Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 71 (1994)

Artikel: Cathedral structures and fire
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DOI: https://doi.org/10.5169/seals-54159

Cathedral Structures and Fire

Les structures des cathédrales face aux incendies

Kathedralen und Feuer

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SUMMARY

The paper considers the historical perspective of the construction of Cathedrals in the context of previous public assembly buildings. It examines the history of fires in Cathedrals and the reason for their occurrence. The methods of providing structural fire protection are discussed relative to the fire prevention and protection plans. The methods of fighting fires is considered with some of the consequences. Finally an overview is made of the current enthusiasm on fire compartmentation.

RÉSUMÉ

Cet article fait l'historique de la construction des cathédrales dans la perspective des bâtiments destinés aux rassemblements publics. Il passe en revue les incendies ayant endommagé diverses cathédrales et en étudie l'origine et les causes. En se référant aux méthodes de prévention et de protection contre l'incendie, il expose les mesures structurales de protection à envisager, les procédés de lutte contre le feu et quelques conséquences possibles. L'auteur souligne l'engouement actuel pour le compartimentage destiné à freiner l'extension de l'incendie.

ZUSAMMENFASSUNG

Im Kontext zuvor diskutierter öffentlicher Versammlungsstätten wird die Bauweise von Kathedralen historisch beleuchtet. Dabei kommen die geschichtlichen Feuersbrünsten in Kathedralen und ihre Ursachen zur Sprache. Mit Bezug auf Brandverhütung und Brandschutz werden mögliche konstruktive Massnahmen, die Art der Feuerbekämpfung und ihre Folgen diskutiert. Abschliessend wird auf den gegenwärtig vorherrschenden Enthusiasmus für Brandabschnitte eingegangen.

1. HISTORICAL CONTEXT

1.1 Our great Norman Cathedrals and Minsters that survive in a number of our City's were an extraordinary achievement. It is interesting to look at their precursors. The Saxon Cathedrals, many of which were on the same site are an obvious choice, but I believe that their real origin lay in the construction of the Roman Bath Houses and Basilicas, which were built in many places throughout England and were of a surprisingly similar size and style to our Cathedrals.

1.2 The Basilica (public hall) in London was 150 m long with a nave and side aisles, the nave being 17 m wide and 25 m high, this approximates to the size of the main nave and choir of St. Pauls Cathedral. The Principia (Headquarters building for the army) in Caerleon whilst only 64 m long was of cruciform shape with a 25 m wide nave and a height probably of around 30 m. Bath houses were also built in similar sizes. Whilst Basilicas often had timber roofs, in Bath Houses barrel vaults in tiles were sometimes used, as in the City of Bath. It is interesting that the records show that in England the Temples were generally smaller than the Basilicas and Bath Houses. Leisure centres were obviously more popular than churches even in 200 A.D.!

1.3 However to return to our great Cathedrals. Once the Cathedrals had been completed, and some collapsed during construction as Master Masons and Bishops strove to stretch the boundaries of existing rules, the buildings then survived well providing that they were well maintained and politically supported. The biggest threat to their existence being fire or alterations affecting their overall stability. The additions of spires to pre-existing towers was a common cause of failure, though this often took many decades to occur. Salisbury Cathedrals splendid medieval spire being the only real survivor. However we are concerned here primarily with fire and as an introduction it is worth looking at the history of two of our Cathedrals.

2. CAUSES OF FIRES

2.1 York Minster is an obvious choice given the publicity from the 1984 fire. Ten major fires are recorded in the history of the buildings on this site. The first three occurred in the Saxon Buildings pre-dating the present Minster and these recorded fires were major sackings of the buildings by marauding Vikings and finally by William the Conqueror as a punishment for the City resisting his troops. Thereafter the current Norman Minster was constructed. The first recorded fire being an accidental fire in 1137, though there is no information on its cause. Similarly in 1464 there is a record of a well within the Church being used for fire fighting, but with little more information. In 1745 there was a lightning strike that threw down a pinnacle but fortunately caused no fire. In 1753, whilst re-leading the roof, the workmen left a dish of hot coals on a gutter which ignited the timber resulting in a fire in the roof over an aisle. In 1829 there was a major fire in which the roof, the organ and all the internal timberwork to the Choir was lost and this was an act of arson by a lunatic. In 1840 there was a fire in the tower as a result of a candle being left in the Bell Chamber. Finally in 1984 there occurred the major fire in the South Transept in which the roof was completely lost. The cause of the fire has not been proved, but is believed to have resulted from a lightning strike, when a flash over from lightning tape to an electrical fitting set light to roof timbers.

2.2 The present building therefore has a record of six major recorded fires over a period of 850 years. However it is known that in the last couple of Centuries there have been a number of minor fires occurring within the building, that had been quickly put out and caused little damage.

2.3 Wells Cathedral has a more fortunate record, in that during its history it has only suffered one significant fire when the spire caught fire and fell in 1439. No evidence remains as to the cause of the fire. Otherwise the Cathedral has been fortunate with no other reported fires.

2.4 The history of the York Minster in a good example of the threats and causes of fire with historically five major causes being apparent:- Lightning, Hotwork on the Roof, Candles, Arson and Accident.

2.5 If we consider the current threats to buildings, candles have largely been replaced by electricity. However it is a moot point as to whether this has reduced or increased the threat, as figures appear to show that 50% of fires in Listed Buildings are caused by electrical faults of one sort or another. The three most common electrical causes being old wiring, adhoc extensions and heat sources of one type or another.

2.6 Lightning is still a concern and even with modern lightning protection systems secondary affects can be disastrous as was probable in 1984 fire at York. The dangers of contractors hotwork is now I well understood, and the relatively recent fire at Uppark House highlights these dangers. Most institutional owners of historic buildings have formal and well regulated systems for hotwork, which are essential to reduce the risk to acceptable levels. Arson is a continual concern and it is estimated that nationally 25% of all fires are deliberate and that these are responsible for over 50% of the total national loss due to fires. The final cause is an ever present concern, the accidental fire due to carelessness in smoking, cooking, work rooms etc. The fire at Windsor Castle seems likely to have been caused by a tungsten spotlight being placed too close to curtains screening the alter in the Private Chapel.

3. FIRE PREVENTION

3.1 It is now common practice for Cathedrals to have fire plans covering the prevention, protection from, and detection of fires and also to have a detailed action plan covering what to do in the event of a fire. Clearly prevention is the most important of these issues and the most important element in prevention is people. The maintenance of vigilance and adherence to good working practices being the best preventative measure of all to avoid the risk of fires.

3.2 The vigilance of all the building users being the greatest protection against arson and accidental fires. The adherence to good working practices including the correct use of hot work permits, the correct installation, inspection and maintenance of all electrical and lightning circuits, and the appropriate working procedures for heating installations and other equipment.

4. FIRE PROTECTION

4.1 The protection of the building against fire falls into two elements, the passive protection, such as structural measures to limit the spread of and to contain fires and active measures to fight the fire. Passive protection of the structure includes compartmentation and venting, and the protection of structural materials to give them enhanced fire resistance. Cathedrals by their very nature are large open buildings with a relatively light fire load at floor level, though many Choirs have a significant amount of timber and organ lofts are a well known hazard. The main structure is normally of stone and the greatest fire load is therefore usually in the timber roof. Compartmentation is an important element for the containment of fire spread and at ground level compartmentation is negligible with one large open space. Many of the Cathedrals have stone vaulted ceilings and these provide a splendid fire compartment between the body of the building and the roof spaces with the highest fire load. Also most Cathedrals have central towers and these usually form a competent fire-break between the main four roof spaces over the Nave, Transepts and Choir providing that accesses through the walls have fire doors where appropriate. The fire at York was stopped at the Tower but in order to prevent the fire spreading under the crossing, the transept roof close to the Tower had to be deliberately collapsed by the fire brigade.

4.2 There is much discussion at present about the need to further compartment the roof spaces in our Cathedrals by the introduction of vertical fire compartments, at say 25 metre intervals through these spaces in an effort to prevent the spread of fire should one occur. Apart from the major roof spaces the fire at Windsor Castle highlighted the danger of hidden voids in buildings, which can spread a fire very rapidly as the voids may act as chimneys.

4.3 The spread of fire can also be partially contained by venting to atmosphere near the source, so preventing the rush of hot gases and smoke to elsewhere in the building. The venting the roof spaces can be achieved with vents on fusible links, so that in the event of a fire roof vents are opened, allowing the fire to burn upwards and to inhibit its spread.

4.4 The predominate structural materials used in Cathedrals are stone and timber. Stone has a good fire resistance and whilst it is possible to treat timbers to reduce the surface spread of flame and also to impregnate them with retarders, to my knowledge no-one has yet proposed such a solution for the existing roof timbers in one of our Cathedrals. The cost of the treatment being excessive for the reduction in risk that would be achieved.

5. FIRE DETECTION

5.1 Detection is the next item of the sequence preceding the implementation of active protection systems. Early detection of a fire is crucial and as can be seen from the history of York Minster there have been a number of fires in the last two Centuries which were minor, quickly detected and quickly put out, but for example the fire in 1829 which destroyed the Choir was lit at between 2 and 3 o'clock in the morning and was not discovered until 7 a.m., by which time it had gained such a hold that it took the best part of a day to put out. It is common place now to have smoke detectors throughout Cathedrals connected to remote alarm facilities.

5.2 There is however a dichotomy here, in that if you have a roof space with no lighting and no detectors there is no need for any electrical wiring in the area. The installation of detectors requires the installation of wiring and it is an interesting discussion as to whether the increased risk of fire by the installation of wiring is offset by the reduction in risk by early detection. The gains of early detection certainly do outweigh the added risk of electrical circuits, providing that the circuits are properly installed and well maintained. However if you consider the case of Wells with one fire only in its nine hundred year history and this was probably due to a lightning strike on the spire which no longer exists, it could be argued that we have increased the risk of a fire by the introduction of electrics for detectors and lighting in the roof space. It is possible to use detectors with radio links so obviating the problems with wiring, but they can suffer from operational interference.

6. FIRE FIGHTING

6.1 In the event of a fire being detected there are various active fire fighting systems that can be used, which are in common usage in modern buildings, where they have an exceedingly good record. The Loss Prevention Council records show that, where installed, sprinklers suppress 98% of fires before they take hold. They have been considered in Cathedral roof spaces but the dangers of inadvertent use, the intervention that they cause to the existing historic structure and the costs have made them so far inappropriate. A similar conclusion being drawn for the Royal Palaces in Sir Alan Bailey's Report. Mistprays are a relatively new technology that combined with early detection, can be effective and overcome many of the concerns about damage to fabric from inadvertent use. But as for sprinklers the combination of disadvantages make them unlikely to be used. Another active automatic system would be inert gases, but the spaces in Cathedrals are so large and so draughty that they would be totally ineffective. Other in-built systems that have been considered in Cathedrals include the installation of blown foam equipment in the roof voids, but simple tests have not as yet proved their effectiveness in generating sufficient foam at the right location.

6.2 The only positive assistance of which I am aware is that used on many Cathedrals is the installation of dry risers up to the roof spaces, so that the Fire Brigade can connect hoses at this level to fight a fire.

6.3 To consider further some of the aspects of fighting the fire and its consequences. Safe access for the Fire Brigade is of prime consideration for the Officer in Charge of fighting the fire and many Cathedral roofs, particularly those with timber vaults, would be too dangerous for fire fighters to enter in a fire and access along the parapets would similarly be too hazardous, so that the fire would probably have to be fought from outside hoists and ladders. Cathedrals with stone vaulted roofs create a safer working platform for the fireman though these roof spaces are invariably cluttered with many ties, cross-beams, raking members etc. so that access is not easy.

6.4 One of the consequences of fighting a fire is the huge volumes of water that are usually pumped into the building which creates significant problems of its own. A typical vault pocket might contain 20 tonnes of water which would almost certainly cause collapse of the vault fields and in a Cathedral with particularly slender walls, the out-of-balance loading prior to collapse of the vault fields could result in instability of the walls. The large volumes of water will saturate the stonework and the rubble fill present in many walls and the thousands of gallons of water percolating into the foundation material could in some soils cause short and long term foundation movement. It is not just the fire that creates structural problems but the consequences of the necessary fire fighting techniques which can be equally damaging.

6.5 The need to consider all these issues in a combined and balanced manner is crucial and must be addressed as a policy matter. A fire plan can be drawn up covering not only these issues but the evacuation of people and items of value, as well as the disaster plan for coping with the aftermath.

7. CONCLUSIONS

7.1 Having quickly covered some of the aspects of fires in Cathedrals I would like to make a few general observations. The Country has suffered a number of significant fires in historic buildings over the last few years including Hampton Court, Uppark House, York Minster, Windsor Castle and this unusual concentration of major fires in our heritage buildings has I believe, caused something of an overreaction to the problems of fire in historic buildings. The addition of compartmentation within the major roof voids of our Cathedrals is an issue which is being accepted but which I feel may be counter-productive. The compartments can only be of half an hour to one hour rating and being retrofitted within a complex building fabric will have difficulty achieving significant containment. What is highly likely is that the installation of these compartments will create further enclosed spaces within the roof void where air cannot easily circulate and are very likely to increase the problems of corrosion of lead and decay of timbers. The inclusion of a fire compartment as a possible measure to inhibit a possible fire, may therefore be causing the very probable deterioration to materials which may have been in the roof for nine hundred years. Also the inclusion of these compartments within the roof spaces, destroys the appearances of these splendid roof voids, many of which put our best medieval barns to shame. Each building must be considered separately on its merits.

7.2 I believe there should be more active discussion of the view that we should perhaps accept that there will be a major fire periodically in our historic buildings, but that a major loss and replacement is better than disfiguring most of the heritage structures in the Nation. Many of these buildings have been with us for nine hundred years, let us not over-react in the space of a few years and take actions that future generations will regret.

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