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I[redacted]re and the Development of Thailand: Past to Future

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Abstract

This paper reviews history of infrastructure in Thailand and points out turning period, success, difficulties and drawbacks in accordingly to the National Economics and Social Development Plan that have great effects to the planning and development of the infrastructure projects or vice versa. Conclusions are: the existing infrastructures should be maintained in good operation and services for well-being of people and the new infrastructure projects should also be developed continuously, conforming to the demands and to support the economic growth and social development. More frequent disasters and crisis enforce the paradigm shift in rethinking in planning, design, construction, operation and maintenance of the infrastructures. The value-added designs to achieve the uses of appropriate technology and sustainability concerns are recommended.

Keywords: infrastructure development, turning period, appropriate technology, sustainability, paradigm shift

1. Introduction

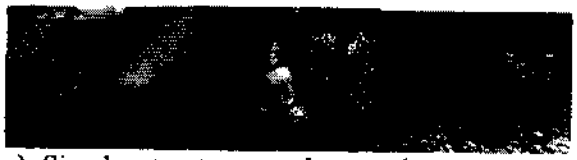
Infrastructure (infra + structure) means a substructure or underlying foundation, specially the basic installations and facilities on which the continuance and growth of a community [1]. Examples of infrastructure are various hydraulic structures (Dam, spillway, reservoir, flood protection dike and drainage structures), transportation (Road, railway, bridge, tunnel, waterway, port or airport and pipeline), buildings, utilities (Power plant, water supply plant and waste water treatment plant). The infrastructure is the mechanism or the important key of success in community well-being and development. Reviews of the historical ages of infrastructure thus, would give understanding and sound basis for future development.

2. Historical Development

Thai's identity, engineering knowledge and infrastructure development have been founded and evidenced since the human in the Historical age survived easily in the nature, form communities in or nearby the caves or along the rivers. They learnt to use fire, invented weapon, tool and accessories made of bronze or steel, learnt to make the earthenware with color print, learnt to make beads or used precious stones. When they learnt to cultivate, fishing and had barter trade, the immobility social was shift to the agricultural and trade social.

Beginning of the Dhavaravadee age, human still had simple infrastructure, built the buildings with natural materials or by modifying the nature (Fig. 1a). However, the construction of infrastructures employed various fields of knowledge e.g. city planning by means of pacing survey, excavating the moat to form the flood protection dike, and provide storage for consumption, irrigation as well as waterway for transportation and defense. Construction was labor-based and the structures used natural materials e.g. ferricrete cut, clay brick, organic mortar and plastering agents made from rubber or animal skin. Oversea trading by the communities closed to the sea had also brought the construction technology, architectural and art style from various civilizations e.g. Greek-Roman, Chinese-Indian, Arabian-Persian and Khmer. Context of Thai style building consists of using natural materials, gable roof which could provide good ventilation, preventing the

high intensity of sun light and rain (Fig.1b), the elevated floor provided more functional space and could survive from flooding.



a) Simple structure used natural materials or only necessary modification of the nature [2]

b) Thai's architecture and art in the Buddha history and legendary stories on the Fa Daet Songyang famous stone

Fig. 1: Infra structures in Dhavaravadee Age.

During Sukhothai age (before 1238-1583), design and construction of infrastructures used its self knowledge or adapted the transferred technology from the mentioned civilization e.g. excavated moat, flood protection dike, dam and reservoirs for irrigation and water supply [3]. There was about 123 kilometer flood protection dike or the road embankment from Sukhothai to Sri Sutchanalai and Cha Liang. The existing road in Srisutchanalai was the same as the Roman road. Production and uses of ceramic which learnt from Chinese as decorative accessories and water pipe were found (Fig. 2a). The existing forms of Khmer's sanctuaries had been changed gradually to the Srivichaya or Lankan style, and finally had become a unique style. Sophisticated arts of Gandara, Gupta and Pala had great impacts to the identity of Davaravadee through Sukhothai, thus Buddha statues had been built (Fig. 2b).

a) Dike, moat, road, storage and ceramic pipe

b) Sanctuaries or pagodas which had become the Sukhothai unique style

Fig 2: Infrastructures in Sukhothai Kingdom.

Prior to and during the Shukhothai kingdom, there were Lopburi kingdom and communities of Khmer civilization, thus numbers of sanctuaries in Thailand had been built in different ages of Khmer: Prei Kmeng (1180-1290, e.g. Khao Noi); Preah Ko - Bakheng (1420-1470, e.g. Panomwan); Kok Ker (1464-1490, e.g. Muangkaek); Bahuan (1560-1630, e.g. Pimai and Panomrung); and Khleang-Bahuan (1510-1560, e.g. Muangtum). They represented advanced planning and construction technology e.g. surveying by means of Surya cycle - Ecliptic) with Vernal - Autumn equinox and Summer - Winter solstice and Soma cycle), excavating reservoir (Barai) to intercept and store water, using ferricrete , sand stone or clay brick as construction materials with gravity interlocking or steel connections, using spread and raft footing with balanced loading. Different functions of the sanctuary were pre-determined for religion respect, hospital or temporary accommodation (Fig. 3).

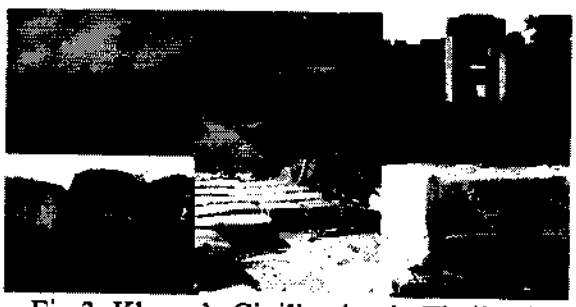


Fig 3: Khmer's Civilization in Thailand.

Ayudhya kingdom was first established in 1350, on the location among the three rivers (Lopburi, Pasak and Chao Phraya), thus technology had been transferred through the trade e.g. defense and military engineering and construction. The bypass of "Chao Phraya" river had been excavated during 1534–1547 (which has become part of the main river while the existing river has become the smaller canals called Khlong "Bangkok Noi" and "Bangkok Yai"), original idea to bypass the Indian to Pacific Ocean ("Khong Khra") had been brought into consideration. During 1590-1605, during 1610–1628 a road to "Phra Buddha Bhat" (19 km) had been surveyed and constructed using modern instrument to get the nearly straight alignment. During 1656-1688, architectural and art were still based on religion and power respects while the technologies which made great changes to the infrastructures were astronomy, masonry building with candle holes, water supply plant and clay pipe (Fig. 4). The bypass canal called "Khlong Mahachai" (or "Khlong Sanam Chai" or "Khlong Than") from "Khlong Khok Kham" to the "Tha Chin" river had been excavated during 1703-1709 and had been the main access between Ayudhya and the sea. A large sediment delta was formed and called "Tha Chalom" and "Maha Chai".

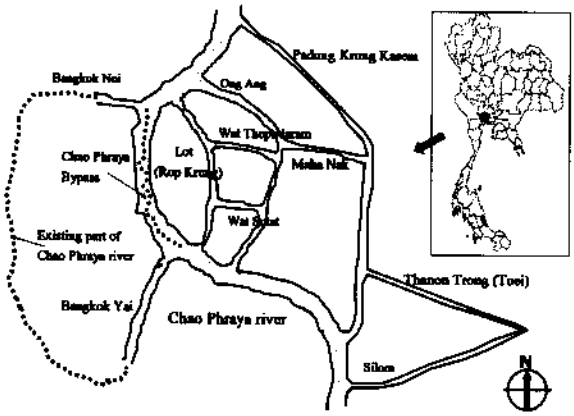
a) Architectural and art styles, adaptive light opening and candle holes.

b) Water supply plant and clay pipe.

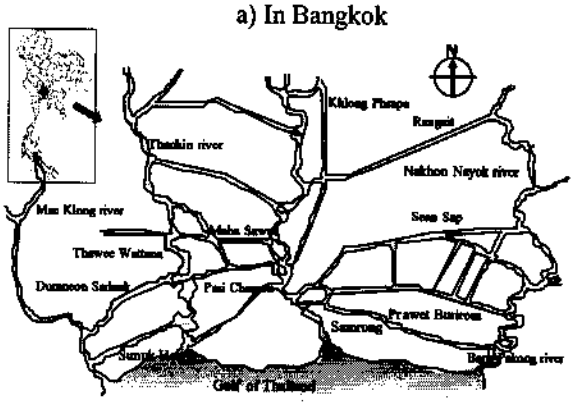
Fig. 4: Infrastructures in Ayudhya Age.

During short period of Thonburi (1767-1782), the first moat in Bangkok named "Khlong Lot" had been excavated to join with the "Chao Phraya" river and form "Rattanakosin" island (Fig. 5a).

During 1782–1809 of Rattanakosin, the new moats ("Khlong Rop Khrung" or "Khlong Rattanakosin") were excavated and named differently according to the locations [4]. In 1817, the excavation of "Khlong Lad Luang" and "Khlong Sunak Hon" to connect the "Mae Klong" and "Tha Chin" rivers nearby the exit to the Gulf of Thailand (Fig. 5b). Due to the critical flooding in Bangkok in 1831, a monument for water level measurement was first built in the "Chao Phraya" river. Accordingly, about 100 bypasses were excavated in the Bangkok and sub-urban, the most important canal called "Khlong Saensap" (or "Khlong Bangkanak", 56 km) was started excavating in 1837.



a) In Bangkok



b) In sub-urban

Fig. 5: Moats and Canals in Bangkok and Sub-urban during 1782-1936.

King Mongkut (1851-1868) had made the great changes in Thailand's infrastructures e.g. first made of steam engine vessel (1861-1863) and forecasting the solar eclipse precisely.

In 1853, the first lighthouse and navigator trench were constructed by the "Harbor Department (Kromata)" and in 1860 the "Ship Act" was first launched to regulate the water transportation and accident claims. Numbers of canal had been labor-based excavated in Bangkok e.g. "Khlong Padung Krung Kasem", "Khlong Toey" and "Khlong Hua Lam Phong" for flood prevention and water transportation, and also in sub-urban e.g. "Khlong si" and "Khlong Mahasawat" (1859), "Khlong Damneon Saduak" (in 1866, consists of about 200 sub-canals and bypasses), "Khlong Phasi Charoen" (in 1867). The first three modern roads had been constructed: New Road (Chareon Krung, 1861-1864), Bamrungmuang and Fueng-Nakorn (1863-1864), following that the cars have been brought in to Thailand. The "Khlong Khra" bypass was revisit several times during 1858-1868 but no decision.

Important milestone of change in infrastructure works had been held during 1868-1910, when modern technology has been employed in designs and constructions, which some were the large scale projects. Due to the water shortage in 1890-1891, the private company got the permission to excavate the 15 irrigation canals called "Khlong Rangsit Prayulsak" by means of equipment. The first water supply plant was started construction in 1914 e.g. intake structure for the raw water from Chao Phraya river at "Sam Rae" Pratumthani through "Khlong Bang Luang Chiang Rak" and the excavated canal "Khlong Pra pa" with numbers of siphon to "Samsen" water supply plant, elevated tanks were also built (Fig. 6a). Few canals had been excavated during this period e.g. "Khlong Prem Prachakorn"and "Khlong Thawee Wattana" and in 1872 the company which completed the excavation of "Suez canal" did ask the permission to perform the excavation of "Khlong Khra" but no decision was made due to the defense reasons.

The first railway from Bangkok to Nakhon Ratchasima was started in 1891 and the first part from Bangkok to Ayudhya (71 km) started operating in 1896 (It was also the day when the Railway Department or now the State Railway of Thailand – SRT was established), then it continued operating to Nakhon Ratchasima (up to 256 km) in 1900. Large and multi-stories buildings were constructed with various classic styles that had been transferred from famous European architects and engineers, while combined Thai's roof and modern structure was used for the "Chakri Maha Prasat" throne hall (1875-Fig. 6b). Electricity, power plant, telegraph and telephone were also started in this period, the construction has turned to equipment based rapidly.

a) Elevated water tank, Bangkok railway station and Khun Tan Tunnel.

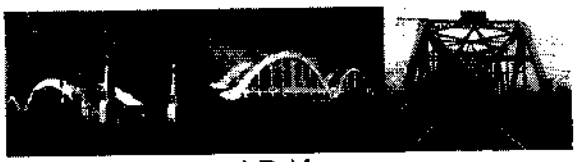
b) Buildings - Throne halls

Fig. 6: Illustrations of Infrastructures during 1989-1910.

During 1910-1925, water transportation has been gradually superseded by motor transportation. Extension of the railway to Chiangmai were completed in 1921, while the first "Khun Tan" railway tunnel had been constructed during 1918-1929 [4], famous vierendeel bridges "Tha Chompu" in Lamphun were started construction in 1919), the through truss bridge "Rama VI" had been constructed to cross the Chao Phraya river during 1922-1926. Extensions of the railway had been completed e.g. extension to the South (Padang Beza) in 1926, to the East (Aranyaprathet) in 1926 and Ubon Ratchathani (up to 575 km) in 1930, respectively. Extension of roads in Bangkok were done to support the increasing motor transportation, city planning and expansion, bridges had been constructed, including the "Ratchadaphisek" vierendeel bridge in Lampang, which was completed in 1917 (Fig. 7a). Other infrastructures were: "Rama VI", the first irrigation dam had been completed in 1916 and following with other large dams e.g. Chao Phraya dam in 1957 and Bhumibol dam in 1964 (Fig. 7b). Dredging of the "Chao Phraya" river had been first done during 1934-1936 to resolve the critical floods in middle part of Thailand which had been occur since 1917. The Bangkok International Airport (BIA) had been

constructed after the first aircraft arrived in Bangkok in 1911, and took 96 years to complete the new Suvannabhumi International Airport (Fig. 7c). The pilot mailing airways between Bangkok and Chantaburi was started in 1920, and the aviation section (prior to be the Department of Civil Aviation-DCA) was founded in 1925. Thai's engineers had admiral capability in planning, design, construction, operation and maintenance of various infrastructures. The Department of Highway (DOH) was first established in 1912 as a section under the Railway Department, there was 775 km of the constructed road during 1871-1916, and the first highway manual called "Instruction Manual for Highway" was first used in 1918. At that time, there were three main highways of Thailand: No. 1-Phaholyothin (1,005 km), No. 2-Sukhumvit (385 km) and No. 4-Phetchakasem (1,274 km).

The Water Transportation Act was first launched in 1912. Accordingly, the Bangkok Port and the Port Authority of Thailand (PAT) were first started in 1932, prior to construction of the deep sea ports: Map Ta Phut, Songkhla, and ports in Chiangrai, Chiang Khong and Ranong Only the liners named Thai Marine Navigation Co. Ltd. was founded in 1940.



a) Bridges

b) Rama VI, Bhumibol and Chao Phraya dams

c) Existing Bangkok International Airport and Suvannabhumi Airport

Fig 7: Infrastructures during 1910-1925.

During 1925-1932, infrastructures had been developed continuously even the country was suffered from economic crisis, the second through truss bridges crossing the "Chao Phraya" river had been constructed during 1929-1932, the first thin shell barrel roof structure in Hua Hin was completed in 1929 (Fig. 8).

Fig. 8: Illustrations of Infrastructures during 1925-1932.

3 Turning Period and Contemporary Age

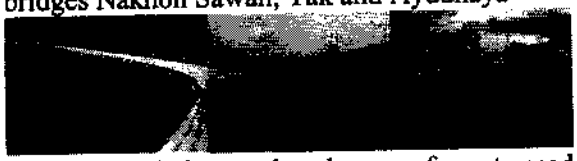
Turning period of Thailand's infrastructure development has taken place more or less after the World War II (1939-1945 that Thailand's had been suffered in both economic and social) to 1982 (Baht crisis), when the population, demand of work, residence and transportation had been increased rapidly as well as the attempts to resolve the communism trouble. In 1952, there was about 12,930 kilometer of highway in Thailand following the 40 years of construction, thus the government launched the four years plan (1952-1955) for constructing the new highway that provided the network for better motor transportation. In 1958, the United States Operations Mission (USOM) provided technical support to design and construct the main highway No. 3 "Friendship" (Saraburi to Nakhon Ratchasima and extension to Nongkhai - 616 km). Numbers of bridges had been constructed during the war e.g. in Khanchanaburi, Pai (Mae Hong Son) and Lopburi (Fig. 9a), two through truss bridges crossing over the "Chao Phraya" river were started constructing in 1954 (Fig. 9b), and three suspension arch bridges in Nakhon Sawan, Tak and Ayudhya had been completed (Fig. 9c). During 1956-1962, the government provides four to six percent of fiscal year budget for constructing the new main and minor highways in parallel to the rehabilitating the existing highways. The prestressed concrete (PC) bridge has been used to lengthen the span e.g. The "Sarasin" bridge from mainland to Phuket and the highest viaduct bridge "Khun Pha Muang" in Phetchabun was completed (1973) to connect the motor transportation in North and North Eastern part together (Fig. 9d). So far, more than 55,000 km of highway has been constructed, the DOH continues constructing the new highways,

upgrading the existing highways to be the four-lane divided highway, improves the accessibility and safety, plans and constructs the new motorway. So far, two motorways have been operated: the motorway No. 7 Bangkok-Chonburi (82 km) and No.9 OBRR- East, West and South, totally 165 km had been completed (Fig. 9e). By the way, the SRT has performed the improvement projects since 1992 e.g. replacing the existing lumber tie, sleeper or barrier with those PC, constructing the dual tracks system, improving the control signals and extending the new routes.

a) Memorial bridges in Khanchanaburi, Pai and Lopburi

b) Krung Thonburi and Krung Thep bridges

c) Three classic concrete suspension-arch bridges Nakhon Sawan, Tak and Ayudhaya



d) Highest viaduct and early age of prestressed concrete girder bridges in Tak and Phuket

e) OBRR and Motorway by the DOH

Fig. 9: Famous and Memorial Bridges in Thailand since the Turning Period.

In 1960, Thai Government decided to have a master plan for Bangkok and construct the new airport (which has become the Suvannabhumi international airport) following the study and recommendations made by the consultant. The International Airways was also founded in 1960 and the Airport Authority of Thailand was founded in 1979 (now is the Airports Thai PCL- AOT) to responsible for six international airports at Bangkok, Chiangmai, Phuket, Had Yai, Chiangrai and Suvannabhumi.

Technology in building design and construction had rapid changes during 1966-1982 e.g. better quality of construction materials, used of computer in structural modeling, analysis and design, progress in construction technique, labor skill and used of heavy equipment. Interesting architecture and structural system had been built during 1965-1977 e.g. thin shell, fold plate, grillage, hyperbolic-paraboloid (Fig. 10).

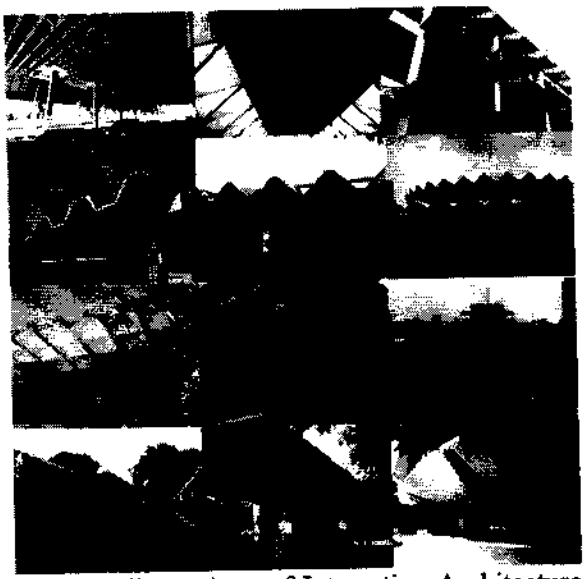


Fig. 10: Illustrations of Interesting Architecture and Structural System during 1965-1977.

During 1982-1993 or "building boom" period, a large numbers of building and high rise building had been built rapidly in Thailand. Unfortunately, some had been built for profit speculating rather than true demand, thus they could not be completed while the quality in both design and construction of some projects has been in doubt hence, Ministerial Rule for building assessment has been launched to assure the safety of individual and social.

In 1972, the Expressway Authority of Thailand (EAT or now is EXAT) was founded, the first stage of expressway "Chalerm Maha Nakhon", 27.1 km and the first cable-stayed bridge were completed in 1981 and 1983, respectively. Other expressways had been

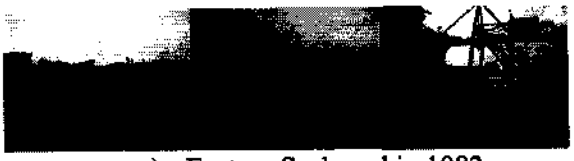
constructed and completed e.g. Srirach (3.8.4 km, in 1993), Chalongrach (18.7 km, in 1996), Udorn Ratthaya (22 km, in 1998) and Burapavithi (53 km, in 1998), respectively (Fig. 11a). Numbers of bridge had been constructed in Greater Bangkok by the PWD/DPT or the Department of Rural Highway-DOR (Fig. 11b). All the viaduct and bridge used more interesting technology e.g. PC I-girder, PC segmental box girder or with free cantilever construction and cable-stayed bridge with composite floor, most the constructions used heavy equipment.

a) Express way and bridges by the EAT

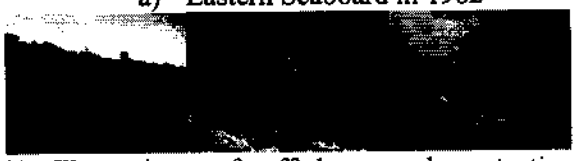
b) Bridges by the PWD/DPT or DOR

Fig. 11: Expressway and bridges by the EAT, PWD/DPT or DOR.

During 1982 – 1986, the government decided to implement the Eastern Seaboard project which mainly consists of the Laem Chabang deep seaport and Map Ta Phut industrial estate (Fig. 12a). Even the project seemed hard to success at the beginning but it could recover the crisis and immobility in construction industry promptly as well as lead to the numbers of related project e.g. the bypass railway from the seaboard to the North Eastern, the Outer Bangkok Ring Road (OBRR) and motorway, the Inland Container Depot (ICD – at Lad Krabang while the existing freight station at Paholyothin was superseded), Off-dock Container Freight Station (CFS), private investments in raw water and petroleum pipelines, including the Suvannabhumi airport. The mentioned projects provided opportunity to Thai's engineers to learn inter-disciplines and advanced technology and have been diversified to various off-shore projects e.g. seawall, revetment, bulkhead and groin have been constructed to protect the shore from critical hazardous wave and scouring (Fig. 12b).



a) Eastern Seaboard in 1982



b) Illustrations of off-shore and protective structures

Fig. 12: Current Works in Ports, Marine and Coastal Engineering.

Other water pipelines and plants had been accomplished after Sam Sen water supply plant (700,000 m^3/day): at Thonburi (160,000 m^3/day, in 1967, Bangkaen (3,200,000 m^3/day, in 1979) and Mahasawat (800,000 m^3/day, in 1994), respectively. The Metropolitan Water Authority Act was first launched in 1967 and the Provincial Water work Authority Act was first launched in 1979, the Metropolitan Water work Authority (MWA) and the Provincial Water work Authorities (PWA) were founded in the same years as the Acts. The authorities has attempted to increase the capacity and efficiency of operation e.g. constructing new pipeline, plants and replacing the existing pipe with HDPE pipe (Fig. 13a). On the other hands, pipelines for petroleum products have been constructed and operated by the private firms since 1991 e.g. Sriracha to Map Ta Phut, Lumlukka, Saraburi, access to Bangkok International and Suvannabhumi airports with tentative extensions. Raw water pipelines have been constructed and operated by the private firm since 1992 from Nong Pla Lai – Map Ta Phut (Cha Cheong Sao) and Prachinburi.

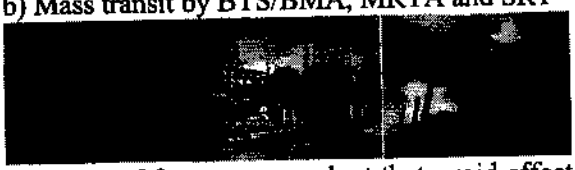
The Greater Bangkok's mass transit has been implemented by several means e.g. bus or Bus Rapid Transit -BRT) by Bangkok Mass Transit Authority (BMTA), Bangkok Transit System PCL (BTS – Green line, 44.7 km and the

ongoing extensions) under the responsibility of Bangkok Metropolitan Authority (BMA) and Mass Rapid Transit Authority (MRTA – Blue line, 42.4 km with tentative extensions) and the ongoing airport rail link (Red line, by SRT), respectively (Fig. 13b).

When more critical in conflict between acquisition of energy sources and reservation of natural resources, constructing of new hydropower or multi-purposes dam in Thailand seems not possible. By the ways, energy from the existing sources or processes is sometimes in doubt of stakeholders. It is therefore, seeking the future source or alternative of clean or green energy and together with the necessary infrastructure for plant or process have become the interesting issues (Fig. 13c).

a) Increasing the capacity of water supply plant and improve the distribution line

b) Mass transit by BTS/BMA, MRTA and SRT



c) Needs of future power plant that avoid effect or impact to natural resource and environment

Fig. 13: Illustrations of Improvement and Further Development of Infrastructures.

4. Policy and Planning

The National Economics and Social Development plan (NESD) in relation with the infrastructure development in Thailand could be divided into three main periods. The first period of plan needed infrastructures to support and accelerate the development, started in 1963, when Thai's government agreed to have the master development plan to enhance the efficiency and effectiveness of country development systematically. The first National Economic Development Plan (1963-1969) was launched. The plan integrated the development of infrastructure to promote and support the increasing of private and international industries and investments that might accelerate the growth of economics. The second plan (1967-1971) added the word "Social" then it has become the NESD plan, integrated the development of human resources to conform the demand, considered the participation from private. Numbers of Universities were founded in regional parts of Thailand to provide higher education that most necessary for country development. The third NESD plan (1972-1976) accelerated the consumption of natural resources, improved the economic structure to increase agricultural and industrial products and export. During this plan, it seemed benefits seemed not directly handed to the low income people, this unbalanced development introduced the word "relative poorness". The fourth NESD plan (1977-1981) started while the communism trouble had not yet calmed down aimed to promote the social ubiquity and development, economic growth and distribution of income, regional production and development, public service or welfare, reservation of natural resources and environment. However, the plan had been caused problems in financing because of the higher oil price and expenditure for defense.

In the second period, the infrastructure had been developed rapidly but seemed not definitely support the economic growth and social development. During the fifth NESD plan (1982-1986), political situation recovered from communism trouble but faced to the problems of poorness. The joined government-private committee had cooperated in the economics restructuring and other aspects including updating the regulations. It was the first time that the natural gas and petroleum from "Ao Thai" has been brought to refine and consumption and used as raw materials in petrochemical industry. The government started the Eastern Seaboard project. The industry and economic were then recovered according to the "Plaza Accord" that most Japanese investments moved to South East Asian, including Thailand. The construction industry then, had been recovered even it was the Baht crisis in 1984. The sixth NESD plan (1987-1991) started with relatively low target of economic growth and aimed to maintain and support economic stability. The plan was readjusted according to

the over-forecasting of economic growth during 1987- 1988 as well as to emphasize the six aspects of development which are: 1) competitive capability; 2) infrastructure; 3) natural resources and environment; 4) human resource; 5) authorities; and 6) budgeting and financing. Following the instability in political situation in 1992, the seventh NESD plan (1992-1996) considered the lack of infrastructure, utilities, and the increasing in gap between saving and investment. The plan aimed to accommodate Thai people in adapting themselves to conform the high and rapid expansion of the international economic and attempted to distribute the income to regional and rural, accelerate the development of human resource, life quality and maintain the natural resources and environment. Following the continuing crisis during 1992-1995, the Government decided to float the Baht values.

The third period of the NESD plan has brought the re-thinking of appropriate technology and sustainability in well-being and infrastructure development. The eighth NESD plan (1997-2001) attempted to readjust the development with public or social participation. The plan aimed to achieve the balanced development with sustainability, maintain and use the economic to develop the qualified human resource with well-being and happiness as well as enhanced the regional and rural development. According to the continuing severe of economic crisis, number of business firms and authorities were affected, the plan was readjusted promptly thus, some strategies had never been implemented. The ninth NESD plan (2002-2006) had been drawn by means of public brain-storming and participation, aimed the human resource to be the central of development, continued to develop the quality of life and social, well-being, management of natural resources and environment with sustainability, promoted the self-support, public mind. The plan also aimed to increase the capability in science, technology and competition that might possibly increase the national income, eliminate poorness. Currently, the tenth NESD plan promoted the "happiness society" which is the self-survival and integrated approach to eliminate the poorness, "value creation" in the production, "safety net" for management of risks in financing, energy, marketing of raw inputs, labor and investment. The plan also attempt to promote the uses of knowledge, innovation rich biological resources and identity with security and sustainability, competitiveness and survive in globalization.

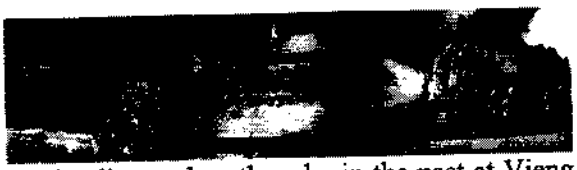
5. Public Participation and Regulations

The King Ramkhamhaeng the Great's famous stone inscription has been the evidence shows the policy and construction of infrastructures to provide better quality of life for people in the kingdom as well as the regulation, these represented the public mind and responsibility to social in large. However, construction of the infrastructures in the past had been performed in order to survive, with believes or respects to the nature, religion or power of the kingdom but seemed not involve public participation. The more complexity of the social, stakeholder and public participation would become the important issue in decision making prior to implement the infrastructure project. Roles of stakeholder and public participation have been clearly brought into considerations in developing the infrastructure projects since beginning of the second stage expressway. Numbers of existing regulations had been readjusted and new regulations had been launched, including the attempts to have the inter-connectivity among the concerned engineering regulations e.g. the second Building Act B.E. 2535, the Energy Conservation and Promotion Act B.E. 2535, the Environment Conservation and Promotion Act B.E. 2535, the Factory Act B.E. 2535 and numbers of Ministerial Rules [5]. Instead of regulating and controlling the permission, construction and utilizing of the buildings or factories, the Acts concern much more satisfied conditions of both individual and social. Other important regulations which have been launched by the same time are Acquisition Act B.E. 2530, Toll Road Act B.E. 2542, Decentralization of Local Government Organization Act B.E. 2542 and Bureaucratic Reform Act B.E.2545. Having public participation would perhaps, create difficulty or drawback but it is only the way to get good cooperation. Following the regulations, numbers of government authority had been privatized. Various organizing and management structures of the infrastructure project have been introduced e.g. Build-operate-transfer (BOT) and Build-Transfer-

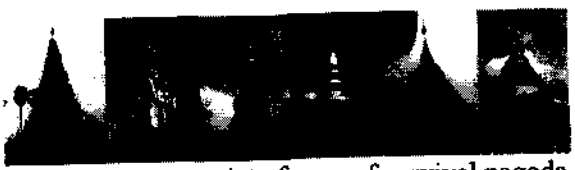
Operate (BTO), which have made numbers of projects or mega-projects possible without allocation of the fiscal year budget but some created problems in contractual matters, financing, organizing, management, transfer of technology or lack of interdisciplinary concerns, thus effected to success and benefit.

6. Disasters

Numbers of the infrastructures in Thailand has been affected or damaged by natural disasters [6] e.g. flooding earth quake, land subsidies, wind or storm, debris flow and land slide and tsunami. According to the historical records, "Wat Chedi Luang", Chiangmai was damaged by the earthquake in 1545, "Vieng Khum Kham" was flooded, settled down and sunken under the ground level (Fig. 14a). Numbers of reservoir were caused by land subsidies e.g. "Khwan Phayao" in Payao and "Bung Borapet" in Nakhon Sawan. Earthquake caused by the "Tha Khak" fault relocated part of the "Mae Khong" river which has become the reservoir at "Bung Khong Long", Nong Khai. On the other hands, some buildings learnt to build the sound and stability forms and appropriate proportion of sanctuaries or pagodas could survive from the mentioned disasters (Fig. 14b). The mentioned records and the more frequent disasters had enforced re-thinking in engineering works the words "appropriate technology" and "sustainability" have been revisited [7], planning and design of the infrastructures might concern uncertainties or risks from both natural and human-made disasters e.g. collapse of the structure, accident and fire (Fig. 14c).



a) Flooding and earthquake in the past at Vieng Khum Kham and Wat Chedi Luang



b) Various appropriate forms of survival pagoda

c) Current disasters caused by flood, wind and fire

Fig. 14: Learning Lessons from Natural Disasters and Resolutions.

7. Paradigm Shift

Shift of paradigm in thinking, planning, design, construction towards the operation and maintenance of the future infrastructure aims to maintain and reserve the natural resources and environment which could be achieved by the recommended value-added design in three main aspects as follows.

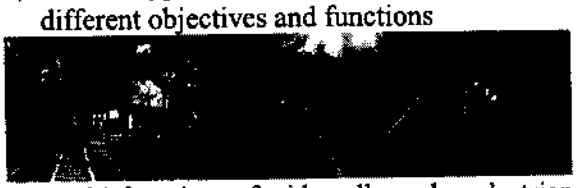
First, planning and design of most infrastructures should attempt the "multi objectives or purposes" as much as possible, while the soundness, safety and durability must not be affected. However, when it is not possible to do so, the most appropriate alternative should be selected (Fig. 15).

Second, engineering economics should be applied for all scales of infrastructure projects, feasibility study should consider the return periods of natural disasters that conform the period of study or economic life, while design should attempt to lengthen service life or possible operation during emergency conditions or lacking of maintenance budget, feedback evaluation for further betterment would be necessary (Fig. 16).

Third, design and construction should aim to harmonize with the nature, avoid or minimize the disturbance to the nature, use of non-structure or passive approach as possible, use of natural materials which can be naturally decomposed or renewed without hazardous waste or pollution. The infrastructures should be either the self-maintenance or maintenance-free (Fig. 17).

a) Bridge design with specific propose or multi-purposes

b) Various types of bus shelter are suitable for different objectives and functions



c) Multi-function of sidewalk and pedestrian bridge

d) Bridge underpass instead of U-turn and wharf

e) Top slab of RC box culvert to function as bridge deck

e) Irish Bridge allows both over flooding and local transportation at the same time

Fig. 15: Illustrative Design Alternatives and Optimization.

a) Spread footing would eliminate piling and excavation cost

b) Use of pile bent pier instead of piled footing to avoid working in the water

c) Provide sub-drain to reduce water pressure and construction cost

d) Multi-rows of pipe would be more advantage when emergency

Fig. 16: Illustrative Applications of Engineering Economics, Uncertainty and Risk.

a) Slope cut and sodding can efficiently stabilize the hill side or embankment

b) Sodding at the depressed median can prevent soil erosion and dust dispersion effectively

c) Wide side ditch eases maintenance, controlling and clearing debris and sediment

d) Simple building with appropriate ventilation and shed can provide comfort temperature

Fig. 17: Illustrative Appropriate Technologies and Sustainable Designs.

In addition, uses of new challenge light weight and renewable materials e.g. structures with tension member which ease the erection or construction, maintenance and rehabilitation have become more interesting and popular (Fig. 18).

Fig.18: Illustrations of Interesting Light Structures with Tension Members.

8. Concluding Remarks

Value and identity of Thai's engineering in development of infrastructure have been constituted from survive and living with respected to the nature and environment, working with ethics and public mind, technology transferring with adaptation or modification to conform context of living, ability to synthesize the knowledge and skill. The infrastructures have reasonably supported the economic growth and social development e.g. provided the well-being and civilization even few of them seemed not be functioned or could not be the mechanism of development. Because of the uncertainties and risks from the more frequently disasters and crisis, both the maintained existing infrastructures and the new design and construction should be based on the re-thinking and more concerns in natural resources and environment. Three main aspects of value-added design to achieve the uses of appropriate technology and sustainability concerns are recommended: 1) attempts for multi-objectives or purposes design; 2) use engineering economics as analysis; and 3) uses appropriate technology and concerns sustainability.

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