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Building Regulation Systems for Creation of Resilient Urban Area in Emerging Economy -Lessons from Japanese Experience for 100 years-

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Abstract

Rapid urbanization such as increase of population in urban areas and spread of built-up area, is going on at global scale and is especially prominent in emerging economy countries which invites various serious problems. Among these, increase of risk of disasters such as earthquake, fires, or floods is the most serious. This situation prompts policy makers to recognize importance of quality control of buildings to prevent increase of risk by disasters caused by poor quality construction. For this purpose, many developing countries have prepared building codes and introduced building regulatory systems in their own countries referencing those in developed countries such as the United States, or European countries. However, in some cases the purpose has not been fully achieved which is manifested by facts that buildings in such countries still suffered heavily, disproportionate to by low-impact natural hazards in terms of seismic intensity or wind force in comparison with those assumed in the codes. This paper shows the facts and overview of situation faced by various countries that emerges from projects and programs supported by international or donor organizations.

Effective implementation of building regulation requires various conditions including availability of human resources and social capital, such as government officials, and practitioner such as engineers, architects or foremen. In addition, general social culture of compliance to codes is very basis of effective implementation. Japan is one of examples that experienced extremely rapid modernization, economic growth and urbanization. It introduced the first building regulation in 1919 for specific buildings in limited cities and has been making every effort to expand the target buildings and applied cities, as well as to improve compliance to the codes based on lessons from disasters and study on changing societal needs.

This paper gives an overview of the current situation and challenges in various developing countries emerging through technical cooperation activities, then introduces analysis of the efforts in Japan through a historical perspective and finally introduces policies and strategies applied in Japan including capacity development of government officials, mobilization of expertise in private sectors for building regulation, improvement of legal schemes, collaboration with relevant regulation of qualification of architects/engineers and license for construction business and utilization of cooperation from other sectors such as financing institutes, fire services, supply service of water, gas, or electricity. Through the analysis on the Japanese history of struggles for 100 years to find out implication applicable to corresponding problems of current developing countries, significant lessons could be extracted. Based on these, several practical and doable recommendation will be presented which would be applicable to developing countries who may be facing challenges in limited resource and capacity. (434 words)

Keywords: building regulation, implementation of regulation, developing country, lessons from Japanese experience, practical and doable recommendation

1. Introduction

Rapid urbanization such as increase of population in urban areas and spread of built-up area, is going on at global scale and is especially prominent in emerging economy countries which invites various serious problems. Among these, increase of risk of disasters such as earthquake, fires, or floods is the most serious. This situation prompts policy makers to recognize importance of quality control of buildings to prevent increase of risk by disasters caused by poor quality construction. For this purpose, many developing countries have prepared building codes and introduced building regulatory systems in their own countries referencing those in developed countries such as the United States, or European countries.
However, in some cases the purpose has not been fully achieved which is manifested by facts that buildings in such countries still suffered heavily, disproportionate to by low-impact natural hazards in terms of seismic intensity or wind force in comparison with those assumed in the codes. In fact, most of casualties by earthquakes were caused by collapse of buildings of non-compliance to codes/standards. This paper shows the facts and overview of situation faced by various countries.
First, this paper gives an overview of the current situation and challenges in various developing countries emerging through technical cooperation activities, then introduces analysis of the efforts in Japan through a historical perspective, and introduces policies and strategies applied in Japan including capacity development of government officials, mobilization of expertise in private sectors for building regulation, improvement of legal schemes, collaboration with relevant regulation of qualification of architects/engineers and license for construction business and utilization of cooperation from other sectors such as financing institutes, fire services, supply service of water or electricity. Through the analysis on the Japanese history of struggles for implementation of building regulation for 100 years to find out implication applicable to corresponding problems of current developing countries, significant lessons could be extracted. Based on these, several practical and doable recommendation will be presented which would be applicable to developing countries who may be facing challenges in limited resource and capacity.

2. Overview of introduction building regulation in developing contries

2.1 Overview in the South East Asia

South East Asia is a region where the growth of economy has been rapid for recent decades. A large portion of it locates on Ring of Fire where seismic and volcanic events are active. Most of countries in the area have introduced seismic design codes and building regulation shown in Table 1 (Order of countries: GDP per capita) to ensure the safety of structures against earthquake in accordance to seismic hazards in each of the countries.

Indonesia and the Philippines, which have experienced huge disasters in cities with large population, have published seismic codes since 1970s. Thailand, Vietnam and Myanmar are the countries where strong seismic sources are found in their territory, published their seismic code rather rate in 2000s. Singapore does not have strong seismic source in the territory but it prepares own seismic code for application to important structures on soft soils.

As shown in Table 1, those countries which have sites in seismic prone areas published own seismic codes. However, their codes are almost the same as referred original codes which is shown in the 4th column of Table 1 except assumed maximum acceleration (seismic loads) or soil condition. It can be seen from Table 1 that Eurocode 8 and ASCE 7 are the only two codes referenced in these countries.

2.2 Overview on technical assistance by international organization and donors 書き換え予定

International organizations and donors have been supporting many developing counties to introduce building codes and implement them such as building regulation including building permits. The World Bank reviewed them and published a report, “Building Regulation for Resilience -Managing Risks for Safer Cities” , and further analyzed experience of Japan and published the next report, “Converting Disaster Experience into a Safer Build Environment: the Case of Japan,”. [1], [2]

Table 1 - Seismic codes in South East Asia

Country	Existence of seismic code	current code	referenced codes	Difference from original
Singapore	Exist	2013 (1st edition)	Eurocode 8	Applied in a country where maximum acceleration is small
Malaysia	Under development	-	-	Eurocode 8 will be adopted
Thailand	Exist	2009 (1st edition)	ASCE 7-05 (2003 NEHRP)	Spectrum on logarithm expression for marsh soil site
Indonesia	Exist	2012 (3rd edition, 1st edition in 1991)	ASCE 7-10 (2009 NEHRP)	Undefined displacement constant area
Philippines	Exist	2010 (6th edition, 1st edition in 1972)	UBC 1997	Revised importance factor partly
Vietnam	Exist	2006 (1st edition)	Eurocode 8	Subdivided building importance factor
Myanmar	Under development	-	ASCE 7-05	Unclear in detail
Brunei, Laos, Cambodia		survey not completed		

3. Current situation of damage by earthquakes in developing countries

The authors have been studying reports of damage by earthquakes and found that in many cases in developing countries, serious damage occurred even by small shaking acceleration. Bohol Earthquake 2013 in the Philippines caused huge damage such as casualty: 222, injured: 796 and totally damaged buildings: 13,249 and partially damaged 53,683 (NDRRMC update SitRep No. 33 issued on October 31, 2013). Philippine Institute of Volcanology and Seismology (PHIVOLCS) reported that maximum intensity is VII on the Philippine intensity scale, which is similar to MMI (Modified Mercalli Intensity Scale) and recorded maximum acceleration at Tagbilaran Observation Station, 40 kilo meters from the Epicenter, is 214 gal, which is far smaller than assumed ground acceleration applied to the damaged area by the National Structural Code (NSCP), 0.4g (400 gal). Most of causes of seriously damaged buildings are analyzed to be improper design or construction work (Figure 1, 2, and 3). Building regulatory scheme with building codes is

Figure 1 An example of improper structural design: (Left) Exterior view of District Health Care Center of Sagbayan, (Right) connection of a column and beams at different level, which might cause the failure because of local strong stress

Figure 2 Examples of serious damage in columns in Market Building in Loon: (Left) Heavy damage at the bottom of most of columns, (Right) Detail of the damage. The causes may be improper casting and insufficient compaction of concrete, congestion of rebar caused by concentrate of overlapping splices, and imprecise positioning of longitudinal rebar.

Figure 3 An example of improper rebar works in Market Building in Loon: (Left) Failures at panel zones (joints of columns and beam), (Right) Detail of damaged part. Hoops are not installed at the panel zones.

expected to play a role to have buildings to comply with building codes. However, it is not fully realized in many developing countries such as the Philippines. Some of the authors conducted interview surveys in several municipalities in the Philippines (Figure 4). Some of building officials replied to the interviewers that they do not fully review structural designs because manpower of local authority for building regulation is limited and they usually do not have engineering knowledge to review structural designs (they focus on issues such as ownership of building lots, border of building lots between adjacent lots, height, building coverage ratio or floor area ration of buildings). This shows that a certain number of buildings are not verified to be compliant to building codes in structural design and construction procedures, and that building regulator system could not ensure compliance because of limited capacity.

Figure 4 Interview survey on reviewing procedures of application for building permit in the Philippines:

(Left) Design documents for building permit to a municipality in Metro Manilla. The documents are not enough for complete check to the codes such as on structural design. (Right) Interview to building officials of a municipality in suburban of Metro Manila on application documents. The documents are far less compared to the case of Metro Manila.

4. Overview of building regulation in Japan

4.1 Start of modernization in Japan

Japan secluded herself from other countries for about 250 years. After Meiji Restoration (change of political system from feudalism by Shogun to modern centralized system under Emperors) in 1868, Japan started modernization by introducing western culture and technologies. Modern building technologies such as brick, reinforced concrete and steel structures were introduced into Japan. Various efforts were done to capacitate herself to construct those structures such as learning theory and technologies from invited foreign professors, human resource development of practicing engineers, foremen and skilled workers, production of new building materials such as steel and cement, and so on.

4.2 Introduction of building regulation by building codes in 1919

Along with economic development and urbanization, there emerged needs to regulate construction activities to prevent urban problems and disasters in urban areas. In 1919 Japan enacted a new law, Urban Building Law, and relevant legal documents including technical standards were prepared. This implies it takes about 50 years for Japan to learn modern building technologies by practitioners such as architects, engineers, contractors, and foremen to be widely used in the society, and to recognize necessity of building regulation.

This law was applied to only six major cities because necessity of regulation was not so urgent in other areas and capacity to implement the regulation was limited. Small buildings such as detached houses were exempted from building permit because of the same reason of the limited capacity (report to authorities is required). In accordance to increase of necessity of regulation and development of capacity of implementation, application of the law was expanded in number of cities step by step.

At the time of introduction, implementation authorities were prefectural governments, which are 1st level local governments and had more administrative capacity compared to the 2nd level of municipalities. The Urban Building Law was succeeded by current Building Standard Law (BSL) in 1950. Under the new law, municipalities are allowed to implement building regulation but limited to ones which have enough capacity. These history and procedures show that Japan introduced and developed the building regulation in accordance to implementation capacity.

4.3 Relevant legal schemes to regulate buildings

To regulate huge number of construction activities is quite difficult task because clients/owners have wide variety in sense of compliance. Some of them have high motivation of economic interest compared to compliance. In case of Japan, BSL is the basis of building regulation which stipulate that all the buildings shall comply with technical requirements of the law and relevant standards and certain buildings need to pass review by building officials and obtain building permits. However, compliance to the codes has not realized for a long time in spite of huge efforts of the authorities such as increase of human resources for activities such as patrolling, strengthening of penalty. Problems caused by non-compliant buildings often became big social issues, and opinion leaders and mass media criticized the authorities. BSL was called one of the most socially influential laws with the lowest compliance for a long time.

Under such situation, other related legal schemes to support building regulation were prepared (Each of the schemes had its own objective but some kinds of mechanism/effect to contribute to building regulation was included). Architectural Engineer Law, or Kenchiku-shi Law, is a sister law of BSL which was enacted in the same year of 1950. This law defines qualification of architectural engineers who are allowed to conduct design of buildings and supervision of construction work. It also stipulates the engineers should follow BSL and be penalized in case of violation. This law supports the building regulation system by regulating professionals working in design and supervision of construction business.

Construction Business Law is another law which contribute to regulation of buildings. One of objectives of the law is to ensure quality of construction work. For the objective it requires contractors to obtain license for construction business and defines qualification for engineers for quality control.

Administration on labor and workers has been working for every sector of business. In construction sector, vocational training has been continuously conducted. Also, certification for qualified skilled workers were prepared which also contribute to ensure quality of construction work.

4.4 Supports from other sectors

Supports from outside of building regulation were also tried to introduce. Government Housing Loan Corporation (herein after referred as GHLC. Governmental financial institute to provide loans for individual families to obtain houses and developers to supply them) played a very big role especially in conventional wooden houses constructed by carpenters by user-friendly specifications and manuals. Strict site inspection at each of key stages of construction is conducted for disbursement of loans. These procedures contribute much to good quality of buildings. This is clearly proved by the Hanshin-Awaji Earthquake 1995. Damage ratio of detached houses with GHLC loan is far small compared to ones without it. Collaboration with financial institutes generally works well because both have common interest (not only GHLC but also any of financial institutes). Financial institutes usually request collateral for the loan, usually houses or buildings. The financial institutes expect those should have good quality and durability, and good evaluation in the market for cases they have to seize them and sell in the market. This relation between financial institutes and houses/buildings is common in all the houses/buildings in all the countries with market economy. The authors find this relation working in several countries as a natural market mechanism in their surveys.

Collaboration with fire department and police department is another effective way. Fire safety of buildings with enough fire-safety equipment such as fire alarm, fire hose, fire escape, and fire doors and regulation on use of flammable materials in important part of buildings, is one of the most critical issues for their own mandatory. It is also critical for safety of fire fighters because they are exposed to more serious danger in buildings with poor fire-safety equipment. Police department in Japan has their own regulation relating buildings such as planning, equipment, or business hours for specific use such as gambling, amusement in separated sections and so on. Both of the departments have far strong power to owners or managers of buildings compared to building regulation authorities in Japan. Collaboration with them such as joint inspection is conducted.

The other collaboration with supply services of drinking water, electricity or gas is pursued. Building regulation authorities request those organization to confirm compliance to regulation such as obtaining completion certificate of construction work when they start their services for new buildings. Even though contribution by those is limited because they have their own mandatory and obligation to supply them for public hygiene and comfortable life, this approach is worthy to try. Some countries have already tried and realize some contribution depending on situations of each countries.

Neighboring community could contribute to effective implementation on issues, non-compliance to which affects neighboring community such as set back from roads, height regulation, or occupation. Preparation of channels to report to regulatory authorities encourage the contribution.

4.5 Out-sourcing schemes

Shortage of human resource in governmental authorities has been always a very critical issue for building regulation. Especially review of structural design is the one of most serious ones because it requires advanced engineering knowledge which is often difficult for ordinary governmental officials to obtain. Another serious one is site inspection as it is quite time-consuming for building officials to go to construction sites (Japan does not have officials specific to site inspection). Therefore, various schemes of out-sourcing have been introduced in Japan as below.

1) Structural design or review by qualified engineers for structural design

Architectural Engineer Law allows 1st Class Architectural Engineer (1st class Kenchiku-shi) to design any kinds of structural design, which often requires advanced expertise. For the situation, new higher qualified license, 1st Class Architectural Engineer specialized for Structural Design, was created by amendment Architectural Engineer Law in 2006. After that, structural design of large buildings such as 20 meters in height or higher in reinforced concrete structure must be done by engineers with this new qualification or reviewed by them. The review is usually conducted by designers' colleagues of the same consulting companies. This contributes quality of structural designs.

2) Peer review by the third party (Kozo tekihan)

A big scandal that a structural engineer applied building permits with fake structural calculation for a long time. During the period building officials could not recognize the fake. Based on this experience, complete peer review on structural design of large buildings (such as 20 meters in height or higher of RC structure) by the third party was introduced including conducting each step of structural calculation by the reviewers.

3) Building permit and site inspection by private organizations

One of critical causes of serious damage by Hanshin-Awaji Earthquake (Kobe Earthquake) 1995 is identified to be intentional negligence of the building codes. Many of them could have been avoided if site inspection by building officials were conducted. At that period, site inspection by building official was not enough because of insufficient human resources of building regulatory authorities. Based on this lesson, the Building Standard Law was amended to introduce resources of private sector. Based on this amendment more than 100 organizations are established and designated after strict examination to satisfy conditions stipulated by the law and related legal documents. Now almost 90% of building permits and site inspection is done by these private organization. This situation allows the building regulatory authorities to concentrate their job which only governmental authorities could conduct such as prevention and correction of illegal or non-compliant buildings.

4) Special permission on buildings by highly advance technologies (permission based on Article #38 of BSL)

BSL has a scheme from the beginning in 1950 to give special permission on technologies which is not stipulated in BSL such as new innovative technologies, materials, and so on. The objective of this scheme is not to hider application of innovative technology. This scheme is also applied in structural designs such as tall buildings of 60 meters in height or higher which must be designed with time history response analysis, seismic isolation (now standard is prepared and no need for special permission), and so on. Application is made to Minister of Construction (as of time of enactment) and the Minister is to organize a reviewing panel consisting of engineers and researchers of high knowledge. Based on report of assessment of applied technologies or designs, the Minster issues certificate which is attached to apply for building permit to regulatory authorities. This scheme works as support for building regulatory authorities to review structural design of highly advanced technologies.

5. Recommendation from experience of Japan

Japan introduced building regulation in 1919 and had enormous difficulties in implementation. BSL is called one of the most significant laws with the lowest compliance for a long time. In order to improve the situation, the responsible ministry and regulatory authorities have tried every possible measure to improve the situation and still they continue to work on the issue. Some of the measures worked well and some did not, which highly depends on social and economic situation. It implies measures which worked well in Japan do not necessarily work well in other countries and vice versa. Many lessons could be found in the 100-year history of struggle in building regulation in Japan. Recommendation from overview of the experience of Japan could be summarized as blow.

1) Feasible and doable solution based on social and economic situation of each of the counties

Complete review and site inspection require huge amount of human capacity both in numbers and knowledge. At first stage Japan introduced building regulation only six big cities where control of construction of buildings was urgent. Also, buildings which needs building permit were limited to large scale ones excluding small ones such as houses for single family. This legal framework was designed to meet the capacity of regulatory authorities at that time. Then cities and areas where building permit is required have been expanded in accordance to increase of capacity of authorities.

Technical capacity of regulatory authorities is another important issue. At first, regulatory authorities were limited to prefectural government (1st level local government), which had fairly high capacity to govern the area/jurisdiction. The regulatory authorities were expanded in the new law (the Building Standard Law in 1950) to municipal governments (2nd level local government), limited to ones with enough capacity. At the same time, qualification scheme for building officials (examination) was introduced. Also, a new scheme was introduced for municipal governments which have limited capacity which receive only building permits of small buildings. In those jurisdiction, application of permits of large building have to be submitted to prefectural governments,

Another big issue is mobilization of resources of private sectors. Various schemes are introduced in Japan explained in the previous chapter. In designing these schemes, careful consideration is necessary on conflict of interest among stakeholders such as owner/investors, designers of buildings, contractors, and so on. Governance of each of these private organization and authorities which give licence/qualification should be pursued.

2) Comprehensive approach to create foundation of regulation in society

As far as results of our survey in construction sites in developing countries, most of non-compliance to codes and standards is not intentional. In other words, most of non-compliance is caused by lack of technical knowledge of designers (engineers and architects), supervisors, engineers for construction quality control in contractors, foremen and workers. For the situation, development of technical capacity of each of the groups should be focused such as seminars or vocational training. Qualification schemes may work to encourage them to learn technical knowledge. Japanese government prepares qualifications not only for architects and engineers, but also engineers for construction quality control and skilled workers.

One of the most important stakeholders is owners/investors who are the final decision makers of all the construction procedures. Those who order non-compliant buildings should be strictly punished. Besides, sense of compliance and recognition of safety of owners/investors is quite influential to all the relevant people to realize compliance for safe buildings.

Therefore, comprehensive approach and activities targeting all the stakeholders is recommended.

3) Regulation by building regulation authority with supports by other sectors

Building permit and site inspection by regulatory authorities or assigned organizations is a legal scheme which most of countries introduced in common. Many countries find difficulties to achieve full implementation of the scheme and face serious problems such as construction without building permit and non-compliance to codes/standards especially in developing countries. Increase of capacity of the authorities and mobilization of private sector is a possible and ordinary solution. Besides those, many countries try to introduce support from outside of building regulation, such as fire department and police department. Collaboration with supply service of drinking water or electricity is also applied when they start the supply for new buildings.

Financial institutions often contribute to create safe and good quality buildings through their natural behaviour in market economy to keep collaterals for the loan. This mechanism could be strengthened by policies by governments. Government Housing Loan Corporation (GHLC) in Japan is a very successful example.

6. References

[1] The Global Facility for Disaster Reduction and Recovery (GFDRR), The World Bank, Building Regulation for Resilience -Managing Risks for Safer Cities, 2016

[2] The Global Facility for Disaster Reduction and Recovery (GFDRR), The World Bank, Building Regulation for Resilience -Converting Disaster Experience into a Safer Build Environment-: the Case of Japan, 2018

[3] H. Kato, T. Narafu, Y. Ishiyama, R. Ison, J. Sakuma, and S. Kita, Comparison Studies on Structural Codes – Seismic Codes in South East Asia, 16th World Conference on Earthquake Engineering, Chile, 2017

[4] Tatsuo Narafu, Toyokazu Shimizu, Yasushi Sanada, Yukio Tamura, Noriyuki Mita, Susumu Takahashi, Hayato Nakamura, Atsuko Itsuki, Lessons Learnt from Damage to Buildings by Bohol Earthquake and Typhoon Yolanda 2013 in the Philippines, Bulletin of IISEE No. 49, Building Research Institute (BRI), 2015

[5] Tatsuo NARAFU, Yuji ISHIYAMA, Kazushi SHIRAKARA, Makoto KINOSHITA, Tomohiro HASEGAWA, Hayato NAKAMURA, and Kozo NAGAMI, Basic Study on Strategies for Earthquake Disaster Mitigation on Buildings in Developing Countries -Possibility of Building Codes and Building Permits-, Proceedings of the Institute of Social Safety Science (ISSS) No. 33, November 2013

[6] Tatsuo NARAFU, Basic Study on Strategies for Earthquake Disaster Mitigation on Buildings in Developing Countries -Lessons from Experience of Building Permit Scheme in Japan-, Proceedings of the Institute of Social Safety Science (ISSS) No. 34, May 2014

[7] T. Narafu, Y. Kamemura, K. Shirakawa, K. Nagami, H. Imai, H. Hosaka, R. Okamoto, J. Sakuma, Basic Study on Legal System and Practice of Building Permit in Developing Countries, Part 1: Indonesia, Annual conference of the Architectural Institute of Japan (AtIJ) in 2011

[8] T. Narafu, N. MIiyata, J. Sakuma, H. Imai, H. Nakamura, H. Hosaka, R. Okamoto, Basic Study on Legal System and Practice of Building Permit in Developing Countries, Part 2: Philippines 1/2 and 2/2, Annual conference of the Architectural Institute of Japan (AtIJ) in 2012

