BRICK MASONRY STRUCTURES

INTRODUCTION

This technical note discusses the key issues associated with brick masonry, presents a list of items which need to be noted when undertaking a visual inspection and presents some repair and intervention measures. Brick masonry is constructed by the bedding of bricks in mortar to form a homogeneous mass and bond them in such a manner that loads and stresses are distributed throughout the mass without the tendency to overstress the structure.

The purpose of the mortar mix is to distribute the pressure throughout the brickwork, to bind the bricks together and to prevent the transmission of heat, sound and moisture from one side of the wall to the other. The integrity and long-term performance of brick masonry structures can be influenced by the quality of the brick and mortar components themselves, the environmental exposure and external loadings acting on the structure.

QUALITY OF BRICKS

The quality of bricks can be defined as compressive strength, density, resistance with respect to salt attack, expansion due to water absorption and to a lesser extent thermal expansion and soluble salt content. Significant moisture movement and associated expansion can cause distortion and cracking of both the brick and the combined masonry structure.

QUALITY OF THE JOINTING MORTAR

The jointing mortar must provide adequate strength to the brickwork and exhibit durability in its exposure environment. Different mortar classes and mixes are required depending on the exposure conditions. The compatibility of mortar properties (such as thermal expansion, drying shrinkage, moisture changes and compressive strength) with those of the brickwork is of paramount importance in ensuring the integrity and soundness of the brick masonry structure.

When repointing joints the mortar mix must reflect the existing brick and mortar strengths. Bricks may be spalled by repointing mortar which is much harder than the existing mortar. Mortar with high cement content can shrink away from the bricks, thus producing fine cracks that allow water penetration. Cement-rich mortar is also less pervious than, say, the existing softer lime mortar and therefore salt laden water permeating through the joint will be forced to flow through the brick. Thiscan transfer the fretting problem from the jointing mortar to the brick. In addition, excess water pressure may result in bulging, cracking and overall distortion and deterioration.

Essentially the mortar must contain enough cement to be durable and not shrink but should take into account the prevailing quality of the brick and mortar. Typical classes of mortar mixes include: for very weak existing mortar 1:3:12 mix of cement:lime:sand; if mortar not too hard 1:2:9 mix of cement:lime:sand; and more stronger general use mortar 1:1:5.5 mix of cement:lime:sand.

THE INFLUENCE OF EXPOSURE CONDITIONS

The exposure conditions have a major influence on the performance and durability of brick masonry. Environmental factors which could affect the brickwork include the following:

- Cold temperatures, and in particular frost formation, can adversely affect the durability of both the brick and mortar components;
- Weathering and migration of water, especially if it contains dissolved salts, can cause deterioration, fretting and crumbling of exposed surfaces of both brick and mortar.;
- Salt damp can lead to spalling and splitting of brickwork especially where the damp-proof course is ineffective;
- Salt-water spray in coastal areas can cause significant damage to bricks and mortar, thus resulting in loss of integrity in affected areas;
- Wetting and drying of reactive soil foundations can cause opening of joints, cracking and movement. Fresh cracks with clean faces and possibly loose fragments of mortar or bricks should be investigated in more detail;
- Accumulation of debris and vegetation and associated root system can cause considerable damage;
- Inadequate drainage of infill material behind walls and abutments can result in the application of significant lateral loads. In addition, the water and salts can accelerate the deterioration of the brick and mortar components; and

• Differential settlement, differential wetting and movement of a part of the ground can cause cracking of masonry walls and abutments.

EXTERNAL LOADINGS

The following sources of external loadings can affect the structural adequacy and durability of brick masonry.

• Earth pressure caused by backfilling resulting in bulging and disintegration;

• Root growth and/or excess water can further enhance the deterioration;

• Interaction/slippage between brickwork and other material structural elements such as steel and concrete; and

• Traffic overloading resulting in distortion, sagging, cracking and fracturing of the brickwork.

PRINCIPAL CAUSES OF DETERIORATION

The principal causes of the deterioration of brick masonry structures as influenced by the brick and mortar quality, environmental conditions and external loading, and which can affect their longevity and modify their load carrying capacity, can be summarised as follows:

• Fretting of bricks and/or jointing mortar;

• Cracking due to differential settlement of foundations or between separate parts of the structure;

• Spalling and splitting of bricks and disintegration of the jointing mortar.; and

• General cracking of the brick masonry structure.

• Distortion in the form of bowing and bulging of walls and shape of brick masonry arches.

VISUAL INSPECTION

Visual inspection is the easiest and yet one of the most important of techniques used for the assessment of the condition of structures. A visual inspection will basically detect obvious indicators of brick masonry distress/deterioration. Observations during visual inspection should focus on the location and extent of the following most common features of distress/ deterioration (refer Figs 1 – 12).

• Cracking – type, number;

• Brick crushing, splitting, spalling, fretting, salt effect;

• Mortar loss, fretting and general deterioration;

• Dislodgement or loss of bricks;

• deformation of brick masonry arches

• cracking, sagging or flattening;

• Severity of deferential settlement – if visible;

• Lateral movement of walls relative to other parts;

• Efflorescence, leaching and water movement in brick and/or jointing mortar;

•Tilting, bulging, sinking, and other deformation of abutments, parapets and wing walls;

• Fracturing or separation at the juncture of brick and steel or concrete components;

• Evidence of damage by tree roots or plants;

• Defective drainage conditions in various parts of the brick masonry structure and erosion;

• Scouring at base of piers and abutments;

• Damage to foundations – if visible;

• Evidence of fresh cracks with clean faces, loose fragments of mortar or bricks; and

• Damage due to vehicular or mechanical impact.

Fig. 1 - Efflorescence and leaching on brick work due to water moving down from above

Fig. 2 - Traffic vibrations in the steel beam could have caused the crack

REFERENCES

1. ARRB TR Contract Report No. RC2724 (2002) for VicRoads, "Understanding Brick Masonry Structural Elements", (R&D Project 2002/856) by A. Shayan.
2. Building Research Establishment (BRE) Digests, 362, 441, 442 and Good Repair Guides 24 and 28.

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REPAIR OR INTERVENTION MEASURES

Before deciding how to proceed with a particular repair or intervention measure, distress or defects identified as part of a visual inspection may have to be investigated further or be monitored for some time. It is best to seek specialist advice.

DISTRESS/DETERIORATION	SUGGESTED ACTIONS
Salt Efflorescence and lime leaching	Waterproofing and improving drainage
Sulphate attack on jointing mortar	Rake out loose mortar. Repoint with sulphate resisting cement or blended cement (ie fly ash etc) of same strength and colour
Cracked or fretting/crumbling jointing mortar	Waterproofing, repointing with same strength mortar. Replace soft lime mortar with same chemical composition
Crack in crown of brick arch. Deterioration of mortar and mortar/brick bond	Restore jointing mortar as above. Assess load carrying capacity
Cracking in brick pier at juncture with steel or concrete	Incorporate stainless steel in brickwork above the capping
Cracking caused by settlement	Horizontal stitching. Remove mortar and insert stainless steel ties across crack along brick length
Water leakage from road surface	Improve drainage, replace deteriorated mortar joints
Rising damp and salt attack	Waterproof base of brickwork with membrane. Wash off salt, remove and replace mortar with blended cement
Cracking of edge of retaining wall due to moisture expansion	Insert suitable strip of compressible material to allow for movement and keep out debris
Displacement of abutment wall caused by earth pressure	Use anchors to pin back wall
Cracks through brick and mortar	Cut out and stitch in matching brick using same mortar as close as possible to existing, in both strength, colour and if possible chemical composition

Fig. 3 - Horizontal crack on the crown of the arch. Now filled

Fig. 6 - Scour at the base of abutment wall needs restoration

Fig. 4 - Water seepage through the arch. Source of percolating water from the road above

Fig. 7 – Severe cracking of wall due to settlement and pressure from behind

Fig. 5 - Cracking in the brick pylon from the interaction of blue stone capping and steel beam

Fig. 8 – Diagonal cracking due to movement and pressure from behind.
Failed repointing work

Fig. 9 – Repointing of diagonal cracking on dirty wall

Fig. 12 – Typical combination of brick walls, bluestone capping and steel beams

Fig. 10 – Diagonal cracking caused by movement

Fig. 11 – Extreme loss of weak jointing mortar, which requires refilling and repointing