Historians of architectural education commonly focus on academic, design-oriented curricula and date the earliest architectural education in America to 1867 when Massachusetts Institute of Technology (MIT) opened its program under the direction of William Robert Ware. More recently, Mary Woods, Jeffrey Cohen, and other historians have broadened the study of architectural education to include training for the craftsman-builder, revealing a porous distinction between craft and architecture before the drive for professional recognition by architects in the mid- to late nineteenth century. But little attention has been given to a third important constituency for architectural training in America—civil engineers. Their education is important not only because engineers designed, supervised, and contributed to many structures, but also because it shaped an American “engineer's aesthetic” that influenced early European modernists like Le Corbusier, Erich Mendelsohn, and Walter Gropius, and in turn shaped modern architecture. Engineering education was also significant for late nineteenth- and early twentieth-century American architects like William Le Baron Jenney, George B. Post, Charles McKim, John Root, William Holabird, Julia Morgan, and Frank Lloyd Wright, all of whom studied architecture in engineering programs.

America’s first architectural education for engineers was offered at the United States Military Academy at West Point, New York, beginning in 1816. At a time when architectural influence in America derived primarily from England and most American architectural education was informal, the Military Academy provided scientific instruction based on the Ecole Polytechnique in Paris, the model for engineering schools throughout Europe. The engineering course included architectural theory from Jean Rondelet and Jean-Nicolas-Louis Durand, two authors whose works were widely studied in Europe and whose influence on America has long been suspected but never traced. This course was most highly developed under Dennis Hart Mahan who taught engineering at the Academy from 1830 through 1871. Mahan joined the ideas of Rondelet and Durand with Quatremère de Quincy’s theory of character in a comprehensive curriculum that concentrated on materials, structure, and rational design. With an emphasis on functionality, practicality, and appropriateness, Mahan instructed cadets in architectural elements, classical ornamentation, character, and architectural composition, and he wrote what appear to be America’s first architectural textbooks.

Engineers trained at the Military Academy had wide influence in nineteenth-century America. While only a select few became civilian architects, many were active in building design and construction for the government, in the advancement of materials, and as proponents of standardization. Even more significantly, many became educators at schools of engineering well before the establishment of America’s architectural programs. Their continued dissemination of Mahan’s theory of functionality and structural efficiency at the end of the century provided a counterpoint to the academic, design-oriented curricula that have traditionally been the focus of architectural education.
to architectural education that was primarily academic in orientation, influencing American architecture well into the twentieth century.

The United States Military Academy: The First Years, 1802–30

The United States Military Academy was established in 1802 when President Thomas Jefferson signed the Military Peace Establishment Act authorizing a peacetime military and formalizing education for the Corps of Engineers. Plans for such a school had long been discussed, and early proposals to locate it in Washington advanced far enough for Benjamin Henry Latrobe to prepare building designs. Instead, the Academy was established on a rocky promontory in the Hudson River at West Point, 60 miles upstream from New York City, where French engineers had been instructing the American military since formation of the Corps of Engineers in 1779.

Although historians disagree on Jefferson's exact motives for founding the school, his appointment of Jonathan Williams as the school's first superintendent signaled his desire that the school provide advanced scientific education along European models. Long recognized for his appreciation of the art of architecture, Jefferson also acknowledged architecture as a practical discipline, which he considered more important than aesthetics given the country's great need for internal improvements. Williams, whom Jefferson knew from Paris and Philadelphia, proposed a broad, scientific, mathematics-based curriculum modeled after the Ecole Polytechnique, one that would prepare an engineer to work as "a draughtsman, a surveyor, a navigator, an architect, and a calculator on any subject."

While there, the two purchased thousands of charts, maps, pamphlets, and books, including titles later heavily used in the teaching of architecture: Durand's *Précis des Leçons d'Architecture données à l'École Polytechnique* and Rondet's *Traité théorique et pratique de l'art de bâtir.* Thayer and McRee also ordered models from workshops of the Ecole Polytechnique demonstrating construction of “arches, roofs, domes, etc.” in both stone and carpentry. With their purchases, the library and classrooms of the Military Academy immediately became among the best equipped in America.

Thayer’s new professor of engineering was French engineer Claudius Crozet, a graduate of the Ecole Polytechnique and Ecole du Génie et de l’Artillerie who had served as bridge engineer in Napoleon’s army. With his architectural education and construction experience, one of Crozet’s first acts at West Point appears to have been designing the North Barracks building, a four-story hip-roofed structure of rough stone erected in 1817 to house 160 cadets in forty rooms. His engineering course, first taught in the fall of 1816, encompassed mathematics, “architecture including its draughtsmanship and shading.”
the military art of fortifications, and geography. Lectures, he wrote in his “Programme,” would use “the models and materials he has brought with him” and “follow the method of teaching and the authors of the Ecole Polytechnique.”

Despite little record of the content of Crozet’s engineering course, evidence suggests he followed the teaching of his French professors closely. A protégé of Gaspard Monge, Crozet based his course on descriptive geometry, for which he wrote America’s first textbook. For engineering, he used Joseph-Mathieu Sganzin’s *Précis des leçons d’un cours de construction* (1809), and for architecture Durand’s *Précis des Leçons d’Architecture*, both of which were French-language compilations of lectures given by Ecole Polytechnique professors. Durand’s elementary proportional principles of the architectural orders, for example, were dutifully copied into drawing notebooks by cadets like Hannibal Day, who graduated from the Academy in 1823 (Figure 1). By all accounts, however, Crozet’s course was highly theoretical; his emphasis on military over civil engineering and lack of practical instruction led to criticism and reprimands. Ultimately, his repeated clashes with Thayer over curriculum development and cadet discipline led to court-martial proceedings for insubordination. He left the Academy in 1823 to become principal engineer of Virginia.

Despite initial plans to emphasize engineering at the Academy and appropriations for a chair in the subject, West Point failed to fill a growing need for trained engineers in America. The options for such training elsewhere were limited: scattered courses in engineering at schools like Yale and Brown were not comprehensive; instruction in drawing schools was neither scientific nor mathematical; and apprenticeships were severely limited by the small number of experienced practicing engineers. As the country prospered under international peace in the early 1820s, Congress looked specifically to military engineers to prepare surveys, plans, and estimates for roads, canals, and other internal improvements. Increasingly, Superintendent Thayer and other members of the academic board came under pressure to add a full civil engineering program.

David Bates Douglass (1790–1849) was named professor of civil engineering upon Crozet’s departure in 1823 and quickly established a comprehensive engineering course in which civil architecture was a key component. After graduation from Yale College, Douglass had been immediately commissioned in the Corps of Engineers, for which he trained at West Point. Following the War of 1812, he returned to the Academy as assistant professor of natural philosophy (1815–20), professor of mathematics (1820–23), and professor of engineering (1823–31).

Douglass brought practical experience to Crozet’s theoretical course, which he initially adopted with little change. Under Thayer’s curriculum, the first three years included mathematics, surveying, mechanics, and other scientific subjects, with the entire fourth year devoted to civil and military engineering. There cadets applied knowledge of descriptive geometry to stoneworking problems, used mathematics and calculus to determine material strengths and stresses, and under Douglass’s tutelage continued the study of classical architectural elements and proportion first introduced in the drawing course of mathematics professor Charles Davies (Figure 2).

Douglass’s architectural instruction included “Elementary parts of buildings and their combination; orders of architecture; construction of buildings and arches; canals; bridges, and other public works; machines used in construction; also the execution of a series of drawings, consisting of plans, elevations and sections, to illustrate the principal parts of the course.” The phrase “elementary parts of buildings and their combination” reveals continued reliance on Durand’s *Précis des Leçons*, a book regularly consulted by Douglass’s assistant professors. But Douglass also supplemented Durand’s lessons with his own material. A handwritten “Description of the Course” in Douglass’s papers reveals that his lectures on architecture began with an “Introduction (Historical)” followed by a “Description and Analysis of the Different Architectures” covering Egyptian, Grecian, Roman, Lombardic, Christian, and “Composite Architecture.” Much of this historical material was borrowed from James Elmes’s *Lectures on Architecture* (1821), a popular nineteenth-century book and one of the most consulted architectural titles in the Academy library.

In its overall organization, Douglass’s architectural course was similar to William Strickland’s 1824 lecture series at Philadelphia’s newly established Franklin Institute. Like Strickland, Douglass illustrated his lectures in the history of architecture with models, including forty-six construction details for vaults, arches, and roofs; twelve carpentry details; five models of the orders; four models of classical buildings, including the Parthenon and “hypothetical temple of Paestum”; and twenty-eight models and casts of Greek and Roman details. Believing the design of a building came not from a designer’s imagination or current fashionable style but from its “object” (use) and its construction, both of which gave a building “essential character and forms,” Douglass preferred models of classical antiquity for both their historical value and clear expression of the “orders of construction.” Models of Greek and Roman architecture, he felt, taught cadets that form followed structure and function. But unlike Strickland, Douglass also provided instruction in architectural composition.
to his “Description of the Course” are lecture notes on “elements, architectural design, composition, and arrangement of edifices according to the purpose for which they are intended,” and, neatly paraphrasing Durand’s Précis des Leçons, their “reunion . . . in considering the plan, arrangement, distribution and architecture of cities.”43 In his combination of history, theory, and application of fine arts and engineering, Douglass’s architectural course was without American equal.

The last and most important section of Douglass’s “Description of the Course” extensively covered materials, construction techniques, and the process of construction, and it was more theoretical than any of Strickland’s lectures. Entitled “Technical Architecture,” this part of the course integrated architecture with engineering and followed design and history according to “the order of their application,” not “in the order of dependence.”44 Incorporating material from Sganzin’s Elementary Course in Civil Engineering, which appeared in an English translation in 1826, his own experience, and, perhaps most significantly, Rondelet’s Traité théorique et pratique de l’art de bâtir, Douglass taught the design and construction of buildings, bridges, roads, and canals, all as essential works of “Civil Architecture.” Assistant professors consulted Rondelet regularly during class preparation, and cadets copied Rondelet’s maxims in their notebooks.45 Writing in the fall of 1827, for example, Wash-
ington Hood attributed “three rules for determining the thickness of walls” to Rondelet, adding that they “accord very well with those buildings constructed by Palladio.” Summarizing the rationalism of Rondelet and Durand, Hood continued: “The orders of architecture ought not to be regarded as simple objects of decoration, but as an integral and constitutive parts of an edifice. It results from the principle that their employment is abused every time that solidity and convenience does not require them.”

Although common practice at the Ecole Polytechnique, the Ecole des Beaux-Arts, and throughout Europe, West Point’s use of Durand’s lessons alongside Rondelet’s treatise, both of which Douglass inherited from Crozet, was wholly unique in America.

A number of cadets trained by Douglass went on to significant careers in architecture and related fields. Hood, who graduated in 1828, joined the Corps of Topographical Engineers, which supervised construction for the Army, numerous public works in Washington, and federal buildings throughout the United States. Extant drawings in the Winterthur Library reveal that Hood also designed public buildings, bridges, canals, forts, and railroad lines. Edward Brickell White (class of 1826) became a prosperous architect in Charleston, South Carolina, designing numerous churches and the city’s Market Hall (1841) and winning the Custom House competition (1849). In early 1850, White and Major William Turnbull (class of 1819) were called upon by the building committee of the new Smithsonian to examine the collapse of the main hall’s center portion. Their unique scientific background and experience on large public buildings—Turnbull was superintendent of construction on the New Orleans Customhouse in 1848–49—led them to conclude that the building’s timber frame was inappropriate and should be rebuilt with fireproof construction.

Beginning in the 1830s, Army engineers were at the forefront of advancements in fireproof construction, development of structural iron, testing of materials, and standardization. One of the earliest American tests of structural iron took place at the West Point Foundry in 1836, overseen by assistant professor Thomas Cram (class of 1826). In the 1850s, Robert Anderson (class of 1825) disseminated further test results of iron in his capacity as overseer of iron fabrication and testing at the Trenton Iron Works for the Treasury Department’s Construction Office. This office was led by Alexander Bowman (class of 1825) who promoted the adoption of “fireproof” wrought-iron construction, which he had first used in New York’s Assay Office (1853–54). Bowman, whose influence on design is discussed below, also maintained a public sample room to promote use of new materials and led efforts to standardize the design, detailing, and specifications for public buildings, which were published and disseminated widely. Unsurprisingly, Bowman attributed his success in the office to his education at the Military Academy: his interest in structure and materials allied him with Rondelet, and his promotion of function, economy, durability, and standardization remained true to principles of Durand, both of whom he had studied under Douglass.

Between 1823 and his resignation in 1830, Douglass taught his course in engineering and architecture to 268 cadets at the Academy, one quarter of whom became engineers. He was succeeded as professor of engineering at West Point by his student, Dennis Hart Mahan, who further developed the architectural course and formulated a theory of architecture that he taught at the Military Academy for over forty years.

Dennis Hart Mahan

Dennis Hart Mahan (1802–71) was born to John Mahan, a carpenter in Norfolk, Virginia, and entered the Military Academy in 1820 with a deep interest in civil engineering. He excelled at the Academy, ranking first in his class every spring, and in his second year became an assistant professor of mathematics. Like all cadets, Mahan began his study of civil engineering and architecture under Douglass in the autumn of his fourth year. Mahan graduated first in the 1824 class of thirty-one cadets and remained at the Academy as assistant professor of mathematics (1824–25), then assistant professor of engineering (1825–26). While assistant professor, he was the second highest user of the Academy library, furthering his education by delving deeply into engineering treatises in both French and English.

Persistently ill with pulmonary problems exacerbated by West Point’s long, windy winters, Mahan requested leave to recuperate in Europe and to study French engineering improvements and education. In July 1826, the War Department authorized his travel, directing him to maintain a journal and submit regular reports on “roads, bridges, canals, the improvement of rivers and harbors, construction and labor saving machinery.” Arriving in a Paris crowded and restless under the second Bourbon restoration, Mahan lodged his first year with a French family while recuperating and improving his language skills. During this year he would have visited the newly reconsecrated Church of Sainte-Geneviève and seen François-Joseph Bélanger’s new iron dome over the Halle au Blé, both of which he knew from Rondelet’s treatise, and inspected the bridges of Jean-Randolphe Perronet. Carrying a letter of introduction from General Jacob Brown, he also toured the Ecole Poly-
technique and probably attended lectures by Durand. In the spring of 1827, Mahan made the first of many trips outside Paris, touring the south of France to inspect civil engineering improvements and then traveling north to visit fortifications along the frontier. He passed the winter of 1827–28 in Italy, returned to Paris in the spring, and then spent six summer weeks in England, devoting much of his time to inspecting canals and locks. His reports to Washington are filled with detailed engineering observations but fail to comment on the buildings he visited.

Mahan’s letters reveal that his interests were directed less to military engineering than civil engineering, the focus of his studies under Douglass. In a long report to Secretary of War James Barbour dated 25 March 1828, Mahan detailed the system of French technical education and its division into practical and theoretical schools with preparatory courses at the Ecole Polytechnique and advanced training in schools for mines, bridges and roads, and artillery. Two days later he wrote a private letter to Barbour requesting permission to extend his leave and study civil engineering at the Ecole des Ponts et Chaussées, with which he had become familiar having spent time “under the direction of” Louis Becquey, royalist director of the school and the Corps des Ponts et Chaussées from 1817–30. Acknowledging concerns of Congress that the Military Academy educate civil engineers to facilitate improvements throughout America, Mahan wrote that the school was “of extreme importance to our Military Academy and to our country. This institution offers a fund of information which can be obtained by no other means than by being on the spot.”

Rather surprisingly, Washington directed Mahan to attend the Ecole du Génie et de l’Artillerie at Metz, perhaps reflecting a concern that instruction at the Academy had already shifted too far from military engineering. He enrolled at Metz in January 1829 and remained there until April 1830, attending courses more advanced than those of both West Point and the Ecole Polytechnique, taking copious notes, and collecting lithographed textbooks that he later used in his own teaching. There he also studied “architecture as applicable to military buildings and fortifications” and engineering under Jean Victor Poncelet, the renowned bridge expert who influenced him greatly and became a lifelong friend.

Mahan left France only months before the insurrection leading to the July Monarchy and arrived in New York in July 1830. He was immediately assigned to West Point as assistant professor of engineering and, upon Douglass’s departure that fall, became principal professor of engineering, a position he held until his accidental Hudson River drowning in 1871. A leader among the faculty, he was an effective teacher and prolific author (Figure 3). But he was never truly beloved by cadets, earning the nickname “Old Cobbon Sense” for his stress on applied practical knowledge combined with a persistent and unfortunate nasal ailment. Unlike Douglass before him, Mahan had no practical field experience. What he brought to Douglass’s curriculum, however, was probably the most advanced theoretical background of any civil engineer in America and unparalleled firsthand knowledge of Europe’s newest architectural and engineering improvements.

Like Crozet, who had designed cadet barracks shortly after his arrival at West Point, it is probable that Mahan put his experience in architecture to use designing the new Cadet Chapel, a building whose authorship has never been firmly established (Figures 4, 5). While no documents definitively tie Mahan to the design of the building, his knowledge of architecture far surpassed that of the Academy faculty of 1830. With its double row of columns supporting a barrel-vaulted nave, the chapel is distinct in contemporary American religious architecture but similar to buildings Mahan would have seen in France such as Sainte-Geneviève in Paris or Saint-Vaast in Arras, both of which reflected long French debates on the use of free-
Figure 4  Attributed to Dennis Hart Mahan, Cadet Chapel, United States Military Academy, West Point, N.Y., 1835. Undated photograph by Stockbridge

Figure 5  Attributed to Dennis Hart Mahan, Cadet Chapel, interior. Undated photograph by Stockbridge
standing classical columns for churches.70 Moreover, its severe Greek Revival portico, expressed cornices, and quoining on the rusticated ashlar exterior reflect architectural principles found in Mahan’s textbooks on architecture that he began writing the same year.

Mahan’s first task as professor was to strengthen the course in civil engineering, combining theoretical with practical knowledge and emphasizing basic and enduring comprehension of fundamental principles.71 He began by updating Sganzin’s elementary and outdated engineering textbook with Supplements to Sganzin, a seventy-seven-page illustrated text focusing on bridges, dams, and canals that was lithographed at the Academy on a press he had purchased in Le Havre.72 As a supplement, he wrote a separate textbook on architecture that appears to be unknown and unstudied by architectural historians.73 A mere twenty pages in length, Mahan’s Architecture began with a description of Greek and Roman architecture, which he praised for both rational construction and “linear composition” that created “a strong and pleasing sensation in the observer.” He followed with condemnation of Gothic architecture, arguing it should be “totally rejected in the present state of the world.”74 While Mahan’s rejection of the Gothic style is unsurprising given his education under Douglass, it departs from Rondelet, who praised the skill, intelligence, and rational achievement of Gothic construction.75

The remainder of Mahan’s text was devoted to “the true object of architecture which we have defined to be the design and erection of edifices in general, and to the general principles which should always be kept in view in effecting this object.”76 He began his discussion of architectural principles with three paragraphs translated verbatim from Durand’s Précis des Leçons, arguing that distribution, not decoration, was the principal concern of the architect, for it embraced true “suitableness” (convenance) and economy.77 The remainder of Mahan’s book, however, offered little practical advice to the cadet, omitting just the sort of material he was seeking to introduce to the course of civil engineering.

Mahan soon began writing new texts in civil engineering to “supply the place of Sganzin.”78 He did not see these books as original contributions and “claimed no merit” for their content, regarding them as “compilations from a very wide range of reading” condensed to fit the student’s time.79 By 1834–35, he had printed a new, 172-page textbook entitled Outlines of the Course of Civil Engineering that included five “supplemental notes” and a 16-page Note on Architecture with nine plates.80 This wholly new architectural text was subsequently issued separately under its own cover and revised by Mahan two more times in the following six years, but it underwent no further revision after about 1839.81 Nor was Note on Architecture included when Mahan commercially published his expanded engineering text in 1837 as Elementary Course of Civil Engineering, a widely used text and reference book.82

More concise than his earlier book, Note on Architecture is divided into four sections that appear to correspond with the sequence of classroom instruction.83 After a discussion of the Greek and Roman orders (five pages) and an introduction to the “Elements of Edifices” (six pages), Mahan provided “general principles of composition or design in architecture” (two pages), followed by “composition or design” (four pages). He closed with a three-paragraph critique—deleted from the third edition—on the “failure” of current architecture. Unlike contemporary European architectural treatises and later American textbooks, Mahan’s discussion of the orders in Note on Architecture, as well as the brief historical introduction that precedes it, generally lacks both prescription and prescription. Stylistically, Mahan continued to prefer Greek architecture for its “broad plane horizontal masses,” “predominance of the horizontal over the vertical,” “distribution of the masses, the arrangement of the details, and the parsimony shown in the decorations,” which, he wrote, “all contribute to a noble repose.”84 Roman architecture was equally praiseworthy but “differed essentially” from the Greek in the greater variety of buildings and complexity of moldings and ornaments. The opposite of Greek simplicity, Gothic architecture remained “totally unsuited to the style of building required by the habits of civilized nations in the present day” due to its “great confusion arising from the innumerable division of the masses [and] the profusion and variety in the ornaments and details.”85

Mahan’s description of the orders was conventional and drawn from a variety of sources. Plates of the Tuscan, Doric, and Ionic orders and their pedestals, for example, were clearly copied from Sir William Chambers’s Treatise on the Decorative Part of Civil Architecture.86 Types and profiles of moldings were also copied from Chambers while simplified cornice diagrams were traced from Durand’s Précis des Leçons (Figure 6).87 But Mahan was not dogmatic in his presentation, for he did not see the orders or even style as the essence of architecture.

Mahan’s focus was practical and functional. In his second section on the “Elements of Edifices,” a taxonomy borrowed from Durand, he provided simple rules for measure, proportion, placement, and the “combination of elements” drawn from a number of sources, including Durand, Chambers, and Palladio.88 Together with models, drawings, and chalkboard lectures, these lithographed books formed the nucleus of his course and provide important evidence of its emphasis and content.
Although Academy cadets spoke and read French, an essential language for the study of advanced science and engineering, Mahan’s books filled an obvious need for comprehensive yet concise English-language texts that introduced architecture as a science. Most American architectural books published in the early nineteenth century were pattern books or builders guides, either reprints of titles by British writers like Abraham Swan or Peter Nicholson, or popular books by American architects like Asher Benjamin, John Haviland, or Minard Lafever.89 Mahan’s approach was altogether different. He did not teach simple construction techniques or provide patterns for copying but focused on principles of structure and materials as well as theories and methods of architectural design: he presented architecture as an integral part of the engineering discipline.

By 1845, the form and content of Mahan’s course in civil engineering was largely set.90 Spanning the entire fall semester of the fourth year, Mahan’s curriculum reversed the sequence of Douglass’s course in which architecture preceded
technical aspects: Mahan thoroughly grounded cadets in the study of materials, construction and machines before applying these concepts to the design of buildings, bridges, roads, canals, and railroads. Each day, the class of thirty to forty cadets was divided into three groups for a ninety-minute engineering seminar. Cadets were expected to have studied their lithographed textbooks and to demonstrate their knowledge in class at the blackboard; their performance was graded daily, as were their notebooks and sketchbooks. Seminars were followed and supplemented by daily three-hour sessions in the drawing studio where cadets made notebook-size ink drawings of geometrical figures and copied drawings and plates from various sources, including Mahan’s textbook (Figures 7, 8). In addition to architectural elements, they drew construction details, buildings, canal locks, bridges, and roads, followed by elaborate ink and colored wash renderings that closely resemble student drawings from French engineering schools (Figures 9–12).

Like Douglass, Mahan taught from the Academy’s collection of drawings and models. In the 1830s and 1840s, he and his assistants prepared many new drawings to illustrate lectures and serve as examples for cadet work. After the 1840s, Mahan increasingly used drawings of Treasury Department customs houses, marine hospitals, and other building types. These not only provided practical architectural examples but illustrated up-to-date materials and construction practices and demonstrated immediate application of scientific principles and compositional methods. He also continued to improve the model collection, spending 6,200 dollars between 1830 and 1837 on purchases including the “Ionic Temple on the Theseus,” the Erechtheon, the Arch of Theseus, and the Maison Carrée at Nîmes. On 19 February 1838, the Academy suffered a devastating fire that destroyed much of this collection and a number books in the library. Demonstrating the importance of architecture in his course, Mahan’s first priority was not replacement of...
Figure 9  George Welcker, “Carpentry,” West Point drawing notebook, 1834–35. West Point Museum Art Collection, United States Military Academy, West Point, N.Y.

Figure 10  Welcker, “Wooden Bridge.” West Point Museum Art Collection, United States Military Academy, West Point, N.Y.
Figure 11  Edward Beckwith, rendering of Turin bridge, 1841–42. West Point Museum Art Collection, United States Military Academy, West Point, N.Y.

Figure 12  Beckwith, rendering of canal lock, 1841–42. West Point Museum Art Collection, United States Military Academy, West Point, N.Y.
By 1841, the collection of architectural models included fourteen, including one of each of the five orders, the Parthenon, the Temple of Neptune at Paestum, and the “New York Exchange”; construction models included a roof truss and twenty models demonstrating stonecutting.  

During the last decades of his career, Mahan continued to refine and augment his lessons in architecture. In the 1850s and 1860s he increased class time devoted to architecture, and in 1857 wrote that the course was being reformed so that architecture could be “taught in a rather more practical manner,” making use of “finely illustrated examples from our recently erected public buildings built by the engineer corps, which have the merit of being constructed on modern principles and with the latest improvements.” Throughout, architecture remained an essential component of the engineer’s education.

Mahan’s Theory of Architecture

Mahan taught that architecture “is the art which embraces the design and erection of all structures destined for the use of man” and divided it into three classes: civil, military, and naval architecture. This seemingly simple statement at the opening of Note on Architecture classified all structures, including fortifications, roads, canals, bridges, and buildings, as architecture with common principles in both design and construction. And it defined architecture as a practical art, not imaginative like painting or sculpture, involving more than mere construction or utilitarian fulfillment of need. For Mahan, architecture as useful construction relied on science and reason to be functional and solid. But as an art, architecture was required to have legible character suitable to its location, use, and place in society.

Mahan’s theory and curriculum in architecture were unique in nineteenth-century America. Guided by principles of utility and economy from Durand, his course included a thorough, rational understanding of materials and construction drawn largely from Rondelet and a theory of character applicable to all structures taken from Quatremer de Quincy. Function, structure, and character were united and made evident in the composition of a building, which he taught as a simple system or method adapted from Durand that could be easily remembered by cadets for application to civil architecture of all types.

Like Crozet and Douglass before him, Mahan was a rationalist: he believed that architectural form was essentially structural, however refined and adorned. The organization of his course, which followed Rondelet’s Traité and shared its emphasis on the “material circumstances of construction,” reveals the primacy of structure in Mahan’s theory. After beginning with the properties of wood, stone, brick, concrete, and cast iron, empirical test results and algebraic expression of the strength of materials were introduced. Construction techniques applicable to many types of structures were then taught, such as the design of simple structures for firm soils or grillage foundations where great strength alone is required. Throughout, Mahan emphasized economy in the rational use of materials. Expensive cut stone masonry, for example, was to be “restricted to those works where a certain architectural effect is to be produced by the regularity of the masses, or where great strength is indispensable.” Only after attaining a thorough understanding of materials and construction developed through scientific analysis, mathematics, and descriptive geometry did cadets begin their study of canals, bridges, and buildings according to the same analytical approach.

In Mahan’s rational theory of architecture, the most important elements of buildings were those that comprised the structure, not walls but the “isolated supports, as columns, pillars, and pilasters.” Fundamentally structural rather than symbolic, these “constituent and essential parts of an edifice” were to be used only where required, their size “immediately derived from the functions which they perform.” In “buildings of an ordinary character where great strength alone is required,” he believed, unadorned square piers should be used, with round columns reserved for use only where “a certain architectural effect is to be produced.” Distinguishing between isolated structural supports and decorative columns, Mahan showed little interest in proportional rules for the orders, writing that archaeological evidence had demonstrated “no invariable rule was followed in arranging either the forms or the dimensions of the different orders.” Nor did he follow architectural conventions for determining intercolumniation or the size of an entablature, teaching that all measure and proportion derived from structure or function, not from convention or imitation of an ideal.

Unlike Rondelet and Durand, Mahan did not see walls as essential tectonic elements but, like roofs and vaults, as parts to “cover and protect the interior,” a utilitarian view that extended to virtually all building elements. The cornice, for example, served to cover and protect the building from rain, whereas moldings were useful according to their function as “covering, supporting, binding, and contrasting” elements. Pilasters were not applied decoration but structural reinforcement of walls at angles, corners, or...
“points of junctions of the partition walls”; with horizontal stringcourses and cornices, they “perform functions similar to the corresponding members of the order,” together forming “vertical and horizontal chains . . ., firmly uniting all the parts of the edifice.”113 Windows, doors, and flues were elements “destined to light and ventilate the interior,” their “distribution” in the building “arranged with a regard to healthiness, a good light, and the preservation of objects within.”114 All parts of a building were either structural or functional, the latter arranged according to use or simple, practical rules of measure, proportion, and placement.

In his teaching, Mahan agreed with Rondelet that “the essential goal of architecture, before everything, is to construct solid buildings and in them to use an appropriate quantity of material, chosen and placed in the work with art and economy.”115 But his was not an aesthetic of mere functionality or structural efficiency, for Mahan believed that civil architecture—which included sacred, monumental, municipal, and domestic—should be also classical in decoration. Like Rondelet and Durand, Mahan found the orders useful for their retained conventional symbolism, different from each other not by structural capacity but in the character of their decoration. The use of a particular order, he felt, “should correspond with the character of the edifice, being heavy or light according as the edifice is of a severe, or an elegant cast.”116 It is this belief that “every edifice should have a distinct character appropriate to its destination” that distinguishes Mahan’s theory of architecture from that of both Durand and Rondelet.117

Character, for Mahan, was of three types applicable to all kinds of structures: “general character,” “the character of style,” and “the character of ornaments.” In bridges, for example, “general character” is expressive of the essential nature “to bear heavy loads” of traffic on the deck above and “to withstand severe shocks” of nature below: a bridge should therefore be massive and express strength; it “should not only be solid, but should appear so.”117 “Character of style” should reflect the locale of the bridge—rustic where appropriate, ornate in cities or near “buildings of a sumptuous character.” The “character of ornaments” should be suitable for their purpose and reflective of the bridge’s general character. “Some modern bridges,” he noted as an example, had small columns and entablatures above the starlings, a feature that served no purpose, destroyed the overall massive character of the bridge, and detracted from legibility, all principles Mahan found essential.118

Mahan’s theory of character derived from Quatremère de Quincy’s extensive article “Caractère” in the first volume of Encyclopédie Méthodique. Architecture, which he knew from the Military Academy library.119 Unlike Quatremère, however, whose well-developed theory distinguished between physical or visible character and moral or intellectual character, each of which was then further subdivided into essential character, distinctive character, and relative character, Mahan concentrated on physical characteristics.120 Also unlike Quatremère, who found essential character to be unchanging and related to the theory of type in its reflection of the origin and ideals of architecture, Mahan found the essential character of a structure in its use and construction, not in its origins, to which he gave no place in his teaching.121 Just as he had condensed the principles of Rondelet and Durand, so Mahan took from Quatremère only that necessary to quickly teach engineers the importance of communicative architectural symbolism.

Mahan believed it important that every structure have and express “a distinct character appropriate to its destination” and that “the utility and suitableness of each object should be obvious.”122 “Suitableness” governed the general principles of architecture and could be general—appropriate to all buildings—or particular—dependent on the specific nature and object of the building. General suitableness embraced solidity, which “should be not only real but apparent,” economy, which requires “judicious frugality in the materials,” and regularity. From these “three elements of suitableness” came the principles of simplicity, symmetry, correspondence of parts, and harmony of proportions. Particular rules of suitableness require that every building have a distinct character in accordance with its use, be “subordinate to the locality which it is to occupy,” and respond to immediate physical circumstances.123

Mahan’s emphases on character and suitableness—his translation of the French term convenance—highlight his indebtedness to contemporary French architectural theory where convenance was generally accepted to mean the agreement between a building and its purpose.124 Mahan shared Durand’s view that convenance was attained when a building was solid, salubrious, and commodious, a definition that aligned Durand more with contemporary engineers than with architects.125 Mahan also agreed with Rondelet that a building should express its sound construction—a point slighted by Durand—and with Quatremère that it should express its character through conventionally understood forms and decoration. For Mahan, architectural form was not an academic, constructional, or geometric ideal. It was an expression of function, structure, and context.

At the end of Note on Architecture, Mahan developed a method of architectural composition beginning with “general principles of composition or design in architecture.”126 Like Durand, Mahan taught that buildings should be symmetrical, regular, and simple, explaining that the parts of a
building should suit their function and be subordinate to the whole, that nothing superfluous should be added, and that “the utility and suitableness of each object should be obvious.”  

Necessary rooms of a building were first to be arranged in section and plan, depending “upon the destination of the edifice and its locality,” followed, once the volume of the building was established, by the “parts common to each area,” such as walls and stairs. Just as Mahan’s curriculum followed from materials through construction to application, so the precise breadth, depth, and form of the building were to follow from the spans of its selected structural system. The designer was then, wrote Mahan, able to “judge the effect arising from the distribution of the principal masses” and design the facade, which derived “naturally from the general distribution of the parts of an edifice, and in all cases [was] subordinate to it.”

The first phase of the composition process was rendered in a sketch “without any regard to proportions,” followed by “rough drafts” of the plan, section, and elevations drawn to scale with “the dimensions of the parts being accurately expressed in numbers placed on the drawing.” The unit of measure used for the drawing (and the building) was the “interaxis,” or distance between centerlines of the detached supports or columns, which when subdivided resulted in “a collection of squares.” Derived from the building’s structural system, this grid established the overall plan and proportions of the building; it determined the location of pilasters, stringcourses, and cornices on the elevation and, together with bisecting “semi interaxes,” was used to regulate the placement of “doors, windows, columns, pilasters, etc.” More practically, it also organized plan, section, and elevation drawings vertically on the drafting board.

In the first edition of Note on Architecture (1834), Mahan illustrated the “object and advantages of this arrangement” with the plan, section, and elevation of a two-story building around an interior courtyard (Figure 13). Like the compositional system itself, the building derived from Durand’s Partie Graphique des Cours d’Architecture where it was one of the simplest buildings illustrated. Mahan edited Durand’s design by deleting sculpture in the niches of the front and courtyard elevations, dropping one of the two corner stairs, and rendering only half of the building’s plan. Yet at the same time he enhanced the plate’s pedagogical value through addition of the structural grid, lines that are also found lightly penciled onto half of Durand’s plan in the Military Academy’s copy of the Partie Graphique (Figure 14).

The culmination of Mahan’s architectural lessons, this compositional system derived the form of a building from its use and “all the conditions of suitableness,” rationalized according to its structural system. Like Durand, Mahan united the plan and elevation with a grid that fixed the location of all elements of the building, but he did not adopt Durand’s compositional system without significant modification. Where Durand began with an abstract geometrical grid that organized serial composition of conventionally accepted elements, Mahan began with the function and form of a building and only then generated a compositional grid from its structural system. Where Durand first composed a “horizontal combination”—the plan—which then gave rise to a near infinite number of “vertical combinations,” or elevations, Mahan advocated three-dimensional composition of the building according to its function and location. And where Durand used the grid to organize spaces, with principal axes corresponding to the centerlines of rooms, Mahan used the grid to organize the building’s plan, section, and elevation according to its structural frame. Both taught a simple compositional system for engineers with little time to study and master architecture. Mahan’s theory, however, did not rely on extensive knowledge of preexistent building types or elements; it was one that could easily be committed to memory, transmitted orally, and applied widely.

Despite an emphasis on function and structure as primary determinants of form, Mahan’s theory and compositional system did not fully align the art of architecture with the science of construction, for expression of character was equally important. Where general character as the legible expression of function was inherent in the structure, character of style and character of ornament relied on the addition of decoration and detail. For Mahan, such decoration was predominantly classical, culturally determined and applied according to economy and context. But increasingly as the nineteenth century progressed, engineers who adopted Mahan’s theory and system saw such applied ornament as optional and omitted it, resulting in an engineer’s aesthetic both condemned and heralded for its functional honesty and structural efficiency.

Mahan’s lessons in composition were unique in nineteenth-century America and anticipated the central role of composition in later architectural education. Contemporary pattern books focused on rules of thumb and decorative patterns that could be copied, while courses and lecture series for housewrights and architectural apprentices focused on history, proportion, drawing, and proper details, but almost never on building composition. Thomas Ustick Walter, for example, promised discussion of composition in his 1840 lecture series at Philadelphia’s Franklin Institute. Although his sixth lecture covered “principles in the composition of beauty,” such as unity of design, contri-
Figure 13  Mahan, *Note on Architecture*, plate 9

Figure 14  Jean-Nicolas-Louis Durand, “Applications de la 1er des Formules Précédentes” showing pencil grid lines on plan, from *Partie Graphique des Cours d’Architecture* (1821), plate 20. Copy in United States Military Academy Library.
guity, variety, symmetry, and regularity, Walter did not unite these principles with tectonics or teach a system of architectural composition as did Mahan. By the end of the nineteenth century, Americans were increasingly interested in architectural composition, studying it almost exclusively while attending the Ecole des Beaux-Arts in Paris or from French expatriates teaching in then-new American schools of architecture. Unlike Mahan’s structurally derived compositional grid, this system emphasized knowledge of building types as precedents and composition along formal axes that united external volumes and internal spaces largely along networks of circulation according to classical aesthetic principles.

Use of Mahan’s compositional system by Academy graduates is difficult to detect: abstract, theoretical, and applicable to structures of all types, it can appear simply as rational design. Its influence can be found, however, in work of the Secretary of Treasury Supervising Architect’s Office, established in 1852 to design buildings and oversee construction in areas throughout the United States where architects were scarce. Although New England architect and engineer Ammi B. Young led design in the office, buildings produced reveal the influence of Captain Alexander Hamilton Bowman, who supervised Young’s work. Bowman graduated from the Academy in 1825 and returned there in 1851–52 as instructor of military engineering under Mahan, a position in which he would have learned—and possibly taught—Mahan’s rational theory and method. Under Young and Bowman, the Treasury Department’s Italianate-style buildings were organized according to a structural grid that allowed modification to a particular site through subtraction or addition of structural or window bays. This grid also allowed for efficient construction and the economical use of premanufactured materials in standardized sizes, such as cast-iron columns and beams. Young’s Federal buildings were not representatives of a pattern adapted to a particular community but rather products of a rational design method that allowed them to be easily modified to suit changes in size and function. Modest in form, economical to build, and employing the latest in advanced materials and fireproof construction techniques, yet with dignified character befitting Federal presence in a small community, these buildings exemplified the architectural principles of Mahan’s course at West Point.

Mahan’s Influence

The influence and impact of Mahan’s course in architecture is not yet fully known and can at present only be suggested. Between 1830 and 1871—the years he taught at West Point—1,781 men graduated from the Academy. Over 20 percent became engineers, and many of them were involved in the design or construction of buildings. Outstanding graduates of the Academy were annually appointed to the U.S. Army Corps of Engineers, which was charged with the design and construction of “public buildings, roads, bridges, canals, and all such works of a civil nature.” Following the Army Reorganization Act of 1838, the Corps of Topographical Engineers was made responsible for all government civil engineering work and most construction by the military and the Treasury Department, including lighthouses, marine hospitals, customs houses, and army buildings throughout the country. The Corps of Engineers was left to concentrate on fortifications.

While a few Academy graduates were responsible for the design of buildings, many more supervised construction, often making design adjustments as they adapted standard plans to context, available materials, and local construction skills. In Washington, Andrew Humphreys (class of 1831) worked with Robert Mills on construction of the War Department Building and collaborated with William Strickland on the House of Representatives, in the process improving acoustics in the hall. Long before designing the Pension Building, Montgomery Meigs (class of 1836) supervised construction of Walter’s additions to the Treasury, Patent Office, and Post Office, working side by side with Mills. He went on to oversee construction of Walters’s design for the U.S. Capitol, making changes to material selections for better fireproofing, lighting, and ventilation, devising the construction system for the cast-iron supported dome, and hiring European craftsmen for decoration. Meigs was succeeded as engineer in charge of the Capitol by William Franklin (class of 1843). After the Civil War, Nathaniel Michler (class of 1848) was responsible for public buildings and grounds in Washington, recommending locations for new parks and a new White House. He was followed in this position by Orville Babcock (class of 1861), who, among other duties, superintended construction of the State, War, and Navy Building, and Thomas Casey (class of 1852), who completed construction of the State, War and Navy Building, the Washington Monument, and the Library of Congress.

Numerous graduates supervised construction of Treasury Department buildings throughout the United States and were praised for their work by Secretary James Guthrie, who found them to be well acquainted “with the principles of construction, quality of materials, and prices” and “to be a good judge of work and have had experience in the management of laborers and in the construction of public works.” These men brought to their tasks the principles
of economy, utility, and rational structural design—all of which were highly valued—and an understanding of design and appropriate character that allowed them to effectively work with architects and translate drawings into buildings.

Like Meigs, other graduates of Mahan's program became “architects,” responsible for a building’s design. Barton Alexander (class of 1842) designed the Washington Old Soldiers' Home (1851–57) and reconstructed the central block of the Smithsonian (1853–55), guided by principles of safety, solidity, and economy. Ornamentation was simple but enough, he explained, “to enable the building to do its duty with grace and dignity.” After taking command of the Rock Island Arsenal in 1865, Thomas Rodman (class of 1841) designed ten multistory fireproof buildings with uniform stone facades that lined both sides of a main avenue. Still others designed lighthouses up and down the Eastern seaboard.

Many graduates of Mahan's course became Army officers and were frequently responsible for the design and construction of military posts during America’s westward expansion. Talbot Hamlin wrote in Greek Revival Architecture that these military buildings were “of excellent proportion, good examples of a much simplified development of a type.” More recently, Alison Hoagland has published significant work on the rationalization and standardization of Army construction, much of it led by Academy graduates.

One of the earliest such attempts, though not adopted, was the set of standard plans and specifications prepared in 1859 by Don Carlos Buell (class of 1841) for fourteen different building types. While quartermaster of the Army during the Civil War, Meigs was more successful than Buell, publishing widely used model plans in 1872. Like those prepared for buildings in the Treasury Department, Meigs's model plans were not intended as patterns to be invariably copied but rather as economical, rational designs to be adapted by educated officers according to local situation, climate, and availability of material. In 1882, Meigs was succeeded as quartermaster by Samuel Holabird (class of 1849), who rejected outright the idea of patterns for Army buildings, believing instead that “each plan must grow out of the necessities of the case and thus be perfectly adapted to its surroundings.” It is likely that Holabird felt standard plans published by a highly regimented and disciplined organization like the Army would be unquestioningly copied without adaptation to local circumstance.

The concentration of graduating engineers was highest in the years from 1821 to 1850 when well over one quarter of the graduates went on to serve the nation’s railroads, canal companies, and other enterprises. Among the most prominent of these civilian engineers was William Sooy Smith (class of 1853), who worked on many Chicago building projects as structural engineer or consulting soils and foundation expert. At the Military Academy, Smith would have studied engineering from the sixth edition of Mahan's Elementary Course of Civil Engineering, which covered several types of foundations, including grillage, cofferdams, and caissons.

Almost 10 percent of the three thousand men who graduated from the Military Academy between 1802 and 1903 became professors, teachers, or other academics, many of them in engineering schools. The need for trained architects and engineers to oversee improvement of the nation's infrastructure led to the establishment of numerous civilian schools of engineering where there was often no divide between architecture and engineering. A number of these nineteenth-century schools modeled their curricula at least in part on that of the Military Academy, including the Rensselaer Institute, Union College, the Sheffield Scientific School at Yale University, the Lawrence Scientific School at Harvard University, and the Chandler Scientific School at Dartmouth College.

Soon after its founding in 1824, the Rensselaer Institute offered engineering courses, including architecture, based on the Academy's curriculum. These were taught by Amos Eaton, who had lectured on botany at West Point from April to June of 1822 alongside Crozier. At the end of Eaton's course in 1835, students were tested on twenty-three qualifications, the twenty-second of which stated that "he must be so far versed in architecture as to be enabled to direct the construction of bridges and other works of engineering, in a comely style." That year, four graduates were awarded the degree of “Civil Engineer,” the first such degree in any English speaking college or university. Following Eaton's death in 1842, the engineering course continued under B. Franklin Greene, using Mahan's Elementary Course of Civil Engineering as its primary text.

In 1852, Yale established a School of Engineering that became one of the core departments in its Sheffield Scientific School, naming William Augustus Norton to lead the program. Norton, who taught engineering at the Academy under Mahan following graduation in 1831 and then established Brown University's engineering program, modeled his Yale curriculum after that of the Academy. His course included subjects such as “The Principles of Architecture” and “The Science of Construction in all its departments; with a discussion of the nature, strength, and mode of preparation of building materials.” In February 1847, Harvard established “an advanced school of instruction in theoretical and practical science, and in the other usual branches of academic learning.”
which it named the Lawrence Scientific School that June.\textsuperscript{175} Henry Lawrence Eustis, an 1842 graduate of the Military Academy, was appointed professor of civil engineering in 1849, organizing the engineering program and teaching there until his death in 1885.\textsuperscript{176} He was succeeded by Winfield S. Chaplin, an 1870 Academy graduate who remained at Harvard until 1891.\textsuperscript{177} Although few details are known of Eustis’s course, it is probable he followed the teaching of Mahan, for whom he had served as assistant professor after graduation.\textsuperscript{178} The 1850–51 catalog for the Lawrence Scientific School lists engineering courses in “the nature and properties of building materials and their applications to the construction of railroads, canals, bridges, etc.,” and a course in descriptive geometry with “its application to masonry and stone-cutting, the construction of arches, etc.”\textsuperscript{179} Until a program dedicated to architecture was established in 1894, all architectural education at Harvard’s Lawrence Scientific School was taught in Eustis’s or Chaplin’s engineering courses, which focused on materials and construction and trained virtually all of Boston’s leading architects.\textsuperscript{180} Among Eustis’s students who went on to notable architectural careers were William Robert Ware, William Le Baron Jenny, and Charles Follen McKim.\textsuperscript{181}

In 1852, three years after Eustis began teaching at Harvard and the same year that Yale began its School of Engineering, Dartmouth established the Chandler School of Science and the Arts.\textsuperscript{182} In 1867, Dartmouth received a substantial gift from Thayer, a Dartmouth graduate and West Point’s influential former superintendent, to establish a School of Architecture and Civil Engineering.\textsuperscript{183} The school opened in 1871 under the direction of Robert Fletcher, an 1868 Academy graduate, assisted after 1873 by Arthur Sherburne Hardy, an 1869 Academy graduate;\textsuperscript{184} among members of the Board of Overseers of the School was Dennis Hart Mahan.\textsuperscript{185} Using Mahan’s \textit{Elementary Course of Civil Engineering} as its primary textbook, the course at Dartmouth focused on “Civil Engineering and two Auxiliary Subjects,” one of which was “General principles of architecture; rules applying to the erection of buildings generally.”\textsuperscript{186}

As collegiate engineering education grew more widespread, Mahan remained in contact with his former students, periodically visiting them to inspect model collections, teaching methods, and curricula. During one such tour of Rensselaer, Dartmouth, Sheffield, and Lawrence he wrote, “their programs of studies compare, for the most part, [with] what is taught in the Academy.”\textsuperscript{187} By 1866, the year Ware published his plans for architectural instruction at MIT, Rensselaer, Union College, Sheffield, and Lawrence had graduated a total of 241 men from their engineering programs, many of whom became architects.\textsuperscript{188} In fact, 13 percent of the men who were members of the American Institute of Architects in 1870—the elite of the profession at that time—had studied in engineering schools; twenty years later, 10 percent of the members had received such training.\textsuperscript{189}

Following Mahan’s death in 1871, engineering education at the Academy declined. The course was taught by Junius Brutus Wheeler, an 1855 graduate who adopted Mahan’s curriculum and text books but reportedly turned away from Mahan’s emphasis on practical instruction toward theory.\textsuperscript{190} As West Point became increasingly defensive and introspective during the last decades of the century, its engineering program lost touch with rapid scientific and technological change and ceded preeminence in science and engineering to the growing number of civilian schools and universities.\textsuperscript{191}

Conclusion

Nineteenth-century American engineers played a significant role in the design and construction of buildings, for which many were well trained in the nation’s first engineering school at the United States Military Academy. Like numerous engineering programs that followed, the curriculum was comprehensive and included instruction in architecture that emphasized rational structure, economy, efficiency, and appropriate character. Building on the course of Douglass, his instructor at West Point, Mahan for forty years taught a rational theory of architecture based on contemporary French architectural sources. The books he wrote were America’s first architectural textbooks from perhaps America’s first architectural theorist.

Mahan’s teaching was widely disseminated in nineteenth-century America by graduates practicing engineering and architecture during a period of great national expansion and by students who founded and taught at other engineering schools. Combining structural rationalism and the expression of function with a system of composition, Mahan’s simple yet comprehensive architectural theory guided the creation of buildings of all types, shaping formation of the American engineer’s aesthetic.

Notes

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9. The 16 Mar. 1802 act emphasized engineering and placed the school under control of the Corps of Engineers. Many historians see Jefferson’s act as part of a larger campaign to advance internal improvements, while others believe he founded the Academy to promote Republican values in a military dominated by Federalists. For the former, see Peter Michael Malloy, “Technical Education and the Young Republic: West Point as America’s École Polytechnique, 1802–1813” (PhD diss., Brown University, 1975). For the latter, see Theodore Crackel, “The Founding of West Point: Jefferson and the Politics of Security,” Armed Forces and Society 7, no. 4 (Summer 1981), 529–43; and Crackel, West Point: A Bicentennial History (Lawrence, Kans., 2002).

10. Writing to Peter Carr on 7 Sept. 1814, Jefferson proposed three levels of architectural education at the University of Virginia: civil architecture taught as a fine art, military architecture, and the basics of architecture taught to mechanics. Sunday Documents on the Subject of a System of Public Education for the State of Virginia (Richmond, 1817), 12–18. When the University was established in 1818, however, the only architectural education was provided by the professor of mathematics, as Jefferson and others considered fine arts instruction a luxury. Acts Passed at a General Assembly of the Commonwealth of Virginia (Richmond, 1818), 11–15. Throughout the 1820s, Jefferson persisted with efforts to introduce more extensive instruction of “military and civil architecture” into the mathematics curriculum as instruction in the fine arts had yet to be established. See Thomas Jefferson to president and director of the Literary Fund, 5 Oct. 1824, in Early History of the University of Virginia as Contained in the Letters of Thomas Jefferson and Joseph C. Cabell (Richmond, 1856), 479–82.


16. Centennial of the United States Military Academy, 62. William’s 1808 plan to reorganize the Academy into a national school of engineering named Latrobe professor of civil and military architecture, accepting Latrobe’s offer in his letter to Williams of 28 Dec. 1807. Van Horne, Correspondence and Papers of Latrobe, 2:512–13; and Jennings Wagoner Jr. and Christine Coalwell McDonald, “Mr. Jefferson’s Academy,” in McDonald, Thomas Jefferson’s Military Academy, 142–44.


19. George W. Cullum, Biographical Register of the Officers and Graduates of
22. Thayer to Joseph Swift, 12 Aug. 1816, Thayer Papers, 2:78 (see n. 14); James McRee to Swift, 14 Sept. 1816, Thayer Papers, 2:85; and Thayer to Swift, 12 Feb. 1817, Thayer Papers, 2:115.
24. Crackle, West Point, 75 (see n. 9).
25. “Programme de Claude Crozet,” 18 Sept. 1816, Record Group 77, Records of the Chief Engineers, Entry 20, Letters and Papers Received (Irregular Series), 1789–1831, NARA.
26. Hunter and Doody, Claudius Crozet, 17; and Claudius Crozet, Treatise on Descriptive Geometry (New York, 1821).
27. Sidney Forman, West Point (New York, 1950), 57; and Fox, “Les regards étrangers sur l'École Polytechnique,” 65 (see n. 6).
28. Hannibal Day, West Point drawing notebook, 1823, Special Collections and Archives, United States Military Academy Library (hereafter USMA Library), West Point, N.Y. Day’s drawing notebook is 15.5 inches high and 19 inches wide with ink drawings on the recto of each sheet. Day’s parallel of the orders agrees in linework, text, and arrangement with Durand’s parallel in Précis des Leçons, 1:4, held in the Special Collections and Archives, USMA Library.
29. The Apr. 1819 Report of the Board of Visitors to the Academy, for example, found that “the practical application [of the Course of Instruction] in the department of Engineering is not sufficiently attended to.” Annual Report of the Board of Visitors to the United States Military Academy Made to Congress and the Secretary of War for the Year 1819 (West Point, 1894), 6.
30. Hunter and Doody, Claudius Crozet, 23–24; and Daniel Parker to Thayer, 23 Sept. 1819, Thayer Papers, 3:97.
32. Crackle, West Point, 96–97.
34. Crackle, West Point, 98; and Stephen Ambrose, Duty, Honor, Country (Baltimore, 1966), 99.
35. Davies graduated from the Academy in 1815 and was professor of mathematics from 1823 through 1837; his Treatise on Shades and Shadows (1832) remained a textbook until 1865. Edward Holden, “Tentative List of Textbooks,” in Centennial of the United States Military Academy, 450 (see n. 7). The book saw numerous editions and was used widely, including by Richard Upjohn to teach young drafters in his office. Judith Hull, “The School of Upjohn: Richard Upjohn’s Office,” JSAH 52, no. 3 (Sept. 1993), 297.
36. Regulations of the United States Military Academy at West Point (New York, 1823), 11.
38. The four-page undated manuscript is held in the Douglass-Hale Papers in the Warren Hunting Smith Library at Hobart and William Smith Colleges, Geneva, N.Y. I thank Linda Clark Benedict, archivist, for providing me with copies. Although it is possible the “Description of the Course” dates from Douglass’s tenure as professor of civil engineering and architecture at New York University (NYU; 1816–17), it is more likely his course at NYU, which was brief and constantly interrupted by duties designing the university’s Washington Square building, followed the course he developed during his seven-year West Point tenure.
40. Cohen, “Building a Discipline,” 143–45 (see n. 2).
41. “List of Model Specimens on Hand in the Engineering Department, U.S. Military Academy,” undated, File Misc. 4, Douglass-Hale Papers. Adjacent to items on this list are fifteen notes “ord.” and 11 “x” marks, which correspond with models later listed in Academy inventories. Although some of the Academy’s models were made at West Point (Alexander Macomb to Thayer, 7 Jul. 1824, Thayer Papers, 4:19 [see n. 14]) or obtained from England (Thayer to Thomas Aspinwall, 27 Oct. 1828, Thayer Papers, 4:149; Aspinwall to Martin Van Buren, 13 Mar. 1830, Thayer Papers, 5:19), most were made in Paris (Nathaniel Niles to Thayer, 30 Oct. 1828, Thayer Papers, 4:152.)
42. Douglass, handwritten note, File Misc. 4, Douglass-Hale Papers.
44. Douglass, File Misc. 4, Douglass-Hale Papers.
45. Smith checked out Rondelet on 18 Jan., 29 Jan., and 8 Feb. 1825; Greene on 9 Nov. 1824. “Circulation Records.”
47. I have been unable to locate the source of this quotation, which may have come from one of Rondelet’s 129 articles on construction in the first two volumes of Quatremère de Quincy’s Encyclopédie Méthodique: Architecture (Paris, 1788). On Rondelet’s articles, see Middleton and Baudouin-Matuszek, Jean Rondelet, 199–207.


52. Sara E. Wermiel, Army Engineers Contributions to the Development of Iron Construction in the Nineteenth Century (Kansas City, 2002), 32.


56. Forman, West Point, 87 (see n. 27).

57. Griess, “Dennis Hart Mahan,” 24 (see n. 17).

58. “Circulation Records” (see n. 37); and Griess, “Dennis Hart Mahan,” 118–19.

59. Captain John L. Smith to Dennis Hart Mahan, 6 Jul. 1826, NARA (see n. 21); transcript in Mahan Papers, CU361, Special Collections and Archives, USMA Library (see n. 28).

60. Rondelet used Sainte-Geneviève, whose construction he saw to completion after Soufflot's death, as an example throughout his Traité. Rondelet, Traité, (bk. 9), pl. 196–98 (see n. 21). The Halle au Blé is illustrated in Rondelet, Traité, (bk. 7), pl. 163–64. In his Elementary Course of Civil Engineering (New York, 1837), Mahan criticized the level deck bridge (150), an obvious reference to Perronet's work. On European criticism of Perronet, see Antoine Picon, French Architects and Engineers in the Age of Enlightenment, trans. Martin Thom (New York, 1992), 160–84.


62. Originals are held in the NARA; transcripts are held in the Mahan Papers.

63. Antoine Picon, L'invention de l'Ingénieur Moderne. L'École des Ponts et Chaussées 1747–1851 (Paris, 1992), 317. In a letter dated 6 Nov. 1828, James Brown, American minister to France, wrote to Henry Clay, secretary of state, that Mahan had spent time “under the direction of M. de Becquey, Director of the Ponts et Chaussées et des Mines.” NARA, transcript in Mahan Papers.

64. Mahan to James Barbour, 27 Mar. 1828, NARA, transcript in Mahan Papers.

65. Alexander Macomb to Mahan, 21 May 1828, NARA, transcript in Mahan Papers.

66. Frederick Artz, The Development of Technical Education in France (Cambridge, Mass., 1966), 170; and Griess, “Dennis Hart Mahan,” 128–31. On the lithographed textbooks of Metz, see Michael Twyman, Early Lithographed Books (London, 1990), 66–75, 323–27. Several bound volumes of lithographed textbooks from Metz dating to the 1820s and believed to have been owned by Mahan are held in Special Collections and Archives, USMA Library.


68. Griess, “Dennis Hart Mahan,” 172; and James L. Morrison, “The Best School in the World”: West Point, the Pre-Civil War Years, 1833–1866 (Kent, Ohio, 1986), 94.

69. Cracket, West Point, 107–8 (see n. 9); and Rod Miller, West Point: U.S. Military Academy (New York, 2002), 103–5.


72. Dennis Hart Mahan, Supplements to Sganzin (West Point, ca.1831), Special Collections and Archives, USMA Library; and Griess, “Dennis Hart Mahan,” 133, 198, 201.

73. Dennis Hart Mahan, Architecture (West Point, ca.1831). Architecture is similar to Mahan's Supplements to Sganzin in handwriting, letter density, and paper, suggesting that they were both lithographed around 1831. The only copy of Architecture that I have located is in the Special Collections and Archives, USMA Library. It was lithographed at the Military Academy on five sheets of untrimmed paper (each 13.625 inches by 16.5 inches) that were folded and top sewn in three places. There is no cover, listing of author, or date on the cover of Note on the Construction of Floors, also in the Special Collections and Archives, USMA Library. Mahan's books are not included in Henry-Russell Hitchcock, American Architectural Books, exp. ed. (New York, 1976).

74. Mahan, Architecture, 4, 7. His description of Gothic bears striking resemblance to Elmes's Lectures on Architecture, 373–75 (see n. 39). “Circulation Records” (see n. 37) indicate Mahan checked Elmes's Lectures out of the Academy library on 8 Feb. 1831, a mere two weeks after he had checked out Durand's Précis des Leçons et Partie Graphique.

75. Concerned more with practical and technical details than theoretical precepts or visual effects, Rondelet's appreciation of Gothic was much less nuanced than that of Soufflot, despite Rondelet's acknowledgement in his 1780 Mémoire that Soufflot's aim at Sainte-Geneviève was “to unite in one of the most beautiful forms the lightness of Gothic construction with the purity and magnificence of Greek architecture.” See Middleton and Baudouin-Matuszek, Jean Rondelet, 71, 202–3, 210 (see n. 46).

76. Mahan, Architecture, 7, emphasis in original.

77. Ibid., 8; and Durand, Précis de les Lectures, 88 (see n. 37).

78. Mahan to Thayer, 3 Nov. 1833, Thayer Papers, 5:113–14 (see n. 14). Dennis Hart Mahan, Note on the Construction of Floors, 1–4; Note on the Construction of Roofs, 5–9; Note on the Construction of Paritions, 10–11; Notes on Joints and Straps, 11–19; [gap in pagination]; Note on Centres for Large Arches, 35–40; Note on Wooden Bridges, 40–45 (West Point, c. 1831). In bound lithographed textbook signed and dated “John Macomb, May 1832.” Special Collections and Archives, USMA Library.

79. Mahan, preface to Elementary Course of Civil Engineering (1837), iv (see n. 60); and Mahan to Captain Brewerton, 4 Aug. 1849, Mahan Papers (see n. 59).


Second edition: *Notes on Architecture* (West Point, ca.1838), 16 pp., 8 pls. Copies in the Special Collections and Archives, USMA Library (bound with other texts under title *Notes on Engineering*); Gilder Lehrman Collection, New York (copy of Henry Hallack, USMA 1839); and Avery Library, Columbia University. The second edition differs from the first in minor textual emendations and the omission of the ninth plate.

Third edition: *Notes on Architecture* (West Point, ca.1840), 16 pp., 8 pls. Copies in the Special Collections and Archives, USMA Library; and Brown University Library (copy of Calvin Benjamin, USMA 1842). The third edition differs from the second in minor textual emendations and deletion of the last three paragraphs criticizing the contemporary state of American architecture.

82. Mahan, *Elementary Course of Civil Engineering* (1837). The book saw seven editions in Mahan’s lifetime, selling over 15,000 copies. Edwin Layton, “Mirror-Image Twins: The Communities of Science and Technology in Nineteenth-Century America,” *Technology and Culture* 12 (Oct. 1971), 570. Following Mahan’s death, the book was revised by De Volson Wood and saw three more editions before 1900. The second edition was edited by Peter Barlow and published in Glasgow and Edinburgh (1843, 1845, 1847), and a later edition was translated into Japanese and published in 1890 in Tokyo.

83. This conclusion is based on two sources. On 2 Oct. 1854, Mahan wrote Colonel Robert E. Lee that most of his teaching was from textbooks and the chalkboard. Mahan Papers. The copy of *Notes on Architecture* in the Avery Library, Columbia University, (second edition, ca. 1838) contains penciled notes in the left margin indicating that the historical introduction and approximately one-third of the section on “Elements of Edifices” was covered in the “1st class, 1841” while the rest of “Elements of Edifices,” “General principles of composition or design,” and “Composition or Design” were covered in the “2nd class. 1841.” The ownership of this copy has not been determined.

84. Mahan, *Note on Architecture* (1834),12. Unless noted otherwise, all page references to *Note on Architecture* are to this first edition, and all references to the title of the book are also to the first edition; the title was changed to *Notes on Architecture* in the second and third editions.


87. Durand, *Précis des Leçons*, v. 1, pl. 6 (see n. 21). Comparing *Note on Architecture* with the copy of Durand’s *Précis des Leçons* in the USMA Library Special Collections and Archives reveals that the size and spacing of these line drawings is identical in Durand’s and Mahan’s books.

88. In his taxonomy, Mahan conflated two categories from Durand, “Elements of Buildings” and “Combinations of the Elements.” For Durand, “Elements” included building materials and elements such as walls, detached supports, floors, walls, and roofs, while “Combinations” were parts of buildings like porches, vestibules, stairs, and rooms that were made from the elements and were then composed into buildings. Durand, *Précis des Lectures*, 89ff., 119ff. (see n. 17). From Chambers, Mahan took the rules that the heights of windows may vary from 2/5 to 2/3 of the width of the opening (Mahan, *Note on Architecture*, 9; Chambers, *Treatise on Civil Architecture*, 117), that the ceiling height of a square room should be between 2/5 and 5/6 of its width (Mahan, *Note on Architecture*, 10; Chambers, *Treatise on Civil Architecture*, 131), and that the height of galleries should be 1/5 to 1/2 of the width (Mahan, *Note on Architecture*, 10; Chambers, *Treatise Civil Architecture*, 131).

From Palladio, Mahan took the rules that the width of a window should be 3/4 to 3/5 the width of a room (Mahan, *Note on Architecture*, 9; Palladio, *Four Books on Architecture*, trans. Robert Tavenor and Richard Schofield [Cambridge, Mass., 1997], I:XXV, 60), that the architrave “around” a window should be 1/6 the width of the window (Mahan, *Note on Architecture*, 9; Palladio, *Four Books*, I:XXVI, 61), and that successive stories of a building decrease in height by 1/4, along with the height of the windows (Mahan, *Note on Architecture*, 10; Palladio, *Four Books*, I:XXIII, 58, and I:XXV, 60, respectively).


90. Griess, “Dennis Hart Mahan,” 163 (see n. 17).

91. From 1840 through 1850, the engineering course at West Point consisted of 108 class periods: materials, construction, and civil engineering filled thirty-two periods, stonecutting filled nine, and machines filled twelve periods. Only two periods were dedicated solely to architecture. Twenty-two periods were then devoted to a review of all subjects. Griess, “Dennis Hart Mahan,” 180.

92. Mahan led the seminar for the most advanced group and assistant professors led the other two sections. Griess, “Dennis Hart Mahan,” 185–88.

93. Ibid., 194–95.

94. Cadets had previously studied drawing during the second and third years under Robert Wier. See David M. Reel, “The Drawing Curriculum at the U.S. Military Academy During the 19th Century,” *West Point, Points West* (Denver, 2002), 51–60.


97. Mahan to George Welcker, 6 Aug. 1842; Mahan to Welcker, 19 Aug. 1844; Mahan Papers.


100. “Inventory of Public Property.” Mahan to Delafield, 28 Jun. 1841, Mahan Papers.

101. James St. C. Morton, ed., “Papers Submitted to the Board of Visitors, 1857,” in *Report of the Secretary of War* (Washington, n.d.), 209. In 1844, Mahan proposed to increase class time devoted to architecture from 2 to 8 of the 104 periods, which was not approved by the superintendent. Mahan to Captain Thomas, 14 Dec. 1844, Mahan Papers. Ten years later, when the Academy program was expanded from four to five years, Mahan used...
the additional time to expand his instruction in architecture and civil engineering. Mahan "to USMA Academic Board, 24 Jul. 1854, Mahan Papers. By 1860 the study of architecture had expanded to 6 out of 104 periods, and instruction in architectural drawing, which Mahan found offered in other schools of engineering, increased in the late 1860s. Griess, "Dennis Hart Mahan," 180. I have been unable to locate an exact record of time spent on instruction in architecture after 1860; Mahan's penciled "Programme of the Courses of Civil & Military Engineering" of 1864–65 does not separate the various subjects in the course of civil engineering. Mahan Papers.

102. Mahan, Note on Architecture, 1 (see n. 80).

103. This definition is from Peter Collins, Changing Ideals in Modern Architecture (Montreal, 1965), 198.


105. Although not discussed by Mahan, steel as a structural material was covered in Miner Knowlton's artillery course as early as 1841. Knowlton, Notes on Gunpowder, Percussion Powder, Cannon and Projectiles (West Point, 1841), 33–35.

106. Mahan, Elementary Course of Civil Engineering (1837), 62–63 (see n. 60).

107. Ibid., 53.


109. Ibid. These square piers were not the "attic order" cited by Pliny or by Raphael in his famous letter to Leo X and must therefore be distinguished from "square orders" used by Americans such as Thomas Jefferson in the Monticello dome, Robert Mills at St. Michael's Church, or John Haviland at the Franklin Institute. Mahan here seems to be advocating a utilitarian order.

110. Mahan, Note on Architecture, 3. On p. 13 he also wrote that "the Ancients . . . appear to have had no fixed rules by which the proportions of the parts were determined."

111. Mahan, Note on Architecture, 7. This taxonomy is borrowed from Chambers, Treatise on Civil Architecture, 27–28 (see n. 86).

112. Mahan's terms "horizontal chains" and "vertical chains" are literal translations of Durand's chaînes verticales and chaînes horizontales from the Précis des Leçons, pt. 1, sec. 2, 40–41 (see n. 21), and Partie Graphique, 187 (see n. 37).

113. Mahan, Note on Architecture, 6, 14.

114. Rondelet, introduction to Traité, 1:xxvi (see n. 21).

115. Mahan, Note on Architecture, 2. As an example, he compared the Parthenon with the "hypethral temple of Paestum." "The former," he wrote, "presents an air of lightness and elegance suitable to structures of grave cast." Mahan's lack of interest in architectural origins echoes that of Rondelet; see Middleton and Baudouin-Matuszek, Jean Rondelet, 212 (see n. 46).


117. Ibid., 12–14.

118. Convenance has no exact English equivalent. Robin Middleton consistently translates it as "propriety" while David Britt translates it as "fitness" in Durand, Précis de les Lèctures, 206 n. 11 (see n. 37). See also David Britt, "Translator's Introduction," in Nicolas Le Camus de Mézières, The Genius of Architecture (Santa Monica, 1992), 14; Antoine Picon, "From 'Poetry to Art' to Method," introduction to Durand, Précis de les Lèctures, 32–33; and Werner Sambenheim, Symétrie, Goût, Caractère (Paris, 1986).

119. Durand, Précis de les Lèctures, 84, and Picon, French Architects and Engineers, 112–13 (see n. 60).

120. Mahan, Note on Architecture, 11.

121. Durand, Précis de les Lèctures, 137, and Mahan, Note on Architecture, 12.

122. Mahan, Note on Architecture, 14. On p. 15 he continued: "To determine the interaxis for edifices without columns requires great discrimination on the part of the architect. For this purpose he must consider with attention the position and dimensions of the most important parts, as the piers of arches, the partition walls, the trusses of the roof, the breadth of the windows and their piers, etc., and from these determine the interaxis."

123. Ibid., 10.

124. Ibid., 15. Mahan’s "three classes of drawings"—sketch, rough draft, and finished drawing—correspond with Durand's division of drawing into croquis, sketch, and working drawing. Durand, Précis de les Lèctures, 188.

125. Mahan, Note on Architecture, 15.

126. Ibid., 188, but it may have come as well from Monge's system of descriptive geometry which Mahan used in teaching stonecutting. See Dennis Hart Mahan, Stonecutting, 15 pp., (West Point, 1835), Special Collections and Archives, USMA Library (see n. 28).

127. Later editions of Mahan's Notes on Architecture lack this ninth plate, perhaps because Mahan instead relied on models, large drawings, or chalkboard diagrams to illustrate his lesson on composition.


129. This copy is now held in Special Collections and Archives, USMA Library, with other books purchased in France by Sylvanus Thayer.

130. Durand, Précis de les Lèctures, 120. See also Durand's plate, "Marche à suivre dans la Composition d’un Projet quelconque," Précis des Leçons, pt. II, pl. 21 (see n. 21).

131. Durand, Précis de les Lèctures, 121, 126.
138. Durand, “Marche à suivre dans la Composition d’un Projet quelconque,” *Précis des Leçons.* Durand’s lectures are inconsistent on whether the structural element or the center of the space should be on the grid line. In the first volume, he states that walls, columns, and pilasters should be placed on the axes. Durand, *Précis de Lectures,* 120. This passage is similar to that in Mahan’s *Note on Architecture,* 15. In the *Partie Graphique,* Durand states that walls are to be placed on axial lines set equidistant on either side of the principal axis, which is the center of the space. Durand, *Précis de Lectures,* 188.

139. Durand, *Précis de Lectures,* 73.


141. On Walter’s lectures, see Jennifer Amundson, “Thomas Ustick Walter’s *Lectures on Architecture*” (PhD diss., University of Delaware, 2001); and Amundson, introduction to *Lectures on Architecture,* 1–29 (see n. 39).


145. Lee, *Architects to the Nation,* 3–4, 47–49 (see n. 49).

146. Bowman was “Engineer in Charge” of the department from 1853 through 1861. Lee, *Architects to the Nation,* 42; and Wermiel, *Army Engineers Contributions,* 34–35 (see n. 52).

147. Cracked, *West Point,* 132 (see n. 9); and Callum, *Biographical Register,* 1:271 (see n. 19).


153. Norton was assisted after 1867 by William Petit Trowbridge, an 1849 graduate of the Military Academy. See Winfield Scott New Orleans Customhouse (1848–49), where he was followed by P. G. T. Beauregard (USMA 1838) in 1853 (Lee, *Architects to the Nation,* 41; Karen Kingsley, *Buildings of Louisiana* [New York, 2003], 94); John Kurtz (USMA 1842) at the Federal Building in Backport, Maine (Lee, *Architects to the Nation,* 56); Gustavus Smith (USMA 1842) at the Marine Hospital in New Orleans (1855–56; Wermiel, *Army Engineers Contributions,* 41); and William Franklin (USMA 1843) at the Customhouse and Marine Hospital in Portland, Maine (1855–57; Wermiel, *Army Engineers Contributions,* 41).


156. Ibid., 6–27.


181. Ware studied at Lawrence from 1854 until graduating summa cum laude in 1856. He later established the programs of architecture at MIT and Columbia University. Chewning, “William Robert Ware,” 22–26 (see n. 1). Jenney entered Lawrence in 1851 but left before graduation to continue his studies in Paris at the Ecole Centrale. Theodore Turak, *William LeBaron Jenney* (Ann Arbor, 1986), 16–23. McKim entered Lawrence in 1866 intending to become an engineer but dropped out soon after finding he had little love for mathematics. Leland M. Roth, *McKim Mead & White, Architects* (New York, 1983), 16–17. H. H. Richardson, who applied to West Point but did not attend, may also have attended classes in the Lawrence School while a student at Harvard College. On Richardson’s application to the Academy, see Mariana Griswold Van Rensselaer, *Henry Hobson Richardson and His Works* (New York, 1888), 4; Margaret Henderson Floyd, *Henry Hobson Richardson* (New York, 1997), 18; and James F. O’Gorman, *Living Architecture* (New York, 1997), 39.

182. Quoted in Leon Burr Richardson, *History of Dartmouth College* (Hanover, N.H., 1912), 422.


185. Mahan to Asa Dodge Smith, 5 Dec. 1867, Mahan Papers (see n. 59).

186. Quoted in William Phelps Kimball, *First Hundred Years of the Thayer School of Engineering at Dartmouth College* (Hanover, N.H., 1971), 9, 16.

187. Mahan to General Thomas G. Pitcher, 1 Nov. 1869, Mahan Papers.

188. James Gregory McGivern, *First Hundred Years of Engineering Education in the United States* (Spokane, Wash., 1960), 73; and William Ware, *Outline of a Course of Architectural Instruction* (Boston, 1866).

189. Woods, *From Craft to Profession*, 160 (see n. 2).

190. Ambrose, *Duty, Honor, Country*, 204 (see n. 34).

191. Ibid., 197; and Walter Scott Dillard, “The United States Military Academy, 1866–1900: The Uncertain Years” (PhD diss., University of Washington, 1972).

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