Building technology, codification and storm damage

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Introduction

Severe storms that have struck Europe over the last 10 to 15 years have lead to huge damage figures to buildings. Evaluations of the damage have been carried out e.g. in Denmark and France after the Christmas storms in 1999. Storm damage to buildings has been contributed to errors made during construction or a lack of maintenance. Most of the reported damage on buildings has been found on secondary elements, as roofs and facades. Damage to the main structure of buildings is hardly occurring anymore. On the other hand, standards for structural tend to focus on the overall loading on buildings, not only regarding the loads, but also regarding the calculation of structures.
The role of wind loading standards has been discussed after major storm events, but major changes to these documents have not been made, based on these storm events. This paper describes some recent developments in building technology, and places these developments against the development of wind loading standards (especially EN 1991-1-4) in Europe.

Some observations in building technology

Over the last 2 decades, building technology has developed fast. Developments in materials, but also increasing demands, e.g. to energy use, comfort levels inside buildings, etcetera, may have direct or indirect consequences to the vulnerability against storm damage. Some observations are described here:

1. There is an increasing use of relatively new materials in facades. Examples are plastics such as Lexan, newly developed fixings methods but also light weight facades made from aluminium are relatively new. Usually these should be designed for a lifetime of 50 years. There is very limited experience with these materials, so the durability is not always clear at the design stage.
2. More facades occur not as a flat skin, but have external elements, such as sunblinds. These external elements are prone to wind loads. These loads are not given in the Eurocode. Application of such elements requires both product-based (force or pressure coefficients) and project based information (e.g. the wind field around a building).
3. With increasing need for durable energy sources, large potential is seen in placing solar energy systems on roofs. These systems have a value which exceeds by far the value of a traditional roof covering and also includes additional functions. Failure of such elements can not be treated in the same way as failure of a roof covering material.
4. More and more, high rise buildings are being built, increasing the vulnerability against wind loads, but also increasing the risks (a failure leads to higher consequences). The vulnerability should be covered in the codes, with increasing wind load with height. The risks may be covered by applying different consequence classes.
5. We see a much more international market, not only regarding industry, but also regarding workmanship; Facades on large buildings may be mounted by several independent teams, not communicating with each other. Errors made will then occur as damage during wind storms.

When storm damage occurs, one or more of these aspects are involved with the damage. The wind serves as a messenger in those cases.

Role of wind loading standards

Wind loading standards should ensure a certain level of safety for all structures being built. This level is defined in basis of design codes, as EN 1990. An acceptable probability of failure is defined for the lifetime of the structure. This level may differ between structures of different importance.

In the Eurocode system, but also in all loading standards around the worlds, the acceptable probability of failure due to wind loads is higher than for other loads. Though EN 1990 gives a probability index b = 3,8 as basis, careful analysis of the rules applied (including safety factor) leads to the conclusion that a b = 2,8 is implicitly applied. The reason is simply a matter of economy and acceptance in society. Using the same level of safety would mean an increase of the safety factors by at least 30%, leading to about 30% more expensive structures.

Related to this aspect is the role of insurance policies for storm damage. In the Netherlands, a wind speed of 14 m/s is mentioned above which a damage may be contributed to storm. This wind speed is much lower than the design wind speeds applied. A part of the lower safety which is accepted in our codes is therefore covered by the insurances.

Wind loading standards give values for the wind speeds and pressure coefficients, which together give a wind load. Not all building shapes or situations can be covered by a code. In many countries, local loads on e.g. roof covering products, are not included explicitly in the codes. This was also the case in the Netherlands before 1990.

When in January and February 1990 the wind storms hit the Netherlands, there was a huge amount of damage to roofing tiles and flat roofs. New tiles, replacing tiles damaged in January, have been blown off again in February. The industry and roofing associations concluded that this could be a threat to their business. An initiative was taken to prevent such damage in future. A couple of years later, in the Netherlands, NEN 6707 was published, together with a guidance document NPR 6708. This performance based code, which is part of the law, is now the basis on which pitched and flat roofs, including their fixings, are being calculated. The storms since then, in October 2002 and January 2007, have shown that only limited damage to roofs built using this code, has been found. This shows that a specific code, including methods to determine both the wind loading and wind resistance, can serve to mitigate damage in future.

Concluding remarks

Though the majority of storm damage can be contributed to factors such as bad workmanship, lack of maintenance or ageing of materials, still there is a role for wind loading standards in the mitigation of storm damage. The most vulnerable parts of buildings, such as cladding and roofing elements, are not covered sufficiently in our current standards. Experience with a specific standard for fixings of roof coverings in the Netherlands, which is part of the public law, shows that this can increase the quality of such structures by a great extent, and help mitigating the amount of storm damage.

This will become more important in the near future. The trend towards creating buildings with light weight elements, which are often more expensive, and the trend to increasing the amount of functions to the building shell, such as solar energy products, will create higher risks. These trends both lead to increasing the vulnerability and to an increase of the total damage sum after a storm event. This possible risk can be reduced by the application of up-to-date rules in building codes and regulations.

(Insured) storm damage to an outside ceiling: A situation not covered in standard building codes

Storm damage to a light weight façade (wind was coming from the left)