Baker Memorial Lecture 2017: Nidaros – The Portland cement cathedral

Per Storemyr

Per is a geologist and geoarchaeologist who specialises in prehistoric and historic procurement of materials, in particular stone, for building and utilitarian use. He has almost 30 years' experience working on projects across Norway, in other parts of Europe and in Egypt. Currently, he is employed at the Norwegian Millstone Centre in Sogn og Fjordane county, Western Norway. Per also works with weathering and conservation of old stone buildings and rock art and runs his own company, Archaeology & Conservation Services (www.per-storemyr.net).

Ladies and gentlemen, dear colleagues!

I don't like to interrupt fine dining and fine conversations, for we have the finest food and we are talking about the finest binder that was ever invented! We are celebrating lime tonight – the glue that binds us together – a grand material with a history reaching back perhaps 12,000 years. But we are also troubled by another grand material – the material that shapes our modern world, a material we cannot do without, yet is unsuitable for restoring the stone buildings that we care so much for – Portland cement. It gave us big hopes back in 1824, only 200 years ago, when Englishman Joseph Aspdin patented his invention (although, as we know, he was standing on the shoulders of Roman giants).

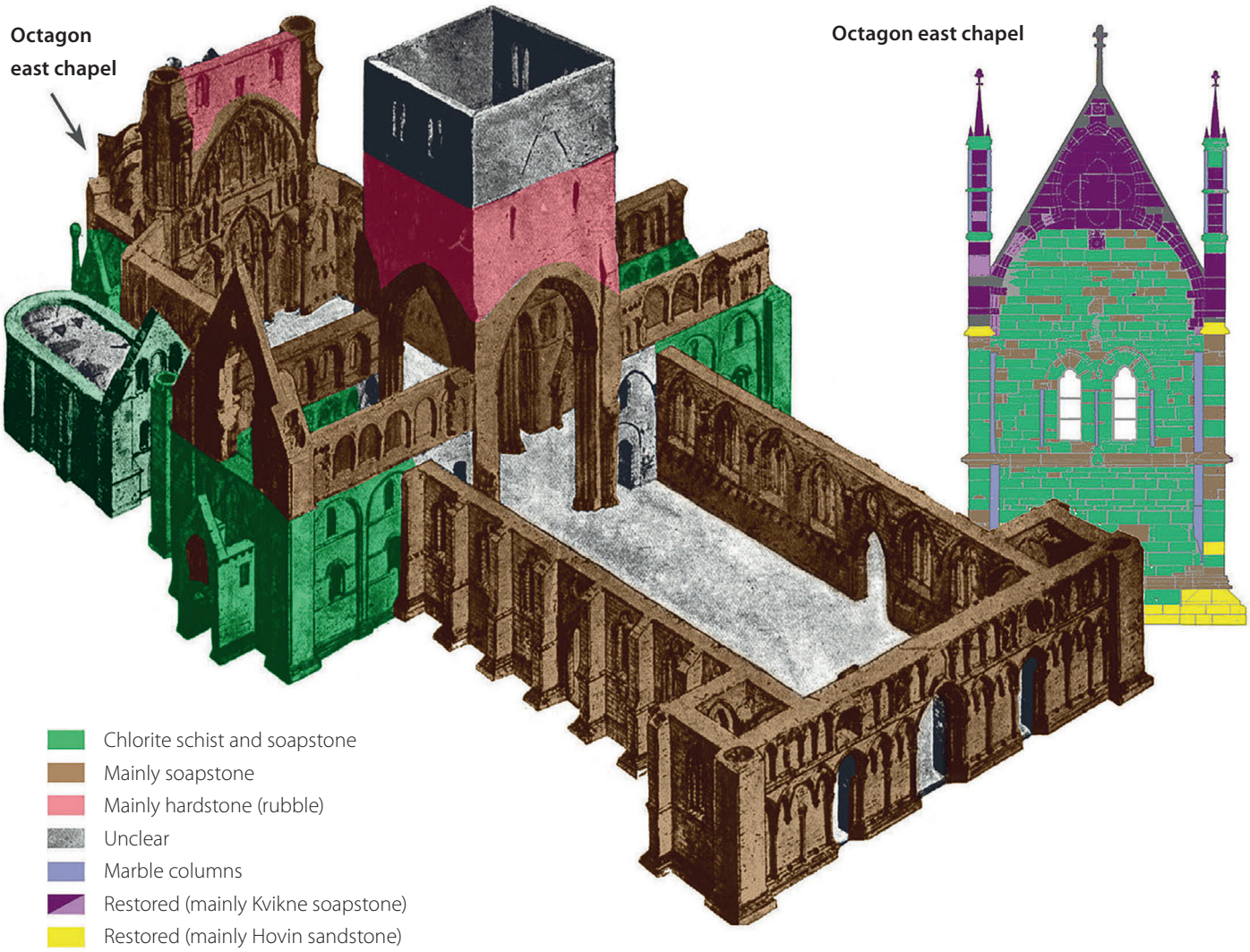
I have been given a task tonight: to discuss Joseph Aspdin's legacy at Nidaros Cathedral, how his invention ousted traditional local lime during the restoration and reconstruction of the cathedral, which started in 1869.

But first, I want to say that I am deeply honoured to have been asked to deliver the Baker Memorial Lecture. I am new to the Building Limes Forum, and I know very little about the pioneering work of Eve and Robert Baker at Wells Cathedral in the 1970s, at the very start of the lime wave that has since swept across Europe in response to the problems caused by the widespread use of Portland cement and the resulting damage to our stone buildings. Traditional lime is the solution, the material that was used to construct the buildings. I have been a follower of lime for some time, but lately I've become a true addict, as you perhaps may have realised from my lecture about lime burning in Western Norway earlier today.[1]

My knowledge about what the Bakers initiated at Wells and elsewhere might be limited, but I know something about Nidaros Cathedral, for it has been deep within my heart for nearly 30 years now. I made my doctoral thesis on the cathedral, I have written a book and many papers about it,[2] [3] and I worked at the cathedral for years. I sincerely want to thank my former employer, the Nidaros Cathedral Restoration Workshop, for inviting me to give this lecture.

The stones of Nidaros Cathedral

Nidaros Cathedral is the northernmost of Europe's great medieval cathedrals. It is often called the 'soapstone cathedral', since it is largely built from



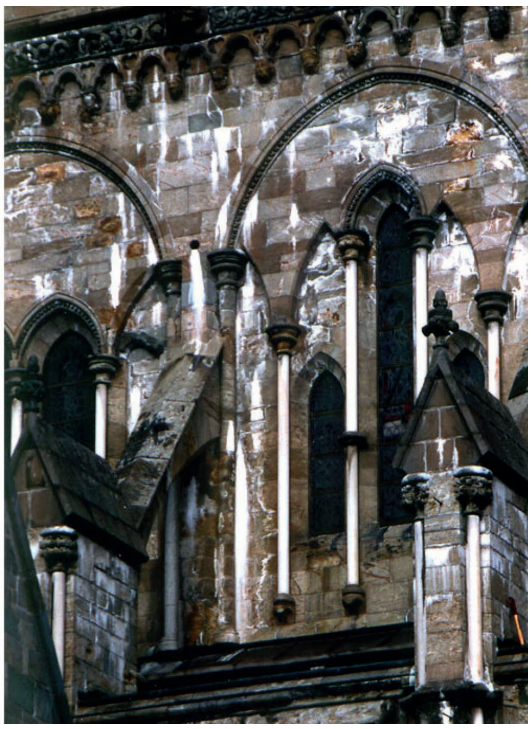
this softest of stones, like so many old churches in Norway. This is a result of geology: we simply don't have fine limestone or real freestone up here. And there isn't much soapstone either, which is the closest you can get to a local freestone. Consequently, many different quarries – no fewer than 70, to be precise – were put to work, which means that Nidaros is also a 'chlorite schist cathedral', a 'sandstone cathedral', a 'granite cathedral' and, especially, a 'marble cathedral'. The last is in a good English tradition – think of Purbeck marble – and there are no fewer than 10,000 marble columns decorating the cathedral. In fact, generally, Nidaros is an English cathedral; almost everything was based on English traditions and innovations.

So we share a common heritage: not only architectural, but also as regards Portland cement.

The legacy of Portland cement at Nidaros Cathedral

Over the past 150 years, Nidaros has become the 'Portland cement cathedral'. It is a true icon and is regularly referred to in scientific works discussing the pros and cons of Portland cement. Scientists are interested in the damages that we have reported: cracking of masonry, water infiltration, frost damage and, especially, all the salts derived from cement – salts that simply eat up medieval stonework. There is also an aesthetic side, for the cathedral is renowned for its many white calcite crusts, just like stalactites in a limestone cave. But at Nidaros the stalactites originate from the calcium hydroxide in Portland cement.

Fig. 1 Remaining medieval masonry at Nidaros Cathedral in 1869. Colours indicate the main stone types used, from multiple quarries. Drawing by Joakim Mathisen, Nidaros Cathedral Restoration Workshop; stone types added by Per Storemyr.



Figs. 2 and 3
The choir at Nidaros Cathedral just after reconstruction in the 1880s (left) and in 1994 (right), before the last restoration in the early 2000s. The white calcite crusts and salt efflorescence are a result of leaching of calcium hydroxide and sodium from Portland cement used in the 1880s, and particularly during a restoration prior to 1920. (Credit: Fig. 2 Nidaros Cathedral Restoration Workshop; Fig. 3 Per Storemyr)

When I started working at the cathedral almost 30 years ago, Portland cement was the standard binder used in restoring its damaged stonework. I was not the only one to question this practice. Restoration architects began their questioning as far back as the 1950s, but this didn't result in much change. Seventy years later, the tide has turned: now the cathedral even has its own kiln producing traditional lime. Congratulations!

But why did Portland cement get such a grip on the cathedral? We all know the standard story about Portland cement replacing traditional lime in Europe, and worldwide. In Trondheim there are some particularities, for Portland cement was probably introduced to the region by the very architects who were in charge of the restoration in the mid to late 19th century. They were educated abroad, typically in Germany, so they knew very well about this new and promising material.

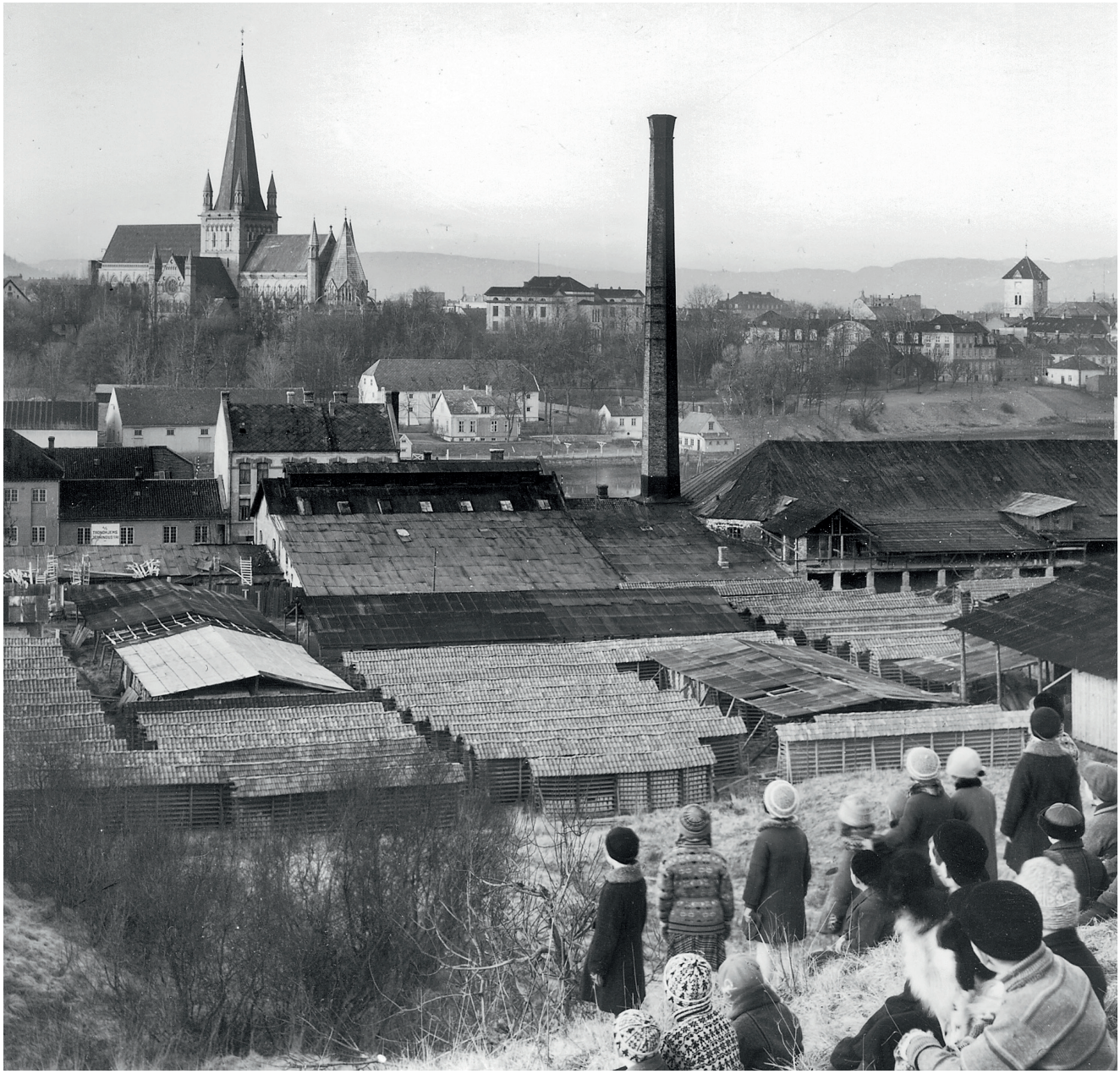
But the first load of Portland cement for the cathedral came from England, shipped from Newcastle in 1869. It was extremely expensive: almost ten times more costly than local lime, produced across the region at many places along the Trondheim Fjord. Therefore, there was no question about using cement alone. Instead, a little bit was added to the cheap local lime, with the aim of making it stronger, and the practice worked quite well. There are, in fact, few damages at places restored with this early form of lime-cement mortar.

The architects soon turned to Germany and the Portland cement factory in Hemmoor near Hamburg. Hemmoor, which is now a German national cement museum, was the most important supplier until the turn of the century, but by 1892 it had competition from the first regular Norwegian producer – the Slemmestad factory near Oslo. With more producers and falling prices, the mortars used at the cathedral became increasingly cement-rich, yet they still seem to have been reasonably good and adapted to the purpose.

This was until the end of World War I. For in 1918 a second cement factory was established in Norway, at Kjøpsvik, far up in the north. Production began by 1920 and from then on, due to national regulations, Kjøpsvik was the sole supplier to the cathedral for more than 70 years. Soon, the traditional lime-cement mortars were replaced by pure cement mortars – even cement 'soups' were injected into the masonry – and before long the cathedral started to suffer. Large parts of the newly built nave and the west front, as well as second generation restoration works all over the cathedral, became infested with this new cement.

And it is a cement with a major problem: it has a very high component of alkaline salts – sodium carbonates to be more precise – which has been disastrous for the cathedral. These cement salts effectively 'eat up' the stone fabric, in addition to the more general cement problems of cracking, water penetration and frost damage.

Furthermore, the latest parts of the building – the upper section of the west towers originally built in the 1960s – are in fact not real natural stone constructions, but concrete clad with soapstone. One may wonder what will happen to the concrete, for with such a high content of alkaline salts it may be prone to 'concrete



disease' or (more correctly) alkali-silica reactions. Many modern concrete constructions in Norway suffer from this disease, and hundreds of millions of Norwegian krone have been put into the repair of such structures over the past decades.

Whatever the reason, the Nidaros Cathedral Restoration Workshop is facing troubles with the west towers, but I am confident that it will solve the problem, as long as necessary grants are given. However, it is, of course, not easy to restore a cathedral so infested with concrete and Portland cement mortars. In many cases, it may not be possible to work with old-fashioned lime mortars, nor is it necessarily desirable for parts of the building reconstructed with the use of cement mortars alone. These are modern neo-Gothic constructions! But medieval parts certainly can and should be restored using traditional 'fat' lime mortars.

Thus, we are faced with a classical situation. It reminds us of good old Aristotle, who stated, way back when: 'Pros ton kairon' – Do what the occasion requires! Be practical!

Back to lime

Twenty years ago, as I finalised my doctoral thesis on the weathering and conservation of the cathedral, I was rather pessimistic. Portland cement was still being used and it was difficult to obtain traditional Norwegian lime, as local/regional production had ceased decades before. Although experimentation was under way, and

Fig. 4 Nidaros Cathedral was under reconstruction by 1930. In the foreground is the brickworks at Bakklandet, which also delivered traditional lime during the early stages of the restoration from 1869. (Credit: Nidaros Cathedral Restoration Workshop)

the modern lime wave had certainly also hit Norway, the general picture was rather bleak. In my book *The stones of Nidaros. An applied weathering study of Europe's northernmost medieval cathedral* (1997), I wrote that the traditional production and use of lime is a forgotten craft in present-day Norway.

This was only 20 years ago. Although we now struggle with imported natural hydraulic lime, sold and used as 'pure lime' (this is not nice!), the situation is rapidly improving. Lime is far more readily available and is used in many conservation projects, and – more importantly – the traditional craft of burning and slaking lime is spreading. At least five projects have been or are being undertaken: in Oslo, Røros, Hamar, Hyllestad and – not least – here in Trondheim. We are experiencing a growing and much-needed diversity in our struggles to rediscover an almost forgotten craft.

Yet, what have we actually learnt from the projects? There are some videos and PowerPoint presentations available, but very little that helps us truly learn from each other. How have the new local limes really performed at restoration works?

Thus, this is my challenge to us all: to provide easily available, hard documentation – 'This recipe works, this does not work.' Since the Nidaros Cathedral Restoration Workshop is a centre for conservation in all of Norway, it has a very special responsibility, and it ought to be backed generously in the future by the Norwegian Directorate for Cultural Heritage. We need to start a national programme for local lime burning, slaking and use of local limes. It was a substantial industry until World War II; now it is time not only to carry out experimental work, but also to fully rediscover and investigate a major part of our cultural heritage.

Fig. 5 Building the flying buttresses of the reconstructed nave in the 1920s, with buckets full of Portland cement. (Credit: Nidaros Cathedral Restoration Workshop)

Fig. 6 Building the belfry of the southern west tower in the 1950s, using Portland cement mortars in both cores and joints. (Credit: Nidaros Cathedral Restoration Workshop)

Fig. 7 The reconstructed cathedral. The west front of Nidaros Cathedral today. (Credit: Per Storemyr)

How wonderful that this conference is showing that people are taking responsibility for this. We meet, we discuss, we eat and we drink. Many new contacts are made. We are experiencing diversity across Europe. We are rediscovering our dear almost-forgotten craft!

Thanks

I want to thank the organisers for a superb conference. I specifically want to thank all the British among us. We share a long history. A thousand years ago you gave us lime, but in the 19th century you also gave us Portland cement. You gave us a hell of a lot of problems!

A big toast for lime. Tonight we celebrate the glue that binds us together!

The Baker Memorial Lecture was given by Per Storemyr on Friday 8th September 2017, in the Great Hall of the Archbishop's Palace, Trondheim, Norway.

Endnotes

1 P. Storemyr, 'Experimental archaeology: Building a limekiln in Western Norway', *The Journal of the Building Limes Forum*, 24, 2017.

2 P. Storemyr, *The stones of Nidaros. An applied weathering study of Europe's northernmost medieval cathedral*, PhD thesis, no. 1997:92, Norwegian University of Science and Technology, Trondheim, 1997. Download PDF (19.1 MB) here: perstoremyr.files.wordpress.com/2010/07/1997_storemyr_the_stones_of_nidaros.pdf

3 P. Storemyr, *Nidarosdomens grunnfjell. En reise i steinbryternes fotspor fra Det gamle Egypt til Europas nordligste katedral* (The quarries of Nidaros: A journey in stone from ancient Egypt to Europe's northernmost medieval cathedral), Nidaros Domkirkes Restaureringsarbeiders, Trondheim, 2015. Information (in Norwegian) here: per-storemyr.net/2015/08/21/nidarosdomens-grunnfjell-les-utdrag-og-omtaler-av-boken