UCONN
COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES

Wind Loads on Greenhouses

In most sections of the U.S., the wind load is the greatest force that a greenhouse will be subject to. This can occur from hurricanes, tornados, or the sudden squall from a passing weather front.

Wind loading is a complex phenomenon. The wind forces that act on the greenhouse are influenced by numerous factors including the basic wind speed, building orientation and exposure, height and shape and doors or vents that may be open.

The wind passing over a greenhouse creates a positive pressure on the windward side and a negative pressure on the leeward side. These can combine to create a force that wants to collapse or overturn the structure. It can also create a force similar to an aircraft wing that wants to lift it off the ground.

Wind speed

The basis for wind load design is the wind speed map that has been developed by the American Society of Civil Engineer (ASCE-7) and is based on National Weather Bureau data. It is made up of wind speed measurements at 33' above the ground in open terrain based on a probability of recurrence every 50 years.

Basic wind speed varies from 85 mph in the western part of the country to as much as 150 mph along the Gulf Coast and southern Florida. Each state develops its own wind speed chart, by municipality, that is appended to the building code. Either the International Building Code (IBC) or the National Fire Protection Association 5000 Building Code is the basis of structural design in all states. The National Greenhouse Manufacturers Association (NGMA) has developed standards and recommendations that are used in conjunction with the above codes.

Velocity pressure

In greenhouse design, the basic wind speed is converted to a velocity pressure in pounds per square foot (psf). The velocity pressure varies as the square of the velocity. This value is modified to take into account that the wind speed is reduced for buildings less than 33' high and for areas where obstructions such as trees or hilly terrain reduce exposure. It is also modified by an importance factor (I) that takes into account the hazard to human life. Except for greenhouses in hurricane areas, this factor is 0.87 for production greenhouses and 1.0 for retail sales greenhouses.

To illustrate with an example; the velocity pressure for a production greenhouse with a 12' effective building height located in a suburban setting in a non-hurricane area with potential 90 mph wind would be about 14.4 psf

Force coefficients

The full velocity pressure does not normally occur on all surfaces of the greenhouse because of shape and orientation. The wind generally hits the surfaces at some angle, such as a roof, depending on the building profile. This creates an aerodynamic effect. Force coefficients have been developed for these different surfaces and affect the loading. These are also increased by a factor that accounts for wind gusts.

Using the above example, the velocity pressure, on a 30' x 100' free-standing glass greenhouse with the wind perpendicular to the sidewall would be about +14.9 psf for the windward vertical sidewall, -7.3 psf for windward facing roof, -14.0 psf for the leeward facing roof and -5.6 psf for the leeward facing wall.

On a 30' x 100' free-standing hoophouse the loadings would be +11.2 psf for the lower section of the windward sidewall, -5.1 psf for the top ½ of the roof and -9.4 psf for the lower section of the leeward side.

You can see that the structure has to withstand various loads depending on the direction of the wind and the shape and size of the structure. When the area of the different surfaces is multiplied by the loading, the total force that the surface has to withstand can be determined. For example, the 10' x 100' windward sidewall of the glass house would have to withstand a load of 10' x 100' x 14.9 psf = 14,900 pounds. In many parts of the U.S., the magnitude of the largest forces are comparable to the snow load.

The forces on gutter-connected houses are calculated the same way. They are the greatest on windward section and less in subsequent sections. With taller gutter-connected greenhouses being built today, the forces can be very large.

The loads on individual structural members and the greenhouse glazing also have to be calculated. The structural engineer does this during the design process.

The loading can become even more critical if a large opening such as a door or vent is left open on the windward side of the building during high winds. If this happens, a positive pressure builds up inside the greenhouse so that not only is there an uplift suction force on the outside due to the aerodynamic effect , there is also pressure on the inside equal in magnitude acting in the same direction. This force could be large enough to lift the greenhouse out of the ground unless it is anchored well.

From the above discussion, it is apparent that a good design for the structure and foundation are needed to get good service over the long life of the greenhouse. Before signing a contract for a new structure, check that the design will meet the building code in your area.

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Connecticut Design Wind Loads

APPENDIX M

BASIC WIND SPEED

MUNICIPALITY	BASIC WIND SPEED (3 second gust)	MUNICIPALITY	BASIC WIND SPEED (3 second gust)	MUNICIPALITY	BASIC WIND SPEED (3 second gust)	MUNICIPALITY	BASIC WIND SPEED (3 second gust)
Andover	100	East Haven	110	Morris	90	Southbury	90
Ansonia	100	East Lyme	110/120[1]	Naugatuck	100	Southington	100
Ashford	100	Easton	100	New Britain	90	South Windsor	90
Avon	90	East Windsor	90	New Canaan	100	Sprague	100
Barkhamsted	90	Ellington	90	New Fairfield	90	Stafford	90
Beacon Falls	100	Enfield	90	New Hartford	90	Stamford	100
Berlin	100	Essex	110	New Haven	110	Sterling	100
Bethany	100	Fairfield	100/110[2]	Newington	100	Stonington	110/120[5]
Bethel	90	Farmington	90	New London	120	Stratford	100
Bethlehem	90	Franklin	100	New Milford	90	Suffield	90
Bloomfield	90	Glastonbury	100	Newtown	90	Thomaston	90
Bolton	100	Goshen	90	Norfolk	90	Thompson	100
Bozrah	110	Granby	90	North Branford	110	Tolland	100
Branford	110	Greenwich	100	North Canaan	90	Torrington	90
Bridgeport	110	Griswold	100	North Haven	100/110[2]	Trumbull	100/110[2]
Bridgewater	90	Groton	120	North Stonington	110	Union	90
Bristol	90	Guilford	110	Norwalk	110/110[3]	Vernon	100
Brookfield	90	Haddam	110	Norwich	110	Voluntown	110
Brooklyn	100	Hamden	100/110[2]	Old Lyme	110/120[1]	Wallingford	100
-lington	90	Hampton	100	Old Saybrook	110	Warren	90
.aan	90	Hartford	90	Orange	110	Washington	90
Canterbury	100	Hartland	90	Oxford	100	Waterbury	90
Canton	90	Harwinton	90	Plainfield	100	Waterford	110/120[1]
Chaplin	100	Hebron	100	Plainville	90	Watertown	90
Cheshire	100	Kent	90	Plymouth	90	Westbrook	110
Chester	110	Killingly	100	Pomfret	100	West Hartford	90
Clinton	110	Killingworth	110	Portland	100	West Haven	110
Colchester	100	Lebanon	100	Preston	110	Weston	100
Colebrook	90	Ledyard	110	Prospect	100	Westport	100/110[2]
Columbia	100	Lisbon	110	Putnam	100	Wethersfield	100
Cornwall	90	Litchfield	90	Redding	100	Willington	100
Coventry	100	Lyme	110	Ridgefield	90	Wilton	100
Cromwell	100	Madison	110	Rocky Hill	100	Winchester	90
Danbury	90	Manchester	100	Roxbury	90	Windham	100
Darien	100	Mansfield	100	Salem	110	Windsor	90
Deep River	110	Marlborough	100	Salisbury	90	Windsor Locks	90
Derby	100	Meriden	100	Scotland	100	Wolcott	90
Durham	100	Middlebury	90	Seymour	100	Woodbridge	100
Eastford	100	Middlefield	100	Sharon	90	Woodbury	90
East Granby	90	Middletown	100	Shelton	100/110[4]	Woodstock	100
East Haddam	110	Milford	110	Sherman	90		
East Hampton	100	Monroe	100	Simsbury	90		
East Hartford	110	Montville	110	Somers	90		

1. Areas south of I-95 = 120 mph; areas north of I-95 = 110 mph
2. Areas south of Rt. 15 = 110 mph; areas north of Rt. 15 = 100 mph
3. Areas south of I-95 = 110 mph; areas north of I-95 = 100 mph
4. Areas east of Rt. 8 = 110 mph; areas west of Rt. 8 = 100 mph
5. as south of Rt. 184 = 120 mph; areas north of Rt. 184 = 110 mph