Paston Great Barn – South Range, Paston. North Walsham.Norfolk

Structural Condition Report

Ref: 241057/S Paterson
Approved By: Tom Lefever
Date: 26 Mar 2025
Status: For Information
Version: 2

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1.0 INTRODUCTION

1.1 Brief

1.1.1 Conisbee was appointed following a competitive tender process by Natural England to act as Structural Engineers for repairs to the South Range, part of the wider complex at Paston Great Barn.

1.1.2 Conisbee are acting as lead consultant, with a team of sub-consultants including Daniel Connal Partnership who are providing cost advice and tender documentation, and Survey Solutions who are providing a measured building survey.

1.1.3 The appointment is to undertake an assessment of the structure, considering its condition and an analysis of its structural behaviour, to specify structural repairs, and prepare a costed schedule of works suitable for tender purposes.

1.1.4 Repairs are to be developed in line with the conservation principles of minimum intervention and maximum retention of the existing building fabric, with reversible repairs where possible.

1.1.5 This report is intended for the use of our client, and no liability can be accepted for use by any third party.

1.1.6 This report should be read alongside all Conisbee design drawings and specifications, Conisbee Hazard Assessment, and building survey drawings by Survey Solutions. These are presented in Appendices A, B and C respectively.

1.2 Background

1.2.1 This appointment follows a previous overall condition survey, carried out by Nicholas Warnes Architects. As part of this a visual (non-intrusive) inspection was undertaken on 20 September 2023. The findings and recommendations were presented in a report dated 7 November 2023.

1.2.2 Whilst this report covered the entire barn complex, most relevant to the structure of the South Range were the reported concerns relating to its roof structure. These included the noted failure of one of the supporting roof trusses, and the perceived inadequacy of a number of joints to other trusses. The report noted excessive downward deflection of the roof adjacent to the failed truss, as well as lateral spread.

1.2.3 Concern over the roof structure was such that temporary support was recommended to the existing trusses to prevent collapse, as well as fencing-off of the Range from the adjacent public footpath. These works were arranged in accordance with a schedule prepared by Nicholas Warnes Architects (‘Stabilisation Repairs’ dated 11 December 2023).

1.2.4 Trusses were resupported with ‘Acrow’ type props, with the end of the failed truss fixed to its supporting post at the eaves with steel straps, as well as the removal of tiled coverings to the impacted area of roof.

1.2.5 Proposals for a more permanent repair to these structural concerns are the primary focus of this report.

2.0 BUILDING CONTEXT

2.1 Building Description

2.1.1 The South Range is a single-storey, detached structure to the southern boundary of the Paston Great Barn complex. It is a long, narrow range, which is largely open fronted on its northern side with walls of brick and flint to the remainder. To the western end, there is a loft with a timber floor (accessed via steps from the open fronted section) which is enclosed in solid walls. The roof is hip ended of shallow pitch, covered in clay pantiles. These are supported on common rafters, spanning between purlins, which themselves are supported by Queen Post trusses. These trusses are supported by the external walls, and on oak posts off masonry plinths to the north side of the open section.

2.2 History

2.2.1 Paston Great Barn (the ‘main’ barn) was constructed 1581 by Sir William Paston and has since had a long association with the Paston family. It is one of the largest and best-preserved surviving examples of a medieval great barn in England. It is constructed of coursed flint external walls, with limestone quoins and brick and flint buttresses, supporting an impressive pitched thatched roof. The roof structure is of alternating hammerbeam and tie-beam oak trusses. The ‘Engine Shed’ is attached to the western flank of the barn and is of similar construction.

2.2.2 There are adjoining outbuildings to the east and west of the barn, more modest in stature, formed in solid brick external walls and clay pantile pitched and hipped roofs. We understand these are thought to have been constructed in around 1880.

2.2.3 The history of the Barn complex is discussed in detail in the article 'A Tale of Two Barns: Paston and Waxham' by Anthony Rossi (alongside that of Waxham Barn). This article was written during a program of repair in 1997/1998. Although clearly not the focus, the South Range is mentioned. Based on the construction of the steps, the author asserts that it is of earlier construction that the other outbuildings.

2.2.4 It is noted that at the commencement of the project, the open frontage was supported on piers of fletton facing brick, with precast concrete beams between, representative of agricultural use after the Second World War. Timber elements were found within the roof dated 1975, implying a further phase of 20th century alternations.

2.2.5 During the course of the repair works, the brick piers and precast concrete were removed and replaced with the current oak posts, the bases of the brick piers presumably reused as the current brick plinths. Record drawings of these works are not available.

2.3 Statutory Protections

2.3.1 The wider site benefits from a number of protections both as an important heritage asset, and an ecological habitat.

2.3.2 The barn complex is Listed Grade II*, and the Main Barn is a Scheduled Monument. The South Range is not mentioned in the Official List Entry for the barn, however this is presented below for context.

TG 33 SH 4/80

PASTON BACTON ROAD Paston Great Barn

16.4.55

*II**

Barn. Dated 1581. Coursed Quaternary flint and chert with brick and Lincolnshire Limestone ashlar dressings. Thatched roof.

East side. Two full height double doors symmetrically placed flanked by slated stepped buttresses. Further stepped buttresses at intervals. Slit lights to flanks, the lower halves blocked. Gabled roof. North gable wall with two tiers vertical slits and further slit light at apex. Date plaque 1581.

West side. Three stepped buttresses and doors opposite the eastern entrances. Slit lights as before. Later flint and brick engine house built against wall with hipped thatched roof. Over south door a plaque bearing inscription: THE BILDING OF THIS BEARNE IS BI SIR W PASTON KNIGHTE (sic). South gable with two tiers ventilation slits and further light in apex.

Interior. Ventilation slits splayed on interior. Magnificent roof of alternating tie beam and hammerbeam trusses, all on arched braces dropping to wall posts on timber corbels. Queen struts rise to principals and are linked to collars by arched braces. Subsidiary collars above. Three tiers butt purlins and curved windbracing below second tier. Scheduled Ancient Monument, County number 168.

Listing NGR: TG3219034538

2.3.3 We understand from discussions undertaken by our client with Chris Young (Conservation Design & Landscape Team Leader – North Norfolk District Council) that there is some uncertainty as to whether the South Range legally forms a part of the Grade II* listing as part of the curtilage. In any case, any intrusive works should be discussed and agreed in writing with the Conservation Officer prior to commencement, whether this be on the basis that formal consents are confirmed as not required, or through a Listed Building Consent application. Early engagement with such bodies is always advisable to ensure that they are brought 'along the journey' of the design development.

2.3.4 The Great Barn is an exceptionally valuable habitat for bat species, and contains the only know maternity roost of Barbastelle bat inside a building in the UK. Other species known to use the buildings are; Barbastelle, Brown Long-eared, Common Pipistrelle, Soprano Pipistrelle, Nathusius' Pipistrelle and Natterer's, with two other species recorded in the vicinity.

2.3.5 The barn therefore is designated a Site of Special Scientific Interest (SSSI), National Nature Reserve (NNR), and a Special Area of Conservation (SAC).

2.3.6 Any works must therefore but be undertaken with the upmost care to minimise disturbance to the protected elements of the site. Whilst working in winter can reduce disturbance to bats, it can never be eliminated, and there must be year-round management of any works. These must be undertaken by contractors with adequate skills, experience, and briefing as to the ecological sensitivities.

3.0 INVESTIGATIONS

3.1 Scope

3.1.1 A visual inspection was undertaken by Sam Paterson and Lexie Chirimunjiri of Conisbee on 18 February 2025. Access was available to all areas both internally, with the focus of investigations on the open-sided range rough, as our brief. Externally only the northern elevation could be accessed, with other elevations only accessible from neighbouring land under different ownership. All inspections were made from ground level and were visual only. No intrusive investigations were made at this stage.

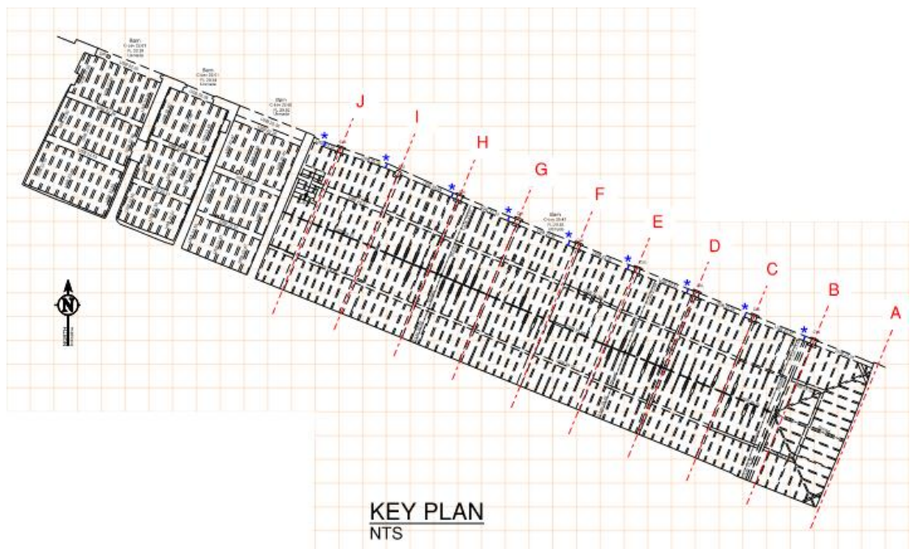
3.1.2 Prior to our inspection, measured building surveys were carried out by Survey Solutions. The drawings arising from this were available during our inspection.

3.1.3 Whilst our investigation work has been taken far enough to satisfy the requirements of the brief, it has, of necessity, not been exhaustive. The findings cannot therefore be warranted to apply to areas of the building not inspected or investigated.

4.0 OBSERVATIONS

4.1 General

4.1.1 To assist in locating observations and subsequent recommendations around the structure, the open-sided range has been split into lettered bays in accordance with the plan below, coinciding with the end wall and truss locations.



4.2 External

4.2.1 The area of roof local to the apparent failure was clear - with tiles removed and a temporary plastic membrane covering in place, secured with battens. This made it difficult to ascertain any distortion to the roof plane and ridge line in this area from a remote visual inspection. (Photo 1)

Photo 1

4.2.2 Elsewhere the roof coverings appeared in reasonable condition, with some minor undulation to the pitch and ridge lines.

4.2.3 The arrangement of supporting structures to the open north elevation was found to consist of oak posts of approximately 200x200mm, supported from low brick prints (approximately 340x340mm on plan, and 460mm high) via an oak plate capping bearing onto the top of the masonry. An oak bressummer beam spanned between the posts, supporting the truss and common rafter ends. The oak posts were jointed to the bressummer, most likely with mortice and tenon joints, with oak pegs visible to the surface. (Photo 2)

Photo 2 – overall view of the open front elevation framing, with displaced bressummer connections highlighted

4.2.4 The bressummer beam was formed in several pieces along its length, with each section jointed with a simple half-lap. A number of these joints were displaced; opening up with the bressummer beam generally spreading outwards to varying degrees along its length. This was most severe towards Truss I. This to be fixed with small hexagonal head screws through the top face of the joint.

4.2.5 A number of the oak posts were found to be leaning outwards; present at B, D, and F (found to be up to a 12mm variance from vertical measured over 600mm). Equally, a number of posts were found to have rotated, twisting about the vertical axis. This was most pronounced to Trusses H and I, but also present at C and G to a degree that was visually apparent. Other more slight distortions may be present to other posts. The brick plinth to Truss I also appeared to have suffered some overturning towards the north, implying an outward thrust in this direction.

4.3 Internal

4.3.1 The failure of Truss I was immediately apparent. This was presented as a horizontal split along the upper chord of the truss, extending from its support on the bressummer beam. The split appeared to have occurred at the birds mouth joint of the chord over the bressummer, with the upper timber remaining in place, and the lower section split away and moved downwards (Photo 3). The previously mentioned outward spread of the bressummer, the rotation of the post, and overturning of the plinth base all concentrated on this bay are further evidence that this area of structure is compromised.

Photo 3 – Failed end of Truss I

4.3.2 Signs of potential timber decay or infestation were noted to the base of the post to Truss I with some loss of section apparent, although the full extent of this could not be established from a visual inspection alone (Photo 4). There also appeared to be some decay to the northern end of the lower chord, however much of this was obscured by the steel strapping.

Photo 4 – Decay to base of post to Truss I

4.3.3 The vertical acrow props (off timber bearings on the ground) and steel strapping included in the Nicholas Warnes schedule were present and appeared to be sound at time of inspection, although its ability to meaningfully restrain any outward movement for any length of time is perhaps uncertain. Vertical propping was also present to the adjacent Truss H.

4.3.4 Spliced sections of timber were present to the lower chords of Trusses C, D F, G and H. These were located adjacent the northern eaves, near to the Queen Post. Newer timber of similar section size was spliced to the parent chord to the northern end, with pairs of steel plates each side, fixed with four through-bolts either side of the joint. The bolts were located near the centroid of the section, staggered vertically a short distance above and below. (Photo 5)

Photo 5 – Steel splices to lower and upper chords to eaves, with strengthening strap to purlin

4.3.5 From visual inspection, it appeared that these joints had displaced downwards. The gap between the timber sections at the joint appeared to widen towards the bottom of the members up to approximately 5-10mm, with the gap closing towards the top.

4.3.6 Splice plates were present to the upper chords, in a similar location near to the eaves on Trusses B, C, D, E, F and H. These plates were shorter than those to the lower chord, with only 3 bolts either side of the joint. Signs of deflection were not as apparent to these from ground level.

Photo 6 – Spliced ends at the ridge; in steel to the upper chords, and timber to the rafters

4.3.7 Similar splices were also present to the upper chords at the ridge of Trusses C, D, E and F, with newer timber to the ridge side (Photo 6). These were also present to the primary rafter to the eastern hip-end at eaves and ridge, and to the southern purlin adjacent Truss B.

4.3.8 Common rafters ends were spliced at the ridge in a number of locations, with new timber to the ridge side, jointed with timber plates either side, bolted through the rafters.

4.3.9 Adjacent Truss B, a number of the rafter feet to the north side had been spliced with plain scarf joints. These appeared to be additionally fixed with stainless steel screws.

4.3.10 Signs of potential decay were noted to the lower chord of Truss F between the Queen Posts, as evidenced by discolouration and potential surface growth to the timber, and a horizontal split along much of this length (Photo 7). An ongoing cause of this decay, such as exposure to dampness, was not clear during inspection. As such it may be a historic issue.

Photo 7 – Discolouration and potential decay to lower chord

4.3.11 Potential decay was also noted to the southern upper chord of Truss J (Photo 8). This was evidenced by loss of section visible at the surface between the eaves and the purlin. Again, a clear ongoing cause was not evident from visual inspection.

4.3.12 As a general comment, throughout the roof structure there was a mix of differing ages and species of timber. A number of the truss elements and purlins appeared to be formed in more roughly shaped and historic timber (potentially hardwood), with some historic strapping present to the southern eaves. Truss I was typical of this.

4.3.13 Elsewhere, common rafters, and several of the truss chords were of more regularised and clearly more modern sections, likely to be softwood. Even more recent timber was present to the spliced sections and some individual rafters. Where bolted steel plates are included these are clearly a 20th century intervention, and based on their condition likely to be the latter part of this century.

4.3.14 The wall plate was spliced in a number of locations, formed of timber of clearly differing ages and degrees of regularisation.

Photo 8 – Suspected decay to Truss J upper chord

4.3.15 The arrangement of truss end bearings was variable. To Trusses G and H the arrangement was more conventional with the upper chord bearing onto the lower chord with a mitered cut (Photo 9). To other trusses, however, there was a less conventional joint with the upper chord half-lapped with the lower. This half lap joint was secured with additional modern bolts in most cases (Photo 10).

4.3.16 To the northern end of Truss I, prior to failure, it appeared that the upper chord was the supporting element, via its birds mouth joint onto the bressummer, although this left only a small proportion of the section depth remaining. The lower chord appeared to have been half-lapped and bolted to this. It should be noted that the chords to Truss I were of notably smaller cross section than the remaining trusses. It appeared that a small section of timber, perhaps a former brace previous cut, was present to the underside of the lower chord near this support.

Photos 9 and 10 – Showing varying truss end details

4.3.17 In all other cases the lower chord was bearing onto the bressummer or wall plate, and was notched to its top face following the roof profile, and to the northern side this left a very shallow depth remaining, less than 100mm in some instances (Photo 11).

Photo 11 – Shallow end bearing to truss end

4.3.18 The variability of the roof arrangement and materials, coupled with the observations made by Anthony Rossi described in 2.2.4 of this report, overall gives the impression of a roof which has been adapted a number of times since its construction. This is perhaps unsurprising given its age and past as a more ‘workmanlike’ agricultural building.

4.3.19 The southern wall was found to be leaning outward at its eastern end (where faced in brick). This lean may be present elsewhere but this could not be precisely established due to the uneven nature of the flint facings. In any case, cracking or other signs of significant distress which might imply an ongoing issue were not noted.

5.0 DISCUSSION

5.1.1 The roof has clearly suffered a localised failure to Truss I. This appears mostly likely the result of its shallow cross section at its bearing support onto the bressummer beam, causing excessive shear stress in the upper chord end where compromised by excessive notching to form the birds mouth joint. Such stresses would be far in excess of those recommended by contemporary codes of practice. The presence of any decay, or pre-existing natural faults in the timber, may also have impacted the local strength of this element.

5.1.2 The outward spread of the eaves bressummer, post, and slight rotation of the brick plinth in this vicinity can largely be attributed to the failure of this element and the resulting redistribution of stress throughout the structure.

5.1.3 The damage to this section of the upper chord is clearly beyond the point of repair, and some replacement will be necessary. Replacement on an entirely ‘like-for-like’ basis would unfortunately merely recreate a detail which would appear to have been defective in the first instance, so additional strengthening of this joint will be required, alongside partial replacement of elements, whilst retaining the existing timber as much as possible.

5.1.4 Elsewhere, whilst more minor movements were observed, these did not indicate a significant loss of stability.

5.1.5 The deflection noted to steel plate splice connections to truss chords are likely the result of initial movement, immediately after installation as the load is take up by the connection. Clearance around bolted fasteners and small gaps in joints due to construction tolerances will allow for some initial rotation as the load is applied before reaching equilibrium. These truss elements are generally axially loaded, with bending forces a more minor component. At this time we do not feel these joints are structurally compromised.

5.1.6 More minor splices to purlins and rafters appeared to be performing adequately at time of inspection, and no clear external source of degradation was encountered.

5.1.7 A number of the other truss joints are unconventional, which is to be expected in a former agricultural structure. These appeared to be performing at time of inspection, and likely benefiting from measures installed during the 20th century works, such as additional fasteners through key connections, and replacement of decayed timber.

5.1.8 The truss bearings to the northern side (onto the bressummer beam) do warrant some attention, particularly noting the failure of Truss I. These chords are heavily notched to their top side over the support, and the anticipated shear stress in the slight remaining timber is not justifiable under codes of practice. Therefore, some strengthening measures to these joints would also be prudent.

5.1.9 Equally it should be noted that the open section of barn is some 25m long, without intermediate buttressing walls or piers. There stiffness of these connections are therefore key to the stability of this structure, and strengthening this would provide additional robustness against lateral wind loads.

5.1.10 The displacement of the half-lap connections in the bressummer has likely been contributed to by some outward thrust at the rafter feet as well as drying of the timber. The purlins were noted as of small cross section during inspection, and therefore some deflection of these in the plane of the roof pitch would result in some spread at the eaves. This does not appear to have caused instability at this time, but some simple strengthening of the half-lap connections would be advisable to better transfer any lateral forces between the trusses.

5.1.11 The rotation of the posts about the vertical is perhaps indicative of warping of these members. It is likely that these were installed as unseasoned ‘green’ timber. As its moisture level reaches equilibrium with its new environment warping, twisting, and the formation of shakes is common. This is not usually a structural issue.

5.1.12 The potential decay noted to post base to Truss I, and to chords of Trusses F and J, do warrant further investigation. The nature of decay, and the degree of section loss, cannot be fully established by an Engineer’s visual inspection, and some intrusive investigation would be required.

5.1.13 The extent of repair to these elements (if any) would be informed by such an investigation, but at this stage the need for repair to the post base at Truss I is clear, and will be required to some degree. Provisional allowance should also be made for repairs to Trusses F and J, with the requirement for these to be confirmed on site.

6.0 RECCOMENDATIONS

Arising from our inspection and subsequent assessment, we would recommend the following steps are undertaken;

6.1 Repair to the northern end of Truss I

This will entail the replacement of the split length of the upper chord with new, seasoned, species matched timber, with a bolted scarf connection back to sound timber of the existing chord. Whilst this does result in the loss of some historic timber, this is limited to the sections damaged beyond repair. Replacement is undertaken in matching material, and jointed using traditional techniques. The use of metal fasteners is clearly well established in this structure through previous repair.

Additionally, the bearing of the truss end must be strengthened. This will be achieved with a new timber 'corbel' bracket, fixed to the existing bressummer and post with bolted steel fasteners. This has the effect of increasing the length of the timber bearing, and allows for force transfer away from the heavily notched sections. This is a reversible addition to the existing open-front structure, with the posts and bressummer only introduced in the 1990s.

This approach is presented in SK001 in Appendix A.

6.2 Strengthening of the other Northern Truss ends

Although functioning at time of inspection, our assessment has revealed that the northern end bearings of these trusses is vulnerable to failure in a similar manner to Truss I. We'd consider that strengthening of this joint with a new timber brackets a prudent measure to reduce the risk of further failures.

This approach is presented in SK002 in Appendix A.

The arrangement of Truss B is atypical in that it is slightly offset from the supporting column. The approach to strengthening this truss is presented in SK005 in Appendix A.

6.3 Strengthening of bressummer half-lap connections

The displacement of these connections implies a lack of continuity across the half-lap joint. Whilst not yet at concerning at this stage, increasing their stiffness now may prevent this movement progressing to a point requiring more intensive intervention. This could be completed simply and unobtrusively with the introduction of stainless steel bolts through the half lap joint. The bolt heads and nuts can be counterbored and plugged with matching timber to reduce any visible impact.

This approach is presented in SK003 in Appendix A.

6.4 Potential timber decay

Evidence of fungal decay or infestation was noted to timber elements during this inspection, but non-intrusive investigations can only give a superficial analysis of the impact to structural strength. We would advise that further intrusive investigation is undertaken to establish the extent of any decay. This could be completed fairly simply through close-up inspection by a specialist joiner using probing with hand tools to establish the extent of decay and whether the sections have been compromised.

The extent of repair will be established following this investigation, however at this stage we would suggest the repair of the Truss I post base is likely to be required at a minimum. This can be completed with bolted half-lap joint. This element was a 1990s introduction and therefore the small loss of decayed fabric is not considered unreasonable.

The approach to repair of the post base is presented in SK004 in Appendix A.

For costing purposes, provisional allowance should also be made for repair to the lower chord of Truss F, and the southern upper chord of Truss J. We'd suggest provisional allowance is made for the following;

> Truss F – allowance for bolting a new seasoned oak member of matching section to the existing lower chord, from the northern queen post to the south wall, with 12No M10 stainless steel bolts.
>
> Truss J - allowance for bolting a new seasoned oak member of matching section to the existing southern upper chord between the eaves and the purlin, with 12No M10 stainless steel bolts.

This approach retains the existing section in-situ, minimising loss of historic fabric, and is a largely reversible repair.

The decision to include these elements into the works carried out will be made following site investigation, along with agreement of finalised details of the repair.

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