

To:	Emma Henderson, British Museum	Job number:	1635-02
From:	Civic Engineers	Date:	02/09/2022
Subject:	British Museum - KEB Window Frames	Cc:	Darren Thomas, Stace

## British Museum – KEB Window Frames

### Introduction

Civic Engineers were asked to attend site on 26<sup>th</sup> July 2022 to view window W1 of the KEB Level 01. This window faces on to the back of the Boiler House. During this visit the windows W2 to W7 were also viewed as much as practical externally and internally. As part of the KEB Tunnels project it is proposed to relevel the area adjacent to Window W1 to improve the drainage in this area. The window has been reported as defective and there is a concern that works in this area will cause further damage to the window.

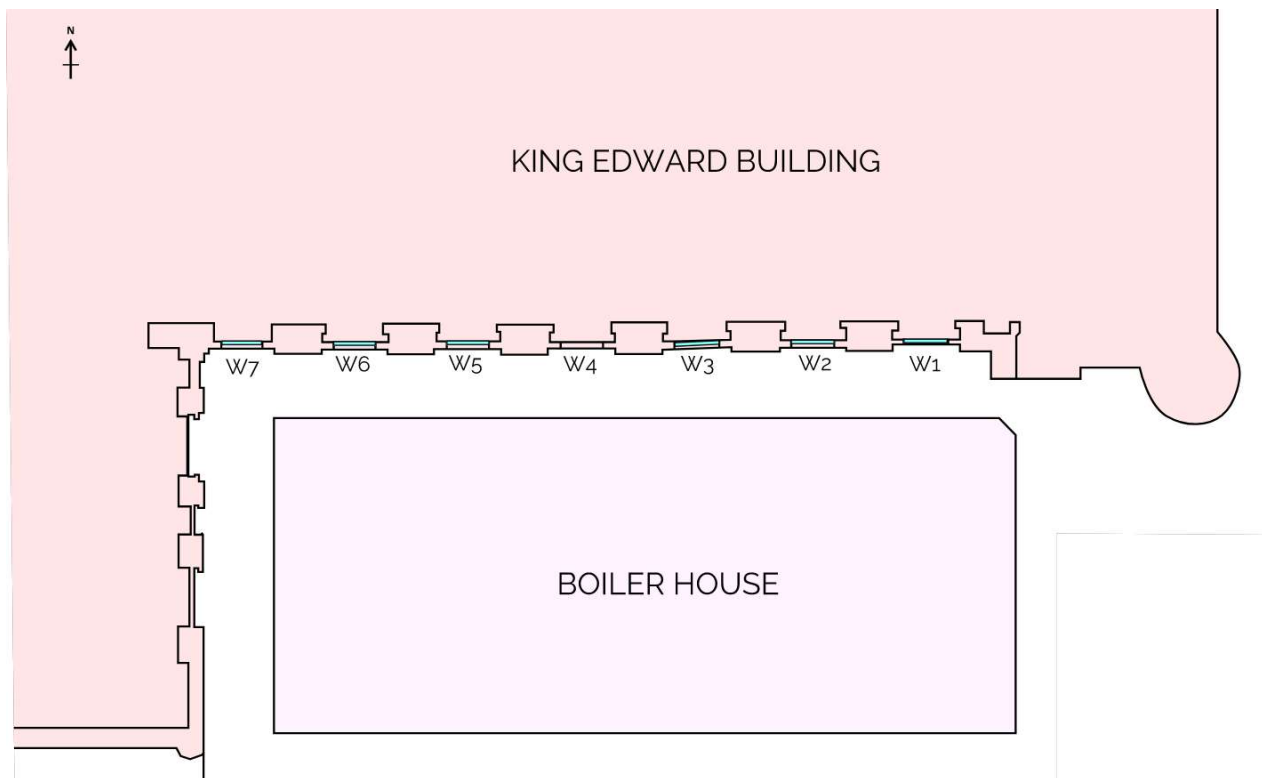


Figure 1: Location plan of window in KEB Level 00

### Findings on site

The window was viewed on site and significant bowing could be seen in the window with the glass panels pushing inwards in a curve. Refer to section on SK 300 at the end of this note to see curvature. The curve of the window was causing the metal of the window frame to crack. It was noted that the bottom of the window frame had significantly expanded. The frame had expanded more at the east end than the rest of the bottom of the frame. A couple of panes of glass had cracked at the east end of the window.



*Figure 2: Expansion of window frame at base at east end and cracked window panes above*

Signs of damp, such as peeling paint and staining were noted on and below the window sill on the inside of the building. The external stone window sill was cracked in the middle and this crack was visible internally as well.



*Figure 3: cracked window sill*

**British Museum – KEB Window Frames**

Whilst the window W1 at the end of the alleyway behind the Boiler house was found to be in the worst condition it seems to be a problem that is affecting all the windows (W2-W7) in the façade at this level in the alleyway with varying degrees of curvature to the windows and cracking of glass.

**Causes of Defects**

It seems likely that that the damage seen in the window frame is caused by corroding metalwork of the frame. When steel corrodes and turns into rust it expands by approximately six times it's original volume. This generates a significant amount of pressure. In this case it appears that the expanding steelwork at the bottom of the window has caused the whole window to bow as the force of the rusting window frame pushes the window up against the masonry arch at the top of the window. The force of this rusting appears to also have cracked the window sill at the mid point. Water hitting the window from rain would run down the window and sit on the bottom of the frame before running down the sill. As the bottom of window frame has corroded this has allowed more of the protective paint to be pushed aside and for water to access the metalwork underneath exacerbating the situation.

As such we do not think this is a structural issue (for example indicating foundation movements), but a local problem with the window frame.

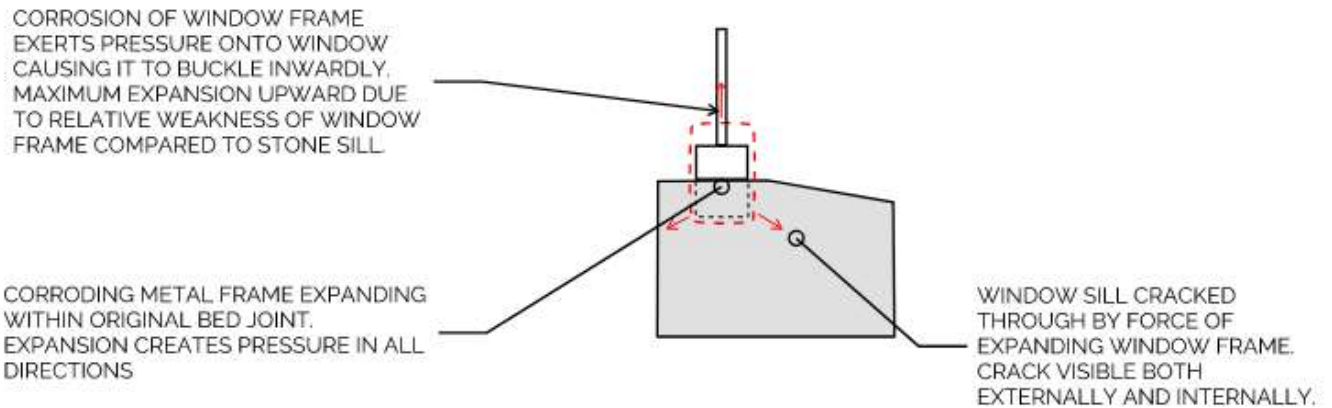
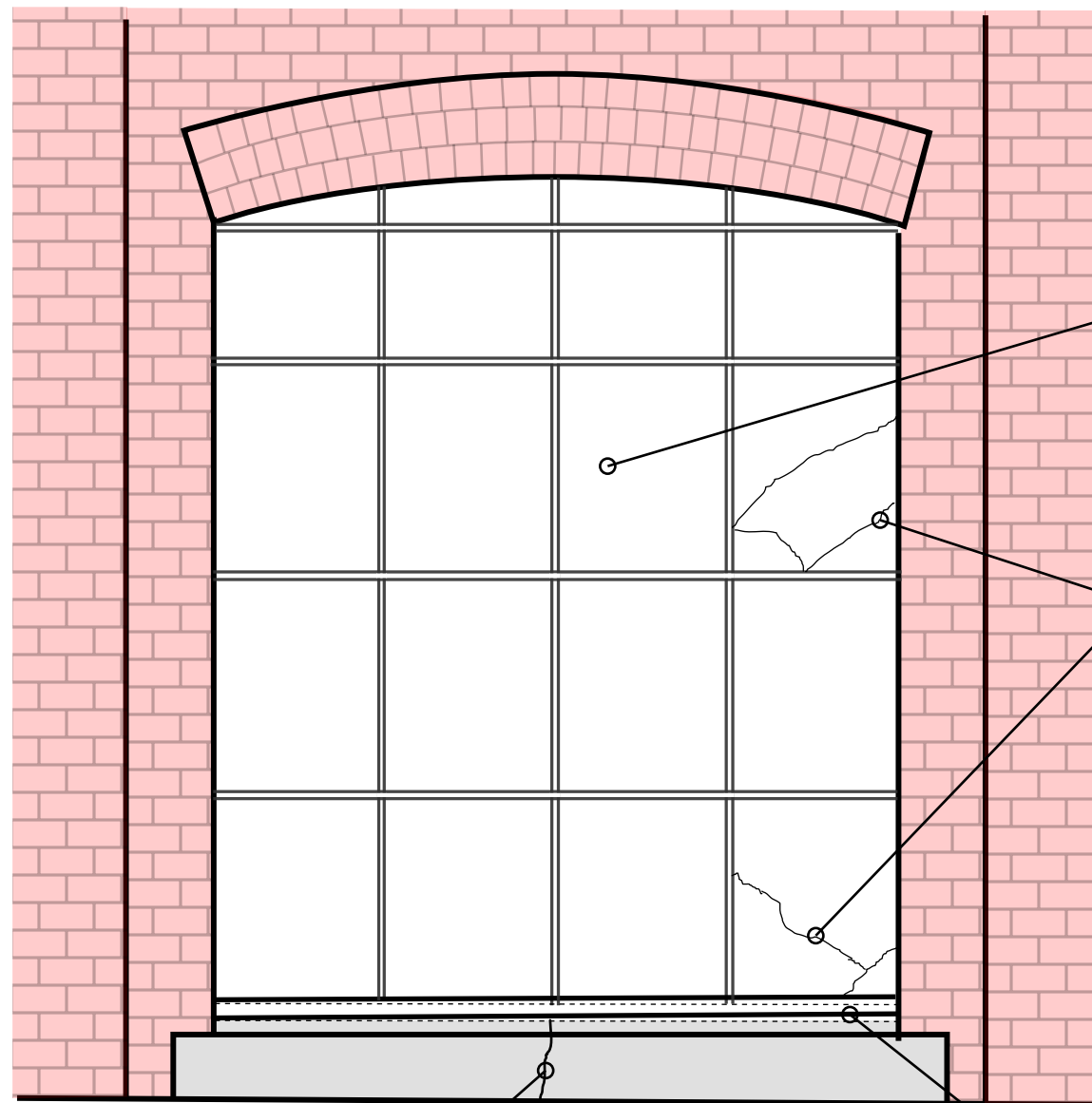


Figure 4: Schematic of action within sill

**Suggested Remedial Works**

It seems sensible to remove the glazing and window frame of Window W1 and clean out any rusting metalwork and repair any cracks in the stone sill. This should allow a new window or the existing one refurbished and repaired to be installed. Advice should be sought by a window or waterproofing specialist for the installation of new windows and repair work and how they can be detailed to avoid the issue recurring. We also recommend that the other windows W2-W7 are also repaired as they seem to be deteriorating in a similar way. We would envisage that the remedial works to the drainage outside the window W1 could cause further damage to the window and it would be sensible to either replace this window during the works or to put up protection over the window before the works are undertaken in case of the window deteriorating during the works.



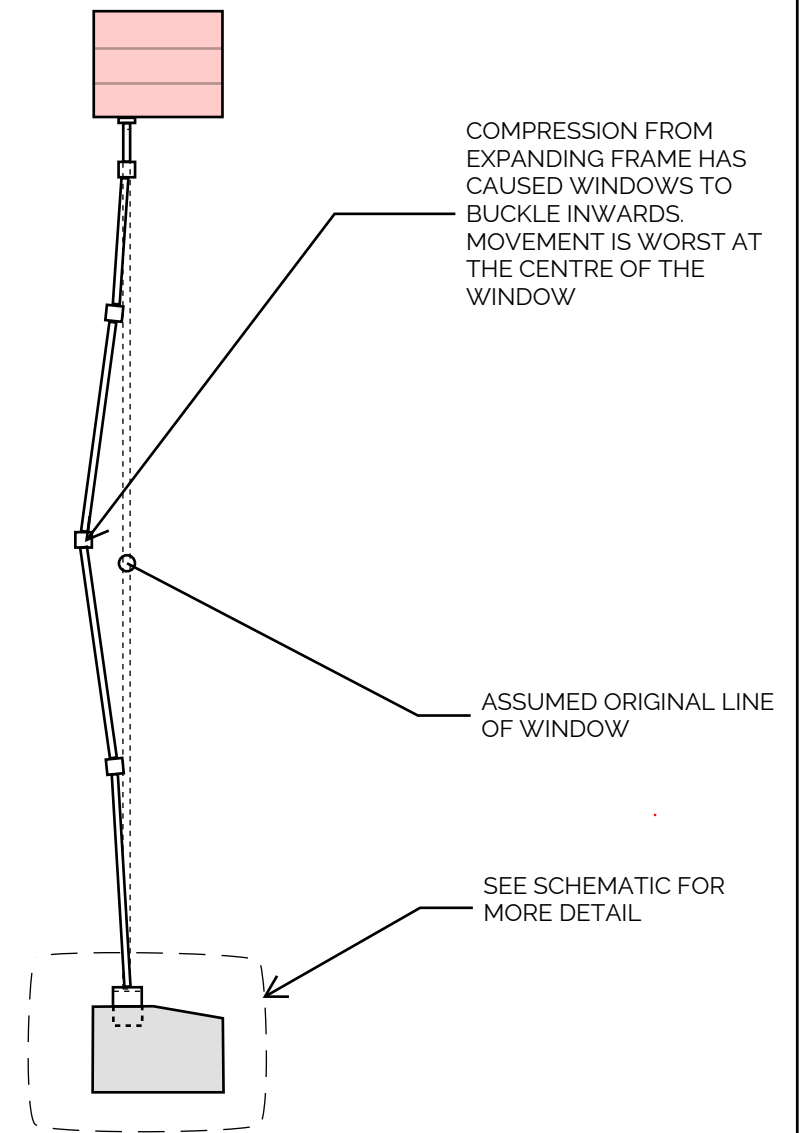
RAILINGS OVER WINDOW OMITTED FOR CLARITY

CRACKING TO A NUMBER OF WINDOWS AS FRAME HAS BUCKLED

CRACKING THROUGH WINDOW SILL NOTED INTERNALLY AND EXTERNALLY

**ELEVATION OF WINDOW W1**  
1:20 @ A3

EXPANSION OF WINDOW FRAME AT BASE OF WINDOW HAS CAUSED WINDOW FRAME TO BULGE INWARD. DOTTED LINE REPRESENTS ASSUMED ORIGINAL POSITION OF WINDOW FRAME



COMPRESSION FROM EXPANDING FRAME HAS CAUSED WINDOWS TO BUCKLE INWARDS. MOVEMENT IS WORST AT THE CENTRE OF THE WINDOW

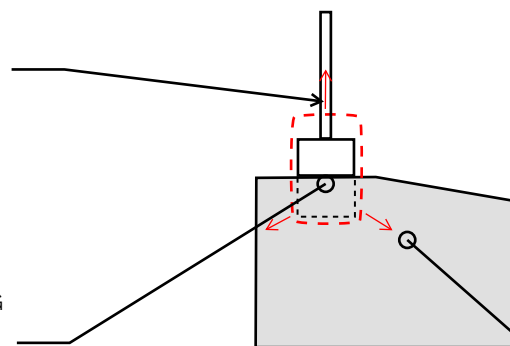
ASSUMED ORIGINAL LINE OF WINDOW

SEE SCHEMATIC FOR MORE DETAIL

**SECTION THROUGH CENTRE OF WINDOW**  
1:20 @ A3


CORROSION OF WINDOW FRAME EXERTS PRESSURE ONTO WINDOW CAUSING IT TO BUCKLE INWARDLY. MAXIMUM EXPANSION UPWARD DUE TO RELATIVE WEAKNESS OF WINDOW FRAME COMPARED TO STONE SILL.

CORRODING METAL FRAME EXPANDING WITHIN ORIGINAL BED JOINT. EXPANSION CREATES PRESSURE IN ALL DIRECTIONS



WINDOW SILL CRACKED THROUGH BY FORCE OF EXPANDING WINDOW FRAME. CRACK VISIBLE BOTH EXTERNALLY AND INTERNALLY.

**SCHEMATIC OF ACTION WITHIN SILL**  
1:10 @ A3

06.09.22	P01	ISSUED FOR INFORMATION	FG	JB
Date	Rev	Description	Drawn	Chkd
				
Project British Museum - KEB Tunnels - Window				
Title Elevation, Section and Schematic of damaged window				
Project Number	Drawing Number	Scale @ A3	Revision	
1635-02	SK300	As Shown	P01	