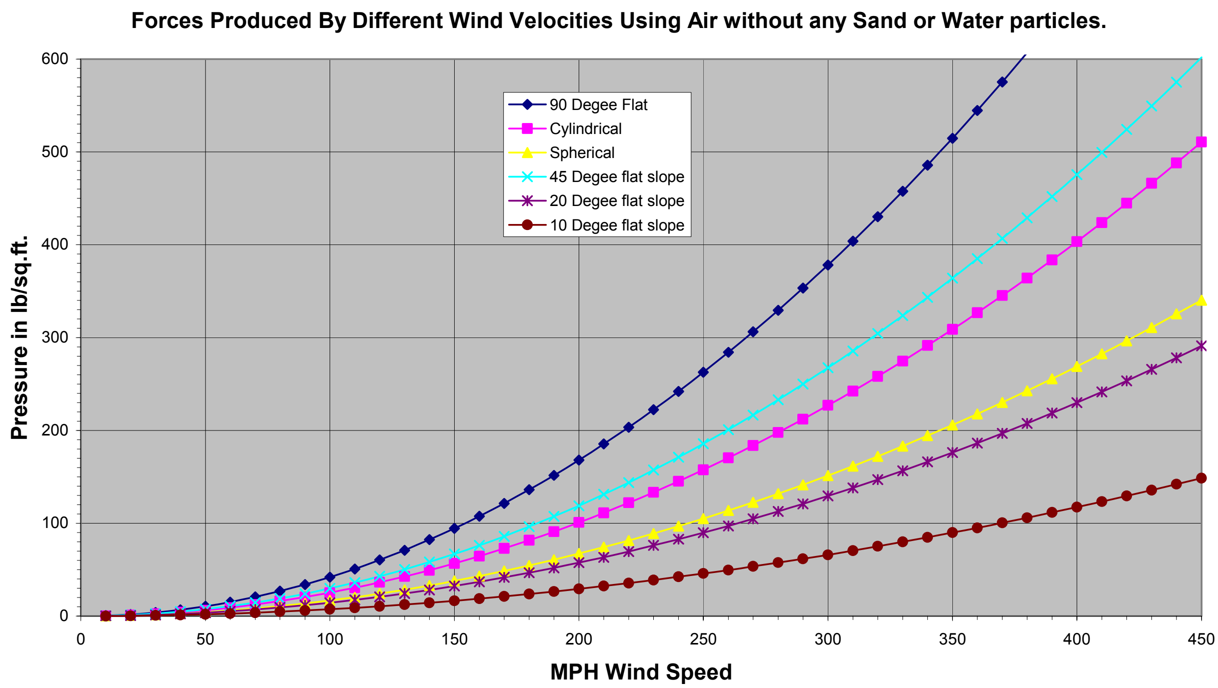
PS High Wind Speed Forces
(2/25/2007)

This report is intended to give a familiarity with the forces of wind. It is intended to aid in the building of polar shift survival quarters by giving engineering design considerations.

The force of wind on the outside of different shape structures is shown in the following chart http://home1.gte.net/mikelob/WindF-1.gif.



Note that a wind at 300 MPH (482 KM/Hr) will exert a pressure of 378 lb/sq ft (2.6 lb/sq inch or 1845 Kg/sq meter or 185 gm/sq cm) and wind at 400 MPH (672 KM/Hr) will exert a pressure of 672 lb/sq ft (4.7 lb/sq inch or 3280 Kg/sq meter or 328 gm/sq cm) on a 90 degree surface with respect to wind direction. Other shapes and sloped surfaces result in less surface pressure. A dome would be similar in shape to a sphere. Note the smaller the angle the wind makes with the surface the less the force.

The formula for pressure in lb/sq ft = (wind speed in MPH)^2 times K where K = .00420. For conversion 100 lb/sq ft = .694 lb/sq inch = 48.8 gm/sq cm = 488 Kg/sq meter and 1 mile/hr = 1.609 KM/hr. This graph was constructed from a table of measured values found in a CRC handbook of tables for "Applied Engineering Science" (R620.03 CRC) see page 436.

The explanation below the table says: The wind-pressure forces on structures are larger than the impact pressure of the wind, due to suction forces on the leeward side. The pressures are also higher on tall structures. The net force is usually 40% to 100% higher than that due only to the stagnation pressure (impact) of the wind. The factor used for the flat plate in the above table is 1.68.

Example of how one might apply this graph:

A 8ft by 40ft long container full of household goods typically weighs about 20,000 lb. Next assume our container is loaded at about 40,000 lb of after PS building materials and equipment and is sitting on the ground or on a slab at ground level. Now assume wind blows perpendicular to and of equal strength on all parts of one side of this container. The floor is 8 ft by 40 ft long or 320 sq ft. This results in a floor loading of (40000/320) = 125 lb/sq.ft. Typically the floor is about the same size as the sides in surface area. From the graph of wind force on a flat surface we get that at wind speeds roughly greater than 170 miles/hr (274 KM/hr) the unit would begin to slide, assuming a coefficient of friction of 1 or less. At this wind speed there is an equal force on the side to what it weighs. If anchored down it would begin to receive tipping forces trying to pull the near side out of the ground.

At 300 MPH the container will be pushed on the side with more than 3 times it's weight (378/125). With a wind of 400 MPH the container will have a force of 5.3 times it's weight (672/125). Now wind tends to be slower near the earths surface, so in actuality there would be a gradient of wind speed due to height above the earth's surface. Thus the above numbers give only a rough order estimate to give an order of magnitude for the forces involved for average wind speed hitting the side of a container. If hills and other wind barriers surround the container, then this would help increase the maximum wind velocity before the container would move. I doubt the sheet metal sides unprotected would hold up under this kind of air pressure. At this point we assume no blowing rocks, sand or dirt. If the unit ever breaks loose from the ground it would easily tumble or become air born at wind speeds around or greater than 170 Miles/hr (274 KM/hr).

Now one might ask at what wind speed does it take before things in general begin to blow away? Assume coefficient of friction = 1 or force to move it is equal to it's weight.

Assume a 1 ft square rock of density about 3 gm/cc resting on the ground with wind blowing on one side. One ft = approximate 30.5 cm. Thus weight= volume times density = (30.5^3)*3 = 85118gm/(454gm/lb) = 187 lbs. Thus from the wind pressure table if wind only (no sand or dirt) were blowing at greater than 212 miles/hr (341 KM/hr) then this rock would begin to move and begin to take off and rapidly accelerate.

If say the wind speed were 312 MPH then one can expect the maximum projectile speed of this large rock bouncing along the earth surface to be something like about 100 MPH. The best I can recall from a TV show I once watched the trebuchets (siege engines) that were used to break down castle walls could use a round sand stone projectile that could weight up to about 90 lbs and traveled about 60 MPH and were about 19 to 20 inch in size. The many feet thick castle walls were no match for these impacts.

So the bottom line is anything of any weight or size to it becomes a deadly dangerous projectile once it leaves the ground at around 200 MPH.

Assuming a car of about 3,000 lb with a side surface area of about 15*4 = 60 sq ft. This gives about 50 lb/sq ft pressure on the ground. With a drag coefficient of about .5 then a wind that produces about 100 lb/sq ft would be enough to start to move it with the wind. This is equivalent of a wind blowing at 160 MPH (257 KM/hr). Yes, as the wind increases in speed expect cars and vehicles to start tumbling before boulders do.

Summary: In general with just air blowing in the wind (no sand, water, or dirt) one can estimate most objects will begin to move and become airborne at between 160 miles/hr and 220 miles/hr (257 KM/Hr to 354 KM/Hr).

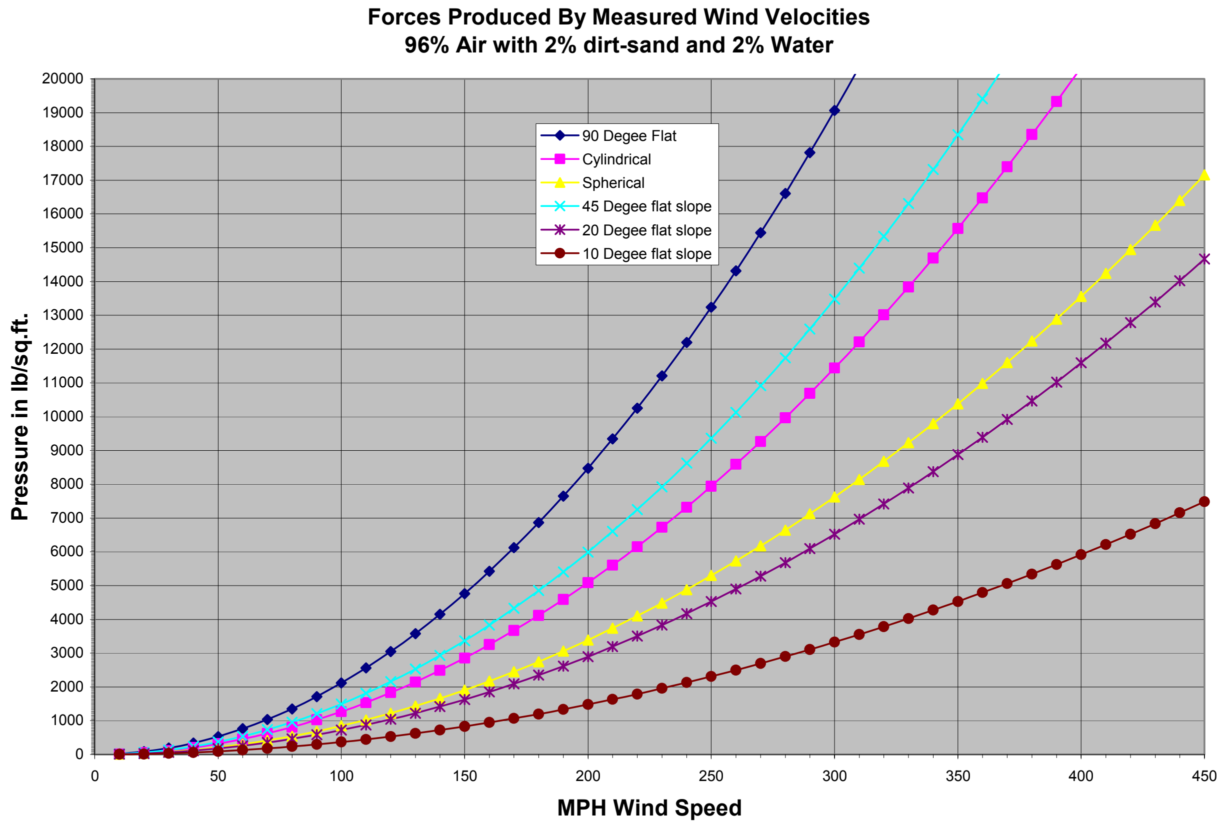
Now lets take a look at what it takes for dirt and sand to start blowing across the land.

Any one who has been to the desert, beaches or dust boll knows it doesn't take much wind to start sand and dust blowing. What the amount or percentage this is with wind speed I have not been able to find measured reference data on yet. The concern is that as more and more sand and dirt gets picked up into the air then the pressure it exerts at any one speed goes up proportional to the weight of a cubic ft of this mix as compared to a cubic ft pure air (density ratio).

During the PS it is likely to have earthquakes of vertical g force greater than one. This means that dirt, sand, and rocks will bounce into the air. If at the same time winds are of sufficient magnitude to catch the dirt then this will begin to move as a dense cloud rapidly across the landscape. I would expect rather dense clouds of blowing dirt and sand to be possible with winds above 160 miles/hr (257 KM/hr) under these conditions. Dirt could be moved great distances and easily completely cover things up. It's just a chance we all will be taking.

As an example: If one assumes its possible for 2% dirt and 2% water blowing with sufficient wind speed to stay airborne then how much additional force does this result in?

Density of air is about .00119 gm/cc (cc=cubic centimeters). With water = 1 gm/cc and sediments (sand-dirt) about = 2 gm/cc. Assume high winds cause a blowing mixture of 2% dirt, 2% water and 96% air. Resulting density is about (.98*.00119)+(.02*1)+(.02*2) = .0612 gm/cc. Since wind force is proportional to density we get .0612/.00119 = 51.4 time more force of pressure than air alone. At this time I can only estimate this to occur around or above 160 Miles/Hr. This would result in a force of 51.4*107.6 = 5530 lb/sq ft (38 lb/sq inch or 2700 gm/sq cm or 27000 KG/sq Meter) for a surface 90 degrees to the wind. This is equivalent of the weight of about two cars for each square foot for a wind of just 160 miles/hr (257 KM/hr). I don't know many structures that will withstand this much force. See http://home1.gte.net/mikelob/WindF-2.gif



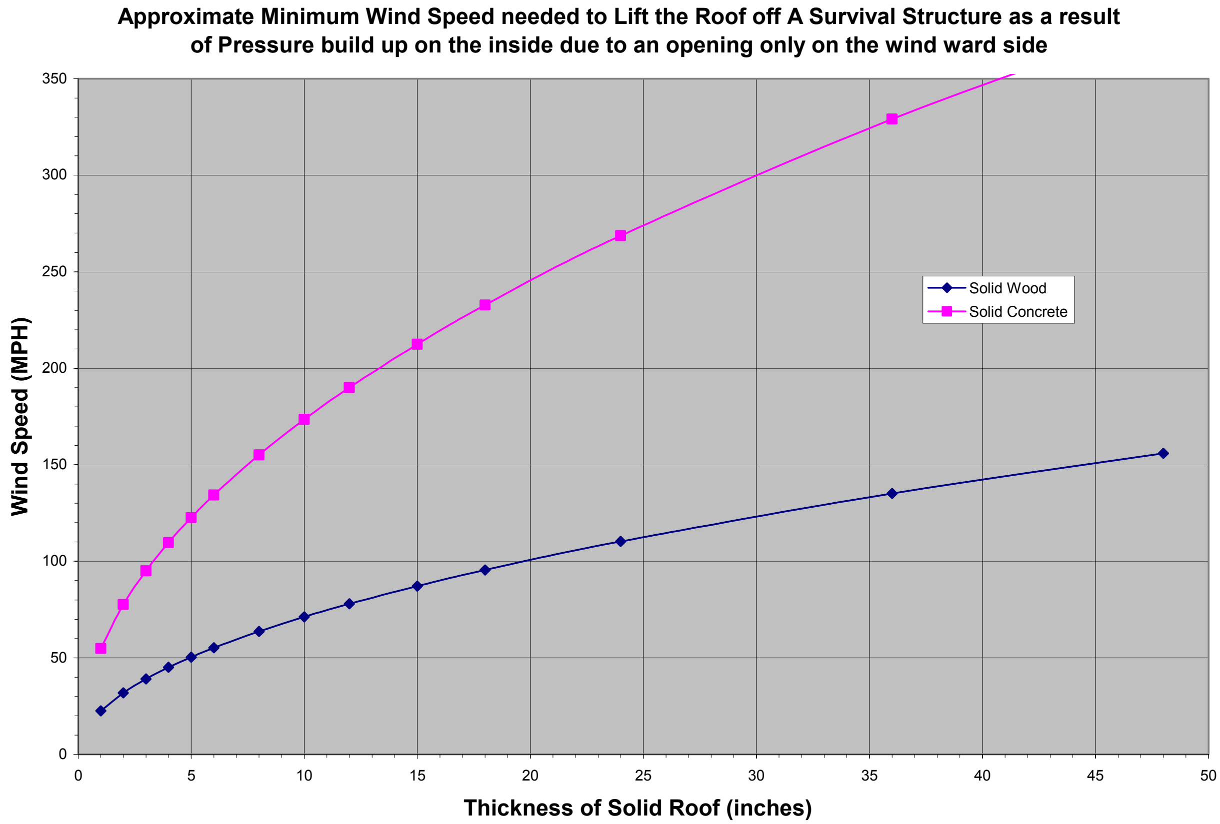
Summary: With wind picking up sand, dirt and water (total of 4%) it can easily produce over 51 times the surface pressure, as compared to pure air, at above an estimated 160 Miles/hr (257 KM/hr). At one percent the force is approximately 13 times that of air alone. Wind blowing water and dirt can produce significant forces on anything standing in it's way. With sand, dirt and water in the air even at low percentages of .15 to .2% one can expect double the forces of air alone. This extra force would significantly lower the speed at which things in general become airborne.

Accumulating wind pressure inside the structure: You might have seen TV news pictures of tornados or hurricanes where the house suddenly blows apart from the inside out. These are examples of this pressure build up.

Lets look into the amount of pressure that develops inside a structure with wind blowing from one side. Assume the wind leaks into the up-wind side by way of cracks around the door, a hole in the wall due to tree trunk punctured hole, a broken window(s) or a small vent hole left open as examples. Assume that the other sides of the structure do not allow the pressure to leak off as fast as it builds up.

Lets ask how much wind speed does it take to lift off a roof only if not securely attached to its walls or foundation due to only this inside pressure gradient build up.

Concrete weighs about 143 lb/cu ft. If one built a box or rectangle out of reinforced concrete then, how much would it take to lift the top slab off if it were 12" thick and not securely attached to the walls? Looking this pressure of 143 lb/sq ft up on our chart for wind speed we get anything over 190 Miles/hr should apply an upward force grater than it's weight. For a 6" slab that weighs 71.5 lb/sq ft a wind of greater than 130 Miles/hr (209 KM/hr) would be needed. See http://home1.gte.net/mikelob/WindF-3.gif.



Now if the walls are securely attached and expected to break away at the slab or floor, then in order to use the above chart one would estimate the average resulting thickness as if all of the wall weight or area were distributed over the ceiling. My thinking is an average wood house roof thickness would range somewhere in-between 2 to 6 inches with about 4 inches as an average. This gives approximately 45 MPH as the theoretical separation of unsecured walls from foundation.

Now from past experience we know average houses can stand more wind speed than this. A more likely answer would be around 90 MPH. There are other factors to be considered. As the flow of wind goes over the roof does it push down on half the roof and tend to lift the other half. If so the above chart results for wind speed need to multiplied by a factor of approximately 2. Some shapes create a vacuum like the surface of a wing some shapes would help hold the roof on. Take your best guess based on shape, size, location and surroundings.

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