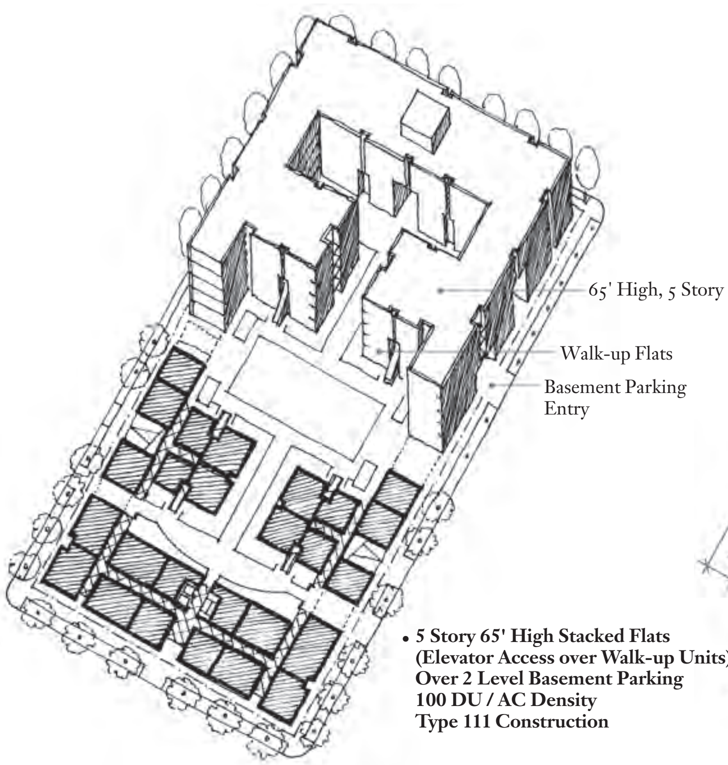
Right: Medium- and high-density residential typologies.



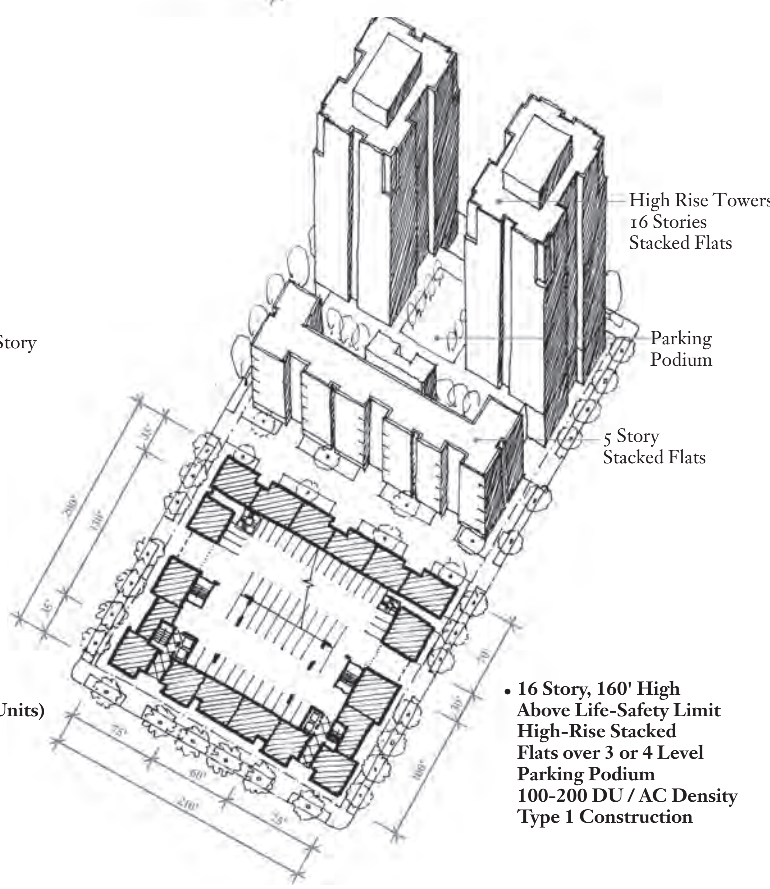
• **4 Story Stacked Flats**
Elevator & Corridor
Access Around 1 Level
Parking Podium
35-40 DU / AC Density



• **8 Story, 85' High**
Below Life-Safety Limit
Mid-Rise Stacked Flats
Over 2 Level Parking Podium
75-100 DU / AC Density
Type 1 Construction



• **5 Story 65' High Stacked Flats**
(Elevator Access over Walk-up Units)
Over 2 Level Basement Parking
100 DU / AC Density
Type 111 Construction



• **16 Story, 160' High**
Above Life-Safety Limit
High-Rise Stacked
Flats over 3 or 4 Level
Parking Podium
100-200 DU / AC Density
Type 1 Construction

Vancouver, “scissor stairs” are permitted, where two straight-flight stairs interlock in a single concrete-framed shaft. This enables the stair shaft to be located behind the elevators in a compact core, enabling construction of a small floor plate and a slender tower. Vancouver’s residential towers have floor plates as small as 4,000 sq.ft. in area.

In California, the building code requires a minimum 30-ft. separation between the two stair shafts, and on any floor the travel distance between the doors to the stairs must be half the maximum diagonal dimension of the floor plate. The result is a much bigger core and a larger floor plate. In San Francisco floor plates as large as 10,000 sq.ft. are currently being proposed for highrise towers in new downtown residential districts on Rincon Hill and around the Transbay Terminal.

Cost Comparisons

With the help of several contractors, we were able to develop a cost-comparison index to show the differences between various construction types. The costs are for building construction only and exclude the cost of land. They are presented here in the form of ratios so that comparisons can be made easily between the different types. The cost comparisons are shown at the bottom of the residential density chart.

If the cost of a single-family dwelling is rated as 1.00, a semi-detached dwelling is 0.95, because of the savings provided by a shared party wall. The cost of a row house is further reduced to 0.9 because of party walls and reduced frontage. Stacked walk-up units increase in cost to a ratio of 1.20 because of additional stairs, while elevator-accessed corridor units over a parking podium increase to 1.25 units because of increased construction cost of elevators and shared circulation areas.

Midrise construction costs range up to 1.60 to 2.00, while highrise units increase in cost to up to 2.50 and more.

These comparisons are ratios, and, of course, should be considered in relation to many other factors, including civil-engineering costs and infrastructure and soil conditions. However, they are useful in helping make a preliminary assessment of the most appropriate density in relation to construction type and local market conditions. Most importantly, location affects land costs, and where these are high, higher densities — and therefore higher construction expense — can offset the overall cost of development, since the latter represents a smaller part of total costs.

Case Study

In a study Solomon E.T.C./WRT produced for the Greenbelt Alliance in 2003 for the proposed town of Coyote Valley south of San Jose, California, we used the density chart and diagrams similar to those here to illustrate how a variety of arrangements could be combined to create a mixed-use, compact, transit-oriented community. The last image shows a portion of this vision plan.

As a whole, the result of our work was a grid of streets and blocks that offered a multitude of opportunities for different types of housing and a range of densities, while at the same time creating a continuous urban fabric. The diagrams were especially valuable in helping form a consensus with the local community activists, since it was possible to give them a clear picture of the nature of housing and the character of the streets and neighborhoods being proposed. The diagrams were also helpful in determining the best overall density that could meet the requirements for 20 percent affordable units throughout the 50,000-dwelling-unit town.

Another effective tool for achieving agreement was to showing photographs of examples of local residential development in San Jose at various densities that people were familiar with. Understanding the cost and construction-type implications was also essential in order to be realistic about what could be achieved in terms of affordable housing on a “greenfield” site.

To advocate overall densities that were too high and required the widespread use of stacked concrete-framed multistory housing would have been an unrealistic proposition in the current San Jose market. At the same time, to propose densities that were too low would have meant the loss of open space, an inability to support transit service, and a lost opportunity to create a pedestrian-friendly, compact community.

For Coyote Valley we ended up proposing an overall average density of 28 dwellings per net acre. These dwellings went together to form neighborhoods that consisted of a wide range of building types, and which offered a variety of choices for future residents, but which was still in character with the surrounding environment of San Jose and its suburbs.

The proposed plan for the Coyote Valley development made use of the residential typologies described here.

All drawings and photographs accompanying this article are courtesy of Solomon, E.T.C., a WRT Company.


Jefferson Park
Parker St. One-way Westbound St.
Union St. One-way Eastbound St.
Overpass
Caltrain Station
Monterey Hwy.
Santa Teresa Blvd.
Town Center Green
Bailey Ave
Light Rail Station