Technical Note No. 9

TESTING PRESSURES

Introduction

Cladding systems and components are routinely tested to determine properties such as resistance to wind load, airtightness and watertightness. However, the pressures used for these tests are often different, and it is easy to become confused as to the purpose of these tests.

This technical note aims to explain the normal procedure for determining test pressures, and to give guidance on the applicability of test results.

Site wind loading

The key performance criteria for designing any cladding system is the windloading that is likely to be experienced at the particular location. Windload is determined by following the procedures in BS 6399: Part 2. Normal practice is to determine the wind load based on a 5m diagonal dimension (a typical distance between cladding fixings), that will occur just once, on average, in any 50 year period. This wind load is then often rounded up, typically to the nearest 400Pa, and a minimum wind load of 800Pa is required by CWCT (CWCT, 1996).

Rounding-up of wind load is aimed at manufacturers of standard components or systems, such as windows, which are more cost-effective if they are designed and tested to some target value.

Stating the actual site wind load, and testing at pressures other than 800, 1200, 1600 and 2000Pa, is usually only cost effective where the majority of the cladding system is being tailored to the particular building (bespoke cladding) and design savings can be made.

In either case the wind load stated by the specifier is the **design wind load**, i.e. that value which the cladding must be designed to resist.

Wind load testing

Testing for resistance to wind load is divided into two basic elements - serviceability testing and safety testing. Separate positive and negative wind load test pressures can be applied if the design wind load has different positive and negative magnitudes (negative wind pressure is normally the greatest). This (again) is particularly appropriate when testing bespoke cladding.

Serviceability wind load testing

For a serviceability wind load test a component or sample of the cladding is subjected to both positive and negative pressure differentials equal to the design wind load, to ensure that when the 1-in-50-year wind load occurs the cladding system or component neither fails (by moving too much - this assessment is usually deflection limited) nor ceases to be weathertight.

The deflection of parts of the component or system are monitored and compared to pre-defined limits. An excessive deflection may lead to damage to fixtures and fittings, failure of joints, or may simply be unnerving for the occupants of the building.

The serviceability test is always followed by a repeat of the tests for air and watertightness, to ensure that the cladding will perform after experiencing the 1-in-50-year wind load (this wind load may occur in the first or fiftieth year of the life of the cladding, may never occur, or may occur on successive days - it is a statistical measure).

Safety wind load testing

For a safety test the objective is to determine whether the cladding has a factor of safety beyond the design wind load. This test is usually only performed for flexible cladding systems, where stress limits may be exceeded

and permanent deformation occur. The test sample is subjected to positive and negative application of 50 per cent above the design wind load. A limit is placed on the residual deformation of the cladding system.

It is important to note that the designer of a cladding system may alter the design of structural members and fixings to ensure that the elastic limit of materials is not quite reached at the design wind load - this will often allow the minimum use of materials. The 50 per cent overload will cause the elastic limit to be exceeded, but should not cause the system to fail, or components to become detached. It is important that fixings are capable of passing this test, as the cladding should not fail structurally during this test.

Weathertightness tests are not repeated following the safety test, as the sample is expected to have deformed permanently. This test is also not applied to components such as windows which are only to be mounted in rigid walls - the hazards associated with structural failure are much less, and the number of fixings is greater (they are also generally over-designed).

The wind load tests are structural, and are related to issues of health and safety, and so must be performed to the full wind load (and beyond for safety).

Air and watertightness testing

Air and watertightness testing may be required for a number of reasons. Airtightness affects occupier comfort (draughts), energy usage (mass transfer) and watertightness (water droplets entrained in air flows). Watertightness is essential to avoid damage to the cladding system and to the contents of the building, and failure of watertightness must be accommodated in terms of provision for drainage.

Airtightness testing for energy usage

Energy usage is important on a day-to-day basis. Assessing the airtightness of the cladding as it relates to energy use must therefore be based on a sensible day-to-day average pressure difference. Moreover, the test may also be performed for positive and negative pressure differentials, as both lead to energy wastage.

As stated above the design wind load is based on a single gust of wind, occurring once in 50 years on average. However, on a day-to-day basis the average wind load on a cladding system is much less. Typical values for pressure differential when assessing energy usage are 25, 50 or 75Pa. A 50Pa dynamic pressure corresponds to a site wind speed of 9m/s (assuming a difference of 1.0 in external and internal pressure coefficients) - this is about 20 miles per hour, and probably represents a windy day for many UK sites. A 75Pa dynamic pressure similarly corresponds to a site wind speed of 11 m/s (about 25 miles per hour).

Systems which rely on a sealing action under pressure may not perform as well at low pressures as at high pressures.

The selection of either 25, 50 or 75Pa is left to the specifier. The 50Pa difference is preferred as it is a normal step in the airtightness testing procedure defined in BS 5368: Part 1.

Airtightness testing for occupier comfort

Occupier comfort will be affected by the occurrence of draughts. If a draught occurs every time there is a gust of wind then the occupier could have reasonable cause to protest about the performance of the cladding system or component.

However, to understand the factors which govern the occurrence of draughts it is necessary to understand how wind behaves other than the 1-in-50 year peak wind load. The voluntary European wind load standard, ENV-1991-2-4 includes a calculation of the number of gusts (Appendix B, Figure 1). This graph indicates the number of times, in a 50 year period, that a gust occurs at some proportion of the peak wind load. For example, a gust at 75 per cent of the peak wind load will occur, on average, $10^{1.6}$ times in a fifty year period (about 40 times). Similarly a gust at 50 per cent of peak wind load

will occur $10^{3.3}$ times, or about 2000 times in 50 year (40 times per year, on average). Neither of these could be considered enough to cause a problem.

A gust at 25 per cent of peak wind load will occur about $10^{5.4}$ times - this is an average of 5000 per year, or about 10 per week. This is much more likely to be noticed and would cause a discomfort problem.

Sensibly then, airtightness should be assessed at a pressure somewhere around 25 per cent of the peak wind load. For convenience, test pressures are banded into the classes 300 and 600Pa for walls; lower values are sometimes used for windows.

Guidance on selecting between these pressures is a little more difficult to find. The designer could simply take 25 per cent of the peak wind load and round up to the nearest of 300 or 600Pa. Air-tightness test pressure is normally chosen purely on how airtight a building is required to be regardless of the wind load; for prestige or air-conditioned buildings it is often advisable to take the highest classification.

Watertightness testing

Watertightness is important to the occupant of a building. Significant water penetration may cause visible damage to soft furnishings and carpets, and if undetected could also lead to the breakdown of glazing or glass unit seals or even structural damage within the cladding system.

Determining a suitable test pressure for watertightness testing is a little more complex as the watertightness test is not undertaken at the design wind pressure - the positive wind pressure. A particular issue is that a short term gust has little relevance to water penetration - the quantity of water that can be blown into an opening in a few seconds is very small, and unlikely to cause problems. Moreover, peak rainfall does not correspond to the highest wind speeds - indeed driving rain is often variable in direction, due to the vortices causes by strong air flows around a building. The greater problem is that peak rainfall occurs for long durations at lower wind speeds. Windows are tested with the pressure applied for periods of 5 minutes at lower pressures and this has been found in practice to be an appropriate test.

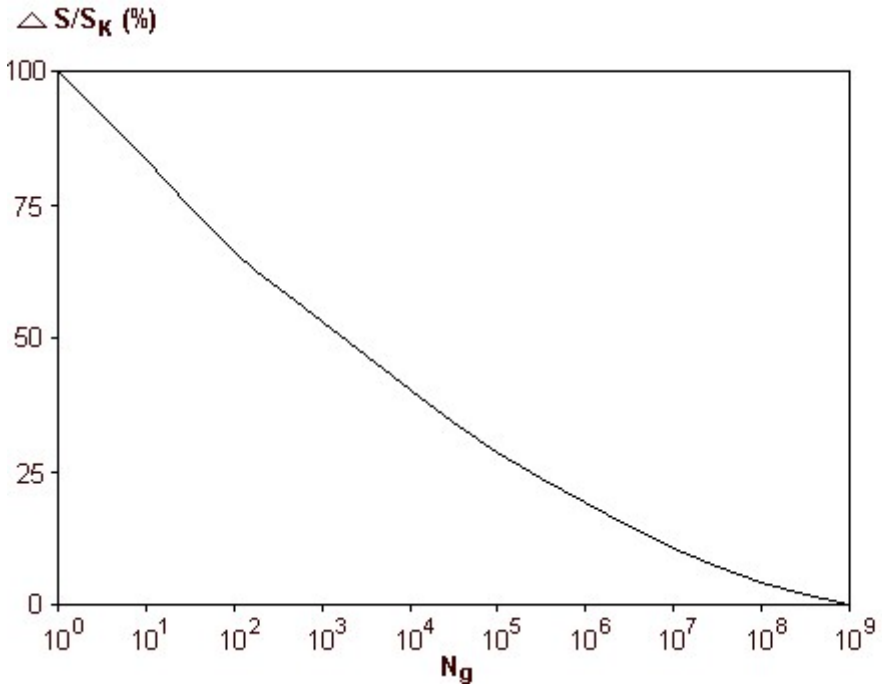

Figure 1 Number of gust loads N_g for an effect $\Delta S/S_k$ during a 50 years return period

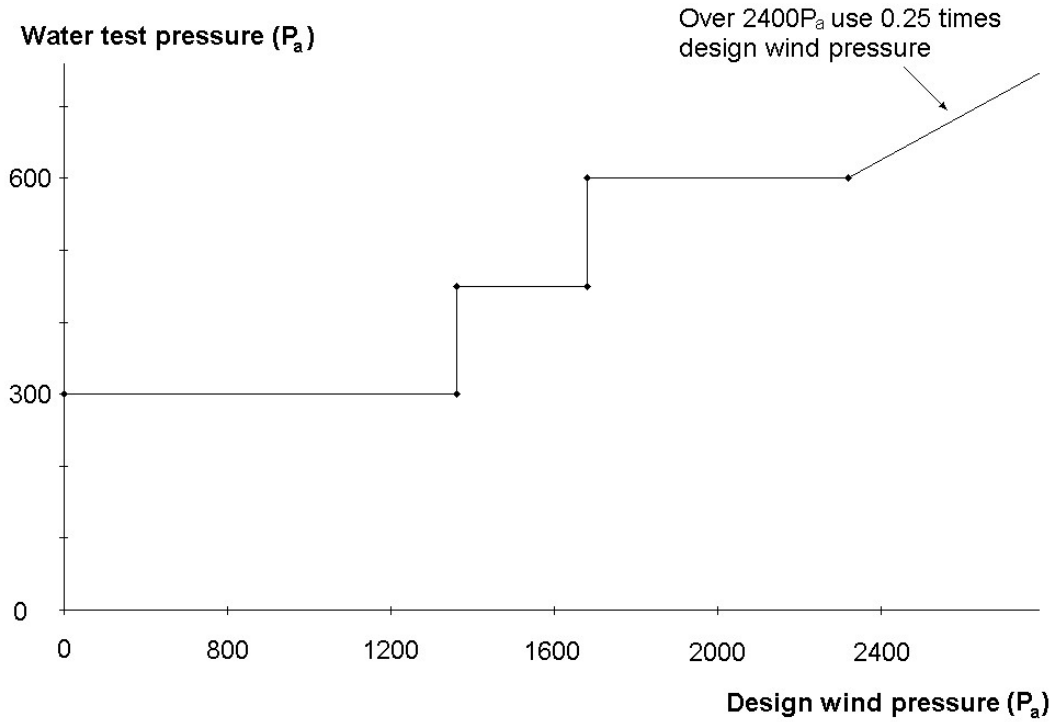

Figure 2 Watertightness test pressure appropriate for different levels of peak wind pressure

Again it is sensible to use standard values. Using values in common with the airtightness test also has some merit and for this reason watertightness is typically assessed at 300 or 600Pa. For curtain walling a 450Pa value has been added. Figure 2 shows the watertightness test pressures recommended for different levels of design wind pressure. The step function approximates to a slope of 0.25. Interestingly, the North American practice adopts a slope of 0.2.

Summary of air and watertightness testing

The pressures at which air and watertightness of a cladding component or system are tested have previously been based on rules-of-thumb. However, these rules can be justified, as shown above, and support the choice of pressures previously obtained from experience.

References

BS 5368, *Methods for testing windows,* Part 1, 1976, *Air permeability test,* British Standards Institution.

BS 6399*, Loading for buildings.* Part 2, 1997, *Code of practice for wind loads*, British Standards Institution, London.

CWCT, 1996, *Standard for Curtain Walling,* Centre for Window and Cladding Technology, University of Bath.

Eurocode 1, 1995, *Basis of design and actions on structures - Part 2-4: Actions on structures - Wind actions*, European Committee for Standardisation.

CWCT Technical Notes 1 – 30 have been part-funded by the DETR under research contract 39/3/338 (CI 1354)

CWCT
The Studio, Entry Hill, Bath, BA2 5LY

T: +44 (0) 1225 330945
cwct@cwct.co.uk
www.cwct.co.uk