

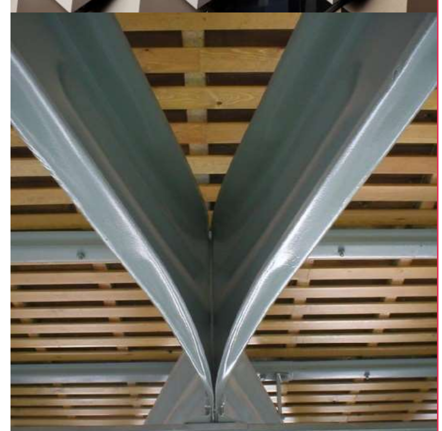


# Principal Staircase Report

## S.1 Structural Condition Appraisal

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Client Name: Shenton Group

Client Address: 3 Oxford Court, Manchester, M2 3WQ

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# 1.0 Introduction

1.1 Curtins were commissioned by *Shenton Group*, the Client, to undertake a structural condition assessment of the grand staircase at Cuerden Hall.

1.2 A structural engineer from this Practice visited the property during January and February 2021 over several visits to undertake the appraisal.

1.3 All observations were largely based on visual appraisal only. It should be appreciated that opening up may reveal additional defects to those that were apparent at the purely visual inspection. All observations were made from ground level, and all observations were made with the naked eye.

1.4 Non-structural matters are not addressed unless they have a direct effect on the structure.

1.5 This report has been prepared on behalf of the Client, *Shenton Group*, and it must not be reproduced in whole or part, or relied upon by any third party without the express prior written authority of Curtins Consulting Ltd.

## 2.0 Description of Structural Form

2.1 The principal staircase is within the eastern extension of Cuerden Hall which was added by the architect Lewis Wyatt around 1816-1819. This principal staircase is described within the Historic England listing (List Entry Number:1362174) as being an original feature of this extension, and we are lucky to have access to the original drawings some of which have been used as illustrations below.

2.2 The grand staircase provides access between ground floor and first floor within a high lantern space with a decorated ceiling above. Decorated oak balusters separate the large handrail and outer stringer. There are no vertical posts which bear down to the ground at the landing corners.

2.3 No opening up works has been undertaken to prove the form of construction and so the description below is based on the drawings available and the knowledge of the design of staircases at the time this one was built.

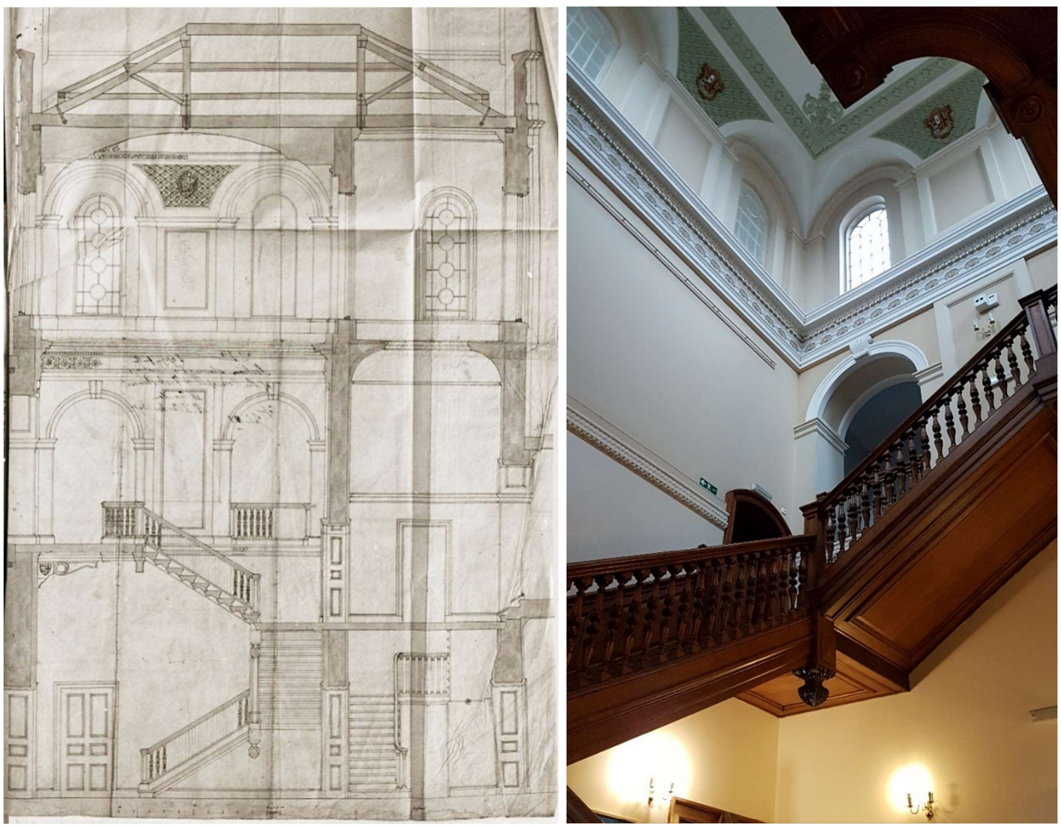

Figure 1: Grand timber staircase and cantilevering balcony within decorated lantern.

**The Principal Staircase**

2.4 It is clear from the shape and construction of the steps on the original drawings that the design was intended to work as 'cantilever' stairs which appear to float or hang over an open atrium seemingly without vertical supports below. Stairs of this type became quite typical of the Georgian era as they were structurally efficient and could be adapted to suit both modest service stairs or lavish grand staircases in larger households.

2.5 In it's traditionally implemented form, this name is slightly misleading as the stairs do not actually cantilever out from the wall (usually only bear between ca 100-200mm into the wall, and in this case project out into the stairwell ca 1200mm) but instead take support from the step below resulting in trust line action (effectively flat arching) down the stairs. Intimate connection between each step is therefore essential for the load transfer. The vertical load applied creates a 'twist' or torsion in each step which is resisted by the masonry wall.

2.6 These staircases were most commonly constructed in solid stone blocks which worked well in transferring the compressive forces down each step without distorting and in working with the masonry wall to resist the torsional forces. For larger staircases this would be quite expensive and so were often used as a display of wealth due to the materials and craftmanship involved.

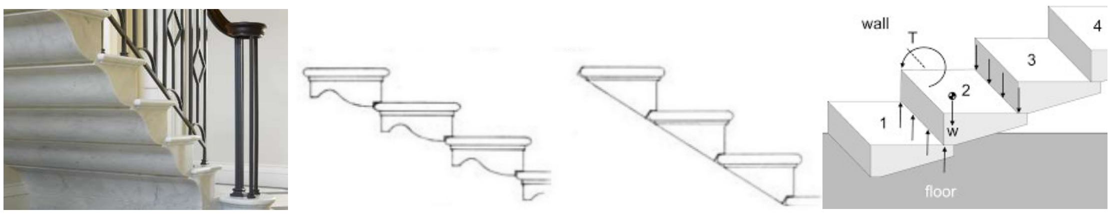


Figure 2: Example of stone cantilevering staircase (left), different shapes of stairs (centre) and diagram of load transfer (right).

2.7 The principal staircase at Cuerden however appears to be made entirely out of timber but from the drawings available, its construction appears to work following the same principle as for a stone staircase. The original drawings show that each step consist of interlocking timber elements with additional pieces reinforcing each connection. Each step bears onto the step below with a carved brace between the tread and the riser to make it work as one element.

2.8 In the illustrations in Figure 2, a rebate can be seen between the riser of the step above and the tread of the step below. This small detail was found to provide some horizontal reactions between the steps which greatly reduced the torque in the wall. While it appears that this detail was widespread knowledge since the early C18th (nearly 100 years before) it is not present in the design of the stairs for Cuerden (see Figure 3 (right) where riser sits directly on tread below). As there are many examples without this rebate it seems that it was not strictly necessary for the function of the stairs but meant that the restraint in the wall had to work much harder.

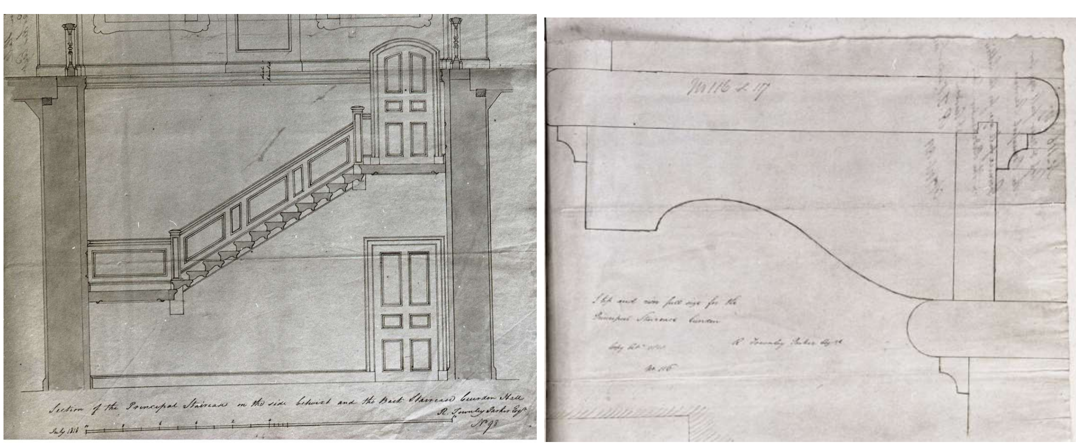

Figure 3: Drawing of principal stair showing no vertical supports at each landing (left) and detail of stair composition (right).

2.9 This carved brace might appear to be too decorative to be hidden by a closed stringer and wainscot panel below, but its shape actually has a structural function as it has been shown to be stronger than a plain triangle and is common in these types of stairs from this era[1]. Perhaps the original intention was for it to be on show as it is on the service stair, but that the addition of a closed stringer was deemed prudent to secure the free ends of each step over such a large staircase.

**First Floor Balcony**

2.10 In the north eastern section on the first floor there is a cantilevering balcony overlooking the stairwell. In contrast to the stairs it appears that this section does cantilever to some degree from the wall. The soffit panelling and the floor structure above is supported by four outrigger beams in turn supported by shallow brackets below.

2.11 On the north side, the outrigger supports the top of the stair as well as that section of the balcony.

2.12 At the end of each cantilevering outrigger there is a point load applied by the balustrade posts which presumably support the horizontal edge beams between them.

2.13 The beam drawn below the line of the stairs and post on the detail below does not appear to have been built. While these drawings are helpful in understanding the intent behind the design, we cannot know if it was built exactly like these illustrations show unless we open up and assess the current construction.

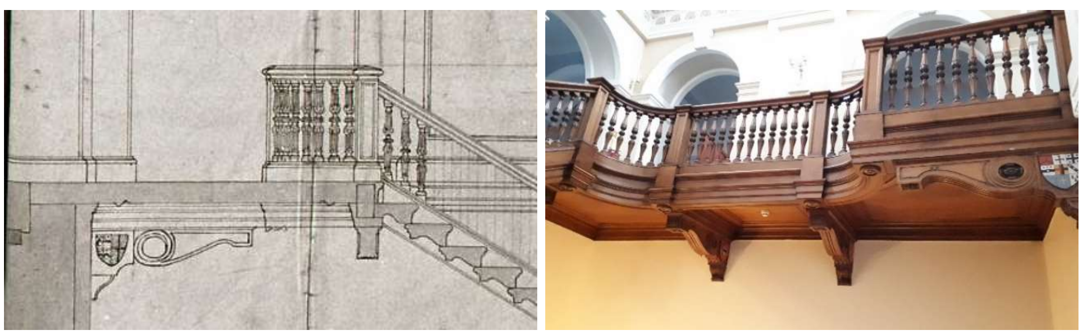

Figure 4: Detail of cantilevering balcony (left) and picture of balcony from stair below (right).

**Service staircase**

2.14 While smaller and more modest than the principal staircase, the service stair appears to be constructed in much the same way. The only differences include that the service stair has a open stringer (where you can see the end of each step) and that it is effectively a dog-leg stair and therefore likely accommodates support from a beam at the landings.

2.15 Practically this means that the steps only have to accommodate the thrust from the stairs of that flight as opposed to the sum of the flights above as well which results in smaller deformation. While the steps still slope slightly this may be explained more by the shrinkage in the timber than by its construction.

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[1] Clive Richardson (2015) 'Cantilever staircases' *The Structural Engineer*, pp 44-46

## 3.0 Factual Survey Notes

3.1 The geometry of the timber staircase is cranked down towards the outer stinger throughout. This displacement can be seen in the floor finishes both on the staircase and on the balcony.

3.2 The amount of displacement increases as you approach the first-floor balcony landing where it reaches ca 40mm vertical displacement between opposite sides of the same step.

3.3 Modern finishes cover the timber elements so their condition could not be assessed.

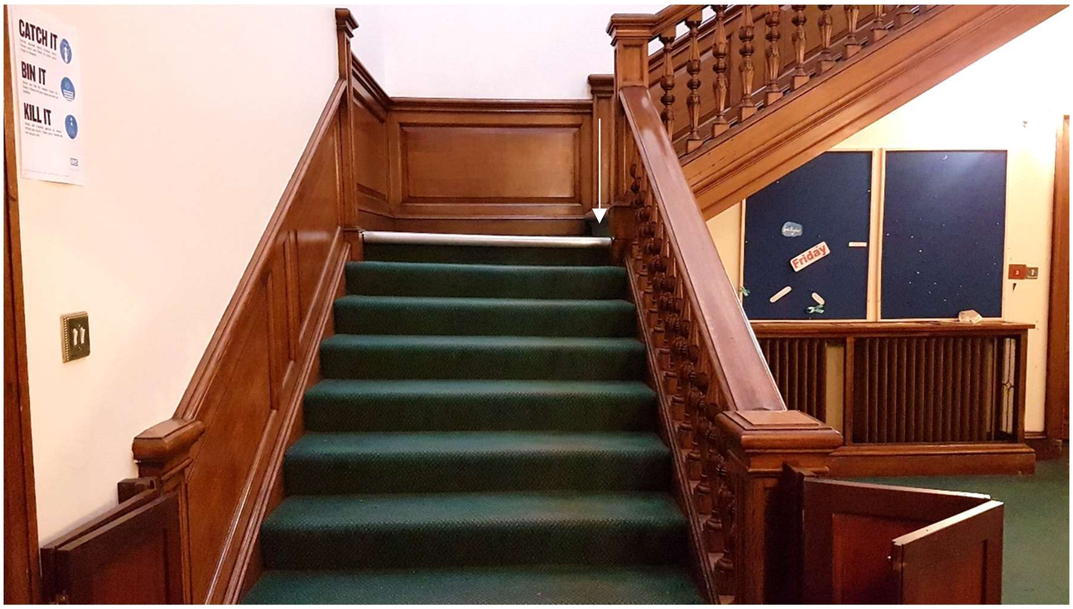


Figure 5: Stairs cranked down towards outer stringer throughout.

3.4 Ca 5-10mm open joint between stringers and post at corner landings.

3.5 Ca 5mm gap between balusters and stringer.

Figure 6: Evidence of movement in timber stringer and baluster connection. Note gaps at interface and at connection with post.

**First Floor Balcony**

3.6 The carved cantilevering brackets supporting the balcony and the balcony finishes are also cranked down towards the centre of the stairwell (ca 50-60mm).

3.7 Modern finishes cover the timber elements.

Figure 7: Cranked geometry of balcony elements towards centre of stairwell. Notice the shadow below the open halfdoor.

**Service staircase**

3.8 There is a slight downward crank of the stairs towards the outer stringer.

3.9 It is supported at ground floor by partition walls beneath.

3.10 Likely to have beam supporting last step at each dog-leg landing.

3.11 Modern finishes cover the timber elements.

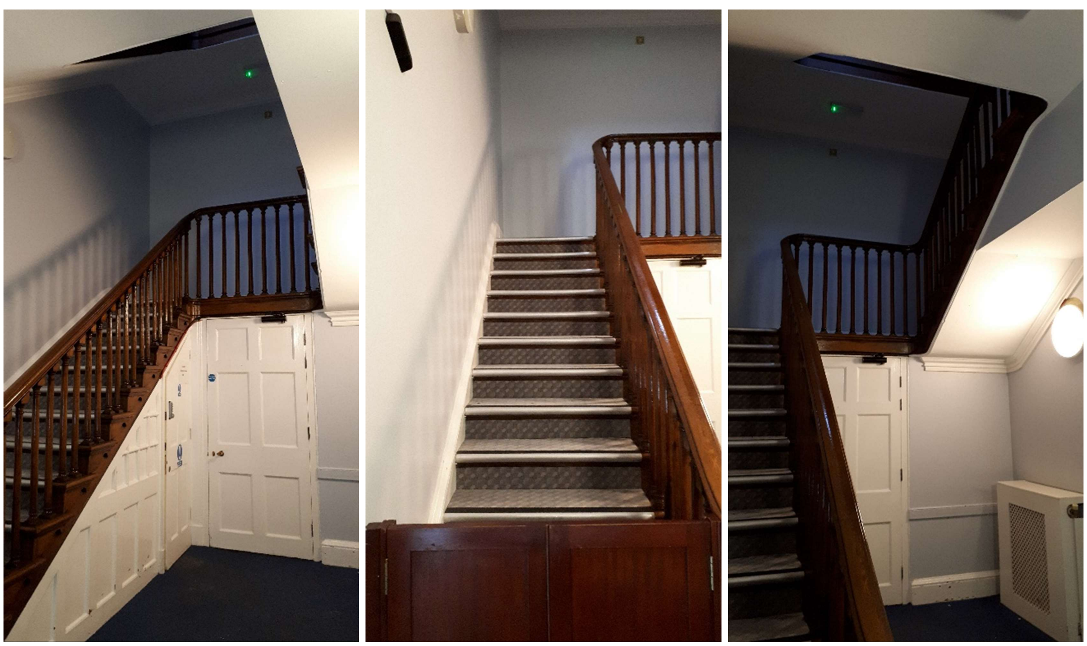

Figure 8: Service dogleg stair has an open stringer and steps are cranked down very slightly towards outer stringer.

# 4.0 Principal Interpretive Findings

**Principal Staircase**

4.1 The principal stair in Cuerden hall works on the principle that each tread bears on the tread below. It relies on the torsional restraint at the point where it is built into the wall (with only minimal bearing) to prevent it from tipping backwards. This gives the appearance that it 'floats' within the atrium space without vertical supports.

4.2 On closer observation, displacements observed both in the steps and in the joints at various stringer interfaces become clear signs that the stairs have moved since it was first built.

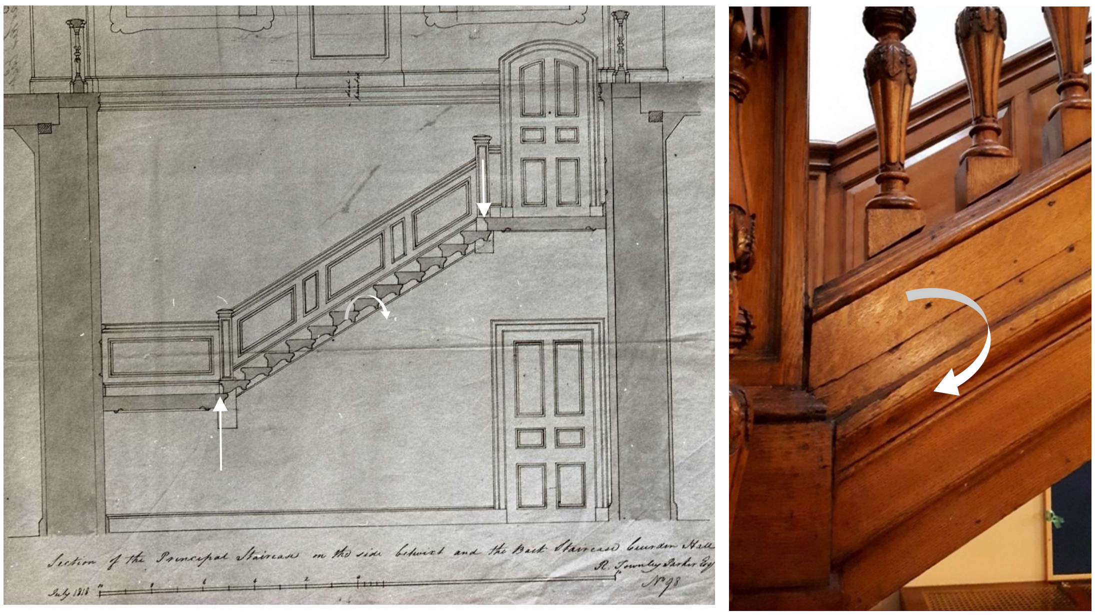

Figure 9: Evidence of movement with open joints between stringer and corner 'post'.

4.3 The pattern of these open joints is appropriate in the context of the construction of the stair described above where there is a backwards rotation. The stringer appears to hold each flight together and let the multiple elements act as one. It is therefore not surprising to see that the joint between the stringer and the post is tight at the bottom and open at the top at the bottom of a flight but the other way around at the top of the flight of stairs (illustrated in the image above).

4.4 We can also see an open joint between the individual balusters and the stringer and we can therefore conclude that the stringer has moved independently to the balusters and therefore that the balustrade works independently to the stairs and does not provide any additional support or restraint.

4.5 This type of construction typically made of stone has here been adapted to timber which has different material properties. While stone tends to retain its shape and does not typically deform under domestic loads, timber is rather more variable. For instance, timber can shrink or expand depending on its moisture content and can deform due to persistent loading over time (phenomenon called creep). As opposed to stone, timber is not brittle and does have some elastic capacity allowing it to deflect under certain loads.

4.6 While it might first appear that the stair has deflected (due to inadequate construction or supports perhaps), a quick walk up and down does not convince us that this is the case. The stairs feel quite solid and do not feel ‘bouncy’. This bounce would be the typical outworking of elastic deflection in timber which affects serviceability (ie. how it feels to use it).

4.7 We therefore believe that the open joints and sloping observed in the steps are due to a combination of shrinkage in the timber due to changes in temperature and moisture content, the tightening of interlocking carpentry joints over time, and creep due to 200 years of loading and unloading.

**Balcony**

4.8 The balcony suffers noticeable vertical deformation.

4.9 As described in section 4.6, the balcony (like the stairs) feels solid underfoot with no immediate deflection under the imposed load of walking.

4.10 Therefore, this deformation is believed to be a result of long term creep. Under a similar mechanism to that described in section 4.7

4.11 The deformation of the balcony above may also have contributed to reduced vertical support at the top of the stairs which has translated down through the outer stringer into the flights below.

**Service staircase**

4.12 There is a slight downward crank of the stairs towards the outer stringer, but this might be the outworking of changes in the timber rather than strictly structural deficiencies in support.

4.13 This staircase needs to be load tested or intrusively investigated.

# 5.0 Summary and Recommendations

5.1 Broadly speaking, our interpretation from the above is that the principal stair has gradually undertaken the observed deformation over time and has now reached a state of equilibrium. We believe that the slanted steps and balcony are an unsightly serviceability issue although this would need to be confirmed through further investigations.

5.2 We therefore do not propose any repairs or adjustments to this staircase at this time if it can be avoided, and instead propose to undertake a load test for the type of loading that it is likely to experience to determine its capacity.

5.3 The load test seeks to confirm (or disprove) the working theory described in section 4 that the deformation is caused by long term creep and the closing of carpentry joints rather that a de-facto structural failure.

5.4 If the results of this load test are not satisfactory, remedial solutions would then have to be undertaken. This could range from something like a sign limiting the amount of people allowed on the stair at a time, to full propping and heavier engineering works to 'lift' the staircase up, and anything in between depending on what is required. A practical "half way" resolution would be to lift the floorboards on the balcony and add timber firrings to level the floor, or to overlay the existing boards.

5.5 A full options appraisal and structural remedial design would be required, in which the conservation of the original fabric and aesthetic significance of the staircase would be a key consideration.

5.6 We also recommend a load test to be undertaken on the service stair to confirm it is suitable for the proposed loading that it will be subject to.

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