Variable Form Generation

MAIA SMALL
ANDREW THURLOW
Roger Williams University

Introduction

Over the last three centuries, as developing industrial techniques and architecture schools propagated new design and construction models, architects saw opportunities to employ social agendas through large-scale production. In education, burgeoning modernists opined that beauty could be classified and rigorously taught to students as a matrix of components that would sponsor an ideal, universal result. Likewise in the profession, standardization created the paradigm of the prototype, a singularly designed component that could be mass-produced and transported easily and sold in bulk quantities. Since one design could have such a large effect, architects hoped to bring good design through production to the masses and instead often failed with notorious consequences: a dogmatic simplification of social roles, monotonous repetition that denied individuality and the reinforcement of economic division. This trap has been caused by one primary equation: the inverse relationship between repetition and cost. More recent models have sought to soften that requirement to allow for increased variety and individuation to avoid a perception of cultural homogeneity, and to restructure the equation. Below is a list of historical models in this area of study:

Parallel Production (PP) → Highly Repetitive

Parallel production models maximize design sameness to maximize mechanical production cost and efficiency. These highly repetitious systems in architecture are found primarily in factory built structures: manufactured housing, teaching modules, construction trailers and franchise design. This lineage stems from not only the travel trailer industry, but early examples of packaged houses as well, such as the Buckminster Fullers Dymaxion House and the Lustron House. Another PP example would be the Sears Roebuck, and Company Catalog-bought Modern home kits that presented the purchaser with factory cut and organized materials for assembly on site. Early examples of urban models are corporate or institutionally controlled urbanism, such as factory towns or worker camps. While not factory built, many developer designed communities, such as Levittown, New York continuing into today's MacMansion suburbs, could be classified as parallel production systems because their production efficiency stems from a highly similar repetition of materials and output on site. These models have generally been highly successful economically because of their low cost and mass scale, however, they have generated industries of design that have mostly eliminated the position of architects and any pretense of social intention. In some cases, they have caused dangerous consequences in an American cultural environment that promotes personality and independence; through the promotion of a generic blandness, inhabitants have complained of a lost sense of individuality and an increased feeling of cultural detachment.

Kit of Parts (KOP) → More Similar, Less Unique

Kit of Parts systems describe a way to organize the design or construction of a building through pre-made building assemblies that can be organized or

reassembled easily within the system. Prior to new forms of industrial manufacturing, KOP systems are actually one of the oldest forms of ideological pre-Modernism. For example, in the 18th century, J. N. L. Durand cataloged canonical design elements and imagined how they could be refigured through different programs or building types. This intention to codify geometry and proportion offered a detachment from the unique to the systematic and propelled typology and universality in design. An urban example could be John Nash's design for Regent Street in London in the early 1800s where the repetitive facade elements modulated in terms of the urban fabric. In manufacturing, the Kit of Parts systems developed primarily after World War II and the excesses of industrial steel and large scale manufacturing technology for ship and weaponry construction. The Case Study housing program in California, specifically the Eames House, was perhaps the most well known example, where the catalog purchased components could not only be assembled and distributed during construction, but could ideally be reorganized or adjusted or replaced easily by the owner at a later date. While there is more variety possible through this system, it is limited often to color, composition and material type. The pieces are predetermined, and design comes through arrangement.[1]

Cellular Construction (CC) → Similar Material, Similar Form

The most common type of American construction, cellular systems essentially balance between small unit repetition and custom, unique building. Based on models by such engineers as Albert Farwell Bemis, efficiency in this way of building relies upon standardized units and dimensions, for example: the 4'x8' plywood panel, the 32" x 6'8" door, 5/8" gypsum wall board thickness, etc.[2] Alvar Aalto described its opportunities:

> One further phenomenon in architecture should be called to mind in this context, the oldest and at the same tie the more recent technique: standardization. Standardization is usually seen as a method that makes everything uniform and schematic. It is clear that this is not so. Properly standardized building elements and raw materials are such that one can achieve a wide variety of results by combining them in different ways. I once suggested that nature herself is the best standards committee, but in nature, standardization is practiced almost exclusively in the smallest possible units, the cells. This results in millions of different combinations that never become schematic.[3]

CC systems allow for reasonable efficiency within predictable geometries, but are inflexible and resistant to formal and material experimentation. (Aalto also complained about the limitations of standardized bricks in the U.S. when he tried to do rounded forms.) While seemly infinite variation should occur, because of the economic and social pressures, design tends to be limited to predictable conventions: straight walls, ninety degree angles, four foot dimensions, predictable wall thicknesses, etc. Because the degree of factory production is limited and much of the work is on site, the quality of construction is dependent on labor skill. Anything that deviates from a conventional system transfers from the highly economically efficient category of "standard" to the unaffordable "custom," typically only available left to high-end residential or museum construction. Also, because variety is linked to cost, the division of interests (stereotypically: contractors = cost, architects = quality) leads not to partnership, but to conflict and, under the pressures of time and cost, quality generally falls to ease.

Unique Form Generation (UFG) → Unique form, Similar Material

UFG models include design systems that allow for the mass production of entirely non-repetitive form. These are found exclusively in emerging technology and processes, such as large-scale 3D printing machinery that can "print" a building out of concrete much like their Rapid Prototyping powder-based 3D printing counterparts on the very small scale. The advantages of these systems are that form individuation and customization could be highly complex and geometrically unique on a very large scale, however, so far, they are relatively untested and material options are very limited.

Variable Form Generation (VFG) → More Unique, Less Similar

Because UFG are so limited in developing technology and material output, their formal opportunities do not offset their required sameness. Thus, we believe the current optimum option is the Variable Form Generation model. VFG systems allow for mass customization of form embedded within the built material. Unlike the three types listed above, these systems do not constrain repetition to cost. Some indulgent historical highlights:

The design for the idealized Industrial Cité by Tony Garnier in the early 20th century intended to employ the variable reinforced concrete systems of August Perrer.[4] Reinforced concrete could be employed in precast and cast in place manners and with high amounts of variability to accommodate changes in housing or commercial density. Reinforced concrete offered a way to create mass construction, quickly efficiently, using local materials and at the same time engender various forms, geometries and options.[5]

As well, during the turn of the 20th century, H.P. Berlage housing developments in Amsterdam in the Netherlands also employed the use of brick in a highly repetitive and unique way. Social housing in southern Amsterdam had two intentions: to bring housing in an efficient manner to the masses and to create a sense of ownership and place among its residents. The larger social goals not only include efficient methods of construction and quick turnover, but provided, often at the detail scale, beautiful crenellations, articulated windows and rounded ornament that gave each district its own character. Often certain types of moves would be repeated, but with variations in location or scale to create contextual responses and personal flair. This model was also used in other forms during the predominance of the Amsterdam School such as in the housing of De Klerk in Northwestern Amsterdam that also provided a variety of brick techniques, layouts, details and patterns. The reason it transgressed the Cellular model to become a VFG model is that they were deployed systematically on a vast scale over neighborhoods and employed repetitive manual techniques with unique outputs.

Another example of this era of repetitive and variable models was the Hector Guimard's designs of Metro stations in Paris. The stations, a small-scale deployed urban system, used standardized iron components in combination with custom and modulated pieces to create a recognizable system of entries that also responded directly to the conditions of each site and neighborhood. [6] Their ornamental enthusiasm cloaked their industrial processes and proved that the Art Nouveau did not rely on the Arts and Crafts model of contextual, labor intensive, manual production. The formal, sinuous qualities both gave an aesthetic brand to the city and let each entry have its own character and subtlety.[7]

At the large scale, the 1930s development of the Tennessee Valley Authority created a system of landscape and infrastructure with the same methods and techniques, but with highly contextual output. The systems here were not manufacturing, but a trained workforce, methods of material delivery and engineering models. The result was a multi-state system of landscape alteration and dramatic elements of infrastructure that was both clearly identifiable and ultimately variable. (The Alcoa Aluminum Company also built many dams around the same area and time, yet they are distinctly different in character.) The TVA was so compelling as a system, that it drew Le Corbusier to one of his only two stops in the United States-- the other being New York City.

While these historical VFG models mostly use manual processes, contemporary VFG processes have increased dramatically with the use of computer numerical controlled machinery. The direct translation from digital environments into material production processes has offered a greater complexity and precision and the freedom from reliance on manual skill and technique. The constraints so far are the scale of the machines available and how the variable components integrate into an over all design. The following are three examples of our design proposals for VGF systems.

Gabion Field: National AIDS Memorial

> Existence is no more than the precarious attainment of relevance in an intensely mobile flux of past, present, and future.

> The past itself, as historical change continues to accelerate, has become the most surreal of subjects - making it possible... to see a new beauty in what is vanishing.
>
> Susan Sontag

The first project is a finalist entry for the National AIDS Memorial located in Golden Gate Park. While the location was specific, the design included more a technique for making objects with in a loose landscape. The specific response within itself included variations of a particular system employed across an existing landscape.

Figure 1. Memorial view.

Unlike the instantaneous and overwhelming disasters that the world has seen recently through political and natural destruction, the pandemic of AIDS has crept and spread towards societal erosion over decades. But while the destruction is vast, there is no singular marker in time of remembrance, anniversary of an event that becomes a collective acknowledgement. Instead, linkages of individual stories have become a global network; sadness and loss has become not only a personal and local process, but a global emotional experience as well. We experience grief through a new sense of scale. In an environment of a disease that captures and changes lives throughout the world, over time, incrementally, in hidden and overt ways, in all economic and social environments, through political passages, this design proposal for a National AIDS Memorial is more a memorial landscape than monument.

It is a loose and interactive system of distributed components, an open network of landscape organized by choreographed figures; it is not a fixed, pristine, idealized object intend to charm or abstract a complex experience. The project deploys wire-mesh-architecture in the existing landscape of the Memorial Grove in Golden Gate Park. These objects, as a landscape of spirit, elevate a series of layers of screening and overlapping to express light weight organizations of air and space, containers of program, eddies and swirls of density. They also house remembrance by becoming a framework for memento, such as for red ribbons-- or the impromptu self-organized memorials, such as in New York City after 9/11. (Imagine the impossibility of a red ribbon appended on a wire for every person who contracted HIV...) The wire frameworks offer a structure for layers of memory so that remembrance is not abstract, but instead has texture, individuality-- so that it remains conscious and alive.

The design is a distributed composition of wire structures across the AIDS Memorial grove in Golden Gate Park in San Francisco. The wire gabions are distributed into the surrounding forest and out into the meadow where they densify and help to form organized spaces. The wire is deformed to create benches, walls and portals. The wire lattice also creates an atmosphere of framework, without interfering with the lush surroundings or treading heavily upon the ground. The figures become more angelic, more spirits in the material world that guide the space of the memorial garden. The figures, as trunks, operate like columns of collected space, similar in scale and nature like surrounding trees. They would be both visual clues of another type of garden space and space defining objects.

> ...space goes through them...looking at them we can notice that they are made by air, like a sculpture.
>
> Harry Bertoia

Figure 2. Memorial view.

The wire-mesh-components shape space, they are meshes which consist of braids and linkages, a form of architectural drapery, like

webs floating in the air, "strong yet delicate in appearance." The individual wires are joined together to create an airy and light structure that can be extended in multiple directions. Their fabrication would be done through a combination of fabrication techniques, but most specifically using CNC milling to establish formwork in which wire would be laid. A four-axis mill would mill foam in the shape of the three-dimensional forms with channels. The channels would describe the lenticular wire shapes and would allow the wire to be inlaid and welded in place. Then once formed, the formwork would be removed and two haves would be attached to create an upright gabion. Each gabion would then be powder coated with opalescent paint and treated to withstand the salt air of the park. Once completed, the gabions would be brought to the site and installed into poured in place foundation anchors. As the memorial could gather individually placed ribbons, they would seem to almost hang suspended in space.

The Ogive: Urban Pavilions

The second VFG project is for an ogival system of construction used in two examples: as an urban art display system and as a roof system as part of a park pavilion. Ogive describes a formal logic between two components that follow one another, joining and separating in predictable intervals. In both projects, the ogive strategy is used to structure changeable surfaces that allow for variable formal articulations that remain continuous. To create a surface and structure that vary but are also a replete system, we employed a strategy much like Guillard's Parisian Metro station entries-- less a specific design and more a sensibility of form that could be used at various scales to create a series of urban infrastructures. The Ogive is structural, simple but with variability for use in different contexts and for a variety of programs. The following two projects demonstrate some of its possibilities.

Urban Art Display: the Obvita Slide

The Obvita Slide project is a proposed art pavilion that avoids the enclosed and separate nature of "pavilion," and instead creates pavilion-less-ness: an open, permeable framework. It is a performative envelope that

Figure 3. Urban Art Pavilion view.

offers three grotto-like territories for grouping and viewing art within an existing interior or exterior environment. Each created space is discreet in scale, delicate, textural and organized nodally along the sinuous, continuous surface structure. The slide encourages the adventure of new movement patterns and circulation while broadcasting art by nesting into an existing and familiar space, as a symbiotic organism folds into its pair: the urban environment provides and enclave, while the slide activates its interior.

The Obvita slide is constructed as a 38 zone, large fiberglass shell mounted to a framework of braided ogive-shaped, or lenticular aluminum extrusions. The aluminum extrusions are simply bent into shape and held where they converge. Each zone contains several individual panels that are vacuum-formed over unique CNC foam molds and micro-patterned with machined toolpath profiles, as new-ornament. This micro-ribbed effect is pronounced where there is no art displayed and becomes flatter towards display areas.

This VFG model involves two types of form variation: the panels can adapt to the structure and the structure can reconfigure or refit into different locations. While the structural pieces are all different, their fittings work together to allow it to be reset and reformed. This structure is light and strong and can be assembled and reassembled in different locations over time or for different types of display. Each time it is erected, it either uses the surfaces from before if it is in the same shape or requires replacement pieces in some locations that fit into its new shape. The new shapes can determine new relationships between the work displayed on

Figure 4. Urban Art Pavilion view.

the surface and the public spaces it defines. Art could also be hung in place of the panels or from the aluminum extrusions. Viewers can experience the artwork both from inside and out-- or through the slide display surfaces. While the slide expands to move through the urban area as a system, it is easily demountable and, when stacked, comfortably fits into a small space for storage. The panels are simply fastened to the aluminum tubes which are themselves slotted to fit together much like tent poles.

Urban Information Pavilions: the Boston Atoll

like the islands outside of Boston, are not isolated and differentiated from their surroundings, but are rather tied to an existing network of life and energy of the city. They supervise and cultivate, draw in for rest and propel towards discovery. The atolls become stations for enjoyment, pools to relax, patience in the city, softness in the

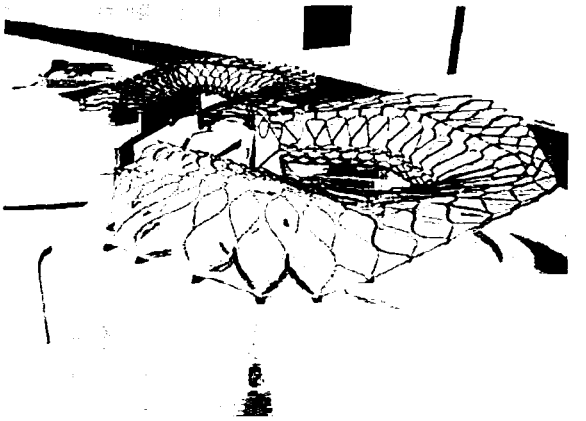

Figure 5. Urban Information Pavilion view.

stimulating surround. They entice as pockets of program, a bookstore that opens to a café and information that is available 24 hours aday. They are grottos, small in scale, delicate and textural, within a complex and vast urban fabric. They also define a space within the greenway to encourage the adventure of new paths, directions and trajectories. Each building has a central exterior court space around which the pavilion program wraps to create a seamless transition between programs and interior and exterior spaces.

A glass fiber-reinforced fabric-covered canopy frames views onto the city and surrounding linear park spaces. The pavement extends beyond the massing of the pavilions and unfolds into the landscape terminating in a CNC milled textured granite scalar model representation of the Boston Harbor Islands. The roof system not only defines the interior and exterior of enclosed spaces, but articulates the nature of each program and building. The cafe and bookstore are the most enclosed and have the tightest pressure of ogival pieces. The information pavilion has a looser structure with more openings to describe the permeability of the programmatic intention. Parts of this roof are simply open as a lattice or trellised area.

The VFG function of this project is through the way in which the roof structure would be made of variable pieces created from laser-cut metal and covered with CNC milled and formed pieces. The system is intended for this specific location, but as a pavilion type, it could become a large design deployed through a city that responds to the specific natures of both programmatic and site desires. Boston, specifically, is full of historical and natural

sites that could each sponsor a pavilion adjusted to convey its unique characteristics.

Ethics of Standardization

These projects promote architecture that employs a strategy of manufacturing that allows the designs to shift their specificities and reacts to local conditions. They argue that variation as essential to good design systems and that architecture can partner with construction techniques. They do not promote a specific technique, nor do they promote an ultimate solution or technological answer.

Ironically, while standardization and industrial processes were jumpstarted in Europe, where post war housing spurred quick innovation and socialism encouraged repetitive, collective models, it has been in America where standardization has taken deep root. European models of the build environment offered a complex web of aesthetic, individuality and historical significance. Thus a few projects that systematized output did not reform a sense of cultural identity. The new developments also were typically small in scale, medium density to either create urban infill or not compete with agricultural lands, and worked off of existing aesthetic or stylistic models. In America, where the western cultural influence was short, style relatively artificial in its significance and land so easy to acquire that low-density projects could amble into available suburban space, repetitive models were and are still employed because of their quick profitability. Since there was little cultural or stylistic context, developers appropriated faux models and then repeated them to force a sense of cultural attachment. Local conditions were never allowed to develop-- the capitalistic models replaced local-based cultural evolution and essentially franchised architectural style. American housing was a brand, that promoted lifestyle instead of daily habits and local conditions promoting spatial and aesthetic models. Eventually, the market has continued to crush the need for architects in housing. Since the masses have grown up through a false sense of iconography, they seek the same models already provided. Because of this, people rarely desire their own architects nor can they afford an industry that promotes one-off designs. Architects can engage a larger social commentary by reengage the systems in effect: developer logics and their effects on land and production models that link cost and repetition. As much as the industrial production models offer immediate responses to a lack of housing and urban infrastructure, we must resist their temptation, to instead allow for local variation, complex visions and incremental change.

Endnotes:

[1] Hernandez, Antonio "J.N.L. Durand's Architectural Theory. A Study in the History of Rational Building Design," Perspecta No. 1, 2 pp. 153 - 160.

[2] Bemis, Albert. Evolving House. Cambridge: The Technology Press, Massachusetts Institute of Technology, 1956.

[3] Aalto, Alvar. Sketches. ed. G. Scihldt and trans. S. Wrede, Cambridge: 1978. "The Influence of Construction and Materials." 1938. pp. 60 - 63.

[4] Britton, Karla, Auguste Perret. London: Phaidon Press Limited, 2001. pp. 4 - 15.

[5] Weibeson, Dora. Tony Garnier: The Cité Industrielle. New York: 1969. pp. 11 - 20, 107 - 112.

[6]Graham, F. Lanier. Hector Guimard. New York: The Museum of Modern Art, 1970.

[7]Jaulmes, Laurent. Hector Guimard: Fontes Artistiques. Paris: Galerie du Luxembourg, 1971.