# The Art & Science of Stair Design

## *Follow the Formulas, and You Won't Trip Up*

*by Harris Hyman, P.E.*

One of the tasks the designer usually leaves for the builder to work out is the design of stairs. This seems to be true whether the plans are prepared by a service, an architect, or even the builder's own pet draftsman.

The only exception seems to be in public buildings, when the plans must be reviewed by the fire marshal; here the stairs are part of the exit system and must conform to a relatively rigid set of specifications. The rest of the time, stair layout is a site project.

Good stair design goes almost completely unnoticed in the building's interior. This is, of course, part of the challenge of stair design. When the stairs get noticed, it generally is because they are uncomfortable or clumsy. On the good ones, you climb and descend without thinking about it. At best, the builder can avoid complaints about the stairs; compliments are never awarded.

The generally accepted rule for well-designed stairs is

$$(2 \times R) + T = 25"$$

meaning that the height of two risers plus the width of a single tread should equal 25 inches. Many combinations fit this rule: seven-inch riser with 11-inch tread, eight-inch riser with nine-inch tread, six-inch riser with 13-inch tread, and most everything in between.

A look at the formula shows that the tread must become shorter with steeper risers, and the tread must lengthen with shallower risers. This is based on the fact that the femur (the thighbone) has relatively little variation in humans. The average length is about 19 inches, and the difference in femur length between the shortest and tallest adults is only about two inches. The length of the femur gives you the swing in your step, and this swing can cover only a limited ground, either up (steep stairs) or out (shallow stairs).

Recent changes in the NFPA fire codes for public buildings have fixed the stairways at seven-inch rise and eleven-inch tread. This gradually is becoming a standard in residential construction as well. The wisdom of this rule can be argued, considering both comfort and the amount of space used by the stairway. The shallower treads eat up much more space.

An example might be useful. A typical floor-to-floor dimension is nine feet (or 108 inches). To lay out a set of stairs, guess at a typical riser. Eight inches is useful for a start.

108" total rise / 8" per riser = 13.5 risers

This obviously won't work since there must be an even number of risers, but it puts us in the ballpark. So refigure:

108" rise / 14 risers = 7¾" per riser

By the rule of $(2 \times R) + T = 25"$, the tread should be 9½ inches. The total length of the stairway is calculated by:

length = (n - 1) × T

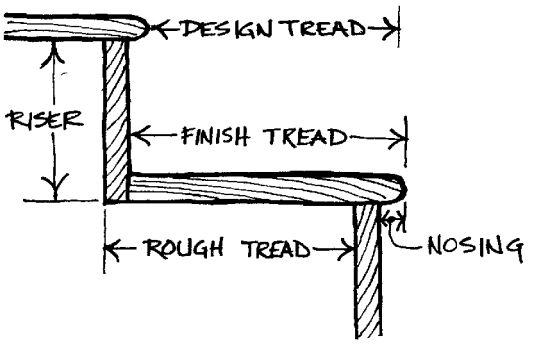
10'3½" = (14 risers - 1) × 9½" per tread

If the 10'3½" is available for the stairs, you're set, but if it is not, stairs that are a little steeper might fit. To make them steeper, try one less riser to cover the same height.

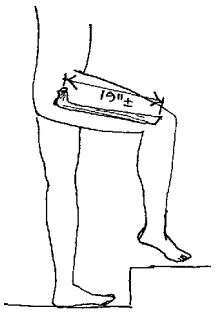
108" rise / 13 risers = 8-5/16" per riser

The corresponding tread must be 8⅜ inches. The total stairway length then becomes 8'4½", which might fit the plan better. Two or three tries should produce the right design specification for most cases.

There are a few things to keep in mind. The length of the tread that was calculated was the *rough* tread,




*The design tread, from nosing to nosing, measures the same as the rough tread cut in the stringers. The nosing adds an inch or so to the finish tread.*




*Stair design is based on human anatomy—in particular the length of the thighbone, which varies little from one person to another.*

the tread cut in the stringer, or "carriage," as it is called down east. The *finish* tread includes a nosing that extends out over the riser. You'll have to cut wood that is 1¼ inches wider—and perhaps even two inches wider—than the rough tread, depending on how you build the stairs.

If the stairs already have been designed and are specced on the drawings, did the architect mean the rough or the finish treads with the number on the drawing? My guess is that it would be the rough tread, since this is the result of the design calculations.

The other troublesome item comes from the fact that stairs run from finish floor to finish floor, and the treads rest on top of the stringers. The stringer must be set lower than the treads by the tread thickness. I have never seen a project where the builder has actually installed a stairway with an excessive bottom step and a short top step, but I have seen a number of stringers lying on the scrap pile. (I've done it too.)

Open risers are a little out of fashion these days, but when this system is used, the treads should be about 1½ inches wider than the "design" treads. The extra width is taken up in overlap. The design tread is still nose-to-nose.

The maximum convenient height for a riser is about nine inches. Beyond that, the stairway becomes a ladder. The basic difference between a stair and a ladder is that it is most convenient to descend a ladder facing *in*, while you descend stairways facing *out*.

In between stairways and ladders are stepladders, which are not particularly usable in most buildings. So, if a stairway requires a slope of more than 52 degrees (nine-inch risers, seven-inch treads), the best approach is to go directly to ladders. The maximum rise on a ladder should be 12½ inches.

There also is a minimum slope to a stairway, with a maximum tread of 17 inches and a corresponding rise of 4½ inches. If a stairway is any shallower, it should be a ramp. If the ramp is to be accessible by wheelchair, the maximum slope (by code) should be 1:12.

Handrails usually are set at 2'10" above the front edge of the stairs. That is, the vertical measurement from the tip of the nosing to the top of the handrail should be 34 inches. This conforms to most codes and to general comfort among adults.

Headroom—also measured vertically from the tip of the nosing to the ceiling above—should be run from about 7'6" on the very shallow stairways to about 9'0" on the very steep ones.

These are the ordinary design approaches—"standards" is a little too strong a word. They work well enough in most cases, and following them should keep the builder out of most trouble. They are, however, based on going *up* the stairs, not *down.*

Descending is a slightly awkward movement, really a controlled fall. Some people, mostly young, bounce down stairs rather than stepping down. Because of these problems with descending, the rules for stair design may be modified in the near future.

There is also some question about the nosing, which may also be critical to good design. If the nosing is too short, you tend to kick the risers, and if it is too long, there is a tendency to stumble over it. Current typical practice uses one inch to 1¼ inches.

Codes are under constant development, and builders should check them over from time to time. Except for public buildings, there are no codes in rural Maine, but they are used frequently in more urban areas. The residential contractor also should keep an eye on the FmHA Minimum Property Standards so as not to close off this market. A couple of local banks use the MPS as "standards" for house building.

And finally, remember to use the electric screwdriver sitting in your toolbox. Stairs assembled with some glue and drywall screws are really squeak-proof. And you *know* how home owners fuss about squeaky stairs. ■

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