DIGITAL PROCESS:
INTEGRATION OF DIGITAL FABRICATION IN ARCHITECTURAL
CRAFT OF NEPAL

A THESIS INVESTIGATION
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INTRODUCTION

The prevalence of digital technology opened up a new process for craft, driving a paradigm shift in the world of art and architecture. Printing and web technology further attributed to making digital technology ubiquitous in various geographic locations and across architectural cultures. The production of architectural craft in response to technology is evolving from manual-based approaches into a new era of digital production and mass customization.

Nevertheless, in a developing country like Nepal, the integration of such technologies in the craft of art and architecture is still far from realization because of the prohibitive set-up costs and the mandatory use of the computer required utilizing digital fabrication. In a developing country, inexpensive labor and widely available materials negate the payoff of this technology; in contrast, in modern, industrialized places such as Japan, labor, raw materials, and energy are expensive and robotics and automation are valued highly by industry for their impact on efficiency. Yet some aspects of Nepalese material and
production culture provide a niche for the use of automated, computer-based fabrication. For example, in a vernacular building, one intricately carved traditional door/window takes months to complete using traditional hand techniques. Tools and techniques are predominantly unchanged from the medieval era and the numbers of skilled artisans are declining. Knowledge is difficult to transmit to younger generations of workers because of both disenchantment with difficult, manual labor and the challenge of developing the hand coordination to carry out intricate carving. This has resulted in a key aspect of traditional Nepalese architecture becoming endangered.

Besides this, there are problems with architects designing these ornate pieces using computer-based tools or hand drawings and then having the drawings translated into carvings, since traditionally carvings that the wood carvers produced would be made up as they carved. It makes it difficult for a designer’s vision to be translated into a project.

Threats to traditional, indigenous technology, paired with continued demand for carved building elements, creates a need for a “system” that allows craft to keep up with design technology. This thesis studies the possibility of formalizing the informal manufacturing process of traditional craft through digital fabrication.
Samvat 107 Sri Paramadevapka maharajasya Jaya Verma. Eighteen years ago while excavating the ground for foundation of a new building near Maligaon, Kathmandu in May of 1992, a life size (171 x 49 cm) standing male figure carved in local buff sandstone was discovered with this inscription engraved on it.¹ Later archeologists and historians deciphered this Brahmi script to read- “King Jay Verma on 185 AD...” This milestone discovery supported Lain Singh Bangdel’s claim that Nepalese craft-culture can be traced back in history at least two thousand years (404 A.D).² Even though no such material artifacts this old are available, historians believe Nepalese craftsmen developed a diverse craft tradition afterwards that evolved to include other mediums like wood and metals as well.³ A Chinese traveler Wang Hsuan Tse described the Lichchhavi kingdom in his travelogue in the seventh century mentioning woodcrafts, sculptures, and ornament to be prevalent in those days. His description of the mastery of artisans provides evidence for impressive skill in manipulating metal, stone, and wood.
This reveals that the base of craft in Nepalese architecture began to take shape in this Lichchhavi period (300 – 879 A.D.). Carvers used stone, wood, terracotta and metal as their media sculpting religious idols and ornament integrated with buildings and water supply infrastructure. Waterspouts, Chaityas, Stupas, and idols are still intact, as they were made of stones. In this era, Nepalese social and economic relations expanded northwards to China (Tibet) and India. Tibetan and Lichchhavi royalty intermarried, expanding social and economic exchange and opening new possibilities for crafters and traders. Nepali sculptors went to China and demonstrated their mastery in wood, metal and stone crafts. Artifacts of this era were named after the ruling individuals, while little is known of the identity of the artisans that created the work.

Despite this the fact that little is known of the artisans of this period, history records Araniko’s name as a master craftsmen. Araniko practiced the Pagoda Style of architecture and introduced the style and construction methods to neighboring Tibet, and from thence to China where he built magnificent Swetachitya in China. The artifacts from this period were so important to the culture of Nepal, Tibet, and China that their influence was lasting upon later periods, and many artifacts served as a prototypes for later work.

After the Lichchhavi period, the Thakuris ruled (879 AD- 1200 AD) and the famous Kasthamandap, made of wood, stone and brick, was constructed during this era. The intricate details in wood and the use of timber elements in religious structures started in this period.

Crafting skill further developed as Malla kings (1200 – 1769 A. D.) divided Kathmandu into three kingdoms - Kathmandu, Bhaktapur, and Patan. Art and craft began to intensify among these kingdoms as a result of competition among kings to demonstrate the magnificence of their kingdom. This period is regarded as the golden period in the craft history, and is known by a growing push to create impressive landmarks that, in turn, advanced the technology of each craft. Stone, metal and wood artisans began to have their workshops in the ground floor of their houses, and craftwork began to be integrated within families, with skill passed down generation-to-generation through oral instruction and intense on-the-job training.
During this period, trading activities along a trade route between Tibet, China and India intensified. Traders and artisans were emerging as important people in the society and, as in medieval Europe; the great undertakings of these artisans were religious structures and palaces. Instead of Cathedrals, Hindu believers erected magnificent temples and palaces around beautiful squares of Kathmandu, Bhaktapur, and Patan. Their mastery can still be witnessed today in the Palace Squares, listed as a World heritage site by UNESCO.


During and after the Malla period, houses built in Kathmandu used carving as a celebration of religious belief and status. Wood was used extensively for doors, windows, pillars, and struts; stones were employed for decorative sculptures and foundations; metals were applied as cladding for the wooden elements and
roofs; decorative bricks used for walls and cornices became common in residential architecture; and extensive use of metal with wood and brick became typical of religious buildings. Motifs for doors, struts, windows and cornices contained flowers, religious deities, and religiously significant animals. Carved struts supporting a cantilevered, tiered metal roof was one of the most popular ornamental elements for buildings.


During the golden period of Nepalese craft history, the region became more isolated from the outside world, and Nepalese craftsperson maintained indigenous tools and technology suitable to the materials available and to the
demand for traditional ornamentation. By the end of the eighteenth century, Nepal, with the influence of Tibet, China and its surrounding central Asian cultures had clearly established its own architectural style; today almost all of the landmarks in existence are from this golden Malla era.

After the unification of the three kingdoms by King Prithvi Natravan Shah in 1758, there was no notable development in Nepalese architecture and craft leading up to the current time. Crafters still practice this ancestral skill with similar primitive tools and techniques.

During this dark era of crafts, powerful Rana Premiers (Rana period 1846- 1951) maintained a close relation with the British- governed India. Rana Minister JB Rana visited Europe during this period and introduced crafters to Neoclassical and Victorian styles, which upon their return was introduced into Nepalese art and architecture. Massive white palaces and government office with Roman columns and motifs were built as a result.

The Singha Durbar, the secretariat building in 1927 (Left) at Image reprinted from http://www. kvptnepal.org/archive_singhadarbar.php last visited November 12, 2010)
At present, artisans are practicing their skill in the same media (woods, bricks, stone and metals) and with the same age-old tools and techniques as they have for the past centuries. In 1951, Nepal opened its border to the outside world and the introduction of the automobile catalyzed a modern tourism industry. With tourism, a focus on the values of traditional craft and artisanship re-emerged. Architects and entrepreneurs concentrated upon reviving this traditional craft in new construction, as well as conserving ancient construction. Demand for traditional craft increased once again for residential, commercial, and institutional buildings such as museums: the Patan Museum and the Hotel Dwarika are contemporary architectural examples that have implemented traditional crafts in their features.

During the industrial age of the nineteenth and twentieth century when Western countries implemented systems of mass production, this development was still far-removed from the craft industry in Nepal. In response to the difficulty of producing handmade architectural elements, and the lack of sensible, industrially-produced replacements, Dwarika Das Shrestha, an entrepreneur of the Dwarika hotel, started to buy and amass old architectural elements such as doors, windows, and handmade terracotta bricks from his current, decaying medieval building. Using these old elements and materials, he built a new hotel building that integrated carved wood and terracotta work representing ten million hours of work from the best craftsmen in Nepal.\(^6\)

The Hotel Fulbari, the Hyatt, and the World Expo pavilions are some other landmarks that used extensive manual carvings and decorations completed using traditional methods. Perhaps influenced by the fresh integration of craft...
with new building, local residents in response have begun to renovate their old houses in the traditional way instead of demolishing old structures only to replace them with modern concrete and glass boxes. For example, a local resident of Bhaktapur named Rabnindra Puri was awarded a UNESCO Asia Pacific heritage Award in 2004 for the restoration and revitalization of an old and neglected farmhouse exhibiting medieval craft technology.

In recent years, Nepal has taken part in international trade fairs promoting the export of architectural elements such as doors, windows, temples, decorative bricks. The World Expo in Hanover 2000, The Flora Expo Japan 2004, and The Shanghai Expo of 2010 are examples of venues in which traditional Nepalese architecture and craft has been exhibited. Craftsmen spent months to construct the Nepal pavilions and their ornamental components for these expos, and gathered extensive recognition from visitors.

The SONA (Society of Nepalese Architects), the NEA (Nepal Engineers Association), and government byelaws now require facades construction and renovation in protected historical zones to use traditional treatments and materials.

All these situations promise a strengthening market for craft in Nepalese architecture and suggest new tools to meet this growing demand. Yet the techniques used by the crafts-people have remained unchanged and even today, the basic constructional elements of a house are produced by hand with the help of minimal tools. This indicates that despite the potential for modernization, the existing production process hinders widespread integration of
craft and everyday architecture because it is time consuming and labor intensive. What is critical in this sense is to confront the process, as it exists now and integrate new methods of production that can make the introduction of craft viable in a modern construction economy.

It is believed if one overlooks the past; the tools of the present and future will lose their relevance. Thus, I will describe in summary the ancient tools and techniques of Nepalese craft that have remained unchanged up to today.

Clockwise from top left: Chosen designs are sketched on paper; sketched paper is cut so that the outline remains and pasted to the medium (wood, stone, or metal); tool; chisel and hammer - subtracts the medium, the completed piece is
Sometimes wooden artifacts are used as a base for metal craft. Metal is placed over this wooden mold and mallets are used to shape the sheet metal over the wood mold, in this case completing an image of Bhairab of Hanuman Dhoka (shown below).

(Left to Right) The intended design is first drawn on a piece of locally handmade paper, a sheet of copper is cut to size and the design drawn on it; working from the front on a traditional floor-mounted anvil, the artist creates the basic form by
following the drawn outline with a rectangular headed hammer. The sheet is then turned over and the image beaten out from the back – “reposed”. With hammers, fine dies, and punches the artist further refines all the details of the design. Picture reprinted from Patan museum.com last visited December 12, 2010.

In traditional Nepalese architecture, these small examples are repeated innumerable times in the creation of intricate building elements. This process is used from small-scale carvings up to the large-scale production of building elements such as doors, windows, columns, and other lattice works. In latticed windows, many individual wooden pieces are carved and attached together. Doors are produced by carved rectangular wooden panels. When a building is under construction, particularly in masonry buildings, these wooden elements are placed in the wall as it is built. Posts and other parts of the building structure are produced from smaller carved components, to fit together as a larger integrated entity.

Having discussed the history and methods of craft, some conclusions can be drawn from the point of view of craft and its production process. First, the theme of material and the mastering of tools and their applications have remained consistent: today particularly relying on hand tools and traditional materials such as wood, stone, and limited sheet metals.
Secondly, there is a constant challenge in learning and upgrading skills, through the exchange of craftsmen and through social and economic exchange, with other countries. For example, medieval master crafter Araniko walked miles to China and Nepalese crafters traveled Europe in the mid Nineteenth century, and in both cases brought new crafting skills (Neoclassical and Victorian Style) into the country. This shows support for the integration of new tools and technologies with traditional craft in the future, and one can speculate that proposed digital technology will not only stretch the capabilities of crafts people but also might produce the emergence of new forms of crafts. These “new forms” have yet to be defined in the Nepalese context of architecture and the arts.
NOTES:


What is Craft

The term ‘craft’ has a broad definition and is often interpreted in a variety of different ways. Dictionaries define ‘craft’ as both a noun — “activity involving skill in planning, making or executing” - and as a verb - “exercise skill, care or ingenuity in making things.”¹ The word quite often signifies the skill of making. Rosy Greenlees, executive director for The Crafts Council of the United Kingdom, defines craft “as an activity where a process of exploring material takes place.” In her view, “craft entails intellectual and physical activity where the maker explores the infinite possibilities of materials and processes to produce unique objects.”² Richard Sennett in his book The Craftsmen writes that craft “inhibits skills and conducts dialogue between thinking and executing.” Such dialogue, he further adds, “grows into sustaining habits for the sake of problem finding and problem solving.”³ Echoing the definition of Sennett and Greenlees, Malcolm
McCullough observes craft as “tenure of intense knowledge of manipulating medium (such as wood, metal or paper) where this ‘knowledge’ is refined through involvement and practices.”

These many definitions of craft agree in bringing together a notion of skill with the act of making or execution. With practice and through the process of craft, such skill further grows and becomes refined in a cycle acting both within particular works and among many works over time. Although the exercise of creative skills covers a large spectrum of work from potters, weavers, carvers to modern day fabricators, in this thesis, the crafts and crafts techniques considered are those relating to architecture and building construction. For this purpose, craft is defined as follows: Craft is the exercise of creative skill physical or intellectual (Greenlees) in manipulating medium (Malcolm) for the sake of problem solving, as said by Sennett.

Following this definition, skill is pivotal in creating craft, which grows over time. What expands and refines such skill is the key quest for artisans since the beginning of civilization. In order to cultivate skill, primitive and even modern craftsmen must learn to use tools as an extension of their hands.

From this, it can be concluded that computers and allied technology are modern day tools, used by modern craftspeople as an extension of their hands and minds in applying their skills in making crafts.
NOTES:

   Craft- Skill in planning, making or executing (noun), to make or produce with care, skill, or ingenuity (Verb).
   http://www.oxfordadvancedlearnersdictionary.com/dictionary/craft_1
   Craft- an activity involving a special skill at making things (noun), make something using special skills (verb).


Digital Tools

As introduced in chapter three, artisans for a long time developed and relied upon tools\textsuperscript{1} as an extension of their hands in the process of creative making. These tools changed, were refined, and replaced by new tools throughout history in order to overcome the limited strength and speed of human body, to improve the quality of work, to develop specialized knowledge among a group of workers, or to increase production to meet a growing demand for craft.

Exploring the definition of a tool can provide insight to its relationship to the craftsperson. Malcolm McCullough considers tools as effectors or probes that transmit an author’s intent and alters the medium or material being worked upon.\textsuperscript{2} In this sense; along with their capability of working as an extension of the body as in the case of hand tools, it is practical to consider a computer or a machine as a tool. Even though there is wide acceptance that traditional tools
are not viable in Nepal for meeting the modern day’s demand for crafted artifacts, the intervention of machine tools and automated tools remains very limited if not completely absent. To create a case for new production technology in Nepalese craft, the advantages of machine-based tools over hand tools can be explored.

**Limitations of Hand Tools**

**Limited Human Capacity**

The human body possesses limitations in strength, with an added inability to combine or mix tools. For example, the human has only two hands, and hands can hold only one thing at a time. This reality triggered the invention of clamps, jigs, and vices for holding work pieces like an extra hand. A more important innovation in industrial production is the machine tool, which generates power beyond human capacity and is able to combine different tools at the same time. In sum, using machine-based tools improves capacity and reduce the hours of labor.

**Risk Versus Certainty**

For British writer, craftsman, and educator David Pye, craft production is the “use of any kind of techniques or tools in which the quality of the final product is undetermined, but depends on the judgment, dexterity and cares which the maker exercises as he works”. In the second chapter of his book, *The Nature and Art of Workmanship*, first published in 1968, Pye differentiates between making things by hand tools as “workmanship of risk” and making by power-driven tools
as the “workmanship of certainty.” According to Pye, workmanship of risk is that in which hand tools are deployed and the quality of the result is uncertain. Even though a skilled crafter takes the aid of jigs and more refined hand tools to overcome or minimize inherent complexities in the process, “the final quality of the product in such practice is always at risk during the process of making.”

The arrival of computers and automation in this process paved the way for diminishing such “workmanship of risk” and creating “workmanship of certainty.” Modern industrial production as Pye describes, is an example of “workmanship of certainty” where, the quality of the result is predetermined before the thing is made. Pye differentiates these two kinds of workmanship using the example of writing by hand with pen versus machine printing. Handwriting in this case is characterized by “risk” and the printing press as “certainty.” The printing press is guided by the craftsman’s hand, and automation ensures the highest standard of workmanship and in an expansion of “certainty' allows for the work to be reproduced ad infinitum.

**Knowledge Sharing**

Primitive hand tools and manual skills are limited to single person, and the synchrony between the hand tools with the mind poses a challenge to the transfer of knowledge. With the advent of jigs, crafters could produce multiple copies of a single product, and different crafters could use the same jig. Yet even in the case of jig work, the synchrony of minds and bodies was always critical to the quality of the product.
Machine Tools

With the Industrial Revolution in the 1800s, mechanized tools centered skill and strength on the machine, reducing the human body to a mechanical adjunct. These new tools changed the linear process of making products. Rather than making products one at a time, these new machine-based tools drove the efficiencies of standardized and interchangeable components, leading to mass production and ultimately a more uniform quality and cheaper price for products. Under industrialism, differences between the bodies of the craftsman or machinist are irrelevant, in the same way as differences in the minds of computer, users are irrelevant to data processing.

The arrival of computers led to a more convenient process of developing craft. Although the humanistic feeling of touching during craft making is far more rewarding than the feedback from a machine the positive impacts of machine production cannot be overlooked. These modern day “tools’ can have a multilayered impact upon crafting, ranging from tools that can augment certain traditional carving activities, with nominal impact on the activities themselves, to more pervasive (or invasive) impacts in which the tool is the basis for an entire environment within which the whole production process occurs.

Digital Fabrication

Digital fabrication technology is characterized by a process beginning with digital representation and moving towards a realization of physical craft using
computer-based technologies. It has “shifted the role of the computer merely as a representation device to that of a tool for instrumentalized fabrication.” Within this context, the development of a virtual model using Computer Aided Design (or CAD) is the beginning of this process. The digital model has an ambiguous function, as it is not merely a representation but the actual design, as well as a visual outcome of all design decisions.

In the production of craft, a model in the computer can be fed directly into Computer-Aided Manufacturing (or CAM) tools to create physical artifacts. The process between CAD and CAM tools organizes and documents design data and provides room for adjusting the model using different modeling methods such as parametric design, which allows for mass customization among details and parts.

**Parametric Model**

CAD software generally operates with geometrical components like lines, rectangles, arcs, and circles. These components combined with dimensions and other elements form design drawings. As these traditional CAD tools are based on static geometrical shapes, making a change requires altering all related geometrics and propagating this change through the entire model in order to make the model correct. To overcome this inefficiency, modern day CAD CAM software contains a design feature referred to as ‘parametric’ model geometry. This is a method of linking dimensions and variables to geometry – whereby modification in the mathematical parameters of the geometry changes the geometry and all linked geometries in real-time, instead of the geometry
requiring manual manipulation by the user. In digital design, a parametric model suggests the potential of all possible alternatives and conditions for a given geometry.

The notion that particular crafted elements can have a formula or a flexible structure is not new, but something that has already been used in Nepalese architecture. Such parametric elements range from small, repetitive struts to whole roofs or walls produced through manual labor representing a great deal of time and money. Parametric design tools can reduce the complexity of computer models and greater variety of desired shapes and sizes.

Parametric variations of traditional window (Image reprinted from the book “The traditional Architecture of Kathmandu Valley,” by Wolfgang Korn, page- 107)
Mass customization

Mass customization is defined as “developing, producing, and delivering affordable goods with enough variety and customization that everyone finds exactly what they want”\textsuperscript{6} and “with near mass production efficiency.”\textsuperscript{7}

The Industrial Revolution realized mass production, mass marketing and a mass distribution system. Nevertheless, in recent years, advancement in digital media is making it increasingly possible to “mass customize” products and components, rapidly responding to consumers with customized products at mass production prices. This is replacing the mass production system in cases where new technology can satisfies growing product variety and individualization, yet this new technology can also lower cost and production time. This ‘mass customized’ process of production combines economies of scale production with parametric generation and automation of the production process. Apparel, computers, watches and other products such as those made by Nike shoe, Dell inc., and BMW have already started to become customizable using new computer-based technology providing choices, in real time, at a lower cost, and with a higher quality.

In a mass customization-based system, the whole entity or product is broken down into small modular parts whose size varies from small to large depending upon demand and choices. Modular components in turn are made up of a number of components that can be assembled together quickly and easily to
create custom solutions. Compared to Henry Ford’s successful “one size fits all” system of mass production, mass customization has the advantage of allowing variation, and flexibility.

**Digital Complexities**

**Procedural Literacy**

Understanding digital procedures in production is critically important for crafters and designers in order to realize the benefits of computer-based technology. According to Michael Mates, the term ‘procedural literacy’ refers to “the ability to read and write computational processes, to engage procedural representation and aesthetics, to understand the interplay between the culturally-embedded practices of human meaning-making and technically-mediated processes.” He emphasizes the importance of this knowledge for new media scholars and practitioners. This notion of knowledge requirement is equally important in the case of Nepalese crafts persons as digital fabrication technology is entirely new to their context. Lack of procedural knowledge might bring more frustrations, and artisans will do what preexisting hand tools make easy even though they are less productive compared to new tools.

**Non-Reversible Process**

The digital fabrication process offers rules and restrictions along with positive opportunities. In the end, the fabrication process is non-reversible. Digital
modeling tools, including software such as Mastercam, and Surfacecam, control the tool path in the case of a computer-controlled router; this software, consequently, can be used to simulate the path of the tool prior to cutting the object. However, these simulations cannot guarantee the final product is error free and that on-site problems with milled components will not arise.
NOTES:


When computer aided design (CAD) emerged in the 1980s, it was primarily used for the two-dimensional and three-dimensional representation of physical components. Over the years, it gained popularity in the aerospace, automotive and shipbuilding industries as it could be used to draw and manage unimaginably complex shapes and assemblies. Digital design evolved into a new phase of expansion as CAD became combined with computer-aided manufacturing (CAM) systems. When used in conjunction, CAD data is translated into CAM data that controls a machine tool during manufacturing. The success of this design-to-production process in a few pioneering industries was later transferred to other industries, including architecture. The application of CAD and CAM processes together in architecture not only change the existing “construction process” paradigm but also permitted expanded the creative potential of designers beyond what could be represented before the advent of digital technology.¹
New York based architectural firm SHoP is one of the pioneers in integrating digital fabrication into their design practice. Unlike standard architectural practices, the firm takes part in all parts of building process, from design to fabrication. Utilization of parametric modeling for complex geometries and digitally fabricated components is a part of SHoP’s standard digital practice. In their words, this process contributes to “blurring the boundaries” between the architects design drawings and contractor’s shop drawings. Here, modeling software is used to develop the design and then the same data is fed into CAM tools to produce digital crafts.

![Digital production diagram](chart)

Modeling Software used to develop complex geometries is not always applied to its full potential, and may be only considered “inside the box”. Customizing software through scripting expands a user’s technical and creative boundaries. For the 290 Mulberry project, SHoP’s design team developed a parametric script for developing variation in the form, technical data, design and fabrication.
plans for a system of brick panels. This digital information was fed directly into a CNC (computerized numerical control) machine to digitally fabricate the molds for the final brick panels. As an alternative or supportive process to manual and hand tools, computer software integrated the working process of bricklayer/craftsperson when the digital mold for the brick panels was used to guide the size and positioning of the bricks. The same digital data is used from the base virtual model to study the rippled brick panel, to vary panel shape and size, to estimate cost, and to make contract documents and shop drawings. In sum, Shop characterizes this process as “a more holistic approach to design and construction.”

While ShoP fabricated formwork in order to mold large-sized brick panels, another example of integration of digital fabrication in design comes from Gramazio and Kohler, who utilized a more advanced six-axis industrial robotic arm to prefabricate walls with slightly varying brick orientation and achieve intricate ornamentation in the “Programmed Wall Project”.

The programmed wall by DFab Laboratory (Gramazio & Kohler, ETH, Zurich, 2006).

Bernard Cache's Objectile

“... Objects are not designed, but rather calculated by computer and industrially produced by digitally controlled machinery.”

- Bernard Cache

Digital tools opened up new opportunities in surface articulation, where designers are proposing innovative designs in the creation and production of complex curved and variable forms, useable to cover larger surface areas. Bernard Cache and his collaborator Patrick Beauce takes the notion of industrial
production to a certain extreme by using their own software based on TOPCAD, which enables calculating the designs of curved and variable shapes and producing those using numerically controlled machines (CNCs).

Bernard Cache’s surface ornamentation in Objectile

Caches’ objectile works are nonstandard modes of production, which by his description is a “Zero-error” procedure. Intricate, undulating surface design are interpreted into control paths and program a cutting tool to mill the surface of material, giving it repetitive or unique cut out or relief pattern. These “objectile” pieces are not only “strictly reproducible” but also “purely deformable” by changing the value of certain variables in the digital code.
While Cache’s work was more concentrated on timber and small scale, others took the technology to a larger scale and broader variety of material. These are just a few examples from the digital design spectrum. Computers translate the architect’s design forms directly into material form, providing continuation of the design process into fabrication and construction. The computer takes the place of hand tools boosting productivity, consistency and cost efficiencies.
Such efficiency advances with the development and refinement of digital tools, as predicted by ShoP, “in the future, building designs can be issued to contractors in the form of three-dimensional digital models to be broken down into elements and fed into respective fabrication computers. Later individual components are assembled on site.”

Thus, digital processes are innovating across a broad spectrum of process and product in creating building components and ornamentation, and propose more progress in the days to come. Whether it is the ShoP’s ripple brick panel or Cache’s objectile or Williamson’s CNC milled wood panel or Herzog & de Meuron’s metal panels, they all represent a potential advantage that can be gained in Nepalese craft culture if these design and production technologies are adopted, which would not only provide relief from hand tools but would also integrate a whole process, from design to realization, through a single base of design data. In such a process, architects get an opportunity to work directly as a coordinator to guide the process towards the conception of the whole.
NOTES:


2. ibid


While restoring and revitalizing the medieval royal palace of Patan in 1997, Austrian crafter Walter Pichler designed and fabricated new "simplified" brackets and pillars in order to match the historical building components and intricate ornamentation.¹ Typical design motifs from the Malla period have inspired (see previous page image) these modern interpretations containing a certain level of geometric abstraction in industrial materials and produced through industrial production process. This is the historic moment of celebration of Nepalese craft, where traditional craft is reinterpreted using new technology, and with an increase in capacity that ensures that all people have access to this important level of ornament and intricacy.

This thesis proposes such an integration of digital technology with traditional architectural craft in Nepal in order to increase the capacity of craftspeople and extend creative possibilities. The problems of existing Nepalese crafting procedures is labor intensive, involves the “workmanship of risk,” and creates challenges to the transfer of knowledge, while in the contemporary world trends in digital practice has resulted in the production of mass customized crafts through tools that are integrated from design to production. Supported by examples of work from emerging architectural practice, it is may be proposed that digital technologies can provide a great deal of support for traditional craft and in order to develop new practices in craft. The traditional process will change, but the tradition of integrating ornament into architecture can be preserved. I would like to restate this concept in the following points:
1. Nepalese architecture currently possesses elements characterized by intricate carvings and ornamentation. Traditional hand tools used to achieve these outcomes are always labor-intensive, and time consuming. As they possess similar patterns and modular structures and sizes, current and emerging digital production tools such as, parametric modeling and CNC fabrication may provide more streamlined and efficient production of individualized elements.

2. Hand crafters are diminishing generation by generation because of a lack of interest in learning the skill, and failure in handing down knowledge through oral guidance or on-the-job training. Synchrony of body and mind is necessary to the quality of the outcome. On the other hand, digital tools save and process data, produce reproducible elements, and can be applied in a consistent manner, where difference in the body is irrelevant. While hand tools require almost the same amount of time to repeat the production of each item, digital tools reduce time repeatedly once the initial model and tooling controls have been created, permitting easy reproduction of the same item or the change in some variables to create customized elements. In Malcolm McCullough’s words, “even the fools can do it.”

3. Digital technology helps in archiving, systematizing, and sharing of digital files and allows the passing of knowledge to future generations. The same file is used from design to production.
In golden era (Malla Period) of Nepalese history, demand, pride, and relation of craft to economic prosperity pushed the development of craft technology. There are adequate contemporary demands that might bring the same. Demand for traditional references in existing (renovation, restoration) and new architecture, broad appreciation amongst the global community and local tourism industry can actively push the integration of digital technology forward, as it promise to achieve not only fast and precise production but also desired amount in desired time, which is unseen to this point in Nepalese craft production.

Revolutionary potential exists within the Nepalese craft industry, with abundant opportunities, to accommodate the integration of digital technology. Perhaps the greatest danger presented in moving forward is the potential loss of the human element in craft.

It is widely accepted that artisans throughout history used tools and the process is available during their time. Moreover, it is also accepted that digital tools will continue to become an integral part of our lives, and future generations will regard the computer as one of the essential elements of the creative process. Today’s craftspeople should not be fearful of adapting to new tools since this has happened many times in the history of craft.

The outcome of digital deployment on creativity is, however, dependent on procedural literacy. It may be easier for a machine to perform repetitive tasks and process large amount of materials, but a certain level of training and knowledge is required to generate scripts and G-codes. The complexity is not
reduced but transformed in the digital process, yet the complexities are reasonably overcome in light of the technology's potential in pushing the boundaries of traditional craft and bringing changes to working conditions and improvements in systems. “The real change we call for cannot occur, however, without beginning.” as stated by Kieran and Timberlake and this is time to begin.
NOTES:


39. GTZ. *Images of Century: The Changing Townscapes of Kathmandu*
