開発途上国の建築生産における現代建築の適応に関する研究

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	出版者: 小倉暢之
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	作成者: 小倉, 暢之, ディヴィッド・レオニデス・T・ヤップ, 田上, 健一, Ogura, Nobuyuki, David Leonides T. Yap, Tanoue, Kenichi
	メールアドレス:
	所属:
URL	http://hdl.handle.net/20.500.12000/11027

Chapter 3 Technical Adaptation

3-1. Introduction

It is not clear that the Philippines introduce the 1st concrete architecture in southeast Asia. Also it is not clear when the CHB used in the Philippines. We must investigate whether the use of masonry to CHB contributed to its adaptation in the Philippines. However, in our research we got some valuable information by interviews.

- The widespread use of CHB was first done in the 1960's (Sugay, 1999)
- Well aware of world architecture movements, the architects of the first quarter of the 20th Century used the Philippines as the showcase of tropical architecture in raw concrete (in 1903 Perret of France built his first reinforced concrete structure .) Architecture in reinforced concrete was a hybrid derived from the old Spanish masonry technology with the application of a distinctive roof line, openness of fenestration and the mediation of wood to soften the brutality of artificial stone.(Manahan, 1994)

Concerning the introduction of RC in the Philippines, we got next comments.

- The Americans first introduced Reinforced Concrete (along with other US-made materials) after the war. There was a big shift of construction material from wood to concrete. The technology first used was poured concrete, through chuts. (Sugay, 1999)

Concerning the CHB commercially made in the Philippines, it is as well as RC. Also it is not clear when the 1st cement plants established in the in the Philippines. At the same time, we can face the question why concrete a widely used material in the Philippines, why concrete favored over structual steel in the country?

- Steel construction is sometimes ideal because it is lighter, smaller sections are used, and it has the same strength as concrete. (Aronmin 1999)

- Reinforced Concrete (RC) is widely used in the Philippines because the skill required in RC is low as compared to other standard-intensive material such as steel sections, Furthermore, the cost of using the material is low and is readily available.

Much structural steel in the country is imported; therefore, it is very much affected by fluctuations in importation cost. There came a time that cost became comparable to RC, however, at present, with the rise of the dollar, there is, again, a marked difference in cost. Locally produced steel sections are the small sections. Large sections are made to order. Since steel construction is not very popular in the country, the tendency of suppliers and manufacturers is to keep inventory very low. Available sections are usually the small sections, which are used for small projects (e.g.houses). As a rule, sections on stock are in the scale of 8" to 10" wide flanges. High-rise developments require bigger sections, which still have to be made. The obstacles, therefore, are:

(1) the availability of steel supply and
(2) manufacturing lag time.

Based on experience, projects in the country are usually in a rush. In practice, structural engineers in the country take these obstacles into consideration, and design for RC, practically by default.. An alternative is to use built-up sections in place of wide flanges, which uses flat plates. This entails labor, which adds to the cost. Wide flanges are, in this case, more price-competitive, however, as mentioned, inventory poses as a problem.

Though partially, corrosion is not so much a deterrent to using steel sections. It is more of the unavailability and cost that influence designers to favor RC (Norido,2000).

- Steel construction in RP was widely used in the early 90's, and engineers found the system itself good for its advantages. But engineers tend to decide against using the system due to lack of confidence on local products and labor, unless properly supervised. A critical task in Steel Construction is erection, and engineers tend to have no confidence in the local welders, workmanship. Due also to out migration of good engineers, the development of steel technology in the country stagnated. There were not enough skilled workers (Aromin, 1999).

- The technology of steel construction has been in the country for a long time, probably as early as the 195O's. In terms of suppliers, there are at least 10 manufacturer - suppliers in the country, and these are mostly reliable (Nolido, 2000)

3-2. Factor of Cost

Based on the prices in 1999, I provide a comparative cost between Structural Steel, Reinforced Concrete and Steel Reinforced Concrete. Admittedly, steel construction is potentially faster than RC, so comparatively speaking, there may be some significant trade-off in using one over the other. By practice, clients in the country are typically more cost-conscious rather than time conscious. Though steel construction may have its advantages, the added cost for Structural Steel (SS) tends to make clients decide against it, say, in bids. The decision to build in RC or SS is made by the designer prior to the bid (Nolido, 2000).

Based on the prices in 1999, a comparative cost ratio between Structural Steel, Reinforced Concrete, Steel reinforced Concrete is:

Reinforced Concrete	100%
Structural Steel	130% - 150%
Steel Reinforced Concrete	115% - 120%

At best, if the client is time-conscious, the best solution is SS, owing to the time factor. That is, despite the cost, because this may not be a substantial amount. For eexample, for a high-rise project the given cost is P 15,000/sqm, of which the structural component is P 5,000/sqm. This translates to about P2,OOO/sqm more if the structure were to employ SS. Therefore, in terms of total project cost, P 2000 : P 15,000 is just around 10% more, which may by acceptable (Nolido, 2000).

3-3. Construction Process and Method

There is one question what are the criteria for design to be considered for the ff. Applications of RC/SS. According to the NSCP (National Structural Code oft he Philippines), the minimum sections for RC (200 to 300 mm beams @ 4.0 m [span] intervals) is actually over-designed for even a 2-storey structure. The foreman on the construction site is aware of the code, therefore in terms of implementation, this standard is what is actualized.

Residntial;

For residential applications, designing in steel would only require sections of about 4" deep for beams, and columns at 6". Owners of houses tend to perceive sections this thin as weak, therefore, owing to the psychological factor due to the occupants of these developments, designers go for RC.

Single-detached houses;

Single-detached houses tend to be unique in form; formworks for RC are therefore not refused and thrown away after one use. Comparatively, single-detached units are more expensive.

Multi-family and medium-rise housing;

Multi-family and medium-rise housing tend to assume the character of high-rise developments; these are done in the box system (i.e. 100% concrete), Where formworks may be reused from one level to another. This reduces construction cost per unit.

However, as the development increases the height, the time and labor cost for hauling of materials to the upper levels increases construction cost.

Row houses and low-cost housing;

Row houses and low-cost housing units are basically identical in plan; forrmworks in this case may be reused around 3 to 4 times (from One housing unit to another) before being thrown away. Costs per unit are therefore considerably reduced.

Industrial;

For industrial buildings, a major consideration is spans. This is where the inherent strength of SS comes into play. For spans at 20-30 m, SS employs sections at 1/2 that of RC. For compression requirements, RC is ideal for compression members. Recently, composite beams are being used (i.e. RC slabs on wide flange bems). The combined material function in cohesion, wherein the slab acts as stiffener for the steel member.

Institutional / Commercial;

For institutional and commercial purposes, the composite sections also work well. This technology is most ideal for commercial applications because this yields to smaller sections. Steel construction is also ideal for this application, because the smaller steel sections translate to more salable space (Nolido, 2000).

For the question, with regard to bays (poured concrete), has changes in technology affected its scope and dimensions, we have got the comments below.

- The innovation in terms of poured concrete is the improvement in strength of concrete .
- There exists no fixed norm or module for building construction in the Philippines. By practice, the structural engineer follows the design of the architect, therefore it is not for the structural engieer to dictate a set module. This is apart from the fact that developments in the Philippines usually maximize in that the whole lot is occupied by a structure. This is unlike the Case in first world countries where a

structure occupies just one side of a big piece of land, and the rest is landscaped. Given this situation in the Philippines, it is difficult to employ modules because structures follow the shape of the lot (Nolido, 2000).

For the question, what are the standards used in concrete design in the Philippines (e.g. ASTM)?

- By law, the National Structural Code of the Philippines (N.A.C.P) is followed as standard for all reinforced concrete construction. The code is very similar to the A.S.T.M. (Nolido, 2000)
- In the Philippine experience, the state of architecture goes about as a cyclical interaction of the real property market and the needed technology to build:

High real property

↓

Higher requirements

↓

Needed Technology

↓

New technological developments

↓

Higher technological solutions

The progressive use of reinforced concrete as building technology also followed this trend: In the late 80's, after the EDSA revolt; economic activity was revitalized, giving rise to new buildings; but along with this came the rise of prices of real property. Space became expensive, therefore a need for smaller columns. The solution to this was the development of High-Strength Concrete at 6000 psi (at this time, othe countries were using 10,000 to 12,OOO psi). The first Project to use 6000 psi (when the norm was 3000 to 4000 psi) was The Pacific Plaza Condominium in Ayala Ave. Contractors were apprehensive to build at this strength, but when the building was built, they became comfortable trying even 8000 psi (this started in 1989). In the 1990's, the Pacific Plaza

Towers was built at 52 storeys. High stregth concrete at 10,000 psi was used. The new technology required services of US consultants. Several requirements required good quality control:

(1) good aggregate
(2) very clean sand
(3) the right temperature
(4) silica fume
(5) the right amount of water
(6) admixtures to make the concrete workable
(7) skilled manpower

Due to difficulty in making high-strength concrete, and the lack of good labor locally, it cannot be practicably done here. Foreign input is required for manpower training and tech. (Aeomin,1999)

For the question, what new systems are now used for considering other forms of loading [e.g. torsion and wind pressure]? The computer software called STAAD Outin the 1990,s. This made prediction of loading effects on structural design considerably easier. The program generates a 3-dimmsional image of the structure and shows the effects of specified forces to the structure (Nolido, 2000). For the question, what standard/system of design is used to integrate design for earthquakes, there are two ways by which earthquake forces may be analyzed:

- Static Analysis- in this method, it is assumed that the ground is stationary, and that it is only the upper floors that move.
- Dynamic Analysis- in this method, it is assumed that the ground moves, which induces movement on the upper levels of the structure, the approach is essentially energy-based. This method better simulates what actually happens, therefore tends to be more reliable. This approach is required by the code on high-rise structures(i.e. 20streys and above). For bothmethods of of earthquakes design, the structure is made bulkier by as much as 50%. Whether the top or bottom of the

structure is made bulkier, actually depends on the configuration. For instance, for high-rise buildings, column sections can generally be reduced at every 4 doors. Therefore in factoring in earthquake loads, if there are fewer columns on the upper levels, sections are no longer reduced.(Nolido, 2000)

- Force Design and Displacement Design - force design was employed to low-rise structures (i.e. 7 - 10 storeys); for Dynamic Analysis, both are required (Aromin, 2000)

For the question, what other structural systems employ RC? And /or steel framing?, 100% Reinforced Concrete or Boxed System, produces more shear stress due to design, tends to be too stiff, cannnot go beyond 160 ft.

3-4. Practice of Structural Engineering

3-4-1 Timber

Before the 1900s, most buildings were 1-2 storey. So structural engineering was unknown as a discipline. Civil engineers did architectural and structural analyses on their own for all architectural engineering.
In 1920s timber piles were used reaching only 30 feet. The Crystal Arcade was designed by Jose Cortez (who was educated in the US) in 1930. This was a landmark building with glass floors and skylights.

3-4-2 Reinforced Concrete

Before the 1900s, most buildings were 1-2 storey. So structural engineering was unknown as a discipline. Civil engineers did architectural and structural analyses on their own for all architectural engineering.

The period of 1940s witnessed the shift from the use of wood as a structural material to concrete. Especially, late 1940s engineers archieved the development of reinforced concrete as a building material. Before the advent of research in reinforced concrete technology, the maximum strength of concrete was 2,000 PSI. Raul Ura developed the post-tensioning technology in the early part of 1950 and mass produced concrete joists. Shell construction using reinforced concrete as a material was introduced in 1956 with the construction of the UP Chapel by Locsin. The strength of concrete was approximately 3,000 PSA. In the late 1950s, the standard strength of concrete ranged from 1,800-2,000 PSI.

In the early 1960s PHILSTRESS, CONSTRESS, and PERMASTRESS (manufacturers of pre-stressed reinforced concrete components) produced plant-assembled pre-stressed piles with strengths ranging from 3,000-4,000 PSI and reaching lengths of up to 40 feet in 1962. In the mid-1960s, pre-stressed piles with good bending qualities were built with lengths reaching 90-120 feet. The maximum capacity for piles was 50 tons.

The PNB Building in Escolta was the first building to use piles with 100 tons capacity. In the early 1970s, the standard strength of concrete was 3,000 PSI.

3-5. Use of Building Materials

3-5-1 Exterior Finishes

Before 1900's adobe and wood are prevalent materials used for offices. At the turn of the century until just before the war, Philippine hardwoods were extensively used for exterior finishing such as Ipil and Narra (1st class wood), Lauaan, Apitong and Tanguile. From 1950's shell piqueta finish for exterior walls became popular. The technique became popular in the early 1970s and lasted until the late 1970s. Examples of buildings using this finish are the Ayala Museum and the Makati Stock Exchange Building which was built in 1971. Brick veneer finish also became popular during this period. After 1980's pre-cast ballustrade system become popular during this period. In the late 1980s, Glass Fiber Reinforced Concrete (GFRC) is tried in the Philippines. An example is the Robinsons Galleria Building. The use of granite as exterior finishing becomes popular in 1993 and 1994. Two attachment processes are employed: wet and dry. The Philippine Stock Exchange (PSE) Tower 1 uses imported granite and employs the dry process. The use of Benguet granite on the other hand uses the wet process. Paint (in pastel tones) is widely used during this period. Granite like paint are also popular. Metal Cladding (by Reynolds and Aheco Bond) appear in quite a number of buildings such as the JMT Tower. Mosaic exterior finish is also used such as in the BIR Building built in 1996.

3-5-2 Interior Finishes

At the turn of the century until just before the war, wood panels, painted or wall-papered surfaces were widely used. After 1970's the use of chip boards and particle boards come into use during this period. After 1980's, synthetic Fiber Carpets are introduced. For interior finishing wood walls, bamboo panelling, and synthetic stones come into use. As substitutes for traditional wood finishing, PVC trimmings, gypsum boards, waterproof gypsum, and pre-cast gypsum mouldings become popular during this period. Gypsum boards become particularly popular in 1997-1998.

3-5-3 Window Systems

Around 1900's use of punched windows (steel mullions) with glass in fixed, awning, and steel casement windows. For office buildings, the use of this type of window was popular until the late 1950s. Presently, this type of window is still used in small buildings where budget is a major consideration. From 1920-1940 during this period, glass blocks come into use. In 1960's aluminum sliding windows come into use. The period from 1970 to the early 1990s witnessed the recurrence of glass blocks. Glass tinting comes into fashion during this period. The Stick System of glass cladding (using aluminum frames) come into use. An example is the Rufino Tower. In 1990's

Analok Finish and powder coated aluminum frames becom popular. Mullionless aluminum case windows also make their first appearance. Another popular material is the use of frameless glass. Polycarbonate window systems are popularized. Panelized system of glass cladding; combinations of punched, stick, and panelized systems become widely used. The use however depends tremendously on the requirement of the cliend and the budget. An example is the Citibank Tower I.

3-5-4 Roofing Materials

Before 1900, Clay tiles is the common roofing material during this period. Thatch roofing is also common. In the early 1900s, Galvanized Iron as a roofing material was introduced. The first to appear had the brand name "Apollo Ga. 24" and was sold in lengths of 8 feet and 12 feet. Presently, galvanized iron sheets are still popular among residential uses and small office buildings. Before WW2 terracotta tiles for roof decks come into use. An example is the UP College of Liberal Arts Building. Asbestos cement tiles become popular particularly from the 1960s to the 1970s. The use of long span galvanized iron roofs become popular during this period. Popular brands are Philsteel and Metal Forming Corporation. In 1980's tegula concrete tiles become popular. The Eternit roofing system likewise become popular. In 1990's coconut coir come into use as building materials. As part of government's programs to develop alternative building materials for low cost housing, non-traditional materials such as coconuts have been experimented upon to determine their potential as alternative building materials. Curved roofs come into use.

3-5-5 Flooring Materials

In 1920's-1940's terracotta floor tiles come into use during this period. Another popular flooring material are mosaic floors. An example is the UP College of Engineering. After WW2 polished concrete became a popular floor material for low-cost housing. Mosaic floors became widely used in office lobbies. In 1970's popular flooring materials during this period are: vinyl tiles, Bulacan marble, carpets, and crazy-cut marble. Raised floors for concealing wiring systems are introduced. The cost however is exorbitant (5,000/sq,m.) and are therefore not widely used. In 1990's the use of raised flooring are probably a result of the advent of computers where units are interconnected using a LAN system. Laminated floors make their first appearance. Glazed granite tiles also become popular. An example is the SM Megamall. Vitrified tile systems also come into use.

3-6. Practice of Tropical Design

Tropical design is one character of Philippine architecture. In 1880-1900 houses were built with wide eaves popularly called "medya-agua" to protect the house against harsh weather conditions.

During the period of 1946-1949, it could be observed that the work of architects exhibited a general concern for the effects of climate on architecture. Among the common features during this period were: large window openings, sun-shading devices, and ventilation in terms of open spaces. The use of vertical and horizontal sun shading devices became popular during the 1950s and 1960s.

In 1960's the works of Pablo Antonio, Cesar Concio, and Felipe Mendoza attests to this. Wide overhangs (made of concrete roof extrusions) became widely used. This began in the 1960s and lasted until the 1980s. Considerations for the climate (as expressed in tropical design) could be seen in the works of Bobby Mañosa (San Miguel Head Quarters Building and other resorts); Toti Villalon (DAP Building); Nestor David; UP Faculty.

In 1980's an example of a building that took tropical design into consideration is the Ateneo Building Science Complex by Bobby Mañosa. After 1990's the advent of tower structures and the popularity of glass curtain walls set back advocacies for tropical design considerations during this period. There are however a growing number of architects who incorporate tropical design features in their works. An example of such a project is the Rockwell Center by Bobby Mañosa.

3-7. Practice of Building Technology

3-7-1 Airconditioning Systems

Before the war, only the opera house was provided with airconditioning. "Canetex", a form of fiber insulation came into use. The direct expansion system came to be used for offices and theatres.

Prior to 1956, there were no practicing airconditioning consultants. Suppliers would design systems for buildings. In the late 1950s, centralized airconditioning systems became fashionable in Forbes Park residences. An example is the Stonewall residence.

Fiberglass insulation became favored over styrofoam insulation. In the early 1960s, the Araneta Center was built. This became the country's first airconditioned stadium. The Campos residence was also built during this period (1960). The use of chilled water systems were employed for taller buildings. An example is the Philam Life Building which was built circa 1960-62. Airconditioning consultants from the US bases in Clark and Subic arrived during this period. There were likewise a few independent There were likewise a few independent consultants such as Val de la Fuente, Mr. Campos, and Mr. Juinio from UP. These consultants provided their services in the design of buildings such as the San Miguel Head Quarters Bldg., Makati Stock Exchange, Meralco Building (1968), CCP (1969).

The chilled water system became widely used for large buildings such as the PICC (built in 1975) and other hotels. Buildings such as the PICC (Philippine International Convention Center), CCP (Cultural Center of the Philippines), and 1st Citibank Building heightened standards for the quality of airconditioning systems. Many airconditioning consultants emerged with the advent of hotel design in the early 1970s. The zoning system for airconditioning design came into use. Variable air and volume supply came into use. Individual fan coil units became popular in hotels. Airconditioning of office building further made the profession attractive.

Polyfoam, Ewafoam , and other foam-based products became popular as insulators. This period witnessed a growing concern for the "sick building syndrome" popularized in the US. Building management came into use. An example is the Bank of Philippine Island (BPI) Building that was built in 1983. Sound traps also became popular during the 1980's.

Polyurethane insulation came into use during the 1990's. In 1991, the growing concern for the sick building syndrome made airconditioning specialists increase the tonnage requirements from 7-10 cfm to 20 cfm. An example is the Citibank Tower 2. Special requirements for tower structures are: 1) one main compressor at the basement level, 2) an AHU unit for every floor, 3) a cooling tower at the roof deck, and 4) a machine room at intermediate floors to counteract friction loss.

3-7-2 Lighting Systems

From 1880's to 1990's, Lighting solutions for residential buildings consisted of large window openings, use of transoms, ventanillas, and screens. This practice lasted until 1919.

The worldwide oil crisis from 1974-1975 made designers revitalize the study of daylighting solutions. Landmark buildings during this period were the Philam Life Building and the San Miguel Head Quarters Building.

3-7-3 Water Surply and Sanitary Services

In 1880, the Carriedo Water System was inaugurated. The system was supplemented by water from esteros and cascos. The outhouse ("kubeta" or toilet) was used. The method was unsanitary however because wastes from the cistern leached into the ground. In 1908, the Montalban River was tapped as an additional water source by the Americans.

In the early 1920s, the Ipo Dam-Novaliches-Manila Water System was developed and tapped water from the Angat River. The La Mesa impounding dam was opened. The Alat River served as a supplementary dam. The Manila Water System served opulent areas. Middle and lower income citizens bought water from cascos (for 6 months). Bathing and washing was done in the river. Waste disposal methods were observed as follows:

1. Wrap and throw system done by lower income families.
2. Antipolo system (container under toilet) was popular in rural areas and suburbs.

Pail system was done in Binondo, Sampaloc, and Tondo.

In 1955, under the administration of President Ramon Magsaysay, the National Sanitary Engineering Law and Master Plumbing Law was created to regulate the practice. In the late 1950s, Ayala Corporation introduced sanitary sewage systems in their developments. A sewerage treatment plant was built in Dasmariñas Village in Makati. Though expensive, a recirculating drinking water system was first used in the high-end projects of Locsin and other architects particularly in hotels. The use of airconditioning and fire protection systems increased water loads. Tank type water closets came into fashion.

In the early 1960s, a law was passed requiring all subdivisions who applied for water supply connections with MWSS were required to set up their own sewage systems and sewage treatment plants. In the mid-1960s, probably to save on construction costs, the storm drain was joined to the waste water pipes which brought about the pollution of rivers.