10
The collapse of 1284 at Beauvais Cathedral

S. Murray

In interpreting the factors lying behind the collapse of the upper parts of the choir of Beauvais Cathedral in 1284, certain architectural historians have attempted to go beyond the simplistic view that the limits of material and expertise had been reached in this gigantic structure, and rather to identify specific factors of weakness in its design. Such factors identified in previous studies include inadequate foundations; piers which were too widely spaced; the faulty design of certain units in the upper superstructure, notably the upper piers of the central vessel and the intermediary uprights of the flying buttresses.[2]

Recently some of the methods developed for testing design projects in modern concrete construction have been applied to problems in gothic structure: namely the system of model analysis using a two-dimensional epoxy model, charged with weights to simulate loading and wind-forces.[3] These studies have represented a break-through in our understanding of the nature of the stresses set up inside the gothic structure, and for the art historian, untrained in the technical formulae of structural engineering, are of particular value in producing visual evidence which can be read almost like a contour map.

However, none of the studies made of the Beauvais collapse have made full use of the two kinds of source which ought to provide the architectural historian with his main evidence: stylistic analysis, coupled with a review of the primary textual sources. Such sources will provide us with information as to which parts of the building collapsed, and will enable us to distinguish between campaigns of repair which followed immediately after the collapse and later work

of repair and restoration. The resultant chronology of the work of repair will enable us to use the cathedral itself as a "model", with a view to establishing sources of structural weakness. Finally, comparisons with contemporaneous monuments of similar specifications will enable us to define what made Beauvais Cathedral so different from the rest.

The choir of Beauvais Cathedral was first built with three straight bays covered by quadripartite vaults, flanked by double side-aisles on each side, and terminated to the east by a seven bay hemicycle ringed by an ambulatory and seven radiating chapels of equal depth. Documentary and stylistic evidence suggests that the work was begun around 1225 and completed up to the eastern piers of the crossing by 1272 (Fig. 1).[4]

The so-called "Bucquet aux Cousteaux"[5] collection of copies made in the eighteenth century from the now-lost archives of the cathedral chapter provides the source which relates that "on Thursday November 29, 1284 at 8.00 p.m. the great vaults of the choir fell and several exterior pillars were broken; the great windows smashed; the holy chasses of St. Just, St. Germer and Ste. Eutrope were broken and the divine service ceased for forty years. Several pillars were interposed in the choir arcade in order to fortify it."[6]

The same source tells us that the disaster of 1284 was the second collapse which had occurred at the cathedral.[7] The account of the first collapse has not been taken seriously by subsequent historians, because it was said to have occurred in 1225, the date which has been assigned by modern scholarship to the commencement of work on the choir. Our text specifies that the collapse affected the straight bays of the choir; that it resulted from the over-wide spacing of the piers, and that the repairs were of a make-shift nature, involving the addition of iron ties between the piers, remains of which could still be seen by the author of the text.

The first collapse, if indeed it occurred at all, must have been a relatively minor affair, and was quickly repaired, not leaving any stylistic or archaeological evidence which would enable us to be certain as to its nature. The collapse of 1284, on the other hand, was clearly a major event and the cathedral was still not repaired in 1339. We have a copy of a text from the chapter deliberations for this year, which relates that Guillaume de Raye, master of the masonry at

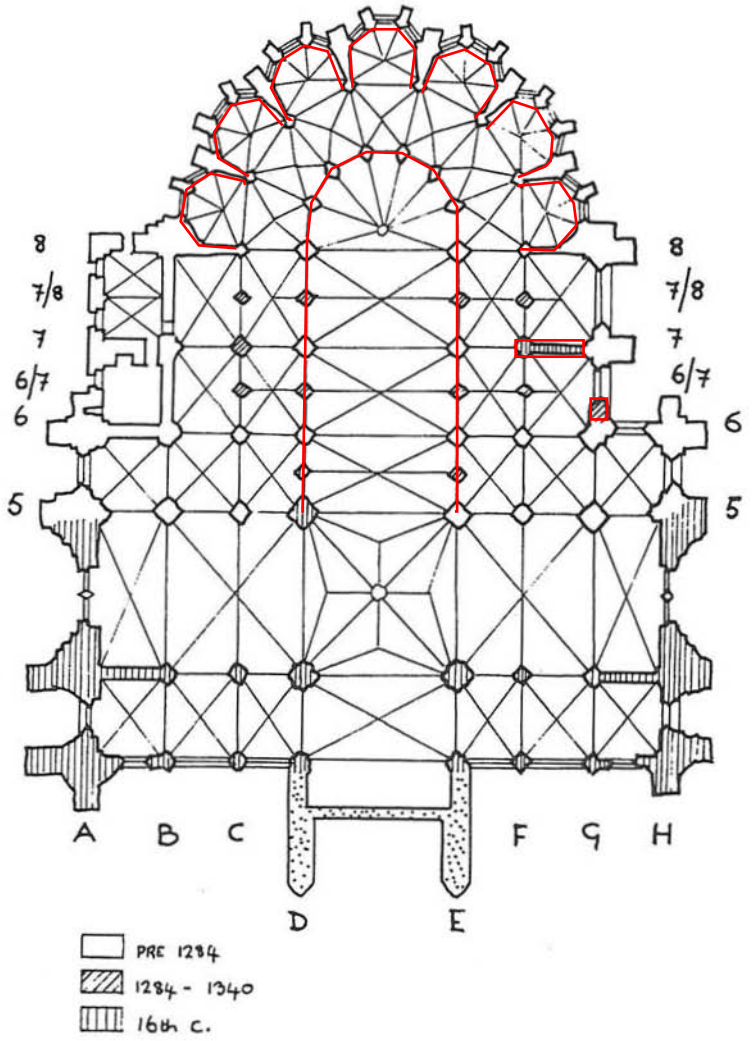

FIGURE 1. *Plan of Beauvais Cathedral, showing repairs after the collapse.*

Beauvais Cathedral, Aubert d'Aubigny stone cutter, and Jean de Maisonchelle chaplain and master of the works had recently considered the works which were to be done at present in the cathedral, by which works the church would be all rebuttressed ("reconfortée"), all vaulted, with the scaffolding removed, and all ready for the divine service, and without which works the church

could not continue to stand. The author of the text then goes on to specify work on raising a great pillar ("pillier" can mean buttress, or flying buttress upright, as well as interior pier), installing the flyers, reseating the sick arches, remaking the windows and closing in the body of the church. Purchases of the materials are recorded, including 800 "pendens", or stones for the severies of vaults, 400 of which are said to be "old", or in other words, re-used, and are therefore not paid for.[8] Such re-use of material suggests that although the collapse was a serious one, some of the fallen masonry could be salvaged, and parts of the vaults may have remained intact, and could be demolished and the stones re-employed.[9]

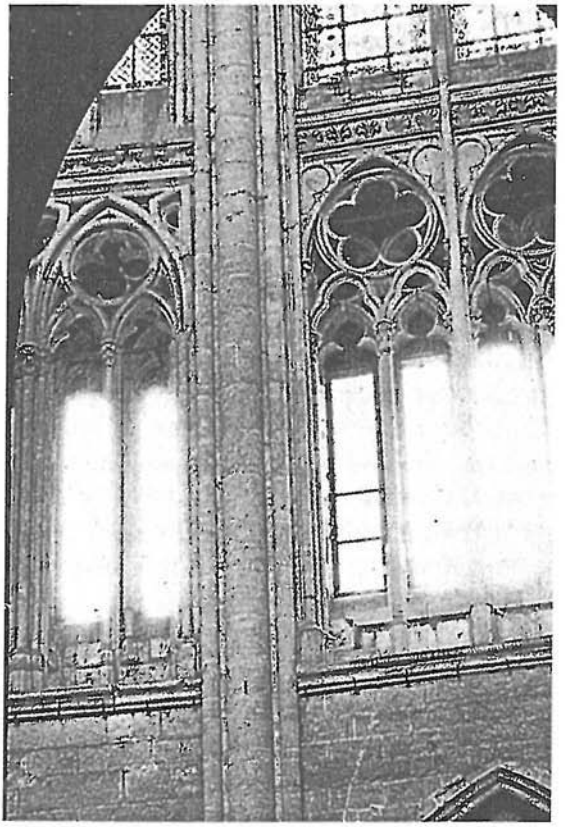

FIGURE 2. *Detail of the triforium at bay 8 on the north side, showing the transition from pre-collapse to post-collapse tracery.*

A survey of the forms of the tracery, capitals and bases reveals quite clearly that everything from the sill of the triforium of the central vessel, up to the high vaults was rebuilt in the straight bays of the choir (Fig. 2). At the same time the additional piers were inserted in the main arcade, to create sexpartite vaults in the central vessel. While it is impossible to distinguish between new and re-used masonry in the vaults, it is noticeable that three of the present clerestory windows are different from the others in the tracery patterns used, raising the possibility that they might constitute units pieced together out of elements surviving the collapse (Figs. 3 and 4).[10]

The upper hemicycle (including the vault) remained intact, as did the hemicycle flying buttress system (Fig. 5). Only the exteriors of the upper hemicycle piers were rebuilt, replacing an arrangement which Viollet-le-Duc reconstructed (on paper) as openwork tabernacles, with fully detached shafts.[11] The fact that this feature of the otherwise intact hemicycle was rebuilt, presumably after the 1284 collapse (although the masonry is anonymous in terms of stylistic identifying forms) led Viollet-le-Duc to his theory that it was precisely this element in the design of the upper superstructure which caused the collapse. His account of the differential settlement of the coursed masonry, as opposed to the detached shafts has become a "classic" interpretation of the potential mechanics of collapse, and it has secured many adherents.[12] If we follow Viollet-le-Duc's thesis, then we must view the source of the weakness in the design of the upper superstructure as essentially a longitudinal one, running on the east-west axis of the building. For Viollet-le-Duc, moreover, this was a faulty detail in an otherwise well-conceived structure, the "Parthenon of French Gothic".[13]

We wish to argue, on the other hand, that the collapse occurred not because of a faulty detail which had produced a longitudinal weakness in the upper superstructure, but rather because of a critical lack of lateral buttressing at a point in the choir which is easily ascertainable; moreover that the factors causing this weakness arose from grave errors of judgement by the master planners of Beauvais Cathedral, both in the laying out of the plan, and in the nature of the superstructure.

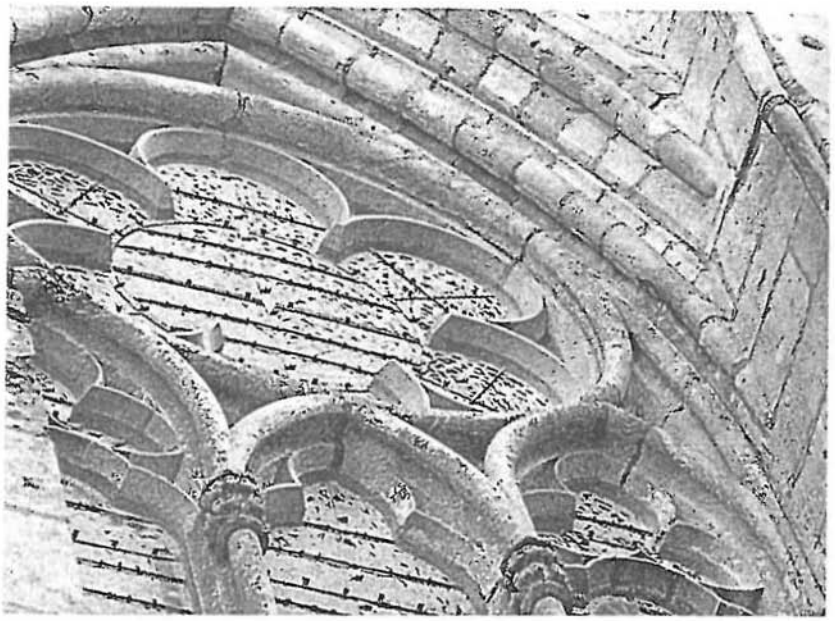

FIGURE 3. *Detail of re-used tracery in clerestory window.*

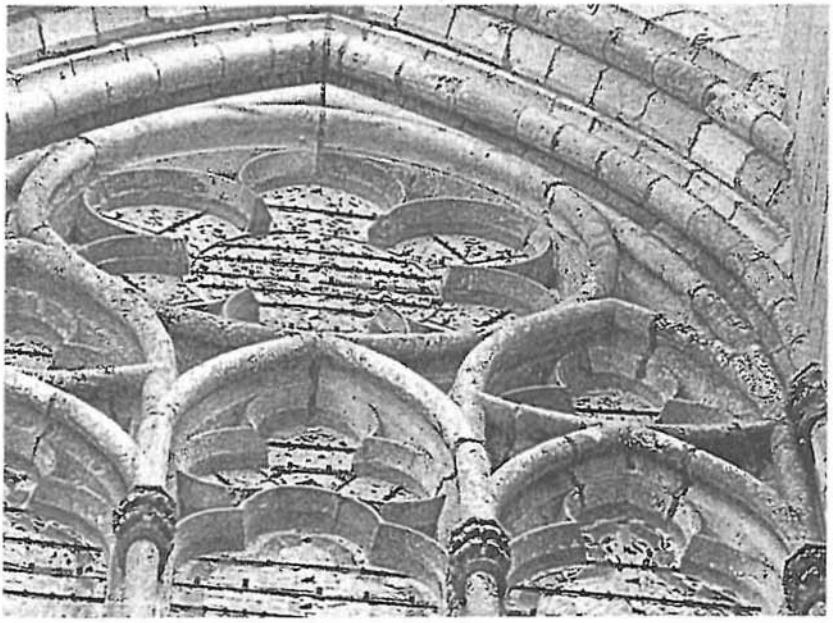

FIGURE 4. *Detail of tracery made in the campaigns of repair after the collapse.*

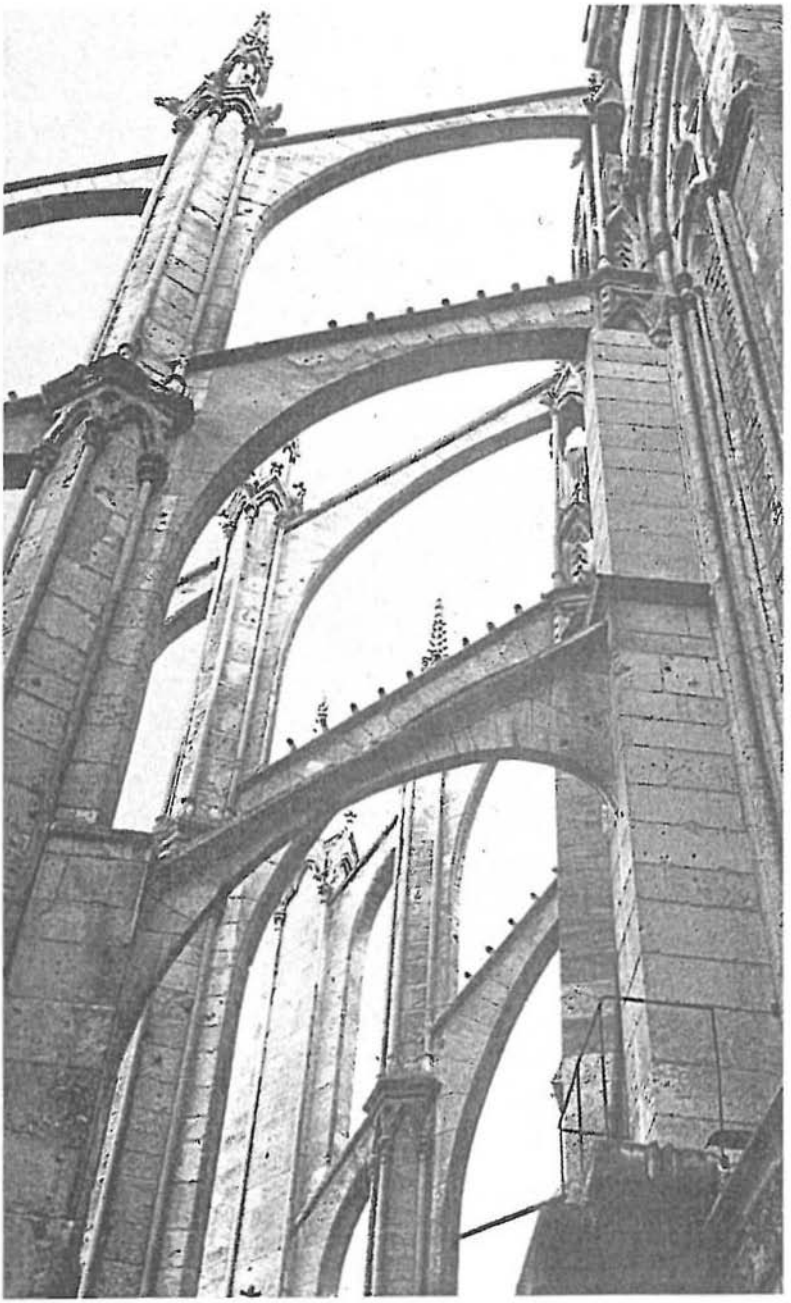

FIGURE 5. *Exterior of the hemicycle at clerestory level.*

There is only one bay of the choir where we find that all of the vertical members have been rebuilt, including the piers of the central vessel (in their upper parts); the intermediary piers dividing the double aisles; the intermediary flying buttress uprights on top of these piers, and the outer massive flying buttress uprights from which the entire buttressing system is generated: namely the middle bay of the choir, marked on our plan as bay 7. This leads us to identify the stylistic features enabling us to distinguish between pre-collapse and post-collapse masonry.[14] As far as the flying buttress uprights are concerned, these criteria include above all the transition of base forms from the low "pancake"-like moulding on a simple flat-sided octagonal plinth to a much taller type with an upper rim, a flattened area below it, and a flared lower lip rather like a trumpet bell. The pre-collapse flying buttress uprights have detached *en délit* shafts supporting gabled arcades on their flanks, whereas their post-collapse counterparts have recessed panelling.[15]

Following these criteria we may determine that two of the main outer flying buttress uprights have been rebuilt on each side (in bays 6 and 7) and that in the straight bays of the choir only one of the intermediary uprights on each side has been rebuilt, namely at bay 7 (Figs. 7, 8, 9 and 10). The intermediary uprights at bay 6 show no sign of having been rebuilt, and employ *en délit* shafts and bases of the low variety (Fig. 9).

Evidence of the lateral distortion associated with the collapse of 1284 can also be established by identifying units in the interior of the aisles which were rebuilt after the collapse. The rebuild included not only the extra piers interposed in the main arcade, but also the piers dividing the double side-aisles at bay 7. Pier C 7 on the north side has a continuous moulding around it with a rounded upper rim; a flat depressed area, and a flared lower lip in the form of a trumpet bell (Fig. 11). This kind of base contrasts with the simpler forms of the adjacent piers (Fig. 12) and suggests a date well into the second half of the thirteenth century.[16] Its counterpart on the south side (F 7) has an undulating surface and hexagonal plinths for the shafts which allow it to be associated with the work of Martin Chambiges (Fig. 13). More specifically, the details of the plinth design of F 7 are similar to the piers of the north transept (1510-1518), and it seems possible that a text recording certain repairs to pillars in the choir

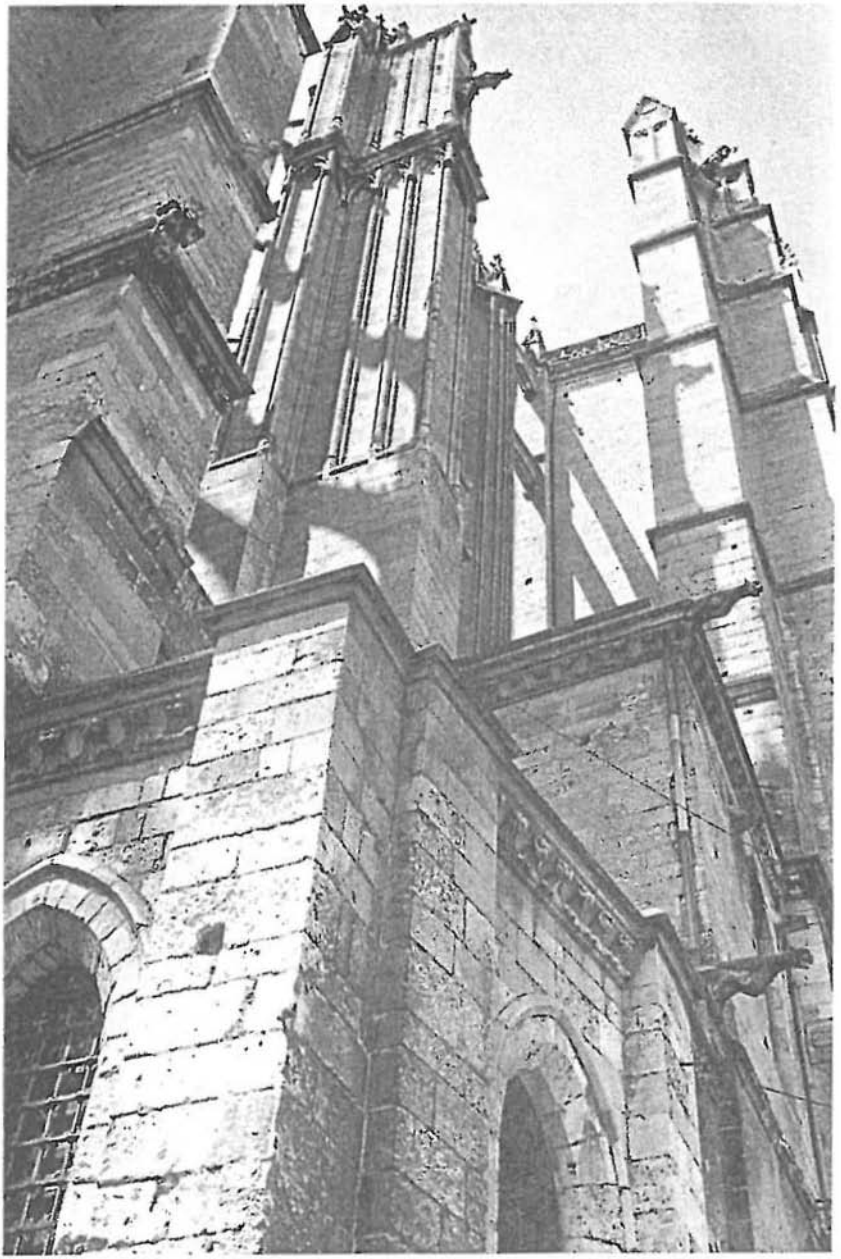

FIGURE 7. *Outer upright of flying buttress, bay 7, north side.*

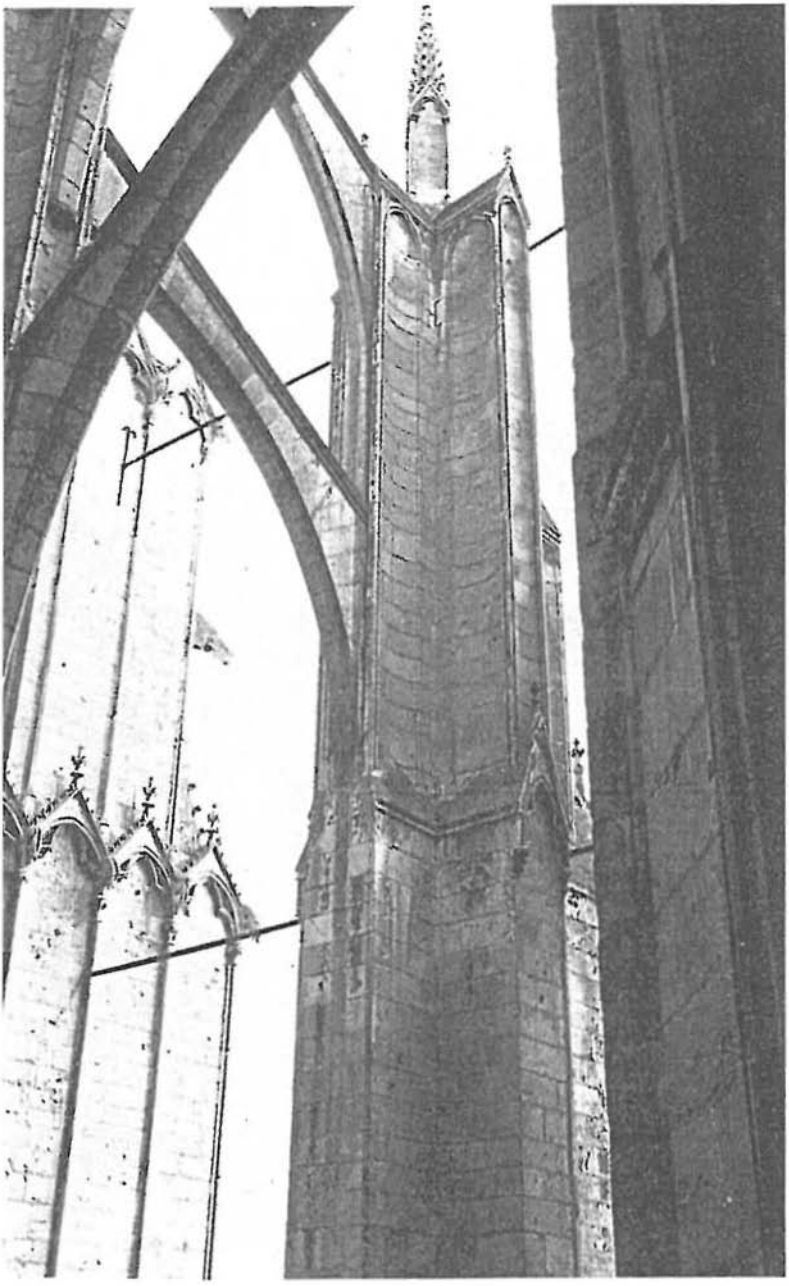

FIGURE 8. *Outer upright of flying buttress, bay 7, south side.*

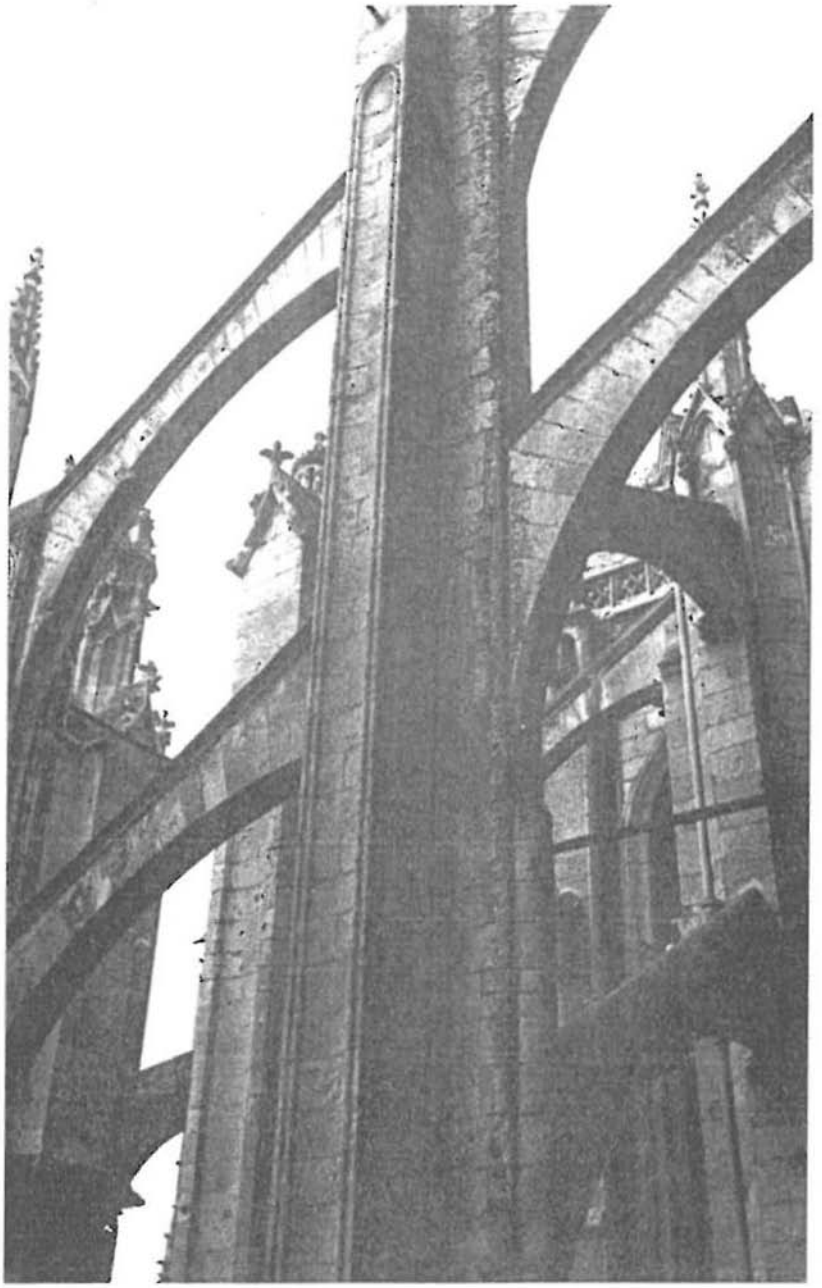

FIGURE 9. *Intermediary flying buttress upright, bay 7, south side.*

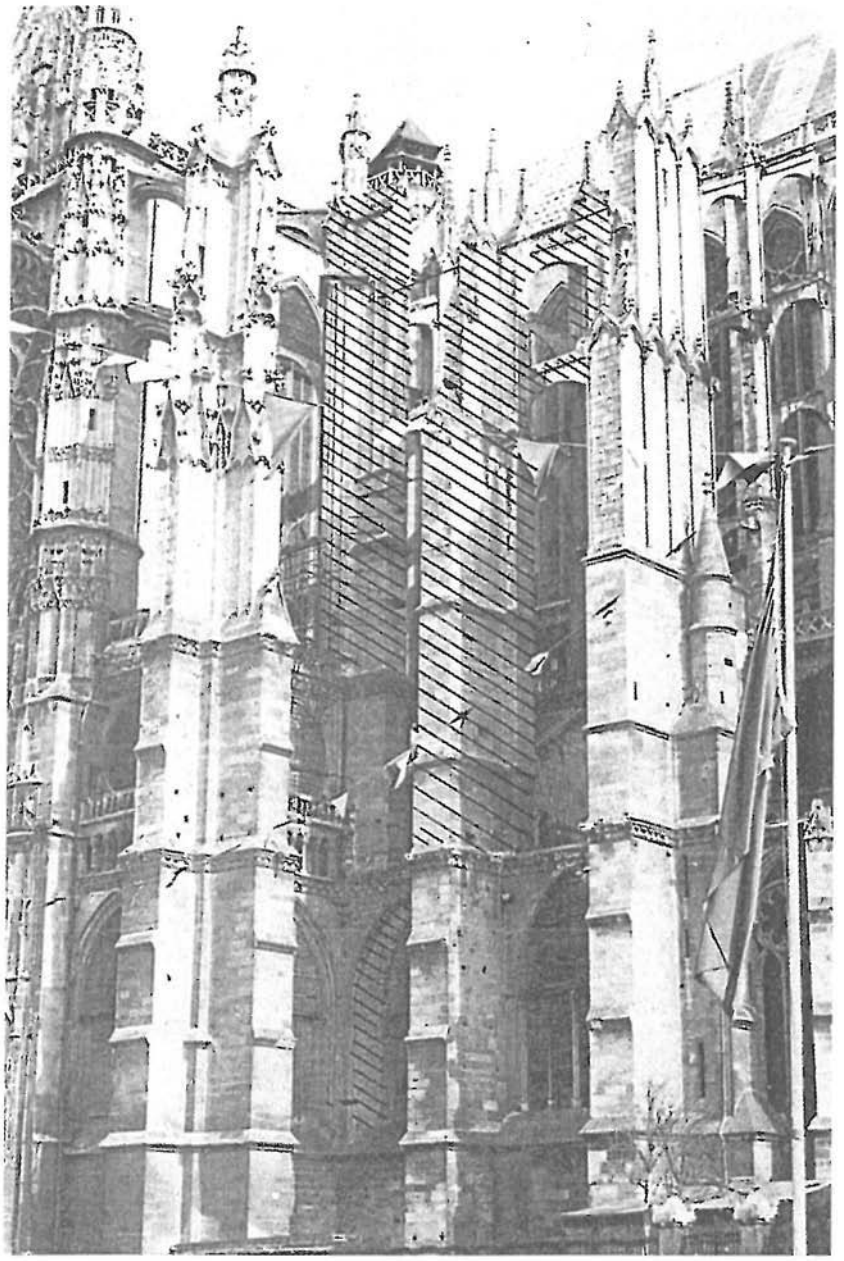

FIGURE 10. *General view of the south side of the choir. Cross-hatching indicates parts rebuilt after the 1284 collapse.*

completed in 1517 might refer to the reconstruction of this pier.[17] At the same time, a solid wall was built, coursed into the masonry of the pier, and extending out to the exterior wall, thus dividing two bays of the outer aisle which had been originally intended to be open.

Thus, we have seen that at bay 7 (and only in this bay) all of the vertical members of the original structure were rebuilt in some way. We suggest that there were two special causes of weakness, one of them common to all gothic chevets of this type, and the other peculiar to the design of the Beauvais choir.

Firstly, it is evident from the plan that this is the only bay where the lateral thrust of the high vaults was not countered by the heavier masonry at the east and western terminations of the choir (Fig. 1). It is of interest to find an analogous situation in the very well-documented building history of the cathedral of Troyes, where it was necessary in the 1360's and again in 1402 to consolidate the lateral buttressing at a point corresponding to this.[18] It is, of course, inherent in this kind of plan that whereas the blocks of masonry dividing the radiating chapels provide a kind of internal buttress, this kind of support is absent in the straight bays.

These inherent problems were exacerbated by two factors which are peculiar to the design of the Beauvais choir. In both plan and elevation this work has been seen as involving a marriage of elements from the Chartres-Reims-Amiens family with elements from buildings with the kind of pyramidal elevation used at Cluny III, Bourges and St. Quentin. Thus, the tall inner aisle and ambulatory with its own triforium and clerestory is distantly related to the similar arrangement at Bourges. Another point of similarity between the two buildings is the wide spacing of the piers of the main arcade in such a way as to produce aisle bays which are rectangles with their long sides running in an east-west direction, rather than approximating to squares, as at Amiens.[19] On the other hand, the plan with seven radiating chapels and a projecting transept reflects Amiens, as do the steep proportions of the central vessel, where we find that the height of the upper parts from the triforium sill to the top of the clerestory windows approximates to the height of the sill above the floor.

The bay system at Beauvais Cathedral is highly eccentric, the lateral dimension of each bay varying around 15.30m.[20] but the longitudinal dimension going from an enormous bay of 9.05m.

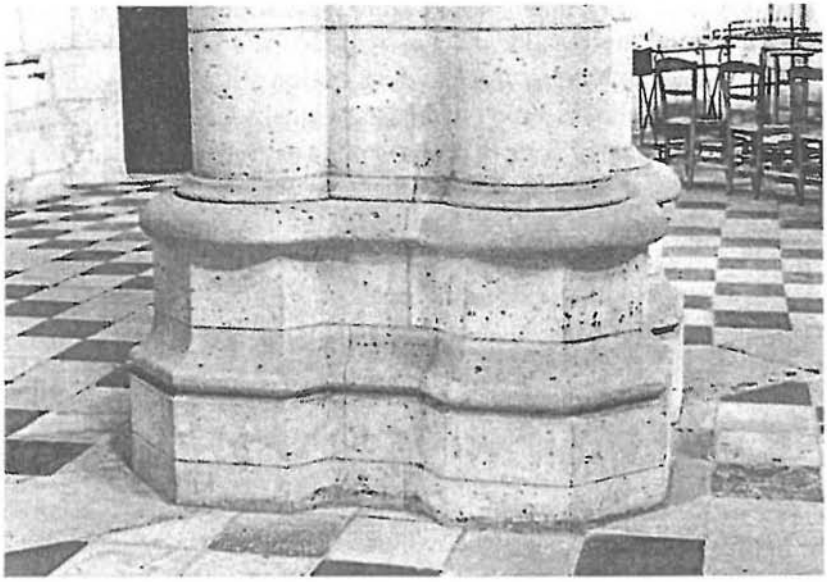

FIGURE 11. *Pier C 7 in the north choir aisle.*

FIGURE 12. *Pier B 7 in the north choir aisle.*

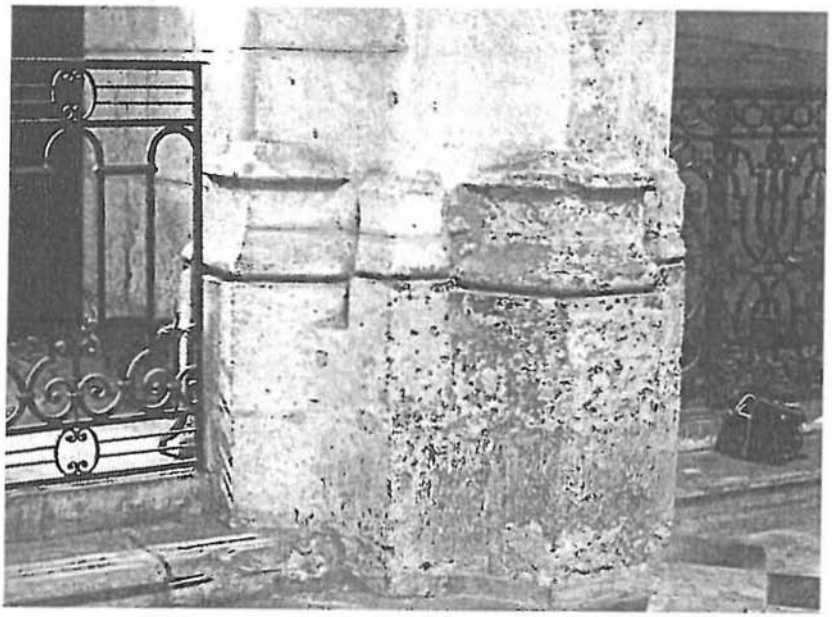

FIGURE 13. *Pier F 7 in the south choir aisle.*

adjacent to the hemicycle to 8.76m. and finally to a bay of 7.92m. adjacent to the crossing.[21] Even the narrowest bay at Beauvais is considerably larger than the bays used at Amiens or Reims. The greater area of each of the vaults of the central vessel would produce a unit which was heavier, and exerting a greater outward thrust. On the other hand, the relatively narrow inner aisles produced inner flyers which were quite short, and which did not therefore have the weight and inward thrust of a flyer with a wider span.[22] It is obviously important to note that the heaviest vault of the central vessel (bay 7-8) was supported on its western side by a lower superstructure which was, for the reasons defined above, significantly weaker than in the adjacent bays.

We have seen that the intermediary aisle piers at bay 7 were rebuilt at two different periods, the pier on the north side towards 1300, and the pier and chapel dividing wall on the south side around 1517. It is very significant to note that the corresponding piers at the east side of the largest vault of the central vessel (vault D E 7-8) began to fail towards the end of the nineteenth century. Photographs

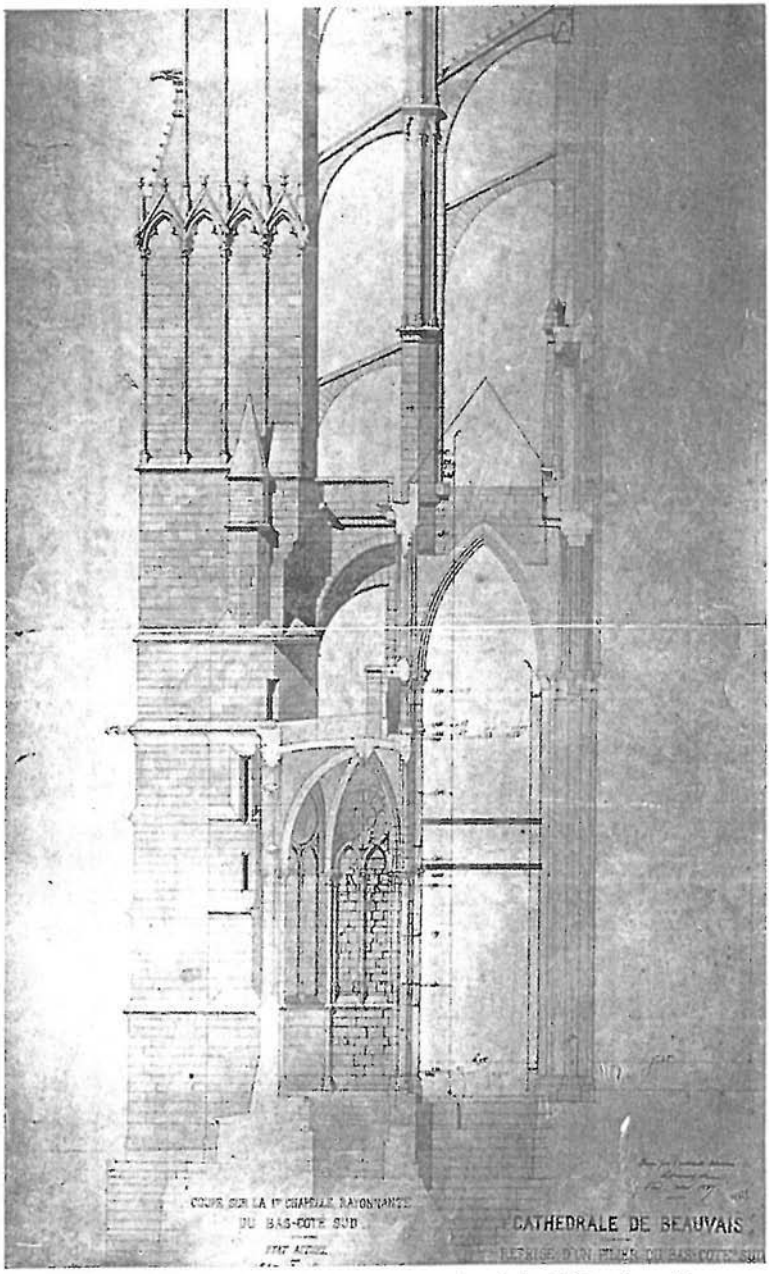

FIGURE 14. *Drawing made for the restoration of pier F 8 by the architect Sauvageot in 1897 (MH. 201374).*

and drawings[23] made at this time reveal precisely how they would have failed, had they been left unattended (Fig. 14). The plumb line indicated in our restoration drawing reveals that the inward buckling of the piers in the chapel mouths on either side of the choir at bay 8 occurred at the height of the springing of the vaults of the first radiating chapels and adjacent aisle bays. This buckling would probably have resulted from the inward thrust of these vaults coupled with the rotational movement produced by the tendency of the higher inner aisle vaults to push outwards (see rotational arrows sketched on the section, Fig. 15). The chapel wall at bay 8 provided the extra strength at this point which allowed the piers at C 8 and F 8 to remain solid for six centuries after the completion of the choir: we suggest that the absence of such support in bay 7 was a critical factor leading to the collapse of 1284.[24]

We must lastly examine the second idiosyncratic feature of the Beauvais choir which may have contributed to the collapse: the placing of the vertical members in the upper superstructure in such a way that their entire mass was not directly over a supporting pier, but instead projected partially over a void. This practice is generally termed "*porte-à-faux*."[25] The existence of such a lack of axial alignment in the placing of the intermediary uprights of the flying buttresses around the hemicycle has, of course, been common knowledge since the publication of Viollet-le-Duc's dictionary, in which he gave a section of the upper parts of the choir at bay 8, where the straight bays turn into the eastern hemicycle.[26] Benouville later published a full section of the choir at bay 8, including the lower parts.[27] It is particularly unfortunate that most subsequent discussions of the collapse have been based upon the evidence of these drawings, since it was precisely this part of the choir which remained solid, and which does not, therefore, embody all of the weaknesses which led to the 1284 collapse.

We are obviously caught in something of a dilemma since we cannot be certain as to the nature of the elevation at bay 7 before the rebuild, and particularly as to whether the intermediary flying buttress uprights were pushed slightly over the inner aisle, as were their counterparts in the hemicycle. Measurements carried out in the adjacent bay 6 (on the north side, where easy access is possible to the tops of the aisle vaults) have confirmed that the intermediary upright

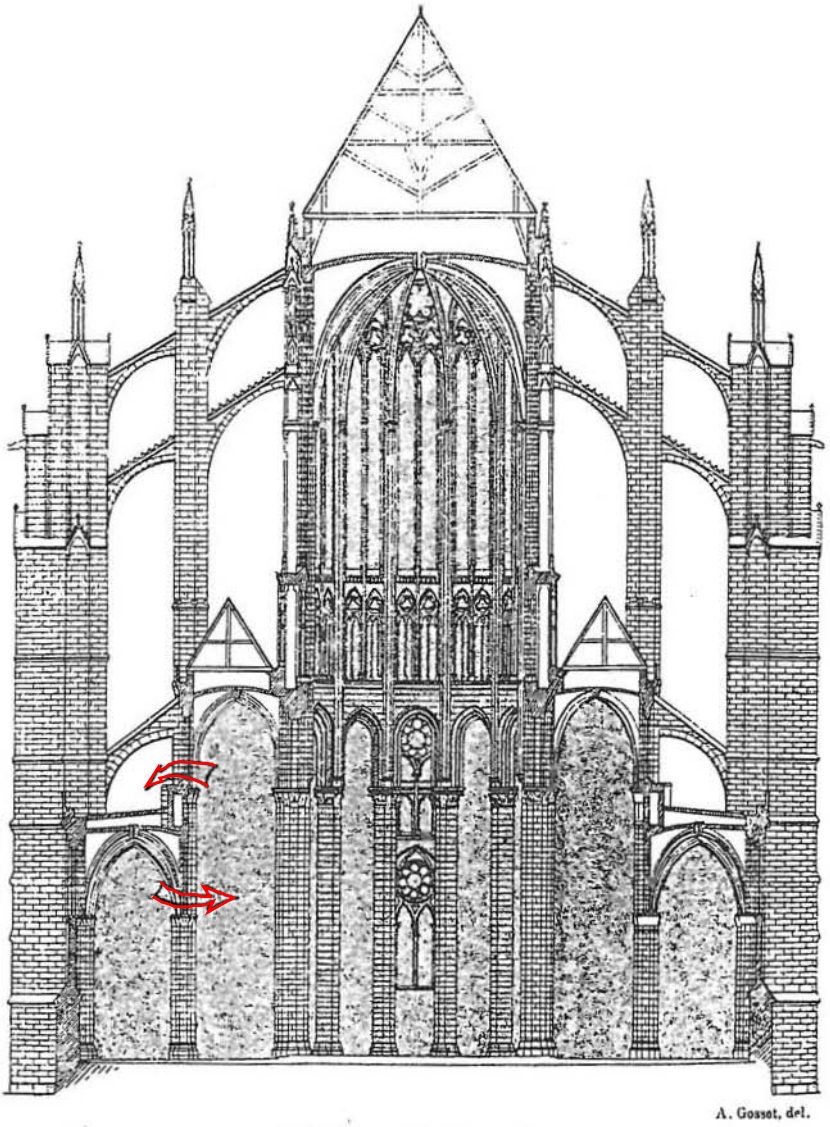

FIGURE 15. *Section of Beauvais choir at bay 7* (Congrès Archéologique, *1905).*

was, indeed, carried *porte-à-faux* here, and there is thus every reason to believe that the same arrangement was used throughout the straight bays.[28]

The *porte-à-faux* device in itself should not be considered as a direct cause of the collapse, since it was also used in the turning bays of the hemicycle without unfortunate consequences. The question is obviously a relative one: in the turning bays the weight of the central vault was less (since its area is smaller and it has more supports) and the massive outer uprights were more stable, since they are solidly based on the divisions between the chapels.

This leads us to a consideration of the nature of the outer flying buttress uprights at bay 7. The discussion of the nature of the collapse given by both Viollet-le-Duc and Heyman was based upon the premise that these outer uprights remained firm. We have seen, however, that the stylistic evidence reveals quite clearly that the units at bay 7 on each side were rebuilt, and a closer examination of the unit on the south side reveals that it cannot be considered as the massive and stable prop as supposed in earlier accounts of the collapse. The projection of the unit is quite shallow (about 3.00m. beyond the surface of the wall), and a significant proportion of the total depth of the unit (about a quarter) projects over the outer aisle (Figs. 15 and 16). We are thus dealing with *porte-à-faux* not only in the intermediary upright, but also in the heavy outer upright at this point.[29] We are not equipped with the engineering expertise which would enable us to predict the effect that such an overhang would have upon the interior transverse arch which partially supported it. This would depend to some extent upon the coursing of the masonry involved. In the intermediary uprights, the stones are of great width, some of them running across the entire width of the pillar, so that the weight of the overhanging portion could be carried by the corbel action of these wide stones, and would not bear down directly upon the arch underneath. Had smaller stones been used, allowing the weight of the vertical unit to bear directly upon the arch partially supporting, the arch would have suffered unfortunate consequences. This can be demonstrated using the cathedral itself as a model. The massive outer buttress at G 6, which was originally intended to form the corner of a transept tower, was constructed with à portion of its depth projecting over the adjacent chapel window (Figs. 10 and 17). The stones of the projecting portion of the buttress being small, it seems certain that the enclosing arch of the chapel window must have borne a certain amount of the weight of the overhanging

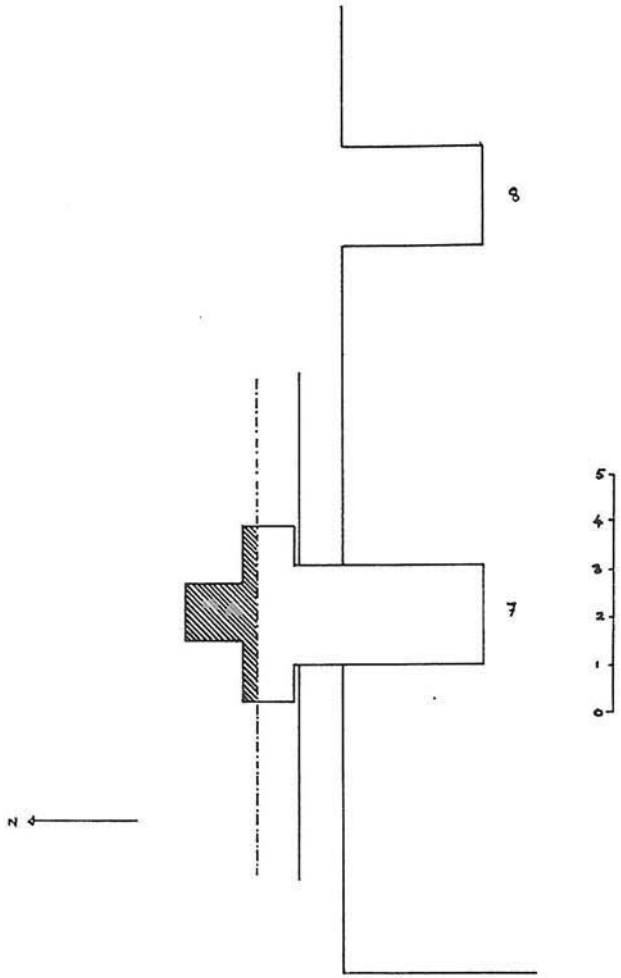

FIGURE 16. *Section of outer flying buttress upright at G 7 (cross-hatching indicates* porte-à-faux*).*

buttress above. The thin voussoir stones of the window have failed, several stones at the crown of the arch have broken, and the geometry of the arch has been severely distorted. It was found necessary in the campaigns of repair immediately following the collapse to insert a narrow strip of masonry to eliminate the overhang.[30]

We suggest that a similar situation of *porte-à-faux* on the part of the exterior flying buttress uprights at bay 7 caused the transverse

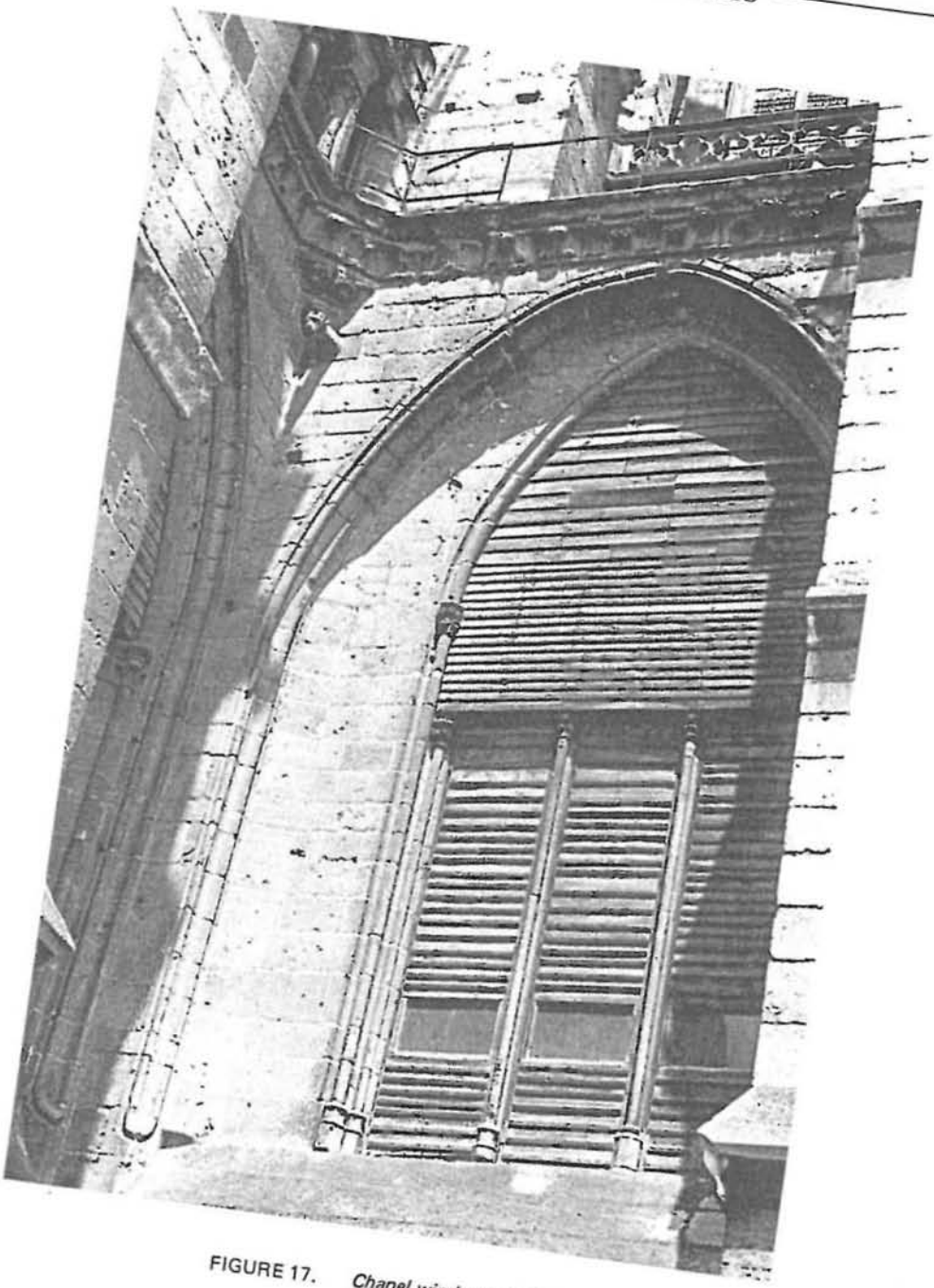

FIGURE 17. *Chapel window at G 6-7.*