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BEAUVAIS CATHEDRAL AS A CULTURAL LABORATORY OF TECHNICAL LIMIT

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ABSTRACT

This study examines the structural and cultural significance of Beauvais Cathedral, arguably the most daring architectural experiment undertaken within the Gothic system. Construction began in 1225 in the historical region of Picardy, at a moment when the great cathedrals of northern France were already testing the limits of what medieval builders believed masonry could achieve. At Beauvais, however, this ambition was pursued with exceptional intensity. The choir, rising to 48.5 metres, represents the most radical expression of the vertical aspiration that progressively came to define Gothic architecture during the thirteenth century. The research approaches the building through a combined reading of structural behaviour, historical documentation, and comparative architectural analysis. By bringing these perspectives together, the study examines the technical conditions that led first to the partial collapse of the choir in 1284 and later to the failure of the great crossing spire in 1573. Particular attention is given to the geometry of the vaults, the remarkable slenderness of the structural system, and the role of flying buttresses together with early iron reinforcements in the control of horizontal thrusts. Taken together, these elements reveal a building conceived very close to the boundary of structural equilibrium, where the pursuit of lightness approached the natural limits of masonry construction. Beauvais Cathedral, however, cannot be understood solely in technical terms. Its history also provides a deeper insight into the nature of architectural knowledge itself. The failures that punctuated its construction did not merely interrupt the project; they generated understanding. Collapse, in this context, appears not simply as an accident but as a moment of learning, transforming the building into a kind of laboratory in which medieval builders explored—sometimes at considerable risk—the possibilities of their structural system. Long before the principles of masonry mechanics were formally articulated, Beauvais had already posed many of the questions that those principles would later attempt to resolve. Seen from this perspective, Beauvais is more than an unfinished monument. It stands as a material reflection on the delicate relationship between ambition, risk, and equilibrium. Its incomplete form reminds us that architectural progress rarely emerges from certainty alone. More often, it grows from the recognition of limits and from the capacity to learn when those limits are reached. In this sense, the cathedral may be understood as a true genuine of the limit: a building whose greatest legacy lies not only in its height, but in the knowledge that its very fragility helped to reveal.

KEYWORDS: Gothic Architecture, Beauvais Cathedral, Structural Failure, Gothic Engineering, Technical Limits, Cultural Interpretation of Technology, Medieval Construction, Masonry Structures.

1. INTRODUCTION

In the history of European architecture, few buildings express so clearly the delicate balance between ambition and limit as Beauvais Cathedral (Rodríguez Elizalde, 2025a, 2025c). Begun in 1225 in the historical region of Picardy, the project emerged at a moment when the Gothic system had already reached a remarkable degree of technical refinement. Yet the builders of Beauvais did not merely continue that tradition; they sought to extend it, testing the very boundaries of what masonry construction could sustain.

From the outset, the enterprise carried a distinct sense of audacity. The exceptional height pursued in the choir—unprecedented even among the great French cathedrals—reveals a deliberate attempt to push the vertical logic of the Gothic system to its most extreme expression. In doing so, the building approached a threshold at which structural equilibrium could no longer rely solely on inherited practice, but required an increasingly subtle understanding of forces, geometry, and construction.

The subsequent history of the cathedral soon reflected this tension. Two major collapses, followed by partial reconstructions, interrupted the original ambition and left the monument in its present, unfinished form. These episodes, however, should not be read merely as failures. Rather, they illuminate the nature of medieval building practice itself, in which faith, empirical knowledge, and structural intuition were inseparably intertwined. Beauvais thus stands as a powerful reminder that Gothic architecture was not merely a stylistic achievement, but an ongoing exploration of the possibilities—and the limits—of matter.

Beauvais Cathedral is therefore more than an unfinished monument (Figure 1). It may also be read as a material expression of the human desire to surpass limits and, at the same time, as a living ruin that continues to confront both time and gravity even today.

Figure 1: South Transept Elevation of Beauvais Cathedral, Showing the Monumental Rose Window and the Structural Articulation of the High Gothic Choir (Photograph by the Author).

The thirteenth century was, for Western Europe, a period of remarkable structural confidence. Following the achievements of Chartres Cathedral, Reims Cathedral, and Amiens Cathedral, the Gothic language had reached a high degree of technical maturity (Branner et al., 1963). Master builders had learned to reduce structural mass until stone itself seemed almost dematerialized into light: vaults rose with unprecedented slenderness, walls dissolved into expanses of polychrome stained glass, and flying buttresses converted thrust into equilibrium. Yet each new achievement carried with it a familiar temptation—to build higher, lighter, further.

Within this atmosphere of technical emulation and spiritual ambition, the project of Beauvais Cathedral sought to surpass every known precedent.

The choir was designed to rise to 48.5 metres, a height that no masonry construction has since equalled (Figure 2, left). What had been conceived as the culmination of the Gothic system soon revealed itself to be its limit. The progressive transformation of the Gothic structural system can be clearly appreciated through a comparison of cathedral sections (Figure 3).

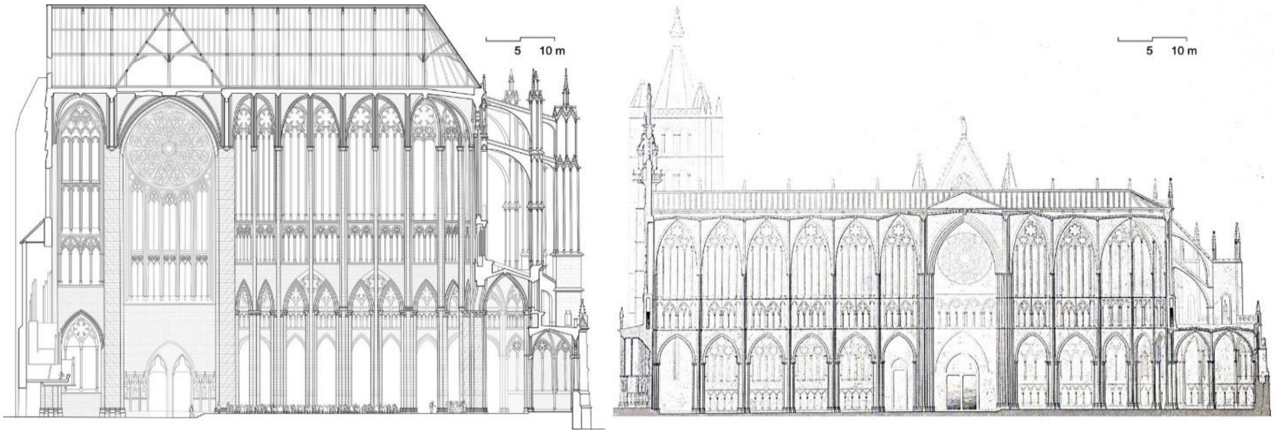

Figure 2: Comparative Longitudinal Sections of Beauvais Cathedral and León Cathedral (Graphics by Chœur d'Hommes de La Villette (Chœur d'Hommes de La Villette, n.d.) and Francisco Pérez Baquero (Pérez Baquero, n.d.)).

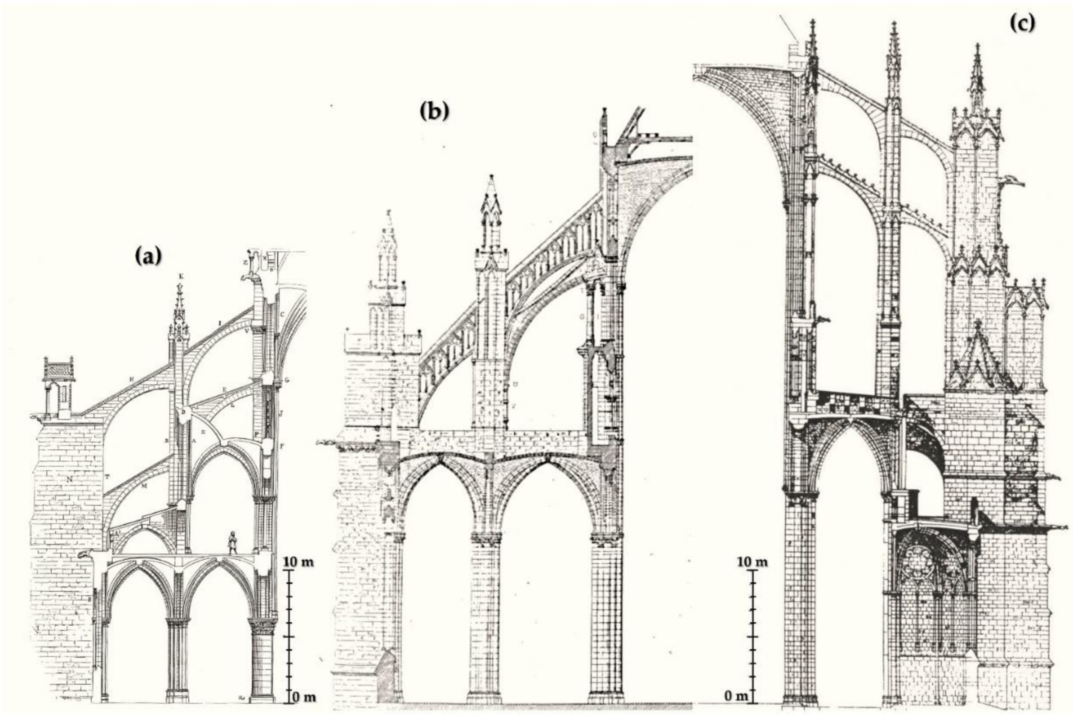

Figure 3: Comparative Sections of High Gothic Cathedrals: (a) Notre-Dame de Paris, (b) Amiens Cathedral, (c) Beauvais Cathedral (Drawing by the Author Based on Sections by Viollet-le-Duc (Viollet-le-Duc, 1868)).

In this sense, the history of Beauvais Cathedral is the history of a frontier. Where other cathedrals express the triumph of intuitive calculation, Beauvais speaks of collapse as a form of knowledge. Its choir, completed in 1272, collapsed scarcely twelve years later, in 1284 (Como, 2009; Murray, 2016; Wolfe & Mark, 1976). Stone, pushed to the extreme of its resistance, could no longer sustain the intended equilibrium. Yet far from yielding to failure, the builders reconstructed the structure, reinforcing its piers, widening the flying buttresses, and employing—pioneeringly—iron tie bars to contain the lateral thrusts (Figure 3). The cathedral thus became an experimental laboratory in which ruin was at once error and revelation (Figure 3).

Figure 4. Flying Buttresses and Iron Tie Bars Added to Reinforce the Structure After the Collapse of the Choir in 1284 (Photograph by the Author).

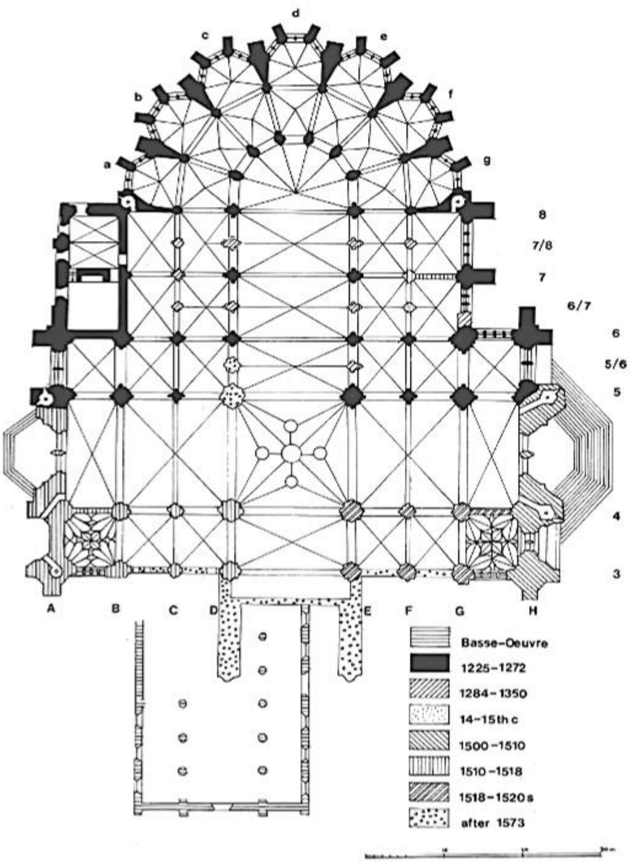

Figure 5: Ground Plan of Beauvais Cathedral Showing the Different Construction Phases and Later Structural Interventions (Murray, 1989).

In structural terms, Beauvais Cathedral represents the critical point of the Gothic system: an architecture of absolute verticality, where mass is reduced to its very limit and geometry acquires an almost theological authority as an instrument of order and salvation (Figure 6). Yet the significance of the building cannot be confined to structural analysis alone. Beyond the technical data, its meaning extends well beyond the strictly engineering domain.

Figure 6: Interior View of the Choir Vaults Illustrating the Extreme Verticality Achieved by the Gothic Structural System (Photograph by the Author).

The unfinished building, suspended between faith and physics, thus acquires an exceptional symbolic value. As Eugène Viollet-le-Duc observed, it represents both an exceptional execution and the most authentic and complete expression of the builders' theoretical understanding at that moment (Viollet-le-Duc, 1868). Yet it is precisely its fragility that ultimately conferred meaning upon its existence. Beauvais Cathedral did not merely experience structural failure; it produced knowledge. It revealed that beauty and risk are inseparable, that technical progress depends upon the recognition of limits, and that calculation—long before it became an equation—was fundamentally a cultural act.

The progressive increase in structural slenderness in High Gothic cathedrals becomes particularly evident when their geometric proportions and structural ratios are compared (Table 1).

Table 1: Structural Proportions of Selected High Gothic Cathedrals (Data Compiled by the Author).

Cathedral	Approx. date	Interior height (m)	Nave span (m)	Height/span ratio	Height/pier thickness ratio
Chartres	1194–1220	36.0	8.4	4.3	6:1
Reims	1211–1275	38.0	8.5	4.5	8:1
Amiens	1220–1269	42.3	11.3	3.7	10:1
Beauvais	1225–1272	48.5	13.6	3.5	16:1

As shown in Table 1, the progressive increase in the height-to-pier thickness ratio reflects the growing structural audacity of High Gothic architecture. The value observed at Beauvais—approximately 16:1—represents an exceptional level of slenderness in medieval masonry construction.

The Cathedral of Saint-Pierre de Beauvais has long attracted the attention of historians of architecture and structural engineers due to its exceptional ambition and the dramatic collapse of its choir in 1284. Since the nineteenth century, scholars have interpreted the monument as a key moment in the evolution of Gothic structural experimentation. The pioneering writings of Eugène Viollet le Duc already recognized Beauvais as the most radical expression of the constructive logic of Gothic architecture (Mark, 2016; Viollet-le-Duc, 1868), describing it as the ultimate attempt to translate structural theory into built form.

Later structural interpretations further deepened this perspective. Studies by Robert Mark and Jacques Heyman reframed Gothic cathedrals through the lens of structural mechanics, emphasizing the equilibrium of masonry systems and the conditions under which collapse may occur. In this context, Beauvais became a paradigmatic case for understanding the limits of slender masonry structures. Subsequent historiographical work, particularly by Stephen Murray, expanded the discussion by situating the cathedral within the broader cultural and historical dynamics of medieval architectural production, exploring the relationship between ambition, construction processes, and institutional context.

While these studies have greatly advanced the understanding of Beauvais from structural and historical perspectives, recent scholarship has begun to explore its broader cultural implications. In particular, the cathedral can be interpreted not only as an extreme experiment in Gothic engineering but also as a symbolic expression of the technological imagination of the thirteenth century.

In previous work, the author has examined this monument from complementary perspectives. A structural analysis of its geometric ambition and the mechanisms leading to the collapse of the choir highlighted Beauvais as a critical moment in the evolution of Gothic engineering (Murray, 1980, 2014; Rodríguez Elizalde, 2025a). A subsequent study explored the philosophical implications of technological ambition embodied in Gothic architecture, interpreting Beauvais within a broader reflection on the relationship between technology and human aspiration (Rodríguez Elizalde, 2025c). Additional research has addressed the cultural and symbolic dimension of the cathedral, emphasizing its role as an architectural expression of the limits of technical ambition (Rodríguez Elizalde, 2025b).

Building upon these contributions, the present article proposes a broader interpretative framework through which Beauvais Cathedral may be understood as a cultural laboratory of the technical limit. Rather than focusing exclusively on structural failure or historical development, the study examines the monument as a site where engineering experimentation, symbolic aspiration, and the experience of failure converge. From this perspective, the monument becomes a site where engineering experimentation, symbolic aspiration, and the experience of failure converge, revealing how medieval architecture functioned simultaneously as a technological enterprise and a cultural act.

The study of Beauvais Cathedral is today doubly pertinent. From the perspective of architecture and heritage engineering, the building constitutes a reference case for understanding the mechanisms of stability and collapse in historic masonry structures. Its response to horizontal thrusts, the interaction between materials (stone, wrought iron, and timber), and the evolution of its reinforcement systems provide an empirical lesson of the highest order. Yet from a broader perspective, Beauvais also allows us to address a philosophical and educational question of considerable depth: how can fragility be assimilated as an intrinsic component of technical knowledge?

In an age in which digital technologies and artificial intelligence appear to promise infallible precision, Beauvais Cathedral reminds us that every human creation is, by nature, imperfect and vulnerable. Error, far from being an anomaly, forms part of the creative process and of the ethical dimension of technique. For this reason, the cathedral continues to function as a school for engineers, architects, and thinkers alike: its ruin does not represent the end of a constructive system, but rather its most lucid turning point.

The present study is therefore situated within a dual perspective. On the one hand, it seeks to analyse the structural phenomenon of Beauvais Cathedral with the rigor demanded by historical engineering: its geometric conception, the physical causes of its collapse, and the solutions adopted after the catastrophe. On the other hand, it proposes a humanistic reading of its significance: the building as a metaphor of limit, calculation as a form of culture, and ruin as a revelation of knowledge. In this sense, Beauvais Cathedral may be read as an architectural text, legible both through the analytical mind of the engineer and through the reflective gaze of the philosopher.

Beauvais Cathedral was never completed, yet what was built endures. And it is precisely this endurance—at once incomplete and enduring—that transforms the cathedral into an emblem of the human spirit: the will to surpass limits while knowing that every work, even the most audacious, ultimately rests upon an awareness of its own fragility.

2. OBJECTIVES

The present research pursues a dual objective—both technical and humanistic—arising from the attempt to understand the structural limits of the Gothic system while also reflecting on the cultural meaning of risk and imperfection in architectural creation.

The first aim is to analyse, from a scientific and constructive perspective, the case of Beauvais Cathedral as an extreme example within medieval engineering. Conceived in the thirteenth century to attain a choir height of 48.5 metres, its structure represents both the culmination and the critical threshold in the development of the French Gothic system. The study seeks to identify the technical factors that led to the collapse of 1284 through an examination of its geometry, structural slenderness, and the configuration of its lateral thrusts, together with the later reinforcements introduced in iron and timber. In this respect, the principal objective is to understand the mechanics of the limit conditions: the moment and the structural conditions under which stone ceases to follow the geometric ideal and the constraints of physical reality assert themselves.

The second objective, complementary to the first, is to explore the symbolic and pedagogical dimension of structural failure as a form of knowledge. Beauvais Cathedral does not merely teach engineers how to reinforce a vault; it also invites a broader reflection on fragility as an intrinsic component of creative intelligence. In an age that often equates progress with the elimination of error, the case of Beauvais encourages a reconsideration of what might be called a "pedagogy of the limit": the form of learning that emerges from the tension between ambition and measure, between confidence in technique and the recognition of its vulnerability.

The study therefore seeks to establish a dialogue between calculation and culture, showing how structural analysis can illuminate philosophical and aesthetic questions, and vice versa. From the perspective of heritage engineering, the research aims to provide a rigorous and quantifiable interpretation; from that of the humanities, a critical reflection on its broader significance.

In this sense, Beauvais Cathedral may be understood simultaneously as an experiment in engineering and as a kind of implicit moral treatise written in stone. Its history invites a reconsideration of the relationship between technique, beauty, and professional ethics, reminding us that every constructed work—like every civilization—rests upon a delicate equilibrium between audacity and knowledge.

3. METHODOLOGY

The analysis of Beauvais Cathedral calls for an inherently interdisciplinary perspective, in which structural engineering, construction history, and the symbolic interpretation of heritage converge. The methodological framework adopted here brings together the technical examination of the masonry fabric with a hermeneutic reading of the monument as a cultural text, allowing calculation and culture to enter into dialogue within a shared interpretative horizon.

3.1. Historical–structural Analysis

The first phase of the research focuses on the historical reconstruction of the building process and its transformations over eight centuries. To this end, an extensive review of documentary sources has been carried out—including cartularies, chronicles, restoration reports, and archaeological studies—complemented by the technical and theoretical literature from Eugène Viollet-le-Duc (1863) to the contemporary analyses of Jacques Heyman (1995) and Robert Mark (1982) (Condit & Mark, 1983; Heyman, 1967; Huerta Fernández, 2014; Mark, 2016; Viollet-le-Duc, 1868; Wolfe & Mark, 1976).

This approach situates Beauvais Cathedral within the continuum of European Gothic architecture, clarifying both its direct lineage from Amiens Cathedral (Figure 3) and Reims Cathedral (Table 1) and its distinctive singularity. Unlike its predecessors, Beauvais pushed verticality to a ratio of total height to choir width approaching 4:1, whereas the equilibrium values verified in Amiens did not exceed 3.2:1 (Heyman, 1977). This geometric excess constitutes the starting point for understanding its behaviour at the limits of structural stability.

In parallel, a typological and dimensional comparison has been undertaken with other reference cathedrals—Chartres Cathedral, Bourges Cathedral, León Cathedral (Figure 2), and Burgos Cathedral—in order to evaluate the degree of innovation or rupture represented by Beauvais within the Gothic system. Proportions, wall thicknesses, arch spans, and vault heights have been expressed through slenderness indices and lateral thrust ratios, using values drawn from previously published measurements and normalized as relative indices (h/e) (Rodríguez Elizalde, 2025a). This quantitative approach makes it possible to translate the constructive risk embodied by Beauvais Cathedral into a measurable scale without stripping it of its symbolic dimension.

3.2. Material and Constructive Evaluation

The second methodological phase addresses the material analysis of the masonry fabric, with particular attention to the relationship between stone, iron, and timber. The cathedral constitutes a pioneering case of the structural use of iron within a medieval building, employing square-section bars embedded within the walls and the keystones of arches. The study of these interventions—

documented in the campaigns of the fourteenth century and reinforced during the sixteenth and nineteenth centuries—makes it possible to examine the evolution of consolidation strategies in response to material fatigue and the residual thrust of the vaults.

At the same time, the constructive and empirical dimension of Gothic craftsmanship is considered. The master builders of the thirteenth century lacked analytical calculation: their knowledge derived from practical geometry, visual proportion, and learning through trial and error. The methodological analysis has therefore sought to reconstruct, as far as possible, the decision-making processes of a medieval builder, identifying the implicit rules of stability embedded in regulating tracings, scale models, and layout cords. This archaeotechnical perspective seeks not merely to measure but to understand how the collective intelligence of masons was capable of generating complex structures without recourse to equations, relying on intuition in the absence of formal mathematics.

3.3. Symbolic and Comparative Interpretation

The third methodological strand incorporates a hermeneutic and symbolic reading supported by the contributions of Erwin Panofsky, Umberto Eco, and Gilbert Simondon, among others (Eco, 1967; Panofsky, 1966; Simondon, 2017). The building is analysed simultaneously as a technical artifact and as a cultural text, in which every constructive decision expresses a worldview. Thus, the extreme verticality of the choir is interpreted not merely as a search for lightness or luminosity, but as the architectural translation of transcendence: elevation as both theological sign and metaphysical aspiration.

This perspective is enriched through comparison with other European cathedrals—such as Amiens Cathedral, Burgos Cathedral, León Cathedral, and Segovia Cathedral (Bony, 2023; Heyman, 1977; Huerta Fernández, 2006)—in which the experience of Beauvais was transformed into structural prudence. Comparative analysis makes it possible to trace how the "failure" of Beauvais functioned as a form of collective technical memory that shaped the subsequent decisions of builders.

3.4. Integration of Approaches

Finally, the methodology assumes the necessity of integrating quantitative and qualitative perspectives. Proportions, thrusts, and stresses are interpreted as material manifestations of a cultural logic. Each technical datum acquires meaning when inserted into the symbolic horizon that produced it. In this balance between measurement and interpretation lies the essence of the present work: the understanding that calculation itself is a form of culture, and that culture—when expressed architecturally—may be read as a moral calculus of risk.

The method does not seek to deliver definitive judgments about Beauvais Cathedral, but rather to restore its experimental character, recognizing in it the origin of a pedagogical tradition that continues to challenge contemporary technology: learning from limits, accepting vulnerability as part of the creative process, and recognizing that every structure—whether physical or conceptual—exists in suspension between order and collapse.

4. RESULTS

The structural and cultural analysis of Beauvais Cathedral allows it to be understood not only as the technical limit of French Gothic architecture, but also as a synthesis of knowledge that anticipates certain principles of modern engineering. Read from a contemporary perspective, the building reveals three principal planes of results—structural, material-constructive, and symbolic—each illuminating a different aspect of the same phenomenon: the encounter between human ambition and the resistance of matter.

4.1. The Geometry of Risk

The first result of the geometric analysis confirms that Beauvais Cathedral surpassed the empirical stability parameters that appear to have guided builders of its time. The choir, begun in 1225 and completed in 1272, reaches a height of 48.5 meters to the keystone of the vault, with an internal width of 12.3 meters. The ratio $h/e = 3.94$ significantly surpasses those of Amiens Cathedral ($h/e = 3.25$) and Reims Cathedral ($h/e = 3.10$), situating the structure at the theoretical limit of stability for a masonry construction (Figure 3 and Table 1) not sufficiently confined by developed flying buttresses (Huerta Fernández, 2014; Rodríguez Elizalde, 2025a; Viollet-le-Duc, 1868).

The arcade arches, with an approximate radius of 7.2 meters, generate a horizontal thrust estimated—according to models derived from Jacques Heyman and adapted to the proportions of the building—at between 23 and 27% of the self-weight of the arch. Such values would normally require buttresses of greater mass or a system of flying buttresses inclined at less than 25° (Boothby & Coronelli, 2024; Heyman, 1966, 1977). At Beauvais, however, the flying buttresses rise nearly 30 meters above their base, reaching an inclination of barely 17°, significantly reducing their efficiency in transmitting structural forces (Heyman, 1967, 1977).

This disproportion produced a critical structural condition: horizontal thrusts were not adequately dissipated, and the structure operated partly in tension rather than in pure compression (Murray, 1989, 2016). The vault keystones exhibited stress concentrations at the intersections of the diagonal ribs, while the clustered piers—barely 1.1 meters in diameter at the core—experienced phenomena of localized buckling (Allen et al., 2003; Murray, 2014). Archaeological evidence suggests that the first longitudinal crack appeared in the spring of 1283, affecting the southern side of the presbytery. One year later, in May 1284, the partial collapse of the choir confirmed the structural consequences already suggested by its geometry: stone had reached its limit (Wolfe & Mark, 1976).

4.2. From Catastrophe to Learning

The second result, of a constructive nature, lies in the response that the builders themselves gave to the disaster. The collapse of 1284 did not mark the abandonment of the project but its transformation (Murray, 1989, 2021).

During the following decades, the cathedral chapter ordered a reinforced reconstruction that incorporated significant technical innovations. The piers were enlarged, the flying buttresses were doubled, and wrought-iron bars were inserted as a form of structural stitching or tensile restraint —one of the earliest conscious uses of metal as tensile reinforcement in medieval architecture (Heyman, 1967; Murray, 1980, 1989; Rodríguez Elizalde, 2025a; Taupin, 1993).

Archaeometric studies and Carbon-14 dating (^{14}C) carried out in recent decades in various cathedrals (Disser et al., 2014; Leroy et al., 2015) have confirmed the presence of medieval iron reinforcements in Beauvais Cathedral. Some were likely planned in early construction phases, while others correspond to later consolidations. Specialized literature characterizes these elements as low-carbon wrought iron and documents their tensile function in controlling thrust and limiting the opening of vault springings. In the chevet of Beauvais there exists a specific inventory of metallic elements (LRMH/Médiathèque), accessible upon request. Their function was to prevent displacement at the vault springings and to restrain the progressive spreading of the arcade arches.

These data allow Beauvais Cathedral to be reconsidered as an early laboratory of hybrid structural solutions, a place where the experience of failure gradually gave rise to innovation.

The collapse of the crossing spire in 1573 occurred abruptly, shortly after its completion and in the days following the celebration of the Feast of the Ascension. The scholarly literature generally attributes the failure to the insufficient global bracing of the structure combined with the extreme slenderness of the four crossing piers required to sustain a superstructure of such exceptional height (Courtenay, 2016; Murray, 1980; Rodríguez Elizalde, 2025a; Wolfe & Mark, 1976). Although other explanations have been proposed (Frankl, 1962; Heyman, 1967; Viollet-le-Duc, 1868), there is still no complete quantitative consensus regarding the precise mechanism of collapse.

In any case, and unlike the episode of 1284, the event of 1573 illustrates how the accumulation of new architectural ambition upon an already delicate structural foundation inevitably increased the systemic vulnerability of the whole.

4.3. Structural Comparisons: from France to Spain

Comparative results with other cathedrals demonstrate the role of Beauvais as both reference and warning. After its collapse, no European cathedral again attempted such extreme height. Amiens—completed only a few years earlier—remained the practical limit, while cathedrals such as Rouen, Troyes, and Narbonne adopted more cautious proportions.

In Spain, where Gothic architecture developed with a certain chronological delay, the influence was indirect yet profound (Bork & Schurr, 2018; Frankl, 1962; Heyman, 1977). León Cathedral (1255–1302) maintains an interior height of 30 meters (Figure 2), with walls reduced almost entirely to stained glass and remarkable visual lightness; however, its buttresses are more robust and its double-arched flying buttresses ensure a more efficient transmission of thrust (Gómez Moreno, 1974; Navascués Palacio, 1990; Pérez Baquero, n.d.).

Burgos Cathedral, particularly in its fifteenth-century expansions, adopts an even more rational criterion: vertical elevation gives way to structural filigree and equilibrium (Andrés Ordax, 1993; Frankl, 1962).

Finally, Segovia Cathedral, begun in 1525—two centuries after the collapse of Beauvais—represents one of the clearest examples of Gothic maturity: verticality yields to solidity, and the structural language becomes refined to the point of classical serenity (Cortón de las Heras, 1997; Ruiz Hernando, 1994).

These comparisons demonstrate that the failure of Beauvais acted as a form of collective technical memory: risk was transformed into prudence, and audacity into measure.

4.4. Current Structural Behavior

Since the late twentieth century, Beauvais Cathedral has received sustained technical attention from French heritage institutions. Following the restoration campaigns carried out during the 1980s and 1990s, the Direction du Patrimoine and the Laboratoire de Recherche des Monuments Historiques (LRMH) promoted a series of observation programs aimed at monitoring the stability of the choir and the crossing, as well as studying the evolution of cracks inherited from earlier collapse episodes.

Among these initiatives, particular importance attaches to the *Projet d'étude préalable* prepared by the architecte en chef des Monuments Historiques André Taupin, together with the subsequent Plan d'observation pour le suivi de la cathédrale, both preserved today in the archives of the LRMH (Taupin, 1993, 1995, 1996).

These documents emphasize the necessity of periodic monitoring through levelling surveys, crack gauges, and manual measurements—based on analogue rather than electronic instrumentation—with the objective of detecting differential displacements and possible variations in the geometry of the flying buttresses. Although the program does not detail the exact sensors employed, it outlines a systematic, long-term methodology of observation that has since become a reference model for the structural management of historic monuments in France.

In parallel, the *Inventaire général du patrimoine culturel of the Région Hauts-de-France* carried out in 1994 a photogrammetric survey of the vault plan of the transept (code IVR22_19946001370P), constituting the first systematic metric record of the intrados of the vaults and the springing points of the flying buttresses.

This survey has served as a basis for subsequent comparisons and has demonstrated that, since the late twentieth century, the global deformations of the building remain within ranges compatible with its present state of stability.

Material studies conducted by LRMH—particularly those dedicated to the lead roofing and wrought-iron reinforcements (Taupin, 1996)—have shown that the mechanical behaviour of the cathedral today depends less on large structural movements than on environmental factors: thermal expansion, hygrometric variation, and differential alterations of mortar (Heyman, 1967; Huerta Fernández, 2014; Murray, 1989, 2011).

The building therefore remains in a condition of dynamic equilibrium, characterized by micro-adjustments distributed throughout the year without compromising the overall structural stability.

Technical monitoring of Beauvais Cathedral continues regularly. In recent decades, both LRMH and the *Centre des monuments nationaux* have incorporated laser-scanning and BIM modelling techniques in the study of other French cathedrals, suggesting a methodological evolution that may in future be extended to Beauvais (Allen et al., 2003; Benouville, 1891; Branner, 1962; Murray, 2014).

Overall, the available data allow us to conclude that the cathedral maintains global stability within the limiting conditions characteristic of an extremely slender structure.

The monitoring program initiated in the 1990s has made it possible to prevent significant new displacements and has gradually consolidated Beauvais as a "laboratory monument." In this context, structural surveillance is no longer understood merely as an emergency response (Allen et al., 2003), but rather as the contemporary continuation of the same search for equilibrium that once guided its medieval builders (Taupin, 1993; Taupin & Hoffsummer, 2009).

4.5. Aesthetic and Structural Interpretation

Technical analysis inevitably leads to a broader interpretation: Beauvais Cathedral is not merely an engineering experiment but also a masterpiece of what might be called the aesthetics of risk (Rodríguez Elizalde, 2025a, 2025b).

Each numerical datum—proportion, mass, stress—translates into visual emotion. Gothic architecture transforms statics into poetics: the structure does not conceal effort; it reveals it (Casati Calzada & Gálvez Ruiz, 2007; Como, 2015). At Beauvais, that visibility becomes dramatic.

Slender piers, extremely high vaults, and flying buttresses that appear almost suspended in air give the entire composition the impression of standing on the verge of collapse, as if the form itself were expressing its own danger (Courtenay, 2016).

This aesthetic tension anticipates what twentieth-century structural theory would call the resistant form—beauty emerging directly from structural function (Heyman, 1967).

Unlike the "resolved" cathedrals—such as Chartres Cathedral, Burgos Cathedral, or Toledo

Cathedral—Beauvais preserves an unfinished gesture. It is a suspended work, permanently poised between ideal and ruin (Branner et al., 1963; Lavinia, 2024).

From a historical perspective, this condition makes Beauvais Cathedral an exceptional object of study; from a symbolic perspective, it becomes a mirror in which our own technological condition is reflected: the enduring human aspiration to master matter while remaining conscious of the limits that govern it.

4.6. Synthesis of Results

The preceding analysis points to five main findings

- Geometric limit. Beauvais Cathedral attained an exceptional degree of slenderness ($h/e \approx 3.9$), surpassing the empirical stability thresholds that were implicitly known to thirteenth-century builders (Allen et al., 2003; Courtenay, 2016). In doing so, the structure approached the very boundary at which Gothic masonry could remain in equilibrium.
- Constructive innovation. The early introduction of iron elements as structural reinforcement anticipates later hybrid solutions in which compression in masonry is complemented by tensile resistance in metal.
- Evolution of risk. The history of the building illustrates a transition from an initial design-related instability (the collapse of 1284) to a condition of accumulated structural vulnerability that culminated in the fall of the crossing spire in 1573. This distinction reveals the difference between a theoretical structural limit and the long-term effects of temporal degradation.
- Cultural influence. What might first appear as failure was gradually transformed into technical knowledge, influencing the development of later Gothic architecture, particularly in cathedrals such as León, Burgos, and Segovia.
- Persistent equilibrium. Through successive adaptations and interventions, the monument has maintained its stability over centuries, offering a remarkable example of structural resilience and of the capacity of historic buildings to evolve without losing their meaning.

In this sense, Beauvais Cathedral teaches perhaps more through what it lost than through what it preserved. Its ruin becomes a source of knowledge; its endurance, a lasting lesson. Through the dialogue between calculation, stone, and time, the cathedral ultimately appears as a form of thought—a silent treatise on the equilibrium between matter and idea.

5. DISCUSSION

Beauvais Cathedral represents one of the most illuminating episodes in the history of Western architecture, not only for the structural lessons it offers, but also for the depth with which it invites reflection on the relationship between knowledge, limit, and beauty. The partial ruin of the building should not be understood as the failure of a technique, but rather as the culmination of an experience: the moment at which human ambition encounters its own frontier and, in doing so, discovers within that boundary a new form of understanding.

5.1. Limit as Knowledge

From the perspective of the history of engineering, Beauvais Cathedral may be understood as the moment when medieval geometry approached its practical limit. The builders of the thirteenth century had carried structural intuition to an extraordinary level of refinement. In the absence of formal mathematical calculation, Gothic construction relied on a delicate balance between empirical experience and symbolic proportion. Stability was judged by the trained eye, by the tension of the measuring cord, and by a profound confidence in the continuity of the natural—and ultimately divine—order.

Beauvais disrupted that confidence. Its collapse revealed that beauty does not necessarily guarantee safety, and that a form may appear perfect without being structurally stable. What seemed at first a tragedy ultimately opened the path toward a new form of technical awareness. From that moment onward, architecture began to be understood not only as an act of praise expressed in stone, but also as a domain of knowledge.

The limit thus appears not as defeat, but as revelation. What was challenged in 1284 was not only a structural configuration, but an entire paradigm of confidence in geometric sufficiency. The conviction that geometric purity was sufficient to guarantee stability was fractured, forcing the recognition that every form must submit itself to the judgment of matter. From that experience onward, medieval construction would begin to be understood, centuries later, as a field in which successes and failures alike reveal the laws of equilibrium. As Jacques Heyman (1995) demonstrates in The Stone Skeleton (Boothby & Coronelli, 2024; Heyman, 1966, 1967, 1977), the modern understanding of masonry stability arises precisely from the analysis of collapse and from the search for the limit conditions that govern it. From this perspective, medieval ruins may be read as places where technique learned to think through error (Rodríguez Elizalde, 2025b).

Beauvais Cathedral thus inaugurates what may be called "a pedagogy of the limit"—not a renunciation of ambition, but its maturation. The building reminds us that risk is not the enemy of technique, but one of its necessary conditions; that every genuine advance arises from the unstable interval between what is already known and what human imagination still seeks to achieve.

5.2. Verticality and Its Politics

The second axis of discussion concerns the political and symbolic meaning attached to height. In the medieval world, verticality functioned as a form of discourse: a visible proclamation of faith, authority, and civic prestige. Cathedrals did not compete solely in beauty or refinement, but also in hierarchical standing. To build higher was to affirm the primacy of a diocese, the prosperity of a city, or the influence of a bishop. Within this context, Beauvais Cathedral was not only a spiritual undertaking but also a political gesture—an attempt to inscribe in stone the moral and economic prominence of one community among its neighbours.

The collapse of 1284, however, profoundly altered the meaning of that aspiration. Where a summit had been sought, a warning appeared. Beauvais transformed what had been a "politics of height" into something closer to an ethics of measure. In the decades that followed, Gothic architecture gradually moved away from the competition for verticality and directed its inventiveness toward other forms of expression: the luminosity of space, the refinement of proportion, and the search for harmony. What the thirteenth century experienced as catastrophe was later understood, in the fourteenth and fifteenth centuries, as a lesson.

This symbolic reversal also invites reflection in the present. The contemporary technological race—whether directed toward the conquest of space, the expansion of digital infrastructures, or the development of artificial intelligence—reproduces, in another form, that same impulse toward ever greater heights. The history of Beauvais Cathedral reminds us that progress cannot be separated from responsibility, and that the recognition of limits does not represent an obstacle to advancement, but rather one of its most necessary conditions.

5.3. Matter as Language

In aesthetic terms, Beauvais Cathedral marks a significant shift in the way material is understood within architecture. Stone ceases to be merely a neutral medium and emerges as a protagonist in its own right. Its physical behaviour—its fractures, its slight deformations, and its capacity for resistance—enters directly into the architectural discourse. Ruin, in this context, no longer appears as an external accident but becomes part of the narrative of the building itself.

Matter under stress thus becomes legible in a particular way. In the broader tradition of Gothic architecture, weight and light had long functioned as metaphors of the soul; at Beauvais, however, fracture becomes a metaphor of knowledge. Each crack may be read as a correction inscribed by the material itself, a silent response of stone to the intentions of its builders.

Seen in this way, Beauvais Cathedral may be understood as the point at which medieval architecture begins to develop a form of self-criticism. The building, in a certain sense, reflects upon its own conditions of possibility. It is precisely this moment of awareness that lends the monument a distinctly modern character.

Within contemporary aesthetic thought, architectural form is often interpreted as an attempt to grant permanence to what is otherwise ephemeral. At Beauvais, this impulse acquires a particular intensity. The stone seems almost to resist gravity in the same manner that memory resists oblivion. Its incompleteness should therefore not be regarded as a deficiency, but as a condition of permanent vigilance—an openness that suggests the work remains, even today, engaged in questioning its own possibility.

5.4. Failure as Inheritance

The collapse of Beauvais Cathedral did not interrupt the development of Gothic architecture; rather, it helped to redirect it. The memory of the event persisted within the tradition of the builders' workshops, transmitted from generation to generation as a practical lesson. Gradually, master builders came to understand that true mastery did not consist in pursuing height without restraint, but in maintaining the delicate equilibrium upon which every structure ultimately depends.

In this way, the cathedral became a structural warning—a kind of negative reference that quietly guided the subsequent evolution of the style. During the centuries that followed, the extreme verticality attempted at Beauvais gave way to a more measured architectural rationality, visible in cathedrals such as León, Burgos, and Segovia.

- At León Cathedral (Figure 2), transcendence is no longer pursued primarily through height, but through light.
- At Burgos Cathedral, the daring of structural ambition gives way to a refined filigree of forms.
- At Segovia Cathedral, Gothic architecture acquires a new serenity—almost Renaissance in its restraint and composure.

Each of these monuments may be understood, in one way or another, as a response to Beauvais: an interpretation of the limit it revealed.

This gradual shift—from the pursuit of pure ambition toward the search for equilibrium—may be read as a sign of technical maturity. Progress in architecture does not occur only through the invention of new forms, but also through the capacity to understand and avoid past excesses. In this sense, Beauvais should not be regarded as a melancholic ruin, but rather as an instrument of learning: a structural laboratory whose lesson remains relevant for contemporary engineers. It reminds us that safety does not eliminate risk; rather, it emerges from the conscious understanding and management of it.

5.5. The Contemporary Echo: from Gothic to Artificial Intelligence

The final level of discussion concerns the continuing relevance of Beauvais Cathedral in the contemporary technological context. The logic of the limit is not confined to the medieval past. It reappears whenever human ingenuity advances toward new technological frontiers. Each phase of innovation—no matter how sophisticated its instruments—eventually encounters the same structural condition: the need to recognize the boundaries within which technique can operate without losing stability or meaning.

Today, as in the thirteenth century, humanity confronts the vertigo of its own creations. Algorithms, artificial intelligences, and automated systems often appear to promise unprecedented precision; yet beneath that appearance of control there pulses the same risk that brought down the vaults of Beauvais: the temptation to forget fragility (Murray, 2014; Rodríguez Elizalde, 2025b, 2025c).

Medieval engineering and contemporary computational engineering share, at their core, a similar impulse: both reflect a deep confidence in the human capacity to impose structure upon the world. The experience of Beauvais, however, reminds us that such confidence has always required a measure of humility. Medieval master builders learned—often through trial, adjustment, and occasional failure—to observe the behaviour of stone and to respond to it. In a different way, the engineer of the present faces a comparable task: to recognize the limits embedded in code, in energy systems, and in the broader ethical consequences of technological action.

From this perspective, Beauvais Cathedral acquires a significance that extends beyond its historical moment. The building becomes a kind of mirror in which technique reflects upon itself. The medieval aspiration toward verticality and the contemporary pursuit of virtuality arise from a comparable human desire: the attempt to transcend material condition (Murray, 1989). What differs is the form taken by failure. In the thirteenth century, collapse appeared in the form of fallen masonry. Today it may emerge through the breakdown of complex systems, through algorithms that lose coherence, or through infrastructures whose scale exceeds effective human oversight.

Yet the underlying lesson remains remarkably constant: without limit there can be no form, and without awareness there can be no equilibrium.

For this reason, the "pedagogy of the limit" suggested by Beauvais Cathedral offers a valuable framework for contemporary technical education. It encourages future engineers and architects to recognize that fragility is not merely a defect to be eliminated, but a condition that sharpens understanding. Those who acknowledge risk—and who accept the responsibility that accompanies it—are ultimately better equipped to create with genuine ethical awareness.

5.6. The Aesthetics of Equilibrium

From an aesthetic point of view, Beauvais Cathedral may be understood as the triumph of a precarious equilibrium. Each element appears pushed to the edge of what it can sustain, and yet the structure endures. It is precisely this condition that gives rise to its singular beauty: the beauty of effort held in balance, of a moment that seems about to yield and yet remains suspended.

The light that passes through its stained glass is therefore not the serene light of perfection, but the more fragile light of resistance. In a symbolic sense, that same light also illuminates the history of technique itself. For in the end, the science of limits—the patient understanding of where matter resists and where it must yield—is also the science through which permanence becomes possible.

Seen from the present, Beauvais Cathedral appears not merely as a ruin, but as a manifesto. It does not speak of what was lost, but of what was sustained (Murray, 2014; Pihan, 1885): of the knowledge that arises when matter and idea find their point of equilibrium.

In synthesis, the preceding discussion allows us to affirm that Beauvais Cathedral belongs not only to the historical past of Gothic architecture, but also to the continuing future of technical thought. Its history carries a double meaning: it stands as a warning, but also as a promise. A warning that ambition, when detached from measure, may lead to collapse; yet at the same time a promise that even failure, when understood, can be transformed into knowledge.

The ruin of Beauvais, therefore, should not be read as an ending, but as a particular form of permanence. Like every great work of architecture, the cathedral does not merely endure in stone; it continues to instruct. Eight centuries later, its lesson remains strikingly relevant: that calculation is never purely mechanical but part of culture itself, and that culture, if it wishes to endure, must possess a lucid awareness of its own limits.

Beyond its historical and structural specificity, Beauvais Cathedral invites a broader reflection on the cultural nature of technical knowledge itself. The building shows that technological systems do not evolve solely through optimization, but also through critical encounters with their own limits. In this sense, the cathedral may be understood not only as a medieval experiment, but as an enduring epistemological model: a reminder that innovation emerges from the tension between aspiration and constraint. From this perspective, Beauvais belongs not only to the history of Gothic architecture, but also to a wider cultural discourse in which technique is shaped by uncertainty, risk, and reflective self-correction.

6. CONCLUSION

Beauvais Cathedral may be regarded as one of the most lucid expressions of the European architectural imagination, precisely because it embodies the persistent tension between technical reason and spiritual imagination. Within this building, matter and idea appear to converge in a fragile moment of equilibrium—measured not only by its extraordinary height, 48.5 metres of ambition and vertigo, but also by the depth of knowledge that its history, and even its ruin, has transmitted to subsequent generations.

The analysis presented here suggests a fundamental conclusion: Beauvais Cathedral should not be understood simply as a failure, but rather as an experiment. It was an experiment carried to the extreme limits of the Gothic system, where medieval architecture encountered the boundary separating what could be built from what could only be imagined. The collapse of the structure did not extinguish confidence in technique. Instead, it transformed that confidence. In the decades that followed, European builders began to recognise that architectural greatness does not lie in surpassing every limit, but in understanding where those limits reside.

From a structural perspective, Beauvais represents the culminating point of the Gothic system. Its geometry may rightly be described as a geometry of risk: extreme slenderness, horizontal thrusts that were not always adequately counteracted, and piers reduced to the minimum section capable of sustaining the loads imposed upon them. These conditions eventually led to collapse—an event that modern structural mechanics can interpret with clarity, but which medieval builders may well have experienced as something closer to revelation. Through that experience they discovered that form alone does not guarantee stability; that empirical calculation must be accompanied by an intuitive understanding of material behaviour; and that the aspiration to lightness must always be reconciled with the inescapable logic of gravity. Knowledge of this kind, transmitted gradually from workshop to workshop, altered the course of Gothic construction. Later cathedrals—among them León, Burgos, Seville, and Segovia—display a more measured balance, where prudence emerges as a constructive virtue and equilibrium replaces defiance as the guiding aesthetic principle.

Yet the significance of Beauvais extends beyond the structural sphere. Its legacy is also cultural. The cathedral reminds us that fragility is not the opposite of strength; in many cases it is one of its conditions. Every structure, whether physical or institutional, exists within a narrow zone of tension, and permanence depends less on the absence of error than on the capacity to learn from it. In this respect, Beauvais anticipates a broader ethics of technique whose relevance has not diminished. Even in an age increasingly shaped by algorithms and artificial intelligence, the lesson of the thirteenth century remains clear: without limits there can be no knowledge, and without awareness there can be no meaningful progress.

The history of Beauvais also suggests that ruin itself may contain a form of wisdom. When architecture approaches its extreme conditions, it ceases to be merely construction and begins to resemble a form of material reflection on the human condition. The unfinished choir and the iron-reinforced walls should not be read as signs of weakness, but as evidence of adaptation. The building persists, resists, and continues to instruct; its partial survival represents, in many respects, a quiet victory over time.

From the perspective of heritage engineering, the cathedral provides an exemplary case for understanding structural resilience in historic constructions. Each intervention—from the iron tie bars introduced during the Middle Ages to the sophisticated monitoring systems employed today—has extended the life of the building without altering its essential meaning. In the delicate equilibrium between stability and ruin that characterises the monument, Beauvais reveals the beauty of conscious maintenance: the union of careful calculation with respect for historical memory.

At a broader cultural level, the cathedral may also be understood as a metaphor for the human condition itself: the persistent aspiration to rise, even while recognising that every height carries its own risk. Where other monuments present an image of triumph, Beauvais offers something more complex. Its grandeur lies not in the absence of failure, but in the transformation of collapse into knowledge, error into method, and ruin into lasting instruction.

The preceding discussion may therefore be summarised in several essential observations

1. A critical point in Gothic architecture. Beauvais Cathedral represents both the structural limit of the Gothic system and one of its most ambitious aesthetic achievements.
2. The emergence of technical awareness. The collapse of the choir in 1284 contributed to a growing understanding in which geometric ambition increasingly yielded to structural experience.
3. A reflection of the human condition. The unfinished state of the monument reveals a broader truth: human knowledge often advances through the recognition of limits.
4. A pedagogy of the limit. Learning through error remains one of the most enduring lessons for contemporary education in architecture and engineering.
5. Ruin as continuity. Rather than disappearing, Beauvais Cathedral became a living laboratory of equilibrium, prudence, and reflection.

Beauvais Cathedral was never completed, yet what was built still stands. Within that incompleteness lies a profound insight: knowledge is not measured by perfection, but by the awareness of limits.

For this reason, the cathedral—like technique itself—should be understood not as a finished doctrine but as an open process, one that brings together reason and beauty, calculation and culture. Eight centuries later, Beauvais continues to speak to those who build, those who study, and those who teach. Its lesson, inscribed both in stone and in the spaces left unfinished, may ultimately be expressed in a simple idea: every human work endures not only because of what it achieves, but because of what it teaches.

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REFERENCES

Allen, P. K., Troccoli, A., Smith, B., Stamos, I., & Murray, S. (2003). The Beauvais Cathedral Project. *IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops, 1*. https://doi.org/10.1109/CVPRW.2003.10004

Andrés Ordax, S. (1993). Catedral de Burgos. In Edilesa (Ed.), *Las Catedrales de Castilla y León* (pp. 42–65).

Benouville, L. (1891). Étude sur la Cathédrale de Beauvais. In *Encyclopédie d'Architecture*, Vol. 4 (pp. 52–70).

Bony, J. (2023). *French Gothic Architecture of the 12th and 13th Centuries*. University of California Press. https://doi.org/10.2307/3332318

Boothby, T. E., & Coronelli, D. (2024). The Stone Skeleton: A Reappraisal. *Heritage, 7*(5), 2265–2276. https://doi.org/10.3390/heritage7050107

Bork, R., & Schurr, M. (2018). Gothic Architecture. *Art History*. https://doi.org/10.1093/obo/9780199920105-0126

Branner, R. (1962). Le Maitre de la cathédrale de Beauvais. In *Art de France*, Vol. II (pp. 77–92).

Branner, R., Jantzen, H., & Palmes, J. (1963). High Gothic. The Classic Cathedrals of Chartres, Reims, Amiens. In *The Journal of Aesthetics and Art Criticism, 22*(1). Princeton University Press. https://doi.org/10.2307/427856

Casati Calzada, M. J., & Gálvez Ruiz, J. C. (2007). Técnicas históricas de análisis estructural de las catedrales góticas. Aplicación a la catedral de León. *Revista de Obras Públicas, 154*(3482), 55–66.

Chœur d'Hommes de La Villette. (n.d.). Analyses acoustiques. Chœur d'Hommes de La Villette. https://www.choeurdhommesdelavillette.fr/recherches-architecturales/analyses-acoustiques/

Como, M. (2009). The Collapse of the Beauvais Cathedral in 1284. The Conjecture of the Creep Buckling Piers. In K.-E. Kurrer, W. Lorenz, & V. Weltzk (Eds.), *Proceedings of the Third International Congress on Construction History, Brandenburg University of Technology Cottbus, Germany, 20th–24th May 2009* (pp. 393–400).

Como, M. (2015). Statics of Historic Masonry Constructions: An Essay. In Springer (Ed.), *Masonry Structures: Between Mechanics and Architecture* (pp. 49–72). Springer International Publishing. https://doi.org/10.1007/978-3-319-13003-3_3

Condit, C. W., & Mark, R. (1983). Experiments in Gothic Structure. *Technology and Culture, 24*(2), 261. https://doi.org/10.2307/3104043

Cortón de las Heras, T. (1997). La construcción de la catedral de Segovia (1525–1607).

Courtenay, L. T. (2016). *The Engineering of Medieval Cathedrals* (pp. 1–360). https://doi.org/10.4324/9781315239989

Disser, A., Dillmann, P., Bourgain, C., L'Héritier, M., Vega, E., Bauvais, S., & Leroy, M. (2014). Iron reinforcements in Beauvais and Metz Cathedrals: From bloomery or finery? The use of logistic regression for differentiating smelting processes. *Journal of Archaeological Science, 42*(1), 315–333. https://doi.org/10.1016/j.jas.2013.10.034

Eco, U. (1967). *La struttura assente. Introduzione alla ricerca semiologica*. Bompiani.

Frankl, P. (1962). *Gothic Architecture*. Harmondsworth, Middlesex: Penguin Books.

Gómez Moreno, M. E. (1974). *La Catedral de León*. Editorial Everest.

Heyman, J. (1966). The stone skeleton. *International Journal of Solids and Structures, 2*(2). https://doi.org/10.1016/0020-7683(66)90018-7

Heyman, J. (1967). Beauvais cathedral. *Transactions of the Newcomen Society, 40*(1), 15–35. https://doi.org/10.1179/tns.1967.002

Heyman, J. (1977). The gothic structure. *Interdisciplinary Science Reviews, 2*(2), 151–164. https://doi.org/10.1179/030801877789826213

Huerta Fernández, S. (2006). Geometry and equilibrium: The gothic theory of structural design. *Structural Engineer, 84*(2), 23–28. https://oa.upm.es/701/1/Huerta_Art_001.pdf

Huerta Fernández, S. (2014). The Debate about the Structural Behaviour of Gothic Vaults: From Viollet-le-Duc to Heyman. *Proceedings of the Third International Congress on Construction History, Brandenburg University of Technology Cottbus, Germany, 20th–24th May 2009*, 837–844.

Lavinia, D. T. (2024). Flying Buttresses and the Artistic Expression of Vertical Ambition in Gothic Church Architecture. *Art and Society, 3*(4), 1–12. https://doi.org/10.56397/as.2024.08.01

Leroy, S., L'Héritier, M., Delqué-Kolic, E., Dumoulin, J. P., Moreau, C., & Dillmann, P. (2015). Consolidation or initial design? Radiocarbon dating of ancient iron alloys sheds light on the reinforcements of French Gothic Cathedrals. *Journal of Archaeological Science, 53*, 190–201. https://doi.org/10.1016/j.jas.2014.10.016

Mark, R. (2016). Robert Willis, Viollet-le-Duc and the structural approach to Gothic architecture. In Routledge (Ed.), *The Engineering of Medieval Cathedrals* (pp. 1–13).

Murray, S. (1980). The Choir of the Church of St.-Pierre, Cathedral of Beauvais: A Study of Gothic Architectural Planning and Constructional Chronology in Its Historical Context. *The Art Bulletin, 62*(4), 533–551. https://doi.org/10.1080/00043079.1980.10787813

Murray, S. (1989). *Beauvais Cathedral. Architecture of Transcendence*. Princeton University Press.

Murray, S. (2011). Back to Beauvais. In R. Odell Bork, W. W. Clark, & A. McGehee (Eds.), *New Approaches to Medieval Architecture* (pp. 45–60).

Murray, S. (2014). Plotting Gothic: A Paradox. *Architectural Histories, 2*(1), 1–14. https://doi.org/10.5334/ah.bs

Murray, S. (2016). The collapse of 1284 at Beauvais Cathedral. In Routledge (Ed.), *The Engineering of Medieval Cathedrals* (pp. 141–168).

Murray, S. (2021). Cathedral. In *"Remove Not the Ancient Landmark". Public Monuments and Moral Values*. https://doi.org/10.4324/9781003144458-24

Navascués Palacio, P. (1990). La catedral de León: de la verdad histórica al espejismo erudito. *Medievalismo y Neomedievalismo en la Arquitectura Española: Aspectos Generales. Actas del 1er Congreso, Ávila, Septiembre 1987*, 17–66.

Panofsky, E. (1966). *Gothic Architecture and Scholasticism* (9th ed.). The World Publishing Company.

Pérez Baquero, F. (n.d.). León. Sección longitudinal de la Catedral. *Academia Colecciones, Real Academia de Bellas Artes de San Fernando.* https://www.academiacolecciones.com/estampas/inventario.php?id=R-4298

Pihan, L. (1885). *Beauvais: sa cathédrale, ses principaux monuments*. H. Trézel.

Rodríguez Elizalde, R. (2025a). Beauvais Cathedral: The Ambition, Collapse and Legacy of Gothic Engineering. *Heritage, 8*(6). https://doi.org/10.3390/heritage8060203

Rodríguez Elizalde, R. (2025b). The Cathedral of Beauvais: Ruin as Discourse. The Gothic Structure and the Fall of Technical Meaning. *Journal of Cultural Analysis and Social Change, 10*(3), 658–671. https://doi.org/10.64753/jcasc.v10i3.2473

Rodríguez Elizalde, R. (2025c). The Fragile Sky of Beauvais Cathedral: Gothic Architecture and the Posthuman Condition of Technical Ambition. *Journal of Posthumanism, 5*(11), 44–63. https://doi.org/10.63332/joph.v5i11.3629

Ruiz Hernando, J. A. (1994). *La Catedral de Segovia*. Edilesa.

Simondon, G. (2017). *On the Mode of Existence of Technical Objects*. Univocal Publishing.

Taupin, J.-L. (1993). Cathédrale de Beauvais: de l'incertitude à la décision. *Proceedings of the IABSE Symposium on Structural Preservation of the Architectural Heritage*, 645–652.

Taupin, J.-L. (1995). Réflexions sur la cathédrale Saint-Pierre de Beauvais. *Ananke, 12*, 86–100.

Taupin, J.-L. (1996). Le fer des cathédrales. *Monumental, 13*, 18–27.

Taupin, J.-L., & Hoffsummer, P. (2009). Case Studies: The Cathedral of Saint-Pierre in Beauvais. In *Roof Frames from the 11th to the 19th Century: Typology and Development in Northern France and in Belgium: Analysis of CRMH Documentation* (pp. 108–121).

Viollet-le-Duc, E.-E. (1868). *Dictionnaire raisonné de l'architecture française du XI° au XVI° siècle.* https://www.google.es/books/edition/Dictionaire_raisonné_de_l_architecture/LndJAAAAMAAJ?hl=es&gbpv=1&pg=PA207&printsec=frontcover

Wolfe, M. I., & Mark, R. (1976). The collapse of the vaults of Beauvais Cathedral in 1284. *Speculum, 51*(3), 462–476. https://doi.org/10.2307/2851708