New Wind Design Criteria for Traffic Signal Support Structures

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16. Abstract

The American Association of State Highway and Transportation Officials (AASHTO) *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals* have been revised in its entirety through a major research project conducted under the auspices of the National Cooperative Highway Research Program (NCHRP Project 17-10). The new document was approved in 1999 by all state departments of transportations for adoption by AASHTO and was published in 2001. The revisions include updated provisions and criteria for extreme wind loads and new provisions and criteria on fatigue design. These provisions differ considerably from those in previous editions of the specifications. The impact of the new wind load and fatigue provisions on the design of traffic signal supports from the standpoint of safety and economy had not been studied and was the main goal of this project. Wind load calculations and design of a span wire traffic signal structure in Alabama were performed using the design criteria in both the 2001 AASHTO specifications and the 1994 edition of the specifications. The results were compared and the impact of the 2001 specifications on design of span wire traffic signal structures in Alabama was illustrated.

17. Key Words AASHTO, traffic signal sign support, span wire, extreme wind loads, structural support	**18. Distribution Statement**

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Executive Summary

The American Association of State Highway and Transportation Officials (AASHTO) *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (Supports Specifications)* were revised in its entirety through a major research project conducted under the auspices of the National Cooperative Highway Research Program (NCHRP Project 17-10). The new document was approved in 1999 by AASHTO for adoption by all state departments of transportation, and was published in 2001. The revisions included updated provisions and criteria for extreme wind loads and new provisions and criteria on fatigue design. These provisions differed considerably from those in previous editions of the specifications. This research project studied the impact of the new wind load provisions on the design of a span wire traffic signal support structure.

Wind load calculations in the 2001 *Supports Specifications* were revised to use a three-second gust wind speed, rather than a fastest-mile wind speed. A series of maps, representing 10, 25, and 50-year mean recurrence intervals, was updated to one 50-year mean recurrence interval map with importance factors used to adjust the intervals. Height factors were adjusted for the three-second gust wind speed, and drag coefficients were slightly modified. The increase or decrease in calculated wind pressures, which result from the use of the 2001 *Supports Specifications*, is primarily due to the differences in the 1994 and 2001 wind speed maps. The criteria for fatigue design, which can be significant for certain structure configurations, were not applicable for the selected span wire traffic signal support structure.

The tasks conducted during this research project included identifying the impact of the new wind criteria provisions on the design of a span wire traffic signal support structure. A spreadsheet was developed to analyze the selected structure configuration. Design wind loads from the different wind speed maps for the 1994 and 2001 *Supports Specifications* were compared for a large number of cities across Alabama to determine the effect of the new wind provisions.

Section 1
Introduction

AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 1994* (hereafter referred to as the *Supports Specifications*) (AASHTO, 1994) have been totally revised based on work conducted under NCHRP Project 17-10 (Fouad *et al*, 1998). The project, which was completed in 1997, addressed a variety of technical topics and presented new wind maps, revised wind loading criteria, and new fatigue provisions. The revised *Supports Specifications* was submitted to the AASHTO Highway Subcommittee on Bridges and Structures (SCOBS) for adoption consideration. The standard specifications, which were balloted and approved for adoption by all states, were published in the summer of 2001 (AASHTO, 2001).

The changes in the wind loading criteria provided by the new 2001 *Supports Specifications* represent a major and fundamental update to the wind loading criteria of the 1994 *Supports Specifications*. These changes, representing over 20 years of progress in wind technology, update the *Supports Specifications* to the most current wind methodology. Additionally, new fatigue design criteria were added for structures subjected to fatigue loads.

Problem Statement

A major concern about the 2001 *Supports Specifications* is the use of a new wind map and wind provisions that may result in significant changes in the applied loads. Wind load calculations in the 2001 *Supports Specifications* are now based on a 3-second gust wind speed, rather than a fastest-mile wind speed. The previous series maps, representing 10-, 25-, and 50-year mean recurrence intervals, was reduced to one 50-year mean recurrence interval map with importance factors used to adjust the intervals. Height factors were adjusted for the 3-second-gust wind speed. The coefficients of drag were modified slightly. The increase or reduction in calculated wind pressures, which result from the use of the updated wind map, are primarily due to the differences in the 1994 and 2001 wind speed maps.

The new wind map for Alabama in the 2001 *Supports Specifications* can be divided into two wind speed regions: 1) 90 mph for the northern 80 percent of the state, and 2) 100 mph to 140 mph in the hurricane region. These regions correspond to fastest mile per hour wind speeds ranging from 70 to 100 mph depending on the site location and the mean recurrence interval in the 1994 specifications. Differences in wind loads computed according to the two maps are therefore site-specific.

Objective and Scope

The main objective of this study was to evaluate the safety and economy of span wire traffic signal support supports in Alabama that are designed in accordance with the revised wind load and new fatigue provisions published in 2001 by AASHTO. The scope of the work included the following:

1. Determining the impact of new wind load provisions on the design of span wire traffic signal structures. The study included performing analyses and design examples for span wire traffic signal support structures located at 10 sites in Alabama. Base shear and foundation forces were computed as part of the analyses. Designs included the selection of the pole and span wire sizes. The examples provided ample information for illustrating the impact of the new wind load provisions on the safety and economy of structural supports designed in accordance with the new wind load provisions.
2. Performing analyses and design examples using the 1994 AASHTO *Supports Specifications* and comparing to the results using the provisions of the 2001 AASHTO *Supports Specifications*.
3. Developing of an extensive Excel spreadsheet, which was used for the analysis and design of the traffic signal structures under study. The spreadsheet was used for performing load computations, stress analysis, and the selection of member sizes. Two spreadsheets were developed, one for each of the AASHTO *Supports Specifications*.

Section 2
Historical Perspective

Wind Loads

The first wind load standard containing wind speed maps was published in 1972 by the American National Standards Institute (ANSI, formerly ASA), Standard A58.1 (ANSI, 1972). The design basis wind speed was given as the fastest-mile wind speed. Figure B-1 (see Appendix B) provides the 25-year mean recurrence interval wind map (Thom, 1968) that was one of three maps published by ANSI and later adopted by the AASHTO 1985 *Supports Specifications* (AASHTO, 1985). Until 1994, the AASHTO *Supports Specifications* (AASHTO, 1994) continued to use this map that was produced by Thom in the late 1960s. A revision to the wind load standard was published by ANSI in 1982 (ANSI, 1982). This standard separated loads for the main wind-force resisting system and the components and cladding of buildings. In addition, it used one wind speed map for the 50-year mean recurrence interval (MRI) and introduced the importance factor to obtain wind speeds for other MRIs. In the mid-1980s, the American Society of Civil Engineers (ASCE) assumed responsibility for the committee that establishes design loads for buildings and other structures. ASCE Committee 7 made minor changes to the ANSI A58.1-1982 provisions and published the revised version as ASCE 7-88 (ASCE, 1990). A revised version of ASCE 7-88 was published as ASCE 7-93 (ASCE, 1993) with no changes in wind load provisions.

In 1996, ASCE published ASCE 7-95 *Minimum Design Loads for Buildings and Other Structures* (ASCE, 1996), which included major changes to wind load provisions and featured a new wind map based on three-second gust wind speeds. Adopting the three-second gust design wind speed instead of fastest-mile wind speed required modification of exposure (height and terrain) coefficients, gust effect factors, importance factors, and some pressure coefficients. The ANSI/ASCE 7-95 is the basis for the wind load provisions of the 2001 AASHTO *Supports Specifications*, which includes modifications specific to the design of sign, signal, and light support structures. The ASCE 7-95 map was adopted for use in the 2001 *Supports Specifications* and is shown in Figure B-2.

ASCE published new editions of the loading standard in 2000 and again in 2002. ASCE 7-98 (ASCE, 2000) and ASCE 7-02 (ASCE, 2002) included additional revisions to the wind load provisions such as refinement of wind speed contours in hurricane regions and the addition of a directionality factor. However, these changes were not as drastic as those presented in ASCE 7-95.

Section 3
Wind Load Comparisons – 1994 vs. 2001 AASHTO *Supports Specifications*

The changes in the wind loading criteria in the 2001 AASHTO *Supports Specifications* represent a major and fundamental update to the wind loading criteria of the 1994 *Supports Specifications*. These changes, representing over 20 years of progress in the wind technology, update the *Supports Specifications* to the most current wind methodology. The effects of changing the wind loading criteria and wind map are reviewed in this section of this report. Differences in design wind loads as a result of using the new wind speed map and calculation method were compared for a large number of cities across Alabama to determine the effect of the new wind provisions on the design of structural supports. A comprehensive list of 69 cities in Alabama was selected for evaluation in this study. The list was representative of urban and rural areas in Alabama. Comparisons were made between the 2001 and 1994 *Supports Specifications* for counties that had the same wind speed design criteria and ice loading criteria. For each site, comparisons were made between the 2001 and 1994 *Supports Specifications* by calculating wind pressures for the 25-year mean recurrence interval (MRI), which is typical for the design of a span wire traffic signal structures. For the 1994 *Supports Specifications*, wind pressures were calculated per Section 1.2.5(A) with a drag coefficient of 1.0. For the 2001 *Supports Specifications*, wind pressures were calculated per Section 3.8.1 with a drag coefficient of 1.0 and an importance factor based on a 25-year MRI.

Wind and Ice Maps for Alabama

For this project, the wind maps of the 1994 and 2001 *Supports Specifications* were trimmed and enlarged to focus on Alabama. For the 2001 *Supports Specifications*, Figure B-3 provides the 50-year MRI basic wind speed for Alabama. Importance factors are used to vary the mean recurrence interval, which is 0.87 for the 25-year MRI for wind speeds of 100 mph and less and 0.8 for wind speeds of 110 mph and greater. The wind map for Alabama, based on the 1994 *Supports Specifications*, is shown in Figure B-4. It represents the 25-year mean recurrence interval, which is generally used for span wire traffic signal structures.

Wind pressures calculated for the 25-year MRI for the 1994 and 2001 *Supports Specifications* are shown in Appendix A as Tables A-1 and A-2, respectively. Figure B-5 provides a general comparison of wind pressures of the 1994 and 2001 *Supports Specifications* for the 25-year MRI. By visual examination of Figure B-5, wind pressures due to design wind speeds of 70 and 80 mph in the 1994 *Supports Specifications* are comparable to wind pressures due to 90 to 95 mph and 100 to 115 mph for the 25-year MRI in 2001 *Supports Specifications*.

The ice loading map, which appears in the 1994 and 2001 *Supports Specifications*, is provided in Figure B-6. An enlarged map of Alabama is provided in Figure B-7. The northern half of Alabama has an ice loading, while the southern half does not.

Selection of Cities

A list of 69 cities selected for study is shown in Table A-3, sorted by county. This list provides wind sites that include population centers, as well as the rural parts of Alabama. The county seats for the 67 counties of Alabama, plus two coastline cities, are provided in the list.

Site Groupings

The basic wind speeds and importance factors for the 25-year mean recurrence intervals for the 2001 AASHTO *Supports Specifications*, as well as the 25-year wind speeds from the 1994 AASHTO *Supports Specifications*, were determined for each of the 69 cities, and are shown in Table A-3. The 69 cities were sorted by three-second gust wind speed for the 2001 *Supports Specifications*, and by the 25-year wind speeds for the 1994 AASHTO *Supports Specifications* (Table A-4). As shown in the table, the 69 cities can be grouped into 10 site-specific locations, which have the same three-second gust wind speed, as well as the same 25-year wind speed from the 1994 AASHTO *Supports Specifications*. The 10 wind sites that are the basis of this study are summarized in Table A-5. It is interesting to note that approximately 80 percent of the cities are located in wind site number 1. Wind site number 1 is further divided into two divisions: 1a and 1b, with and without an ice loading, respectively.

Wind Pressure Comparison

For each of the 10 site-specific locations, the wind pressure was calculated for heights from the ground line to 200 feet above the ground line for the 2001 and 1994 *Supports Specifications*. Figures B-8 through B-27 show the effective wind pressure for 25-year mean recurrence intervals, as well as the ratio of wind pressures for the 2001 to 1994 *Supports Specifications*. The numbers in parentheses are the number of cities out of 69 that are represented by the data. As shown in the graphs, the wind pressure distribution according to the 1994 *Supports Specifications* exhibits a step function, whereas the 2001 *Supports Specifications* has a gradual change of wind pressure with height. All graphs show higher wind pressure ratios for heights less than 15 feet than for heights greater than 15 feet.

Figure B-28 shows the average and range of ratios of wind pressures for the 2001 to 1994 *Supports Specifications* for the 25-year mean recurrence intervals for the ten sites in Alabama. In general, the range of wind pressure ratios will vary from approximately –12 percent to +16 percent from the average ratio, with a slightly larger range near the coastline. Changes in wind pressures for Site 1, which represents approximate 80 percent of the land area in Alabama, indicate, on average, a change in wind pressure of 9 percent decrease for a 25-year mean recurrence interval. The change in wind pressure for all sites could vary as much as 18 percent decrease to 83 percent increase and is dependent on wind speed and elevation. The largest increase occurs near the coastline.

As shown in Figure B-28 for the 25-year mean recurrence interval structures, Site 2 shows an average of 9 percent decrease in wind pressure. Sites 3 and 4 show the greatest average increase in wind pressure of 1 percent and 12 percent, respectively. Sites 5 and 6 show an average increase of 25 percent. For Sites 7, 8, 9, and 10, wind pressures show an average increase of 37 percent, 49 percent, 61 percent and 55 percent, respectively.

Summary

In comparing the 1994 versus the 2001 wind specifications, it is apparent that changes in wind pressure, either decreasing or increasing, are highly site-specific. These changes are also dependent on wind elevation. Based upon this analysis, only a slight decrease in wind pressure will occur for 80 percent of Alabama, which is represented by Site 1. The greatest decrease in wind pressure will occur at Sites 1 and 2. The greatest increase in wind pressure will occur near the coastline, as represented by Sites 3 through 10. For 25-year MRI structures, which include span wire traffic signal structures, the greatest increase in wind pressure occurs in Site 9.

Section 4
Design Comparisons for 1994 vs. 2001 AASHTO *Supports Specifications*

Structure Configuration

A typical span wire traffic signal support structure, as shown in Figure B-29, was selected so that designs could be compared between the 1994 and 2001 *Supports Specifications*. The span length was 105 feet. The span wire supports three traffic signals. The vertical support is a hollow tubular steel pole with a yield stress of 50 ksi. The span wire is attached to the pole at one foot below the top of the pole.

Design Criteria

Criteria specific to the design of span wire traffic signal support structures were identified. For the 2001 *Supports Specifications*, the wind loads were based on a 25-year mean recurrence interval. Wind and ice loads were calculated per Section 3 in the specifications. Allowable stresses for steel were calculated per Section 5. Increase in allowable stresses was calculated per Section 3.4. Span wire strength was designed per Section 5.13. Span wire tensions were calculated per Appendix C. The simplified method in Section C.7 assumes that the vertical supports are rigid, which means pole deflections are ignored. The detailed method in Section C.8 assumes that the vertical supports are flexible, and are considered in the span wire tension calculation. Pole deflections were limited to 2.5 percent of pole height per Section 10.4.2.1.

For the 1994 *Supports Specifications*, the wind loads were based on a 25-year mean recurrence interval. Wind and ice loads were calculated per Section 1.2 in the specifications. Allowable stresses for steel were calculated per Section 1.4. Increase in allowable stresses was calculated per Section 1.2.6. There is no provision for span wire strength in the 1994 specifications, so the criteria of the 2001 specifications were used. There is no procedure to determine span wire tensions, so the criteria of the 2001 specifications were used. Pole deflections were limited to 2.5 percent of pole height per Section 1.9.1.

The selected structure configuration of Figure B-30 was designed for the following criteria:

1) for the 1994 *Supports Specifications*,
    a) For sites with no ice, use Group I and Group II load combinations
        i) Considering pole deflection in span wire tension calculation
        ii) Ignoring pole deflection in span wire tension calculation
    b) For sites with ice, use Group I, II and III load combinations
        i) Considering pole deflection in span wire tension calculation
        ii) Ignoring pole deflection in span wire tension calculation

2) for the 2001 *Supports Specifications,*
    a) For sites with no ice, use Group I and Group II load combinations
        i) Considering pole deflection in span wire tension calculation
        ii) Ignoring pole deflection in span wire tension calculation
    b) For sites with ice, use Group I, II, and III load combinations
        i) Considering pole deflection in span wire tension calculation
        ii) Ignoring pole deflection in span wire tension calculation

[Group I load combination = Dead load
Group II load combination = Dead load + Wind
Group III load combination = Dead load + 1/2Wind + Ice]

Analysis

Two spreadsheets were developed to analyze the selected structure configurations for both the 1994 and 2001 *Supports Specifications*. The spreadsheets included load calculations, determination of span wire tensions for Group I, II and III load combinations, and effects of support deflections on the span wire tensions. The spreadsheet also calculated forces, stresses, and allowable stresses at ground line of the pole. Should the reader desire further detail, the sample spreadsheet calculations developed for both specifications may be obtained from the authors.

Structure Sizes Designed Using 1994 *Supports Specifications*

The span wire traffic signal support structure in Figure B-30 was designed for group II and III load combinations for wind speeds ranging from 50 to 100 mph using the 1994 *Supports Specifications*. Tables A-6 thru A-9 provide pole weights and sizes and span wire sizes considering and ignoring pole deflection for group I and II load combinations and for group I, II and III load combination for 50 mph to 100 mph. Ground line reactions for each design are provided in Tables A-10 through A-13.

Structure Sizes Designed Using 2001 *Supports Specifications*

The span wire traffic signal support structure in Figure B-30 was design for group II and III load combinations for wind speeds ranging from 85 to 150 mph using the 2001 *Supports Specifications*. Pole sizes are provided in Tables A-14 and A-15 for designs considering and ignoring pole deflection. Ground line reactions are provided in Tables A-16 and A-17. Group II load combination controlled the design in all cases, so there was no increase for Group III load combination.

Impact of Ice Loading

For the 1994 *Supports Specifications*, the ice loading (Group III) controlled the design only at the lower wind speeds. For the 2001 *Supports Specifications*, the ice loading (Group III) did not control the design for the selected structure configuration. Therefore, inclusion of ice loading [Group III (dead load + ½ wind + ice)] affected the design comparisons only at the lower wind speeds.

Impact of Pole Deflection

For the selected configuration, pole weights were reduced by up to 46 percent, if the deflection of the pole was considered in the calculation of the span wire tensions. A detailed comparison of pole weights is provided in Table A-18 and A-19 for the 1994 and 2001 specifications, respectively. The simplified procedure of Section A.7 in the specifications results in higher tensions in the span wire if the pole is considered rigid (i.e., ignoring deflections), as compared to the detailed procedure in Section A.8, where the pole deflection is considered in the design procedure.

Impact of the New Fatigue Provisions

There are no fatigue criteria for span wire traffic signal structures.

Structure Weight Change by Site

Tables A-20 and A-21 provide structure weight comparisons for site numbers 1 through 10. Structure weights are provided for the following:

1. 1994 *Supports Specifications*
2. 2001 *Supports Specifications* for group I, II, and III load combinations
3. Pole weights considering pole deflection
4. Pole weights ignoring pole deflection

The tables show no change in pole weights for the northern 80 percent of Alabama, which is represented by Sites 1a and 1b, to an increase 52% along the coastline, which is represented by Site 10.

Section 5
Summary, Conclusions, and Recommendations

Summary

The impacts of the new wind load provisions in the 2001 *Supports Specifications* on the design of span wire traffic signal structures were the focus of this project. Changes in design from the 1994 to 2001 *Supports Specifications* are dependent on site, wind speed, and ice loading. The effects of these changes on the design of a span wire traffic signal support structure were determined.

Conclusions

In general, the following conclusions can be made based on the study of the new wind design criteria for span wire traffic signal support structures:

1. General: In comparing the 1994 versus the 2001 wind specifications, it is apparent that changes in wind pressure, either decreasing or increasing, are highly site-specific. These changes are also dependent on wind elevation. Based upon this analysis, only a slight decrease in wind pressure will occur for 80 percent of Alabama, which is represented by Site 1. The greatest increase in wind pressure will occur near the coastline, as represented by Sites 3 through 10. For 25-year MRI structures, which include span wire traffic signal structures, the greatest increase in wind pressure occurs in Site 9.
2. Ice loading: The addition of the ice loading (Group III) did not control the design per 2001 *Supports Specifications.*
3. New wind load provisions: There was almost no change in structure weights due to the new wind load provisions vary considerably by site. Structure weight due to 2001 AASHTO wind load provisions when compared to the 1994 *Supports Specifications* had almost no increase for the northern 80 percent of Alabama. Changes in weight for all sites across the state varied from a 1 percent decrease to a 52 percent increase.
4. Pole deflection: Pole weights were 33 to 46 percent higher when pole deflection was not considered in calculating the span wire tension, as compared to design that considered pole deflection.
5. New fatigue criteria: No change, since span wire traffic signal structures are not susceptible to fatigue loadings.

Recommended Future Work

Recommendations for future work include the following:

1) Present the impact of the 2001 *Supports Specifications* on the design of support structures in a workshop for the Alabama DOT.

2) Determine the impact on selected structure configuration when considering the use of a variable message sign (VMS), attachments for walkways and lighting, and different chord spacings.
3) Determine the impact of “Section 11: Fatigue” in the 2001 *Supports Specifications* on the design of other structure types, such as a traffic signal mast arm structure and high mast lighting poles.
4) Study the new wind load provisions of ASCE 7-02, including the revised wind map, to determine if such changes should be incorporated in the future revisions of the AASHTO *Supports Specifications*.

Section 6
Acknowledgements

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Appendix A
Tables

Table A-1. Wind pressures for 1994 *Supports Specifications*

Wind Speed, mph	**50**	**60**	**70**	**80**	**90**	**100**
Height Above Grade (ft)	**Wind Pressure (psf)**	**Wind Pressure (psf)**	**Wind Pressure (psf)**	**Wind Pressure (psf)**	**Wind Pressure (psf)**	**Wind Pressure (psf)**
0	8.7	12.5	17.0	22.2	28.0	34.6
5	8.7	12.5	17.0	22.2	28.0	34.6
10	8.7	12.5	17.0	22.2	28.0	34.6
15	10.8	15.6	21.2	27.7	35.0	43.3
20	10.8	15.6	21.2	27.7	35.0	43.3
25	10.8	15.6	21.2	27.7	35.0	43.3
30	11.9	17.1	23.3	30.5	38.5	47.6
35	11.9	17.1	23.3	30.5	38.5	47.6
40	11.9	17.1	23.3	30.5	38.5	47.6
45	11.9	17.1	23.3	30.5	38.5	47.6
50	13.5	19.5	26.5	34.6	43.8	54.1
60	13.5	19.5	26.5	34.6	43.8	54.1
70	13.5	19.5	26.5	34.6	43.8	54.1
80	13.5	19.5	26.5	34.6	43.8	54.1
90	13.5	19.5	26.5	34.6	43.8	54.1
100	15.1	21.8	29.7	38.8	49.1	60.6
110	15.1	21.8	29.7	38.8	49.1	60.6
120	15.1	21.8	29.7	38.8	49.1	60.6
130	15.1	21.8	29.7	38.8	49.1	60.6
140	15.1	21.8	29.7	38.8	49.1	60.6
150	16.2	23.4	31.8	41.5	52.6	64.9
160	16.2	23.4	31.8	41.5	52.6	64.9
170	16.2	23.4	31.8	41.5	52.6	64.9
180	16.2	23.4	31.8	41.5	52.6	64.9
190	16.2	23.4	31.8	41.5	52.6	64.9
200	17.3	24.9	33.9	44.3	56.1	69.2
AASHTO (1994): $p_z = 0.00256 * (1.3 * V)^2 * (C_d = 1) * C_h$						

Table A-2. Wind pressures for 2001 *Supports Specifications* (25-year MRI)

Wind Speed, mph	**85**	**90**	**100**	**110**	**120**	**130**	**140**	**150**
Importance Factor	**0.87**	**0.87**	**0.87**	**0.80**	**0.80**	**0.80**	**0.80**	**0.80**
Height Above Grade (ft)	**Wind Pressure (psf)**	**Wind Pressure (psf)**	**Wind Pressure (psf)**	**Wind Pressure (psf)**	**Wind Pressure (psf)**	**Wind Pressure (psf)**	**Wind Pressure (psf)**	**Wind Pressure (psf)**
0	15.6	17.5	21.6	24.0	28.5	33.5	38.8	44.6
5	15.6	17.5	21.6	24.0	28.5	33.5	38.8	44.6
10	15.6	17.5	21.6	24.0	28.5	33.5	38.8	44.6
15	15.6	17.5	21.6	24.0	28.5	33.5	38.8	44.6
20	16.5	18.5	22.9	25.5	30.3	35.6	41.3	47.4
25	17.3	19.4	24.0	26.7	31.8	37.3	43.3	49.7
30	18.0	20.2	24.9	27.7	33.0	38.8	44.9	51.6
35	18.6	20.9	25.8	28.7	34.1	40.0	46.4	53.3
40	19.1	21.5	26.5	29.5	35.1	41.2	47.8	54.8
45	19.6	22.0	27.2	30.2	36.0	42.2	49.0	56.2
50	20.1	22.5	27.8	30.9	36.8	43.2	50.1	57.5
60	20.8	23.4	28.9	32.1	38.2	44.8	52.0	59.7
70	21.5	24.1	29.8	33.2	39.5	46.3	53.7	61.7
80	22.2	24.8	30.7	34.1	40.6	47.6	55.3	63.4
90	22.7	25.5	31.4	35.0	41.6	48.8	56.6	65.0
100	23.2	26.0	32.1	35.8	42.6	49.9	57.9	66.5
110	23.7	26.6	32.8	36.5	43.4	50.9	59.1	67.8
120	24.1	27.0	33.4	37.2	44.2	51.9	60.2	69.1
130	24.5	27.5	34.0	37.8	45.0	52.8	61.2	70.3
140	24.9	27.9	34.5	38.4	45.7	53.6	62.2	71.4
150	25.3	28.3	35.0	38.9	46.3	54.4	63.1	72.4
160	25.6	28.7	35.5	39.5	47.0	55.1	63.9	73.4
170	26.0	29.1	35.9	40.0	47.6	55.8	64.8	74.3
180	26.3	29.5	36.4	40.5	48.2	56.5	65.5	75.2
190	26.6	29.8	36.8	40.9	48.7	57.2	66.3	76.1
200	26.9	30.1	37.2	41.4	49.2	57.8	67.0	76.9

AASHTO (2001): $p_z = 0.00256 * K_z * G * V^2 * I_r * (C_d = 1)$

Table A-3. Wind sites sorted by county

County	City	Site No.	Ice Loading	AASHTO 1994	AASHTO 2001	
				Wind Speed, 25-yr MRI (mph)	Wind Speed (mph)	Importance Factor, 25-yr MRI
Autauga	Prattville	1b	No	70	90	0.87
Baldwin	Bay Minette	8	No	70	120	0.80
Baldwin, Coastal Area	Gulf Shores	10	No	80	140	0.80
Barbour	Clayton	1b	No	70	90	0.87
Bibb	Centreville	1b	No	70	90	0.87
Blount	Oneonta	1a	Yes	70	90	0.87
Bullock	Union Springs	1b	No	70	90	0.87
Butler	Greenville	1b	No	70	90	0.87
Calhoun	Anniston	1a	Yes	70	90	0.87
Chambers	Lafayette	1b	No	70	90	0.87
Cherokee	Centre	1a	Yes	70	90	0.87
Chilton	Clanton	1b	No	70	90	0.87
Choctaw	Butler	2	No	70	90	0.87
Clarke	Grove Hill	4	No	70	100	0.87
Clay	Ashland	1a	Yes	70	90	0.87
Cleburne	Heflin	1a	Yes	70	90	0.87
Coffee	Elba	4	No	70	100	0.87
Colbert	Tuscumbia	1a	Yes	70	90	0.87
Conecuh	Evergreen	5	No	70	110	0.80
Coosa	Rockford	1b	No	70	90	0.87
Covington	Andalusia	5	No	70	110	0.80
Crenshaw	Luverne	3	No	70	95	0.87
Cullman	Cullman	1a	Yes	70	90	0.87
Dale	Ozark	3	No	70	95	0.87
Dallas	Selma	1b	No	70	90	0.87
De Kalb	Fort Payne	1a	Yes	70	90	0.87
Elmore	Wetumpka	1b	No	70	90	0.87
Escambia	Brewton	7	No	70	115	0.80
Etowah	Gadsden	1a	Yes	70	90	0.87
Fayette	Fayette	1a	Yes	70	90	0.87
Franklin	Russellville	1a	Yes	70	90	0.87
Geneva	Geneva	5	No	70	110	0.80
Greene	Eutaw	1b	No	70	90	0.87
Hale	Greensboro	1b	No	70	90	0.87
Henry	Abbeville	1b	No	70	90	0.87
Houston	Dothan	4	No	70	100	0.87
Jackson	Scottsboro	1a	Yes	70	90	0.87
Jefferson	Birmingham	1a	Yes	70	90	0.87
Lamar	Vernon	1a	Yes	70	90	0.87
Lauderdale	Florence	1a	Yes	70	90	0.87
Lawrence	Moulton	1a	Yes	70	90	0.87
Lee	Opelika	1b	No	70	90	0.87
Limestone	Athens	1a	Yes	70	90	0.87

Table A-3: Wind sites sorted by county (continued)

County	City	Site No.	Ice Loading	AASHTO 1994	AASHTO 2001	
				Wind Speed, 25-yr MRI (mph)	Wind Speed (mph)	Importance Factor, 25-yr MRI
Lowndes	Hayneville	1b	No	70	90	0.87
Macon	Tuskegee	1b	No	70	90	0.87
Madison	Huntsville	1a	Yes	70	90	0.87
Marengo	Linden	1b	No	70	90	0.87
Marion	Hamilton	1a	Yes	70	90	0.87
Marshall	Guntersville	1a	Yes	70	90	0.87
Mobile	Mobile	9	No	70	125	0.80
Mobile, Coastal Area	Dauphin Is.	10	No	80	140	0.80
Monroe	Monroeville	4	No	70	100	0.87
Montgomery	Montgomery	1b	No	70	90	0.87
Morgan	Decatur	1a	Yes	70	90	0.87
Perry	Marion	1b	No	70	90	0.87
Pickens	Carrollton	1a	Yes	70	90	0.87
Pike	Troy	1b	No	70	90	0.87
Randolph	Wedowee	1a	Yes	70	90	0.87
Russell	Phenix City	1b	No	70	90	0.87
Saint Clair	Pell City	1a	Yes	70	90	0.87
Shelby	Columbiana	1a	Yes	70	90	0.87
Sumter	Livingston	1b	No	70	90	0.87
Talladega	Talladega	1a	Yes	70	90	0.87
Tallapoosa	Dadeville	1b	No	70	90	0.87
Tuscaloosa	Tuscaloosa	1a	Yes	70	90	0.87
Walker	Jasper	1a	Yes	70	90	0.87
Washington	Chatom	6	No	70	110	0.80
Wilcox	Camden	1b	No	70	90	0.87
Winston	Double Springs	1a	Yes	70	90	0.87

Table A-4. Wind sites sorted by wind speed and site number

Site No.	County	City	Ice Loading	AASHTO 1994	AASHTO 2001	
				Wind Speed, 25-yr MRI (mph)	Wind Speed (mph)	Importance Factor, 25-yr MRI
1a			Yes	70	90	0.87
	Blount	Oneonta				
	Calhoun	Anniston				
	Cherokee	Centre				
	Clay	Ashland				
	Cleburne	Heflin				
	Colbert	Tuscumbia				
	Cullman	Cullman				
	De Kalb	Fort Payne				
	Etowah	Gadsden				
	Fayette	Fayette				
	Franklin	Russellville				
	Jackson	Scottsboro				
	Jefferson	Birmingham				
	Lamar	Vernon				
	Lauderdale	Florence				
	Lawrence	Moulton				
	Limestone	Athens				
	Madison	Huntsville				
	Marion	Hamilton				
	Marshall	Guntersville				
	Morgan	Decatur				
	Pickens	Carrollton				
	Randolph	Wedowee				
	Saint Clair	Pell City				
	Shelby	Columbiana				
	Talladega	Talladega				
	Tuscaloosa	Tuscaloosa				
	Walker	Jasper				
	Winston	Double Springs				
1b			None	70	90	0.87
	Autauga	Prattville				
	Barbour	Clayton				
	Bibb	Centreville				
	Bullock	Union Springs				
	Butler	Greenville				
	Chambers	Lafayette				
	Chilton	Clanton				
	Coosa	Rockford				
	Dallas	Selma				
	Elmore	Wetumpka				
	Greene	Eutaw				
	Hale	Greensboro				
	Henry	Abbeville				
	Lee	Opelika				

Table A-4: Wind sites sorted by wind speed and site number (continued)

Site No.	County	City	Ice Loading	AASHTO 1994	AASHTO 2001	
				Wind Speed, 25-yr MRI (mph)	Wind Speed (mph)	Importance Factor, 25-yr MRI
	Lowndes	Hayneville				
	Macon	Tuskegee				
	Marengo	Linden				
	Montgomery	Montgomery				
	Perry	Marion				
	Pike	Troy				
	Russell	Phenix City				
	Sumter	Livingston				
	Tallapoosa	Dadeville				
	Wilcox	Camden				
2			None	70	90	0.87
	Choctaw	Butler				
3			None	70	95	0.87
	Crenshaw	Luverne				
	Dale	Ozark				
4			None	70	100	0.87
	Clarke	Grove Hill				
	Coffee	Elba				
	Houston	Dothan				
	Monroe	Monroeville				
5			None	70	110	0.80
	Conecuh	Evergreen				
	Covington	Andalusia				
	Geneva	Geneva				
6			None	70	110	0.80
	Washington	Chatom				
7			None	70	115	0.80
	Escambia	Brewton				
8			None	70	120	0.80
	Baldwin	Bay Minette				
9			None	70	125	0.80
	Mobile	Mobile				
10			None	80	140	0.80
	Baldwin, Coastal Area	Gulf Shores				
	Mobile, Coastal Area	Dauphin Is.				

Table A-5. Wind site classifications for Alabama cities

Wind Site No.	No. of Cities	Ice Loading	AASHTO 1994	AASHTO 2001		
			Wind Speed, 25-yr MRI (mph)	Wind Speed (mph)	Importance Factor, 25-yr MRI	Representing
1a	29	Yes	70	90	0.87	Approximately northern 45% of Alabama
1b	24	No	70	90	0.87	Approximately middle 35% of Alabama
2	1	No	70	90	0.87	Transitional hurricane winds for approximately lower 20% of Alabama
3	2	No	70	95	0.87	
4	4	No	70	100	0.87	
5	3	No	70	110	0.80	
6	1	No	70	110	0.80	
7	1	No	70	115	0.80	
8	1	No	70	120	0.80	
9	1	No	70	125	0.80	
10	2	No	80	140	0.80	Coastline of Alabama
Total	69					

Table A-6. Pole and span wire sizes for group I and II load combinations considering pole deflection for 1994 *Supports Specifications*

Wind velocity (mph)	Pole weight (lb)	Tip diameter (in)	Ground line diameter (in)	Wall thickness (in)	Span wire size (in)	Assumed span wire min. breaking strength (lb)
50	379	7.74	11.80	0.125	3/16	3,990
60	402	8.34	12.40	0.125	3/16	3,990
70	498	6.54	10.60	0.188	7/32	5,400
80	580	7.94	12.00	0.188	1/4	6,650
90	678	9.64	13.70	0.188	9/32	8,950
100	818	12.04	16.10	0.188	5/16	11,200

Table A-7. Pole and span wire sizes for group I, II and III load combinations considering pole deflection for 1994 *Supports Specifications*

Wind velocity (mph)	Pole weight (lb)	Tip diameter (in)	Ground line diameter (in)	Wall thickness (in)	Span wire size (in)	Assumed span wire min. breaking strength (lb)
50	429	9.04	13.10	0.125	7/32	5,400
60	429	9.04	13.10	0.125	7/32	5,400
70	498	6.54	10.60	0.188	7/32	5,400
80	580	7.94	12.00	0.188	1/4	6,650
90	673	9.54	13.60	0.188	9/32	8,950
100	818	12.04	16.10	0.188	5/16	11,200

Table A-8. Pole and span wire sizes for group I and II load combinations ignoring pole deflection for 1994 *Supports Specifications*

Wind velocity (mph)	Pole weight (lb)	Tip diameter (in)	Ground line diameter (in)	Wall thickness (in)	Span wire size (in)	Assumed span wire min. breaking strength (lb)
50	448	9.54	13.60	0.125	7/32	5,400
60	545	12.04	16.10	0.125	1/4	6,650
70	690	9.84	13.90	0.188	9/32	8,950
80	835	12.34	16.40	0.188	5/16	11,200
90	981	14.84	18.90	0.188	3/8	15,400
100	1,132	17.44	21.50	0.188	7/16	20,800

Table A-9. Pole and span wire sizes for group I, II and III load combinations ignoring pole deflection for 1994 *Supports Specifications*

Wind velocity (mph)	Pole weight (lb)	Tip diameter (in)	Ground line diameter (in)	Wall thickness (in)	Span wire size (in)	Assumed span wire min. breaking strength (lb)
50	580	12.94	17.00	0.125	9/32	8,950
60	580	12.94	17.00	0.125	9/32	8,950
70	690	9.84	13.90	0.188	9/32	8,950
80	835	12.34	16.40	0.188	5/16	11,200
90	981	14.84	18.90	0.188	3/8	15,400
100	1,132	17.44	21.50	0.188	7/16	20,800

Table A-10. Ground line reactions for group I and II load combinations considering pole deflection for 1994 *Supports Specifications*

Wind velocity (mph)	Group I load combination			Group II load combination		
	Shear (lb)	Moment (lb-ft)	Axial (lb)	Shear (lb)	Moment (lb-ft)	Axial (lb)
50	761	21,313	524	1,444	39,470	524
60	761	21,313	547	1,836	50,297	547
70	768	21,496	645	2,188	59,792	645
80	774	21,665	728	2,842	78,004	728
90	785	21,980	829	3,718	101,763	829
100	796	22,281	970	4,892	133,554	970

Table A-11. Ground line reactions for group I, II and III load combinations considering pole deflection for 1994 *Supports Specifications*

Wind velocity (mph)	Group I load combination			Group II load combination			Group III load combination		
	Shear (lb)	Moment (lb-ft)	Axial (lb)	Shear (lb)	Moment (lb-ft)	Axial (lb)	Shear (lb)	Moment (lb-ft)	Axial (lb)
50	768	21,496	576	1,521	41,720	576	2,010	55,227	724
60	768	21,496	576	1,899	52,126	576	1,993	55,011	724
70	768	21,496	645	2,188	59,792	645	1,869	51,620	793
80	774	21,665	728	2,842	78,004	728	2,139	59,244	877
90	785	21,980	823	3,698	101,231	823	2,691	74,383	974
100	796	22,281	970	4,892	133,554	970	3,463	95,492	1,123

Table A-11. Ground line reactions for group I and II load combinations ignoring pole deflection for 1994 *Supports Specifications*

Wind velocity (mph)	Group I load combination			Group II load combination		
	Shear (lb)	Moment (lb-ft)	Axial (lb)	Shear (lb)	Moment (lb-ft)	Axial (lb)
50	768	21,496	595	2,038	56,437	595
60	774	21,665	693	2,826	78,364	693
70	785	21,980	840	3,784	105,112	840
80	796	22,281	988	4,940	136,896	988
90	814	22,780	1,137	6,300	174,183	1,137
100	847	23,704	1,294	7,857	216,725	1,294

Table A-13. Ground line reactions for group I, II and III load combinations ignoring pole deflection for 1994 *Supports Specifications*

Wind velocity (mph)	Group I load combination			Group II load combination			Group III load combination		
	Shear (lb)	Moment (lb-ft)	Axial (lb)	Shear (lb)	Moment (lb-ft)	Axial (lb)	Shear (lb)	Moment (lb-ft)	Axial (lb)
50	785	21,980	730	2,056	56,988	730	3,096	86,089	881
60	785	21,980	730	2,844	78,815	730	3,095	86,071	881
70	785	21,980	840	3,784	105,112	840	3,086	85,952	991
80	796	22,281	988	4,940	136,896	988	3,366	93,628	1,140
90	814	22,780	1,137	6,300	174,183	1,137	4,139	114,882	1,291
100	847	23,704	1,294	7,857	216,725	1,294	5,045	139,750	1,452

Table A-14. Pole and span wire sizes for group I, II and III load combinations considering pole deflection for 2001 *Supports Specifications*

Wind velocity (mph)	Pole weight (lb)	Tip diameter (in)	Ground line diameter (in)	Wall thickness (in)	Span wire size (in)	Assumed span wire min. breaking strength (lb)
85	464	9.94	14.00	0.125	7/32	5,400
90	498	6.54	10.60	0.188	7/32	5,400
95	527	7.04	11.10	0.188	7/32	5,400
100	562	7.64	11.70	0.188	1/4	6,650
110	597	8.24	12.30	0.188	1/4	6,650
115	638	8.94	13.00	0.188	9/32	8,950
120	673	9.54	13.60	0.188	9/32	8,950
125	719	10.34	14.40	0.188	9/32	8,950
130	777	11.34	15.40	0.188	5/16	11,200
140	882	13.14	17.20	0.188	5/16	11,200
150	990	10.74	14.80	0.250	3/8	15,400

Table A-15. Pole and span wire sizes for group I, II, and III load combinations ignoring pole deflection for 2001 *Supports Specifications*

Wind velocity (mph)	Pole weight (lb)	Tip diameter (in)	Ground line diameter (in)	Wall thickness (in)	Span wire size (in)	Assumed span wire min. breaking strength (lb)
85	615	13.84	17.90	0.125	9/32	8,950
90	684	9.74	13.80	0.188	9/32	8,950
95	736	10.64	14.70	0.188	9/32	8,950
100	795	11.64	15.70	0.188	5/16	11,200
110	853	12.64	16.70	0.188	5/16	11,200
115	911	13.64	17.70	0.188	3/8	15,400
120	963	14.54	18.60	0.188	3/8	15,400
125	1,021	15.54	19.60	0.188	3/8	15,400
130	1,074	16.44	20.50	0.188	3/8	15,400
140	1,190	18.44	22.50	0.188	7/16	20,800
150	1,346	15.34	19.40	0.250	7/16	20,800

Table A-16. Ground line reactions for group I, II and III load combinations considering pole deflection for 2001 *Supports Specifications*

Wind velocity (mph)	Group I load combination			Group II load combination			Group III load combination		
	Shear (lb)	Moment (lb-ft)	Axial (lb)	Shear (lb)	Moment (lb-ft)	Axial (lb)	Shear (lb)	Moment (lb-ft)	Axial (lb)
85	768	21,496	611	2,134	58,840	611	2,059	57,091	759
90	768	21,496	645	2,086	57,238	645	1,863	51,543	793
95	768	21,496	674	2,303	63,299	674	1,915	53,056	822
100	774	21,665	710	2,559	70,467	710	1,983	55,041	860
110	774	21,665	745	2,852	78,519	745	2,152	59,695	895
115	785	21,980	788	3,173	87,276	788	2,360	65,439	939
120	785	21,980	823	3,484	95,731	823	2,559	70,904	974
125	785	21,980	869	3,850	105,704	869	2,795	77,382	1,020
130	796	22,281	930	4,291	117,733	930	3,081	85,251	1,082
140	796	22,281	1,034	5,175	141,735	1,034	3,648	100,786	1,186
150	814	22,780	1,146	5,500	150,810	1,146	3,879	107,244	1,301

Table A-17. Ground line reactions for group I, II, and III load combinations ignoring pole deflection for 2001 *Supports Specifications*

Wind velocity (mph)	Group I load combination			Group II load combination			Group III load combination		
	Shear (lb)	Moment (lb-ft)	Axial (lb)	Shear (lb)	Moment (lb-ft)	Axial (lb)	Shear (lb)	Moment (lb-ft)	Axial (lb)
85	785	21,980	765	3,209	88,992	765	3,092	86,031	916
90	785	21,980	834	3,556	98,904	834	3,081	85,895	985
95	785	21,980	887	3,948	109,726	887	3,083	85,925	1,038
100	796	22,281	947	4,384	121,757	947	3,103	86,435	1,099
110	796	22,281	1,005	4,869	135,117	1,005	3,329	92,657	1,157
115	814	22,780	1,067	5,363	148,717	1,067	3,612	100,471	1,222
120	814	22,780	1,119	5,836	161,722	1,119	3,878	107,801	1,274
125	814	22,780	1,177	6,333	175,328	1,177	4,160	115,559	1,332
130	814	22,780	1,230	6,850	189,511	1,230	4,457	123,730	1,384
140	847	23,704	1,352	8,023	221,607	1,352	5,144	142,635	1,510
150	847	23,704	1,509	9,156	253,541	1,509	5,816	161,512	1,666

Table A-18. Pole weights for 1994 *Supports Specifications*

Group Load Combination	I and II only	I and II only		I, II and III	I, II and III	
Basic Wind Speed (mph)	Weight Considering Pole Deflection (lb)	Weight Ignoring Pole Deflection (lb)	Percent Difference For Gr. I and II only	Weight Considering Pole Deflection (lb)	Weight Ignoring Pole Deflection (lb)	Percent Difference For Gr. I, II and III
50	379	448	18%	429	580	35%
60	402	545	36%	429	580	35%
70	498	690	39%	498	690	39%
80	580	835	44%	580	835	44%
90	678	981	45%	673	981	46%
100	818	1,132	38%	818	1,132	38%

Table A-19. Pole weights for group I, II, and III load combinations for the 2001 *Supports Specifications*

Basic Wind Speed (mph)	Weight Considering Pole Deflection (lb)	Weight Ignoring Pole Deflection (lb)	Percent Difference
85	464	615	33%
90	498	684	37%
95	527	736	40%
100	562	795	41%
110	597	853	43%
115	638	911	43%
120	673	963	43%
125	719	1,021	42%
130	777	1,074	38%
140	882	1,190	35%
150	990	1,346	36%

Table A-20. Structure weight comparisons by site considering pole deflection

Site No.	AASHTO 1994		AASHTO 2001		
	Wind Speed, 25-year MRI (mph)	Pole weight (lb)	Wind Speed (mph)	Pole weight (lb)	Change in Weight Relative to 1994 Spec.
1a	70	498	90	498	0%
1b	70	498	90	498	0%
2	70	498	90	498	0%
3	70	498	95	527	6%
4	70	498	100	562	13%
5	70	498	110	597	20%
6	70	498	110	597	20%
7	70	498	115	638	28%
8	70	498	120	673	35%
9	70	498	125	719	44%
10	80	580	140	882	52%

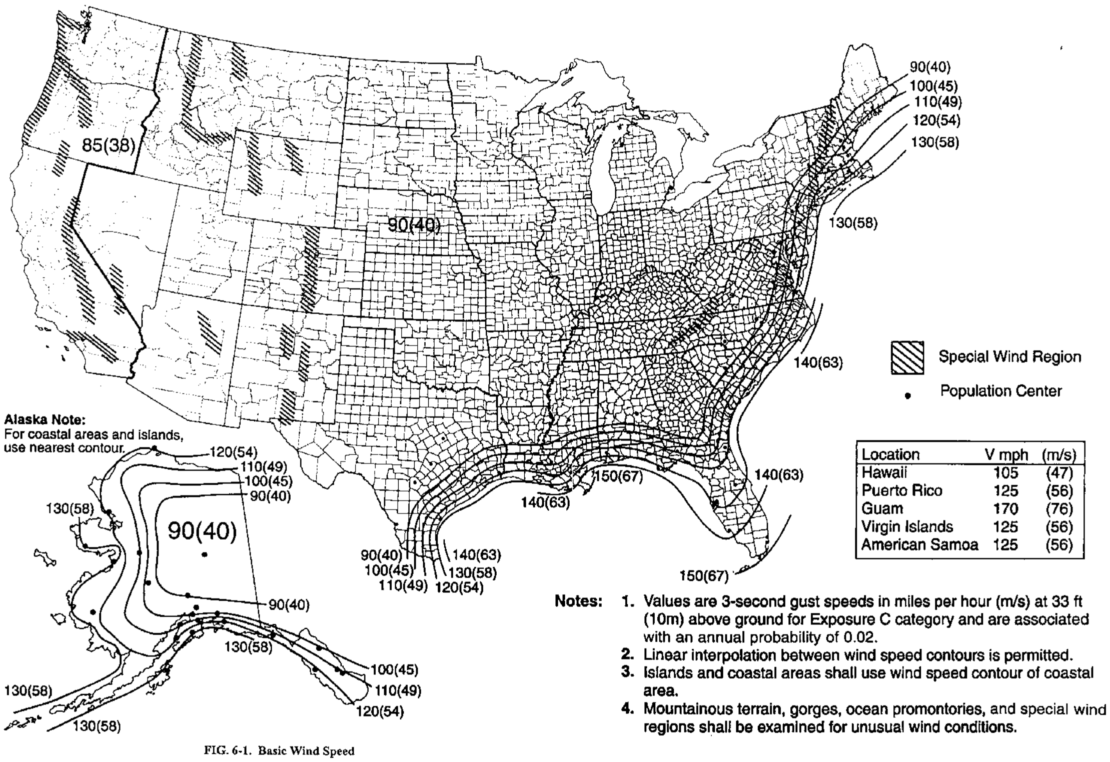
Table A-21. Structure weight comparisons by site ignoring pole deflection

Site No.	AASHTO 1994		AASHTO 2001		
	Wind Speed, 25-year MRI (mph)	Pole weight (lb)	Wind Speed (mph)	Pole weight (lb)	Change in Weight Relative to 1994 Spec.
1a	70	690	90	684	-1%
1b	70	690	90	684	-1%
2	70	690	90	684	-1%
3	70	690	95	736	7%
4	70	690	100	795	15%
5	70	690	110	853	24%
6	70	690	110	853	24%
7	70	690	115	911	32%
8	70	690	120	963	40%
9	70	690	125	1,021	48%
10	80	835	140	1,190	42%

Appendix B
Figures

ISOTACH 0.04 QUANTILES, IN MILES PER HOUR: ANNUAL EXTREME-MILE 30 FT ABOVE GROUND, 25-YR MEAN RECURRENCE INTERVAL

Figure B-1. Wind map: 25-year mean recurrence interval (Thom, 1968)



Location	V mph	(m/s)
Hawaii	105	(47)
Puerto Rico	125	(56)
Guam	170	(76)
Virgin Islands	125	(56)
American Samoa	125	(56)

Notes:

1. Values are 3-second gust speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category and are associated with an annual probability of 0.02.
2. Linear interpolation between wind speed contours is permitted.
3. Islands and coastal areas shall use wind speed contour of coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

FIG. 6-1. Basic Wind Speed

Figure 2-2. Basic wind speed (ANSI/ASCE 7-95, 1996)

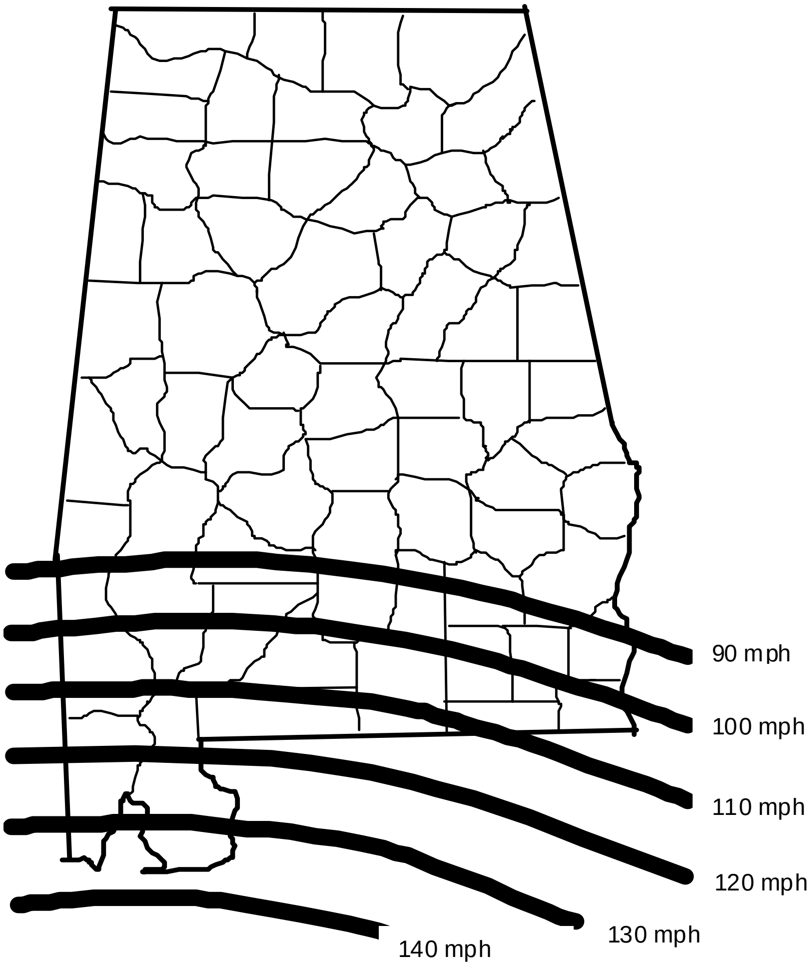


Figure B-3. Basic wind speed for Alabama (AASHTO, 2001)

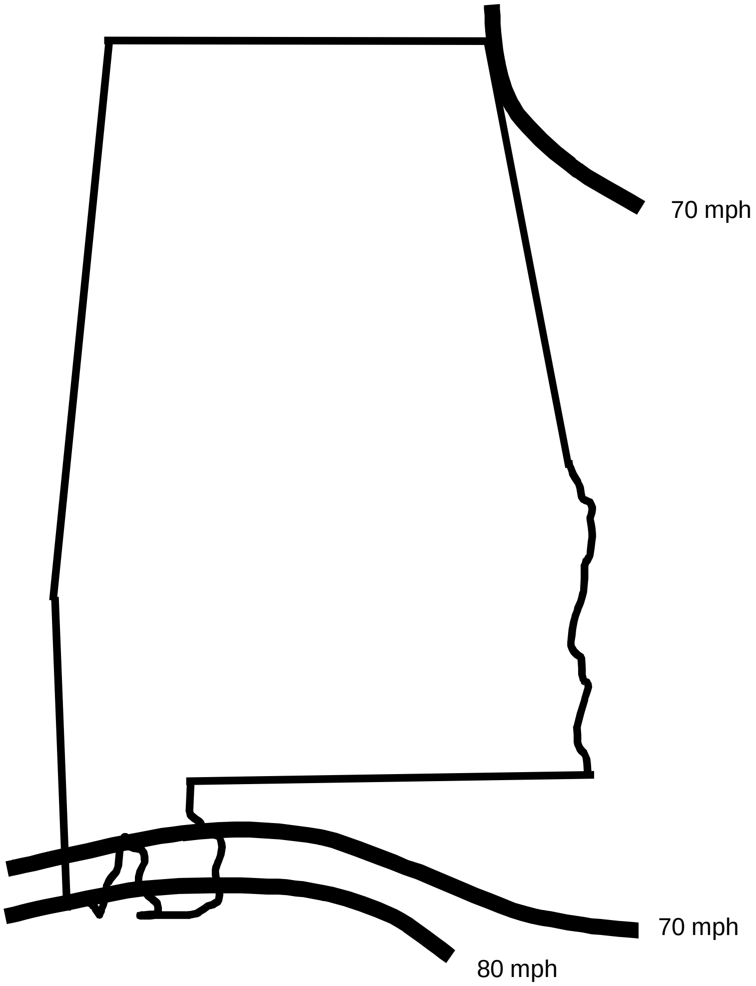


Figure B-4. Wind speed for Alabama, 25-year mean recurrence interval (AASHTO, 1994)

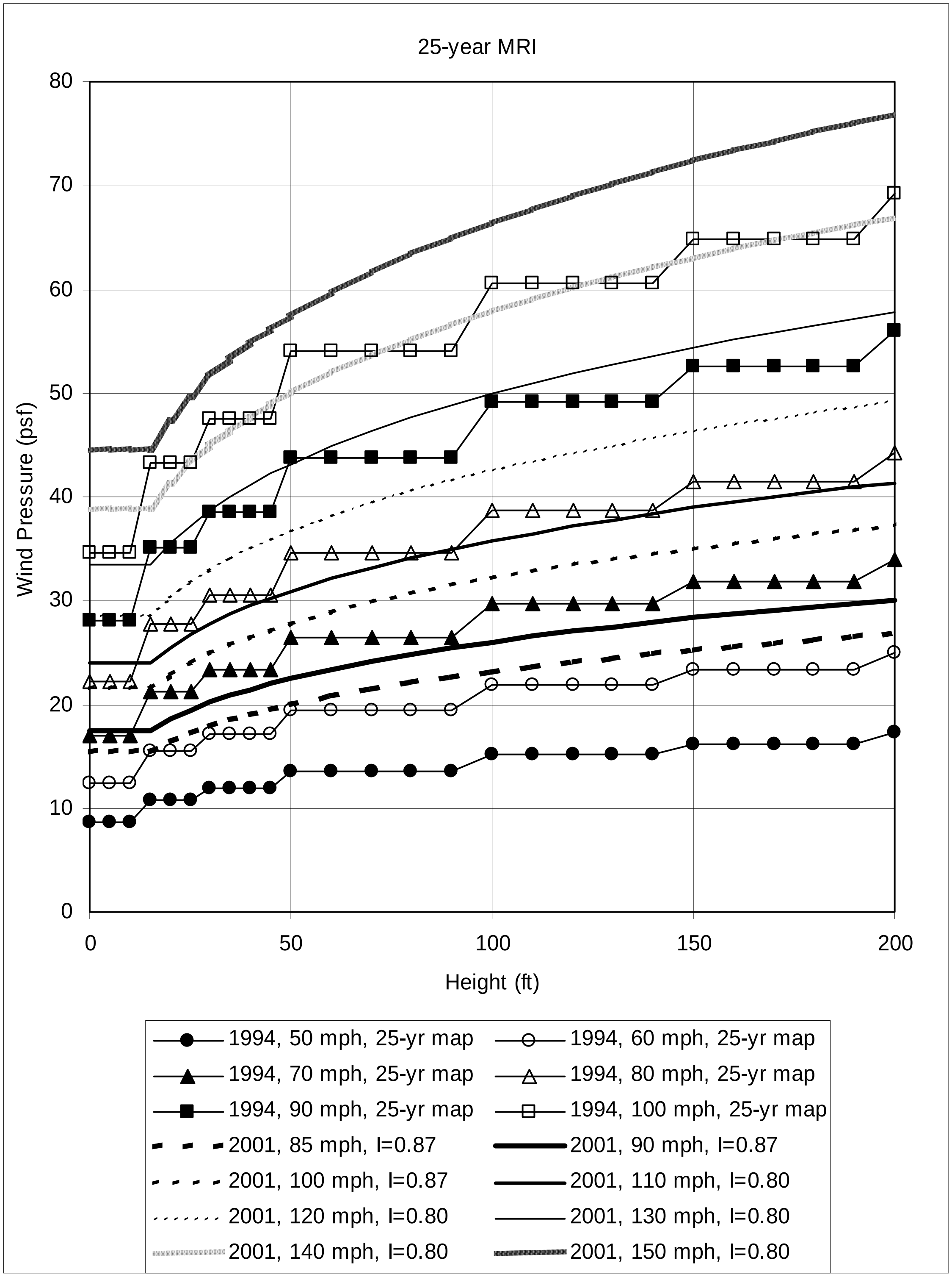


Figure B-5. Wind pressure comparisons for 25-year mean recurrence interval

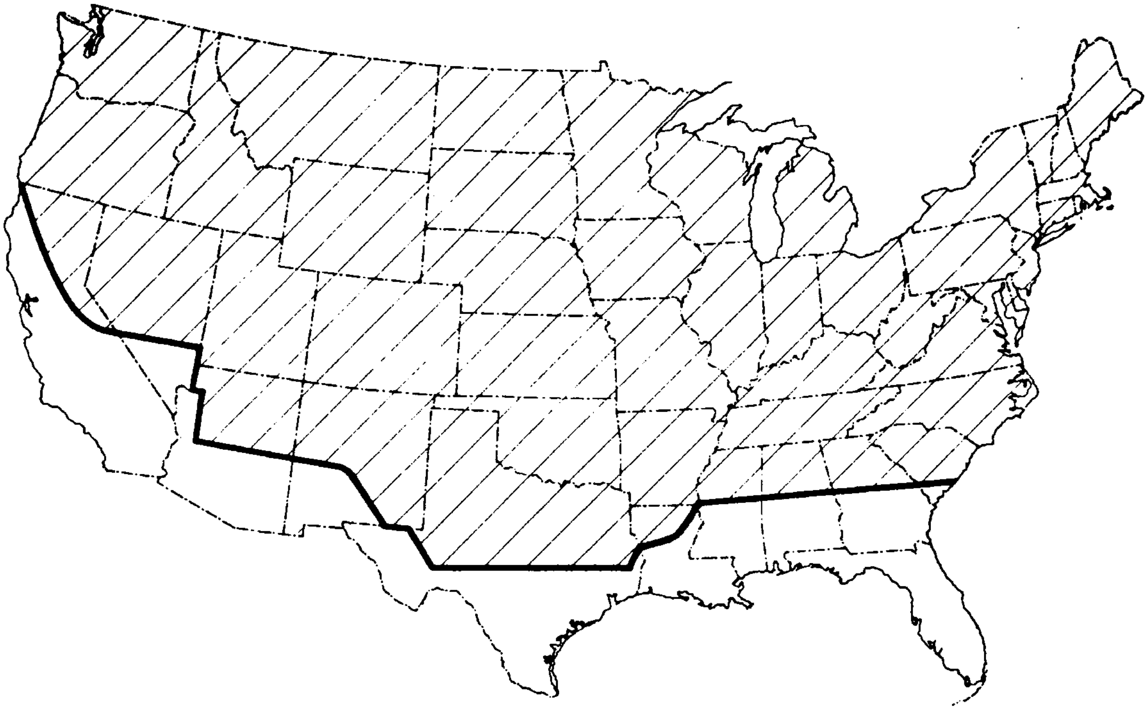


Figure B-6. Ice loading map (AASHTO, 1994 and 2001)

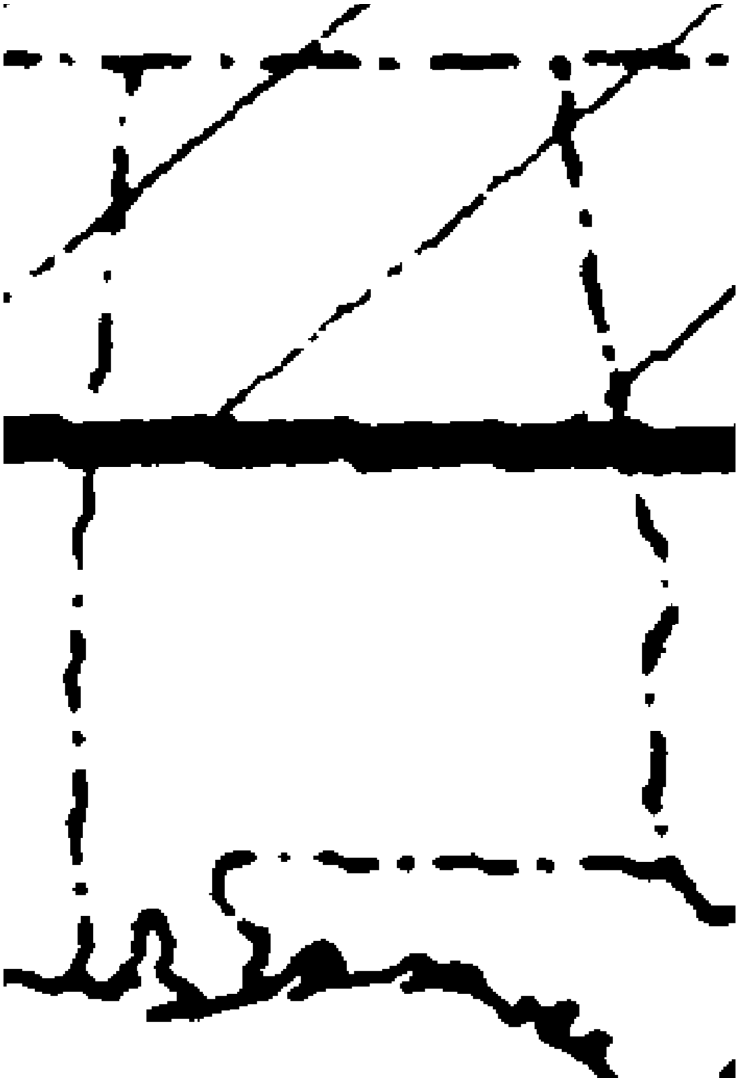


Figure B-7. Ice loading for Alabama (AASHTO, 1994 and 2001)

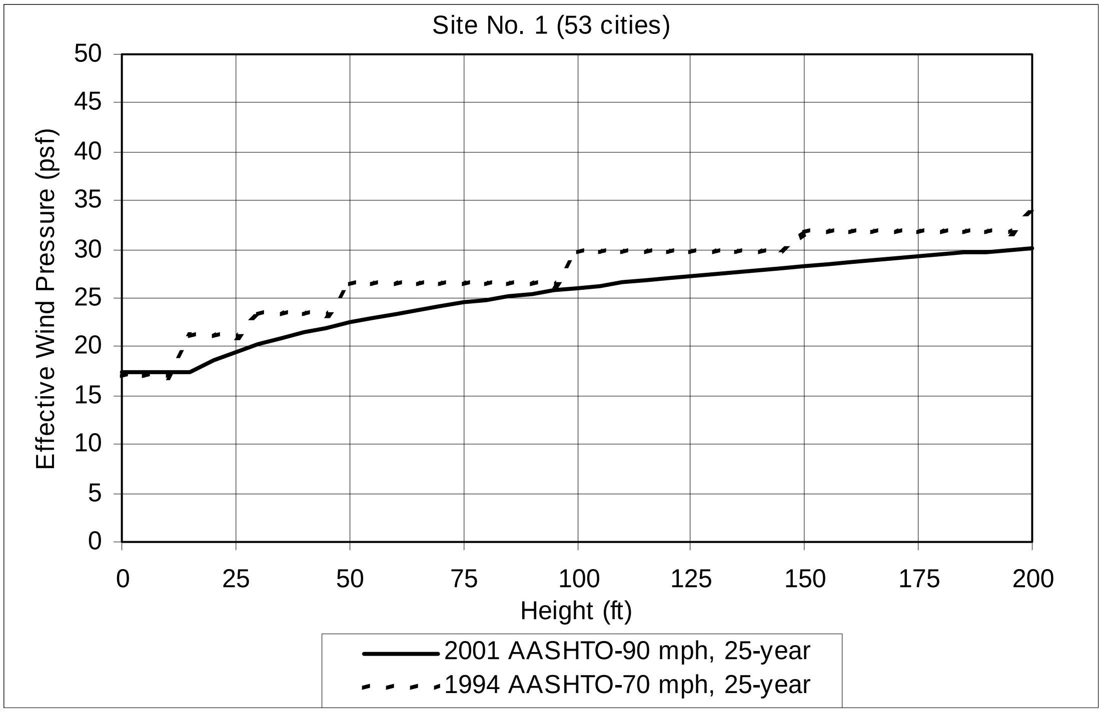


Figure B-8. Site nos. 1a and 1b: effective wind pressure

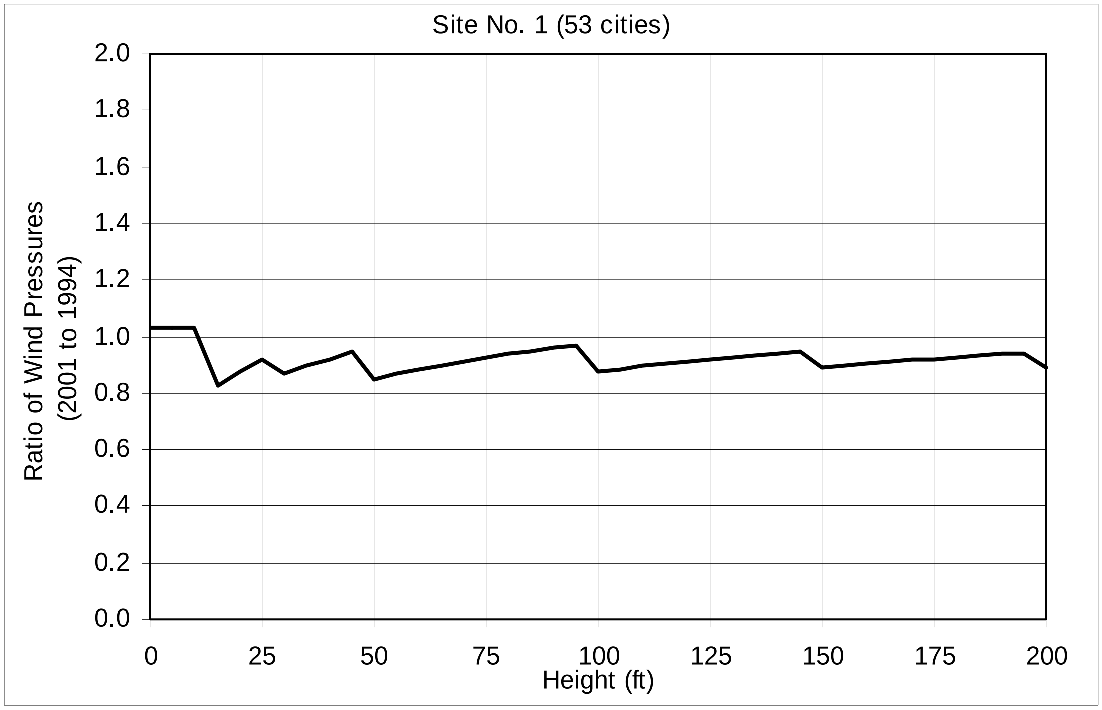


Figure B-9. Site nos. 1a and 1b: ratio of wind pressures (2001 to 1994 specifications)

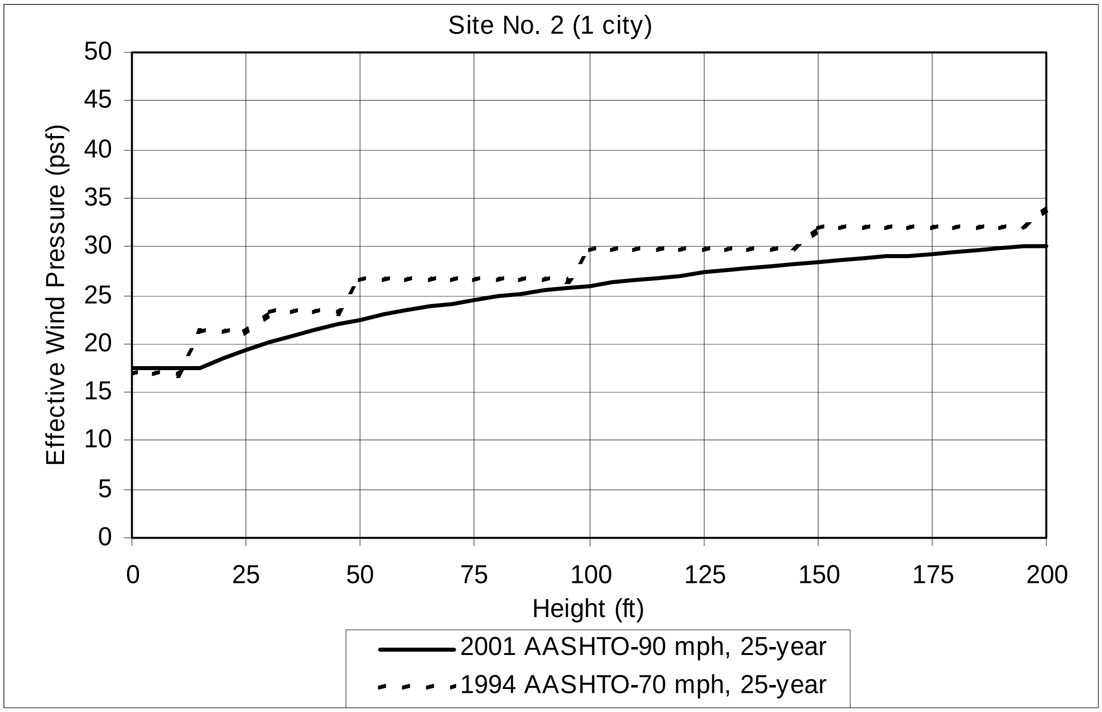


Figure B-10. Site no. 2: effective wind pressure

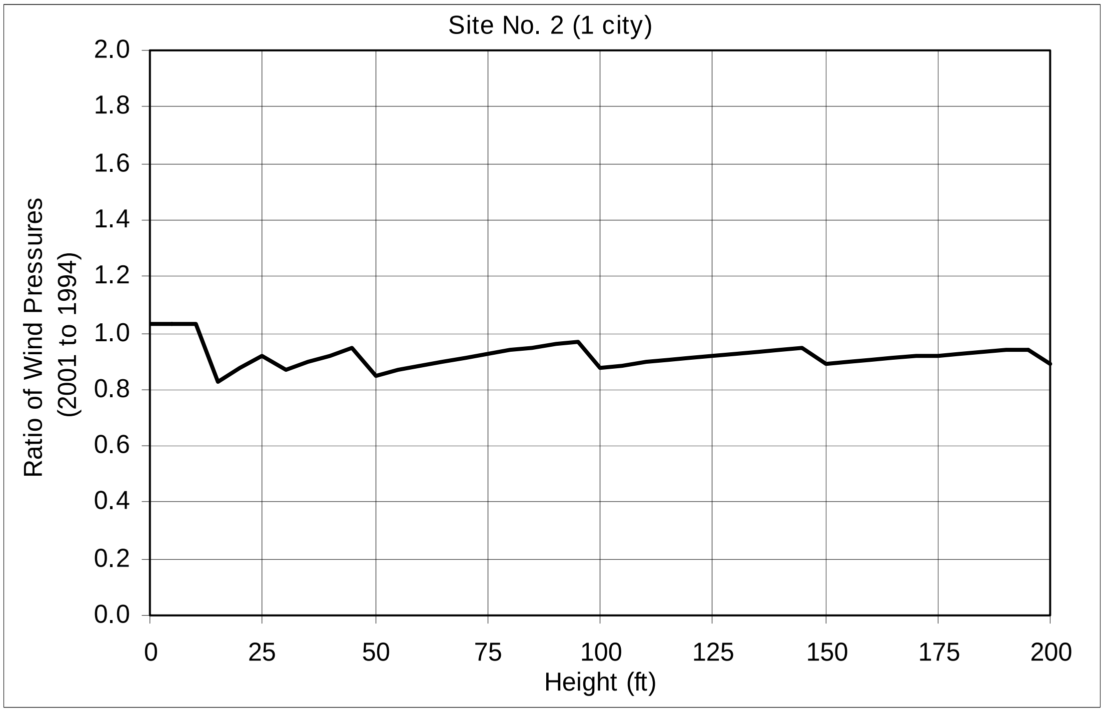


Figure B-11. Site no. 2: ratio of wind pressures (2001 to 1994 specifications)

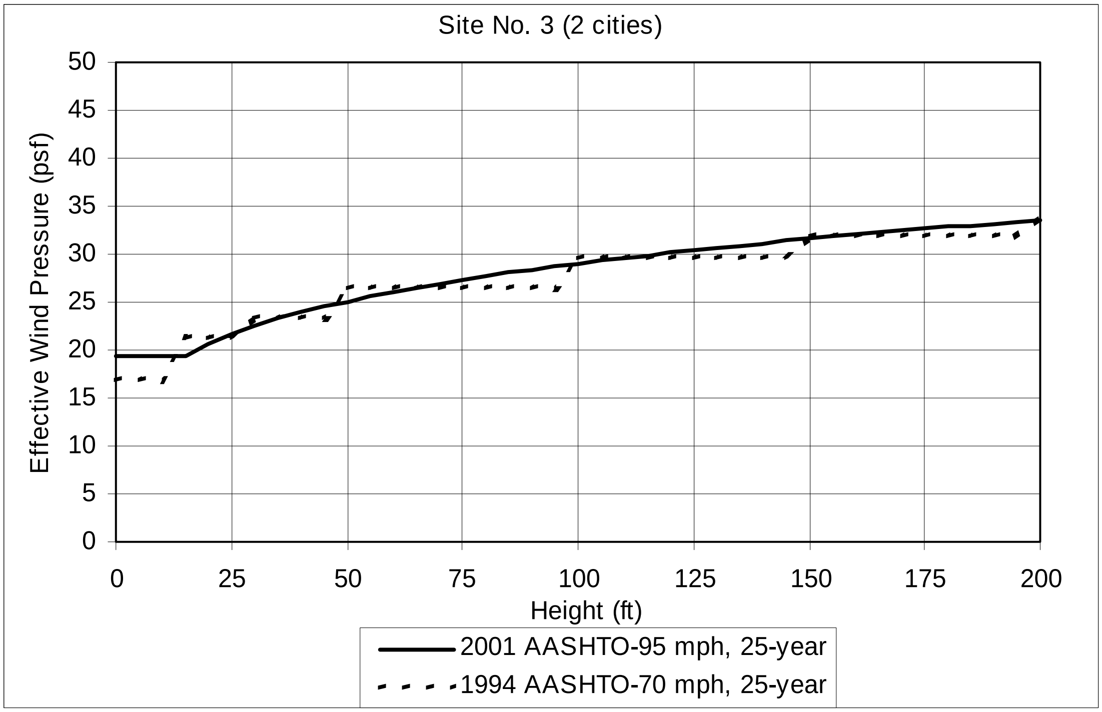


Figure B-12. Site no. 3: effective wind pressure

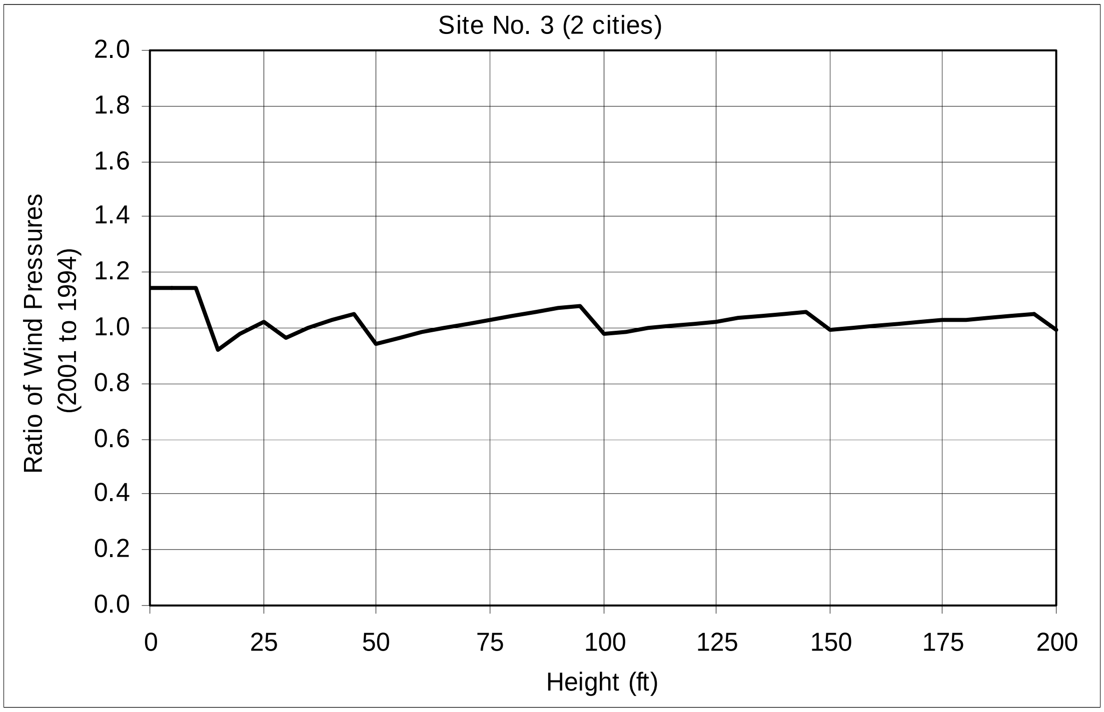


Figure B-13. Site no. 3: ratio of wind pressures (2001 to 1994 specifications)

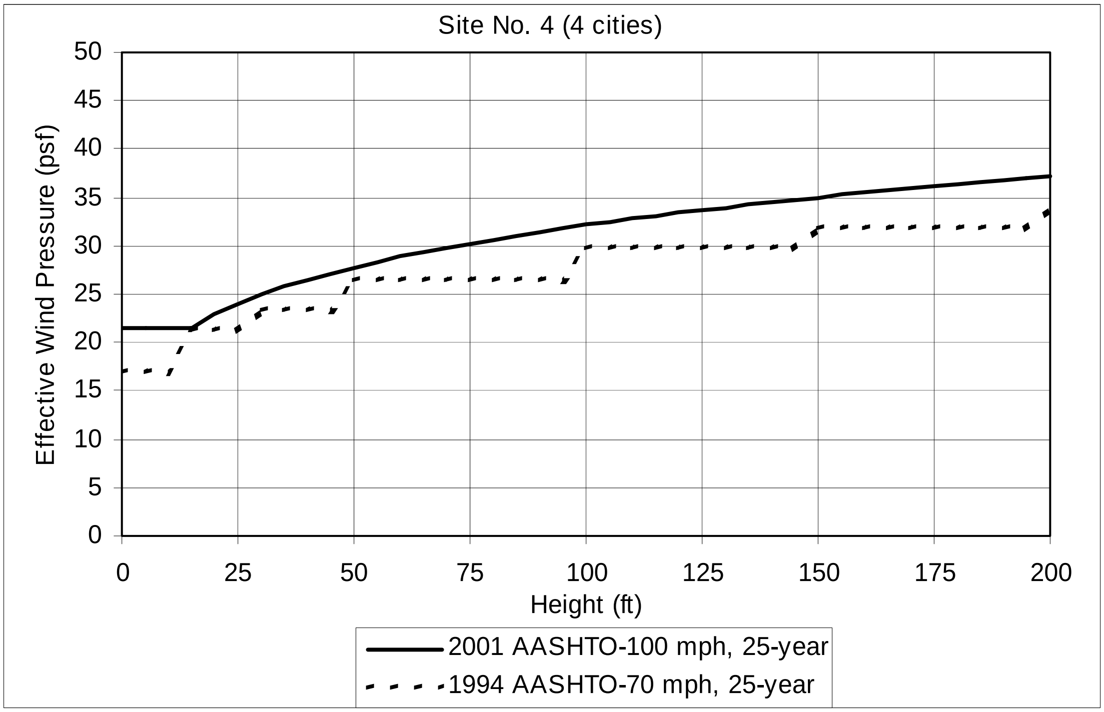


Figure B-14. Site no. 4: effective wind pressure

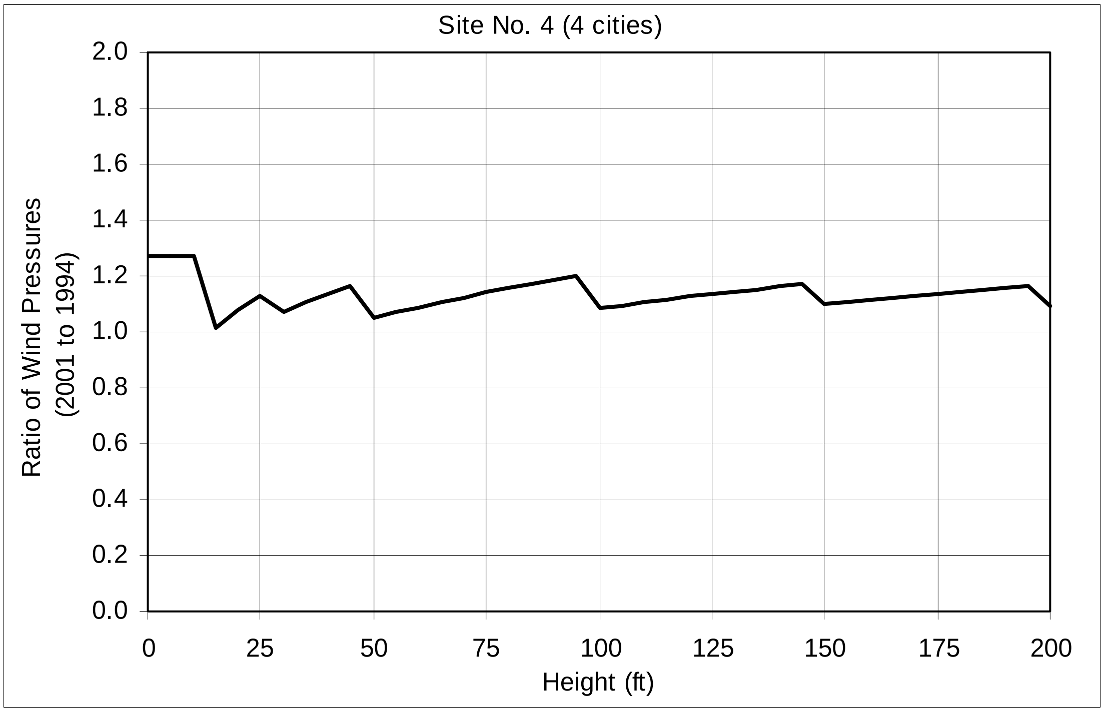


Figure B-15. Site no. 4: ratio of wind pressures (2001 to 1994 specifications)

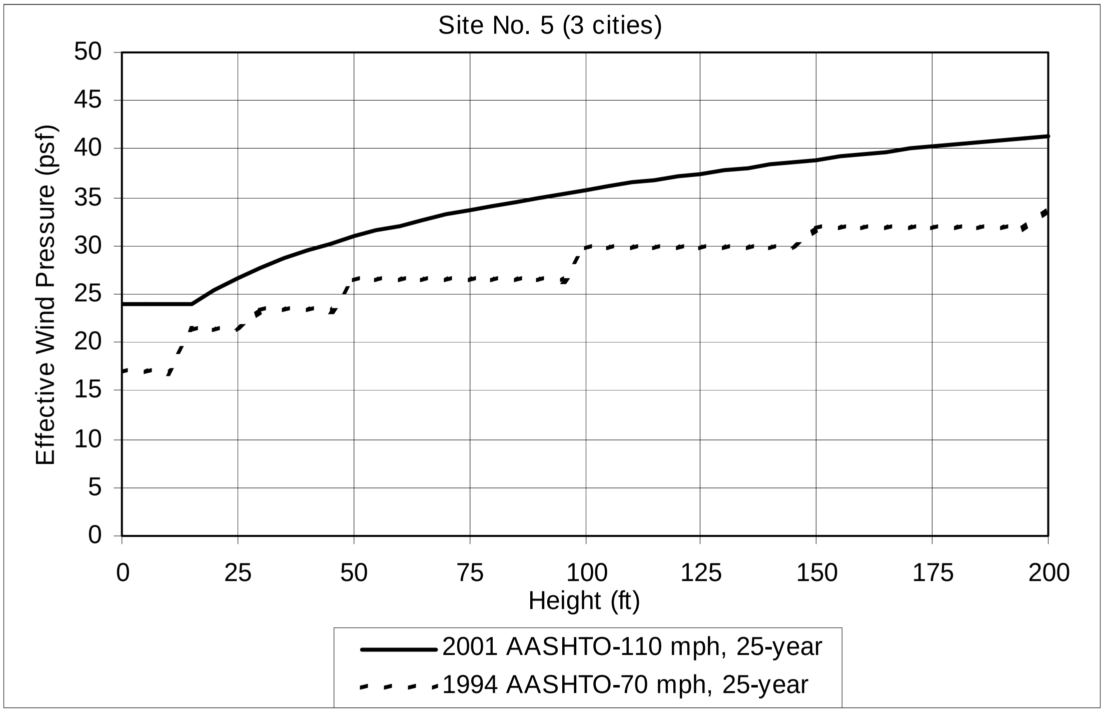


Figure B-16. Site no. 5: effective wind pressure

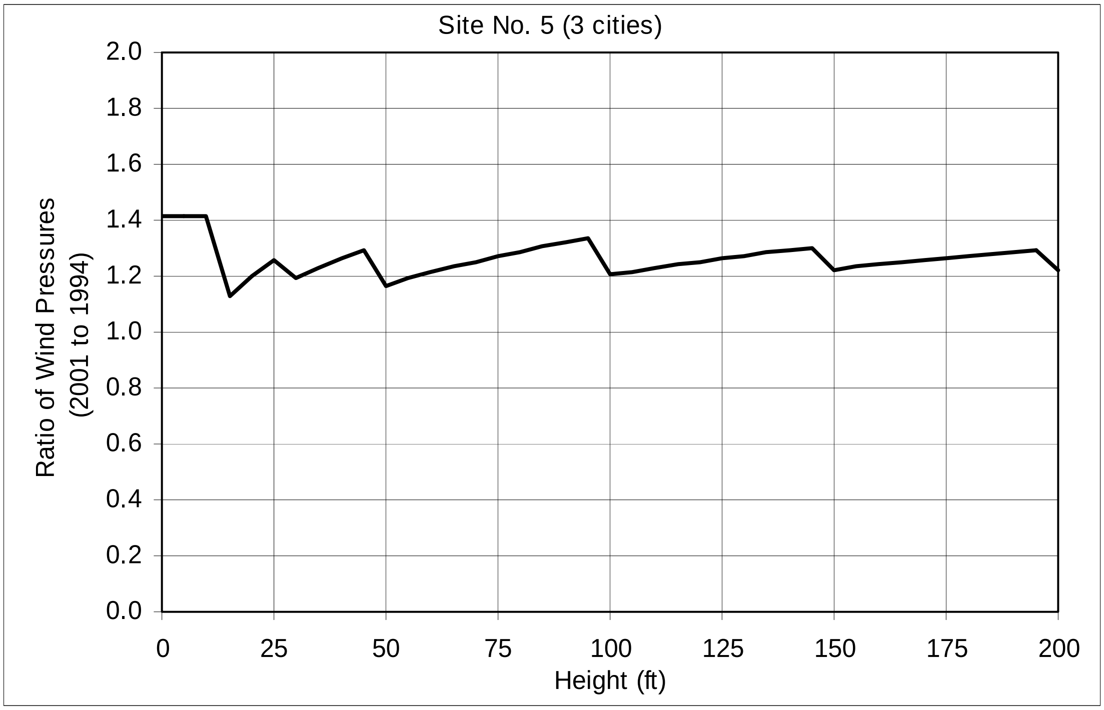


Figure B-17. Site no. 5: ratio of wind pressures (2001 to 1994 specifications)

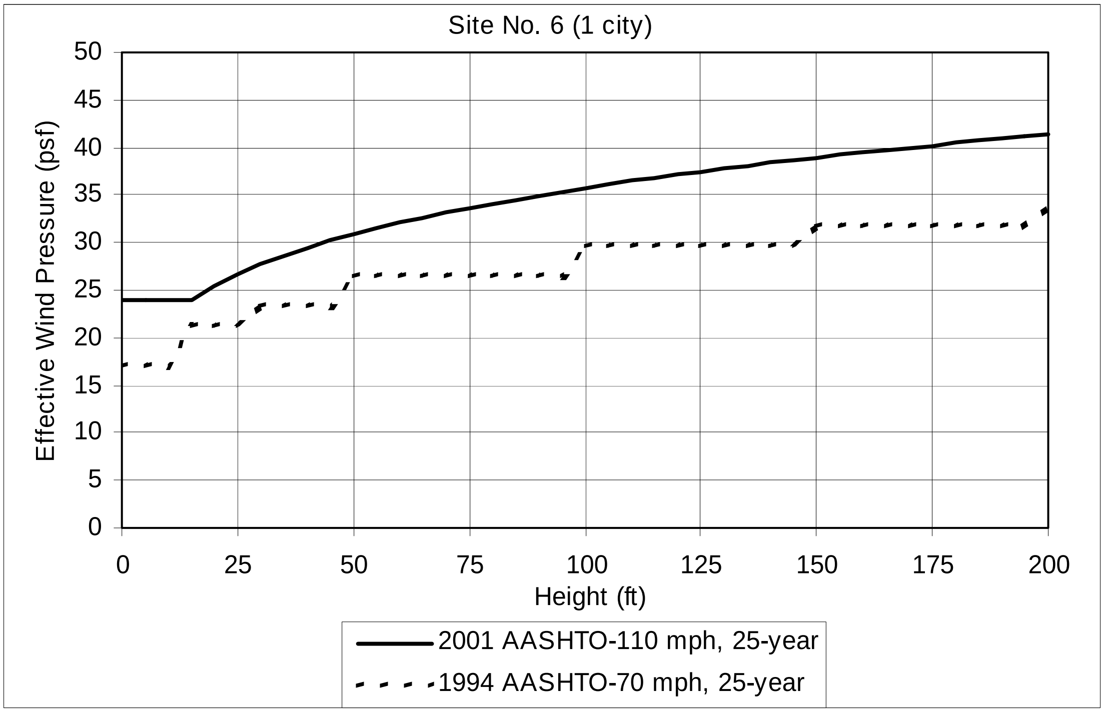


Figure B-17. Site no. 6: effective wind pressure

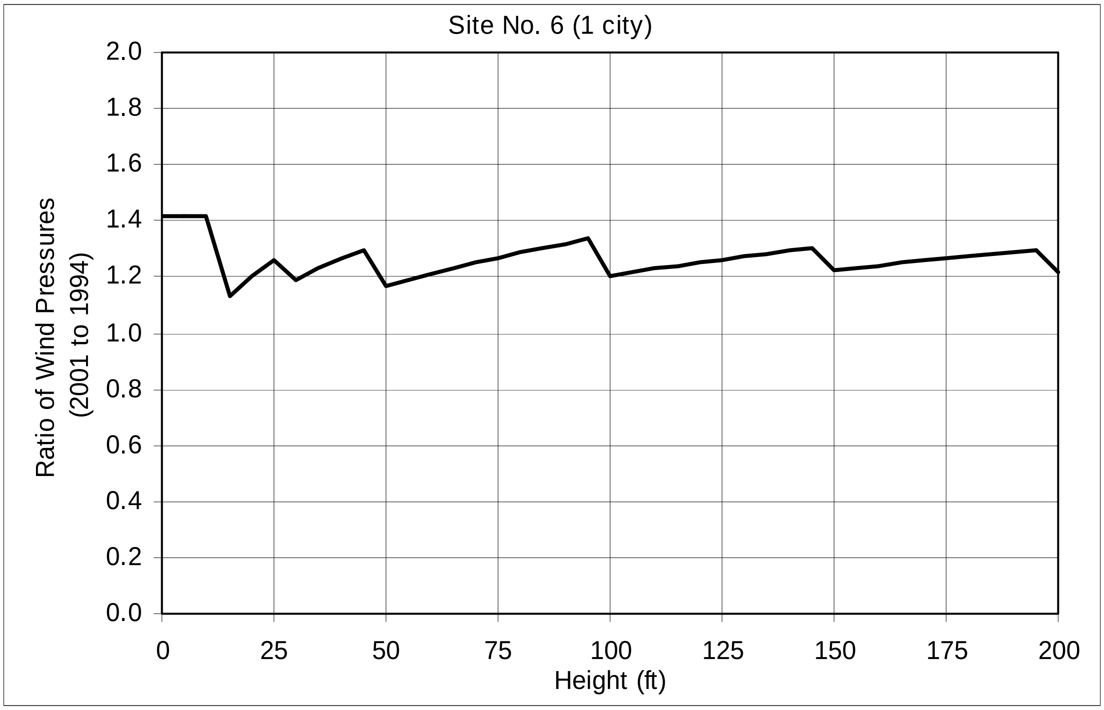


Figure B-18. Site no. 6: ratio of wind pressures (2001 to 1994 specifications)

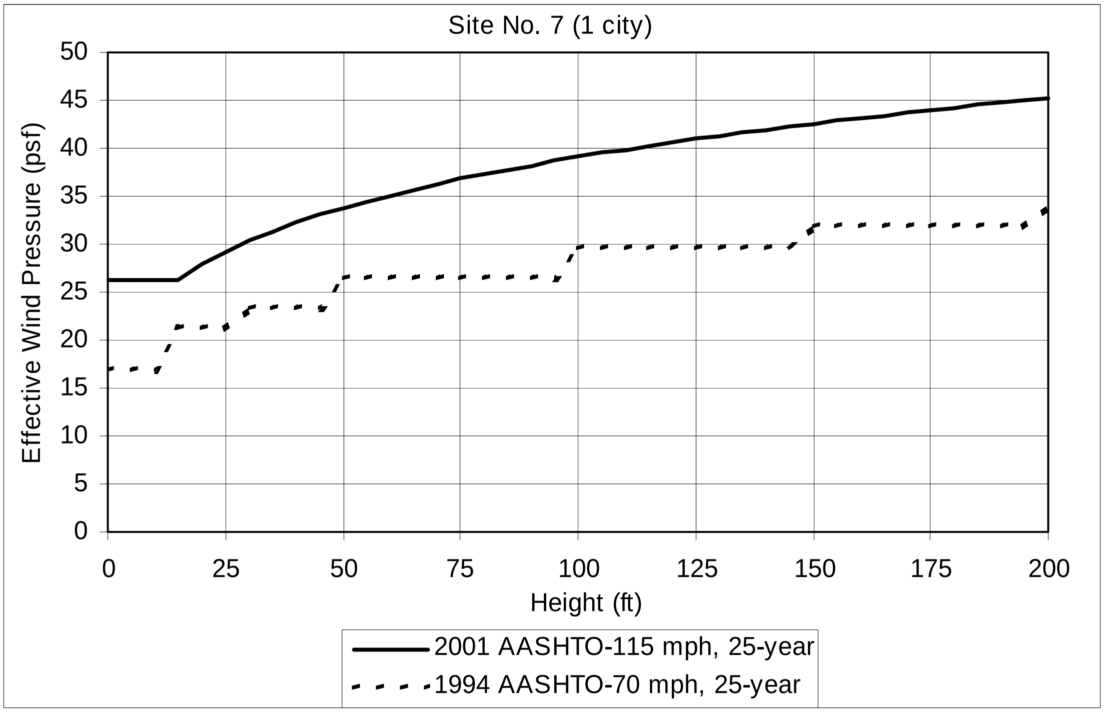


Figure B-20. Site no. 7: effective wind pressure

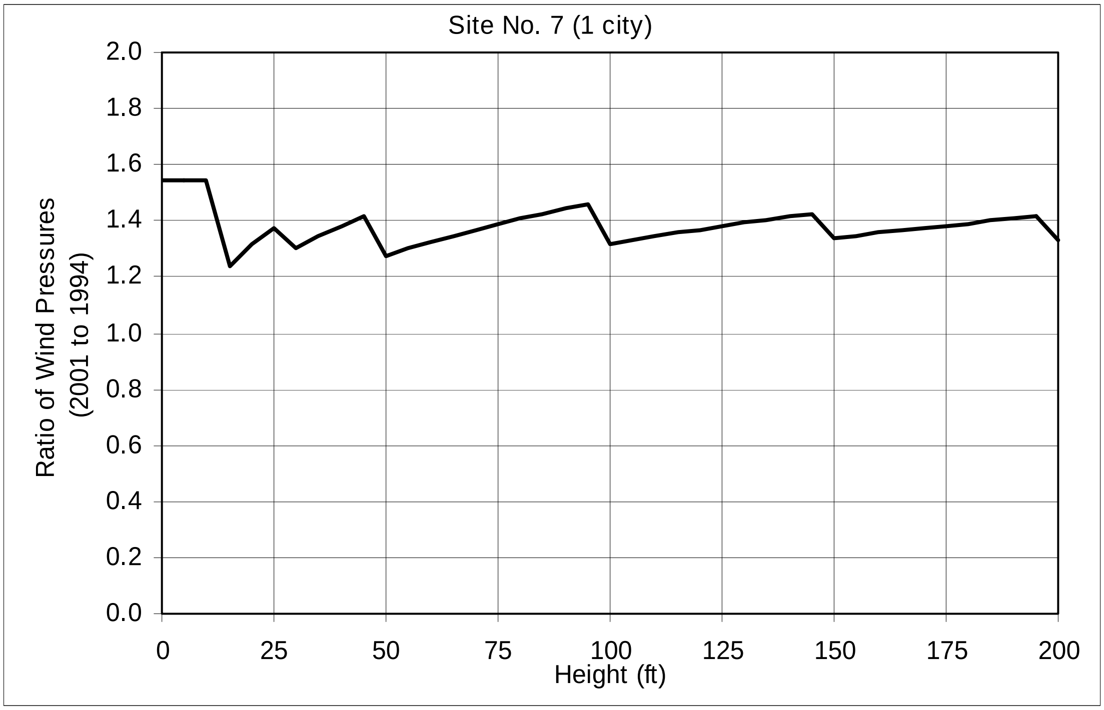


Figure B-21. Site no. 7: ratio of wind pressures (2001 to 1994 specifications)

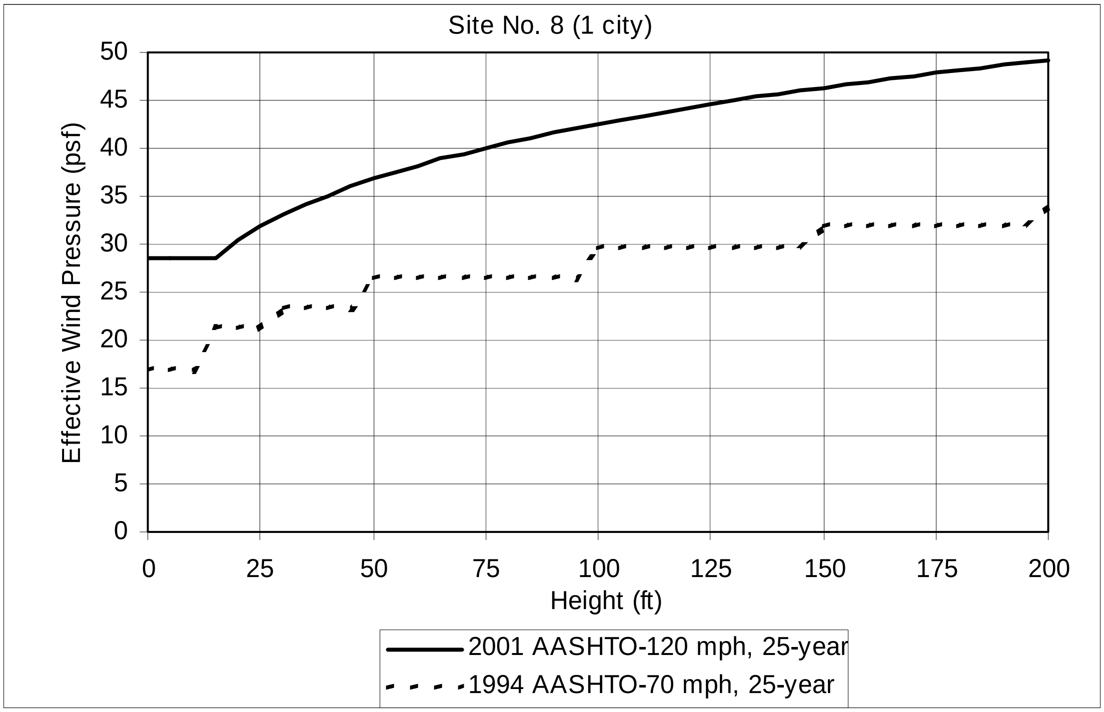


Figure B-22. Site no. 8: effective wind pressure

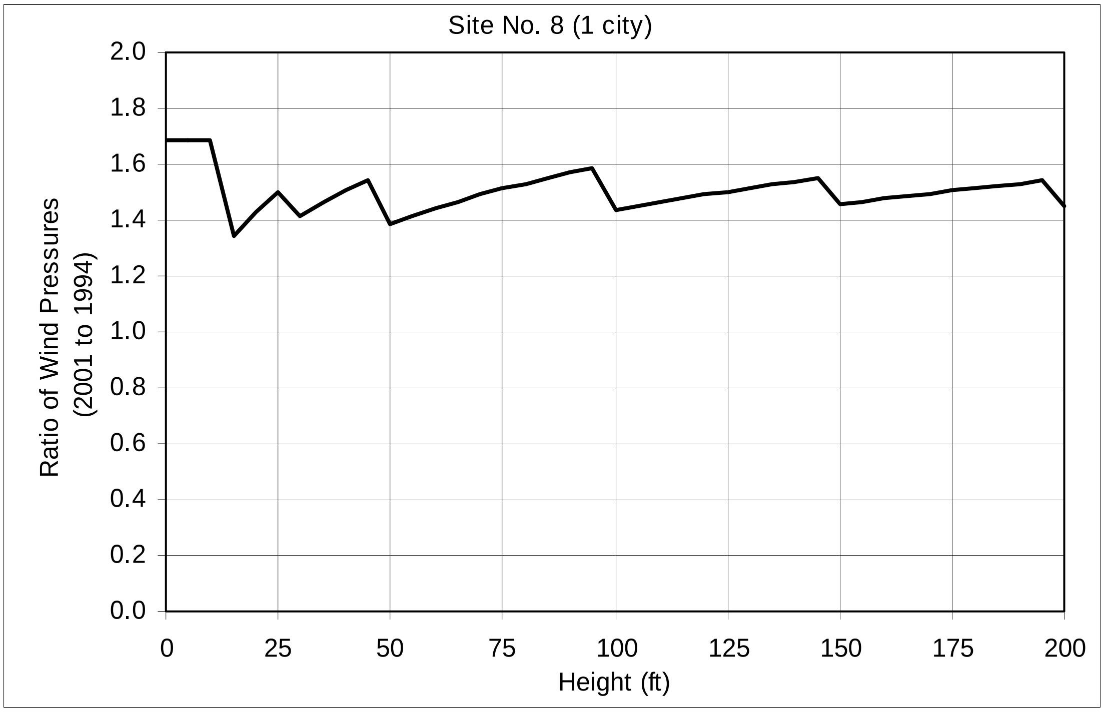


Figure B-23. Site no. 8: ratio of wind pressures (2001 to 1994 specifications)

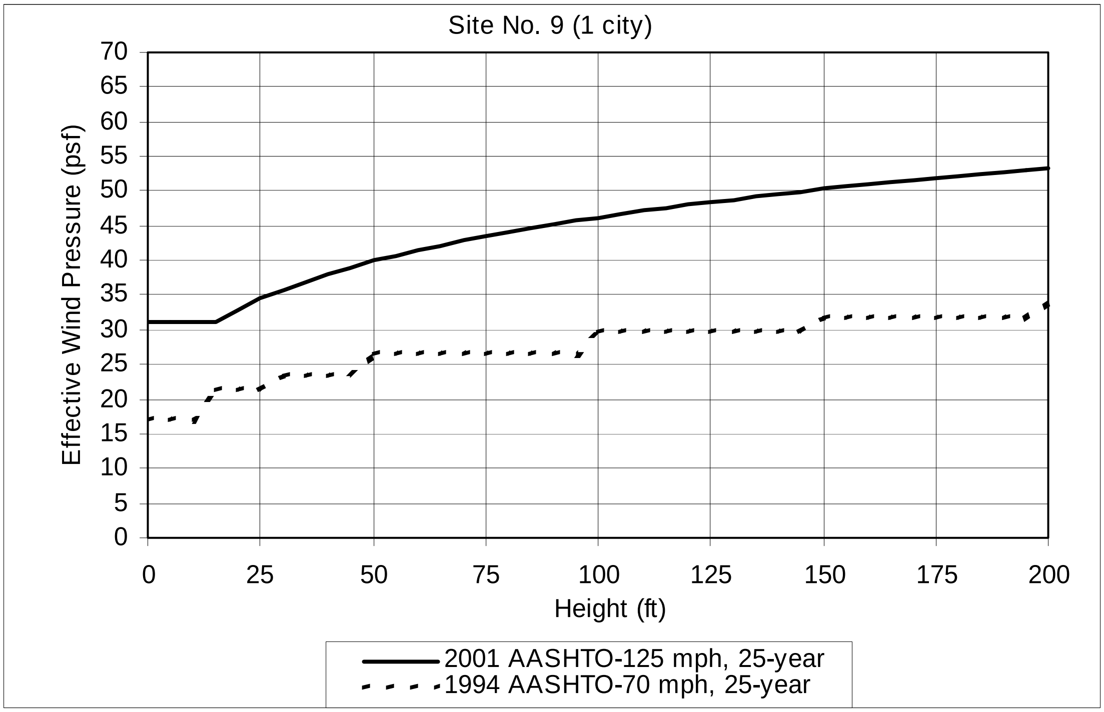


Figure B-24. Site no. 9: effective wind pressure

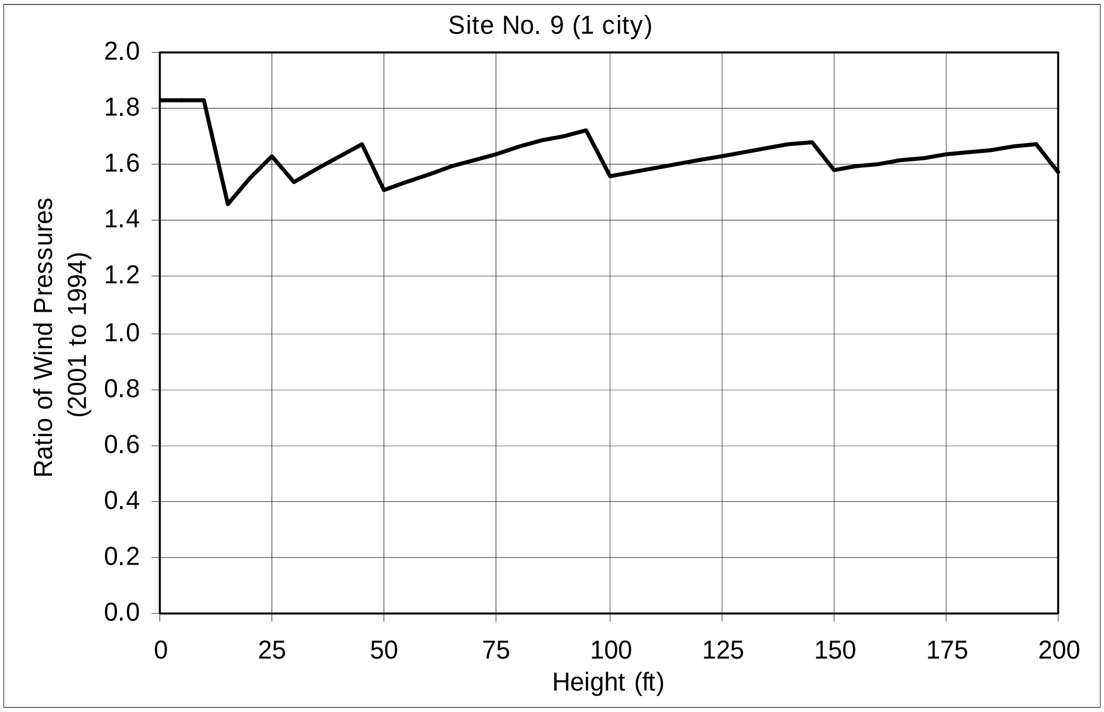


Figure B-25. Site no. 9: ratio of wind pressures (2001 to 1994 specifications)

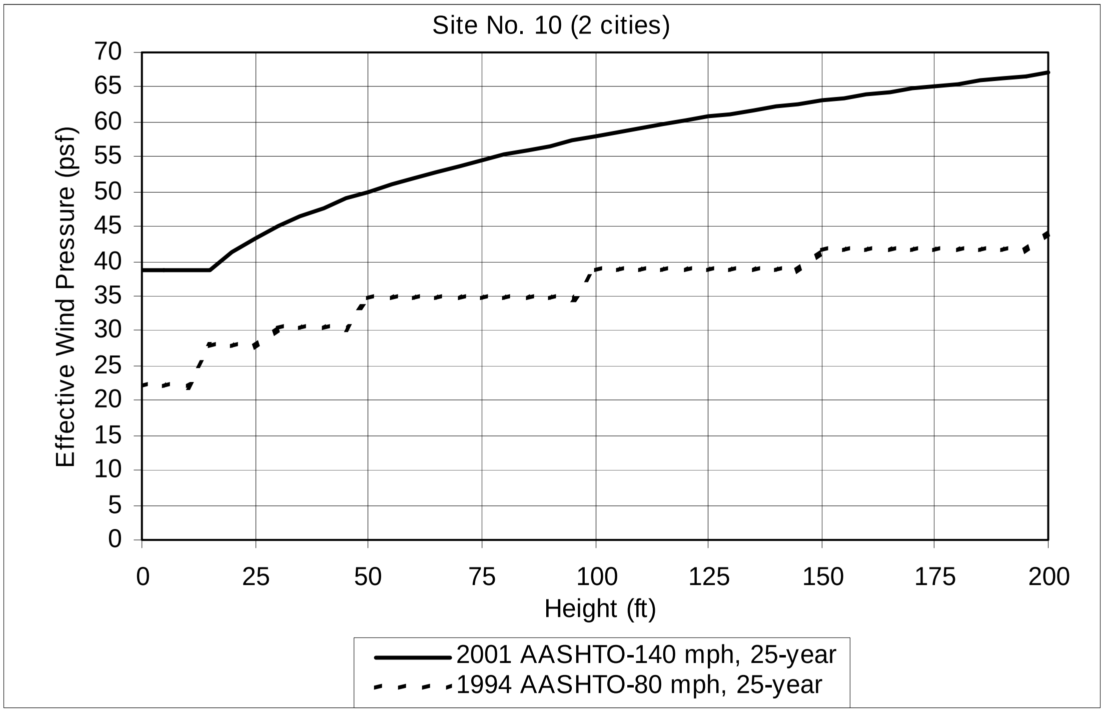


Figure B-26. Site no. 10: effective wind pressure

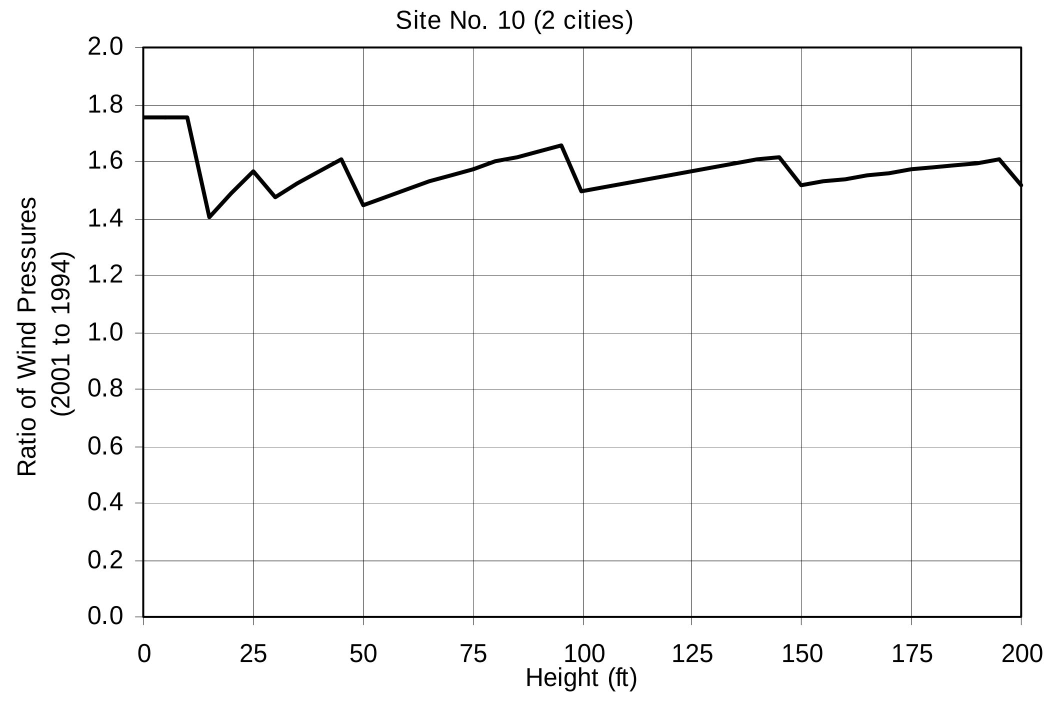


Figure B-27. Site no. 10: ratio of wind pressures (2001 to 1994 specifications)

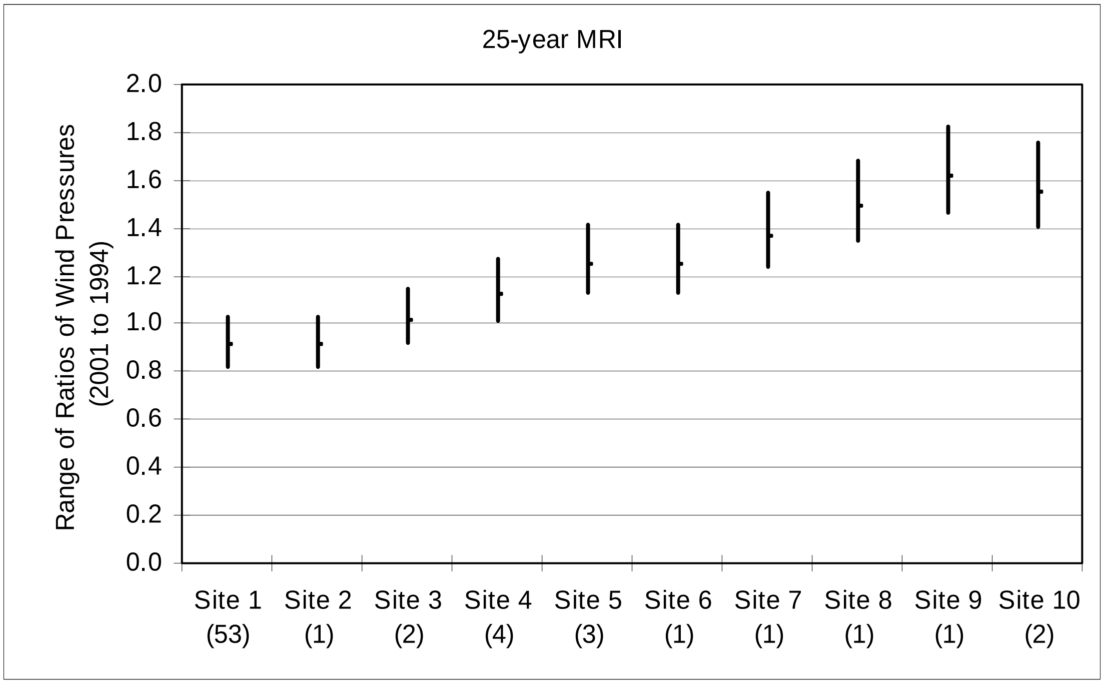


Figure B-28. 25-year MRI: range of ratios of wind pressures (2001 to 1994 specifications)

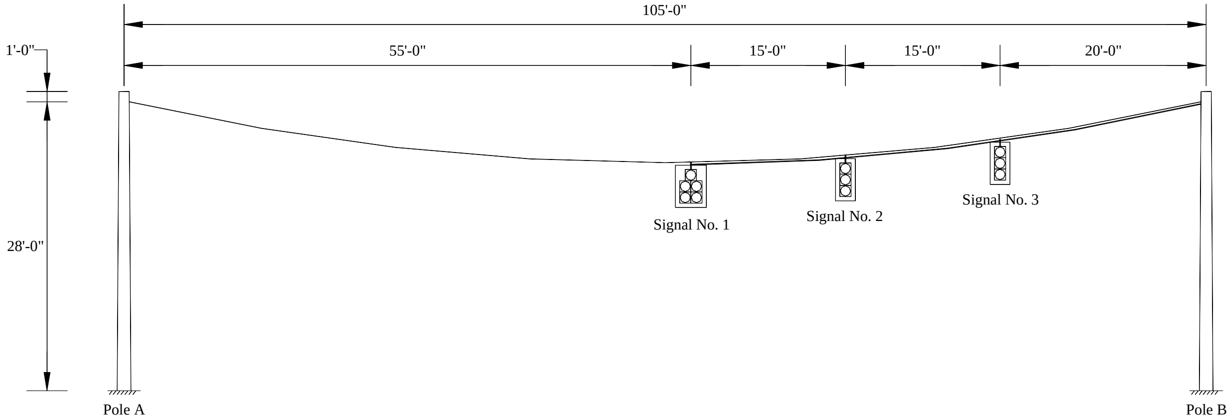


Figure B-29. Structure configuration

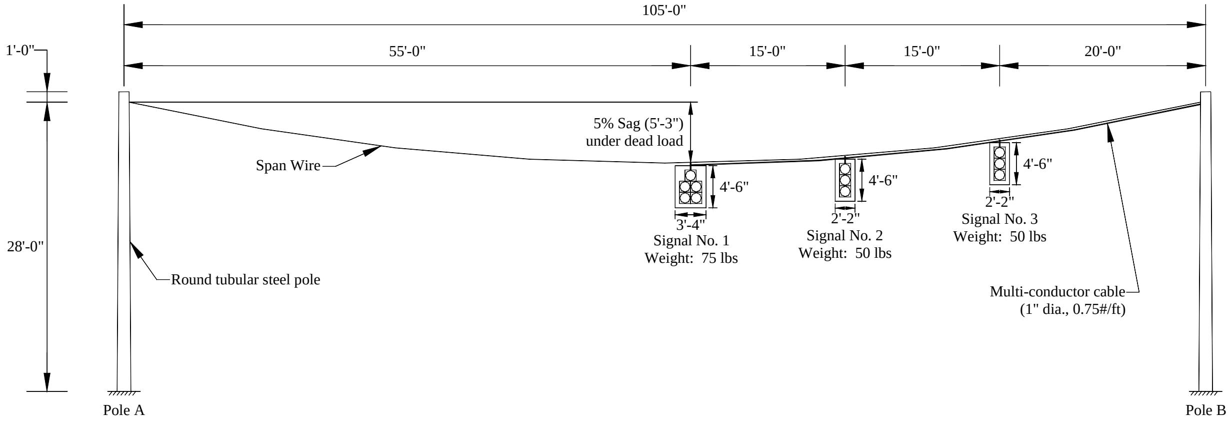


Figure B-30. Detailed structure configuration