Restoring Notre Dame

How Do You Restore 850 Years Of History?

On April 15, 2019, the world watched in horror as the 850-year-old Notre-Dame Cathedral in Paris went up in flames. The fire burned for over eight hours, long into the Parisian night. People came outside and stood on street corners to watch; they gasped as the roof collapsed and the spire toppled. You don't have to know much about Gothic architecture or the cathedrals of Europe to know Notre-Dame is transcendent. It is world famous and watching it burn felt like watching history disappear.

But in the light of day, it turned out that much of the structure was there. The iconic twin bell towers are standing tall and the flying buttresses are still intact and holding. So much of the cathedral is made of stone and unable to burn, yet, fire temperatures had reached up to 1,800˚F and hours of continuous water had doused the structure. The damage assessment was only just beginning.

Almost immediately people were questioning whether the cathedral would be restored exactly as it was or with a modern twist. How does an 850-year-old structure get restored using the building materials of today? The restoration must be a combination of old-world artisanship and new-world technology. It is a construction project on a massive scale under the weight of architectural and historical significance, and with the whole world watching.

Fire in the City of Light

Notre-Dame had been undergoing a large renovation project, launched in 2018, when the fire struck. There was a full set of scaffolding atop the cathedral so that workers could access the roof and spire. In fact, just days before the fire, 16 copper statues depicting the 12 apostles and four evangelists had been removed from the roof where they had watched over Paris for over 100 years.

The 12 Apostles, and other architectural elements of Notre-Dame had been removed weeks before the fire.

The fire broke out amidst the scaffolding that covered the lead roof. The fire alarm sounded, the cathedral was evacuated, and initially guards went to the wrong location looking for the fire. This allowed the fire to burn freely for approximately 20 minutes before firefighters arrived and started to battle. Over 400 firefighters came to fight the fire.

Due to the cathedral's construction and historical contents, firefighting techniques were altered slightly. To prevent damage inside the cathedral, water was sprayed using deluge guns at lower-than-usual pressure. Water was not dropped from the sky because heated stone can crack if cooled suddenly. One particular concern was molten lead falling from the roof onto firefighters.

In the end, most of Notre-Dame's wooden roof and spire were lost, collapsing onto the stone vault that forms the ceiling above the nave. As the roof collapsed onto the vault some debris fell through to the cathedral below. However, due to the rib vaulting in the stone, most sections remain intact. Many artifacts, relicts and paintings were saved as they were housed within the cathedral, which is essentially insulated by the stone architecture. There is significant smoke damage throughout the building, which heated up to between

1,500˚F and 1,800˚F. However, the full nature of the building's degradation is still unknown.

Just removing the scaffolding that burned will take months. It is estimated there are 50,000 tubes of scaffolding that reached temperatures of over 1,500˚F. Some of the tubes fell through the roof and into the interior, and some are still standing, fused together by the heat.

South face of the cathedral 30 days after the fire. (Photo courtesy of Eric Coffman)

The cause of the fire is likely to be either faulty electrical or the simple flick of a cigarette in the wrong place. While there was a no-smoking policy at the construction site, there were also reports of cigarette butts found. A criminal investigation is ongoing, however, targeting any single worker will be difficult. The next steps to address are the restoration, and how to pay for it.

Funding the Future

Immediately after the blaze, millions in donations poured in from corporate heavyweights, and individual and private donors. To date, most of the big donors have not paid up. One of the issues is that French billionaires are perceived as only wanting to fund restoration activities with the chance to influence architectural features, not pay for the down and dirty cleanup and safety measures that naturally must come first. In actuality, most of the money coming in at this point is from Americans, through an organization called "Friends of Notre Dame de Paris" founded in 2017. The organization's president, Michel Picaud, stated that 90% of the $4.1 million dollars donated for restoration has come from Americans.

French President Emmanuel Macron pledged cleanup and restoration would be complete before France hosts the 2024 Olympics. In June 2019, the French National Assembly passed a reconstruction bill. The bill shall collect the $954 million in pledged donations for reconstruction. However, French Parliament has yet to pass the bill as opposition believes a five-year cleanup plan is too ambitious and unattainable.

Regardless of who pays and when, there is a lot of cleanup to conduct. Anyone working in construction today understands deadlines and budgets. Imagine a construction project like Notre-Dame cathedral, which took two centuries to complete in the first place.

Cleaning Up a Cathedral

Construction work on Notre-Dame is nothing new; it has essentially been under construction or in some state of restoration for over 850 years. All in all, it's a patchwork of design, craftsmanship and centuries. Victor Hugo described Notre-Dame as: "a central mother church ... It has the head of one, the limbs of another, the haunches of another, something of all." Others have called Notre-Dame a Frankenstein: a mishmash of different architecture styles throughout the centuries.
Before any restoration can begin, the massive cleanup is underway.

The once tourist-filled grounds are now a highly secured construction site. Workers wear protective gear and facemasks due to contaminants; for example, there is a high concentration of lead onsite due to the lead roof. Workers also regularly take blood tests to monitor lead exposure. The wooded roof covered the stone vault as a way to waterproof the stone structure. The wood roof was covered in lead. Consequently, there is a high concentration of lead and debris on the portion of the roof that didn't give way.

There are 40 cleanup teams onsite under the guidance of four lead architects. All debris is being carefully removed. Debris containing stones or relics that need to be preserved is brought out and marked indicating where it was found, then stored for replacement later. The stained glass windows have been removed for cleaning and protection.

"Americans are very generous toward Notre-Dame and the monument is very loved in America. Six out of our eleven board members are residents in the U.S."
– Michel Picaud, President, Friends of Notre Dame de Paris

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Sealed windows (glass removed) and roof tarps run underneath melted scaffolding. (Photo courtesy of Eric Coffman)

Outside the cathedral, a tarpaulin covers the roof to protect the interior. The flying buttresses held firm during the fire. However, their structural integrity is still unknown. For now, the buttresses are being shored up underneath with wooden bracing.
Inside, some of the support columns have been reinforced. There are nets that span the nave on the inside to catch debris and to indicate to workers where things fall. Robots and excavators traverse the marble floor carefully gathering up beams and scaffold and other debris. It is a slow and painstaking process.

Rebuilding a Relic

Just how to reconstruct the cathedral is a topic of much discussion in the world of architecture and historical preservation. Some want it restored exactly as it was. Others want to reconstruct with a nod to where we are now; put the 21st century stamp on it – as has been done over the centuries at Notre-Dame. Still others would like to see rebuilding with modern materials but preserving the old look and feel.

Andrew Tallon capturing digital data inside the Notre Dame cathedral – circa 2010

In 2010, Andrew Tallon, a professor from the United States, conducted a comprehensive 3D laser mapping of the entire cathedral which may help in its reconstruction.

Tallon was able to capture precise measurements and a 'record of reality.' Andrew Tallon passed away due to cancer in November of 2018. His work with images captured by the drone-borne, 360-degree spherical cameras he deployed at the 800-year-old cathedral continued until his death. This mapping data can be employed in the reconstruction phase to show how the building's damaged areas were before the fire and therefore how to recreate them. The four teams working onsite use modeling data from the 3D mapping in a central database.

One of the significant challenges to rebuilding Notre-Dame will be replacing the wooden roof. The roof was constructed from centuries old oak beams. It will be difficult to find the right size of oak timber needed to rebuild. The 13th century forests that provided the original wood no longer exist in France. Timbers need to be 2 feet by 2 feet and up to 30 feet in length. Finding this size oak is harder than it used to be.

It is still unknown whether the masonry is sound. Yes, it survived the fire, however it is not yet known if the intense heat from the fire weakened the structure. And the integrity of the masonry is still being evaluated. The efforts to save Notre-Dame have really just begun.

Old World Repairs

This is a monumental project that has never been done before. Despite Macron's unrealistic five-year plan, some experts have estimated it could take between 10-20 years to actually complete the restoration. One of the issues is finding the workers to complete the painstaking restoration work. There quite literally may not be enough skilled workers who know how to do this specialized type of restoration.

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Training An Army of Artisans

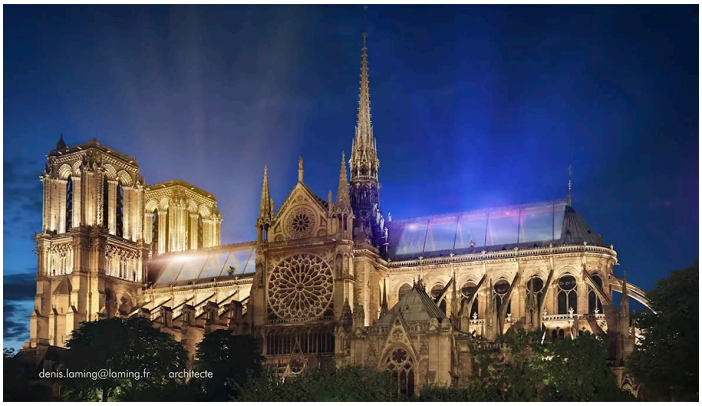
The French organization, Les Campagnons du Devoir, is a group descendent from ancient craftsmen that trains people in manual trades relating to stone, wood, metal, leather and textiles. They are true artisans who train for years to learn their trade and then travel around France repairing the country's architectural treasures. Their ranks of stonecutters, woodworkers, quarrymen, roofers and sculptures may ultimately be tasked with restoring Notre-Dame. However, according to their secretary-general, hundreds of craftspeople will need to be trained, which would increase reconstruction time.

Visioning a New Notre-Dame

The big question regarding how to reconstruct the cathedral, exactly as it was or in a more modern way, rages on in France with proponents on both sides dug in.

Vincent Callebaut Architecture proposes a new solar powered roof design.

With a chance to affect the most iconic building in the world, the suggestions—both preposterous and original—have poured in. One company proposed to collect the ash, dust and damaged stone from the rubble, and turn it to 3D printable powder. The powder can be used to essentially reprint the pieces that were destroyed. They have done this successfully with relics at other buildings in Europe. This technology quite literally mixes old with new.



Architect Denis Lamin's vision of a retractable roof and spire reconstruction.

An architectural design competition was announced by the government for a new spire and rooftop.

Some of the proposed ideas include:

- Endless beam of light spire into the sky
- Stained glass roof and spire
- Baccarat crystal spire
- Glass greenhouse roof and spire
- Futuristic metal roof and spire
- Rooftop garden, rainforest or conservatory
- Rooftop pool

The French government has the ultimate say, but it is anticipated that the French people will have a say. For now, the cleanup trudges on while decisions about how to rebuild and who will pay for it are battled out in French government.

A Brief History of a Long Life

Notre-Dame de Paris—our lady of Paris—reaches far back into history. Planning began in 1160 under the conception and direction of then Bishop of Paris, Maurice de Sully, who chose to build it in the Gothic style and dedicate it to the Virgin Mary. Churches and houses were demolished for construction of Notre-Dame which actually sits on the Ile de la Cite, a small island in the Seine River.

King Louis VII and Pope Alexander III were present as the first stones were laid in 1163. The cathedral was constructed slowly over many decades; first the choir and ambulatories were constructed, then the high alter, later the sections of the nave were built, and the bases of the façade were completed. In the mid-1200s, details such as the iconic rose stained-glass window were added. And in the early 1300s, the massive stone flying buttresses were added – a signature aesthetic of Gothic architecture.

The construction of Notre-Dame took over 200 years, and during its 850-year lifespan, relentless damage and countless restorations and repairs have been made. The Huguenots damaged it in the 1500s. King Louis XIV commissioned repairs and then later that century, revolutionaries damaged, pillaged and ransacked the building.

It was in a significant state of neglect when, in 1831, Victor Hugo wrote The Hunchback of Notre-Dame to restore interest and care in the cathedral, which it did. The book was a huge success and in 1844, 25 years of restoration work began.

The structure was damaged again in WWII, but victorious bells tolled when Paris was liberated from German occupation. In the 1960s, to mark its 800th anniversary, centuries of grime and soot were cleaned from the façade. In 1991, aspects of the exterior were replaced. In 2018, as $6.8 million renovation of the spire and rooftop began; it was during this work that the fire broke out in April 2019.

Along with the Eiffel Tower, Notre-Dame is the symbol of Paris and of France. Before the fire, upwards of 13 million people visited the cathedral each year. It while it remains a major point of interest and visitation, today no one is getting too close.

850 Years of Construction

1163 – First cathedral stone laid
1177 – Choir completed
1182 – High alter completed and first mass held
1190 – Bases of the façade put into place
1220 – Innovative use of rib vaults in the ceiling employed
1250 – Upper gallery of nave completed
1300s Flying buttresses employed
1548 – Damage suffered by Huguenots
1699 – Major renovations commissioned by King Louis XIV
1726 – Modifications to roof made
1789 – Revolutionaries damage, pillage and ransack building
1801 – Catholic Church regains control and begins cleanup
1831 – Victor Hugo's The Hunchback of ND, restores interest and reverence
1844 – Restoration work begins that lasts for 25 years
1944 – Bells ring out as Paris is liberated from Germany
1963 – Centuries of grime and soot cleaned from façade
1991 – Exterior replaced
2018 – Renovation of spire begins
2019 – April 15: Massive fire breaks out
2019 – June 15: First Mass held at ND since the fire – just 30 attendees wearing hardhats

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