Measuring tower movement and its impact on full circle change ringing
– are we entering a new era?

The CCCBR Stewardship & Management Workgroup has been developing new equipment to investigate the dynamics of church towers during full circle change ringing. These notes aim to set the scene by summarising some earlier work to measure tower movement and why it is important, before mentioning the latest work.

Why is tower movement important? Contrary to what may be thought on first reading, it is not that bell ringing is likely to cause damage to or the collapse of many church towers. The forces generated by swinging bells are generally accepted by structural engineers to be considerably lower than those due to high winds. The problem is more the converse, that movement of a tower during ringing can make it quite difficult to strike the bells well in changes. While relatively few towers should be "blamed" for poor striking, there are a few towers where even the most experienced ringers have difficulty striking accurately and such towers have gained a reputation for being extremely "wobbly". Importantly, there are a very few cases where bells have been rehung but tower movement is exacerbated. Clearly, bell hangers and structural engineers involved in such projects do not wish this to be the outcome so ideally would like to be able to make predictions of tower movement using sound engineering principles prior to making any alterations.

Readers may remember that Harry Windsor MBE [1] pioneered studies of tower movement in Brailes, Warwickshire, then for Coventry Cathedral. His obituary in The Ringing World (page 1012, 2007) mentions how he became involved in tower movement studies. Using his engineering knowledge, he designed and constructed measurement equipment, made measurements in several towers and started to gain new insights into tower movement. In 1994, he co-authored a booklet published by the CCCBR on his initial work "*A Practical Analysis of the Interaction between Church Bells and towers*". A landmark 2-day seminar organised by the Towers and Belfries Committee (now part of the Stewardship and Management Workgroup) of the CCCBR was held in Brailes in 2002 (as reported in The Ringing World, issue 4760 in July 2002) at which many interested parties including ringers, bell hangers, bell advisers, mathematicians and engineers participated.

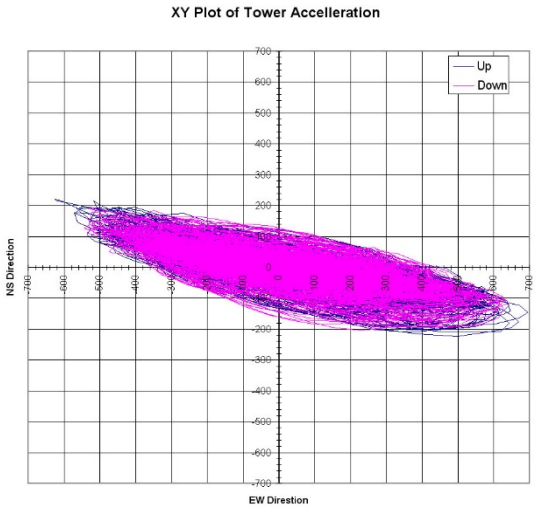
Interest in tower movement increased considerably and Harry, ably assisted by other ringers with engineering expertise, particularly William Jones and Andrew Preston, visited several towers, collected data and analysed tower movement during change ringing. By this time, the potential for wider use of such measurements was being appreciated; the Committee also recognised that electronic technologies had advanced significantly and were becoming readily available at a price that would be affordable for the CCCBR. Bernard Stone who also part sponsored the project, with the assistance of William Jones designed and manufactured new 4-axis equipment to replace the single axis system that Harry had developed and used until then. The first prototype had been produced and was demonstrated at the CCCBR annual meeting in 2005 (as reported in The Ringing World on page 495). This was being used and evaluated in towers, with a further 3 replica sets being manufactured when Harry sadly passed away in 2007.

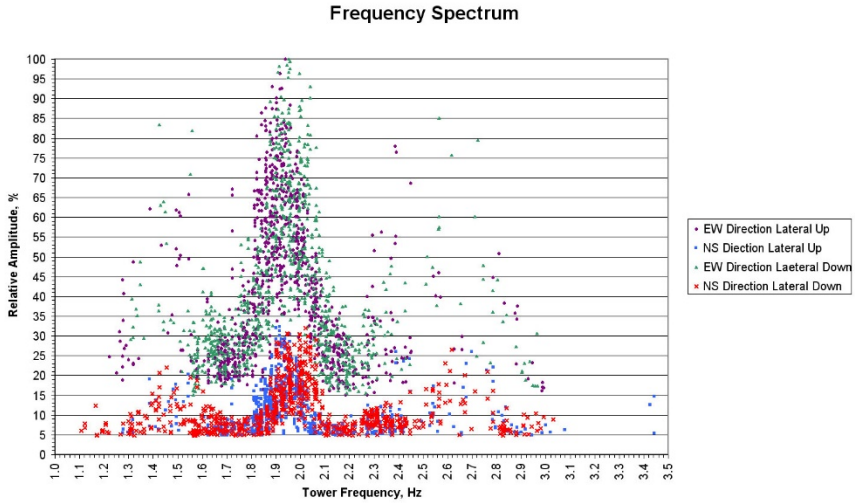
[1] Harry's MBE was awarded in January 1994 for his pioneering work on the measurement of tower movement, in the Coventry Guild

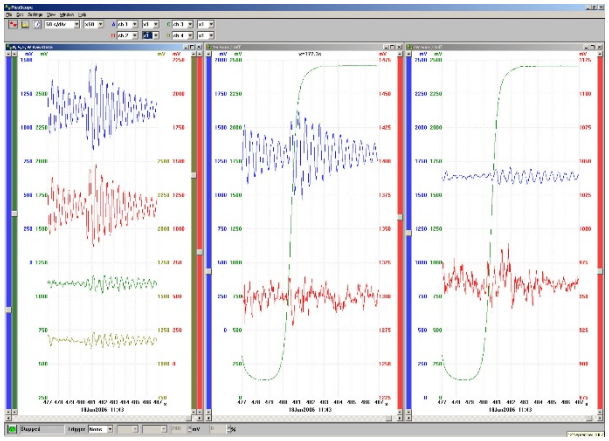
Figure 1 - Prototype four channel tower movement measurement electronics being developed in about 2005 – (Photo from CCCBR Towers and Belfries Committee Records)

Very importantly, it was also becoming clear to the Towers & Belfries Committee that structural engineering companies, with the backing of appropriate professional indemnity, would probably have to undertake measurements, do the analysis and interpret the origins and potential impact of tower movement on of ringing. Only then could they and bell hangers depend on using the information obtained when advising on bell restoration and installation projects. Preliminary negotiations with engineering companies were underway in the mid 2000s.

To round off this retrospective summary, some of the hardware produced by Harry, William and Bernard was eventually located and collected from former Committee Members during the last few months of 2021. Each of the 4 blue diecast boxes in figure 1 contains an accelerometer and associated electronics, one for each axis of the tower (for example typically north, south, east and west), the larger box took the outputs of the accelerometers into oscilloscope software on a PC, for subsequent analysis. In the documents and records also retrieved, I found what I deduce were preliminary results obtained (figures 2, 3 and 4). Other hardware and a lot of information is probably lost for ever; in the last 15-20 years, electronics technologies have moved on still further, UK manufacturers have closed down, computer based records have been lost, software programmes are obsolete, old PCs were private property and no longer work even if they still exist, not to mention a few brain cells that no longer have the same powers of recall. (There are serious lessons here!)







Figures 2, 3, 4 - Charts showing data collected during tower movement measurements in 2006 (from old CCCBR Towers and Belfries Committee records, but with no further detail)

A new phase

A new phase in tower movement measurement by the CCCBR started when Gordon Breeze was introduced to members of the Committee several years after Harry's work was left in abeyance. He has revisited the fundamental mathematics of bell and tower dynamics. As electronic technologies have continued to move on at a great rate in the last 15 – 20 years, the Workgroup, funded by the CCCBR, has recently purchased new components to form a tri-axial multi sensor system capable of measuring tower movement during full circle change ringing. Gordon designed and assembled this new equipment and we tried it out for the first time in a tower in December 2021. There is very little to see in a photograph of this new equipment - as with a lot of electronics in the 2020's, the functional heart of the equipment is microscopic, and all that is visible is the ubiquitous laptop PC!

It is premature to present the preliminary results using the latest equipment but the indications are that it works as hoped and does indeed detect the effects of the forces generated by a bell when rung full circle in a tower. Charts similar to those in figures 2 (X - Y plot) and 3 (frequency spectrum) can be produced with the new equipment as was hoped and expected. Further analysis is underway and we are planning to take more measurements in the same and other towers, to refine our understanding of what we are measuring. Every tower is unique - how each is constructed and of what materials is rarely known in detail.

A major question remains as to how measurements such as those made using the new equipment could be used by structural engineers and bell hangers. This is a key focus of the next phases of this work programme.

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Footnote – This summary was researched and compiled in the last few months of 2021. Sources included various documents including Towers & Belfries Committee minutes and reports, along with personal recollections from some of those named or involved at the time. I am very grateful to those who I have consulted. If anyone has further information that would correct or add to that above then I will be glad to receive it. I also apologise for any errors or misunderstanding.