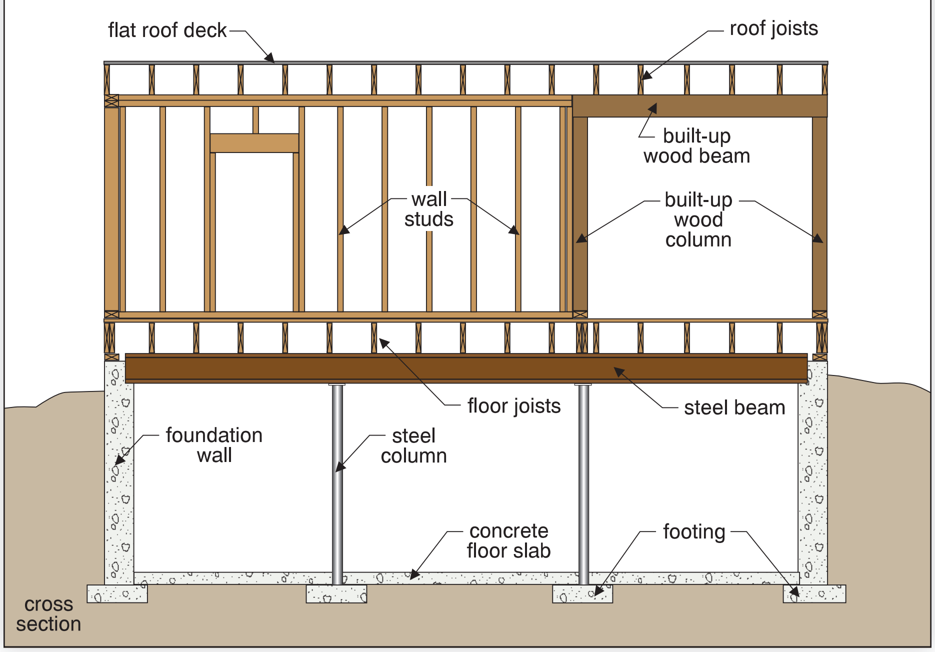
5.0 Beams (Girders)

FUNCTION

Beams (girders) are large horizontal members that carry the floor loads from the floors, walls and/or roofs to the columns or foundation walls. Floor joists rest directly on beams. Walls and columns often sit on floors, so they may rest indirectly on beams.

Beams - shown in relation to house structure



MATERIALS

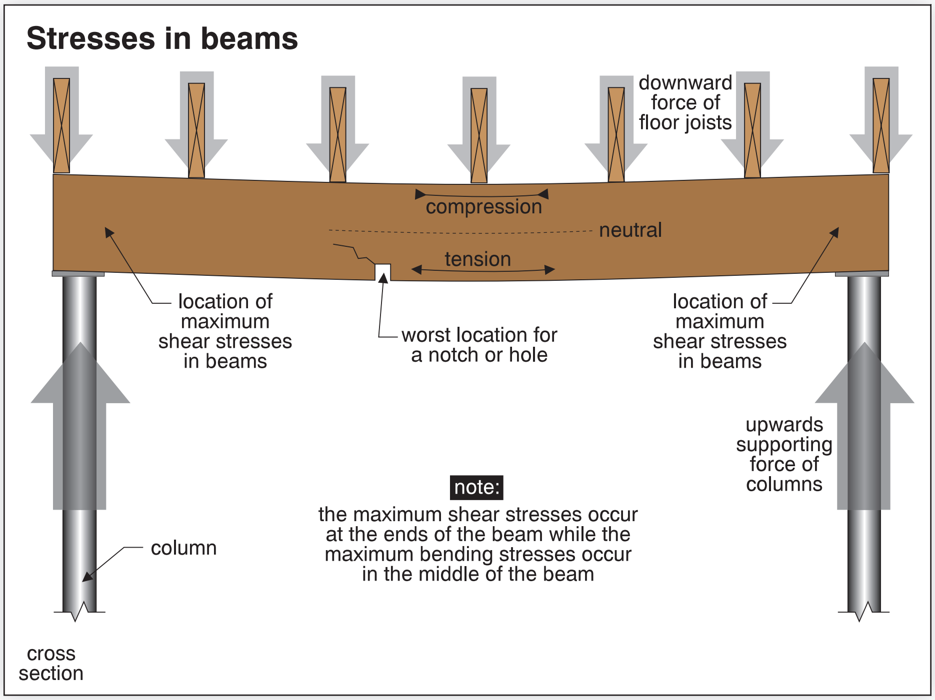
Beams are traditionally wood or steel. Wood beams might be solid, built-up, **laminated (glulams), laminated veneer lumber** (**LVL** – think of it as overgrown plywood), **laminated strand lumber** (**LSL**) or **parallel strand lumber** (**PSL**). These last four are known as **engineered wood** products.

LOADS ON BEAMS

Beams see primarily vertical loads from the weight of floor systems and the live loads above. Lateral loads or tension (uplift) forces may be induced by wind. Beams might fail in bending or shear. Bending is, of course, a combination of compression (felt by the top part of the beam) and tension (felt by the bottom part of the beam).

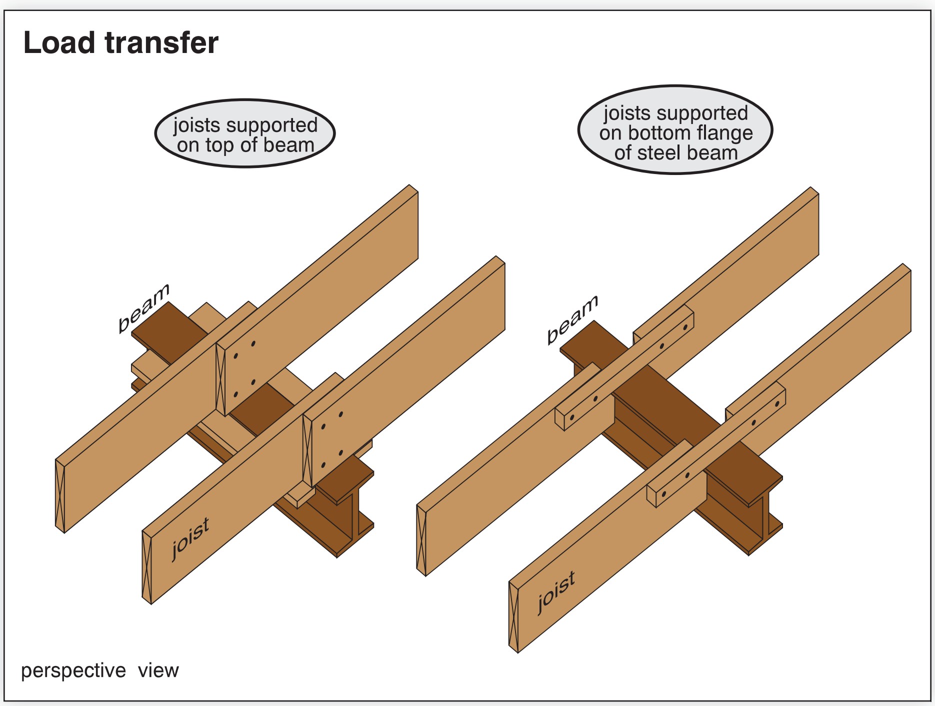
NOTCHING WORSE IN BOTTOM

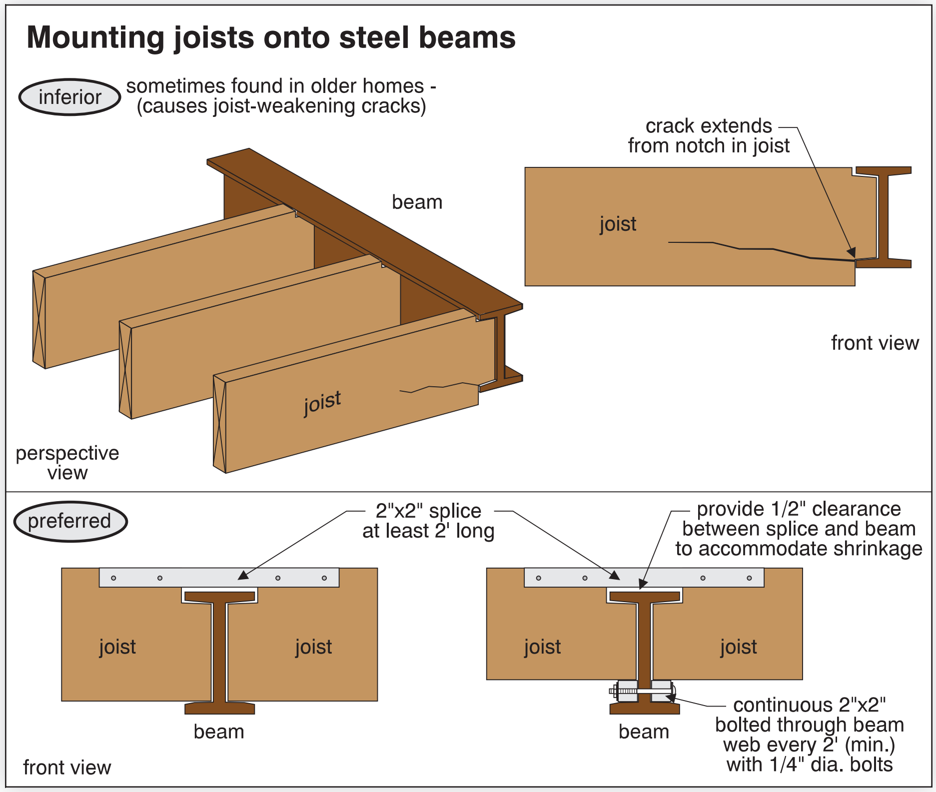
Wood is fairly good in both tension and compression, but it is slightly better in compression. A notch cut in the bottom edge of a beam is more likely to result in failure than one cut in the top edge, although as a general rule, notches and holes should not be cut in beams.



LOAD TRANSFER

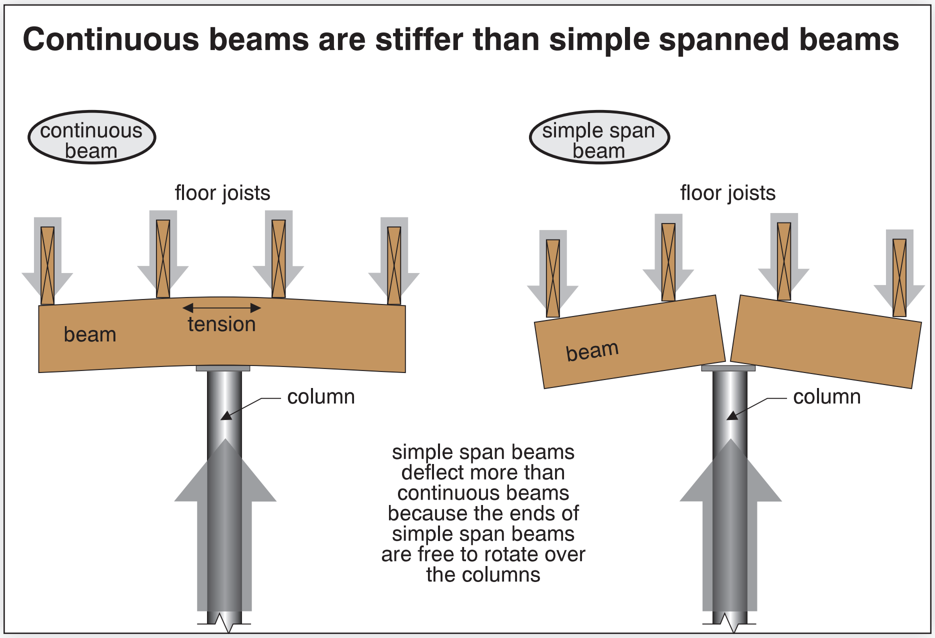
Beams transfer their loads vertically to columns or foundations. Beams may receive their loads on a vertical or horizontal face. Joists may rest on top of beams or be fastened to the sides of beams. Joists may also be supported on the bottom flange of a steel beam.





BEARING Beams require 3 inches of solid bearing at each support point if resting on concrete or masonry, and 1½ inches if resting on wood or metal. (In Canada, beams require 3½ inches of end bearing on any material.) The bearing should be the full width of the beam to avoid crushing or rotation. The end bearing should be level and continuous.

CONTINUOUS BEAMS ARE STIFFER THAN SIMPLY SUPPORTED Beams are important fundamental structural members. Beams or joists that are continuous over an intermediate support deflect less than individual beams that run from one support to another. Many builders take advantage of this by using long beams with several intermediate supports. A more rigid floor system is achieved this way.



5.1 Conditions

Commonly found beam problems include –

1. rust
2. rot or insect damage
3. sag
4. poor bearing
5. rotated or twisted beams
6. split or damaged
7. notches or holes
8. poor connections of built-up components
9. weak connections to columns
10. weak connections to joists
11. inadequate lateral support
12. concentrated loads
13. missing beam sections
14. prior repairs

5.1.1 Rust

CAUSES Steel beams can rust, although this is not a common problem. High moisture levels often combined with incomplete shop priming paint are the causes.

STRATEGY If rust is experienced, it is most likely to be where the beam rests in a pocket in an exterior foundation wall. Check this area closely.

5.1.2 Rot or insect damage

STRATEGY We've talked about looking for these in various spots. Again, rot is most likely where the beam rests on the foundation wall near the building exterior. Probe with a screwdriver or awl wherever beams are exposed.

SOIL CLEARANCE We've also discussed the need for beams to be at least 12 inches above the soil in earth-floor crawlspaces.

5.1.3 Sag

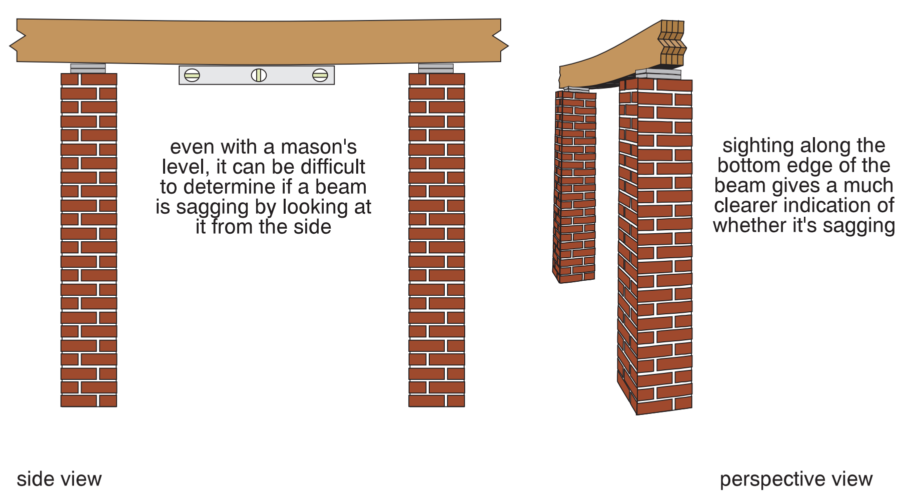
CAUSES Beams may sag because they are overspanned for their size. Another way to look at this is to say that they are undersized for their span.

This may be –

- an original construction mistake
- the result of construction activities in the house (such as adding another floor)
- the result of removing intermediate supports (columns)

STRATEGY Sight along the underside of beams between supports to look for sag. In some cases, a mason's level is necessary, although if you can't see the sag with your naked eye, it's probably not serious enough to worry about.

Sight along beams to check for sag



5.1.4 Inadequate bearing

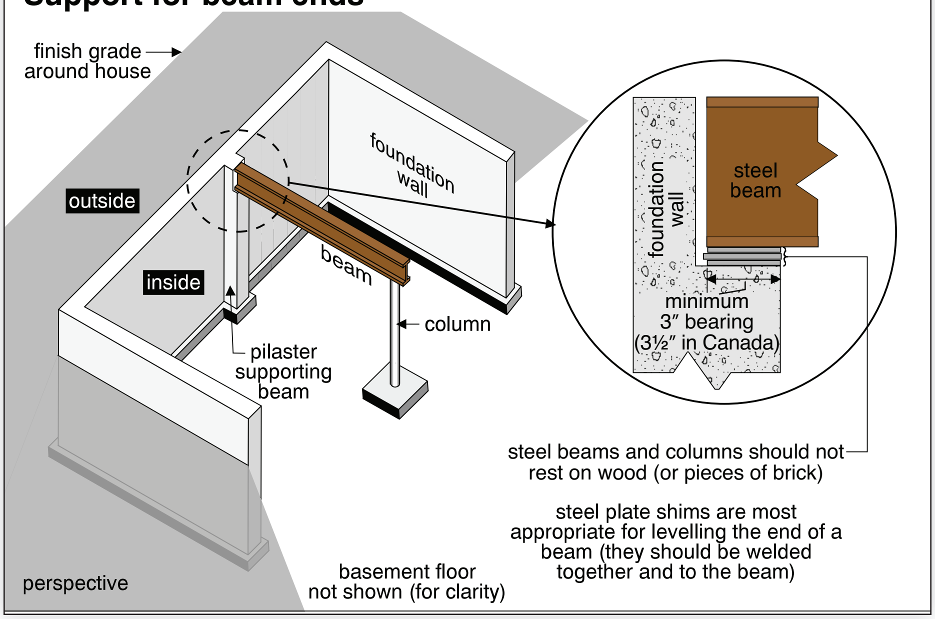
Steel or wood beams should rest on flat, full width bearing surfaces.

CAUSES Where bearing is inadequate, it may be the result of –

1. an original construction mistake
2. deterioration of the foundation material or column
3. settlement of the foundation or column
4. sagging of the beam
5. loss, movement or crushing of shims between the bottom of the beam and the foundation or column

STRATEGY Steel beams should only be supported with steel shims. Steel shims should be welded to the beam so they will not move. Watch for shims that have slid out from their position. Watch also for wood shims under steel beams. They often crush and creep. Shims will often move because the top surface of the foundation wall is not level.

Support for beam ends



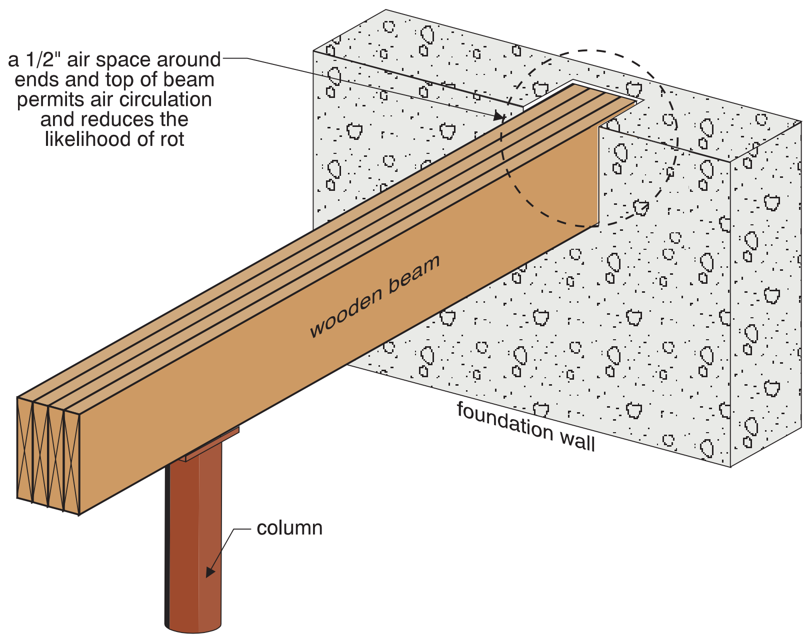
Wood beams can sit on wood shims, although they should provide continuous bearing on the top and bottom of the shim. The shims should be secured in place with adhesive or mechanical fasteners. The shims should be of a wood at least as hard and dense and the beams. Cedar is soft and doesn't make good shims.

BEAMS REST ON SOLID MASONRY Beams on masonry walls should rest on at least 4 inches of solid masonry in thickness (Canada says 7½ inches). Many recommend that the beam ends rest on solid masonry or concrete all the way down to the footing. In any case, beams should not rest directly on a hollow concrete block.

SPACE AROUND BEAMS IN FOUNDATION POCKETS

Where beams sit in foundation walls, the end, top and sides should have a ½ inch air space to allow the wood to dry out. If a wood beam is buried in a concrete or masonry foundation wall, it is more likely to rot. In some cases, the end of the beam in the foundation is coated with pressure treating chemicals to make the beam more rot resistant.

Air gaps around ends of wooden beams

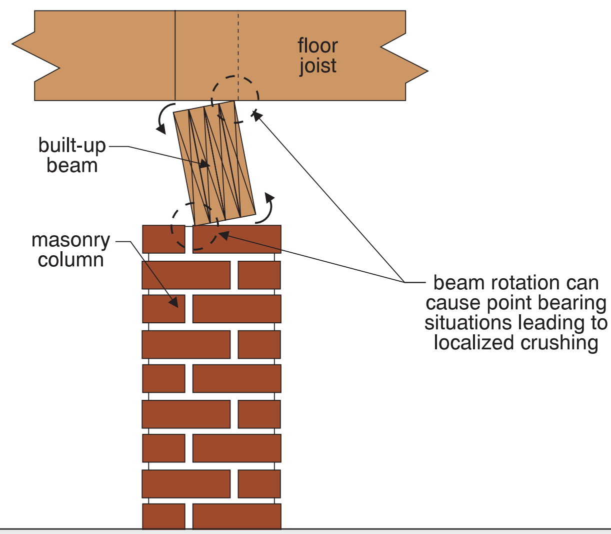


5.1.5 Rotated or twisted beams

CAUSES Beams may rotate or twist because of natural warping on drying, or they may twist as a result of the live loads imposed on them. Tall, slender wood structural members in a horizontal orientation (beams and joists) will want to twist to the flat position when loaded from the top. This tendency to twist can cause point loads and crushing.

STRATEGY Watch for beam rotation creating point bearing situations and crushing at joists, columns and foundations.

Rotated or twisted beams



5.1.6 Split or damaged wood beams

CAUSES Wood may split as it dries, forming **checks**. Checks generally have a starting and ending point within the beam itself (assuming the beam is solid wood). Checking is not considered serious unless the checks go all the way through the beam. Checking in the sides of beams is somewhat more serious than in the tops or bottoms. In most cases, it's not a problem.

SPLITS Splits in beams are more serious than checks and are usually the result of notching of the beams or weak end bearing connections. Splitting of beams is a shear failure. Shear failures in beams are unusual without a considerable amount of bending, unless the beam has been weakened by notching or drilling.

STRATEGY Where you see gaps in a beam, try to identify whether they are the result of checking caused by drying of the wood, or splitting. Splits usually begin at an edge or end of the beam or a notch. Checks are more likely to start and stop within the length of the beam.

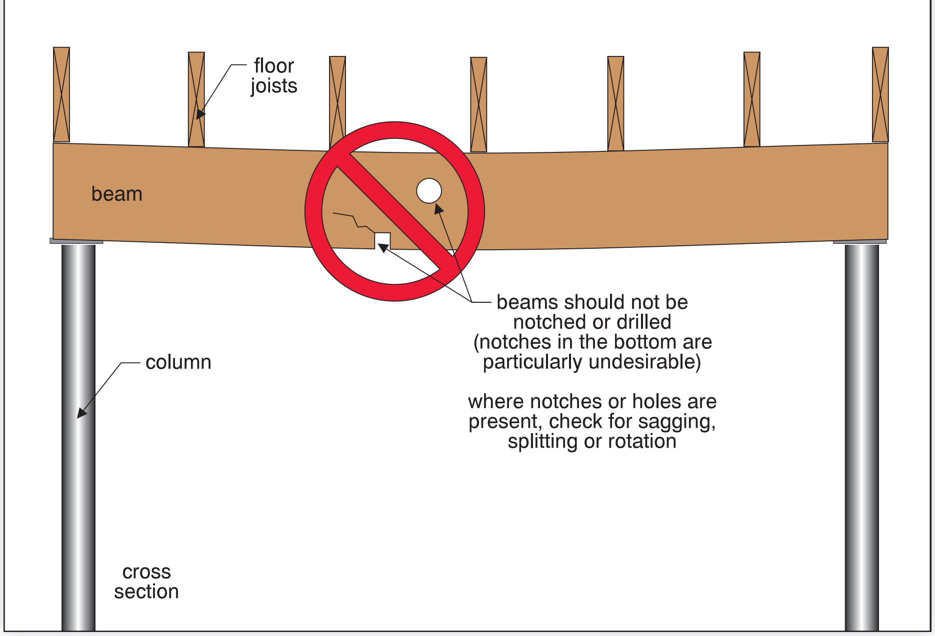
Watch for any places where the beam may be split. Depending on the size and location of the split, the problem may be serious or trivial. You should be able to evaluate the performance of the beam given the damage that it has incurred. Is the beam sagging, twisting or showing evidence of any distress as a result? Has the bearing of the beam been lost or weakened as a result of the split? The older the split is, the more time there has been for problems to manifest themselves.

5.1.7 Notches or holes

Beams should not be notched and holes should not be drilled. Where this has been done, check for sag, splitting or rotation of the beam, especially if the notches are in the middle third of the span.

Repairs can be made relatively inexpensively to wood beams, and may make sense as a preventative measure even if you see no signs of distress.

Notches or holes not allowed in beams

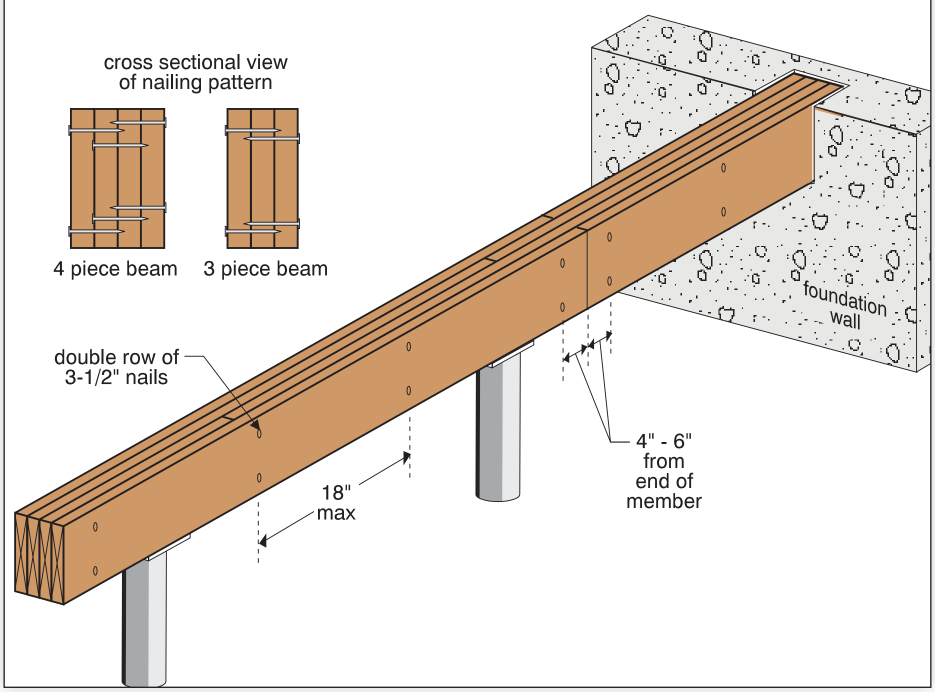


5.1.8 Weak connections of built-up components

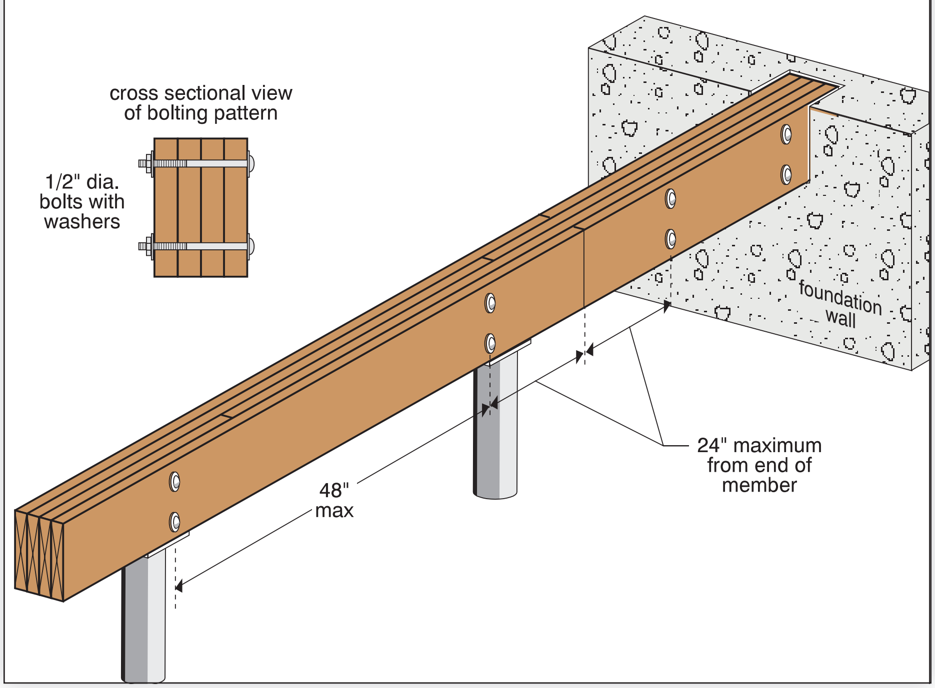
Rather than a single solid beam, a beam may be **built-up** out of two inch dimensional lumber.

Built-up wood beams are typically made up of three, four or five two by eights (2x8s) or two by tens (2x10s). These must be nailed or bolted together so that all the individual members act as a single component. Generally speaking, two sets (one for each side) of two nails are visible every 18 inches along the length of the beam.

Nailing of built-up wooden beams



Bolting of built-up wooden beams



Joints in **individual** beam members are best made over bearing points. Continuous span beams (not simple span beams) may have joints within 6 inches of the end quarter point of the beam span. In this area, the bending forces and the shear forces are relatively low. The joint is permitted near interior supports only, not near the foundation wall. There shouldn't be more than one joint at each quarter point. If there are four, two by eights in the beam, three must be continuous through the quarter point. Joints should be at least four feet apart.

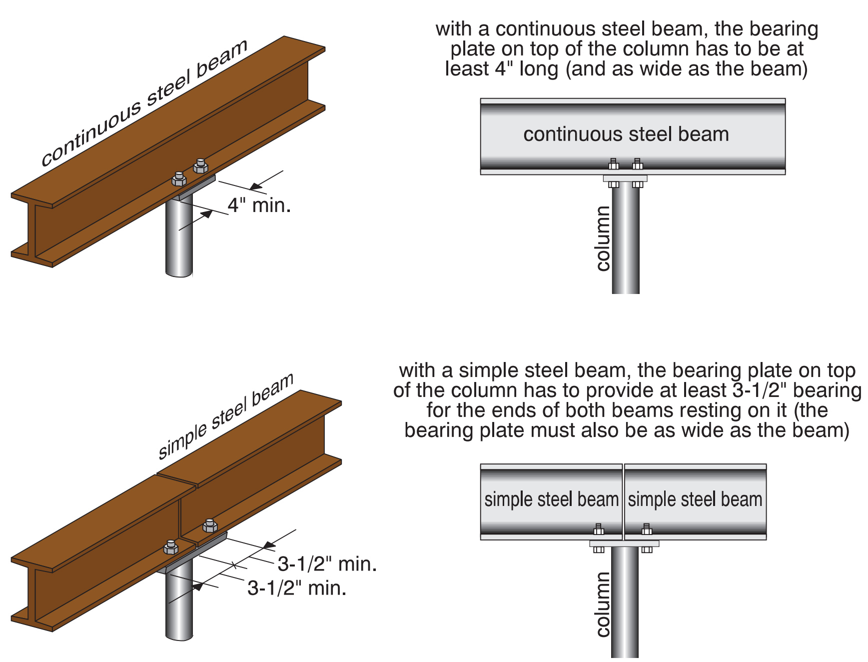
STRATEGY Look for evidence of built-up beam members pulling apart. Where butt joints occur in beam components, ensure that there is no individual sag of these components, nor separation of the joint ends. Sight along the underside of the beam for sagging.

5.1.9 Weak connections to columns

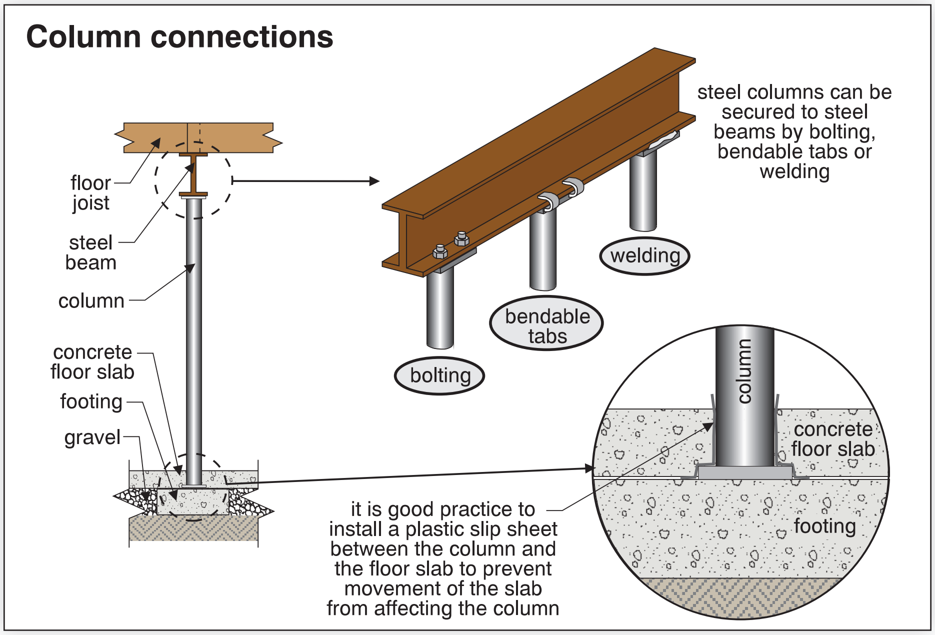
CAUSES This is an installation issue, typically, although it can be a result of column or beam movement.

STRATEGY We've talked about the importance of adequate bearing surface for beams on columns. The column bearing plates should be as wide as the beam, and at least 3½ inches in length for each beam end supported. Plate modifications are often required on steel columns to achieve this bearing. Where it is not provided, recommend changes.

Beam bearing - simple versus continuous beams



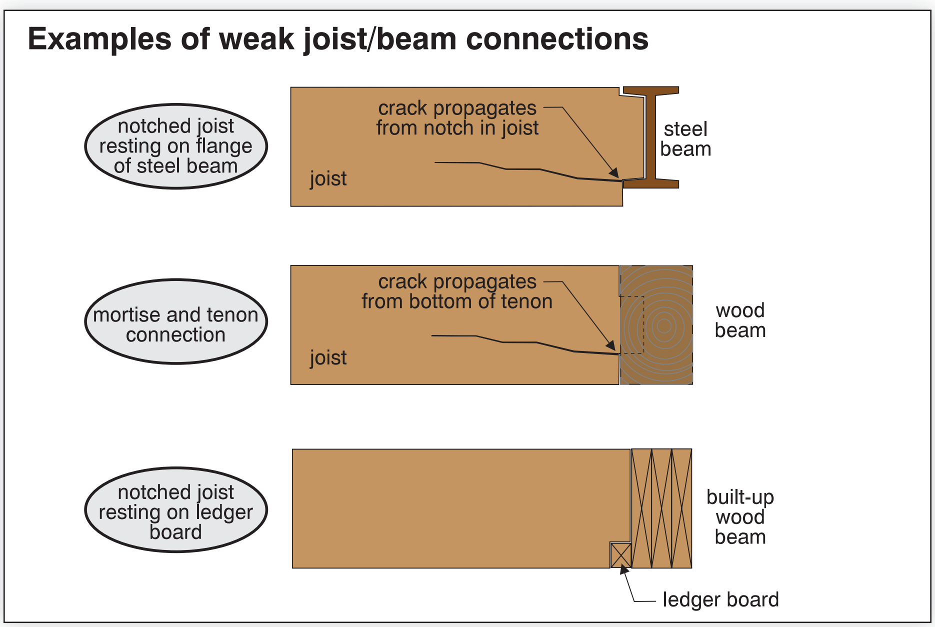
We've also talked about steel columns to steel beam connections. Watch for bolts, welds or tabs that are not secure.



5.1.10 Weak connections to joists

Joists must be properly secured to beams to successfully transfer their load. There are several joist/beam connection methods, some of which are better than others.

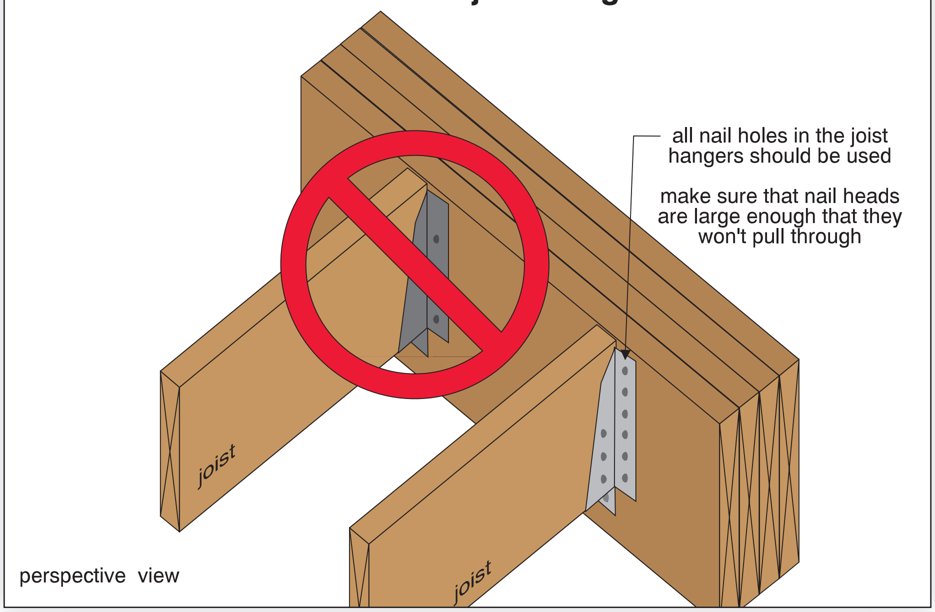
STRATEGY Watch for evidence of movement of the joists relative to the beams. The joists and beams should act as a unit. Pay particular attention to notched joists resting on beams or ledger boards, and to mortise and tenon joints.



JOIST HANGERS

Joist hangers must be the right size for the joists, and must have an adequate number of the proper nails (not roofing nails!). Typically, all nail holes in the hangers should be used. You can't comment on nail type, other than to make sure the head is big enough that it won't pull through. You can check whether there's a nail in each hole.

Watch for insufficient nails in joist hangers



Watch for joists that are sagging or twisted. Either of these may weaken the joist/beam connection. Joists must extend at least 1½ inches onto or into the beam support.

5.1.11 Lateral support

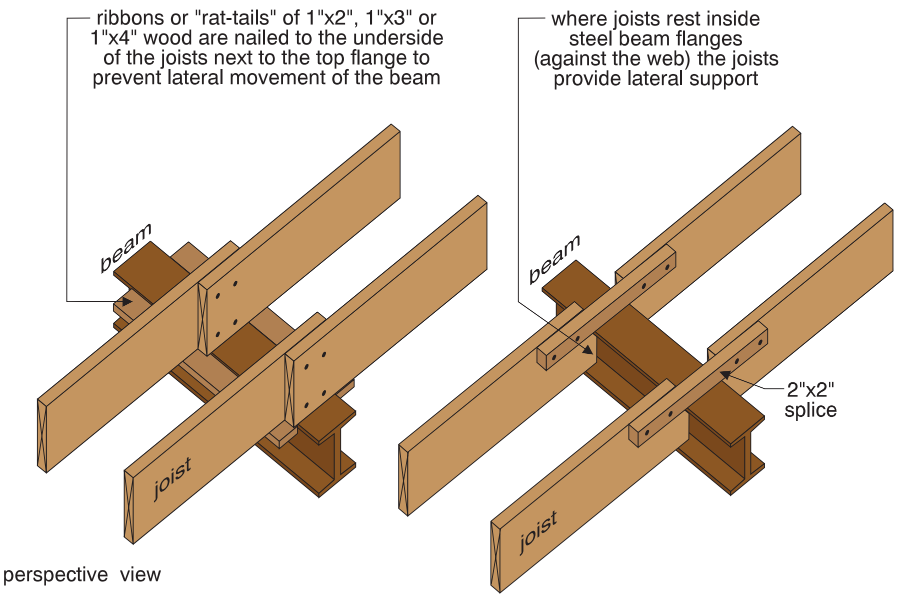
A vulnerable arrangement with respect to lateral support is wood joists resting on top of a steel beam. Let's look at a few situations.

STRATEGY

Look for lateral bracing on either side of steel and wood beams.

1. Floor joists nailed to the tops and sides of wood beams provide adequate lateral bracing.
2. Ribbon boards (one by two, for example) run along either side of the top flanges of steel beams are nailed to the underside of joists to provide lateral bracing. These boards also keep the joists from twisting.
3. Where joists rest inside steel beam flanges against the web, the joists provide adequate lateral support.

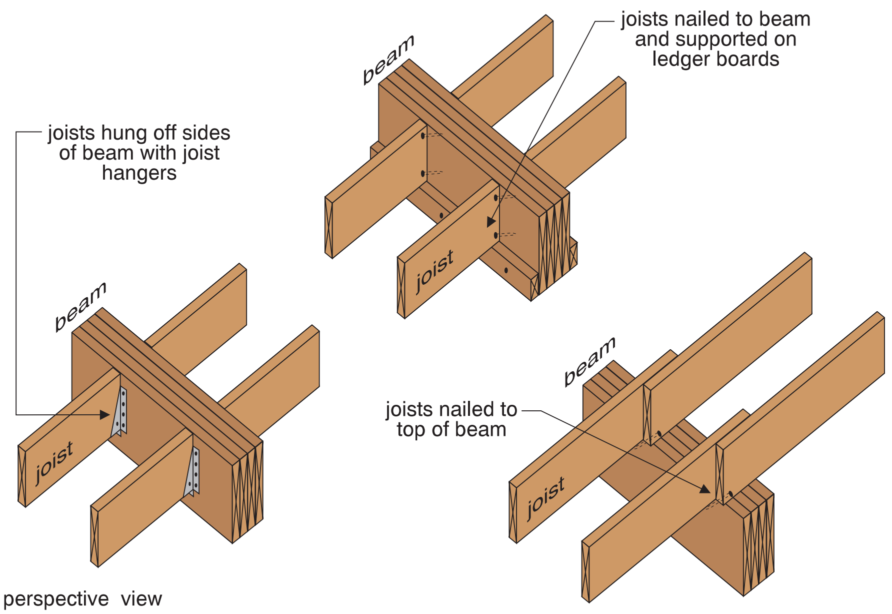
Lateral support for steel beams



perspective view

4. Where joists are hung off the sides of beams with joist hangers or ledger boards, adequate lateral support is provided.

Lateral support for wood beams



perspective view

Most other joist/beam connections inherently provide lateral support.

5.1.12 Concentrated loads

Where a beam is loaded near its midpoint by a column from above, for example, the beam may be overstressed.

TWO COLUMNS INSTEAD OF SEVERAL JOISTS

Most beams are **uniformly loaded**. This means that several floor joists and wall studs rest on top of the beam along its length. Where a wall is removed or rooms are rearranged above a beam, loads from the next story may be collected and transferred down through one or two columns instead of a continuous bearing wall. This changes the loading on the beam below from a widely distributed load to a concentrated load.

As a general rule, concentrated loads should be carried straight down through the building to a footing. Where a column bears on the mid-span of a beam, the beam is likely to deflect excessively. The solution is to provide a column under the beam, immediately below the column above.

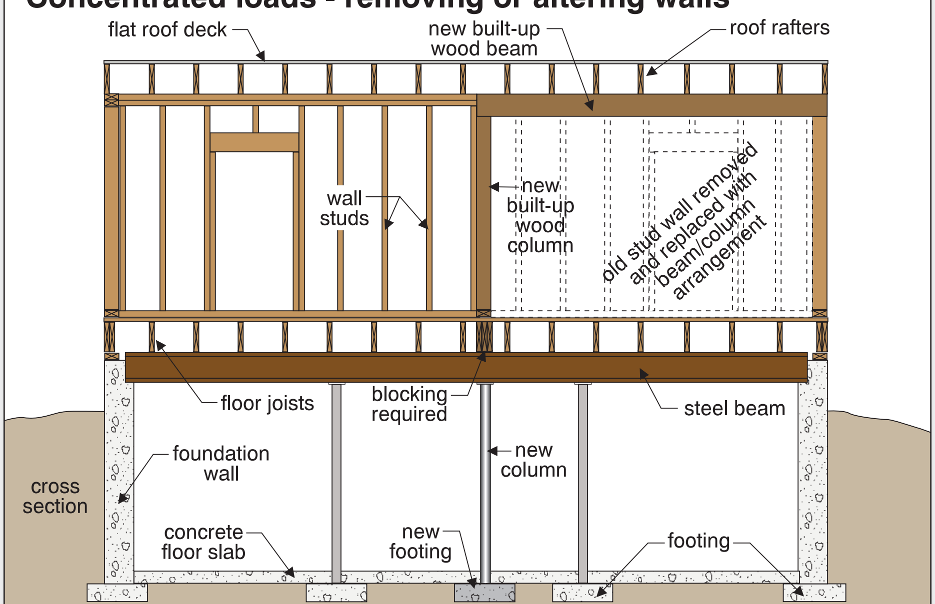
COLUMNS ON SUBFLOORS

There is another problem that sometimes occurs when a column rests on a subfloor. It's common for the subfloor to be supported by joists, and the joists rest on top of a beam. A column may be resting on the subfloor between two joists. The subfloor will deflect once the live loads are applied, by people, furniture, wind and snow.

THINK VERTICALLY

The load from the column must be carried continuously. Blocking is required under the subfloor immediately below the column. The blocking can carry the load from the column through the subfloor, down to the beam. The beam, in turn, should have a column immediately below the blocking. At the bottom of the column should be a footing. Any discontinuity in this vertical transferring of loads can lead to structural distress.

Concentrated loads - removing or altering walls



when a wall is removed, the uniform load on the beam is converted to a concentrated load that must be carried all the way down to the footings (see shaded area of illustration) watch for solid blocking to transfer the load from the column above to the beam, and a new column below the beam

As a general rule, when thinking about how structures react, think vertically, try to follow loads down through the building and watch for the weak connections or offsets. We'll talk more about offset vertical loads when we talk about bearing walls.

5.1.13 Missing beam sections

BEAMS REMOVED

It's rare for beams to be missing entirely. However, it's not unusual for individual sections of beams to have been removed. These areas are usually easy to identify because of the discontinuity in the beams and the lack of support for joists.

JOISTS HANGING IN MID AIR

It is strange how joists, in some cases, can remain seemingly supported in mid-air. In reality, the subfloor is holding the joists up and the loads are being transferred to supported joists on either side. If joists are unsupported for long enough, the live loads will usually deflect this area.

DELAYED REACTIONS

The movement may not appear as soon as a section of beam is removed, but may occur with changes in lifestyle and house loading, which always occur when a house changes hands. Just because a beam has been cut out for some time and hasn't sagged or the joists haven't moved, does not mean that we can ignore the situation. When the new family brings their aquarium, bookcase or record collection into the house and puts it where the beam has been cut, the result will be significant.

5.1.14 Prior repairs

WAS REPAIR SUCCESSFUL?

As always, where a beam or any structural member has been repaired, you should ask yourself why the repair was necessary and whether it is likely to be successful. Some situations are difficult to analyze because a resupported beam has sagged. Has the sagging continued and worsened despite the reinforcing? Has the sagging been stopped by the repair?

SUBSEQUENT MOVEMENT

Some detective work is required here to evaluate the reinforcement and try to determine whether subsequent movement has occurred since the reinforcing was added. The reinforcing can be in the form of sistering of beams or adding columns below. Sometimes the columns added below are very informal. They are often too slender, do not provide enough bearing at the top, are not well connected at the top, do not rest on a footing but simply on a thin concrete floor, and are often not connected directly to the floor and/or footing.

Where you see evidence of continued movement, further investigation and repair should be recommended. Where there is no evidence of on-going movement, you may want to recommend monitoring.

MONITOR MOVEMENT

One way to monitor beam performance is to measure the distance from the mid point of the beam (where sag will be greatest) down to the floor, and write the results on the beam at the point you measured, with the date. You can measure periodically thereafter to find out if it's getting worse. This works great unless the floor moves!