Cutting Up Time:
Craft and Technology in the Niches Project

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In this paper, which will cite as illustrations some of the documents that have resulted in the completion of the Carnegie Mellon University College of Fine Arts Niches, we will discuss the interdependent relationship between craft and technology in architectural computer modeling practice. We will suggest that practical uses of the computer demand the counterbalancing intimacy of craft in the design studio. Our goal in the Niches Project was to couple direct tactile experience, historical knowledge, and the precise operations afforded by computers.

Keywords: trends in practice, CAD, CADCAM, stonecarving, architectural design, technology, craft.

1 Prologue

The first paradox we faced as completion architects of the College of Fine Arts Niches, on the campus of Carnegie Mellon University, was that construction had begun more than seventy years before, predating both world wars, relativity, talking pictures, and TV, by an architect whose training couldn’t have been more different from our own. How could we faithfully “complete” a building according to another architect’s distant intentions while remaining true to our own time? Could the computer help us, or would its presence be anomalous? How architects’ perceptions of craft and technology have changed over the intervening years, from conception to completion, forms the backdrop to our application of contemporary technology to an ancient task: stonecarving in the late 20th century with the aid of computers.

2 History

In 1907, the young New York architect Henry Hornbostel won the competition for the master planning for Andrew Carnegie’s new Carnegie Technical Institute, now Carnegie Mellon University. Trained at the Ecole des Beaux Arts in Paris, his formal, biaxial plan for the campus proposed two perpendicular quadrangles, separated by a ravine and spanned by a bridge. One quadrangle related to Forbes Avenue and the neighboring population, while the other, symbolically thought of as the body of a ship, had at its prow En-
gineering Hall at the edge of Panther Hollow. At the stern of the ship, in opposition to the smoke—belching rotunda of the engineering building, the College of Fine Arts was planned (Figure 1).

After winning the competition, Hornbostel became the first Dean of the College and architect of its building and many others on campus. The master plan inspired the bi-axially classical building plan, steel-framed, brick, and terra-cotta construction, featuring a Great Hall into which all the arts would gather. As both architect and educator, he proposed that the building itself inspire students of all the arts through a fragmentary display of the great works of western civilization (Figure 2). To this day, the ornamental program includes paintings depicting musical scores, great works of painting, antique plaster casts, industrial Pittsburgh scenes, as well as Hornbostel's own Hell Gate Bridge, which spans the Harlem River at the northern tip of Manhattan.

The conceptual center of this composition is an ambitious history of architecture. Five monumental limestone niches form the main facade of the College of Fine Arts Building (Figure 3). Each niche was intended to represent an introduction to the architecture of one of civilization's major eras: Medieval, Greek, Roman, Renaissance, and “Eastern.” Despite physical and temporal remove, they would have provided instructive physical models literally at the doorstep of the young working class American students of the students of the Ecole des Beaux Arts. That is, if they had been completed.

By 1911, the building proper was substantially complete and carving had begun on the stone set into place for the Roman and Renaissance niches. What happened next is the subject of much speculation, but there is little doubt that carving was interrupted shortly before America's entrance into World War I and was not to begin again for over 70 years.

3 Practice

Like great ideas, great buildings remain vital despite the passage of time and changing fashion. Hornbostel's reputation as a practitioner of non-traditional, “free-style” classicism has been growing during the last 20 years. The new East Campus buildings at Carnegie Mellon acknowledge their debt to Hornbostel for the lively, but decorous, architectural patterns which he established for the institution. His works in Pittsburgh, and elsewhere, have begun to receive critical and restorative attention as his eclectic production is reevaluated. For example, Hornbostel's Old Law School Building on the campus of Emory College was recently renovated by architect Michael Graves. Hornbostel's free interpretations of the classical language, the handling of materials, and fine detailing stand out and are increasingly relevant to contemporary architects. In this context, the completion of the College of Fine Arts Building assumes increased importance.

In the spring of 1990, the carving on the niches began anew, thanks to the generosity of Carnegie Tech Alumnus Verner Purnell, who donated the funds needed to complete the project in his parents' memory. Upon the recommendation of architectural historian Richard Cleary, we were commissioned by Dean Lowry Burgess to revive the work which Hornbostel had left unfinished. Although our experience with stone construction was similar to that of most other contemporary architects, limited as it is to veneers of thin uncarved slabs, we have been experimenting in our teaching and practice with hybrid approaches to craft traditions and contemporary technology. With carvers from England, France, South America, and Czechoslovakia, we were invited to focus our thinking on how carved stone can become more efficient and affordable as a building technology in contemporary practice.
Figure 1. Campus Plan Aerial View.
*Carnegie Mellon University Archives*
Figure 2. College of Fine Arts Building, Interior.
Carnegie Mellon University Archives
At first the task seemed fairly straightforward. Guided and inspired by Hornbostel's preliminary sketches which we assumed to be comprehensive, we initially adopted a tentative, deferential stance towards their application. However, we quickly realized that their apparent clarity masked serious inconsistencies. The authenticity of the historical models chosen for representation was often questionable. The correspondence between the design dimensions and the stone itself was inconsistent. Hornbostel's elaborate decorative preferences did not seem to be economically possible, even given Mr. Purnell's generosity. We concluded that realizing Hornbostel's conceptual intentions would involve a more elaborate research and design process than anyone had envisioned. Fulfilling Hornbostel's vision within a contemporary schedule, but without compromising historical accuracy, proportions, and craft, became our goal. At a practical level, we hypothesized that a hybrid design process using conventional tools and computers might expedite document delivery and fabrication without losing the qualities traditional media supply. We speculated that the computer's ability to save, duplicate, refine, measure, arrange, and vary data might also enable us to automate many of the laborious design procedures normally associated with the development of historical architecture.

Although necessarily divergent from Hornbostel's sketches in detail, our revisions approach consistency with his intentions. We have attempted to realize the general scheme in a less decorative, more strictly architectural, manner. Surviving sketches suggest that his niche compositions were conceptually different than his building design overall. In contrast to the classically reductive Great Hall, the Niches were elaborately conceived to emphasize their decorative aspects (Figure 4). They were also inventive in their interpretation of the monuments from which they were derived—a tribute to Hornbostel's compositional flair rather than his historical veracity. In resolving our strategy for the resumption of the project, we decided to employ the restraint and clarity which Hornbostel brought to the rest of his building. Reducing his decorative emphasis, foregrounding the architecture, and representing accurately in detail exemplary fragments, we arrived at a consistent stance that was also economical.

After developing an overall composition for the five niches (Figure 5) we focused on each in greater detail. Because we were retained at the same time as the team of stone carvers, we established a fast-track schedule of drawing deadlines to meet the carvers' needs. As a result, the project team began to meet at least once weekly at a regular time to review the progress of the drawings and carving, and to collaborate on their modification and refinement.

4 Methodology

Our working methods evolved over time. A pattern emerged. For each niche, the language of the period was thoroughly researched for the most appropriate source elements and the rules that guide their reproduction and combination. At the beginning of the project, we developed each design using traditional media, piece by piece, scanned the manual drawings, and traced the resulting designs. Manual sketching was preferred because it allowed rapid, fuzzy, combinations of countless source elements in alternative designs. Furthermore, access to scanning equipment or large capacity storage devices was not readily available, discouraging digital documentation of our broad, early searches through source books. However, as our work progressed, we refined this process. In the final phases of the project, as our understanding of the use of the program and the geometry of the niches increased, the computer took on a more central role in the early development of each element. After two years of work, we had a better sense about which source ele-
Figure 3. Engineering Hall and the College of Fine Arts.
Carnegie Mellon University Archives
ments we wanted to use, encouraging us to scan and manipulate them on the computer from the start.

Once each element was modeled on the computer, the computer was used to produce full-sized drawings—base and face molds—that not only facilitated carving but allowed precise control of the complex semicircular geometry enclosures. In addition, the design files were used to guide computer driven robotic saws that performed some of the basic masonry for column and capital elements. This allowed the carvers more time to concentrate on the refinement of carving in situ that reduced on-site masonry to a minimum in time and complexity.

Figure 4. Greek Niche, sketch, circa 1912.

Henry Hornbostel
Due to the practical time pressures we faced, no attempt at developing intelligent modeling programs for each language was attempted, and nothing commercially available offered useful alternatives. Rule-based systems, enabling the manipulation of each language, would certainly have helped us. To be useful, these systems would have to possess shape grammar interpretation capabilities, an intuitive interface, and sensitive modeling and output capabilities.

5 Sequence

During Hornbostel's lifetime, the Renaissance Niche was the only niche to be completed. Unlike the Medieval, Greek, and Eastern Niches, which had not been touched, the carving of the Roman Niche, at the main entrance to the building, had been begun and left unfinished. This gave us a good opportunity to begin to internalize original intentions by completing Hornbostel's initial gestures. Aside from a number of details, including metopes, keystones, and statues, the large semi-dome above the entrance was blank. Hornbostel's only sketch for this niche shows an elaborately coffered design. After a number of awkward manual and computer studies, hindered by our stereometric inexperience as much as any other factor, we developed a simpler design based on the Pantheon's dome. An oculus above displays representations of the earth, moon, sun, and stars. The keystones flanking the entrance are devoted to busts of Hornbostel himself as Bacchus, and Purnell as Mercury. At Dean Burgess' suggestion, the metopes feature a Latin invocation to students of the college to create, CREARE (Figures 6 and 7).

With the Roman Niche underway, our attention shifted to the Greek and Medieval Niches. Although not begun by Hornbostel, the Greek Niche was fairly straightforward. Taking our cues from Hornbostel again, we adapted the Greek orders from three exemplary sources: the Doric from the Parthenon, the Ionic from the Erechtheion, and the Corinthian from the Choragic Monument of Lyssicrates (Figures 8, 9, and 10). The process involved photocopying and redrawing, scanning and rescaling images of the elements. Although existing stone had been carved in place whenever possible, files for the columns, capitals, and bases were prepared on the computer and used to drive lathes offsite—the finished masonry was shipped when ready. As a result, site masonry work was faster and simpler, enabling less costly apprentices to do more of the "roughing out." The carvers could devote their time almost entirely to carving. This use of the computer was especially effective. Because the underlying forms of the Greek Orders are easily geometrically definable, they are perfectly suited to computer modeling.

Geometric rules also characterize the elements of Medieval architecture. The computer was routinely used to produce full-size molds for all the elements of the Medieval Niche. Although we initially explored the use of a Medieval tracery program developed for the Macintosh by a Carnegie Mellon graduate student (Carlson 1993), we ultimately concluded that it couldn't help us to reproduce the subtle geometrical shifts and dimensions we discovered in the selected precedents—we continued the hybrid process initiated in the Greek Niche. However, in contrast to the Greek architect, who completely defined the ornamental program for his carvers, Medieval master builders established a collaborative framework for individual expression. We attempted to reproduce this process computationally by composing a basic structure from precedents at Chartres, Reims, Westminster Abbey, and St. Gilles de Gall, among other sources which also provided opportunities for free expression. In these areas, the computer proved useless, and the traditional approach of the carvers to the potential of the material dominated. A similar approach characterized our work on the Eastern Niche as well (Figures 11, 12, and 13).
Figure 5. Conceptual elevation sketch, 1990.
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6 Limits

In developing these designs, we were frustrated by the discrepancy between the geometric refinement and ease of use of two-dimensional drawing programs, and their three-dimensional counterparts. For example, with the help of a colleague, we attempted to computer model a useful, three-dimensional representation of the Pantheon dome. We wanted to study the proportional relations of the coffer elevations to their sections. The models we produced were simply too imprecise to be very useful (Figure 14). An intuitive,
fast, and precise three-dimensional modeling program that enabled sketching and refinement would be invaluable to a project of this type that exhibits complex geometries and language characteristics.

On the other hand, in the production and manipulation of full-size molds, the computer was essential. Traditionally, molds were hand-drawn, full-size, on the basement floors of cathedrals, and then cut from zinc sheets. Today, printing on heavy mylar from computer files, we can collapse the design and “setting-out” procedures into one activity.

While the computer has clearly begun to benefit aspects of architectural practice, it has yet to revolutionize architecture itself. Although we hope that this project will encourage other architects to consider carved stone as a rapid and economical building material, we doubt it will do so. Until architects stop considering computer innovations as metaphorical extensions of existing drawing tools, they won’t realize the real potential of the medium itself. The computer is not just another pencil. There is a difference between what operations are offered and what a practicing architect will use. We focused on how existing, readily available, technology can positively contribute to architectural practice. We
Figure 8. Greek Niche, conceptual sketch, 1990.
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Figure 9. Greek Niche, Corinthian capital, computer drawing.
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discovered that our architectural habits often stood in the way of useful applications of the computer in the design process. Design and production conventions need to be reconsidered in light of these new possibilities.

7 Experience

As we become better able to produce simulated reality, we lose appreciation for natural reality itself, and with it the value of experience. Experience is at the heart of the College of Fine Arts Niches Project. The act of making something and the acquisition of
Figure 11. Gothic and Medieval Niche, conceptual sketch, 1991.

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this skill can be a source of great pride, as evidenced by the craftsmen who have helped to realize our designs for the Niches. The rewards of labor are labor itself.

Craftsmen do what they always have, relying on experience and continuity as a teacher. Technologists, meanwhile, invent and experiment with belief in better possibilities for lightening the burden of human activities in the future—they value speed and efficiency more than tactility and beauty. Given these perceived values, it is sometimes difficult to embrace the promise of technology in our practice. While we are great believers in its virtues, progress has its price in terms of knowledge, skill, and experience. While inventors of an earlier time represented progressive experimentation and discovery, too often technology today has ceased to be experimental, determined by the marketplace's consumptive appetites. Attracted by the image of the new and the intoxication of saving labor and time, the modern era technologist invents compulsively, believing that progress is inevitable, inherently good, and certainly profitable (Lindsey and Rosenblatt, 1992).

Figure 12. Gothic and Medieval Niche, Venetian panel, computer drawing. 
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Figure 13. Gothic and Medieval Niche, Venetian panel, photograph.

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The title of this paper refers to opposing images of pre- and post-industrial life. In craft, we can picture the individual, the handmade, the one-of-a-kind, what writer David Pye has called “the workmanship of risk,” while in technology, we may see the team, the machine-made, or the repetitive series, the so-called “workmanship of certainty” (Pye, 1968).

Through these images, we can easily appreciate the simple virtues of each approach to making something. We may also make value judgments. From one point of view, craft relates to the scale of the individual, while technology relates to the “scalelessness” of the machine. Craft is intimate and tactile, while technology is remote and cold. But, virtues can easily become vices. What is intimate and tactile to a craftsman can easily seem cloy-
ing and claustrophobic to a technologist; likewise, to a craftsman what seems remote and cold might be viewed as sleek and universal by the technologist (Lindsey and Rosenblatt, 1992).

There is a strong and undeniable link between what one makes and how it is made. If design is engaged entirely within one medium, the exploration is defined by the limits of that medium. However, if design is engaged within multiple media, the exploration will be defined by opportunity, rather than limit. Where one approach poses difficulty in producing new knowledge of a problem, another may open a fruitful path.

Our resolution of these contradictory perspectives relates to the notion of hybrid rather than synthesis. In both our teaching and practice, we emphasize the importance of developing a hybridization of media in the design process. Physical and computer modeling are interdependent activities. We are encouraged to use media appropriate to each specific moment of inquiry. Rather than dwell on computer technology per se, we focus on the craft of making through all available media and technologies (Lindsey and Rosenblatt, 1993).

9 Epilogue

Recently, a former teacher of ours visited our school. Upon greeting us, he asked what we were working on and we told him about the niches. “I didn’t know you were classicists,” he said, perhaps remembering the constructivist skyscrapers we had designed in graduate school. “We’re not,” we said, “it’s the technology of building in stone that intrigues us.” Triumphant, he responded quickly, “Oh, then you’re technologists!” “No,” we stammered, “we’re architects.” He paused for a moment and a smile spread across his face. “Only at Carnegie Mellon,” he began, “can classicism and technology result in architecture.”

References


