Wind forces on mobile homes

Schriever, W. R.

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/40000710
Canadian Building Digest, 1977-06

Canadian Building Digest

Division of Building Research, National Research Council Canada

CBD 188

Wind Forces on Mobile Homes

Originally published June 1977.

W.R. Schriever

Please note

High losses of mobile homes input . As their numbers are increasing constantly, the problem "is serious and" growing. It is estimated that there are now 200,000 mobile homes in Canada and that every year the mobile home population is increased by another 75 to 100,000 Canadians. Of all single detached homes constructed in Canada in 1974 21 per cent were mobile homes. The purpose of this Digest is to assess the nature of the wind loss problem, to describe the effects of the wind forces on a typical mobile home and to suggest methods of providing greater safety by anchoring mobile homes to the ground.

The problem

It is a popular belief that wind damage to mobile homes is associated only with hurricanes and tornadoes, and that because these types of storms are not common in Canada there is no need to worry. This is not correct. Wind speeds capable of destroying mobile homes can and do occur in every part of Canada. Gusts in thunderstorms, for example, often produce winds sufficient to push an unanchored mobile home off its blocks and roll it over. This can result in the complete destruction of the unit and, frequently, injury to its occupants rather than the minor damage usually experienced in ordinary houses.

It is difficult to estimate the over-all economic consequence of this situation because, as stated by the Insurers' Advisory Organization in a report dated September 1976,[1] no separate records of wind losses are kept in Canada, wind losses being covered by general fire and extended coverage policies. It is known, however, that wind losses are high in some areas. One insurance company reported, for example, that in Nova Scotia from 1972 to 1974 it collected $260,000 in premiums from about 1800 mobile homes and that the losses, however caused, were $530,000.

Most codes, including the National Building Code[2] and the applicable CSA Standard, Z240.2,[3] contain requirements for anchoring mobile homes to the ground. Unfortunately, it appears from inquiries with local building inspectors that anchorage requirements are often not enforced. This, in spite of the fact that all new mobile homes manufactured under CSA Z240.2 are factory equipped with metal straps that run under the cladding over the top of the frame, ready to be hooked up to ground anchors.

Wind Forces on Mobile Homes

To appreciate wind effects on a mobile home, it is necessary to understand the pattern of air flow over the structure and the pressures and suctions produced by the flow. From this it will be possible to estimate the wind speed a mobile home can resist without anchorage and to suggest methods of tying it down.

For purposes of analysis the wind flow around a mobile home can be considered to be laminar. For simplicity, only the critical wind direction, at right angles to the longitudinal axis of a "single-wide" mobile home, will be considered. As the air flow is deflected upwards over the roof, three turbulent zones are created (Figure 1). In the first, located in front of the mobile home, the pressure is greater than in the undisturbed flow, creating inward force on the windward wall. The second is on the lee side, where the pressure is lower than in the undisturbed flow, producing suction on the leeward wall. The third turbulent zone is located over the roof, where the flow will "detach" from the roof along the leading edge and form a relatively shallow turbulent zone. It is here that the greatest suction (or lift) is produced.

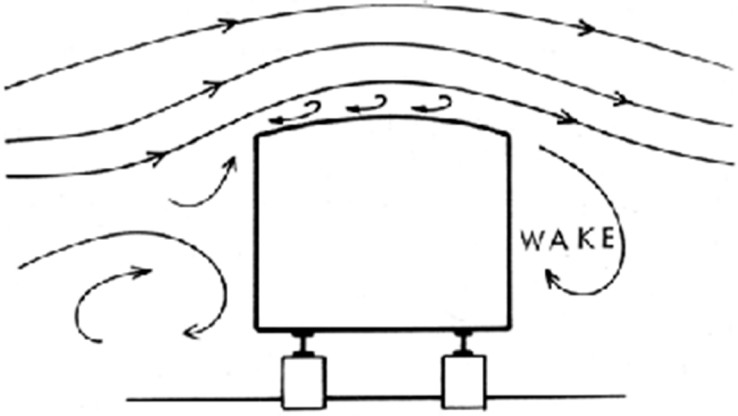

Figure 1. Wind flow over a mobile home.

Figure 2 shows that the suction on the roof is not uniform, being higher near the windward edge than near the leeward edge. The distribution of pressures and suctions have been determined from model tests in wind tunnels.

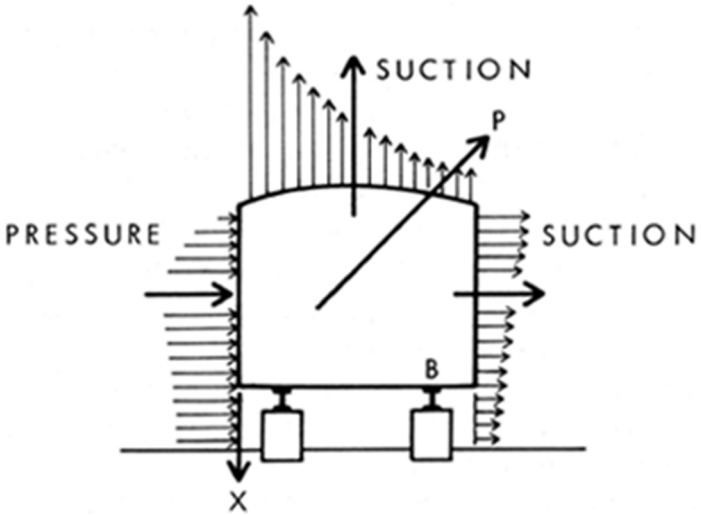

Figure 2. Pressures, suctions and resulting forces on mobile home.

Figure 2 also shows the three resultant forces on the front, back, and roof, which for the stability calculation can be combined in a single resultant force, P. This force produces both an overturning moment about the pivot point B, where the mobile home frame rests on concrete blocks, and a horizontal force tending to shift the mobile home horizontally on the blocks.

The overturning moment is resisted by a "restoring" moment produced by the weight of the unanchored mobile home. The mass of the common types of larger mobile homes (single-wides) is about 15 to 20,000 pounds (7,000 to 9,000 kg). Horizontal shifting is resisted by friction between the steel frame and the blocks. The overturning moment is usually the more significant of the two effects because of the relatively narrow base provided by the frame and the considerable lift developed by the suction on the roof.

Estimating Allowable Wind Force

In order to discover what wind force an unanchored mobile home can withstand, a calculation was made to determine the speed required to just overcome the restoring moment of its weight. This was estimated to be from 45 to 50 mph (70 to 80 km/h) for a typical mobile home, or considerably less than the design gust speeds of about 70 to 80 mph (110 to 130 km/h) specified for many of the more populated parts of Canada and very much less than the design gust speeds for some coastal areas of about 90 to 100 mph (160 km/h) or more (Figure 3). The design gust speeds of the National Building Code of Canada are calculated as the speeds reached or exceeded, on the average, once in 30 years.

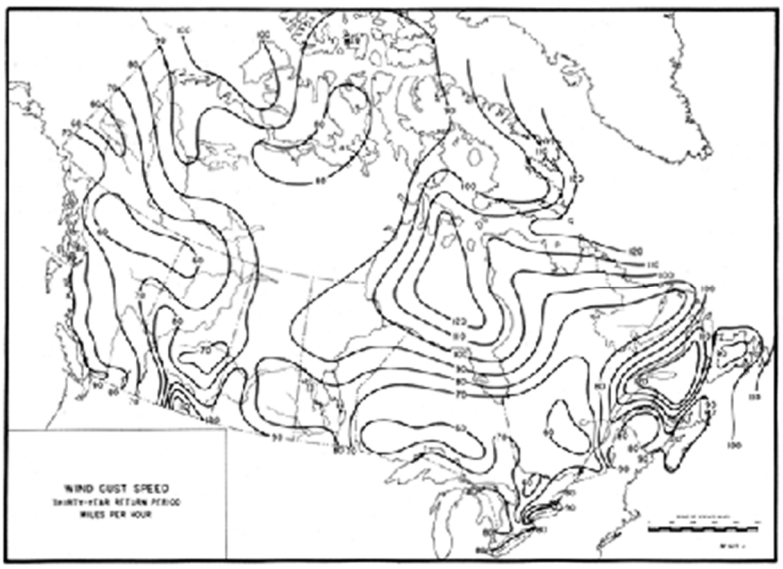

Figure 3. Wind gust speeds in miles per hour, based on a 30-year return period. (Source: NBC Supplement No. 1, 1965.) Note: Because of its small scale this map is not accurate enough to give values for design purposes.

Considering this large discrepancy one may well ask why even more unanchored mobile homes have not been lost in the past in Canada. The reason is probably that many mobile homes are located in treed or generally sheltered areas where speeds near the ground often (but not always) remain below the design wind speeds. Design values are based on the assumption that a building or mobile home is located in an exposed location such as at the edge of a development adjacent to a large open field.

Protection Against Overturning Moment

Protection against wind forces can be achieved by anchoring the mobile home into the ground along both longitudinal walls. A calculation of the force required to just maintain equilibrium in an 80 mph (130 km/h) gust speed (producing a velocity pressure of 17 lb/ ft², 0.83 kN/m³) shows that the required anchor force is 3900 lb (17 kN) or 55 lb/lineal ft (0.8 kN/m). This is for the assumption of a 14- by 70-ft (4.3- by 21-m) mobile home with the space underneath closed in by a skirt and the two main frame members 8 ft (2.4 m) apart. These figures should not be regarded as too accurate, perhaps more as an indication of the order of magnitude of the forces involved. The actual forces could be even higher, for, as mentioned earlier, some areas in Canada experience higher gust speeds than 80 mph (130 km/h).

In order to protect a mobile home properly against both overturning moment and sliding force, two types of ties are recommended: over-the-top ties, and frame ties. Figure 4 shows one such arrangement[4]. Frame ties alone would, in fact, reduce the chance of overturning, but many mobile homes do not have enough internal strength to transmit high wind loads to the supporting steel frame. Frame ties alone would hold down the frame, but the walls and roof might be torn off. It is recommended, therefore, that both over-the-top and frame ties be used for single-wides. Double units or "double wides" 24 ft (7.3 m) in width or more are more stable and could be expected to withstand the usual design gust speeds without the use of over-the-top ties.

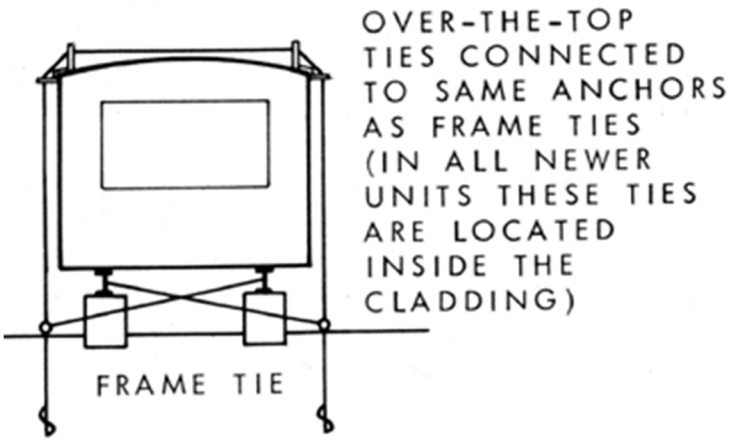

Figure 4. The two basic types of ties against wind forces.

The number of over-the-top and frame ties required for a given design gust speed depends on a number of variables, particularly the length and width of the mobile home, size and type of tie-down cables or straps, soil conditions and holding power of ground anchors. Table 1 lists number of frame and over-the-top ties for different wind speeds[5](for an anchor that can withstand a force of 4600 lb (21 kN) without failure).

Table 1. Number of Ties Required for Different Design Gust Speeds

Design Gust Speed mph (km/h)	Mobile Homes 12 to 14 ft Wide and 60 to 70 ft Long	
	Number of Frame Ties	Number of Over-the-Top Ties
70(112)	4	2
80(128)	5	3
90(145)	7	4
100(161)	8	6
110(177)	10	7

Several types of anchor can be used, including screw augers, expanding anchors, and concrete deadmen. The latter would be used where rock is close to the surface. Anchors are usually installed to a depth of about 4 ft (1.2 m), but holding strength for any type does depend on the soil characteristics. A 6-in. (15 cm) diameter screw auger, for example, might withstand a pull of 5000 lb (22 kN) in stiff clay but only half as much in sandy soil.

Piers and footings sufficient to carry the weight of the mobile home as well as the extra load imposed by the tightening of the tie-down system and the overturning moment produced by the wind are also very important. Manufacturers recommend a maximum pier spacing of about 10 ft (3 m), with the end piers no further than about 5 ft (1.5 m) from the ends of the mobile home. Frame ties should be positioned near a pier.

Additions and canopies must also be tied down (Figure 5). Damage in mobile home courts is often initiated by flying parts from unanchored canopies, carports, etc. It is important, correspondingly, that tie-downs be installed on all mobile homes in a mobile home court. If, during a storm, nearby mobile homes are not tied down, they can be blown into those that are, causing a chain reaction.

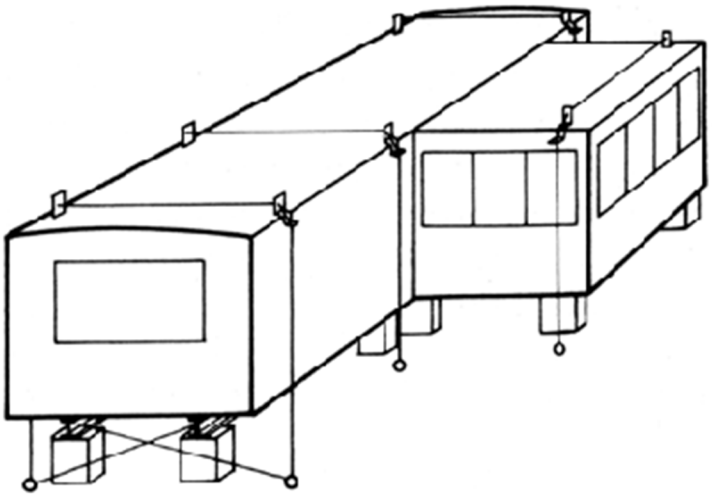

Figure 5. Additions and canopies must also be secured by over-the-top tie-downs.

Concluding Remarks

Owners, builders and municipal authorities should be aware of the potential hazard of wind damage to mobile homes and ensure that all "single-wide" mobile homes are properly anchored to the ground. Although some mobile homes seem to escape damage without anchorage in sheltered sites, it is advisable to anchor all such homes, for it is often difficult to determine potential wind hazard at a particular site. Most new homes are already equipped with metal straps ready to be hooked up to ground anchors, so that it is relatively inexpensive to take this precaution.

In areas with cold winters where piers are subject to frost heaving there may be a problem with tie-downs, which would counteract heaving forces and thus apply potentially large and destructive forces to the units. In such areas, particularly for homes on frost-susceptible soils, the pier foundations should either extend below frost level or be set on a properly designed below-ground skirt of rigid foam insulation.

References

1. Insurers' Advisory Organization of Canada, Improving the Safety of Mobile Homes, Toronto, Sept. 1976, 56 p.
2. National Building Code of Canada, 1975. National Research Council of Canada, Associate Committee on the National Building Code, Ottawa, 1975, 357 p.
3. Canadian Standards Association, Structural Requirements for Mobile Homes, CSA Standard Z240.2, Toronto, 1976.
4. Defense Civil Preparedness Agency (U.S.), Protecting Mobile Homes from High Winds, Washington, D.C., June 1972, 16 p.
5. Harris, R. B., Wind Forces on Mobile Homes, University of Michigan, Department of Civil Engineering, Ann Arbor, Mich., June 1962, 96 p.