Arch 264: Off-site Fabrication

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"Professor Buntrock’s course provides a uniquely rigorous model for efforts in academia to engage with issues of practice. Students in her seminar are allowed to understand issues of practice through direct contact with professionals and fabrication facilities. However, the potential in this suturing of academics and practice extends beyond simply mimicking those experiences which can be gained through professional practice. By merging the unique opportunities offered in field research with [access to] fabrication facilities and professionals, and the expanded insights gained in seminar research and discussion, Buntrock’s Off-Site Fabrication provides an exciting and diverse introduction to issues of fabrication in practice."

Brian Padgett

If you apply for a teaching position at the University of California, Berkeley, you will be asked to write two syllabi, one for a course in the university catalog and one for a course you would like to teach.

When I applied, I proposed "Off-Site Fabrication," and began teaching it in Fall 2000. Students at Berkeley were, at the time, not particularly inclined to study construction, and the first year there were only four, one working on a PhD in Construction Management and three Masters of Architecture students. We fit in a single car, driving to what my department chair ennobled as "the beauty spots of Northern California."

In an essay on the course for Ed Allen’s newsletter Connector, a student named Tom Reiner summarized his experience a few years later:

"...Buntrock kept her students hopping with weekly class trips to various fabricators around the San Francisco Bay. Two visits contrasted the industrial efficiency of a producer of panelized-wood systems with the careful craft of a builder of Japanese temples using traditional tools and methods. Both manufacturers used principles of off-site construction to assure quality and consistency. However, their distinctive products reflected fundamentally different production values in cost, labor, design, and speed; all are key factors for the designer to understand and accept.

A small steel fabrication shop, eerily quiet due to the slow economy, spoke of the possibilities available to designers when a manufacturer’s business suddenly falls off and [it] is willing to consider a more challenging and unusual project.

A pre-cast concrete plant demonstrated the importance of processes to the final product, for an efficient method of production can create a sense of inertia and result in a rigid and inflexible building system.

A curtain-wall fabricator and a heavy steel fabricator [each] emphasized the need for collaboration between the design team and the fabricator. A few moments of consultation can save many hours of frustration when dealing with an inexperienced designer unfamiliar with the fundamental aspects of their products and processes."

Some of the fabricators listed above are regulars: Joinery Structures, Japanese-trained carpenters; Computech, a panelizer that started thirty years earlier as a truss plant; XKT, the large-scale steel fabricator. For many years, I was friends with the president of Walters and Wolfe, a local curtain waller that was one of the largest in the nation, prospering from demand in the IT industry. Each year we visited, the students were surprised by the simplicity of the shop – and Tom Reiner, author of the text quoted above, subsequently worked there for a year, first rising summer
mornings to work on the line, then detailing for a part-time job while back in school.

I proposed this seminar out of an interest in component fabrication, an outgrowth of research done in Japan in 1998 while on an NSF post-doc. I make the point to my students that prefabrication is neither a sudden shift in architectural practice – in our area, examples can be found as far back as the 1849 Gold Rush – nor, to my mind, particularly trendy. It is, however, already important in the construction of good architecture, and will become even more so.

I believe the manner in which construction is often taught, sitting in a lecture hall, is simply wrong. The course I designed emphasizes instead observation and empirical learning, appreciating the stories offered by experienced individuals, and incorporating higher-level analysis to what is seen and heard.

Because communication is important to fabrication success, this could be called a surprisingly verbal class. Students need to understand how to work with and speak with fabricators; all too often in their early years, they expect an architect should lead even when they do not have sufficient knowledge to do so. Interviews and site visits suggest a different perspective.

"Nash [student]: Who leads the project?

Tony [fabricator]: ...those guys were great because they listen. Some architects don't listen. It might be insecurity, or maybe not. They've built up resistance around them to listening to other people’s ideas because it might draw their focus away... It might be that some of it is arrogance... it’s interpreted as arrogance at any rate. But I don't think that it is, I think it’s a self-defense mechanism that they’ve built up to get their project done, but a lot of times it’s very limiting. They’ll march on down a path that could have been done more efficiently or be better for them and the client if they had listened to more people along the way."4

As I wrote my initial syllabus in Chicago, I did not realize how ideal an environment I would find in the Bay area. We see many approaches to off-site fabrication, three hours once a week (originally in the late afternoon, but a 9-12 slot is in fact more likely to hit production shifts right when things slow down). Even if we drive an hour each way, we still have an hour at the shop – ample time to learn a lot. As students get increasingly enthusiastic, they even occasionally agree to steal an hour from sleep, getting on the road a little earlier.5

California’s conditions are perhaps unusually supportive of such a class. High labor costs and an affluent population support a strong craft community: not only those Japanese carpenters with elegant imported planes, but old-fashioned artisans working in wrought iron and soft metals, and immigrants mixing precise colors in concretes, the shelves and counters they produce shipped to retailers from coast to coast.

The state requires 30% of new classrooms be manufactured portables – and our school population only seems to increase.

Even in our present mortgage crisis, production housing is still being built. The panelizer we visit is an established union shop, sometimes on one slow shift, sometimes on two frenetic ones. They make thousands of houses a year, stacked stud frames on trailers neatly numbered. They scold students, arguing architects cannot add or even now draw a 2x4 at two inches by four – hardly easy to integrate into a process that relies on lasers and mylar measuring tapes for its precision. They underscore that simply importing AutoCAD is not going to be enough.

In addition, in our area there is heightened interest in environmentalism and affordability, reduced impact on site and increased opportunities to recycle, economies of scale. That panelizer has zero waste, even being paid for the sawdust collected by ducts at each saw blade.

The East Bay includes the Port of Oakland, too, not only a source of old shipping containers, but also expanding our market up and down the coast and across the ocean.
And anyone who has opened Dwell is probably aware that many of the leading professionals in the market are in my backyard. We alternate our own visits to fabricators by inviting architects to Wurster Hall to tell us their tales; folks like my favorite, the East Bay’s Michelle Kaufmann, or Mark Anderson, a member of our faculty. Los Angeles is also an easy hop, and we sometimes bring a speaker in on a commuter flight for a different perspective.

Through a core group of regular site visits and architects, I have come to understand how fabricators respond to economic ebb and expansion, experimenting, egged into innovating in slow times. Our last deep dip was in 2002, when many tried new product lines: the curtain waller offered interior doors, the panelizer produced ornamental trims and vent grilles, the Japanese carpenters tried a tearoom kit. Their definition of acceptable work shifts, as Reiner earlier suggested. One year, Computech might claim they never do a single custom home – the next, one is on the line. Fabricators often report current conditions as a baseline. I am in a position to clarify for the students what I see in annual snapshots.

Every year I also add a few emerging enterprises. Although not strictly applicable, I was at one point excited about an Asian outfit that unspooled light gauge steel off the back of a truck bed, computers controlling cutting and folding of each stud for a small home. It was, unfortunately, gone by the subsequent semester. In more recent years, fabricators are rethinking the seismically-resistant steel frame. I added Conxtech just this year. They have a nifty system: a quickly assembled joint, five-story tall tubular columns, beams on a string dropped into place, frames measured in minute fractions of a millimeter. It has not yet taken off, and in the meantime, they, too, are experimenting with other lines, including bathroom units for the health care industry, the trades coordinated with greater ease in off-site, repetitive assembly.

As some industries grow stronger, others are on the wane. We see them, too. Metal shops once fringed San Francisco Bay; they are being driven out by noise and toxicity conflicts with residential demand in the same areas. As survivors describe the conflict, students see
the steady decline of small industry and understand it might affect their options as architects.

I learned to keep some constants in the mix, while also exploring emerging approaches and technologies. It is time-consuming to line up these trips and prepare fabricators for a fruitful talk with students. My first year, I went everywhere twice, which helped me to understand what each site would underscore. With a few regulars in the mix, I bring more depth to discussion and balance demands on my time.

But to keep it interesting to me, I try a different concentration each year. At one point I inclined to craft, small shops struggling to precisely install shop-built stairs or concrete countertops and dog baths that required special trips just to template. These are not, though, helpful for highlighting supply chains, and I realize now students find small shops less intimidating, are more inclined to go on their own – so I think I should instead concentrate my efforts on the larger fabricators and unusual opportunities.

One year, Zahner was in town, skinning the deYoung Museum in a complex cladding of computer-stamped copper sheet, so we went to the site – and a pair of students arranged to go on to the plant in Kansas to see more, although in truth they found a fabricator much like we have here at home. Zahner sets itself apart as a better service; we saw that part on the construction site.

Another year, we had a connection to a group that was, at great effort and expense, trying to use stacked shipping containers as artists’ studios. An inspector spent a morning at a resellers with us, explaining the containers carried aloft above our heads in the maw of clamping cranes. The following week we went to the artists’ hive and heard how egress and seismic safety concerns led the city to cut off water and wattage. The students saw how hard, in fact, it is to use what Paul Rudolph once optimistically entitled the “twentieth-century brick.” We’ve explored shipping containers more than once; it’s natural when so many visionary projects suggest they are an effective architectural solution in port cities like our own.

As I organize the semester, I try to incorporate work in wood, steel, concrete and maybe glass – what I think of as the major materials of architecture. On their own, students sometimes explore oddball examples, like an architect and fabricator that collaborated to integrate Toyota tailgates along a balcony. I set the baseline; students bring their own spin in their original research, outside work interviewing architects and fabricators and reporting their results. They have a great deal of flexibility about what they choose, with my input mostly based on encouraging rigor in their quest.

The speakers, site observations and interviews are not unified by obvious issues like material or scale, production lines or output. Instead, I make an effort to underscore the common issues that these sites reveal, using Alistair Gibb’s 1999 book, *Off-site Fabrication*. In truth the text is not an easy sell. It is expensive and ugly, and its prose is leaden. Architecture students do not automatically take to it. But Gibb’s book demonstrates something that is good pedagogical strategy: its points are simple and clear, its presentation succinct and strong. Gibb describes off-site fabrication and assembly in sets: customized, one-off or uniform output off an assembly line; labor-based vs. mechanical systems; linear, flat or volumetric units. Gibb establishes ranges in choices about cost, quality, and time or how shifting work off-site and out of the elements enhances productivity. In the end, I think, architecture students grow a grudging admiration for this ugly text. (And, as far as I can tell, the engineering students never see anything wrong with it.) I would not mind a more accessible text, one that does not require the extra effort to incorporate. I kind of hope another former student of this seminar, Ryan Smith, now a professor at the University of Utah, will accomplish this when his book comes out with Wiley in a few years.

As one example of how Gibb enhances what we see, location is an early area of insight in the class. Students become aware of how where we point ourselves underscores the nature of work. A fabricator is concerned with access – but to what? Crafters who engage in a high degree of collaboration are often close to the central city, where most professionals will be. Structural work spreads out, demanding space for storage and staging incoming materials (often themselves prefabricated components from further up the supply network); these sites are at urban edges. Panelizers and truss plants demand daunting supplies of timber; long strings of railroad
stock deliver it from further north along the coast. The fabricators and precasters may also barge their output to sites, whether on this coast or Asian shores. This is most evident for students at the moment, as the Bay Bridge, linking Berkeley to San Francisco, is rebuilt. Its caissons were poured in steel segments, up to 230 tons each, shaped at an old Navy yard. Precast decks from elsewhere on the Bay are as much as 750 tons a segment. There is no alternative to barges in such situations: driving home on the highway, we will again recall hearing a fabricator share the impact the California Highway Patrol has on infrastructure and architectural elements, on their weight, their height, their length.

For me, the most interesting and unexpected outcome of this course has been its interdisciplinarity – but this is also one of its more important features. It was accidental in the first year, as that early Construction Management student drove us around the Bay. I now make a point of asking a colleague in engineering to recommend the class to her students – and she and others from her department sometimes come along for our field trips. For engineering and CM students, an emphasis on qualitative over quantitative aspects of architecture is new; the architecture students, in turn, often find themselves challenged to greater rigor in their assessments. Informal discussions in returning automobiles have played an unanticipated role in accomplishing this awareness.

In our visits, I often establish clear pairings for comparison, perhaps fabricators working with materials at different scales, such as a Spancrete precaster and those concrete countertops, or ornamental metalwork and structural steel. I’ve also often asked the students to investigate the same project first from the architect’s or engineer’s point of view, and then talk to fabricators, where insights into problems and delays are often made explicit.

Thus storytelling has a place in the class; I have come to feel that narrative is increasing important in assuring that one is paying attention in this age. Students find important information in interviews.

“Nash [student]: What’s your worst fabrication story?

Tony [fabricator]: I built a staircase backward one time. It was when we were first using CAD and I think the plans got printed out backwards. We built the spiral backwards. I was doing a lot, too many things, I was doing sales, marketing and you can get pretty scattered. I didn’t have a fabrication manager at the time, so at a certain point you need to separate the duties.

We had to rebuild it, save the staircase and sold it to another client. The client was really understanding, it was totally my mistake, but I will never do that again.”

Compare that tale with another point the student raised in the same paper, underscoring his emerging awareness of the value of careful planning:

“Since the stair needed to be installed in Hawaii, he took the time to create a scale model of the stair, which could be broken apart to fit into a standard shipping container. He went further to generate scale representations of all the equipment that would be necessary to erect the stair on site and placed that inside the scale-shipping container as well. Lastly, he generated a detailed computer model of the path to get the stair parts from the drop location to the room where it was to be installed.”

Interviews are not an easy aspect of the course. I coach the students on questions, repeatedly remind them to triangulate knowledge, check their major points for accuracy. Students are reluctant to make cold calls, but I also believe that they need to know how to talk to people outside their comfort zone to be effective as architects. So the students accept the interviews. The full title of my course is “Off-Site Fabrication: Opportunities and Evils.” I suspect at first many consider the interviews one of the evils.

One student, Kristi Dykema, relayed her approach to two distinctly different interviews, one with an efficient, award-winning architect, and the other with her metal crafter, a character known locally as “the jeweler,” one who practices in a way little different from how he might have fifty years ago:
“Having met with Anne Fougeron of Fougeron Architects earlier in the semester about the collaboration process between architects and manufacturers, I had been introduced to the idea that [small-scale steel fabricator] Dennis Luedeman operated in a unique world. She and I spoke at length about the trust she places in his abilities, the pleasure her clients received with the end results of her collaboration with him, and the need to ‘let go’ of complete control over the work she assigned to him. I pushed her to describe the challenges of this relationship and what ‘letting go’ meant to her, but she was reluctant to divulge too much information.

I had a difficult time getting in touch with Anne from the beginning. Having been warned of her incredibly tight schedule, I began the interview scheduling process three weeks before the interview needed to take place. She spoke quickly and, after exactly thirty minutes, gracefully exited to her next meeting.

…I never scheduled a meeting with Dennis. I showed up at his shop unannounced.

I couldn’t see very well beyond the padlocked gate. There seemed to be a fairly large room in the front, maybe one in the back. Dust filled any light that moved through the space. Stacks of sheet metal and piles of steel rods covered the floor area around the gate. A large dog arrived first. Slowly, Dennis made his way through the dusty darkness and stood at the gate. He waited for me to speak first.

Nervously, I introduced myself and shared my reasons for coming to his shop. He opened the gate and disappeared again. I assumed I was invited to follow, though he still hadn’t spoken. I found him again at a table in the middle, carving slices out of an apple with a pocketknife. ‘OK, so what do you need to know?’ I explained I had come to learn and listen on the advice of Anne Fougeron. He smiled at that. And we began to have a conversation.”

Students, to a much higher degree than I see in other classes, seem to follow the trajectories set in this class for years afterwards. I think the independent nature of their original, field-based research is a key reason why. The class has also become more international as a result of the open-ended nature of their search. I teach this class in the Fall term. The last half of the semester gets pretty shaggy, with Thanksgiving yielding quickly to finals and juries and a rush to get away from campus. I began setting the hand-in date for the second paper at the end of our finals period, well after students had gone home. So they followed up on discussions with a precaster in our area by visiting a remote rural site where steel forms were made, or interviewed others in Hong Kong. They learned to follow the stories they found further back, or applied the ideas of the class in new environments.

I taught this seminar six times, each Autumn from 2000 through 2005, involving about 55 students. I am returning to the class again after being on a research leave for two Autumns. In the meantime, former students have already carried its impact forward. One used what he learned as the basis for a prestigious fellowship we offer, going around the world over a year, as he compared handicraft and computerized production systems. When he returned, he had a publishing offer from Routledge (one, regrettably, he never pursued) and sufficient knowledge to use computerization to carve the curving beams and complex joinery of his thesis mock-up on a computer-controlled machine. Another spent his thesis year designing classroom portables, and a third proposed steel prototypes for his, consulting local fabricators along the way. Nash, the interviewer portrayed here, went on to SHoP, a firm whose fortuitous name is actually derived from the partners’, Sharples Holden Pasquarelli; another went on to work for Michelle Kaufmann. Two of the CM students are now on faculties, while a third finishes her PhD; one of the architecture students, Ryan Smith, is also working his way towards tenure, using an interest in prefabrication as an important area of his research. The Connector author, Tom Reiner, is at Buro Happold in L.A. and teaching as an adjunct at Sci-Arc. And I confess, I have lost touch with many, if not most, of the students from the seminar. Students, of course, brought earlier experiences into the classroom, as well, but those I hear from say they are building on the broad territory of off-site fabrication in ways as
varied as the topic can offer, and they tell me that the class played a role in how they do so.

Appendix 1: Class schedule (2008) with questions for early in-class seminar.

Appendix 2: Sample comparison sheet.

Appendix 3: Sample interview questions.


5 We travel to fabricators and the occasional construction site by carpool, and I confess this is my greatest worry; I see my students drive, and at times, I decide some should not drive again. Even writing this endnote probably increases my liability by acknowledging it, but finding a safe way to travel off campus is an important challenge if one wants to add empirical insight in education, and one I feel should be acknowledged for others.

Car pools create other problems as well. For many years I would give drivers a campus parking pass in trade for driving, and this was sufficient. This year, students and I are discussing gas stipends for drivers.

6 “The Mobile Home is the 20th Century Brick” Architectural Record (April 1968) p. ___.


8 Hurley, appendix.

9 Hurley, unpublished student paper.