Concrete Geometry: Playing with Blocks

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Abstract

This article describes a design/build exercise conducted in an Architectural Materials and Methods class to achieve three interrelated objectives: (1) to apply physically the semester’s theoretical focus on the constituent process and languages of architecture investigations, (2) to capitalise on the physical and aesthetic properties of concrete masonry to explore fabrication and detailing in the design process, and (3) to examine preconceptions about solo work and team work in architectural education and practice.

What makes this project unique among other design/build projects is its emphasis on Concrete Masonry Units (known as CMU in the USA) and their visual, tactile and functional properties. The junior and senior students were allowed three building elements: an 8’ cube of space, an unlimited number of concrete blocks, and the visual ecology of a site. The structural vocabulary that Frank Lloyd Wright developed consisted of a three-dimensional field of lines through which the solid elements of the building were located, enabling the voids to be integral to the whole and equally meaningful. Using these elements, students were asked to design/build temporary structures in a field next to the airport hangar on campus. The pedagogical objective was to adopt Wright’s creative spirit, as opposed to quoting his architectural language.
Introduction
For the last decade or so there has been a renewed interest in materials, programmes and engagement with the real in schools of architecture and construction management. This change reflects a theoretical and practical shift in interest (or expansion of interest) from media to building. This pedagogical shift parallels a reassessment by the professional community of the near-total segregation of the processes of design and of building. Design/build has become (along with so-called green architecture) the ‘next new thing’ in Architecture/Engineering/Construction (AEC) industry where, in the over-oxygenated language of sales, a recent publication asserts that design/build has been widely accepted as the dominant project delivery system in the USA (Beard et al. 2001; ZweigWhite 2007).

The article describes an Architectural Materials and Methods class which gave students the opportunity to design and construct actual small structure. An experimental design/build exercise described here was conducted in the middle four weeks of a 15-week semester. This project is unusual, and unusually challenging, in the realm of first design and construction projects because of its emphasis on the language of Concrete Masonry Units (which are known as CMU and are made from cast concrete, Portland cement and aggregate). In other words, this project is unusual because it places the consideration of CMUs at the beginning of the design/build process, not at the end. As Carpenter (1997) notes, the unique and particular physical qualities of materials should be utilised as the source of subsequent design thinking and construction decisions. Materials, he continues, should be seen as design generators, fertile ground for imaginative exploration and discovery. Students gain important knowledge by familiarising themselves with the visual, tactile and functional properties of materials in full scale. It is also valuable for them to consider the historic applications and cultural symbolism of the materials.

It was not uncommon for certain classes in India to place at the core of their children’s education a materials training which consisted of being able to identify materials by touch (texture and heft) alone and, further, being able to assemble a stipulated pallet of materials ‘blind’ (Dewey 1959). While such detailed training is beyond our scope, it would be hard to argue against the value of learning to ‘see’ with one’s hands as a way of sharpening one’s perceptual awareness, and following naturally from that sharpening one’s ability to articulate the differences in words and drawings. In Immanuel Kant’s words “The hand is the window on to the mind” (Tallis 2003, 4).

Approaching materials this way makes students effortlessly receptive to an understanding of principles common to all design/construction/engineering projects that grow directly out of materials, in this case, CMUs.

Historical context
Architectural practices and the building industry in the USA reflect the ascendance of the scientific method, commercialism, mass production, professionalism and specialisation. In From Craft to Profession (1999), an in-depth study of the emergence of the professional architect in early America, Mary Woods describes how craftsmen-builders came to see themselves as professional architects during the 1800s. With the new professionalism came a separation of visual thinking from daily life, and a sequestering of what had previously been general knowledge to a specialty. There was a shift of focus in design from play to professionalism, and from exploration to accuracy (Hale 1994).

The adoption of orthogonal drawing as the standard mode for architectural seeing and representation during the sixteenth century freed architects from the need for day-to-day site supervision. This development has also been identified as a source of the rift between thought and action, design and building. Historians trace the mechanisation of thought and the divergence of builders from architects from long before the nineteenth century: Western expansion led to the standardised project-delivery systems common in the USA, which emphasised cost-efficiency through stratification (Zambonini 1988). During the same time, well before academies of architectural education were established in the United States, a change occurred in Paris that...
was to affect the teaching of architecture in America. The teacher-architect Jean-Nicolas-Louis Durand (1760–1834), who wrote, ‘Architects should concern themselves with planning and with nothing else’, expressed the new theory in two books. William Ware, who founded the first American school of architecture at Massachusetts Institute of Technology in 1868, echoed Durand: ‘Architecture may be called the prose, as sculpture and painting are the poetry, of art’ (Pfammatter 2000).

The central position of the design studio in contemporary US professional programmes of architecture was modelled on the atelier system of the eighteenth-century École des Beaux Arts and the hygienic theoretical methodology established at the Parisian École Polytechnique in the nineteenth century. Scientific prescriptives for production and recognition were valued above the personal and unpredictable processes of artistic production. Also opposed to traditional apprenticeship, the ‘theoretical lessons’ of the architect consisted of information imparted in the classroom, which the architect would apply to ‘solve’ planning problems (Franzen et al. 1999). This standardisation of representation can also be seen as the beginning of the separation of architect from artist. Though modified somewhat by the German Bauhaus teaching plan, the central focus of an architect’s education remains the design form, with functional craftsmanship in any of the building arts completely unknown.

The importance of scale and materiality in the process of architectural invention seems as intuitive as an understanding that the mind and body work in tandem. This view is supported by recent knowledge of the anatomical and functional links between brain and body, which point away from the generally accepted compartmentalised view. But the idea that learning engages the entire physiology, and conversely that the body teaches the mind, is lost because of the low status of physical labour in both architecture culture and the culture at large, where it is stigmatised by a presumed absence of thought. In the USA, every aspect of building is seen as a product of intellect. This attitude of course is not new. Architects, like everyone else, struggle to shrug off any association of their mission with manual labour. Plato’s epithet banus, directed at men whose work was delivered through their hands instead of their heads, launched a mind/body dualism that characterised mechanical work as completely independent of imaginative work, if not in direct opposition to it. In modern English, the term ‘mechanic’ has connotations as varied as the person using it, but in general the word is understood as a depreciative term connoting the automatic and impersonal. Webster’s Ninth New Collegiate Dictionary (1983) gives: ‘workman, hand, labourer, workingman, artisan, roustabout’ as definitions for ‘mechanic’. Word for Word: A Dictionary of Synonyms (Clark 1990) lists the following synonyms for ‘mechanical’: ‘automatic, instinctive, impulsive’. As analogies, it lists ‘stereotyped, hackneyed, dull, stupid, dense’; as contrasts, it lists ‘vital, essential, fundamental, spirited’. In a parallel contraction of meaning, the term ‘design’ has taken on limited connotations, focusing more on the aesthetic and theoretical dimensions of design than on the integrative nature of the process itself (Boyer & Mitgang 1996).

Current interest in construction studios signals a profound redefinition of these terms and relationships. This shift acknowledges the fact that construction, too, requires a way of thinking: that embodied experience is qualitatively different from abstraction and is a critical component in the evolution of ideas (Sergison & Bates 2001; 2004). In this new view, acknowledge of architecture based solely on paper and lines are both irresponsible and arbitrary.

**Knowing through making**

‘The concrete block? The cheapest (and ugliest) thing in the building world… Why not see what could be done with that gutter-rat?’ (Frank Lloyd Wright 1945, 234).

The first moulded concrete block appeared in 1882, but mass production of concrete blocks did not develop until Harmon Palmer patented a cast-iron hollow block machine in 1900. The aesthetic and structural potential of the concrete block attracted Wright again and again throughout his career. Initially built in brick, stucco and stone,
Wright’s Prairie Style was later built in concrete block. In the 1920s Wright had developed Knit Blocks with which he built four Textile Block homes (Museum of Modern Art 1999, 170).

In 1936, Wright developed the Usonian, many of which were fabricated in concrete block. In the 1950s, the Usonian inspired the Usonian Automatic do-it-yourself kit house. Wright’s Usonian automatic house was conceived as a style of home which could be affordably produced and bring style to the masses. Over a 15-year period, he built about a hundred of these homes. He used the word Usonia as an abbreviation for United States of North America.

With a grant from the National Concrete Masonry Association Foundation (NCMAF; Herndon, Virginia) we were fortunate enough to have the time and materials to follow Wright’s lead and investigate the creative possibilities of the concrete masonry block in an Architectural Materials and Methods class. Juniors and seniors in a pre-professional architecture programme were instructed to design and construct small temporary outdoor spaces built of concrete blocks, forming a continuous interior and exterior fabric.

**Aims**

‘Working out steps by hand gives the mind that feel of the materials which is essential to mastery in any art or trade’ (Barzun 1991, 92).

The purpose of this project was the cultivate the students’ awareness of concrete masonry blocks and to engage them in dreaming of possibilities, discovering limitations, making compromises, coming to realisations and reflecting on the process. In the design studio, most of the tools at our disposal are utilised to evoke architecture’s visual qualities alone, foreclosing on the fundamental richness that comes in a synthesis of touch, sound and movement.

The project was designed to focus attention on two fundamental and interrelated issues: modular units and the logic of construction techniques. First-hand knowledge of modular units—not only what they look like, but their texture, their heft and their particular joining requirements—expand a student’s conceptual range and design intelligence. Actual experience handling modular units and meeting the demands of construction techniques gives an understanding that cannot be duplicated in any other format.

The interrelationships between the inside and outside of natural surroundings summed up what appears early in Wright’s houses as fundamental to whole design and its continuous cycle as part of nature. The students faced the challenge of understanding the creative opportunities Frank Lloyd Wrights found in concrete blocks. The project also encouraged a great variety in creativity as students sought to execute the concept as thoroughly as possible. The end goal was to ensure that every space in the final design was active and engage investigations into formal and spatial composition and with a focus on the geometric pattern.

**Process**

The collaborative design/build competition took four weeks, or eight class sessions. Students met twice a week for two and a half hours each for a total of 20 hours. The six steps, which were completed over the course of eight sessions, were as follows:

- **Step 1: Design challenge**
- **Step 2: Brainstorm**
- **Step 3: Visualisation**
- **Step 4: Selection**
- **Step 5: Full-scale fabrication**
- **Step 6: Judgement**

**Step 1: Design challenge**

Before reading the assignment, students took a field trip to watch the production of blocks at a local fabricator. It was like scene from The Craftsman, in which Richard Sennett writes beautifully of bricks and their manufacture (2008). Students learned there that this inorganic building material comprises particulates of many organic materials (see Figure 1). They also learned that geomorphological force the drives concrete block’s elements, its composition, its structure and the dynamic processes (McKee 2008).
After visiting the fabricator, the class was introduced to the assignment as an exercise in design and as an integrated process. Like real-world challenges, the brief was very open-ended, and students were reminded that many different solutions are possible. The design brief outlines a fairly straightforward programme. Students were given a ground plot approximately 8’ x 8’ in a grassy field adjacent to an airport hangar and a small man-made hill on which to construct a free-standing architectural form that functions simultaneously as inside and outside. Whether monolithic or airy, the piece had to be constructed of concrete blocks with rebar and gravel for stability. Programmatic design requirements are described in narrative form for maximum interpretive variation.

**Step 2: Brainstorm**

After the plant visit, students had one class session to create mock-up models of their designs in order to understand the various interactions within volumetric shapes. The brainstorming process loosely paralleled CMU fabrication in the sense of assembling of a mix of ingredients, manipulating and moulding these ingredients and finally, setting them in a particular form.

To promote creativity, students were encouraged to complete independently as much of the first phase as possible. They generated sketches and ideas for their proposed solutions to the problem and worked through them with help from faculty, discussing the pros and cons of each idea. Finally, students in groups then selected the strongest elements of each design to be combined into one final design concept that addressed Wright’s interest in the transition from inside to outside space. This relates back to the very initial assignment regarding the shaping and defining of space with the goal of creating continuous space rather than an inside versus an outside (see Figure 2).

**Step 3: Visualisation**

From this point on, the challenge was to visualise form and space relationships while working out
construction plans (see Figure 3). Part of the exercise required the finished product to be equally viable from all sides. Students then faced the task of refining their ideas to match their CMU requirements. This assignment also reinforced the importance of working in steps and allowing revision to play a role in the creative process.

The nine teams, which each comprised four students, that described their structure’s aesthetic and physical produced digital renderings, scale models and brief essays on the concept and features to the first jury, and, of course, the chosen full-scale masonry construction, which was presented to the second jury. The clarity, craft and completeness of the submission were the ultimate goal.

Step 4: Selection
Judging occurred in two rounds. The goal of the first round was to avoid being eliminated, and the goal of the second round was to win one of three prizes underwritten by the grant-giving foundation. All entries were submitted without identifying marks (logos, text, insignia or images). To ensure objectivity, the entries were assigned random numbers. The first jury, two local architects and one alumnus, evaluated nine design solutions based on these criteria: static stability, exploitation of the concrete blocks, and, most importantly, the manipulation of mass, volume and space. As in real-world practice, chance, luck and uncertainty outcomes were key components of successful project delivery in this step. The teams selected to build their proposed designs demonstrated a characteristic important to success in the immersion experience: an ability to handle unexpected problems.

Step 5: Full-scale fabrication
The jury selected four designs to be fabricated in the field. The chosen designs were carried out with the support and cooperation of everyone in the class. During the build process, design decisions continued as students tested constructional capabilities, gauged visual results and developed the design to incorporate ideas that emerged from this process. Construction was not directed by standard reference but rather proceeded through collaboration and trials involving both materials and methods. Detailing emerged in the field as the students modified the designs as necessary, taking environmental and aesthetic issues into account. The best phrase to describe the spirit of their work is ‘thinking on their feet’ (see Figure 4).

The challenges of production (tools, concrete saw, drilling machine, etc.) fostered student interaction and collaboration in their methods of construction. They learned the safe use of common hand and power tools. The faculty encouraged students to push the boundaries and to stay open to exploration and analysis. The instructor capitalised on unanticipated results by turning them into learning opportunities (for example, by asking, ‘What do we have here? Where do we go now?’). Naturally, it was necessary to intervene when safety issues arose.
Step 6: Judgement

Finally, the four structures, each an experiment in the innovative use of the concrete block, were judged by a panel of professionals: one local architect, one professor of architecture, one professor of construction management and one representative from the State of Ohio Concrete Masonry Association (OCMA). Judging was qualitative as well as quantitative. Each member of our panel of judges scored each entry on the following criteria:

- Aesthetic Concept (the visual appeal of the design, including overall appearance; the use of colour, shape and texture; and integration with the surrounding landscape)
- Innovative Use of Concrete Masonry Materials (novel use of standard concrete masonry products)
- Functional Use of Concrete Masonry Materials (how well the design utilises the various capabilities of traditional concrete masonry units as a building material)
- Constructability (how well the design was built)

The winning team received a $1,000 cash prize for their radical angle of concrete blocks emerging from the ground (Figures 5 and 6). The second-place team received $500 and the third-place team received $250.
Evaluation

The purpose of this exercise with juniors and seniors was to cultivate awareness of the entire architectural endeavour: of dreams, limitations, compromises, realisation and afterthoughts. In this respect students, the professor and the department all perceived the project as a success. Critical appraisal of the project has led to a recasting of the exercise as a semester-length course in which design and fabrication detailing will be conducted in a time frame that allows more students to participate in multiple phases of the process, something that was impossible within the constraints of a four-week exercise.

Most beneficial to students was the experimental and collaborative learning process unique to the design-build methodology. In a traditional design-studio setting, students are normally left alone with their work except for desk and class critiques. In this project, however, student interaction became physically alive: a corrective to the solitary nature of the balance of the semester’s work. The process naturally demanded an unusually intensive and exacting collaboration, and a willingness to reach consensus with minimal compromise. This communication with teammates advanced a primary lesson that ‘architecture is a collaborative effort and not exercise in isolation’ (Carpenter 1997). The exercise also offered students the opportunity to engage in cross-disciplinary approaches and reach out to the professional community (concrete producers, contractors, engineers, etc.).

Students learned through hands-on construction supplemented by discussion. They learned the design/build process as a six-step method:

**Step One:** Read the design challenge; understand requirements.

**Step Two:** Brainstorm design solutions; make sketches and written notes.

**Step Three:** Visualise design solutions to work out construction feasibility.

**Step Four:** Undergo first round of judging, in which designs for fabrication are selected.

**Step Five:** Execute design at a scale of 1:1.

**Step Six:** Undergo second round of judging, in which three prizes are awarded.

The students found the design/build process to be both beneficial and frustrating. Most students seemed to endorse collaborative design/build in principle and appreciate its potential to enhance the quality of learning, but they found many problems in the way the design competition was executed. The first group of quotations from students evaluations gives a fairly enthusiastic assessment of the design/build competition. In response to the question ‘What did you like most about this architecture student design competition?’ students said:

*The ability to design what we wanted, then build it.*

*That we actually get to design and build something.*

*It was nice to actually see how our design looks in real life.*

*It was my first design competition, so it was good to see how everything came together.*

The following quotations, however, pointed to several problems, mostly related to the judging of the design competition. When asked ‘What did you dislike most about this architecture student design competition?’ students said:

*The judging approach. I don’t think artists and architects think the same way.*

*The pace. How the projects were actually judged. Judging was not made completely clear.*

*The jury process. Designs were eliminated due to buildability although they scored the highest. Maybe if you could make it work that would have shown innovation.*

*People did not stick to program and still moved on.*
Conclusion

The argument implicit in these design/build exercises can be stated as three points:

1. The Architectural Materials and Methods class is energised by democratic experimentalism, one in which association (of scope, method and character) is not merely a means to predefined goals but rather the process for the ongoing revision of these goals, as well as of the methods for attaining them.

2. The Architectural Materials and Methods class must invite a recombination of roles and people.

3. The Architectural Materials and Methods class must not only immerse students in new technology but also continually challenge the biases embedded in computational tools.

At the end of the project, students typically leave with manual drawings, digital renderings, a brief essay describing the concept and features of the structure and the full-scale masonry construction. The piece itself is a record of action which students became stimulated knowingly by concrete masonry, ‘in altering, making, or identifying them with’ themselves (Sennett 2008, 144). In other words, it is an environment that becomes a reflecting surface in which the students can see the traces of their action, something that enables them to talk about how they are learning. Students gain an awareness of design, materials and the collaborative process. They are exposed to the surprising notion that there are multiple ways to conceptualise, represent and test ideas. They become participants, not merely spectators, and (in theory, at any rate) understand design and construction as an integrated process that begins with the consideration of materials. In this spirit, using methodology already in place in the professional world, we must work together to foster changes in curriculum formats that merge construction technology with design.

References


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