The acoustics of church bell-towers for change ringing

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ABSTRACT

In a changing urban environment the tradition of ringing bells in church bell towers has, in some circumstances, been significantly curtailed by the complaints of residents. This paper examines some of the issues involved in treating bell towers in order to balance the longstanding tradition of change ringing against the need to minimise neighbourhood complaints.

INTRODUCTION

Change ringing or ringing rounds consists of a group of bell ringers pulling ropes attached to a wooden wheel that in turn swings a bell through a rotation of 360 degrees. On the upward swing of the bell the clapper inside the bell strikes causing the bell to ring. The English tradition of ringing changes involves the ringers 'playing' their bells in a sequence of varying complexity. In its simplest form the bells are rung from the highest bell to the lowest bell in accordance with a strict tempo. Changes in the ringing pattern are called by the bell captain, usually according to a predetermined pattern.

In recent years the Australian and New Zealand Association of Bellringers have been actively pursuing the installation and replacement of change ringing bells in a series of churches. This has, in part been due to the efforts of the Celtic Trust in the UK who have been building a repository of decommissioned bells and facilitating their re-installation into other bell towers within the Commonwealth. The creation of new ringing towers and the refurbishment of others has led to a number of councils requiring the towers be assessed for potential impact on the amenity of the surrounding neighbourhood. The author has been involved in three bell tower projects, providing the opportunity to consider the establishment of design levels for towers in the future.

In the installation or replacement of a round of bells a number of sound levels should be considered; the level in the ringing chamber, in the church itself and in the surrounding district. In addition the local council may require that the sound from rehearsal periods not exceed a certain level above the background noise level. Usually this level is 5dB above the background level.

The author has had some success to date in making submissions to councils that state that the tradition of change ringing is part of the culture of our cities and suburbs. In fact in examining the structure of a bell tower it is evident that the operation of the tower is to radiate the sound of the bells from 'on high' radiating to the surrounding region.

This is reflected in the recommendations contained in a booklet published by The Central Council of Church Bell Ringers in the UK which states;

> Those carrying out installation and care of bells must have in mind the need to limit local annoyance, but must recognise the need to preserve their carrying power and the range of reasonable audibility.

INTERNAL TOWER ACOUSTICS –

The Ringing Chamber.

The primary consideration in the bell tower is achieving a good balanced level for the ringers. A useful point of departure is establishing an expected level from the bells at the source. A series of readings have been taken in the bell chamber to establish such levels. Obviously the level of the ringing bells is dependent on which bells are being rung and the sizes of the individual bells.

The following measurements were taken at St Andrews Cathedral and St James church in Sydney and St Judes church in Randwick. In each case the levels were measured with a calibrated Bruel and Kjaer 2231 sound level meter with the response speed set to FAST. One exception is the St Judes measurement where a 2250 meter was used. The measurements were made in the bell chamber within a distance of 1-2 metres from the nearest bell. All measurements were A weighted with the exception of the Peak level at St Judes which was C weighted. The bell ringers were asked to ring a pattern that resulted in each bell being rung an equal number of times.

Table 1. Bell Chamber Levels (dBA)

Church		Leq	Peak
St Andrews	12 bells	116	131
St Andrews	Middle 8 bells	114	129
St Judes	8 bells	117	122 (C)
St James	8 bells	110	

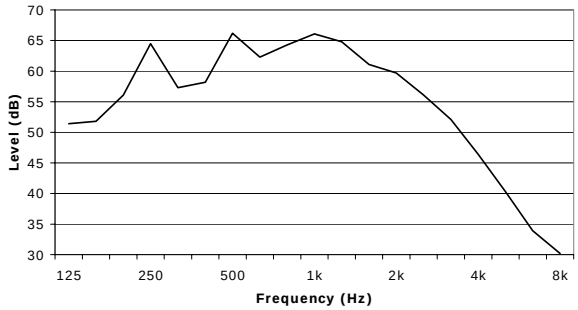
The table shows that the level generated by the bells is a function of the number of the bells being rung and the weight of the bells. The bells at St Judes are the heaviest of the eight measured, ranging from 213kg to 762kg. The middle eight in the St Andrews group are 261kg to 678kg with the lighter St James bells weighing 192kg to 555.5kg.

The level in the ringing room must be adequate for each ringer to hear their own bell against the others whilst being able to distinguish the calls from the bell captain on the changes. A number of ringers were asked to indicate towers that they considered where at the desirable level for effective change ringing. Obviously ringers will get used to the tower they ring in the most but most ringers in Sydney ring in several towers over the course of a month.

Two pieces of advice were taken, firstly the ringers of St Judes Randwick reported that visiting ringers had confirmed their view that the Randwick tower was both a good level and a good mix and a ringer who had worked on the installation of several towers advised that the desirable level in the ringing chamber was 75dB.

A five minute measurement was made in the ringing chamber of St Judes, producing a level of 77dBA. The spectral response indicates a variation in the response of 12dB to 2kHz with a 12dB per octave roll-off above that frequency. There is a strong harmonic response with a fundamental frequency of 250Hz which may be a resonant mode in the ringing chamber.

Fig. 1-Frequency range in Ringing Chamber



From these results it appears reasonable to propose that a level of 75dBA should be set as a desired level for the ringing chamber. It appears that a good mix of bell levels is achieved where there is a reasonably even frequency response up to 2kHz for a time integrated measurement where all bells are rung equally. This is supported anecdotally by ringers who have stated that the overtones of the bells tend to mask or 'muddy' the sound in the ringing chamber.

An ideal tower has been proposed by D.E. Potter(1985:848) in The Ringing World magazine, illustrated over;

In such a tower the Bell chamber and the Ringing chamber are separated by an intermediate chamber, sometimes referred to as the mixing chamber. Although the bells ring in the upward position into the upper section of the tower, with an expected degree of mixing occurring through the reflections within the tower, the intermediate chamber is considered advantageous in providing adequate mixing of the direct sound to the ringing room. Additionally the provision of two floors between the bells and the ringers should provide the required 40dB reduction of level to the ringers.

This approach was taken in the author's work in the towers of St Judes and St James. In each case the bell frame was mounted above an existing floor. An additional floor was built under the bell frame, providing, in the case of St Judes a 12dB loss to the mixing chamber. The floor above the ringing chamber introduced an additional 22dB loss. This was later improved by providing a better seal on the trapdoor to achieve the current level of 77dBA.

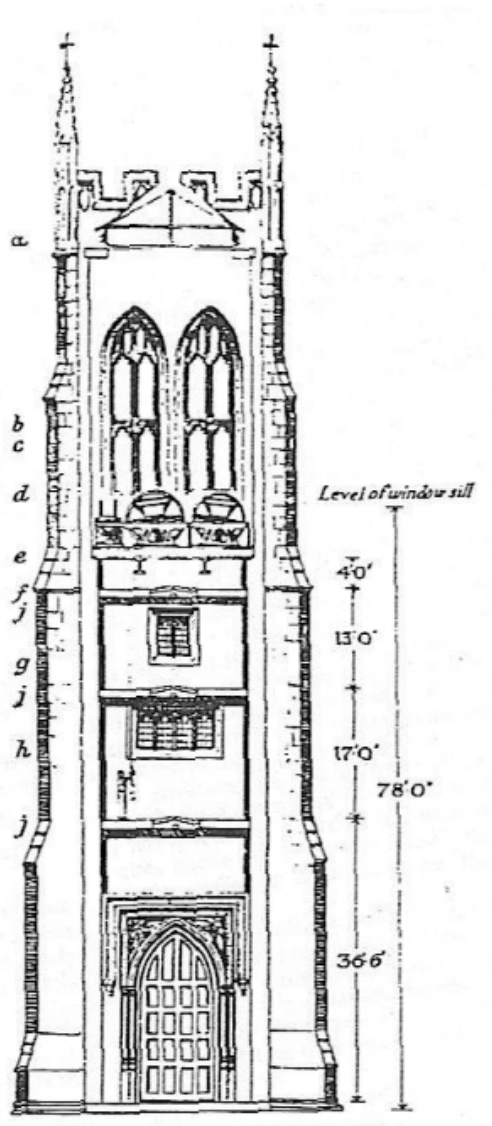


Fig. 2 Ideal Tower

EXTERNAL TOWER ACOUSTICS –

Treating the Bell Tower

As has been pointed out above, it is desirable for the sound of the bells to be heard in the surrounding region. There are however, instances where it is necessary to reduce the level of either individual bells or the entire group. In some towers the proposed or existing position of the bells is adjacent to an

opening, resulting in the dominance of a particular bell or group of bells. This is refered to as 'shouting' by the ringers. Additionally, bellringing is one of the few forms of musical performance where the players must rehearse publicly. The experience of the ringers spoken to is that the wider community is more inclined to accept short periods of ringing on Sundays for the church service and on Saturdays for weddings but are less tolerant of several hours of ringing taking place on the weeknights when less well played practise sessions occur. In order to achieve a fully operational tower that can ring openly during traditional ringing times whilst minimising disturbance to the neighbours during rehearsal times the following approach has proven reasonably successful.

From the illustration of the ideal tower it can seen that there should be no openings in the tower below the upper reach of the bells. D.E. Potter (1985:848) further suggestes that there be a void of at least 5 metres above the bells. In the case of St Judes Randwick the existing bells were positioned next to shutter openings in the tower resulting in direct sound from the individual bells being radiated from the shutters. This produced an unevenness of sound around the tower. This was resolved by closing the shutter openings allowing the sound of the bells to mix within the tower before radiating from smaller shuttered openings 2 metres above the bells, illustrated below;

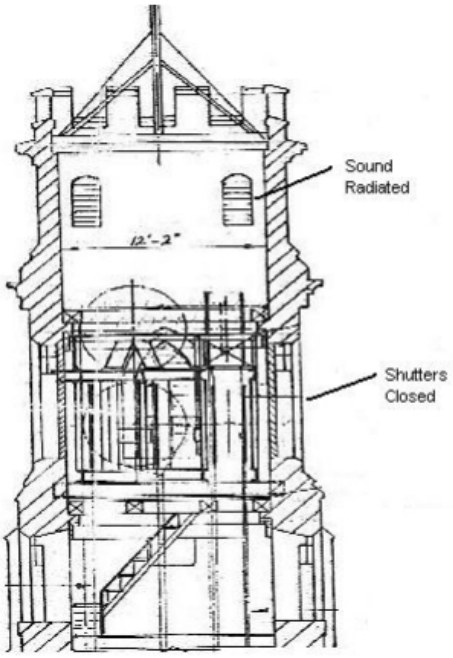


Fig. 3: Upper section of St Judes Tower

The lower shutters had to be treated in a way that would allow removal of the sound isolator for repair work on the shutters. This was achieved by installing two layers of 18mm fibre cement sheet separated by 75mm of Rockwool. A sectional drawing of the construction is shown over;

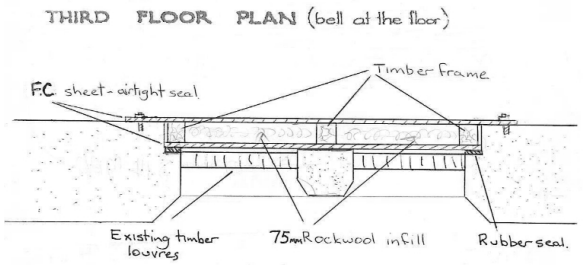


Fig. 4: Louvre Sound Control Detail

The desired level in the surrounding area is fairly subjective with little published data on the levels of bell towers in their surroundings available. One series of measurements are available from the Ringing World magazine for a tower in East Ilsley in the UK where levels of 66 to 86dBA were measured at unpublished distances from the tower. In performing an assessment of a tower the readings are most likely to be taken at a distance that equates to that of the nearest resident. The following measurements were made on this basis so there is little information on levels at greater distances from the towers.

Table 2. External Measured Levels (dBA)

Church	Distance	Leq open	Leq closed
St Judes	30m	67	
St Pauls	10m	72	61
St Marys	50m	69	
St James	50m	64	
St James	15m	76	

The towers measured were St James and St Marys in Sydney, St Judes in Randwick and St Pauls in Burwood.

St Pauls is the only church the author has measured where a sound control system has been utilised. St Marys has a system but it was not used during the period the measurements were taken.

In the case of St Pauls Burwood a nosie control system was introduced following complaints from neighbours, despite the fact that the church had been ringing for over 60 years.

The form of the sound control can be broken down into two separate types; the hopper system and the trap system. The hopper system consists of an enclosure that is mounted over the tower louvres with an opening lid, usually manually operated via a pulley system. See the illustration below;

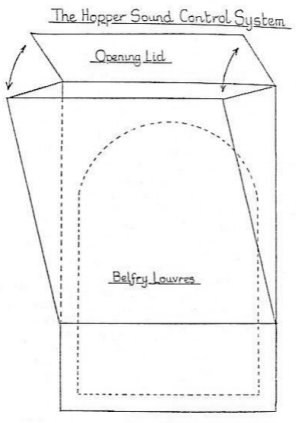


Fig. 5: Hopper sound Control

The alternative approach has been to utilise an existing floor above the bells. In circumstances where such a floor exists a trap door or series of trapdoors are made operable within the floor effectively blocking the sound from the openings in the upper section of the tower.

CONCLUSION

In considering a set of objective measures for levels in and around bell towers the following suggestions are made.

In the case of new installations in a tower the expected level of the bells will be in the vicinity of 110 to 120dBA depending on the number rung and the weight of the bells. Further measurement of bells in the bell chambers would be useful to build on the existing data set.

A level of 75dBA in the ringing chamber should provide a level that will allow the bell captain's calls to be heard whilst maintaining an adequate level from the bells to the ringers. An even spectral response with a 12dB/oct roll-off above 2kHz appears to be desirable although further measurements are recommended to confirm this.

Levels in the surrounding areas can not be specified although there is a general recommendation that the bells should be heard unhindered when the sound radiates from the upper section of the tower, with a sound control system utilised to reduce the level to an acceptable point, if called for by local authorities, for practise sessions. The local authority usually specifies a level above the background noise. In NSW that level is, currently, 5dB above background.

Such an approach will probably produce an acceptable result for open ringing for short periods on Saturdays and Sundays with a reduced level to the surrounds during practise periods. However, it does little to address the conflict of residents demands for quiet enjoyment against the tradition of change ringing in bells towers where a full peal will take in the order of 3 hours to ring through the changes.

REFERENCES

Sound Management, The Towers and Belfries Committee, The Central Council of Church Bell Ringers, U.K., date unknown.

Potter, D.E.. 1985, *The Ringing World,* U.K. Publisher unknown.