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SIGNIFICANCE OF THE "FACTOR OF SAFETY" IN WORKING STRESSES FOR STRUCTURAL TIMBERS

The belief that a timber with a so-called "factor of safety" of 3 or 4 will carry three or four times the load for which it is designed is erroneous and has been the cause of failures through the overloading of structures. Only a small part of the usual "factor of safety" for wood is available for taking care of overloading; most of it is required to adjust for the known variability in the strength of clear wood, the effect of defects, the moisture conditions of service, and the duration of the load.

Some of the working stresses assigned by the Forest Products Laboratory to structural timbers, when compared with laboratory test data on small, clear specimens, have an apparent "factor of safety" as high as 10, but in reality such factors make allowance for an accidental overload of only 50 per cent. A general explanation of how this "factor of safety" is taken up largely in adjusting laboratory test data to service conditions is given below.

VARIATIONS IN THE STRENGTH OF CLEAR WOOD. The strength of clear wood varies a great deal within a species. It is not uncommon to find one piece of wood twice as strong as another piece of the same species, although both pieces may be clear, straight-grained, and sound. It is evident, therefore, that part of the "factor of safety" as measured by comparison of working stresses with average strength values for a species would be used up in making the working stresses safe for the weaker timbers. If a builder could sort over his timbers and cull out those that fall below a prescribed minimum strength, he could by rejection of relatively few timbers assign his structure considerably higher

working stresses without reducing his true factor of safety. The dense, strong timbers of Douglas fir and southern yellow pine, for example, can be selected by inspection and they can be assigned stresses 1/6 higher than unclassified timbers of the same species.

EFFECT OF DEFECTS. Defects have about the same effect on strength in all species; that is, a given defect in a given location in a given timber reduces the strength of the timber from the strength of clear wood by about the same percentage, whatever the species. Grading rules applicable to all species have been formulated by the Forest Products Laboratory limiting the size and location of defects in timbers for the various grades, and provisions have been made in the permitted stress for loss of strength resulting from the defects allowable in each grade.

MOISTURE CONDITIONS OF SERVICE. Dry wood fibers are stronger than wet wood fibers. Because of the checking that accompanies drying, however, many large timbers are no stronger after drying than when green; hence the stresses permitted in the dry timbers are based on green strength values. For large timbers in damp locations the working stresses must be decreased to make allowance for some deterioration which in such timbers is not offset by any gain in strength due to the dryness of the fibers. In small high-grade timbers checking is not serious; dry 2x4's, for example, are actually somewhat stronger than green 2x4's. In order to avoid the inconvenience, however, of having two working stresses for timbers in dry locations—one for large timbers and one for small timbers—the size of defects permissible in each grade for small dimension timbers has been increased.

DURATION OF LOAD. Part of the "factor of safety" is necessary to make timbers safe for loads that may be left on a long time. Laboratory tests indicate that if a certain load will cause failure in a structure if it is left on for a given time, nine-tenths of that load

would cause failure if left on ten times as long. If a builder could be sure that his structure would never be subjected to the design load for long periods, he could safely use higher stresses. It is for this reason that in designing for combined live, dead, and wind loads, stresses 50 per cent higher than those permissible if the load were made up of live and dead loads alone may be used, provided the resulting sections are not less than those required for the actual live and dead loads alone.

OVERLOADING. Part of the "factor of safety" plays the role of a true factor of safety; that is, it makes allowance for small accidental overloads that may be left on a structure for a short time. This factor is not designed to take care of large overloads. In good construction occasional timbers might be expected to fail immediately if they were subjected to only twice their design loads. Forty per cent of the timbers would probably fail if such loads were applied for a long time. It is evident, therefore, that timbers should not be deliberately subjected to long-time loads much greater than the design load.