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Project: 19047- Technical Note 3	27 August 2019
Baydon Church – St Nicholas Defects to the Chancel and Vestry stone walls	
Client : Baydon Church LPPC / Whitton Parish PPC	
Revision History: First issue	

1. Objective of this note

To provide background and history of inspections and a record of the defects as noted to date to the stone walls.

2. Executive summary

2.1 The Chancel

2.1.1 The Chancel north east corner is subjected to a combination of seasonal ground movements on account of clay soils below the relatively shallow foundations together with thermal movements within the stone wall make up. The ongoing year on year movements has resulted in fatigue of the lime bonded stone walls in the North West corner.

2.1.2 This fatigue to the flint and clunch wall which will have loose rubble filled mortar bonding the two leaves has occurred and shown externally by loose flint panels and outflow of some small rubble fill and internally demonstrated by increasing crack movement.

2.1.3 Without intervention now the flint walls to the corner will fail and progressive defects to the Chancel occur.

2.1.4 In addition, the lime stone frame to the east gable stain glass window installed in mid nineteenth has signs of past and current distress in that the key stone and tracery stone work in the form of opening joints that should be under compression not tension.

2.1.5 Without intervention within the next 18 months there may be damage to the stain glass and onward distress to the stone work.

2.2 **The Vestry**

2.2.1 The vestry to the side of the north wall of the chancel, built in mid nineteenth century is on shallow foundations on to clay that is subjected to seasonal movement. The up and down movement of the outer north east corner has caused the east gable verge stone work to become loose and is need of repair. As the roof connects to the verge stone work water ingress at this junction is inevitable and progressive decay of the building fabric in this area will occur.

2.2.2 Without intervention there will be ongoing distress to the verge and not unforeseeable that stone work copping stones may fall. Onward damp problems of water ingress will continue until the area of Vestry is remediated.

2.3 Recommendations

2.3.1 Initial recommendations for remedial works will be developed in Milner Associates Technical Note 4.

2.3.2 The outline proposal is to provide a buttress and underpinning to the corner of the Chancel wall. Underpinning to be fully considered and its effect on creating a hard spot and interference with the graves.

2.3.3 The current scaffold should be removed once the temporary works presented in Technical Note 4 are followed.

2.3.4 Further investigations are recommended to obtain more technical data on the soils below the church in understanding the clay level of sensitivity to moisture changes and in finding the depth of the chalk bed.

2.3.5 Mapping of actual grave locations should be carried out as best can be done from the surface.

3. The Church building – What we know

Church in the historic village of Baydon

St Nicholas, Baydon

Figure 3.1 – church location and church south elevation

3.1 Building notes from Historic England

3.1.1 Grade II with elements of c1100, c1200, C15 and C19.

3.1.2 Limestone and flint panels, chancel flint on stone footings, north aisle flint. Lead roofs.

3.1.3 East window to chancel 1857-58. Restoration in 1876 and 1892.
North aisle 1857-58 almost wholly rebuilt.

3.1.4 South aisle C15, re-roofed C19. Chancel arch rebuilt on skew on C12 responds.
Chancel three bays, ties bracketed to corbelled wall posts, probably C17.

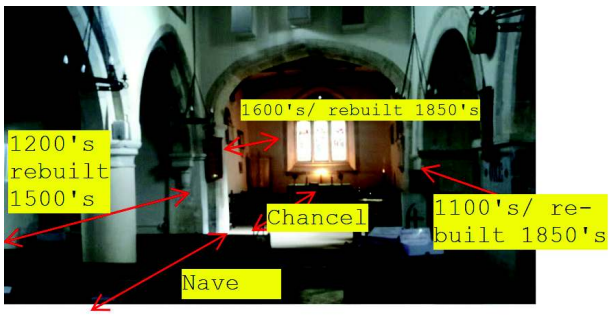


Figure 3.2: marked up picture (August 2019) from the tower end looking east of the church showing approximate dates of the building. Not shown is the vestry built in the 1850's to the north of the Chancel.

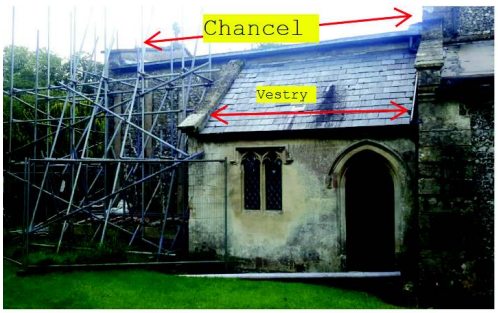


Figure 3.3: north view of vestry (August 2019)

4 Distress to Chancel walls and back ground to inspections undertaken.

4.1 The Chancel north facing wall and east gable has since 2013 been the subject of concern with internal and external vertical cracks appearing.

4.2 Historically there is evidence of past remedial works. The south facing wall has had repairs carried out with door infill and a buttress built to the south east corner at an unknown date but estimated to be nineteenth century. The stone work around the east window has dark mortar patches which suggests previous repairs. In addition, the stone work externally appears to have had historic repairs. Internally there is signs of new hard cement render to the chancel that is up to 1.2 m approximate height; there is no date to this work but it is estimated to be mid twentieth century work.

Figure 4.1- earliest photo known from 1991 when the underfloor heating was installed to the chancel area and no record or sight of the in the photo known. From the photo repairs to the mortar in the stone work over the east window key stone might be made out but this is not proven.

4.3 Milner Associates understand that the most recent concern occurred in 2013 and the cracking has been perceived to be getting worse since then. The LPCC had in 2014 appointed SDS Consulting Structural Engineers to undertake an inspection and monitor and report on the cracking in the chancel walls. It is noted that the summer of 2013 was a hot sunny one and this may have been the catalyst for the Church to investigate cracks that had appeared or worsened in 2013.

4.4 SDS Consulting noted that through 2014 small changes to the cracks in the order of 0.5 to 0.75mm occurred with closing of cracks to the winter months. SDS state that *the cracking to the walls is noted to be opening and closing with the possibility of a trend*

towards continuous opening, although only small changes has occurred in the monitoring.

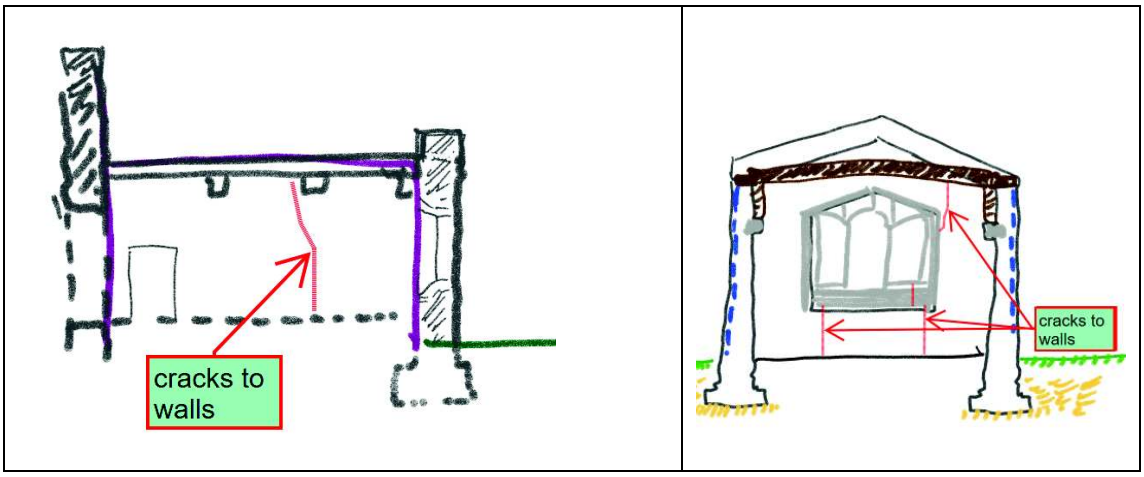


Figure 4.2 diagrammatic view of the location of the vertical cracking to the internal walls known to be in place in 2013.

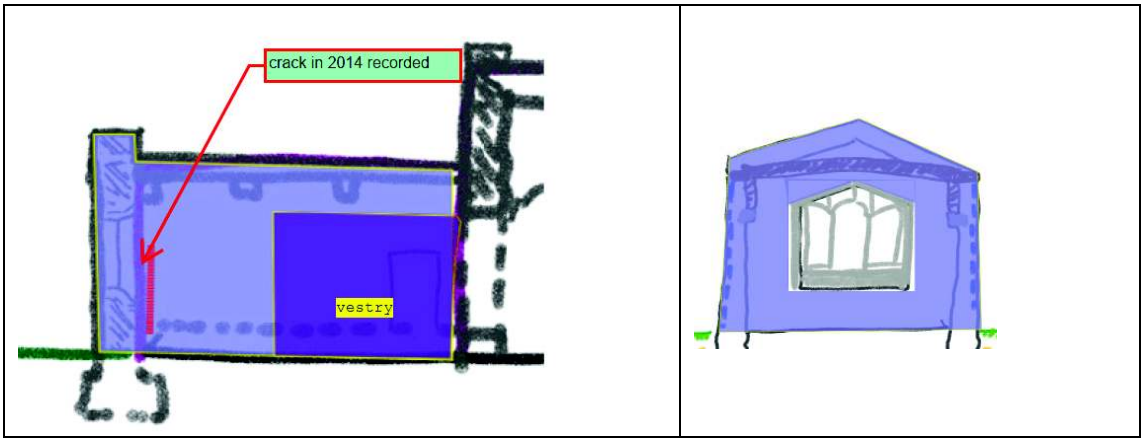


Figure 4.3 diagrammatic view of the location of the vertical cracking to the external known to be in place in 2013.

4.5 In the autumn of 2018 following a very dry summer the cracks worsened and external cracking appeared which was significantly larger than the internal cracks.

4.6 The external flint work appeared in places to be loose and the Church LPCC brought in a scaffold company to prop the chancel gable wall. The scaffold was installed in December 2018.

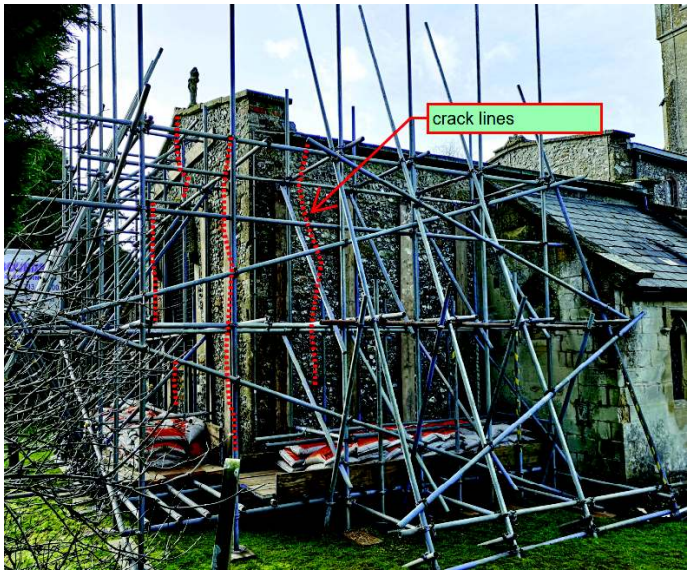


Figure 4.4 : scaffold used to butress the walls as installed in December 2018; photo 16th March 2019 – highlighted for ease of understanding cracks noted on the walls externally.

Figure 4.5 : internal view of the chancel 16th March 2019 – highlighted for ease of understanding cracks noted on the walls internally.

4.7 During the walk round inspection by Martin Milner – 5th April 2019 the cracks to the internal walls and the external flint walls to the chancel were as noted in the SDS Consulting Engineers findings. In addition, a number of historic cracks to the east window stone work was noted and additional cracks to that was noted in the SDS report dated November 2014.

5 Internal Findings from investigations spring and summer 2019

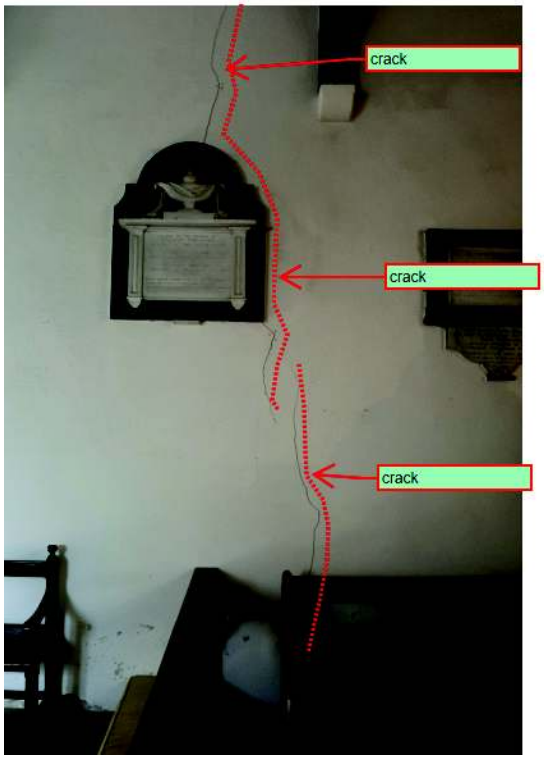


Fig 5.1 a - North wall – part (east north)

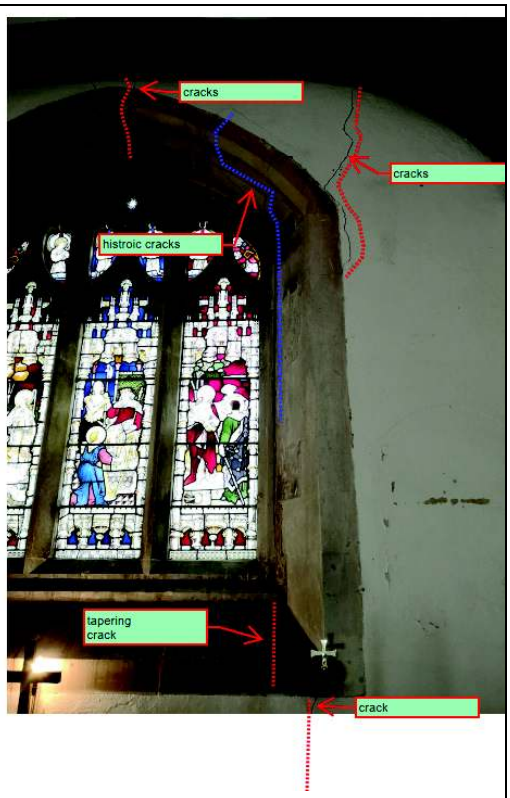


Fig 5.1 b East wall – part (south east)

Fig 5.1c

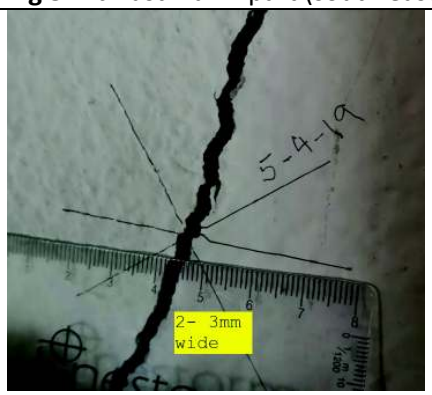


Fig 5.1d

Figure 5.1 – cracks noted in 5th April 2019 to the north wall and east gable wall- lower areas of cracks

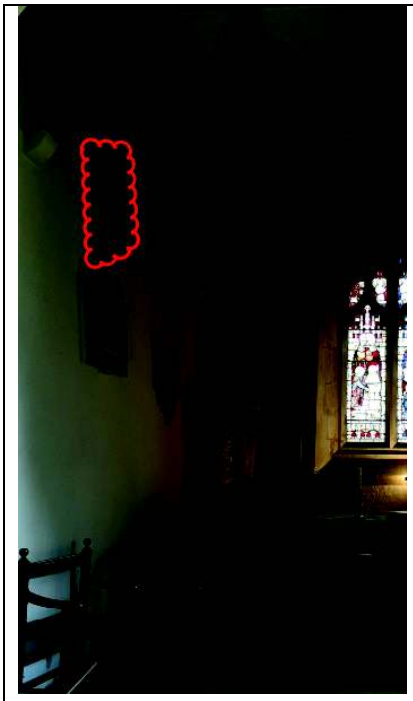


Fig 5.2 a Location of crack guage –north wall - installed 5 April 2019

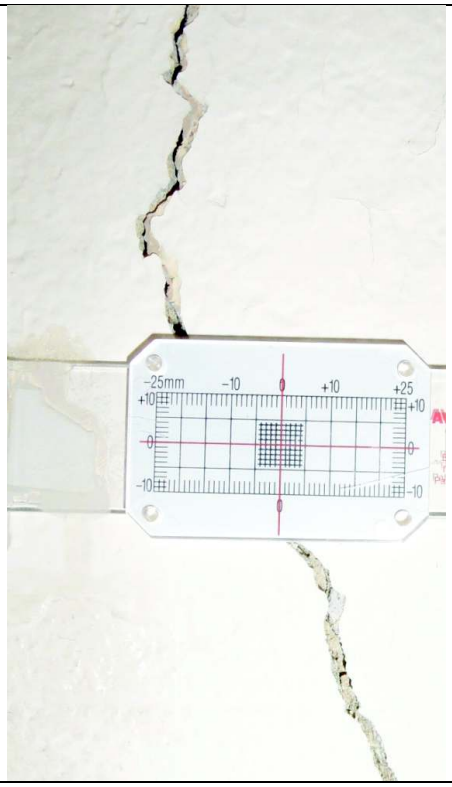


Fig 5.2b Guage and cracks around – 5th April 2019 – crack widths 1 – 2mm –

Fig 5.2 c Location of crack guage –east wall- installed 5 April 2019

Fig 5.2 d Guage and cracks around – 5th April 2019 – crack widths 3 to 6 m on the render but not taper back to the crack in the wall itself.

Figure 5.2 internal cracks as of 5th April 2019 as recorded by Milner Associates note that the render suggests bigger crack than is seen- this may be due to the opening and closing which the render is a true reflection of the movement.

Figure 5.3 internal cracks as of 8th August movement noted approx. 0.8mm opening – at the east gable wall.

Figure 5.4 internal cracks as of 8th August movement noted approx. 0.5mm step rather than increase in width – at the north wall.

Figure 5.5 gable wall and east window as of 5th April 2019 - Note darker pointing around the stone window frame which suggests historic repairs. There are signs of new movement and in particaluar the key stone at the top of the window.

Figure5.6 gable wall and east window as of 8th August 2019 - Signs of new movement and in particaluar stone rotation.

Figure5.7 gable wall and east window as of 8th August 2019 - Signs of new movement and in particularly stone step.

Figure 5.8 gable wall and east window cill as of 5th April 2019 - Signs of movement in stone cill; some recent some historic.

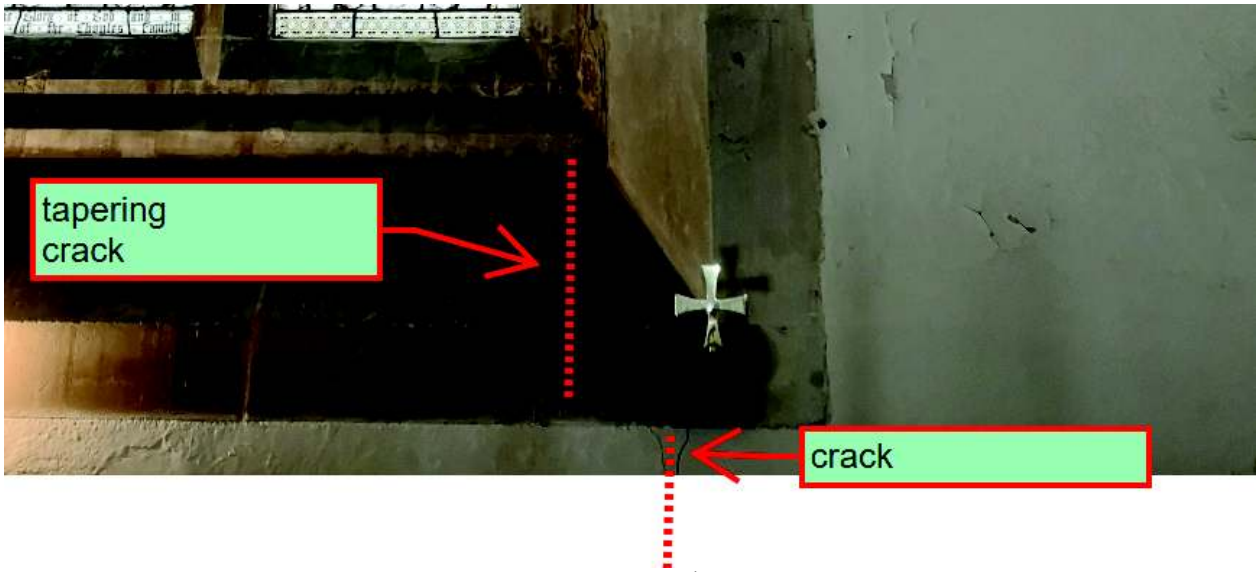


Figure 5.9 gable wall and east window south side as of 8th August 2019 - Signs of new movement and in particaluar stone cill rotation.

Figure 5.10 south wall as of 8th August 2019 – No Signs of movement

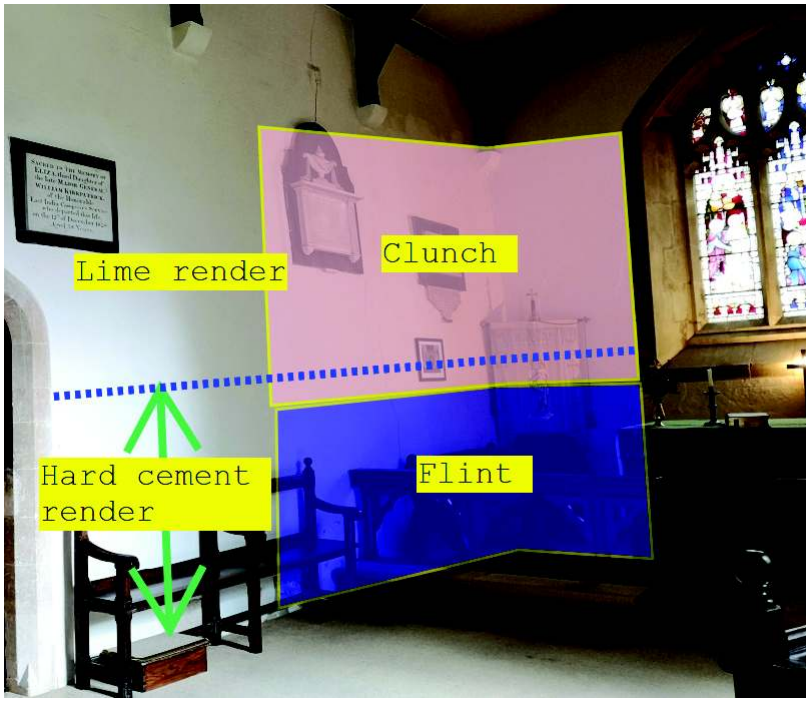


Figure 5.11– findings of the wall make up in the chancel north east wall corner .

Fig 5.12 a Flint low level and clunch upper

Fig 5.12 b Example of clunch

Fig 5.12 c Flint walling lowever levels

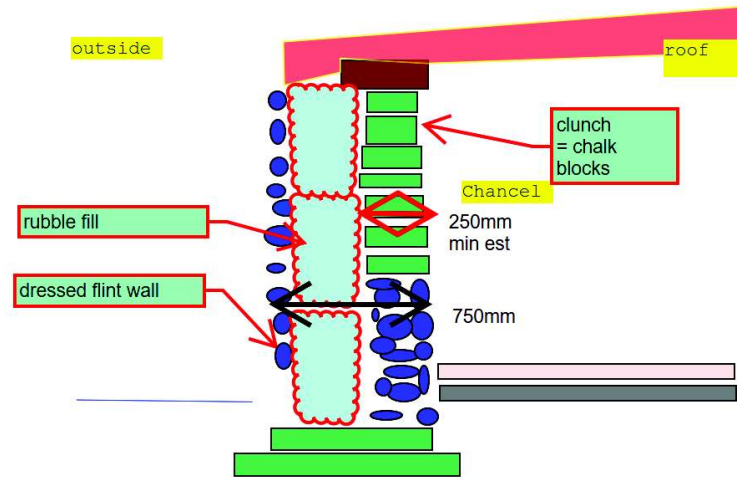


Fig 5.12 d

Figure 5.12 Findings of the wall make up in the north west corner

6 External Findings from investigations spring and summer 2019

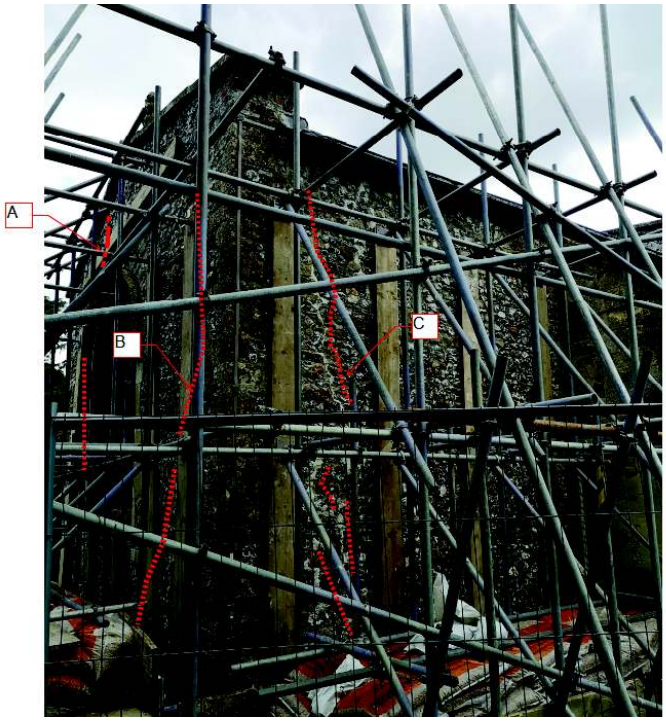


Figure 6.1 view of the North east corner with marked areas of the significant cracks in the flint work.

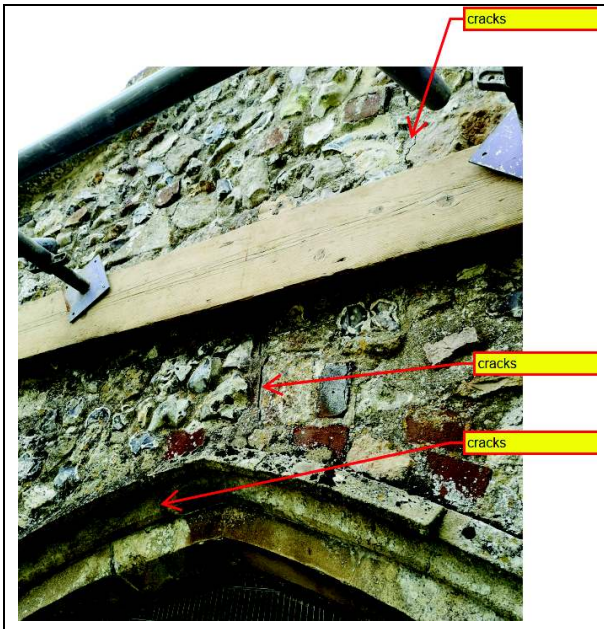


Fig 6.2 a

Fig 6.2 b

Fig 6.2 c

Fig 6.2 d

Figure 6.2 – East gable cracks above window highlighted - crack widths vary from 2 to 5 mm. Loose failed mortor opened up cracks to suggest larger crack widths.

6.1 At the instruction of Milner Associates in May 2019 temporary lime putty mortar was installed into the significant cracks to stop the loose dry lime and sand fill from migrating out of the cracks. In addition flints were loose and progressive failure would have occurred without intervention.

6.2 It has been noted that during the inspections that the scaffold has become detached from the walls. This is considered due to the combination of the ground to which the scaffold is bearing is drying and shrinking and the weight of the scaffold pushing in to the earth and graves below.

6.3 The scaffold currently is providing restaint to the bulging flint work to the north corner.

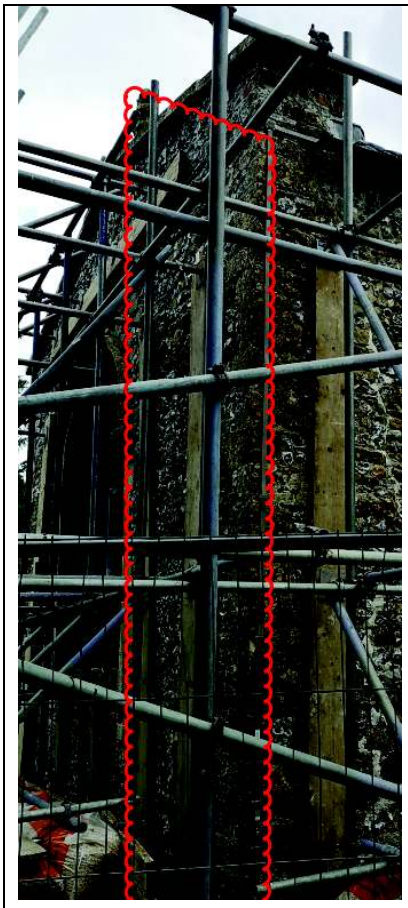


Fig 6.3 a

Fig 6.3 b

Figure 6.3 – North East corner east wall gable - crack widths vary from 2 to 10 mm. Loose failed mortor opened up cracks to suggest larger crack widths.

Fig 6.4 a

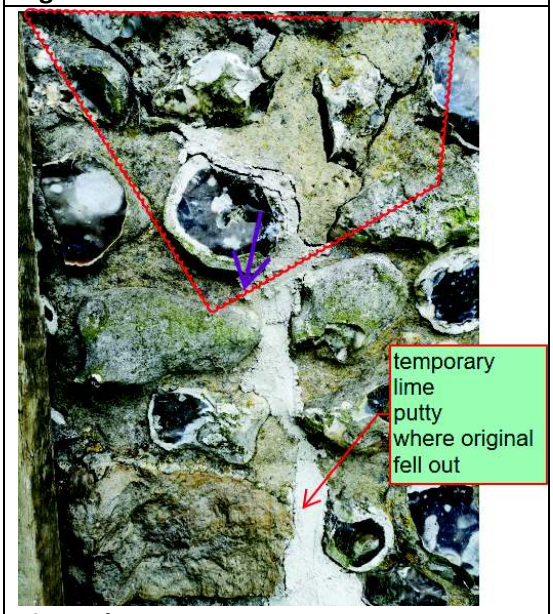


Fig 6.4 b

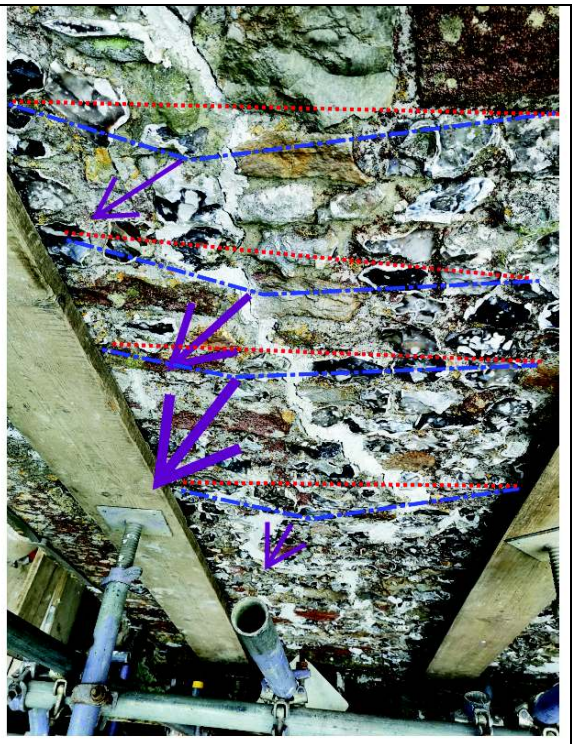


Fig 6.4 c – bow outwards 20 to 40mm

Figure 22 – East gable cracks highlighted - crack widths vary from 2 to 10 mm. Loose failed mortor opened up cracks to suggest larger crack widths.

6.4 At the instruction of Milner Associates in May 2019 temporary lime putty mortar was installed into the significant cracks to stop the loose dry lime and sand fill from migrating out of the cracks. In addition flints were loose and progressive failure would have occurred without intervention.

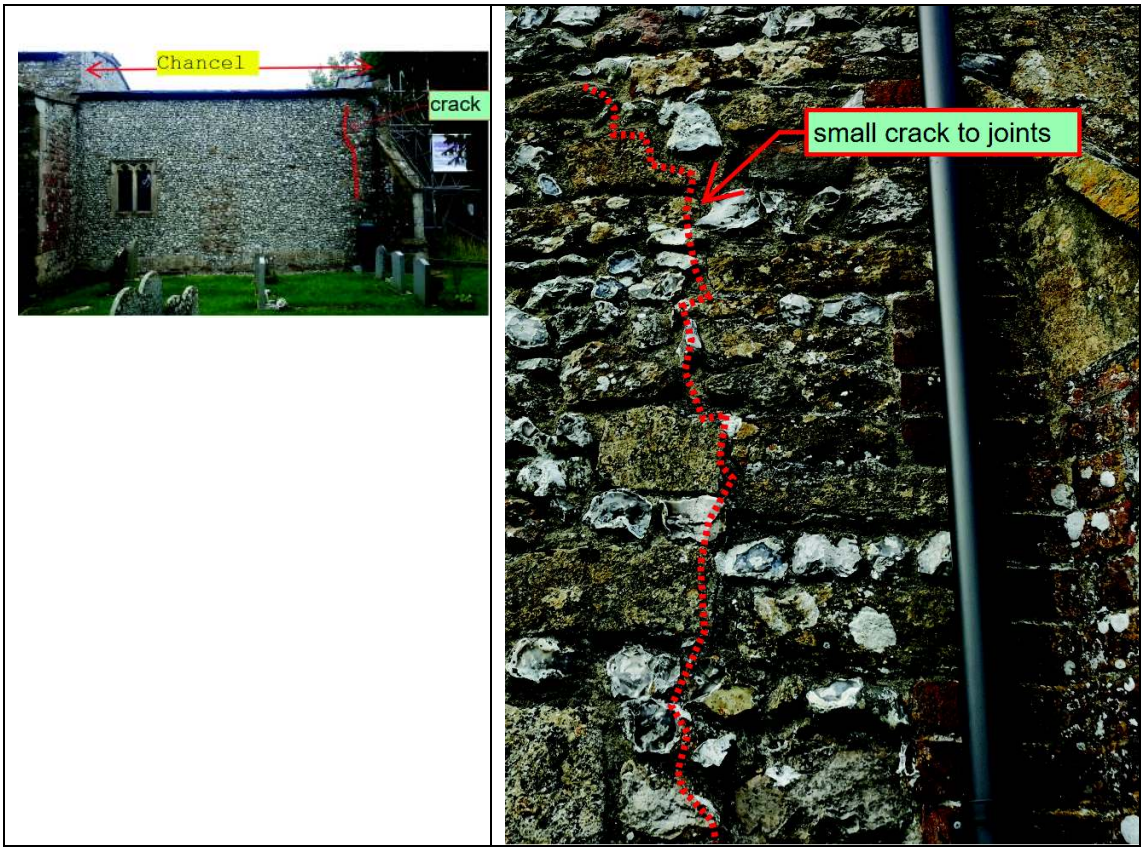


Figure 6.5 – south wall externally (photo August 2019) showing crack (1-2mm) noted during April 2019 visit.

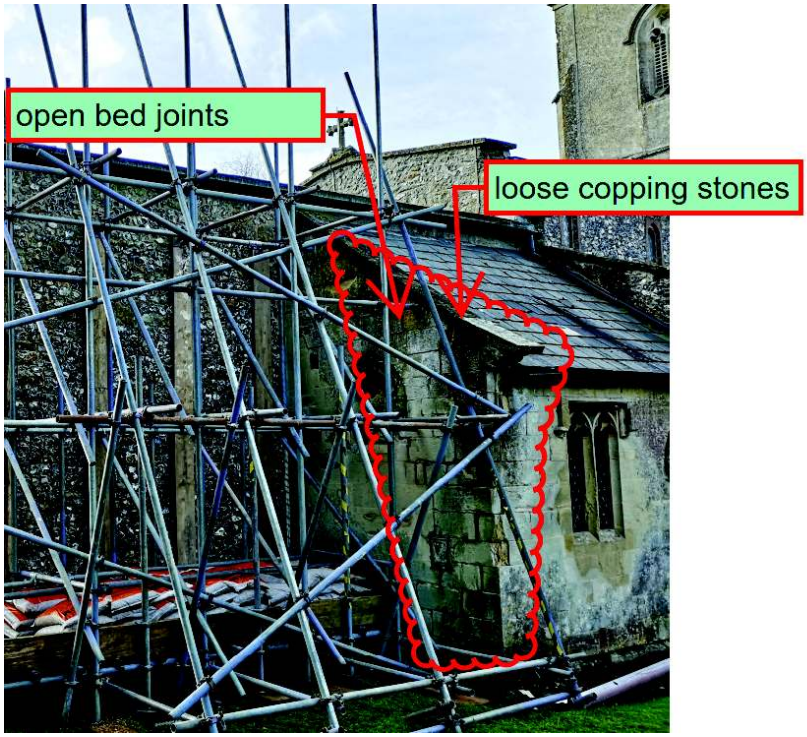


Figure 6.6 – Vestry wall externally (photo August 2019) showing cracks loose copping stones.

7 Ground conditions known

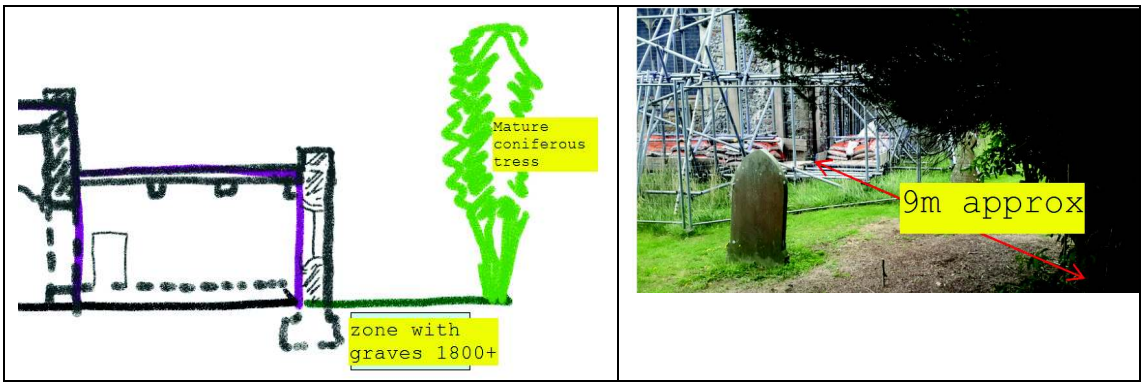


Figure 7.1 – externally there are mature tress within 9 m of the chancel. The ground as noted from the walk over inspections shows the ground to be uneven but this may be due to the graves collapsing over time. Note that there are decious trees in the neighbours gardens.

7.1 The published geology shows the site to be underlain by:
7.1.1 Clay with Flints Formation – Clay, Silt, Sand and Gravel
7.1.2 Seaford Chalk Formation – Chalk
7.1.3 Note that the reports from the grave digger are that chalk is to be found at some 1.5m depth.

7.2 Trial pit inspection found the clay with flints from about 300mm below the current external ground level. The clay was found to be under the chancel wall foundations at about 750mm below ground level. Milner Associates techncial note 2 provides findings from the trial pit inspections.

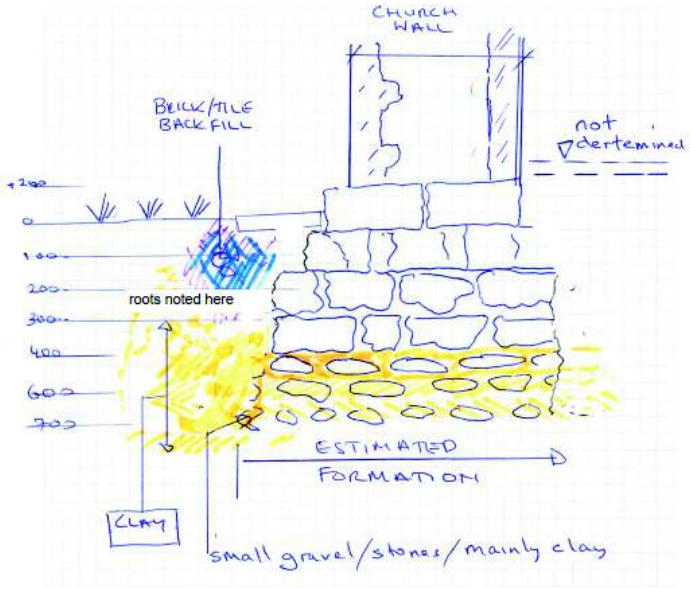


Figure 7.2 – Chancel foundation bearing cross section

7.3 The findings of the trial pits provide confirmation of the clay soils below foundations. Further tests are needed for the plasticity of the clay to determine its propensity to ground moisture movements.

7.4 The ground bearing capacity of the clay with flints is high and easily capable of supporting the church structure.

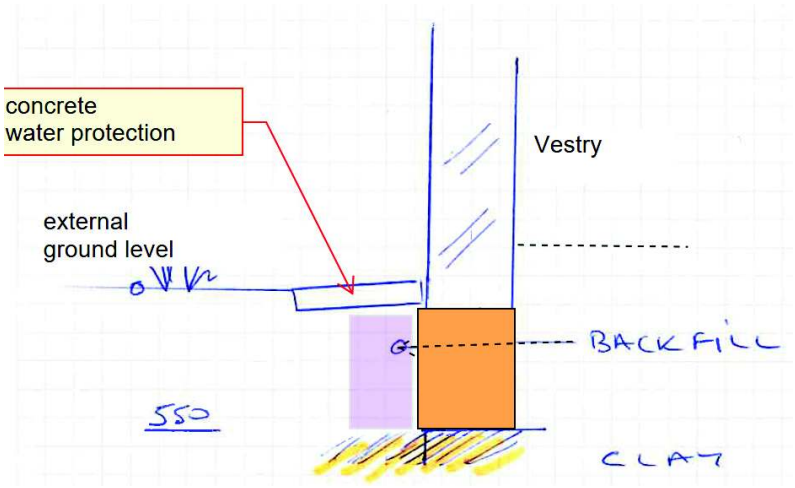


Figure 7.3 – Vestry foundation bearing cross section

7.5 In Milner Associates experience the clay will be sensitive to significant ground moisture changes that will occur in dry summer periods.

7.6 The foundation levels for the chancel will be subject to less movement than the vestry as it is founded deeper. However, the presence of the mature coniferous trees and deciduous trees from the neighbouring garden will create conditions where more moisture will be withdrawn from the clay in dry summer periods.

7.7 Coniferous trees are considered in the main to be high water demand trees but can be classed as moderate. The trees appear to be a form of Redwood and for the purposes of the assessment taknen as moderate water demanding trees. The soil is considered to be medium shrinkable but tests are needed to determine this.

Clay shrinkable classification	Tree water demand for mature 20 m tree	Minimum foundation level to NHBC guidelines with a tree at	
		9m distance	15m distance
Medium	Moderate coniferous	1.45m	0.9m
Medium	Low	0.9m	0.9m
Low	Moderate	1.2m	0.75m
Low	*Low*	*0.75m*	*0.75m*

7.8 The best case is low shrinkable clay and low water demand, but this is not considered likely. The more likely position is at best low / moderate requiring a corner foundation at 1.2m and at worse medium / moderate needing 1.45m depth for the chancel corner and 0.9m for the vestry.

7.9 Location of graves around the north east ground area local to foundations is not known. It is not unknown for graves to be dug close to a church wall but from what we can see from current grave markers this does not appear to be the case here. However, records show that there was a row of graves allocated along the east gable wall line.

7.10 Internally it is understood that no tomb or crypt or grave is present in the gable wall area. This is not proven, and significant investigations will be needed to determine this. The rebuilding of the vestry in the 1600s and remodelling in 1800s does not suggest tombs and crypts and the distress to the walls is not suggestive of this kind of foundation interference.

7.11 Structurally it is possible that a grave can undermine a church wall foundation but the walls being at 750 mm below the external ground level a continuous close row of graves would be needed which for logistical reasons of grave side wall stability is not normal.

7.12 There is no signs to suggest the wall movements are related to grave collapse or undermining of the foundations.

7.13 The presence of graves shall be considered in the remedial works.

8 Surrounding area and buildings

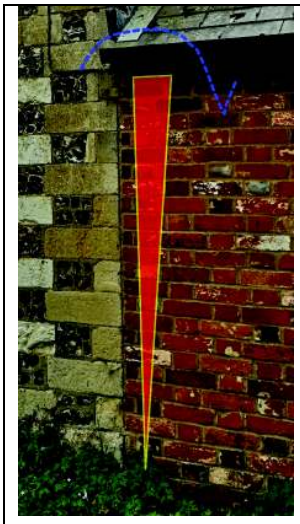


Fig 8.1 – signs of foundation movement on building next to church

Fig 8.2 – signs of foundation movement on building next to church

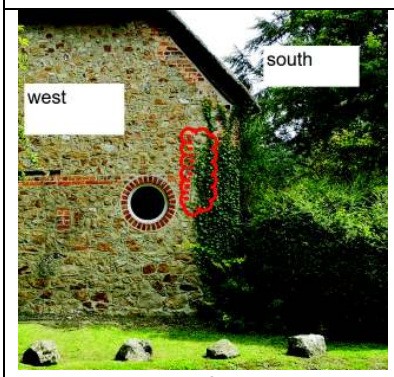


Fig 8.3 – signs of thermal cracking on new hard clunch building near by the church

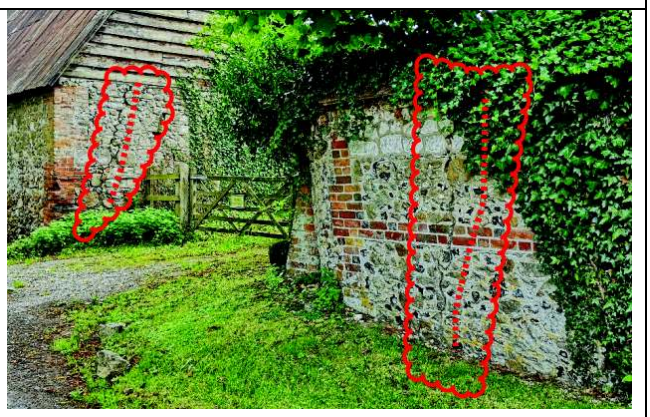


Fig 8.4 – signs of foundation movement and thermal movements on clunch and flint walls near to the church

8.1 A brief walk around the neighbouring buildings to the church was carried out to look for historic building techniques common to the area and ones that might support the theory of the cause of the distress being witnessed on the Chancel and Vestry.

8.2 The surrounding buildings are all of an later build period than the church chancel but the signs of distress caused by founndation and thermal expansion of similar materials are evident.

8.3 Most interesting is the farm buildings next to the church that have the same approach to building the Chancel walls of flint at lower levels and soft clunch blocks at the upper levels.

9 Summary and recommendations

9.1 Foundations

9.1.1 The cracks to the chancel and vestry are consistent with seasonal induced movements.

9.1.2 The ongoing year on year movements has resulted in fatigue of the lime bonded stone walls in the Chancel North West corner and in the north gable wall of the vestry.

9.1.3 For the Chancel this fatigue occurs in the flint and clunch with rubble filled cavity. The current external loose flint panels and outflow of some small rubble filled bonding suggests progressive failure.

9.1.4 Foundation movements due to clay soil

9.1.4.1 The seasons create ground moisture changes and this with clay soils present under the church can cause foundation movements.

9.1.4.2 The clay soils found under the buildings footings is vulnerable to moisture changes in that it will swell on wetting and shrink on drying. In depth laboratory tests are needed to demonstrate this and determine the level of vulnerability.

9.1.4.3 Tree roots can remove water and large trees found near to the corner (within 9m) is likely to influence the soil conditions.

9.1.4.4 Soil investigations are needed but it is considered likely that the minimum foundation depth should be at least 1.2m at the corner of the chancel and the vestry should have at least 0.9m compared with .75m and .5m deep footings.

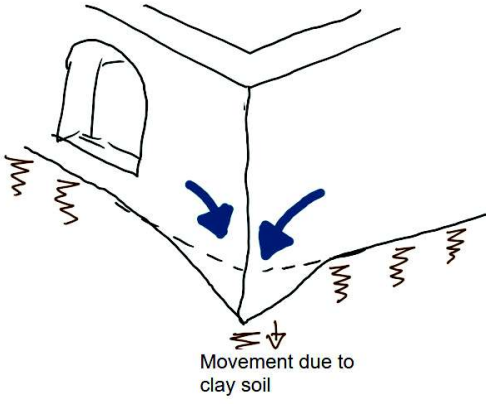


Figure 9.1 Diagramatic elevation of the movement on the Chancel from clay soils

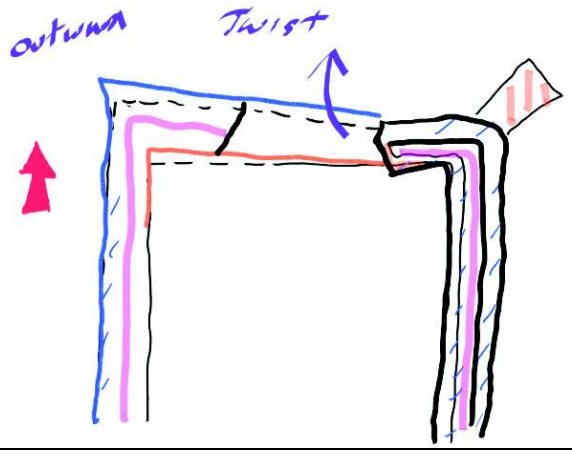


Figure 9.2 Diagramatic Plan on Chancel East wall

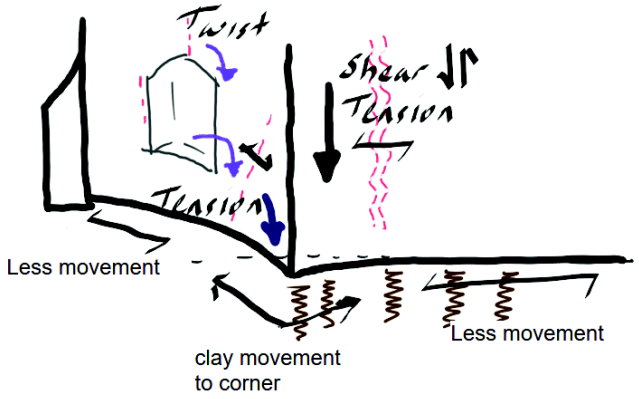


Figure 9.3 Diagramatic summary elevation of the movement on the Chancel from clay soils

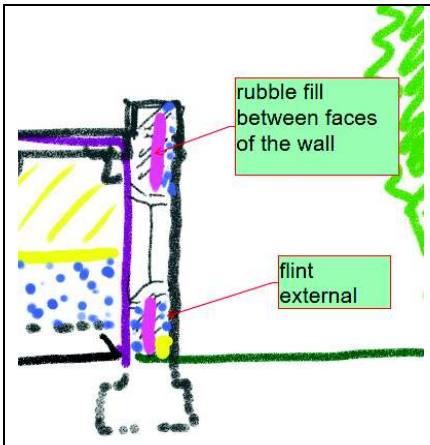
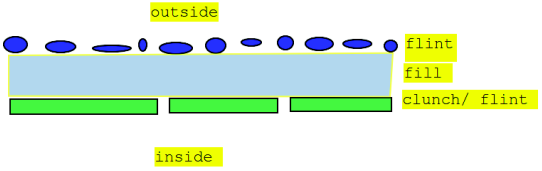
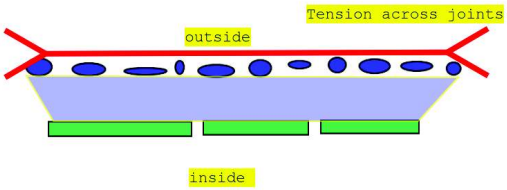
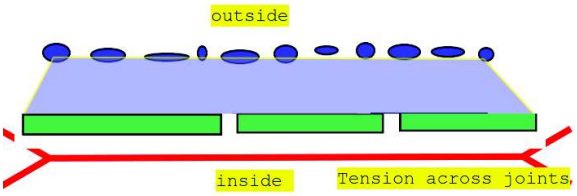
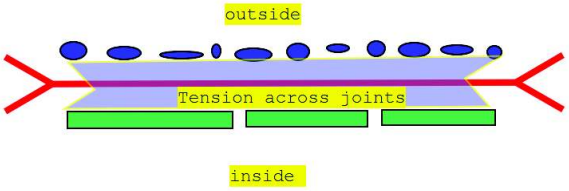
9.1.5 Foundation movements due to grave / tomb undermining

9.1.5.1 There is no evidence so far of undermining by graves or tombs/ crypts. A detailed grave review is needed on the east elevation.

9.1.6 Stone thermal movement

9.1.6.1 The summer months the air can heat up walls and cause them to expand. The internal face of the church walls will be significantly cooler than the external walls in the summer months and warmer than the external walls in the winter months.

9.1.6.2 The chancel walls being of substantial thickness will show more signs of thermal movement as noted below in figure 9.1

 Section of wall to the chancel	9.4 section of wall with the different materials through the wall.
 Diagramatic plan on wall	9.5a As built – diagrammatic view of tension in the wall. Parallel stone work inside and out side
 Diagramatic plan on wall	9.5b Summer months : Heated external skin Reduced heat internally
 Diagramatic plan on wall	9.5c Winter months Cold external Warmer internal
 Diagramatic plan on wall	9.5 d General thermal expansion of the wall creating tension through the wall

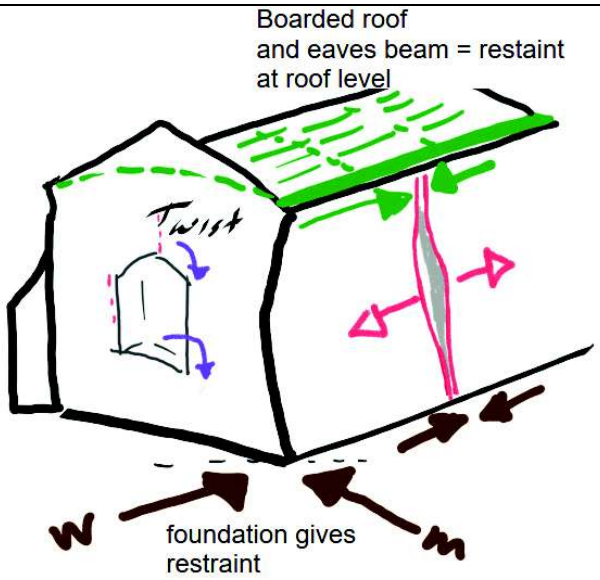


Figure 9.6 – diagramatic view of the chancel wall subjected to thermal movement due to different temperatures from inside to outside. Plus the restraint to the movement at the top and bottom of the wall.

9.1.6.3 The change in temperatures in the walls can cause differential expansion and contraction which in turn causes fatigue at masonry bonding.

9.1.6.4 Foundations provide a stabilising buttress and roof eaves plates create tie forces at this level. The mid span of tall walls is relatively free to move and larger cracks can occur at the centre as noted at the chancel wall.

9.1.6.5 The south side is the most sensitive to thermal expansion with the mid-day sun being present on the wall. There is a buttress on this wall at the east and this may be having been introduced to stop tension crack failures in this wall. In addition, the winter sun may keep this wall more in line with the thermal level of the internal skin of wall and so the seasonal differences may not be as great as the north facing wall.

9.2 Recommended remedial works to the Chancel

9.2.1 After considering the progressive movement and distress the remedial works required are to provide a buttress and underpinning element at the North east corner. Initial remedial works will be developed further in Milner Associates Technical note 4.

9.2.2 Additional works to repair the “bursting” flint panel to the northern corner is also recommended and this work will occur before the buttress and underpinning due to the urgent need of this repair to install integrity back to the wall.

9.2.3 Without intervention now to the flint walls at the corner they will fail and progressive defects to the Chancel occur.

9.2.4 In addition, the lime stone frame to the east gable stain glass window, that was installed in mid nineteenth century, has signs of past and current

distress. The current distress is located at the key stone and tracery stone work in the form of opening joints; these joints should be under compression and not tension as currently observed.

9.2.5 Without intervention within the next 18 months there may be damage to the stain glass and onward distress to the stone work.

9.2.6 The scaffold to the gable is not providing any current support other than stopping the north facing flint walling from bursting. The scaffold is in the way of remedial works and access, and with recommended internal propping and external flint panel work bracing should be removed. See technical note 4 for initial recommendations for temporary works.

9.2.7 Recommended remedial works to the Vestry

9.2.8 The vestry to the side of the north wall of the chancel, built in mid nineteenth century is on shallow foundations on to clay that is subjected to seasonal movement. The up and down movement of the outer north east corner has caused the east gable verge stone work to become loose and needs repair. As the roof connects to the verge stone work water ingress at this junction is inevitable and progressive decay of the building fabric in this area will occur.

9.2.9 The need for underpinning is still to be considered as it has survived adequately without this need but the rebuilding of the stone work to the roof verge line is needed with tying back to reinforce it. Initial remedial works will be developed further in Milner Associates Technical note 4.

9.2.10 Without intervention there will be ongoing distress to the verge and it is not unforeseeable that stone work copping stones may fall. Onward damp problems of water ingress will continue until the area of Vestry is remediated.

9.3 Summary Recommendations

9.3.1 Initial recommendations for remedial works will be presented in Milner Associates Technical Note 4.

9.3.2 Further investigations are recommended to obtain more technical data on the soils below the church in understanding the clay level of sensitivity to moisture changes and in finding the depth of the chalk bed.

9.3.3 Mapping of actual grave locations should be carried out as best can be done from the surface.

<End>