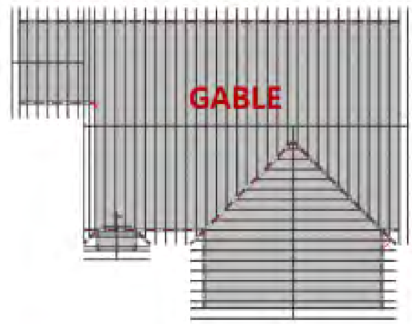
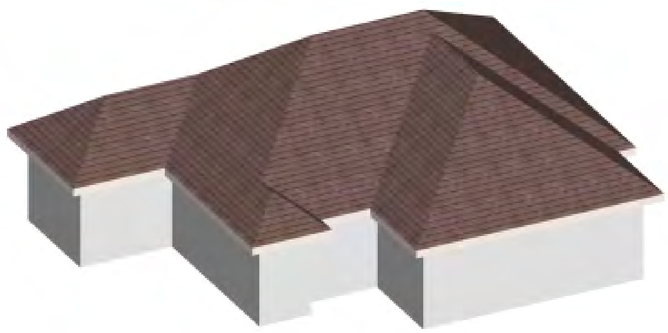
ROOF GEOMETRIES

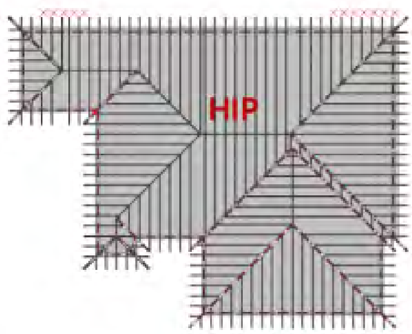
REFERENCE (d5) INTRODUCES THESE BASIC ROOF FORMS AND DISCUSSES, GEOMETRY, ROOF PITCHES, AND CONSEQUENT SPACE CREATED UNDER ROOF.



THE GABLE

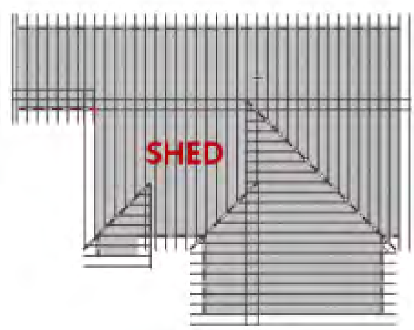
*MOST COMMON ROOF FORM, VERY SIMPLE, FLEXIBLE.
*ROOF PITCHES MEET AT A RIDGE. TYPICAL ARE SYMMETRICAL PITCHES EACH SIDE
*ROOF PITCHES CAN BE ASSYMETRICAL WHICH INCREASES FLEXIBILITY AND ALTERS THE AESTHETIC.





THE HIP

*FOUR OR MORE SIDES THAT ALL SLOPE UP TO A RIDGE.
*OR IN THE CASE OF A SQUARE PLAN FORMAT, TO A POINT, IN WHICH CASE IT MAY BE REFERED TO AS A 'PYRAMID' ROOF
*THIS IS ABOUT EQUAL IN SIMPLICITY TO THE GABLE ROOF. THE ROOF ITSELF IS MORE COMPLICATED TO BUILD BUT THERE ARE NO END WALLS TO CONSTRUCT.
*AND THERE IS LESS AVAILABLE SPACE UNDER ROOF

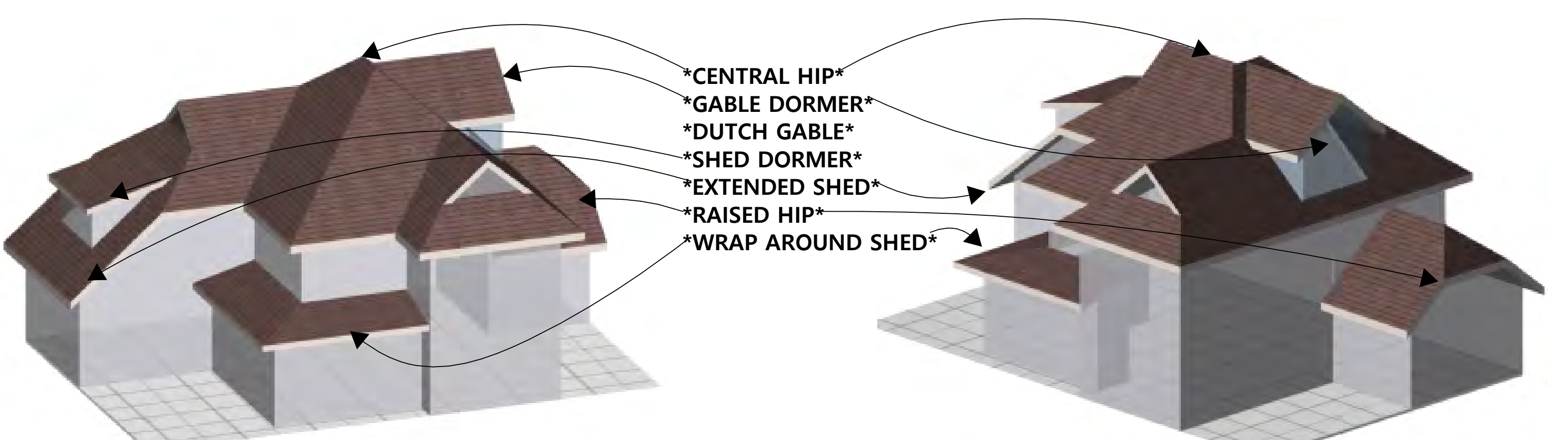


THE SHED ROOF

*REFERS TO A SIMPLE SINGLE PITCHED PLANE.
*LOTS OF CONFIGURATION COMBINATIONS.
*THIS SAME PLAN FORMAT IS BETTER SUITED TO THE GABLE OR HIP. SOME AWKWARD CONNECTIONS EXIST IN THIS ILLUSTRATION.
*A MORE LINEAR GEOMETRY IS USUALLY MORE SUITABLE TO THE SHED.
*SHED ROOF SAMPLE PROJECT NEXT SHEET WILL RE-DESIGN THIS SHED IN A ,ORE SUITABLE FORM.

COMPOSITES

GENERAL_THIS ILLUSTRATION SUGGESTS THAT THE THREE BASIC ROOF TYPES CAN BE COMBINED QUITE FLEXIBLY. IN FACT MANY ROOFS ARE COMPRISED OF SOME COMBINATION OF THESE 3 ROOF TYPES. JOINING OF ROOF PLANES ARE AT THE RIDGE, THE VALLEY, THE HIP. RIDGE BOARDS OR BEAMS, VALLEY BEAMS, HIP BEAMS ARE THE STICK FRAME MEMBERS DOING THE JOB. THE ROOF PLANES THEMSELVES ARE CONSTRUCTED WITH RAFTERS.

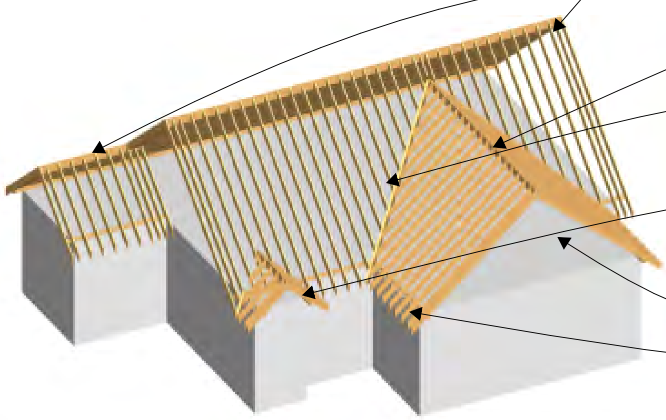


STICK FRAMING

GENERAL_BELOW ARE LISTED SOME OVERVIEW COMMENTS ON STICK FRAMED ROOFS.
DEFAULT THIS PROJECT_STICK FRAMING IS THE DEFAULT FOR SPACE USE AND CONSTRUCTION FLEXIBILITY. TRUSSES CAN OFTEN BE SUBSTITUTED. JUST BE AWARE OF ALL THE PROS AND CONS.
USE OF SPACE UNDER ROOF_MAYBE THE PRIME DETERMINANT. IF USEFUL SPACE IS WANTED STICK FRAMING IS LIKELY THE BETTER CHOICE.
THERMAL ENVELOPE_WITH CONDITIONED SPACE IMMEDIATELY UNDER ROOF THE ROOF PLANE ITSELF BECOMES, AT LEAST IN PART, THE INSULATION PLANE. INSULATION STRATEGY (AND THICKNESS!) WANTS TO BE ANALYZED EARLY AS IT CAN DIRECTLY EFFECT THE STRUCTURAL MEMBER (DEPTH) SELECTION.
LOCAL LABOR_ROOFS ARE THE TRICKIER PART OF MOST HOME FRAMING. JUST CHECK THAT EXPERIENCED LABOR IS AROUND. THIS MAY SEEM A NON ISSUE BUT SOME REGIONS WHERE SMALL SLAB ON GRADE TRUSS ROOFED HOMES ARE THE NORM THERE MAY NOT BE FRAMERS WITH STICK FRAME ROOF EXPERIENCE.

PRIMARY COMPONENTS ONLY

*THESE ILLUSTRATIONS DO NOT SHOW (REQUIRED) SECONDARY FRAMING NEEDED TO COMPLETE THE FRAMING SYSTEM.



THE GABLE ROOF-STICK FRAMING

PRIMARY GABLE_SITTING ABOVE THE CORE HOUSE. FRONT AND BACK BEARING WALLS SUJPPORTING RAFTERS JOINED AT THE TOP AT THE PRIMARY RIDGE MEMBER.

EXTENDED GABLE_THIS EXTENSION SHARES THE BACK WALL AND BACK RAFTER PLANE. VERY COMMON+SIMPLE.

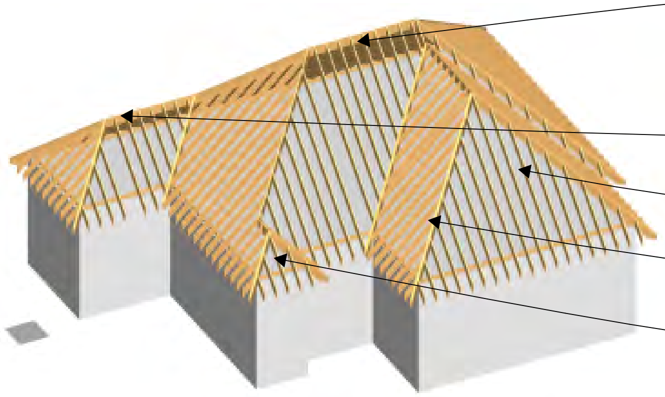
REVERSE GABLE(S)_TERM FOR GABLES THAT JOIN PRIMARY GABLE PERPENDICULARLY (AT 90^{O})

THE VALLEY_REVERSE GABLES REQUIRE VALLEYS AND VALLLEY BEAMS TO OPEN AND CONNECT THE INTERNAL SPACE. THE VALLEY BEAM IS COMMON BUT HAS SOME PEFORMANCE REQUIREMENTS.

OVERFRAME_REVERSE GABLES CAN LAY ON TOP OF THE ROOF THEY ADJOIN. IF THERE IS NO USEFUL SPACE GAIN IT IS A SIMPLE OPTION. RAFTERS WOULD SIT ON A FLAT VALLEY 2X MEMBER (NOT SHOWN) RESTING ON THE RAFTERS BELOW.

THE ENDWALLS_DO NOT SHOW BUT WOULD BE 2XFRAME WALLS

OVERHANGS_EAVE OVERHANGS USUALLY ARE RAFTER EXTENSIONS-LENGTH AS DESIRED. THESE ARE USUALLY PREFERRED TO GET RAIN WATER AWAY FROM THE HOUSE PLANE. RAKE OVERHANGS ARE AT THE GABLE ENDS AND ARE FAIRLY TYPICAL BUT NOT REQUIRED. THERE ARE 2 TECHNIQUES FOR FRAMIN GTHESE (NOT SHOWN).



THE HIP ROOF-STICK FRAMING

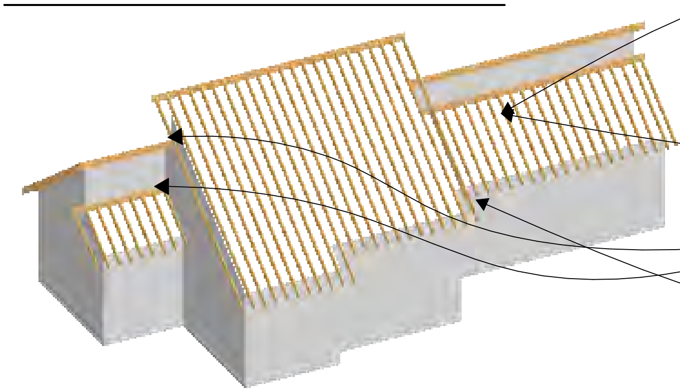
PRIMARY HIP_SITTING ABOVE THE CORE HOUSE. THIS ILLUSTRATES THE PRIMARY DISTINCTION WITH THE GABLE. THERE ARE NO END WALLS. ONLY ROOF. THE LOOK IS DIFFERENT. THERES IS LESS SPACE AVAILABLE BELOW ROOF. ROOF FRAMING IS A LITTLE MORE COMPLICATED BUT THERE ARE NO END WALLS TO FRAME (AND PUT SIDING ON).

EXTENDED HIPS_THE HIP ROOFS FLEXIBILITY ALLOWS THESE EXTENSIONS TO BE PLACED AT ANY END WALL/CORNER.

REVERSE HIP_THE HIP ROOFS FLEXIBILITY ALLOWS THESE EXTENSIONS TO BE PLACED ANYWHERE AROUND THE PERIMETER AT VIRTUALLY ANY SIZE.

OVERHANGS_THE HIP USUALLY ENCOURAGES A UNIFORM EXTENDED RAFTER OVERHANG AROUND THE ENTIRE PERIMETER.

OVERFRAMES_ARE SIMILAR TO THE GABLE ROOF OVERFRAME, BUT CAN HAVE A CONDITION AS SHOWN THIS ILLUSTRATION WITH WAHT TO DO WITH THE MAIN HIP MEMBER- STOP IT OR RUN IT THROUGH.



THE SHED ROOF-STICK FRAMING

GENERAL DESIGN_THIS REVISED SAMPLE DESIGN LAYOUT IS MORE SUITABLE TO THE SHED ROOF. THE ABOVE DESIGN IS SUITABLE TO THE GABLE AND HIP. NARROWER AND LONGER SUITS THE SHED ROOF. 'L' AND 'U' CONFIGURATIONS CAN ALSO WORK. REVERSE GABLE ('T' SHAPES) AND LONG ROOF RUNS ARE NOT INHERENTLY COMPATIBLE.

SHED ROOF PLANES_THE ROOF PLANES WITH THE SHED ARE, AS SHOWN THIS DESIGN, RECTANGULAR AND SIMPLE. WHEN THEY CAN BE INCORPORATED INTO A DESIGN TO STAY THIS SIMPLE THEY CAN BE A COST EFFECTIVE APPROACH. THEY CANNOT HELP BUT HAVE A 'CONTEMPORARY' LOOK.

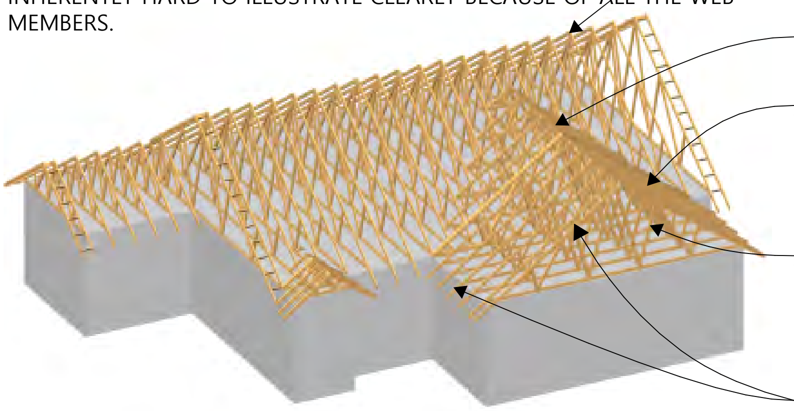
CENTER SUPPORT_THIS DESIGN IS SHOWING SHEDS FRONT AND BACK MEETING AT A CENTER WALL. THAT CENTER CONDITION IS A ROOF BEARING ONE. SINGLE SLOPE DESIGNS CAN RUN ROOFS FRONT TO BACK- AND CENTER BEARING ELIMINATED. THIS REQUIRES LONGER STRUCTURAL SPANS AND LONGER ROOF PLANES, WHICH WANT EXAMINATION.

THE TRUSS

GENERAL_BELOW ARE LISTED SOME OVERVIEW COMMENTS ON ROOF TRUSSES.
THIS PROJECT_ SOME DESIGNS THIS PROJECT ARE BEST SUITED TO THE TRUSS ROOF AND ARE DRAWN THAT WAY OR ARE SPECIFIACCLY NOTED AS GOOD CANDIDATES FOR SUBSTITUTION.
USE OF SPACE UNDER ROOF_MAYBE THE PRIME DETERMINANT. IF USEFUL SPACE IS WANTED TRUSSES ARE A POOR CANDIDATE. IF STORAGE SPACE ONLY IS WANTED OPTIONS EXISTS SUCH AS THE 'ATTIC TRUSS'.
THERMAL ENVELOPE_THE TRUSS PERFORMS THE BEST THERMALLY WHEN DEEP BLOWN INSULATION COVERS THE CEILING AREA, AND NO ONE EVER HAS TO GO UP THERE. WITH STORAGE OR HVAC EQUIPMENT AND DUCTWORK UP THERE A COMPROMISED SITUATION WILL EXIST.
LOCATION OF MANUFACTURER_CHECK EARLY TO DETEMINE IF TRUSSES ARE AN OPTION AT ALL. EXCEPT FOR SERIOUSLY REMOTE SITES THEY USUALLY ARE.
LOCAL LABOR_ROOFS ARE THE TRICKIER PART OF MOST HOME FRAMING. SOME AREAS ARE LABOR CHALLENGED. IN VERY GENERAL TERMS THE TRUSS ROOF IS SIMPLER AND FASTER TO INSTALL THAN THE STICK FRAME ROOF. TRUSS MANUFACTURERS HAVE ENGINEERED THE ENTIRE PACKAGE AND WILL PROVIDE A KIT OF PARTS, AND A SET OF DRAWINGS. CRANE INSTALLATION SOMETIMES VERY SMART AND OR NECESSARY.

TRUSS WEBS MAKE THESE COMPLICATED

*THESE ILLUSTRATIONS ARE HARD TO DECIPHER.TRUSSES ARE INHERENTLY HARD TO ILLUSTRATE CLEARLY BECAUSE OF ALL THE WEB MEMBERS.



THE GABLE ROOF-TRUSS FRAMING

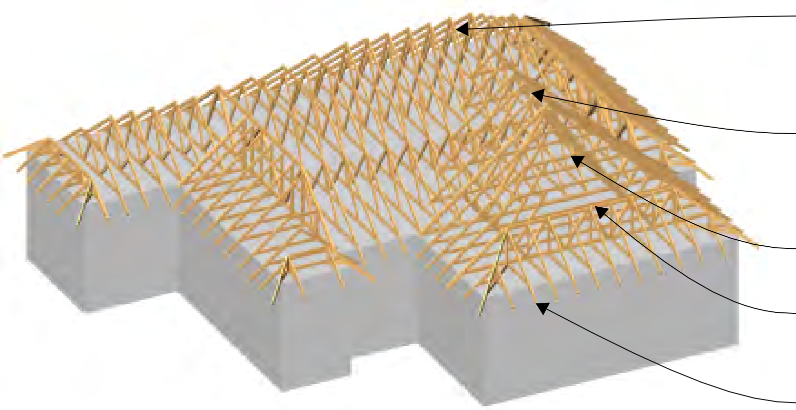
PRIMARY TRUSS_THIS IS THE PRIME EFFICIENT RUN OF PRATT OR 'W' PROFILE TRUSSES AT 24" OC THAT DEFINES/SETS THE PRIME GABLE. THE 'W' SHAPE OFFERS SOME SPACE IN THE TRUSS SPACE FOR HVAC OR MODEST STORAGE PER PROFILES SHOWN

REVERSE GABLE TRUSSES_MOVING FORWARD THESE ARE FULL (SHORTER SPAN) TRUSSES OUT TO THE FRONT ENDWALL.

THE GIRDER TRUSS_THIS DOUBLE OR TRIPLE (WITHOUT OVERHANGS) IS CARRYING (CAN CARRY) THE MAIN TRUSSES. THE MAIN TRUSSES WOULD BE SUPPORTED AT THE BOTTOM CORD OF THE GIRDER TRUSS WITH HANGERS. THIS IS WHOLLY COMMON, BUT ALSO UNNECESSARY IF A BEARING WALL EXISTS UNDERNEATH

THE ENDWALL TRUSS_THIS SHOWS AS JUST ANOTHER TRUSS TO BE 'FILLED IN' AND SHEATHED. OPTIONS INCLUDE AN 'END WALL TRUSS' WHICH IS MADE OF VERTICAL MEMBERS LIKE A STUD WALL. WHICH GIVES THE FRAMER 16" OR 24" OC NAIL BASE AS REQUIRED. ANOTHER OPTION IS TO OMIT THIS END TRUSS AND FIELD FRAME A FULL WALL OVER THIS END BEARING WALL

OVERHANGS_EAVE OVERHANGS USUALLY ARE TOP CORD TRUSS EXTENSIONS-LENGTH AS DESIRED. RAKE END OVERHANGS ARE SIMPLE LADDERS AS SHOWN FOR SHORTER OVERHANGS. LONGER OVERHANGS WANT CANTILEVERED OUTRIGGERS (NOT SHOWN). RAKE OVERHANGS ARE NOT REQUIRED.



THE HIP ROOF-TRUSS FRAMING

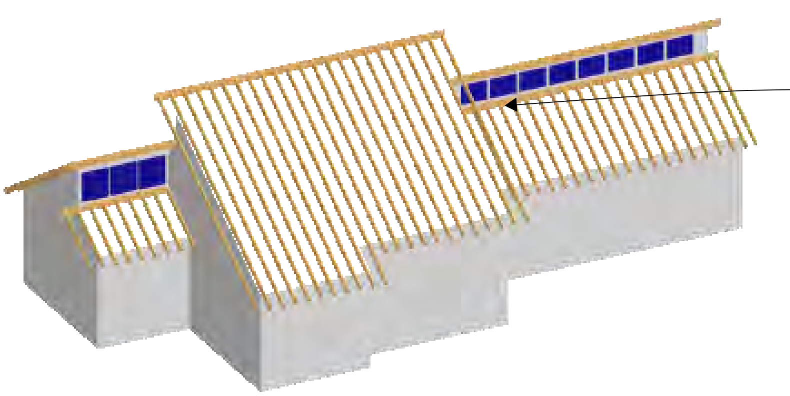
PRIMARY TRUSS_THE FULL HT TRUSSES RUN THE LENGTH OF THE RIDGE LINE. WHEN THE HIP LINES HIT THE RIDGE THE TRUSSES NEED TO STEP DOWN ACCORDING TOTHE ROOF PITCH. THE LINES OF THE HIP ARE CREATED BY THE STEP DOWN TRUSSES. TYPICAL HIP TRUSS SITUATION.

REVERSE GABLE TRUSSES_SHORTER TRUSS BUT SAME CONDITION. THERE MAY OR MAY NOT BE FULL HT TRUSSES. STEP UP OVERFRAME MEMBERS NEEDED TO FILL IN THE ROOF AREA BACK TO THE PRIMARY. STEP UP TRUSSES- OR IN FILL FIELD FRAMING- ARE BOTH USED.

STEP DN TRUSSES_FROM FULL HT TRUSSES DOWN TO THE PREFERRED GIRDER TRUSS LOCATION

GIRDER TRUSS+OUTRIGGERS_THE MULTIPLE PLY GIRDER TRUSS HAS PERPENDICULAR AND THE HIP CORNER OUTRIGGERS 'HUNG' OFF THE GIRDER TRUSS. THIS APPROACH USED AT ALL SPACE EXTENSIONS

OVERHANGS_THE HIP USUALLY ENCOURAGES A UNIFORM EXTENDED TOP CORD MEMBER OVERHANG AROUND THE ENTIRE PERIMETER.



THE SHED ROOF TRUSS FRAMING

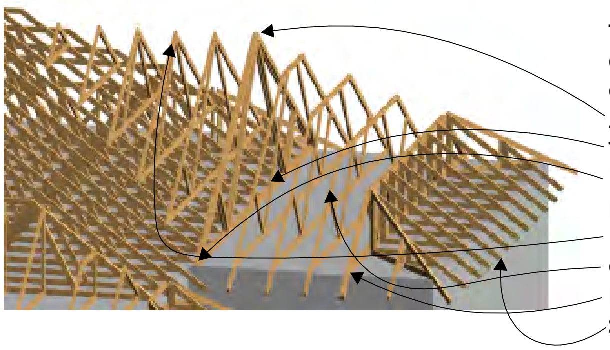
CONTRADICTION_TRUSSING THIS IS POSSIBLE AS THE TRUSS PROFILES REQUIRED ARE CAPABLE STRUCTURALLY. TAKING ADVANTAGE OF THE VERTICAL WALLS BETWEEN ROOF PLANES FOR OPEN SPACE AND GLASS THIS ROOF CONFIGURATION IS HAMPERED WITH TRUSSES. ALSO NOTE THAT THE SINGLE SLOPE IS THE EASIEST TO BUILD AND IS NOT BECKONING FOR TRUSSES BECAUSE OF FRAMING COMPLICATIONS. THAT SAID, MONO AND SCISSOR MONO TRUSSES IN SHED ROOF DESIGNS CAN BE SMART TO USE IN THE RIGHT SITUATIONS.

TRUSS FLEXIBILITY- AND LIMITATION

COMPLEX DESIGNS_ONE CAN TAKE A COMPLEX DESIGN AND HAVE A TRUSS MANUFACTURER BREAK IT DOWN INTO MANY TRUSS PARTS. THEIR COMPUTER GENERATED DRAFTING AND ENGINEERING (AND MANUFACTURING IN SOME INSTANCES) ALLOWS THESE COMPLEX PACKAGES TO COME TOGETHER AS A SYSTEM. THIS IS NOTED TO MAKE A POINT ABOUT TRUSS FLEXIBILITY. THIS DOES NOT MEAN IT IS THE SMART THING TO DO.

SYSTEM ECONOMY_TRUE OF TRUSSES AND OTHER 'SYSTEM' APPROACHES THERE IS A BREAK POINT WHERE THE EFFICIENCIES SOUGHT IN A SYSTEM GET LOST BECAUSE THE DESIGN TIPPED OVER THE COMPLEXITY LINE. THEN THE 'SYSTEM' BECOMES A LIABILITY.

COMPOSITE SYSTEMS_TRUSSES AND STICK FRAMING CAN ALWAYS BE COMBINED ON A JOB. THAT IS A JUDGEMENT CALL PERMITTING EACH METHOD TO DO WHAT IT DOES BEST. CHARACTERISTICALLY TRUSSES HAVE A TOUGHER TIME WITH 1/2 STORIES AND DORMERS, AND OPEN WITH OPEN VAULTED SPACE.



CLOSER DETAIL OF A HIP ROOF REVERSE GABLE

TRUSS IMAGES _TRUSSES IN CONTEXT ARE A LITTLE DIFFICULT TO VIEW AND MAKE SENSE OF. THIS IS A 'BLOW UP' OF THE HIP TRUSS PACKAGE SELECTED TO MAKE CLEARER NOTE OF A VERY COMMON TRUSS PACKAGE CONDITION THAT IS WORTH GRASPING. THIS APPEARS COMPLEX BUT IS COMMON AND USUALLY COST EFFECTIVE.

THE GIRDER TRUSS_USUALLY 2 OR 3 PLY

'HUNG' PRIMARY TRUSSES_HANGERS CONNECT PRIMARY TRUSSES TO THIS GIRDER.

BIG POINT LOAD_TRUSSES DON'T MAGICALLY MAKE A LOAD DISAPPERAR. THESE GIRDER POINT LOADS NEED TO BE ACCOUNTED FOR. THEY CAN BE LARGE.

GABLE STEP UPS_SOMETIMES THIS OVERFRAME ID FIELD FRAMED.

HIP STEP DOWNS_ENGINEERED (DIMENSIONED) TO FOLLOW CORRECT ROOF GEOMETRY.

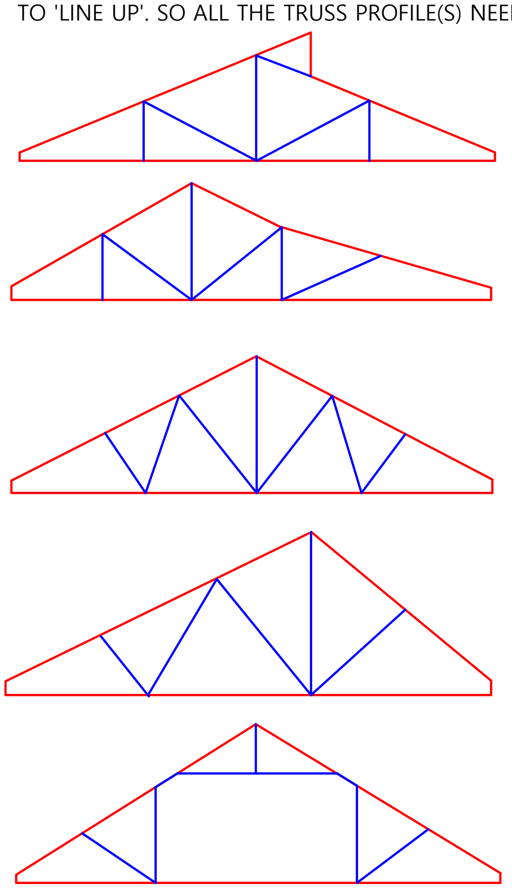
STEP DOWN GIRDER_REFER BACK TO d3A.4

'MONO' OUTRIGGERS_FOLLOW THE PITCH AND CREATE THE OVERHANG

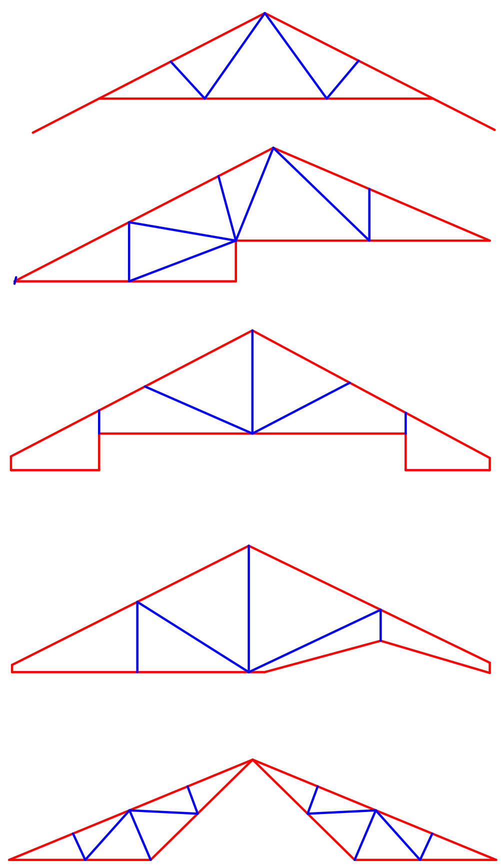
PROFILES AS NEEDED

CHECK THE INTERNET_GAZILLIONS OF TRUSS PROFILES ARE AVAILABLE TO TAKE A LOOK AT. A FEW ARE SHOWING BELOW.

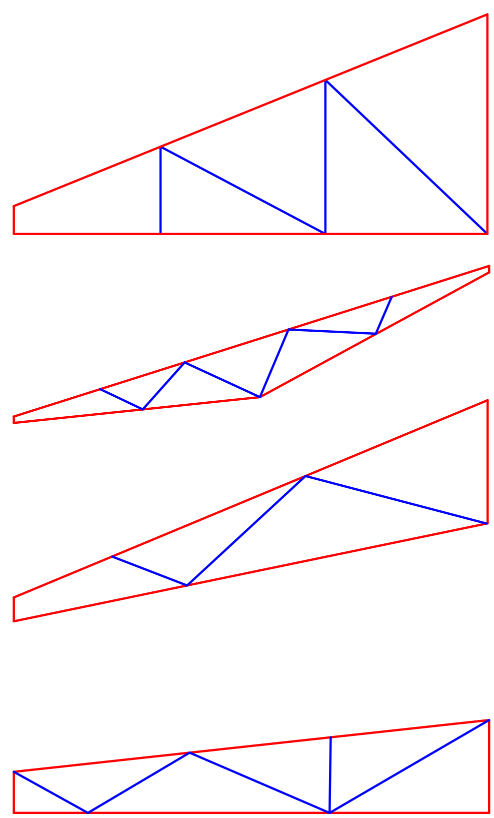
ALWAYS CHECK PLAN AND PROFILES_ANY TRUSS PROFILE CAN BE DRAWN TO ADDRESS A DESIRED CONDITION. MIGHT BE A ROOF PROFILE TO TO SUIT AN AESTHETIC, OR TO BEST ACCOMODATE PV PANELS. MIGHT BE AN ATTIC STORAGE REQUIREMENT, OR TO INCORPORATE HVAC DUCTING. OR SUITABLE MODEST OPEN SPACE DESIRE. ALL ARE REASONABLE. REMEMBER EACH PROFILE HAS 2 BEARING POINTS(A SPAN) THAT ARE A SET DISTANCE APART. WHEN A PLAN'S EXTERIOR WALLS CHANGE, THE BEARING POINTS (THE SPAN) CHANGES. THE TRUSS PROFILE CEASES TO 'LINE UP'. SO ALL THE TRUSS PROFILE(S) NEED TO BE CONSIDERED- AND HOW THEY INTERCONNECT.



ROOF PROFILE VARIATIONS



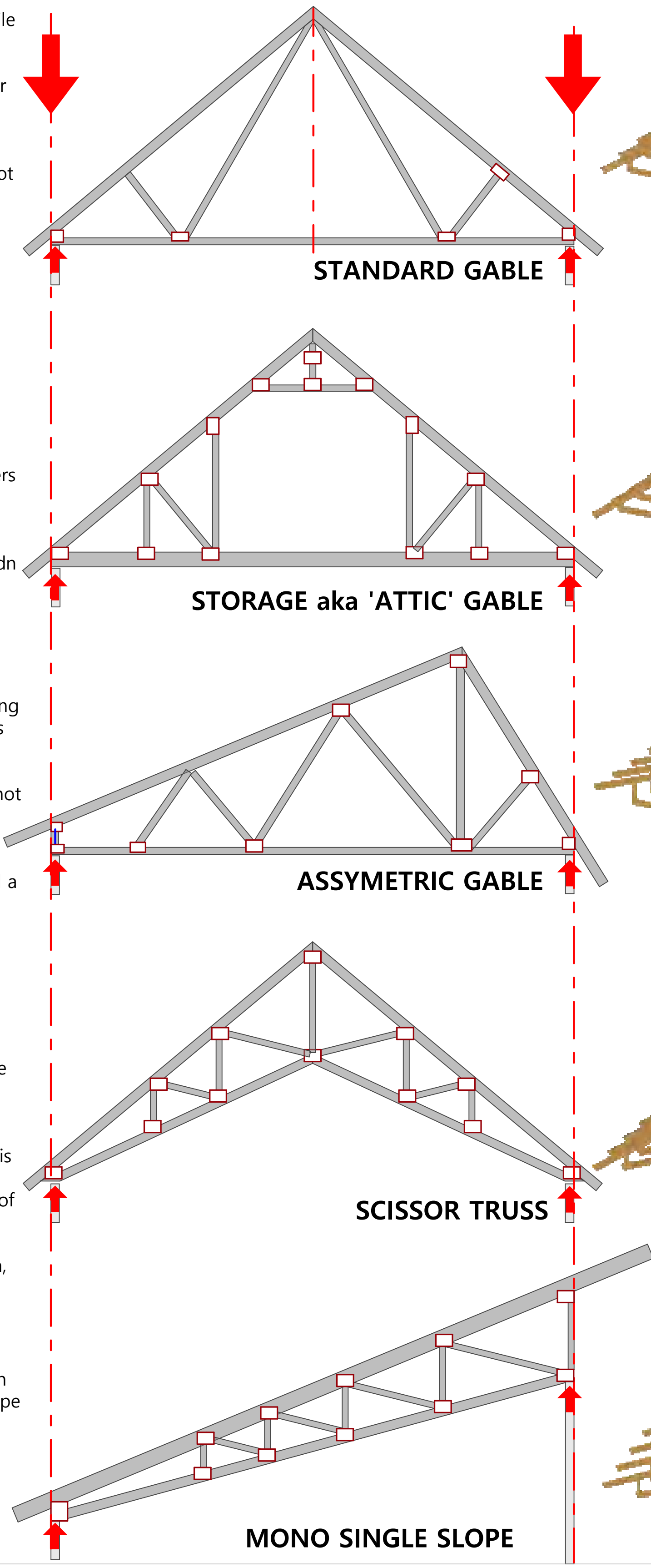
RAISED CEILING PROFILES



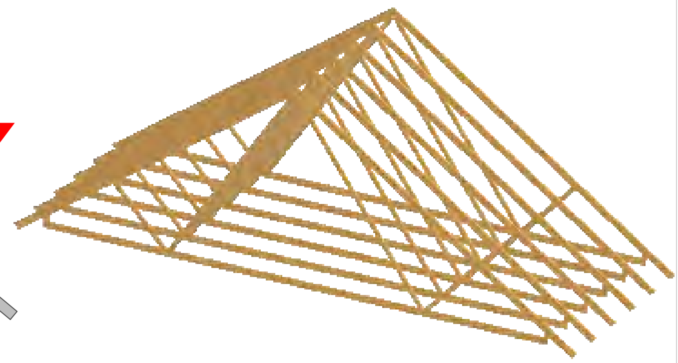
SINGLE SLOPE PROFILES

TRUSS LOADING

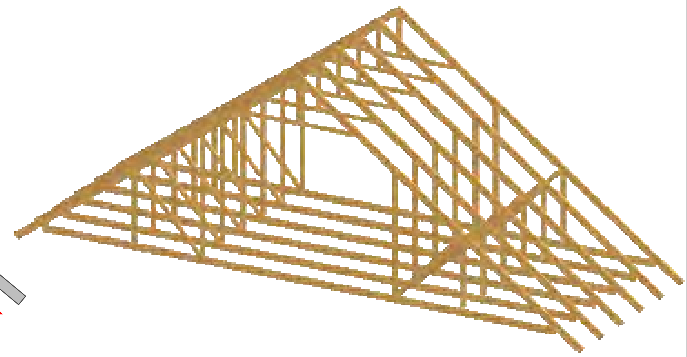
ALL GRAVITY_(MOST) TRUSSES RESOLVE LOADS INTERNALLY SO THE NET RESULT IS A DOWNWARD ACTING GRAVITY LOAD. THIS IS ONE OF THE STRUCTURAL CONVENIENCES OF TRUSS DESIGNS
EXCEPTIONS_DON'T KNOW



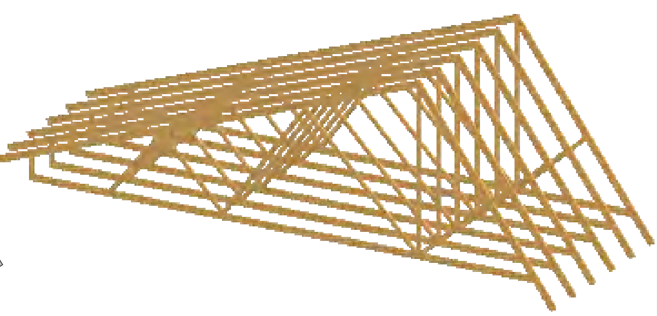
STANDARD GABLE
*This common pratt profile offers the most space accessible from below. Viability of this storage or hvac space is very much linked to the thermal envelope strategy. Deep truss floor insulation is not easily compatible.
*This 3 part pratt (or 'w') truss has limited span capacity.



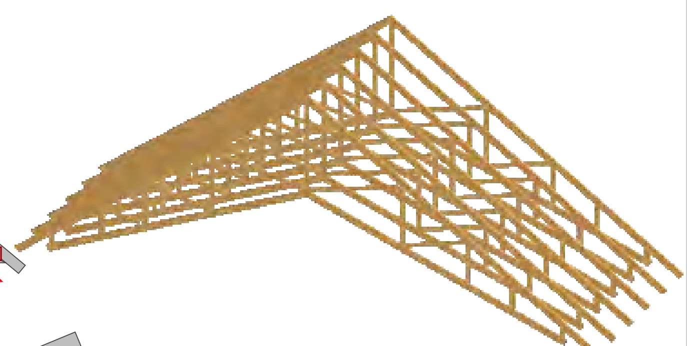
STORAGE GABLE
*This truss profile is specifically designed to maximize open space within the truss. The top and bottom cord members usually need to be increased to 2x6 or 2x8.
*Adequate access in the form of a generous pull dn stair is consistent.



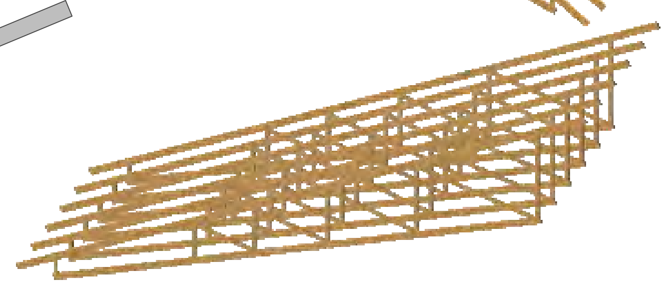
ASSYMETRY
*This profile is representing that differing roof pitches are doable. This is essentially an exterior design preference issue-not a structural or practical one.
*Noting a raised heel option on either end and a pitch option both sides there are endless shapes possible.



THE SCISSOR TRUSS
*This is a common truss that allows (creates) a vaulted space to generate higher ceilings at very modest cost and complication.
*The lower interior pitch is usually half the higher exterior pitch. An 8:12 roof pitch results in an 4:12 interior ceiling. This is a structure based limitation, not an aesthetic one.



THE SINGLE SLOPE
*A way to increase a span capacity over a single slope vaulted space.
*Ditto above the interior pitch will be half the exterior. The lower cord can be set as low as flat.



STICK FRAME LOADING

NOT ALL GRAVITY_STICK FRAME ROOF RAFTERS DO NOT RESOLVE THEMSELVES INTO VERTICAL GRAVITY LOADS ONLY. BY NATURE ALL/ANY RAFTER INSTALLED ON A PITCH HAS A VERTICAL LOAD COMPONENT AND A HORIZONTAL LOAD COMPONENT. THE FRAMING SYSTEM NEEDS TO BE AWARE OF THIS HORIZONTAL 'PUSH' COMPONENT AND RESIST IT. THERE ARE LOTS OF WAYS TO DO THIS.

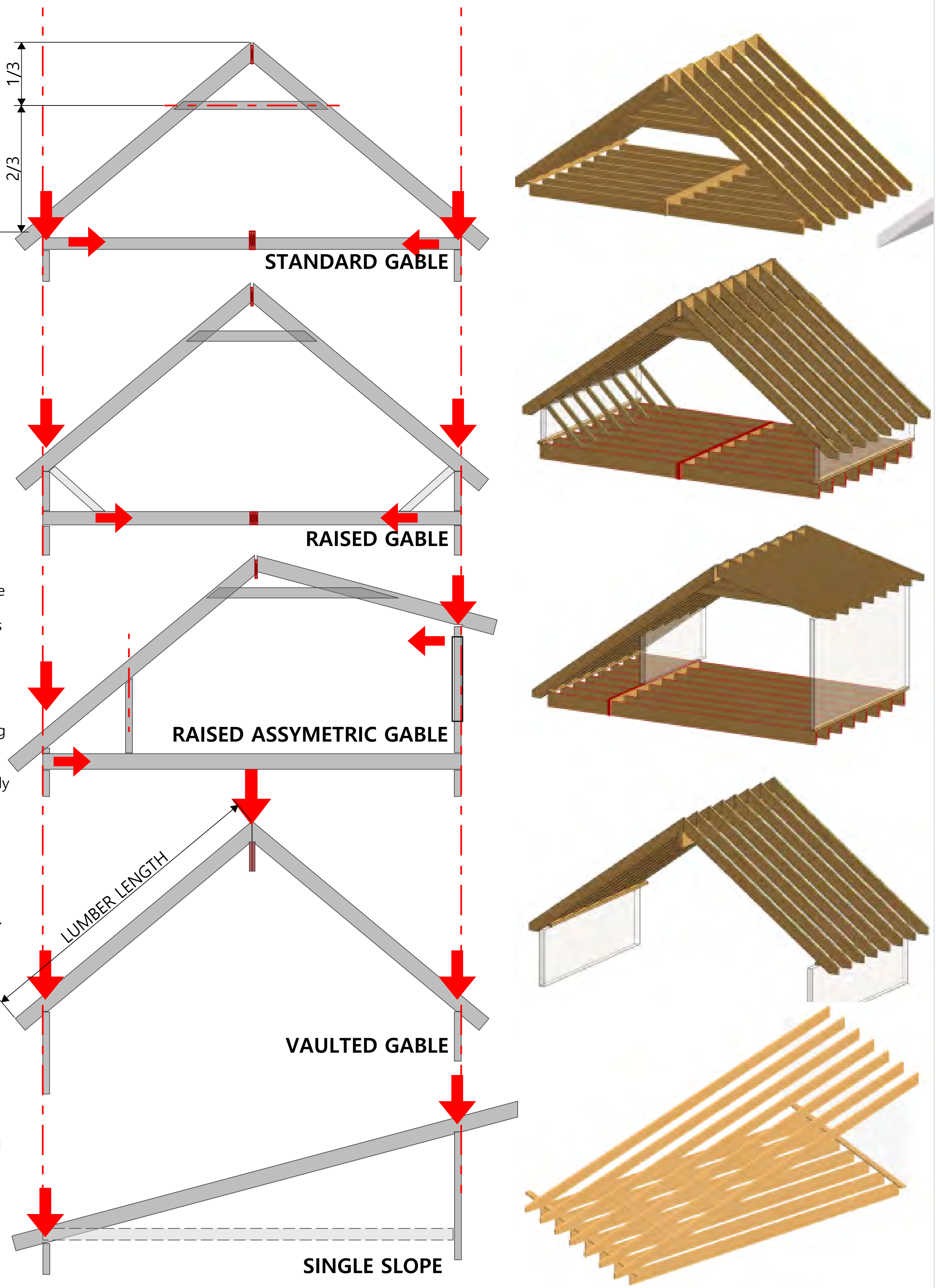
STANDARD GABLE
*This is probably the american standard 'baseline'. The big early decision is how this space is to be used as many other decisons follow that determination-as dead unconditioned attic space, as storage space, as habitable space. The floor, the heels, the bracing, the insulation, are all contingent on that intention.

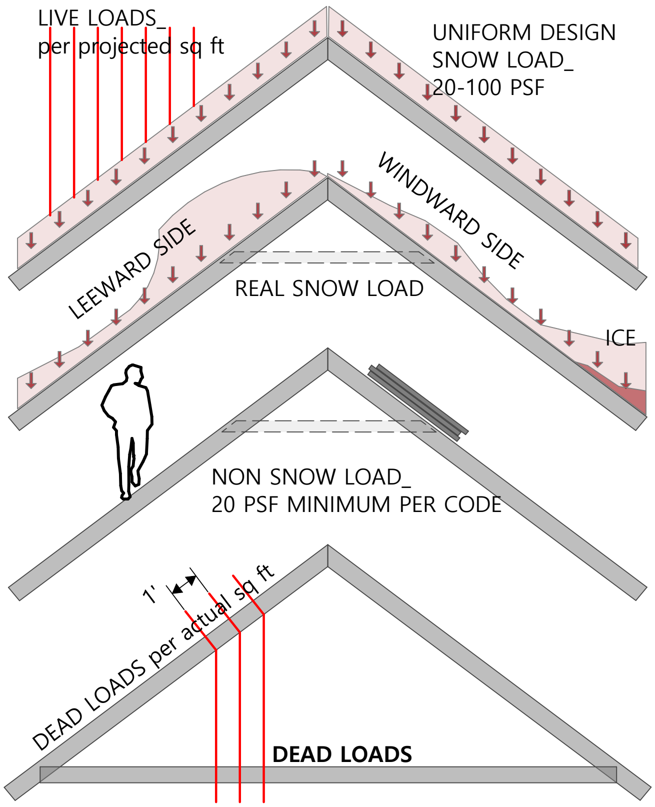
RAISE THE ROOF
*This same gable can be lifted to any ht. The practical criterion are creating more space and allowing for insulation, ventilation per a chosen strategy.
*The lateral push from the rafters does need resolution.

ASSYMETRY
*This profile is representing that differing roof pitches are doable. and space can be created under roof almost as desired.
*This profile seen a lot in $1^{1/2}$ story designs with the smaller/more attractive scale facing the front and the boxier/taller condition facing rearward.
*The new england saltbox is related but evolved differently

THE OPEN GABLE
*This gable type requires a ridge beam (opposed to a ridge board) that must support 1/2 tributary width of the rafter spans each side. With a ridge beam in place all horizontal thrust is eliminated.
*This is a simple concept. but a big challenge exists in supporting that ridge beam. That needs spatial and structural consideration.

THE SINGLE SLOPE
*Simple enough with or without a constructed ceiling plane.
*Span length often is an important criterion as this member spans the full distance. All the 'gable' samples above are required to essentially satisfy 'half' span lengths.





ROOF GRAVITY LOADING

***SNOW LOAD ALLOWANCES** _RECORDED GROUND SNOW LOADS ARE UTILIZED AS A PSF ALLOWANCE. CALCULATIONS, AND SPAN TABLES USE THESE ALLOWANCES AS AN AVERAGE MAXIMUM LOADING.(d2.9)

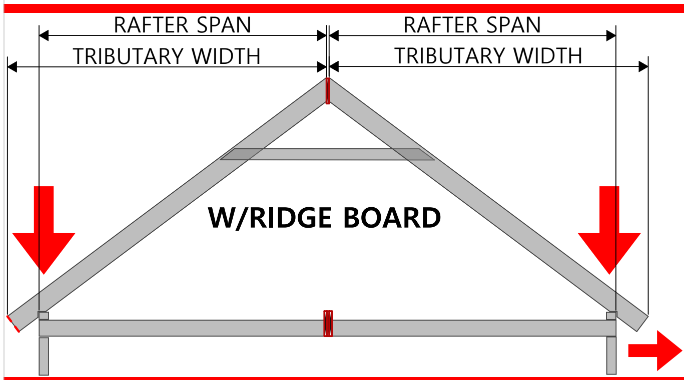
***REAL SNOW LOADS**_WIND PUSHES SNOW AROUND. FREQUENTLY THE WINDWARD SIDE OF A ROOF HAS ITS ACCUMULTED SNOW BLOWN UP AND OVER TO THE LEEWARD SIDE. ADDITIONALLY ROOF VALLEYS CAN ACCUMULATE SNOW-, AND EAVES CAN ACCUMULATE ICE BUILD UP AS A NATURAL THAW/FREEZE CYCLE. SO ULTIMATELY THAT SNOW LOAD IS NOT ALWAYS SO UNIFORM. SNOW REGIONS KNOW HOW TO CONSIDER THESE NATURAL INCONSISTENCIES. THE UNEQUAL SNOW LOADING IS A SECOND IMPORTANT REASON FOR THE COLLAR TIE (CONCEPT) [c7.x]

***NON SNOW LIVE LOADS**_ESSENTIALLY CONSIDER CONSTRUCTION MATERIAL, CONSTRUCTION BODIES, AND MAINTENANCE ACTIVITY, AND WIND. SO EVEN IN NON SNOW AREAS A MINIMUM DESIGN LOAD OF 20 PSF IS REQUIRED.

***DEAD LOADS**_AS WITH FLOOR OR WALL LOADING THE WEIGHT PER SQUARE FT PER EACH ASSEMBLY ITEM CAN BE ADDED TO REALIZE AN ACCURATE TOTAL. MOST SPAN TABLES WILL OFFER 10 PSF AND 20 PSF OPTIONS, SOMETIMES 15 PSF.

***DEAD LOAD AND ROOF PITCH**_LIVE LOADS ARE FIGURED PER HORIZONTAL SQUARE FT.. DEAL LOADS NEED TO BE FIGURED ON A REAL SQUARE FT BASIS WHICH THEREFORE INCREASES AS A PITCH INCREASES. WHEN SPAN TABLE CONSIDER A PITCH THEY ARE INTERNALLY CONSIDERING THAT CONDITION.

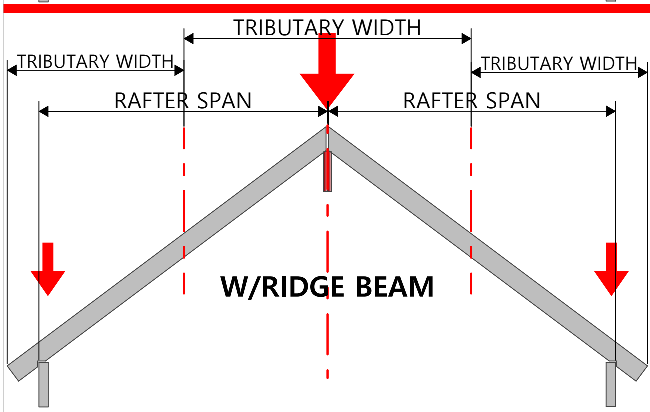
***2 LOADS COMBINED**_BE CONSCIOUS OF ANY CEILING/ATTIC LOADING THAT MAY IMPACT RAFTER DESIGN. TRUSSES NATURALLY CONSIDER THIS.



RAFTER CONDITIONS WITH RIDGE BOARD

***LOADING**_ALL ROOF LOADING CARRIED TO THE OUTSIDE WALLS. THIS BRACE CONDITION AT THE RIDGE NEEDS THE HORIZONTAL LOAD AT THE WALL TO BE RESOLVED. (c7.9-7.11)

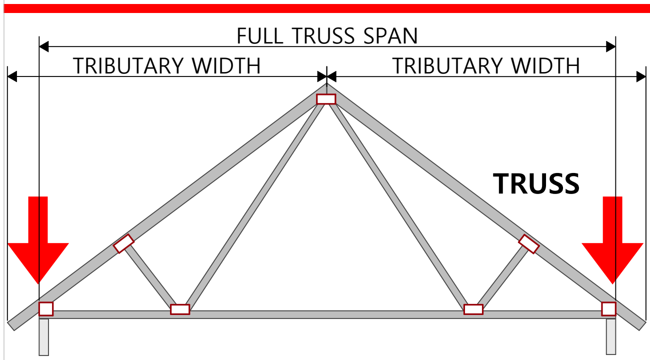
***RAFTER SPANS**_RAFTER SPAN TABLES ARE TYPICALLY EMPLOYED USING GROSS SPANS AS SHOWN, AND WHEN OVERHANGS DO NOT EXCEED 2', AND ICE BUILD UP IS NOT A CONSIDERATION. TECHNICALLY CENTER OF BEARING TO CENTER OF BEARING IS THE REAL SPAN CONSIDERATION. TECHNICALLY OVERHANGS ARE INTEGRAL TO THE BEHAVIOR OF THE BEAM, AND THEREFORE IF GEATER THAN 2' OR INCLINED TO ICE RAFTER SPAN SELECTIONS MAY WANT CHECKING.



RAFTER CONDITIONS WITH RIDGE BEAM

***OBVIOUS LOADING**_THE RIDGE BEAM-BASED ON THE HALF SPAN RULE-IS REQUIRED IN MOST VAULTED CEILING SITUATIONS. THE RIDGE BEAM BECOMES A POST AND BEAM SYSTEM AND POST LOCATIONS AND THEIR SUPPORT, AND CONSEQUENT RIDGE BEAM SPANS, BECOME STRUCTURAL DESIGN CONSIDERATIONS.

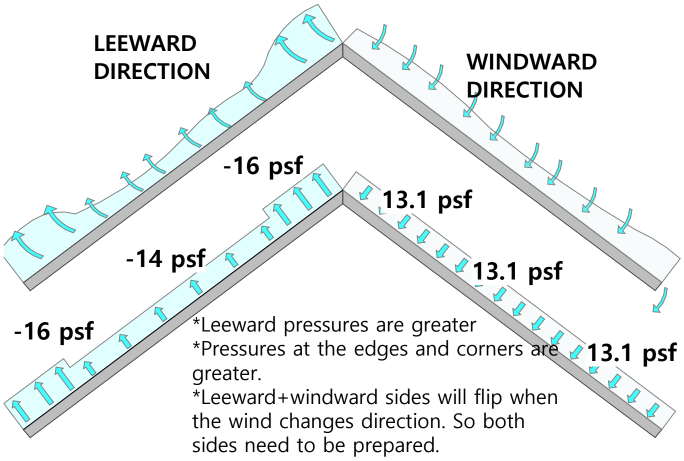
***RAFTER SPANS**_RAFTER BEHAVIOR IS THE SAME AS NOTED ABOVE. IN THE VAULTED CEILING THE THERMAL PLANE IS NECESSARILY THE ROOF PLANE SO THE INSULATION STRATEGY/CAVITY INSULATION DEPTH MUST BE CONSIDERED ALONG WITH THE RAFTER STRUCTURAL DEPTH DECISION.



TRUSS CONDITIONS

***LOADING**_ALL ROOF LOADING CARRIED TO THE OUTSIDE WALLS. BECAUSE OF POTENTIALLY LONGER SPANS AND 24" OC SPACING EACH POINT LOAD ON THE OUTSIDE BEARINGS WALLS CAN BE LARGE AND WANT ADEQUATE SUPPORT CONFIRMATION.

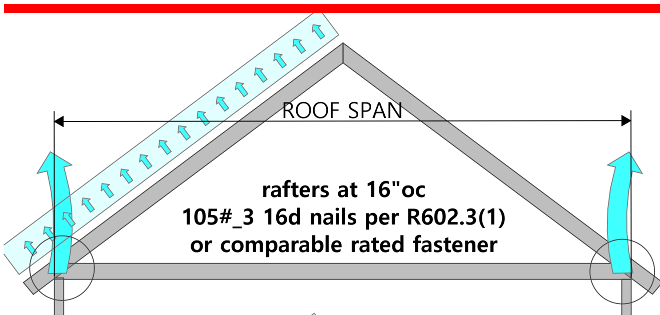
***TRUSS ENGINEERING**_IS LOCAL. ALL LOCAL LOADING/CONDITIONS SHOULD BE CONSIDERED INCLUDING WIND AND UNBALANCED LOADING.

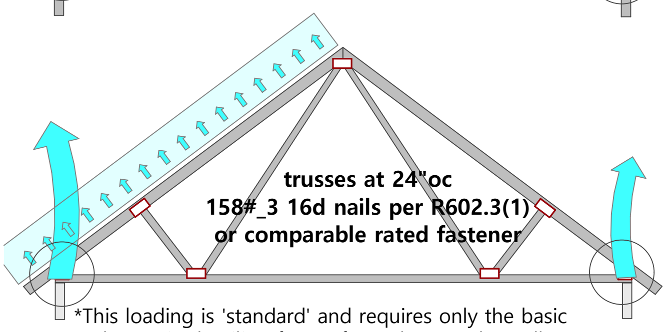


WIND LOADING ON ROOFS_(c8)

***WIND ZONES_** (d2.12) MAPPED WIND SPEEDS GET TRANSLATED INTO WIND FORCE IN PSF. ONLY THEN CAN SPECIFIC ENGINEERING BE ATTEMPTED. THE DEVIL OF COURSE IS THE EVER CHANGING NATURE OF WIND FORCE, DIRECTION, PREDICTABILITY.

***WIND BEHAVIOR_**WIND IS A FLUID FORCE. WHEN IT HITS AN OBSTACLE IT IS NOT ELIMINATED, BUT IT FINDS A WAY AROUND THE OBSTACLE. ON THE WINDWARD SIDE THE FORCE IS PUSHING. WHEN IT HITS AN OBSTACLE IT IS 'COMPRESSED', AND IT HURRIES UP (GETS STRONGER) WHEN FINDING A WAY AROUND THE OBSTACLE. AS IT EXITS, ON THE LEEWARD SIDE, IT HAS THE EFFECT OF PULLING. THAT LEEWARD CONDITION IS CLASSIFIED AS A NEGATIVE FORCE AND IS OF EQUAL OR GREATER MAGNITUDE. PRESSURES AROUND THE BUILDING'S SIDES AND ACROSS THE ROOF ARE PRESENTED IN TABLE 301.2(2), AND FIGURE 301.2(2). SEE (c8)





*This loading is 'standard' and requires only the basic code required nailing for roof members to the wall.
*Heavier loading is common, and may require hardware 'clips' which are common, cheap, and easy to install. aka 'roof tie downs', 'tie down clips' (or straps)', uplift clips (or straps), 'hurricane clips'.

UPLIFT ON ROOF STRUCTURAL MEMBERS _(c8)

***KEEPING THE ROOF ON_**THE WIND LOAD ON THE LEEWARD SIDE OF THE ROOF SURFACE IS THE ONE THAT IS LIFTING. THE ROOF AS AN ENTITY IS PREVENTED FROM LIFTING OFF THROUGH ITS OWN DEAD LOAD AND THE CONNECTIONS OF EACH ROOF FRAMING MEMBER TO THE WALL. FORTUNATELY THERE IS A TABLE R 802.11 THAT ALLOWS AN EASY DETERMINATION OF THAT LOAD IN TERMS OF CONNECTIONS AT EACH RAFTER OR TRUSS. THE AMOUNT OF LOAD IS BASED ON THE PSF WIND LOAD PER SQUARE FOOT AND THE SQUARE FOOTAGE INVOLVED. THE WIND LOAD PSF IS A VERY CONVOLUTED DETERMINATION MADE BY OTHERS. THE SQUARE FOOTAGE IS A SIMPLE FUNCTION OF THE ROOF SPAN AND THE CENTERS OF THE REPETITIVE FRAMING MEMBERS.

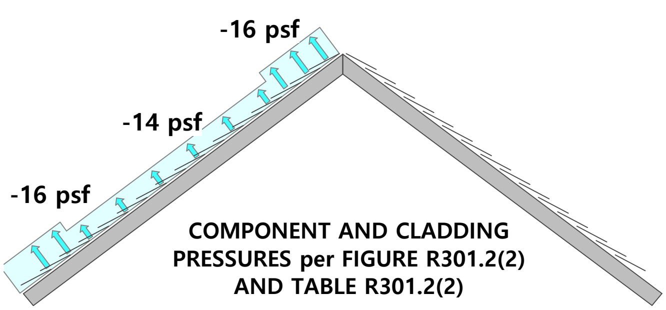
R802.11 Roof tie-down.

TABLE R802.11
RAFTER OR TRUSS UPLIFT CONNECTION FORCES FROM WIND (ASD) (POUNDS PER CONNECTION)

EXPOSURE B

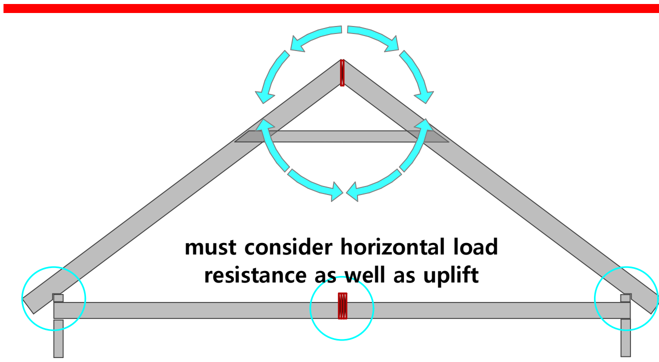
RAFTER OR TRUSS SPACING	ROOF SPAN (feet)	110 Roof Pitch < 5:12	110 Roof Pitch ≥ 5:12	115 Roof Pitch < 5:12	115 Roof Pitch ≥ 5:12	120 Roof Pitch < 5:12	120 Roof Pitch ≥ 5:12	130 Roof Pitch < 5:12	130 Roof Pitch ≥ 5:12	140 Roof Pitch < 5:12	140 Roof Pitch ≥ 5:12
		Ultimate Design Wind Speed V_{ULT} (mph)									
16" o.c.	12	70	60	96	88	118	106	162	149	209	194
	24	94	82	116	105	144	130	198	182	255	237
	28	105	92	132	117	161	145	222	203	287	266
	32	114	100	145	129	176	160	248	226	319	296
24" o.c.	12	116	104	148	132	175	162	244	224	314	292
	24	142	124	178	158	216	196	298	274	384	356
	28	158	138	198	176	242	218	334	306	432	408
	32	172	160	218	194	268	240	370	340	480	444

***COMPONENTS AND CLADDING:_**BUILDING ON FLAT TERRAIN (EXPOSURE C), FLATTER ROOF PICTHES, AND GREATER ROOF SPANS WILL INCREASE THIS LOADING. BUT NONE OF THIS LOADING PRESENTS A PROBLEM FOR PRETTY SIMPLE TIE DOWN HARDWARE.



KEEPING THE ROOFING ON_(c8)

***COMPONENTS AND CLADDING:_**THE WIND FORCE IS MESSING WITH THE COMPONENTS AND CLADDING ATTACHED TO THE BUILDING SHELL. PRESSURES ARE ESTABLISHED AND THE FASTENINGS REQUIRED TO HOLD THOSE MATERIALS IN PLACE ARE LISTED. MANUFACTURERS OF COMPONENTS AND CLADDINGS (ROOFING, SIDING) ALSO PROVIDE ATTACHMENT DETAILS. THE COMPONENT AND CLADDING FIGURE R301.2(2) SHOWS THE PRESSURE ZONES THAT GRAPHICALLY SHOW US WHERE THE PRESSURES ARE GREATER ABOUT THE WHOLE BUILDING SHELL- EDGES AND CORNERS. THOSE PRESSURE ZONES 1 THRU 5 KEY INTO TABLE R301.2(2) WHERE PRESSURES IN PSF CAN BE DETERMINED.

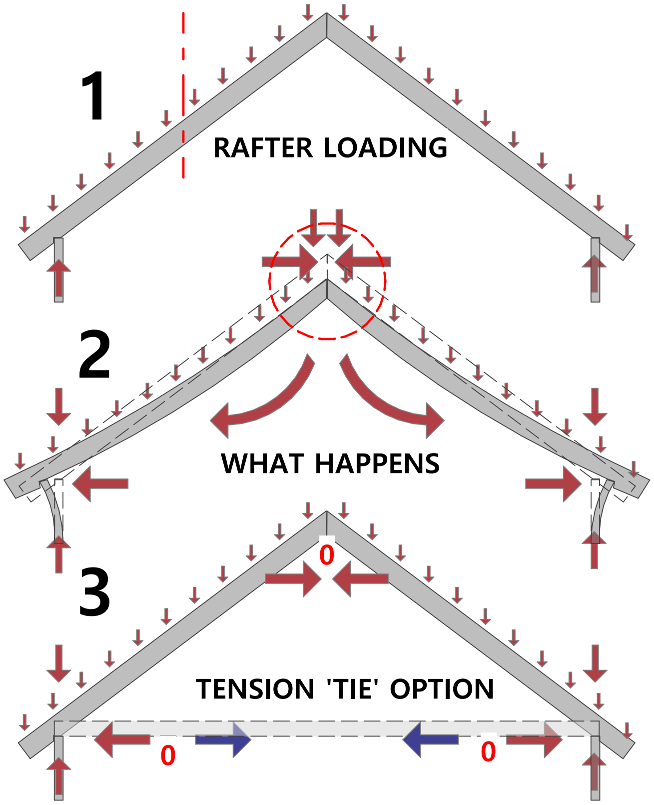


STABILIZING THE ROOF MEMBERS_(c8)

***KEEPING THE RIDGE TIGHT_**KEEPING RAFTERS AND RIDGE MEMBER TOGETHER IS A DEFENSE AGAINST WIND PRESSURES THAT ARE PUSHING AND PULLING FROM EVERY CONCIEVABLE ANGLE. MAINTAINING A TIGHT TRIANGLE JUST MAKES SENSE.

***COLLAR TIES_**ARE REQUIRED IN RAFTER ROOF CONSTRUCTION. 1-1X4 @ 48" OC RAFTER TO RAFTER IS ALL THAT IS REQUIRED. TRUSSES DO ALL THIS RESISTANSE WORK BY THEMSELVES. CLOSER CENTERS AND DEEPER COLLAR TIE MEMBERS ARE BETTER.

***VAULTED CEILINGS WITH RIDGE BEAMS_**WHERE COLLAR TIES ARE NOT VISUALLY REASONABLE STRAPS ARE PERMITTED FROM TOP OF RAFTER, OVER THE RIDGE, TO TOP OF RAFTER ON THE OPPOSITE SIDE OF THE RIDGE.



RAFTER THRUST

THE BRACED RIDGE_IS WHEN THE RIDGE IS NOT FUNCTIONING AS A BEAM - AND IS MOST COMMON. WHEN EMPLOYED THERE IS A HORIZONTAL THRUST THAT HAS TO BE ADDRESSED. SMART TO ADDRESS THIS SITUATION AND THE UPLIFT SITUATION SIMUTANEOUSLY AS A SINGLE SOLUTION CAN OFTEN HANDLE BOTH PROBLEMS. NOTE AT THE BOTTOM THIS SHEET THERE ARE CONDITIONS UNDER WHICH THRUST IS A NON ISSUE. ALSO NOTE THE UPLIFT LOADING IS ALWAYS A CONDITION.

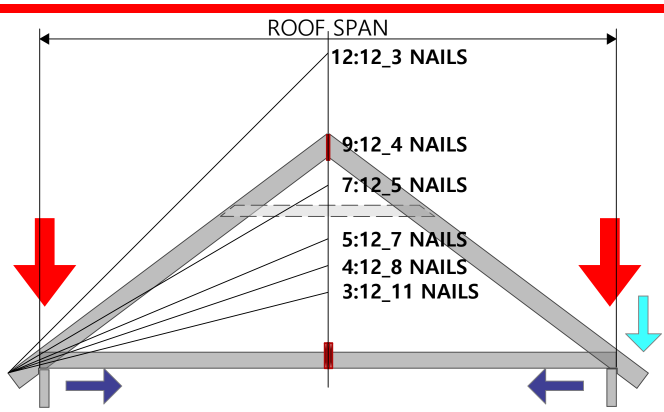
1_LOAD COMPONENTS_THE PITCHED RAFTER MEMBER IS CARRYING THE LOAD TO ITS SUPPORT POINT. IN A 'DIAGONAL' DIRECTION. THAT DIAGONALLY DIRECTED LOAD HAS A VERTICAL AND A HORIZONTAL CONPONENT. THE VERTICAL COMPONENT WILL BE HANDLED BY THE SUPPORTING WALL. WHAT ABOUT THE HORIZONTAL CONPONENT???

2_PUSHING THE WALL

THAT HORIZONTAL COMPONENT WANTS TO PUSH THE WALL OUT. A FRAME WALL-WITHOUT ASSISTANCE- WILL BOW OUT. THIS IS NOT AN ABSTRACTION. IT HAPPENS- READILY. BIGGER LOADS AND LOWER PITCHES INCREASE THIS PUSH,-aka-THRUST,=aka-HORIZONTAL LOAD. HELPFUL TO GET A SENSE FOR THIS.

3_RESTRAINING THE WALL

THAT HORIZONTAL COMPONENT NEEDS TO BE NEUTRALIZED. IF IT IS TIED BACK TO THE OTHER SAME CONDITION ON THE OTHER SIDE IT CAN BE NEUTRALIZED. GENERICALLY THIS IS CALLED A TENSION TIE. A TENSION TIE NEEDS BE STRONG ENOUGH INTERNALLY TO NOT PULL APART. THE CONNECTION TO THE RAFTER GENERATING THAT PUSH ALSO NEED TO BE UP TO THE TASK. THIS CONNECTION IS THE TRICKIER PART.



*CODE_TABLE 802.5.2 PRESCIBES THE NUMBER OF NAILS REQUIRED EACH SIDE OF THE TOTAL ROOF SPAN CONNECTING A TENSION TIE (RAFTER TIE OR CEILING JOIST) TO THE OPPOSING RAFTERS. THE NUMBER OF NAILS IS A SIMPLE WAY TO DEAL WITH THIS.

RAFTER CONDITIONS WITH RIDGE BRACE

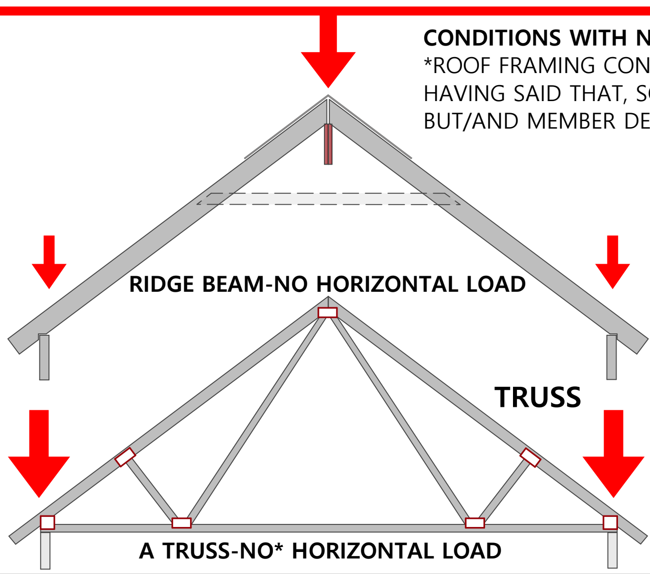
***FACTORS_**THE SPAN AND THE ROOF UNIT LOAD CONTROL THE GRAVITY WEIGHT NEEDING TO BE MANAGED. THE PITCH DICTATES HOW THAT LOAD GETS PROPORTIONALLY RESOLVED. THE LOWER THE PITCH THE GREATER THE HORIZONTAL THRUST AND THEREFORE THE MORE NAILS NEEDED TO RESIST THAT THRUST. THE WOOD MEMBERS ASSUMMED AS THE RAFTER OR CEILING JOIST TIE ARE SELDOM THE WEAK LINK IN THE CHAIN. IT IS THE CONNECTION. THE CODE ASSUMES A VERY CONVENTIONAL DETAIL AS SHOWN THIS ILLUSTRATION. VARIOUS CONNECTION CONDITIONS ARE SHOWN[cC7.X]

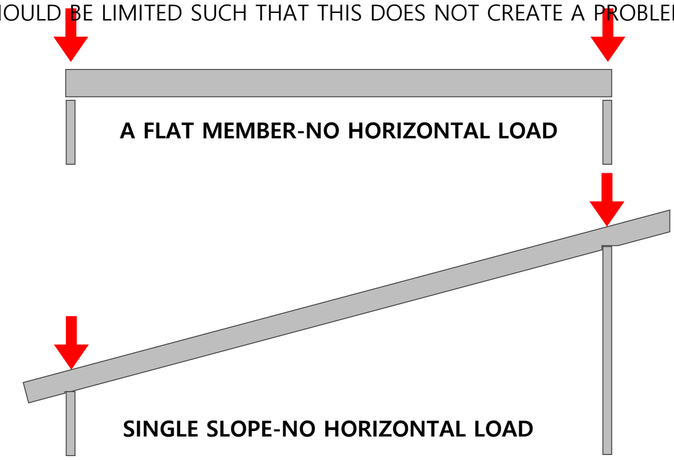
TABLE R802.5.2
RAFTER/CEILING JOIST HEEL JOINT CONNECTIONS

RAFTER SLOPE	RAFTER SPACING (inches)	GROUND SNOW LOAD (psf)															
		20				30				50				70			
		Roof span (feet)															
		12	20	28	36	12	20	28	36	12	20	28	36	12	20	28	36
		Required number of 16d common nails per heel joint splices															
9:12	12	3	3	4	4	3	3	3	4	3	3	4	5	3	4	5	7
	16	3	4	4	5	3	3	4	5	3	4	5	7	3	5	7	9
	24	3	4	6	7	3	4	6	7	3	6	8	10	4	7	10	13

CONDITIONS WITH NO HORIZONTAL LOAD

*ROOF FRAMING CONDITIONS BELOW ARE NOT BRACED AND TRANSFER GRAVITY LOADS VERTICALLY. HAVING SAID THAT, SOME MODEST 'PUSH' CAN BE GENERATED BY WAY OF MEMBER DEFLECTION, BUT/AND MEMBER DEFLECTION SHOULD BE LIMITED SUCH THAT THIS DOES NOT CREATE A PROBLEM.



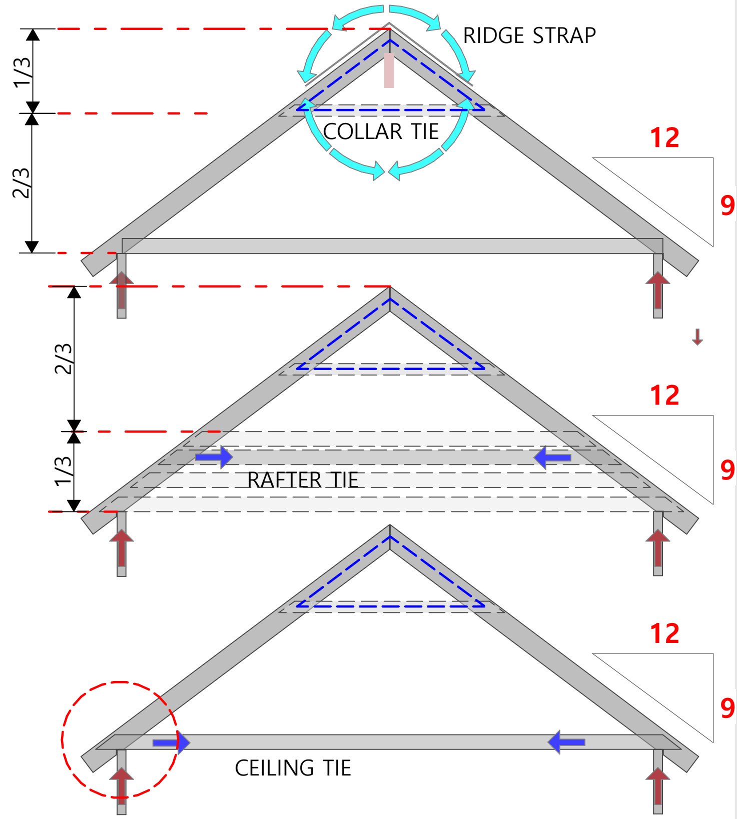


CODE R802.3

COLLAR TIES_TERM USED FOR RAFTER TO RAFTER CONNECTIONS LOCATED IN THE UPPER THIRD OF THE RAFTER. THEIR PRIMARY JOB IS 'TRIANGULATING' THAT UPPER PORTION OF ROOF TO HELP WITH WIND FORCES (PUSH AND PULL) AND WITH UNEQUAL SNOW LOADING, NOT PREVENTING THE WALL SPREAD PREVIOUSLY DISCUSSED. THE REQUIREMENT IS FOR 1X4'S EVERY 4' MIN OC. CODE DOES NOT SPECIFY/QUALIFY ALL CONDITIONS UNDER WHICH COLLAR TIES ARE REQUIRED SO ONE WANTS TO ASSUME THEY ARE UNIVERSALLY REQUIRED. GABLE ROOF, HIP ROOF, ASSYMETRICAL ROOF, ROOF WITH RIDGE BEAM, -ALL REQUIRE THEM. AND THIS MAKES SENSE AS ONE CONSIDERS THEIR PURPOSE OF KEEPING THE RIDGE AND RAFTERS TOGETHER UNDER UNDER UNPREDICTABLE WIND PRESSURES AND UNEQUAL SNOW LOADING. RIDGE STRAPS ARE PERMITTED AS AN ALTERNATIVE.

RAFTER TIES_TIES IN THE LOWER THIRD OF THE RAFTER SITUATION AND USED AS STRUCTURAL TENSION TIES HOLDING RAFTER TO RAFTER AND CONSEQUENTLY KEEPING THE EXTERIOR WALLS VERTICAL. CODE REQUIRES 2X4 MEMBERS AT 4' MIN OC.. THIS MINIMAL REQUIREMENT ALONE MAY BE WOEFULLY INADEQUATE. IF RAFTER TIES ARE THE METHOD OF CONTROLLUNG THRUST, ADJUSTMENTS ARE REQUIRED WITH RAFTER MEMBER SIZE AND NAILING. SEE BELOW

CEILING TIES_ARE RAFTER TIES-ON THE CEILING PLANE OF THE FLOOR BELOW. THEY MAY BE CEILING JOISTS (WITH NO LIVE LOADS ABOVE), OR ATTIC FLOOR JOISTS (WITH LIVE STORAGE LOADING ABOVE), OR FLOOR JOISTS (WITH HABITABLE SPACE AND LIVE OCCUPANCY LOADS ABOVE). IN ALL 3 CASES THESE MEMBERS SPAN ACROSS AND TIE WALL AND RAFTER TO WALL AND RAFTER. TABLE 802.5.2 NOTED THE PREVIOUS PAGE PRESCRIBES THE NAILS REQUIRED CONNECTING CEILING TIE TO RAFTER. EACH NAIL HAS A RESISTANCE CAPACITY IN POUNDS. THE MORE NAILS REQUIRED INDICATES A LARGER HORIZONTAL LOAD.



RAFTER ADJUSTMENTS BASED ON RAFTER TIE HT

CODE CHARTS_EVERY RAFTER SPAN CHART NOTES THIS ADJUSTMENT AT THE BOTTOM__

HEIGHT OF RAFTER TIE_BASED ON RELATIVE HT ABOVE CEILING PLANE

SPAN ADJUSTMENT_CALLS FOR REDUCING SPAN CAPACITY BY A PERCENTAGE, THEREBY INCREASING THE RAFTER MEMBER SIZE.

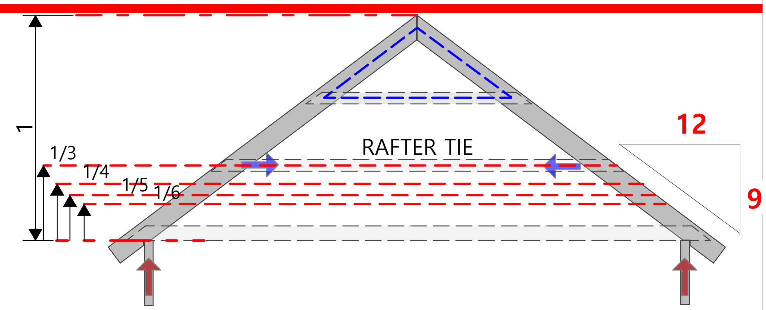
NAILING ADJUSTMENTS BASED ON RAFTER TIE HT

CODE CHARTS_AT THE BOTTOM OF TABLE R802.5.2

HEIGHT OF RAFTER TIE_BASED ON RELATIVE HT ABOVE CEILING PLANE

NAILING ADJUSTMENT_NAIL COUNT INCREASED BY A FACTOR BASED ON THAT HEIGHT.

RAFTER SPAN ADJUSTMENT	NAILING COUNT ADJUSTMENT
1/3 HT____.67 REDUCTION FACTOR	1/3 HT____1.5 MORE NAILS
1/4 HT____.76 REDUCTION FACTOR	1/4 HT____1.33 MORE NAILS
1/5 HT____.83 REDUCTION FACTOR	1/5 HT____1.25 MORE NAILS
1/6 HT____.90 REDUCTIONFACTOR	1/6 HT____1.2 MORE NAILS

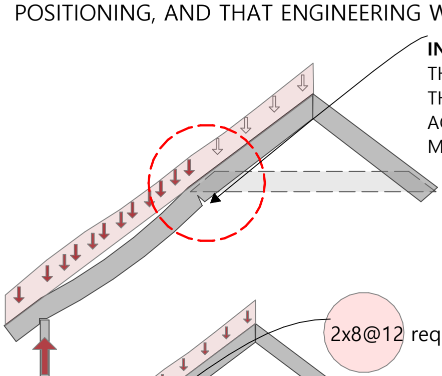


WHY THE BIG DEAL_THIS PROJECT IS EMPHASIZING THIS IDEA OF THRUST BECAUSE IT IS REAL AND CAUSES PROBLEMS. NOTHING WRONG IN THIS ARENA WITH A LITTLE OVERBUILD.

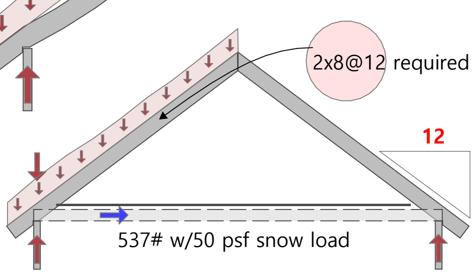
SAMPLE CONDITIONS ILLUSTRATING THE ABOVE

REAL CALCULATIONS_RESISTANCE REQUIRED AND RAFTER SIZE REQUIRED ARE

CODE REQUEST_IS TO DEFAULT TO A RIDGE BEAM WHEN RAFTER TIES ARE ABOVE THAT 1/3 HT. THIS MAY BE GENERALLY WISE BUT PROPER ENGINEERING WILL PERMIT HIGHER POSITIONING, AND THAT ENGINEERING WILL SUPERCEED CODE.



INCREASED 'MOMENT'.THE TIE STABILIZES THE RAFTER ABOVE THE TIE CONECTION. THE WHOLE RAFTER LOAD THEN WANTS TO ACT BELOW THE TIE CONNECTION. SO MORE MEAT NEEDED IN THE RAFTER.



X(HOWMANY?)-nails

*THIS LUMBER TO LUMBER NAILING AT 90^{O} IS CONSIDERED A SINGLE SHEAR CONNECTION.

*A SHEAR RESISTANCE IN POUNDS IS ASSIGNED TO A NAIL (OR SCREW OR BOLT) BASED ON STEEL QUALITY AND DIAMETER (CROSS SECTIONAL AREA) OF THE SELECTED FASTENER.

*THE RESISTANCE VALUE OF THE LUMBER GRADE AND SPECIES IS CONSIDERED.

*THE RESISTANCE REQUIRED IS THEN DIVIDED BY THE ASSUMED VALUE PER NAIL TO ARRIVE AT THE COUNT REQUIRED.

*16d NAILS FOR THIS APPLICATION WILL BE VALUED AT ABOUT 120# PER NAIL.

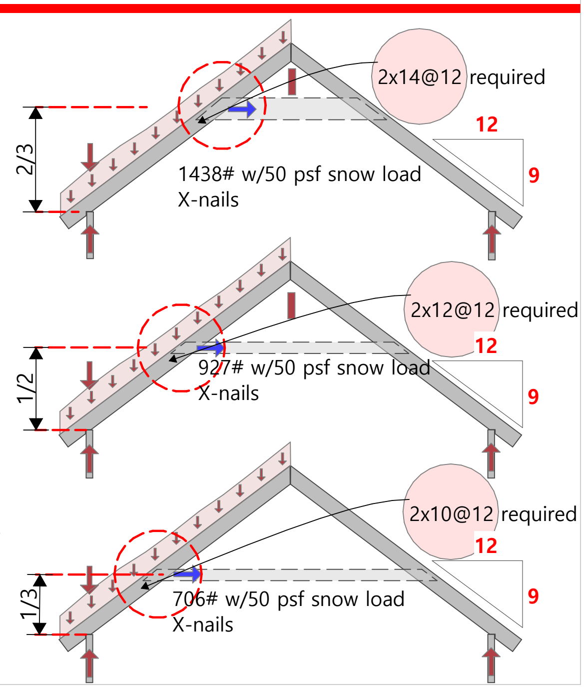


TABLE R802.5.2
RAFTER/CEILING JOIST HEEL JOINT CONNECTIONS[a, b, c, d, e, g]

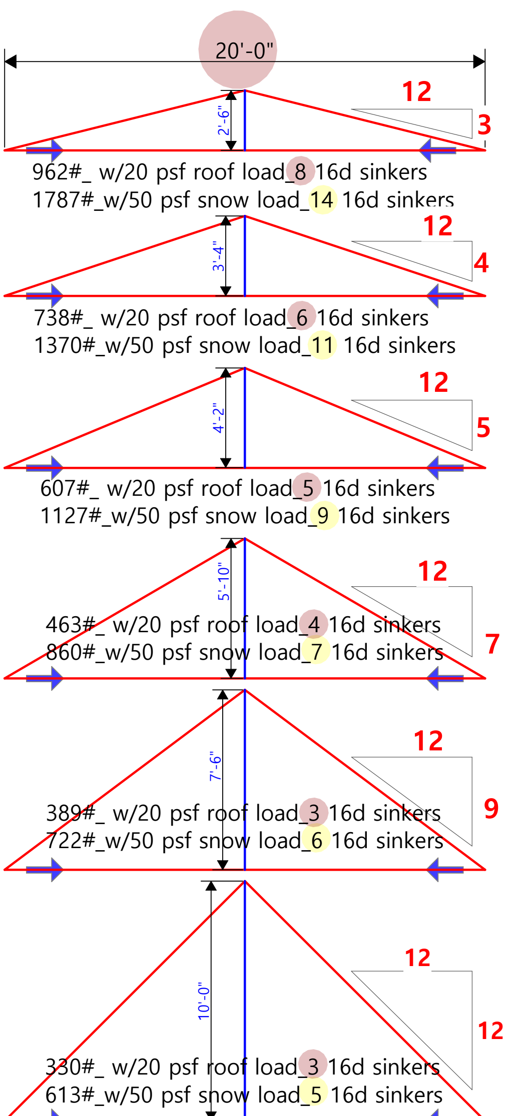
RAFTER SLOPE	RAFTER SPACING (inches)	GROUND SNOW LOAD (psf)															
		20[f]				30				50				70			
		Roof span (feet)															
		12	20	28	36	12	20	28	36	12	20	28	36	12	20	28	36
		Required number of 16d common nails[a, b] per heel joint splices[c, d, e]															
3:12	12	4	6	8	10	4	6	8	11	5	8	12	15	6	11	15	20
	16	5	8	10	13	5	8	11	14	6	11	15	20	8	14	20	26
	24	7	11	15	19	7	11	16	21	9	16	23	30	12	21	30	39
4:12	12	3	5	6	8	3	5	6	8	4	6	9	11	5	8	12	15
	16	4	6	8	10	4	6	8	11	5	8	12	15	6	11	15	20
	24	5	8	12	15	5	9	12	16	7	12	17	22	9	16	23	29
5:12	12	3	4	5	6	3	4	5	7	3	5	7	9	4	7	9	12
	16	3	5	6	8	3	5	7	9	4	7	9	12	5	9	12	16
	24	4	7	9	12	4	7	10	13	5	10	14	18	7	13	18	23
7:12	12	3	4	4	5	3	3	4	5	3	4	5	7	3	5	7	9
	16	3	4	5	6	3	4	5	6	3	5	7	9	4	6	9	11
	24	3	5	7	9	3	5	7	9	4	7	10	13	5	9	13	17
9:12	12	3	3	4	4	3	3	3	4	3	3	4	5	3	4	5	7
	16	3	4	4	5	3	3	4	5	3	4	5	7	3	5	7	9
	24	3	4	6	7	3	4	6	7	3	6	8	10	4	7	10	13
12:12	12	3	3	3	3	3	3	3	3	3	3	3	4	3	3	4	5
	16	3	3	4	4	3	3	3	4	3	3	4	5	3	4	5	7
	24	3	4	4	5	3	3	4	6	3	4	6	8	3	6	8	10

X(HOWMANY?)-nails

*THIS LUMBER TO LUMBER NAILING AT 90° IS CONSIDERED A SINGLE SHEAR CONNECTION.
*A SHEAR RESISTANCE IN POUNDS IS ASSIGNED TO A NAIL (OR SCREW OR BOLT) BASED ON STEEL QUALITY AND DIAMETER (CROSS SECIONAL AREA) OF THE SELECTED FASTENER.
*THE SHEAR VALUE ALSO MUST CONSIDER THE WOOD SPECIES.
*THIS CHARTED CODE NAIL COUNT REQUIRES 16d COMMON NAILS (.162" DIAMETER) THAT HAVE A SHEAR VALUE IN SPF OF 120#. CODE DOES NOT SPECIFY THE WOOD SPECIES.
*ALTHOUGH THIS GETS A LITTLE ANAL THE IDEA HAS VALUE-. OTHER NAILS, INCLUDING SINKERS NOTED BELOW AND PROPRIETARY GUN NAILS WILL HAVE DIFFERENT DIAMETERS/SHEAR VALUES. IF ONE KNOWS THE LOAD, AND THE NAILS SHEAR VALUE FOR A WOOD SPECIES, THEN SIMPLE DIVISION WILL GIVE THE NAIL COUNT.

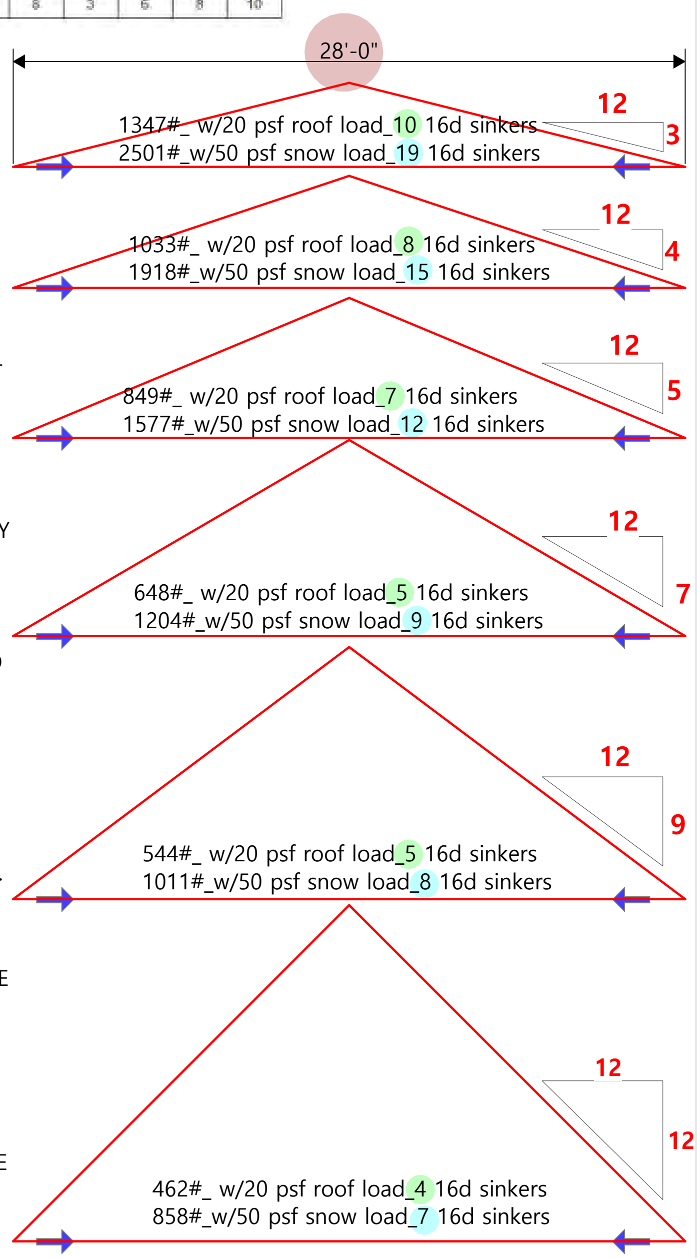
THRUST CALCULATOR AVAILABLE ON-LINE

http://www.timbertoolbox.com/Calcs/raisedtiethrust.htm

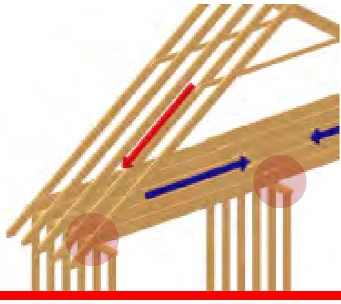


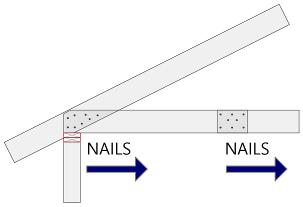
COMPARABLE CALCULATIONS

***CODE**_LISTS THE NAIL COUNT FOR 16d COMMON NAILS IN THE CHART ABOVE.
***CALCS**_FROM STRUCALC SOFTWARE, AND AS SHOWN THESE 2D PROFILES, GIVE THE THRUST LOAD AND CONSEQUENT NAIL COUNT FOR 16d SINKERS WHICH ARE MORE COMMONLY USED AND HAVE A SLIGHTLY SMALLER DIAMETER THAN THE 16d COMMON NAIL. THE STRUCALC LOADING IS GENERALLY A LITTLE HIGHER AND BECAUSE THE VALUE PER NAIL IS SLIGHTLY LESS, MORE NAILS AS NOTED ARE REQUIRED.
***ON-LINE FORMULA**_AN EASY TO USE ON LINE CALCULATOR USING AN UNCOMPLICATED FORMULA RESULTS IN LOADING MORE OR LESS INBETWEEN THE CODE'S LENIENT INTERPOLATED RESULTS AND THE MORE CONSERVATIVE STRUCALC. NUMBERS FOR THOSE CALCS DO NOT SHOW THIS PAGE. THIS ON-LINE CALCULATOR ALLOWS ONE TO SET THE RAFTER TIE HEIGHT AND IS CERTAINLY MORE ACCURATE THAN THE CODE ADJUSTMENT FACTORS FOR RAFTER TIE HEIGHT.
***INCONSISTENCIES**_ NOTED ABOVE ARE COMMON WITH ALL SORTS OF WOOD FRAME CONDITIONS. LETS CALL THEM 'THE VARIABLES'. CONSIDER THERE ARE 'FACTORS OF SAFETY' BUILT INTO ALL THESE CALCULATIONS.



THE ROOF c7.12
HEEL JOINT CONNECTION OPTIONS





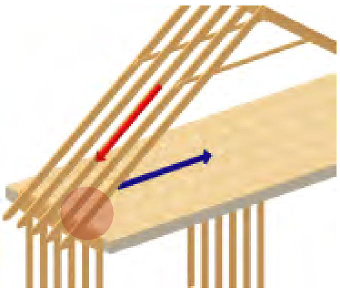
CONNECTION CONTINUITY WITH SHEAR NAILS

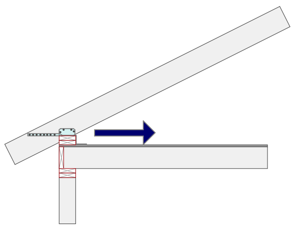
***CEILING JOIST TO RAFTER_**IS THE HEEL JOINT CONNECTIONS DISCUSSED THE LAST 2 PAGES. THIS EXAMPLE HAS THE JOIST SITTING ON THE WALL PLATE. THERE IS NO 'HEEL HEIGHT'. THE JOIST AND RAFTER ARE WORKING TOGETHER. THE RAFTER IS PUSHING AND THE CEILING JOIST IS PULLING. THE NAILED (OR PLATED) CONNECTION KEEPS THE LOADING BALANCED.

***CONTINUITY_**THIS CEILING JOIST REQUIRES A CONTINUITY OF RESISTANCE ALL THE WAY ACROSS TO THE OPPOSING RAFTERS- ANY SPLICED JOISTS REQUIRE THE SAME CONNECTION STRENGTH.

RAFTERS SET ABOVE THE CEILING PLANE

***RAISED HEEL HT_**MANY PROJECTS THESE DAYS ARE RAISING THE RAFTERS ABOVE THE CEILING JOIST PLANE TO ALLOW FOR A BETTER INSULATION AND POSSIBLE VENTILATION SITUATION. THIS CHANGES THE STRUCTURAL DYNAMIC SOME BECAUSE THE RAFTER AND CEILING JOIST MAY NOT BE DIRECTLY CONNECTED. THE RAFTER IS STILL PUSHING SO NEEDS TO BE CONTAINED. THERE CONNECTION REQUIRED FROM RAFTER DOWN TO THE FLOOR PLANE SHEATHED SURFACE OR DIRECTLY TO THE ATTIC JOISTS. NOTE A SHEATHED FLOOR PLANE ABSORBS ALL THE THRUST REQUIREMENTS IN ALL DIRECTIONS SO THE RAFTER CONNECTION CAN BE MADE TO SHEATHING SURFACE.

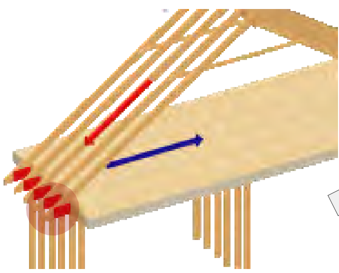


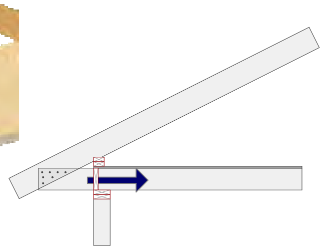


HARDWARE

***RIGHT ANGLE CLIPS_**ALLOW PERPENDICULAR NAILING OR SCREWS TO BOTH PLATE AND RAFTER AND THEREFORE GAIN FULL SHEAR VALUE. A BIGGER (2X6) FLOOR PLATE GIVES MORE SURFACE FOR BIGGER SLIPS. SOME CLIPS WORK WITH STRUCTURAL SCREWS WHICH GIVE MUCH HIGHER SHEAR VALUE THAT NAILS.

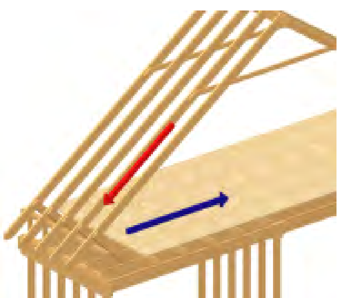
***TENSION STRAPS_**CAN CONNECT PLATE TO RAFTER HORIZONTALLY. TWIST STRAPS FIT THIS GEOMETRY. MORE LENGTH, MORE NAILS . STRAP TIES CAN BE NAILED INSIDE THE PLATE ONTO THE FLOOR JOISTS.

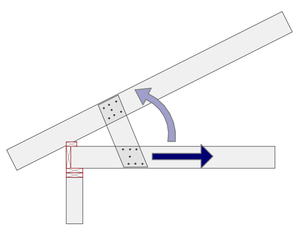




EXTENDING CEILING JOISTS

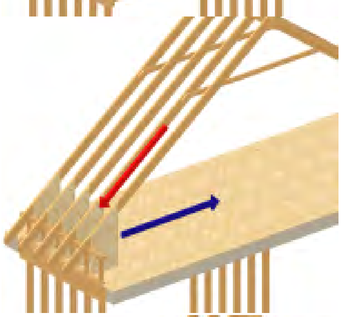
***SEE ABOVE_**ACTUALLY A VERY SIMPLE DETAIL NOT USED OFTEN TODAY. THE JOIST CANTILEVERS OUT AND TIES TO THE RAFTER OUTBOARD. THE RAFTER STILL BEARS DIRECTLY ON THE WALL. THIS JOIST IS THE SOFFIT BOTTOM. END WALL CONDITION WILL VARY FOR GABLE AND HIP ROOF CONDITIONS, BUT NOT COMPLICATE EITHER WAY. NOTE THE DECENDING LENGTH AND SPAN OF HIP RAFTERS WILL HAVE A CORRESPONDING REDUCTION IN THRUST LOAD AND IN MANY CASES WILL GET BY WITH TOENAILS.

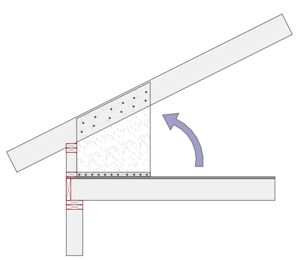




BRACING TO JOISTS

***OFFSET CONNECTION_**STRAIGHT FORWARD BRACE BETTER SERVED WITH A WIDER SELECTION- SAY 2X8 OR 2X10- WHICH INCREASES NAILING CAPACITY FOR RESISTANCE TO THE TORISIONAL/OVERTURNING TENDENCY THIS DETAIL. THIS NEEDS AN OPEN FLOOR DECK AT LEAST AT THE PERIMETER TO PERMIT THE NAILNG INTO THE CEILING JOISTS.

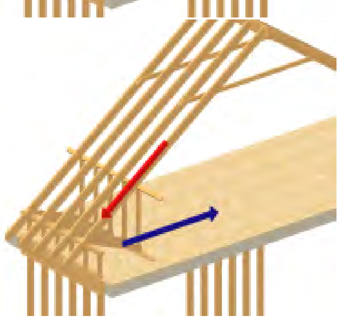


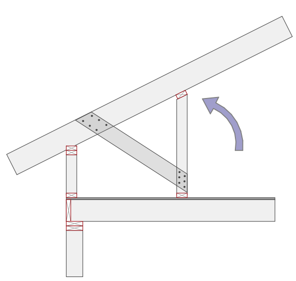


OSB IS EFFECTIVE AND FLEXIBLE

*2X4 FLAT NAILERS ON THE FLOOR DECK PERPENDICULAR TO THE PERIMETER PLATE GIVE A NAILING PLACE FOR THE BOTTOM NAILING SEQUENCE. PLENTY OF NAILING ON THE FACE OF THE RAFTER. THESE CAN BE AS BIG AS THE LOAD REQUIREMENT DEMANDS.

*OSB IS A GOOD 'BRACING' MATERIAL, AND EASY TO CUT AND SHAPE.





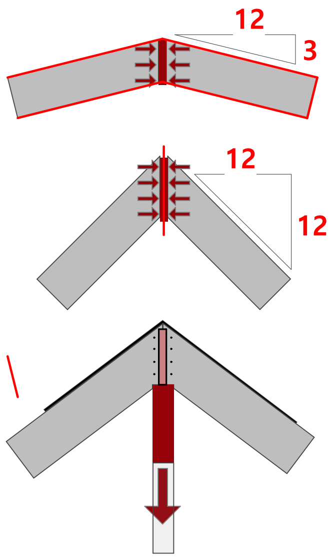
USING KNEEWALLS

*BEHAVING A SIMILAR WAY TO THE ABOVE 2 DETAILS. THAT RAFTER IS PUSHING OUT AND WANTS TO OVERTURN THE BRACING CONSTRUCTION.- WHICH IS TIED TO THE FLOOR AND CAN'T GO ANYWHERE. THIS IS A STICK FRAME VERSION OF THE OSB DETAIL ABOVE. THE FARTHER INBOARD THE KNEE WALL GOES THE SMALLER THE OVERTURNING TENDENCY AND THE MORE STABLE THE CONDITION.

*THIS KNEEWALL CANNOT HELP BUT TAKE A LITTLE LOAD FROM THE RAFTER AS THE RAFTER DEFLECTS. THIS IS NOT NECESSARILY A PROBLEM, IN FACT ONE CAN ARGUE THIS WOULD STIFFEN THE CEILING JOISTS.

RIDGE TERMINOLOGY

***BRACE/BOARD/BEAM_**THE WORLD OF FRAMING (AND CODE AND ENGINEERING) RECOGNIZES THE DISTINCTION IN BEHAVIOR OF THE RIDGE BRACE WITH ITS ATTENDING THRUST, AND THE RIDGE BEAM ELIMINATING THAT THRUST. THE TERM BRACE IS USED TO DENOTE ITS FUNCTION. A RIDGE BOARD IS THE MEMBER USED TO ENABLE THE BRACING FUNCTION. THE RIDGE BEAM IS FUNCTIONING AS A BEAM AND CARRYING ROOF BASED GRAVITY LOADING VERTICALLY DOWN. THIS GRAVITY LOAD ONLY SYSTEM OFTEN USES POST AND BEAMS AS THE SUPPORTING SYSTEM- BUT WALLS CAN AND ARE ALSO USED AS THE SUPPORTING METHOD.

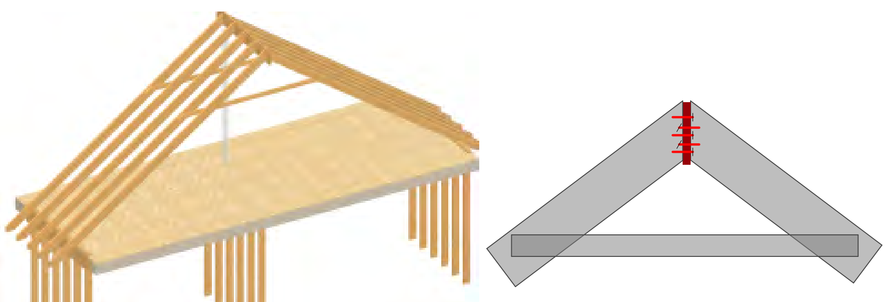


THE RIDGE 'BRACE' MEMBER aka RIDGE BOARD

***CODE_R802.3_**A SINGLE 1X MEMBER AT LEAST AS DEEP AS THE RAFTER END CUT IS REQUIRED. RAFTERS NEED TO ALIGN/OPPOSE EACH SIDE OF THE RIDGE MEBMBER WITH AN ALIGNMENT TOLERANCE OF THE WIDTH OF THE RIDGE MEMBER (THEREFORE A 3/4" OR 1 1/2" ACTUAL OFFSET TOLERANCE). 'FULL' OPPOSED BRACING IS THE GOAL.
***TYPICAL_**2X MEMBER ARE MOST TYPICAL. FOR SLOPES UP TO 7 IN 12. THE NEXT DIMENSIONAL LUMBER DEPTH DEEPER THAN THE RAFTER MEETS THE END CUT REQUIREMENT. SO A 2X8 RAFTER NEEDS A 2X10 RIDGE. 8 IN 12 SLOPES AND UP WILL REQUIRE 2 DIMENSIONAL SIZES UP. SO A 2X10 RAFTER NEEDS A 2X14 RIDGE. AS A BRACE THIS DOES NOT NEED TO BE 1 MEMBER. IT COULD BE A 2X8 ON TOP OF A 2X8. A SIMPLER SOLUTION IS USING A SINGLE PIECE ENGINEERED RIM BOARD.
***NAILING CONNECTION_**CODE SUGGESTS 2 OPTIONS. TABLE R602.3(1)

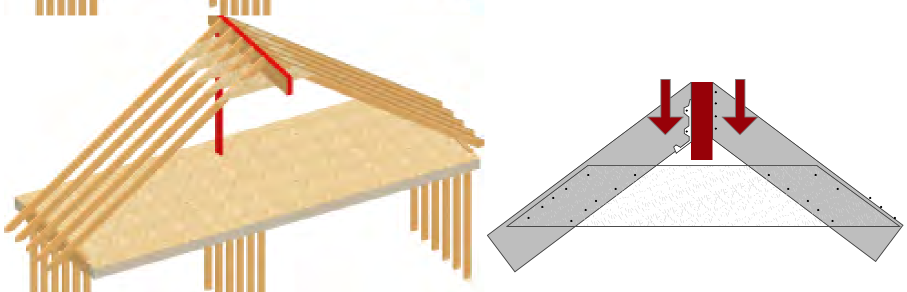
THE RIDGE BEAM

***CHAPTER (c5)_**INFO PRESENTED ON FLOOR BEAMS AND SUPPORTS ARE MOSTLY APPLICABLE TO THIS ROOF CONSTRUCTION. GENERICALLY POST AND BEAM LOGIC RULES. THERE IS NOTHING
***THE BEAM_**ALWAYS HELPFUL TO DO SOME PRE-DESIGN WITH A ROOF POST AND BEAM SO SUPPORT POTENTIAL CAN BE CONSIDERED- WHICH DIRECTLY EFFECTS SPANS AND THERFORE BEAM SIZE. REALLY SMALL HOMES MAY ALLOW A SINGLE AND SIMPLE RIDGE BEAM FROM ENDWALL TO ENDWALL. BUT MORE OFTEN POSTA WILL BE REQUIRED AND THE LOAD PATH NEEDS TO BE TRACKED ALL THE WAY DOWN.
***THE SUPPORTS_**POSTS BIG ENOUGH TO AVOID SLENDERNESS WOBBLES ARE REQUIRED. THIS CAN BECOME AN ISSUE WITH STEEPER PITCHED ROOFS AND OR VAULTED CEILINGS AS THE POSTS CAN GET QUITE TALL., AND THE LOADS SUBSTANTIAL.



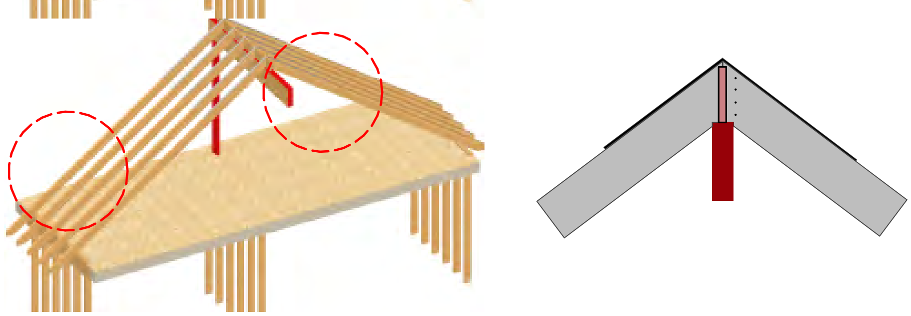
TYPICAL BRACED SECTION

***RAFTER TO RIDGE BRACE_**CODE TABLE 602.3(1) SHOWS GENERIC RAFTER TO RIDGE NAILING REQUIREMENTS. HISTORICALLY A SAGGING ROOF HAS RAFTER PULL DOWN AND AWAY FROM THE RIDGE. THE CAUSE IS UNEQUAL SNOW AND WIND LOADING, AND TIME CREEP. ALL CAN BE FIXED WITH COLLAR TIES, AND BY PREVENTING ANY THRUST AT THE BOTTOM OF THE RAFTERS.
***THIS PROJECT_**IS A COLLAR TIE FAN AND, AS A RULE OF THUMB, LIKES TO SEE A 2X6 TIES AT ALL OPPOSING RAFTERS.



FLUSH RIDGE BEAM

***RAFTER TO BEAM_**NOT CODE SPECIFIED, BUT SHOULD HAVE A SHEAR CAPACITY EQUAL TO THE GRAVITY LOAD IN ORDER TO LET THE BEAM DO ITS JOB AND RELIEVE THE HORIZONTAL THRUST. HANGERS EXIST SPECIFICALLY FOR THIS PURPOSE.
***COLLAR TIE ALTERNATIVE_**USING SHEETGOODS UP TIGHT TO BEAM. THINK OF AS A DROP GUSSET THAT PERMITS A BUNCH OF NAILS AND TRUELY KEEPS RAFTERS TIGHT TO THE RIDGE BEAM. IF THIS CEILINGS GETS SHEETROCK THIS HORIZONTAL FLAT AREA WILL LOOK CLEANER AND AVOID THE INEVITABLE SHEERROCK CRACKS IF TAKEN UP TO AND UNDER THE DROP BEAM.



DROP RIDGE BEAM

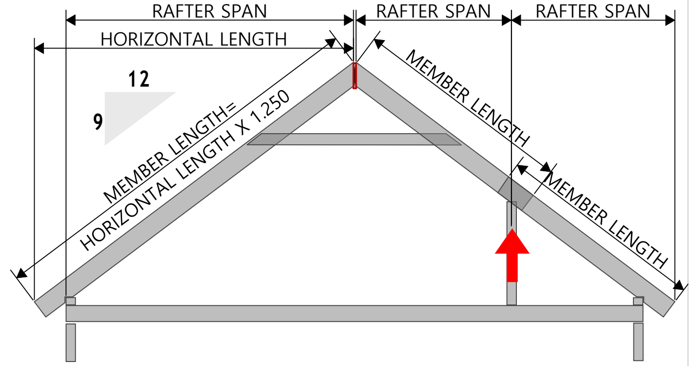
***RAFTER TO BEAM_**RAFTERS SIT ON THE BEAM. EITHER A BRACE MEMBER OR BLOCKING IS WANTED TO KEEP THE RAFTERS 'PLUMB'
***COLLAR TIE ALTERNATIVE_**THIS SAMPLE SHOWS A METAL STRAP TIE OVER THE TOP OF THE RAFTERS THAT KEEPS THE RAFTERS TIED TO THE RIDGE AND ALLOWS THE BEAM TO REMAIN OPEN AND VISIBLE AS/IF DESIRED FROM BELOW. AND STRAPS ARE A STEP SAVER WHEN ENGINEERED RAFTERS ARE USED.

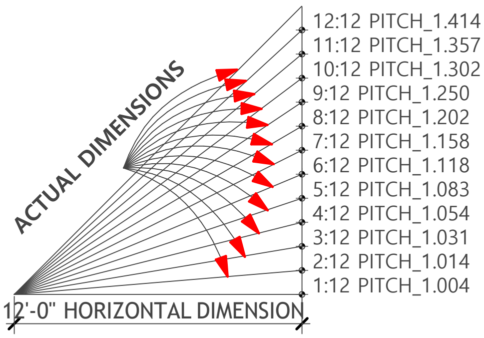
RIDGE BEHAVIORS

***CROSS OVER AND CONDITIONAL BEHAVIOR_**BELOW COMMENTS INTENDED ONLY TO STIMULATE SOME THOUGHT ABOUT HOW THIS INTERCONNECTED ASSEMBLIES BEHAVE
*IF COLLAR TIES ARE INSTALLED EVERY RAFTER THEY WILL ASSIST IN THE TENSION REQUIREMENTS OF THE RAFTER OR CEILING TIES INSTALLED BELOW AS TENSION TIES.
*IF A RIDGE BRACE IS PERIODICALLY SUPPORTED WITH KING POSTS THRUST WILL BE REDUCED.
*IF A RIDGE BEAM DEFLECTS THE RAFTER WILL PUSH OUT.
*IF A RAFTER IS NOT ATTTACHED TO THE RIDGE BEAM ADEQUATELY IT CAN 'DROP'AND THE RAFTER WILL PUSH OUT.

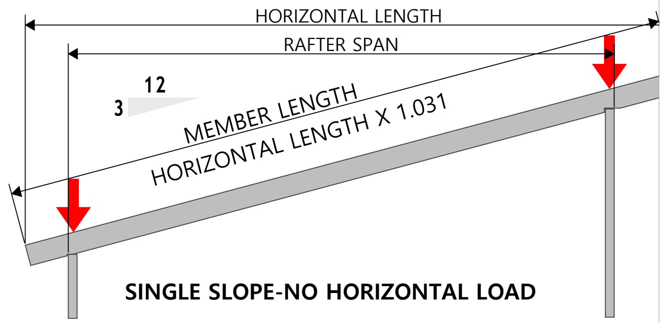
RAFTER LENGTHS

***SPAN AND PITCH AND OVERHANG DEPENDENT_**FOR SINGLE PIECE RAFTERS FULL MEMBER LENGTH NEEDS DETERMINATION. THE MULTIPLIERS BASED ON PITCH ARE 100% ACCURATE. TAKE THE HORIZONTAL SPAN AND OVERHANG (FROM A PLAN VIEW) TIMES THE MULTIPLIER. NOTE DIMENSIONAL LUMBER CAN BE LENGTH LIMITED.
***BREAKING THE SPAN_**INTERMEDIATE KNEEWALL SUPPORTS, BEAM SUPPORTS ARE AN OPTION, AS IS USING OVERHANG OUTRIGGERS TO CONTROL RAFTER LENGTH. BREAKING THE SPAN HAS CONSEQUENCES IN THAT LOADS NEED TO BE TRACKED DOWN TO THE FOUNDATION.





HORIZONTAL TO ACTUAL DIMENSION MULTIPLIERS FOR TYPICAL ROOF PITCHES. MULTIPLIERS ALSO WILL CONVERT HORIZONTAL AREAS TO AREAS ON PITCH



DIMENSIONAL LUMBER

***DIMENSIONAL LUMBER_**THE MORE TYPICAL RAFTER SELECTION BY FAR IS THE 2X MEMBER. 2X6, 2X8, 2X10, 2X12. NO INTRODUCTION NEEDED.
***THE GOOD_**DECENT STRUCTURAL EFFICIENCY, FLEXIBLE, EASY TO WORK, ECONOMICAL.
***THE BAD_**CAN BE INCONSISTENT, AND NOT SO STRAIGHT. LIMITED LENGTHS. SEE MEMBER LENGTH NOTES ABOVE.

ENGINEERED 'LSL' MEMBERS

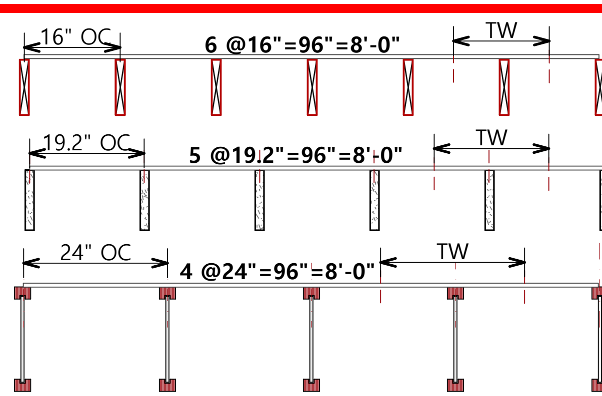
***LAMINATED STRAND LUMBER_**THIS 'LSL' CATAGORY OF ENGINEERED STRUCTURAL MEMBERS MIMIC DIMENSIONAL LUMBER SIZES-WITH SOME ADDITIONAL DEPTHS BASED ON THE MANUFACTURER.
***THE GOOD_**THESE WORK VERY MUCH LIKE DIMENSIONAL LUMBER, ARE STRAIGHTER, LONGER, AND STRONGER.
***THE BAD_**HEAVIER AND MORE PRICEY AND NOT UNIVERSALLY STOCKED AT BUILDING SUPPLY OPERATIONS.

ENGINEERED 'I' RAFTERS

***SAME AS JOISTS_**THIS PRODECT IS THE SAME AS USED FOR FLOOR JOIST, THERBY OFFERING A LOT OF SIZES., LOAD CAPACITIES, AND LONG LENGTHS.
***THE GOOD_**EFFICIENT STRUCTURAL MEMBERS OFFERING LONGER SPANS AND LIGHTER WEIGHTS. AND GREATER DEPTHS WHICH CAN BE AN INSULATION INTEGRATION BENEFIT.
***THE BAD_**THERE ARE INSTALLATION CONDITIONS AND DETAILS THAT NEED TO BE FOLLOWED. THESE ADD SOME STEPS TO THE INTALLATION PROCEDURE.

CENTERS

***ON CENTER_**CENTERLINE TO CENTERLINE OR 'ON CENTER' ABBREVIATED AS O.C. IS THE LANGUAGE.
***INCREMENTS OF 8'_**CENTER SELECTIONS ARE IN SYNC WITH THE STANDARD LENGTH OF SHEATHING WHICH IS 8'.
***ROOF RAFTER CENTERS_**ARE MORE FLEXIBLE THAN FLOOR FRAMING CENTERS FOR 2 REASONS. THERE IS NO ACTIVE PEOPLE TRAFFIC WANTING A 'STIFF' FLOOR, AND THE DEFLECTION LIMITS ARE L/180 WHICH ALLOWS MORE FLEX IN THE ROOF. CHANGING RAFTER CENTERS ON A ROOF BASED ON SPAN IS ALSO USUALLY EASY AND CAN RESULT IN SOME LUMBER AND INSULATION EFFICIENCIES.



SPAN TABLE

***SPAN TABLES_**DO HAVE SOME DETAIL DISTINCTIONS BUT IN PRINCIPLE ARE THE SAME AS FOR FLOOR JOISTS. SPACING OPTIONS, MEMBER DEPTH OPTIONS, LOADING OPTIONS AND ROOF PITCH OPTIONS. INTERPOLATION IS ALWAYS PERMITTED. THERE ARE CONTRIOLLING AUTHORITIES, AND ACCEPTED ENGINEERING PARAMETERS THAT ENSURE SPAN CHARTS 'FOLLOW THE RULES'.

DIMENSIONAL LUMBER

***THIS CHART_**THIS ONE OF MANY OF THE CODE CHARTS IN CHAPTER 8 FOR ROOF RAFTERS. SNOW LOADS UP TO 70 PSF ARE INCLUDED AS ARE MOST WOOD SPECIES, WOOD GRADES, FRAMING CENTERS.

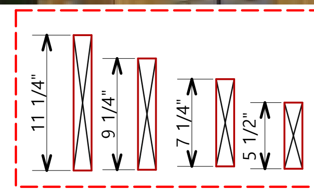
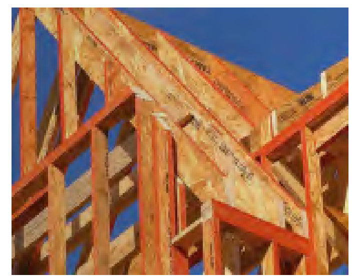


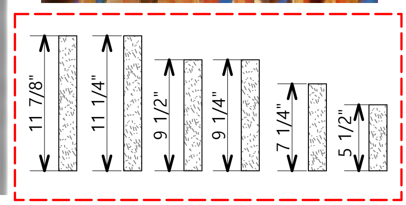
TABLE R802.4.1(2)
RAFTER SPANS FOR COMMON LUMBER SPECIES (Roof live load = 20 psf, ceiling attached to rafters, L/Δ = 240)

RAFTER SPACING (inches)	SPECIES AND GRADE		DEAD LOAD = 10 psf					DEAD LOAD = 20 psf				
			2 × 4	2 × 6	2 × 8	2 × 10	2 × 12	2 × 4	2 × 6	2 × 8	2 × 10	2 × 12
			Maximum rafter spans[a]									
			(feet - inches)	(feet - inches)	(feet - inches)	(feet - inches)	(feet - inches)	(feet - inches)	(feet - inches)	(feet - inches)	(feet - inches)	(feet - inches)
16	Hem-fir	#2	8-4	13-1	17-3	21-11	25-5	8-4	12-3	15-6	18-11	22-0
	Hem-fir	#3	7-5	10-10	13-9	16-9	19-6	6-5	9-5	11-11	14-6	16-10
	Southern pine	SS	9-4	14-7	19-3	24-7	Note b	9-4	14-7	19-3	24-7	Note b
	Southern pine	#1	8-11	14-1	18-6	23-2	Note b	8-11	13-7	17-2	20-1	23-10
	Southern pine	#2	8-7	13-5	17-1	20-3	23-10	7-9	11-8	14-9	17-6	20-8

ENGINEERED 'LSL' MEMBERS

***THIS CHART_**IS A LOUISIANA PACIFIC (LP) CHART FOR THEIR LSL PRODUCT. THERE ARE 3 'STRENGTHS' OR CAPACITIES FOR THE LSL PRODUCT NOTED BY THEIR BENDING STRENGTH RATINGS (Fb), AND THEIR DEFLECTION CAPABILITIES (E). THE HIGHER THE NUMBERS THE BETTER THE PEFORMANCE WHICH IS EASY ENOUGH TO GRASP BY LOOKING AT THE RELATIVE SPAN CAPACITIES.





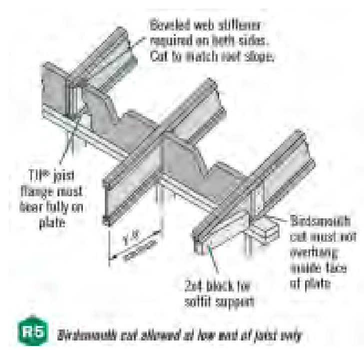
20 PSF ROOF LIVE OR SNOW LOAD (125% OR 115%)

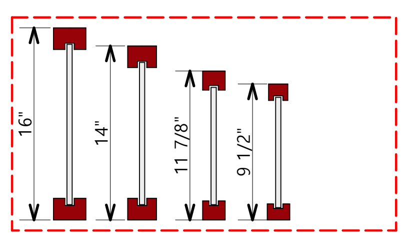
Spacing	Grade	10 psf Dead Load							20 psf Dead Load						
		3-1/2"	5-1/2"	7-1/4"	9-1/4"	9-1/2"	11-1/4"	11-7/8"	3-1/2"	5-1/2"	7-1/4"	9-1/4"	9-1/2"	11-1/4"	11-7/8"
12"	1730F_b - 1.35E	10'-2"	16'-0"	21'-1"	26'-0"	26'-0"	26'-0"	26'-0"	9'-3"	14'-6"	19'-2"	24'-5"	25'-1"	26'-0"	26'-0"
	2360F_b - 1.55E	10'-8"	16'-9"	22'-1"	26'-0"	26'-0"	26'-0"	26'-0"	9'-6"	15'-2"	20'-0"	25'-7"	26'-0"	26'-0"	26'-0"
	2500F_b - 1.75E	11'-1"	17'-5"	23'-0"	26'-0"	26'-0"	26'-0"	26'-0"	10'-1"	15'-10"	20'-11"	26'-0"	26'-0"	26'-0"	26'-0"
16"	1730F_b - 1.35E	9'-3"	14'-6"	19'-2"	24'-5"	25'-1"	26'-0"	26'-0"	8'-4"	13'-2"	17'-4"	22'-2"	22'-9"	26'-0"	26'-0"
	2360F_b - 1.55E	9'-8"	15'-2"	20'-0"	25'-7"	26'-0"	26'-0"	26'-0"	8'-9"	13'-9"	18'-2"	23'-3"	23'-10"	26'-0"	26'-0"
	2500F_b - 1.75E	10'-1"	15'-10"	20'-11"	26'-0"	26'-0"	26'-0"	26'-0"	9'-2"	14'-4"	18'-11"	24'-2"	24'-10"	26'-0"	26'-0"
19.2"	1730F_b - 1.35E	8'-8"	13'-8"	18'-0"	22'-11"	23'-7"	26'-0"	26'-0"	7'-10"	12'-4"	16'-4"	20'-10"	21'-5"	25'-4"	26'-0"
	2360F_b - 1.55E	9'-1"	14'-3"	18'-10"	24'-1"	24'-8"	26'-0"	26'-0"	8'-1"	12'-11"	17'-1"	21'-10"	22'-5"	26'-0"	26'-0"
	2500F_b - 1.75E	9'-6"	14'-11"	19'-8"	25'-1"	25'-9"	26'-0"	26'-0"	8'-7"	13'-6"	17'-10"	22'-9"	23'-4"	26'-0"	26'-0"
24"	1730F_b - 1.35E	8'-0"	12'-8"	16'-8"	21'-3"	21'-10"	25'-11"	26'-0"	7'-3"	11'-6"	15'-1"	19'-4"	19'-10"	23'-6"	24'-10"
	2360F_b - 1.55E	8'-5"	13'-3"	17'-6"	22'-4"	22'-11"	26'-0"	26'-0"	7'-8"	12'-0"	15'-10"	20'-3"	20'-9"	24'-7"	26'-0"
	2500F_b - 1.75E	8'-9"	13'-10"	18'-2"	23'-1"	23'-10"	26'-0"	26'-0"	7'-11"	12'-6"	16'-6"	21'-1"	21'-8"	25'-8"	26'-0"

ENGINEERED 'I' RAFTERS SPAN TABLES

***THIS CHART_**IS A WEYERHAEUSER CHART FOR THEIR 'TRUSS JOISTS'. NOTE IN THE TJI COLUMN ARE THE SERIES CHOICES FROM 110 TO 560. CHECK THEIR LITURATURE AND THE DISTINCTIONS IN THE FLANGE DESIGN AND WEB THICKNESS ARE DETAILED.

***CHECK INSTALLATION DETAILS_**INCLUDED IS BUT 1 OF AN ENTIRE CHART OF INSTRUCTIVE DETAILS. THE CAUTION WITH ALL 'I' JOIST PRODUCTS IS THE THIN WEB WHICH HAS STRUCTURAL LIMITATIONS IN MANY TO MOST JUNCTURE CONDITIONS.





9½"-16" JOISTS

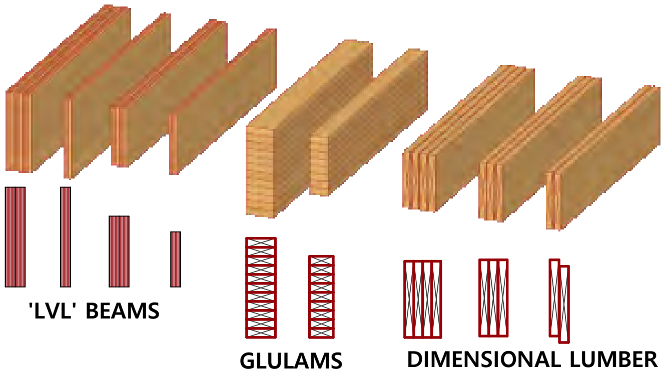
ROOF SPAN TABLE

Maximum Horizontal Clear Spans—Roof

O.C. Spacing	Depth	TJI®	Design Live Load (LL) and Dead Load (DL) in PSF											
			Non-Snow (125%)				Snow Load Area (115%)							
			20LL + 15DL		20LL + 20DL		25LL + 15DL		30LL + 15DL		40LL + 15DL		50LL + 15DL	
			Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
16"	9½"	110	20'-0"	17'-10"	19'-1"	16'-11"	19'-2"	17'-2"	18'-5"	16'-7"	17'-2"	15'-7"	15'-11"	14'-9"
		210	21'-2"	18'-10"	20'-2"	17'-10"	20'-3"	18'-2"	19'-6"	17'-6"	18'-2"	16'-6"	17'-2"	15'-7"
		230	21'-11"	19'-6"	20'-10"	18'-6"	20'-11"	18'-9"	20'-2"	18'-1"	18'-10"	17'-0"	17'-9"	16'-2"
	11⅞"	110	23'-11"	21'-4"	22'-9"	20'-2"	22'-8"	20'-6"	21'-5"	19'-10"	19'-5"	18'-7"	17'-11"	17'-4"
		210	25'-3"	22'-6"	24'-1"	21'-4"	24'-2"	21'-8"	23'-3"	20'-11"	21'-4"	19'-8"	19'-8"	18'-8"
		230	26'-1"	23'-3"	24'-10"	22'-0"	24'-11"	22'-4"	24'-0"	21'-7"	22'-5"	20'-4"	20'-9"	19'-3"
		360	27'-9"	24'-9"	26'-5"	23'-5"	26'-7"	23'-10"	25'-6"	23'-0"	23'-11"	21'-7"	22'-7"	20'-6"
		560	31'-11"	28'-6"	30'-5"	27'-0"	30'-7"	27'-5"	29'-5"	26'-5"	27'-6"	24'-10"	26'-0"	23'-7"
	14"	110	27'-2"	24'-3"	25'-7"	23'-0"	24'-9"	23'-4"	23'-4"	22'-4"	21'-2"	20'-5"	19'-6"	18'-11"
		210	28'-9"	25'-7"	27'-4"	24'-3"	27'-1"	24'-8"	25'-7"	23'-9"	23'-3"	22'-4"	21'-5"	20'-9"
		230	29'-8"	26'-6"	28'-3"	25'-1"	28'-5"	25'-5"	27'-0"	24'-7"	24'-6"	23'-1"	22'-7"	21'-10"
		360	31'-6"	28'-2"	30'-0"	26'-8"	30'-2"	27'-1"	29'-0"	26'-1"	27'-2"	24'-7"	25'-8"	23'-4"
		560	36'-3"	32'-4"	34'-6"	30'-7"	34'-8"	31'-1"	33'-4"	30'-0"	31'-2"	28'-3"	29'-6"	26'-9"
	16"	110	29'-5"	26'-11"	27'-5"	25'-6"	26'-5"	25'-2"	25'-0"	23'-10"	22'-8"	21'-10"	20'-5"	20'-3"
		210	31'-10"	28'-5"	30'-0"	26'-11"	29'-0"	27'-4"	27'-5"	26'-2"	24'-10"	23'-11"	22'-8"	22'-2"
		230	32'-10"	29'-4"	31'-4"	27'-9"	30'-7"	28'-2"	28'-11"	27'-3"	26'-2"	25'-3"	24'-2"	23'-5"
		360	34'-11"	31'-2"	33'-3"	29'-6"	33'-5"	30'-0"	32'-2"	28'-11"	30'-1"	27'-2"	26'-0"	25'-10"
		560	40'-1"	35'-9"	38'-2"	33'-11"	38'-4"	34'-5"	36'-11"	33'-2"	34'-6"	31'-3"	31'-8"	29'-8"

NO SPAN TABLES FOR THE RIDGE, VALLEY AND HIP

***RIDGE, VALLEY AND HIP MEMBERS** _CONDITIONS VARY SIGNIFICANTLY AND PRECLUDE SPAN TABLES BEING USEFUL. WHEN THESE MEMBERS ARE ACTING AS BRACES THEY HAVE A DIFFERENT REQUIREMENT SET THAN WHEN THEY ARE ACTING AS BEAMS. SO THE FIRST DECSION IS WHETHER THE FRAMING SYSTEM IS TO BE BRACED OR GRAVITY LOAD ONLY. EXAMPLES OF EACH 'SYSTEM' IN THE CONTEXT OF A FULL ROOF ARE PRESENTED THE NEXT COUPLE OF PAGES TO GIVE A SENSE OF THE BIG PICTURE. THE GABLE AND HIP ROOF GEOMETRIES OFFER THE CHOICE OF BEING BRACED OR GRAVITY LOAD. THE SHED ROOF IS BY ITS NATURE A GRAVITY LOAD SYSTEM ONLY.



MEMBER OPTIONS

***BEAMS AND BEAM BEHAVIOR** _SEE (c5.2, 5.3, 5.8)

***THESE 3 OPTIONS SHOWN**_ARE THE MOST COMMON IN ROOF FRAMING. THE GLULAM IS MORE OFTEN ASSOCIATED WITH AN OPEN, VISIBLE CONSTRUCTION. ATTIC OR HIDDEN CONSTRUCTION IS LOOKING FOR THE MOST COST EFFECTIVE AND FLEXIBLE STRUCTURAL SOLUTION WHICH WILL LIKELT BE DIMENSIONAL LUMBER OR LVLS.

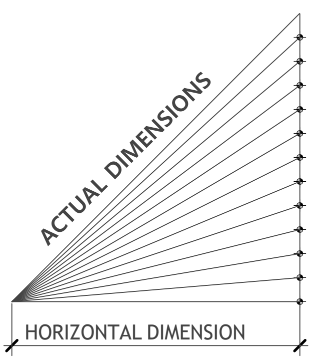
***TIMBER**_POST AND BEAM IS ALSO VIABLE BUT NORMALLY SEEN WHEN THE SYSTEM IS DESIGNED TO BE EXPOSED TO VIEW. TIMBER POST AND BEAM IS A BIT OF A SPECIALTY AND REQUIRES EXPERIENCED HAND AND EYE.

***LENGTHS**_MEMBER LENGTHS CAN BE A DETERMINANT. DETEMINING ACTUAL RAFTER LENGTHS (c7.13) IS EASY ENOUGH AS IS DETERMING HIP AND VALLEY MEMBERS WHICH ARE YET LONGER GIVEN THE SAME SPAN CONDITION. LENGTH RESTRICTIONS MIGHT DETERMINE MEMBER SELECTION OR MAY ENCOURAGE INTERMEDIATE SUPPORTS TO REDUCE LENGTH REQUIREMENST

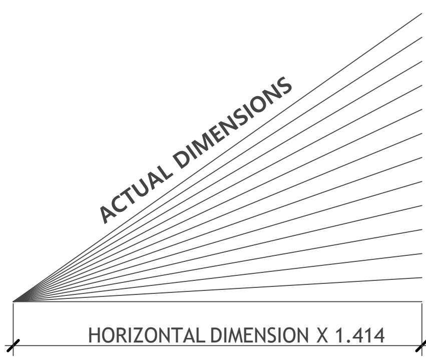
BASIC GEOMETRY-FACTORS/MULTIPLIERS ARE CHARTED BELOW.

***THE SYMETRICAL HIP**_WITH EQUAL ROOF PITCHES THE HIP AND VALLEY NECESSARILY SIT AT 45° IN THE PLAN. THEIR RELATVE LENGTH IS THEREFORE ALWAYS A MULTIPLIER OF 1.414. THE ANGLE OF THE RAFTERS IS SET BY THE PITCH. THE ANGLE OF THE HIP OR VALLEY IS LOWER. AS IT MAINTAINS THE SAME HT AT THE ADJACENT RAFTERS OVER AN INCREASED LENGTH.

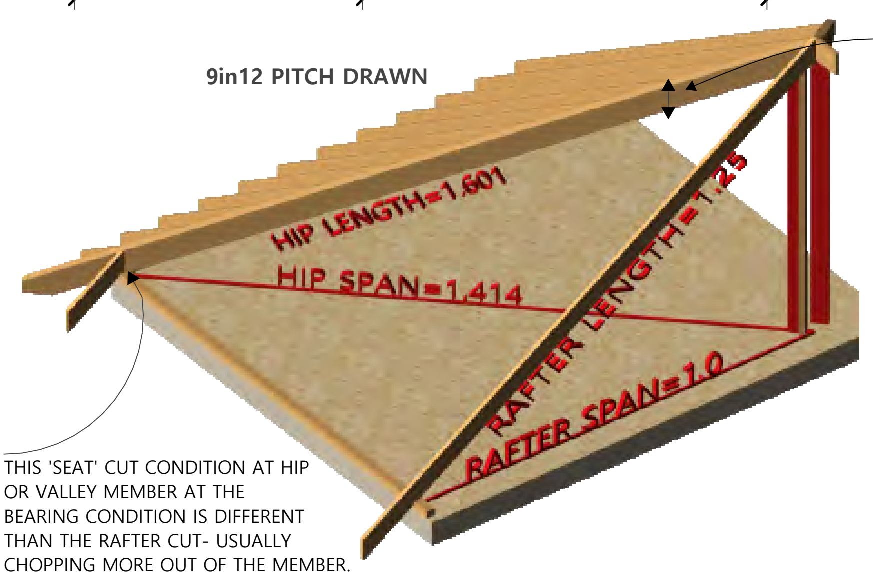
***THE CUTS**_RAFTERS MEETING A RIDGE OR HIP BOARD MUST BE AS DEEP AS THE PLUMB CUT. KNOWING THE PLUMB CUT OF THE RAFTER SETS THE MINIMUM DEPTH DIMENSION FOR RIDGE AND HIP MEMBERS. THE STEEPER PITCH HAS A DEEPER PLUMB CUT. SO THE HIP/VALLEY AND RIDGE MEMBERS ARE NECESSARILY DEEPER THAN THE RAFTER-SOMETIMES 1 'SIZE' AND WITH STEEPER PITCHES MAY NEED TO BE 2 'SIZES' DEEPER.



PITCH OF ROOF PLANE	PITCH EQUIVALENT IN DEGREES	RAFTER HORIZONTAL LENGTH ADJUSTMENT	PLUMB CUT ADJUSTMENT-RAFTER DEPTH X
12:12 PITCH	45.00°	1.4.14	1.4.14
11:12 PITCH	42.51°	1.357	1.357
10:12 PITCH	39.81°	1.302	1.302
9:12 PITCH	36.37°	1.250	1.250
8:12 PITCH	33.69°	1.202	1.202
7:12 PITCH	30.26°	1.158	1.158
6:12 PITCH	26.57°	1.118	1.118
5:12 PITCH	22.62°	1.083	1.083
4:12 PITCH	18.43°	1.054	1.054
3:12 PITCH	14.04°	1.031	1.031
2:12 PITCH	9.46°	1.014	1.014
1:12 PITCH	4.76°	1.004	1.004

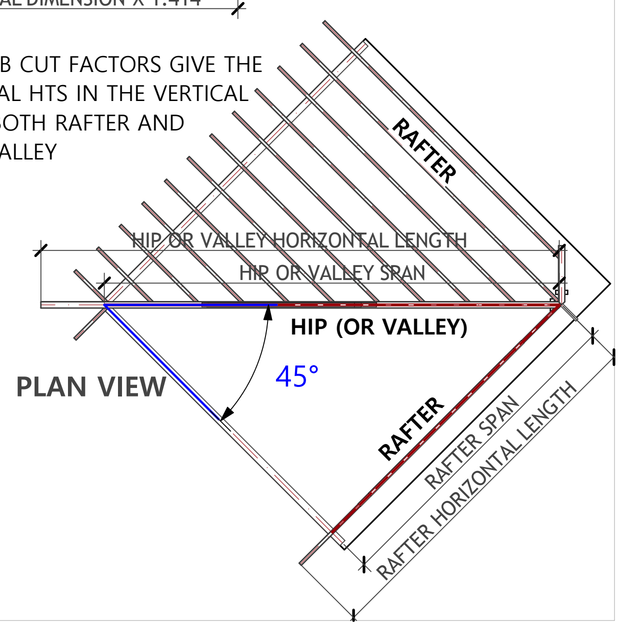


PITCH OF ROOF PLANE	PITCH EQUIVALENT IN DEGREES	HIP/VALLEY LENGTH ADJUSTMENT X RAFTER	PLUMB CUT ADJUSTMENT-HIP/VALLEY MEMBER DEPTH DEPTH X
12:12 PITCH	35.27°	1.732	1.245
11:12 PITCH	32.92°	1.685	1.192
10:12 PITCH	39.81°	1.642	1.162
9:12 PITCH	30.51°	1.601	1.131
8:12 PITCH	27.94°	1.564	1.106
7:12 PITCH	25.24°	1.530	1.082
6:12 PITCH	22.42°	1.500	1.060
5:12 PITCH	19.47°	1.474	1.043
4:12 PITCH	16.42°	1.453	1.028
3:12 PITCH	13.24°	1.436	1.015
2:12 PITCH	10.03°	1.424	NA
1:12 PITCH	NA	1.416	NA



PLUMB CUT FACTORS GIVE THE ACTUAL HTS IN THE VERTICAL FOR BOTH RAFTER AND HIP/VALLEY

THIS 'SEAT' CUT CONDITION AT HIP OR VALLEY MEMBER AT THE BEARING CONDITION IS DIFFERENT THAN THE RAFTER CUT- USUALLY CHOPPING MORE OUT OF THE MEMBER. THIS CAN REQUIRE A STRUCTURAL CHECK.

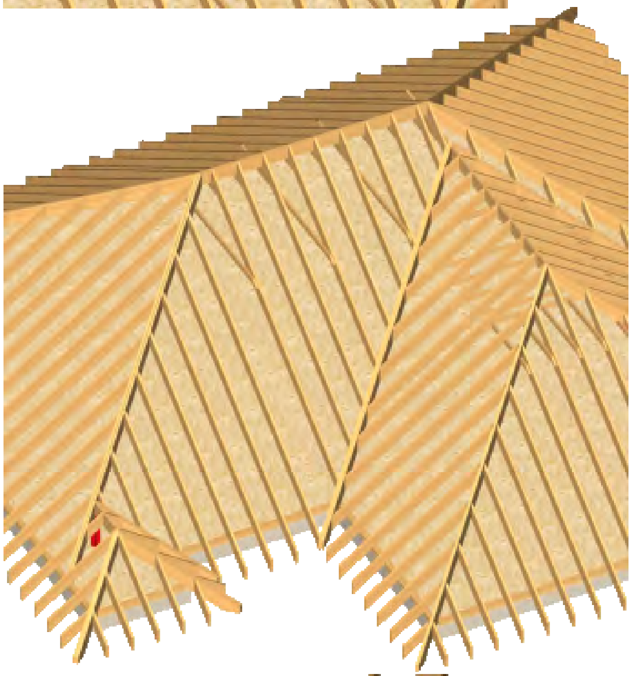


HIP AND VALLEY STRUCTURAL ROLES

RIDGE MEMBER

DIMENSIONAL LUMBER_SEE (c7.13). 2x DIMENSIONAL LUMBER 1 OR 2 DEPTHS GREATER THAN THE RAFTERS IS A DEFAULT CHOICE. THIS VIGNETTE IS SHOWING A BUTT CONDITION NEEDED IN MOST RIDGE MEMBERS AS THE RIDGE WILL EXCEED AND SINGLE PIECE LENGTH. DEIMENSIONAL LUMBER LENGTHS IS NOT A LIABILITY IN THIS CASE.IT IS IN HIP AND VALLEY MEMBERS.

OTHER OPTIONS_ENGINEERED RIM JOISTS ARE A GOOD OPTION. AVAILABLE IN LONGER LENGTHS AND GREATER DEPTHS AND STRAIGHT. THIS CHOICE IS LESS COSTLY AND LIGHTER THAN LVL'S OR GLULAMS- THAT WILL WORK BUT ARE NOT STRUCTURALLY NECESSARY.



VALLEY MEMBER

VALLEY IS A BEAM_ALL VALLEYS ARE SUPPORTING RAFTERS AND NEED TO BE DESIGNED AS A BEAM. LOADING AND SPAN OPTIONS ARE DISCUSSED THE NEXT COUPLE PAGES. LOADING IS A LITTLE TRICKY.

SUPPORTS_USUALLY THE LOWER MORE HEAVILY LOADED END IS SUPPORTED AT AN OUTSIDE BEARING WALL. A CONDITION IS THE END CUT OF THE MEMBER TO GET IT SEATED WITH NEEDED BEARING AREA. THIS IS A FRAMING 'HOW TO' THAT GOES BEYOND THE PURPOSE OF THIS GUIDE. THE HIGH END OF THE VALLEY BEAM IS MORE LIGHTLY LOADED- BUT STILL OBVIOUSLY NEEDS SUPPORT. (c7.xx)

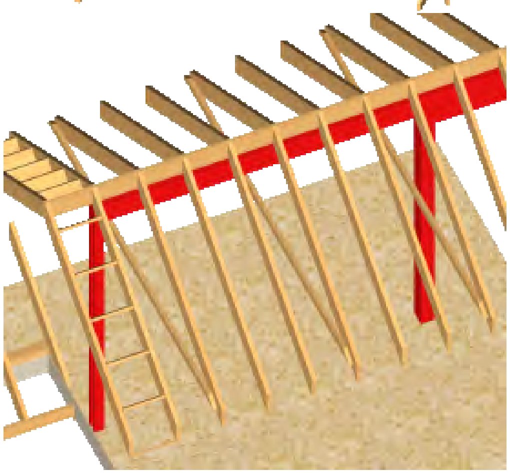
OPTIONS_DIMENSIONAL LUMBER LENGTHS CAN BE A LIMITATION. AND MORE THAN 2 PLYS CAN BECOME A SHEATHING/ROOFING 'CONDITION'. LVL'S ARE ALWAYS VIABLE. NOTE THE LVL'S ARE ALSO BETTER AT THAT LOW END BEARING (AND SHEAR) WHEN THE MEMBER GETS CUT TO FIT THERE.

HIP MEMBERS

AS BRACE_THE BOTTOM OF THE HIP MEMBER MUST SIT AT OR BELOW THE RAFTERS BRACING INTO IT (SAME AS THE RIDGE). THE MEMBER LENGTH CAN EXCEED STANDARD STOCK DIMENSIONAL LENGTHS.

DIMENSIONAL LUMBER_THE INSTALLATION WANTS THE HIP TO BE 1 PIECE, SET IN PLACE, AND RAFTERS FRAMED INTO THEM. SO DOUBLING DIMENSIONAL LUMBER MEMBERS, WITH OFFSETTING JOINTS, CREATES 1 BUILT UP PIECE.

LVL_SINGLE PIECE, AND STRAIGHT. SOME PREFER THE LVL BECAUSE THIS IS HASSLE FREE.

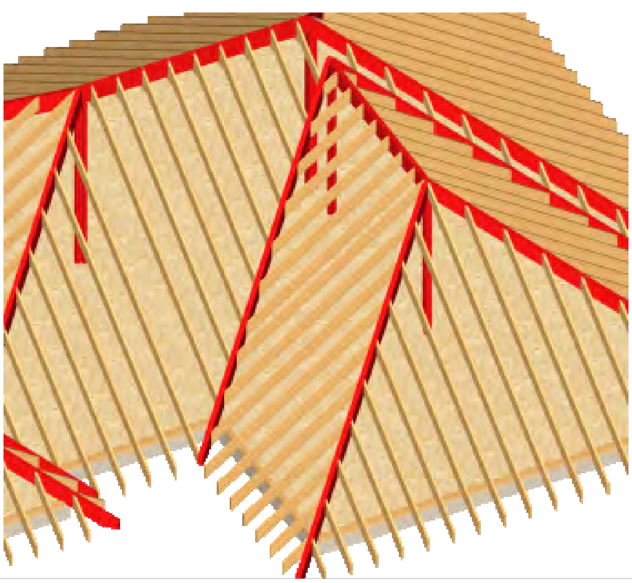


RIDGE BEAM

STRAIGHT BEAM DESIGN_SEE (c7.13). ROOF LOAD, TRIBUTARY WIDTHS, AND THE POST TO POST SPAN SET UP THIS BEAM DESIGN. CALCULATIONS REQUIRED, AND SELECT THE BEST BEAM TO SUIT. BEAM OPTIONS MORE COMPLETELY DISCUSSED IN (c5 FRAME FLOORS).

POST SUPPORTS_DITTO CHAPTER (c5) FOR POST THINKING. NOTED- AND VERY VIABLE ARE USING 2X MEMBER BUILT UP TO SUIT THE WOBBLE PROBLEM AND TO SUIT MULTIPLE BEARING HTS AND CONDITIONS NOT UNCOMON IN A ROOF (SEE JUNCTURE OF RIDGE AND HIP/VALLEY BEAMS BELOW)

WALL SUPPORTS_2XFRAME WALLS ARE STRUCTURALLY VIABLE. THE BEAM IS ELIMINATED. IT IS SIMPLE. THE LOADING TO BELOW IS CONTINUOUS AND NEEDS TRACKING AND OF COURSE THIS ATTIC TYPE SPACE AS SHOWN IS KIND OF CUT IN HALF.



THE POST AND BEAM HIP ROOF

STRAIGHT BEAM DESIGN_SEE (c7.13). DITTO ABOVE REGARDING LOADS AND CALULATIONS. THIS POST AND BEAM HIP IS NOT PARTICULARLY COMMON BUT STRUCTURALLY VIABLE.

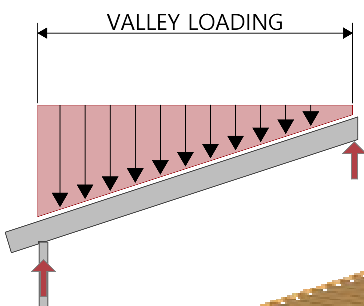
FLUSH BEAMS AND RAFTERS_AS SHOWN WOULD BE A CLEANER AND SMARTER WAY TO FRAME THIS. THE WHOLE 'FRAME' COULD BE FIRST SET. THEN THE RAFTER FRAMING IS CUT AND FIT.

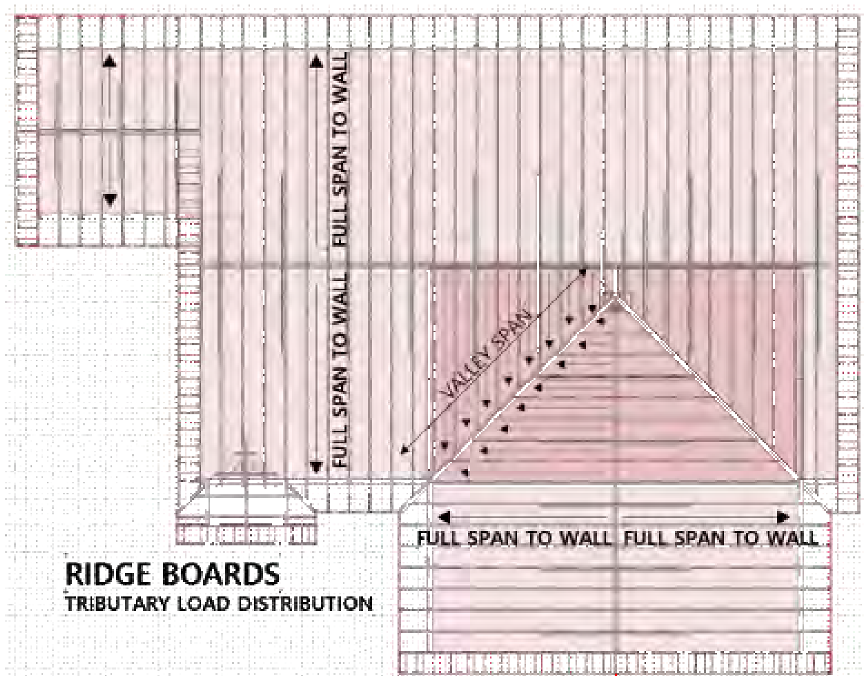
DROP BEAMS ALL RAFTERS ON TOP_NOT SHOWN WOULD BE AWKWARD PARTICULARLY SEATING RAFTERS ON TOP OF THE HIP AND VALLEY BEAMS. SEAT CUTS AND NAILING A CHALLENGE.

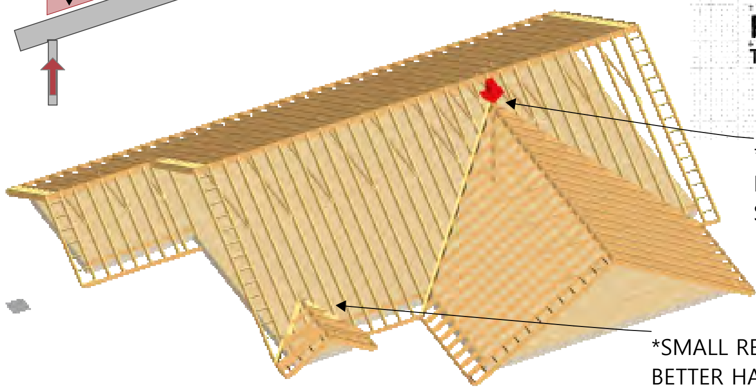
BEAM SUPPORTS_TYPICAL COMMENTS FOR ANY POST AND BEAM. THE POST LOADING NEEDS TO BE TRACKED. NOTED AGAIN IS THAT POST LOADING IN THE MIDDLE OF SPACES BELOW PRESENTS A NEW SET OF STRUCTURAL PROBLEMS. THE COMMON ONE IS THESE POST LOADS REQUIRE BEAMS BELOW DEEPER THAN THE FLOOR PACKAGE NEEDS TO BE. SEE (c5.17) FOR OPTIONS WITH THESE FLOOR LOADING CONDITIONS.

LOAD DISTRIBUTION WITH RIDGE BOARDS

RIDGE AS BRACE_ALL LOADING HEADS DOWN THE RAFTER TO THE WALL. THE OVERHANG LOADS ARE PART OF THAT TRIBUTARY WIDTH AND CARRIED AT THE WALL.
VALLEY AS BEAM_SAME DISTRIBUTION-FROM THE RIDGE DOWN TO THE VALLEY BEAM. SEE LOAD DIAGRAM BELOW. THESE VALLEY BEAMS DO REQUIRE CALCULATION.
VALLEY BEAM LOADING_IS ALWAYS 'TRIANGULAR' . THE LOWER END CARRIES MORE LOAD AND THE HIGHER END CARRIES LESS LOAD. THE HIGHER END WANTS SUPPORT CONSIDERATION. THE LOWER END USUALLY FALLS ON AN EXTERIOR BEARING WALL WHICH WILL HAVE A DIRECT PATH TO FOUNDATION.

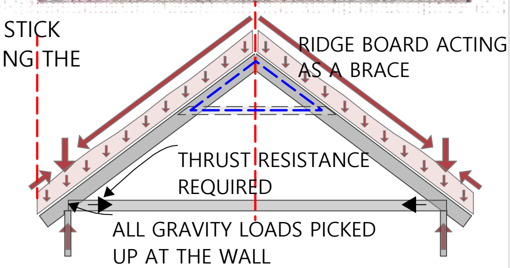






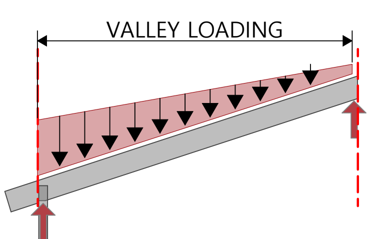
*REVERSE DIRECTION GABLE STICK FRAMING-WHEN NOT SHARING THE SAME RIDGE HT-SEE (7.22)

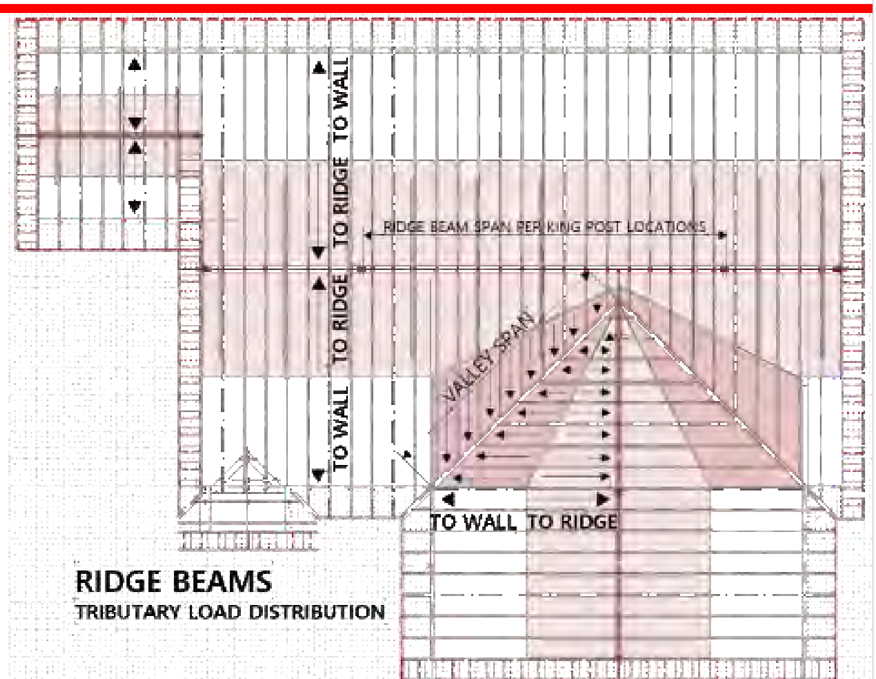
*SMALL REVERSE GABLES OFTEN BETTER HANDLED AS AN OVERFRAME.

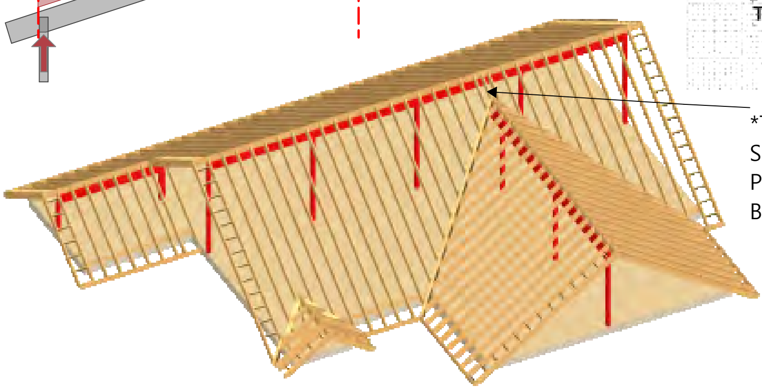


LOAD DISTRIBUTION WITH RIDGE BEAMS

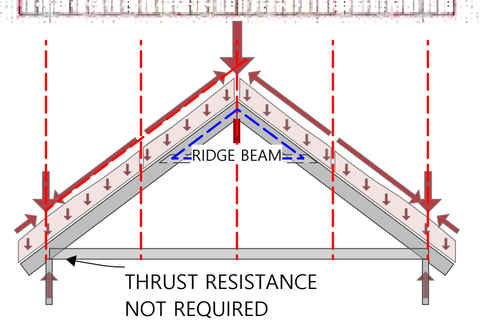
RIDGE AS BEAM_1/2 SPAN RULE APPLIES SO, EXCLUSIVE OF THE OVERHANG LOAD, THE RIDGE IS TAKING TWICE THE LOAD IMPOSED ON THE OUTSIDE WALLS. AND THERE IS NO PUSH ON THOSE WALLS. THE OVERHANG LOADS ARE NECESSARILY MANAGED AT THE WALL.
RIDGE BEAM AND POSTS_PRIMARY KEY IS POSITIONING POSTS SO THEIR LOADS CAN BE CARRIED BELOW. THE SPACING IN AN ATTIC SPACE NOT MATTER.
VALLEY BEAM LOADING_1/2 SPAN DISTRIBUTION APPLIES. THIS TRIANGULAR LOADING LOADING IS LESS (1/2) THAN WITH BRACE DISTRIBUTION. THE LOWER END CARRIES MORE LOAD AND THE HIGHER END CARRIES LESS LOAD. THE HIGHER END WILL MEET A RIDGE BEAM AND REQUIRE A SUPPORT POST. THE LOWER END WILL FALL ON AN EXTERIOR BEARING WALL.





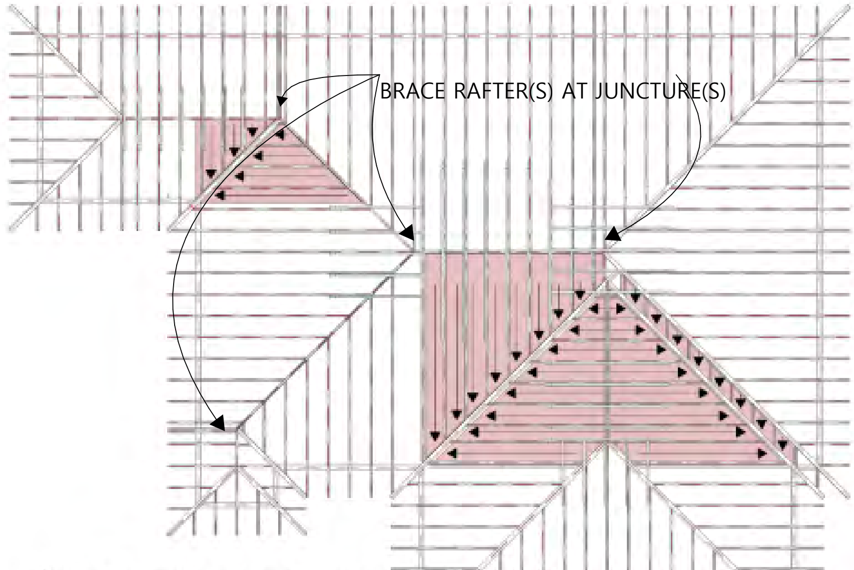


*THIS POST AND BEAM SUPPORT SYTEM HAS EVEN POST SPACNG AND MODEST BEAM SIZE

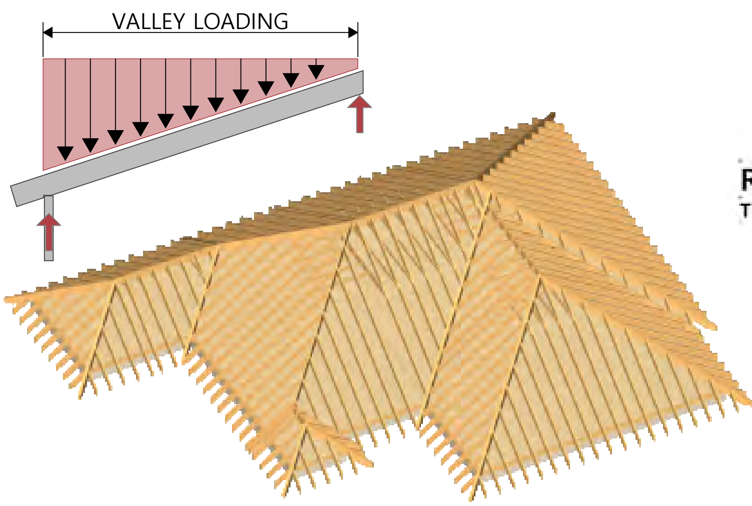


LOAD DISTRIBUTION WITH RIDGE BOARDS

RIDGE AS BRACE_ALL LOADING HEADS DOWN THE RAFTER TO THE WALL. NOT SHOWN, THE OVERHANG LOADS ARE NECESSARILY MANAGED AT THE WALL.
HIPS AS BRACE_DITTO WITH LOADING ON THE OUTSIDE WALL. NOTE SOME CHOOSE EVEN IN THIS 'BRACED' CONSTRUCTION TO TREAT THE HIP AS A BEAM. THIS PROJECT DOES NOT(c.22).
VALLEY AS BEAM_SAME DISTRIBUTION-FROM THE RIDGE DOWN TO THE VALLEY BEAM. SEE LOAD DIAGRAM BELOW. THESE VALLEY BEAMS DO REQUIRE CALCULATION.
VALLEY SPANS_THIS LARGER VALLEY WILL WANT THE UPPER CONNECTION ADDRESSED PER ONE OF THE OPTIONS (c7.20). THE 2 SMALLER VALLEY SPANS (AND LOADS) MAY WELL SURVIVE WITH RAFTER BRACE SUPPORT AT THE JUNCTURES.



RIDGE+HIP BRACES, VALLEY BEAMS
TRIBUTARY LOAD DISTRIBUTION

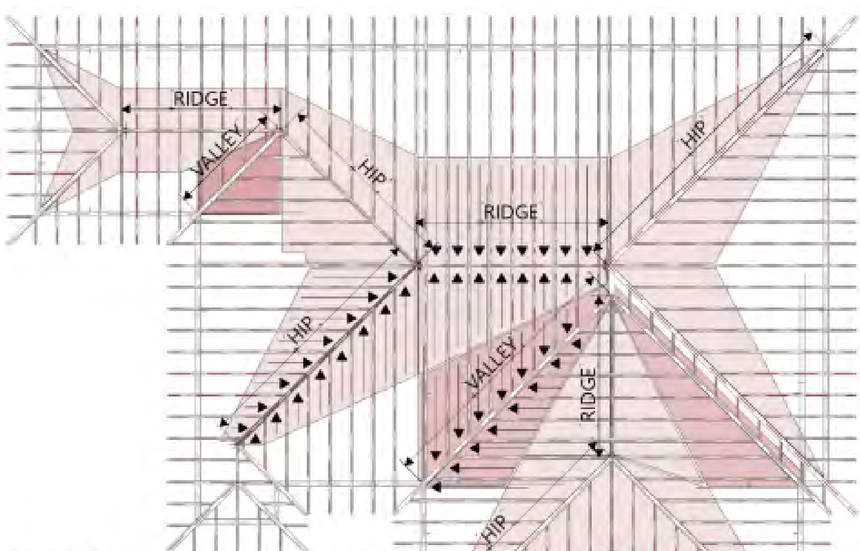


BRACED PACKAGE

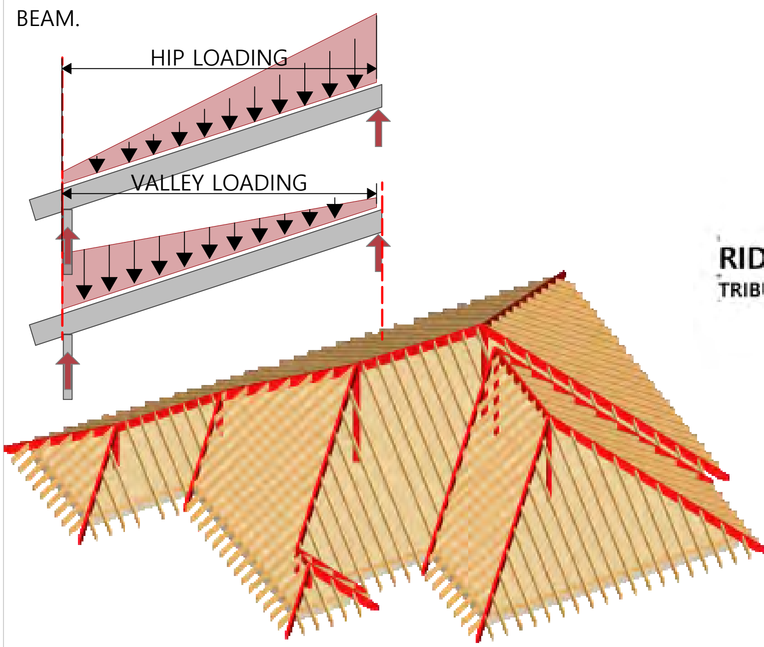
SYSTEM_THE HIP SYSTEM IS BY NATURE A BRACED ONE. WHEN TIGHTENED UP WITH REGULARLY SPACED COLLAR TIES IT BECOMES THE WIND RESISTANCE CHAMP.
THRUST_EACH RAFTER DISTRIBUTES THAT PUSH, JUST AS ALL RAFTER LOADING DOES, ON THE OUTER WALL BASEDON THE RAFTER LENGTH (HENCE LOAD). THE HIP ROOF IS CHARACTERIZED BY EVER DECREASING RAFTER LENGTHS. MANY OF THOSE SHORTER RAFTERS WILL ONLY REQUIRE STANDAD TOE NAILING. LONGER RAFTERS MAY WANT ATTENTION.

LOAD DISTRIBUTION WITH RIDGE BEAMS

RIDGE AS BEAM_1/2 SPAN RULE APPLIES SO, EXCLUSIVE OF THE OVERHANG LOAD, THE RIDGE IS TAKING TWICE THE LOAD IMPOSED ON THE OUTSIDE WALLS. AND THERE IS NO PUSH ON THOSE WALLS. THE OVERHANG LOADS ARE NECESSARILY MANAGED AT THE WALL.
VALLEY AS BEAM_1/2 SPAN DISTRIBUTION APPLIES. LOADING ON THE VALLEY IS LESS THAN WITH BRACE, AND THE LOAD IS NECESSARILY 'TRIANGULAR'.
HIP AS BEAM_CONSISTENT WITH THIS SYSTEM THE HIPS WOULD BE TREATED AS BEAMS. THEIR LOADING IS ALSO TRIANGULAR BUT WITH LOADING REVERSED FROM THE VALLEY BEAM.

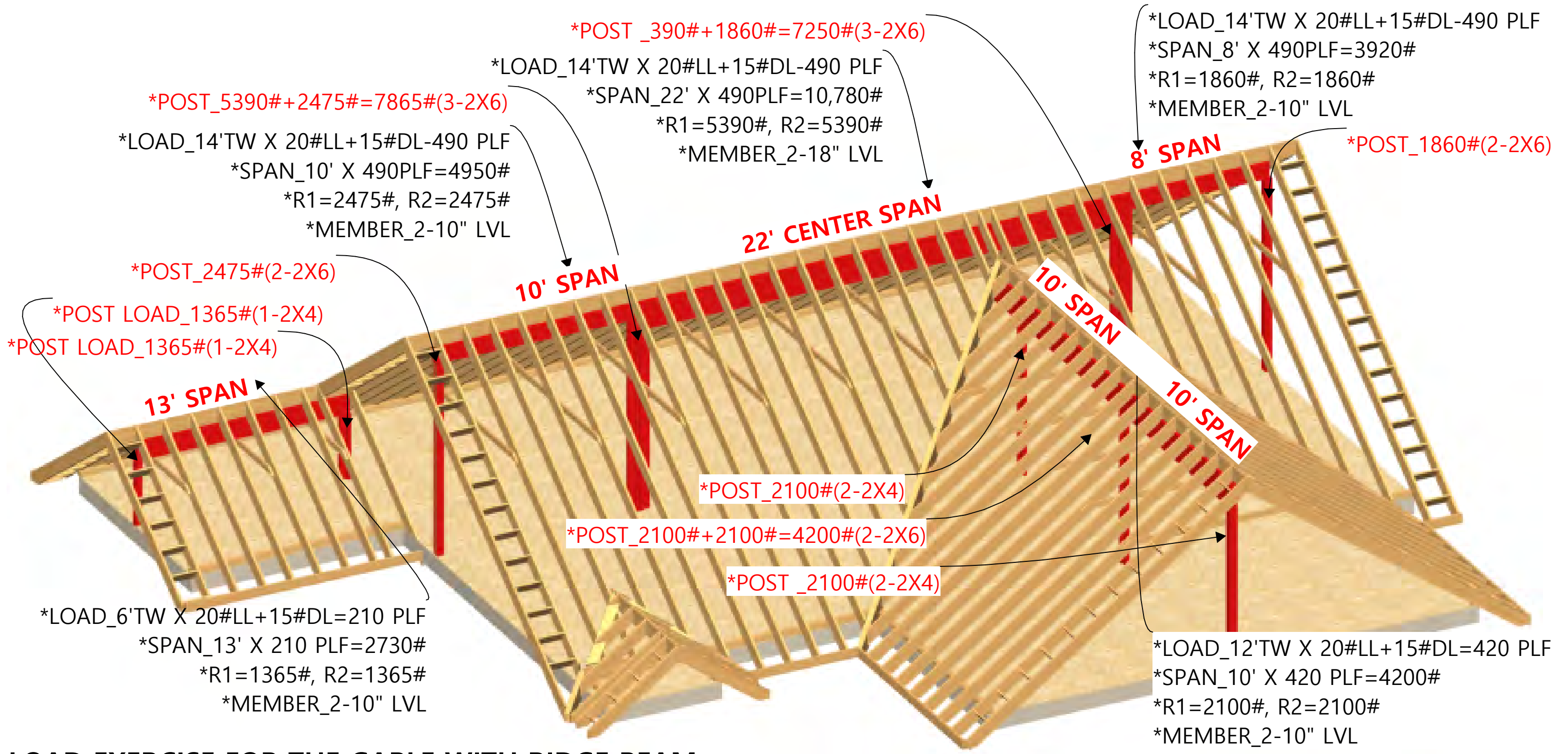


RIDGE, HIP, VALLEY BEAMS
TRIBUTARY LOAD DISTRIBUTION



ALL BEAMS?

RIDGE, HIP, VALLEY AS BEAMS_1/2 SPAN RULE APPLIES, SO WITH A HIP ROOF GEOMETRY MANY OF THE MEMBERS END UP WITH TRIANGULAR LOADING GRAPHICALLY SHOWN ABOVE IN THE PLAN.
POSTS_SHOW IN ALL JUNCTURE CONDITIONS RESULTING IN RIDGE,HIP, AND VALLEY BEAM SPANS REQUIRING CORRESPONDING CALCULATION.
BUT_THE HIP ROOF IS INHERENTLY A TIGHT BRACED GEOMETRY AND THERE ARE FEW CIRCUMSTANCES UNDER WHICH A POST AND BEAM RESOLUTION MAKES MUCH SENSE.

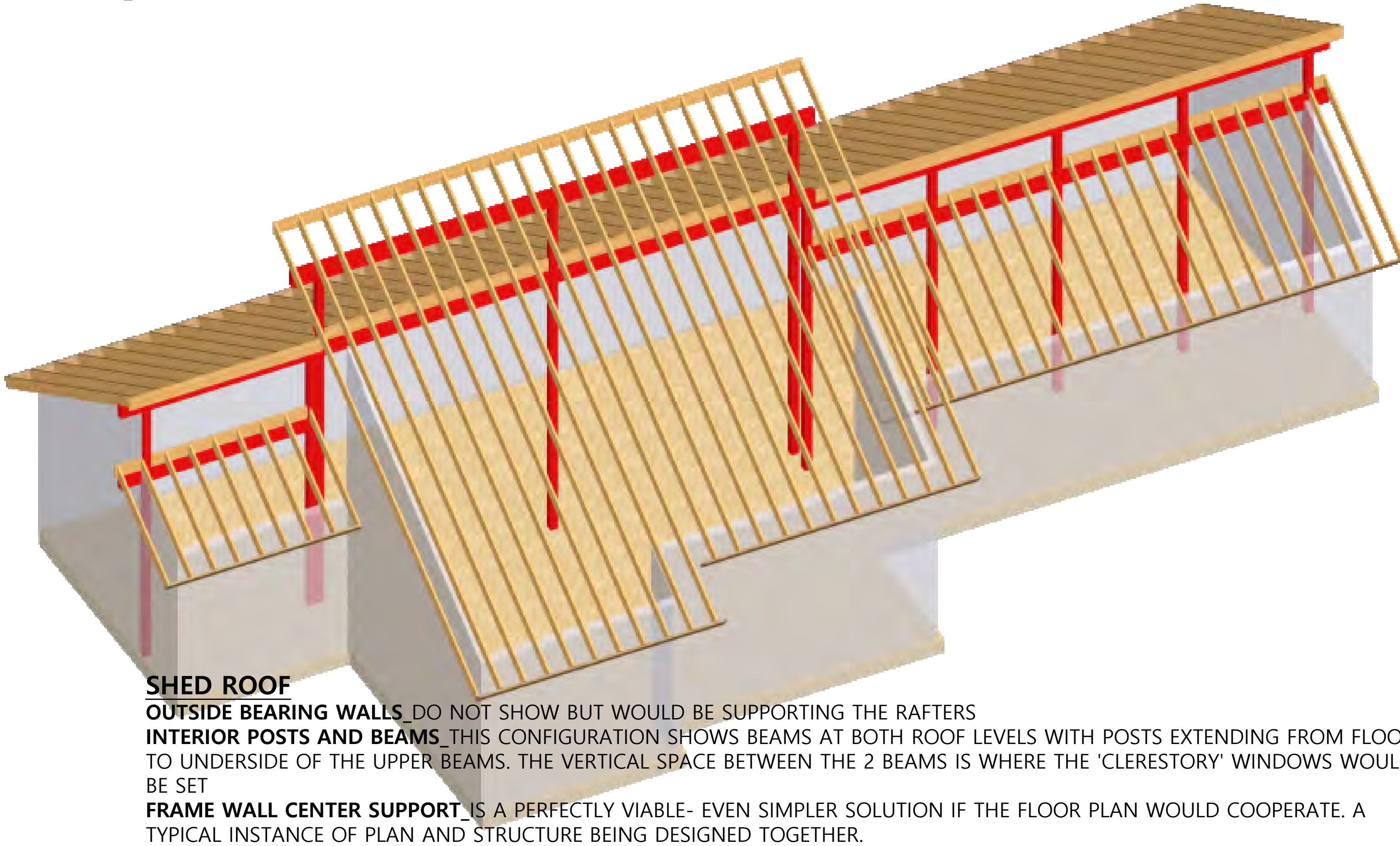


LOAD EXERCISE FOR THE GABLE WITH RIDGE BEAM

THE RIDGE BEAMS_IS CHANGED FROM THE EQUALLY SPACED SAMPLE (c7.16). LETS ASSSUME THE MUCH LONGER CENTER SPAN OF 22 FT IS SPECIFICALLY BECAUSE BEARING POINTS FOR THESE DECENT SIZE LOADS ARE PRESENT IN THE MAIN FLOOR DESIGN BELOW. SO A BIGGER BEAM (2-18" LVL'S) IS NEEDED UP HERE. WITHOUT THIS BIGGER BEAM PRESUMABLY A BEAM IN THE FLOOR WOULD BE REQUIRED WHERE 18" OF DEPTH IS NOT REASONABLY AVAILABLE. THIS ATTIC SPACE DOES NOT HAVE BEAM DEPTH RESTRICTIONS.

POSTS_ALL HAVE DIFFERING LOADS BASED ON THE ACCUMULATED TRIBUTARY AREA, AND ALL LOADS NEED TO BE PICKED UP AND TRACKED DOWN TO THE MAIN FLOOR AND ULTIMATELY THE FOUNDATION. LOAD TRACKING IS SOMETIMES SIMPLE AND SOMETIMES CAN CAUSE EXTRA WORK AND EXPENSE BELOW. IT IS THE POST AND BEAM CONFIGURATION AND THE LOAD TRACKING THAT ALL RIDGE BEAM SYSTEMS NEED TO RESOLVE. NOTE ALSO UNAVOIDABLE POSTS THAT IN AN ATIC STORAGE SPACE LIKELY ARE NOT A PROBLEM, BUT IF THIS SPACE IS INTENDED AS HABITABLE SPACE THEN LIKELY THEY ARE A PROBLEM.

COMPARISON_THE COMPARABLE BRACE REAFTER SYSTEM AVOIDS THE POST PROBLEM, BUT RAFTER THRUST NEEDS TO BE CONTAINED.



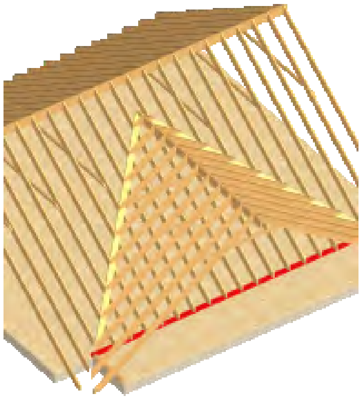
SHED ROOF

OUTSIDE BEARING WALLS_DO NOT SHOW BUT WOULD BE SUPPORTING THE RAFTERS

INTERIOR POSTS AND BEAMS_THIS CONFIGURATION SHOWS BEAMS AT BOTH ROOF LEVELS WITH POSTS EXTENDING FROM FLOOR TO UNDERSIDE OF THE UPPER BEAMS. THE VERTICAL SPACE BETWEEN THE 2 BEAMS IS WHERE THE 'CLERESTORY' WINDOWS WOULD BE SET

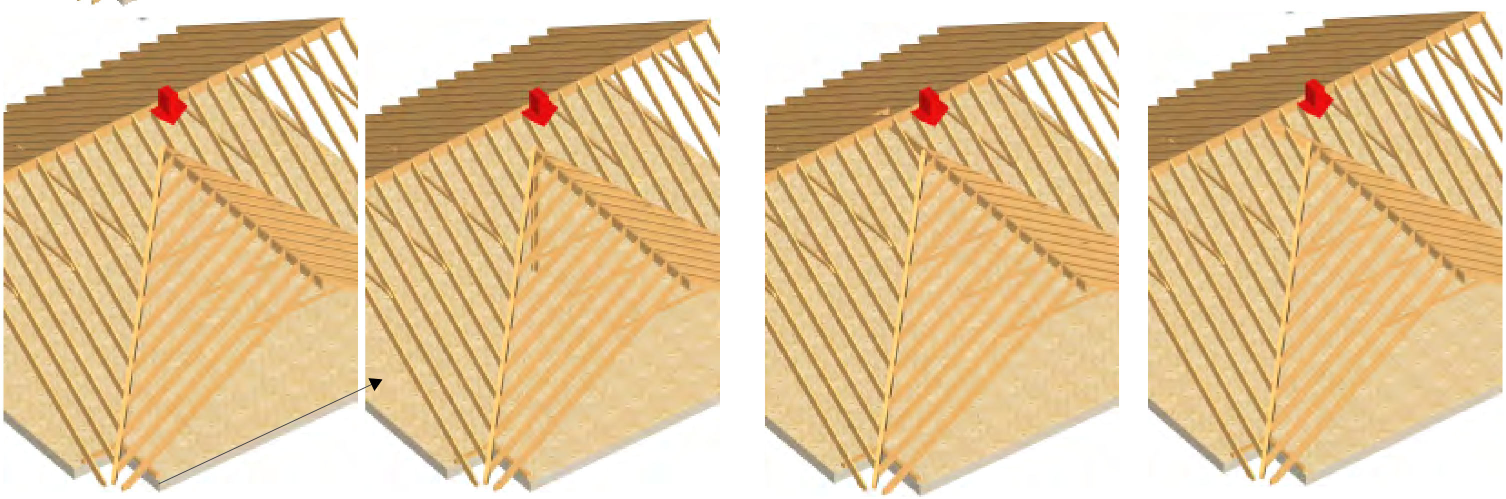
FRAME WALL CENTER SUPPORT_IS A PERFECTLY VIABLE- EVEN SIMPLER SOLUTION IF THE FLOOR PLAN WOULD COOPERATE. A TYPICAL INSTANCE OF PLAN AND STRUCTURE BEING DESIGNED TOGETHER.

COMMON CONDITIONS WITH THE BRACED ROOF



THE OVERFRAME

*THE REVERSE GABLE RAFTERS SIT ON TOP OF THE PRIVE ROOF RAFTERS. THEY MAY REST ON A 'FLAT' 2X THAT WILL DISTRIBUTE THE LOADING FROM ACROSS THE LOWER RAFTERS.
*THE PRIME ROOF RAFTERS MUST RUN THRU- IN THIS CASE TO THE PLANE OF THE FROMT WALL AND MUST BE SUPPORTED THERE BY WALL OR BY BEAM- OR SOME COMBINATION.
*GENERALLY MORE COMMON TO USE THE OVERFRAME FOR SMALLER REVERSE GABLE SITUATIONS BOTH BECAUSE THE SUPPORT CONDITION/SPAN WOULD BE EASIER TO HANDLE, AND THERE WOULD BE LESS SPACE UNDER THE REVERSE GABLE THAT IS BEING ELIMINATED FROM USE.
*FROM A TOTAL LOAD STANDPOINT IT IS HE HIGHER ROOF ONLY THAT THE LIVE LOADING GETS ASSIGNED TO- BUT THERE ARE 2 DEAD LOAD LAYERS THAT DO NEED TO BE ACCOUNTED FOR.



FLOATING REVERSE GABLE

*THIS 'REVERSE GABLE' CONDITION IS A CONCERN. THERE IS NO APPARENT SUJPPORT FOR THE BEARING VALLEY BEAMS.

KING SUPPORT

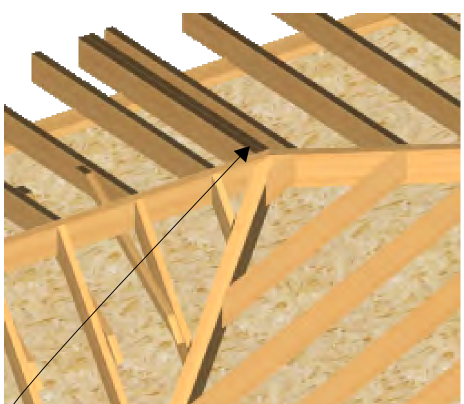
*THE OBVIOUS SOLUTION IS PUTTING A POST UNDER THE JUNCTURE. NEEDS SUPPORT BELOW AND INTRODUCES A POST (OBSTACLE).

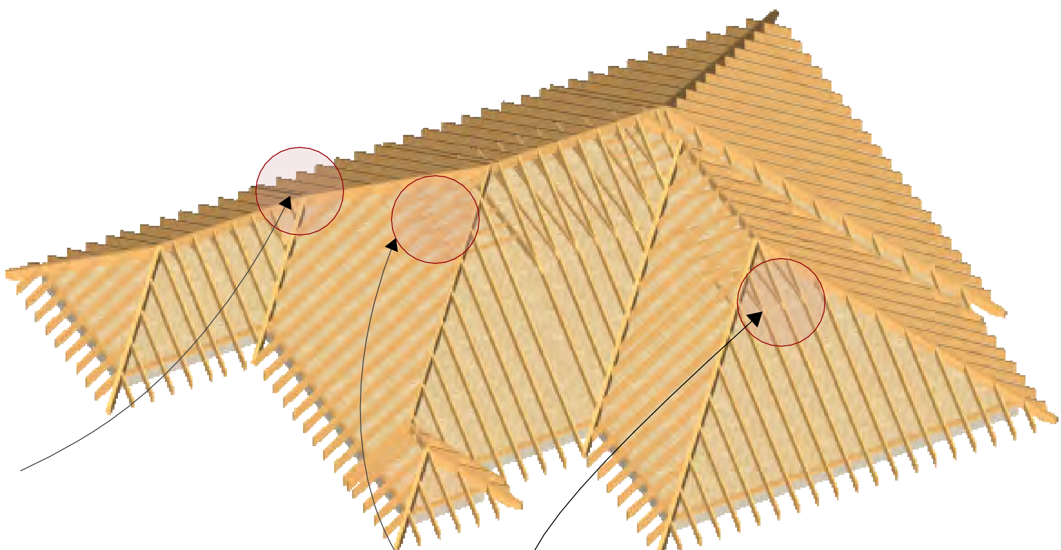
THRU RIDGE

*SOMETIMES THE RIDGE MEMBER CAN BE RUN THRU TO A SUPPORTING SOMETHING- IN THIS CASE TO A SHORT HEADER BETWEEN RAFTERS ON THE BACK ROOF PLANE.

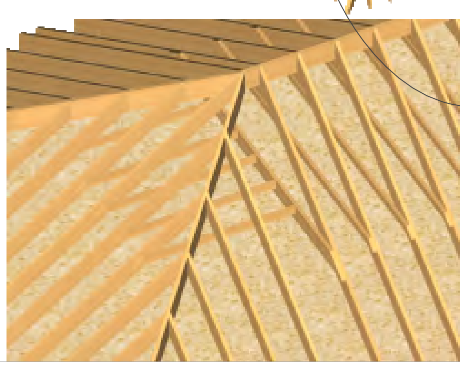
THRU VALLEY MEMBER

*THE VALLY MEMBER IS NECESSARILY 'ON LANE' WITH THE RIDGE ABOVE AND CAN BE SUPPORTED THERE. BEST WHEN THE 2 RIDGE HTS ARE NOT THAT FAR APART

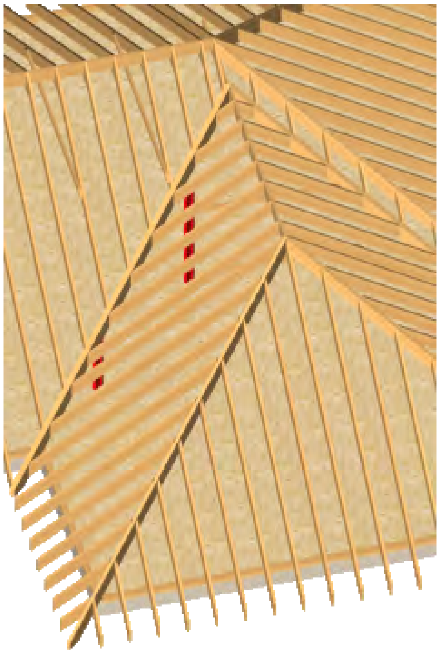


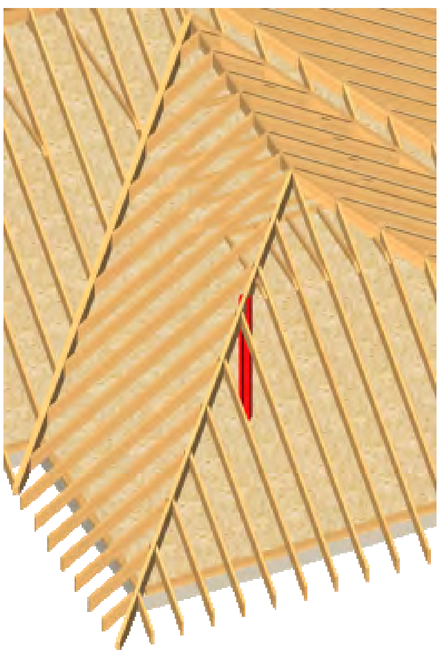


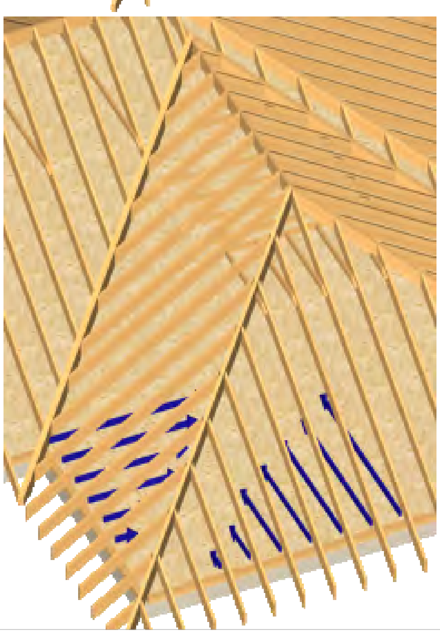
***BRACING THE HIP JUNCTURES**_COMMON CONDITION WITH DECENDING HIP MEETING A VALLEY BEAM AND RIDGE BOARD. ADDING RAFTER(S) FROM THE OPPOSING SIDE TO MEET THAT JUNCTURE WILL STABILIZE THIS BRACED CONDITION. THE RESISTANCE TO THE THRUST AT THE WALL PLATES IS THE BIG DEAL.



***REVERSING THE COLLAR TIES**_THE HIP ROOF IS MULTI DIRECTIONAL. TURNING COLLAR TIE DIRECTION REQUIRES THE CONNECTING TIE TO BE BEEFIER. THIS SHOWS AN INCREASED DEPTH IN THE MEMBER. MORE EFFECTIVE WOULD BE AN ADDITIONAL FLAT 2X MEMBER STIFFENING THE TIE IN THAT LATERAL DIMENSION.







VALLEY BEAMS-

***BEAM BEHAVIOR_**ALTHOUGH RIDGE AND HIP MEMBERS BEHAVE AS BRACES IN THE BRACED RAFTER SCENARIO- THE VALLEY DOES NOT AND MUST BE DESIGNED AS A BEARING BEAM. SEE THE DIAGRAMS ON (c7.12, c7.13) SHOWING THE TRIANGLAR OR HALF TRIANGULAR LOADING. WHILE THERE ARE THESE REDUCED LOADS IN THE VALLEY BEAM, THERE IS ALSO A LONGER SPAN. TAKE THE RAFTER SPAN AND MULTIPLY BY 1.414. SO LONGER VALLEY BEAMS GET TO BE SUBSTANTIAL- AND LVL OFTEN ARE CALLED FOR.

***POSTS_**VALLEY SUPPORT POSTS CAN BE INSTALLED TO REDUCE THAT SPAN AND THEREFORE THE VALLEY MEMBER SIZE. THE POSTS DO NEED TO LOAD TRACKED, AS WITH ANY BEARING POST. IF OPPORTUNITIES ARE THERE ONE CAN PLACE THE POST OR POSTS WITHOUT TOO MUCH SOPHISTICATION. THESE VIGNETTES ARE VALID FOR VALLEY OR HIP SUPPORT. THEY CAMN BE 2X4 OR 2X6 MEMBERS BUILT UP SGUARE OR IN A MORE RIGID 'T' CONFIGUTATION. CAN BE SLIGHTLY OUT OF PLUMB, OR TRIANGULATED. THE WHO;E ROOF PLANE IS LATERALLY RIGID SO A SLIGHTLY CROOKED POST WILL DO NO HARM.

HIP BEHAVIOR

SPLIT OPINIONS_IN BRACED ROOF FRAMING THIS PROJECT TREATS THE HIP AS A BRACE, BUT WILL LOCATE POSTS UNDER THOSE LONGER HIPS AS A DEFENSE AGAINST 'COLLECTIVE SAG'. NOTE SOME CONSIDER THE HIP A BEAM, ALONG WITH THE VALLEY. ALL DO AGREE THAT WITH ROOF PITCHES 3 IN 12 AND LOWER THE HIP SHOULD BE CONSIDERED A BEAM, AND THAT IS CODE SPECIFIED.

HIP SAG-

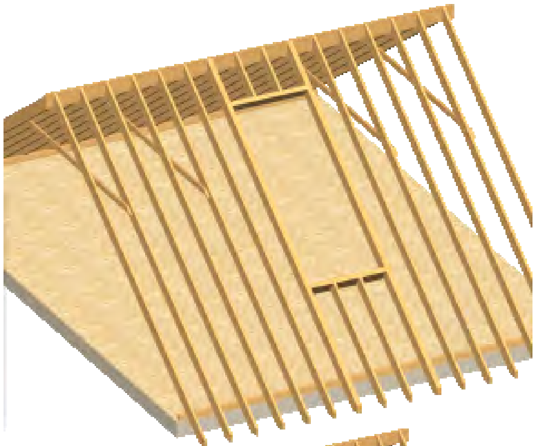
***WHY_**HIP SAG IS NOT INEVITABLE. WITH TIGHTER CONSTRUCTION, SHORTER HIP LENGTHS, AND STEEPER PITCHES IT MAY NEVER BE EVIDENT. BUT IT DOES HAPPEN. LOOSE CONSTRUCTION, LONGER HIPS, AND LOWER PITCHES CAN BE CAUSAL. OTHER CAUSES REGARDLESS OF ROOF GEOMETRY, ARE DEFLECTING RAFTERS, SHRINKING OF WOOD MEMBERS, LOOSENING OF NAIL CONNECTIONS AT THE HIP -OR AT THE HEEL-. SO A LITTLE SAG OCCURS WHICH IS NOT A STRUCTURAL LIABILITY REALLY BUT CAN BE EVIDENCED FROM THE GROUND PLANE WHEN THE ANGLES ARE RIGHT. ONE CAN SEE A BOWING IN A LONG HIP.

***SAG POSTS_**THERE IS NO REAL QUALIFIABLE/QUANTIFIABLE ENGINEERING TO APPLY HERE. THIS PROJECT JUST USES A GENERAL RULE OF THUMB TO PUT IN SUPPORTING POSTS UNDER LONGER HIPS WHERE THEY HAVE ADEQUATE SUPPORT IN THE FLOOR PLANE AND ARE NOT IN THE WAY. INVENTIVE TECHNIQUES PERMITTED.

***HIP BECOMES A BEAM_**IF ENOUGH POST SUPPORTS ARE PLACED UNDER THE HIP MEMBER SUCH THAT IT CANNOT DEFLECT THEN IT BECOMES A BEAM. EVEN A SINGLE 2X10 MEMBER INTENDED AS A BRACE WILL FUNCTION PERFECTLY WELL AS A BEAM IF THE POST TO POST POSITION PERMIS THE 2X10 TO NOT DEFLECT. THIS AUTOMATICALLY REMOVES THE THRUST PRESSURE.

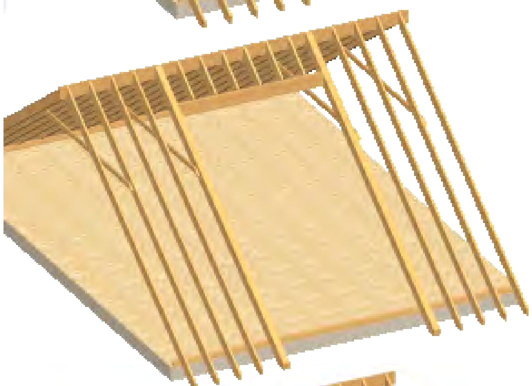
DIMINISHING RAFTER LENGTHS

RAFTER THRUST RULES_AS RATHER EXHAUSTIVELY NOTED (c7.11, c7.12), THE RESISTANCE TO RAFTER THRUST IS A FUNCTION OF LOAD, SPAN, AND PITCH. THIS DIAGRAM IS INTENDED TO SHOW THE REDUCTION IN RESISTANCE REQUIRED AS RAFTER LENGTHS GET SHORTER DOWN THE HIP RUN. STANDARD TOE-NAILIING IBECOMES ADEQUATE ON THESE SHORTER SPANS.



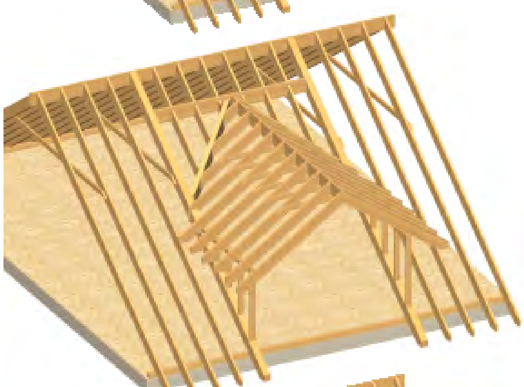
ROOF OPENINGS

***RAFTER SUPPORT_**THESE RECTANGULAR OPENINGS IN A PITCHED ROOF ARE NO DIFFERENT FROM ONES IN A FLOOR. (c5.19). THE LOAD DISTRIBUTION WORKS THE SAME. BIGGER OPENINGS REQUIRE BIGGER HEADERS AND MORE RAFTER PLIES. NOTE ALSO SMALL OPENING SURVIVE WITH SINGLE HEADERS AND RAFTERS.
***SIZE/USES_**THE SMALLER OPENINGS MAY JUST BE ALLOWING FLUE SIZED PIPES THRU THE ROOF. OPENINGS AS SHOWN MIGHT HOUSE SKYLIGHTS. THESE USED TO BE COMMOM FIREPLACE CHIMNEY OPENINGS. THE HEADERS WANT TO BE SET PLUMB (VERTICAL) OR SQUARE (90^0 TO THE RAFTERAS SHOWN) AS BEST SUITS THE PROBLEM.



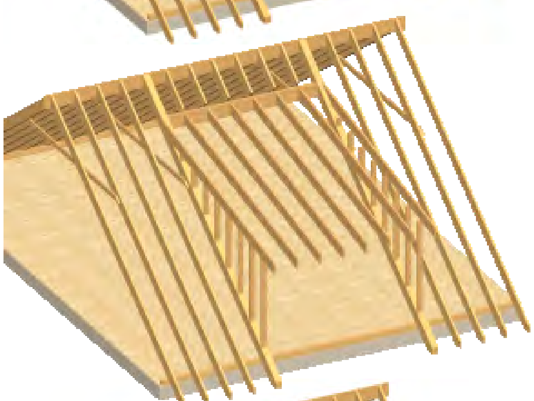
BASE FRAMING

***RAFTERS_**BUILT UP RAFTER ARE OFTEN CARRING THE DORMER LOAD AND NEED TO BE SELECTED ACCORDINGLY. 2 OR 3 MATCHING RAFTERS ARE COMMON. LVL MEMBERS ALSO AVAILABLE IS MATCHING DEPTH TO THE RAFTER MEMBER DEPTH.
***HEADER_**STRUCTURAL REQUIREMENTS BASED ON THE COMPLETED FRAMING FORMAT AND THE LOAD DISTRIBUTION, AND OF COURSE THE SPAN BETWEEN RAFTERS. THE HEADER CAN BE SET PLUMB (VERTICAL), OR SQUARE (90^0 TO THE RAFTER). THAT DECISION IS BASED ON WHAT THE TIE-INS TO THE HEADER LOOK LIKE.



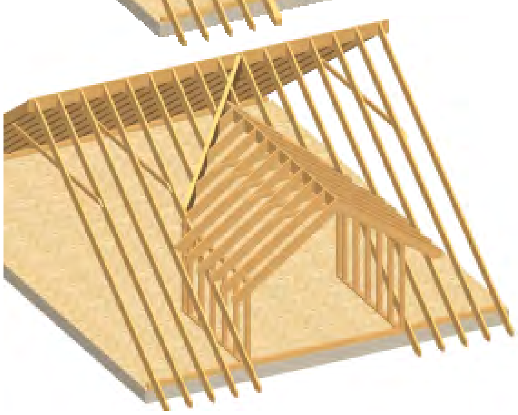
TRADITIONAL GABLE DORMER

***TYPICAL DETAIL_**FRAMING THIS ILLUSTRATION IS TYPICAL AND SHOWS HOW FUSSY AND INEFFICIENT A DORMER IS. LOTS OF SMALL TRICKY CUTS, DIFFICULT TO AIR SEAL AND INSULATE. THE DORMER ALSO GIVE LIGHT AND SPACE TO AN UPPER OR ATTIC LEVEL AND ARE AESTHETIC SAVIORS TO A LOT OF HOME DESIGNS.
***TRADITIONAL HIGH HEADER_**THE HEADER IS SET TO RECEIVE THE DORMERS RIDGE BOARD SO THE RAFTER FRAMER FRAMING ABOVE THE VALLEY IS BROKEN WITH RAFTERS ABOVE AND BELOW THE HEADER. THIS HIGHER HEADER ALLOWS THE DORMER SPACE TO BE OPEN TO ITS RAFTERS. ANOTHER DORMER FORMAT IF SPACE ALLOWS THE DORMER TO HAVE ITS WALLS AT AN ACCEPTABLE FLAT CEILING HT (7'-6" OR HIGHER), THEN THE HEADER IS SET AT THE CEILING HT AND THE DORMRS REVERSE GABLE ROOF IS OVERFRAMED.



SHED DORMER

***USING HEADER_**DOUBLE OR TRIPLE RAFTERS DEFINE THE WIDTH OF THE DORMER. DORMER WALLS ARE BUILT ON TOP OF THE RAFTER- AND BELOW AS/IF WANTED- BUT ALL LOADING IS KEPT OFF THE FLOOR PLANE. THE HEADER IS CARRYING HALF THE RAFTER LOAD ABOVE AND BELOW THE HEADER. HEADER LOAD AND SIZE NEED CHECKING.
***USING RIDGE_**SHED DORMERS CAN HAVE THEIR RAFTERS SET AT THE RIDGE WHICH IS A SIMPLER FRAMING. THE BRACE OR BEAM QUESTION COMES UP.
***LONG DORMERS_**THE ROOF FORMAT OF THE SHED DORMER ALLOWS IT TO STRETCH OUT ALONG A RIDGE LINE PERMITTING A LOT MORE SPACE TO BE CAPTURED INSIDE. THE LONGER DORMERS ARE BETTER SERVED BY USING THE RIDGE- AVOIDING A LONG SPAN HEADER. OR A LONG SHED CAN RUN ITS RAFTERS UNDER THE RIDGE AND SISTER TO THE RAFTERS ON THE OPPOSING SIDE. STICK FRAMING IS FLEXIBLE.



OTHER METHODS

***VARIATIONS IN FRAMING_**THERE ARE SEVERAL METHODS FOR FRAMING THE UBIQUITOUS GABLE DORMER, AND USUALLY A FRAMER WILL PROCEED WITH THE METHOD THEY ARE MOST COMFORTABLE WITH.
***THIS METHOD_**IS SHOWN BECAUSE IT DOES NOT USE BUILT-UP RAFTERS OR HEADERS. THESE DORMER WALLS RUN DOWN TO THE FLOOR AND PUT THE DORMER'S GRAVITY LOADS THERE. THE LEFT SIDE VALLEY BEAM IS EXTENDS UP TO THE RIDGE, AND SUPPORTS THE RIDGE MEMBER END AND THE OPPOSING SHORT VALLEY. THIS FRAMING LEAVES THE 'VAULTED PROFILE INSIDE THE DORMER OPEN AS DESIRED. SMALL DORMERS OFTEN NEED THAT EXTRA CEILING SPACE TO BE USEFUL.

THERMAL ENVELOPE OPTIONS AT THE ROOF 1

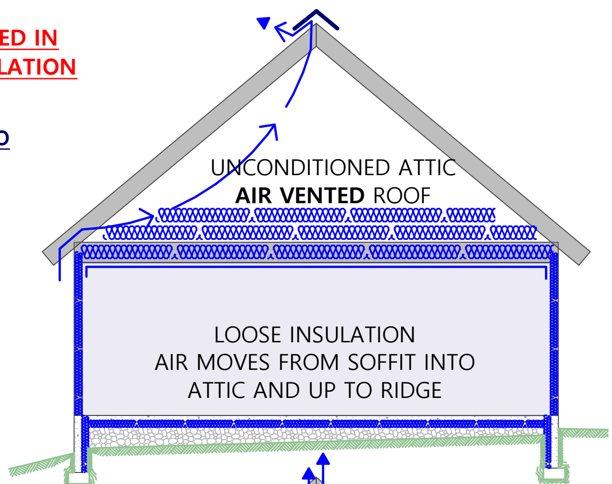
THE SPACE UNDER ROOF-LIVING SPACE?, MEP SPACE?, UNCONDITIONED STORAGE?, UNUSED?.
***1. CRITERION FIRST_**ESTABLISHING PROJECTED USE IS THE FIRST DECISION.
***2. MEP SPACE ALLOCATIONS_**REFER TO CHAPTER 9 ON THE THERMAL ENVEOPE AND (d9.9-9.11) SPECIFICALLY. IN A SENTENCE THERE IS WISDOM IN HOUSING ANY AIR HANDLERS AND THEIR DUCT SYSTEMS WITHIN INSULATED AND CONDITIONED SPACE.
***3. CLIMATE ZONE_**CODE REQUIRED MINIMUM COMPONENT R VALUES NEED TO BE KNOWN, AN UNDERSTANDING OF HOW FAR BEYOND THOSE REQUIREMENTS ONE MAY WANT TO GO-AND AN UNDERSTANDING OF THE DEW POINT SITUATION, IS ALL REQUIRED FOR BEST DECISIONS.
***4. INSULATION STRATEGY + STRUCTURE_**THIS EXERCISE EMPASIZED INSULATION THICKNESS REQUIRED PER STATEGY PER CLIMATE ZONE, AND MAKES COMMENT ON WHAT STRUCTURAL LIMITATIONS MAY BE INVOLVED.

INSULATION REMINDER

***SPRAY FOAM-CLOSED CELL**
***SPRAY FOAM-OPEN CELL_**
***RIGID BOARD INSULATION_**POLYISO, XPS, EPS
***LOOSE INSULATIONS_**FIBEGLASS, CELLULOSE, ROCK WOOL
ALL HAVE AN R-VALUE OR A CONDITIONAL R-VALUE. ALL HAVE A PERM RATING, A PERM RATING PER INCH, OR A CONDITIONAL PERM RATING OFTEN DEFINED BY THE SURFACE FINISH. THE AVAILABLE PRODUCTS EITHER NEED BEST ADVISE FROM A PROFESSIONAL OR A LOT OF RESEARCH. THE BUILDING SCIENCE COMMUNITY IS A PLACE TO GET THE BETTER OBJECTIVE SPECIFICATION INFORMATION. THESE DIAGRAMS USE ACCEPTED AVERAGE R-VALUES TO DETERMINE THICKNESSES. SO THESE THICKNESSES MAY VARY FROM OTHER SPECIFIC CHOICES.

DEPTH OF STRUCTURES NOTED IN RED BASED ON 'LOOSE' INSULATION RATED @ R-3.5 PER IN

DEPTH OF FLOOR STRUCTURE TO CONTAIN INSULATION IN RED
ZONE 1_R-30 =8+"
ZONE 2_R-38 =11"
ZONE 3_R-38 =11"
***ZONE 4a_R-49 =14"**
***ZONE 4b_R-49 =14"**
***ZONE 4c_R-49 =14"**
***ZONE 5_R-49 =14"**
***ZONE 6_R-49 =14"**
***ZONE 7_R-49 =14"**

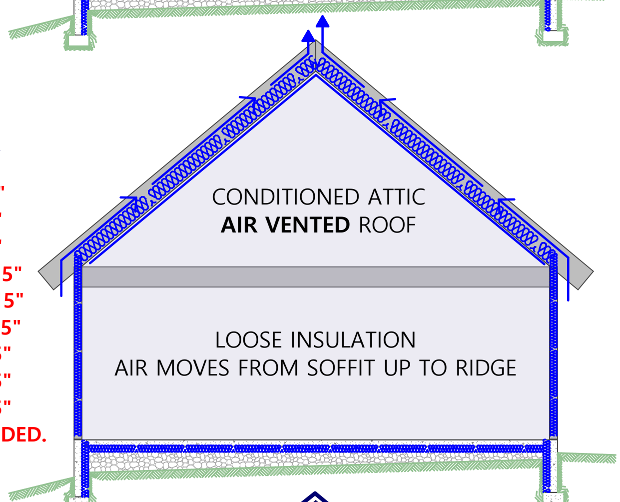


VENTED ROOF

TRADITIONAL UNCONDITIONED ATTIC

***DESCRIPTION_**THE TRIED AND TRUE AND BETTER WAY TO VENT AN ATTIC SPACE IS WITH CONTINUOUS SOFFIT VENTING AND CONTINUOUS RIDGE VENTING. MOISTURE COLLECTING ON SURFACES ON THE UNDERSIDE OF ROOF IS THE EVER PRESENT CONCERN AND MOVING AIR ACROSS THOSE SURFACES IS THE IDEA BEHIND KEEPING THEM DRY(ER) THE ATTIC INSULATION NEEDS TO BE ADEQUATE, UNMOLESTED.
***HIGHLGHTS_**MAINTAINING AIR FLOW AND ADEQUATE INSULATION AT THE PERIMETER PRACTICALLY ALWAYS SUGGEST RAISING THE ROOF A BIT. AND IF THE ATTIC IS TO ACCESSED/USED FOR ANY REASON, A UTILITY FLOORING SHOULD BE CONSIDERED. IT IS WHEN THE INSULATION PLANE GETS COMPROMISED THAT BOTH ENERGY AND MOISTURE COMPROMISES SHOW UP.

DEPTH OF ROOF STRUCTURE TO CONTAIN INSULATION IN RED
ZONE 1_R-30 +1"AIR SPACE=9+"
ZONE 2_R-38 +1"AIR SPACE=12"
ZONE 3_R-38 +1"AIR SPACE=12"
***ZONE 4a_R-49 +1"AIR SPACE=15"**
***ZONE 4b_R-49 +1"AIR SPACE=15"**
***ZONE 4c_R-49 +1"AIR SPACE=15"**
***ZONE 5_R-49 +1"AIR SPACE=15"**
***ZONE 6_R-49 +1"AIR SPACE=15"**
***ZONE 7_R-49 +1"AIR SPACE=15"**
NOTE 2" AIR SPACE RECOMMENDED.

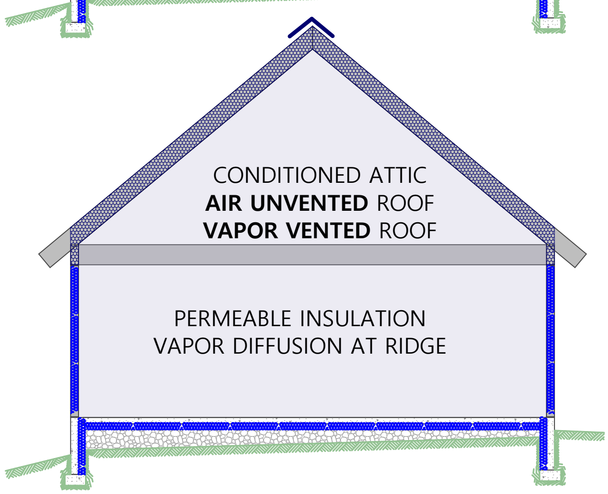


VENTED ROOF

TRADITIONAL CONDITIONED VAULT

***DESCRIPTION_**VAULT, OPEN, CATHEDRAL CEILING HERE IS SYNONYMOUS. CEILING IS ATTACHED TO THE UNDERSIDE OF THE ROOF STRUCTURE, INSULATION RESIDES IN THE CONSTRUCTION CAVITIES **AND** A MINIMUM 1" VENTILATION SPACE REMAINS TO THE UNDERSIDE OF THE ROOF SHEATHING. CONTINUOUS VENTING AIR ENTERS AT THE SOFFTIIT AND EXITS AT THE RIDGE (VENT). CONTINUOUS VENTING IS A MUST.
***HIGHLGHTS_**PROFESSIONALS AGREE THAT THE CODE REQUIRED 1" AIR SPACE IS NOT ENOUGH (2" RECOMMENDED). AND GETTING EVEN/ADEQUATE AIR FLOW IN REALITY IS VERY DIFFICULT. BOTTOM LINE IS THIS APPROACH IS RISKY AND A LAST CHOICE. OTHER BETTER OPTIONS EXIST.

DEPTH OF ROOF STRUCTURE TO CONTAIN INSULATION IN RED
ZONE 1_R-30 =8+"
ZONE 2_R-38 =11"
ZONE 3_R-38 =11"
*ZONE 4a_R-49 =14"
*ZONE 4b_R-49 =14"
*ZONE 4c_R-49 =14"
*ZONE 5_R-49 =14"
*ZONE 6_R-49 =14"
*ZONE 7_R-49 =14"



VAPOR VENTED ROOF

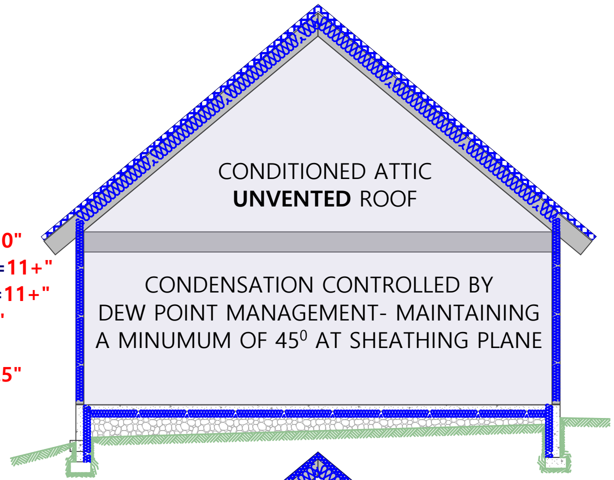
NON TRADITIONAL CONDITIONED VAULT

***DESCRIPTION_**INSULATION RESIDES IN THE CONSTRUCTION CAVITIES SNUG TO THE BOTTOM OF THE SHEATHING WITHOUT AN AIR VENT SPACE. PERMEABLE INSULATION INCLUDING OPEN CELL SPRAY, AND LOOSE INSULATIONS ARE VIABLE. THESE ALLOW VAPOR TO MOVE THRU THEM AND NATURALLY RISE, AND ESCAPE THRU THE VAPOR DIFFUSION OPENINGS AT THE RIDGE. NO AIR VENTING, NO SOFFIT VENTS.
***HIGHLGHTS_**THIS IS NEW TO THE CODE, IS HOPEFULLY A BETTER METHOD TO CONTROL MOISTURE IN ANY WARMER CLIMATE UPPER CEILING SPACE. METHOD CURRENTLY LIMITED TO CLIMATE ZONES 1,2,3.

* **UNVENTED ROOF**_THESE COMPARISONS SHOW 4 INSULATION STRATEGIES FOR THE UNVENTED ROOF. THESE SCENARIOS SHOW WITH OUR CONVENTIONAL GABLE ROOF GEOMETRY- BUT ARE FULLY VALID FOR SINGLE SLOPE OR FLAT ROOF GEOMETRIES ABOVE CONDITIONED SPACE. THE COLDER CLIMATE CONSTRUCTION COMMUNITY IS A RESOURCE FOR OTHER THOUGHTS AND OPTIONS. AND TIPS AND TRICKS FOR DEEP RIGID INSULATION INSTALLATION.

RIGID BOARD XPS ON DECK R-6.5 PER IN+PERMEABLE/LOOSE @ R-3.5 PER IN IN RAFTER SPACE

ZONE 1_R-5(1")+R-25 (7+")=7+"
ZONE 2_R-5 (1")+R-33 (7+")=9.5"
ZONE 3_R-5 (1")+R-33 (9.5")=9.5"
ZONE 4a_R-15 (2.3"-3")+R-34 (10")=10"
ZONE 4b_R-15 (2.3"-3")+R-39 (11+")=11+"
ZONE 4c_R-10 (1.5"-2")+R-39 (11+")=11+"
ZONE 5_R-20 (3"-4")+R-29 (8.5")=8.5"
ZONE 6_R-25 (4"-5")+R-24 (7")=7"
ZONE 7_R-30 (4.6"-6")+R-19 (5.5")=5.5"
X"_MIN. RAFTER DEPTH TO CONTAIN PERMEABLE/LOOSE INSULATION TYPES PER CODE



UNVENTED ROOF

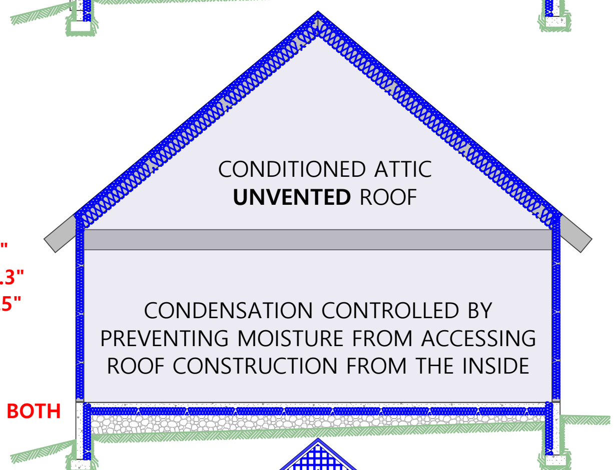
CODE PERMITTED HYBRID 1

***DESCRIPTION**_RIGID INSULATION BOARDS ABOVE SHEATHING DECK TO MAINTAIN TEMPERATURE AT THE INSIDE SHEATHING SURFACE ABOVE 45^0. PERMEABLE SPRAY OR LOOSE INSULATION TIGHT TO UNDERSIDE OF SHEATHING INSIDE. THE RELATIVE AMOUNT OF EXTERIOR RIGID TO INTERIOR PERMEABLE IS IMPORTANT AND CLIMATE ZONE BASED.

***HIGHLGHTS**_THIS HYBRID IDEA IS A COST AND CONSTRUCTION COMPROMISE. RIGID INSULATION IS MORE EXPENSIVE PER R THAN (MOST) BLOWN LOOSE INSULATION, AND REALLY THICK EXTERIOR RIGID HAS SOME CONTRUCTION CHALLENGES. 2 INSULATION PROCESSES REQUIRED.

SPRAY CLOSED CELL BASED ON R-6.5 PER IN+PERMEABLE/LOOSE @ R-3.5 PER IN

ZONE 1_R-5(1")+R-25 (7+")=8+"
ZONE 2_R-5 (1")+R-33 (9.5")=10.5"
ZONE 3_R-5 (1")+R-33 (9.5")=10.5"
ZONE 4a_R-15 (2.3")+R-34 (10")=12.3"
ZONE 4b_R-15 (2.3")+R-39 (11+")=13.3"
ZONE 4c_R-10 (1.5")+R-39 (11+")=12.5"
ZONE 5_R-20 (3")+R-29 (8.5")=11.5"
ZONE 6_R-25 (4")+R-24 (7")=11"
ZONE 7_R-30 (4.6")+R-19 (5.5")=10+"
X"_MIN. RAFTER DEPTH TO CONTAIN BOTH INSULATION TYPES PER CODE



UNVENTED ROOF

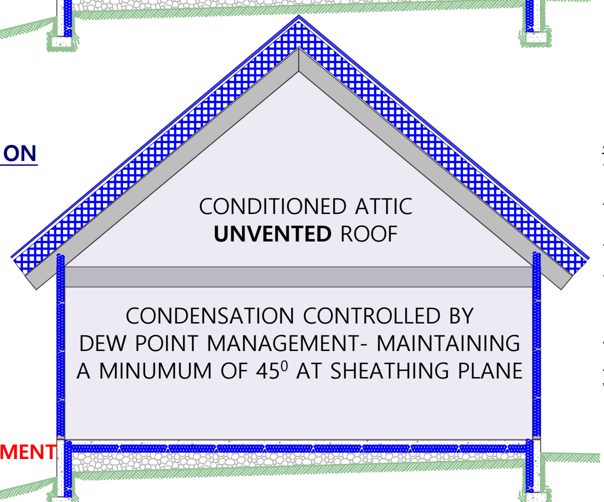
CODE PERMITTED HYBRID 2

***DESCRIPTION**_CLOSED CELL FOAM ON UNDERSIDE OF SHEATHING TO R-VALUE/THICKNESS NOTED WITH PERMEABLE SPRAY OR LOOSE INSULATION TIGHT TO THE CLOSED SELL APPLICATION. THE CLOSED CELL FOAM IS BOTH AIR AND VAPOR IMPERMEABLE PREVENTING INTERIOR MOISTURE FROM GETTING TO THE SHEATHING SURFACE.

***HIGHLIGHTS**_THIS HYBRID IDEA IS ALSO A COST BASED COMPROMISE. CLOSED CELL FOAM IS THE MOST EXPENSIVE, SO MIXING IT WITH A LESSER EXPENSIVE PERMEABLE COMPANION ACHIEVES THE DESIRED R AT A LOWER COST. (AND AN ADDITIONAL PROCESS.)

ABOVE DECK RIGID BOARDS BASED ON XPS @ R-5 PER IN

ZONE 1_R-30(6")=AS NEEDED
ZONE 2_R-38 (7.5")=AS NEEDED
ZONE 3_R-38 (7.5")=AS NEEDED
ZONE 4a_R-49 (10")=AS NEEDED
ZONE 4b_R-49 (10")=AS NEEDED
ZONE 4c_R-49 (10")=AS NEEDED
ZONE 5_R-49 (10")=AS NEEDED
ZONE 6_R-49 (10")=AS NEEDED
ZONE 7_R-49 (10")=AS NEEDED
AS NEEDED_THE STRUCTURAL REQUIREMENT ALONE SETS THIS REQUIREMENT



UNVENTED ROOF

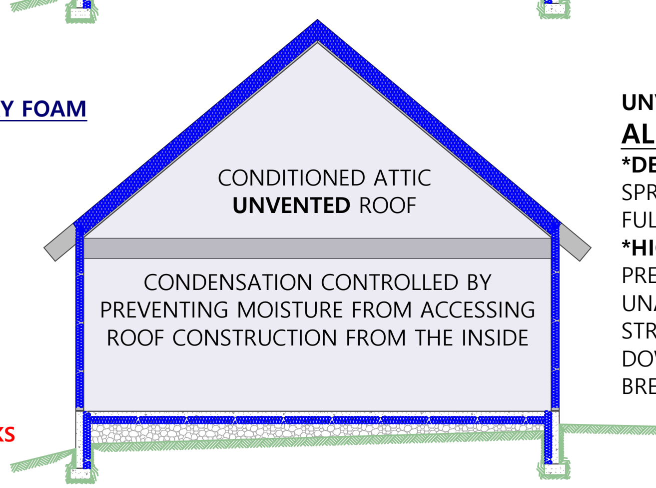
ALL RIGID INSULATION ABOVE DECK

***DESCRIPTION**_ALL RIGID INSULATION BOARDS ABOVE THE ROOF SHEATHING. TYPE OF RIGID INSULATION MATTERS AS IT DETERMINES THICKNESS.

***HIGHLIGHTS**_THE EXTERIOR CONTINUOUS INSTALLATION IS THE BEST R/INSULATION OPTION, AND PROTECTION OF THE STRUCTURE/SHEATHING AGAINST MOISTURE. COMING TO REAL TERMS WITH THE INSTALLATION IS IMPORTANT. EXTRA DEEP FASTENERS ALONE CAN BE A COST AND INSTALLATION CONCERN. CHECK WITH THOSE EXPERIENCED WITH THIS APPROACH.

IN STRUCTURE CLOSED CELL SPRAY FOAM BASED ON SPF @ R-6 PER IN

ZONE 1_R-30 (5")=NOMINAL 6"
ZONE 2_R-38 (6.5")=NOMINAL 8"
ZONE 3_R-38 (6.5")=NOMINAL 8"
ZONE 4a_R-49 (8+=NOMINAL 10"
ZONE 4b_R-49 (8+")=NOMINAL 10"
ZONE 4c_R-49 (8+")=NOMINAL 10"
ZONE 5_R-49 (8+")=NOMINAL 10"
ZONE 6_R-49 (8+")=NOMINAL 10"
ZONE 7_R-49 (8+")=NOMINAL 10"
NOMINAL_ANY RAFTER TYPE WITH NOMINAL DEPTH OR GREATER WORKS



UNVENTED ROOF

ALL CLOSED CELL IN STRUCTURE

***DESCRIPTION**_UNDERSIDE OF SHEATHING GETS SPRAYED WITH CLOSED CELL POLYURETHANE TO FULL CODE REQUIRED THICKNESS (OR BEYOND).

***HIGHLIGHTS**_INSTALLATION WISE THIS IS A PRETTY GOOD APPROACH. ONE STEP, ALMOST UNAVOIDABLY TIGHT, FALLS WITHIN MOST STRUCTURAL RAFTER DEPTHS REQUIRED. DOWNSIDE IS COST AND LACK OF THERMAL BREAK OFFERED BY THE EXTERIOR RIGID OPTIONS.

WALLS AND ROOFS

*THE PRINCIPLES BEHIND EFFECTIVE INSULATION AND CONDENSATION CONTROL ARE VERY SIMILAR. REFERENCE[c6.17-c6.21] WHICH ADDRESSES FRAMING CENTERS, INSULATION TYPES AND R-VALUES, DEW POINT CONSIDERATION, AND VAPOR MANAGEMENT,ALL APPLICABLE, AND NOT BEING REPLICATED THIS CHAPTER.

TABLE N1102.1.2 (R402.1.2) INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[i]	FLOOR *R*-VALUE	BASEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	20 or 13 + 5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.40	49	20 or 13 + 5[h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13 + 5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20 + 5 or 13 + 10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.32	0.55	NR	49	20 + 5 or 13 + 10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

CODE R
NOTED IS ONE VALUE THAT CAN BE REALIZED WITH A SINGLE INSULATING MATERIAL. OR WITH A HYBRID APPLICATION WITH 2 INSULATING MATERIALS.

TABLE R806.5
INSULATION FOR CONDENSATION CONTROL

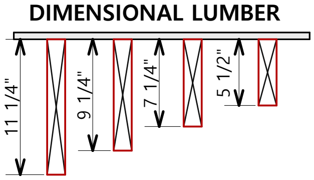
CLIMATE ZONE	MINIMUM RIGID BOARD ON AIR-IMPERMEABLE INSULATION *R*-VALUE[a, b]
2B and 3B tile roof only	0 (none required)
1, 2A, 2B, 3A, 3B, 3C	R-5
4C	R-10
4A, 4B	R-15
5	R-20
6	R-25
7	R-30
8	R-35

CONDENSATION CONTROL
*THIS TABLE APPLIES TO HYBRID NON VENTING ROOF APPLICATIONS NOTED ON THE PREVIOUS PAGE AS HYBRID 1, AND HYBRID 2. THESE R VALUES ARE THE EXTERIOR RIGID BOARD IN HYBRID 1, AND THE CLOSED CELL SPRAY APPLICATION AGAINST THE ROOF DECK IN HYBRID 2. BUILDING SCIENCE HAS DETERMINED THAT THE CORRECT 'PROPORTION' OF IMPERMEABLE (RIDGID AND CLOSED CELL) TO PERMEABLE/LOOSE INSULATIONS IS NECESSARY-WHEN BOTH ARE USED- TO ACHIEVE THE CONDENSATION CONTROL WANTED. THIS PRINCIPLE IS ALSO VERY MUCH AS WORK IN THE WALL ASSEMBLY. [c6.20].

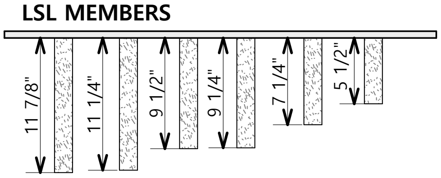
FRAMING AND INSULATION

*THE STRUCTURE HAS TO DO ITS JOB. MEMBER DEPTH IS ALWAYS INVOLVED. INSULATION MUST DO ITS JOB. A REQUIRED DEPTH IS INVOLVED. PREVIOUS 2 PAGES PROVIDE (DEPTH) NUMBERS TO FOR BOTH BASED ON A CHOSEN CONDITION AND APPROACH. BELOW BOTH STRUCTURE AND INSULATION ARE REPRESENTED GRAPHICALLY TO SCALE AS A VISUAL AID.

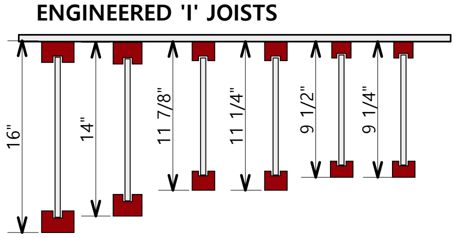
DIMENSIONAL LUMBER



LSL MEMBERS

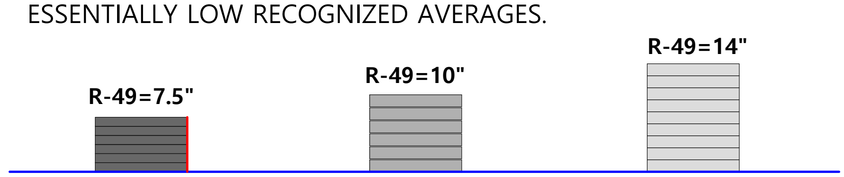


ENGINEERED 'I' JOISTS

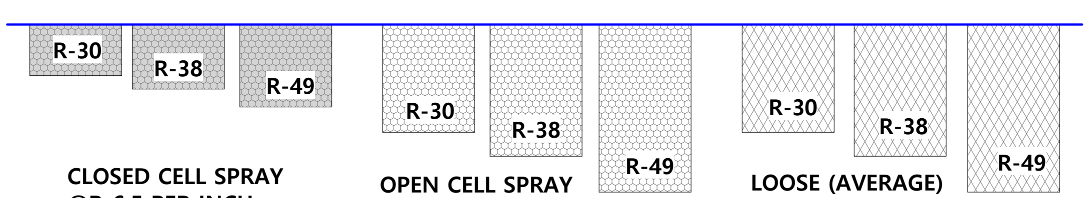


INSULATION VALUES

[c6.18] LISTS VALUES FOR PRODUCTS APPLICABLE TO BOTH WALL AND ROOF/CEILING APPLICATIONS. THESE LISTS ARE EASILY FOUND AND, UNFORTUNATELY ALL VARY A BIT. NUMBERS USED HERE ARE ESSENTIALLY LOW RECOGNIZED AVERAGES.



POLYISO@R-6.5 PER INCH   XPS@R-5 PER INCH   EPS@R-3.5 PER INCH



CLOSED CELL SPRAY @R-6.5 PER INCH   OPEN CELL SPRAY @R-3.5 PER INCH   LOOSE (AVERAGE) @R-3.5 PER INCH