GROUND SNOWLOAD DATABASE FOR NEW MEXICO

by

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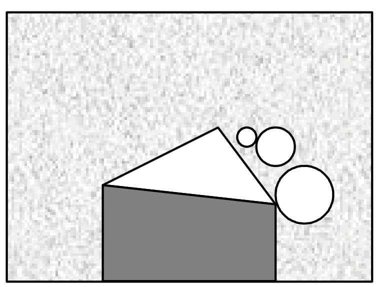

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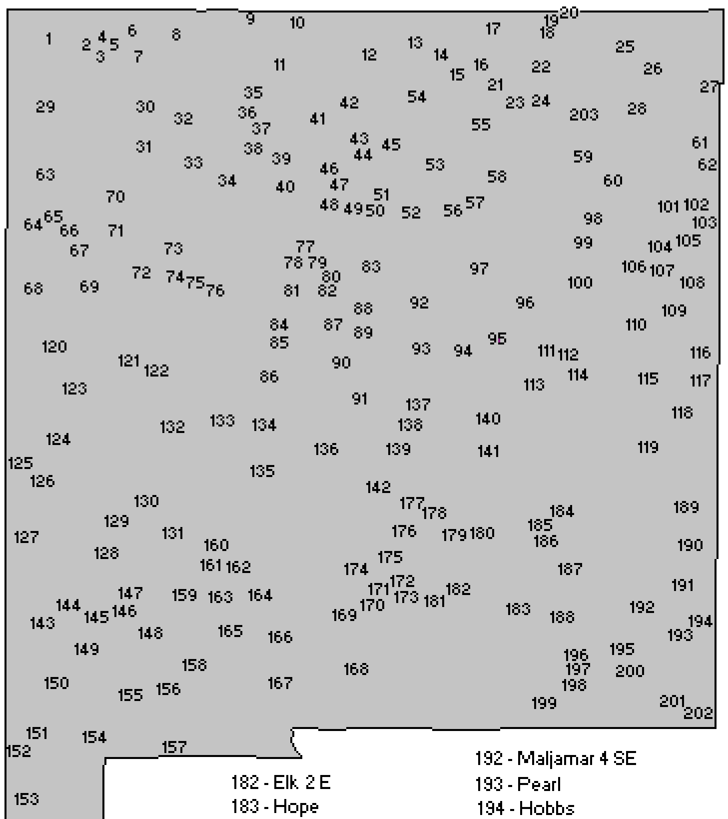
ABSTRACT

Buildings and other structures are designed to withstand wind and snow loads, according to the building code adopted by the local jurisdiction. Due to the great topographical variation in New Mexico, especially in the northern half of the state, current building codes do not provide data specific to this region. This project was undertaken to use information from available snowfall database to provide 'ground snow' data for 203 localities dispersed throughout the state of New Mexico. The original focus of this project was Northern New Mexico due topographic variations. However sites throughout the state were included in this final document, although data from some of the sites in the southern half of the state were not available.

This document is divided into three sections. Section 1 provides a map of the localities for which 'ground snow load' was available from a weather station data, and specifies the maximum recorded ground snow number, and the numbers corresponding to statistical estimates of 50 and 100 year recurrence intervals. Section 2 discusses the rationale for this study, presents the source and analysis behind the information presented in Section 1, and its intended treatment in the current Uniform Building code. This may help the reader is interested in authenticity, or in finding other uses of this information beyond the design of structures. The actual data itself is provided as an Appendix, with the idea that it will not be circulated as part of this document, but will be available upon request from the sources on this cover page.

SECTION 1. GROUND SNOW DATA

1 - Shiprock
2 - Fruitland 2 E
3 - Farmington Ag. Sci.
4 - Farmington FAA
5 - Farmington 3 NE
6 - Aztec Ruins Natl Mon.
7 - Bloomfield 3 SE
8 - Navajo Dam
9 - Dulce
10 - Chama
11 - El Vado Dam
12 - Tres Piedras
13 - Cerro
14 - Red River
15 - Eagle Nest
16 - Philmont Ranch
17 - Vermejo Park
18 - Raton KRTN
19 - Raton Filter Plant
20 - Lake Maloya
21 - Cimarron 4 SW
22 - Maxwell
23 - Miami
24 - Springer
25 - Des Moines
26 - Grenville
27 - Clayton WSO
28 - Pasamonte



175 - Mescalero
176 - Ruidoso 2 NNE
177 - Capitan
178 - Fort Stanton
179 - Picacho 2 WSW
180 - Tinnie
181 - Mayhill R.S.
182 - Elk 2 E
183 - Hope
184 - Bitter Lakes WLR
185 - Roswell WSO
186 - Roswell FAA
187 - Hagerman
188 - Artesia 6 S
189 - Crossroads #2
190 - Tatum
191 - Lovington 2WNW
192 - Maljamar 4 SE
193 - Pearl
194 - Hobbs
195 - Western AG-minerals
196 - Lake Avalon
197 - Carlsbad
198 - Carlsbad FAA
199 - Carlsbad Caverns
200 - Waste Isolation P.P.
201 - Ochoa
202 - Jal
203 - Abbott

29 - Newcomb
30 - Otis
31 - Chaco Canyon N. M.
32 - Lybrook
33 - Star Lake
34 - Torreon Navajo M.
35 - Gavilan
36 - Lindrith 2 SE
37 - Regina
38 - Cuba
39 - Wolf Canyon
40 - Jemez Springs
41 - Abiquiu Dam
42 - El Rito
43 - Alcalde
44 - Espanola
45 - Truchas
46 - Los Alamos
47 - Bandelier N.M.
48 - Cochiti Dam
49 - Santa Fe CAA
50 - Santa Fe 2
51 - Santa Fe
52 - Pecos R. S.
53 - Gascon
54 - Taos
55 - Ocate 1 N
56 - Las Vegas 2 NW
57 - Las Vegas FAA
58 - Valmora
59 - Roy
60 - Mosquero
61 - Hayden
62 - Amistad 3 ESE
63 - Tohatchi 1 ESE
64 - Gallup FAA
65 - Gallup 5 E
66 - Fort Wingate
67 - Mc Gaffey 5 SE
68 - Zuni
69 - El Morro N. M.
70 - Crownpoint
71 - Thoreau 5 ENE
72 - Grants Airport
73 - San Mateo
74 - San Fidel 1 N
75 - Cubero
76 - Laguna
77 - Bernalillo 1 NNE
78 - Corrales
79 - Sandia Crest
80 - Sandia Park
81 - Albuquerque WSFO
82 - Tijeras R. S.
83 - Stanley 1 NNE
84 - Los Lunas 3 SSW
85 - Belen
86 - Bernardo
87 - Tajique 4 NW
88 - Mc Intosh 4 NW
89 - Estancia
90 - Mountainair
91 - Gran Quivira N. M.
92 - Clines Corners 7 SE
93 - Pedernal 4 E
94 - Vaughn
95 - Pastural 6 SSE
96 - Santa Rosa
97 - Dilia 1 SSE
98 - Bell Ranch
99 - Conchas Dam
100 - Newkirk
101 - McCarty Ranch
102 - Rinestine Ranch
103 - Obar
104 - Ute Dam
105 - Logan
106 - Tucumcari 4 NE
107 - Tucumcari FAA
108 - San Jon
109 - Cameron
110 - Ragland 3 SSW
111 - Alamogordo Dam
112 - Sumner Lake
113 - Yeso
114 - Fort Sumner
115 - Melrose
116 - Clovis 13 N
117 - Clovis
118 - Portales
119 - Elida
120 - Fence Lake 1 N
121 - Hickman
122 - Pietown 19 NE
123 - Quemado
124 - Jewett R. S.
125 - Luna R. S.
126 - Hood R. S.
127 - Glenwood
128 - Gila Hot Springs
129 - Beaverhead R. S.
130 - Adobe Ranch
131 - Chloride R. S.
132 - Augustine 2 E
133 - Magdalena
134 - Socorro
135 - Bosque del Apache
136 - Bingham 2 NE
137 - Corona
138 - Corona 11 SSW
139 - Ancho
140 - Ramon 8 SW
141 - Farnsworth Ranch
142 - Carrizozo
143 - Redrock
144 - Cliff 11 SE
145 - Silver City
146 - Fort Bayard
147 - Mimbres R. S.
148 - Faywood
149 - White Signal
150 - Lordsburg 4 SE
151 - Animas
152 - Rodeo
153 - Eicks Ranch
154 - Hachita
155 - Gage 4 ESE
156 - Deming
157 - Columbus
158 - Florida
159 - Hillsboro
160 - Hot Springs CAA
161 - Truth or Consequences
162 - Elephant Butte Dam
163 - Caballo Dam
164 - Aleman Ranch
165 - Hatch 2 W
166 - Jornada Exp. Range
167 - State University
Ex - Agricultral College
168 - Orogrande 1 N
169 - White Sands N. M.
170 - Alamogordo
171 - Mountain Park
172 - Cloudcroft
173 - Cloudcroft 2
174 - Tularosa

Figure 1. Available sites for ground snow load information (www.wrcc.dri.edu)

Table 1. Ground Snow Load in New Mexico Localities, Sg
(data provided is inches of ground snow, which is the same as the snow-load in psf)
(GROUND SNOWLOAD DATABASE FOR NEW MEXICO, Professor Arup Maji, UNM, 1999)

NUMBER	LOCATION	Years of Data	Maximum Recorded Snowdepth (inches)	100 year Snowdepth (inches)	50 year Snowdepth (inches)
1	SHIPROCK	51	12	11.0	9.1
2	FRUITLAND 2E	51	8	8.2	7.3
3	FARMINGTON AG	21	11	12.0	10.4
4	FARMINGTON AIRPORT		12		
5	FARMINGTON 3NE		7		
6	AZTEC RUINS	51	11	11.3	10.3
7	BLOOMFIELD 3 SE	68	10	10.3	9.1
8	NAVAJO DAM	36	15	14.5	13.0
9	DULCE	53	40	39.5	36.2
10	CHAMA	51	49	54.6	51.1
11	EL VADO DAM	51	45	39.0	34.6
12	TRES PIEDRAS	51	23	22.7	20.5
13	CERRO	51	27	23.5	20.8
14	RED RIVER	51	99	86.3	75.2
15	EAGLE NEST	51	42	40.1	34.7
16	PHILMONT RANCH		16		
17	VERMEJO PARK		16		
18	RATON KRTN RADIO	21	16	16.8	15.2
19	RATON FILTER PLANT	46	20	19.4	17.5
20	LAKE MALOYA	51	73	68.5	59.7
21	CIMMARON 4 SW	95	40*	29.3*	24.8*
22	MAXWELL	50	20	19.4	17.1
23	MIAMI		12		
24	SPRINGER	51	26	23.0	20.1
25	DES MOINES	47	14	15.1	14.0
26	GRENVILLE	51	15	15.1	13.2
27	CLAYTON AIRPORT	87	200*	105.7*	67.7*
28	PASAMONTE	51	16	17.5	15.6
29	NEWCOMB		4		
30	OTIS	42	15	15.0	14.0
31	CHACO CANYON	51	11	12.0	10.8
32	LYBROOK	48	18	18.9	17.1
33	STAR LAKE	51	12	12.6	11.6
34	TORREON NAVAJO	38	14	13.8	12.6

	MISSION				
35	GAVILAN		37		
36	LINDRITH 2 SE	28	22	26.6	24.0
37	REGINA		24		
38	CUBA	51	22	21.3	19.2
39	WOLF CANYON	47	46	48.4	44.6
40	JEMEZ SPRINGS	51	20	19.3	17.7
41	ABIQUIU DAM	42	15	15.6	13.6
42	EL RITO	51	21	19.4	17.4
43	AL CALDE	46	13	14.1	12.4
44	ESPANOLA	51	9	11.3	10.0
45	TRUCHAS		21		
46	LOS ALAMOS	51	40	35.0	30.1
47	BANDELIER MON.		27		
48	COCHITI DAM	24	13	15.6	13.5
49	SANTA FE AIRPORT		6		
50	SANTA FE 2	27	16	16.7	15.0
51	SANTA FE		12		
52	PECOS RANGER STATION	51	15	16.6	15.3
53	GASCON	46	44	38.1	34.9
54	TAOS	51	25	21.5	19.2
55	OCATE 1 N	39	20	18.9	16.9
56	LAS VEGAS 2 NW		27		
57	LAS VEGAS AP	51	26	24.8	21.9
58	VALMORA	51	24	21.0	18.5
59	ROY	51	23	21.5	18.8
60	MOSQUERO	73	60*	50.4*	38.6*
61	HAYDEN		5		
62	AMISTAD 3 ESE	51	16	13.5	11.3
63	TOHACHI ESE	14	15	17.8	15.2
64	GALLUP FAA AP	26	13	14.7	13.4
65	GALLUP 5 E		14		
66	FORT WINGATE		14		
67	MC GAFFEY 5 SE	50	30	31.5	28.7
68	ZUNI	50	14	15.6	14.0
69	EL MORRO MON.	51	20	21.6	19.9
70	CROWN POINT		10		
71	THREAU 5 ENE	40	17	16.8	15.1
72	GRANTS AIRPORT	45	24	19.8	16.1
73	SAN MATEO		19		
74	SAN FIDEL 1 N		12		
75	CUBERO	22	23	24.0	20.6
76	LAGUNA	51	17	17.4	15.3
77	BERNALILLO 1 NNE		12		

78	CORRALES	17	8	10.2	9.1
79	SANDIA CREST		95		
80	SANDIA PARK	51	30	30.4	27.6
81	ALBUQUERQUE WSFO AIRPORT	65	35	24.4	18.2
82	TIJERAS RANGER ST.		15		
83	STANLEY 1 NNE	45	13	11.7	10.8
84	LOS LUNAS 3 SSW	42	5	6.5	5.5
85	BELEN		9		
86	BERNARDO	37	9	8.4	6.7
87	TAJIQUE 4 NW		13		
88	MC INTOSH 4 NW		13		
89	ESTANCIA	51	39	31.9	26.6
90	MOUNTAINAIR	51	42	37.3	31.5
91	GRAN UIVIRA MON.	51	19	20.5	18.3
92	CLINES CORNERS	31	20	24.3	22.1
93	PEDERNAL 4 E	51	21	20.1	17.9
94	VAUGHN		14		
95	PASTURA 6 SSE		8		
96	SANTA ROSA	51	17	17.0	15.0
97	DILIA 1 SSE	51	20	19.9	17.7
98	BELL RANCH	51	60*	44.7*	33.3*
99	CONCHAS DAM	51	25	22.4	19.2
100	NEWKIRK	49	13	15.1	13.4
101	MCCARCHY RANCH				
102	RINESTINE RANCH				
103	OBAR				
104	UTE DAM				
105	LOGAN				
106	TUCUMCARI 4 NE	93	70*	47.6*	37.1*
107	TUCUMCARI FAA				
108	SAN JON	51	22	22.1	19.0
109	CAMERON	51	17	17.1	15.3
110	RAGLAND 3 SSW	51	15	17.1	15.4
111	ALAMOGORDO DAM	51	5	5.7	4.9
112	SUMNER LAKE	24	14	17.7	15.3
113	YESO	51	18	18.1	16.1
114	FORT SUMNER	51	16	14.2	12.4
115	MELROSE	51	14	13.9	12.4
116	CLOVIS 13 N	50	13	11.5	9.5
117	CLOVIS	89	10	11.2	10.0
118	PORTALES	51	10	10.2	9.2
119	ELIDA	51	11	10.4	8.7
120	FENCE LAKE 1 N	35	22	20.5	18.6
121	HICKMAN				

122	PIETOWN 18 NE	11	15	16.9	15.8
123	QUEMADO	47	12	11.6	10.7
124	JEWETT R. S.				
125	LUNA R. S.	51	48	39.4	32.7
126	HOOD R. S.	45	14	15.1	13.1
127	GLENWOOD	51	14	14.3	11.4
128	GILA HOT SPRINGS	42	15	14.4	12.4
129	BEAVERHEAD R. S.	50	24	22.8	19.8
130	ADOBE RANCH	38	24	21.0	17.4
131	CHLORIDE R. S.	50	14	14.7	12.7
132	AUGUSTINE 2 E	51	12	13.6	12.0
133	MAGDALENA	46	12	13.0	10.9
134	SOCORRO	68	17	14.9	12.6
135	BOSQUE DEL APACHE	51	17	16.3	13.2
136	BINGHAM 2 NE	45	8	8.0	7.1
137	CORONA				
138	CORONA 11 SSW	16	30	34.3	30.4
139	ANCHO				
140	TAMON 8 SW				
141	FARNSWORTH RANCH				
142	CARRIZZOZO	51	12	11.0	9.2
143	REDROCK	51	5	5.2	4.4
144	CLIFF 11 SE	51	7	8.0	6.8
145	SILVER CITY				
146	FORT BAYARD	101	8	9.6	8.5
147	MIMBRES R. S.	51	19	18.1	15.5
148	FAYWOOD	51	12	9.1	6.8
149	WHITE SIGNAL	51	15	17.6	15.4
150	LORDSBURG 4 SE	51	9	9.3	7.7
151	ANIMAS	51	12	12.3	10.5
152	RODEO				
153	EICKS RANCH				
154	HACHITA	51	7	7.2	6.1
155	GAGE 4 ESE	49	6	6.4	5.2
156	DEMING	43	11	10.1	8.3
157	COLUMBUS	51	7	7.5	6.6
158	FLORIDA	45	15	12.0	9.0
159	HILLSBORO	51	20	18.2	15.7
160	HOT SPRINGS CAA				
161	T OR C	24	10	11.1	9.2
162	ELEPHANT BUTTE DAM				
163	CABALLO DAM				

164	ALEMAN RANCH	51	10	10.3	8.9
165	HATCH 2 W	51	12	11.2	9.1
166	JORNADA EXP. RANGE	46	8	8.2	7.0
167	STATE UNIVERSITY	40	9	10.4	9.1
168	OROGRANDE 1 N	51	7	7.7	6.7
169	WHITE SANDS N. M.	51	12	10.1	8.4
170	ALAMOGORDO DAM	51	5	5.7	4.9
171	MOUNTAIN PARK	51	14	14.7	13.2
172	CLOUDCROFT	12	33	38.8	35.7
173	CLOUDCROFT 2				
174	TULAROSA	50	6	6.3	5.2
175	MESCALERO				
176	RUIDOSO 2 NNE	7	22	27.7	25.1
177	CAPITAN	43	18	21.6	19.4
178	FORT STANTON				
179	PICACHO 2 WSW	19	17	20.0	17.8
180	TINNIE				
181	MAYHILL R. S.				
182	ELK 2 E	52	24	23.4	20.3
183	HOPE	30	15	17.3	14.3
184	BITTERLAKES WLR	49	16	14.8	12.7
185	ROSWELL WSO				
186	ROSWELL FAA	26	16	16.4	14.3
187	HAGERMAN				
188	ARTESIA 6 S	51	9	10.8	9.5
189	CROSSROADS #2	51	4	3.8	3.0
190	TATUM	51	12	12.1	9.9
191	LOVINGTON 2 WNW				
192	MALJAMAR 4 SE	51	15	16.0	13.8
193	PEARL	49	11	12.2	10.5
194	HOBBS	51	12	12.0	10.2
195	WESTERN AG	13	5	6.4	5.3
196	LAKE AVALON				
197	CARLSBAD	51	7	7.4	6.4
198	CARLSBAD FAA	51	13	12.6	10.8
199	CARLSBAD CAVERNS	51	12	11.0	9.5
200	W. I. P. P.	13	2	3.3	2.8
201	OCHOA	51	10	10.4	8.5
202	JAL	51	15	12.8	10.4
203	ABBOTT	46	16	14.9	12.7

* Caution

One word of caution in the use of the data in Table 1, is that for a few locations there was a single data point that is very high and an obvious malfunction of the instrumentation. The reported statistically based MRI in Table 1 did not discard that data point. Therefore the numbers are unrealistically high. The data specific to these sites are discussed here to allow the user to decide on their own what number is pertinent.

Item 21, Cimmarron 4SW: This site had a 40" snow recorded in 1951. Other than that the highest on record since 1904 is 21".

Item 27, Clayton Airport: This is one of the oldest sites, starting in 1896. Data is missing for 1900 – 1909, and again for 1993 – present. There is an obviously erroneous entry of 200" in 1940. Other than that, the highest on record since 1986 is 14".

Item 60, Mosquerro: This site had a 60" snow recorded in 1944 and in 1946. Other than those to data points, the highest on record since 1926 is 20".

Item 98, Bell Ranch: This site had a 60" record for 1948, which coincidentally was also the first year that there was any available data. Other than that one data point, the highest on record since 1948 was 17".

Item 106, Tucumcari 4NE: This site had a 70" datapoint for 1926, and some datapoints showing 40". However, since 1950, the highest on record is 15".

Based on the designer's past experience of a site, the he/she may choose to ignore the 50 and 100 year MRI numbers for these sites on Table 1 and simply base their design on the highest recorded data point for the past 50 years. A better approach would be to obtain the raw data and develop their own statistically valid 50 and 100 year MRI for these sites. It is of significance that the problematic data is always from a period prior to 1950, and it is impossible to scientifically validate or ignore them by independent means. Also, some sites in Table 1 had too few years of data point for statistically significant MRI numbers, and only the highest snowfall or record has been reported.

SECTION 2. RATIONALE FOR A SNOWLOAD DATABASE

The snow-covered scenes depicted on holiday cards suggest that people like a little snow during the wintertime. Nevertheless snow and winter-storms are a major catastrophe, especially in Northern New Mexico. Parts of southern New Mexico such as Roswell and Ruidoso also experienced snow load related damage to structures in the later part of the 1990s. The blizzard of March 1993 left much of the eastern United States covered in snow, 15 inches in Birmingham, AL, more than 2 feet around Albany, NY, and 8 foot drifts in eastern Kentucky. That snowfall resulted in more than 200 deaths, and left 3 million people without power due to downed power-lines. The biggest US snowstorm on record, the blizzard of March 1988 blanketed Albany, NY in 4 feet of snow and was responsible for around 400 deaths. Such large winter-storms can cause structural damage to buildings and utility structures. The price tab for insurance companies in for the 1993 storm was around $200 million. Consequently, rooftop snow is an important consideration for the design of buildings in many parts of the United States.

The most relevant information for designers is the ground snow-load (Sg, also referred to as Pg), based on a 50 year Mean Recurrence Interval (MRI), or a 2% chance of being exceeded in any given year. The Uniform building Code (UBC) that governs the design process for most of the US (soon to be replaced by the International Building Code in the yr. 2000) provides ground snow-load data in the form of contour plots. These plots are based on the American Society of Civil Engineers design manual (ASCE 7-95). The snowfall information particular to New Mexico is shown in Figure 2, with the design ground snow-load data shown in Figure 3. In Figure 3 the altitude of possible locations is in feet in bracket and the corresponding 50-year MRI ground snow-load is in pounds per square feet (psf). It may be observed from these maps that for large portions of this state, particularly those locations in the mountainous northern half (areas marked CS), the snow-load information is not available. Considering that these areas are well populated, and the population base is growing, this study was undertaken to provide the necessary information to the designer.

Estimating Ground Snow Loads (Sg)

Snow accumulation is considered for both vertical and horizontal loads on a structure. While the weight of snow is vertical on the roof, the weight of the accumulated snow adds to the lateral load that results from earthquake load. Since structures are designed for a combined effect of wind, snow, earthquake and regular building occupancy, snow-load is also relevance to earthquake resistant design. In New Mexico, which is categorized as a earthquake Zone IIB, critical structures must therefore consider appropriate snow-loads for designing earthquake resistant structures. Buildings of average importance, such as office buildings, shopping malls, etc. are to be designed on the basis of 50-year Mean Recurrence Interval (MRI). Essential facilities such as fire stations, police stations, emergency facilities and some healthcare facilities are designed to a 100-year Mean Recurrence Interval (MRI), or a 1% probability of being exceeded in a given year. On the other hand, buildings representing a low risk to human life, such as agricultural facilities are designed to a 25-year MRI.

The probabilistic analysis is based on a statistical analysis of yearly data for a specific site. Two types of sources are available for the snow-load data. First, more than 250 National Weather Service stations around the country take daily or hourly measurements including snow, and provide frequent 'water-equivalent' measurements. The water-equivalent measurement is a more accurate estimate of the weight of snow since it has been converted to an equivalent weight of water that eliminates the effect of the compaction of the snow on the ground. Since there are few such sites they do not provide information specific to the locations discussed in this document. The information provided here is therefore based on measured ground snow depth at local sites. This number has to converted into an equivalent load to be of use to the designer. The specific gravity of snow ranges from 0.05 to 0.1 for fresh snow to 0.3 for wind-packed or consolidates snow. The average is commonly assumed to be 0.19, which is equivalent to 12 pounds per cubic foot. Therefore the data in Table 1, (inches of snow) is also the weight of ground snow-load (in psf., pounds per square feet).

The probability of ground snow-load (Sg) of magnitude *x* is can be described by a log-normal distribution function as shown by the equation below:

$$F_{S_g}(x) = \Phi\left[\frac{\ln(x) - \lambda_g}{\xi_g}\right]$$

Here λg is the mean and ξg^2 is the variance of ln(Sg). Φ is the standard normal probability integral available in most statistical books. One attribute of a probabilistic analysis is that the 50-year MRI can be higher or lower than the actual highest datapoint recorded during the past 50 years, depending on the variation of the year to year data. A larger variation or scatter in the available data leads to a higher estimate of the 50 or 100 year MRI.

One word of caution in the use of the data in Table 1, is that for a few locations there was a single data point that is very high and an obvious malfunction of the instrumentation. The reported statistically based MRI in Table 1 did not discard that data point. Therefore the numbers are unrealistically high. These sites were discussed at the end of Table 1 in Section 1.

The actual design roof snow-load is determined from the ground snow-load (Sg) provided in Table 1 using a number of factors discussed in the UBC code and the ASCE 7-95. These factors include the effects of i) terrain, ii) exposure, iii) thermal condition, iv) importance factor and v) roof slope. Most structural designers are familiar with this methodology, the references are readily available and a further discussion is beyond the scope of this article.

References

- Michal J. O'Rourke, "Snow-load on Buildings", American Scientist, January-February, 1997.
- White Richard N., and Salmon Charles G., "Building Structural Design Handbook", 1987, pp, 26-33.
- ASCE Standard 7-95.
- Data Source: Western Regional Climate Center, Nevada (www.wrcc.dri.edu).

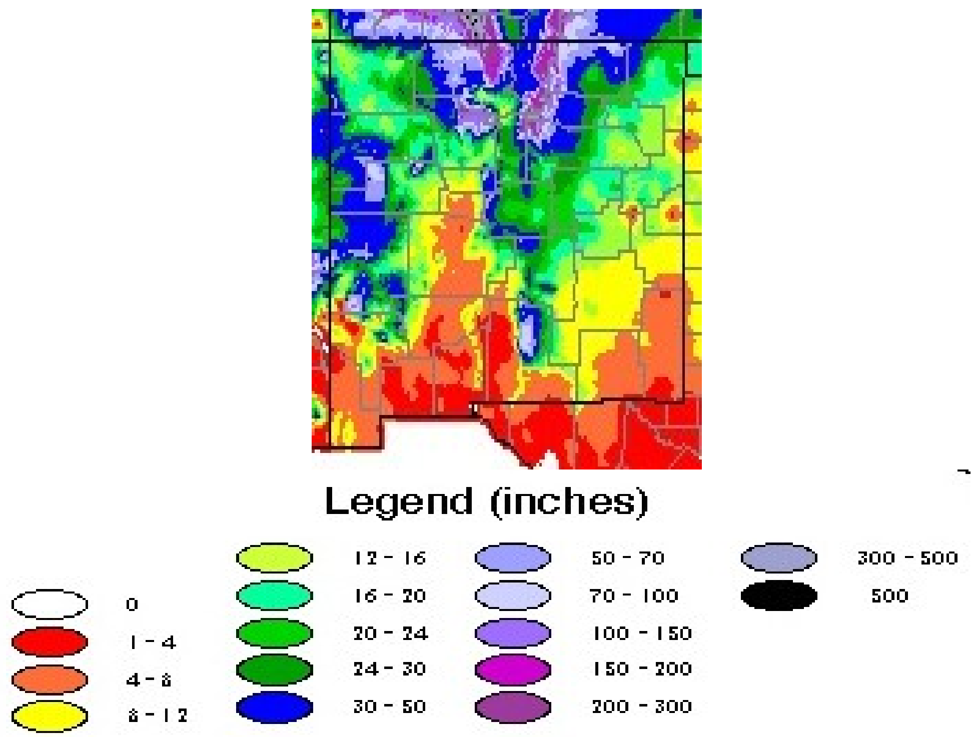


Figure 2. Mean Annual Snowfall Data for New Mexico (1961-1990)

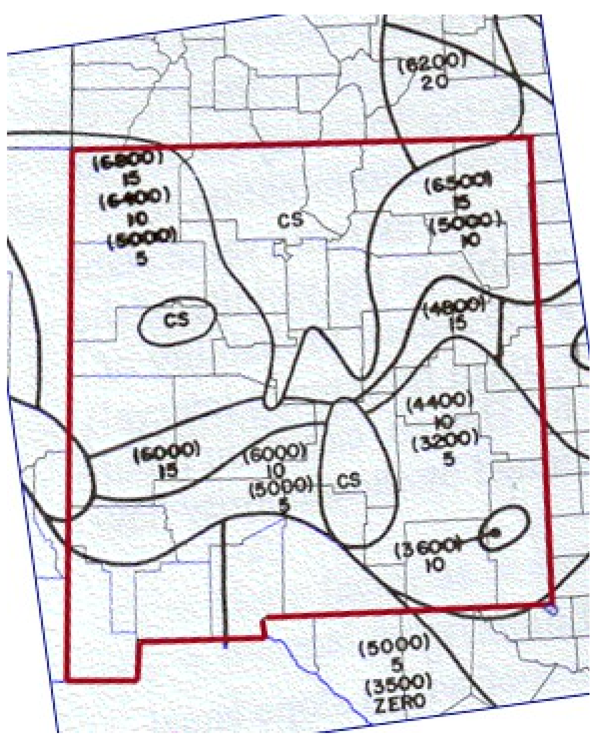


Figure 3. ASCE-7 Snowload Map of New Mexico