ANTHONY-JOHNSON
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Site Address:

PulverToft Barns,
Pulvertoft House
Gedney Broadgate

Site Survey:

The site comprises two individual barns, serviced by an entrance off a public highway. Both barns are noted as being suitably dis-used, with one containing ageing farm implements.

The barns are set to land that contains made ground with boundaries to the rear and side of the site, separating the land from adjacent fields and a neighbouring property.

It is proposed that the barns be converted for residential use. The purpose of this survey is to therefore determine the suitability of the structures for conversion.

Site Survey:

Block Work Barn:

The first barn in the complex comprises a purpose-built single-storey structure with block work skin to side and rear elevation, formed of 200 mm wide hollow core blocks. The barn is enclosed to three elevations, with open front allowing for access and storage of plant.



Image 1.0: Gable End of Structure

Internally the block walls are butressed against wind loading via built-in piers at 2.5 m centres and these run from ground level to the underside of steel trusses formed from equal angles welded to form trusses with horizontal bottom running front to back at eaves level.



Image 2.0: Gable end block work with sliding action having forced blocks out.

To the front elevation, trusses are supported by circular hollow steel sections, 100 mm in diameter, running from ground to underside of truss.



Image 3.0: CHS steel post, set at suitable centres, providing support to end of truss.

To two locations, CHS sections have been removed and a 127x76 universal beam supplemented to provide support to the truss mid-span of the opening. It is evident that these front sections have been struck at some stage in that they have buckled about their minor axes. However it is noted that the mass of the structure over is such that the universal beams have not deflected vertically as a result of losing part of the minor axis strength.



Image 4.0: infill universal beam providing support to truss over longer span.

The structure is provided with a weatherproof finish via corrugated steel sheets with corrugations running such they shed water directly from apex down to eaves. These are supported intermittently via timber purlins, set to the head of the steel trusses. Additional purlins, formed from equal angle steel sections provide both support to the corrugated steel sheeting and restrain the trusses against rotation about their minor axes at suitable centres along the span of the trusses.

The structure appears sound in that no movement was observed within the main elevations of the block work and that the roof remains both intact and functioning as intended with no deflection evident. However, to the side elevations it is noted that deterioration has occurred in the block work to the head of corner piers with deterioration in both instances occurring on the front elevation and this is likely the result of thermal movement within the supported steel roof pushing the wall out such that it fails over time. In reaching this conclusion it is noted that the base of both side walls remains both intact and free of deterioration. By contrast, towards the head of the wall, cracks arising as a result of thermal expansion and contraction were noted and these are likely the result of a lack of restraint. Block work has similarly been pushed out such that large gaps have been formed in perps and this is reflective of the larger expansion exhibited by the steel as compared to the concrete blocks.



Image 5.0: Expansion in steel trusses has pushed blocks out of alignment, causing stepping and splitting along bed joints and perps.

Two doors were noted on the rear elevation of the barn and these are inset with timber lintels spanning over the head. Formed of multiple 225mm high timbers join together. Decay was noted on the outermost timbers, reflective of a failed gutter allowing moisture ingress.



Image 6.0: Decay to outer most timber of door lintel.

Blocks to the head of masonry piers were noted as having been shunted marginally, forming a horizontal crack that is representative of thermal movement within the steel trusses and restraint between the steel and the uppermost block.



Image 7.0: Shunted Block to head of internal buttresses.

Internal to the structure, some stepped cracking and vertical cracking was noted as passing through block work local to corner returns in the building and this is likely representative of thermal movement with cracking about the weakest points in the block work. The use of a higher strength mortar to the side elevation has resulted in restraint between block and mortar hence, rather than sliding, the blocks have been pulled apart.



Image 8.0: Stepped cracking and vertical cracking to existing block wall, indicative of thermal movement.

To the gable end furthest from the main road, it is noted that some deviation has occurred within the line of the wall, with the mid-span elevation bellying in an outward direction, following a stepped crack that has resulted in an outward rotation of the block work. It is noted that this is minor and may be rectified sufficiently through the use of helical crack stitch reinforcement so as to Cross-stitch Block work together, either side of the crack.

Minor inward deviation was also noted to the rear elevation and this is likely the result of wind loading forming suction, internal to the building, particularly given the rear elevation is sheltered from prevailing winds. On this basis, incorporation of a new front elevation to the structure would alleviate wind suction on the internal elevation of the wall and the formation of internal partitions would Provide restraint against any further horizontal movement. However, it should be noted that horizontal movement in this instance is minor to the rear elevation and that the building overall remains structurally sound.



Image 9.0: Stepped cracking with bellying in block wall to gable end.



Image 10.0: Marginal bellying noted to rear elevation.

Finished floor level, internal to the single-story Barn appears to be Earth with crushed brick, forming a storage area for farm machinery.

Topsoil to the area, having been exposed was noted as being extremely damp, likely representative of a heavy silt and potentially clay geology to the underside preventing free drainage.

Conclusion:

The barn is noted as being structurally sound with no deviation noted in the lower sections of walls, implying suitable foundations to the structure. It is noted as lacking an internal finished floor, indicating that a suitable slab may be formed, with modern levels of insulation over.

The structure is noted as being sound in that the envelope of the building remains in plane. However, defects within individual structural elements should be addressed as these will have a direct impact upon the building. In conjunction with the application being made by the client's architect, it is noted that the following defects are such that they affect significant structural elements such that the longer-term stability of these elements would be of detriment to a residential property:

- Structural elements are considered as being suitably sized for their given task. However, damage to the Universal beams to the front elevation will have resulted in a loss of structural strength and should be replaced. Similarly, damage to fixings and shunting of trusses have clearly resulted in damage to the supporting block work.

- Movement within existing blockwork walls is of concern. The reasoning for this is that remedial works to make good will not prevent thermal movement from arising again. The rear elevation of the structure requires an expansion joint, so as to prevent the development of stresses within the masonry. Front corners to gable walls clearly require a form of restraint, so as to prevent shunting of higher level block work. Such thermal mechanisms would inadvertently result in overall long-term failure of the building. Decoupling of steels from block work and restraint of block work may be achieved through the introduction of a suitably sized wall plate.

- Steel trusses set to the roof should be de-coupled from the supporting block work so that they may slide, whilst still being provided with vertical support. Where mechanical fixing is required to the block work, slotted bolt holes should be provided with a means of decoupling.

- The gable wall, set facing the field is noted as having both a stepped crack through blockwork and an outward belly within masonry. It is advised that this should be stabilised, given that it has allowed for the independent lateral movement of two resultant sections of wall along the juncture of the crack.

Where conversion is warranted, on the basis of works having been made to ensure long term stability, internal partitions should be set to a suitable ground bearing support, such that partitions provide buttressing to the rear elevation. It should be noted that the front elevation will inadvertently proffer a means of preventing internal wind suction, which in this instance is likely the primary cause of bellying to the rear long-span elevation. The roof structure is noted as being suitable for the inclusion of a light weight finish and spans between front and rear are such that they warrant the inclusion of light weight supporting elements to finishes.

Main Barn:

The man barn comprises a purpose built grain storage structure, similar in principle to a portal framed barn in that it is designed to resist sway and spread induced by wind and snow respectively through moment resisting connections at eaves. Cladding to the structure is hung to side elevations and propped to the roof all via a series of purlins, transferring loads back into the main portal style frames, contained within the interior of the structure.

External overview:

The main barn is formed of corrugated cement sheets, running vertical to all elevations and corrugated cement sheets to the head running up from eaves to apex. To each end of the barn is set a steel roller shutter door, providing a weather tight finish and access for large farm machinery. The majority of the exterior was found to be in good overall condition. Vertical deviation to main elevations was not noted and the ridge line was found to remain straight and run true throughout.



Image 11.0: Side elevation of Main Barn (rear)

Likely the result of high winds, damage has occurred to the corrugated cement sheeting to one gable end with the sheet having clearly failed and been torn off, exposing the underlying steel framing.



Image 12.0: Rear elevation with failed cladding

The barn is set to a concrete base with concrete plinths clearly evident to the perimeter.

A large quantity of husks, deposited to the side elevation of the structure are indicative of its former use as a grain store.

Interior overview:

Internally, the structure is formed of purpose made lightweight steel truss Portal frames, set at 4 m centres with steel purlins formed from rolled steel angles, set at 1 m centres to the head of the trusses.



Image 13.0: Internal view of the structure

Trusses clearly form sway frames with increasing depth when running from apex to eaves such that at the eaves there is sufficient lever arm to resist the bending moment induced by sway. The same is noted to vertical elevations with depth of trusses increasing toward the eaves, thus forming a haunch member.



Image 14.0: Haunches formed through deepening structural elements toward eaves.

Bracing is evident within the roofline such that sway along the axis of the building is transferred via compression and tension in the bracing members to the corner return of the structure, where cross-bracing and horizontal bracing ensure that it is transferred as tensile and compressive forces down to foundations.



Image 15.0: Bracing to end of structure.

The internal floor is finished with a concrete slab, sub-divided into bays for the intentional introduction of expansion joints between pours. These are noted as being set so as to control cracking within the finished floor. Deterioration in the concrete is clearly not evident and is reflective of a structure that has been suitably formed. A drainage gully to the rear elevation of the structure indicates the overall depth of concrete as being in the region of 500 mm. This in of itself implies a structure set to suitable foundations.



Image 16.0: Internal view of finished floor, with concrete divided into bays through introduction of expansion joints.

Discussion:

Findings of the survey indicate the following:

Structural elements are noted as being slender. On this basis, it is considered that purlins are restrained by the existing cement sheet cladding, reducing the effective length of these elements so that the full strength of the structural steel is achieved. Purlins provide the same to trusses, which are again considered slender in nature.

Unlike portal framed buildings, formed of solid structural steel elements, frames in this instance have been built up through the combination of individual thin walled elements to form trusses, which have then been combined to form portals. These form suitably light weight primary structural elements for the sole purpose of supporting the building over, resisting sway via deep haunches at eaves level. As such, the portal frames require both purlins and rigid cladding as a means to restrain them against buckling about the minor axis.

The reduction in depth of frame trusses at ground support level indicate that they have been designed as pinned bases, hence no moment resistance may be assumed in resisting sway at the base of the structure.

The profiled nature of the cladding gives rise to a structure that sheds wind loads at eaves level, allowing for an aero-dynamic eaves that does not attract significant thrust from wind loading. This coupled with the height to width and height to depth ratios of the building all point to a building where wind loading to vertical side elevations is low. By contrast, the presence of cross bracing and steel purlins all point to a building in which both purlins and bracing transfer wind loads applied to gable end back into foundations, thus removing sway from the building.

Conclusion:

Based upon the findings of the survey, it is considered that the building is suitable for the formation of a residential dwelling unit internal to the existing frame. The recommendation is based upon the premise that the existing structural elements will only be employed as a means to support a rigid external weatherproof finish capable of providing plate action to the internal structural elements.

Thin walled steel truss frames are noted as being inadequate for the addition of further loads and as such, the inclusion of a first floor internal to the structure would require additional supporting members, likely formed of stud walling.

Given the lack of moment resisting connections to the base of the structure, catenary action within the frame is unlikely in the event of a fire and stability against inward rotation is likely provided by the fire resistant cement cladding, with its major axis proffering sufficient compressive strength to allow for arching. On this basis, sufficient protection to the steel elements should be provided as part of the design process. Cladding should similarly be chosen on the basis of providing plate action through fixity back to structural elements, so as to provide lateral restraint to purlins about their minor axis thus preventing both torsion and lateral torsional buckling of members.

Given prior use of the existing structure, it is considered that the internal finished floor is likely formed to a suitable thickness of concrete for the inclusion of internal partitions. External examination indicates that it will proffer support to stud walls with first floor over.

Openings within the external cladding will require the addition of elements such that loads from self weight, wind and snow would be transferred suitably across the new opening.