DEVELOPMENT OF SNOW LOAD DESIGN DATA FOR THE UNITED STATES 1/

By

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Introduction

The design snow loads in use at present in the United States (except Alaska) are published in the ASA (now American National Standards Institute, ANSI) Standard A58. 1-1955 3/. The map giving the loads in psf was originally prepared by the U. S. Weather Bureau 4/ and is said to be for seasonal snow pack exceeded once in 10 years. The material in this report was later published by the Housing and Home Finance Agency 5/. Only a small amount of water equivalent of snow data were available at the time; so the analysis had to be based mostly on seasonal snowfall and an assumed value of snow density. As a result, the 10 year mean recurrence interval does not appear to bear a rational relationship to the loads given on the map. The loads in the south are much too high and all loads appear to be for a much longer mean recurrence interval. There have been numerous communications on local snow load situations and calculations, but these do not constitute a formal solution to the standards problem. Nevertheless these are a valuable contribution to general knowledge of the problem. There are many foreign standards on snow loads among the most modern and best is the Canadian standard 6/ and 7/.

As far as is known most snow load standards of other countries are based on snow depth or snow pack depth. This requires that some assumption be made about the density of the accumulation. Since the density varies quite widely and has a frequency distribution of its own, the true distribution of loads must come from the distribution of water equivalent of the snow pack. This is the basis for the proposed new ANSI Standard. The research on snow loads is still in progress and it appears certain that there will be further developments in the next few years which will lead to rapid revisions of the ANSI Standard.

Station Level Design Loads

As with all structures constantly exposed to the weather, if the structure can withstand the maximum snow load in the snow season it can withstand any other load in that season. Therefore, the proper design meteorological variable is the series of maximum annual snow pack water equivalents. These have in recent years been available from U. S. Weather Bureau first order station records. It was found that the lognormal distribution fit this extreme value series very well 8/. The distribution was fitted to some 140 first order stations by estimating the means and standard deviations of the annual extreme water equivalent for each station. Isolines were then drawn on maps of these two statistics.

While the simple lognormal distribution fits the annual extreme series at northern stations, at southern stations, a snow pack does not occur every year; so the population is a mixture of extremes and zeros, the zeros being distributed randomly among the extremes. The most general distribution of water equivalent is then a mixed distribution function given by

$$G(u) = q + p\ N(u). \qquad (1)$$

Here u is equal to ln w where w is the annual extreme water equivalent of the snow pack; N is the normal distribution function; p is the probability of a snow pack occurring, and q equals 1-p or the probablility of it not occurring. Clearly at northern stations p = 1 and q = 0 giving the ordinary lognormal distribution. Since the normal distribution is completely defined by its mean and standard deviation, equation (1) is defined at every first order station by the sample mean and standard deviation of ln w and the probability of a snow pack occurring. Contours of these three statistics were drawn which defined the water equivalent distribution at any point having a snow pack regime corresponding

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2/ Environmental Data Service, ESSA, Washington, D. C.

to the meteorological stations in its vicinity 8/.

Application to the ANSI Standard

The design value is always a quantile i.e., a value associated with a preassigned probability. Since equation (1) gives probabilities, it must be inverted to obtain quantiles. Expressing the variable in standard form $(u-\bar{u})/s(u)$ where $\bar{u}$ and $s(u)$ are the sample mean and standard deviation, the inversion of equation (1) becomes

$$u(G) = s(u)\ N^{-1}\left[(G(u)-q/p\right] + \bar{u}. \qquad (2)$$

Since $G(u)$ gives the probability of being less than u, the design quantile is given by $u(1-G)$ which is the value of u which is exceeded with probability $1-G$. The mean recurrence interval corresponding to G is $R-1/(1-G)$. $u(G)$ is the logarithm of w; so the design quantiles in terms of inches of water are $\exp[u(G)]$. For the ANSI Standard R = 50 years; hence $1-G = 0.02$. A map was prepared of design values by reading from a grid placed on the $\bar{u}$, $s(u)$, and p maps and computing $\exp\left[u(0.98)\right]$ for each grid point. This is shown in Fig. 1.

Figure 1 is not meant to be the final answer to design snow load but is only meant to substitute for the present map in the 1955 Standard on which it is a distinct improvement. ANSI felt an urgency to publish a new edition of the Minimum Design Loads Standard after completion of the seismic and wind loads portions. This left insufficient time to completely revise the snow load portion of the Standard; hence the new Standard will not be final in respect to snow loads.

Future Plans

The principal weakness of Figure 1 is that it does not adequately account for changes in elevation. It is anticipated, however, that it will form the basis for adjustment to higher elevations and exposures; hence the isolines are shown in mountainous areas where they only apply to the meteorological station exposures. Work is now in progress to develop elevation and exposure corrections. With the new flexibility in the process of preparing ANSI Standards, no difficulty is anticipated in issuing a revised version of the snow loads. This would include the Canadian roof shape coefficients 7/ which it would be extremely difficult to improve upon.

REFERENCES

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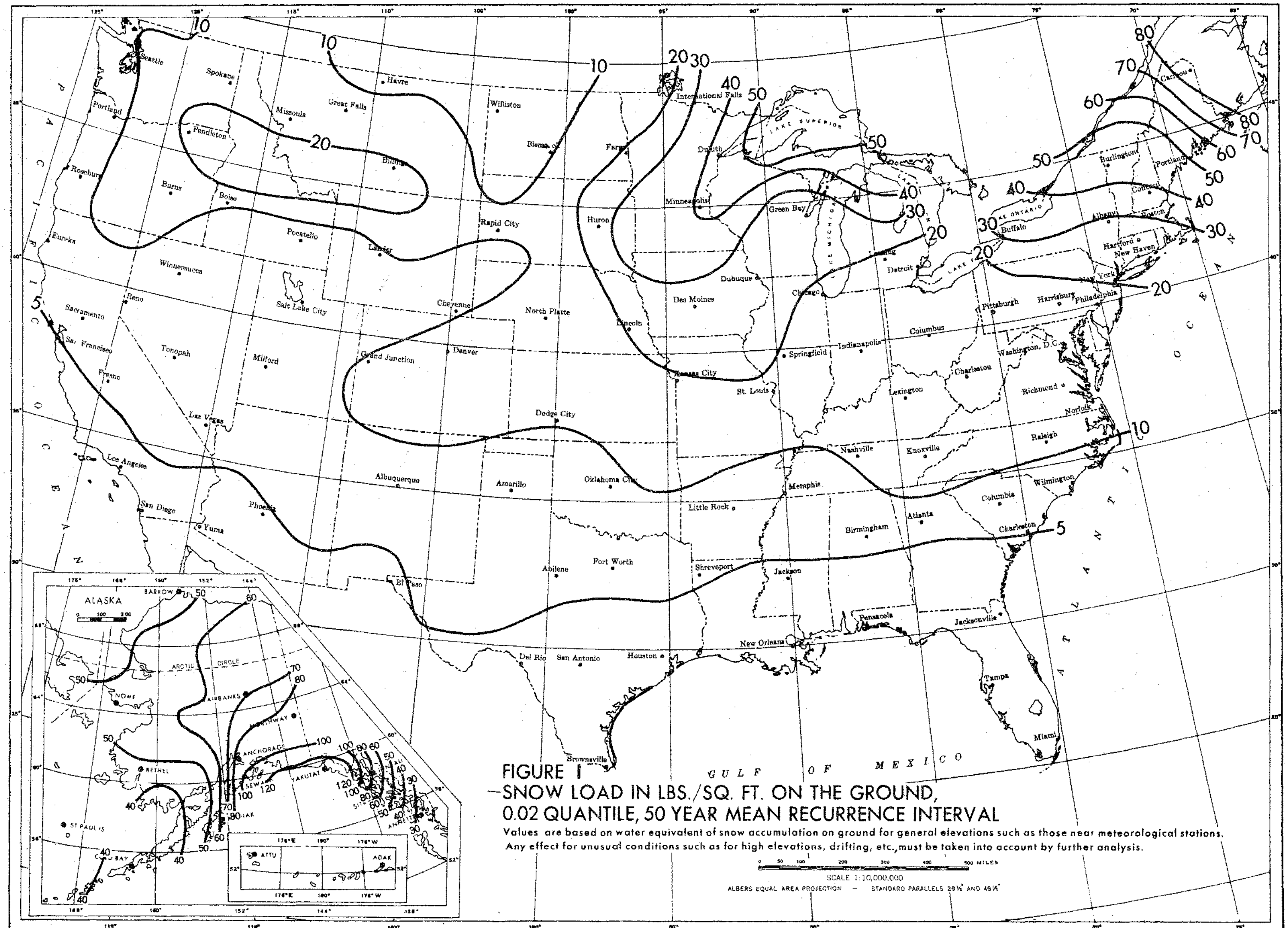

FIGURE 1
—SNOW LOAD IN LBS./SQ. FT. ON THE GROUND,
0.02 QUANTILE, 50 YEAR MEAN RECURRENCE INTERVAL

Values are based on water equivalent of snow accumulation on ground for general elevations such as those near meteorological stations. Any effect for unusual conditions such as for high elevations, drifting, etc., must be taken into account by further analysis.

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Base map by United States Weather Bureau
MAP 1815B 1/63

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