Chapter 2 Loads

Background

The purpose of this chapter is to explain what basic design criteria were used to develop the design aids for engineered post-frame structures in Chapter 3. The chapter is intended to provide background to the building planner. In practice, NRCS personnel will select the wind speed for their respective areas and proceed to the member sizing charts in Chapter 3.

The first step in designing an engineered structure is to determine the loads that would be applied to the structure. The 1996 Revision of the 1994 Standard Building Code states in Section 1601.2.2:

"Buildings and structural systems shall possess general structural integrity to reduce hazards associated with progressive collapse to levels consistent with good engineering practice. The structural system shall be able to sustain local damage or failure with the overall structure remaining stable. Compliance with the applicable provisions of ASCE 7 shall be considered as meeting the requirements of this section." (SBCCI, 1996)

ANSI/ASCE 7-95 Minimum Design Loads for Buildings and Other Structures, therefore, was used to determine loads in this handbook. (ASCE, 1996)

Two types of buildings, partially open and enclosed, are commonly constructed as composters and stacking sheds. An open building is defined by ASCE 7-95 as a structure having all walls at least 80% open. Due to the bin walls on most of the composters and stacking sheds, they do not meet the criteria for open buildings.

Partially open buildings (See Figure 2.3 & Figure 2.4) are designed using a static frame analysis method known as the stiffness matrix method. In this method, the individual structural members are sized to carry all anticipated design loads based on the relative stiffness of the members composing the frame.

Enclosed buildings can be designed by the stiffness matrix method or the diaphragm analysis method. The diaphragm analysis method accounts for the diaphragm action provided by the metal cladding on the building. This method sometimes allows more economical post sizing, however, more detail is involved in making proper connections to assure that the loads can be safely transferred through the cladding and supporting structure. Additionally the building must meet the following conditions:

- The maximum length to width ratio is 3 (i.e., a 40 foot wide building can be no longer than 120 feet).
- The endwalls must be continuous from ground to eave and designed as a shear wall to transfer the anticipated loads. Limited openings are allowable.

The diaphragm design method is outlined by ASAE Standard EP484 Diaphragm Design of Metal-Clad, Post-Frame Rectangular Buildings. (ASAE, 1990)

For this handbook, the stiffness matrix method was used to develop the member sizing charts for the composters and stacking sheds.

Determining Wind Loads

The **basic wind speed** is defined in ASCE 7-95 6.2 as the 3-second gust speed at 33 ft (10m) above the ground in Exposure C (Open Terrain) and associated with an annual probability of 0.02 of being equaled or exceeded (50-year mean recurrence interval). This is the standard from which all wind load calculations begin.

For the planner using this guide, the basic wind speed, which can be found on Figure 2.5 on page 2-6, or Table 1 on pages 2-7 and 2-8, is all that is needed to determine member sizes.

To better understand how the wind speed is used to size members, the following brief explanation is given.

A factor K_z is given in Table 6-3 of ASCE 7-95 to adjust the value of the basic wind speed to the design height. Once again, this has already been accounted for in the member selection tables given in Chapter 3 of this handbook.

Agricultural buildings are classified as Category I structures in ASCE 7-95. **Category I** consists of "Buildings and other structures that represent a low hazard to human life in the event of failure including, but not limited to agricultural facilities, certain temporary facilities, and minor storage facilities."

Wind loads (velocity pressures) are calculated according to the provisions of ASCE 7-95 6.4. Since agricultural buildings are classified as Category I structures, the velocity pressure is multiplied by an importance factor of 0.87. In comparison, velocity pressures of buildings that represent a substantial hazard to human life (Category III) or structures designated as essential (Category IV) must be multiplied by an importance factor of 1.15. In summary, therefore, we are allowed about a 15% reduction in the calculated velocity pressures for our composters and stacking sheds due to the nature of the buildings, while schools, hospitals and other Category III and IV buildings have the velocity pressures raised by about 15%.

The wind loads must be calculated for the roof and the walls. Windward and leeward sides of the buildings, considering wind directions normal and parallel to the roof, must be analyzed. Loads must also be calculated for positive and negative internal pressure. After all of the scenarios are determined, the worst case is used.

Determining Snow Loads

Ground snow loads, p_g, to be used in the determination of design snow loads for roofs shall be as set forth in ASCE 7-95 Figure 7-1. Ground snow loads are converted to **sloped-roof snow loads**, p_s, using the equations in ASCE 7-95 Section 4. Except for remote mountainous regions of Oconee and Pickens counties, the roof snow load is less than 10 psf, and the sloped roof snow loads are less than 10 psf for all counties in South Carolina.

Determining Live Loads

Live loads are loads produced by the occupancy of the building, and not construction loads. The only live loads that would apply to the single story composters and stacking sheds are roof live loads, most likely due to maintenance workers or equipment. According to Table 1604.6 in the Standard Building Code, 10 psf is the minimum roof live load allowable for greenhouses, lath houses, and agricultural buildings. We will use 10 psf, therefore, as a minimum roof live load.

Determining Dead Loads

Dead loads consist of the weight of all materials of construction including but not limited to walls, floors, roofs, and cladding. In estimating dead loads for the purpose of design, the actual weights of materials should be used. In the absence of that data, weights of building materials are listed in Appendix A of the Standard Building Code.

Combining Nominal Loads

ASCE 7-95 2.4 gives basic equations for combining nominal loads using allowable stress design. The combinations that apply to our design are:

- *Dead Load + (Roof Live Load or Snow Load)*
- *Dead Load + Wind Load*
- *Dead Load + (Roof Live Load or Snow Load) + Wind Load.*

Since it is not likely that a roof live load that is caused mainly from maintenance workers and equipment will be applied while there is snow on the roof, the two loads would not be used in the same scenario. In South Carolina, roof live load is greater than snow load, so it would be used.

The combination of loads which produces the most unfavorable effect in the building is to be used as the design load. Dead load and wind load govern the composters in this handbook, while dead load and live loads govern wide, partially open stacking sheds at low wind speeds.

Allowable Bending Stress

Design provisions and equations for bending members are detailed in Part III of ANSI/NFoPA NDS-1991 National Design Specification for Wood Construction. The allowable bending stresses and other base design values for visually graded dimension lumber are found in the NDS-1991 Supplement. These references were used in the development of the member sizing charts in Chapter 3. The method of analysis used requires the maximum stresses to be calculated for each member of the structure and compared to the allowable stresses given in the NDS Supplement. In this way, members were selected that would adequately carry the anticipated combined stresses applied to them.

Free Body Diagrams

Figure 2.1 and Figure 2.2 on the following page show free body diagrams of two typical waste management buildings. These diagrams demonstrate that the loads applied as a result of wind pressure are not always what one expects. The direction of wind loads on various structures is detailed in ASCE 7-95, Chapter 6.

Free Body Diagrams (continued)

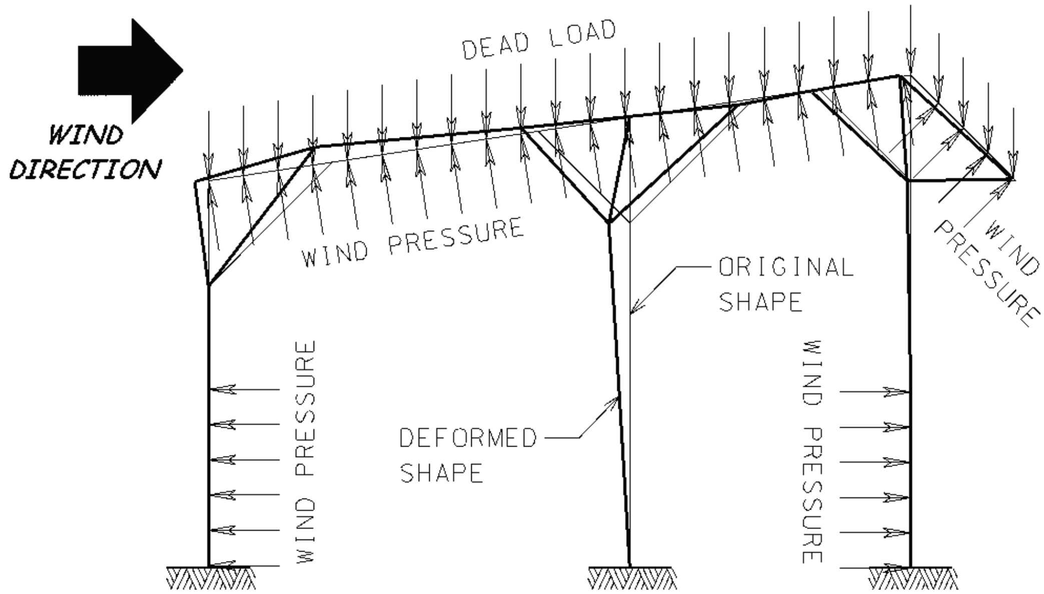

Figure 2.1 An example of a free body diagram showing the loads applied to a partially open composter.

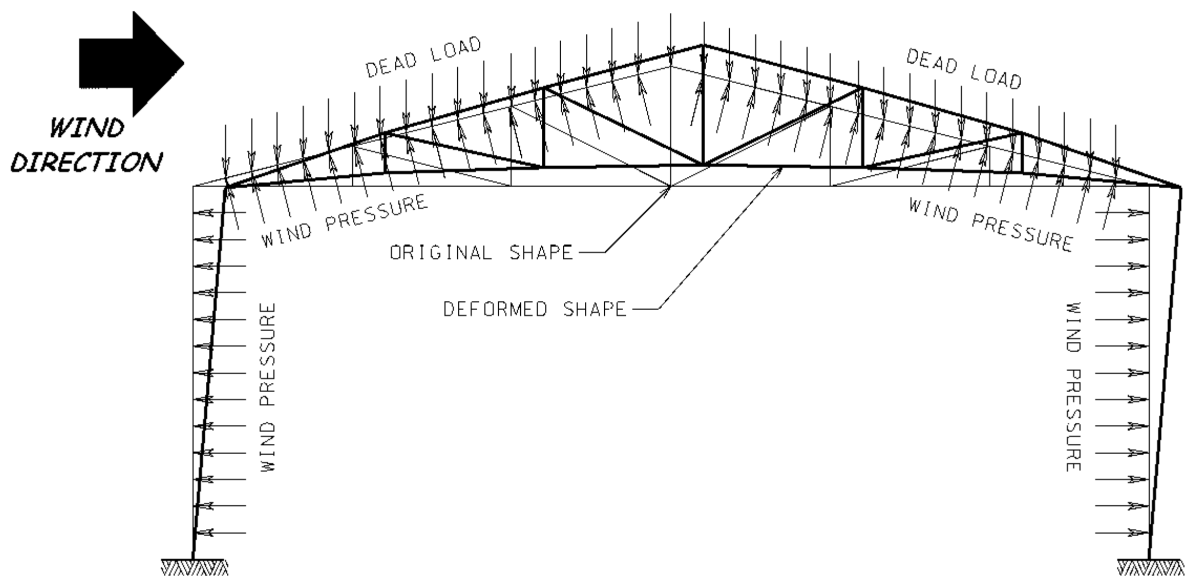

Figure 2.2 An example of a free body diagram showing the loads applied to an enclosed stacking shed.

Typical Composters and Stacking Sheds

Figure 2.3 An example of a partially open composter in South Carolina.

Figure 2.4 A partially open building used as a composter and a stacking shed.

Basic Wind Speed Map

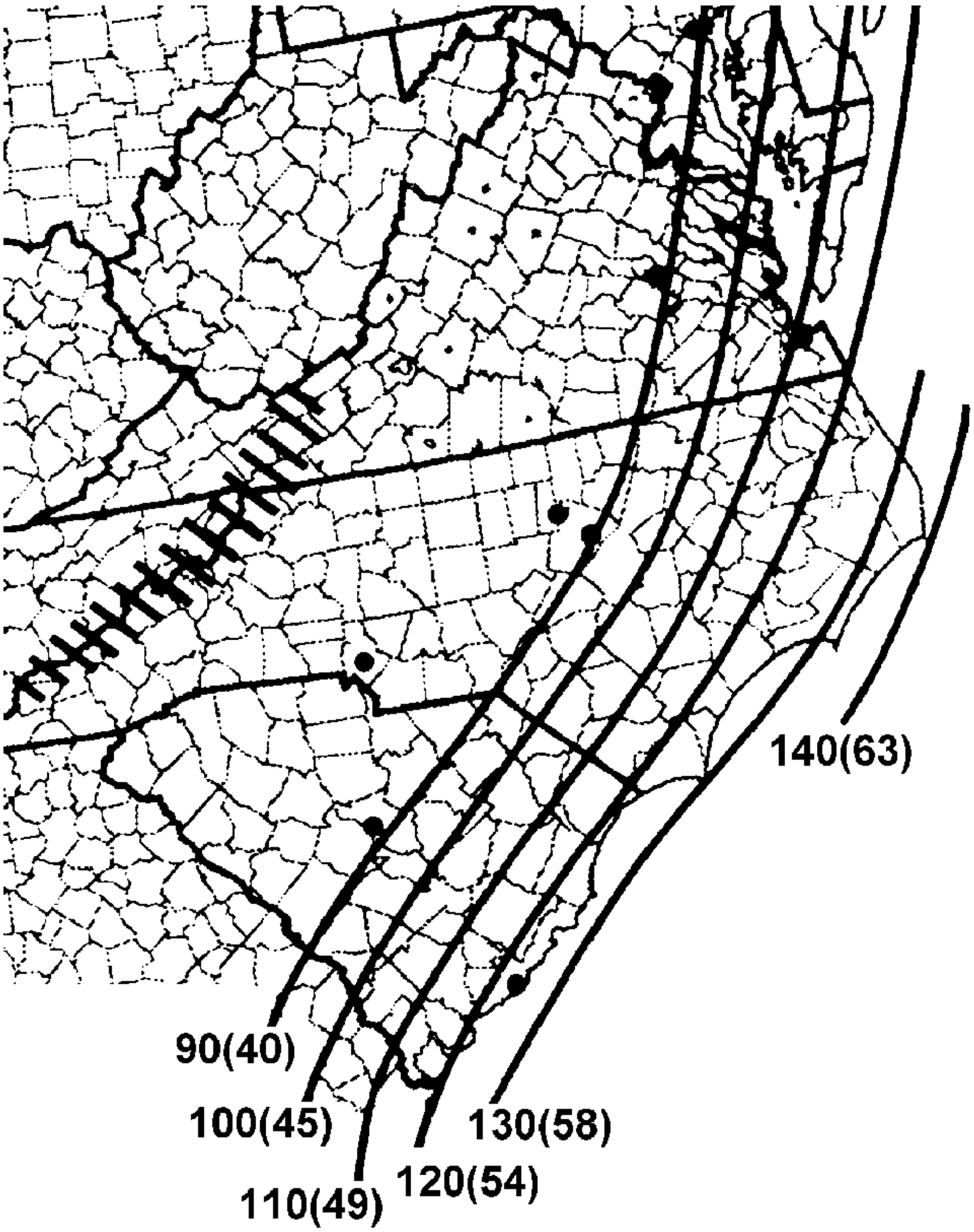

Figure 2.5 Excerpt from FIG. 6-1. Basic Wind Speed ANSI/ASCE 7-95

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.

Table 1 - Basic Wind Speeds by County (South Carolina)

County Name	Basic Wind Speed(mph)
Abbeville	90
Aiken	90
Allendale	100
Anderson	90
Bamberg (eastern)	105
Bamberg (western)	100
Barnwell	100
Beaufort	120
Berkeley	120
Calhoun	100
Charleston	130
Cherokee	90
Chester	90
Chesterfield	90
Clarendon	110
Colleton (eastern)	120
Colleton (western)	110
Darlington	100
Dillon	110
Dorchester (eastern)	120
Dorchester (western)	110
Edgefield	90
Fairfield	90
Florence	110
Georgetown (eastern)	125
Georgetown (western)	120
Greenville	90
Greenwood	90
Hampton	110
Horry	120
Jasper (eastern)	120
Jasper (western)	110
Kershaw	90
Lancaster	90
Laurens	90
Lee	100
Lexington	90
Marion (southeastern)	120
Marion (northwestern)	110
Marlboro	110
McCormick	90
Newberry	90
Oconee	90

	Orangeburg (eastern)	110
	Orangeburg (western)	100
	Pickens	90
	Richland (eastern)	95
	Richland (western)	90
	Saluda	90
	Spartanburg	90
	Sumter	100
	Union	90
	Williamsburg (eastern)	120
	Williamsburg (western)	110
	York	90