The Design of a House: the Team
Creating a home takes a team of people and several steps. The team will include a client, a designer or architect, and a builder or contractor.

Sometimes a new house is designed for a builder who acts as client and will build it “on spec” meaning s/he intends to build and sell it. Other times a homeowner will purchase a piece of land and hire the design and building of the home. When selecting someone to design the home, they have the choice of a designer or an architect.

A designer is someone who typically has some professional training, such as a two-year college degree in Architectural Design (AAS). They may be a Certified Professional Building Designer (CPBD), which requires a minimum educational level, three years of supervised work, and passing an extensive exam. Typically, a person with these qualifications is quite capable of designing a house, and coordinating with a team of an engineer, a builder, and permit plan’s examiner. An architect is someone who has completed a 5 year professional Bachelor’s (B.ARCH) or Master’s (M.ARCH) degree program, followed by a 3 year (min.) internship (IDP), and passing a very extensive architect’s licensure exam. Architects are trained to design all scales of buildings, from houses to skyscrapers. They typically focus on commercial buildings, including offices, schools, civic buildings, and multi-family housing; occasionally they specialize in houses.

The Design of a House: Phases
There are several steps in the process of designing and building a house. These steps are recognized by both designers and architects, and called “Phases of Design Services” by the American Institute of Architects (AIA).

Schematic Design
Schematic Design is establishing a concept of the house, typically in plan view, where the basic “parts” of the house are...

1 Refer to http://www.aia.org/aiaucmp/groups/ek_members/documents/pdf/aiap026834.pdf for more in depth information.
conceptualized. It also includes establishing the project goals and requirements, including a “Program” (list of required functions) and any restrictions or requirements from the applicable zoning codes. These drawings are referred to as “Schematic Drawings”. They are often done through the use of freehand sketching, followed by some drafted plans. Figure 1.2

**Design Development**

Design Development takes the concept of the house, and develops it into more precise floor plans and exterior views, and develops design elements such as building materials, windows, and doors. These drawings are also referred to as “Design Drawings”, or sometimes “Plans” since they have drafted floor plans, along with other drawings. Figure 1.3

**Construction Documents**

Construction Documents “translate” the Design Development phase into drawings that represent the construction requirements needed to build the desired design. These drawings are called “Construction Documents”, or “Prints”, thereby establishing the term “Print Reading”. Before the advent of printers and plotters, and large-format copy machines, hand-drafted Construction Documents were duplicated on blueprint machines, and called Blueprints. That term has now shifted to “Prints”, “Working Drawings”, “Construction Documents”, or simply “CDs”. Figure 1.4

**Permitting** involves the designer, architect, or builder to submit the Construction Drawings to the City or County jurisdiction in order to obtain building permits for the home or remodel. Building permits are required for all new structures that are “habitable” (i.e. people “dwell” in, like a house, hobby space, or office) that are more than 200 sq. ft. in size.

**Bidding** occurs when the permits are either under review, or complete, with the goal of getting a set price for the construction from a builder or general contractor. Sometimes an owner will seek just one bid from a preferred contractor, other times they will seek competitive bids from two or more contractors.

**Construction Administration**

Construction Administration is the last phase, whereby the designer or architect makes site visits to ensure that the
home or remodel is being built as intended and shown on the Construction Documents.

**Figure 1.5  Freehand Presentation Perspective (Pencil, Pen, Markers and Airbrush)**

**Learning the Language of Drawings: Types of Drawings**

**Freehand**
Freehand drawing typically starts the Schematic Design process. The designer uses a pencil or pen, on trace paper or vellum, to explore floor plan layouts, along with exterior and interior views to explore design ideas. Figure 1.5

**Presentation**
Presentation drawings are created when the designer has developed the design to a point where they want to show it to the client, typically at the end of Schematic Design, and during Design Development. The designer may use orthogonal and 3-D drawings, and add color and material reference to add realism. Figures 1.5-1.7

**Orthogonal**
Orthogonal drawings are the basis of creating Design Development drawings and Construction Documents; they represent the form of a house in measurable, flat 2-D drawings. Orthogonal drawings include floor plans, exterior elevations, cross-section drawings and 2-D details that describe the spaces in the house and its construction. These are most often drawn with a CAD software program, like AutoCAD or Revit. Figures 1.6 and 1.7

**Perspective**
Perspective drawings are very useful to visually describe a design, and represent what we see in 3-D form. They are used during Schematic Design and Design Development; they are sometimes used just before or during construction to advertise a project. Perspectives can show either the exterior or the
interior of a design; color can add a sense of depth. Perspectives can be generated by hand using a one-point (Interior Elevations) or two-point (Exterior Elevations); or by using CAD software, like Sketch-Up or Revit. Figures 1.5 and 1.8

**Oblique Projection**

An Axonometric drawing shows a “bird’s eye view” (from above) but it is a type of scaled drawing, and does not have perspective, i.e. heights remain equal instead of diminishing to represent distance. It can be created by placing the floor plan angled, on a drafting board, with one side at 30 degrees, and the other side at 60 degrees, off of the parallel bar. The corners of the house (or room) are then projected up at the correct scale. An Axonometric drawing can be quickly created without CAD software.

**Overview of Construction Documents**

Construction Documents are scale drawings, representing various aspects of the building and the site (property or lot) that it sits on. These drawings are “miniature” or reduced views of the actual building. They are drawn to a known scale, which describe the proportion of the reduction of size, relative to full size. Refer to “Drawing to Scale”, page 6.

The most common size of construction drawings is 24”x36”, also called “ARCH D”. A large format plotter is required to produce these drawings. Some designers will have a reproduction service or print shop plot out their full-sized set. Most jurisdictions will accept smaller sized sets for permit; 11”x17” being the smallest accepted, which can be printed on many laser printers and inkjets.

**Site Plan**

The Site Plan shows the house on its site (lot) from a bird’s eye view. Property lot lines are shown, along with landscape, contour lines, surrounding streets, easements, utilities, driveways, sidewalks, and decks. Since the Site Plan is illustrated from the bird’s eye view, the roof on the house is often shown rather than the outline of the house; and interior rooms in the house are not shown. An outline of the building footprint may be present.
A residential Site Plan is typically drawn at a scale of 1"=10’ (decimal feet scales are referred to as “engineering scales”) or 1/16"=1'-0”, or 1/8"=1'-0”,. The exact scale used is dependant upon the size of the lot, and how much detail is needed. An arrow showing North is always displayed. Figure 1.10

**Floor Plans**

Floor Plans are a view looking down into each floor, from an imaginary horizontal cut through the house and walls at 4'-5’ above the floor. Floor plans are the most-used drawings in the set. They provide information about location of walls, doors, windows, plumbing fixtures, and cabinets. Dimensions show the size of each room, along with the overall size of the house. The use of symbols and abbreviations provide more information about sizes of doors, windows, and finish materials. Floor Plans for houses are most often drawn at 1/4"=1'-0” scale. Each plan should have an arrow showing North. Figure 1.3

**Exterior Elevations**

Exterior Elevations are “flat” views of the exterior of the house. Without showing true perspective, all parts of these drawings can be scaled, or measured. Elevations show vertical heights between floors, along with roof pitch, and finish materials. Exterior Elevations for houses are most often drawn at 1/4”=1'-0” scale, matching the Floor Plans. Figure 1.11

**Interior Elevations**

Interior Elevations are “flat” views of the interior walls of the house. Without showing true perspective, all parts of these drawings can be scaled, or measured. Interior Elevations show architectural elements, like kitchen and bath cabinets, tile patterns, wainscot, built-in shelving, and fireplaces. They are drawn in a variety of scales, including 1/4”=1'-0”, 3/8”=1'-0” or 1/2”=1'-0”, depending on the amount of detail required. Figure 1.12

**Sections**

A building Section is a vertical cut though the building, showing vertical heights between floors and providing general information regarding the construction of walls, roof, and foundation. Sections often show floor heights, top of plate, and exterior wall elevations. Figure 1.13
height, and roof pitch, similar to Exterior Elevations. Section locations and direction of view are shown on floor plans. Figures 1.4 and 1.7 Sections for houses are most often drawn at 1/4”=1’-0” scale, matching the Floor Plans and Elevations; Details can provide more information. However, Sections may also be drawn at 1/2”=1’-0” or larger, thereby, avoiding Detail drawings, when appropriate. Figure 1.13

Details
Details are created when additional information is needed, beyond what shows on the Sections. Common Details are provided for footings, windows, doors, staircases, and special architectural trims. Figure 1.14

Title Blocks
Title Blocks are areas on Construction Drawings that provide information about the project. This includes the name of the project (typically the owner), date drawn, address of the site, name of designer/architect and other consultants, and the number of the sheet. Figure 1.15

Drawing to Scale
Construction Documents for a house are drawn using Architectural scale, meaning the drawings are reduced to a proportion of a foot, using fractions. The scale 1/4”=1’-0” is common for architectural drawings, and means that each 1/4” measured on a drawing represents 1’-0” in reality. Figure 1.16

Construction Documents for a house may have the Site Plan drawn using Engineering scale, meaning the drawings are reduced to a proportion of a foot, using decimals. The scale 1”=10’ is common for a Site Plan, and means that 1” as measured on the drafted or sketched Site Plan equals 10’-0” in reality.

Figure 1.14  CD Details
Acer Lane Residence, Andre Debar, debar architecture

Figure 1.15 Examples of Titleblocks

Engineer’s tri-scale, www.dickblick.com

Architectural tri-scale, www.dickblick.com
Figure 1.16

When hand-drafting or reading plans, one uses a triangular architect’s scale — this scale or “ruler” has six different sides, with eleven different scales represented:

3”=1'-0"
1 1/2”=1'-0"
1”=1'-0"
3/4”=1'-0"
1/2”=1'-0"
3/8”=1'-0"
1/4”=1'-0"
3/16”=1'-0"
1/8”=1'-0"
3/32”=1'-0"
1/16”=1'-0"

To read the scale, you find the scale listed on either the right or left end. Scales on the left side are read left to right. Scales on the right side are read right to left. Inches for a foot can be found between the 0 and the end of the scale. Figure 1.17

Figure 1.17 Architectural Scale Measurements

Notice the different scales represented (unfortunately, not to scale in this drawing) and how the measurement is read.

Top image: scale is 1/4”=1'-0”, measurement is read right to left, starting at 0.
Middle image: scale is 1/2”=1'-0”, measurement is read right to left. Inches of measurement are to the right of 0.
Bottom image: scale is 1/8”=1'-0”, measure is read from left to right, starting at 0.
Chapter Two

Trade Math

The term *Trade Math* refers to calculations that are specific to the design and construction of a building. In the U.S. we use the “imperial system” of measurement, i.e. feet and inches. Figure 2.1 Some of the more common math functions that designers use in drawings are adding and subtracting whole numbers and fractions (feet and inches and fractions of inches), converting decimals to fractions and vice versa, and calculating percentages and volumes.

**Numbers, Fractions, Decimals and Percentages**

A *whole number* is simply a number that does not have any “subparts”. Examples include 0, 1, 2, 31, 102.

A *fraction* is a portion of a whole number, expressed as a number of parts divided by another number of parts. An example is ½, in which the 1 is the number of parts in the fraction, and the 2 is the total number of parts. In this case, the fraction expresses 1 part of a total of 2. The top or left side number is the *numerator* and the bottom or right side is the *denominator*. Examples include 1/2, 3/4, 5/8, 125/126. In the building trades, *fractions* typically represent parts of an inch, or parts of a foot, and are typically no smaller than a 16th (1/16) of a foot.

A *decimal* is a portion of a whole number described in tenths, hundredths, etc. *Decimals* express units of 10. A period follows the whole number and the decimal parts are on the right. Examples include 0.75, 0.125, 0.0625.

A percentage is a portion of a “whole” element. Percentages are represented by whole numbers and or decimals, followed by the % symbol. If all parts of the whole are represented, it is 100%. Examples include 10%, 25.5%, 150%.

**Operations of Trade Math**

*Addition*

When drawing designs and plans for a house, *addition* is most often used when adding up dimensions on various drawings in order to get overall building sizes and other compound measurements. Remember, when adding up feet
and inches, it is easiest to:

- add all inches first
- convert inches over 12 to feet, leaving “left over” as inches
- carry the feet to the left (if adding in column)
- add the feet

Example - Adding Whole Numbers:

<table>
<thead>
<tr>
<th>12’-2”</th>
<th>12’-2”</th>
<th>19”</th>
<th>1’-0”</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 14’-8”</td>
<td>+ 14’-8”</td>
<td>-12”</td>
<td>+ 14’-8”</td>
</tr>
<tr>
<td>+ 11’-9”</td>
<td>+ 11’-9”</td>
<td>+ 11’-9”</td>
<td>+ 11’-9”</td>
</tr>
<tr>
<td>19”</td>
<td>1’-7”</td>
<td>38’-7”</td>
<td>38’-7”</td>
</tr>
</tbody>
</table>

set up add inches simplify add feet solution

1. What is the height from the basement to the second story plate/header in Figure 2.2?
   - 8’-1”
   - +1’-0”
   - +9’-1”
   - +1’-4”
   - +8’-1”
   - 27’-7”

2. What is the height from the ridge of the roof to grade?
   - 10’-8”
   - +8’-1”
   - +1’-4”
   - +9’-1”
   - +4’-0”
   - 28’-2”

3. How tall is the wall at the dormer?
   - 4’-10½”
   - -1’-10”
   - 3’-0 ½”

Number Format

When writing feet and inches, observe these conventions:

- Inches only? Leave off the feet: 3”, 4 1/2”, 6”
- Feet, no inches?
  Use '0' for inches.
  3’-0”, 42’-0”, 100’-0”
- Feet, no inches, but a fraction of an inch?
  Use '0' for inches.
  4’-7/8” OR 4’-0 7/8”

© 2013
Topographic elevation references on a site plan are often in decimals, using feet and decimals of feet, while building elevation references are in fractions (feet, inches, and fractions of an inch). Therefore, it may be necessary to convert between the two.

When adding fractions with the same denominator, simply add all the numerators, and keep the denominator the same. Often you will then simplify the fraction, unless the numerator is odd.

**Example - Adding Fractions, Same Denominator:**

\[
\frac{1}{4}" + \frac{1}{4}" = \frac{2}{4}" \text{ (simplify to 1/2")}
\]

When adding fractions with different denominators, find a common denominator, then complete the addition.

**Example: Adding Fractions, Different Denominators:**

\[
\frac{3}{8}" + \frac{3}{8}" = \frac{6}{8}" \quad \frac{8}{8} + 1/8 = \frac{9}{8}" = \frac{1}{1/8}" = \frac{1}{1/8}"
\]

**Subtraction**

When drawing designs and plans for a house, subtraction is most often used when subtracting dimensions on various drawings in a set in order to know the size of various portions of the building. Remember, when subtracting feet and inches:

- “borrow” a foot and add to inches column if inches being subtracted are larger than the first number’s inches

**Example - Subtracting Whole Numbers**

\[
14'-3" - 11'-9" = 2'-6"
\]

**Example - Subtracting Fractions, Same Denominator**

\[
\frac{3}{4}" + 1/4" = 2/4" \text{ (simplify to 1/2")}
\]

When subtracting fractions with different denominators, find a common denominator.

**Example - Subtracting Fractions, Different Denominators:**

\[
\frac{3}{4}" - \frac{5}{8}" = \frac{6}{8}" - \frac{5}{8}" = \frac{1}{8}" = \frac{1}{8}"
\]
**Multiplication – Area**

When drawing designs and plans for a house, multiplication is most often used by multiplying length and width of portions of the building to determine square footage. Square footage, or square feet (sq.ft. also written s.f., SF or Sq.Ft.), is the unit of area. Calculating square footage is done for a variety of reasons during building design, including calculating window ventilation and daylighting requirements, or to determine size of rooms. Many floor materials require square foot or square yard calculations.

Square footage calculations may include either fractions or decimals. When calculating, it is easiest to convert any fractions to decimals, and then simply use a calculator to complete the multiplication. Additionally, fractions of an inch are often rounded to create an easier to manage calculation.

**Example - Area Calculation**

Calculate the square footage of a room that measures 12’-2 ¾” x 10’-6”.

- **Round 2 ¾” to 3” to create 12’-3”**
- **Convert 3” to 0.25’ (3 ÷ 12) and 6” to 0.5’ (6 ÷ 12)**
  
  \[12.25' \times 10.5' = 128.625 \text{ sq. ft.}\]

Some carpet is measured in square yards (sq.yd). A yard is equal to three feet. To calculate square yards divide square feet by 9 (3x3).

**Example - Square Yard Calculation**

Calculate how many square yards of carpet to order for a room that measures 12’-2 ¾” x 10’-6”.

- **Round 2 ¾” to 3” to create 12’-3”**
- **Convert 3” to 0.25’ (3 ÷ 12) and 6” to 0.5’ (6 ÷ 12)**
- **Divide by 9**
  
  \[(12.25' \times 10.5') ÷ 9 = 128.625 \text{ sq. ft.} ÷ 9 = 14.29 \text{ sq. yd}\]

---

**Figure 2.6 Plan for Square Footage and Cubic Volume Examples**

**Figure 2.7 Example Problems, Multiplication & Division**

1. What is the interior square footage (including shower) of Master Bath in Figure 2.5?

\[14'-3 \frac{3}{4}'' \times 8'-10 \frac{1}{2}'' = ? \text{ Sq Ft}\]

\[14.3125' \times 8.875' = 127.0234375 \text{ Sq Ft}\]

round to 127 Sq Ft

2. If the ceiling of the Master Bath is 8'-0", what is the cubic volume?

\[127 \text{ Sq Ft} \times 8 \text{ Ft} = 1016 \text{ CuFt}\]

3. If the Master Bath has a ventilating fan that exhausts at a rate of 120 CFM, how many minutes will it take to change all the air in the room?

\[1016 \text{ CuFt} \div 120 \text{ CuFt per Min} = 8.46 \text{ Minutes}\]
Another form of area calculation involving multiplication is percentage. A percentage is usually less than 1 and can be represented by a decimal. The % symbol indicates the number shown as a percentage is 100 times the decimal number, such as 0.45 is 45%.

Example - Area Percentage
What is the lot coverage (percentage) of a 1,500 s.f. house on a 5,000 sq.ft. lot?

\[
\frac{1,500}{5,000} = \frac{X\%}{100\%} = \frac{5,000X}{1,500 \times 100} = \frac{5,000}{150,000} = 0.3 \times 100 = 30\%
\]

Multiplication – Volume
Multiplication is also done to calculate the 3-D volume of a space, also known as the cubic volume, or cubic feet (cu. ft). Volume calculated by multiplying width times height times depth (WxLxH), or area times height. Cubic volume is used by the structural engineer to determine footing size. Cubic volume is calculated to size ventilation for bathrooms, kitchens and whole house ventilation systems. Airflow is measured in cubic feet per minute (CFM).

When multiplying feet and inches, it is easiest to convert the inches into decimals and then use a calculator to complete the computation. Often the number is rounded to either the tenths decimal place, or to the nearest whole number.

Example - Volume Calculation - Cubic Feet:
Set-up 12'-3" x 10'-6" x 7'-6" = ? cu.ft.
Convert \((12' + \frac{3}{12}') \times (10' + \frac{6}{12}') \times (7' + \frac{6}{12}') = ? \text{ cu.ft.}\)
Decimals 12.25' x 10.5' x 7.5' = 9,646.875 cu.ft.
Solution 12'-3" x 10'-6" x 7'-6" = 9,647 cu.ft. (rounded)

A delivery of concrete is measured in cubic yards (cu.yd). A yard is equal to three feet. To calculate cubic yards divide cubic feet by 27 (3x3x3).

Example - Volume Calculation - Cubic Yards
A new garage slab will be poured. It is 22'-0" x 14'-0" by 5" thick. How many cubic yards of concrete need to be ordered?

Set-up 22'-0" x 14'-0" x 4" = ? cu.yd
Convert 12' x 14' x (5/12') = ? cu.yd
Decimals 12' x 14' x 0.417" = 70 cu.ft
Divide 70 cu.ft \(\div 27 = 2.59\) cu.yd
Solution 22'-0" x 14'-0" x 4" = 2.6 cu.yd (rounded)
**Division**

When drawing plans for a house, *division* can be used to divide a space into equal parts; such as placing evenly spaced windows on a wall, support columns on a plan, or concrete pier footings in a crawl space.

Another common *division* problem is designing stairs; you take the total distance between two floors (“floor-to-floor height”), then divide by the “ideal” height of each riser or, (the code maximum if tight on space), and you will then have the number of risers. Risers are figured out first with division, then treads with multiplication. *Figures 2.7 & 2.8*

When *dividing* feet and inches, it is easiest to convert the inches into decimals and then use a calculator to complete the computation.

**Example Problem:**

Set-up \[ 12'-6" \div 4 = ?'-?" \]

Convert \[ (12'+\frac{6}{12'}) \div 4 = ?'-?" \]

Decimals \[ 12.5 \div 4 = 3.125' \]

Convert back \[ 0.125' \times 12 = 1.5" \text{ or } 1 1/2" \]

Solution \[ 12'-6" \div 4 = 3'-1 1/2" \]

**Figure 2.10 Example Problems, Multiplication & Division**

1. **How many risers are needed in Figure 2.8?**
   - floor to floor = 9’-10”
   - max. riser height in residential = 8”
   - \[ 9'-10" \div 8" = ? \]
   - convert floor-to-floor to inches
     \[ (9 \times 12") + 10" = 118" \]
   - \[ 118" \div 8" = 14.75 \text{ risers, not possible} \]
   - So round up to 15 risers

2. **If there are 15 risers and 14 treads at 11” each, how long is the run of stairs (horizontally)?**
   - \[ 14 \times 11" = 154" \text{ or } 12'-10" \]
   - (154"/12 which = 12.83’; 0.83’x12=10”)

**Figure 2.11 Stair Section**

*Terpin Remodel, Michelle Mueller, Architect*
Chapter Three

Site Plans

The Site Plan shows the house on its site (lot), from a bird’s eye view. Another name for this type of drawing is “Plot Plan”.

Types of Site Plans

Design Site Plans
Site plans for Design Development convey a general sense of the location of buildings (house, garage, sheds), along with landscape elements, decks, walkways, garden walls, fences, swimming pools, pergolas, trellises, etc. Site furniture such as tables, chairs, benches etc. are often included. For steeper sites, topographic information (contour lines showing grade) may be shown. Design site plans often have color applied, to indicate landscape and hardscape items. Landscape items include trees, bushes, gardens, lawns, and plantings. Hardscape is paved areas such as patios, walkways, driveways.

Construction Site Plan
Site plans for Construction Documents show details, and provide reference, for all construction related to the site work and location of buildings. A site plan is a drawing showing “site improvements”, or any construction on the site.

For our purposes in Residential Print Reading, a site plan will typically include property lot lines, easements, utilities, the house, garage, outbuildings (such as storage buildings), critical dimensions, decks, landscaping, paving, retaining walls, fences, grades (topography or slope) and elevation (height) references. Because a large area is shown on a site plan, the drawing is at a smaller scale than typical floor plan. Site plans are often drawn at 1/8”=1’-0” or 1’=1’-0” scales. Many building permit jurisdictions require a site plan that is a minimum size of 1”=1’-0” in scale.

Describing a Site with a Legal Description
The most basic component of the site plan is the perimeter or boundary of the property, also known as the lot. Every property can be located and described with a legal description, which is a written description delineating a specific piece of property. This legal description can then be drawn as the site, or lot.
**Metes and Bounds**

A short history of Land Legal Descriptions starts in early America, and leads to understanding the *metes and bounds* method of legal descriptions. In the original colonies, ownership of individual parcels of land was often established before the region was systematically surveyed by a surveyor. Parcels of land were described using key features of the landscape such as large rocks or trees to describe the boundaries of the owned land. To legally describe (survey) this land later, each property line segment was surveyed and its compass direction (bearing) and length recorded. This system is called metes and bounds. Metes (a measurement) and bounds (a boundary) surveying produced land ownership maps like the property shown in Figures 3.4 and 3.5. Note that the compass directions are by convention listed as so many degrees east or west of north and south.

The metes and bounds method is one way to measure and describe a property, and is especially useful with irregular-shaped properties, such as one finds in hilly areas of west Portland. The metes are given in feet, determining the length of any side of the property. The bounds are directions or bearings, which determine the angles of each of the corners, and are measured in degrees. These bearings relate to a compass that is 360 degrees in a circle, and each quadrant have 90 degrees. Each degree is further divided into 60 parts, called minutes.

*Figure 3.4 Example of a Metes and Bounds survey*

*Figure 3.5 Colonial Property Metes and Bounds Survey and Written Description*

“Beginning with a corner at the intersection of two stone walls near an apple tree on the north side of Muddy Creek road one mile above the junction of Muddy and Indian Creeks, north for 150 rods to the end of the stone wall bordering the road, then northwest along a line to a large standing rock on the corner of John Smith’s place, thence west 150 rods to the corner of a barn near a large oak tree, thence south to Muddy Creek road, thence down the side of the creek road to the starting point.”

www.surveyhistory.org
Each property that uses metes and bounds starts its reading from a specific “point of beginning” (POB), which is typically an iron rod, driven into the ground. This POB was used to establish the boundaries for other adjacent properties. The metes are measured in feet, and originate from measure in rods (16.5’) or surveyor’s chains (66’). Figure 3.6

**Tier and Range**

A second piece of history describes how *Tier and Range* surveys created a large-scale referencing system for a large part of western and central U.S.A. The area that runs from the western border of Ohio to the Pacific, along with a portion of the southeastern states constitutes the “public land states”. The US Bureau of Land Management created a system to describe this land, called the “rectangular survey system”, creating the United States Public Land Survey System – also known as the Tier and Range System. Using imaginary reference lines called “parallels” or “baselines” (east-west, similar to latitudinal lines), and “meridians” or “principle meridians” (north-south, similar to longitudinal lines), lands were mapped in large grids. The intersection of these two basic reference lines – the baselines and principle meridians, is the beginning point of each land reference. There are 31 sets of baselines and principle meridians across the continental US. The last, most westerly one, is the Willamette Meridian which passes through the Willamette Valley of Oregon and through the City of Portland. Figure 3.8

In Portland, the intersection of the Willamette Meridian and Willamette Baselines was historically marked with a stone obelisk, called the Willamette Stone, located on what is now SW Skyline Blvd. in Portland. It was replaced with a stainless steel monument in 1985. All property in Washington and Oregon is measured in relation to the Willamette Stone. Figure 3.9

Using the intersection of a baseline and principle meridians, a grid system was surveyed. From the principle meridians and baselines, the *tier and range* system was then constructed. Horizontal lines, parallel to the baselines, were constructed, creating six mile strips called *tiers*. They are numbered in order, from the baseline, and given a letter designation of N or S, depending on their location relative to the baseline.

Likewise, *ranges* that run parallel to principal meridians were also established in six mile strips. Together, the tiers...
and ranges create a grid of six mile squares, called *townships*, which are 36 square miles, or 23,040 acres. *Figure 3.10*

The townships were further broken up into 36 *sections*, each section being a one mile square, and about 640 acres in size. At the smallest scale, each section was divided into *quarters*, and each quarter divided into four *quadrants*. *Figure 3.11*

The Tier and Range systems, and its subsequent subdivisions set the stage for developing the *lot and block* system of Legal Descriptions. The United States and Canada began using the lot and block system in the 19th century, as cities grew into the countryside. Land owners created a plat of their land using the Tier and Range systems, and then subdivided it into smaller lots that were sold off. This method became especially widespread post-WWII, as suburban development created many new plats of land. The lot and block method is often seen in the relative flat areas of east Portland. An example of a lot and block legal description is “1N1E14CD Highland Park Addition, Block 13, Lot 24.” *Figure 3.12*

It is important to keep in mind that tax maps do not show built structures, easements, or fences. Easements are often written out and included in land deed information, which would include a written description and/or plat map of either metes and bounds or lot and block type. Many cities will show an overlay of tax lots on an aerial photo, but these are approximate and cannot be used in place of a licensed Surveyor’s plat map. If building on a property with an existing house, garage, shed or fences, a Surveyor’s map filed with the city is the only legal and accurate description of elements located in relation to property boundaries.

**What’s on a Site Plan**

Site plans typically include a fairly long list of items, including:

- Existing and proposed topographic contours and any new or existing retaining walls
- Elevations (height of the grade) at lot corners
- Property lines
- A north arrow
- Adjacent streets
- Location and dimensions of any easements
- Location and dimensions of driveways
- Location of utilities
- Decks, walkways, and any paving
- Existing and proposed landscape elements
- Onsite water management features, such as bioswales or rain gardens
- Existing and new buildings, shown as either the shape of the roof or the outline of the building footprint
- Elevation of the main floor of buildings
**Definitions**

*Easements*: a homeowner’s agreement with another adjacent property owner to use a portion of that property for a specific purpose, such as to pass an underground utility service through the neighbor’s property, and onto to their own.

*Contours*: imaginary lines on a plan that represent areas of sloped ground; the vertical space between them are contour intervals. For a moderately steep site, contours are shown for every one foot of grade change; for steeper sites contours may show every 2 or even 5 feet of grade change. Also called *topographic lines* or *topo lines*.

*Retaining walls*: concrete or other masonry walls built to support an area of soil, creating a terrace or terraces on an otherwise sloped site.

*Setbacks*: the minimum distance required by local Zoning Codes, from property lines to any building.

*Onsite water management*: the collection of water on a property to prevent it from going into the city sewer or rainwater collection system. Water is collected from the roof, via gutters and downspouts, and conveyed into rain garden features or drywells, for absorption and evaporation.

*Grading plans*: a type of construction document that represents re-grading of a steep site. Re-grading is often “cut and fill”, meaning that soil will be cut out of steep areas of the site, and filled into flatter areas of the site, so as to provide a flatter area to build a house. Both the existing and proposed topography is illustrated, with existing contour lines shown as dashed lines and proposed contour lines shown as solid lines.

*Utilities*: location of utilities to be accessed from the street including water lines, sewer lines, natural gas lines and electric conduit (if applicable).

**Reading a Site Plan**

First, the *property lines* will typically be shown on the site plan, along with site dimensions. The property line is a bold line that is created by a long line and two dots or two short dashes. A metes and bounds surveyed site will include the
“readings” or metes and bounds description along each property line. A lot and block surveyed site will show lot and block numbers, along with dimensions along front, side, and rear property lines. Setback lines, as required by zoning laws, will be shown. Adjacent streets, along with existing utilities, will be designated.

The next most important aspect of a site plan will be the location of the proposed, or existing house, along with garage, off-street parking, walkways and decks, paving, and landscape elements. The building will be shown as either the outline of the exterior walls, or the shape of the roof with the exterior walls dashed in.

Any slope on the site must be accounted for. If the site is relatively flat, then the elevation, or height of the land, (grade) will be shown at the four corners of the property. If the site has a fairly gentle slope, then the contour lines, showing the height of the grade, will be drawn in solid or dashed lines. If the site is somewhat steep, and the grade needs to be adjusted, then the site plan will also serve as a “grading plan”. A grading plan is a part of the construction document that represents re-grading of a steep site. Both the existing and proposed topography is illustrated, with existing contour lines shown as dashed, and proposed contour lines shown as solid.

The Acer Lane home (Figure 3.14) has an Architectural Site Plan, Drawing 1 on sheet A0.1, drawn at a scale of 1”=10’. The north arrow indicates that north direction is to the left. Sometimes plans are shown with north facing to the left or right (rather than toward the top) to maximize page layout. The lot, as indicated by a “dash–dot dot” property line, is 110.09’ on the south side, 110.26’ on the north, 51.95’ on east, and 47.93’ on the west (also, refer to County Tax map Figure 3.15). Setbacks, as required for zoning, are drawn as dashed lines, and are noted as “5’ SIDEYARD SETBACK”, and “10’ SETBACK”. For ease during the permit process, it is best to provide dimensions for these setbacks. Note how “crowded” the notes are around the front porch steps, and the southwest corner of the house. Better placement of these notes would make for easier reading. Note also that the convention for text on Architectural drawings is to write in ALL CAPS.

Existing City utilities are noted on N.E. 45th Avenue, and include the sewer line (SS), the water line (W).
The house faces onto N.E. 45th Avenue, which is noted at the bottom of the site plan. The proposed home is noted as “NEW SINGLE FAMILY HOUSE”. The first floor will be built to a height of 113.50’, and the basement built at 104.58’; note the use of decimals of feet, which match to the system used by surveyors. These numbers relate to elevation above sea level, which is common for civil engineering drawings and typical for site plans. Grades are provided around this site plan, including grades at the four corners of the lot (106.50’ at the northeast corner, 112.04’ at the southeast corner, 109.66’ at the southwest corner, 106.33’ at the northwest corner, and a grade of 110.50’ right next to the southeast corner of the house.

Existing landscape elements to remain on the site are shown as thick, solid lines, like the large tree just west of the front porch. This tree is noted as “400 SF EXISTING TREE CANOPY 12” DIAM. BLACK HAWTHORNE”. New landscape elements are as dashed, including a “NEW 2” CALIPER (min.) DECIDIOUS TREE”, located just south of the Black Hawthorne. The existing contour lines are shown across the site, as solid lines. The highest, or “tallest” contour shown is +112 (feet), and the lowest contour shown is +106 (feet), meaning the site slopes down, from the south towards the north, for a total of approximately 6’. There is provision for onsite storm water management; a “STORMTECH S310 STORMWATER FACILITY or 22’ L. EASTSIDE SOAKAGE TRENCH” is noted at the northeast corner of the site. A fence is shown on the north side of the site. The conventional line type for a wood post fence is a line with small boxes distributed along it.

Note that the house is shown as a single line, indicating the outline of the house, and not the roof. The railing at the front and back porches are shown with two lines, and each step or riser is indicated as a single line. There is no garage, but the parking space, also known as a parking pad, is shown just south of the house. It is drafted using hatched lines to indicate pavers for the parking surface. The dimensions of the parking pad are noted as 9’ x 18’; the driveway is also noted as 32.00’ x 10.00’. Window wells are shown on the south side of the house as two lines, and noted “KEYSTONE TYPE WINDOW WELLS”.

Utility connections to house are noted on the north side of the house as “ELEC METER”, and “GAS METER”. A heat pump unit is called out on the south side of the house, and noted as “AC UNIT”.

Figure 3.15 The Acer Lane house property, as shown on Multnomah County Tax map
Chapter Four

Floor Plans

Types of Floor Plans

Design floor plans convey a general sense of the layout for a home, including walls, windows and doors, kitchen and bathroom layouts, and a few pieces of furniture to provide a sense of scale for the rooms. These plans often have some color applied or material representation to provide graphic interest for viewer for a presentation to clients, on a website, or in a portfolio. The addition of color and/or materials is called “rendering.” Figure 4.1.

Construction Document floor plans show dimensions and details regarding the location of walls, windows, doors, and kitchen and bath layouts. Figure 4.2. Construction Documents are used by a contractor to build from, and are also used for building permit application. The drawing sheet with the Floor Plans often has detailed schedules showing types, styles, and sizes of windows and doors, along with information indicating the types of finishes within each room.

Showing Building Elements in a Floor Plan

A floor plan is a drawing showing the general, overall construction requirements for a home. It is the most referenced of the drawings, providing detailed dimensions regarding location of building elements (walls, doors, windows, plumbing fixtures and built-ins). The floor plan is an imaginary cut at approximately 4'-0" from the floor, showing building elements as either “cut through” or as an outline for elements below the cut, such as a partial height wall, a window sill, furniture, or stairs.

The typical floor plan is drawn at ¼” =1'-0", so there is limited space to provide the necessary information regarding the size of components and other details related to building elements. To solve this, a series of industry standard symbols have been devised to refer to detailed schedules for windows and doors, and to indicate plumbing, mechanical, and electrical information.

Walls

Because of insulation requirements, most exterior walls are typically constructed of 2x6 studs, and, together with interior and exterior finish materials, measure about 7". (A 2x6 stud measures 1 1/2" x 5 1/2") Some exterior walls have an additional rainscreen of battens under the siding, making the total thickness of a wall about 8”. An exterior wall with a brick veneer measures about 11 1/2". Exterior walls in homes before the 1980’s were typically built with 2x4 studs and measure about 5". Walls on a Floor Plan are shown as a dark outline because they are “cut through”. Other types of exterior walls are discussed later in this Chapter.
Interior walls are typically constructed of 2x4 studs, and together with interior finish materials, measure about 4 1/2”. They are also shown as a dark outline on a floor plan. An interior wall that has a toilet in front of it will need to be constructed with 2x6 studs, to accommodate the 4” diameter plumbing waste pipe and vent pipe in the wall.

Partial-height walls serve as room dividers or guardrails at the top of a stairwell. Since they are typically 3'-0" to 3'-6" high, and are not “cut through” in their architectural plan, they would be shown as an outline with a medium line width on a Floor Plan.

Doors

A typical hinged door is drawn with two lines close together, representing a “cut” of the door leaf, which is about 1 3/4” thick. The door swing is also shown on the floor as a fine, imaginary line created by the edge of a door as it opens and closes. The drawing will also show a threshold as part of an exterior door; drawn as a line projecting a bit beyond the outside of the door. An interior door shows no threshold line on the floor, unless there is a change of flooring materials.

Bi-fold doors are commonly used on closets, drawn as though they are partially open. Sliding doors or patio doors are drawn similarly to a sliding window. French doors are a pair of hinged doors, and pocket doors have the door leaf partially shown within a cavity formed in the wall. See Figure 4.3

Door sizes can be noted right next to the door on the plan; the first two numbers are the width, the last two numbers are height. They may be noted using typical feet and inches, i.e. 3'-0"x6'-8" or simply the digits, i.e. 3068. Figure 4.5

Another method is to assign every door a letter or a number that refers to a door schedule. Figure 4.6 The schedule then provides the door size, hardware information, material of door and frame, and a “type”. The “type” refers to the style, such as panel, flush, and typically there is a drawing of each different door type. Figure 4.4

Windows

A typical window is drawn with two lines very close together, representing a “cut through” of the double-paned glass, which is about ½” thick. The drawing will also show a window sill as a line projecting out a bit from both the interior and exterior side of the wall.

The most common window “type” or operation is hung:
single hung windows have the bottom half slide upwards, and double hung have both the top and bottom half operate, or open. Hung windows allow for 50% of the window to be operable, an important thing to consider when determining egress (code requires one window have 5.7 s.f. operable area in each bedroom for emergency exiting), and ventilation (code requires 4% of floor area in operable window area). Another fairly common window type is a slider, having one side (usually the right side) that slides open. Sliders also have 50% operable area. Casement, or “French” windows, swing open towards the outside, providing 100% operable area. “Picture windows” or Fixed windows don’t open, and do not provide any egress or ventilation. Sometimes, you will find that a central Fixed window has operable, smaller casement or hung windows on each side of the Fixed window. A bay window is hung, casement, or fixed windows placed in the form of a square or bowed shape which “stick out” from the side of the house. There are other forms of specialty windows, such as circular, arched top, or Palladian.

Window sizes can be noted right above the window; the first two numbers are the width, the last two numbers are height. Figure 4.10 Another method is to assign every window a letter or a number that refers to a window schedule. The schedule then provides the window size, frame material, manufacturer, and operation, along with special notes regarding things like tempered glass. Figure 4.9

Finish Materials
The finish materials are often called out on a Finish Schedule of a custom house; occasionally they may be simply called out on the floor plan. A single line will indicate the end of change in floor materials, such as wood flooring abutting cork flooring in a kitchen.

Cabinets, Appliances, Equipment, Symbols
Kitchens and Laundry Areas
You will find cabinets, appliances, plumbing fixtures and other equipment drawn on the floor plan. The lower cabinets are shown simply with a single line, indicating the face of the cabinets 2'-0” from the wall. The upper cabinets are shown 1'-0” from the wall and are drawn with a dashed line to indicate they are above the imaginary “cut line” of 4 feet of the plan. Cabinets are also called “casework”.

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Appliances shown on a floor plan include range (also called a stove), range hood, cooktop, refrigerator, dishwasher, built-in ovens, washing machines, and clothes dryers. The hood, like upper cabinets, is drawn dashed to indicate it is above the cut plane. Dishwashers and built-in ovens are drawn with a shorter dashed line to indicate they are below the counter or “hidden” from view. Appliances such as the range, cooktop, washing machine, and clothes dryer are drawn with medium or medium light lines to indicate they are below the cut plane. Appliances that are taller than the cut plane, such as the refrigerator, are still shown with a medium/light line to provide consistency to the graphic language of “appliance”.

Equipment in a kitchen includes a microwave and/or a garbage disposal. Plumbing fixtures include sinks and faucets and floor drains. The line weights of equipment and fixtures is also medium/light. If anything is below the counter it is shown with a short dash, if it is above the cut plane it is a long dash. **Figure 4.11**

**Bathrooms**
Like the kitchen, you will generally find cabinets drawn on the floor plan. Plumbing fixtures, including toilet (also known as a water closet), vanity (which includes the sink, also known as a lav or lavatory), tub, and shower, will also be shown on the Floor Plans of bathrooms. Tub and shower areas may be fixtures with or without a glass door or pre-fab units with waterproof built-in wall enclosure. A shower may also be custom-built with a floor drain, lines to indicate slope of floor (minimum 1/4” per foot), and possibly a tile pattern at the floor.

**Utility Rooms**
A utility room usually houses a furnace and water heater. The furnace should ideally be located in the heated space of a house, within the “thermal envelop” (insulated space). A forced air furnace will need to have its room ventilated; the manufacturer may call for grills on the door to increase air flow.

**Fireplaces**
Brick, wood burning fireplaces have become less common in urban areas as wood smoke and ash negatively impact air

![Figure 4.11 Example of Kitchen and Laundry Plan](image1)

*Kitchen and Mudroom/Laundry, Keri Salim, designer*

![Figure 4.12 Example of Bathroom Plan](image2)

*Master Bath plan, Keri Selim, designer*

![Figure 4.13 Wood-burning Masonry Fireplace](image3)

*Remodel Clay Corp. 607 Rumford Fireplace Company | 3623 Rumford Drive | Jacksonville, FL 32277*
quality. The firebox of a masonry fireplace is angled on the sides to radiate heat into the living space. Masonry fireplaces have brick chimneys and require large foundations beneath them Figure 4.13 Other options are a natural gas fireplace insert or insulated fireplace made of steel. These are also called zero clearance, as they are placed on an exterior wall, and are surrounded by wood studs. They vent to the exterior of the house or through a metal chimney through the roof. Figure 4.14

Stairs
A staircase, or group of steps, are shown on a floor plan by illustrating the width of the stairs, and each riser, or step up. A single line shows each riser and the horizontal space between risers are the treads. Stairs going down from a plan are shown completely. Stairs going up have a symbol called a “cut line” that appears at the same area as the plan cut line on a straight run of stairs. If there is a landing, often the cut line will be after the landing. Stairs above the cut line are shown dashed.

The City of Portland has a very useful brochure at their Portlandonline website. Go to: http://www.portlandoregon.gov/bds/article/93024 to find “Brochure 8 – Stairs”. There you will see drawings of various staircases, along with their terminology and code requirements. A floor plan typically shows the requirements for the rise and run of a staircase, in an abbreviated format, such as a note that says “14 R @ 7.25” and 13 TR @ 10.50”, indicating there are 14 risers (steps up) that are each 7 1/4” high, and 13 treads that are 10 1/2” deep.

Room Titles
Each room shown on the floor plan is labeled with it name, indicating its function. The font size of the room title, or name, is larger than the plan notes and dimensions. Under the room title, the interior room dimensions may be given. This is not for the builder’s use, as they would use the other dimensions to establish the foundation and frame of the house; it is simply provided for the homeowner to have a sense of the size of each room. Other data that could appear under the room title might be a room number, floor material, and/or ceiling height above finish floor (AFF). Room numbers are much more common in commercial plans.

Hose Bibb
A hose bibb is an exterior, or outdoor, water fixture to

Figure 4.14 Fireplace Insert (l) and Gas Fireplace (r)

Figure 4.15 Two Stairs -- Up and Down from Main Floor

Figure 4.15 Stairs Going Up and Various Symbols
connect a hose to, also called a spigot. There are typically two or more of these, located conveniently for car washing, or gardening purposes. The symbol is a cross or T with the initials HB. Figure 4.15 upper left corner

**Smoke Detectors**

Smoke Detectors are required by building code and must be shown on permit drawings. They occur on the ceiling and are always shown on floor plans. The symbol is a circle with an S in it. Figure 4.15 bottom

**Electrical Outlets, Light Fixtures, & Switches**

Electrical outlets, along with light switches and light fixtures may be shown on a floor plan. However, in the case of a more complex electrical and/or lighting system, a separate plan may be drawn to show these elements. If the kitchen is the only room with an extensive lighting and electrical layout, it can be made into a larger-scale separate plan. Electrical outlets look like a circle with two lines through, attached to the wall. Light fixtures may vary quite a bit as there are many varieties of fixtures, such as recessed downlights, surface mounting ceiling lights, track lights, pendants, chandeliers and wall sconces. The symbol for a light switch looks like a dollar sign with one line. The wiring is shown between light fixtures and switches, or switches and electric outlets as a dashed line. Figure 4.16

**Attic and Crawl Space Access**

Building code requires the first floor over a crawl space have a panel that can be removed to provide access into the crawl space. Crawl space access may be located on an exterior wall, but modern construction practice typically puts it inside the home. Access is also required of the ceiling under an attic. Access to these spaces is needed in the event of repair of electrical or plumbing lines, or ductwork. The access panels are shown as dashed lines and noted with their size. Figure 4.17

**Cross Section Symbol**

The location of a Building Section is shown on the plan with a symbol referencing the drawing and sheet number of the section drawing. The top number is the drawing number, the bottom is the sheet number. Two of these cross-section symbols are placed opposite each other, just outside of the floor plan, with lines through the wall, showing
where the imaginary “cut” or section occurs. The symbol may have an arrow and drawing/sheet number icon on both sides, or an arrowhead and a foot on the other side. The arrow and/or foot face the direction the Building Section drawing shows. Figure 4.18

**Elevation Symbols**

Interior elevations may be noted on the floor plan. They use the same arrowhead with drawing and sheet numbers as the Building Section, but without any extra lines. Figure 4.18 Interior elevations are drawn as needed, to show unique architectural details that cannot be expressed in the floor plan alone. Examples of these include kitchens and bathrooms, where elevations are needed to show cabinets, architectural millwork, and special wall finishes like tiles. Figure 4.19

**Dimensioning Floor Plans**

*Dimensions* provide the required measurements of the building, needed for construction. These measurements are provided by a system of horizontal and vertical lines placed around, and sometimes inside of, the floor plan.

Dimensions consist of three parts: the *dimension line* is intersected by an *extension line* and marked with a “tick” mark. The dimension numbers sit on top of the dimension line. Figure 4.20 Dimension numbers are always expressed in feet and inches, and fractions, if needed. If the dimension is an even foot, such as 8 feet and no inches, the inches should be indicated 0”; i.e. 8'-0”.

The most common dimension style used by designers and architects is the system of aligned dimensioning. The measurements, or dimensions, are placed above the line, and are centered on the line. Horizontal dimensions are placed along the bottom and top of the floor plan, and vertical dimensions are placed on either side of the floor plan. The dimension numbers are placed upright when you turn the drawing 90 degrees, clockwise. Figure 2.18

**Exterior Dimensions**

Dimensions are to the outside of the wood stud frame wall, or the outside of a masonry wall; these will also align with the outside of the foundation wall. This way, the Floor Plan and the Foundation Plan will replicate the same overall dimensions.
Each line of dimensions is referred to as a “string”. The first, or outer string of dimensions should be the overall measurement of house. The second line of dimensions should include “jogs”, changes of plane, or bays of the house. The third string of dimensions generally will measure to the centerline of windows and doors, and to the centerline or face (either method is acceptable) of interior stud walls that touch the exterior walls. Centerlines can be indicated with a dash dot dash line type as in Figure 4.20 or with an intertwined CL above the tick. You’ll see some variety in these rules because each house is unique and needs to be considered on its own. The goal is always to provide a complete set of dimensions for the builder, in a direct, consistent, and easy-to-read manner.

**Interior Dimensions**

Occasionally, there will be interior walls whose dimensions cannot be shown outside of the floor plan. In this case, place a string of dimensions inside the house, capturing as many required measurements as possible. This dimension line should reference an exterior wall, and dimension to the face of the interior walls, centerline of interior walls, or centerline of interior doors, as the case may be (staying consistent with interior wall dimensions shown at exterior). If an opening for a specific piece of equipment (an appliance, or plumbing fixture) needs to be created, you can simply note the dimension as “Field Verify”. This could be the case in a custom-sized bathtub, or refrigerator, as an example. Sometimes a dimension could be simply stating a design intent, as in the case of centering a door on a wall; in which case a dimension line can be placed with the note “EQUAL” on each dimension. An important note: Never dimension wall thicknesses. It is not necessary to describe to a builder the thickness of a wall, as the thickness is determined by the pre-made building materials that are noted in the Building Section. As noted in “Walls” section of this chapter, the thickness of an exterior wall consists of the studs, sheathing, finishes, and a varying sized rainscreen. Dimensioning the thickness of a wall in the plan often creates an inconsistency between the plan and building section. The “rule” of dimensioning is to only dimension something once.

**Dimensioning with Masonry Veneer Walls**

As noted in the “Walls” section brick veneer will add the thickness of the brick (2 3/8” plus a 1” airspace) to the total wall thickness. Design and dimensioning of a house with brick veneer should be done in increments that reflect the size of bricks, so that bricks do not need to be cut at the corners. This will insure that brick walls look visually balanced and do not have one corner of cut bricks.

**Dimensioning Modular Unit Walls**

Exterior modular block walls are always dimensioned to their outside edges and to all openings.
for doors and windows. Like brick, block walls are best used in their modules and not cut. The most common block to use for exterior walls is concrete block, known as concrete masonry units (CMU). However, these are rarely used for homes in the Pacific Northwest, as they are difficult to insulate. There are other block type products emerging in the house-building market that are more suited to the Northwest, including:

Rastra ICF’s (Insulated Concrete forms) are panels that are manufactured in Arizona, and are made of made of 85% recycled expanded polystyrene (Styrofoam) and 15% cement. They are structurally strong, energy-efficient, non-combustible, mold-resistant, and sound absorbent. One would likely consider Rastra system early in the design phases of a house. The panels are made in specific sizes that the design would need to conform to. (Check out www.rastra.com for more information).

Faswall Blocks are made in Philomath, Oregon, so are a great choice for a locally made product. They are a self-insulated block with 85% recycled, mineralized wood chips and 15% cement. The thick walls provides a more energy efficient and quiet wall system than conventional frame construction. The 24” long blocks stack up without mortar, using an interlocking tongue-and-grove end design, and are reinforced with metal rebar like concrete blocks. (Check out www.faswall.com for more information).

SIPS can be used for walls and roofs. SIPS (structural insulated panel system), are pre-made panels with insulating foam that are covered on each side with structural facings, typically oriented strand board (OSB), a type of plywood. Each panel is factory-made for a specific house, with pre-cut panels in the shape of each elevation. SIPS wall panels are energy-efficient and quiet, compared to typical stick-frame walls. Wall thickness options include 4.5”, 6.5”, or 8.25” depending on the target level of insulation (R-value). The completed set of construction documents will be turned over to the SIPS manufacturer, who will convert the plan and elevation requirements into the actual SIPS panels.

**Kitchen and Bath Dimensions**

When designed by an architect or interior designer, standard dimensions as described in this chapter apply to kitchen and bathroom plans. However, another type of designer, the NKBA-certified kitchen and bath designer uses different conventions. The National Kitchen and Bath Association (NKBA) is an organization which has developed its own form of dimensioning, based on the requirements of cabinet installers. All dimensions are called out in inches. Architectural trim is shown on the plan, such as window casings and dimensions to aid in exact measurements. In addition to walls, and window and door openings (with trim), centerlines of appliances and plumbing fixtures are dimensioned. Figures 4.12 and 4.21
Chapter Five

Elevations

**Elevations** are orthographic projections showing interior or exterior walls of a building, in a “flat” view. The elevations you find in a set of residential plans are typically the exterior views; interior elevations are most often done only for rooms with unusual details or built-ins. Typically, all four exterior elevations are included in a set of plans for a building permit. Exterior elevations are labeled for *the direction that the wall faces*, not the direction that the viewer is facing when looking at the wall.

**Types of Elevations**

*Design Development Elevations* convey a general sense of the basic form of the outside of a home, and the location and style of windows, doors, roof, and exterior details. This is a very useful series of drawings during the design phase, illustrating the size, scale, and the overall exterior look of a house.

These types of drawings often have some color applied to provide graphic interest for the viewer. Shading and shadows provide a sense of depth at roof overhangs, and other offsets like bay windows. *Figures 5.1 and 5.2*

*Construction Document Elevations* show a more detailed version of the windows, doors, roof style, and exterior materials. This type of drawing uses symbols to show the location and extent of roofing and siding materials. All trims will be shown, and vertical dimensions will indicate overall heights between floors. *Figure 5.3*

**Showing Building Elements in an Elevation**

*Walls*

Exterior walls are shown with their finish materials, which would include lap siding, vertical siding, board and batten, masonry, or stucco-like finishes. These finishes are shown as symbols; lines indicate siding, battens, or panels; rectangles indicate bricks or concrete masonry units (CMUs) and dots indicate stucco, plaster or concrete. Exterior walls are often shown to project a bit beyond the foundation below because the finish materials add thickness to the structural wall assembly of wall studs. Trim boards are shown at the base or corners of the siding.
Roofs
The exterior Elevation will show the roof form, or type, in a flat, or orthographic form. In other words, no perspective is shown – making it easier to show elements drawn to scale. There are several typical residential roof types, including gable, hip, shed, and gambrel. Gables have two equally sloped sides; hips have four equally sloped sides; sheds are sloped in one direction; gambrels are like gables, but have two different slopes on each side. Figures 5.4 and 5.5 In drafted elevations, the top peak of the roof will not be dimensioned, but will be implied by a roof pitch shown; details will be elaborated in the Building and Wall Section.

In addition to the roof form, the exterior materials are shown, which include wood or asphalt shingles, or metal standing-seam. The symbols used are box-like squares for shingles, or lines for the metal roofing.

Windows
Exterior Elevations show windows with their “operation”, or how they open. (Refer to Chapter 4, Floor Plans, for more information on window types). A hung window will have a horizontal “bar” across the center to show two window sashes that pass one another, and vertical arrows will indicate if the bottom pulls up (single hung), or if the bottom pulls up and the top pulls down (double hung). Likewise, a sliding window will have a vertical bar, and a horizontal arrow indicates the portion of the window that opens. A casement, (also known as a “French style” window) will swing open to the outside. A dashed line goes from outside corners to where the center of the hinged side on a casement window. Awning windows are basically like casements, just turned in a different direction, so the hinge is at the top. Fixed windows, also known as picture windows, have no vertical or horizontal bar, and no arrows. They can’t open and their lack of bars and arrows indicates they are “non-operating”. The pieces of glass in a window or door are called glazing or lites. The Single-hung window in Figure 5.6 shows an “8 over 1” style, indicating that the upper window sash is divided into 8 parts by mullions. Window sizes can be found on the Floor Plans or Schedules.

Doors
Exterior doors are also shown on the Building Elevations. Doors are drawn as solid rectangles (called a flush door), or
as panels set into rails and stiles, a paneled door. Glazing is shown if appropriate. Trim is shown around the door opening. Doors also show operation. For hinged doors a dashed line goes from outside corners to the center of the hinged side. Overhead garage doors may or may not show dashed lines similar to an awning window with the point at the top of the door. Slider doors, also called patio doors, are shown with an arrow on the side that slides open. A pair of doors are called French doors and are usually glazed, also showing the hinge location. Figure 5.7

Dimensions

Dimensions on elevations provide the required measurements needed for framing the house vertically. Dimension styles follow the protocol shown in Chapter 4 Floor Plans, using aligned dimensioning. As with dimensioning Floor Plans, dimension numbers are always expressed in feet and inches, and fractions if needed. If the dimension is an even foot, such as 8 feet and no inches, the feet should be indicated as a 0”; i.e. 8'-0". Figure 5.8

Symbols

A number of symbols are used on Elevations. Building Section symbols are shown. Datum points that look like a circle with a checkerboard may be called out on the elevations based on critical elements, such as the first floor height and top plate heights. The first floor subfloor (sheathing) is often called out as 0'-0". A center line across the elevation shows floor and ceiling locations. Light dashed lines are used to indicate foundations below grade. Section markers similar to those on floor plans are often shown on elevations as well. Window designations such as a letter in a hexagon or diamond may be shown on elevations instead of floor plans and are linked to a window schedule. Figures 5.8 and 5.9
Reading Elevations
The plans of the Acer Lane residence have one sheet of exterior elevations; Drawings 1, 2, 3, and 5 on sheet A3.1. You will see a list of notes indicating roofing, siding, and trims. Each elevation has a series of horizontal lines, with long dashes and dots between, providing vertical dimensioning between floors. These dimensions correspond exactly to the Building Section Drawings (Sheet A4.1). Also, note that the outline of the basement walls and footings are shown as a dashed line, at the lower level of each drawing. The exterior finishes are indicated with both notes, and also symbols; siding is shown with horizontal lines, shingles with small “boxes”, metal roofing with vertical lines, and the exposed concrete of the foundation is symbolized with small dots (known as stippling).

West Elevation
The West Elevation shows the front of the house, or the side that faces the street. The pitch of the porch roof is noted as 3:12 (which is said “3 in 12”) — meaning for every 12 feet (or units) horizontal, the roof goes up 3 feet (or units). The pitch of the main gabled roof of the house, covering the attic, is noted as 10:12, same as the East Elevation. The front porch shows the guardrail as a series of small verticals. The front door has 3 panes of glass, and a window above it. A pair of casement windows are shown just south (to the right) of the front door.

South Elevation
The South Elevation shows a number of windows, as compared to the north side. The increase in windows on the south side is due to the Architect’s desire to create a Passive Solar home; meaning south facing windows collect solar gain during the (occasional) sunny, cooler days, adding heat to the home. During the warmer summer days, some of the sun is shaded by the small roof form that connects the front and back porch roofs. Notice the grade line exposes two smaller windows and a pair of casements to create a daylight basement — meaning windows bring light into the basement. The casements are sized to allow people to escape or “egress” in an emergency. Egress window size is regulated by building codes. The Oregon Residential Specialty Code requires an opening of 5.7 square feet for every bedroom. Doors, of course, count as egress openings.

East Elevation
The East Elevation shows the back of the house, or the side that faces the back yard. The pitch of the porch roof is shown in a similar fashion as the front of the house, it is the same pitch as the main roof of the house. There is a guardrail around the back porch, and you can see the side of the steps (risers) going down to the yard. There is a double back door; and a pair of casement windows are shown just north (to the right) of the back door.

North Elevation
The North Elevation has far fewer windows than the South Elevation, and the windows are smaller by comparison. That’s due to the desire for a Passive Solar House; the south windows are the largest to capture solar gain, and north are the smallest needed to meet basic egress needs from bedrooms, and provide daylight and ventilation to rooms. Note the double doors from the basement, providing ease of access, and a possible Accessory Dwelling Unit (ADU), as a rental unit for the home.
Chapter 7

Foundation and Framing Plans

Foundation Plans

Overview
A foundation provides a base for the even distribution of loads from roof, floor, and walls that travel through the house. The foundation system must be designed to handle all the vertical loads of the house and any horizontal loads from wind or a possible earthquake. Foundation systems are typically built of poured concrete. Concrete is also used for sidewalks, driveways, garage floors and patios—which are referred to as “flatwork”. Flatwork is placed after the building is framed, to avoid damage during the construction process. It’s typically sloped 1/4” per foot towards a drainage area, to avoid water retention on the flat surface.

The stem wall of the foundation system widens into a footing, which transfers loads to the soil. This footing must be sized to match the soil pressure (the soil's ability to resist the loads of the house without sinking): the softer the soil, the wider a footing needs to be. Soils are assigned one of five classifications, depending on their composition and ability to resist the loads placed on them. Soil pressure is measured in pounds per square foot (PSF), and range from a typical 1,500 to 2,500 PSF in the Portland area. The footing must be placed deep enough in the ground to avoid freezing. Each state's Building Code outlines the depth of frost zone for each county. If the footing rests on soil above the freezing level, it is subject to expansion and contraction from ice and water in the soil, potentially causing foundation cracking and other damage.

Foundation Types

Continuous Foundation
The most common Foundation Type for homes in the Pacific Northwest is the Continuous, or Spread, Foundation. This consists of a footing and foundation wall that runs under the exterior walls. The footing is the wider area of the foundation that spreads the load (or weight of the building) to the soil it sits on.

After a building site is cleared of landscape and foreign debris, it is ready for the foundation work. Excavation is done and footings are poured. After the footings set, foundation
wall formwork is placed. After the concrete stem wall is poured into forms, anchor bolts are placed in the top of the stem wall. These anchor bolts are used to hold the mudsill onto the stem wall. Figure 7.1 The size of the stem wall and the footing is determined by 1) the load of the building which depends on the number of stories, and 2) the soil bearing capacity, as described above. One can then determine the stem wall thickness and the footing width by using one of the reference tables in the Building Code.

There are two basic types of Continuous Foundations. The most common type found in homes built starting in the 1960’s to the present, is the crawl space foundation. This consists of a short stem wall and a footing, creating a small space between the ground and the underside of the floor framing. Figure 7.2 A crawl space will have foundation vents which are approximately 8” x 16” screened openings in the stem wall, to allow for air to circulate and ventilate throughout, preventing moist air from seeping into the house. In some cases, the crawl space may be finished with a 2” concrete slab (sometimes known as a “rat slab”) and insulation; creating a “non-vented crawl space” for energy efficiency. When the stem wall extends down 6’-8’ or more, the extra vertical space can be used as a basement, with the addition of a concrete slab floor. Figure 7.3 If a basement is planned instead of a crawl space, basement windows are provided in the foundation walls. Basements are either heated (conditioned) or not, but are not required to be ventilated the way crawlspaces are.

The Continuous (or Spread) Foundation system (described above) provides support for all building loads at the exterior of the building. Loads from interior bearing walls are typically supported under the first floor of a house by a girder beam, which is in turn supported by a post and column sitting on a concrete pier footing (also called “spot footing,” “pad footing” or “post + pier footings”). The width, depth and height of the pier footing is calculated based on the load, and the soil bearing capacity.

A moderately sloped lot can be accommodated with a Stepped Foundation—a type of Continuous Foundation where the footing and stem wall “step down” to match the slope. This solution works with either a Crawl Space or Basement Foundation.

**Slab-on-grade Foundation**

Another common foundation system found in some
residential and most commercial buildings is the Slab, or Slab-on-grade foundation. A continuous footing adjoins the concrete floor slab, and generally is less expensive than a continuous foundation with a framed floor. The concrete slab is 3 1/2"-5" thick and does not support interior bearing walls. Additional pads are poured under the slab if interior bearing is required. With this foundation type, the footings are poured first, and then the slab is poured on a base of compacted sand and gravel fill. A 6-mil. polyethylene plastic sheet is placed under the slab as a moisture barrier; for energy efficiency rigid insulation is laid under the slab to prevent heat loss. The slab is reinforced with a welded wire mesh (WW or WWM) to resist cracking. Figure 7.4 The spacing and thickness of the wire is described by the notes on the slab. For example, the note “4” conc. slab w/ W16x28 @ 6 x12” indicates that a slab on grade is 4 inches of concrete with longitudinal reinforcement of size 16 wire with 6" spacing and the transverse is a size 8 wire with 12" spacing.

What is Shown on a Foundation Plan?
The Foundation Plan is drawn to show footings, foundation walls, and floor framing that sits on top of the foundation walls to support the first floor. Also included are any pier footings and foundation vents. The mudsill and anchor bolts are shown in a section detail, along with reinforcing bars (rebar), and are not included on the Foundation Plan.

Foundation Graphics
Footings are normally shown as a dashed line type to indicate that footings occurs below grade. Foundation walls are drawn with the same line weight as walls on a floor plan, as if they were cut horizontally. Foundation vents may be shown dashed or solid medium lines. Posts are shown as heavy lines with a light X inside the square or hatched to indicate solid sawn lumber. Pier pads are shown as a medium solid line. The floor framing (joists and beams) may be shown a variety of ways and will be discussed in more detail later in the chapter.

Foundation Plan dimensions and dimension styles should match exactly to those on Floor Plans. This coordination is because the foundation is built first, before walls, and the exterior of wall studs align with the outside face of the stem wall, at the foundation. Any pier foundations will be dimensioned to the center of the pier, which coordinates with the center of the post and beam, and load onto that pier.
Reading Foundation Plans
We will refer to Renaissance Homes’ Hudson house plans. Figure 7.6 Because this plan is for a speculative house, (a design without a specific site) the north arrow has been omitted. For the purpose of explanation, we will call the top of the sheet “north.”

This foundation plan shows a slab on grade with continuous spread footing at the garage to the left, and a continuous foundation with crawlspace for the main house. Note the overall dimensions of the foundation as 42'-0"x40'-0". All dimensions showing the ins and outs of the foundation wall must be given, as the foundation is the basis of the house and constructed first. The exact width of each foundation wall and footing, as well as footing depth, is found in the notes on the upper right side of the sheet, along with information about soil pressure and vent size. Posts on this plan are shown as black squares and noted with their size. At the garage, notice the larger footings under posts at approximately 12'-9" from the south. The slab on grade is called out with a note. Dimensions show where a “man door” occurs at the north and where the overhead garage door occurs at the south. These dimensions are important, as the stem wall must not extend past the concrete slab at these locations. Elsewhere, the stem wall continues as an 8" curb to keep the wall framing from contacting grade.

The north and south sides of the house have dimensions to the centerline of posts. They are a series of porch posts with spot footings that support a roof at each side. Note that the north side also has a “U” shape, where a 10'-0 1/2" wide section is recessed 7'-0". The note “(2) 2x4” points to a series of posts running down the center of the plan. These doubled-up 2x4’s pick up the point loads from the Upper Floor Framing Plan Figure 7.6 which are point loads from headers and beams above. Instead of pier pads below the posts, a series of continuous strip foundations...
divide the area into bays. Vents are shown as rectangles with an X in them indicating they are a void in the concrete wall. The floor framing (for the 1st floor which rests on the foundation) is shown as a centerline with long and short dashes, spaced 2'-8" apart. As the joists are not strong enough to span across the right area of the house, the span has been broken into (2) 8'-9" wide spans, with an interior footing (see detail 2 on the sheet) as an intermediate support. The 1st floor system is a bit unusual, as the joists are 2'-8" apart (typically they would be 16" or 24" spacing), and the subfloor is 1 1/8" T & G decking (5/8"-3/4" OSB or plywood is more typical). Renaissance Homes also chose to show first floor interior partitions (walls), plumbing fixtures and the furnace as dashed. Stairs are also shown. When these items are shown on a framing plan, it’s to remind the builder where ductwork and doubled up framing members might be required.

Notice that there is no information on this Foundation Plan regarding seismic (lateral) design, as this set of plans uses another sheet, S-8 to create a separate set of “Lateral Plans” for main and upper floors, along with a Holdown and Shearwall Schedule.

What’s Shown on a Floor Framing Plan?
The most common framing system for a floor is the use of wood joists. These joists are typically one of two types: sawn lumber or engineered lumber (“TJI”, “Trusjoist” or “I-joist” are common terms for engineered lumber used as joists). Sawn lumber is milled directly from trees, which are then dried, shrinking 1/2" to 3/4" in actual size, which is why the size used to describe sawn lumber does not include inch marks. For example, a 2x4 actually measures 1 1/2"x 3 3/4" and a 2x10 measures 1 1/2"x 9 1/4". Engineered lumber I-joists are manufactured from wood byproducts, glues, pressure, and heat.

Joists are secured on top of the mudsill, and spaced either 16" or 24" O.C. (on center). The first floor joist size and direction are typically found on the Foundation Plan. Floor joists usually span the width, or more narrow span, of the plan. If the span is too long for the joists to carry loads from exterior wall to exterior wall, then a girder beam, supported by posts and spot footings, provide intermediate support. If a beam is used it may be solid sawn lumber, such as a 4x8, or engineered lumber in the form of a glu-laminated beam.
(glu-lam), parallam or microlam. These types of beams are made of smaller pieces of wood and are glued together under pressure and heat to create strong and stable horizontal support. At the first floor, another possibility is intermediate support that is provided for a short cripple wall and spread footing as shown on the Hudson plans.

Floor joists ends are either overlapped and connected with nails at the intermediate support, or they are butted at the ends and joined with steel straps. Bridging or blocking is placed between joists horizontally to stiffen the system, and prevent the joists from turning or twisting. The joists are covered with a subfloor, and then walls are built on top of the subfloor.

As mentioned above, in the Foundation Plan description, the floor framing that is supported by the foundation will typically be included on the Foundation Plan drawing. An additional Floor Framing Plan is only required for a house with two or more floors. Dimensions may call out the length of span of structural members. The Floor Framing Plan will show joists, beams, headers, posts, and any structural connectors for seismic design.

The joists typically span the shorter direction. If the width is too great for a single span, an intermediary girder beam supported with columns can provide mid-span support, or an interior partition can serve as a load bearing wall to support joist ends.

Plywood floor sheathing should also be shown on framing plans. It’s always placed perpendicular to the direction of joists and joints are offset.

**Framing Graphics**

The Floor Framing Plan(s) will show the framing for the second floor (or third, if there is one) of a house, along with the exterior walls below, and the interior partitions and columns below that support the floor joists or beams. **Partitions that rest on the floor are not shown on a Floor Framing Plan, as they do not provide support for the floor joists or beams.**

Headers which transfer weight horizontally at openings in walls at exterior doors, windows and in doorways of interior load-bearing walls, will also appear on Floor Framing Plans. Remember, for a Floor Framing Plan we are...
looking at the floor structure with walls, beams and columns below. That means the headers shown on a Second Floor Framing Plan are for openings occurring in First Floor walls.

There are several “standard” ways to show framing members graphically. One option is to show the centerline of each joist in a light line, and beams as a heavy centerline. Any doubled up joists are shown as two centerlines next to each other. Joist hangers may also be shown as a “cup” shape, or two L’s next to each joist. Headers are also shown as heavy centerlines.

Notes are on the plan to indicate the size of headers, joists, beams and columns (posts). The Hudson plans use letters and a schedule to call out member sizes. Engineers often use this convention when drafting framing plans. Figure 7.6

Another option that is popular with residential designers is to show beams as a heavy centerline and indicate joist direction as a line with two arrowheads, and the callout above the line. Beams have a note above to indicate size and type; headers are also shown as a heavy centerline. Sometimes bearing walls are shown with a hatch and non-bearing internal partitions may be light lines or omitted. This is sufficient information for a building permit, but allows the framer to figure out specifics of framing in the field. Figures 7.7 & 7.9

A third option is to show every joist and beam and their sizes on the framing plan, along with any joist hangers. This type of drawing is more time-consuming to create, but provides a solid understanding of the structural framework required for construction. Figures 7.8 & 7.10

Plywood sheathing is shown as one 4’x8’ rectangle adjacent to a 4’x4’ square perpendicular to framing direction with a note about the thickness and grade of material. Figure 7.11

**Lateral or Seismic Bracing**

Walls in a house consist of 2x6 studs at the exterior and 2x4 studs at the interior. However, an interior wall that has a toilet in front of it has 4” diameter plumbing pipe running through it and needs to be made with 2x6 studs. All studs are sawn lumber. Wall studs are not drawn on framing plans, nor are they shown in elevation (vertical) view.

Shear panels are special wall panels used to resist lateral (seismic) forces. The specific design for shear panels can be determined from reference to the Building Code (in simple designs), or by a structural engineer. A “braced wall panel” is described in the Building Code, while a “shear wall” is
typically designed by the project’s Structural Engineer. A braced wall panel (BWP), which is typically 48” wide, can be made narrower by the use of an “alternative braced wall panel” (ABWP) measuring 28”-36” wide. A “portal frame wall panel with hold-down anchors” (PFH) can be even more narrow than 28”, and is typically used adjacent to garage doors. Figure 7.11 Any of these required panels, along with metal connectors and straps, are noted on the Floor Framing Plans, or on additional structural drawings. The metal straps can be represented by a line placed on the side of the wall, with notes for its requirements. Because there are so many different seismic design solutions, the location and construction is marked on the Floor Framing Plans (and sometimes also shown on exterior elevations). The exact requirements may be summarized on a “Braced Wall Schedule” along with a “Hold-Down Schedule” located next to the Floor Framing Plan. In the case of the Hudson house, a separate set of plans on S-8 creates “Lateral Plans” for main and upper floors, along with a Holdown and Shearwall Schedule.

**Figure 7.14 “Hudson” Floor Framing Plan**

**Reading Floor Framing Plans**

Refer to the Hudson Plans, sheet S-3.1 (“Upper Floor Framing Plan”) below. Figure 7.14 You will note there are no overall dimensions, as those have been established on the Foundation Plan and the Floor Plans. The floor framing consists of 16” (deep) open-web engineered joists, as shown in note “16 OWJ @ 24” O.C.” Open-web joists are similar to trusses. Headers are shown as centerlines and called out by code, i.e. “H-2” at the window openings, in the upper right area of the plan. The requirements for these headers are found at the top center of the sheet in the “HEADER SCHEDULE”. The H-2 is a 3 1/2” glulam beam, or a 4x8 Douglas Fir structural grade #2, sawn lumber. Beams are also shown with a centerline, and have a code to indicate their size in the “BEAM SCHEDULE”, such as “BM #1” at the south side porch which is a 4x8 Douglas...
Fir grade #2. LVL beams are engineered lumber (laminated veneer lumber). Columns and the walls that hold the floor up are shown. Load-bearing walls have a diagonal hatch.

**Roof Framing Plans**

**Roof Framing Types**

Roof framing is placed after the walls are constructed, and braced. There are three common types of roof structures: trusses, ridge beam and rafters, and ridge board and rafters with collar ties. Any of these types can be used with any roof style: gabled, hipped, shed, clerestory, sawtooth, gambrel. Flat roofs are framed like floors but sloped 1/4” per foot to shed water.

The most common modern roof structure is framed with trusses. These are made at a factory, efficiently engineered with 2x4 studs and metal plates, and delivered to the job site. They are quickly dropped into place and connected with ties to the top plate at the top of the wall. Because they are factory made, and put up at the site so quickly, they are generally the least expensive roof structure. Also, they are designed to span from exterior wall to exterior wall, thereby avoiding interior load bearing columns or walls under the roof (which allows more flexibility in floor plan design). There are many varieties of trusses, including those that allow for a vaulted ceiling at the interior, and those that provide storage or living space in the attic.

Another roof framing type uses a ridge beam with rafters, allowing for a substantial vaulted ceiling at the interior. However, the entire roof structure would be constructed onsite, the ridge beam is difficult to get into place, and engineered metal connectors are used to connect the rafters to the ridge beam. With this system, the ridge beam is solid sawn lumber or a glu-lam, and rafters are either sawn lumber, or I-joists. The ridge beam is a structural, load bearing element that supports half the roof. These constraints typically makes the ridge beam and rafter system the most expensive.

The system using a ridge board (non-structural ridge element) with rafters and collar ties is typically seen in older bungalow homes, built from the 1910’s until about the 1970’s. The collar ties provide tension support to keep the rafters from flattening. During the 1970’s, manufactured trusses became easily available, and began to take the place of the ridge board and rafter method of roof framing.

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There are three common types of roof structures:

- trusses
- ridge beam and rafters
- ridge board and rafters with collar ties

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Figure 7.15  Examples of Truss Types

[Diagram of various truss types]

http://www.barntoolbox.com/roof-truss-types.htm
What is Shown on a Roof Framing Plan

The Roof Framing Plan shows the walls that the roof is set on, and some or all of the framing members. Roof Framing plans vary widely in their complexity. If there is one simple roof shape, such as a gable, and the structure is trusses, then the Roof Plan will consist of showing the direction of the trusses, with a simple note such as “ROOF TRUSSES AT 24” O.C.”. More complex roof forms, such as those with multiple gables, or the use of several dormers, may have all of the framing members shown, and noted. Specifically, rafters, ridge beams, and ceiling joists, along with trusses, are shown on this type of Roof Framing Plan, along with their sizes and the direction of the span. Roof overhangs that project beyond the exterior wall, along with sheathing, are also shown and noted.

Figure 7.16 Example of Roof Framing Plan with arrows showing direction of truss framing

Figure 7.17 Example of Roof Framing Plan with every member depicted

Figure 7.18 Example of Complex Roof Framing Plan, every member shown, including rafter over-framing for form combined with structural truss roof framing
Reading a Roof Framing Plan
The Hudson plans are an example of using a simple roof framing plan, for a simple roof form. Sheet S4.1 Figure 7.19 shows the 2nd floor walls, with the exterior (load-bearing) walls hatched with a diagonal pattern. The trusses will transfer their loads to these walls. The openings (windows) have header requirements noted in a similar manner as the 2nd Floor Framing Plan; each header is numbered and referred to in the Header Schedule. The entire roof framing system consists of trusses, noted as "MANUF. TRUSSES @ 24" O.C.". The arrows under the truss notes stretch across the exterior walls, and end at a solid line that indicates the end of the roof overhang. Note also, there are several details at the left of the sheet, showing flashing at the roof, and also a box of "ROOF GENERAL NOTES".

Figure 7.19 “Hudson” Roof Framing Plan
Chapter 8
Electrical and Lighting Plans

Overview
An Electrical Plan for a house typically consists of information related to placement and types of electrical outlets and lighting fixtures. For a simple house, this is often done as part of each Floor Plan. Occasionally the kitchen area has too many electrical and lighting elements to be shown legibly on the floor plan at 1/4”=1’-0”. In this case, an enlarged plan (1/2”=1’-0” scale) of just the kitchen area may be provided. For more complex home designs, the electrical outlets and/or lighting fixtures are shown on a separate Floor Plan. Another possibility is to provide a Reflected Ceiling Plan which shows lighting and electrical, along with ceiling information.

Electrical Basics
Electrical service to a house is delivered in 120/240 volts, and most typically arrives by an overhead (or underground) service from an electrical utility. The Site Plan may refer to an overhead service drop to the house, or an underground service lateral. When electrical power enters your home, it comes in at the service entry, flows into the electrical meter at the exterior, and the electrical service panel at the interior of the house. From there, the panel diverts the electrical flow into a number of different circuits, serving different parts of the house. The electrician can connect several outlets and/or light fixtures on each circuit, providing 110 volts to each one. Several household appliances need a special, higher-voltage outlet called a “240”, meaning it typically delivers 220-240 volts. These appliances include electric ranges, electric clothes dryers, and some heavy-duty refrigerators and freezers.

If a house has photo-voltaic panels to provide electricity through solar power, the electricity generated flows through the electric meter before entering the house's electrical panel. This allows a house to sell its excess electricity back to the utility company (the meter runs backwards, creating a credit) or to draw electricity from the utility company during periods of heavier usage when the photo-voltaics aren’t producing enough power. The term “net zero” refers to a house that can generate enough electricity over the course of a year that the electrical bill average usage is zero.

Figure 8.1 Residential Electrical Service: overhead service line (wires), service drop (pipe), meter (on wall with plastic dial or digital screen).

http://commons.wikimedia.org/wiki/File:Residence_service_drop.JPG
Electrical Outlets

A typical modern, North American electrical outlet has two vertical slots, with a round hole below or above (depending on how it is installed). The left slot is slightly larger, and is called “neutral”, the right slot is “hot”, and the hole is the “ground”. Older style outlets had equally sized vertical slots and no ground. These are prone to electric shock and should be replaced by a qualified electrician.

When you plug in a lamp, or appliance, the electricity completes the circuit from hot to neutral, making electricity flow through the filament of a light bulb or operate a motor, and back to the neutral. Every appliance with a metal case requires this type of three-prong outlet, along with electronics that have plastic cases like laptop computers. The three-prong provides the grounding, to prevent electric shock. Grounded outlets are typically for 110 volt, with the exception of the appliances mentioned above, which requires a 240 volt outlet.

The most common outlets are duplex (allows for two plug-ins), and four-plex or quad outlets (allows for four plug-ins). Most outlets in newer homes, or older homes with upgrades, have the three-prong outlets described above. Any outlets that are near water, such as in the kitchen and bathrooms, should be a ground-fault circuit interrupter protection outlet. These outlets, commonly called “GFI” outlets, monitor the amount of electrical current flowing from hot to neutral within the outlet. If there is any imbalance, the outlet stops, or “trips” the outlet, preventing the possibility of electrical shock. Any outlets that are on exterior walls are called water-proof, also referred to as WP. This outlet is also GFI, and has a spring-operated cover attached to side of the outlet.

What is Shown on an Electrical and Lighting Plan

Electrical and Lighting on the Floor Plan

As mentioned above, a set of plans for a simple house may show electrical outlets and lighting fixtures on the floor plan. Electrical outlets use a standard symbol (circle with vertical lines) to indicate outlets. Figure 8.3 Dimensions for outlets and lighting fixtures are usually not provided. Building Code dictates that no point along the perimeter of a typical room can be further than 6 feet from an outlet. Kitchens require outlets much more frequently because of the amount of small appliances that are used in that space. Builders know they must provide minimum spacing per code for outlets. Of
course, the client or residential designer can request more outlets than the minimum required by Code. Often the builder, owner, and architect/designer will walk the site after framing to verify exact outlet and light locations.

Light fixtures generally fall into several broad categories: ceiling (or surface) mounted, recessed, pendants, cove, and sconces (wall mounted). Each of these types will have a different symbol, which can be found on the light fixture schedule. Figure 8.3

Standard symbols indicate switches that operate light fixtures. The symbol looks like a dollar sign with one line. In some cases switches are connected to outlets called “half-hot” or “split wired” so they can activate a lamp plugged into them. The plan drawing diagrams the circuit connection, by the use of dashed lines or centerlines, linking lighting fixtures to switches. Typically these lines are drawn organically, meaning they are curvy and without right angles, to differentiate from other lines on the plan. A switch for a light fixture that can be operated by two different switches (a three-pole switch) is designated as such with the number 3, to the right of the symbol. Another addition to a light switch symbol is a “D” to indicate a dimmer switch. Dimmer switches may only be used for LED and incandescent light bulbs, and specially ballasted fluorescents.

Materials used for electrical wiring are controlled by Building Code, so are typically not specified on the architectural plans. The electrical service entry can be noted on the Floor Plan, along with the location of the service panel box. An Electrical Plan, submitted for electrical permit, will call out further information regarding the amperage of circuits, size of electrical panel, and junction box locations.
Lighting on a Reflected Ceiling Plan

A more complex house, with many lighting fixtures or a variety of ceiling heights, may use a separate plan to show the ceiling including light fixtures and switching, beams, soffits, coves and coffered ceilings, etc. Since a typical floor plan, cut about 4’ from the ground, doesn’t show ceiling elements, there are two methods used to solve this. Some designers use an alternate plan view which is created with the idea that the ceiling information is “reflected” onto the floor plan. The plan is called a Reflected Ceiling Plan, RCP, or Ceiling Plan. Figure 8.5 To visualize, imagine you are looking at a Floor Plan with mirrors on the floor surface; what you see is the ceiling information being reflected in the mirror. To create the Reflected Ceiling Plan, the base Floor Plan is used, including heavy cut walls, but without any dimensions. Windows and doors may be shown for reference, as it is sometimes intended for fixtures to be located adjacent to a window, or over a door. Arched openings, soffits, and beams are shown as medium lines because we are looking directly at them (instead of dashed to indicate they are above the cut plane). Notes or dimensions may be included to help the builder construct ceiling elements correctly. As with a Floor Plan that shows electrical and lighting, a legend is provided with symbols depicting the various light fixtures. Figure 8.6 In some cases, a more detailed Light Fixture Schedule is provided. A symbol on the Reflected Ceiling Plan indicates the general light fixture type; ceiling mounted, recessed, pendant, cove, or sconces. Each light fixture symbol has a letter, which corresponds with the Light Fixture Schedule, and provides detail about the fixture, including the manufacturer’s name, catalog number, type of bulb (i.e. CFL, Fluorescent, LED), and wattage.

Another solution is to include a Reflected Ceiling Plan, without dimensions, showing both electrical and lighting information, using the typical symbols. Cabinetry, plumbing fixtures, and furniture are shown in light lines (or lightly dashed) in order to indicate relationships of light fixtures to work spaces and seating areas.

Reading an Electrical and Lighting Plan

The Hudson plans represent a method of creating a plan showing electrical and lighting information, but without creating an entire Reflected Ceiling Plan. For this set of house plans, the designer likely saw no need for a Reflected Ceiling Plan, as the ceilings are flat throughout, with the exception of the Great Room, which has dashed lines labeled...
“box beams” to indicate a decorative coffered ceiling. The CAD Floor Plans are shown with dimensions omitted, and door swings are shown in a light, dashed pattern. This provides much needed space on the Plans to show light fixtures, exhaust fans, switches, and connections between fixtures and switches. A legend of symbols is provided on the right side of the sheet, showing three types of recessed fixtures, along with wall mounted, fluorescent, flood light, and under cabinet fixtures. Electrical symbols call out wall, waterproof, switch-controlled, and 240 volt outlets. Wall switches shown include basic wall types, along with low voltage types. You may notice that there are more symbols on the schedule than appear on these plans. It’s common for an office to have standard legends for symbols that may or may not appear on an individual project’s plans.

As you enter the home, a hanging light fixture (otherwise known as a pendant) is centered over the front door, and recessed can lights are placed on either side of the porch. Another hanging or surface mounted light fixture is found in the entry, as well as down the hall, and in the Dining Room and Den of the main floor. Recessed can lights with “eyeball” trim, which is aimable, focuses accent lighting on the fireplace wall in the Great Room. Under-cabinet lighting is found in the Kitchen, on either side of the cook top. An exhaust fan is shown in the Main Floor Bath, with a switch to the right of the door (as you enter the Bathroom). A sealed fixture, UL rated for wet locations, is over the shower. A triangle over the sink shows the location of a wall-mounted light fixture. Upstairs bathrooms use the same light and exhaust fan symbols. Surface mounted lights are in the bedrooms and recessed cans are in the hallway. At the back of the house, upper left corner there are two flood lights.

Some code-required information is not shown on this particular EL-1, but appears on the Main and Upper Floor Plans including smoke detectors and CFM exhaust fans.
Chapter 9

Plumbing and HVAC Systems

Plumbing Plans

Overview
The plumbing system consists of pipes and related devices, bringing fresh water into a house, and exiting waste water outside the building. The system can be thought of in two general categories; the plumbing fixtures (shown on a Floor Plan) and the piping (shown in a plumbing diagram). For a typical set of house plans, separate plumbing drawings are not done; the plumber simply creates a plumbing diagram, or presents a list of fixtures with pipe sizes to be used, to get the plumbing permit.

Plumbing Basics

Plumbing fixtures for the plumbing system in a house consist of all fixtures that use water. This typically includes a sink and dishwasher in the kitchen; sink, shower, bathtub, and toilet in bathrooms; and a washing machine and laundry sink in laundry rooms.

The piping for the plumbing system for a house typically consists of three basic parts: supply, venting, and waste.

The supply of “potable” or drinkable water, enters the house from the water main (a supply line in the street or an onsite well) and travels around the house in branch lines, typically 3/4” diameter. Branch lines are typically made of plastic tubing (called PEX, or the brand name “Wirsbo”). Water is distributed to the 1st and 2nd floor in risers, traveling vertically one or more stories. Potable water typically comes from the city water supply. Country locations pump ground water from a well for supply. A less common practice is “water harvesting” or collecting rainwater from the roof, storing, and filtering it for potable use.

The venting system allows for each plumbing fixture to release any methane gas that could build up from organic matter biodegrading in stagnant water in the waste lines. Vent pipes, which range from 2”-4” in diameter, can link together, and should always exit the house through the roof. Another benefit of venting is providing positive air pressure to prevent waste water from back-siphoning into fixtures.

The waste system is a series of pipes that collect liquid and
solid waste from plumbing fixtures and range in size from 1 1/2”- 4” diameter. At the end of the waste line, just before it leaves the home to connect to the city sewer (or an onsite septic system), a clean-out (opening into the waste pipe) provides access in the event of a clog.

Because both the vent stack and waste line may be up to 4” in diameter, it’s important to specify 2x6 walls behind toilets. This allows the plumber the flexibility to install pipe sizes that are appropriate to the needs of the system.

**Plumbing Appliances**

In addition to showing the typical fixtures for kitchens and bathrooms, plumbing plans and diagrams include information regarding hot water heating.

Hot water heating is typically done with either a **hot water heater** or a **tankless water heater**. A hot water heater is a 30-50 gallon tank that heats and stores hot water. Unheated water enters the tank, and is heated as the tank becomes depleted through use. Tank systems operate on electricity or natural gas. Tankless (on-demand) water heating can be used in place of the tank hot water heater. A tankless system consists of one or two units, either run by gas or electricity, mounted in a utility area. When hot water demand is triggered by a plumbing fixture, water is instantly heated and delivered to the fixture or appliance. Figure 9.3 Tankless water heating is gaining favor; it has pros and cons. On the pro side is the fact that hot water is not being heated in a large tank 24 hours per day, 7 days per week, creating what is called “standby losses”. So tankless water heating is often more energy efficient. Also, tankless units are also quite small; the average being about 20”x14”x6”, and can be mounted on a wall. They typically last 10 years, longer than a regular water heater and when they fail, they don’t flood due to rupture. On the con side are a few factors to consider; a large amount of energy is required to heat the water quickly on demand, and there is a tendency to “overuse” hot water since there is no tank that runs out. Also, the tankless system must be properly sized to provide the requirement gallons per minute (gpm), taking in consideration that two or three fixtures may be using hot water at the same time. In summary, tankless hot water heating can be an asset when the user requires infrequent hot water throughout the day and evening. For frequent hot water use, an energy efficient hot water tank, with a solar pre-heat, may be the most efficient system.
A **hydronic heating system**, which uses warm water-filled tubes under the floor as a heating system, also needs a hot water heating system. It typically uses its own water heater, separate from the rest of the house, which will show on the Floor Plan.

**Solar hot water** is a term that applies to the use of panels on a roof which use the sun's heat to warm water. In the summer months in the Willamette Valley, much of the hot water needs can be met with the use of solar water heating. The limited sun in the winter can still be used to pre-heat the water, raising the temperature 10-15°F (2.5-5°C), and then routing it back into the hot water heater. Solar hot water panels will be included on the Floor Plan, showing connections between the panels and the hot water heating.

**Terminology**

Both tradespeople and those in the building code industries refer to plumbing fixtures using different terms than are common to most of us. A list of terminology follows:

**Water closet** is an antiquated term that refers to a toilet.

**Lavatory** is another antiquated term that refers to a bathroom sink. It’s often abbreviated to lav.

**Pedestal lavatory** is a bathroom sink with a round or square base sitting on the floor. A wall mounted lavatory is, as the name suggests, one that hangs on the wall without legs, cabinet, or base.

A **walk-in shower** is one with no wall or curb to step over; the floor is sloped to drain water towards the center. It may also be referred to as a “roll-in” or “barrier-free” shower.

A **jetted tub** is a bathtub that is typically a bit wider and deeper than a standard, and has a power features that pump water around the tub. Also called a “whirlpool” or “spa”. A **Jacuzzi tub** is a larger, deeper tub, with a variety of water jetting and bubbling features. Jacuzzi is a brand name. **Figure 9.7**

**Laundry tray** is a laundry sink.

**Hose bib** is an exterior water supply faucet that connects to a hose, for gardening, washing cars, etc.

**What is Shown on a Plumbing Plan**
Plumbing Information and Fixtures on Floor Plans
As mentioned earlier, plumbing fixtures constitute one part of the plumbing system. These are easily incorporated on the Floor Plan, using standard symbols. The systems can then refer to a Plumbing Schedule, showing manufacturer’s information, catalog reference numbers and color/finishes. In some cases a specification (written information) simply refers plumbing fixtures to a general manufacturer, or to be later selected by the homeowner. Venting of any gas-fired appliances must also be noted on the Floor Plan, as in the case of a gas hot water heater or gas range. We will look at Schedules and Specifications in more detail in the next chapter.

Plumbing Information and Fixtures on the Site Plan
Plumbing fixtures and information as related to the exterior, can also be found on the Site Plan, using standard symbols, along with notes. The following would be typical plumbing information included on a Site Plan:

At Building Exterior:
Hose bibs, any downspouts connected to rain drain or onsite rainwater feature, drywells, rain barrels, gas meter.

On the Site:
Water supply and sewer lines (connect from street to house), water meter. Optional: Location of storm water containment (drywells, rain gardens), septic system layout, well for water supply.

Plumbing Diagrams
The “internal” portion, or piping, of the plumbing system is not visible on the Floor Plan. The pipes for the plumbing system ranges in size from 3/4” to 4” diameter, and are easily hidden within the wall and floor framing. The exact size of the various pipes are determined by the building code, and typically left up to the plumber to size, along with the piping layout around the house.

A piping diagram is a type of 3-D pictorial, showing the supply, venting, and waste system around the house, along with the pipe sizes. Figure 9.7 This diagram is typically a simple sketch, not drawn to scale, showing the general location of plumbing components. Different line types show supply, waste, and vent lines. This type of drawing, often done by the plumber for a job, is drawn in either elevation or isometric view. For a multi-family condo or apartment complex, a mechanical engineer consultant for the project

The following would be typical plumbing fixtures to include on a Floor Plan, and reference to a Plumbing Fixture Schedule:

Kitchen:
- Sinks, dishwasher, refrigerators with icemakers (requiring a water supply line)

Bathrooms:
- Tubs, showers, lavatories, toilets, bidets

Laundry:
- Washing machine, laundry tray (sink)

Entertainment Areas:
- Sink

Utility Areas:
- Hot water heater, tankless water heater
would produce detailed plumbing diagrams on a separate Floor Plan. This is called a Plumbing Plan, and would also include a vertical “boxed in” space, called a chase, that could accommodate multiple waste lines, as they travel from upper floors, down to exit the building. In this case, the typical 4” waste line would grow to 6” or 8” or larger, depending on the number of housing units using the waste lines.

**Reading Plumbing Fixtures on a Floor Plan**

The Acer Lane Floor Plans show all of the standard plumbing fixtures on the Basement, 1st Floor, 2nd Floor, and Site Plans.

The Site Plan, Sheet A0.1, *Figure 9.8*, shows the electrical and gas meters on the north side of the house. The northwest corner of the site will provide space for onsite storm water, in the form of a soakage trench. The “Pit of 1 ½” Drain Rock” receives the water from the rain drain that runs around the house. The water then gets routed into the soakage trench.

*Figure 9.8 Acer Lane Site Plan*
Figure 9.9 Acer Lane Plans
Figure 9.9 The Basement Floor Plan and the 1st Floor Plan, along with a Legend (upper left) showing symbols are shown on Sheet A2.1. The symbols for hose bib and downspout show on these plans. The Basement Floor Plan has a Mechanical Room that houses the hot water heater, and a tankless model is shown on the north wall of the room. A 3-piece bathroom with sink, toilet, and shower is also located in the basement. The downspouts, along with hose bibs, are shown on the exterior walls.

The 1st Floor Plan shows plumbing fixtures in the kitchen (double sink and dishwasher), along with a 3-piece bathroom (sink, toilet, and shower). The downspout locations are repeated on this 1st Floor Plan, as they travel the full height of the house.

The 2nd Floor Plan, Sheet A2.2 shows two 3-piece bathrooms; one on the east end, and another on the west end (with a double sink). The laundry room shows a utility sink (laundry tray); although a washing machine is not shown, the room name indicates the required plumbing. Note that the downspouts continue to be shown on this plan, as they travel up towards the roof area.

HVAC Plans

Overview

The HVAC system, short for Heating, Ventilation, and Air Conditioning, and includes a variety of mechanical systems that improve indoor comfort.

HVAC Basics

Heating

The heating portion of an HVAC system provides warmth through conduction (direct contact), convection (through the air), or radiant (solar) heat transfer. Forced Air heating systems, an example of convective heating, create heated air which is pushed through ducts. A duct system also allows for cooled air to be provided. Most Forced Air systems are run by combustion heat creation, while a more efficient Heat Pump system takes advantage of the efficiency of mechanical heat creation. The Mini-Split Ductless system combines the efficiency of a heat pump with the convenience of no ductwork. Radiant heating uses conductive heat transfer to warm occupants of a home through radiators, or in-floor tubes; Passive Solar captures the radiant heat gain from the sun.
**Ventilation**

The ventilation portion of an HVAC system provides for extraction of air in a home to remove unwanted moisture, odors, and other contaminants. This is primarily done through exhaust fans in bathrooms and range hoods and is important to maintaining indoor air quality. All combustion systems and appliances, including gas-fired furnaces, water heaters, clothes dryers, and gas fireplaces, need venting to allow gas byproducts, such as carbon monoxide, to escape from the house. Older furnaces have enough discharge that they need a 6”-8” vertical duct for venting, while newer, more efficient furnaces can vent horizontally through a wall. Gas hot water heaters (tank or tankless), fireplaces and clothes dryers can also vent horizontally through the wall. Some gas fireplaces will vent vertically if they are not located on an exterior wall.

Whole house ventilation systems systematically remove small amounts of air from a tightly-built home (well-sealed, from low infiltration) while capturing the heat in the air being exhausted. These are called Heat Recovery Ventilators or HRV Units. Some areas of the country, including Western Oregon, have higher concentrations of radon, a colorless and odorless, but harmful gas that can enter the house from the soil. A specialized unit called the Radon Gas Ventilator, ventilates this gas out of the home. This is a vent stack that vents air from a home's crawl space (or from under a basement slab), allowing radioactive radon gas to escape through the vent in the roof. The pipe and fan are a part of this radon removal system and are typically shown as a detail, and included on the plans.

**Air Conditioning**

The air conditioning portion of an HVAC system provides cooled and de-humidified air in the summer. Air conditioning may be provided by a unit that shares ductwork with a furnace. A heat pump system, whether ducted or ductless, provides both heating and cooling.

**HVAC Mechanical Systems**

A variety of HVAC systems are available. Here is a description of those most commonly used:

**Forced Air Heating**

Forced Air is the most common heating system in the Pacific Northwest. *Figure 9.10* The system consists of a furnace.
(typically run by gas; older units are run by oil), that heats air, and forces it around the home with a system of metal ducts. The warm air is delivered to rooms through a supply register; air is also collected in a return vent to be re-heated by the furnace. Furnaces require exterior air for combustion, and venting to remove unwanted byproducts.

**Air Source Heat Pump**

The Air Source Heat Pump is a more efficient version of the typical forced air system. *Figure 9.11* This system also consists of a furnace, which is powered by electricity. An outside heat pump unit “captures” the heat in the air to as cold as 35°F (-1°C), and transfers the heat to a fan and ductwork system. Like the Forced Air system, warm air is delivered to rooms through a supply register; air is also collected in a return vent to be re-heated. When the outside air temperature is below 35°F (-1°C), the furnace uses an electrical resistance system as a backup. The use of the Air Source Heat Pump uses less energy than a typical Forced Air furnace.

**Mini-Split Ductless Heat Pump**

Mini-Split Ductless Heat Pump systems work much like the Air-Source Heat Pump, with an outside heat pump unit that “captures” the heat in the air as cold as 35°F (-1°C). The heat is then transferred by a cable, to an indoor wall mounted unit that delivers warm air directly to the adjacent rooms. The heat transfer is directly through the air (convective), and no ductwork is involved. Larger mini-split systems will have several interior units connected by cables to the exterior heat pump, to provide heating and cooling in multiple rooms. Mini-split ductless units are much more efficient than Forced Air System systems, since there is no heat loss occurring through ductwork.

**Ground Source Heat Pump**

Ground Source Heat Pump systems are similar to Air Source Heat Pumps, consisting of a furnace, powered by electricity. Instead of an outside unit “capturing” heat from the air, heat is exchanged through long tubes buried in the ground. This takes advantage of the consistent soil temperature 3’ below the surface, which is about 55°F (13°C) in western Oregon. *Figure 9.12* The equipment and installation costs are very high for this system, but it is the most efficient, and least costly to operate.

**Radiant or Hydronic Heat**

Radiant Floor heating systems, also called Hydronic Heating,
have tubes of warm water buried in a thin concrete floor slab, or under a framed floor. *Figure 9.13* The heated water warms furnishings and occupants in contact with the floor.

**Electrical Resistance**
Electrical Resistance heating uses electricity to warm up coils, which then radiate heat to the surroundings. Older baseboard units (4’-6’ long) have been replaced with small wall mounted units. *Figure 9.14* Heat is more easily distributed when the unit also has a fan to move the warmed air around a room, as in the case of Cadet-type wall mounted heaters. Cadet is a brand very commonly used in Western Oregon.

**Passive Solar**
Passive Solar heating is simply collecting radiant heat from the sun into a room and storing it in a thermal mass (concrete, brick, water), so it can slowly radiate stored heat into a room. *Figure 9.15*

**What is Shown on an HVAC Plan**
A separate HVAC Plan is not usually done for a house. The actual size of a furnace, heat pump, ductwork, and tubes (hydronic) are determined by the installer. However, some portions of the HVAC system should be shown on the Floor Plan, such as appliances that house the combustion process (gas-fired furnace, and gas-fired hot water heater) or mechanical heat transfer (heat pump) along with fans for ventilation.

The Heating portion of the HVAC system shown on the Floor Plan is indicated by drawing the outline of the furnace, and any heat pump units outside. The rest of the system of ductwork, supply registers, and return vents is typically not shown on the Floor Plan. However, it is a very good idea for a designer to come up with a schematic layout for ducts, so it will be known if soffits for the first floor ceiling are needed. *Figure 9.16* It’s also good to indicate the desired location and number of supply registers on a schematic plan. The mini-split ductless units, which are wall mounted, should also be shown as a rectangle, in the appropriate areas of the house, along with the outside unit. Outside heat pump units should also be shown on the Site Plan, for coordination with landscape and screening.

The Ventilation portion of the HVAC system shown on the Floor Plan consists of bath fans, laundry room fan, and a range hood to vent the cooktop in the kitchen. These items
are shown on the Floor Plan, using a symbol that is linked to
the Electrical and/or Lighting Legend. A tightly-built house
will usually have a whole house ventilation system, and the
main unit will be shown on the Floor Plan. A radon removal
system will be shown as a standard cross-section detail on
any of the sheets of the plan set.

The Air Conditioning portion of the HVAC system is part
of the Forced Air Furnace and Heat Pump, so it is included
with those items on the Floor Plan. (A mini-split ductless
system also provided air conditioning, and is included within
mention the system.) Note: Above bracketed sentence does not
make sense to me.

Reading the HVAC System on a Floor Plan
The Acer Lane plans represent a method of creating a Floor
Plan showing all of the standard elements of the HVAC
system, on the Basement, 1st Floor, 2nd Floor, Attic Plan, and
Site Plans.

The Site Plan, sheet A0.1, Figure 9.8 shows a note for an Air
Conditioner unit on the south side of the house. The left side
of this sheet shows details for the Radon Removal System, on
drawing 2/A0.1

Sheet A2.1 Figure 9.9 has the Basement Floor Plan and the
1st Floor Plan, along with a Legend (upper left) showing
a symbol for an exhaust fan. The symbol is found in the
Bathrooms of the Basement Floor Plan and the First Floor
Plan. The furnace is drawn and noted in the Mech. Room
in the Basement, along with a note showing soffit (lowered
ceiling area) to accommodate the ductwork. The First Floor
Plan shows the main duct area enclosed by four walls (just
south of the shower) where it becomes an enclosed chase to
house the main furnace duct. The duct delivers conditioned
air to the First Floor and up to the Second Floor. The
“General Notes” can be found on the left side of this sheet.
Here is where you will find the brand name of the furnace
and exhaust fans required, along with locations for supply air
registers. There is also a note calling for the builder to submit
a duct layout, and another note stating the range hood is to
be selected by the Owner and installed by the builder.

Sheet A2.2 shows the Second Floor Plan, and the Attic Plan.
The Second Floor Plan shows two 3-piece bathrooms; one on
the east end, and another on the west end; both have exhaust
fans. The chase for the furnace duct also shows on this plan.
The Attic Plan notes the location of the Radon Removal Pipe.
Chapter 10
Specifications

Overview
The drawings we have covered so far in this course describe many, but not all aspects of the requirements for a house. Information that cannot be described graphically in the drawings is included in the Specifications, also called “specs”. Specifications are written requirements, including information about the systems, products, and materials for a home. The entire set of plans, or Construction Documents, include the Drawings and the Specifications, and become the set of legal documents describing the design and create the contract between the Builder and Owner.

Extent of Specifications
Some project’s Specifications, list only Building Code basics, knowing that a Builder and Owner will work together to select systems, products, and materials for the home during construction, based on owner preference and budget. Specifications include Building Code requirements as a way to make sure the common requirements are covered. This typically includes energy requirements, and safety glass, among others. Other projects have detailed specs, so several builders can bid on a set of plans that have a complete set of requirements.

Schedules are sometimes confused with Specifications – Schedules are part of the plan set, but do not necessarily act as a Specification. When they provide specific information about systems, products, or materials, they may replace part of the Specifications. Door and Window Schedules call out sizes (and sometimes materials); they can also specify the manufacturer or technical information (like the U-value of glazing). Lighting Schedules typically call out the fixture type and wattage; they can also specify the manufacturer, model name and number, and finish. Plumbing Schedules typically call out the fixture type and maximum flush rate or gallons per minute water flow; they can also specify the manufacturer, model name and number, and finish. Finish Schedules describing finish floor materials, walls and ceiling finishes are usually generic for a house Figure 10.1; however high-end homes often specify manufacturers and colors when listing finishes. Figure 10.2

Figure 10.1 Example of a generic Finish Schedule – notice the paint colors are unspecified.

<table>
<thead>
<tr>
<th>ROOM</th>
<th>FLOOR</th>
<th>WALLS</th>
<th>CEILING</th>
<th>BASEBOARD</th>
<th>TRIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dining and living</td>
<td>1&quot; x 3&quot; oak</td>
<td>1/2&quot; Drywall paint white</td>
<td>1/2&quot; Drywall paint white</td>
<td>Wood</td>
<td>Wood</td>
</tr>
<tr>
<td>Bedroom</td>
<td>1&quot; x 3&quot; oak</td>
<td>1/2&quot; Drywall paint white</td>
<td>1/2&quot; Drywall paint white</td>
<td>Wood</td>
<td>Wood</td>
</tr>
<tr>
<td>Bathroom</td>
<td>Linoleum-tan</td>
<td>1/2&quot; Drywall paint white</td>
<td>1/2&quot; Drywall paint white</td>
<td>Lino-cove</td>
<td>Wood</td>
</tr>
<tr>
<td>Kitchen</td>
<td>Linoleum-tan</td>
<td>1/2&quot; Drywall paint white</td>
<td>1/2&quot; Drywall paint white</td>
<td>Lino-cove</td>
<td>Wood</td>
</tr>
<tr>
<td>Utility room</td>
<td>Linoleum-tan</td>
<td>1/2&quot; Drywall paint white</td>
<td>1/2&quot; Drywall paint white</td>
<td>Lino-cove</td>
<td>Wood</td>
</tr>
<tr>
<td>Hall</td>
<td>1&quot; x 3&quot; oak</td>
<td>1/2&quot; Drywall paint white</td>
<td>1/2&quot; Drywall paint white</td>
<td>Wood</td>
<td>Wood</td>
</tr>
</tbody>
</table>
Where Specifications are Located

Most Specifications for homes are found on the drawing set, often on a cover sheet or on floor plans. Occasionally, a sheet will be dedicated to “General Notes” outlining conditions of construction quality and standards. An example from last chapter are the notes on Acer Lane Sheet 2.1, which we will look at the end of this chapter. Figure 10.4

Occasionally, on high-end, more complex homes, there is a separate book of written Specifications, which most likely include all the various Schedules and manufacturer’s cut sheets for individual fixtures and appliances. The Specs in a book are most certainly more extensive than a simple version on a plan set. However, they take a lot of time to write and sometimes give the impression of a more complex project than is the case; thereby increasing the cost of the project.

Format of Specifications

The Construction Specification Institute (CSI) originated in 1948 as a place to standardize construction practices and develop a system to organize construction information. A format was developed with 16 sections, each addressing a specific area of constructing a building. The system was expanded several years ago, and now has 46 Divisions to be inclusive of all types of construction, including civil engineering projects.

In 1963, a template for Construction Specifications was published; eventually called MasterFormat. It is now published by The American Institute of Architects (AIA) and is formatted using CSI sections. Each of the sections has three parts: “General” (Overview), “Products” (name product or state performance requirements), and “Execution” (prepare for successful installation/construction). MasterSpec covers a variety of materials and systems, including concrete, thermal and moisture protections, door and windows, plumbing, and HVAC. This template has evolved into an electronic format, which an architect, designer, or engineer can purchase, and then edit to suit each project. MasterFormat has architectural, structural, interiors, waterproofing, and landscape architecture specifications among their available products.

Most designers and architects of residential homes have a
standard, simple Specification that they have developed for their practice, which they modify for each project. This type of simple Specification is included on the drawings, as described previously. Large architectural and engineering offices may use the booklet form, with a specification in the MasterSpec format, as this is a standard for complex and commercial projects.

**Types of Specifications**

There are two main types of Specifications: *Performance* and *Proprietary*. A Specification can, and often does, have a mix of both types of specifications for the various equipment, materials, or products within the whole Specification.

**Performance Specifications**

A Performance Specification describes the functional criteria for a particular piece of equipment, material, or product. This type of Specification is used when the way a material performs is more important than any “brand name” or manufacturer, or when multiple manufacturers produce a similar product. It is referred to as an “open” specification as several manufacturer’s products may fit the requirements. Reference Standards are often part of Performance Specifications, as they refer to national or international standards such as IRC (International Residential Code), ASTM (American Society for Testing and Materials), UL (Underwriters Laboratories), etc. and products used must meet these standards. Windows are an example of an item that is easily specified for its performance, which would include U-value, warranty, and frame materials. Doors, roofing materials, and exterior siding are more examples of performance-based specifications.

Performance Specifications allow the Builder to work with materials and methods of construction with which they are familiar. suppliers who provide good customer service, get the best price, or other criteria that make it a good choice.

**Proprietary Specifications**

Proprietary Specifications state the manufacturer (“brand name”) and model number and name, and are also referred to as “closed” Specifications. An example would be if the bathroom plumbing fixtures were to be of a specific matching style, often termed a “suite,” from a specific manufacturer. *Figure 10.3* Proprietary Specifications may also add the clause “or equivalent” to the call out. This means that the Designer or Architect is willing to review other manufacturers products, upon request from the Builder, as an example of a Proprietary Specification in the form of a Plumbing Schedule.
equally acceptable product. This makes it a non-restrictive Proprietary Specification. HVAC equipment, such as a furnace or hot water heater, is another example of equipment that is easily specified by manufacturer, based on the Builder or Designer’s preference.

**Reading Specifications**
The Acer Lane Residence, an architect-designed custom home, has a fairly limited specification on the Floor Plan sheet, under General Notes. Figure 10.4 (also see Figure 9.9) You’ll see there is not extensive detail about construction, as the designer is relying on the Oregon Residential Specialty Code (ORSC), and also has a pre-selected Builder for this custom home. The items covered in the Specification “General Notes” are the ones that focus on areas of the house that will be built to exceed Building Code; there are also some product selections. Note 3 shows that the Architect is calling for a higher energy performance that Code requires. This is a Performance type of Specification. Notes 4 and 5 cover the mechanical system, which is an example of a
Proprietary Specification, as the manufacturer’s name is used for the furnace, hot water, fan and range hood. Note 7 refers to the detailing of the sheet metal roof to match both a national standard’s manual (performance) and the manufacturer’s requirements (prescriptive).

The Ainsworth set of plans is produced by a design/build firm, Renaissance Homes. Figure 10.5 They have established a standard Specification that is used for all of their homes, with minor adjustments to suit the site, and specific circumstances. The standard plans that Renaissance produces are sometimes built by their own construction crews, and sometimes purchased by homeowners who then hire their own builders. Because of the uncertainty of who the builder will be, Renaissance has created an extensive Specification.

The entire Specification is on the Cover Sheet (CS), in the set. The first portion of the Specification is listed under “General Notes”. In this case, the Specifications meet (rather than exceed) Code, but they serve the function of gathering all information about design loads, energy codes, safety glazing, egress (windows, stairways), smoke detectors, venting, and electrical in one location. The notes continue on to include Foundation Notes, Framing Notes, Design Loads, and energy compliance information, covering items related to building code compliance. Many of these notes can be found throughout the plan set, on Foundation and Framing Plans, Sections, and Details; they are listed here again for completeness. Note that there are no Specifications regarding building systems, materials, or products. The reason is that the drawings are considered a standard set, with specific products and materials to be selected by the actual homeowner, determined by preference and budget.

The Waverly Commons project is also an Architect-designed custom home. Sheet A.0 in the plan set provides some Specifications. Under "Permit Info", the note “Electrical, Plumbing & HVAC to be Bidder Designed” indicates that the Architect chose to provide neither a Performance nor Proprietary Specification, but requests proposals from the Builder (and their subcontractors) who bids the project.

A Performance Specification is found under “Energy Code”, where the Architect specifies a “95% Efficient Gas Furnace”, meaning any furnace would be acceptable as long as it is at least 95% efficient (and, of course, meets all Code requirements). The window and door requirements (U=.53 and U=.57 respectively) are also examples of Performance Specifications. Other Performance Specifications are found under “Plan Notes” Bath subsection where the bath exhaust fan and toilet are specified with performance standards. The “General” subsection describes various items meeting Building Code.

Figure 10.6 Waverly Commons Specifications, Sheet A.0

<table>
<thead>
<tr>
<th>LEGAL DESCRIPTION</th>
<th>ZONING INFORMATION</th>
<th>PLAN LEGEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDRESS: 2008 WOODWARD ST, PORTLAND</td>
<td>BUILDING COVERAGE</td>
<td>1” CONCRETE WALL</td>
</tr>
<tr>
<td>PROPERTY OR ID: 025030</td>
<td>LOT AREA: 525 SF</td>
<td>1. INSERT ABSORPTION WALL</td>
</tr>
<tr>
<td>ALT ACCOUNT: 134405859</td>
<td>ALLOWED LOT AREA</td>
<td>2. AIR SPACE</td>
</tr>
<tr>
<td>STATE OR: OR</td>
<td>ALLOWED LOT AREA: 1030 SF</td>
<td>3. CONCRETE WALL ONLY</td>
</tr>
<tr>
<td>TAX ROLL: 1503381</td>
<td>1030 SF</td>
<td>4. CONCRETE WALL ONLY</td>
</tr>
<tr>
<td>WICKHAM COMMONS, LOT S</td>
<td>TOTAL PROPOSED LOT COVERAGE: 1030 SF</td>
<td>5. CONCRETE WALL ONLY</td>
</tr>
<tr>
<td>ZONE: R3</td>
<td>ALLOWED ACCESSORY RADIO COVERPAGE</td>
<td>6. CONCRETE WALL ONLY</td>
</tr>
<tr>
<td>CCYR ZONE: NONE</td>
<td>NOT APPLICABLE</td>
<td></td>
</tr>
<tr>
<td>JURISDICTION: CITY OF PORTLAND</td>
<td>HEIGHT</td>
<td>NOT APPLICABLE</td>
</tr>
<tr>
<td>PERMIT INFO</td>
<td>ALLOWED, 30” PP TO MIDPOINT OF ROOF</td>
<td></td>
</tr>
<tr>
<td>ELECTRICAL, PLUMBING &amp; HAC TO BE BIDDER DESIGNED</td>
<td>PROPOSED 30” PP TO MIDPOINT OF ROOF</td>
<td></td>
</tr>
<tr>
<td>BUILDING AREA</td>
<td>SETBACKS</td>
<td></td>
</tr>
<tr>
<td>HOUSE</td>
<td>GABLE: 19’ 6”</td>
<td></td>
</tr>
<tr>
<td>BASEMENT: 15’ x 15’</td>
<td>BACK: 12’ 6”</td>
<td></td>
</tr>
<tr>
<td>1ST FLOOR: 30’ x 15’</td>
<td>FRONT: 10’ 6”</td>
<td></td>
</tr>
<tr>
<td>2ND FLOOR: 20’ x 15’</td>
<td>GARAGE: 19’ 6”</td>
<td></td>
</tr>
<tr>
<td>TOTAL HOUSE: 3000 SF</td>
<td>STREET FACE GLAZING</td>
<td></td>
</tr>
<tr>
<td>CONDITIONED AREA</td>
<td>REQUIRED GLAZING: 12%</td>
<td></td>
</tr>
<tr>
<td>BASEMENT: 15’ x 15’</td>
<td>FACADE AREA: 900 SF</td>
<td></td>
</tr>
<tr>
<td>1ST FLOOR: 30’ x 15’</td>
<td>GLAZING AREA: 192 SF</td>
<td></td>
</tr>
<tr>
<td>2ND FLOOR: 20’ x 15’</td>
<td>GLAZING AREA: 192 SF</td>
<td></td>
</tr>
<tr>
<td>TOTAL CONDITIONED AREA: 3000 SF</td>
<td>LEGEND</td>
<td></td>
</tr>
</tbody>
</table>

| PLAN NOTES (GENERAL) | | |
|---------------------|------------------|
| 1. ALL DIMENSIONS TO TOE OF JOIST | |
| 2. ALL DOORS LOCATED WITHIN ADJACENT WALL | |
| 3. ALL DOORS WITH SWINGING DOORS U.O. | |
| 4. ALL EXTERIOR DOORS SWING IN U.O. | |
| 5. APPLY SHEET TYPE 60 DP TO ELEVATION | |
| 6. ALL AVOID INCREASING ANGLES WITH CONCRETE TO BE PRESSURE TREATED | |
| 7. EXTERIOR PLASTER TO BE BIDDER DESIGN | |
| 8. EXTERIOR PLASTER TO BE BIDDER DESIGN | |
| 9. MINIMUM FLOOR BORING TO REMOVE DIRT AND DUST FROM INSIDE | |
| 10. MINIMUM FLOOR BORING TO REMOVE DIRT AND DUST FROM INSIDE | |
| 11. ELECTRICAL PANEL TO BE BIDDER DESIGN | |
| 12. ALL ABOUNDING INTERFACE TO BE PRESSURE TREATED | |
| 13. EXTERIOR PAVEMENT TO BE BIDDER DESIGN | |
| 14. ELECTRICAL PANEL TO BE BIDDER DESIGN | |
| 15. MINIMUM FLOOR BORING TO REMOVE DIRT AND DUST FROM INSIDE | |
| 16. MINIMUM FLOOR BORING TO REMOVE DIRT AND DUST FROM INSIDE | |
| 17. MAXIMUM FLOOR BORING TO REMOVE DIRT AND DUST FROM INSIDE | |
| 18. MINIMUM FLOOR BORING TO REMOVE DIRT AND DUST FROM INSIDE | |
| 19. MAXIMUM FLOOR BORING TO REMOVE DIRT AND DUST FROM INSIDE | |

| STAIR NOTES | | |
|-------------|----------------|
| 1. 1ST MAX STEPS RISE NOT TO EXCEED 7” | |
| 2. 2ND MAX STEPS RISE NOT TO EXCEED 8” | |
| 3. 3RD MAX STEPS RISE NOT TO EXCEED 9” | |
| 4. 4TH MAX STEPS RISE NOT TO EXCEED 10” | |
| 5. 5TH MAX STEPS RISE NOT TO EXCEED 11” | |
| 6. HANDRAILS REQUIRED AT START OF STEPS AND FOR 72” OF EACH STAIR | |
| 7. HANDRAILS REQUIRED AT 36” AND FOR 72” | |
| 8. HANDRAILS REQUIRED AT 36” AND FOR 72” | |
| 9. HANDRAILS REQUIRED AT 36” AND FOR 72” | |

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