LOADS AND STRENGTH OF ROOFS.

In making estimates of the weights of roofs it is essential that external appendages, such as lantern lights, ventilators, etc., should all be included, as well as ceilings, attic floors, water-tank and water, and any quantity of fixtures, furniture and storage liable to be sustained by the roof supports. All articles and details of the roof structure and the external and internal appendages should be estimated at their maximum weights, so that the gross estimate shall cover all probable strain-producing loads that are likely to be encountered in the use of the building. In addition to these dead loads there should, in the case of occupied attics, be an allowance for the live load of occupants. This allowance may be somewhat less than the usual allowance of 1¼cwt. for the ordinary floors of dwellings per square foot of their area, as the probability of its containing a moving crowd would be very remote. Probably a ½cwt. to ¾cwt. per square foot would be a sufficient allowance to make for this purpose to include ordinary furniture, but would be exclusive of the weight of the flooring joists, plastered ceiling, etc. The weight of a full water-tank of 2ft. 7in. height of galvanized iron with fittings would be about 2¼cwt. to 2½cwt. per square foot of bottom area, the weight of water being 10lb. per imperial gallon, and there being about 6¼ gallons in a cubic foot. The weight of single ceiling joists of dry fir to sustain attic floor, together with flooring boards, may range from 9lb. to 12lb. per superficial foot; lath and plaster ceiling—two coats 9lb., three coats 10lb. per foot super; ceiling joists for counter ceiling adds 2¼lb. to 2½lb. per square foot. The weight of roof trusses varies with span and pitch, the spacing apart, and the kinds of materials used in the construction. Approximate weights may be obtained by reducing it to the horizontal projection of the floor area covered by the roof, and then multiply a unit area as a square foot by the weight of the horizontal projection of the portion of the roof supported by the truss—i.e., the bay or the space between the centres of two adjacent trusses. On this basis an average may be arrived at for the ordinary pitch of one-quarter span, using a king-post truss, say, up to 35ft. span, and for larger spans a queen-post truss. The weight of a dry fir truss complete, including tie-beam, for 20ft. span will be 1¼lb. per square foot of floor area covered by the half of its bay on each side of it; 30ft. span, 1 9-10lb.; 40 ft. span, 2⅛lb.; 50ft. span, 2 3-5lb.; 60ft. span, 3⅛lb.; 70ft. span, 3 4-5lb.; 80ft. span, 4⅓lb.; 90ft. span, 4 4-5lb.; 100ft. span, 5⅓lb.; for each additional 10ft. of span add ½lb. For intermediate spans interpolate the corresponding proportion of the difference for the spans adjacent to it.

The purlins, ridge board, and ridge roll add 2lb. to 2½lb. per square foot of floor area covered by roof. Common rafters add about 3⅓lb. to 3 2-5lb. per foot super of floor area covered; sheating of 1in. thick boards of fir, spruce, or pine (white) 3lb. to 3½lb. per square foot of roof surface; Georgia pine, oak, ash, 5lb. per square foot. The weight of the external covering adds as follows: lead, 6cwt. to 8 cwt. per square of 100 square feet; slating laid with 3in. lap, including nails, but not battens or iron laths, for doubles 13in. by 9in. and ladies 16in. by 8 in., 8¼lb. per square foot of roof surface; countesses, 20in. by 10in., 8lb.; duchesses, 24in. by 12in., 8½lb.; tiles, 11in. by 7in., plain, with 3in. lap, mortar pointing, including laths and absorbed damp, 18lb. per square foot; pantiles, 13½in. by 9½in., including same as plain tiles, 12lb.; Italian, ridge, and furrow tiles, including pointing and damp, 14lb.; slate battens, 3½in. by 1in., for doubles, 2lb.; for countesses, 1¼lb.; zinc roofing, 14 to 16 zinc gauge, 1½lb. to 1¾lb.; galvanised iron, corrugated, 16 wire gauge, 3½lb.; 18 wire gauge, 2½lb.; 20 wire gauge, 2lb.; sheet iron, 16 wire gauge, 2½lb.; 20 wire gauge, 1½lb.; thatch, including battens, 6½lb. From the foregoing data, approximate weights of roofs can be estimated, making allowance for increase of length of rafters over the span for other roof pitches; thus if the value of the half span be 1, then the length of the rafter for quarter pitch is 1·12, for one-third span pitch 1·2, for three-sevenths span pitch 1·32, for half-span pitch 1.414. These weights of the roof, together with the weight of all appendages, all act in a vertical direction. An allowance for the weight of accumulation of snow is also made, say 5lb. per square foot of floor area covered by roof is considered sufficient for this country. In America this same allowance is made for localities such as St. Louis, Richmond, Louisville (Ky.) in north latitude about 37½deg. to 38deg.; 10lb. is allowed in Baltimore, Cincinnati, and Indianapolis; 15lb. is allowed in Philadelphia, Pittsburg, and Wheeling; 20lb. in New York City, Cleveland, Chicago, Des Moines; 25lb. in Boston, Albany, Buffalo, Milwaukee, St. Paul; 30lb. in Northern New England and New York States, Michigan and Minnesota. Some writers have suggested that the allowance for the stress produced on a roof normally to the inclination of its pitch by wind pressure of the maximum force used in practice, would sufficiently cover the allowance for snow, as before such a maximum wind force could take effect upon the windward side of the roof all the snow would have been blown off it, and hence the allowance for snow according to this suggestion need not be made, except for very cold climates. The suggestion, however, could not apply to flat roofs, "well roofs," and such as are completely sheltered by solid parapets or otherwise protected from the force of the wind. It may be observed that in cold countries the snow is generally frozen into solid ice on sides of roofs to which the sun rays have direct access. The direct stresses on the roof, therefore are distinguished as (1) the permanent loads, estimated on the basis just detailed; (2) the accidental loads—(a) as snow, and (b) wind pressure. These pressures should all be determined separately, and then any combination of them which produces the greatest sum of stresses affecting any member of the truss should the stress value to be adopted in estimating the strength and stiffness of each member thereby affected. The same principle will likewise apply to the stresses produced on the resisting planes of all joints and joint articulated connections with the truss members.

The weight of the roofing material, or the external covering of slates, tiles, etc., as well as that of the snow and the wind pressure direct or reversed, is sustained by the common rafters in the first instance. It is by them transmitted to the purlins which support the common rafters at intermediate points, their ends being supported respectively by the ridge piece or purlin, and by the wall plate. It is usual to divide the external and structural loads, acting upon the common rafters, equally between the points of support, so that each intermediate point shall have double that at each end. Such a distribution, however, assumes that the common rafters