ABSTRACT BOOK

OFFSITE

THEORY AND PRACTICE OF ARCHITECTURAL PRODUCTION

2012 ACSA FALL CONFERENCE
+ MODULAR BUILDING INSTITUTE
REGIONAL INDUSTRY MEETING

SEPTEMBER 27-29 2012
AT TEMPLE UNIVERSITY
IN PHILADELPHIA PA

Ryan E. Smith, University of Utah; John Quale, University of Virginia; Rashida Ng, Temple University

ABSTRACT BOOK

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DIGITAL INNOVATION SESSION I

CRITIQUING CAM: COMPARING COMPUTER-AIDED MANUFACTURING AND TRADITIONAL MANUFACTURING

Dana K. Gulling, North Carolina State University

As architects and designers promote mass customization for off-site construction, they need to recognize that mass customization is not cost neutral. The increased costs are both financial and environmental. There are some financial benefits to mass customization (e.g. increased customer loyalty, lower marketing costs, and lower product research costs[1]); however mass customization does increase the monetary cost of production. The higher prices are often passed onto the consumer. Secondly, mass customization may increase environmental costs through increased production wastes. This is especially demonstrated by computer-aided manufacturing (CAM) equipment that is subtractive—such as computer numerical controlled (CNC) routers, electronic discharge machines (EDM) and water jet cutters. Waste for these processes can be significant and, depending upon the material and process, unrecyclable.

In recent years, mass customization and the associated CAM technologies have transformed offsite construction; however they have not transformed all of building component manufacturing. There are still a number of traditional manufacturing processes that rely on the repetitive use of expensive molds for high production runs. The repetitive use of the mold for these processes is necessary as it distributes the mold's cost over a large number of products. If architects want to customize these traditional manufacturing processes, they will need to design elements that will be used repeatedly throughout their project. I am proposing the term customized repetitive manufacturing to refer to this type of work.

Customized repetitive manufacturing is a necessary alternative to mass customization for some manufacturing. Customized repetitive manufacturing allows for some customization from the designer, while balancing the need for repetition. Simultaneously, it places more restrictions on the designer than mass customization, because each element needs to be repeated a particular number of times in order to remain cost effective. There are architects that illustrate customized repetitive manufacturing in some of their buildings. Examples include Carlos Jimenez's Data Service Building at Rice University (2007) and Alejandro Villarreal's Hesiodo in Mexico City (2005). This work illustrates the flexibility and yet restrictions of designing within traditional manufacturing processes.

This paper will investigate existing studies and literature that examine the processes, benefits, and costs of CAM equipment typically used for mass customization and compare that to traditional manufacturing processes for customized repetitive manufacturing. It is my assertion that CAM is a strong choice for some manufacturing processes, however for other manufacturing processes repetition is needed to reduce costs—both monetary and environmental. In these cases, the architect or the designer should consider customized repetitive manufacturing. This paper will propose a selection of up to 5 fabrication processes that would be better to select CAM technologies for production and an equal number in which traditional manufacturing processes are a better choice. This will help offer designers and architects more knowledge to choose the best process for their off-site manufacturing needs.

1 Piller, Frank T. et al. "Does Mass Customization Pay? An Economic Approach to Evaluate Customer Integration". Productin Planning & Control: The Management of Operations. v. 15. no. 4. (2004) Taylor & Francis Ltd. Pg. 435-444.

YESTERDAY'S TOMORROW WAS TODAY: THE REVIVAL OF MID-CENTURY OPTIMISM IN THE AGE OF DIGITAL FABRICATION

Damon Caldwell, Louisiana Tech University

The introduction of new materials and fabrication techniques into the design arena generally spurs a progressive, visionary tendency among designers, often manifesting as unique furniture and spaces of provocative form. The extent to which these items reflect and enhance the spirit of the prevailing culture can ultimately determine their long-term success and use in architecture. This paper therefore addresses the question of whether contemporary digital fabrication can impart an optimistic spirit onto the larger aesthetic and cultural principles of the constructed environment, using a framework of parallel examination of mid-20th century and early 21st century design conditions as a basis for discussion of future directions of modern culture and design.

Post-war design in America is presented as a case study in cultural optimism, reflected in the acceptance and mainstreaming of progressive design. A historical examination of furnishings, architecture, and contemporaneous writings contributes understanding of the feedback loop of design to ethos, materiality to spirit. Examination of the work of mid-century furniture designers such as Verner Panton, Harry Bertoia, and Charles and Ray Eames, provides insight into the materials they helped introduce into the suburban American home. These items of daily living reinforced the modernist worldview present in popular design writing of the day such as Mary and Russel Wright's Guide to Easier Living.

The formal and material investigations which happened in the everyday home established a springboard for architects of the time to build upon. The larger built works of Eero Saarinen, William Pereira, and Albert Frey can thus be seen as a proving ground for how smaller fabrications could be "scaled up" to lasting architectural constructions.

Contemporary design has undergone a comparable transformation due to the increased use of digital modeling and fabrication technologies. Expansive use of innovative materials and techniques of production have helped loosen functionalist and traditionalist constraints. A corresponding resurgence of progressive design and prefabrication possibilities have entered the mainstream, as seen in the furnishings of Philip Stark and Karim Rashid, and the ubiquity of Dwell magazine. Digitally fabricated installations in (and on) museums abound, but it is the potential to alter the commonplace landscape that has grown the least.

Ultimately, an understanding of the formal morphologies of the fluid and layered materials of the fifties can provide contemporary insight and new avenues for lasting architectural expression. Can we help the larger culture embrace the future that design once promised, or will digital fabrication exist primarily as a niche playground for designers, sidelined from the mainstream culture of the everyday built environment?

DIGITAL INNOVATION SESSION I (CONT.)

WHO ALREADY DOES THIS BETTER? MASS PRODUCTION + CUSTOMIZATION

Marc A. Roehrle, University of Wisconsin-Milwaukee

The architectural academic community had been divided regarding the computer and its role in educating students. This divisive discourse had wasted a great deal of time and energy. While waging this intellectual trench warfare, these two dichotic camps dug-in, and became steadfast in their opinions. The issues at hand, however, were actually quite simple. Rather than supplanting traditional means of learning and designing ("manual representation") this new technology should have been seen as an opportunity to add to the pedagogical agendas of architecture schools. The evolution of computer fabrication from computer drafting has generated another similar discourse. As designers began to explore the possibilities and opportunities that this burgeoning technology offers, they repeat the exact same mistakes previously made. Rather than understanding how the building culture could benefit from the addition of this exciting new means, they see it as a revolution in the building industry: indiscriminately superseding and replacing older methods. The advancement of computers, robotics and other means of fabrication has ushered in new possibilities that architects have been eager to appropriate. Employing the analogy of the automotive industry, we should not look to companies like Toyota who produces millions of identical vehicles each year; we should look to Bentley Motors Limited.

Bentley employs a combination of old world craftsmanship with cutting edge technology to create one of the world's finest cars. To fabricate the rich interiors of each Bentley, 200+ hours of exacting labor goes into the leatherwork and woodwork alone. Bentley employs a series of steps that intertwine and operate seamlessly between a series of digital processes and handcrafted manual techniques. For example, the Coach-worthy leather is first selected and carefully assessed by an inspector who marks any blemishes. These hides are stretched across a digital scanning bed that scans for these marks. The computer then tabulates how to best cut out all the patterns insuring that the blemishes do not mar the final product, which are then sewn by an individual; using a combination of an industrial sewing machine and hand stitching.

Venturi Scott Brown repudiated modernists singular readings and interpretation; "less is a bore" they suggested. Instead they advocated that we aspire towards multiple readings, complexity and contradiction. Their notion of "and, and, and" would greatly benefit the implementation of new technologies. The effective use of strategically implementing means and methods would greatly reduce costs due to errors, redundancy or inefficiency and develop a process where the translation of idea into built artifact is more fluid.

OFF SITE / ON SITE: RE-SITING MODULAR CONSTRUCTION THROUGH ROBOTIC MANUFACTURING

Joshua Bard, University of Michigan

This paper seeks to reconsider the assumed contexts of off-site fabrication and on-site construction relative to modular architecture. Historically the space of the factory – for production – and the place of the architectural site – for installation – have evidenced competing logics which any approach to prefabrication in architecture must mitigate. With the advent of robotic manufacturing in architectural design the authors would like to conceptualize a third, transitive space for the production of modular architecture.

The promises of modular architecture (e.g. higher quality, increased efficiency, lower cost) often align with the logics of industrialized manufacturing and standardized building materials. The factory as a locus for these ambitions provides both a physical context for the efficient production of the architectural body and also an underlying framework influencing architectural ideation. The paper will explore the homogenizing tendencies of the factory environment – an engineered tabula rasa – on the standardized components of modular construction.

Architects often struggle to resolve the conflicting spatial paradigms of the precise factory and the irregular singularities of the construction site. Sites are seldom flat; lines are seldom straight; corners seldom square. Filler strips, shims, and joints often negotiate the disparity in relative tolerance from the factory to realities in the field. The paper will seek to understand these translational coping mechanisms in relation to the changing nature of digital automation.

Digital fabrication suggests alternative inroads to the problems of homogenization and the disjoint between the spaces of on-site vs. off-site production. One already established theme is the ability of CNC machining to push standardized manufacturing toward customization at an architectural scale. While the promise of "mass-customization" suggests one antidote to the ubiquitous industrial production of the built environment, many CNC machines actually reinforce the abstract datum of the factory through work cells sized to mass-produced sheet materials. The inherent dimensional limitations of these tools constrain the tectonic quality of modular architecture.

Our research in robotic fabrication brings these constraints into clearer relief since the work cell of a robotic arm can be equal to that of a shippable module. Thus a robot can work at the scale of and directly in the three dimensional space of the architectural module. Furthermore, robots are becoming increasingly portable and may both operate within the physical limits of the factory and in situ at the construction site. This possibility begins to bridge the divide between conflicting logics of fabrication and installation.

The possibility of robotically working in multiple sites relies on the transitive space of digital models in robotic tooling. While the robot functions in a physical context it is programmed relative to the digital space of a constructed model. That model can contain multiple organizational spaces (i.e. the space of the factory and the space of the architectural site). Furthermore, with advances in digital scanning digital models are increasingly adept at accounting for irregularities in site topography and organization making it possible to translate the specificity of the architectural site into the fabrication environment of the robot.

The paper will use recent research conducted on the topic of robotically applied architectural plaster as a case study to investigate alternative possibilities to create highly complex and unique modular architecture which confronts the homogenization of our built environment as a default setting.

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HISTORY SESSION I

PREFAB + SOLAR AT MIDCENTURY

Anthony Denzer, University of Wyoming

In April 1945 the New York Times announced: "Tomorrow, if it's a nice day in Rockford, Ill., a new house will go up.... It will combine two principles widely acclaimed as inevitable for post-war home building—prefabricated construction and solar planning."

As the Times indicated, prefabrication and solar heating were the two issues that would have interested any progressive architect in the mid-1940s. Yet the two movements rarely intersected. For the most part, architects interested in prefabrication did not pursue solar heating. And vice-versa, solar architects almost exclusively designed one-off custom site-built projects. This historical paper examines those rare instances of intersection, plus the wider affinities and contradictions between prefab and solar at midcentury.

CHERNER AND THE FHA: HOUSING RESEARCH IN THE 1950'S

Jane Murphy, Ohio State University

Perhaps best known as the designer of the Cherner chair, Norman Cherner was also the designer of many low-cost houses designed to be built of component parts. In a 1957 publication, Fabricating Houses from Component Parts, he presents 15 houses, with an average size of about 700 square feet, in three categories: panel, bent and girder construction. During the same year, according to the Cherner Chair Company web site,[1] Cherner's "Pre-built" home was assembled for an exhibition in Vienna by the U.S.Department of Housing, after which it was reassembled in Connecticut to become Cherner's home and studio.

This paper will compare the work of Cherner for the FHA with roughly contemporary work produced for the Housing and Home Finance Agency's Division of Research and presented to the public as "Housing Research paper 29: A Demonstration of New Techniques for Low-Cost Small Home Construction" (April 1954). The research and development of this project was carried out by the Small Homes Council at the University of Illinois at Champaign-Urbana.

The works will be scrutinized for the ways in which they were presented to and received by the public, the impact they had on the design and construction of low-cost single family homes in the 1950's, and the nature of architectural research and testing in the post World War II environment.

1 http://www.chernerchair.com/en/info_about_designers.php

MAIL-ORDER MODERN: SUPERMARKET MAGAZINES, VACATION CABINS, AND MODULAR MEASURE IN THE 1950S

David Hill, North Carolina State University

The November 1957 issue of Progressive Architecture (PA) published several articles under the theme "Modular Assembly." By addressing a range of issues including aesthetics, industrial production, and architectural drafting techniques, PA contributors illustrated a growing fascination with modular systems, and they established two main factors in the future success of modular design and prefabrication: 1) manufacturers' willingness to produce standardized, dimensionally coordinated building materials, and 2) architects' use of "Modular Measure" principles in their schemes. Modularity and prefabrication were gaining momentum among several trade and professional organizations at the time, and the American Institute of Architects, the Association of General Contractors, and the Modular Building Standards Association agreed to promote the "Modular Measure" standard based on a 4" grid. In spite of these optimistic developments, PA noted, "total 'prefabs' have never fulfilled the quantitative promise that they once made—and, in fact, as one builder has said, "the word prefabrication is anathema to the average public." [p.119]

Around this same time, Woman's Day Magazine (published by A+P Supermarkets) featured a series of mail-order plans for architect-designed vacation cabins. Quaint, easy to build getaways for middle-class suburban families, the cabins offered an ideal building type that would combine simple on- and off-site construction. Plans were marketed to the "average public," introducing many readers to modern residential design and—and perhaps less intentionally—modular construction.

PA warned that modular schemes risked sterility, but offered Japanese architecture as an example of grid-based modular systems with variety and grace. George Matsumoto, one of the leading proponents of modular standardization, had already begun exploring this idea. Matsumoto was an award-winning Japanese-American architect and professor in North Carolina following World War II. His design for a modular wood cabin became the first plans that Woman's Day offered, for less than $5 per set. Matsumoto's cabin, and others that would follow in the series, illustrated a novel approach to do-it-yourself retreats because their panelized components could be prepared off-site and attached to site-constructed frames. They provide an early example of architects working with manufacturers[1] and mass media in partnerships that promoted new materials and modular design to a burgeoning post-war audience.

This paper considers technological and social conditions that popularized architect-designed mail-order plans in the 50s and 60s; it examines vital concerns of practice and challenges that mass production and media posed to professional ethics. Standardization and modularity were changing design and construction practices, and they were giving architects new opportunities to have their designs built, perhaps by anonymous purchasers rather than familiar clients. Some architects saw this as an affront to the profession's dignity, but hindsight reveals how these examples from the mid-twentieth century were actually quite radical even as they sought mass appeal. They broadened public consciousness of modern design and challenged the architect's professional conscience. In these projects, the architects explored new possibilities for practice and modular/prefabricated systems. These designs are the precursors of today's wide range of made-to-order house kits, plans, and modules.

1 Douglas Fir Plywood Association sponsored prototype construction of Matsumoto's cabin.

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HISTORY SESSION I (CONT.)

OFF AND ON: SUCCESSES AND FAILURES OF PREFABRICATION OF HOUSES

Linda Brock, University of British Columbia

Architects have always been fascinated with the prefabrication of houses off-site—from the modern masters such as Gropius to the contemporary market-oriented architects such as Michelle Kaufmann. Yet, as noted by Colin Davies: "The early modernists put the prefabricated house at the centre of their programme of reform. Architectural history may pretend otherwise, but the fact is that their prefabricated house projects all failed."[1] The trend of failure continues. However this is not a failure of prefabrication but rather a failure of understanding production methodology, affordability, and cultural norms.

The industrialization of lightwood frame construction contributed heavily towards the success of on-site, mass-produced housing after World War II. This is true of the well known examples such as Levittowns and also of smaller developments. Prefabricated materials such as plywood and gypsum board replaced sheathing boards and lath and plaster. Construction was considerably speeded up with new, widely available tools, some as simple as the retractable tape measure that replaced the folding wood ruler, and the circular saw. World War II provided new processes such as the extrusion of aluminum that resulted in sliding patio doors. Off-site prefabricated units from windows and pre-hung doors to roof trusses reduced cost and sped up construction. From the small builder to the Levitts, the houses were constructed in an assembly line process with each trade moving from one house to another.

A component in the failure of architects in designing prefabricated homes has been the reluctance to address affordability, individual tastes, and need for community. Manufactured homes were often segregated by zoning into "parks" that were often quite pleasant communities and certainty affordable, as occupants did not own the land. The Long Island Levittown is still a viable community with some of the homes still occupied by the original buyers. The paternalistic attitude of many architects failed to recognize individual taste. After WWII people were quite set in their vision of a home and for the most part it was not modern. Their vision was a scaled down version of Mr. Blandings Builds His Dream House.[2] Scaled down meant a rectangular box of 800 sf, but similar to Mr. Balndings, with shuttered windows and, after the invention of float glass, a picture window to frame and announce your presence on the street.

This paper will give a brief review of the successes in prefabrication from the merchant builders such as William Levitt to manufactured housing under the HUD code. This will be contrasted with an analysis of the problems inherent with various modernist attempts. For example Gropius and Wachsmann's General Panel System homes used a module of one meter or 40-inches for the North American market, which was based on a 12 or 16-inch module. The mobile home designed by Frank Lloyd Wright for National Homes in 1970 may have been considered stylish to architects but it was never marketed as a commercial model.

Most importantly the paper will introduce the thesis that the true revolution in the production of housing has less to do with where the pieces are fabricated and more to do with the industrialization of systems, affordability, and an understanding of cultural desires including sense of community.

1 Davies, Colin, The Prefabricated Home (London, 2005)
2 RKO Pictures, 1948.

AN AMERICAN WARTIME DREAM: THE PACKAGED HOUSE OF KONRAD WACHSMANN AND WALTER GROPIUS

Alicia Imperiale, Temple University

The "Packaged House" is an extraordinary example of a prefabricated modular construction system designed by German emigrés Konrad Wachsmann and Walter Gropius during WWII. Its lyricism inspired László Moholy-Nagy to include a photograph of the prefabricated parts *packaged* for delivery in his groundbreaking book *Art and Vision* of 1946. The project is best known for its conceptual richness, but was never fully executed nor a commercial success, but still merits our attention today.

Wachsmann did not have a preconception of the perfect or final house—it remained an *open system* of 10 types of 40"x120" panels on a 40" module. The panels were designed for use as floors, ceilings, or walls and were connected on their edges by custom-designed flat wedge-shaped metal connectors. The *offsite* fabrication of coordinated parts for the house allowed for extremely rapid *on site* construction of the interlocking parts. It was also possible to completely dismantle the building and reinstall it at another site. In addition, many notable architects were invited to propose inventive uses of the parts which highlighted the aesthetic versatility of the system.

In February of 1942, the National Housing Agency allocated $153 million for the development of prefabricated housing for displaced defense workers with a production target of 42,000 houses. In September 1942, the General Panel Corporation was set up to begin the manufacture of the "Packaged House." Wachsmann worked on the project constantly refining the fabrication of the parts, but by May 1945 with the end of WWII, the house was still not in production.

After the war, the General Panel Corporation received Federal grants to be able to take over the former Lockheed Aircraft Factory in Burbank, California. Factories that made armaments could be retooled to make houses for returning GI's and their families! Wachsmann designed the factory production line and machinery and all was ready by mid-1947, but the project erred in its timing again, as the Veterans Emergency Housing program was cancelled.

Wachsmann himself slowed down the process many times along the way. When his ingenious 4-way connector was ready to go into production, he retracted the design, slowing down the process, with fatal results. He had missed his timing, as his custom designed panels were then too expensive to fabricate and were replaced with standard joists and framing, completely destroying the ingenuity and integrity of the prefabricated system.

This was too much for Wachsmann, because it completely undermined the *universality* of the SYSTEM, which was of utmost concern for him. The title *The Dream of the Factory-Made House: Konrad Wachsmann and Walter Gropius*,[1] is telling in that the "Packaged House" remained a dream in that it never did in fact go into production. This is a shame, as the system was an incredible achievement that deserves attention today. Wachsmann is also known for his Mobilar space frame system and his designs for the USAF hangers. These other important projects will be briefly discussed in conclusion to the focus on the Packaged House system.

1 Herbert Gilbert, 1984.

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INDUSTRY INNOVATION SESSION

TECHNICAL AND ECONOMIC CHALLENGES FOR MODULAR CONSTRUCTION IN THE UK AND EU

Ray Glenn Ogden, Oxford Brookes University

This paper will review key technical challenges and solution strategies for modular construction in the UK and EU. These include:

- Economic pressures associated with the varying throughput of off-site manufacturing facilities: This has become acute during the current construction industry down-turn. The imperative to meet the fixed operating costs associated with facilities has led to the demise of both large and medium scale operations. Competition with conventional on-site systems is fierce and greater quantification of the economic advantages of the form of construction is required.

- Carbon reduction: UK and EU governments are committed to low and zero carbon buildings combining very high levels of building envelope performance with low carbon heating, cooling and lighting strategies (and ideally low unregulated energy use). Modular buildings systems have responded by adopting detailing strategies, passive performance approaches and novel plant that can, in combination, deliver the required standards. Despite this it is likely that considerations of aggregated embodied and operational energy will require further design developments particularly for buildings with shorter (25 years and less) design lives.

- Design Quality: The offsite building sector has historically been characterised by relatively low standards of performance and restricted architectural opportunities. Modern systems however offer considerably enhanced performance in areas such as structural stiffness, acoustics and thermal comfort whilst allowing far greater geometrical freedom and good aesthetics.

- Supply, Procurement and Risk: The industry is contending with high levels of perceived risk associated with single point supply and tendering, and contractors, developers and clients tending to view the technology as unconventional and of higher risk. Levels of confidence, awareness and understanding require improvement in order to secure greater willingness to engage with modular solutions.

- System Evolution: Drives to improve efficiency are leading to a broad range of approaches many aimed at increasing the off-site content of buildings beyond room volumes. Areas of innovation include modularised services, lift and stair components, facades and foundations.

This paper will summarise the current state-of-the art in relation to design trends and methods and will outline the key developmental issues facing the sector and recommendations for how aspects of these should be addressed. Resolution of these issues is urgent in order to secure the continued development of the sector.

LOGISTICAL ASPECTS OF PREFABRICATION

Emanuel Jannasch, Dalhousie University

When and how to prefabricate are subtle questions that can't be answered by novel hardware, more capital, or blind faith in the factory. And even solutions that have proven successful in their own time (e.g. precut houses in the interwar years, preassembled wood-frame wall panels in the seventies) – may lose their viability to broader developments in the technological landscape. This paper unravels some of the logistical factors that determine when prefabrication makes sense and when it doesn't, and which approaches to prefabrication can succeed in what kinds of contexts.

The central concept is specific value, or value density. Primary manufacturers add value by reducing the net volume of material. A sawmill doubles the value of wood while reducing it by a factor of 3, for an increase of volume-specific value by a factor of 6. House-framing doubles the value of material again, but increases the volume something like 20 times, so specific value is reduced by a factor in the order of 10. Sawmilling and other primary manufacturing processes naturally take place close to the resource, to minimize transport costs. Construction tends to take place closer to the site, again, to reduce transport costs. Building components and sub-assemblies can also be understood in terms of specific value. Vinyl windows, for example are of a middling value density and are assembled locally out of higher specific value extrusions and hardware that can be shipped from afar.

A survey of freight calculations shows that volume is the dominant factor in transport but that it's far from exclusive. Weight plays a role, but smaller than may be anticipated; various kinds of fragility and climate sensitivities are actually more important. Prepping and handling are also significant. Understanding these factors helps explains why prefabrication is more successful in some aspects of building than others, and why success depends on geographic factors. The differing importance of capital in securing marginal advantage in a given process is also important. Accordingly, some industrial processes are vulnerable to lower-capital competition, others are more secure. Finally, we need to look at some hidden costs of the factory, and some unexpected economic advantages to the decentralized system of mobile piecework-subcontractors that have proven so remarkably resilient over the past century and more.

Overall we discover that each conceivable building component, preformed, pre-assembled or otherwise, has its own context-dependent radius of viability. Centralizing their separate manufactures in a comprehensive plant may simply mean that many components end up getting shipped farther than their value density warrants, or not far enough to give their production machinery a viable market.

However, understanding the principles and evolution of logistics will help us envision new ways of systematizing buildings and components. Some of these are in evidence today, some are yet to be realized. Together they suggest new kinds of construction economy. They also support a more elegant integration of systems, and a better orchestration of visual elements, intervals, and proportions.

INDUSTRY INNOVATION SESSION (CONT.)

A CASE STUDY ON MULTI-TRADE PREFABRICATION

Kihong Ku, Philadelphia University
Paul Broadstone, Virginia Tech
Anthony Colonna, Skanska USA Building

While off-site prefabrication in the construction industry has become synonymous with efficiency, economy and quality, the authors question if the benefits of centralized ‘prefabrication’ can be brought closer to the site to mitigate the economic and energy impacts of packaging and transportation. Anecdotal evidence shows that a number of projects have employed near site prefabrication strategies to (a) reduce transportation cost; (b) escape shipping limitations that prevent producing larger units which would be beneficial to reduce installation time; (c) reduce cost in packing and shipping; (d) reduce construction tolerance accumulation of in-situ assembled components; (e) avoid joint assembly errors; and (f) improve safety and ergonomics during site erection. The authors are proposing a paradigm shift from centralized manufacturing to distributed manufacturing that may change how products are made and delivered to the site. This paper focuses on one of the new methods of distributed manufacturing which is reviewed through a detailed case study on multi-trade prefabrication – an innovative approach improving the construction of buildings (particularly hospitals) by assembling subcontractors in a local warehouse to construct MEP ceiling racks, patient room bathroom pods, and patient room headwall assemblies.

The authors discuss how a company successfully introduced and implemented a multi-trade prefabrication strategy of mechanical, electrical, plumbing (MEP) and drywall trades in a $152-million, 12-story Project. The Project involved unique engineering, manufacturing, and lean contracting strategies that enabled the multi-trade prefabrication strategy and contributed to overall quality improvements, time and cost savings, and safety enhancements. The use of BIM for the 3D layout and design of modularized ceiling void modules, the use of a warehouse near the jobsite for multi-trade preassembly, collaboration between union and open-shop contractors, just-in-time delivery of prefab units are a few examples of the process innovations. To help the company operationalize new types of integrated production processes, the authors have investigated the project planning, design, procurement, construction processes and have examined the benefits of multi-trade prefabrication on project performance.

This paper attempts to capture and integrate the lessons learned in this project to diffuse innovative best practices and develop new value-added business models. As the design and construction community considers fabrication strategies for the future, the authors discuss the opportunities to consider new business models for construction that allow to take advantage of factors such as BIM and engineering capability, an international infrastructure, and well-developed supply chain capacities. The paper opens up questions about how this new multi-trade prefabrication approach can become both viable and profitable migrating from traditional contracting businesses to value-added engineering and off-site construction.

HERE TO SERVE YOU: CUSTOMIZED FABRICATION IN HISTORY AND PRACTICE

Liane A. Hancock, Louisiana Tech University

The application of new technologies in conjunction with visionary business practices has allowed a select group of fabricators to fundamentally influence the built environment. Examining the contemporary metal fabricator Zahner, with supporting historic research on James Bogardus and Francois Hennebique for comparison, this paper reveals systemic approaches to customization, detailing, proprietary control, and labor relations.

Off-site fabricators who deliver total customization in conjunction with precision of detailing allow architects to subvert the appearance of repetition within prefabricated systems. In the 19th century, the architect and fabricator James Bogardus produced innovative cast iron façades. Each installation was infinitely differentiable utilizing customized components to produce a variety of widths of window openings, depths of façade, and detailing of ornament. At the turn of the 20th century, Francois Hennebique’s patented reinforcing steel system provided a refined and versatile method for developing reinforced concrete structures that revolutionized building construction across the globe. Today, Zahner designs and fabricates metal skin systems which allow each unit to be customized in x y and z planes. In addition, Zahner has developed systemic connections to structure that provide further customization, precision, and integration of performative capabilities such as concealed drainage. Patented fabrication processes secure advances in technology, but are also often used as a method of advertising. Both Bogardus and Hennebique distinguished the quality of their products by marketing the exclusive ownership of their fabrication processes. By utilizing workmen who were either directly employed or licensed by these firms, trade secrets were maintained. Today, Zahner holds patents and trademarks on a wide range of services and products: a digital design interface, a structural calculations system, a patterning program, and many proprietary coatings. All expertise is maintained in house through the control of fabrication and installation.

Prefabricated units often allow the use of less skilled labor during installation. If a prefabricated system is highly customized then it becomes necessary for the fabricator to maintain control of labor. James Bogardus, as a fabricator, outsourced production of his cast iron components to independent foundries, but utilized his own workforce for installation. Hennebique ensured quality control through an innovative business model built of franchised offices and licensed contractors that, while typical in today’s market, was unique among his contemporaries. Today, Zahner’s workforce completes installations across the globe, requiring the negotiation of labor contracts with localized unions. As Zahner has broadened its scope beyond sheet metal installation to erection of structure, these negotiations now span between trades, instituting a unique relationship between iron workers, sheet metal workers, and Zahner’s operations. Zahner, Bogardus, and Hennebique are each distinguished by their profound understanding of marketing to an audience of designers and clients seeking infinite customization while requiring warrantee for the quality performance of their products. This understanding in conjunction with their advancement of innovative technology distinguishes these fabricators as instrumental in evolving the built environment.

INDUSTRY INNOVATION SESSION (CONT.)

CUSTOMIZED CONTAINER ARCHITECTURE

Adrian Robinson, Oxford Brookes University

Large-scale urbanization with transitory populations require buildings with even greater adaptability than ever before; buildings that can be designed, commissioned, and assembled with great agility, and then later disassembled using similarly efficient methods. With the emergence of Building Information Modelling (BIM) and Computer Aided Manufacture (CAM) this has opened the possibility of a more agile, customised building product optimized through prototyping, and an integrated design approach for assembly and operation. By using the ISO intermodal container platform, with its universal components and mature manufacturing base, the building product becomes an internationally deployable modular volumetric building with factory finishes, well insulated and air-tight spaces, and capable of use in low to high-rise construction. The research draws on precedents, recent project case studies and virtual and physical prototypes to measure the effectiveness of BIM on analysis, detailing and manufacture, thereby enhancing the value in customised container building design. The use of container technology offers a unique case-study of transdisciplinary innovation and product development transferred directly from manufacturing into construction.

ITERATIVE RESILIENCE: SYNCHRONIZING DYNAMIC LANDSCAPES WITH RESPONSIVE ARCHITECTURAL SYSTEMS

Meredith Sattler, Louisiana State University

On September 1st, 2008 six foot waves hit Grand Isle, Louisiana, destroying numerous buildings in their path. Caused by Hurricane Gustav, the storm surge rolled right over most of this seven foot high barrier island. This was the sixteenth storm that caused major damage to buildings/infrastructure there since the 1893 hurricane (which killed nearly 2,000 people with 130mph winds and 16ft storm surge) and not only devastated the island, but shifted its landmass northeast. In this landscape of devastating forces, unstable ground, and cyclical change, structures that typically last decades are rendered temporary. This paper investigates how a specific deployment of prefabricated architecture creates an adaptive, resilient solution to shifting sedimentation and settlement patterns on Grand Isle, and other barrier island coastal communities.

Because Grand Isle is continuously transformed spatially by climactic, morphological, and resource driven disturbance regimes, altering the island's physical shape, size and socio-economic conditions, it is an ideal case-study site for semi-mobile modular deployment. Currently, most buildings there are elevated on piers to mitigate hydrodynamic destruction caused by seasonal storm winds and flooding; when land beneath them disappears, they are decommissioned. Instead, we propose that modular, elevated structures shift across an expanded grid of friction-pile structural foundations, readjusting their location relative to the transforming landscape, in order to "nestle" into post-disturbance configurations. As the island arcs increasingly southeastward, the building modules are detached, relocated and reattached, via gantry cranes, to the pile grid.

Residences and critical infrastructure buildings, comprised of modular units are elevated above the Base Flood Elevation (BFE: the surface water elevation resulting from a flood with a 1 percent chance of equaling or exceeding that level in any given year) to avoid devastating hydrodynamic forces. But when residences are raised this high, they lose essential connection to the ground plane. The proposed module system organizes units at different levels of elevation and durability, and allows for flexible porches and circulation that mitigate the section between ground and suspended unit.

The most durable modules containing the most critical equipment (e.g. MEP) are elevated safely above the BFE while the building's programmatic spaces step to the ground, suturing the gap between building and earth. As the landscape and structures shift, the pile grid indexes former building locations and change through time, while supporting accessory program and infrastructure.

This adaptable modular design creates an integrated built environment, in an unforgiving landscape, expanding architectural scope and agency through the process of reconfiguration. The module systems ship on barges from the factory, are offloaded with gantry cranes, and brought directly to the building site. The crane lifts modules to their specified height, and the units are fastened into the pile grid (this process will be detailed in the paper). Through the periodic adjustment of module height and location, the architecture remains dynamically responsive to its landscape. Likewise, the architectural process is elongated as siting, design, construction/assembly, and inhabitation iterate to ensure the long term occupation of Grand Isle.

THURSDAY, SEPT 27, 2012 - 3:30PM - 5:30PM

MATERIAL INNOVATION SESSION I

AAC TEXTILE BLOCK SYSTEM

Lawrence Blough, Pratt Institute

Developed as research funded by a 2010-11 NYSCA Independent Projects Award, this paper investigates the form finding and structural potentials of Autoclaved Aerated Concrete (AAC) as an integrated wall and vault assembly system. Using a combination of off-the-shelf AAC products and prefabricated custom components milled on a CNC 3-axis machine, complex forms and intricate surfaces can be developed that are easy to build without highly skilled labor. Using a limited set of components, coded instructions are embedded in the geometry of special joining blocks for ease and speed of erection. Single and double curved vaults can also be produced using precut AAC block types assembled on reusable CNC milled plywood molds.

By using traditional masonry corbelling techniques combined with prefabrication, an alternative AAC component wall system is designed to produce a novel tectonic. Instead of privileging the flatness of the standard AAC assembly system, the size of the modules and ease of workability of AAC can be exploited to quickly construct wall and vault surfaces that are self-supporting. Because the system is non-combustible, insulating, customizable, and requires few additional finishes to produce an efficient envelope, it is well suited for settlement construction following disaster relief.

INVESTIGATION OF THE PROCESS OF DIGITAL DESIGN, VIRTUAL PROTOTYPING, SIMULATION TESTING AND CNC MANUFACTURING OF CONTEMPORARY "POST-AND-BEAM" TIMBER FRAMED BUILDINGS

Faidon Nikiforiadis

Today's building industry is dramatically impacted by the increasing cost of energy, inefficient building methods and the high cost or unavailability of capital. As a result, many forward-thinking developers and public agencies are seeking new options to build energy efficient, cost effective and highly durable buildings, while minimizing holding costs through reduced construction timeframes.

This paper presents the first results of a R&D project conducted in order to deliver a unique solution to meet the needs of these market leaders. The principal aim of the ongoing research and development project is to gradually produce net zero energy multifamily housing and mixed-use structures for sustainable communities, focusing on urban infill, transit-oriented development, public land development and educational campuses.

The work presented demonstrates how precision-built structures, produced in a clean-tech off-site production facility, will be able to exceed the performance of site built at no additional cost while minimizing resources, waste and CO2 emissions.

Recent market forecasts, new government policies and standards indicate that in the next decades there will be a growing market for zero energy and high-performance buildings.

The paper presents an investigation of the Process of Digital Design, Virtual Prototyping, Simulation Testing and CNC Manufacturing of Contemporary "Post-and-Beam" Timber Framed Buildings that can transform the conventional method of construction to a technology-driven model that meets the demands of the future.

PATTERN AND PERFORMANCE: A CAST STUDY

Andrew Cruse, Washington University in St. Louis

This case study presentation will focus on the design and fabrication of a unitized rainscreen curtainwall for a multi-purpose university building on a prominent Manhattan site. The curtainwall's outer leaf is laminated stone which at certain areas is perforated (up to 35% openness) based on a custom pattern. The façade is the result of a international procurement and fabrication process—the stone was quarried in India, prepared in Italy, assembled into unitize sections in Canada and erected in New York. The curtainwall was manufactured using a design assist process working with a prominent curtainwall manufacturer and a curtainwall consultant.

TESSELLATING TERRACOTTA: THE PERFORMATIVE POTENTIAL OF CERAMIC SYSTEMS FOR PREFABRICATION

Clare Olsen, California Polytechnic State University

Abundant and derived from the earth, clay is inexpensive and capable of being manufactured on both small and large scales. When applied to building facades, ceramic is durable and self-cleaning and one of the more durable and sustainable moldable materials that can be formed into highly textured modules. Perhaps it is because of these factors that numerous high-profile ceramic-clad projects have made their mark within contemporary discourse. These include the brightly colored and texturized Central Saint Giles by Renzo Piano and the digitally crafted, peeling rainscreen of Enric Ruiz's Villa Nurbs. The material can take on formal qualities of ornament, coloration, pattern and texture, while the craft has historically managed tessellation with precision and ease. In addition, ceramic performs really well as an ecological material both in terms of its moldable qualities (it can do work through form), and material properties (it can do work through molecular structure). There are numerous historical and contemporary examples of sun and rain mitigating screens and water-shedding surfaces, but there is also tremendous potential in the material to collect and filter water. Given the performative potential of designing with ceramic at the building scale, the ancient material has untapped potential, however, there are still a number of challenges to a more wide-spread use in the building industry. This paper identifies key factors in the proliferation of ecologically-minded designs encorporating this material system, offering case study examples, analyses of current design and construction practices as well as speculations on the potential of the material in prefabricated, performance-based systems.

FRIDAY, SEPTEMBER 28, 2012 - 2:00PM - 3:30PM

COMPONENT SYSTEMS SESSION

OFF BUILDING PRE-ASSEMBLIES: BUILDING ENVELOPE SYSTEMS PRE-ASSEMBLED FOR OPTIMAL MODULARIZATION AND IMPROVED WORKFLOW

Minjung Maing, Georgia Institute of Technology

Building envelope systems with its variety of building materials and methods of installation create many problems of integration with different and adjacent systems when installed on the building. Some of the most successful installations with few integration issues, are of unitized modular curtain wall systems, where much of the assembly of individual module units are done off-site in the factory, tagged, brought to the site and installed in its entirety on the building. The attachment of the curtain wall system to the building structure allows for implementation of this workflow, however similar variations of this workflow concept for other systems need to be addressed to take advantage of similar efficiencies. A level of panelization of the envelope system can also be suggested for non-curtain wall systems and concurrently with a different workflow process. Rather than consolidating the fabrication with the assembly process as done in curtain wall systems, the concept of creating staging grounds for pre-assemblies off the building and even potentially in a proximate site would lend much more flexibility for integration of different types of building envelope systems prior to attaching to the building.

Pre-assembled units would allow opaque wall assemblies, consisting of multiple layers to form the environmental separator from interior to exterior, to undergo the level of quality assurance that curtain wall systems undergo prior to being placed on the building. Whole Envelope Assemblies (WEA) as suggested by the term, will encompass not only the outer layers but the whole wall section, which would be pre-assembled prior to attachment to building similar to its modularized counterpart, the curtain wall.

Hybrids of this concept has been used in some project applications where complexities of the design inherently led to the adoption of more integrated assemblies off-site, primarily to reduce confusion and minimize excessive site work during installation on the building. However, WEAs are geared to be general enough to apply to different ranges of complexity, materials and re-allocate resources to a more safe setting allowing for more focused resolution of the designed and selected envelope systems. The pre-determined staging ground would also create easily accessible arena for studying performance criteria through mock-ups and testing, prototype testing, assembly reviews of the envelope leading directly into full assembly sequence on the same grounds. Analogous to integrated project delivery's premise of early team collaborations for more efficient design process and problem-solving, off-building pre-assemblies provides a workflow and platform for uninterrupted design/fabrication/assembly exchanges, higher intensity quality-controlled work off-site, and shorter on-site work of attachment to the building.

This paper will discuss the conceptual advantages for Whole Envelope Assemblies, use case studies of modularized curtain wall systems to form analogies to modular WEAs, assess current industry practices for design and installation of non-curtain wall building envelope systems, and present test cases of WEAs. The evaluation of the applicability and benefit review will be presented as a collaborative study of industry applications with test applications performed in the academic setting of students applying WEA building envelope concepts to architectural studio design projects.

SCALING DESIGN: UTILIZING MULTI-CRITERIA OPTIMIZATION TO PRODUCE MASS-CUSTOMIZED HOME DESIGNS

Michael S Bergin, University of California, Berkeley

The design of houses has become a highly mechanized process with the most recently available data generously indicating that 28% of houses have direct involvement with an architect. The vast majority of homes in the United States have been built using mass-production tract housing methods where similar home plans are copied, mirrored and rotated to create cul-de-sac communities in suburbs throughout the country. The author proposes a design system that combines Multi-Objective Optimization algorithms with Building Information Modeling parametric software allowing for architects to loosely prescribe designs that can then be tailored to each individual family and variable climactic conditions through the optimization process. The author presents a series of flexible design methodologies for the tailored production of search spaces or Design of Experiments (DoE) for the optimization of the house model for a variety of criteria. A typical optimization routine takes a flexible parametric model and manipulates parameters either through a brute force method (testing every possible scheme) or using a search method such as genetic algorithm or simulated annealing to find the most optimal solutions.[2] In this study, the criteria used to determine an optimal solution is made possible through goal sets, algorithms that code the preferences of an individual designer or community of homeowners by weighting the importance of performance criteria. The accuracy and success of a goal set in driving a flexible parametric model towards a desired solution depends in large part on the type and number of simulations that are loaded into the design software environment. Simulated criteria that have been implemented include day lighting analysis, minimal code compliance, power consumption, cost based on RSMeans construction data, and a variety of spatial adjacency and size requirements.

The availability of modeled family elements produced by many building product manufacturers allows catalogues of building elements to become part of the search space. Instead of modeling generic surfaces and volumes in the design software, actual building components can be dispatched at the design stage. A robust database of prefabricated components would effectively allow a design to search for alternative means of manufacturing itself that may be unknown to the designer. A database of pre-used construction materials is proposed so that solving algorithms can present these alternatives to the designer/client for evaluation as potential solutions and reduce the embodied energy required for new construction projects. The fact that 72% of houses are not designed for their site and inhabitants is troubling. Each community and building site has unique needs and conditions that are rarely addressed in the current system of production. In 2010 there were as many out of work architects as there were homes built by the five largest home builders in the United States.[3] A system as described would make it cost effective for these architects to interface with clients who desire customizations to a home through a web interface. The successful implementation of this mass-customization design system will bring about more comfortable and unique housing solutions that use less energy, receive more daylight and are produced in the most effective manner for durability and cost.

1 LaBarre, Suzanne. "Truth in Numbers." Truth in Numbers. Metropolis Magazine, 15 Oct. 2008. Web. 30 Mar. 2012.
2 Flager, Forest, Welle B, Bansal P, Soremekun G and Haymaker J, 'Multi-disciplinary process integration and design optimization of a classroom building', ITcon, Vol 14, 2009, pp 595–612.
3 Hughes, CJ "Exactly How Many Architects in the U.S. Are Unemployed?" Architectural Record, 10 Oct. 2010.

COMPONENT SYSTEMS SESSION (CONT.)

ARCHITECTS + MANUFACTURING: A CATALOG OF ARCHITECTS CUSTOMIZING REPETITIVE BUILDING ELEMENTS

Dana K Gulling, North Carolina State University

This presentation will identify a catalog of architects who have customized manufacturing processes for the design of repetitive building elements in their buildings. These customized repetitive elements differ from building components fabricated with Computer-Aided Manufacturing (CAM) equipment. Although CAM has transformed a large sector of manufacturing, there are a number of manufacturing processes that use high-cost molds and thus rely on high production runs or repetitive elements to be profitable. I will present a catalog of case studies of architects and their projects that demonstrate the customization of repetitive elements.

THERMAL PERFORMANCE ISSUES OF GLAZING FACADES AND THE USE OF ENVIRONMENTAL PARAMETERS IN EXTERIOR SHADING DEVICE DESIGN

Nik Nikolov, Lehigh University

Today the architectural profession vastly sees its future in the interplay and balance between the natural and built environments. We seek to establish a functional interface between the two and in doing so to improve building performance. We have become dependent on software and numerically-controlled fabrication technologies. We increasingly embrace biomimetic approaches as practical strategies that preference novel and complex forms. We evaluate buildings through performance driven criteria that emphasize the environmental and structural parameters that shape them. These trends in architectural design offer designers, engineers, and contractors the opportunity to combine qualitative and quantitative research methods with flexibility and speed and to address better the environmental demands on and consequences of our buildings.

The building envelope, a.k.a. building façade or building skin, is the most important subsystem of the building, serving as the link between all other components of the building system (struc¬ture, technical services, and the interior walls of the building) and the exterior environment. In the United States, buildings consume 40% of primary energy[1] and 72% of electricity consumption.[2] The commercial building sector's contribution to the overall de¬mand is projected to increase faster than any other sector, and take over the electricity demand of the residential building sector by 2014. Each of these energy demands is closely related to the building en¬velope, and can be decreased with efficient envelope design.

This paper documents the research conclusions, design development, fabrication, and installation of a prototype for exterior shading screen for East and West facing glass curtain wall façades. The screen requirements are to provide full shading of a case-study building's large transparent glazing façade over a pre-determined period of time, provide optimal surface for rain water shedding, as well as optimal porosity to allow for natural light penetration and ventilation. The screen utilizes proprietary self-cleaning photocatalyitic cement sections (TiOCem®) which react with and neutralize common air pollutants such as nitrogen and sulfur oxides, carbon monoxide, and VOC's.

The design and fabrication of the prototype use parametric scripting software that enables environmentally derived data to be incorporated seamlessly into the design process. Data of the building's location, sun position, average rainfall, predominant wind directions, and hours of daylight is taken into account in the form-generation of building envelope components. Through the advanced capabilities of Rhino Script, Visual Basic, and Grasshopper® (parametric modeling module to the NURBS modeling software Rhinoceros™) the goal is to directly correlate environmental variables, such as solar stress, orientation, day lighting levels, ventilation, and others, to component fabrication machines (CNC router, 3D printer, laser-cutter, and water-jet cutter). The algorithm takes advantage of the sun position based on previously published in the public domain algorithms.

1 Environmental Information Administration (2008), EIA Annual Energy Outlook
2 ibid

FRIDAY, SEPTEMBER 28, 2012 - 2:00PM - 3:30PM

MATERIAL INNOVATION SESSION II

RECASTING PRECAST: PEDAGOGY, PRODUCTION, AND PERFORMANCE WITH PRECAST CONCRETE WALL PANEL SYSTEMS

Matt Burgermaster, New Jersey Institute of Technology

This paper describes the pedagogy, process, and projects of a recent industry-sponsored, integrated design studio focused on experimentation with precast concrete in contemporary design applications. Sponsored by the Precast/Prestressed Concrete Institute + Foundation (PCI) and the Mid-Atlantic Precast Association (MAPA), it provides students the 'hands-on' opportunity to work directly with precast concrete materials and systems, their fabricators and suppliers, and professional architects and engineers. As a multi-year partnership the studio aims to advance a collaborative, approach to design education that integrates industry-based knowledge of offsite production with design thinking prevalent in performance-based architectural practice.

While renowned for its constructive brawn, technical advantages, and economic benefits, particularly in industrial building types and infrastructural work, precast concrete has had a comparatively limited application in design-oriented, architectural projects. Indeed the precast concrete industry categorizes its products as either 'structural' or 'architectural' types, a distinction that also reflects a broader, long-standing segregation of the various players in the A/E/C industry, roles they play, and criteria they use to measure success. Such divisions also mirror the persistent difficulty in reconciling the mandates of standardized production methods used to maximize efficiency and ensure quality control (typically the responsibility of the precast contractor) with performance criteria that require a more multivalent, responsive approach to the design of a building's relation to its specific physical, environmental, and cultural contexts (typically the responsibility of the architect). The studio seeks a more integrated and robust relationship between the realms of production and performance. Such ecologies of construction propose an alternative approach that treats a building as an interdependent, adaptive system as opposed to an accumulation of separate components, the result of dissimilar processes, or creation by independent authors - in short, that a building be greater than the sum of its constituent parts and that it act that way.

The course provides an opportunity for student exploration of these issues at an advanced level of creative inquiry, design integration, and technical resolution. It features an intensive, semester-long investigation of a single material type (concrete) and construction process (prefabrication) with a specific focus on the design and development of high-performance precast concrete wall panels and building envelope solutions. As such, the students address problems of surface, form, material, and performance in response to a range of specific site and program-related design criteria. Within workflows that reverse the traditional design-to-construction process by starting with offsite production means and methods, they are challenged to consider both the typical constraints of precast panel production (i.e. panel size and number of form 'set-ups') as well as the potentials of emerging technologies, such as high strength concrete, CNC-milled formwork, and architectural mold/formliner systems, as opportunities for creative invention. This design pedagogy aims to develop an understanding that an effective use of the efficiencies of offsite production is a contextual, strategic practice and, in-so-doing, recast precast concrete wall panels as a state-of-the-art technology for architectural applications.

MOLDED REMEDIATING MODULES: PREFABRICATED COMPONENTS FOR IMPROVING INDOOR AIR QUALITY AND CONDITION

Carmen Trudell, California Polytechnic State University

Prefabrication in architecture holds many promises for reduced material consumption and reduced energy consumption. This we all know well as it has been the promise since the days of Buckminster Fuller, the Metabolists, and Charles and Ray Eames just to name just a few examples. The impact that prefabrication could have on human health has not been explored as deeply as the first two environmental imperatives. Indoor air quality (IAQ) is a compounded issue that if properly addressed through design and construction could have a two-fold benefit. By alleviating the burden of poor indoor air quality, we would both promote healthier occupants and reduce the demand on our heating and cooling systems thereby reducing building use energy.

There are two methods by which prefabrication can positively affect indoor air quality. First is by prevention of off gassing by materials into an enclosed space meant for human occupation. Virtually all plastics, particle boards and other wood composites, adhesives, coatings, and floorings release volatile organic compounds (VOCs) such as formaldehyde and toluene. Many of these VOCs have been linked to respiratory ailments, nervous-system degradation, and cancer. Due to the extreme control, and the ability for designers to be fully engaged in a prefabrication construction process, toxic materials can better be avoided. Also many materials off gas VOCs for a very short duration after installation and then are no longer harmful. Off-site fabrication can address this time lag in the cases where a suitable non-toxic material is not available by applying these materials in an environment where proper precautions can be in place for the appropriation time period.

The second way that prefabrication can address the subject of indoor air quality is by allowing the building materials themselves to actually destroy harmful toxins. Several case studies, including original works by the author, will demonstrate how modular wall systems can successfully integrate air cleaning. A test case sited in Cairo, Egypt uses three different types of air remediating modules for three different scales of pollutants. The modules address particulates (sand storms), gasses (VOCs and other combustion gasses), and heat. These modules can be fabricated from a myriad of ceramics including soils, clay, and concrete in a process that has negligible material waste, and yet produces a beautiful and controlled product. The control afforded by off-site manufacturing is essential for these high-performance modules as the geometries needed to perform on-site particulate separation, for example, is complex and requires highly skilled craftsman to produce. Yet, once the formwork has been created and calibrated to the specific range of particle sizes, the molds can be used repeatedly furthering the material efficiency of the production system.

A tipping point exists where off-site fabrication will undoubtedly prevail as a superior method of constructing buildings. Inclusion of human health performance criteria into the milieu of issues that this method of construction can address will only help push us toward this tipping point.

MATERIAL INNOVATION SESSION II (CONT.)

DIGITAL CONCRETE FABRICATION: CONCEPTS IN PARAMETRIC FORMWORK

Nathan Howe, Kansas State University

Given the piecemeal nature of concrete formwork, the phenomenon of the monolithic result relies on elegant detailing, material choice, and formal continuity. Creating complex form out of concrete poses an intriguing problem, where these disparate constructive elements must be dynamic and flexible. This paper describes the design process for a public spray park competition project. The challenges inherent in the proposed forms included subtle reveals and ledges for water to flow down for its intended purpose. Although concrete is an especially plastic material, often referred to as liquid stone, achieving the desired "liquid" finish for the concrete requires a precise, digitally generated form, particular materials and prefabrication sequence. The project fabrication gives parametric control to CNC fabrication tools for an output of fluid form with a glass-like finish.

The construction precedent in architectural concrete is similar to that of inverted countertop and sink casting, a rigorous procedure for flat forms alone. The programmatic and conceptual aims of the spray park generated forms reaching the size of twenty-five feet by six feet tall by six feet wide, all with non-planar surfaces. To bring the project development in line with the construction logic, every form was designed using ruled surfaces. A parametric model was constructed to define a series of curves from which surfaces were developed. This method allowed for a flexible series of formal and structural designs to be culled through. These tests were then unrolled and a series of paper models were constructed to gain insight on how far to push the geometry along with testing the accuracy of the digital model. After these tests, scaled forms were cast in laser cut acrylic molds, simulating the full-scale process and finish quality.

The benefits and limits of prefabrication and transit have always been critical considerations in the design process. Once the forms are established each one must be strategically broken into a panelized system, with a site-scaled grid defining a generative pattern for subdivision. The resulting precast panels will not be conventional but three-dimensional bent forms held rigid by their curved geometry. At the same time, maintaining a concrete finish which will hold the reflective qualities of glass and reveal the engraved pattern etched into the acrylic is a monumental challenge.

Currently this work is being pursued through small-scale mock-ups. Analogous procedures are being developed to better understand how the acrylic reacts to bending and joining. These prototypes are then tested with concrete pours gaining continual insight in what achieves the desired finish. These tests, and the project as a whole, aim to bring constructive techniques and parametric process into better alignment through a rigorous material investigation. The particular challenges and opportunities of concrete mold generation are well-suited to parametric control, where global changes in components and joinery may result in newly expressive materiality.

MODULAR COMMONS: Z-BLOCKS

Srdjan Jovanovic Weiss, Temple University

The presentation will deliver research on modularity in relation to intimacy and commonness in public space. The modular environment of "Z" Blocks are lightweight reconfigurable blocks that can be used in multiple ways thanks to their smart geometry resembling the Latin letter Z. Designed for diverse artistic environments, the blocks' adaptive design make them simple to arrange into individual, social, and hybrid configurations of varying sizes and degrees of formality and intimacy. The blocks can stand alone as chairs or be combined together to form shelves, benches, tables, bars, walls, podiums, columns, and stairs. The "Z" Blocks set the stage in the broadest sense as an immersive environment for performers, audience and participants alike. Furthermore, the "Z" blocks can be arranged vertically into building partitions, niches, and walls.

Instead of following Le Corbusier's widely published "Modulor", the proportional set of dimensions to cater the human body in interior, "Z" Blocks are serial and focus on a singular and engineered profile that can be repeated. The geometry and angles of a single "Z" block are derived from US medical recommendations for using prosthetic devices offering better sensual comfort during sexual encounters. The specifications of geometric angles offered by the US sexologists informed the skewed angles of the "Z" block.

The paper will present the challenges and successes of the design process, geometry, fabrication, adaptive use, and performance of this product. By the time of this abstract there are three versions of "Z" Blocks produced (1.0, 2.0, 2.1) each with smarter engineering than the previous. They were presented at St.Marks Church (for Danspace contemporary dance community), at the Museum of Contemporary Art of Vojvodina in Novi Sad, Serbia (for the exhibition Ideology of Design) and at The James Gallery, Graduate Center, CUNY in New York (for Prelude series of artistic performances). The version 3.0 is currently in production.

SPECIAL FOCUS SESSION: THEORIES OF FABRICATION PLENARY

INDUSTRIALISED BUILDING SYSTEMS: THE 'PALETTE' OF OPTIONS

Roger-Bruno Richard, University of Montreal

As an industrial product normally comes out of the factory completely finished, the same is expected with buildings. Factory production ("pre" fabrication) is the first degree of industrialisation. The next step is to apply the strategies & technologies of industrialisation to reach a large market. Then, quantity will justify the investment in processes capable of simplifying the operations and eventually getting quality architecture available to the vast majority of people.

But as buildings are site-related and industrialised technologies normally factory-related, the interaction with the site is still an important vector in the generation of an industrialised building system. Accordingly, three categories of Building Systems can be outlined: the site intensive Kit-of-Parts; the Factory-made Module and the Hybrid.

In a sense, these three categories are like the basic three colours (i.e. blue/red/yellow) on the initial "palette" from which an artist can mix the proper hues for his painting. Those three categories will generate 9 building systems types: from "A" to "I". No one type or system is better than the others: there is no World Champion, only systems more relevant to their context.

The four types of systems within the site intensive KIT-OF-PARTS ("Meccano") category are distinguished by the geometry of the structural sub-system which determines the jointing to do at the site which becomes the "final assembly line". Using dry mechanical joints, most of these components can be dismantled and reorganized into a modified or relocated building, thereby allowing for change without demolition according to the sustainability agenda.

In highly industrialized countries, FACTORY-MADE 3D MODULES are quite relevant as they maximize factory production. Road transportation rules in North-America are permitting modules up to ± 4.5 m X 14m whereas the Japanese modules are limited to ± 2.5 m X ± 5.6 m X ± 2.8 m.

The HYBRIDS are aiming at the best of both worlds. The Load-Bearing Service Core is concentrating the complex parts of a residential building in small value-added modules and reducing the job-site activities to simple dry connections to generate large open "served" areas. With Site Mechanization, the site becomes ± a precast concrete structure factory whereas the other sub-systems, being complex and compact, are better served by factory-made components.

FRIDAY, SEPTEMBER 28, 2012 - 4:00PM - 6:00PM

CLASSROOM & DISASTER RELIEF SESSION

SOCIAL PROCESS FOR A MODULAR FUTURE

Margarette Leite, Portland State University
Sergio Palleroni, Portland State University

At Portland State University, students and faculty are about to build their first prototype Green Modular Classrooms in collaboration with modular industry giant, Blazer Industries, and through a unique statewide collaborative initiative known as "Oregon Solutions." In this new social/business/educational model, the university serves as a forum for social change and the student architect and engineer as applied researcher, social activist and entrepreneur. Our first two prototypes will be built this summer, displayed at GreenBuild 2012 and then placed in Northwest schools. This project will be presented collaboratively by students and faculty of PSU.

FRAMESCAPES: MODULAR DEMOUNTABLE SCHOOL FOR BURMESE REFUGEE CHILDREN

David Hill, North Carolina State University

There are over 465,000 displaced people in Eastern Burma, and many of them end up in Thai refugee camps with no right to property and no sense of permanence. The Thai government allows the refugees to set up temporary houses and schools in places like Mae Sot, but the government can also force them to move without much advance warning. This project proposes a modular, demountable school and community center. Though the school building is demountable, the structure holds a sacred position in the community, a reminder that temporality does not imply provisional cheapness.

DESIGNING BETTER PORTABLE CLASSROOMS

Nils Gore, University of Kansas

This paper will describe a design studio process/projects that started with the observation that virtually every school district in the US utilizes portable classroom units as a way of relieving overcrowding and as "short-term" solutions to changing enrollments, shifting demographics and uncertain funding for capital improvement projects.

But even when truly intended for short-term occupancy, these buildings have a way of staying around much longer, and get used as classroom environments year after year. It's not unfair to say that even the best of these units is sub-optimal, in the sense that they have not been designed for maximum educational effectiveness: they have, instead, been designed for transportability, for minimum cost, for rapid deployment. These may be laudable goals for many school districts, but often at the expense of effective learning. Other potential liabilities include poor energy performance, high life-cycle costs, compromised safety and security, teacher dissatisfaction, and negative parent and community perceptions.

This studio assumes that these buildings are here to stay, that they do serve a useful function for school districts and that they could be better designed if districts could forgo a "cheapest is best" attitude toward their procurement. For example, a standard portable unit costs approximately 20% of the cost of a 'bricks-and-mortar' classroom. So what would a portable classroom be like at 50%, or 75%, or 100% of the same cost? It could be substantially better, while still maintaining the advantages of portability.

The Brief: "Develop a portable classroom, optimized for effective learning, that will be substantially better than what the market currently offers. Design the construction system, the manufacturing assumptions, and the transport and installation of the building on unknown sites."

In the resulting projects, special attention was paid to industrial pre-fabrication from the level of the individual component, to the sub-assembly, to the whole building. Ideas of mass customization were played out and illustrated from the factory floor, to the delivery system, to on-site assembly, to building occupancy for different site and program scenarios.

The studio included direct meetings with school district personnel, a visit to a modular building manufacturing plant, and advanced use of BIM and Ecotect for performance evaluation as design development strategies.

The paper will describe the assumptions of the studio, the process as it developed over the course of the semester, the products of the studio, and lessons learned that can be applied in future studios or in practice.

CLASSROOM & DISASTER RELIEF SESSION (CONT.)

HABITAT TEMPORANEI: PROPOSALS FOR POST-DISASTER PROVISIONAL HOUSING

Sandy Stannard, California Polytechnic State University

This paper is the result of a collaboration between the author and an Italian university, working in an Italian context to study the aftermaths of natural disaster.

Inspired by the disaster of the L'Aquila earthquake, a 5.8 magnitude earthquake that struck the Abruzzo region in 2009 which significantly damaged or destroyed thousands of historic buildings, this is a proposal for disaster responsive habitation. Specifically, the challenge presented to a group of undergraduate architecture students was to consider strategies of intervention immediately after the first stages of an emergency, to facilitate the creation of temporary habitation pending reconstruction. These "provisional" post-emergency temporary living spaces were intended to differ from standard emergency shelters, in that the design proposals were required to not only provide shelter but to also provide a sense of community, with an intended timeframe of use ranging from 3 months to 3 years. The challenge included an exploration of innovative forms of development and construction solutions for a transient post-emergency situation, guided by weight, flexibility, mobility, adaptability, deconstrucability/resuability, and climate responsiveness.

RECOVER: DISASTER RECOVERY HOUSING SYSTEM

Anselmo Gianluca Canfora, University of Virginia

A closer look into the practices of camps established to house internally displaced persons and refugees from natural disasters reveals a chronic housing problem: The housing type intended for finite emergency or relief periods immediately following a disaster has become the long term answer; the temporary tents and trailers, by default, have become the permanent solution. Conceived of a housing recovery strategy with a broad anticipatory approach and focused attention on systemic challenges facing disaster recovery housing, the reCOVER multifaceted strategy is characterized by: Advocacy for community-based partnerships; making the most of the advantages prefabricated panelized and modular construction can offer the transitional housing typology; employing sustainable building practices and passive design strategies; forming a consortium of housing manufacturers capable of executing rigorous building specifications and producing large-scale quantities; and forging partnerships with government agencies and consultancy groups to enable viable deployment strategies. From research and educational standpoints, the reCOVER approach is prototypical in nature and generates multi-year, iterative design processes where students learn from direct interaction with community partners, full-scale, hands-on fabrication, and the aggregative effects of interdisciplinary research and collaboration. reCOVER supports constructive exchanges between students, community partners, professionals, consultants and manufacturers to ensure mutually beneficial outcomes.

PREFABRICATED EMERGENCY RESPONSE LIVING (P.E.R.L.)

Peter D.D. Hind, University of Nebraska-Lincoln

After a tornado, the only remaining portions of a home are typically the concrete footings, foundations, and walls. P.E.R.L. takes advantage of this overlooked resource, utilizing the embedded energy and remaining structural integrity of the existing concrete system. Through its use of available off-site techniques, simple transportation, and modular components, P.E.R.L. represents a transformable system that serves as a basis for permanent replacement housing. P.E.R.L. can adapt to topography, existing structural conditions, and family needs. Most importantly, however, it places families back on their own parcels of land, allowing them to remain a part of the community.

FRIDAY, SEPTEMBER 28, 2012 - 4:00PM - 6:00PM

DIGITAL INNOVATION SESSION II

CAR WASH IN A BOX

Carlo Carbone, Universite de Montreal

Architecturally, our eco-friendly car-wash (water is recycled and waste is composted), lies somewhere between the airstream clipper and Mies van der Rohe's modernist service stations. The CWIAB (car wash in a box) responds to the criteria established by our client: transportable, ease of assembly, plug and play set-up, and scalability.

Our strategy for the project was to choose a structural system flexible enough to support disparate components and whose fabrication can easily be adjusted to offer multiple anchoring possibilities for fiberglass water basins, exterior curtain wall panels, and sandwich panel roofing. The BONE structure system was chosen for the platforms' adaptability and just in time production methods.

TRADITIONAL COMPLEX MODULARITY IN ISLAMIC AND PERSIAN ARCHITECTURE: INTERPRETATIONS IN MUQARNAS AND PATKÂNÉ CRAFTS, FOCUSING ON THEIR PREFABRICATED ESSENCE

Negin Dadkhah, Temple University

Muqarnas are a traditional architectural ornament and decorative craft of Islamic and Persian architecture, which resemble stalactite rock formations. Among the most characteristic artifacts and original inventions of medieval Islamic Architecture, they are a structure formed out of small pointed niches with rhythmic modularity and infinite compositions. They were built to break down vaults and domes into multiple facets with the purpose of unifying a dome's transitional zones into a compositional unity.

Early Muqarnas installations are found in Northeastern Iran and Central North Africa. Significant advances in design and construction techniques continued to 17th century. We can see countless and unique pieces examples of this craft in 15th, 16th and 17th century from Iran to Spain.

Although the installation of the Muqarnas was on site, they can be considered as one of the earliest, and at the same time complete samples of modularization and partial prefabrication. This paper proposes using modern technology such as parametric modeling and CNC (Computer Numerical Control) production to understand and revitalize this complex, modular geometry.

In traditional design, the conception and drafting of the Muqarnas was based on a highly coded system. Its geometry needs to be decoded to its basic modules in order to be understandable. Basically, two dimensional representations of the complex three-dimensional Muqarnas form were abbreviated and shortened to provide a very practical way of abstracting the threedimensional complexity to simple modules to simplify its construction.

Here is a brief explanation of the construction of a Muqarnas vault: First a plastered slab was built under the vault that was to receive the Muqarnas. Then a one-to-one scaled working sketch of the Muqarnas was etched on the mentioned slab. Edges of each row were then defined on this two dimensional full scale pattern and then a one-inch horizontal thickness of all the tiers of vault were cast. Cast plates were bonded to the vault and walls. A plumb line was used as to coordinate the vertical location of tiers to etched plan on the ground. Vertical arches were then fabricated out of wood and were added between the horizontal layers. These shaped niches complete the skeleton framework of the installation. Finally, a quick drying plaster was used to cover the whole structure to provide a seamless look.

Although many of the components were built on site, this paper asserts that the entire procedure can be considered as a prefabricated construction. Every part was built separately in series based on the required quantity and dimensions of each module of the two-dimensional plan. Then the components were assembled to create a complex whole.

My intention here is to propose new and innovative interpretations of Muqarnas by using parametric modeling to achieve new varieties of geometry. Since the concept of numerical control is based on abstraction of commands it can be matched with the traditional ways of coding this geometry and generate a highly complex spatial structure—fusing traditional and contemporary modular construction in a new 21st century reimaging of the traditional Muqarnas.

DIGITAL INNOVATION SESSION II (CONT.)

YOUTH HOSTEL DETROIT: REFRAMING DESIGN BUILD EDUCATION THROUGH DIGITAL PRACTICE

Joshua Bard, University of Michigan

Both in practice and academia it is often the case that design and construction are considered two distinct and separate phases of any project's realization. This is both ideologically and contractually supported by current pedagogical and practice models. Acknowledging that modes of operation shift during the process of realizing any project is essential. But, it is no longer a valid assumption that design is a separate act from that of construction and vice versa. This is especially true as the relationship between design intent and the mechanisms for achieving building performance become increasingly inseparable. Emerging technologies aimed at grappling with the dramatic increase in building sophistication and the need for open collaboration increasingly position digital proxies, digital fabrication tools and by extension prefabrication, under the direction of the architect.

What began in the fall of 2010 as a speculative conversation with the director of Hostel Detroit, a non-profit youth hostel located in the re-emerging Corktown neighborhood of southwest Detroit quickly took shape in a graduate level design-build seminar during the spring of 2011 that was designed to explore and confront the apparent divide between design and construction through digital practice. During a short 8-week term, students were pushed to work directly through 3d digital modeling and CNC (Computer Numerical Control) fabrication techniques to design, develop, prototype and fabricate a structure to house multiple overlapping programs. The "super-shed" was to provide secure bicycle and equipment storage, a covered gathering and socializing space and to function as a rainwater collection device supporting a series of small scale organic gardens.

The course emphasized CNC prototyping and prefabrication as a means of developing collaboration, craft, efficiency, tolerance and control. Further, it required students to be cognizant of the realities of strict budgetary and scheduling requirements, materials and processes, structural criteria as well as the logistics of transport and erection.

Because the course focused on CNC prototyping and prefabrication, repeated exposure to digital making heavily influenced the coursework and learning. Fluency through digital practice allowed the scope of the endeavor to increase in scale and complexity. Students leveraged skill in parametric digital modeling to fluidly connect design intent to fabrication. A parametric model developed early in the term was repeatedly refined and revised in an evolving feedback loop with prototyping and design evolution. The structural module, which in this case was a triangulated framework of custom water-jet cut steel gussets and standard dimensional lumber, allowed the units to move quickly from a digital environment into fabrication as a kit of parts which were transported to the site for rapid erection with simple hand tools. Complimentary assemblies for the cladding and structural deck also evolved within the parametric model. Embedded within these components were a series of machined reliefs and channels which located an integrated set of custom designed and prefabricated bike racks and movable door panels.

The course demonstrates the unique educational experience that grows from digital approaches to design thinking and full-scale rapid prototyping in making (and remaking) the project throughout the term.

HISTORY SESSION II

THE PRODUCTION OF R.G. LETOURNEAU'S PREFABRICATED CONCRETE HOMES: MAKING THE TOOL TO MAKE THE THING

Everett E Henderson, Jr.

R.G. LeTourneau is best known for his heavy earth-moving equipment developed in the early twentieth century. Less known is the system he developed for casting a concrete "house-a-day". The patented Tournalayer evolved from 1945 until the 1960s. The early home designs grew more multifaceted with each reiteration. The prefabricated system took the factory to the site where multiple steel forms were used in unison to form communities. The focus of the craftsman shifted from direct construction to making the tool that made the home. While manufacturing processes may not allude to poetics, the potential exists for a meaningful dialog between the machine and the craftsman.

REPEATING SUCCESS AND AVOIDING FAILURES: A HISTORICAL OVERVIEW OF PANELIZED AND MODULAR CONSTRUCTION IN HOUSING

Michael J. O'Brien, Texas A&M University

Prefabrication and modular production of housing is one of the oldest "new topics" in architectural discourse. Panelization, mini-modules and fully modular housing construction strategies have been in use almost as long as precut and kit homes that date back to the early colonial era.

This paper will argue that contemporary and prefabrication production methods for housing could learn important lessons from the historical record and will illustrate the application of panelization dating back to post civil-war efforts by Col. Lyman Bridges and others through the depression era Missouri-Farms prefabrication project to contemporary SIP panel development from the Forest Products Laboratory in the late 1920's to Pulte Home Science's recent housing products.

Similarly, the development of Modular housing from the TVA's demountables through the mini modules developed in Operation Breakthrough, Paul Rudolph's Masonic Gardens Project, Safde's Habitat 67, to contemporary applications of modular housing will be presented.

This historical overview will focus on the convergences of public policy; market need, labor skill, transportation infrastructure, and production strategies and will discuss the impact of these production methods on the architectural design of the house.

THE DISMISSAL OF DYMAXION HOUSE AND DEMOUNTABLE SPACE

Rob Whitehead, Iowa State University

This paper will compare and contrast two of the earliest, technically innovative, and structurally expressive prefabricated structures, Buckminster Fuller's Dymaxion House (1927-45) and Eero Saarinen's Demountable Space building (1942, with Ralph Rapson), by examining their relative commercial and technical failures.

As evidenced by their design proposals, both designers wanted an affordable, easy-to-assemble building comprised of prefabricated building elements, made from contemporary materials, which would be packaged and shipped to the site using the latest manufacturing efficiencies available. To make the buildings easy-to-assemble, both designs seemingly incorporated the same expressive and efficient structural system—a centralized mast protruding from the middle of the structure with a series of tension cables fanning out to support the roof and floors. By centralizing the structure, the on-site work of pouring foundations and connecting to utilities could be minimized, and the structural mast itself became the means by which other elements would be assembled and erected.

In spite of their similarities in structural expression, both projects had incredibly divergent ideas about spatial volume, functional flexibility, architectural expression, and the corresponding level of technological expression and resolution that was required to achieve these goals. In all cases, Fuller produced the
more prescriptive spaces with architectural expressions that resulted from the thoroughly developed myriad of complex inter-related technical solutions for building (e.g., the mast was a means of supporting, shipping and venting the structure and the round floor plan was done to reduce materials, minimize heat loss and to provide adequate lateral stability). Saarinen, however, favored flexibility and expression primarily and often postponed the thorough examination of technical restrictions until late in the project's development (e.g., the mast supported the roof but not the floors, the walls were flat-packed and modular for purposes of expression but they provided no lateral stability, and the means for constructing the building was more optimistic than realistic). These early tendencies for how these designers looked at the relationship between technology, structure, and space would come to define much of their later careers and become a common refrain in critiquing their work.

Fuller's eventually constructed a version of this design, called the Wichita house, which become a well-known commercial failure and serves as an example of the dangers of allowing ideological expressionism to trump spatial and aesthetic concerns. Saarinen's Demountable Space project was never built
and even though he spent much of the next several years participating in many of the first prefabricated house designs (including Case Study houses #8 & #9), he never revisited the bold structural expressionism that he explored in this project. The paper will explore how the ideals expressed in these projects defined their later work in prefabricated buildings and expressive structures. Further, the paper will argue that these initial failures to successfully incorporate a bold, expressive, and efficient structural system as a central conceptual component for prefabricated buildings unnecessarily created a lack of similar explorations for generations, giving way instead to prefabricated structures defined by their box-like small volumes and flat pack facades.

HISTORY SESSION II (CONT.)

NEW WAYS OF LIVING THROUGH PLUG-IN AND STACKING PREFABRICATED MODULAR HOUSING SYSTEMS

Luis Machuca, Malaga University

Throughout history, the different aspects that compose housing have been continuously revised so as to meet the various requirements of human progress. At
present these requirements are determined by the new configurations of family groups, the need for a higher sustainability level, the requirement to improve the industrial process of construction, and by the high prices we pay when purchasing a home.

As a solution to the mentioned problem, this work reviews and proposes different models of housing in the "prefabricated modular housing systems" (PMHS): the "stacking" and the "plug-in" models, in which defines the opportunity to carry out a possible change of the current system of housing production and the way of living. The research is made up of two different parts:

The first part collects the historical framework, whose path reveals the origin and development of plug-in and stacking systems, setting as a starting point the dwellings made by Mies van der Rohe and Le Corbusier for the Exhibition of the Weissenhofsiedlung in Stuttgart, 1927. Both are prototypes searching prefabricated and flexible solutions inside the minimum housing in the way that the spaces of a house could be used differently depending on the needs of its inhabitants. Afterwards this tour is based on the concept of "the bottle and the bottle rack" created by Le Corbusier to carry out the Unité d'habitation in Marseille, which is the first "plug-in" project of the history. The idea of this building will inspire the first draft of "stacking" of prefabricated habitable modules: the Unité d'habitation in Strasbourg (1951).

In the late 50's, the concept of "bottle and the bottle rack" becomes the international model for re-thinking the city of the future, under the nickname "megastructures". The Metabolist group, Archigram and Moshe Safdie, through their research and examples will be the leaders of the tendency.

As it was impossible to carry out the different megastructural designs in the 60's, it became necessary to rethink the PMHS at a smaller scale, leaving the urban one aside. In this sense the Japanese architect Kisho Kurokawa from the Metabolist group advanced the most with his research, building for example the Nakagin Capsule Tower (1972) which is until today the best reference for residential building made under the plug-in concept. During the 70's due to the fascination with the living module, the architects started projects also in domestic dimension, incorporating PMHS into the interior housing design.

The second part of this work analyzes and classifies various current models made with PMHS and their success in comparison with past ones. Furthermore, the study will help us to seek new proposals that improve the present spectrum of the plugin and stacking systems. Finally, the classification of these types will be evaluated focusing on the housing problem, drawing some final conclusions.

INDUSTRIAL BUILDING RELEVANCY: A RETROSPECTIVE OF CRS FIRM INSIGHTS ON DESIGNING PRODUCTION FACILITIES

Marjorie Callahan, University of Oklahoma

The CRS Firm's Industrial Building Type is a masterpiece in retrospect and in its ability to have current relevant application on many levels. The principles of architecture can best be taught through the use the industrial building type to the professional as well as the student of architecture. This paper will focus upon:

(a) Historical relevancy and development of the Industrial Building/Production Facilities with its inherent use of: (1) repetitive patterns of material and structure for cost efficiencies and rapid construction schedules, (2) maximum use of 'green' efficiencies (lighting opportunities (task and general), air ventilation and modular storage bins), (3) proximity to railroad lines and offsite modular parts.

(b) The CRS Firm's contribution in the building type 'Industrial' was in the firm's innovative programming phase (*reference: Future Thrusts (an update of CRS Self-Evaluation/Digest of CRS Board Meeting 08.01.2008). Using Chrysler/Detroit and Herman Miller/Furniture Production Campuses, CRS isolated factors and studied or as they called it "squatted" to uncover three (3) prototypes cognizance of: (a) new energy spaces, (b) landscape inclusion, (c) supplemental research in modularity, and (d) separate prototype lanes.

The success rate of using the modular with pattern familiarity of a Production Facility type project in the classroom is invariably a win and can be applied in practical, real-world design. Its application today is monumental in design and in teaching of principles at the core of this conference. And, its application is relevant and still evolving usefully today.

FRIDAY, SEPTEMBER 28, 2012 - 4:00PM - 6:00PM

SUSTAINABILITY SESSION

A MODULAR ALTERNATIVE: RESPONDING TO CLIMATE

Sandy Stannard, California Polytechnic State University

The Manufactured Home Institute (MHI) estimates that approximately 22.5 million people live full time in more than 10 million manufactured homes throughout the United States. While energy efficiency standards have improved since the inception of the mobile home industry, with the addition of "energy star" rated manufactured homes, the size of this industry represents a significant opportunity for this industry to develop more robust climate conscious responsive prototypes.

This proposal represents an undergraduate thesis investigation of climate responsive manufactured housing. In an effort to reduce energy and material consumption, an affordable, easily transportable and customizable pre-fabricated kit home that is climatically adaptive and responsive to various regions of the United States could serve as a vessel to provide basic human comforts by operating in symbiosis with the systems of the natural environment. Through passive lighting, heating, and cooling design strategies, along with composting toilets, water catchment systems, and modern solar technology, inhabitants of such a home could live off the grid or even contribute to it. The project explores the modification of a basic "kit" by testing the design idea in five basic climate zones: moderate, hot/dry, cold/semi-arid, cold/humid, and hot/humid.

A NOVEL "POST-AND-BEAM" TIMBER STRUCTURAL SYSTEM FOR SUSTAINABLE EUROPEAN MODULAR HOUSES

Faidon Nikiforiadis

The paper presents the recent work of a small and progressive architectural practice to pioneer a new form of modular housing based around the Passivehaus standard built on different levels generating a "Post-and-Beam" timber framed structural form that explores variation in spatial volumes.

The aim of the project was to produce a standardised construction system and range of designs to meet the future housing needs in rural Europe utilising local grown timber and meeting the highest energy performance standards. The project aimed also in developing an exceptional knowledge and application of low energy timber construction typologies, buildability and detailing. The paper presents the efforts made to transfer theoretical knowledge of innovative off-site timber construction systems to practice.

The aim of the research project was to develop and test selected prototype structural components suitable to meet the parameters of a novel contemporary "Post-and-Beam" timber framed housing typology. The structural elements will need to have strength and lightness to enable them to be portable. The objectives of the research were to investigate potential structural materials, fixing systems, manufacturing and assembly techniques, with an emphasis on sustainability (low carbon and material consumption).; assist in the development of the conceptual design and associated real and/or virtual models, based upon promising structural solutions identified; support the structural design and manufacture of prototype components so that can be made efficiently off site; contribute to the development of an innovative product whose design, material technologies and manufacturing techniques enable easy transportation to site and simple assembly on site, whilst also providing the necessary structural functions and facilitating the architectural requirements.

The paper makes a theoretical introduction of the system that has attempted to harness the past experience of suppliers and manufacturers in the timber industry. It explains how their expertise and understanding was used to understand better the process of manufacturing timber products and the different manufacturing possibilities available today.

The paper starts by presenting the main findings of the undertaken literature review, which covered the current timber system technologies used within low energy housing and determined the requirements set by the Passivehaus energy performance standard. This is then followed by a discussion explaining how possible novel technologies were evaluated in order to identify most effective means of achieving the Passivehaus standard. It then presents in detail the process used in designing and developing a new product for affordable, architecturally attractive, high performance"Post-and-Beam timber frames homes for rural European environments.

The work presented contributes to the development of an innovative open system for housing that combines existing and new off-site technologies. The paper also discusses the development of appropriate non-standard techniques for structural analysis and design of such systems according to Eurocode 5. It provides an insight of the need of submission of the designs of the finished components for registration and patent application. Finally it provides recommendations for further research and commercial development of the method of manufacture, delivery and site assembly.

SUSTAINABILITY SESSION (CONT.)

EFFICACY OF SHIPPING CONTAINER UPCYCLING: COMPARISON OF ENVIRONMENTAL IMPACTS BETWEEN TWO HOUSING SYSTEMS

Bradley Guy, Catholic University of America
Stephen Bender, University of Florida

Upcycling shipping containers, also known as intermodal steel building units (ISBUs), for use in the construction of a variety of building types has been adopted as a green building strategy. This paper is intended to contribute to the literature on use of life cycle assessment (LCA) for whole-building (operational and embodied) quantification of the environmental impacts of the built environment and specifically for this modular construction strategy. This analysis differs from assessment of modular construction per se, given that the basis of this construction-type is the reuse of a product originally intended for other uses and as an end-of-life strategy for the containers. This study compares the whole-building life cycle environmental impacts of constructing a traditional wood-framed residential building to the use of the ISBUs for a residence in Gainesville, Florida. In addition, the residence built from ISBUs is designed to reduce operational energy and includes a photovoltaic (PV) array to offset the operational energy consumption through a grid-intertie. The analysis will also estimate the point at which the PV system energy production will achieve whole-building net zero energy use (operational + embodied). The buildings' operational performance is modeled using Energy-10 v1.8 software. In order to account for the thermal bridging effects of the container construction, THERM v6 software will be used to more precisely model the envelope U-values to plug into Energy-10 as a customized assembly. The LCA for the shipping container construction and use of reused containers in lieu of their recycling, and impacts of shipping and construction will be modeled using Athena Impact Estimator v4 software and primary sources of data. The analysis will span project life time from cradle to end-of-life. The baseline for the lifespan of both homes is 60 years. Construction energy use such as transportation of containers, cranes, welders, and plasma cutter, are modeled as accurately as possible for the ISBU residence using primary data from its construction. Construction impacts for a typical wood-frame home are modeled using data from the literature and economic input-output data. The embodied impacts of materials are limited to structure, envelope, finishes, i.e. non-moving parts, whereas the operation impacts account for the average code-compliant energy use of a baseline home and the specific strategies for energy efficiency in the ISBU residence. The primary environmental impact metrics for the operational energy will be site energy use, source energy use and resulting green house emissions expressed as global warming potential (GWP) and the embodied environmental impacts will be GWP, resource use, acidification potential, eutrophication, ozone depletion potential, respiratory effects, and smog potential. The International Organization for Standardization (ISO) 14044 standard is used as guidance for the LCA component of the study. This study seeks to determine the environmental impacts and their potential reduction through the use of shipping containers as a modular housing typology from both a materials reuse aspect and in terms of the environmental costs/benefits in the retrofitting of the containers to meet or exceed new wood-framed energy code-compliant housing construction.

HIGH OCTANE: ECO-ADAPTIVE ARCHITECTURE

Elizabeth Martin, Southern Polytechnic State University

The fast-paced evolution of fabrication and construction methods of building enclosure systems and assemblies is quickly becoming a major issue in today's architectural and educational practices. Researchers and the construction industry are now providing material assemblies that are making enclosures of just 20-years ago obsolete. In the next decade, wholesale building skin replacement systems will be adaptable to seasonal or daily climatic changes.

The abstract proposes addressing three questions:

1.) define moderate and extreme ecologies responses via mapping
2.) describe the range of kinetic pattern and movements
3.) develop and build upon nomenclature to accurately describe the morphology of the kinetics through a series of case-studies both realized (built) and exploratory (research).

The design of an architectural enclosure system is bound, in no small part, to situating oneself in context of our contemporary social and 'cultural' conditions, as well as attendant aesthetic discourse. We cannot help but be 'here' and 'now', observing its intricacies from the midst of our subjectivity; but also reflect on our contemporary condition in the context of a number of pertinent events: ecological changes (weather patterns) + technological advancements (kinetic patterns).

One of the central research themes in ecology is evaluating the extent to which biological richness is necessary to sustain the Earth's system and functioning of individual ecosystems. My aim is to illustrate an alternative perspective exploring how building enclosure elements can be combined to create costand-energy effective, yet adaptable building enclosures in both extreme and moderate climates.

SUSTAINABILITY SESSION (CONT.)

PREFABRICATING CHARLES MOORE: REINTERPRETED SADDLEBAGS AND AEDICULES

C. A. Debelius, Appalachian State University
R. Chadwick Everhart, Appalachian State University
James Russell, Appalachian State University

Inspired by Charles Moore's strategy of the use Saddlebags and Aedicule elements in residential design, this paper describes a design proposal for the retrofit of existing houses in a traditional suburban neighborhood with prefabricated Renewable Energy and/or Efficient Modules (REEMs). The conception and design of the modules is a response to two concerns:

> A 62% increase, between 1978 and 2005, in energy consumption in three of the primary components of residential energy demand: Water Heating, Air Conditioning, and Appliances and Electronics. Recent data on changes in total energy use in U. S. homes between 1978 and 2005 indicates that a number of factors (e.g., Federal energy efficiency standards for major appliances, improved energy efficiency of heating equipment, better window design, better insulation) have led to a reduction in energy use per household of 31%. Notably, while the number of occupied housing units has increased by 45%, total energy use in homes has remained constant (10.58 quadrillion BTU in 1978 compared to 10.55 quadrillion BTU in 2005). Unfortunately, the dramatic 38% reduction in energy consumption for Space Heating has been largely offset by increases in consumption in three areas: Water Heating, Air Conditioning, and Appliances and Electronics. Given the increase in the number of households with dishwashers and with central air conditioning, it is not surprising that the 2005 energy consumption for Water Heating and Air Conditioning was 3.0 quadrillion BTU, an increase of 62% over 1978 energy consumption levels.
>
> The significant number of existing energy inefficient homes constructed prior to 2000. According to the 2009 American Housing Survey National Tables, there are 73M occupied single family detached housing units in the United States: in excess of 60M of those units were constructed before 2000. While improvements in the construction of building envelopes, more efficient energy standards, and the development of renewable energy systems for new residential construction are laudable, it is evident that some means must be found for reducing energy use in older homes in order to reduce residential energy consumption in the decades ahead.

Prefabricated Renewable Energy and/or Efficient systems are proposed as an effective means for reducing energy consumption in existing houses. These systems, comprised of (1) an array of Renewable Energy building skin systems (e.g., Solar PV, Solar Thermal and even solar thermal air preheaters) and (2) Renewable Energy and/or Efficient Modules (REEMs), are designed to decrease energy consumption—either by adding renewable energy capability and/or having more efficient energy systems. The prefabricated modules contain the equipment and components necessary to augment and/or replace the existing energy systems of the house. When a southern exposure is not available, the REEMs will focus strictly on energy efficiency by using high performance tankless hot water heaters and fully integrated ultra-high efficiency HVAC units. Regardless of whether the REEM is fitted with Renewable Energy capability, all modules will take advantage of highly efficient energy systems which are fully integrated into the module structure and require only electrical, plumbing, duct-work, and natural gas hookups.

A primary design challenge for the retrofit is the successful integration of south facing building skin systems and REEMs (typically mounted on a concrete slab-on-grade and connected to the existing building energy systems through an exterior wall) in houses constructed in the United States in the 1950s, 60s, and 70s.

The significance of the project, as distinguished from those proposals that focus on new construction, is the demonstration of a variety of design strategies for reducing residential energy consumption by retrofitting existing houses with mass-produced Renewable Energy and/or Efficient systems.

LIFE CYCLE IMPACT ASSESSMENT OF A MEGAPANEL FAÇADE SYSTEM IN HL23 CONDO

Kyoung-Hee Kim, University of North Carolina at Charlotte

This paper outlines the design process and environmental impact assessment of a prefabricated megapanel façade system for the HL23 condo that the author had involved in. The concept of a mega panel façade system was chosen as an economic alternative of façade construction in urban setting like New York City where the labor cost and construction schedule are the primary concern. A comparative life cycle assessment (LCA) method was selected as a sustainability measuring tool to compare the environmental impacts of a megapanel façade system with a typical unitized facade system. The environmental performance of a façade system was characterized by the energy consumption and CO2 emissions through all stages of the life cycle. The rationalization process of implementing a mega panel façade concept was embedded as part of the design, engineering and fabrication process. The structural glazing strategy was explored with a parametric modeling and structural analysis tool. A series of fabrication drawing extracted from the parametric modeling tool was used to communicate the complex ideas to the fabricator. Transportation methods took into consideration of size limits of oversea shipping and oversize trucking. Details on design process and environmental impact analysis work will be presented at the conference.

DESIGN SPECULATION SESSION

FOLDING MODULAR RETREAT

Jessica Hester-Mautner Braverman, North Carolina State University

Modular architecture refers to the design of any system composed of separate components that can be connected together. One of the beauties of modular architecture is that any one or more components, or modules, can be replaced or added without affecting the rest of the structure. Unlike integrated architecture, modular architecture possesses the ability to be deconstructed, moved and a flexible nature that allows it to perform well in a large variety of architectural applications.

Because of its flexible nature, the Folding Modular Retreat is adaptable to many environments, scales and materials. It is easily fabricated on a CNC router, flat-packed for transportation, and assembly requires only the use of a screwdriver. These properties make it ideal not only for the modern city dweller, but for disaster relief housing as well. Its scale can be easily adapted from the small one-person retreat (shown in corrugated plastic) to large family-sized living spaces. It could be made of one material (shown) or many, including insulated metal panels, formed plastic or plywood. The FMR's ability to adapt to social, economic and environmental conditions makes its use limitless. From a child-sized retreat in the backyard of a city to a multi-person getaway in the middle of the forest, this is a one-module fits all retreat.

FROM 'PART TO WHOLE' TO 'WHOLE TO PART': RETHINKING MODULARITY

Luis Ortega, University of Illinois at Chicago

Since the introduction of digital technologies, research has focused on customization, digital fabrication, and differentiated serialization. In the context of recent advances, modular construction has renewed interest. From modularity based on repetition of a standard part, where all variation is based on the combinatory possibilities of aggregation, modular systems have shifted towards customized modularity.

The new modular architecture constraints are not based on production limitations but rather on logistics: new modularity is based on transport and assembly. The relationship between part to whole has changed. Before, the building was the result of the aggregation of parts. Now, the new design unit is the building itself. The new technical challenge is how to divide it for shipping and assembling.

DESIGN SPECULATION SESSION (CONT.)

PREFABRICATED NESTED BOXES

Kristina H Yu, University of New Mexico

Simple boxes are mistaken as reductions of architecture. Big Box retail may be in part responsible for this misconception. Boring prefabricated boxes may be the other reason. However, the complexity of prefabricated box types requires more attention. The suburban context has created desolate intersections with big box retail that have long vacated. These empty shells once promised economic growth for outlying areas. In recent times, populations have shifted and these retail businesses relocate to newer suburban locales. Cities are left with these decaying reminders of over expansion. Surrounding communities are faced with longer commutes for the procurement of basic necessities. Case studies have shown the difficulty of retrofitting the large interiors of these empty shells.[1] These case studies focus on programmatic changes, however, still accept the form of large interior. How can architecture address the big box retail? The paper will argue for prefabricated offsite constructions as temporal and nested programs that challenge the eminence of one large interior. A taxonomy of existing prefabricated boxes will be studied for their utility, flexibility, and transportability. These boxes will be design tested within the big box. If big boxes were reconceived as open air shells, where the conditions of interiority were loosened, are there opportunities for flexible to temporal retail environments?

This project is concerned with creating space through the layout of prefabricated units. The units become small temporal private businesses housed within the existing shell of the big box, becoming an enclosed marketplace. Research will identify and categorize several key existing module unit types. These types address vast functions ranging from portable restrooms, mobile food trucks, to retrofitted shipping containers. The practical implications associated with the transport of the various unit types from off-site to the box's interior and movement within the structure is key to understanding the constraints of movement. The design of individual units and the big box are less critical for this study. This project is designed to be a site-less proposal for ideas that can be implemented anywhere. The explored ideas are meant to consider the practicality of a module program for the revitalization of the big box.

Within the larger shell of the empty big-box, individual pre-fabricated units can serve as secondary private programmatic components. This exploration will combine smaller private business and public functions in a mutually beneficial organization. This public/private enterprise is designed to increase the overall usage and interest. The public functions serve as the anchor for the market, bringing stability to the project. The self-contained units allow for a flexible design with the potential for a wide variety of layout options and possibility for easily changeable arrangement. This flexibility allows for an interchangeable program that can be adjusted for future increases or decreases in unit number and type. The versatility of the program may lead to increased interest within the community and the prospects for similar arrangements throughout the city.

1 Julia Christensen, Big Box Reuse. (Boston: The MIT Press, 2008 Ellen Dunham-Jones and June Williamson, Retrofitting suburbia: Urban Design Solutions for Redesigning Suburbs. (Hoboken, NJ: Wiley, 2008).

YOUR SPACE KIT: OFF-SITE PREFABRICATION OF INTEGRATED RESIDENTIAL FIT-OUT

Stephen H. Kendall, Ball State University

The residential real estate and development industry will sooner or later recover from the recession. All players will be seeking competitive advantage. Now is the time for residential developers and their architects/builders to shake off obsolete methods, to take new realities seriously, to find new opportunities and to adopt new products and methods in the delivery of an agile and sustainable residential building stock. The key is to recognize the nascent but powerful demand embodied in personal preferences for living environments.

The paper addresses the question of what it takes to adopt a flexible "open building" strategy in the residential market using off-site prefabrication, BIM and advanced logistics. The goal is a sustainable building stock meeting varied and changing demand. The tools are decision flexibility, matched by production flexibility. Why is this important? The reason is that market conditions change, during the pre-construction planning period, during construction and certainly over the life of the real estate asset. Everyone wants to make decisions at the last minute, without loosing money or jeopardizing the quality of the results. This points to the need for design and building processes – and building technologies - that decouple long-term asset value from technical details/spaces that have a shorter life. We should, ultimately, be investing in a building stock with long asset life. Therefore, constructing "open" buildings and later specifying the unit sizes, floor plans and equipment needed to meet market preferences represents an innovation whose time has come. This requires better ways of producing off-site (prefabrication and ready-to-assemble packages), new supply chain processes and more nimble logistics.

My paper focuses on three things. First I briefly discuss the theory of residential open building and show examples of built projects, in the market, around the world. Second, I introduce key products that are the backbone of the next generation of open building projects. Third, I project a business model providing just-in-time residential interiors using off-site prefabrication, improved logistics, and multi-skilled teams for on-site installation inside buildings.

This business/production model is useful in re-fitting buildings being gutted for adaptive reuse or total upgrading, and in newly built residential townhouses or multi-unit residential buildings. My research suggests that products coming into the market enable this way of working to be cost effective. I also show that a design/build residential fit-out business model – using advanced off-site production processes and advanced software - will offer advantages in decision-flexibility, customization, speed and cost/quality control.

HOUSING SESSION I

BEYOND THE TRAILER: RETHINKING AFFORDABLE MANUFACTURED HOUSING IN THE U.S.

Carlos Alberto Reimers, Catholic University of America

There are entire possibilities in low-income housing that the manufactured housing industry has not included or explored sufficiently. Research in the low-income areas of the periphery of some American cities shows an elaborate spatial complexity, building inventiveness, and growing resourcefulness. One of the most important characteristics that make housing in these areas interesting is its progressive character in which investment in housing is limited by the financial available resources. Housing is then built in two or more stages in which household needs are matched with household savings. Some of these residential environments show great potential to consolidate into good urban habitats and become incorporated into cities as healthy neighborhoods.

This paper is based on a study of the long term changes operated in low-income peri-urban areas of Texas. The study identified the characteristics and types of investments made by households in their housing including space use priorities, technology and materials, and amount of the investments made in housing in time.

This paper explores avenues for the manufactured housing industry to expand its offer of affordable housing by developing new products and integrating into their existing products many of the notions operating in low-income housing environments that were observed. The paper proposes concrete examples on how this could be done.

BRITNEY AND K-FED: UNITING PROCESSED AND UN-PROCESSED COMPONENTS IS AFFORDABLE HOUSING

John E Folan, Carnegie Mellon University

This paper utilizes the ARMADILLO House as a case study to illustrate the benefits of utilizing pre-fabriacted light guage steel building components in conjunction with elements addressing the benefits of light gauge steel framing in the production of affordable housing targetted at individuals meeting 40%, 60%, and 80% median income levels in urban environments.

1. Digital Workflow Efficiencies in fabrication chain
2. Efficiencies of on site work with volunteer labor force.
3. Efficiencies of off site work with a volunteer labor force.
4. Reductions in amount of material and energy resources utilized.
5. Reductions in construction and production error

LOCALLY BASED APPROACH TO PREFABRICATED HOUSING

Peter L. Wong, University of North Carolina at Charlotte
Alexander Suryandono, University of North Carolina at Charlotte

On May 27, 2006 more than 5000 people perished in a 6.3 magnitude earthquake in Yogyakarta and Central Java, Indonesia. The earthquake destroyed 100,000 homes and damaged more than 200,000 additional structures. The need for shelter was made worse by the fact that shelter prior to the quake was also needed for the homeless population in these two areas. Many countries and organizations provided assistance in the form of food, medicine, funds, shelter and also housing. The organization "Dome for the World" built a new village in Yogyakarta with bubble-shaped prefabricated houses. These 71 shelters, along with public facilities such as a Mosque, a primary school, a health center, and bathing/sanitary facilities, successfully provided earthquake relief in surrounding villages and towns.

By contrast, similar dome-shaped emergency shelters were installed in the devastating 1972 earthquake in Managua, Nicaragua. In that instance, the Bayer Corporation provided 500 houses of which only 30% were ultimately occupied. The failure of these houses could be attributed to two main concerns: (1) disaster victims, prior to the installation of disaster relief, found a way to erect their own houses, and (2) the morphology of the dwelling did not adapt well to the cultural conditions of the Managuans. A similar failed attempt with dome dwelling structures also witnessed in Kutahya, Turkey in 1970. Like the Nicaraguan situation, it was suspected that the form and shape of the shelter were contributing factors to the lack of architecture's success.[1]

The dome village in Nglepen, Yogyakarta is still occupied today. One of possible reasons is due to the ability for its users to modify and adapt their houses according to specific, local needs. This factor of customization appears to be a significant factor toward the success of these prefabricated units.

This paper aims to analyze and learned from the Yogyakarta, Managua, and Kutahya situations. It will use the basic theory and history of prefabrication as a way to understand the cultural successes and failures of the dome house type. It should be mentioned that prefabricated housing is not popular in Indonesia. However, due to the high demand for housing, sociological factors played against opportunity and need create a certain acceptance, tolerance, or perhaps appreciation of this kind of temporary shelter. Can we assume, given the Indonesian example, that a locally based cultural approach to housing and form provides an appropriate case study to measure the successful application of prefabricated means in architecture? A locally based approach and potential application for prefabricated industrial processes might prove as a viable solution for such urgent building needs. The aim of this paper is to analyze the history, technology, and morphology of small-scale prefabricated dome construction as a way to expose the successes of the Yogyakarta situation. Simultaneously a comparative analysis with parallel scenarios resulting in less than successful results will serve as the counterpoint and lesson to balance this Indonesian example.

1 One of the important sources for this topic originates from Edward Pandelaki and Yoshimitsu Shiozki's research on New-Ngelepen housing. This proposal aims to foreground in more detail the contributions that prefabrication itself played in the success of the Yogyakarta recovery efforts and the lasting effects of the dwelling reconstruction. See E. Pandelaki and Y. Shiozaki, "Social Sustainability of New-Ngelepen Dome Housing as Post-Disaster Housing Reconstruction of Central Java-Yogyakarta Earthquake 2006," conference paper presented at 21st EAROPH World Planning and Human Settlement Congress & Mayors' Caucus, October 2008, Egret Himeiji and Awaji Yumebutai International Conference Center, Japan.

SATURDAY, SEPTEMBER 29, 2012 - 8:30AM - 10:00AM

HOUSING SESSION I (CONT.)

A NEW NORRIS HOUSE: GIVE AND TAKE

Samuel Mortimer, University of Tennessee-Knoxville

In 1933, the Tennessee Valley Authority created a model community as part of the Norris Dam construction project. Built entirely anew, the town of Norris was designed around the principles of the Garden City and was envisioned as a self-sustaining utopian community. A key feature of this New Deal village was the Norris House, a series of home designs built for modern, efficient, and sustainable living. New technologies and prefabricated elements were quietly integrated into aesthetically pleasing, vernacularly-inspired homes, allowing residents to immediately identify with the new structures. Despite their familiar aesthetic, the introduction of electricity and indoor plumbing revolutionized the way residents of the Tennessee Valley would dwell. In light of the 75th anniversary of the Norris Project, a university design/build team reinterpreted the Norris paradigm and created a New Norris House – a sustainable home designed to address the constraints and imperatives of the 21st century. Partnering with a large modular home builder, the academic project team completed the home in a design/build setting over the course of 2.5 years. Currently, the project is in a demonstration and evaluation phase, with qualitative and quantitative assessments being collected around the residency of two live-in subjects. The project received LEED for Homes Platinum certification, and numerous design awards, including the EPA's P3 Award, a Residential Architect Merit Award for single-family housing, and an AIA East Tennessee Honor Award.

This paper seeks to use the completed New Norris House project and its ongoing evaluation as a case study for future built works. Academic collaboration with the modular partner raised several key questions and difficulties—largely related to critical path and quality constraints. It became apparent in the design phase that not all work could be completed in the modular homebuilder's factory; custom finishes (interior and exterior), and specialized MEP systems (home and landscape) were rather completed on-site.

Prefabrication of the student design pushed the modular builder to several of its limits and one-off production tested the capacity of laborers to perform at levels (speed and quality) equal to that of their standard product. This paper will evaluate the project team's ability to challenge and adapt to existing manufacturing and installation systems. What design decisions might have permitted greater factory production and what trade-offs could have been made to this end? Was there inherent value in the give/take of the off-site vs. on-site production? What limitations do modular home builders have which could more easily facilitate one-off productions?

As both a student member of the original design team and later as a researcher/instructor overseeing the project's completion and evaluation, I have been privileged to a unique perspective. I will discuss the nature of the academic and industry partnership and how the home has acted as a vehicle to apply new technologies and techniques, explore policy limitations, and gather real-world marketing feedback. These applications may not have been possible without academic/industry partnership, and all have the opportunity to provide tangible benefits in the form of new products, services, and academic models.

SATURDAY, SEPTEMBER 29, 2012 - 8:30AM - 10:00AM

SOLAR DECATHLON SESSION

UNMOORED ARCHITECTURE: ON MODULES, MOBILITY AND MANUFACTURING IN THE RE:FOCUS HOUSE

Mark McGlothlin, University of Florida

> *If a building looks better under construction than it does when it is finished, then it is a failure.*
> - Douglas Coupland

In thinking of the intersection between the ideas of design process, means of construction, and the role of fabrication, a rather amusing commercial jumps to mind. The commercial is structured around an idealized narrative, unfolding the initial meeting between architect and client. The architect, sporting a stereotypical black suit and contrasting white hair, is walking a potential client though the expansive galleries and spaces of his office, accompanied with snippets of awards and other evaluations of his design brilliance. The client, presented as a modestly refined couple, follows the architect dutifully through his parade, revealing not awe or adulation, but a quiet sense of reserved respect. The story continues to its climax, with the architect sitting across from the couple, asking with an unmistakable punctuated egotism, "and what can I do for you?" The couple's reply begins with a momentary pause, followed by the woman reaching into her purse and disclosing a faucet, which is placed firmly on the desk and followed by the client's verbal provocation, "Design a house around this." The commercial closes quickly and cleverly with the architect looking back to the couple with a slightly perplexed gaze, as if to suggest that his design insight and intuition was unexpectedly challenged by the brilliant richness of the faucet. To be fair, the commercial is clear in its intent to exaggerate the faucet as an object and in doing so take advantage of the architect stereotype with a playful, tongue-in-cheek characterization. That said, the commercial also reveals a different characteristic of the architectural design process that we rarely and reluctantly acknowledge – the increasing centrality of products in design culture.

There are many questions that emerge from the idea of a product-centered design process, ranging from the familiar "kit-of-parts" exercises to the current trends in digital fabrication. This paper does not intend to address the breadth of this topic, but rather to focus on how these ideas are grounded in practice through the unorthodox variant of the Solar Decathlon competition, and more specifically through an examination of the RE:FOCUS house for the 2010 Solar Decathlon Europe. While many of the houses that have competed in the Solar Decathlon competitions have steered towards more speculative ends, the RE:FOCUS house offers an interesting counterpoint, as it is at its core a demonstration of multivalent design themes that lie between convention and speculation, such as componentry, systems, materials, space, use and occupation. These ideas are further intertwined with a running dialogue with the dualities of assembly/disassembly, of permanence/mobility, and of place/placelessness. Through a careful examination of the RE:FOCUS House, this paper will explore the numerous design aspirations and pedagogical questions of design/build experiences and of integrated disciplinary learning, and in doing so further examine the evolving relationship between transformative ideas of design, fabrication and the conventions of construction.

LIVING LIGHT

Edgar Stach, University of Tennessee-Knoxville

The Living Light house is a maximum efficiency, solar-powered home projected to generate twice the power it consumes over the course of a year. The interdisciplinary project team included students and faculty from architecture, landscape architecture, engineering, graphic design, interior design, business, and the culinary arts. Digital modeling determined prefab as the best way to guarantee tight construction for better efficiency and easy delivery to the site. The 3D modeling also allowed careful calculation to design the steel structure and dynamic double facades. The house was fabricated completely offsite and delivered to its location as a single entity.

SATURDAY, SEPTEMBER 29, 2012 - 8:30AM - 10:00AM

SOLAR DECATHLON SESSION (CONT.)

THE URBAN GARDEN; INDUSTRIALIZED NET ZERO ENERGY HOUSING

Joseph Wheeler, Virginia Tech

The promise of factory built housing has risen and receded each decade over the past century, yet has not broken through to mainstream construction. Economy of scale, lower cost, higher quality and faster production are predicted attributes that are now overlaid with concerns of sustainability and energy use. This project proposes a re-examination of industrialized processes and its applicability to high-density living. By integrating architecture and technology, the goal is to make dwelling sustainable and beautiful.

Over the past decade, students and faculty at our university have designed and constructed three net-zero energy houses for the DOE Solar Decathlon. These research initiatives have resulted in considerable expertise in sustainable construction and energy efficient dwellings. All three houses were not only top ranking in the architecture and innovation categories, but also were top performers in energy production and energy efficiency. As a detached single family dwelling, the most recent of the three houses has fulfilled its challenge with regard to competition and dissemination of information to the public. However, considering the larger issue of the nation's energy security and use, new strategies are required to address systemic issues of higher density living and scalable communities. Energy consumption in residential and commercial buildings accounts for 40 percent of our nation's energy budget. Buildings typically operate at less than 50 percent overall efficiency. The housing industry has been reticent to experiment with new techniques that could make buildings less energy intensive. Houses constructed by small, local trades have not changed their construction techniques in decades. The panelized housing industry and prefabricated factory built processes represent some improvement in speed and waste reduction, but overall the results are conservative and energy saving is minimal.
This research is an initial attempt to apply lessons learned from previous work to crack open new ideas regarding residential, high-density construction and the use of energy in buildings. The goal is to develop and optimize an industrialized building system for low and mid-rise residential units. The initial tactic researches the feasibility and viability of a prefabricated building module. The intention is to merge sustainability, energy optimization, mass production and conservation with market demands and trends.

With the corporate partnership of Skidmore Owings and Merrill, our university research group is proposing (currently designing) a mixed use project on a site in south Chicago which will provide a city block design which includes medium and high density housing. The project is designed as factory built-industrialized and is proposed to reach near to net zero energy performance and will utilize fundamental sustainability practices including passive heating and cooling design strategies and water conservation. The goal for the proposed development in south Chicago is to reach net zero status by utilizing self-generated clean energy and large-scale environmentally sustainable and renewable practices.

Our presentation will detail the proposed design including unit plans and innovative integrated residential technologies, strategies for the industrialized production of the units, details of the energy strategies on the highly efficient complex and details of the mixed use city block design proposed as a near to net zero concept.

DESIGN-BUILD: PROTOTYPING A MODULAR, ENERGY-EFFICIENT ENVELOPE SYSTEM WITH STUDENTS

Christian Volkmann, City College of New York

Architectural education is often based on abstract knowledge, which limitedly can be applied to the activities needed in the professional field. One of the potential areas where this separation can be overcome, are academic design-build projects, which are an effective way of teaching students how to concretely "put things together".

When our school was accepted to the "2011 Solar Decathlon", we proposed a 'Solar Roofpod', a roof pavilion applied to the urban roofscape. We suggested to utilize a modular façade 'building block' system, combinable in customized configurations, also energy-efficient, environmentally reactive, attractive, easily transportable (possibly in the elevator) and assembled on site.

Of course, from the ambitious conceptual strategy to the realization of this system –which we produced from scratch in an old firehouse, in a woodshop, and in our school's studio during a period of 18 months– has had several processes of reiteration and adjustments. The intended presentation describes this process, as well as the intellectual effect it has had on the group of ~30 architecture students involved in it.

These effects are paramount to influencing critical thinking and the productivity level of our profession, interdisciplinary skills and social engagement.

SATURDAY, SEPTEMBER 29, 2012 - 8:30AM - 10:00AM

THEORIES OF FABRICATION SESSION I

MODULAR URBANISM

David Karle, University of Nebraska-Lincoln

Modularized building materials and typologies have influenced construction techniques in the discipline of architecture for centuries. From ancient masonry units, to thatch roof construction in Asia and Europe, to contemporary versions including shipping containers; the size, weight, and proportion of the module directly relates to the speed of construction.

This essay will move beyond purely the use of modular building components in the design of space and investigate the modularity and mass-production architectural typologies in direct relationship with the speeds and forms of American urbanization. Not limited to urban centers, but also the ubiquitous suburban condition. The essay will make comparisons between historical and contemporary forms of material and typological modularization.

During the early 20th century the development of modularized building typologies and systems accelerated the speed of urbanization in America. This was aided by techniques of mass production including the assembly line, mass-production of the car, and Sears and Roebuck homes. The great economic boom of this period, coupled with over-crowded urban centers, encouraged movement to the city's periphery. Henry Ford's invention of the assembly line in 1913 enhanced this migration and increased the need to build new homes. For example, the Sears and Roebuck mail-order kits offered 447 different housing styles, selling more than 100,000 homes between 1908 and 1940. Through both modularized systems and mass-production techniques Sears and Roebuck cut costs and reduced construction time by 40%.[1] Another example is Levittown, New York, where the assembly-line concept allowed for the speedy construction of houses — 150 per week, or one every 16 minutes of an eight-hour day.[2] In 1989 William Levitt told the New York Times, *"What it amounted to was a reversal of the Detroit assembly line. There, the car moved while the workers stayed at their stations. In the case of our houses, it was the workers who moved, doing the same jobs at different locations."*

The standardization of materials and architectural typologies can be traced throughout American history and demographic shifts, including the 1924 dimensional lumber sizes, and the development of 4'-0" x 8'-0" sheet material. These historic modular options tend to simplify building components and spaces; trading design for the speed of construction. The popularity and efficiency of modular building systems also became a viable option for commercial based architectural typologies as seen in the construction of big box stores and strip malls on the periphery of urban centers.

Today modular building components still play a key role in both housing and commercial building typologies. But since new fabrication techniques, standard architectural typologies have become less ubiquitous and more adaptive to site, environmental conditions, and programmatic needs.

In conclusion, modular based material and building typologies created for maximum efficiency and optimization in the early 20th century established a standardization or generic building typology for residential and commercial use, which we can still see today. However, new materials, modules, and typologies are being developed to account for new speeds and forms of urbanism in America. Only time will tell if these new modules are viable options.

1 http://www.searsarchives.com/homes/
2 Matt Schneiderman. http://therealdeal.com/issues_articles/william-levitt-the-king-of-suburbia/

SPECULATIVE EVOLUTION: COMPUTATIONAL AND BIOGENETIC ANALOGUES IN CONTEMPORARY ARCHITECTURAL PRODUCTION

Pasquale De Paola, Louisiana Tech University

> *"An abstract machine in itself, any more than it is semiotic; it is diagrammatic (it knows nothing about of the distinction between the artificial an the natural either). It operates by matter, not by substance; by function, not by form."*
> *-- Gilles Deleuze and Felix Guattari, A Thousand Plateaus, page 141*

The redundancy of architectural production necessitates new modes of interdisciplinary research that need to be more engaged in explorations concerning speculative design methodologies. This paper generates from the idea that architectural form and its material expression ought to emerge from the machinic assemblage of energy and matter. Within this framework, biological and material processes are quantitatively defined by mathematical and physical aspects, which determine patterns of growth and morphogenetic variations. Particularly, this tendency gravitates toward a much deeper understanding of biogenetic methodological analogues that are differentiated by Deleuze-derived diagrammatic methodologies of multiplicity. Thus, to fully unpack this framework of complexity, we need to drastically rewire our traditional signification of architectural production and particularly its material expressions and methodologies of construction to address issues related to complex systems and networked assemblies.

Historically, while modularization has defined the early developments of modernist architecture, its extreme modularization and consequent lack of morphogenetic differentiation has led to a sedentary architecture dictated by rigid functionalism in which different inputs had produced the same formal and material outputs. As a result, the signification of a stagnant modular process ought to be critically reframed by generating a new methodology prescribed by complex computational systems based on biological analogues. Ideally, this system can create innovative modes of architectural analysis and material production.

This paper will then examine the use of new models of architectural production as they relate to the operability of specific computational tools such as Grasshopper and Generative Components. Those parametric-associative platforms can facilitate and simulate evolution of construction processes based on components algorithmically organized. Most of this theoretical framework is underlined by diagrammatic modes that deterritorialize the meaning of architectural production in order to open it up to new functions and processes. The Deluzian abstract machine reappears in the form of algorithmic computational design procedure that destratifies traditional architectural production through parametric manipulation of preset numerical data sets. Interestingly, this strategy produces a multiplicity of distinctive procedural and morphogenetic differentiations while operating by matter, not substance; by function, not form.

As contemporary architecture becomes increasingly dependent on the overwhelming digitalization of architectural production, we have to avoid returning to functionalistic approaches based on modularization of inputs and outputs that create stagnant repetition. This paper concludes that the use of computational design strategies facilitates the process of differentiation while implementing a procedural approach where materials becomes genomic variations and protocellular source code that can be algorithmically generated and manipulated. To support this position, my paper will use case studies from the work of Yona Friedman, Christopher Alexander, Michael Hensel of OCEAN and Patrik Schumacher.

SATURDAY, SEPTEMBER 29, 2012 - 8:30AM - 10:00AM

THEORIES OF FABRICATION SESSION I (CONT.)

SYSTEM STRUCTURES IN ARCHITECTURE: TOWARDS A THEORY OF INDUSTRIALIZED CONSTRUCTION

Kasper Sánchez Vibaek, Royal Danish Academy of Fine Arts

The paper suggests the introduction of the notion of system structure in architectural design as a way to conceptualise a systemic level in architecture and construction that lies between general construction techniques and specific architectural results. In order to make such a system structure operational, the elaboration of a system structure model has been attempted that seeks on the one hand to analytically grasp and on the other hand to make it possible to actively work with system structures as part of architectural design.

Such endeavour has roots in the apparent and continuously increasing gap between architectural ideation and the way these ideas are brought to life as real physical manifestations of our built environment. Although this split between idea and execution can be traced all the way back to the Renaissance, the pronounced specialisation of the industrial era as well as the recently emerging and fast developing information technology has further accentuated this tendency addressed as the main problem of the thesis. Architectural design and construction have become a hugely complex matter and fragmentation of the knowledge needed to comply with the task produces risk of incoherent results. At the same time, however, this information technology has also strongly enhanced the ability to deal with complexity through data processing in quantities that were unimaginable just a few decades ago. New advanced managements tools within all fields based on information technology are introduced on a daily basis and both processing speed and storage capacity doubled within only a few years – while the devices that run these software based tools gets smaller and smaller.

The notion of system structure and the proposed system structure model is not an attempt to keep up with this development and follow this track. On a much more basic level represents a way to look as this complex reality of construction and architectural design through a different kind of lens that detects and describes coherent wholes of interdependent elements rather than seeking to describe each of these in their outmost detail. In line with the so-called systems sciences the paper rejects the prevalent scientific view that the degree of detail ‘automatically’ enhances understanding and explanative power. The concept and the model seek to establish the idea of a systems view on buildings and architectural design that through the use of flexible constituent elements facilitates discussion about how architectural wholes are appropriately put together as assemblages of what the current and future building industry is capable of producing.

This is not a reinvention of architecture and architectural creation – it is not an attempt to establish a new architectural paradigm or a different style. It does however represent a new way to look at what is already there – an industrially produced architecture – and argues that this new view can help facilitating a more active use of the present and future building industry in order to create architecture – not just construction – specifically attached to time, place and cultural context – not just expression of smooth processes or cost efficient solutions.

SATURDAY, SEPTEMBER 29, 2012 - 10:30AM - 12:30PM

HISTORY SESSION III

INTO AFRICA: A COMPARISON OF THE METAL, PREFABRICATED STRUCTURES PROPOSED BY AUGUSTE CHOISY (1893) AND JEAN PROUVÉ (1949) FOR THE FRENCH COLONIES

Hilary Bryon, Virginia Tech

In 1949, French engineer and industrial designer Jean Prouvé (1901-1984) developed a housing prototype for the French colonies in West Africa. Three structures were produced and erected: one in Niamey, Niger in 1949 and two in Brazzaville, the Republic of Congo in 1951. The aluminum, prefabricated, modular structures were designed to be easily transported, assembled, and disassembled.

These Maisons Tropicales have been much discussed, exhibited, and curated since their rediscovery and salvage from ruin in 2000. The portrayals inevitably laud Prouvé's innovative and modern approach, yet the record of the typology extends beyond Prouvé's proposal; there is at least one French precedent to Prouvé's design that dates back to the late 19th century.

In 1890, French engineer and architectural historian Auguste Choisy (1841 -1909) developed a system of building construction for colonies in tropical climates: prefabricated, raised above the ground, framed with a light metal skeleton, and easily dis-assembled. The striking similarities between Choisy's plans and Prouvé's prototypes do not end in the descriptions detailed here.

The paper compares Prouvé's Maisons Tropicales with Choisy's colonial constructions proposed more than fifty years earlier, examining in detail the fabrication techniques, constructive systems, and formal compositions of each.

MODULARITY, PREFABRICATION + BUILDING MANUALS IN POSTWAR ITALY: SCENES FROM AMERICA

Alicia Imperiale, Temple University

Italian architect Bruno Zevi, forced to leave Italy during WWII, first studied at Harvard University and was then employed as an architect in the Design and Engineering Section of the Office of the Chief Engineer in the United States Army. In July of 1944 he was reassigned to a post in England, awaiting his return to his native city, Rome after its liberation in 1945. Zevi, with his combined experience in the U.S. and in Britain was exposed to cutting edge modular construction used for temporary and emergency housing, and for hangers and other prefabricated military buildings. He was also exposed to a scientific approach to the design process through Architectural Graphic Standards (first published in the U.S. 1932) and other building manuals which offered a modular and systematized approach to the design and production of buildings.

In contrast, Italy, which was in immediate need of housing and other structures in the postwar Reconstruction did not have such a unified approach to building. Italy's building techniques were strictly in situ traditional methods of construction—and predominantly on site construction. A notion of modularity, if any existed, was only in the brick, concrete block, or gypsum panels used, but nothing that contained any sophistication in terms of prefabrication off site or an intelligence about systems of modular construction.

Upon his return to Rome after the war, Zevi brought this know-how to his position working for the Rome-based American Government outreach service, the United States Information Service (U.S.I.S.). He was stationed as Chief of the Technical Bulletin Section with the Office of International Information and Cultural Affairs in March 1946. Under this umbrella organization, Zevi, along with experts, engineers Bruno Buongiovannini and Pier Luigi Nervi and architect Mario Ridolfi, were tasked with the development, based on American building standards, of the Manuale dell'Architetto (The Manual of the Architect) to be completed in a rapid 6 month period. This Manuale was distributed free of charge by the U.S.I.S to 25,000 architects, engineers, builders, and technicians to attain a systematic approach, through modular and prefabricated elements to the urgent need for housing and other civic structures.

This early work was important for the future of prefabrication and modular construction in Italy and spawned extensive studies and further manuals for construction in rapidly developing and industrializing Italy. Among these are several texts by Giuseppe Ciribini, G. Mario Oliveri, Piero Spadolini and others who furthered the rapid spread of modular construction in Italy through the late 1970s. The emphasis in these later works discussed the issue of prefabrication at a theoretical level as a "system" and orchestration of the various parts that have a logic in their combination, which provides an interesting context to examine contemporary research and the proliferation of parametric modeling and BIM systems of integration and fabrication.

This paper asserts that a historical study provides a critical lens with which to analyze contemporary research, and that they were important steps at the time and are relevant to research today.

HISTORY SESSION III (CONT.)

THE 'SINGLE-POUR SYSTEM': THOMAS EDISON AND THE PRODUCTION OF A HOUSE WITHOUT PARTS

Matt Burgermaster, New Jersey Institute of Technology

This paper analyzes Thomas Edison's invention of a 'single-pour system' for concrete construction as a novel synthesis of industrialized construction methods with this material's dynamic behavior, and speculates on their respective roles in his production of a house without any parts

Originally motivated by the objective of providing a cost-effective prototype for the working class home, this early experiment in mass-production was one of Modernism's first attempts to construct a building with a single material. Edison's 1919 patent proposed a building-sized mold that leveraged the intrinsically dynamic capacity of concrete to form itself into a variety of shapes and sizes, limited only by the design of its formwork. The invention's potential efficiencies resided in the distribution of this material as a continuous flow through an entire building instead of being confined to the prefabrication of its constituent parts. By physically integrating all interior and exterior building components and their associated functions of structure, enclosure, and infrastructure within a single, monolithic concrete cast, all aspects of assembly were eliminated. It was a whole without any parts; a building without joints.

As such, Edison not only invented a new process for constructing concrete buildings, as the title of his patent suggests, but he also, perhaps inadvertently, created the blueprint for a kind of building anatomy – a seamless one - that had yet to be even imagined by the early 20th century architectural avant-garde. This paper re-considers this lost chapter in the history of prefabrication, and its unfulfilled technological promise, as a model for thinking about the alternative roles that the design and construction industries might play in contemporary architectural innovation.

UTOPIA AND PREFABRICATION: YONA FRIEDMAN'S LESSER KNOWN SIDE

Srdjan Jovanovic Weiss, Temple University

Visionary architect Yona Friedman has spent his life proposing fantastical and broad utopian schemes for the future of the traditional city. Friedman's drawings for mega-structures floating above a metropolis, in practically any metropolis worldwide, are widely known, published, and admired. What is less known is the fact that Friedman built three of his proposals: a block of apartments in Haifa, a school in Angers in 1978 and the Museum of Technology in Madra, India, in 1982. More interestingly, Friedman constructed those buildings using modular and prefabricated construction systems available at the time. My essay will look closely at these few examples of Friedman's broad visionary utopia in relation to his choice of pragmatic techniques of modular and prefabricated construction. The presentation and essay will posit that Friedman's visionary thinking and utopian direction in architecture and urbanism has a curious relation to such rationalizing building techniques and systems as prefabrication. Furthermore, the paper will speculate on the future of both visionary, fantastical architecture and its counterpoint in pragmatic construction techniques. We can surmise therefore that utopia and prefabrication are not opposites, but are, more precisely, degrees of completion.

HOUSING SESSION II

COMPACT PREFABRICATION AND THE ACCESSORY DWELLING UNIT

Kristina H Yu, University of New Mexico

In the backyards of mini mansions, the Accessory Dwelling Unit (ADU) is propelling a new form of housing and urban development. These dwellings are often considered an impoverished housing type emerging from auxiliary units for the servant class. ADUs are small, modest, and accessible by secondary darker alleyways from the back or side entries. Despite the negative impressions of early ADU types, current demographic and economic conditions necessitate innovative combinations of multi-unit housing development. ADUs are supporting a growing number of compact unit dwellers that benefit from the geographic centrality of the First Suburbs.[1] While the Baby-Boomer generation continues to age, becoming one of the largest groups looking for alternative housing and care, rising immigrant populations and the splintering of new creative classes are gradually shifting the character of inner-ring suburbs. All of these groups demand more accessible, affordable and diverse housing options located near urban cores. The development of ADUs in backyards, along alleyways and over garages meets the demand of elderly residents who wish to age in place, and non-traditional households that want to live close to a variety of urban amenities. They can provide homeowner stability through additional rental income that helps support their mortgages. The resulting densification and diversification of existing neighborhoods is subtly producing more economical, vibrant, and desirable places to live. A large opportunity exists for architects and prefabrication with the emergence of innovative ADU development policies in forward thinking cities. Off site prefabrication processes suit this unique market niche for compact design.

This paper argues that quality design through prefabrication is critical to increasing the potential value of ADU development. Compact homes demand a higher level of attention to the performance and quality of each square foot. Do-It-Yourself (DIY) projects can be complex and problematic for homeowners. The building process of code compliance, permitting, design, and cost evaluation is a daunting obstacle to overcome. The market is ripe for design and prefabrication to engage in ADU development. Designs are carefully tested for quality of spaces and construction as well as cost efficiencies related to production, in off site prefabrication methods. Like any prefabricated product, there are customized design options. A variety of furnishings, mechanical technologies, and finishes may complement mass production. Consequently, ADU development and prefabrication in the production home market may generate a large amount of new employment opportunities for the entire local building industry. The paper will provide a comparison of metropolitan ADU development policies, analyzing their effect on housing markets and job creation. Portland, Seattle, Santa Cruz, Denver, and Austin have all initiated widespread ADU legislation. These efforts have spurred numerous local architects and builders to shift their practice to prefabricated ADU design.

The benefits ADUs provide for homeowner stability, family care, renter affordability, and new employment opportunities in the housing sector, all increase with prefabricated design. A proliferation of ADUs may help transition sprawling cities towards metropolitan smart growth strategies. The design of ADUs encourages a shifting of priorities. This is a move from prioritizing quantity of square footage to an efficiently laid out plan, quality of construction and overall performance of the home. Compact prefab ADUs located in the First Suburbs could transform the density and enhance the quality of pivotal urban nodes.

1 First Suburb: Lee, Sugie; Leigh, Nancey Green. The Role of Inner Ring Suburbs in Metropolitan Smart Growth Strategies. *Journal of Planning Literature*, Feb2005, Vol. 1, Issue 3, p330-346, 17p. Article differentiates 'inner-ring' and 'first-tier' older suburban developments from new suburban sprawl.

CONSTRUCTION CRITICAL: TECHNOLOGY, MILLWORK, AND INTERIOR SPACE

Michael D. Gibson, Kansas State University

Peter McCleary's theorization of technology articulates that it must be "contextualized" in the "architect's reflection-in-action" rather than merely defined through tools and the way in which they are deployed.[1] While new technologies for design and fabrication are revolutionizing the building industry, McCleary's call for "reflection-in-action" suggests architects must seek a critical approach rather than simply appropriate these new technologies with indifference to how and to what end they are applied. Implicit in such a theorization is that the ultimate trajectory of prefabrication technology and its close cousin, Building Information Modeling, must be to impact the rationalization and performance of architecture – to critically engage construction – instead of merely streamline the workflows of service-oriented firms.

The proposed paper presents a construction critical case study: a commissioned residence that synthesizes advanced performance-driven design technologies and off-the-shelf industrial construction technology. A manufactured steel construction system, identical to those used for rapidly erected warehouses and industrial buildings, will serve as the armature for the project. In the project, the imperatives of production and performance have been the basis for reconsidering construction and its assemblies from the ground up, in a demonstration of McCleary's 'reflection in action.' Rather than a process of compromise, integrating the industrial steel structure has been a catalyst for innovative solutions to daylighting, thermal performance, interior finishes, and spatial development. The project will break ground in the Spring of 2013 and the author is the lead designer and technology consultant.

Further, the project will extend the author's argument posited at the 2008 Northeast ACSA Conference (also the University of Massachusetts Wood Structures Symposium). In this earlier paper, the author explored collaboration with local prefab manufacturers in the development and prototyping of two experimental prefab systems deployed to critically rethink two basic construction means: light wood frame panelization and manufactured wood trussing. The ultimate conclusion of this work was that via technology, construction can reasonably be challenged and innovated by design. Secondly, technology can become a collaborative framework where manufacturers allow the 'hacking' of their production methods by designers who, working within the constraints of production, can with little risk push the performance of architecture from many angles, including sustainability, program, and aesthetics.

The current project realizes this exact opportunity: technology will allow the alignment of performance and the means of construction, a strategy that is shaping the project at many scales. In the spirit of Kieran and Timberlake, the work will ultimately show technology's role in "reorganizing the process of making."[2] By engaging and integrating prefabrication technology critically instead of merely appropriating it, the paper intends to extend and refine a theoretical framework for 'critical' prefab architecture.

1 McCleary, Peter. "Some Characteristics of a New Concept of Technology". in Stein, Jay M. and Kent F. Spreckelmeyer eds. Classic Readings in Architecture. McGraw-Hill; New York, 1999.

2 Kieren, Stephen and James Timberlake. Refabricating Architecture. McGraw Hill; New York, 2004.

HOUSING SESSION II (CONT.)

PREFAB FOR HUMANITY

Ryan Salvas, Auburn University
Robert Sproull, Jr., Auburn University
Justin Miller, Auburn University

In the realm of affordable housing first cost is often a driving factor, however the cost to own and operate a house will outpace this initial outlay of capital. According to the Alabama Association of Habitat Affiliates (AAHA) families eligible for Habitat homes spend up to 30% of their income on utility bills. The majority of those bills are directed toward the heating and cooling loads of the houses. Within the affordable housing market, and particularly in Habitat Affiliates, stick built construction offers the utilization of free, unskilled laborers, but also limits the potential for the houses to develop and implement new energy saving systems. Any modifications to an existing, time-tested Habitat template would require the addition of skilled, paid tradesmen, who add cost and complexity to a bottom line driven market. Habitat for Humanity is scrambling to find solutions that would enable them to create more energy efficient homes, but at the same time make them simple enough that unskilled laborers can still piece the homes together without too much overhead. There is an opportunity to advance the energy efficiency of affordable homes by dividing labor and delivery into two categories; prefabricated construction and stick built traditional construction. By separating the construction sequence of Habitat Homes into two distinct tracks, opportunities arise for the integration of low-cost, energy saving prefabricated elements that could easily be integrated into a minimally modified stick-built habitat house utilizing the same unskilled laborers. One of these prefabricated systems, and a focus of this paper, is the development of a radiant envelope system.

Radiant assemblies for space heating (floors, walls, ceilings) are not a new system, early forms of these assemblies can be found in Roman Villas as well as traditional Japanese house construction. Originally these systems relied upon the use of air as a heat transfer medium. Air, heated in a furnace and directed into cavities within the wall and floor assemblies provided heat to the interior of the building. This technology ceased to be utilized with the development of more efficient fireplaces, stoves and systems of transport until being replaced with fan forced air-heating systems. Current material technologies are allowing for a renewed interest in conditioned air space for both heating and cooling. Radiant cooling is a more recent technology that promises to provide a cooling system that requires less energy than a conventional all-air compressive refrigeration system. The use of water (which can hold more heat than air) as the transfer medium yields a system that can operate at lower temperatures for both heating and cooling. This paper seeks to couple these approaches within a prefabricated radiant assembly that can provide an alternative low energy solution to heating and cooling a residential structure.

RALPH RAPSON'S GREENBELT: THE EVOLUTION OF A PROTOTYPE

Francisco Gomes, University of Texas at Austin

In 2003, Ralph Rapson was one of 16 architects invited by to submit designs for a prefabricated house competition in the Dwell Home Design Invitational – an event which contributed to a reviving contemporary public interest in modern prefabricated residential design. The clients for this house, Nathan and Ingrid Wieler, had approached Dwell magazine with their interest in building a modern house and purchased a wooded rural lot in the North Carolina Piedmont for the construction of the winning design by Resolution: 4 Architecture. During the troubled realization of their house, Nathan Wieler began planning a venture targeting the perceived market for modern prefabricated housing, and contracted with Ralph Rapson and Associates Inc. to further develop their competition submission as a marketable product.

The Rapson Greenbelt evolved continuously from its origin in 1945 as Case Study House #4 published in John Entenza's Arts + Architecture magazine into a growing family of prototypical partially modular house designs marketed by Wieler LLC beginning in 2006. The designs are organized around a central daylit "greenbelt" which was rendered with a glazed roof in the original Case Study project.

The contemporary development of this project describes a continually changing and ever more varied set of designs which illustrate the influence of regional modular manufacturing capabilities, cost implications of varying degrees of factory prefabrication, customer range and preferences, and site circumstances on the Greenbelt designs represented as prototypical. By Rapson's unexpected death in 2008 at the age of 93, the Greenbelt line included a range of prototypes from 570 to 2700 square feet including the Greenbelt Starter, Greenbelt 1, Greenbelt 1½, Greenbelt 2, Greenbelt Piloti, Greenbelt Walkout, and Greenbelt Townhouse. Although the Wieler LLC venture included land development and sales, as well as construction management, during this period only two Rapson Greenbelt houses were constructed: a site built house in New York, and a modular version in Maryland.

Design sketches by Ralph Rapson, design documents from Ralph Rapson and Associates Inc., modular manufacturer production drawings, internal notes from both marketing and implementation teams, and interviews with Nathan Wieler and Toby Rapson document many of the evolutionary forces on the designs. Over three years and hundreds of customer inquiries, the Greenbelt family of prototypical designs grew four times larger than the number of built examples, suggesting that design and manufacturing strategies which facilitate customer customization and adapt to varied manufacturing capabilities are important characteristics for success in the contemporary modular residential market.

HOUSING SESSION II (CONT.)

TOWARD GREEN INFILL HOUSING: A MODULAR "KIT-OF-PARTS"

Lisa D. Iulo, Pennsylvania State University

> *"For Pennsylvania's economy to thrive, it needs a housing market that meets the needs of low- to moderate-income residents. Those needs are far from being met and are increasing along with the demand for housing by the Marcellus Shale gas industry." (State Sen. Eugene Yaw, R-Loyalsock Township)*

Pennsylvania's existing towns offer an achievable vision of sustainable living. Because collective identity is often tied inextricably to historical patterns of development and landuse, towns tend to retain their status as drivers of regional identity. However many such towns have seen loss of population and dispersion of their services; their practical status as efficient centers is greatly diminished. Further when development occurs it usually is not contiguous with existing town fabric.

This paper explores modular building as a response to two apparent and specific needs for housing in Pennsylvania:

- Modest Housing for an aging population – emerging demographics are driving a strong need for high quality, low maintenance housing that is modest in size and cost.
- Demand for Housing Related to the Natural Gas Industry - The rapid expansion of the natural gas industry because of drilling in Marcellus Shale formation is causing unprecedented growth in a region unaccustomed to growth.

The combination of these two needs represent an opportunity for meaningful smart growth that will provide lasting value and lead toward a sustainable future for the commonwealth both now and beyond current trends.

Presenting a model for Modular Infill Development

Infill development augments existing fabric. That means small projects, usually one or two houses at a time. Because it builds upon existing infrastructure, infill development is inherently green. But rarely do we see small green affordable (subsidized or not) housing projects – the reason is size. Small projects can not bear the soft costs required by a team lead integrative design process nor the specific design response associated with unique and historically sensitive context of existing towns. These issues will be addressed through the presentation of The Union County Housing Authority's Energy Efficient Housing Project (EEHP) as model for green affordable infill housing. The EEHP's first new-build house - a duplex - saves more than 50% on energy costs, is comprised significantly of local and recycled materials, and costs little more than might be expected in the market. It also was fabricated locally in one of the region's modular housing plants. The duplex is a result of an ambitious replicable process for projects intended for low-tomedium density context. Through modular building, it is clear that this highly efficient model can be adapted to quickly and efficiently fit a variety of infill conditions through the development of a "Kit of Parts." This "Kit-of-Parts" describes a carefully designed set of modules (based on the union county model) that can be combined and site adapted. Because the modular manufacturing process provides for mass-customization, the houses benefit from both the economy of scale and integrative design process associated with high-performance and context sensitive design.

SATURDAY, SEPTEMBER 29, 2012 - 10:30AM - 12:30PM

PEDAGOGY SESSION

OFF-THE-GRID: THREE ACADEMIC DESIGN/BUILD PROJECTS BUILT OFFSITE, OFF-THE-GRID AND FOR THE PUBLIC

Rocco J. Ceo, III, University of Miami

As Design/Build goes getting anything designed and then built at all with students has great pedagogical value. Seeing lines turn into built form and comparing the conceptual gravity of an idea with the real weight of materials is intoxicating. With a focus exclusively on projects made for the public realm this paper focuses on the opportunities and challenges offered by building off-site, off-the-grid, for the road and then re-assembled on site. Modular, transportable architecture without cranes these projects offer lessons about what can be done in the public realm on limited budgets and time-frames with unconventional production strategies.

Project One: Built for an Orchid company that promotes the public value of epiphytic plants for public consumption, this project is about air, cypress, and oranges. Air gives form to the trellised pavilion made to simulate shade, air movement and the display of orchids. The pavilion acts as an outdoor classroom, site furniture and as a casual classroom for the owners. The structure is made of reclaimed cypress and made to resemble the baskets that are typical support systems for the orchids. The oranges while not part of the horticultural context of the project were used to move the structure and allowed students to easily slide 1700 pound components into place for transport to the site, and onto its foundation in a rural nursery that is "Vanda Heaven."

Project Two: Made for a not-for-profit group (Earth Learning) this project is an organic mobile kitchen to teach the value of sustainable agriculture in an urban environment and the virtue of supporting local food. Built to be off-the grid with solar generated electricity, hot water and an open structure that invites its users into the experience of the kitchen, this project provides a new model for the food-truck/street-food movement. Using an old mobile home the structure was stripped to its chassis, recycled then a new form and use is constructed to serve as a teaching and service kitchen. Used to teach inner city kids about organic healthy food production when in the city, on the weekends it is rented by rural farmers to process produce typically be discarded due to lack of curb appeal.

Project three: A set-up and take down scenario provides the seasonal ritual for the staff of Everglades National Park, Flamingo, and the site of the third project. Designed and built to be seasonal accommodations for visitors who want an overnight experience lodged between a tent and permanent cabin, the Eco-tent, prototype is being built and will ultimately be repeated to provide 40 off-the-grid cabins to replace those destroyed by past hurricanes. The open, modular, and sculptural, the new Eco-tents are designed to be partially disassembled and stored during the off-season (December through May). These cabins recall nautical and natural forms found in the park and are built of reclaimed materials that are a model for how to live in harmony with a world famous ecosystem.

DIGITAL TOLERANCE: ALTERNATE GROUNDINGS FOR COMPUTER FABRICATION PEDAGOGY

Sam Zeller, Kansas State University

As parametric modeling and CNC production continue to join the mainstream of architectural practice, digitally derived forms and materials have become increasingly commonplace. The control inherent in prefabrication is naturally beneficial for digital production, where tolerance is determined by a smaller set of parameters. In most cases, however, the designer must reconcile the controlled environment of off-site fabrication with the complexity of site concerns, varying trades and histories of evolved construction procedure. As a result, designing for prefabrication often requires sensitivity to practices that are conventional and less controlled. In this context, the architect who wishes to push design boundaries through digital means must either use boutique fabricators, or take established practices as a starting point from which to apply the burgeoning toolset. This paper describes a method of digital design teaching that is grounded in the latter approach. By beginning design investigations from an historic construction precedent, this pedagogy proposes a trajectory of making that aligns digital tools and techniques with the rich development of material culture, from craft beginnings through industrialization. These findings are a product of a yearly seminar in advanced construction techniques incorporating digital fabrication methods.

The students in the graduate seminar began with investigations into a given material's historical development, from the initial standardization of early craft guilds, through the industrial production and product development of the modern era and beyond. The work of this research was modeled in Rhinoceros and presented diagrammatically, a process that aligned the methodologies of manufacturing with digital modeling. For the students, this exercise challenged the tendency of digital modeling techniques to drive formal results. The diagrams provide an essential simplicity to the investigation, and highlight the constraints or flexibility of fabrication parameters; they become the basis for a projective construction process. Each student team must identify opportunities for introducing a digital alteration to their researched fabrication method, either through organization, form or procedure. The resulting products are then tested at full scale, and incorporated as a system on an existing architectural framework. The students in the most recent seminar produced metal, concrete and wood façade systems that were applied to an existing hotel façade.

As an instructor in building sciences, I argue for students to be more aggressive in appropriating and manipulating systems and assemblies, rather than accepting manufactured products as given. This mentality parallels current practice in media, particularly in the music industry, where the existing legal structure is at odds with practices like sampling, remixing and dubbing. While frustrating to the modernist structure of corporate music, this concept is completely approachable (even banal) to the average student who is familiar with popular culture. Leaving aside the capability to insert risk and argument into the studio work, this image of creative process is a more accurate designation of "craft" than a traditional image of the craftsman in his shop. If we define craft as deliberate, iterative changes to an established mastery of technique, then the current craft is essentially bound up with histories of off-site and on-site constructive logic.

PEDAGOGY SESSION (CONT.)

PROTOTYPE

Igor Siddiqui

The proposed paper examines the intersection of pedagogy, theory, and practice of prefabrication in design as framed by the graduate-level seminar 'Prototype,' offered annually to architecture, landscape architecture, and interior design students at our school. The notion of the prototype serves as a critical link between studio-based design practice and industrial manufacturing and is as such considered as a term whose meaning, agency, and status need to be further articulated and redefined in the context of contemporary architectural practice.

Processes of prototyping and the resulting prototypes refer to design as a fundamentally iterative practice and suggest a model within which what can be identified chronologically is a first in a series. As a term, the prototype is grounded in the tradition of serialization with origins across interrelated developments in craft production, mass production, and mass customization. In architecture and its allied disciplines today, prototyping is a ubiquitous term that is applied to a broad range of practices and its outcomes, from material experiments and component mock-ups at the scale of products to exemplary design proposals intended for large-scale systematic deployment. Emerging technologies in both design and manufacturing are persistently redefining the status repetition, similarity, and difference in embedded in constructed environments, and thus re-framing the very notion of prototypes in relation to serial production.

The underlying pedagogy of the seminar re-orients the students' projective thinking from site-specific construction to factory production. Rather than simply reproducing existing conceptual and production models from product design, however, the work in the seminar seeks to tease out the specificity as well as the latent possibilities for theoretically thinking and materially producing prefabricated components in the context of architecture and its allied spatial practices. The seminar's modular organization facilitates open-ended exchanges between theoretical inquiry and iterative making. Five interrelated theoretical modules – Standardization and Customization; Craft and Cultural Value; Prototyping – Terms, Concepts, Histories; Patterns – Repetition, Modulation, Variation; and Material Agency – are distributed throughout the semester in order to relate to the ongoing fabrication-based design project that students pursue in small collaborative groups. By linking theory and practice, the studio poses a number of questions, including:

1. How are manufactured products designed not as singular objects, but rather as systems that can aggregate and/or are multiplied in order to meet spatial conditions at larger scales?
2. How do material and digital processes shape notions of repetition and variation, and by extension negotiate the competing demands for standardization and customization, in architectural product design?
3. What are the consequences of full-scale making as an integral part of one's design process and how can experience gained through such a way of working be translated as expertise that is relevant in the realm of manufacturing?

A selection of student work from the seminar will be presented in order to show how each project engages with such questions as well as situates, in a number of different ways, the designer-driven prototyping processes within the overall cycle of product development from design to prefabrication to deployment.

THE BUTLER* BUILDING AS A PEDAGOGICAL INSTRUMENT

Greg Snyder, University of North Carolina at Charlotte

> *"Metal buildings are the dream that Modern Architects had at the beginning of the century finally come true, but they themselves don't realize it. That's because it doesn't take an architect to build a metal building. You just order it out of a catalogue. You just pick the color, the size that you want, number of square feet, style, what you need it for. It comes with a bunch of guys. They put it together in a couple of days. Maybe a week. There you go. You're all set to go into business. Just slap a sign in front."* David Byrne from **True Stories**

The heyday of the ironic observation on the metal building my have past 30 years ago, but the ubiquity of the metal building is still an issue that has weight in the physical and cultural landscape to the extent that the discipline of Architecture is obliged to understand it, and address it critically. Within the critical appraisal of the metal building there is an opportunity to exploit it as a pedagogical instrument that engages several topics integral to the education of the architect. This paper studies the metal building in order to illustrate a framework for addressing historical, theoretical, and design questions that can that can be posited in order to activate the development of a more dimensional understanding of something that is seemingly straight-forward, uncomplicated, and banal. The research is in service of the development of a studio project sequence that aims to elevate the students' understanding and appreciation of the metal building system as something that has the capacity to communicate meaning through the rhetoric of the tectonic and the detail, while also facilitating formal expression that is not limited to the conventional application of the system and its attendant componentry that is too familiar. The position of the paper is that the careful examination of the metal building contributes to a breadth in knowledge that is both applicable to a considered understanding of its emergence, but also reveals opportunities for the articulated metal building to contribute more productively to the contemporary cultural discourse.

The paper examines the following topics:

- Heir to the Crystal Palace: the metal building in the context of the lineage of the steel building and manufactured components
- The metal building kit of parts: the logic of assembly and a lesson in hierarchy
- The material culture inherent in the "off-the-shelf"
- The metal building as an American vernacular
- Froebel and Butler: the metal building goes to Kindergarten

* The trade name Butler Building is used in lieu of the generic term "metal building" in order to emphasize the condition of familiarity that is present when a culture adopts this kind of shorthand.

SATURDAY, SEPTEMBER 29, 2012 - 10:30AM - 12:30PM

THEORIES OF FABRICATION SESSION II

SYSTEMS ANALYSIS AND INTEGRATION IN PREFABRICATION

Emanuel Jannasch, Dalhousie University

Achieving performance and construction efficiencies simultaneously requires the architect to identify, manipulate, and coordinate many different kinds and levels of system. This is especially true where the latent economies of prefabrication are being sought. However, not all systems taxonomies are well formed conceptually, which may lead to design frustrations. Others do achieve internal coherence but fail to address the real complexities of architecture. This paper proposes a novel set of systems principles that are conceptually coherent but nonetheless capable of mapping difficult, real world complexities. These systems tools can clarify some of the design and logistical problems associated with prefabrication.

The paper begins by tracing different ways of decomposing buildings, among them Alberti's triad, Semper's four elements, and the Masterformat, all quite different, but all well formed conceptually. By contrast, the decompositions proposed by Rush and the co-authors of The Building Systems Integration Handbook or by Flynn, Segil, and Steffy, are not well formed, and must ultimately give way to unstructured intuition. By way of context, the systems descriptions proposed by generalist thinkers of the sixties and seventies (Herbert Simon, Howard Pattee, and others) tend to fall into the same pattern.

The main contribution of this paper is a distinction between the extraction and abstraction of systems. Extracted systems and subsystems are both closed and hierarchical but cannot define performance. Abstracted systems and subsystems are capable of performance, but are neither bounded nor hierarchical. Examples are drawn not only from architecture but from other areas of making and from the natural sciences. Extracted systems include systems of assembly, sourcing, subcontracting, and material attributes. Abstracted system include systems of affordance, utility/supply, enclosure, and control. Within these types, some important sub-varieties are illustrated.

A salient characteristic of buildings is the relationship between the two systems types. Interestingly, in loosely integrated commercial practice and in conventional patterns of subcontracting and site assembly, the two systems types are largely congruent. In buildings more tightly integrated, whether for aesthetic or performance reasons, different kinds of discongruity appear. This counter-intuitive result may explain some of the surprising costs of achieving design quality, and the surprising difficulties of realizing certain types of prefabrication.

It can also help explain why some emerging patterns of fabrication are proving successful, and how these patterns may be elaborated and refined.

OFF-SITE / OFF-WORLD: PREFABRICATION FOR EXTREME CONDITIONS AND UNPREDICTABILITY

Genevieve Baudoin & Bruce Johnson, University of Kansas

Prefabrication is perhaps most often used in construction for economic reasons: employing mass production and standardization to ease assembly, reduce waste, and hopefully improve quality. The potential pitfalls to this way of thinking is that it can blind us to the specificities of any given site, employing the same construction methods and materials for any and all given site conditions. On the other side of this are site conditions that are so extreme we are forced into designing through pre-fabrication due to the inaccessibility of working in the open on the site.

In Ridley Scott's infamous Blade Runner, "replicants" are engineered to colonize the frontier of Off-World – a catchier way to say extremely off-site. Designed to outshine humans, replicants can manage the unpredictability of site conditions that cannot be grasped by calculations alone. Replicants may be the product of science fiction, but we have been designing for this kind of unpredictability for decades.

The fledgling space industry of the 1950s adopted extreme pre-fabrication to cope with the radical physical displacement from site, i.e. the distance to the moon. This required a type of remote sensing or an assumed idea of what constitutes site. Empirical experimentation combined with precise scientific models produced a series of prototypes that were honed during the heyday of the space race. This kind of iterative learning as prototyping, adapting to flaws and forecasting for future failure, is often neglected through the process of standardization in the building industry.

The new Amundsen-Scott South Pole Station also builds on this iterative learning model. As a base that has been continuously inhabited since 1957, it has had to cope not only with extreme conditions, but with the unpredictable nature of durability and economy building in full-scale prototypes. Adapting a design to be increasingly durable is a feature that is all but forgotten in today's standard construction methods where homes are not designed to last.

As the movie Outbreak illustrates, the nature of virile outbreaks can be devastating, and devastatingly quick. Designing for the containment of outbreak scenarios is fraught with unpredictable conditions. Not only do these systems need to be designed for any environment, they are protecting against the smallest organisms we know. The speed with which these systems must be assembled, combined with the level of precision to keep out germs is often lost in the world of installing prefabricated modules. Most prefabrication is designed for tolerance in installation, not precision.

Good architecture always has a relationship to site, but architects foraying into prefabrication techniques often minimize any intellectual notions of site when focusing solely on the construction. How do we as architects begin to design using prefabrication without losing sight of one of the most critical aspects of any piece of architecture? Are there lessons to be learned from extreme off-site prefabrication? What are the implications when we consider iterative learning, durability and precision? This paper will examine these questions and the possibilities that they offer in the exchange.

THEORIES OF FABRICATION SESSION II (CONT.)

FORM FOLLOWS STRUCTURE: BIOMIMETIC EMERGENT MODELS OF ARCHITECTURAL PRODUCTION

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> *"If you want to make a living flower you do not build it physically with tweezers, cell by cell; you grow it from seed. If you want to design a new flower, you will design the seed and let it grow. The seeds of the environment are pattern languages"* -- Christopher Alexander, 1970

Recent evolution of architectural materials and fabrication technologies has created an interesting culture of multiplicity where methods of assembly are incessantly challenged by the invasive use of computer-aided design and manufacturing (CAD/CAM). This pervasive development has not only created new generative outcomes but it has also produced new material processes. Thus, emerging materials, renewable energy, and ecological design have created an appealing material culture in which materials and their methods are revaluating our inherited notion of architectural material significance.

What regulates this new framework of complexity? This paper will try to answer the originating question by looking at the concept of emergence and how it might relate to new modes of modularization or architectural production. Ideally, a material process articulated around the Deluzian idea of difference and repetition should be based on the recognition of multiple formal variations; consequently, form ought to be integrated with structure and material to allow for a more pragmatic functionality of its symbiotic apparatus. The ultimate scope of form generative processes is to provide guidelines for fabrication, which in this paper are generated by looking at examples of self-organizing structures characterized by natural apparatuses from which their performance (material) emerges.

Considering that biological materials are widely self-assembled and rapidly self-generating, this paper begins by analyzing the importance of biomimetic approaches to the production of new speculative methodologies of assembly in order to understand how certain organisms or biological forms organize themselves. This framework also allows for a deeper understanding of organized complexity through material pattern recognition methods. Yet, those patterns are not just another architectural formalization of nature, thus reducible to pure aesthetic, but instead they propose a more accurate study of those biological models based on the recognition of reciprocal elements of structure and form. Structures and their material expression have indeed the effect of emphasizing shape. In order to generate the final premises of this research paper, I will look into the work of Frei Otto, emphasizing his attention for those structural and material processes characterized by form finding through biological analogues. Indeed, if you want to design a new flower, you will have to design its seed first. Thus, understanding the new emergent patterns of material practice is what we need to do to avoid a regimental return to architectural production as we know it.

SIMPLE AESTHETICS: SEARCHING FOR A THEORETICAL BASIS FOR DESIGN RESTRAINT

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There is still a division in the architectural community between theory-based designers and those of us who look to building technology as regulators for design. Theory-based designers seem to promote complexity over simplicity, using parametric modeling to generate complex geometric forms and computer aided manufacturing (CAM) equipment for building fabrication. This contrasts greatly with designers who are interested in building technology. We are often calling for design restraint, citing important governing issues such as constructability (both on and off site), integration, performance, and detailing. These constraints are valued for their performance, but we often do not speak of them in terms of their potential resulting effects on building aesthetics. This lack of engagement with aesthetics forces the choice between art-form and reality. Instead, could we as building technologists promote aesthetics through the design of our buildings? Our art-form would favor repetition, rhythm, restraint and simplicity of form.

As building technologists, we often avoid discussions of aesthetics. Even this Fall 2012 ACSA conference, Off-site, has theory listed in its call for abstracts, but does suggest aesthetics in its list of potential topics.[1] Here, theory is reduced to construction, production, and fabrication, without discussing the possibility of aesthetics. The drawback of not discussing the art-form of architecture is that it appears that we assume that construction, production, and fabrication will dictate form. I would argue that although production methods can affect form they do not dictate form. Architects such as Frank Gehry, Zaha Hadid, and Greg Lynn design buildings that typically use complex curves. The offices must collaborate with fabricators to use software and CAM technologies to design and fabricate both structure and skin. In comparison, Foster's Great Court at the British Museum makes use of the same equipment to construct the glass and steel roof. Foster's addition at the British Museum is not complex. It is a simple section of a torus. This demonstrates that the construction technologies do not dictate form; rather the designers have differing aesthetic values. The aesthetics guide Foster's building can also be expanded to include similar architects that use restraint in their designs. Those include Tadeo Ando, Peter Zumthor, and Glen Murcutt.

This paper will seek out theories that establish the aesthetic value of buildings designed with restraint. This paper will survey contemporary theories (within the past 15 years) that value design restraint as an art-form. Based on available theories and writings found, this paper will use case studies that demonstrate these aesthetic values. Issues of rhythm, light, repetition, proportions, contextualization, and exterior space will be addressed. This paper will begin to establish the artistic value that building's designed using the constraints offered by building technologies. This expands our value beyond isolating issues of construction, details, integration, and sustainability to both designer and builder.

1 It lists history of architectural production, modularization and prefabrication; production theory and criticism; postulation, speculation on future of architectural production; parametric modeling and CNC production speculations; and design case studies, prototypes and experiments. http://acsa-arch.org/programs-events/conferences/fall-conference/2012-fallconference/call-for-abstracts. Accessed 29 March 2012

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