Re-building the Christchurch Cathedral steeple with traditional timber frame construction

Dr Andy Buchanan

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1.0 Objective

The objective of this report is to explore options for re-building the steeple and tower of the Christchurch Cathedral using traditional timber frame construction, to achieve essentially the same appearance as the original building.

“Traditional timber frame construction” means traditional mortise and tenon timber frame construction using heavy timber elements, manufactured by craftspeople, and erected in traditional ways. Traditional construction includes raising the steeple by hand in a community steeple-raising event.

Although the emphasis is on traditional construction, some modern timber materials or fastenings or equipment may be included where appropriate.

The target audience of this report is the decision-making organisation which will decide on the future of the Christchurch Cathedral, and implement those decisions.

2.0 Background

2.1 History
The Christchurch Cathedral was constructed between 1864 and 1904. The history of the initial design for the cathedral is described in *A Dream of Spires – Benjamin Mountfort and the Gothic Revival* by Ian Lochhead (1999). This book makes fascinating reading, especially in the light of the subsequent 2010 and 2011 earthquakes. All of the information in this section is taken from Chapter 5 of Lochhead’s book.

The architect commissioned to carry out the design was Sir George Gilbert Scott in London. He was a respected and prolific Gothic Revival architect who designed many New Zealand churches, although he never visited New Zealand. The eventual construction of the cathedral was very similar to the size, shape and appearance of his initial design, but only after endless debates about the structural materials and the appointment of the supervising architect.

The preliminary design of the cathedral was begun in 1859, with many changes during the design process. The design was completed and the foundation stone was laid in 1864. The foundations were completed the following year. In 1881 the nave and the steeple were completed and the Cathedral was consecrated, even though the transepts and chancel remained unbuilt. The western porch was completed in 1894, but the transepts and chancel were not completed until 1904.

After a few false starts, Mr Benjamin Mountfort supervised the construction, making a number of small but significant alterations to Scott’s design. Among others, he added viewing balconies at the top of the tower and replaced Scott’s simple timber steeple design with a more ornate octagonal masonry steeple, with additional masonry pinnacles at each of the four corners.
2.2 Structural materials
Scott’s initial design was based on a timber structure with exterior stone masonry walls, and a timber steeple above a masonry tower. He favoured a timber structure because he understood that timber was widely available in New Zealand, and he was aware of the danger of earthquakes. Copies of these drawings are shown in Appendix A.

Lochhead describes the proposed design as “an internal skeleton of timber cased in a stone shell”, resulting in an unconventional structure where “the congregation and clergy would have been surrounded by a forest of timber construction without parallel in the history of the Gothic Revival”.

This initial design in timber was never built. Scott was asked to change the main structure from timber to masonry, largely because of great cost and difficulty in obtaining the timber. From Scott’s plans, Mountfort estimated that 806 cubic metres of timber would be needed for the nave alone. The huge kauri posts would have each been 15 metres long and 0.7 metres square. Scott therefore produced an alternative design which arrived in Christchurch in 1864 in time for construction of the foundations.

2.3 Historical earthquake damage.
Even during the design in the 1860s, Scott was well aware of the massive Wairarapa earthquake which had caused so much damage in Wellington in 1848. The designers’ awareness of earthquake danger is frequently referred to in Lochhead’s book. In 1881 (less than a year after the steeple was completed), an earthquake caused the top of the new spire to be displaced and the stonework was fractured. The repair included iron reinforcement which was needed when the next earthquake struck in 1888, as the spire was dislodged and the cross was left hanging from iron tie rods. This damage was repaired with bricks and a light weight copper cross, but this was damaged by another earthquake in 1891. The upper portion of the steeple was then dismantled and re-built in timber with copper sheathing.

3.0 The 2010 and 2011 earthquakes

3.1 Earthquake damage
In September 2010 and February 2011, two major earthquakes shook Christchurch, both followed by many aftershocks. The Christchurch Cathedral suffered minor damage in September 2010, however the masonry steeple collapsed February 2011. The top part of the supporting tower also collapsed in February, and most of the remaining tower was subsequently demolished.

There has been intense debate about the future of the cathedral, with many divergent views supporting re-building, modifying or retaining the building. An engineering report by Ms. Miriam Dean (2015) and two structural engineers has allowed the opportunity for reinstatement to be considered as a viable option. Ms Dean’s report says very little about the tower and steeple, but it is expected that any reinstatement would include a new tower and steeple with the same exterior appearance as the original. Her report also refers to the possibility of base isolating the entire building, which would include the foundation of the tower.
3.2 The People’s Steeple project
In 2012, Mr Marcus Brandt visited Christchurch and talked to many people about the possibility of re-building the Christchurch Cathedral using heavy timber frame construction, including a public steeple raising event to be supported by many parts of the Christchurch community.

In 2012, Mr Brandt developed a scale model of the steeple construction, and wrote a 20 page report *The People’s Steeple* describing how the new steeple might be constructed and raised by people-power, in the same way as traditional barn-raising in the US. He also made a promotional video which can be seen at [www.thepeoplessteeple.org](http://www.thepeoplessteeple.org). His report is being updated to reflect the current situation, allowing for the demolition of the base of the tower which took place after writing the first report.

Mr Brandt’s report very strongly promotes the community benefits of engaging a large number of local people in various stages of the fabrication and erection of the steeple, as done in traditional communities in different parts of the world. He describes other timber steeples more than 200 years old, including a similar steeple in Rhode Island which was built in 1726, two years before Captain Cook was born, still in use today.

Prof Andy Buchanan visited Marcus Brandt in Philadelphia in June 2016, as described in Appendix C.
4.0 Why traditional timber frame construction?

4.1 Original plans
The major motivation for re-building the steeple with traditional timber frame construction is that Scott’s original plans for the cathedral had a timber steeple, as shown in the drawing below, and the cathedral would therefore be consistent with the original vision.

**Steeple raising event**
A complementary reason for using traditional timber frame construction is that a community steeple raising event could be a highlight of the reconstruction.

This steeple raising event could be a huge step in Christchurch’s long-term recovery from the earthquakes, attracting world-wide attention. A permanent future benefit is that the people of Christchurch will be able to climb the tower to see, touch and feel the traditional timber construction of the type used when the cathedral was first built.

**Future earthquakes**
The use of timber framing will reduce the weight of the steeple and allow design to limit the damage in any future earthquakes.

The international groups with most experience in the community construction and raising of bridges, barns and other large buildings are the international timber framing fraternity, represented by the Timber Framers Guild in North America and the Carpenters Fellowship in the UK, among others.

Discussions have been had with both of these organisations who are very keen to assist with procurement and the steeple raising.

4.2 Objectives of traditional timber frame construction
If a decision is made to design and construct the steeple using traditional timber frame construction, there are a number of associated objectives, not all of which can be achieved.

Then main objectives are:
- All of the structure should be traditional timber frame construction.
- Any masonry should be done by craftsmen in a traditional way.
- All lifting should be by people power, i.e. no cranes
- Timber construction and lifting must be done in a tight time frame, to allow for volunteer helpers.
- All cladding should be in place at the time of erection, to minimise later scaffolding.
Some of these objectives are mutually exclusive, so compromises will have to be made. For some options later cladding and finishing with scaffolding may be necessary. Some options may involve limited erection by crane.

4.3 Heritage issues
The Christchurch Cathedral is a Category 1 heritage building (number 46) listed as “Cathedral Church of Christ (Anglican)” by Heritage New Zealand (http://www.heritage.org.nz/the-list).

Any restoration of the cathedral will include reconstruction of the tower and steeple in accordance with a conservation plan prepared by suitably qualified people. Guidance on restoration and reconstruction of heritage buildings is given by the ICOMOS New Zealand Charter (ICOMOS 2010).

The objective of the reconstruction would be for the exterior of the tower and spire to be as close as possible to that of the original building, although the internal structure may be modified as a major step towards mitigation of future seismic risk. Much consultation with heritage architects and the proponents of the new tower and steeple would be needed before making any decisions on the appearance, the uses, and the construction materials. This can only be done after a project architect is appointed for the whole project, allowing discussions with a wide range of stakeholders.

To retain the original uses of the tower, the original bells should be installed in the cathedral, with space for bell-ringers to operate the bells on a regular basis with bell ropes, as before the earthquakes. Public viewing at the base of the steeple was very popular before the quakes, so similar public access to the viewing level should be provided. This would require walking access up the full height of the tower. The original steps were enclosed within a section of wall 7 feet thick, but another possibility is timber steps visible inside the tower.

5.0 The steeple raising event
All three tower options include hand-raising of the steeple in a major community event.

Mr. Marcus Brandt (2012) shows a drawing from the obelisk raising in Rome in 1586 to demonstrate the concept of a public raising event, as shown below. Mr. Brandt estimates that the steeple raising for the Christchurch Cathedral would be roughly one third of this size, with perhaps 16 capstans and 500 people. It would require several kilometres of rope, with many blocks, tackles and associated rigging.
The Timber Framers Guild is willing to be contracted to manage the steeple raising. Members of the Guild are often engaged in barn raising and bridge building events throughout North America. Such events are designed to engage a large number of people, as in the photo below of a barn raising in the US. The tradition of barn raising is alive and well in the Amish community in the north-eastern states of the US.
5.1 Telescoping construction

The basic idea for the re-construction of the steeple is to pre-construct the major components and raise them by telescoping, using rigging, capstans, and people power. This concept is strongly related to the traditional raising of masts in tall sailing ships.

The historical principles of telescoping church steeples are described by Lewandoski (2007) which includes the photo and drawing below of the Stowe Community Church in Vermont, built by hand in 1861, as shown below.
6.0 Construction options for the tower

6.1 Re-building the tower
This section discusses three structural options for re-building the tower, which supports the timber steeple. All three options retain the appearance of the original building, and the access and internal uses would be essentially the same. For all three options, the steeple would be made with timber framing.

The three options for the tower are:
1. Original masonry materials, strengthened.
2. Reinforced concrete walls with masonry cladding.
3. Traditional timber frame with masonry cladding.

6.2 Tower option 1. Original masonry tower, timber steeple
Tower Option 1 assumes that the materials and the construction sequence would be as described in the report by Mr. Brandt (2012). His report and the accompanying scale model were prepared before the remaining masonry tower was demolished, so some modifications are required.

This proposal is for the lower section of the tower to be rebuilt in massive stone masonry with the walls 4 feet to 7 feet thick (1.2m to 2.1m thick), as in the original tower. These solid masonry walls would be in keeping with the original construction, and would require some form of post-tensioning or other holding down reinforcing as necessary to provide resistance to earthquake and wind loads, depending on whether or not there is base isolation in the foundations.

The upper section of the tower would be light weight construction, consisting of a masonry veneer on a traditional timber frame structure which could be raised within the lower tower in an initial raising event, before applying the masonry cladding.

The steeple would be prefabricated in traditional timber framing then raised from within the tower. Details of the construction procedure are shown in the Brandt report. Of course much of this could change during the design phase, if this option is selected.

A summary of Tower Option 1 is given in the table below.
### Sketch

#### Part of building

<table>
<thead>
<tr>
<th>Part of building</th>
<th>Proposed construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross and top of steeple</td>
<td>As in original</td>
</tr>
</tbody>
</table>
| Main steeple | Timber frame.  
Octagonal shape.  
Copper cladding.  
Raise in a public event. |
| Public viewing level, with 4 doors, and one pyramid at each corner | The base may need to be cut back to allow raising within the tower.  
Pyramids placed later. |
| Top level in the tower, the bells are at this level | Square cross section.  
Light weight construction - masonry veneer on structural timber frame.  
Raise within the lower tower. |
| Middle level in the tower, for bell ringers | Square cross section.  
Rebuild original masonry  
Reinforce as necessary |
| Lower level in the tower | |
| Ground level in the tower | |

**Possible construction for re-building the tower and steeple. Tower Option 1.**

6.3 **Tower Option 2. Reinforced concrete tower, timber steeple**

Tower Option 2 is based on the tower structure being reinforced concrete walls, with non-structural masonry cladding, to retain the original look while being modernised inside.

Reinforced concrete walls with non-structural masonry cladding would allow much thinner walls, hence more space inside the tower (while retaining the original outside dimensions and appearance), and much more reliable resistance in future earthquakes. The window frames and exposed details would be masonry as in the original building.
**Construction sequence for Tower Option 2 - concrete walls**


Step 2. Clad tower with original masonry.
   Build windows.

Step 3. Construct the timber steeple on the ground.

Step 4. Apply roof cladding to the steeple.
Step 5. Lift the steeple into the tower

There are several options for Step 5, lifting the steeple into the tower. One possibility is to leave one side of the tower open and tilt the steeple into the tower with people power before closing-in that side, but an easier option is to use a crane after the tower is completed.
6.4 Tower Option 3 – Timber structure for the entire tower and steeple
Tower Option 3 is based on the structural materials being traditional timber frame for the entire tower and steeple. The tower would have a non-structural veneer of traditional masonry cladding of the same appearance as in the original cathedral. The window frames and exposed details would be masonry as in the original building.

A summary of the construction process for Tower Option 3 is given in Appendix B.

7.0 Major construction activities

7.1 Possible timeline
The times for design and construction will need to be worked on in more detail, depending on the options selected. The intention is that the sourcing and manufacturing the wood components would take some time, in various parts of the world, followed by delivery to Christchurch. The New Zealand components can be worked on at the same time. For all of the Tower Options, the timber structure, later cladding and finishing with scaffolding would need to be scheduled so that the specialised helpers can spend a short concentrated time on site. This includes both volunteer and paid helpers, from New Zealand and overseas.

The table below summarises the main aspects of the timber design and construction which will have to be programmed.

<table>
<thead>
<tr>
<th>Conceptual design</th>
<th>Preliminary design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full design of timber assemblies</td>
<td></td>
</tr>
<tr>
<td>Sourcing and manufacturing the wood components</td>
<td></td>
</tr>
<tr>
<td>Delivery to Christchurch</td>
<td></td>
</tr>
<tr>
<td>Assembly of timber components</td>
<td></td>
</tr>
<tr>
<td>Erection of timber steeple</td>
<td></td>
</tr>
<tr>
<td>Preparing the rigging</td>
<td></td>
</tr>
<tr>
<td>Inserting the steeple into the tower</td>
<td></td>
</tr>
<tr>
<td>Raising the steeple</td>
<td></td>
</tr>
<tr>
<td>Scaffolding, finishing, cladding</td>
<td></td>
</tr>
<tr>
<td>Installing the bells</td>
<td></td>
</tr>
<tr>
<td>Installing the stairs</td>
<td></td>
</tr>
<tr>
<td>Many other activities to complete</td>
<td></td>
</tr>
</tbody>
</table>

7.2 Constructing the tower and steeple before restoring the main cathedral
An attractive option would be to construct the tower and steeple before or during restoration of the main cathedral. There is no reason why the tower and steeple cannot proceed independently, once the foundations have been completed.
7.3 Major activities
The major activities for design and construction of the tower and steeple are listed below. Many of these items would depend on the structural option and materials selected, and the details developed in the design phases. These activities are listed for Tower Option 2 but are similar for all structural options, but with different emphasis at different stages.

<table>
<thead>
<tr>
<th>Activity</th>
<th>By whom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual design and cost estimates of the timber parts</td>
<td>TFG, PTL</td>
</tr>
<tr>
<td>Appointment of architectural and engineering consultants</td>
<td>Client</td>
</tr>
<tr>
<td>Discussions and negotiations with stakeholders</td>
<td>All</td>
</tr>
<tr>
<td>Preliminary design of tower and steeple</td>
<td>TFG, PTL, Architect</td>
</tr>
<tr>
<td>Pricing of several options</td>
<td>QS</td>
</tr>
<tr>
<td>Structural design of non-timber parts of the tower</td>
<td>PTL, SE</td>
</tr>
<tr>
<td>Structural design of the steeple and any timber parts of the tower</td>
<td>TFG, PTL</td>
</tr>
<tr>
<td>Architectural design of the steeple and the tower</td>
<td>Architect</td>
</tr>
<tr>
<td>Fire engineering design and building services design</td>
<td>Fire engineer</td>
</tr>
<tr>
<td>Obtain building consent (structure)</td>
<td>PTL, SE</td>
</tr>
<tr>
<td>Sourcing and manufacturing the overseas wood components</td>
<td>TFG</td>
</tr>
<tr>
<td>Delivery of the overseas wood components to Christchurch</td>
<td>TFG</td>
</tr>
<tr>
<td>Sourcing and manufacturing the NZ wood components</td>
<td>TFG</td>
</tr>
<tr>
<td>Educational workshop for local carpenters</td>
<td>TFG</td>
</tr>
<tr>
<td>Construction of the foundation for the tower</td>
<td>Main contractor</td>
</tr>
<tr>
<td>Construction of all non-timber parts of the tower</td>
<td>Main contractor</td>
</tr>
<tr>
<td>Assembly of the timber steeple in Cathedral Square</td>
<td>TFG</td>
</tr>
<tr>
<td>Cladding and water-proofing of the steeple. Fix cross at top.</td>
<td>Main contractor</td>
</tr>
<tr>
<td>Construction of four pyramids, one on each corner</td>
<td>TFG</td>
</tr>
<tr>
<td>Cladding of the four pyramids</td>
<td>Main contractor</td>
</tr>
<tr>
<td>Lifting the steeple into the tower</td>
<td>TFG, Main contractor</td>
</tr>
<tr>
<td>Preparing the capstans and rigging</td>
<td>TFG</td>
</tr>
<tr>
<td>Signing off the plan for the steeple raising</td>
<td>TFG, others</td>
</tr>
<tr>
<td>Training of lifting teams</td>
<td>TFG</td>
</tr>
<tr>
<td>Raising the steeple</td>
<td>TFG</td>
</tr>
<tr>
<td>Lifting the four pyramids, cladding lower portion of steeple</td>
<td>Main contractor</td>
</tr>
<tr>
<td>Upper doors, windows, sunscreens,</td>
<td>Main contractor</td>
</tr>
<tr>
<td>Construction of floors for bell ringers, tourist viewing etc.</td>
<td>Main contractor</td>
</tr>
<tr>
<td>Installing the bell frame, lifting and installing the bells</td>
<td>Main contractor</td>
</tr>
<tr>
<td>Construction and installation of stairs</td>
<td>TFG, Main contractor</td>
</tr>
<tr>
<td>Final cladding and water-proofing</td>
<td>Main contractor</td>
</tr>
<tr>
<td>Installation of fire sprinklers, and rainwater downpipes</td>
<td>Main contractor</td>
</tr>
<tr>
<td>Lights, alarms, and other electrical works</td>
<td>Main contractor</td>
</tr>
</tbody>
</table>

TFG = Timber Framers Guild. PTL = NZ timber engineer. SE = NZ structural engineer. QS = Quantity Surveyor

Many of the tasks listed as “main contractor” will be carried out by their sub-contractors in the usual way, with many specialised trades including the masons who will supply and install the cladding, windows and other heritage details.
8.0 Timber materials

8.1 Species
The specific timber species is not important, provided that the wood has sufficient strength, stiffness and durability. It is likely that components manufactured from a number of different species could be provided from different parts of the world. The North American contributions would largely be from American White Oak, with dowels and other small components made from Robinia (Back Locust). The Carpenters Fellowship has offered to investigate a donation of English Oak from forests owned by British Royalty. The long lengths of timber for the steeple could be obtained from New Zealand forests, possibly using plantation grown Douglas Fir.

8.2 Durability and treatment
All timber components must be designed to last for hundreds of years. This will require careful attention to detailing the roofing, flashings and weatherproofing. All exterior surfaces with waterproof cladding would require suitable details to ensure deflection of water, drainage of any water ingress and ventilation to allow drying of any wood which gets wet. Any exterior wooden joinery must be made from durable species and be painted with a suitable paint system. Non-durable timber species will require chemical preservative treatment, but it is likely that most components would be made from naturally durable species.

8.3 Offers of help with supply and fabrication
The international traditional timber frame community has expressed a strong desire to help the project by supplying, manufacturing and delivering pre-manufactured pieces of heavy timber. These offers have come initially from the Timber Framers Guild in the USA and Canada, and the Carpenters Fellowship in the UK. With their help, at least half of the structural timber would be supplied pro bono, accurately cut to size and shape ready for assembly in Christchurch.

These organisations would make this contribution provided that they have an opportunity to engage with and educate the citizens of Christchurch and the local carpenters who would be assisting with fabrication, assembly and erection. Shipping costs would have to be met from the project budget.

Some of the largest timber components could be sourced in New Zealand and be manufactured by local carpenters. There are several members of the Timber Framers Guild in New Zealand, especially in Christchurch and Nelson, and these people have expressed their willingness to assist.

9.0 Contractual options

9.1 Main contractor
It is most likely that one main contractor will be awarded a contract for repair and reinstatement of the Christchurch Cathedral, including the tower and steeple. This main contractor would carry out or sub-contract out all foundation work (including base isolation if required), and would arrange for all construction, cladding and finishing work for the tower and steeple which is not included in the supply and erection sub-contract for the timber work.
9.2 Timber Framers Guild
The Timber Framers Guild is willing to be involved at several stages of the project:
1. After engagement, the Guild would be able to carry out preliminary designs of several options, estimate timber volumes and give estimates of likely costs, for use by the main contractor and project QS.
2. After some decisions have been made about structural options, the Guild would be willing to enter into a design contract, to carry out the structural design of all the timber components, in association with PTL acting as the New Zealand timber engineer. The Guild’s design contract could be directly with the client or as a sub-consultant to the client’s lead structural engineer.
3. PTL could be appointed as the New Zealand timber engineer, directly by the client or as a sub-consultant to the client’s lead structural engineer.
4. After the design has been accepted and approved, the Guild would enter into a sub-contract with the main contractor to supply, deliver, and erect the timber structure.

9.3 Design team
It is expected that a New Zealand design team will be appointed for repair and reinstatement of the rest of the Christchurch Cathedral, including the project architect, lead structural engineer, and quantity surveyor (QS), as well as specialist consultants for foundations, fire safety, weatherproofing, building services etc. PTL is willing to be appointed as the specialist New Zealand timber engineer, to work with the Timber Framers Guild on design and construction of the tower and steeple, and with all other players involved in design and construction.

9.4 Timber Framers Guild design contract
If awarded the design contract, the Timber Framers Guild would employ a suitably qualified design engineer and a project manager for the design phase. The design engineer would be a Guild member who is a professional structural engineer, most likely with a PhD degree in structural engineering. The structural engineer and design project manager may need to visit New Zealand. The structural engineer would work closely with the New Zealand timber engineer who would ensure compliance with all local building codes and regulations. The Guild would produce detailed construction drawings and specifications as necessary, and piece drawings showing the precise fabrication details for every piece of timber in the assembly.

9.5 Timber Framers Guild supply and erection contract
If awarded the supply and erection contract, the Timber Framers Guild would employ a project manager for the supply and erection phase, and a suitably qualified erection manager. Both would be in New Zealand during the planning and construction phases. The erection manager would have appropriate qualifications and experience in rigging and heavy lifting. Both staff would work closely with relevant people in New Zealand, relating to the client, the community, the regulators, and health and safety organisations. The Guild would produce erection drawings and guidance documents as necessary.

The Carpenters Fellowship (UK) would work as a sub-contractor to the Timber Framers Guild wherever appropriate.
9.6 Estimated costs
At this stage there are no estimates of the total cost of the tower and steeple constructed with traditional timber framing methods.

However, at a later stage it is recommended that any estimated costs from the Timber Framers Guild could be separated into two contracts:
1. Structural design.
2. Supply, delivery, fabrication and erection.

The estimated design costs would be for structural design of all timber framing components and connections, in conjunction with PTL and the project Quantity Surveyor. The costs of the New Zealand consultants would need to be allowed for separately.

The Timber Framers Guild initial cost estimate for supply, delivery, fabrication and erection of the timber parts of the tower and steeple would be provided in two versions:
1. Full costs assuming that all materials and labour have to be fully paid for at commercial rates.
2. Reduced costs assuming that a large number of the timber pieces could be provided pro bono by members of the Timber Framers Guild, the Carpenters Fellowship, and other international organisations.

Some early decisions will need to be made as to what is included or not included in the contract with the Timber Framers Guild. All items not in that contract will have to be done by the main contractor. Items needing decisions include the following:
- Façade and roof cladding and finishing, to tower and steeple.
- Installing the bell frame, lifting and installing the bells.
- Construction of floors for bell ringers, tourist viewing etc.
- Construction of stairs.
- Plus many other items not listed above.

10.0 Conclusions
This report has described several options for re-construction of the tower and steeple of Christchurch Cathedral using traditional timber frame construction.

It is strongly recommended that the steeple be re-constructed from traditional timber framing, and be erected with people power in a community steeple-raising event.

The community steeple-raising event could be part of a wider community event to help celebrate the recovery of the people of Christchurch from the devastating earthquakes of 2010 and 2011.

This project could attract valuable international attention for the future benefit of the city of Christchurch and for New Zealand.
Acknowledgements
The author wants to acknowledge assistance from many people including the following:
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Mack Magee, President Timber Framers Guild, m@ftet.com
Bill Keir, Carpenters Fellowship, UK. bill@oakwrights.co.uk
Frederick Baumert, Keast and Hood Structural Engineers. fbaumert@keasthood.com
Mark Belton, Christchurch. mbelton@permanentforests.com

Comments and suggestions from any interested parties are welcome.

References


This report has been written by Dr Andy Buchanan, Emeritus Professor in Structural Engineering at the University of Canterbury, and Principal of PTL Structural Timber Consultants.

Appendix A: Drawings for Scott’s initial timber design.

Plan view

Cross sections
Longitudinal section

South elevation
West and east elevations

These drawings are from pages 135 to 137 of Lochhead’s book.
Appendix B: Tower Option 3 – timber structure for the tower.

Tower Option 3 is based on the structural materials being traditional timber frame for the entire tower and steeple. A brief summary is given below. Possible steps in the reconstruction are shown in the sketches.

Step 1: Construct three major timber segments on the ground.

Step 3. Raise the top section of the tower.

Step 4. Tilt the steeple into the tower.
Step 4. Raise the steeple.
Step 6. Scaffolding, cladding, finishing.
Appendix C: Report of 2016 meetings in Pennsylvania, USA

On the weekend of 10-12 June 2016, Andy Buchanan of PTL met with Marcus Brandt, master craftsman, and Mr. Mack Magee, timber engineer, in East Greenville, PA. Mack Magee is President of the Timber Framers Guild, and a consulting engineer with Fire Tower Engineered Timber. A telephone conference call was made with Mr. Bill Keir, President of the Carpenters Fellowship, UK, and several site visits were made to historical churches.

Site visits
Christ Church in Philadelphia started construction in 1727. From 1754 to 1810, the church building's 196-foot (60 m) tower-and-steeple was the tallest structure in the United States. We were shown around the inside of the masonry tower and timber steeple by Mr. Frederick C Baumert of Keast and Hood, structural engineers, Philadelphia. We climbed from the top of the masonry tower to the open cupola, then to the top of the steeple, with great views of the city of Philadelphia. This steeple was damaged by fire after being struck by lightning in 1906, and was reinstated with new timber framing and an automatic fire sprinkler system.

Two other churches visited were the Great Swamp Church of Christ, in Spinnerstown, PA, built in 1872, and the Central Moravian Church, in Bethlehem, PA, was built between 1803 and 1806. The Central Moravian Church has a timber cupola and bell tower supported on long span timber roof trusses. Marcus Brandt has advised on preventive maintenance of the timber framing over several years.
Timber Framers Guild
The Timber Framers Guild [www.tfguild.org](http://www.tfguild.org) is an educational organisation with a membership of over 1000 timber frame enthusiasts, mostly living in the USA and Canada. The Guild employs a fulltime Executive Officer and several administrative staff. It publishes a monthly journal Timber Framing. The Guild is able to offer professional consulting engineering services and project management of large community events such as the design, construction and raising of large buildings and bridges. The Timber Framers Guild is very keen to assist with the Christchurch Cathedral project, especially if the project will create opportunities for enhancing the mission of the Guild, in promoting the art and science of traditional mortise and tenon timber frame construction around the world.

A sister organisation is The Carpenters Fellowship [www.carpentersfellowship.co.uk](http://www.carpentersfellowship.co.uk) based in the UK which is similarly interested in the Christchurch Cathedral project. The Carpenters Fellowship would work as a sub-contractor to the Timber Framers Guild.

Fire Tower Engineered Timber
Mr Magee’s consulting company is Fire Tower Engineered Timber [www.ftet.biz](http://www.ftet.biz), typical of many similar companies which belong to the Timber Framers Guild. Fire Tower employs five professional structural engineers, some with PhD degrees. The company offers a full service including structural design, drawings, project management, and arranging for fabrication and erection of both traditional and modern timber structures.