

Notre Dame de Paris 2019 Fire

Notes on the response and early discussions on rehabilitation

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The following report has been compiled based on a meeting that was held with ICOMOS France President Jean Françoise Lagneau and ICOMOS France / ICORP member Samir Abdulac in Paris on 13 August 2019. The report also refers back to the discussions held between ICOMOS members of ICORP and ISCARSAH right after the disaster which was documented and compiled in a report dated 11 May 2019. The report also links these discussions in short to the experience of post-2015 Gorkha Earthquake response and rehabilitation in Kathmandu.

Smoke was seen rising from the roof of the Notre Dame cathedral in Paris and at 6:18 pm the alarm was immediately raised. Though fitted with the most highly sophisticated alarm system with smoke detectors, there was initial confusion about where the fire was located. At 6:45 pm the alarm was raised again while the fire had already spread over the wooden roof structure and by 7:00 pm over six hundred firefighters arrived at the site for the rescue mission. However, within an hour of their arrival at 8:00 pm the spire collapsed and the fire engulfed the entire roof structure.



Figure 1: The blaze around the spire of Notre Dame, Image Wikipedia (Wandrille de Prévile)

The Notre Dame de Paris – a short introduction of history and architecture

Notre Dame de Paris is one of the most influential monuments of the French Gothic style developed in the first half of the 12th century. It was emblematic for the scale and technique used during construction. It was begun around 1163 during the reign of Louis VII under Bishop Maurice de Sully and was completed around 1250 with four major phases of remodelling and revision as work progressed. The monument continued to be modified in the course of the following centuries. During the French revolution the monument suffered major damage with destruction of statues and the church was desecrated. In early 1802 the cathedral was returned to the Roman Catholic church and in 1844, the Government of King Louis-Philippe I decreed the restoration of the Cathedral of Paris. Hence, one of the largest restoration

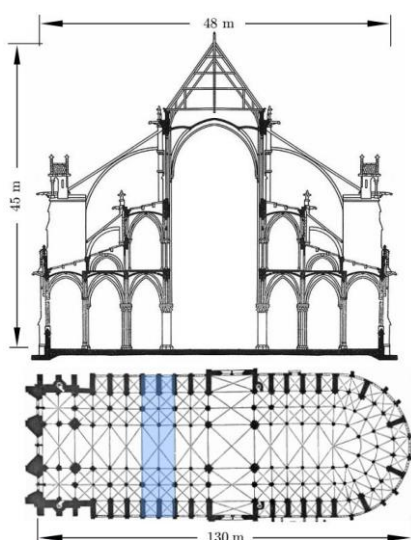


Figure 2: Sketch Section and Plan - image: www.researchgate.net/ (Paolo Vannucci et al)

work on the Notre Dame de Paris took place in the mid-19th century under the supervision of two architects Eugene Viollet-le-duc and Jean-Baptiste Lassaus which brought about major modifications to the monument including a new spire. During a period when most of the medieval past and gothic art was being ravaged, Victor Hugo renewed the interest in the historic past of Paris through his writings which also played a major role in the revival of Notre Dame de Paris.

Notre Dame de Paris is considered one of the finest examples of Gothic architecture. Its design incorporates Gothic elements such as the pointed arch, ribbed vaulted ceilings, flying buttresses, large openings and high ceilings. However, most of the structural components of this architectural style were modelled during the various phases of construction as per structural requirements. For the lateral support of the vaulted ceiling and the fine masonry walls the flying buttresses and supporting piers were introduced. This in addition allowed for larger openings illuminating the interior of the cathedral.

The main western façade of the cathedral as well as the transept portals were highly decorated with sculptures which were damaged during the French revolution. During the renovation work of the 19th century it was possible to revive this masterpiece of the 13th century. To replace an earlier spire that was lost at the end of the 18th century with little documentation, a new spire was constructed inspired by the nearby Sainte-Chapelle spire. Furthermore, copper sculptures of the 12 Apostles and stone gargoyles were introduced.



Figure 3: Notre Dame de Paris in 1750 -Image: Prisma/UiG/Getty Images



Figure 4: Notre-Dame de Paris, by Hamilton, 1827 - Image: Gallica-BnF



Figure 5: Notre-Dame de Paris, by Édouard Baldus, 1860s – Image: Metropolitan Museum of Art

Restoration work of the 20th and 21st century

Partial restoration work of Notre Dame took place during the 20th century. In 1965, the windows of the nave were provided with coloured glass replicating the 12th and 13th century ones. In 1982 major cleaning of the interior of the cathedral took place while a major restoration and cleaning of the northern main façade of the Notre Dame was done in the 1990s. Between 1990 and 1992 the great organ was restored.



Figure 6: Missing gargoyles and deteriorated stonework - image Kai Weise

However, the state of conservation of the Notre Dame de Paris in the early 2000 was appalling with most of the decorative stone elements including the gargoyle and stone balustrade becoming very fragile. The stone masonry of the flying buttresses was unstable while the spire was tied in place using a metal belt. Therefore, a major restoration project was approved as per the report presented by the conservation architect in 2013. In 2018 work began on restoring the spire and one of the flying buttresses on the southern side. The first task of this project was the restoration of the spire. Therefore, in early 2019 huge steel scaffoldings were installed. The eight allegories (statues) on the spires were removed. A few days later the fire gutted the roof and spire of Notre Dame.

Response to the Notre Dame de Paris fire

Once the fire was located the response was carried out in a highly professional manner. The firefighters drew sketches planning out the strategy to approach this situation, clearly reflecting their level of training and knowledge of the historic structure. Water was pumped from the Seine to spray on the inferno while important artefacts were removed from the monument including the most precious relic, the Holy Crown of Thorns. Emergency evacuation was carried out successfully as per preparatory planning.

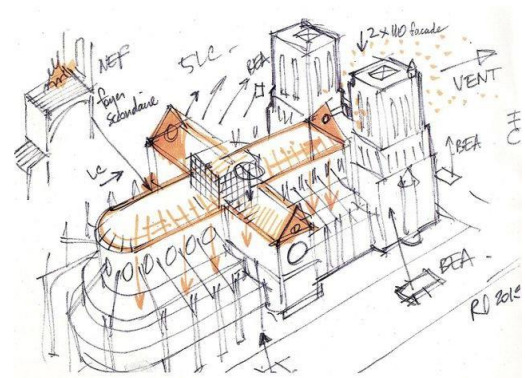


Figure 7: Sketch by firefighters planning strategy on site – Image René Dosne/BSPP

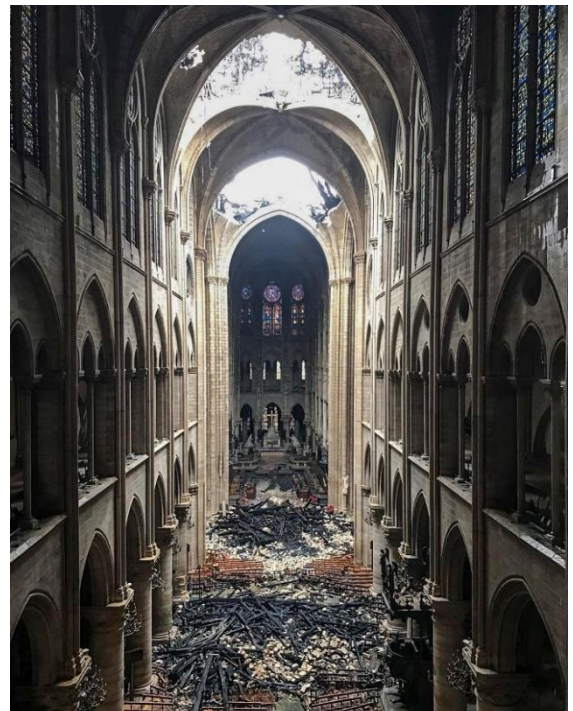
A large fire engulfing the roof and upper sections of Notre-Dame de Paris, with thick smoke rising and scaffolding visible on the left side of the building.

melted and possibly further fuelled the flames. The large sections of wood were later found to be charred only on the surface, which meant that the smaller timber elements were the main fuel for the fire. At 7:37 pm the roof collapsed, beginning with the eastern naïve. The spire which was largely a timber structure caught fire in a spectacular manner and collapsed at around 8:00 pm. The huge steel scaffoldings of the ongoing restoration remained in place but were deformed and welded together by the heat.

[illegible]

The clearing and initial assessment of the monument was done by robotic vehicles which included the removal of timber, stone and remains of the melted lead. Rather surprisingly, and thanks to the extraordinary competence of the firefighters, the stained-glass windows and many artefacts along the side aisle of the cathedral and the main towers and belfry were saved. A team of conservators was involved in salvaging important artefacts. One of the objects also found within the debris that fell into the cathedral was the finial of the spire, the cock.

President Emmanuel Macron visited the site of the disaster the same evening and gave an interview to the media saying that he would prioritize the reconstruction of Notre Dame, bringing the required experts, if necessary, from beyond the borders. He made more definite statements the following day, stating that the Notre Dame would be rebuilt even more beautifully. He also stated that the construction would be completed within five years in time for the 2024 Summer Olympics that will take place in the city. The following day an international design competition was announced by Prime Minister Edouard Philippe to determine whether Viollet-le-duc's spire would be rebuilt or a new design would be chosen "adapted to the techniques and the challenges of our era". These statements have caused experts and those responsible for Notre Dame a great headache.



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Preparing Notre Dame de Paris for research and restoration

On-site cleaning and emergency stabilisation work have been going on since the week following the fire. Visibly the Notre Dame fire destroyed the timber structure of the roof and central spire. Some timber elements fell through the stone vaults and smouldered on inside the cathedral hall. However, the presence of the stone vault prevented the fire getting into the cathedral. Some stone columns inside the cathedral were found to have been damaged by the heat. However, the detail condition assessment of the monument and the impact of the fire on the masonry structure and the stone vault has not been done yet. Most of the restoration work done on the monument within the last few decades were focused on its architectural features. The damage caused by the fire has necessitated major restoration works and this can be seen as an opportunity to carry out research on the condition of the entire masonry structure from the 12th and 13th century.



Figure 11: The on-going consolidating works on Notre Dame seen from the east across the River Seine with the Eiffel Tower in the distance to the left and the spire of Sainte-Chapelle seen next to the crane to the right – Image Kai Weise

The loss of the roof structure and possible damage of the stone vaults that span the main naïve could impact the overall structural stability. The flying buttresses provide the tall stone columns lateral support, and with the removal of the link at the top, this could put pressure on these columns which might already be weakened due to the fire. As a precautionary measure, timber framing has been inserted inside the flying buttresses to counteract the lateral forces. The gable walls of the roof structure which are freestanding now after the loss of the roof structure have been provided with the timber support structures to avoid further damage. The stained glass of the upper windows has been removed for protection and the openings covered. The vaulted ceiling has been covered to protect it from rain water though this was not possible where the massive scaffolding the still stands, erected around where the spire once stood. The damaged interior columns have been temporarily tied using steel-cables and timber planks packing.

The huge metal scaffoldings that were erected for the ongoing renovation works didn't rest on the 12th century roof structure named "la forêt" (the forest). Therefore, when the fire engulfed the entire roof structure, the scaffolding did not collapse which otherwise would have caused even greater damage. One of the major challenges of the site preparation will be to dismantle the huge metal scaffold which is welded together due to the heat from the fire.



Figure 12: Consolidation of flying buttresses, August 2019 – Image Kai Weise



Figure 13: Consolidation of flying buttresses, August 2019 – Image Kai Weise

The burning roof structure and the melted lead fell on the stone vaults. It will be a challenge to clean the stone gargoyles from the melted lead drained through them and solidified. The incredible heat that was generated would have affected the stone as well as the lime mortar. Furthermore, the water that was used to douse the fire would have washed away some of the mortar. This is possibly one of the most critical points requiring assessment to know if the stone vaulted ceiling could be restored or will require complete dismantling. It would of course be possible to inject mortar in between the stone elements if the stone itself hasn't been affected too much. For the detail assessment, two working platforms will be installed above and below the vaulted ceiling.

Considering the safety of the people working on site, temporary stabilisation and site preparation with installation of working platforms will be put in place inside the cathedral before the assessment commence. All the material that has been collected from the destroyed sections of the monument has been stored on site in front of the cathedral.

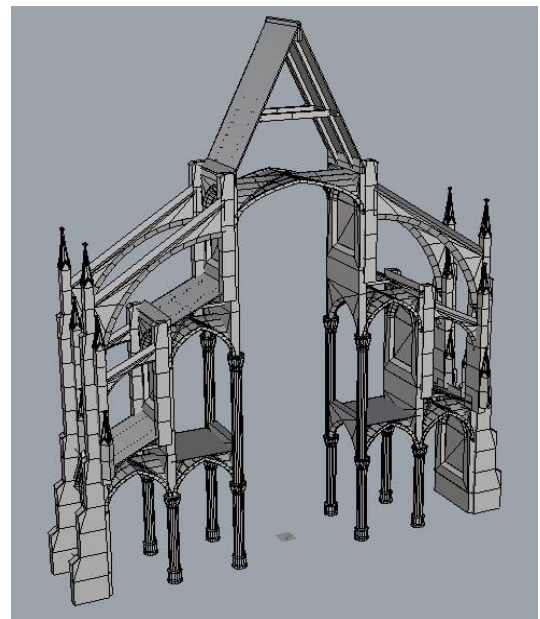


Figure 14: 3D section showing construction elements including stone vaults and timber roofing structure - <http://www.turbosquid.com>

Discussion on design and materials for reconstruction

Already within a week of the fire various design options for a new roof structure could be found floating around on the internet. There were also concerns on the unavailability of the required timber for reconstruction of "la forêt". The statement that there wouldn't be enough appropriate timber, specifically Oak, in France to rebuild the roof structure has been refuted by the authorities who state that even though it is a lot of wood, it would not be a problem to source. They suggest that such statements were floated by steel lobbies who wanted their material to be used to reconstruct the iconic monument.

The unavailability of sufficient amount of timber has led to the discussion on the various possibilities of using metal or reinforced cement concrete (RCC) to rebuild the roof structure, solutions which have already been used for various other restoration work on cathedrals in France. The roofing structure was rebuilt using RCC in the cathedral of Reims and Nantes. The cathedral of Reims was destroyed during the First World War and after hefty discussions on whether it should be kept as a ruin, was rebuilt over the following two decades, with work being completed in 1938 including the RCC roof structure. A large amount of funding was provided by John D. Rockefeller. A fire destroyed the roof of the cathedral of Nantes in 1972 and the Cathedral stayed shut for 3 years while renovations continued in phases till 2008. The roof structure was rebuilt using RCC. The roof of the cathedral of Chartres was destroyed by fire in 1836 due to carelessness during renovation works. The timber roof structure with lead roofing was replaced with a metal structure combining wrought and cast iron with copper roofing. Now one of the oldest metal structures in France, the cathedral of Chartres has been inscribed on the World Heritage List which states "The metal structure, put up in 1837 to replace the roof, is a remarkable element of the 19th century that fully participates in the values of the edifice". We might also want to mention that the Rouen Cathedral spire was rebuilt using iron in 1876.

It is considered that the craftsmanship for the rebuilding of the roof structure similar to the 12th century is still available. The traditional craftsmanship has been continued through the apprenticeship with the masters by the Compagnon du Devoir which is a French organisation of craftsmen and artisans dating from the middle age. However, we must understand that even if timber is used to rebuild the roofing, it will be slightly different due to the way it is worked, for example the timber is sawed and not cut using traditional tools.



Figure 15: A worker decontaminates a playground.
Photograph Christophe Petit-Tesson EPA

The newest issue that has arisen is that of lead pollution caused by the burning lead roofing. Environmental groups have submitted lawsuits against the government and the site was shut for almost a month. Lead continues to be used but only for conservation works. Safety measures are provided for those working with the material. The fire has however brought out a new threat of the lead dust settling around the entire section of the city. Higher levels of lead were found in nearby schools which has required careful cleaning to be carried out. This raises further interesting discussion in regards to what material should be used when restoring the roofing. Options that arise are to follow the example of Chartres with copper, which though expensive would be most resilient and it is now even possible to get copper that doesn't oxidize. Cheaper versions would be tin or galvanized iron sheeting.

During the 19th century restoration carried out in Notre Dame by Viollet-le-Duc a new design of the spire was introduced considering that there was no detail documentation of the earlier structure. With the available details of Viollet-le-Duc design as well as the recent 3-dimensional scanning of the monument, there is enough documentation to reproduce the roof structure and spire if desired.

There is an argument that every period something new was introduced which contributed to the image of Notre Dame de Paris; the 17th century, the 18th century, so why not the 21st century? So, what would be the issues that would determine the final decision? The use of new materials such as reinforced cement concrete was considered to be a wonderful material that would last forever; however, we now know how difficult it is to maintain and restore. So, the solution must consider durability as well as cost and required time to construct. This will be greatly influenced by the various lobbies for wood, steel and concrete as well as possibly insurance policies which require three times the safety factors. The process will continue getting media coverage which will allow for general awareness. We must however also consider that it is possible to profit from this disaster by detailed research on the structure to better understand Gothic architecture.

Moving forward

A scientific committee is being formed to continue more detailed discussions on how to rebuild the roof and spire of Notre Dame de Paris. The committee will possibly include members from UNESCO, ICOMOS (one national and one international) as well as ICCROM. The final decision still lies with the President. However clearly a traditional solution will be followed, particularly since generally the Parisians want the monument to be as it was. The international design competition might need to be carried out since it has already been announced, however this will not bring about realistic solutions.

The next important step once the structure is provided with support and protection will be to carry out a detailed diagnosis. The stone vaults that are only about 24-centimetre-thick would be very vulnerable after the fire and need to be observed. The main walls are considered to be stable however also need to remain under observation. There are however very few engineers in France (or anywhere in the World) who understand traditional structures well. In the Middle Ages when the cathedrals were built, the roof was constructed first to provide weight on the loadbearing system before the stone vaults were constructed.

The monument will need to be made accessible to the people as soon as possible, even if this would take a few years. This will allow people to use the religious structure, view various parts of the monument and reduce political pressure, whereby work can be carried out systematically and without hurry. This will require an overall “umbrella” covering the main roofing area with access to side walls, vaults and buttresses. The possibility of having wooden platforms below the stone vaults is being planned to provide a means of continuing research and restoration works while visitors are protected.

Some notes on comparison to circumstances in Post-2015 earthquake in Nepal

The comparison between the 2019 Notre Dame de Paris fire and the 2015 Gorkha Earthquake and its impact on the monuments of Kathmandu Valley addresses totally different circumstance both in respect to type of hazard and the overall scale of destruction. However, we find that there are many parallels which can be identified, circumstances which might be considered general issues, applicable to a wide range of disasters.

We note the following points:

- there is confusion about who is responsible for the monuments and who owns them;
- there has been a lack of sufficient maintenance to the monuments making them vulnerable;
- immediate response is efficient, be it through trained firefighters or involved community members;
- government policies towards rehabilitation is confused and there is little preparedness;
- initial statements by government assure people that everything will be fixed quickly;
- collection of funds is given priority even before understanding what needs to be done;
- monuments are dealt with as if they are means for political gain;
- there is little understanding for the need to carry out detailed assessments and research;
- stakeholders and communities are initially not consulted;
- there are few engineers who understand traditional structures;
- there are artisans who can carry out the required restoration work but they initially not consulted;
- there is interest for architects to show their creativity by changing historical monuments;
- to fulfil government norms and requisites, the entire procedure becomes highly complex;
- there is political pressure to show that work is progressing;
- there are different stakeholders and lobby groups wrangling for their positions;
- the discussion on building better or strengthening often goes against conservation standards;
- introducing modern technology and materials without understanding the necessity for this.

These are the issues that need to be further discussed to see which can be addressed and by what means. Some of these points are actually being promoted not only at national level but also by international organizations.

Illustrations

Figure 1: The blaze around the spire of Notre Dame, Image Wikipedia (Wandrille de Préville)

Figure 2: Sketch Section and Plan - image: www.researchgate.net/ (Paolo Vannucci et al)

Figure 3: Notre Dame de Paris in 1750 -Image: Prisma/UIG/Getty Images

Figure 4: Notre-Dame de Paris, by Hamilton, 1827 - Image: Gallica-BnF

Figure 5: Dame de Paris, by Édouard Baldus, 1860s – Image: Metropolitan Museum of Art

Figure 6: Missing gargoyles and deteriorated stonework - image Kai Weise

Figure 7: Sketch by firefighters planning strategy on site – Image René Dosne/BSPP

Figure 16: Fire engulfs entire roof of Notre Dame - Image Reuters (Benoit Tessier)

Figure 17: Sketch prepared for salvage team – image <https://allo18-lemag.fr/>

Figure 18: Inside Notre Dame de Paris after the fire – Image AFP

Figure 19: The on-going consolidating works on Notre Dame seen from the east across the River Seine with the Eiffel Tower in the distance to the left and the spire of Sainte-Chapelle seen next to the crane to the right – Image Kai Weise

Figure 20: Consolidation works on southern side, August 2019 – Image Kai Weise

Figure 13: Consolidation of flying buttresses, August 2019 – Image Kai Weise

Figure 21: 3D section showing construction elements including stone vaults and timber roofing structure - <https://www.turbosquid.com>

Figure 22: A worker decontaminates a playground. Photograph Christophe Petit-Tesson EPA