Technical Note No 55

Movement accommodation in building envelopes

This Technical Note is one of a series of three describing the design and assessment of supporting structures and cladding systems to ensure that building envelopes are serviceable throughout their design life. The series comprises:

TN 55 Movement accommodation in building envelopes
TN 56 Accommodation of structural movement
TN 57 Cladding movement

This Technical Note should also be read in conjunction with:

TN 20 Design of sealant joints
TN 21 Tolerance, fit and appearance of cladding
TN 60 Performance of externally rendered cladding systems

Introduction

This Technical Note describes the need to design building envelopes and supporting structures such that the building envelope is not subject to inappropriate movement that may cause failure of the envelope. It also describes the principal mechanisms that allow movement of the cladding.

Non-loadbearing building envelopes have to be isolated from movement of the supporting structure so that they do not resist structural movement, which may induce loads in them for which they have not been designed.

Expansion and contraction of components has to be accommodated by allowing movement to occur at component joints otherwise unintended internal stresses are generated.

Failure to design for this movement can lead to fracture or buckling of components. Even if the structural and cladding movements are not large enough to load the façade components to failure, they may reduce the gaps required for drainage.

All envelope systems should be designed to accommodate their own movement and some structural movement. The movement accommodation of a building envelope system will depend on its detailed design. For instance a stick system based on a 60mm wide transom will accommodate greater floor deflections than one based on a 50mm wide transom.

Increasingly structural engineers are required to undertake detailed design work and provide statements on structural movement before the façade details have been finalised. Prior to the latter, structural engineers tend to work to deflection limits set by structural codes without taking due regard of the structural deflection limits that curtain walling systems can accommodate.

Technical Notes 56 and 57 provide an introduction to movement accommodation in building envelopes. This includes guidance for structural engineers to enable them to undertake a preliminary assessment of the structural deflections that the building envelope may accommodate once a decision has been made on the type of non-load bearing façade (eg: stick system, unitised or panelised curtain wall) and the nominal width of the associated mullions and transoms.

Particularly with large span structures, there is a limit to the extent to which the deflections can be reduced practically. In such situations, it is incumbent on structural engineers to improve predictions of the structural movement at slab edges and provide stiffer solutions where necessary. Failure to do so often results in a need for a structural re-design once the inherent limitations of the façade design solution, on which Planning Consent has been granted, become apparent.

Effect of combined movement

Cladding components will change dimension and shape as a result of changes in load, temperature and moisture CWCT TN 57.

These dimensional changes may reduce the ability of the building envelope system to accommodate movement of the supporting structure CWCT TN 56. Both cladding movement and structural movement have to be taken in to account when designing for movement.

Effect of construction

Tolerances of both the supporting structure and the façade components will determine the final dimensions of any gaps or movement joints in the envelope and the movement accommodation at the fixings or brackets. CWCT TN 21 describes the relevant tolerances and build up of tolerances.

It is important that the as constructed envelope has the required movement accommodation. When specifying fit and appearance it is necessary to specify the acceptable deviations for joint and gap widths and also the movement accommodation required at the joints, fixings and brackets.

Improved movement accommodation of the cladding

The movement accommodation of the building envelope can be improved by using wider joints and/or wider framing members and by using smaller panels and/or more joints. However, the scope for doing this is limited by the need to achieve the intended appearance of the façade.

At best the movement accommodation of a building envelope can only be varied by a factor of two before the appearance becomes radically different and a different method of construction may be required.

Movement accommodation

The ability of a building envelope to accommodate movement depends on the ability of joints to accommodate movement and, in the absence of movement joints, the ability of components and materials to change dimension without inducing unacceptably high stresses and loads.

Materials that should remain unstressed should be isolated from movement of the building envelope system by the use of appropriate movement joints

Design responsibility

The Project Structural Engineer is often not involved in the detailed design of the building envelope, which is the responsibility of the specialist cladding contractor.

This has the following consequences:

- The Structural Engineer is unaware of the actual cladding loads at the design stage.
- The Structural Engineer is unaware of the deflection limits imposed by the building envelope design.
- The Cladding Contractor has to design to accommodate unreasonable deflections that will probably not occur.
- The Cladding Contractor has to design to accommodate frame tolerances larger than are necessary.

It is important that the building envelope design is begun before the design of the building structure is finalised, or at least the weight and movement limitations of the envelope system to be used should be made known to the Structural Engineer. This is not often done, but without knowledge of the weight of the cladding the structural engineer cannot calculate the deflections and without knowledge of the movement limitations cannot know whether the calculated deflections are acceptable.

A full list of contributions that can be made by, and the responsibilities of, the different parties, is given in Table 1.

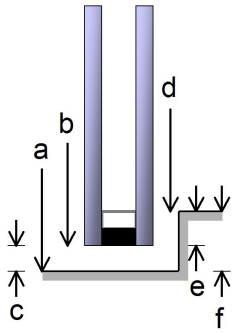
Some of the Information required during the design process may be estimated on the basis of generic behaviour. Guidance on structural and cladding movement is given in Technical Notes TN 56 and TN 57.

However, it is still necessary to make decisions in a timely sequence and to communicate with other parties appropriately. The procurement process, particularly the late appointment of designers and contractors sometimes thwarts this. Clients should be mindful of the efficiency of design that can be achieved by timely appointment of designers and contractors and appropriate briefing so that they share information.

Accommodation of movement in glazing systems

Edge clearance

The ability of framing members in a stick curtain wall to move or deflect in-plane without contacting the glass is governed by the edge clearance between the glass and the frame, Figure 1.



a) Tight size
b) Pane size
c) Edge clearance
d) Opening size
e) Edge cover
f) Rebate depth

Figure 1 Edge clearance

The edge clearance is half of the difference between the tight size and the pane size. Note that it is also the difference between the rebate depth and edge cover.

A minimum edge cover is required, depending on the system design, to accommodate the gaskets or seals and to transfer wind load from the glass to the frame. It follows that the only way to appreciably increase edge clearance is to use a profile with a greater rebate depth.

Stage	Architect	Structural engineer	Cladding detailer
Scheme design	Describe form of supporting structure: • Load bearing masonry • Steel frame • Concrete frame • Floor spans • Cantilevered edges • Fit-out Determine options for cladding system to be used including: • Grid dimensions • Frame and joint widths • Panel sizes • Glazing type • Weight	Set deflection limits based on the proposed cladding system. Provide outline movement prediction for the proposed structure. Give advice on the proposed method of transferring the cladding loads.	Give outline advice on the movement accommodation of the proposed cladding. Give advice on the inherent movement of the cladding system proposed: • Stick system • Unitised system • Bespoke unitised • Panellised
Structural design	Provide information on: • Movement requirements of the proposed cladding. • Maximum weight of the cladding. • Positions for transferring the cladding loads to the supporting structure .	Calculate actual structural movements based on agreed cladding loads and other loads. To include: • Interstorey drift • Floor deflections Movements should be categorised as due to: • Dead load • Cladding load • Live load	Confirm structural engineers assumptions of: • Cladding movement. • Arrangements for transferring loads. • Movement accommodation of the cladding.
Cladding detailing	Agree proposals for accommodating movement within the cladding.	Confirm acceptability of: • Calculated loads	Detail the cladding, support brackets and fixings to: • Have the necessary movement accommodation • Transfer the loads at the agreed positions • Confirm that the loads are acceptable to the structural engineer

Table 1 Recommended actions and responsibilities

The actual edge clearances will depend on the system design and in particular the thermal break detail. The arguments for using 50 mm wide framing members in stick systems are those of cost and the desire to minimise visual impact, 'sight lines'.

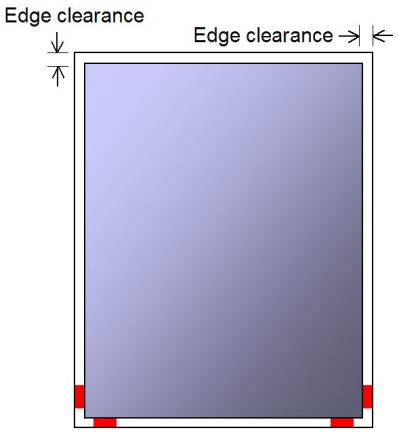


Figure 2 Edge clearance and setting blocks

Setting blocks may restrict the ability for the frame to move. Indeed this is desirable when glazing opening lights. When glazing directly in to stick curtain walling the only blocks used should be two setting blocks to support the weight of the glass from the transom and possibly two 'anti-walk blocks' placed at the bottom on each side of the glass.

Accommodation of movement in sealant joints

The design of sealant joints is described in detail in CWCT TN 20. The lateral movement accommodation of a sealant joint depends on the type of sealant used but lies in the range 5 to 70% and is normally less than 25%. The allowable longitudinal movement is normally twice the allowable lateral movement.

Accommodation of movement in components

Components of non-loadbearing building envelopes such as panels and units should be connected to the building envelope in a way that allows cladding and structural movement to occur without inducing loads in the components. Fixings have to be designed to give the required movement accommodation of the system and movement joints may have to be provided to allow movement of the components.

Accommodation of movement in renders

Rendered surfaces have limited ability to accommodate movement. The acceptable strains in the render will depend on the render itself and any reinforcement within it. Movement accommodation joints may be included in rendered systems to reduce the strains induced in the render. Further information on rendered walls is given in CWCT TN 60.

Serviceability of the building envelope

The building envelope should remain serviceable under normal loading of the envelope and also loading of the building structure. This requires that it should remain safe and undamaged. It should not leak air excessively and should retain its water penetration resistance.

To ensure serviceability following movement of the structure and building envelope, the envelope may be tested in accordance with the requirements of CWCT 'Standard for systemised building envelopes'. The Standard makes provision for moving the test specimen prior to an air permeability test and a water penetration resistance test, Clause 8.13.

The CWCT Standard for systemised building envelopes also has a thermal cycling test. The object of the test is to ensure that the building envelope is

serviceable after cycles of extreme temperature. The test is normally only conducted if the building is to be constructed in a particularly cold climate, outside the UK, or is of novel construction that gives rise to concern about thermal movement of the cladding.

References

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Standard for systemised building envelopes, ISBN 1 874003 20 3, CWCT 2006.

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