DRAFT

St Katherine's The Danish Church
Structural Appraisal of Pinnacles

Prepared for

The Danish Church

November 2015

1.0 INTRODUCTION

This structural engineering appraisal has been prepared by Alan Baxter Limited (ABA) and relates to the two masonry pinnacles on the west elevation of the St Katherine's, The Danish Church in London (see photo 01).

We were approached by Mal Fryer Architects (MFA) to appraise the existing structure and propose the structural principles of a repair scheme to the pinnacles following concerns being raised regarding their structural condition as a result of corrosion due to an assumed wrought iron band.

No opening up works have been done to confirm details and the condition of the existing structures and this appraisal is based on observations made from a cherry picker during a site visit on 4th October 2016. It was possible to access the inside of the pinnacles just below the tracery level, but we have not been able to establish the thickness of the stone.

Further investigation works and a survey of the inside of the pinnacles will be required in order to confirm the assumptions made in this appraisal.

The structure is grade II* listed.

2.0 EXISTING STRUCTURE

ABA's understanding of the existing south tower is shown on drawings 1601/212/01, and is summarised below. The north tower appears to be very similar.

2.1 The Towers (below the traceries)

The two octagonal towers are constructed from loadbearing brickwork faced in Bath stone. Places where facing stonework has failed, has revealed that the stonework is not keyed into the brickwork, but held together with wrought iron cramps. This is an unusual detail.

The thickness of the brick work in the tower changes depending on the height, at the base it is understood to be two bricks thick, below the traceries it is a brick and a half.

The towers are likely to get overall stability from the nave walls.

2.2 The Traceries

The traceries comprise two levels of tracery each approximately 2.4m high. Between the two levels is an iron band (assumed to be wrought) coated in lead and set into the stonework between bed joints.

The stonework in the traceries are straight bonded and is understood to be solid Bath stone (see photo 07). The main components of the traceries are corner columns, mullions and panels. The use of straight bonded masonry is very unusual and compromises the pinnacles ability to work as shell. Instead the various components of the pinnacle should be considered as a 'stack of stones' or column, with little or no restraint except at the level of slab and wrought iron band.

Internally between the traceries, two wrought iron braces can be seen (see photo 02). These are likely to connect to the band and tie the straight bonded stone columns back to the properly bonded rear (undecorated) walls of the pinnacle at the same level as the traceries. The purpose of this strap is to tie the "stack of stones" together. It is therefore an important element of the structure.

At the top and bottom of the tracery level there is a stone slab inside the pinnacle. This too is likely to be performing a structural action, in that it restrains the top of the walls.

2.3 The Spires

The spires are constructed from a different stone, possibly Portland Stone. It was not possible to access the inside of the spires. The base of the spire will be restrained in some way against kick-out forces. It seems unlikely that this restraint could be provided by the slab alone and therefore seems reasonable to assume there could be more metal/ironwork helping to tie the base of the spire together.

Based on what we know of similar structures, it seems likely that the top portion of the spire is solid and is held together by a rod. Whether this rod is connected to the copper finial, or separate is impossible to tell at this stage, but it is likely to be wrought iron.

2.4 Later Repair

Large areas of stonework have been refaced in at least two distinct phases. The first phase is understood to have been around the mid-20th Century and appears to have used a cementitous based repair with copper dowels. The later phase is likely from around the 1980s and appears to use more lime based repair.

3.0 OBSERVED DEFECTS

The assumed wrought iron band, between the traceries has corroded, causing the stonework to spall, leaving the ironwork further exposed. This process has jacked the pinnacles up by around 3-4mm (see photos 03-06).

Globally, the jacking appears to be uniform on all faces and has caused the stonework to part along its horizontal bed joint.

Locally the jacking has caused some stone elements to move out of plumb, as shown on drawing 1601/212/01.

The extent of jacking is similar in both towers, however the amount of exposed ironwork appears to be more on the north tower, this is understood to be due to a recent removal of failed re-facing by a stone mason on north tower only.

In many locations the later re-facing has failed and is coming away from the stonework behind. Due to extent of the re-facing it is not possible to comment generally on the structural condition of the stonework behind, however where exposed no cracks in the stonework were noted. The cracks in the re facing can generally be traced back to a parting in the joints.

4.0 DISCUSSION

The jacking due to the corrosion of the ironwork cannot be reversed nor is it possible to fully treat all the existing ironwork in-situ in order to prevent further corrosion. Without action the iron will continue to corrode, probably at an increasing rate. There will come a point at which the ironwork will not be adequate to perform its structural action and result in potentially serious damage to the pinnacles.

In light of this, we consider that the iron band needs to be removed and its structural action replaced with a new stainless steel member.

There are two ways in which this could be achieved:

4.1 Rebuilding the Pinnacle

In light of the evidence above, this is the approach we recommend.

Rebuilding the pinnacles would enable all the ironwork to be removed, including any likely ironwork within the spire. This option would also provide an opportunity to address any other defects in the structure currently unseen.

4.2 Replacing the ironwork in-situ

We have been asked to consider this approach because it may offer a cost saving. Our understanding of how this could be sequenced is shown on drawings 1601/212/03, the principles of which are summarised below.

Stage A

- External scaffold constructed as required and braced to existing nave walls.
- External bracing added around the pinnacles above and below the existing wrought iron band.
- Internal working platform added, bearing onto existing masonry.
- Existing stone slab to be propped as required.
- Survey points to be set up for continual monitoring

Stage B

- Pack out parting in stonework around pinnacles, inside and outside to reduce bearing stresses in stonework.
- Inside face of stonework to be prepared and 2No new stainless steel ring beams installed, above and below existing wrought iron band, resin anchored to each stone. (This is subject to confirmation of the internal condition of the stonework.)
- Stainless steel ring packed tight to stones and to be erected in sections.
- Cut out existing wrought iron brace inside pinnacle.

Stage C

Following stages A-B each stone will be worked on individually or in max 300mm wide sections (whichever is the smaller). Below is a suggestion as to how this sequence is to be carried out:

- Cut out existing stone immediately above existing wrought iron band.
- Remove wrought iron embedded within stone.
- Replacement stone to be laid.
- Top of stone to be pinned up tight to masonry above.

A suggestion of the sequence of stones to be worked on would be:

- Non-decorated solid ashlar rear face
- Panel sections
- Mullion sections
- Rear corner column sections
- Corner/column sections

5.0 RISKS

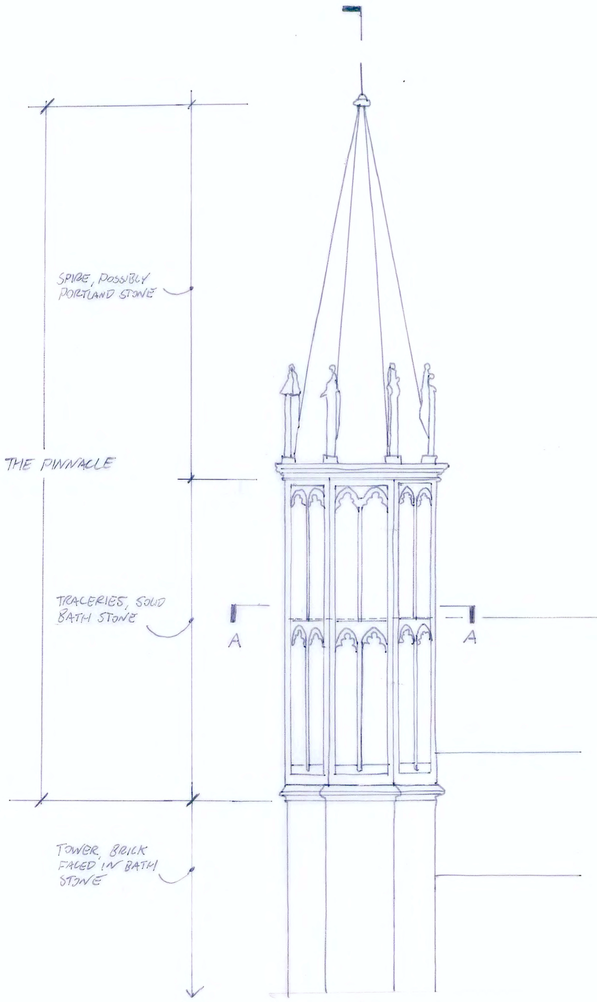
Patently both options come with risks associates with works of this nature, however we consider that removing the wrought iron in situ carries some additional risks which need to be considered.

1. Additional ironwork is likely to exist within the spire, which will have a finite lifespan, and may require significant work at some point in the future.
2. The proposed work will have a significant effect on the existing load paths within the structure. This could require some additional localised repairs/strengthening works, particularly to the straight bonded sections of stonework which are likely to be the most vulnerable.
3. The structure is already known to be very unusual in its construction and so there is a high risk of escalation if further defects of the structure are uncovered part way through the works. This could involve the works becoming equivalent to full dismantling and rebuilding in any case.
4. We have assumed that the ironwork is located between bed joints and can be removed, by cutting out the stonework above. Should the ironwork be connected to the stone below it may be necessary to remove this as well. In the traceries, this stone is highly carved/decorated.

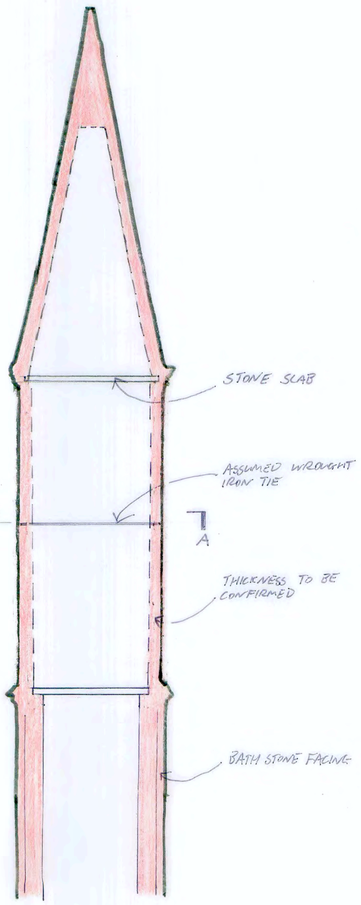
6.0 CONCLUSIONS

The form of these pinnacles is unusual in having straight bonded stonework. This makes them rather delicate. The original builders appear to have recognised this and provided an iron band at mid-height to introduce additional robustness. This ironwork is crucial to the structure of the pinnacles but is now badly corroded. This corrosion cannot be halted and will eventually lead to complete failure of the ironwork, and potentially serious damage to the pinnacles. This situation now needs addressing. The only practical approach is to cut out the ironwork and replace it with a stainless steel band. Doing this without dismantling the whole pinnacle may be theoretically possible, but it has a high risk of escalating with little warning into a complete rebuild. For this reason our advice is that it would be more appropriate to plan for a full rebuilding. Much of the existing stonework could probably be re-used and this would also allow other as yet unseen ironwork to be replaced. If reconstruction in situ is to be attempted a substantial contingency will be needed to try to cover the risk of escalation.

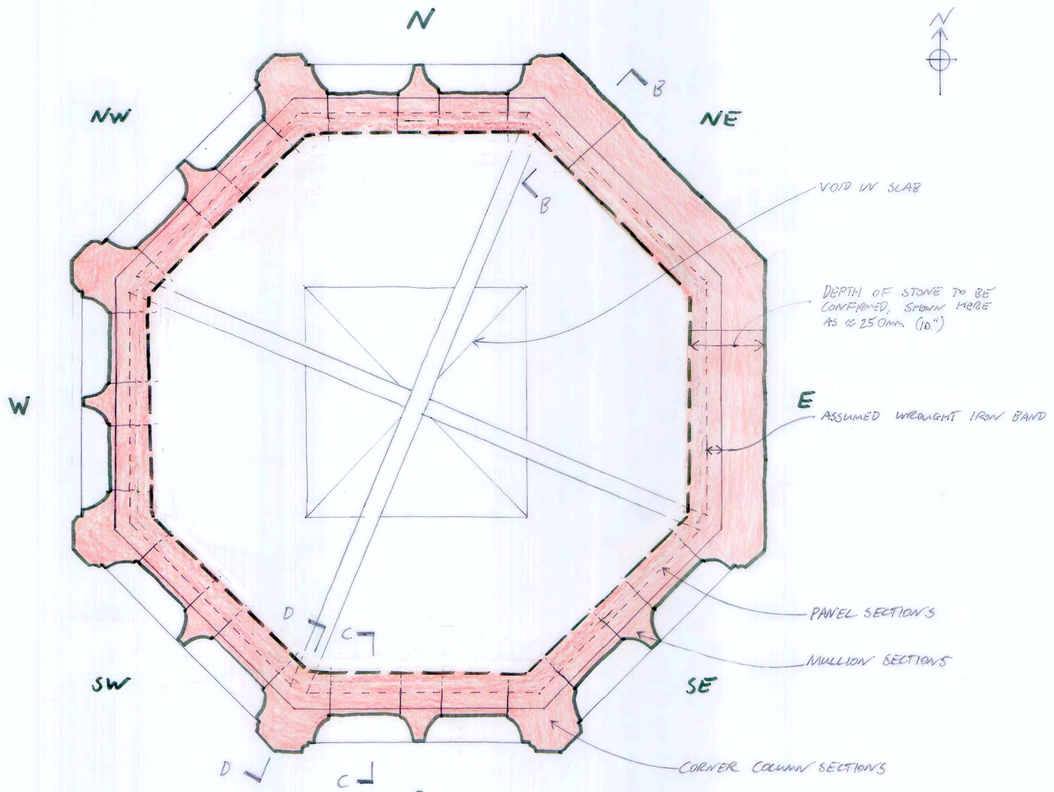
Appendix A existing structure drawings



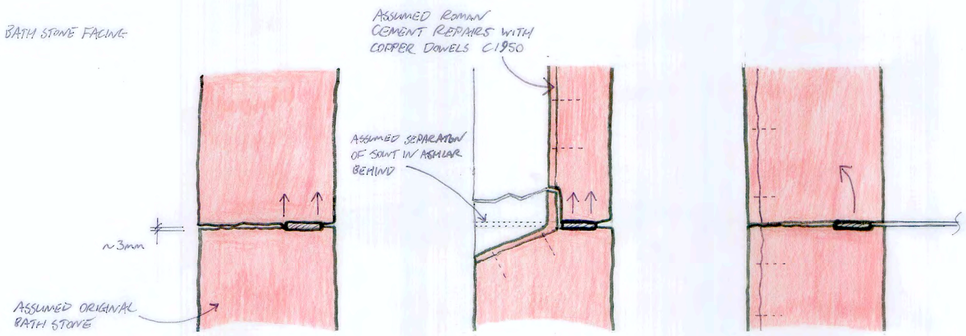
SOUTH TOWER SOUTH ELEVATION
1:50



SECTION
1:50



PLAN A-A
1:10



PUSHING UP
DETAIL B-B

PUSHING UP
DETAIL C-C

PUSHING UP (OVER TURNING)
DETAIL D-D

notes

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS AND ENGINEERS DRAWINGS AND THE SPECIFICATIONS.
2. THIS DRAWING IS BASED ON SITE OBSERVATIONS MADE 04/10/16.

A	4.11.16	ISSUED AS PART OF REPORT	FGo
–	27.10.16	ISSUED FOR INFORMATION	FGo

job
ST. KATHERINE'S, THE DANISH CHURCH

title
SOUTH PINNACLE: PLAN AND SECTION

drawn FGo | checked SBe
date OCT '16 | scale (original - A1) AS SHOWN

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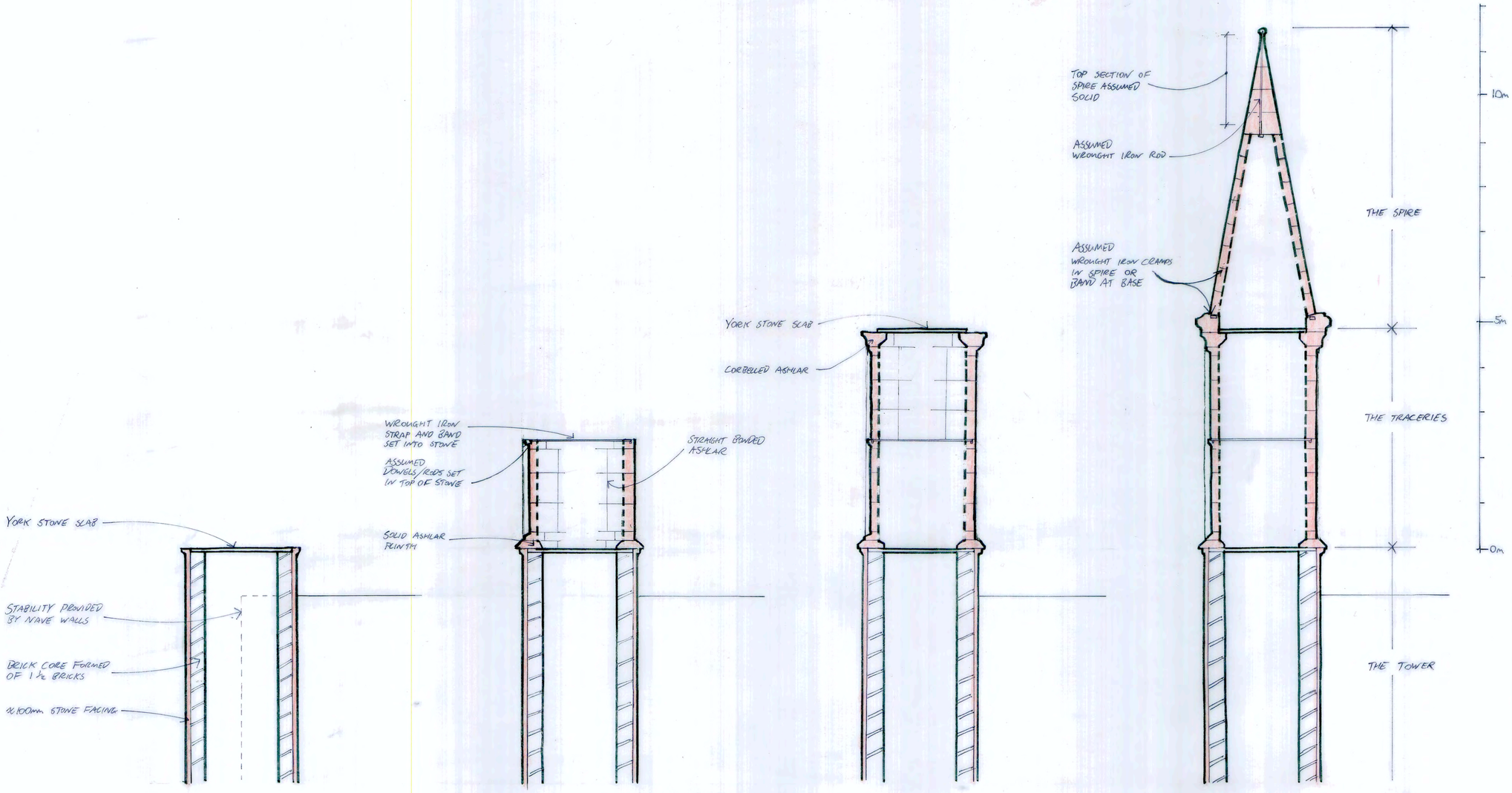
drg. no. 1601/212/01 | rev. A



ASSUMED CONSTRUCTION SEQUENCE OF EXISTING TOWER

notes

1/ THIS DRAWING IS BASED ON OBSERVATIONS MADE DURING A SITE VISIT ON 4/10/16

A	4.11.16	ISSUED AS PART OF REPORT	FGo
–	27.10.16	ISSUED FOR INFORMATION	FGo

job
ST KATHERINE'S THE DANISH CHURCH

title
ASSUMED CONSTRUCTION SEQUENCE OF EXISTING TOWER

drawn: FGo
checked: SBe
date: NOV 2016
scale (original - A1): 1:50

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rev. A

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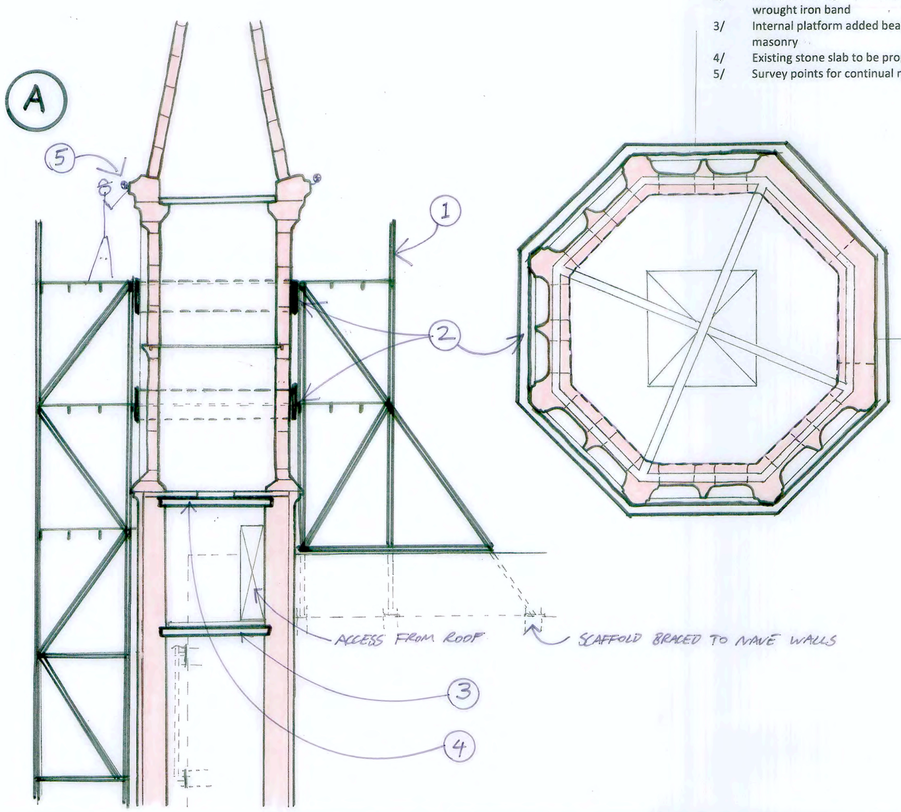
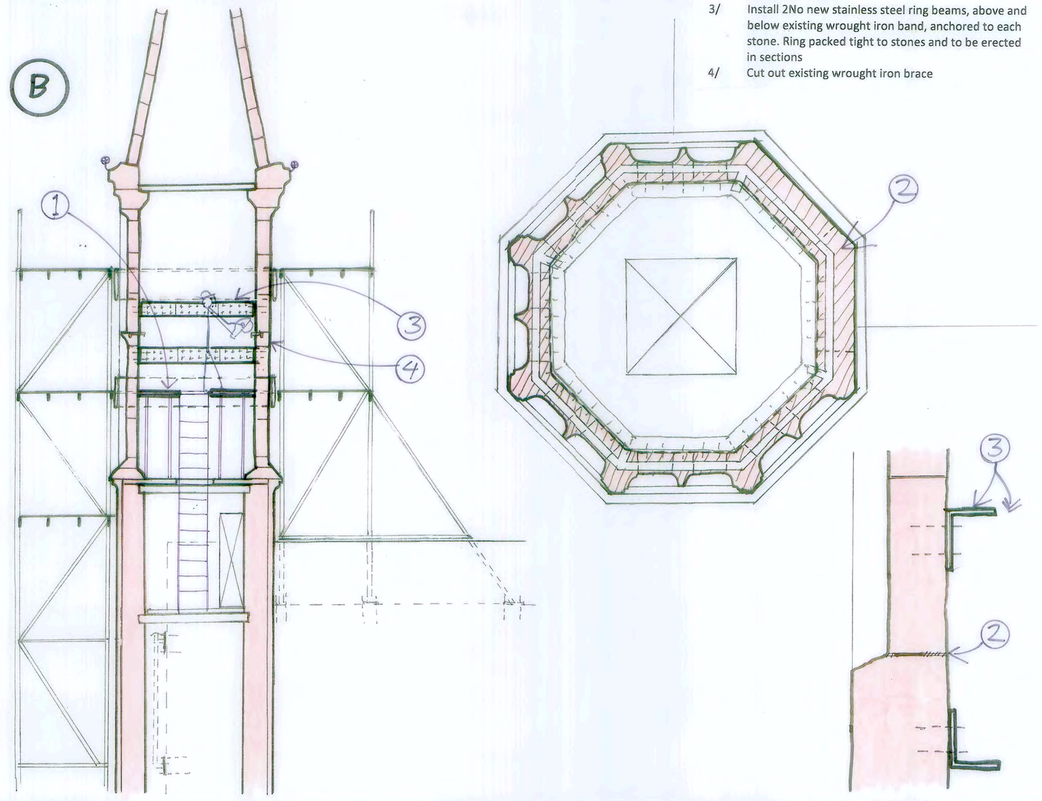


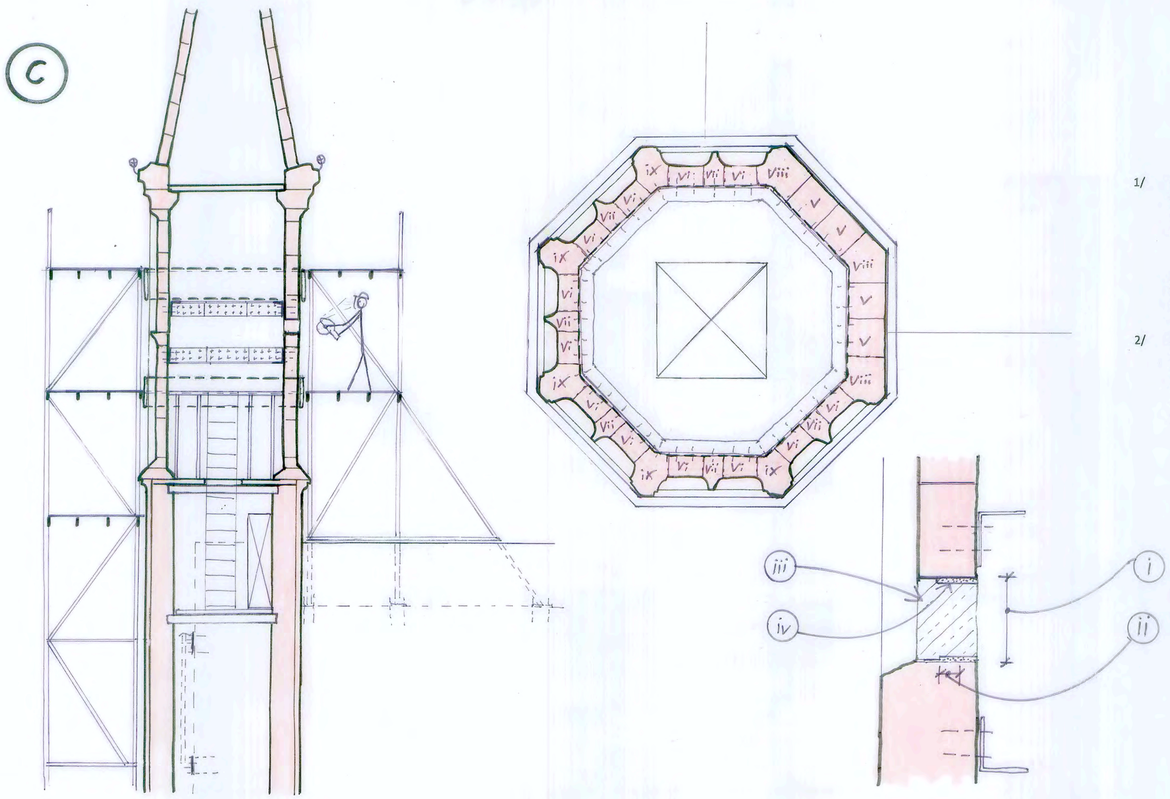
1/ External scaffold constructed as required and braced to existing nave walls
2/ External bracing added above and below existing wrought iron band
3/ Internal platform added bearing onto existing masonry
4/ Existing stone slab to be propped as required
5/ Survey points for continual monitoring added

B



1/ Construct new internal platform
2/ Pack out parting in stonework around pinnacle, inside and outside
3/ Install 2No new stainless steel ring beams, above and below existing wrought iron band, anchored to each stone. Ring packed tight to stones and to be erected in sections
4/ Cut out existing wrought iron brace

C



1/ The Following sequence is to be carried out one stone at a time or in max 300mm wide sections (whichever is the smaller):
- i/ Cut out existing stone immediately above existing wrought iron band. Height of stone to be agreed.
- ii/ Remove wrought iron embedded within stone
- iii/ Replacement stone to be laid
- iv/ Pin up tight to masonry above

2/ Suggested sequence of stones to be replaced:
- v/ Non-decorated solid ashlar rear face
- vi/ Panel sections
- vii/ Mullion sections
- viii/ Rear corner/column sections
- ix/ Corner/column sections

notes

1. *THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS AND ENGINEERS DRAWINGS AND THE SPECIFICATION*

2. *NOTE THAT THIS DRAWING SHOWS AN ASSUMED SEQUENCE OF CONSTRUCTION BASED ON AVAILABLE INFORMATION. THE CONTRACTOR SHALL PREPARE HIS OWN PROPOSALS FOR THE SEQUENCE OF CONSTRUCTION FOR WHICH HE SHALL REMAIN ENTIRELY RESPONSIBLE. THESE PROPOSALS MUST BE SUBMITTED TO THE CONTRACT ADMINISTRATOR PRIOR TO THE COMMENCEMENT OF THE WORKS*

-	4.11.16	ISSUED AS PART OF REPORT	FGo

job
ST KATHERINE'S THE DANISH CHURCH

title
ASSUMED SEQUENCE OF REMOVING THE IRONWORK IN SITU

drawn: FGo
checked: SB
date: NOV 2016
scale (original - A1): AS SHOWN

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rev. -

Appendix B Selected Photographs

Photo 01 – west elevation showing the two towers

Photo 02 – south tower, looking up inside traceries (note assumed wrought iron brace)

Photo 03 – north tower, spalled stonework and repairs revealing assumed wrought iron band behind

Photo 04 – north tower, parting in bed joint, note later repair to side face masking extent of parting.

Photo 05 – south tower, parting in bed joint between traceries (level or wrought iron band)

Photo 06 – south tower, parting in bed joint along non-decorated face (level or wrought iron band)

Photo 07 – straight bonded stonework in tracery

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Reviewed by	Simon Bennett
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Final issued	Click here to enter text.