To the Editor

I read Margaret Maile Petty’s excellent article “Illuminating the Glass Box: The Lighting Designs of Richard Kelly” (JSAH 66, no. 2 [June 2007], 194–219) with great interest and, for the most part, enormous admiration. Petty makes a major contribution to our understanding of the illumination of modern architecture by detailing the way in which Kelly staged the nocturnal display of Mies van der Rohe’s skeletal frames. I was surprised, however, to find myself cited as a source for Petty’s linking of Heinrich Tessenow’s Festspielhaus of 1910–12 in Halle in the temporary discourse of modern architecture, a strong continuity between the two concepts of modern theater with the contribution to that volume. However, Petty’s observation that “if one compares the temporary exhibition in 1927. Although I strongly concur, I have never made the point myself. Moreover, the citation (James-Chakraborty, “The Drama of Illumination”) is for a page (354) of Richard A. Etlin, Art, Culture, and Media Under the Third Reich (Chicago, 2002), well beyond the terminus of my contribution to that volume. However, Petty’s observation that “if one compares the concept of modern theater with the contemporary discourse of modern architecture, a strong continuity between the two disciplines emerges” (197) and many of the points she makes to support it are foreshadowed in the same chapter. There and in German Architecture for a Mass Audience (Routledge, 2000) I, like Petty, discuss the way in which modern architecture’s abolition of ornament and emphasis on space were inseparable from new lighting strategies pioneered by Adolph Appia and Gordon Craig.

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To the Editor

I found David Stanley’s account of his findings under the roofs of the eastern ambulatory and chapel vaults at Saint-Denis and the conclusion he drew from them of great interest, in view of the ambiguities of the account in Sugr’s De Consecratione of the storm that arose while the new chevet was still incomplete (David J. Stanley, “The Original Buttressing of Abbot Suger’s Chevet at the Abbey of Saint-Denis,” JSAH 65, no. 3 [Sept 2006] 354). I also welcomed his recognition of the relevance of structural feasibility to any interpretation of the surviving physical evidence. I refrained from earlier comment both because he attempted no reconstruction drawing of the buttresses and because I lacked adequate first-hand knowledge of the present structure and of all the recent relevant literature. The letters of Andrew Tallon and Robert Mark (JSAH 66, no. 1 [Mar. 2007], 136–38) now suggest a need for further comment on alternative approaches to assessing stability supplementing that in my earlier paper referred to by Stanley (Rowland J. Mainstone, “Structural Insights, and Historical Interpretation,” JSAH 56, no. 3 [Sept. 1997] 316–40, reprinted in Mainstone, Structure in Architecture: History, Design and Innovation [Aldershot, UK, 1999], 123–47).

Tallon rightly criticizes Stanley for taking Blondel’s rule as the basis on which pier sizes were determined in the early Gothic period. I find this doubly questionable. First, I know of no evidence that either it or any of the broadly similar geometric rules current by the sixteenth century were known four centuries earlier. The available evidence indicates that sizing was then based directly on whatever prior experience was seen as an appropriate guide.

Second, although Blondel’s rule recognizes the importance of the profile of an arch or barrel vault on the thrust it exerts, it ignores the influence of the depth and weight of the arch or vault and of the height of its supporting piers or walls. This height is immaterial if collapse can occur only by rotation of each whole pier or wall, as a rigid body about its toe, accompanied by similar rotations at the springing points of an equally rigid arch or vault. But tall Gothic piers and the arches they support never were rigid bodies. These piers are now bowed inward at the level of the aisle vaults and outwards above them, with a resultant pronounced destabilizing spread at the springing level of the main vaults. Rotations at the upper level do not occur at the pier heads. They occur within the arches themselves, at joints between the voussoirs in both haunch and crown regions.

To confirm the structural feasibility of a possible buttressing system, it is necessary to draw on more recent understanding and analytical possibilities. There are basically two potential approaches. One is the purely equilibrium approach. It takes no account of the deformations along load paths due to the internal forces. It is therefore appropriate only where these deformations do not significantly affect the way in which loads can be shared between members. The other approach takes these deformations into account. It becomes essential when tensile continuities mean that the relative stiffnesses along different, geometrically possible load paths have a major influence: the stiffer paths take more load.

Both approaches call for the whole structure to be appropriately modeled, but they demand different types of modeling and, in turn, different types of judgment by the analyst. For historic masonry structures with virtually no tensile continuity, Heyman and I have preferred the first approach using graphical and algebraic modeling, whereas Mark has adopted the latter, using first the experimental technique of photoelastic modeling and then numerical finite element modeling.

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In his letter, Mark makes no reference to Saint-Denis. He is content to draw attention to his past exploitations and to dismiss the approaches taken by Heyman and myself. He casts doubt on my approach for reasons that ignore the considerable prior direct knowledge of Gothic structures and wider experimental and analytical experience underlying the choice, and its rewards in elucidating the structural behavior and construction histories of some major architectural achievements. In choosing differently on the sole basis of compressive continuity, Mark has ignored the vast differences between Gothic masonry and his metal components and reinforced-concrete floors and water tanks. All these would have had uniform material properties, full tensile continuity, and would have been cast or otherwise fully fabricated before being subjected to imposed load.

Gothic masonry is highly heterogeneous with multiple internal joints that leave it with virtually no tensile continuity. Even in compression it gains strength and stiffness only slowly as the mortar stiffens, so that the sequence of construction has a major influence on internal stresses and deformations. These characteristics make it almost impossible to allot realistic deformation properties to the materials, especially if the calculation programs are elaborated to take account of lengthy sequential construction and cracking. With finite-element modeling, the predicted deformations and stresses can appear remarkably precise. But this precision is misleading. Imprecision is inherent not only in necessary simplifications of the modeled geometry but above all in the assumed deformation properties.

The equilibrium approach, whether in an algebraic or thrust-line analysis, recognizes the lack of significant tensile strength and tensile continuity. It assumes that all loads are carried in compression except where thrusts are resisted by iron ties. It is implicitly assumed at the outset that the compression can be resisted and that any resulting deformations can be ignored, unless they are large enough to significantly change the overall geometry. If they are and the structure already exists, they can be taken into account in the initial modeling of the geometry. Where the depth of an arch ring, for instance, would allow different internal load paths, more than one analysis can be made to show the limits between which the path must lie, and it may be possible to narrow the limits by observing local deformations, such as splayed joints between voussoirs. Thus, there is no need to estimate the deformation characteristics of the masonry. Instead, linked judgments are called for about how close the thrust line can approach the boundaries of the cross section without leading to excessive local concentrations of the compression—what Heyman calls the “geometric factor of safety”—and about whether all compressions will be within the capacity of the masonry. But these judgments do not present the same difficulties as arise with the other approach. If the analysis is performed graphically, the principal limitation, as with the simple experimental photoelastic approach, is that only plane sections of the structure can be modeled. Out-of-plane behavior must be considered separately.

If the ability of the twelfth-century remains of Saint-Denis to support flying buttresses is to be tested, the equilibrium approach is therefore the better one to adopt. It should start with a measured survey of the identifiable remains as a basis for one or more tentative reconstruction drawings of at least a representative radial, vertical cross section of the chevet’s full height. These should be followed by assessments of relevant arch and vault thrusts and the plotting of possible thrust lines within the cross section.

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