Derby Diocesan Association of Church Bellringers Consultant's Report	Report DDACB 10/08 Issue 2
Church of St. Peters Belper Design of Sound Control Barrier	Reissue Date 10/3/2009

1.0 Introduction

1.1 This report provides the technical details to support an application for a faculty by the PCC to replace the existing bell sound control system with a safer and better engineered system. Local and invited ringers have long recognised that the 8 bells are suitable for practising advanced ringing methods, often in the form of peals which can last in excess of 3 hours. A sound control system was fitted many years ago to enable ringers to do this without imposing on the tranquillity of the neighbourhood. Replacement of this system is now essential for the following reasons.

- It presents a hazard to safe access to the top of the tower e.g. when there is a need to fly a flag.
- With the passage of time, the structural and functional integrity of the system has seriously degraded.

1.2 Access to the top of the tower is gained through the bell frame and requires the top of the frame to be traversed to reach a wooden ladder set parallel to the west wall. This ladder leads up to a stone platform where a vertical steel ladder continues to the top of the tower. The sound control system makes crossing the frame top, and access to and from the ladder, very dangerous.

1.3 The existing sound control system comprises several counterbalanced plywood doors, each hinged on the north or south tower wall and each carrying a double layer of mattresses. The bell frame is of an “H” frame construction forming a metal “cage” encompassing the bells and when closed, the doors rest horizontally on top of this frame above the bells. Since the tower louvre openings are well above the bell frame, the closed doors block the sound of the bells outside the tower. A system of ropes and pulleys allows opening and closing of the doors to be controlled from the ringing room below.

1.4 The proposed replacement system is supported almost entirely by the bell frame and no significant attachments are made to the fabric of the church tower. For this reason the installation will be reversible should the need ever arise. To provide a comparative noise datum for the replacement system, sound levels have been measured outside the tower at the four compass points with and without the existing sound control in operation.

2.0 Overview of Proposed Replacement System

The replacement is best seen in drawings 2, 5 and 6. A wooden barrier (comprising two skins separated by joists), is installed on top of the upper steel work of the bell frame and contains two opening doors to control external sound levels. These doors are opened simultaneously by means of a single hand-operated winch in the ringing room below. In addition there is a counterbalanced trap door to enable safe access to the top of the barrier (provided the acoustic doors are first closed). The ability to carry out maintenance on the bell installation will not be affected by the barrier.
The design allows installation by a competent DIY team.

3.0 Design Details of Proposed Replacement System

3.1 The bells are supported on thirteen substantial cast iron “H” frames which transfer their loads down into large steel foundation beams set into the tower walls (drawings 1 and 2). The upper ends of the “H” frames are tied together by a frame-work of 3X3X$^{3}/_{8}$ ins steel angle which, being set into the tower walls, remains rigid when the bells are rung. Due to the support given by the cast iron “H” frames, this upper framework is well able to take the weight of the acoustic barrier and can be seen in drawing 2.

3.2 The layout of the new barrier has been governed by two considerations.

- Provision of a safer means of access to the top of the barrier.
- Provision of the smallest acoustic door openings consistent with minimal sound attenuation when in the **open** position. (Small doors are easier to seal effectively and lighter to open).

3.2.1 The largest and most convenient space to gain access through the frame is in the pit of bells 7 and 8. Since (when rung) the bells and their fittings sweep out much of the volume in the pit, it is only possible to provide vertical access via a ladder attached close to the west wall (drawing 2). This in turn determines the position of the trap door in the barrier above. Since the trap door forms part of the acoustic barrier it must be of heavy construction (drawing 7). To aid opening, it is hinged on its north edge and fitted with a rope, pulley and counterbalance weight. Both the open door and its counterbalance mechanism occupy space currently taken by the existing wooden ladder which gives continuing access up the tower. The ladder is therefore moved from the west wall to the south wall where it continues to give access to the stone platform above (drawing 5).

3.2.2 The design approach employed to minimise acoustic door size is to “cover” half of each bell with the barrier unless overruled by other considerations. The need to provide safe access through a trap door results in bells 7 and 8 being the only bells which are more than half covered (drawing 4), although the degree of permanent cover is less than with the existing sound control arrangement. With the existing sound control doors open, the external sound levels of bells 7 and 8 were measured to be the same as for the other bells and so it is concluded that the proposed new system will retain a similar acoustic balance. Applying the above criteria, two identical openings of 965X2290mm result.

3.3 As already mentioned, effective sound attenuation requires the barrier and doors to be of heavy construction and all gaps to be fastidiously sealed. All boarding is of tongue and groove planking laid as two layers, one layer below and one above the joists. The whole barrier rests on acoustic isolating strips placed on top of the bell frame angle iron. The acoustic doors carry heavy duty sealing strip on their closing faces and the trap door incorporates “P” seals on its closing faces. A 10mm gap around the edges of the barrier is sealed to the walls by use of mastic or silicon rubber to allow for expansion and contraction of the barrier.

3.4 The barrier covering comprises 25mm tongue and groove boarding. Drawing 3 shows the layout of the bottom layer and the 47X97mm SC3 timber joists. The voids between the joists are filled with glass wool to help sound attenuation. Drawing 4 shows the top layer of boarding and the “picture frames” which provide a smooth sealing surface for the doors.

3.5 Each of the two doors is carried on four galvanised agricultural gate hinges set east / west near the centre of the barrier (drawings 5 & 6). A central post carries the pulleys and galvanised wire rope which open and close the doors. Simultaneous opening of both doors, plus application of the external winch load via a pulley at the base, ensures there are trivial bending loads on the post. The wire rope passes over a remote surface - mounted pulley and then vertically down the tower through one side of bell pit 3 on to the floor of the clock case below. Here two pulleys transfer the line of the cable to the wall adjacent to the spiral staircase and down to the winch in the ringing room. The calculated maximum load in the wire rope is 168 kg (see Appendix) and so Machine Mart hand-operated lifting winch Model LW250 is used since it has a maximum specified safe working load of 250 kg.

3.6 It is essential that the acoustic barrier does not interfere with maintenance of the bells and their fittings. Successful trials were carried out to demonstrate that the largest wheels (i.e. those of bells 7 and 8) could be easily removed if the barrier were in position. Measurements showed that all stays could be removed except for the stay on bell 8 which will require a 150mm diameter removable (sealed) plug in the barrier (drawings 4 and 5).

4.0 Installing the Proposed New System

In the event that a faculty is granted, the old system will be removed and the new system installed as a DIY project by members of the St Peters ringing team assisted by the Bell Consultants to the Derby Diocesan Association of Church Bellringers. This will ensure that costs remain entirely within the financial means of the local ringers.

Mike Banks BEng CEng MIMechE
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APPENDIX – WINCH CABLE LOAD CALCULATION

Weight of Door (see drawing 3)

Assume density of wood is 609 kg/m^3

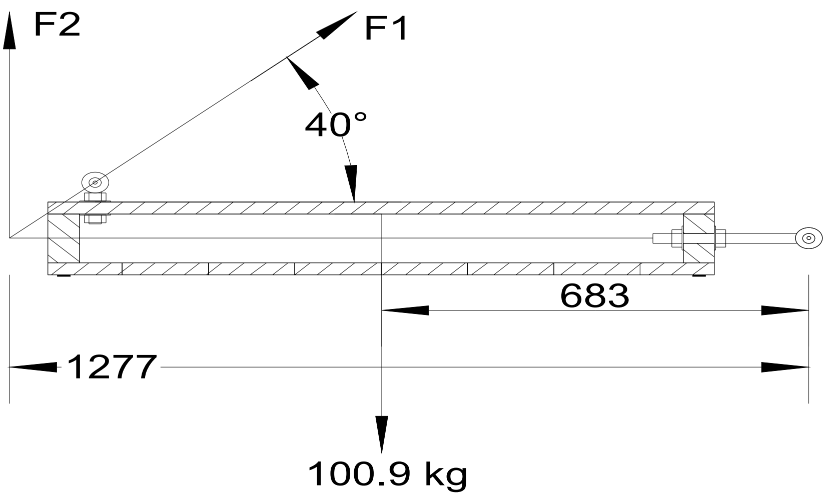
Volume of 50X100 timber in door
= 50X100(1065X2 + 2290X2 + 965) mm^3
= 38375000 mm^3

Volume of T&G boarding in door
= 2X25X2390X1065
= 127267500 mm^3

Total volume of wood
= 165642500 mm^3

Weight of one door = 165642500X609/1,000,000,000 kg
= 100.9 kg

Winch Cable Load – maximum with door closed (see drawing 6)

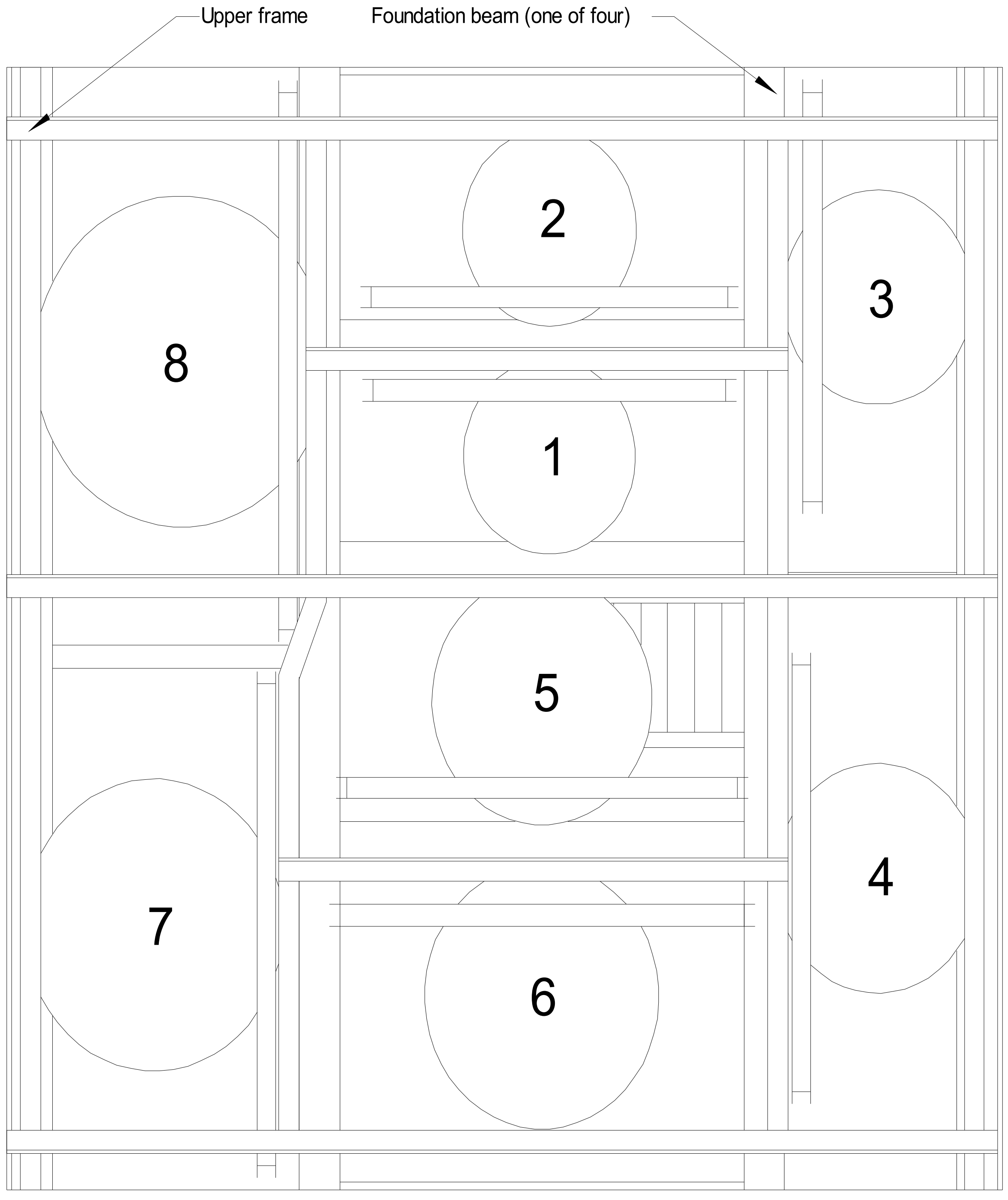


Taking moments about hinge

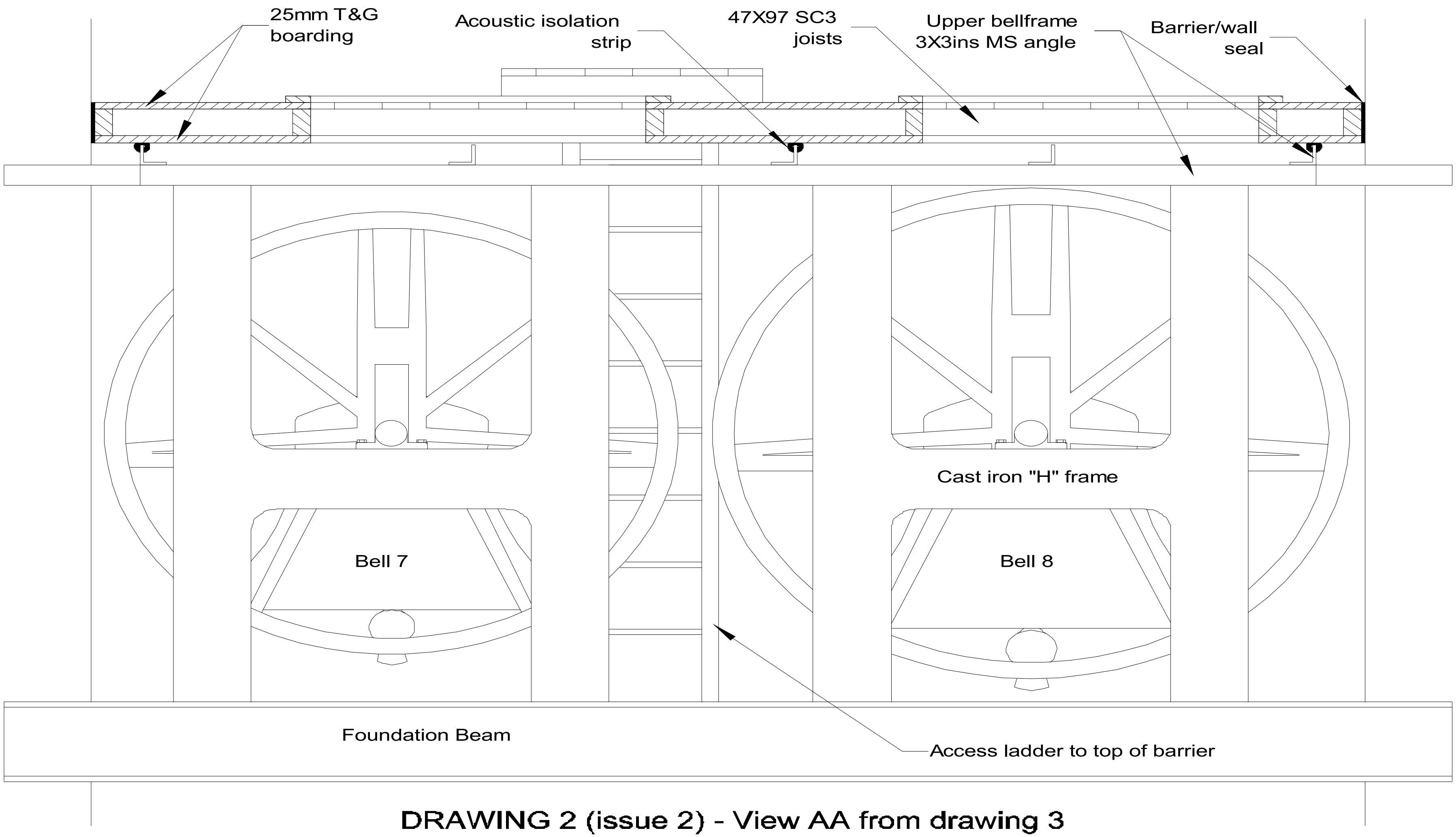
1277 F_2 = 100.9X683 (where F_2 is the vertical component of F_1)
F_2 = 53.97 kg

$F_2 / F_1 = \sin 40^\circ$
$F_1 = 53.97/\sin 40^\circ$
= 84.0 kg

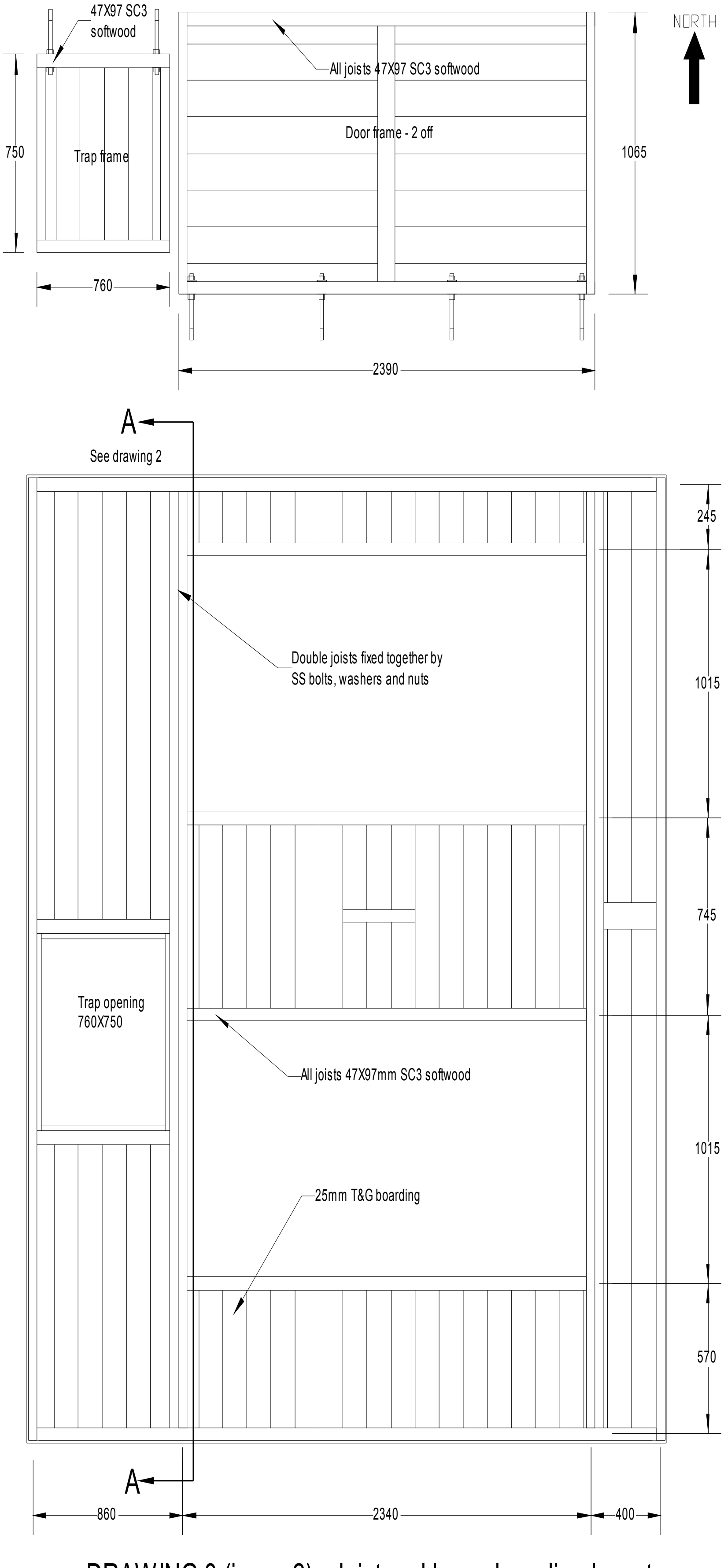
Total winch load for both doors is 84.0X2 = 168 kg (ignoring friction)



DRAWING 1- Bell and frame layout
("H" frames and headstocks omitted for clarity)

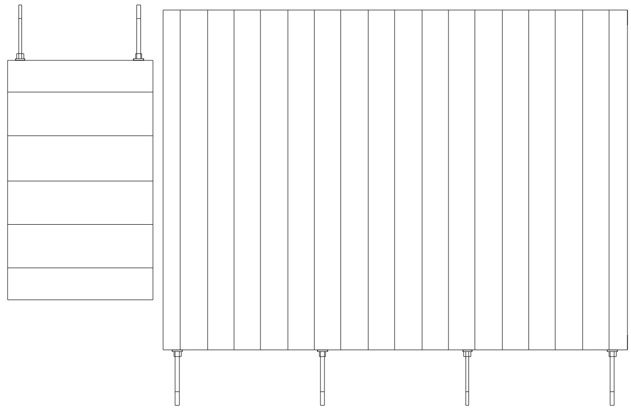


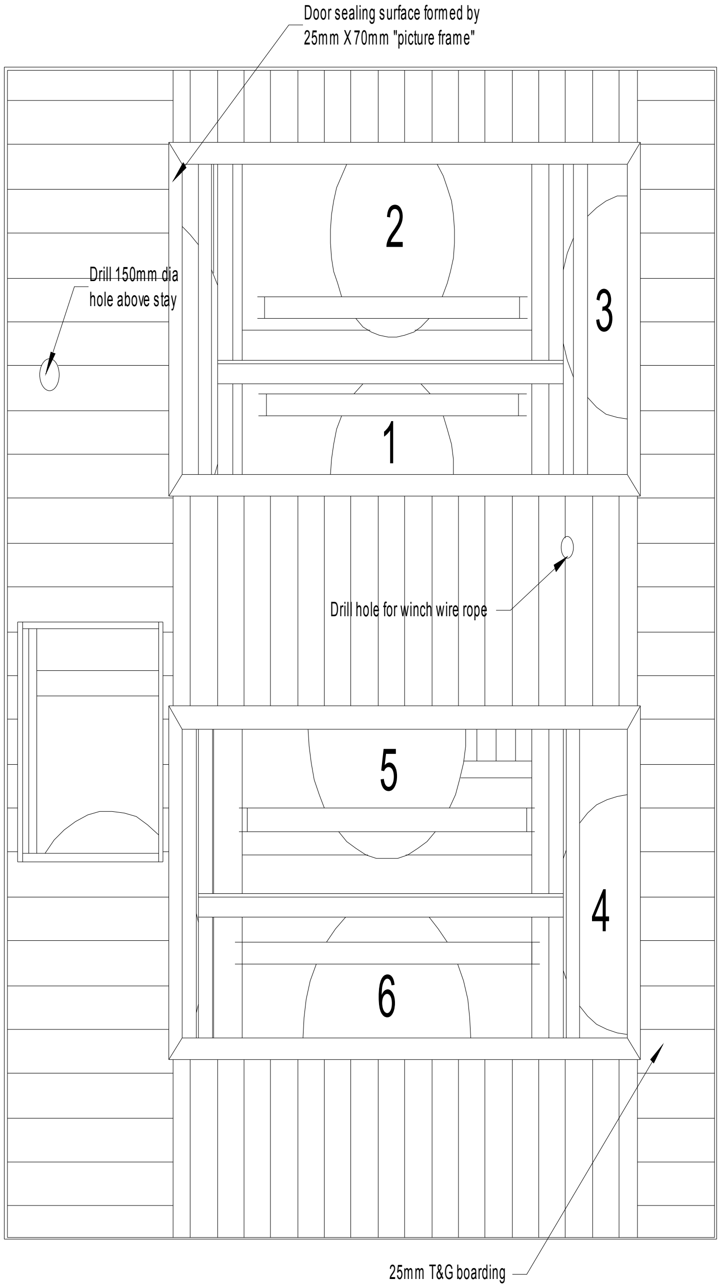
DRAWING 2 (issue 2) - View AA from drawing 3
showing bell frame and new acoustic barrier



DRAWING 3 (issue 2) - Joist and lower boarding layout
- bell frame details omitted for clarity

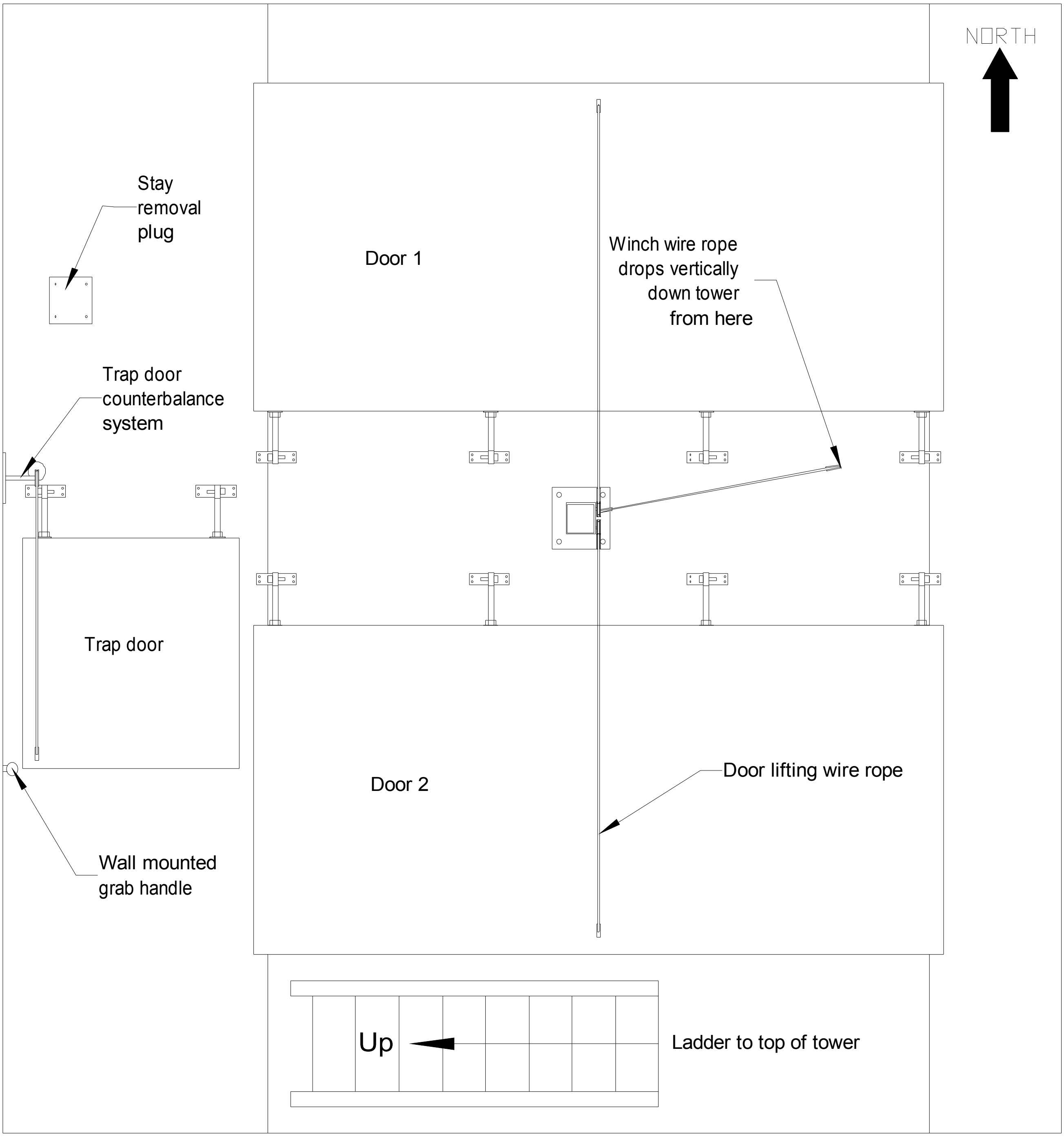
Note - leave a 10mm expansion gap between barrier and wall



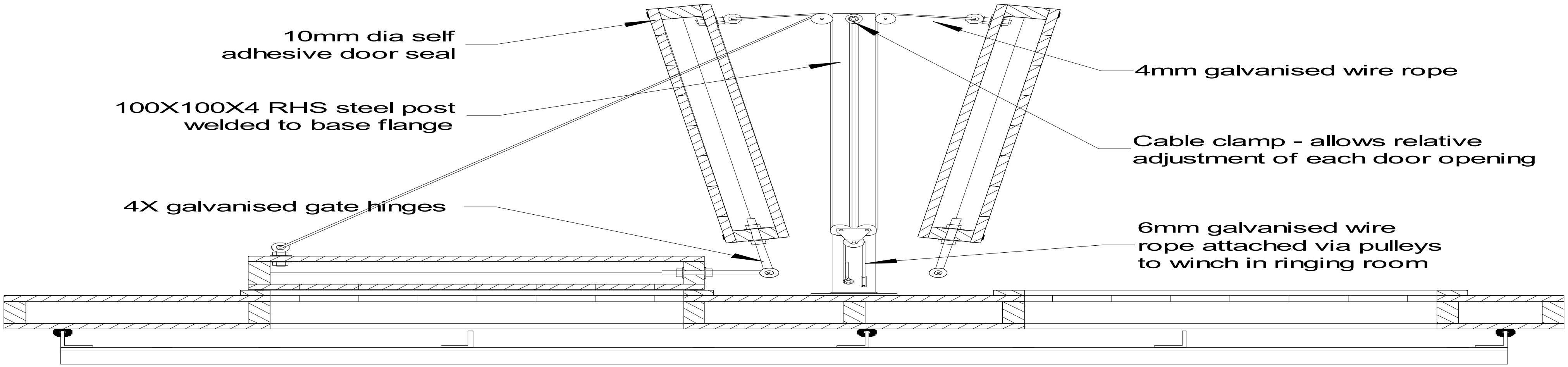


Notes - leave a 10mm expansion gap between barrier and wall
- all boards fixed with SS nails
- seal barrier/wall gap with mastic or silicon rubber sealant.

DRAWING 4 (issue 2) - Layout of top layer of boarding



DRAWING 5 (issue 2) - General layout of acoustic barrier



DRAWING 6 (issue 2) - Layout of door opening system

DRAWING 7 (issue 2) - Counterbalanced trap door