Prefabrication in Developing Countries: A Case Study of India

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Introduction

The role of prefabrication in architecture has been lauded for its potential to increase productivity and efficiency while not sacrificing quality. The values of better, faster and cheaper are applicable to developed countries such as the U.S., Japan, and Europe, whose middle class continues to demand this equation in buildings that range from the remarkable to the prosaic. Developing countries, including China, India, Africa and many parts of South America, that are beginning to rely on prefabrication have the potential advantages of realizing housing quickly and affordably; however, greater reliance on manufactured production has possibly more disadvantages than advantages for these cultures.

With prefabrication, improved working conditions would seem to be agreeable to everyone: instead of building in the weather, international fabricators supply controlled environments with ergonomically considered equipment – and yet in many fabrication environments, reliance on minimal skills, and a disconnect with the community in which workers live, leaves little room for continued fostering of personal and collaborative skills, culture, tradition and community building. The potential for prefabrication to be used to create a bland, monotonous landscape is an issue that developed countries' construction professionals must grapple with. Countries such as India are undoubtedly suffering a greater banality in the built environment by embracing prefabrication. Prefabrication is touted as offering a more sustainable solution to building, but developing counties already rely on vernacular practices for design and construction that require relatively low life cycle energy.

Developing countries continue to embrace technology from their developed country allies. This trend does not seem to see a slowing. The following paper will address this growing trend through the example of India, a country that is transforming quickly by adopting digital, material, and construction technologies from around the world and rapidly transforming its landscape. This paper will illustrate the advantages and disadvantages of prefabrication adoption in this culture and suggest ways in which developed countries' architects and local building professionals may take a leadership role in fostering *both* culture and technology.

Prefabrication in India

Prefabrication in India began with the emergence of the Hindustan Housing Factory. The company was developed by the first Prime Minister of India, Pandit Jawaharlal Nehru, as a solution to the housing crisis that resulted from the influx of refugees from West Pakistan in the 1950s. The Hindustan Housing Factory pioneered the production of pre-stressed concrete railway sleepers to replace dilapidated wooden sleepers on Indian Railways. The company changed its name shortly thereafter to reflect the diversity of its operations. It is now known as the Hindustan Prefab Limited or HPL. Located in Delhi, today the government-run company prefabricates primarily precast concrete for architectural and civil projects throughout greater India.

When HPL began it was intended to produce low-income housing solutions for the deficit in India. Precast wall panels and frame members such as beams and columns provided a much-needed set of tools to erect quick structures for mass housing. The most difficult technology transfer obstacle for the HPL has been the cost of machinery and materials for production. Since the government could not recoup the return on investment for the factory through housing production, prefabrication from HPL

began to service other markets including higher dollar civil and larger public and hotel buildings.

The quality of construction is much higher when components are manufactured in a stable environment such as the factory. This is especially true in India where today, prefabrication has become synonymous with durable, modern, and western construction methods. Materials are used more efficiently, are safer from climatic damage, and can be reused in the material stream. Because of these benefits, a general consensus in India is to move prefabricated building systems beyond precast concrete for large-scale construction to additional market sectors including a resurgent interest in applying prefabrication technology to housing.

Traditional construction techniques involve the use of timber molds or shuttering for roof spans and other structural systems. These temporary timber structures have a short lifespan and due to the volume of construction in the peak seasons of spring and summer for larger well-funded projects are often unavailable. This hinders construction schedules and does not allow projects to be completed before cooler or rainy seasons begin. However, construction does not stop in the summer despite the lack of proper equipment and material. Instead, using makeshift methods for construction on site leads to inappropriate means and hence a sub-standard quality of construction in finished buildings. The prefabricated alternative to roof construction removes the issues of timber molds and shuttering. Prefabrication in Indian housing improves uniformity and brings unskilled labor inside where work is supervised, monitored and controlled.

Material advances in the prefabrication housing market have also helped to mitigate material failures. The use of fly ash in concrete increases its workability and improves thermal performance. In addition, fly ash concrete block is beginning to replace traditional clay bricks because it does not contain expansive soils that cause walls and floors to crack with fluxes of temperature and humidity. Fly ash is captured from the coal burning process that generate electricity and then reused to manufacture more durable and stable building materials in a factory environment. The material manufacturing is more predictable and therefore serves to build more seismically resistant structures.

The government of India has a goal to make housing available for all its citizens by 2010. Among the logistics of this effort is an ambitious new construction initiative. India is planning to accomplish this task through a prefabrication surge in order to build 3-4 level multi-family structures. Kirby Building Systems India Ltd., an affiliate of Alghanim Industries, a company located in Kuwait, has a state-of-the-art manufacturing plant in Hyderabad with the capacity to produce 40,000 tons of precast product annually. In addition, Kirby India has recently launched what it calls a technology-driven Pre-Engineered Steel Building Solutions (PEB). In 2004, Kirby completed a 33-meter high building for the Kolkata-based Garden Reach Shipbuilders & Engineers and a 25 meter building for the North Eastern Council. Likewise, Minaean Habitat India, a subsidiary of Minaean Building Solutions, Canada, is currently developing a prefabricated building framing system that utilizes load-bearing steel panels. Minaean Habitat has also recently launched a modular building division in which structures are designed, engineered and prefabricated ready for use within four days of receipt at site. Minaean has deployed this system in a two-level housing project on the outskirts of Solapur, Mahrashtra.

The HPL and Kirby Building Systems are just two examples of a myriad of prefabrication companies that are emerging within and without India in order to serve the housing demand of one of the most dense, heavily populated, and fastest growing population and economy in the world.

Ethical Dilemmas of Technology Transfer

"Technology transfer can affect the government, economy, and culture of both the transferring and the receiving nations. It opens too many ethical dilemmas."

Prefabrication will continue to grow in India as the demand for fast affordable housing increases. However, technology transfer of prefabrication process, including materials and digital tools, can affect the environment, economy and culture of the receiving country negatively. There are risks associated with the transfer of prefabrication technology. The host country may not have the infrastructure, the manufacturing and/or professional prowess to

accept it. The negative affects can be social, environmental and/or economical.

Transportation

The Auroville Earth Institute in 1999 built a prototype-prefabricated house in New Delhi that showed advances in structural capacity during earthquakes. Initially envisioned as a disaster resistant and cost effective prototype, it was intended that the house would be precast anywhere and shipped by truck to a disaster location. Precast in Auroville, and transported over 2,900 km to New Delhi in a single lorry of 22.5 tons, the prototype was assembled in 66 hours by an 18 man team. The transportation cost alone was equal to the cost of manufacturing the prototype. The model was economically unviable for India. The solution to low cost prefabricated housing must overcome the obstacle of shipping costs. Prefabricating regionally might better serve developing countries. (Fig. 1)

Fig. 1. Precast roof panels being loaded onto a truck to be shipped to another location. Photo Credit: Auroville Earth Institute www.earth-auroville.com

New Technology

The transfer of digital goods and products are relatively simple; however, the transfer of invention and innovation of the process of production is difficult.

Alejandro Moirera, Professor of Architecture at the Universidad Nacional del Litoral reports that in South America building information modeling is being implemented, but the construction culture is not prepared to accept this technology. BIM is being established on the U.S. system of contract structures including phases of schematic design, DD, CDs, bidding and construction. South America has a much more open design build arrangement. In addition, Moirera reports that the large majority of buildings are relatively simple and do not require the complexity of systems coordination and parameters available in the software. Professor Moirera suggests that additional tools be developed for the South American method of project delivery. This would be a software system that allowed for more flexibility in the process for projects that require more or less information. This is likewise an issue in other developing countries, especially India. With the increase of developing countries having digital products such as computers, the developed country providers must consider culture specific tools.

Human Rights

Human rights issues are also of concern with regard to prefabrication technology transfer. As technology made way for mass production and assembly line manufacturing methods in the early part of the 20th century in the U.S., developing countries are using the same process to produce goods abroad today. Along with industrial manufacturing and economic benefits come labor challenges. Prefabrication presents problems: trading traditional handicraft construction jobs for automation. The culture of local building tradition passed through generations is abruptly discontinued. (Fig. 2)

Countries with a rich cultural background find it hard to accept drastic changes that involve a great deal of compromises in every field. This may directly affect technological advances, and in the construction field, it hinders the progress of prefabrication as a primary mode of construction. Prefab necessarily involves fewer laborers on site. It therefore renders helpless many households that depend on traditional methods of construction for their livelihood. With a literacy rate of only 61%, the possibility of the construction industry laborers shifting occupation to an office or even an automated factory is bleak.

The current labor market is a lot different from what it was the last decade. With an influx of the software industries (in the dotcom boom) and an opening for over a million jobs outsourced from America and Europe, the standard of living among the educated class is increasing. Research by the Boston Consulting Group estimates that the number of jobs in India due to outsourcing will reach 30 million by 2020. India, with its 500 million person labor force, is second only to China in the

world. With India continuing to lack in education, questions arise as to how this country will be able to offer equitable opportunity for work in the new technology economy.

Schedule

"Some argue that technology has brought humankind many negative effects, including stress-related diseases caused by people's inability to cope with the world that is moving too fast due to rapid technological progress."

Many less developed countries do not value time as western counties do. The dictum "time is money" has little weight in slower paced cultures. While visiting Uganda, I repeatedly heard the phrase, "We are on Africa Time," which implied that if we get to our destination at all then we have succeeded. Many buildings were under construction; some looked as though they had been for years. In these cultures, time is not measured in minutes and hours but in generations. Regarding construction schedule in less developed countries, specifically India, the concern is how to take advantage of cost reduction while still being able to employ individuals and maintain a cultural lifestyle that is unique to a society.

Fig. 2. Child labor in India
Photo Credit: United Nations

Precision

One of the benefits of prefabrication technology is an increase in the quality of the products. Less developed countries such as India employ vernacular materials and methods in construction. The industry in India does not rely on precision, but the lack thereof in order to build everyday structures. Most members of local communities in India are equipped with knowledge of traditional construction. However, in India, a cultural divide between those that do and those who plan is emerging. This social class structural divide limits the ability for the populous to assimilate alternative methods of building quickly and adopt them into their culture of construction.

Outdated Technology

Great technological advancements are more likely to occur at the synergy between government and industry in developed countries. Even so, construction in the U.S. has failed to be able to capture the heavy government subsidies as military or high tech.

Experience suggests that it is unlikely that the AEC industry will see the scale of funding required to broadly transform its production techniques. Therefore, just as with less developed countries' dependence on transfer from developed countries, in large measure technological changes in the AEC industry rely upon transfers from government research funded industries such as aerospace and automobile production. In short, not only is building relatively not as technologically innovative as other industries, but in less developed countries this is exacerbated. India, for example, is receiving transfers from the U.S. AEC industry, an industry already behind in the latest technologies. This second order transfer means that the technologies are always outdated.

Climate and Vernacular

One of the most significant influences on vernacular architecture is the macroclimate of the area in which the building is constructed. Buildings invariably perform well when built with regard to the local climate rather than a technological trend that may not be as appropriate. The local environment and the construction materials that market can produce governs many aspects of prefab development. Vernacular, by definition, is sustainable, and will not exhaust local resources. For a country that has followed vernacular practices successfully for generations, like India, moving to a concept like prefab may not prove to be climatically as suitable.

For example, in many hot regions of India, masonry walls that are heavy and dense conduct heat slowly. This simple process, called thermal lag, reduces peak cooling loads in summer and peak heating loads in winter. The result is a more comfortable home all year long that produces significant savings in energy. However, in India there are 6 distinct climate zones ranging from cold and dry to warm and wet. Therefore, India's architecture is varied in its use of materials, style of construction and cultural difference that cannot be generalized. Prefabrication in a technology transfer mode struggles take into consideration these vernacular differences.

Proceed with Pulling

Technology is social, environmental and economic before it is technical. The method of its development and use says much more about modern culture than the technology itself. Technology in prefabrication is therefore capability, embodied knowledge in an artifact, method or process. Technology transfer refers to the exchange of capability from one party to another to the mutual benefit of both. A massive technology transfer process has been occurring during the later part of the 20th century in which developed countries are transferring technologies to less developed countries; many efforts have been unsuccessful. This is because many of the technology transfer trials were imposed or forced. In these situations, the technology might take hold for a short while, but will die out in the end.

A more effective method of transfer is the "pull" method. This method can be described as the receiving country "pulling" the technology from the developed country because of need. In this condition, the less-developed country is doing all within its power to prepare for the technology. Therefore, the technology is "just in time," not present any sooner or later than it needs to be. The pull method also has advantages with regard to social and environmental concerns. Instead of being forced to accept, the developing country has prepared an adaptation plan for the conservation of the social, environmental and economic conditions of their country. Again, if transfers are imposed, the technology will have difficulty taking hold without a colossal effort by the giving country, and in most cases will require the provider to make decisions regarding a culture with which they are unfamiliar.

Allan Reddy relates 3 elements that are a requirement for transfer host countries in a pull method: information about the method, an understanding of it, and the means to carry it out. With regard to prefabrication in India it is the bringing together of these elements that may prove the successful transfer of the technology. India must be versed in the technology both in theory and practice and have the ability to support the technology into the long term. It is with this knowledge and capacity that they will be able to make decisions regarding the adoption to the benefit of both economics and social/environmental ethics.

Relatively simple technologies that have been captured in a product such as a cell phone are simply distributed and used by the population

widely. (Fig. 3) These consumption technologies differ from production technologies. Production technology: process or knowledge embodied in the design, manufacturing, distribution, business model for marketing, etc. is difficult to transfer due to cultural barriers. For most less developed countries, and India in particular, the need of production technology, or the knowledge of the process of prefabrication is critical. This will allow India to develop their own methods of prefabrication specific to their needs and specific to their unique social, environmental and economic conditions.

Conclusion

Prefabrication technology has not transferred as easily when compared with other technologies because it is a production technology or knowledge based and not a consumption technology or product based. Technology transfer of prefabrication is not as pertinent to architects as it is to manufacturers of building products, but we are caretakers of culture in the AEC industry. In many cases we are asked to help with many of the transfers that are occurring by way of global practice or working for multi-national firms that are producing prefabricated components and entire buildings for India and elsewhere. Although transfers will continue to occur, especially in the area of prefabrication in building, we should be well aware of how the decisions of U.S. and western architects may have an effect on the ethical dilemmas regarding less-developed countries' development and culture.

Fig. 3. Indian woman talking on a cell phone.
(Source Unknown)

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