CANADA

BUILDING NOTE

HOUSE FRAMING

by

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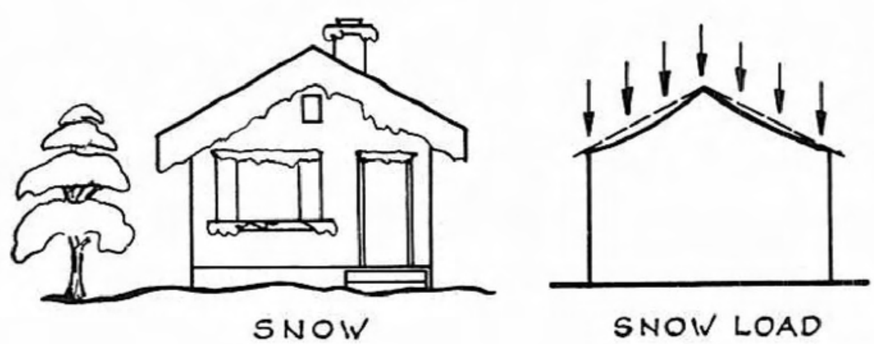
The purpose of the house frame is to give shape, strength, and rigidity to the finished structure under normal conditions of use and climatic loadings. How well any particular house frame does this depends upon size and grading of the lumber and upon the planning and carpentry. As a secondary purpose, we might say that the frame provides a skeleton to which insulation and other exterior and interior materials are attached.

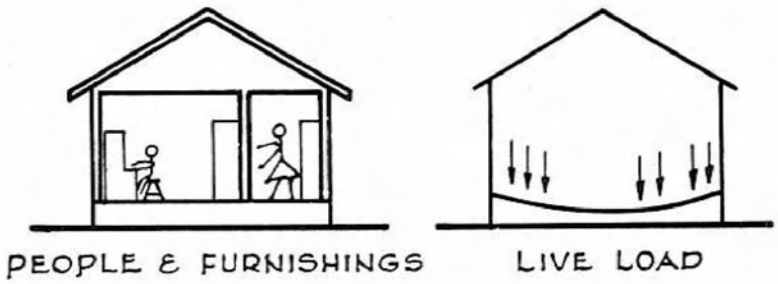
To fulfil this purpose, a house must have the necessary strength and rigidity to resist without damage to interior finishes:

1. Wind loads;

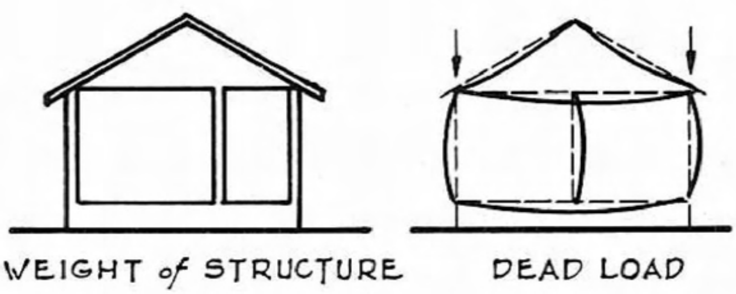
2. Snow loads;



3. Live loads;



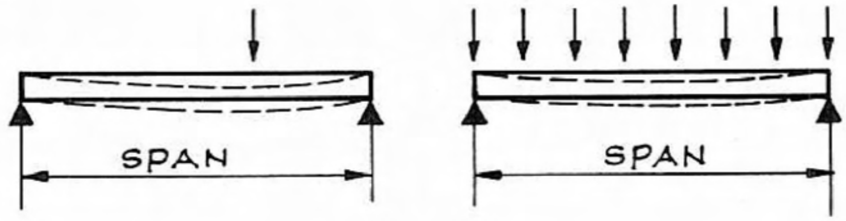
4. Dead loads;



5. Earthquake loads - horizontal loads which are not common to all parts of North America.

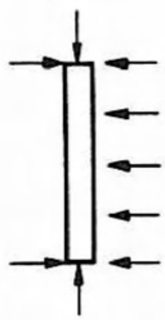
The loads, or combination of loads, to which we have just referred must be transmitted to the foundation by the house frame and the various materials which act with the frame in the finished house. These loads are transmitted to the foundation by the structural components of the house;

1. Acting as beams - bending loads;

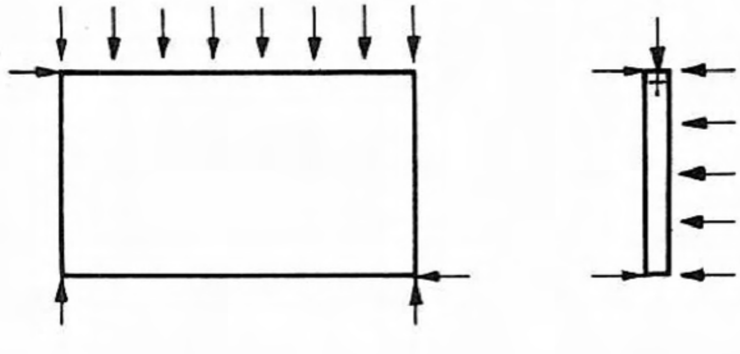


2. Acting as columns - axial loads;

3. Acting both as columns and as beams - bending loads and axial loads;



4. Acting in combination as panels - bending loads, axial loads and racking loads.



Having dealt very briefly in the way of review with the loads which are imposed on a house by use and climatic loadings, we might turn now to the types of framing we may find in various parts of Canada.

There are three main types of house framing in Canada, excluding, of course, plank wall construction which is quite common in the Province of Quebec. Plank wall construction, to my knowledge, is not being used to any great extent, if at all, in house construction in this area. Therefore, we will omit it from this discussion. The three types of framing are:

(1) braced-frame construction;
(2) balloon-frame construction;
(3) western-frame or platform construction.

Braced-frame construction. - The braced-frame construction is said to be the oldest method of framing in America, having been imported from Europe in colonial times. Although in a somewhat modified form, it is still being used in certain areas. Originally this type of framing was characterized by heavy timber posts at the corners, often with intermediate posts between, all of which extend continuously from a heavy foundation sill to an equally heavy plate at the roof line. At the second storey, or second floor level, heavy timber girts were introduced running from post to post and carefully mortised and tenoned with oak pins. These girts supported the second floor joists. Knee braces were usually well fitted and pinned at the corner posts. The quality of the materials and workmanship accounts for the number of old houses of this type of construction that are still standing in many parts of Eastern Canada and the Eastern United States today.

Balloon-frame construction. - The principal characteristic of balloon framing is the use of studs extending in one piece from the sill on the top of the foundation wall to the plate or roof. Joist ends are nailed to the studs and are supported by a ribband or ledger board let into the studs. Corner bracing usually extends from the sill to the ribband and from the ribband to the top plate. Openings in walls must be adequately framed because of the continuity of the studding. To equalize over-all shrinkage settlement, partition studs must extend from joist-supporting beams to partition plates and between partition plates.

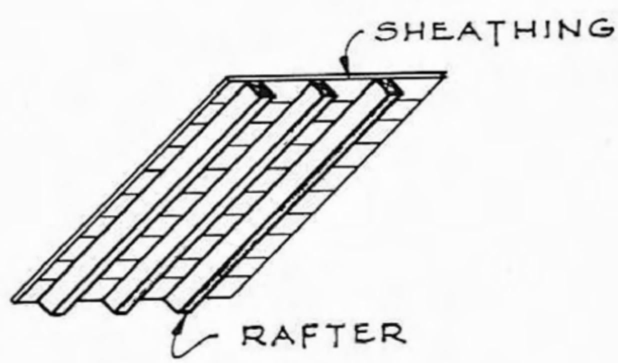
Western-frame or platform construction. - Of these three types of framing, western-frame or platform construction is undoubtedly the most widely used in this area. Unlike braced-frame or balloon-frame construction, it is characterized by platforms independently framed and supported by studs one storey in height. Platform construction is a convenient method of framing because walls may be constructed on each floor level and tilted into place.

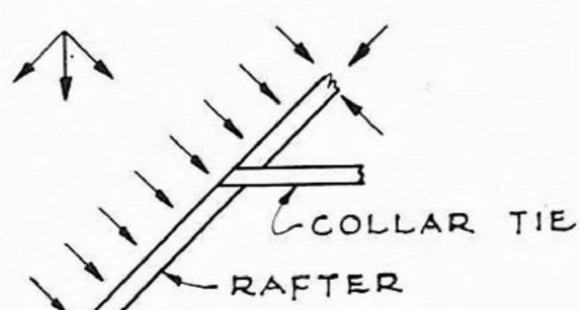
All three types of framing have been developed by experience and good practice to eliminate possible shrinkage difficulties in the lumber. Over-all shrinkage settlement due to the drying out of the lumber has been equalized where possible. Wood from the tree may contain from 30 to 300 per cent water based on the weight of the oven dry wood. This water may be separated roughly into two parts; the free water for the cell cavities and the water held absorbed in the capillaries of the walls of such wood elements as fibres and ray cells. The absorbed water is of most interest when considering shrinkage. When the free water has been removed and the absorbed water remains, wood is said to have reached the fibre saturation point. The fibre saturation point is approximately 30 per cent moisture content for all species. Shrinkage across the grain can be as high as $\frac{1}{4}$ inch per foot of width, if the moisture content of the wood changes from say 21 per cent to 12 per cent. Longitudinal shrinkage on the other hand is relatively negligible.

Basically a house is made up of components which, when interconnected, impart the necessary strength and rigidity to the finished house. These components are:

(1) the roof;
(2) the walls;
(3) the floors.

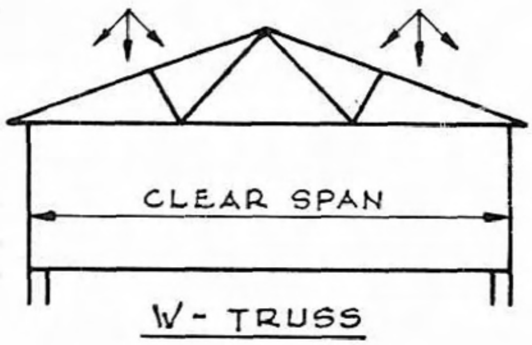
If we follow in order of design, we can deal with each of these components separately. In doing so, the roof may be thought of as being made up of panels. The roof sheathing resists the racking loads and transmits the loads to the rafters, which, in turn, carry bending and axial loads. Collar ties under wind loads frequently act in tension, but under accumulated snow loads may act in compression.

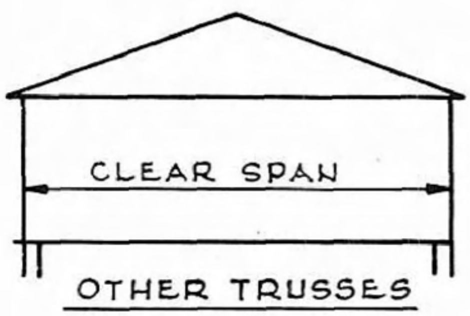




In a structural test on a full-scale house by the Division of Building Research, it was found that under a simulated snow load on the roof, the collar ties were in compression. The rafters deflected or bent to the extent of pushing out the side walls at points where the ceiling joists were not adequately fastened to the butts of the rafters and where there were no interior cross partitions.

Trussed-roof systems are being used more commonly. Such systems do away with interior-load bearing partitions, and greater flexibility is made possible for interior layout. Other advantages are possible, but many of these advantages depend upon each builder's operations.





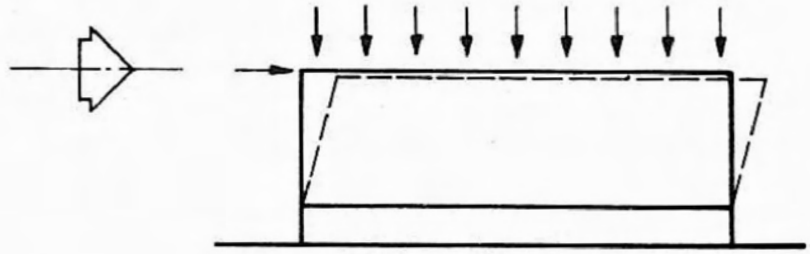
Roof trusses require engineering designing, but proven designs may be used where loading conditions and specifications permit.

A recent test of two W-trusses in the Division's laboratory indicated that even at the point of failure, the lower chords did not reach the maximum allowable deflection of 1/360 of the span for a plaster ceiling. Bolts and split-ring connectors were used for joining the truss members. Other methods of fastening joints have been used successfully, particularly in the United States.

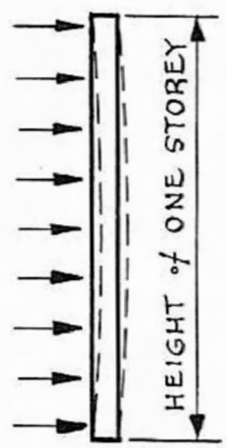
Work was recently undertaken by the Division to obtain comparative information on the strengths of conventional rafter construction and several types of truss construction with the hope that a better basis may be established for the evaluation of the strength of truss construction.

Walls may be constructed in a number of ways. Whole wall sections or panels may be tilted into position. Regardless of the technique, adequate strength must be built into wall construction. A wall resists:

1. Racking loads and axial loads;



2. Bending loads.

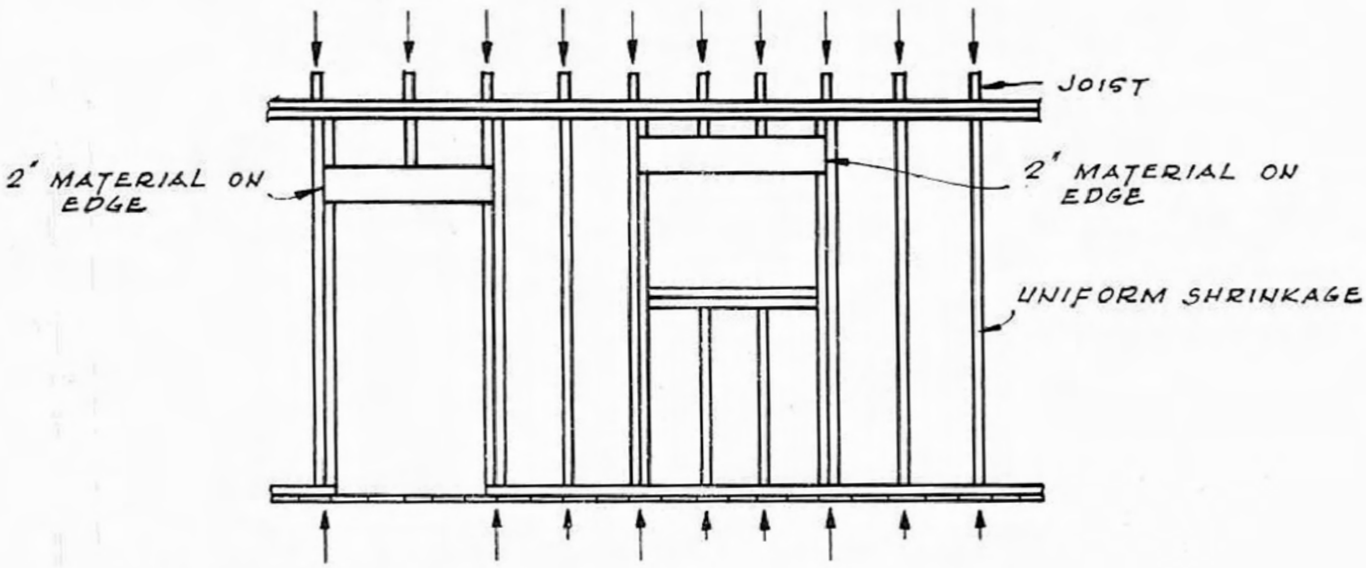


If the type of exterior sheathing does not afford enough racking strength when applied to the wall framing, a bracing method must be employed to make the wall more rigid against the force of the wind, i.e., wind loads. Otherwise, cracks may appear in the interior finishes. The effectiveness of the brace, whether it is a let-in 1 inch by 4 inches, a 2-inch thick cut-in brace, or a continuous 2-inch thick brace, depends upon the skill and judgment of the carpenter.

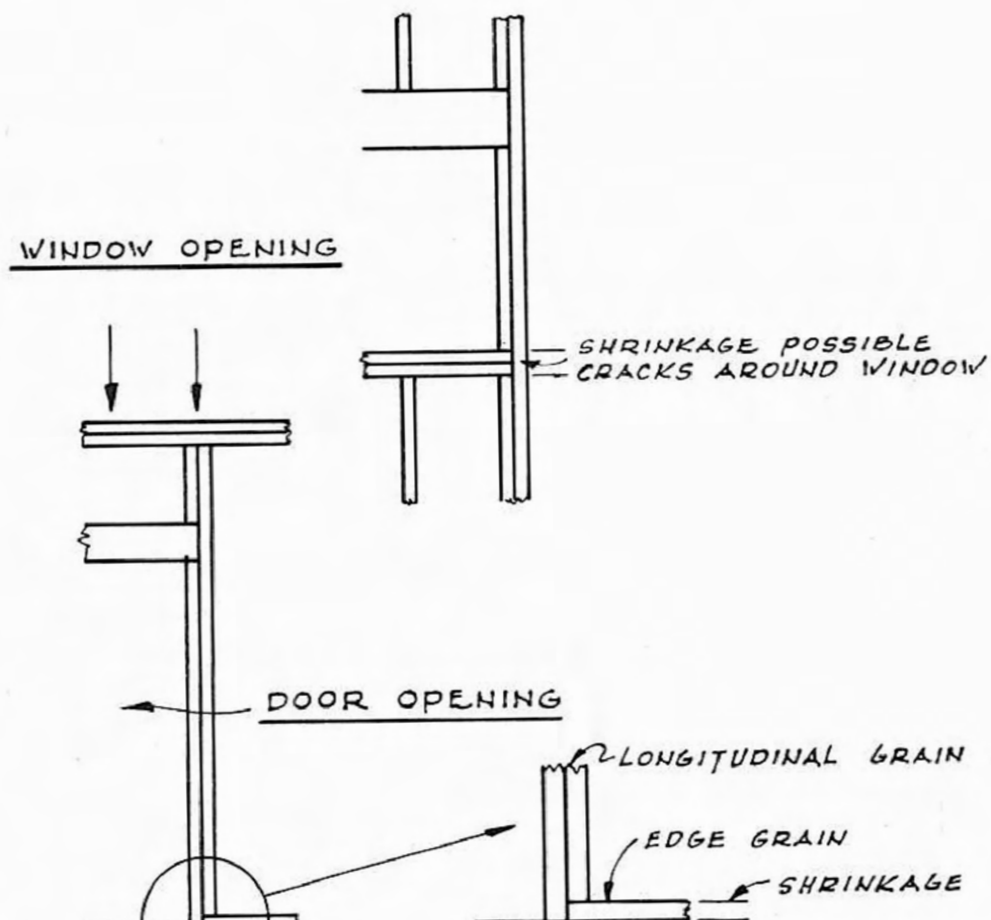
As a matter of interest, it might be mentioned that in 1950 and 1951 the Division made a survey of stud spacing in houses under construction in nine cities across Canada. This survey revealed that, "it is reasonable to expect that in the average Canadian frame house of today, up to 34 per cent of the exterior wall area will be found to have studding so spaced as to be unsuited to the incorporation of factory made building materials designed on a 16-inch module". (The exterior wall area referred to is exclusive of window and door openings.) This means, for instance, that insulation must be cut, and extra time taken to set special pieces into these areas.

Openings in walls are not difficult to frame if the problem of shrinkage in the studs, lintels and plates is kept in mind. By way of review, it might be useful to illustrate this as follows:

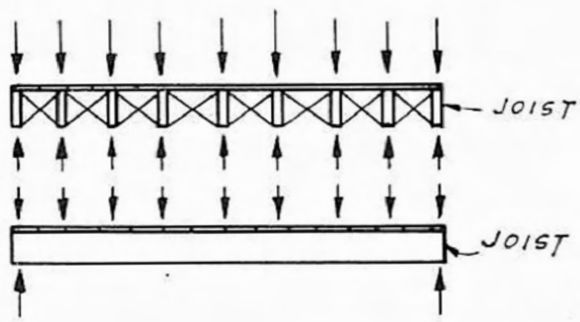
1. Correct method of framing around wall opening;



2. Incorrect method of framing around wall opening.



Floors may be regarded in much the same way as walls and roof systems. Floor joists, cross bridging, sub-flooring and finished flooring, when adequately designed and constructed, are strong and free from uncomfortable vibrations when walked upon. Bending loads are in this case often the most significant.



The right size and the grade of lumber in a floor joist will give the required strength; cross bridging and sub-flooring will give the required stiffness.

"Tests at the Forest Products Laboratory indicate that loads up to 400 pounds concentrated on an area of 1/3 square ft. of a conventional dwelling flooring system are distributed laterally for a considerable distance with only 20 or 30 per cent carried directly by the joist under the load. The flooring system in the tests consisted of joists, bridging, a diagonally laid sub-floor, and a 1-inch finished floor laid across the joists. The load was applied at mid-span." *

One aspect of putting in a floor joist that is well to guard against is large knots on the bottom edge of a joist. Knots on the lower edge weaken a joist considerably. This aspect is a question of the grade of lumber. Lumber that is shaky or checked or cross grained is not suitable. Notches and holes in joists for plumbing pipes and electric wiring also weaken joists and should be guarded against. Notching of the top or bottom of the joists for piping, in general, should not be more than one-sixth of the joist depth and should be located only in the end third of the span. Holes may be bored in the joists if the diameter is no greater than $2\frac{1}{2}$ inches and the edge of the hole is not less than 2 inches from the top or bottom edge of the joist. This usually limits the joist size to a 2 by 8 or larger.

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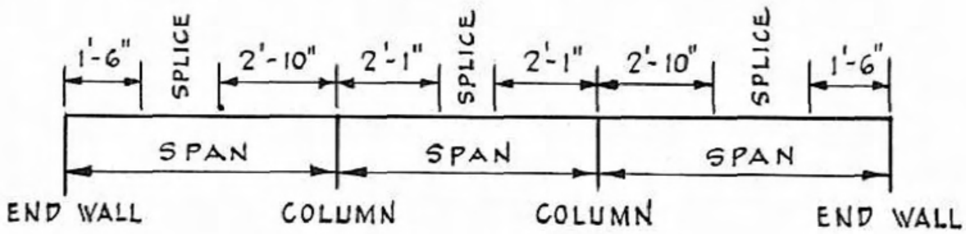
* Wood Handbook No. 72, U.S. Department of Agriculture, Forest Products Laboratory, p.209.

The last detail that might be dealt with is where splices may be made in laminated beams supporting floor joists. Like a roof truss, a laminated beam requires the application of engineering principles in the design, unless details of a proven beam that will fulfil the requirements are available. The advantage of knowing where to splice a beam is that shorter lengths of 2-inch lumber may be used if put together properly, thereby saving a little on the cost.

Computations have been made for the splicing of laminations in the beams given in the table on P. 55 of Central Mortgage and Housing Corporation's Building Standards, 1954, and the following applies:

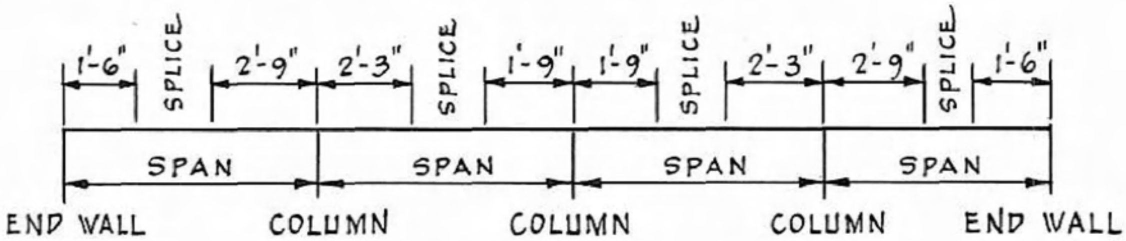
(1) For 3-span beams, splices in one lamination may be made as shown in the following diagram.



3-SPAN BEAM

Note: Splices in one lamination may be made over centre supports.

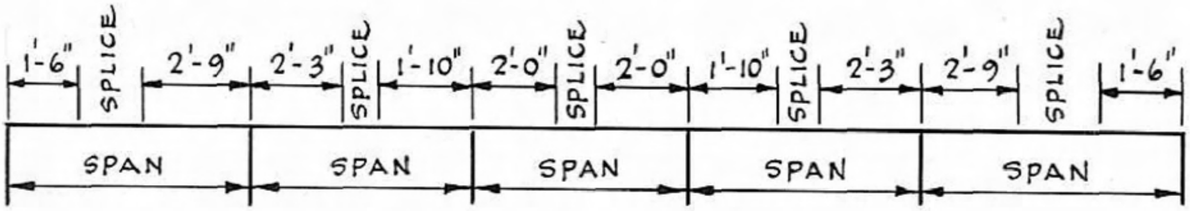
(2) For 4-span beams, splices in one lamination may be made as shown in the following diagram.



4-SPAN BEAM

Note: Splice in one lamination may be made over centre support.

(3) For 5-span beams, splices in one lamination may be made as shown in the following diagram.



5 - SPAN BEAM

Note: Splices in one lamination may be made over two centre supports.

In all three of the beams for which possible locations for splices have been given, adequate spiking together of the 2 inch material is very important. Also, imperfections such as large knots, checks, shakes, and short pieces of lumber should be guarded against.

The purpose in good house framing is to provide adequate strength and stiffness in the finished structure under normal conditions of use and climatic loadings. This purpose can only be fulfilled by:

(1) careful selection of size and grade of lumber;

(2) proper arrangement and fastening of members and components which act together; and

(3) good carpentry.