IOP Publishing

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Chapter 5

Weather extremes

Climate is a difficult thing for people to comprehend because we tend to think in terms of the daily and seasonal variations we call weather. Extreme events such as heavy rainfall causing floods, snowfall causing travel disruptions, or heatwaves stick in our minds. 2003 was not a particularly warm year, in fact the summertime temperatures were about average, but the two week heatwave that sat over Europe in August, which claimed ~70 000 lives, biases our opinion about the summer of 2003. Such events are extreme not only in that they occur infrequently but also that they have profound impact on people and urban areas. As the climate changes as a result of human activity and anthropogenic carbon emissions, the relative probabilities and likelihoods of extreme events will change. The intensity of such events will also change, with hotter, longer heatwaves, and more powerful storms, with higher wind speeds and more rainfall; therefore, what is currently classed as extreme weather may become the norm in the future. Unfortunately, the low-probability nature of extreme weather means that there are few events in historical records, which makes predicting future re-occurrences difficult. As such, there is a lot of uncertainty in climate change projections when it comes to lower probability events such as powerful storms and heatwaves. However, due to their destructive nature to property, infrastructure, and human lives, there is much ongoing research to improve the future forecasting of such events.

5.1 Heatwaves

Heatwaves are periods of calm hot weather (for that location) that persist for several days; this may also be accompanied by high humidity in marine climates. There are several different definitions of what constitutes a heatwave depending upon the region, a common definition which has been used for the UK is three or more consecutive days with daily maximum temperatures above 28 °C, not dropping below 16 °C at night. This definition is useful as it highlights the risk to human health in that the human body is able to withstand high temperatures for short

doi:10.1088/978-0-7503-1197-7ch5

periods, so long as it is able to shed stored heat when temperatures drop, usually at night. Another common and more international definition of a heatwave is the one used by the World Meteorological Organisation: five or more consecutive days where the daily maximum temperature exceeds the average maximum temperature by 5 °C; the baseline period being 1961–90. This definition is useful because it recognises that heatwaves may not always be in the height of summer, and that a particularly hot spring or autumn can be just as dangerous as higher temperatures in summer, due to the time lag associated with the adaptive response of human physiology. However, it does ignore the dangers associated with higher daily minimum temperatures and the associated implications for human health and wellbeing.

Estimates of the number of deaths across Europe as a result for the 2003 heatwave vary from ~15 000 up to ~70 000, depending on the methodology used and the assumptions made regarding how many people would have died during that period or in the following few months. Regardless of the methodology used to estimate the death toll, heatwaves have a profound impact on the populous, especially on vulnerable groups such as the elderly, infirm, or very young. The deaths that occurred as a result of the 2003 heatwave mainly occurred in large urban areas with a distinct UHI, which itself is intensified by the atmospheric conditions typical of a heatwave. The August 2003 heatwave is thought to be the warmest period for up to 500 years, and many European countries experienced their highest temperatures on record; in the UK temperatures peaked at 38.5 °C, and the London UHI was measured to be 9 °C. As we have discussed in previous chapters, high temperatures and reduced thermal comfort have a negative impact on worker productivity. The 2003 heatwave is estimated to have cost the UK economy between £400–500m in reduced manufacturing output.

Global populations are ageing with people living longer in both developed and developing countries. The UK is no different. The percentage of the UK population aged 75 or over is expected to increase from ~8% in 2015 to ~18% by 2085. When temperatures exceed 35 °C, all age groups are at risk; however, it is the elderly (and other vulnerable groups) who are most at risk and likely to be adversely affected by extremes of temperature. It is entirely likely that humans will undergo some form of autonomous physiological acclimatisation to changes in mean temperatures over time. However, research suggests that humans are less able to adapt to rapid, sudden changes in temperatures, particularly if the overall annual temperature variability increases as it is expected to as a result of climate change.

Cold is still the main cause of temperature-related deaths in the UK, with between 35 800 and 49 700 cold-related deaths per year on average. As the climate warms, cold will remain an important climate risk even though winters will become milder overall because minimum temperatures will remain similar to those we experience now. This coupled with the generally poor thermal performance of the UK housing stock and a growing, ageing population means that the number of cold-related deaths is unlikely to change much in the near future. Current estimates indicate only a ~2% reduction in cold-related deaths in the UK by 2050 under a medium emissions scenario (A1B). Current measures to improve the energy efficiency of homes will also reduce the impact of cold weather on the occupants. However, increasing the airtightness of the building fabric and increasing the level of insulation has to be undertaken carefully so as not to increase the risk of overheating, and provisions must be made to allow the removal of heat in the summer months.

The number of hot-days per year has been increasing steadily since the 1960s, and currently there are around 2000 heat-related deaths in the UK each year. As the number of hot days per year is increasing as a result of climate change, so is the risk of a severe heatwave. All but the lowest estimates of climate change (RCP2.6) show that by the 2040s a summer as hot as 2003 will be very common and will considered cold by the end of the century [1]. The ageing population means that the number of vulnerable people is increasing, and thus the number of premature heat-related deaths is also expected to increase. The number of heat-related deaths in the UK is predicted to more than triple by the 2050s, and increase five-fold by the 2080s, under a medium emissions scenario (A1B, median estimate) from the baseline of 2000 deaths per year. This could be further exacerbated by poorly implemented energy saving measures such as increased airtightness and insulation unless also accompanied by increased ventilation provision for example. There is evidence that newer homes are at a greater risk of overheating than older designs, due to improved airtightness and greater insulation, but also due to the removal or masking of thermal mass by use of modern construction materials and methods. At present there are no comprehensive policies in place to adapt the existing building stock to higher temperatures, reduce the urban heat island, or to safeguard homes against heatwaves. There is evidence that most people lack a basic understanding of the risks to health from elevated indoor temperatures, and therefore are unlikely to take measures to safeguard their and their dependents' wellbeing. Particular care will therefore need to be applied to buildings such as schools, hospitals, care homes, and prisons.

Heatwaves by definition are not a common occurrence. In addition to August 2003, other recent heatwaves across the UK were July 2006, July 2010, October 2011, March 2012, July 2013, July 2015, September 2016, and most recently June 2017. While it may appear that heatwaves are becoming more common (which they are due to a warming and more variable climate), these heatwaves were not as disastrous as the 2003 heatwave. This is likely due to the preceding 2003 summer months being abnormally cool, with sudden changes in temperature being more dangerous to humans. Ongoing research into the return periods of extreme weather events such as heatwaves has shown that human activities have increased the likelihood of heatwaves considerably; an event that would have been expected to occur twice a century in the early 2000s can now be expected twice a decade. Furthermore, a more severe 2003 type event has increased from 1 in several thousand to ~1:100 in little over a decade, and is expected to be an average summer by 2040 [1].

As the climate warms, the distribution of summer temperatures is expected to shift to higher warmer regimes, but also stretch, increasing overall variability in temperature, which would further increase the frequency of heatwave events (using the current definitions). Estimates of the effects of climate change on heatwave events are varied. For a 2 °C increase in global mean temperatures, it is estimated that a heatwave event in Europe may be expected to increase in intensity by between 1.4 °C and 7.5 °C [1].

The methods we can employ to keep our buildings cool and safeguard ourselves against high temperatures are similar to those already covered in chapters 3 and 4. Due to the characteristics of a heatwave (high temperatures, intense solar radiation, and high atmospheric stability with little wind), ventilation may be inefficient or even harmful unless the air can be cooled somehow, by evapotranspiration from plants for example, since the external air may be hotter than that inside the building. Due to reduced wind speeds, cross ventilation may well be ineffective at removing heat. Furthermore, thermal mass, which is effective at reducing peak temperatures, may well contribute to higher mean internal temperatures during a prolonged heatwave, particularly if exposed to direct sunlight, unless stored heat can be purged at night. Effort is best placed at keeping heat out of our buildings, such as closing curtains, blinds, or shutters early in the day to keep solar radiation out of the building. This is particularly important for west-facing rooms, which get afternoon and early evening sun, and are the most prone to overheating. External shading also will be effective, whether in the form of roof overhangs, balconies, brise soleil, or even just trees and vegetation; these will reduce the ingress of solar radiation and reduce internal temperatures. During a heatwave where nocturnal temperatures do not drop significantly at night, building heat loss via radiation and convection will be reduced at night; therefore, windows should be left open to allow heat to escape from the structure, purging any thermal mass, which would be enhanced due to the pressure difference between warmer air inside the building compared to outside. If possible, openings on multiple storeys should be used to also utilise the change in pressure with altitude (so-called stack ventilation); however, ground floor openings can come with a security risk. Furthermore, it is imperative that these windows or openings are closed again in the morning, before external temperatures increase, to retain the coolth within the building. Changing the colour of the building will help reduce the risk of overheating by reflecting solar radiation, and additionally increasing the amount of insulation in lofts will assist in keeping homes cool since the majority of solar heat gains are via the roof space.

Finally, more drastic measures to reduce overheating may focus on adding or increasing access to thermal mass within the building structure (coupled with effective night-time ventilation). Modern building materials such as plasterboard are effective insulators, and a dry-lined wall effectively masks any thermal mass behind (the same is true of suspended ceiling tiles). Replacing plasterboard with wet gypsum plaster allows heat to be absorbed from the air by the bricks/blockwork behind. Similarly, replacing carpets or wooden flooring with stone flagstones or ceramic tiles will allow heat to be stored in the screed/concrete floor. These effectively reduce not only the air temperature but also the mean radiant temperature since the surfaces around us are at a lower temperature; this has the effect of making us feel cooler because our bodies, which are almost perfect receivers/absorbers of thermal radiation (a black body), are receiving less radiation from our surroundings, and hence are able to radiate heat more effectively. Ultimately, any heat stored within the building structure needs to be lost to the environment eventually. Either the building needs to be made so thermally massive that the building will take several weeks to reach equilibrium with the elevated external temperatures (e.g. complete stone/concrete construction like a church) or else ventilation must purge heat at night when temperatures are lower. Increasing the ventilation provision of a building by adding a secure floor and ceiling-level vents (preferably on opposite façades) will allow stack-driven ventilation to occur at night, thus removing heat from the building and purging the thermal mass for a new day.

5.2 Storms

While I write this in 2017, storm Aileen is battering my house with 100+ km h^{-1} winds and torrential rain. Meanwhile, across the Atlantic hurricane Irma is causing wide-spread devastation to Florida after already passing through the Caribbean and the Bahamas. The severe impacts of high winds, torrential rain, and storm surges seem highly evident. The number of severe storms per decade has been rising steadily since the 1950s, with the stormiest years coinciding with a sustained positive North Atlantic Oscillation (NAO) index, a measure of sea level pressure anomaly versus the long term average. A positive value of NAO indicates higher pressure and is typical of stronger westerlies over the mid-latitudes, more intense weather systems, and wetter and milder weather over western Europe. Whereas a negative NAO blocks storms moving up from the Gulf of Mexico towards the UK, and the least stormy years are associated with more negative NAO pressures. It seems evident that there is an association between the NAO and the El Niño/La Niña Southern temperature oscillations over the Pacific, but this relationship is not well understood due to the many other factors involved, such as sea ice melt in the Arctic. Unfortunately, this makes predicting future storms and wind speeds very difficult, particularly when considered alongside the other uncertainties associated with estimates of climate change. At the time of writing, the UK Met Office has insufficient confidence in estimates of wind speed from its climate models to include the outputs in the publically available UKCP09 climate projections. This arises largely from the fact that UKCP09 is based upon many different climate models, not just those from the UK Met Office but also those from other Metrological Institutes worldwide. This allowed the formation of the probabilistic climate change projections that have been used throughout this book; however, for wind speed and storminess the results from the various models were so divergent that no confident consensus could be derived. This means that this section is based upon less evidence than the previous sections of this book; however, the risks to buildings, infrastructure, and human life require that it is given consideration. Furthermore, it seems logical that given the trends of increased winter rainfall and increased temperatures that the number and intensity of storms will increase.

People still talk of the 'Great Storm of 1987' that devastated the south of England. Schools were evacuated and pupils sent home (myself included), and people were advised to stay at home where it was safe; meanwhile, outside trees were uprooted, fences and walls were blown over, and roofs were ripped off buildings. In the coastal village where I lived, sea defences were destroyed and sections of coastal roads and footpaths washed away. This storm is considered to herald the onset of increased storminess, with the 1990s being the UK's stormiest decade since the 1920s; however, the 2010s seem set to take this title.

The UK experienced a spell of extreme weather during the winter of 2013/14 (figure 5.1). Between late January and mid-February 2014, a succession of major storms brought flooding and destruction to the UK. During these few weeks around six major storms separated by two to three days hit the UK; these followed an earlier stormy period during December and early January. Overall, during this winter period (December–February) at least 12 major winter storms hit the UK, making this the stormiest period for at least 20 years. January 2014 was the wettest January on record, with more than five months' worth of rainfall recorded in some locations. The most severe of this rapid succession of storms occurred in early-mid February, with the ground still saturated and inundated from rainfall over the new-year period.

These storms resulted in numerous weather-related impacts across most of the UK throughout the winter period. There was major flooding, with the Environment Agency reporting 6000+ properties flooded. The Somerset Levels were very badly affected, with large areas remaining under water from late December through the entire winter period to mid-March. There was also severe flooding along much of the River Thames through Oxfordshire, Berkshire, and Surrey. In addition to flooded properties and businesses, transport infrastructure was also affected, with many roads underwater and several villages on the Somerset Levels being only accessible by boat. The Southwest mainline railway between Exeter and Bristol was also affected by flooding on the Somerset Levels, and was shut down until mid-March. The following online video clip from the Met Office shows the extent of some of the impacts that these storms caused.

Figure 5.1. Weather summary video clip of winter 2013/14 (Crown Copyright. Contains public sector information licensed under the Open Government Licence v1.0). Available from https://doi.org/10.1088/978-0-7503-1197-7.

Figure 5.2. Huge waves batter the Cornish village of Porthleven on 5th February 2014 (©Matt Clark, Met Office).

As well as inland flooding, strong winds and huge waves battered exposed coastlines in the South and Southwest, causing widespread destruction to property and infrastructure. Strong winds, high tides, and tidal surges acted in combination to produce huge waves to batter the coastline (see figure 5.2). The swells produced by the storms had a long wavelength, allowing for the formation of waves with a large amount of speed and energy, and able to reach record heights. The most severe storm during this winter period was on 12th February, with waves of 25 m (82′) recorded off Southern Ireland and wind speeds reaching hurricane force (see table 5.1).

As we can see from figure 5.2, coastal conditions can become exceptionally dangerous. This is not only a danger to human life but can also cause considerable damage to buildings and infrastructure as huge waves overtop coastal defences. The mainline railway through Devon to Cornwall was severely damaged along a coastal stretch of line at Dawlish during the storm of 4–5th February (see figures 5.3 and 5.4), severing a key transport link to the Southwest peninsula for several weeks. This sort of disruption has a knock-on effect for the whole of the rail transport network since many national rail services begin or end in the Southwest along the stretch of line beyond Dawlish. This meant that a significant proportion of the rolling stock became trapped on the Southwest peninsula, causing widespread disruption across the entire rail network. These storms caused considerable coastal erosion, and the rapid succession of storms exacerbated coastal damage since weakened defences could not be repaired before the next storm hit.

Figure 5.4 shows damage to the substantial retaining wall supporting the foundations to the mainline railway. This damage caused by waves overtopping coastal defences is likely a result of the succession of storms progressively weakening the wall. This highlights the need for a more rapid response after storms to check and repair sea defences and infrastructure. It would seem probable that as the climate warms and contains more energy, the weather will become turbulent,

Table 5.1. The Beaufort scale used to describe wind intensity.

Beaufort wind scale	Wind description	Wind speeds in mph (km h^{-1})	Sea description	Probable wave height (max probable) (m)
0	Calm	<1 (<1)	Calm (glassy)	0 (0)
1	Light air	1–3 (1–5)	Calm (rippled)	0.1 (0.1)
2	Light breeze	4–7 (6–11)	Smooth (wavelets)	0.2 (0.3)
3	Gentle breeze	8–12 (12–19)	Slight	0.6 (1)
4	Moderate breeze	13–18 (20–28)	Slight – Moderate	1 (1.5)
5	Fresh breeze	19–24 (29–38)	Moderate	2 (2.5)
6	Strong breeze	25–31 (39–49)	Rough	3 (4)
7	Near gale	32–38 (50–61)	Rough – Very rough	4 (5.5)
8	Gale	39–46 (62–74)	Very rough – High	5.5 (7.5)
9	Strong gale	47–54 (75–88)	High	7 (10)
10	Storm	55–63 (89–102)	Very high	9 (12.5)
11	Violent storm	64–72 (103–117)	Very high	11.5 (16)
12	Hurricane	73+ (118+)	Phenomenal	14+ (–)

Figure 5.3. Damage to the Southwest mainline railway at Dawlish (Devon) after the storm of 4–5th February. Breach of sea defences and destruction of retaining wall, left rails suspended in mid-air after foundations were washed away (©Matt Clark, Met Office).

Figure 5.4. Photo showing damage to the retaining wall bounding the mainline railway at Dawlish (©Matt Clark, Met Office).

resulting in more and more powerful storms. A lack of preparedness will only exacerbate the effects of extreme weather.

The winter of 2015/16 was also exceptional; the mildest December on record was also the wettest, and this was coupled with the seemingly continuous series of storms that swept across the UK. In total, 509.2 mm (~20 inches) of rain fell in the three-month period December 2015 to February 2016. December 2015 was the warmest December since records began in 1910, with mean temperatures about 4 °C above the long-term average. The UK Met Office states that there is a direct link between the warmth and the record levels rainfall, with that December being also the wettest of any calendar month of record, with almost double the normal amount of rainfall at 218.8 mm.

In 2015 the UK Met Office began naming storms rather than just hurricanes, with the first named storm being Abigail which hit UK shores on 10th November 2015; over the next few months there was a rapid succession of storms (see table 5.2) that caused disruption and flooding. The three storms in December provided much of the total month's rainfall, with the storms propelled by the Jet Stream towards the UK, and additional contributions from the El Niño weather phenomenon and anthropogenic climate change. The Jet Stream, which flows from the Gulf of Mexico towards the UK, is responsible for much of our mild weather, and is indicative of a positive NOA. In this case, the positive NOA and strong Jet Stream will have contributed towards the uncommonly mild weather, with the elevated temperatures resulting in greater evaporation of water and leading to increased rainfall.

The 2016/17 storm season saw only five storms, but as the 2017/18 storm season (September–March) begins with storm Aileen currently raging outside, we can only wonder what the future holds.

Table 5.2. Names and dates of storms in the 2015/16 storm season.

Name	Date of impact on UK and/or Ireland
Abigail	12–13 November 2015
Barney	17–18 November 2015
Clodagh (Clo-da)	29 November 2015
Desmond	5–6 December 2015
Eva	24 December 2015
Frank	29–30 December 2015
Gertrude	29 January 2016
Henry	1–2 February 2016
Imogen	8 February 2016
Jake	2 March 2016
Katie	27–28 March 2016

Building codes in the UK already take account of the impact of wind shear forces on buildings. However, projections of climate change indicate that storms will become more powerful, meaning that additional care will need to be applied to the design of buildings in exposed areas where squalls of very strong winds are common, even if they are typically only of a short duration. Violent storms have a variety of names according to the region in which they occur; hurricanes, typhoons, and cyclones are all basically the same phenomenon, consisting of high-speed ~120 km h^{-1} (~75 mph) rotating winds. This is mean wind speed, and individual gusts can be significantly stronger and more powerful. These storms can cause extensive damage (table 5.3), not only by the direct effects of the powerful winds and intense, torrential rainfall, but also indirectly by associated flooding, storm surge, and landslides.

The energy contained within wind and its destructive power increases with the square of its velocity; hence, a 100 km h^{-1} gust can exert a force 100 × greater than a 10 km h^{-1} gust. To resist the lateral forces of these winds, buildings are typically made more rigid or braced somehow. However, more primitive architectures in tropical climates adopt the philosophy of flexibility, allowing structures to sway and give in the winds like the palm trees of such climates. The alternative to these solutions is to shelter the building either via wind breaks or by reducing the profile of the building, making it more aerodynamic or sinking it into the ground.

A building in a location prone to cyclonic storms must be able to withstand the extreme winds that can blow from every direction as the storm moves overhead. The building must also be able to withstand the rapid and extreme changes in air pressure generated by the storm. Severe storms are characterised by this rapid change in pressure, differing them from severe gales. This change in pressure is >±10 kPa (>±10 mb) in a three-hour period. This coupled with the local changes in pressure due to wind flow and the Bernoulli principle (cf. the lift produced by plane wings due to the pressure difference between the top and bottom) means that the pressure across different building elements can be extreme. Additionally, as we have previously discussed, the drop-in pressure due to an intense cyclonic storm leads

Table 5.3. Wind gust velocity and damage to vegetation and property.

Wind gust velocity	Damage
75 mph–93 mph 120 km h^{-1}–150 km h^{-1}	Shrubs, trees, and foliage but unlikely for buildings in good repair.
94 mph–112 mph 151 km h^{-1}–180 km h^{-1}	Considerable damage to shrubs and tree foliage, with some trees blown down. Some damage to building roofs, windows, and doors; minimal damage to building structures.
112 mph–130 mph 181 km h^{-1}–210 km h^{-1}	Extensive damage to trees and shrubs, with large trees blow down. Some damage to building roofs, windows, and doors; minor damage to curtain-walls and small structures.
131 mph–149 mph 211 km h^{-1}–240 km h^{-1}	Shrubs and trees blown down. Extensive damage to roofs, windows, doors, and some curtain-walls. Complete failure of roofing structures on small buildings.
150 mph + 241 km h^{-1} +	Shrubs and trees blown down. Considerable damage to buildings; roofs, windows, and doors. Complete failure of roofing structures on small buildings. Curtain-wall and façade failure of industrial type buildings. Small buildings may be overturned completely.

to a rising sea levels, which can lead to coastal or estuary flooding, particularly if the storm coincides with an astronomical high tide.

Roofs are particularly prone to being damaged or destroyed by the high suction (negative pressure difference) on their leeward side (see figures 5.5 and 5.6) due to the rapid flow of air over the building or a combination of suction on top and pressure underneath the roof overhangs. In taller buildings, the influence of wind gusts and the pressure differences between the windward and leeward sides of a building can set up oscillations in the building structure, which can result in structural failure.

The centre of a cyclonic storm is at extremely low pressure, and if this hits a building that is particularly well-sealed, too quickly, the normal pressure (or even elevated pressure due to temperature differences) inside the building can cause it to explode outward and collapse. This is perhaps an extreme example, but the failure of window and door seals leading to increased air leakage (infiltration) and potentially increased energy bills in the longer term if not remedied is much more likely. This presents a problem as the current tendency is to create more insulated and air-tight buildings on the pretext that they are more energy efficient.

Buildings can be protected from high winds by planting trees, but care should be taken not to plant them closer than ~15 m in case the tree is blown over. The sheltering effect of such vegetation will be effective only over a distance of ~8–10 times the height of the tree. In undulating or hilly areas, building construction along ridges should be avoided since they will experience accentuated wind velocities, whereas lower down in a valley will typically experience lower speeds. However, the reverse may be true in long narrow valleys where wind becomes funnelled along the valley floor; this obviously depends on the orientation of the valley to prevailing winds.

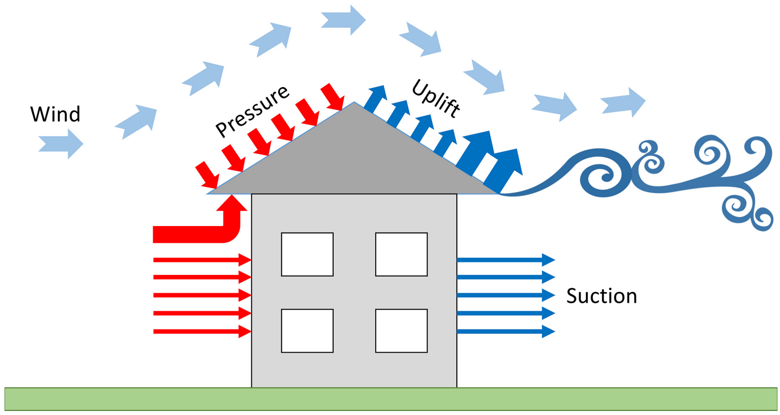

Figure 5.5. Illustration of the forces on a building caused by wind pressure and turbulence.

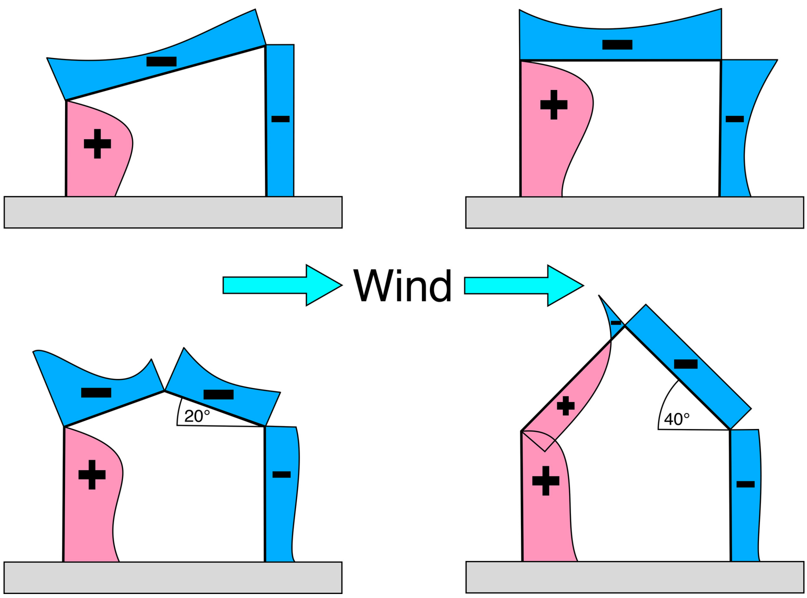

Figure 5.6. Forces exerted on different roofs and façades by the wind; positive signs indicate pressure, while negative signs indicate suction.

The shape of a building is the single most important factor in determining the performance of buildings in cyclonic storms. Compact, simple geometric shapes are best. Buildings should ideally be symmetrical, with square, or even hexagonal floor plans, and roofs should have multiple slopes because these present less area to winds and will perform better under wind load forcing than gable roofs with two slopes. If the site dictates a rectangular shape, then it is best if the length is not more than 3 × the width. Experiments have shown that hip roofs with a pitch in the range 25°–40° are most resistant to high winds. Meanwhile, roofs with a pitch <22° should be avoided due to the increased suction from wind flow (figure 5.6).

All roof elements, such as rafters and purlins, should be securely fixed to the main structure. Additionally, the double nailing of roof tiles is advisable to prevent removal by suction forces. Roof canopies and overhangs should be minimised or avoided if possible, although herein lies a contradiction with reducing temperatures by shading of façades. In some climates, brackets fixed to the main building structure or to the ground can be used to tie down the roof before the storm season starts. Verandas or covered walkways should be built as separate structures rather than extensions to the main structure so they can be blow off without damaging the main structure. Windows and doors are a particular danger in high winds; if these are broken by flying debris or breached by changing pressure levels, wind will have easy access to the building interior, and the resultant uplift pressure in the roof space may cause the destruction of the entire building structure. Furthermore, frames should be securely anchored to the rest of the building structure, and large expanses of glass should utilise shatterproof, toughened glass, and be protected by storm shutters. Many of these design features can be seen employed in the traditional buildings of the world's exposed locations.

Reference

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