

## CASE STUDY 11

# Surveying of historical structures and topographical features at Fountains Abbey, Ripon, North Yorkshire.

**type:** terrestrial laser scanning integrated with traditional topographical survey techniques.

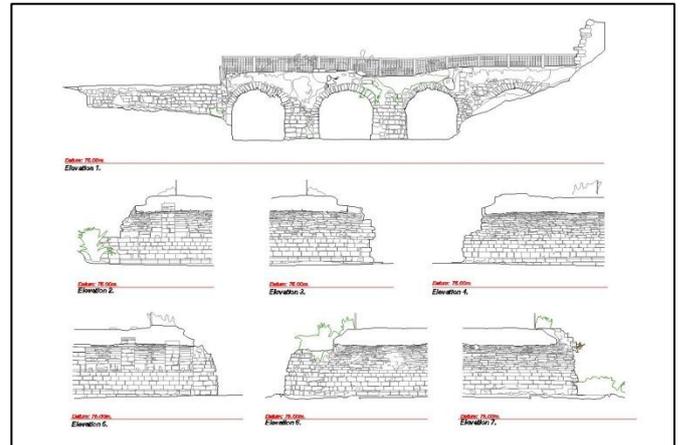
**keywords:** historical digital archival recording by laser scanning technologies.

### Introduction

At the request of the English Heritage Metric Survey Team, we were instructed to undertake a detailed topographical survey of the river course and a stone by stone elevation survey of the tunnel entrances at Fountains Abbey in North Yorkshire. Set in the Skell valley with cliff faces to either side and the river Skell running under the Abbey, Fountains Abbey is the largest monastic ruin in the country and a masterpiece of twelfth century building ingenuity. The Abbey was founded in 1132 by exiled monks and was admitted into the Cistercian Order three years later. One of the Abbeys most important developments was the introduction of the Cistercian system of “lay brothers” upon which Fountains gained its great wealth and economic importance. Its life was brought to an abrupt end in 1539 by Henry VIII’s Dissolution of the Monasteries and in 1767 was landscaped by the Aislabie Family as a picturesque folly forming the backdrop for the Studley Royal Water Gardens, arguably England’s most important 18<sup>th</sup> Century Water Garden. The site was awarded “World Heritage Site” status by UNESCO in 1987 and is run by the National Trust with English Heritage providing support for maintenance and a strategic management plan. In recent years, due to its location the Abbey has been affected by flooding, largely to changes in the environment and an investigation into improvements in water flow through the site and tunnel aperture conditions is being investigated with survey drawings from the Greenhatch Group being used as the basis of the investigation and consolidation.



*Surveying the tunnel entrances.*



*Resultant stone by stone elevations.*

### Instruments and software

Both the topographical survey and the stone by stone elevation survey were undertaken using a combination of a Leica HDS 6200 and a Leica TCRP1201+R1000 total station. The point resolution for the stone by stone work was set at the maximum 1mm resolution at 10m and approx. 10 scans were undertaken over, around and within the tunnels to provide the comprehensive data required to create the sections and elevations using a combined point cloud data set. All the scan positions are tied into a minimum of 4 No control points, being tilt and turn precise field targets coordinated by REDM from the nearby total station. Once each scan was finalised, 360 deg. photography was then taken using a collimation calibrated bracket and a Canon EOS 5d Camera to allow panorama images and also colourised point data to be produced. Additional high resolution images were also taken using the camera and a wide angle aspherical lens to aid AutoCAD drafting of the point clouds in the office. The scanning element of the topographical survey was undertaken in the exact same manner, with field targets observed by REDM before a scan of the environment would be undertaken per setting at a 3-5mm resolution. Each scan would be undertaken prior to any standard fixed prism detail pole work and scan locations were orientated to ensure complete coverage whilst at the same time concentrating on more difficult subject matter such as detailed plinths, paved surface extents, ornate window openings and the like. The resultant data set would be a 3 dimensionally correct series of string lines and level data gained by conventional total station and fixed prism detail pole (up to the base of structures and plinths only) together with a comprehensive point cloud that can be orthogonally sliced to provide secondary 2d detailed data. The total station string line and control point data is then registered, traverse adjusted and coordinated using LSS software and exported into AutoCAD as a 3D and also a 2D data set with contours. Once the point cloud data set has also been fully registered, the 2D AutoCAD data is then further manipulated using Leica Cloudworx AutoCAD plugin and selective orthogonal slicing of the point cloud to provide the desired high resolution topographical and stone by stone drawing results required.

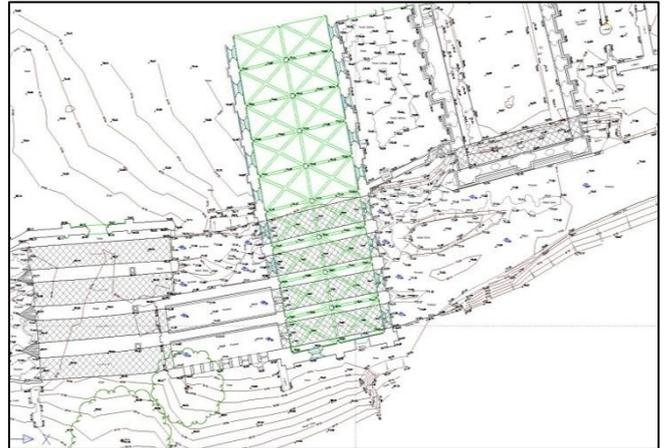
### Why was scanning selected?

In relation to the topographical survey, due to the vast extent of detailed masonry, tunnels and vaulted areas, integration between traditional total station observations via detail pole and contemporary laser scanning techniques were required to provide the necessary resolution for the detailed 2D AutoCAD drawings. By undertaking a comprehensive laser scan of the site whilst at the same time taking observations with a detail pole provided the assurance that all areas could be drawn up with the confidence and no important historical detail was omitted. A traditional detail pole topographical survey could have been undertaken alone, but the level of 2D cartographical information was greatly improved with the backup of a comprehensive point cloud data set.

In relation to the requirement to provide stone by stone drawings of the tunnel entrance and side walls, the environment was equally lent towards laser scanning or photogrammetry techniques. However with cost being an important issue and the requirement for 2D stone by stone drawings rather than the more involved 3D string line drawn stone data, laser scanning became the more suitable option. With large mortar joints between stones being evident, this also furthered the 2d digitising process using point cloud data drafting techniques. We have however, had mixed results over time with this process and clearly defined mortar joints are key to successful 2d stone by stone drawings using laser scanning technology.



*Use of a laser scanner to enhance traditional topographical detail.*



*Resultant detailed 2D topographical drawings.*

### What problems were encountered?

With the site being so complex, drafting and interpretation of the correct components was very difficult to manipulate and digitise, especially as an example, when trying to show an undercroft tunnel below structures such as the Cellarium, a highly detailed vaulted ceiling still intact within the Abbey.

Perhaps the biggest problem however, was the interaction with the general public on site. The survey was undertaken mid-summer to ensure water levels were low for the river bed survey, but this also meant that public attendance was at its highest, falling within the school holidays. To ensure public safety, the correct warning notices and laser safety procedures were obviously observed but as an extra precaution, we also surveyed all the areas of higher public interest (the Cellarium as an example) early each morning before the site opened to visitors. However interaction with the public was inevitable and whilst detail pole topographical work could continue, laser scanning data had to be constantly checked or stopped due to reduced lines of sight during busy periods.

### What were the final 'deliverables'?

With the majority of the project relating to a detailed topographical survey, one important requirement of the "Metric Survey Specification" was to ensure that some form of 3D functionality was available. By ensuring all the main topographical features and levels were surveyed by traditional total station and detail pole methods in a 3d string line fashion, a comprehensive 3D triangulated DTM surface could be issued in DWG form to complement the more detailed 2D topographical drawings also issued. The 2D topographical drawings were presented on overlapping 1/200 scale frames, but the level of detail provided was actually commensurate with 1/50 scale. In relation to the stone by stone drawings provided, these were issued at 1/50 scale as 2D (only) AutoCAD drawings. All drawing information was then checked on site by the Metric Survey Team and then once any amendments were taken care of, stable ink on film copies of each drawing were sent for archival use. In addition, all survey data was then issued to English Heritage in the proprietary formats along with accompanying compulsory Meta data. Finally, to ensure the point cloud data could be further utilised, a Leica Truview Interactive DVD was also issued summarising all drawings in high resolution PDF form together with point cloud interaction and the use of 360deg. panorama images per scan position.