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Guidance document on parapet walls

BD2452 – Safety of Masonry Parapets

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BRE

Department for Communities and Local Government

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Executive summary

The main body of this report contains a draft of our guidance document on parapet walls. In addition, a summary of the basis on which the structural solutions adopted in it were arrived at is contained in an appendix - Appendix A.

Introduction

Parapet walls usually have both of their faces exposed to the weather and therefore tend to get wetter and take longer to dry than other forms of wall construction. The higher levels of dampness tend to increase the rate at which degradation of the parapet wall components occur when compared with similar components used in other forms of wall construction. Consequently, they are likely to require a higher attention to detail during construction and a higher level of maintenance than other forms of masonry wall.

Parapet walls must prevent water from penetrating the supporting masonry wall. Therefore, a great deal of attention is paid to the provision of water management features, in the form of copings, damp proof membranes and weepholes. Small defects in these provisions can lead to severe water ingress to adjacent parts of the building fabric.

This guidance document is set out in the following order:

- Materials
- General guidelines for the construction of parapets
- The placement of components that comprise the parapet wall
- Information on the interface between parapet walls and adjacent components.
- An inspection and maintenance checklist
- A bibliography of other relevant documents

Materials

Bricks and Blocks

Dense aggregate concrete blocks to BS EN 771-3 are normally sufficiently frost resistant for use in UK locations.

F2, S1 or F2, S2 clay bricks to BS EN 771-1 are recommended in order to minimize the risk of frost attack. Under some circumstances F1, S1 or F1, S2 clay bricks to BS EN 771-1 may be used.

Mortars

A mortar mix of 1 part Portland cement, $\frac{1}{2}$ part lime and $4\frac{1}{2}$ parts sand (a 1: $\frac{1}{2}$: $4\frac{1}{2}$ cement: lime: sand (CLS)) is recommended for use in parapet walls constructed from F2, S1 or F2, S2 bricks. If the wall is built with concrete blocks it is likely to be rendered and a 1:1:6 CLS mortar should be acceptable. If the wall is constructed from F1, S1 or F1, S2 bricks use 1: 1: 6 CLS. BRE Digest 362 provides further information about building mortars.

The choice of sand is very important in ensuring a good bond between the units and the mortar. BRE recommends the use of a well graded building sand with a low fines content.

Damp proof courses and cavity trays

Damp proof courses and cavity trays must have good bonding properties to the masonry.

Cappings and Copings

Use frost resistant copings to BS 4729, or other copings to BS 5642. In all instances, copings must include an adequate overhang and include a drip.

Cappings and copings should be capable of being mechanically fixed to the parapet wall. A number of manufacturers produce suitable systems, including preformed metal and g.r.p. cappings.

Render should not be applied to the upper surface of the cappings or copings on parapet walls.

Joint sealants

Joint sealants should be selected according to BS 6213.

Construction guidelines

Stability

Wherever possible, parapet walls should not be free standing; they should incorporate returns at each end or be tied into adjacent structural elements.

To ensure that parapet walls are as stable as possible, wall ties must be used at the following centres in them: horizontal spacing - 450mm; vertical spacing - 225mm.

Where panels are structurally isolated because of the presence of movement joints, slip ties should be incorporated across the joint. The positioning of the slip ties must not affect the subsequent sealing of the joint.

Masonry

Follow accepted good workmanship practice guidance given in BS 5638-3 and BS 8000-3. Use bricks frog up, finishing the mortar pointing with a bucket handle profile. Use stainless steel wall ties. If there is to be a render finish (usual with blockwork), ensure that the joints are raked back by 10mm to 12mm prior to applying the render to provide a good key; with brickwork, do not render both faces of the parapet wall as this is likely to extend the periods during which the wall will remain damp.

When applying render, dampen the masonry to reduce the initial dewatering of the render. Protect new masonry from rain, frost and wind.

Positioning of slip ties

Slip ties should be used whenever a parapet wall abuts an adjacent structural element and across any movement joints that are incorporated in its construction. The slip ties should be made from stainless steel. Three slip ties should be positioned through the height of the wall, and at third points, but not at greater than 225mm vertical spacings. The upper tie should be positioned in the mortar bed of the course below the dpc.

The remaining ties should be positioned $\frac{1}{3}$ and $\frac{2}{3}$ of the distance from the cavity tray to the upper slip tie.

Loading

Parapet walls will be subjected to wind loads. Wind loadings should be calculated according to the procedures in BS 6399-2.

Where the parapet wall is also to act as a safety barrier the appropriate horizontal loadings should be calculated to BS 6399-1.

Procedures for designing masonry for particular loadings can be found in BS 5628-1.

Allowing for movement

Movement joints must be incorporated at appropriate intervals, BS 6093. The spacing of the movement joints in the parapet walls should mirror those in the walls directly below them, where they are present.

Jointing

Joints should be designed according to the procedures described in BS 6093 and sealed according to the procedures described in BS 8000-16.

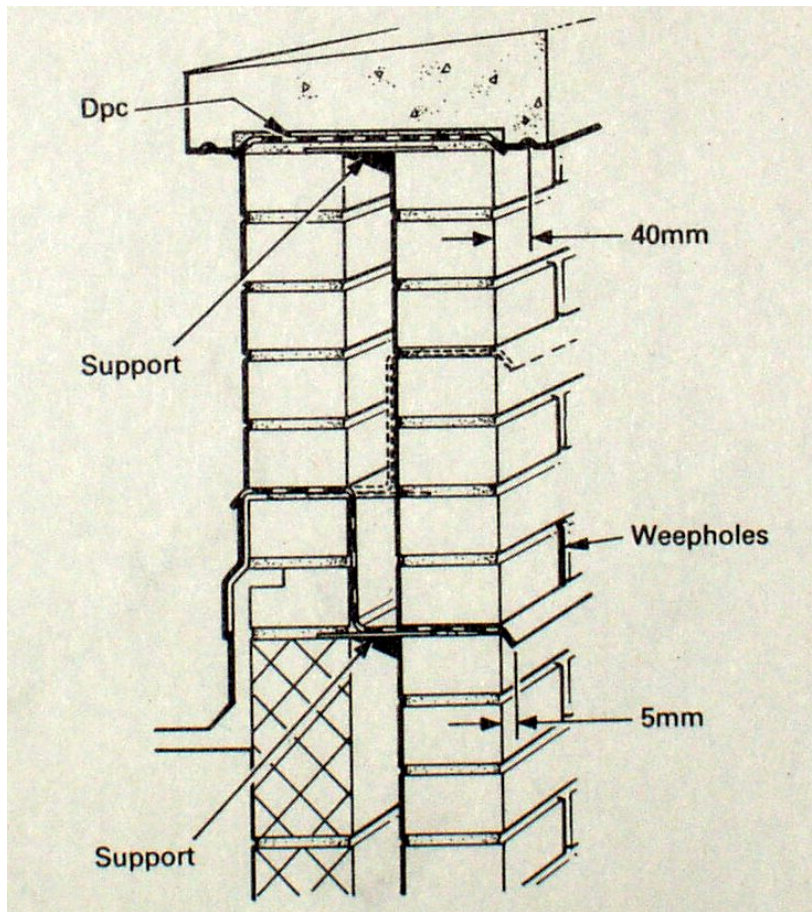
Placement of components

The primary aim should be to prevent water from entering the parapet wall. If the parapet wall is continually damp, problems from sulfate attack may follow.

If water does enter measures should be taken to eject it from the wall and also to prevent it from coming into contact with the inner leaf.

The principle of the weatherproofing arrangements at parapet and roof level is to prevent water entering the roof or the inner leaf. The principle can be applied by using the following practices during the design process:

Figure 1 Cross section showing the arrangement of components in a generic cavity parapet wall



Consider alternatives to using a parapet because of the high risk of failure when compared with other possible options, if this guidance is not followed. A well designed roof overhang is much less likely to lead to rain penetration and will offer better weather protection to the underlying wall.

Prevention of the penetration of rainwater requires the use of:

- copings with an adequate overhang;
- support of the damp proof course below the coping;
- adequate lapping and sealing of the damp proof course below the coping;
- correct installation of cavity trays;

Copings

The coping should be sufficiently wide in order that the throatings are at least 40mm away from the faces of the parapet wall, Figure 1. Coping materials should comply with relevant British Standards where they exist.

The joints between copings are very vulnerable to water penetration. They should be sealed with a sealant that is able to accommodate the movement that will occur between the copings. The joints between the copings should be designed according to BS 6093 and the sealant selected according to BS 6213 and installed according to BS 8000-16.

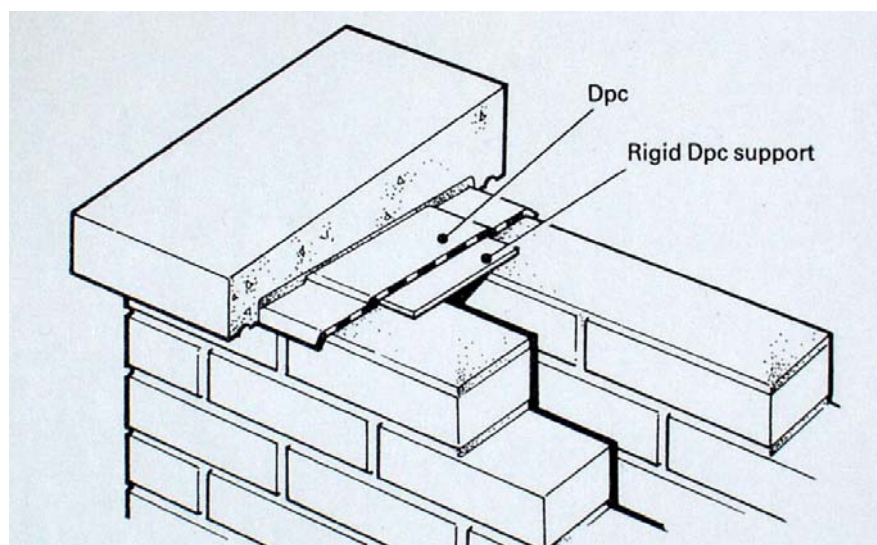
Copings are very often made from porous materials that will become damp when used in a parapet wall. Many sealant manufacturers recommend that a primer is applied to porous substrates if the substrate is likely to become damp in service. The advice of the sealant manufacturer should be sought on this matter.

Damp proof course

The damp proof course is installed between the copings and the uppermost course of brick or block work.

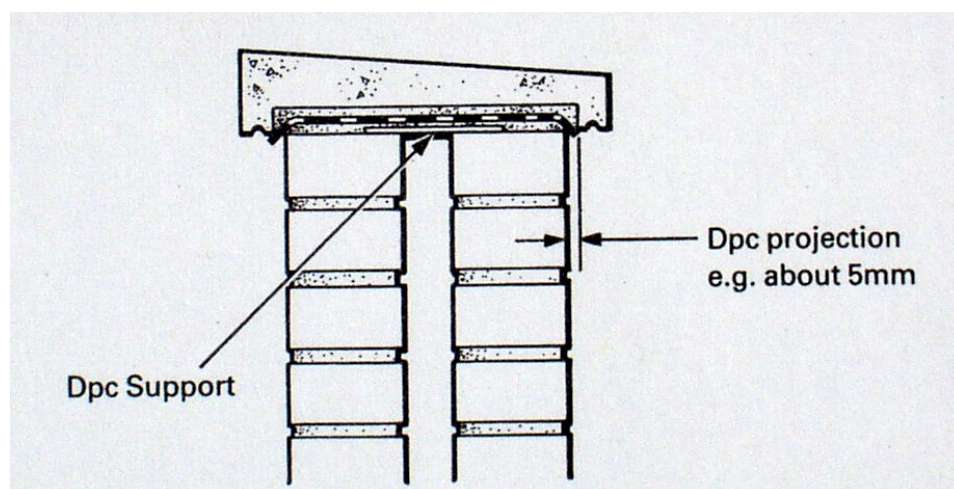
- A continuous damp proof course should be specified.
- All joints in the damp proof course should be overlapped by a minimum of 150mm and sealed.
- The damp proof course membrane should be supported across the top of the cavity with a rigid support such as slate or a suitably stiff plastic material, see Figure 2.

Figure 2 Damp proof membrane on rigid support



- The damp proof course and its support should be bedded on fresh mortar.
- Damp proof course membrane should extent at least 5mm beyond each face of the parapet wall, see Figure 3.

Figure 3 Damp proof membrane extends beyond the brickwork

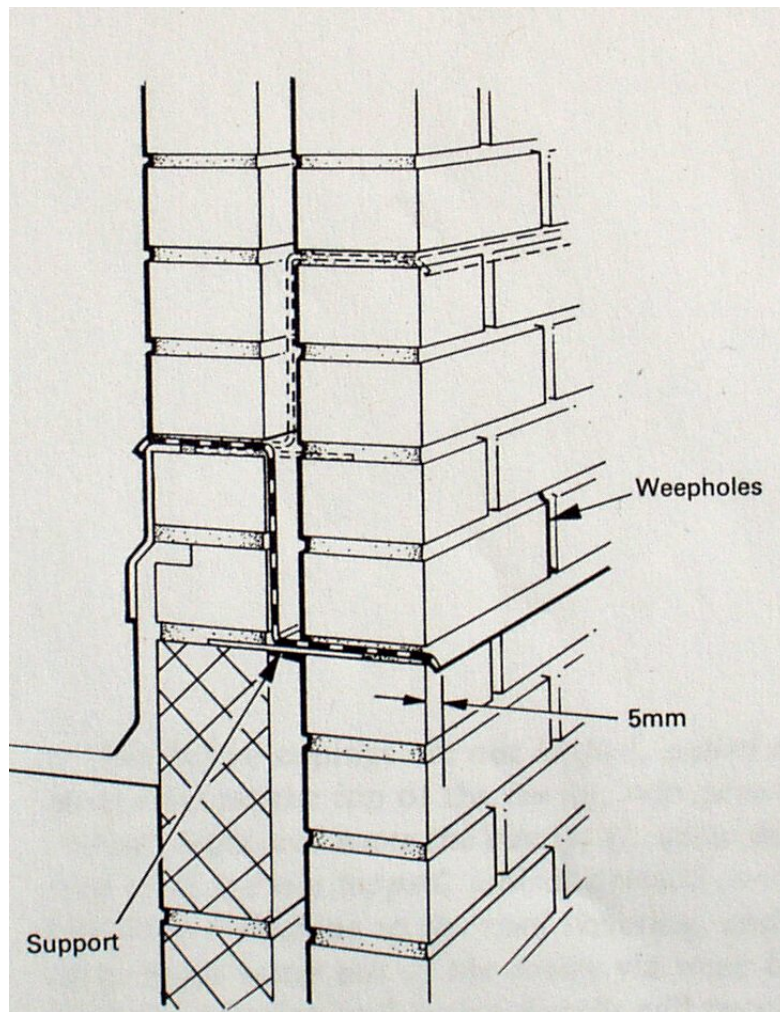


Cavity tray

The cavity tray intercepts water that enters the parapet wall and directs it outside the wall. Acceptable arrangements for cavity trays can be seen in Figure 1.

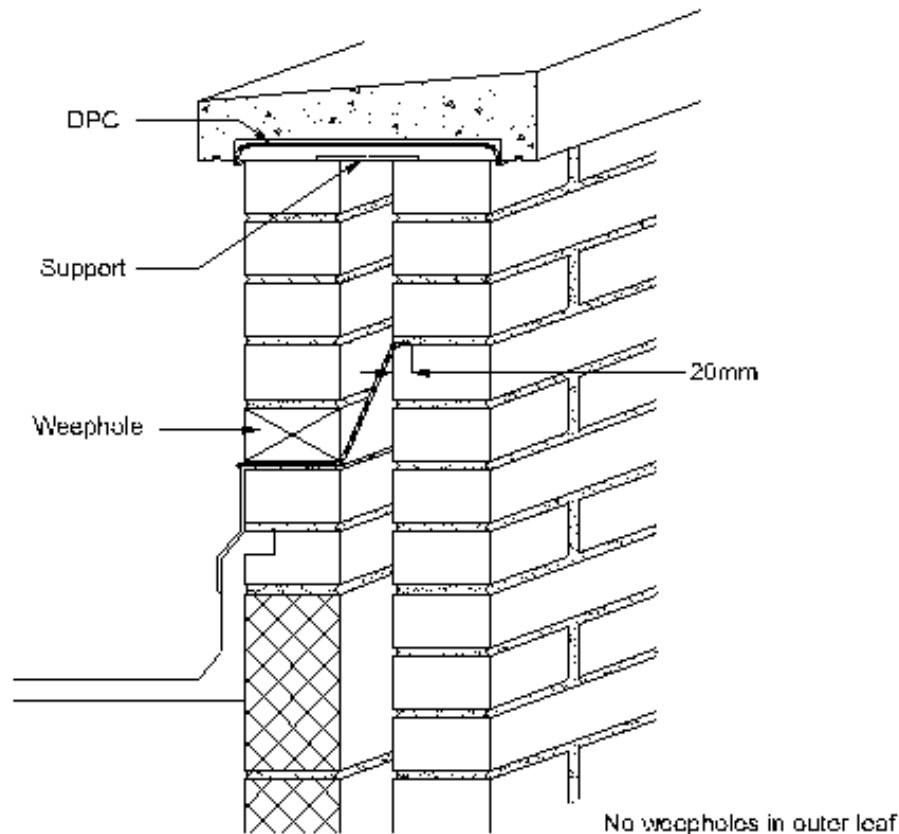
- The step down of the cavity tray at the base of the parapet wall should be at least 150 mm towards the inner or outer face. The cavity tray should project at least 5mm from the finished surface of the wall in order to provide an adequate drip detail. If water is direct across the inner leaf there is an additional risk of water penetration to the roof perimeter junction, and the inner leaf.
- The preferred option is to drain water either towards, or through, the outer leaf. In general outer leaf walls are designed with the expectation that they will have to deal with water running down their cavity side face - the detailing for this solution is shown in Figure 4. Consequently, should water bypass the cavity tray the wall over which the water runs will have other water management measures included, such as cavity trays at window heads. However, if the cavity is fully filled with insulation it is possible that water will be directed towards the inner leaf.

Figure 4 Cavity tray dressed down and supported across the cavity



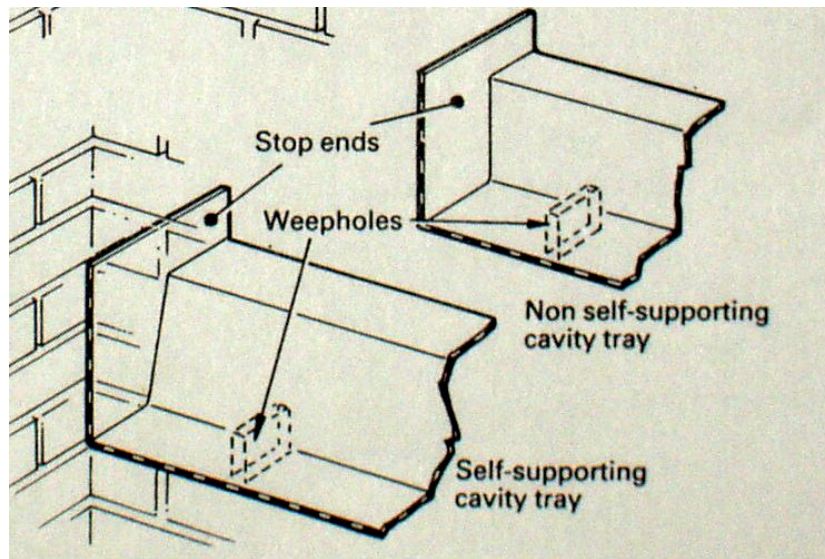
- The presence of a cavity tray introduces a plane of weakness at the base of the parapet wall. An alternative solution is to use a d.p.m. that is fully bedded in the inner leaf but only embedded to a depth of 20mm in the outer leaf - there may be proprietary cavity tray systems that offer a similar solution. This form of construction can be seen in Figure 5. An advantage this configuration confers is that it allows water to pass down through the outer leaf, eliminating the need for weepholes at this level and reducing the level of dampness in this section of the outer leaf of the parapet - a perennial problem with parapet walls. Although this might, to some extent, be seen as compromising the waterproofing, it would only do so in the outer leaf - a part of the façade which is designed to cope with water draining down its cavity face. If this option is adopted, then F1, S1 or F1, S2 bricks may be used to construct the outer leaf of the parapet.

Figure 5 D.p.m. with limited insertion into the outer leaf dressed down and supported across the cavity



- Damp proof membranes used to construct cavity trays should comply with BS 6398 or a material certificated by an acceptable third party should be used. The tray should be dressed down the inner leaf or outer leaf and supported across the cavity horizontally, Figure 4. Purpose made cavity tray units should be used at corners.
- Ensure that the material used to support the cavity tray damp proof membrane support is sufficiently rigid to prevent sagging.
- Ensure that the laps in the cavity tray are at least 150mm in length and sealed and that the cavity tray is fully supported and watertight and that any purpose made corner units are sealed to the tray lengths.
- Where the parapet abuts an adjacent wall a cavity tray with a stop end should be used, Figure 6.

Figure 6 Cavity tray stop ends at abutments



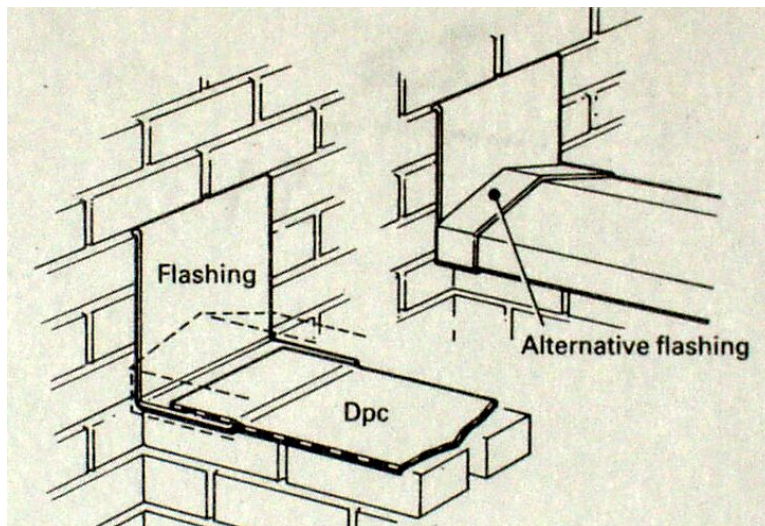
- Weep holes formed from open perpend s should occur immediately above the cavity tray. In exposed locations proprietary weep slots or weep tubes are preferable to open perpend s.
- Cavity trays must be laid on a bed of fresh mortar.
- Ensure that weep holes are formed by leaving open perpend s at intervals of not greater than 1m.
- Take care to avoid blocking holes with mortar droppings, where necessary the droppings should be removed, with care taken to avoid damaging the cavity tray.
- Alternatively purpose made weep holes or weep slots can be built in as work proceeds, but check what the specification requires.
- Ensure that the damp proof course and cavity tray extend beyond the rear face of the wall, Figure 7.
- The cavity tray should be kept free from mortar droppings. Use cavity battens to prevent mortar falling into the cavity tray.
- Care should be taken if wall ties and cavity trays are built into the same bed of mortar.

Adjacent elements

Walls

If the parapet abuts an adjacent wall a flashing should be installed, Figure 7.

Figure 7 Abutment flashings for upper damp proof membrane

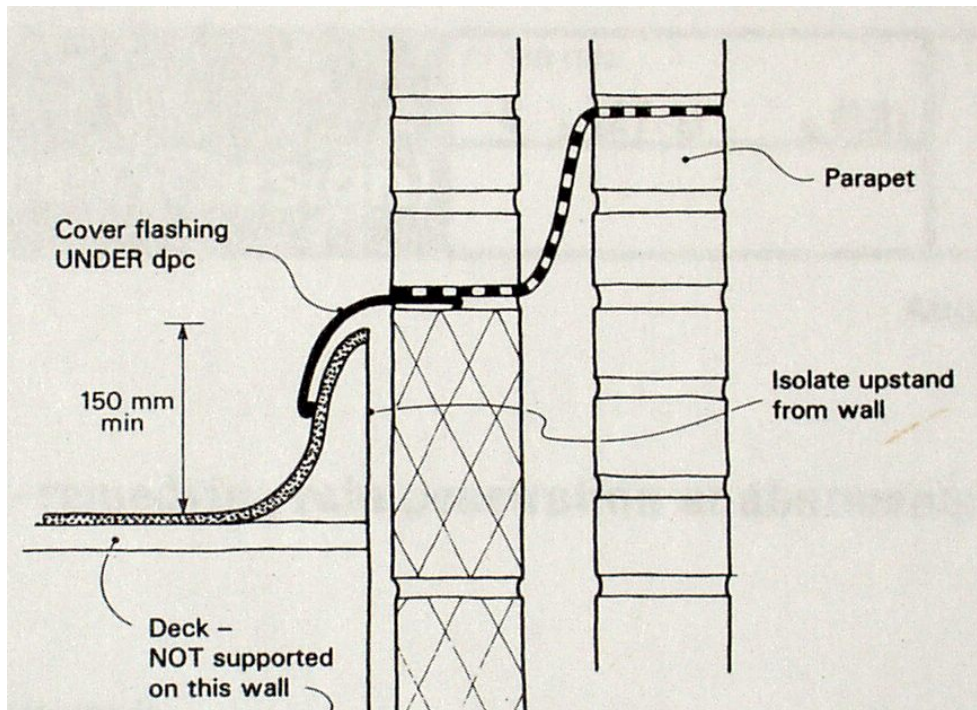


Flat roofs

Most often the cause of water penetration is given as inadequate detailing at abutments and inadequate provision to isolate the roofing membrane from building movement.

- All upstands should be at least 150mm high above the finished roof level and well lapped by secure flashings.
- Flashings associated with the roof should lap under the parapet wall damp proof course. This is especially important when the damp proof course forms a cavity tray that drains water towards the roof, Figure 8.

Figure 8 Roof upstand and parapet wall detail



- Roof cover flashing should be well lapped by the cavity tray.
- Flashings associated with adjacent roof coverings should be set under the damp proof membrane.

Maintenance and repair

Parapets are very often severely exposed to the elements and are a common source of problems and rain penetration. An inspection checklist is shown below and if a parapet wall shows any of the defects listed, in particular those that affect structural safety or weathertightness it will need to be repaired or rebuilt.

Parapet inspection checklist

- Is the parapet plumb, straight and not cracked?
- Have parts become detached and likely to fall?
- Does the wall have adequate resistance to recommended design loads?
- If the parapet serves as a barrier, does it comply with relevant design criteria?
- Is there evidence of water penetration via the parapet?
- Does the wall have the necessary damp proof courses and flashings?
- Is water shed clear of the wall by an adequate coping?
- Does the coping have an adequate weathering detail?
- Are there signs of spalling concrete, rust or excessive movement at joints?
- When was the parapet constructed, how weathered is it, does the degree of weathering seem reasonable for the age of the wall and the degree of exposure?

The repairs or rebuilt wall should incorporate weepholes and the correct damp proof courses below copings.

Bibliography

British Standards

BS 5628. Code of practice for use of masonry – Part 1 Structural use of unreinforced masonry.

BS 5628. Code of practice for use of masonry – Part 3 Materials and components, design and workmanship.

BS 5642: Part 2. Specification for copings of precast concrete, cast stone, clayware, slate and natural stone.

BS 6073: Part 1. Specification for precast masonry units.

BS 6093. Code of practice for the design of joints in building construction

BS 6213. Guide to the Selection of construction sealants.

BS 6398. Specification for bitumen damp-proof courses for masonry

BS 6399: Part 1 Loading for buildings. Code of practice for dead and imposed loads

BS 6399: Part 2 Loading for buildings. Code of practice for wind loads

BS 8000: Part 3 Workmanship on building sites. Code of practice for masonry

BS 8000: Part 16 Workmanship on building sites. Code of practice for sealing joints in buildings using sealants

BS 8215. Code of Practice for design and installation of damp-proof course in masonry construction.

BS EN 771: Specification for masonry units - Part 1: Clay masonry units.

BS EN 771: Specification for masonry units - Part 3: Aggregate concrete masonry units (Dense and light-weight aggregates).

BRE Publications

Digest 362 Building Mortar 1991

Dissemination and exploitation of results

It has been proposed that the guidance is published as an ODPM document in a format that can be downloaded from ODPM or other websites.

Policy implications

No policy implications have been identified.

Appendix A – Summary of assessments made to determine the most appropriate structural solutions

The aim of this project - as summarised in Appendix C - was to determine and analyse the most common structural problems associated with masonry parapets and the potential hazards and dangers that may arise from them.

Following the earlier reports for this project (listed in Appendix B) - which included the results of assessments of parapet walls in a number of the UK's towns and cities - we concluded that the main failure associated with parapet walls and raised gable ends was rain penetration, rather than structural failure. Obviously, this finding is, to an extent, in conflict with the main aim of the project: to determine and analyse the most common structural problems - although if these are not dealt with, they can lead to structural failure of either the parapet or other structural elements.

Indeed, we did not find any evidence of parapet walls that either had - or were obviously about to - suffer a structural failure, while we did find a large number of parapet walls that were showing signs of:

1. Being damp: they were either stained darker as a result of having a high moisture content or had an algal growth on their surface
2. Cracking; and
3. Containing materials that were in the process of disintegrating as a result of the freeze/thaw action - the problems associated with these walls had clearly occurred over a long period of time and are indicative of a lack of an appropriately applied maintenance programme.

In addition, we found it easy to imagine that the cappings or copings associated with some of the parapets showing the symptoms listed above could degrade to the extent that all, or part of them, became loose.

For that reason, we felt that there were three main priorities that should be associated with the output document for this project:

1. Ensuring that the structural solution chosen minimised the compromise associated with the ability of the detailing to keep water out of the building
2. Providing a prescriptive solution to the selection of materials and the detailing associated with the parapet to ensure that the walls were as likely as possible to remain intact masonry monoliths; and
3. Providing a capping/coping detail that was robust and would ensure that the capping/coping would stay in place.

During the production of this document, a range of structural solutions were assessed. The structural issues could potentially cause injuries or worse to people below from what might be termed high consequence, but low probability, events. Conversely those associated with moisture penetration and associated problems with the building fabric might be considered to be relatively low consequence, but high probability

events. However, we judged that, overall (on a UK basis), the economic impact associated with moisture penetration issues far outweighs those of personal injury.

For that reason, each of the potential structural solutions was assessed against this background and the outcome of these assessments is contained in the following tables:

Structural solution	Factors and implications associated with this solution	Conclusion
<p>The parapet should be constructed as a solid wall built on a cavity closer placed on top of the cavity wall</p>	<p>In typical cavity wall construction, the inner leaf is made from concrete blockwork and the outer leaf from brickwork. Over time, the brickwork will absorb moisture and expand; the blockwork will lose water and contract. This will result in a given point in the outer leaf becoming raised in relative to the inner leaf. This is likely to lead to the cavity closer rotating, and this will - in turn - cause cracking in the outer leaf. The cracking is likely to allow water ingress into the main cavity of the building below the closer.</p> <p>In addition, there could be stability issues associated with the parapet wall.</p>	<p>The chances of rain penetrating into the building leading to dampness mean that this was not accepted as not being an acceptable solution.</p>
<p>Place a series of vertical stainless steel bars in the cavity and use these to post-tension the parapet.</p> <p>As the aim would be to improve the parapet wall's ability to withstand overturning, the lower point that the bar would be attached to would need to be some distance below the roof level. We envisage the bar as being screwed into a nut welded to the lower surface of a plate that spanned the cavity.</p>	<p>As the lower end of the rods would be fixed to a location that was below the lower level parapet d.p.m./cavity tray, the rods would need to pass through this d.p.m./cavity tray. It is likely that this would form a weak spot, for the following reasons:</p> <ol style="list-style-type: none"> 1. it would be very difficult to ensure that the detailing through the cavity tray would be waterproof. A proprietary cavity tray could be developed, but it is likely that, even then, 2. fitting the rods into the connectors and around the d.p.m would be difficult; and, in the event that a rod was dropped, it is likely that the d.p.m. would be punctured. The alternative - of placing the rods before the parapet wall was built up - would make it difficult to build the wall up. 	<p>In our opinion, we believe there to be high risks of rain penetration associated with this solution, both to the interface between the cavity tray and the rods, and the rods being dropped into the cavity and piercing the cavity tray/d.p.m. For that reason, we would advise using the other solutions suggested here before using this one.</p>

Structural solution	Factors associated with this solution	Conclusion
<p>Use a reinforced hollow blockwork inner leaf to provide additional robustness.</p>	<p>The minimum thickness of hollow blocks available is 140mm. This means that these blocks cannot be placed onto 100mm blocks without - at the very least - allowing the infill mortar/grout to pass down the cavity; if a membrane of some sort were to be placed below the bottom hollow block to stop this, it is likely that this would act as a bond breaker, reducing the flexural strength of that section of masonry.</p> <p>We contacted a block manufacturer to confirm the minimum block sizes and discussed the issues with him. He offered to look at the possibility of producing a narrower block specifically for this purpose. However, we did not take that offer up as it seemed somewhat artificial to produce a new block to resolve the matter. In addition, it would be extremely difficult to compact the cementitious material around the rebar.</p> <p>In addition, as the reinforcing bars in the inner leaf will pass through the d.p.m./cavity tray, its ability to resist the vertical passage of water will be compromised.</p>	<p>We do not believe that this solution is viable, as - in our opinion - the presence of the reinforcing bars in the inner leaf makes it highly likely that water will pass down the inner leaf into the building.</p> <p>In addition, the lack of a 100mm thick block means that the structural integrity of the inner leaf could be compromised.</p> <p>For these reasons we do not support the use of this solution.</p>
<p>Increasing the number of wall ties in the parapet by halving the wall tie spacing. This will act to increase the degree of interaction between the two leaves: the vertical and horizontal spacings should be 225mm and 450mm, retrospectively.</p>	<p>While this solution does not provide any direct improvement in the stiffness of either leaf, it does provide a means of increasing the certainty that the two leaves will act in unison.</p> <p>When combined with the materials having been specified to ensure that each leaf is a solid monolith, this would: increase the degree of connectivity between the two leaves, thereby ensuring that the two leaves act together - providing a greater guarantee that the resistance to wind loads will be provided by the combined section rather than the sum of two individual leaves; and use materials and methods of installation that are both currently and readily available, in</p>	<p>While this solution is not perfect, it does offer an increase in the combined action of the two leaves of the parapet with only a marginal increase in the likelihood of damp penetrating down the inner leaf.</p> <p>For those reasons, we believe that this solution is</p>

	<p>that they are already being used in the wall.</p> <p>A potential downside is that the ties will, in some cases, be placed into the same bedjoint as the cavity tray/d.p.m., so extra care will need to be taken in these circumstances.</p>	viable.
Increased number of wall ties (continued)	In our opinion, any weaknesses that may be introduced around the cavity tray or d.p.m. will be more than compensated for by the increase in combined action of the inner and outer leaves.	
Tying the parapet into adjacent buildings/building elements or using returns, where this is not possible.	<p>The aim of this solution is to provide additional lateral support to ensure that the lateral stability of the parapet wall is maximised.</p> <p>If neither of these options - adding returns or tying into adjacent elements - the increased number of wall ties should ensure that the parapet walls have a maximised lateral resistance.</p> <p>It should be noted, though, that might not be an appropriate action where the adjoining wall is owned by a third party.</p>	Adopt this approach.
Use proprietary clipped copings at the top of the parapets.	Having identified that the cappings and copings are a potential area of weakness in parapet walls, the use of proprietary clipped solutions is aimed at ensuring that they stay in place.	Recommend that proprietary clipped copings are used.

As a result, our final recommendations were that:

1. An increased density of wall ties be used on the parapet walls
2. The parapet walls should either be tied back to adjacent elements or returns to the parapets be incorporated into the design; and
3. Proprietary clipped copings or cappings should be used at the top of the parapets.

Appendix B – List of previous reports, with references, for this project

BRE output/ milestone reference	Title	Date submitted
213610	M1 D1 Summary of current and existing guidance	30 Nov 2003
213611	M2 D1 Summary of current and existing guidance	30 Dec 2003
213612	M3 D2 Summary of information on existing parapets	18 Dec 2003
213613	M4 D2 Summary of information on existing parapets	18 Jan 2004
213614	M5 D3 Summary of design guidance on parapets	31 Jan 2004
213615	M6 D3 Summary of design guidance on parapets	28 Feb 2004
213616	M7 D4 Site Investigations of Parapet Walls	12 Mar 2004
213617	M8 D4 Site Investigations of Parapet Walls	12 Apr 2004
213618	M9 D5 Primary factors in Construction of Parapet Walls	29 June 2004
213619	M10 D5 Primary factors in Construction of Parapet Walls	29 June 2004
213620	M11 Parapet Walls Workshop	21 Dec 2004
213621	M12 Note of Parapet Walls Workshop	31 Mar 2005

Appendix C – Project summary

The overall aim of this project is to determine and analyse the most common structural problems associated with masonry parapets and the potential hazards and dangers that may arise. Having identified the problems, conclusions and recommendations will be made regarding measures that ought to be taken in the specification, design, construction and maintenance of masonry parapets to ensure that they remain safe and structurally sound for the life of the building.

The specific objectives of this project are to:

- Examine current practice and the established codes and guides that are relevant to the design, construction and maintenance of masonry parapets, including Building Regulations Approved Document A (dealing with types of structure, loadings, ground movement and disproportionate collapse).
- Determine the primary factors that are normally taken into account in the construction of masonry parapets and how structural safety is considered, both during building activities and in later years. Such factors may include building materials, access for construction, access for maintenance, roof or balcony drainage, waterproof membranes and coatings, airborne pollution, problems that may arise from fixing items such as antennae to parapets, potential thermal stress due to weather conditions, adjacent chimneys, air conditioning units etc.
- Produce a report describing the range of potential problems associated with masonry roof and balcony parapets, together with appropriate measures that may be considered to address and rectify them.
- Compile a final report summarising the most significant issues and making recommendations for further work, particularly with reference to the possible need for the development of new or amended building codes and standards relating to the design, construction and maintenance of masonry parapets.