CHAPTER I
INTRODUCTION

1.1 Background

Modern Construction Industry in Indonesia starts long before the independence of the republic with several companies from Netherland. Government of the new republic then nationalized those companies to be state-owned companies and to carried out the construction projects, which mostly belong to government especially the projects of before the 80's. Along the line of economic development, private sector begun to build kinds of building include office building, hotel and central business district. For government projects, the job is tendered by related department, but a construction management and general consultant would be first appointed. The tenders are normally call upon a general contractor, which involved all discipline or specially subcontractors of local companies.

The private sector brings a different system. Most often they have their own project management team and then apply the consultants, such as architects, structural engineer and mechanical, electrical, and piping engineer directly. For big projects, the architect is mostly foreign firm working together with local company, while the local engineering firms have seen better prospect as they have get a very good share of the project.

In recent time, most if not all buildings in Indonesia are built by local contractors. The era after 1970 was the beginning of the construction of high rise building. Some of the early building was designed and built by Japanese. After 1970, some joint ventures companies worked to complete building in Jakarta. The local contractor –from state owned to private sector company- learned very fast and by 1980s these contractors had the capability to build high rise building on their own. Some of them are advanced with construction technology [1].

In line with the globalization, most leading construction companies are having the ISO certificate. It shows that the construction industry in Indonesia has accredited to be able to compete with construction industry world wide. Recently, some companies are having project in the Middle East and South Asia.

On the aspect of the material for construction, most of the companies have been improve their self very well. Portland cement producer are public company and some of them are multi national companies. Right now, there are nine companies as member of Indonesia Cement Association producing cement in Indonesia with total production in 2005 of cement was 33.9 million tons and clinker was 34.004 million tons. As for cement, in 2005 total export of cement from Indonesia reaches the amount of 6.697 million tons [2].

In 1980s, ready mix concrete company starts to operate in Indonesia following the booming in the development of infrastructure and building. At the beginning, concrete production mostly for grade 20 to 30 MPa which is most common design strength for building at that time. Raw material for concrete is readily available in abundance. Recently concrete normally delivered to construction site by ready mix concrete suppliers. Concrete grade up to 60 MPa has been used successfully in building projects. The use of concrete pump is a common practice, pumping up to 160 m high.

On the design practice, Indonesia has adapted the Construction Service Act (*Undang-undang Jasa Konstruksi, UUJK*) No. 18 year 1999 as the standard of conduct for running business in construction industry. Under this act, only certified engineer are allowed to do any activities in construction services. The Construction Service Development Board (*Lembaga Pengembangan Jasa Konstruksi, LPJK*) issues the certificate in coordination with professional association or contractor association. Indonesian Society of Civil and Structural Engineers (*Himpunan Ahli Konstruksi Indonesia, HAKI*) have been given the authority to conduct the certification process for its members. HAKI uses similar system as what has been used in Commonwealth Country for its certification process [1].

The most common and popular structural system used in Indonesia is open frame, all cast-in-site reinforced concrete construction. This type of construction is very popular due to simplicity in the design and the familiarity of the contractor with the system. As taller buildings are being built in big cities, notably in Jakarta, other structural system comes into play. For buildings around 12-storey to 32-storey high, a combination of open frame and shear wall is commonly used. The shear wall often forms the core wall in the shape of C, I or O. As the building gets taller, effort to reduce the floor to floor height is made through the introduction of other gravity system like band beam, flat slab or flat plate and prestressed post-tensioned beams and floors.

1.1.1 Indonesian Concrete Code and Its Nature

Indonesia has its own codes covering nearly all aspects of engineering. The codes are reviewed periodically and revised. In the field of concrete, there are three codes that govern the design; The Indonesian Loading Code SNI 03-1727-1989, the Indonesian Concrete Code, SNI 03-2847-2002, and the Indonesia Seismic Loading Code, SNI 03-1726-2002. All the three codes are biased heavily to the American practices. Due to limited budget, the codes cannot be revised in a fix periodical basis. For example, the Indonesia Concrete Code was first established in 1935, and then revised in 1955, 1971, 1991, and recently in 2002. Indonesian Concrete Code SNI 03-2847-2002 was based on deem-to-satisfy rules. This code specifies design and detailing requirements that are intended to achieve a minimum acceptable safety level. The code provisions are expressed in terms of formulas and procedures.

The code portion of this document covers the proper design and construction of buildings of structural concrete. Among the subjects covered are: specifications; inspection; durability requirements; concrete quality; mixing & placing; formwork; embedded pipes; construction joints; reinforcement details; analysis and design; strength and serviceability; flexural and axial loads; shear and torsion; development and splices of reinforcement; slab systems; walls; footings; precast concrete; composite flexural members; prestressed concrete; shells and folded plate members; strength evaluation of existing structures; special provisions for seismic design; structural plain concrete; an alternate design method.

On the aspect of cement and reinforcing steel for concrete, Indonesia apply national standard for production. Those standards became mandatory by the decision of Ministry of Industry or Ministry of Trade. Those standard mainly refer to similar standard of product from American (ASTM) for cement and Japanese for reinforcing steel (JIS).

1.1.2 The Transition to Performance-based Design Code

Traditional and current design practice for buildings and facilities in Indonesia are generally based on prescriptive minimum building code requirements. Such code requirements generally address life safety and do not consider financial loss and business continuity issues. Structural engineering consultants are frequently brought into the design process late in the game. The end result is often construction that may not meet owner or developer expectations and occasionally results in construction cost and functional and aesthetic sacrifices.

Current design codes, which based on prescriptive minimum building requirements specify design and detailing requirements that are intended to achieve a minimum acceptable safety level. The code provisions are expressed in terms of formulas and procedures. In the allowable stress design (ASD) approach, the strength (resistance) of the material is divided by a safety factor to obtain the allowable strength (stress, deflection, force). In load and resistance factor design (LRFD) or limit state design (LSD), load components are multiplied by load factors and resistance is multiplied by a resistance factor.

Now days, the code development tend to apply new approach which known as Performance-based Design. The approach that has been adopted in developing most reliability-based design codes is to specify the target reliability index, β_T for each aspect of performances. The target reliability index can be determined for a class of structures, components, and/or limit states. Its value depends on the time period. (In general, the reliability index for a structure or component decreases with time).

In the rational analysis, the target reliability is considered as a control parameter subject to optimization. The parameter assigns a particular investment to the material placed in the structure. The more material invested in the right places, the less is the expected loss. The optimum placement maximizes the expected rate return on the investment. Such optimization, possible when economic loss components dominate over life, injury, and culture components, leads to the principle of equal marginal returns in the case continuous parameter space and differentiable costs. The principle of minimum expected total costs governs the design of all parts of a structural system, whether a single bolt, a member, or a single structures in a fleet of structures, i.e., a multi-structural system [3].

1.2 Hypothesis

Performance-based design, as a recent developed approach, determines the best optimization between benefit and loss. The methodology based on sufficiently realistic environmental and material models so it is possible to make satisfactory prediction of the future behavior of a concrete structure. It includes all aspect of structural performances, i.e., safety, serviceability and durability. It is also suitable to work on specific conditions of environmental, such as in Indonesia, as long as the models for analysis could be developed.

Indonesian Concrete Code SNI 03-2847-2002 which biased from American practices is already considering some aspect of performance of concrete structures. Performance of safety has reached a better provision than other performances which is serviceability and durability. Performance of serviceability and durability have been taken into consideration but still not as strike as the performance of safety.

On developing performance-based design code, it is needs complete information and many research to synchronize the code and the local conditions of Indonesia. One hypothesis regarding to the question about the performance-based code for common buildings is that the conditions in Indonesia, on the aspect of material productions and fabrication were not behind the developed countries and having good opportunity to apply the principle of performance-based design.

With the specific condition in Indonesia, regarding to scopes of serviceability and durability, another hypothesis also might come forward. At this moment, Indonesian Concrete Code is set the performance on serviceability and durability of the concrete structures not to be suitable with the local or specific demand on Indonesia both socially and environmentally.

1.3 Research Objective, Scope, and Methodology

1.3.1 Research Objective

A structural design code is basically a set of requirements to be satisfied by a class of structures to be designed in a jurisdictional area. These requirements include value and/or procedures to determine design load and resistance. Therefore, the development of the code involves not only determination of a safety factors, but also verification of the nominal (design) values of load and resistance as well as analytical procedures (structural analysis).

A general objective of a design code is to ensure that the structures designed according to the code provision will have minimum safety level. More specific objectives may be appropriate for same classes of structures. The definition of safety can be expressed in terms of the expected risk (i.e., consequences of failure), the failure probability, or the reliability index. Code objectives may vary, depending on the comparison criterion and target safety value. Some examples of code objectives are as follows [4]:

- Design a structures to have a reliability index (β) close to some specified target value (β_T).
- Design a structure to have a probability of a failure lower than the predetermined maximum acceptable value for a pre-selected period of time (e.g., one year for a temporary structure).
- Maximize the total utility, which is the difference between revenues and costs. The costs usually include the initial cost, cost of maintenance, and expected cost of failure (actual cost of failure multiplied by the probability of failure).

Revenues may include profits and user convenience. This part is exclude from this report.

This research aimed to analyze the performance indices for safety, and serviceability of structural concrete concentrated on the conventional practice. On the basis of material supply, manufacturing, standard and workmanship for construction industry in Indonesia must be taken into account for determination of performance index for strength, serviceability and durability, which are will cover in this research. Construction industry in Indonesia is facing several obstacles on building infrastructure such as workmanship, tools, and material production. These kinds of obstacles of course induce the reliability for each structure produced by certain level of construction industry. Within the process, it needs to integrate many variables to determine the long term service –it means the performance- of the concrete structure.

1.3.2 Scope

The scope of the research include common buildings made of reinforced concrete limited by some conditions, i.e.;

- The material observed only ordinary concrete and normal reinforcement, exclude high performance or neither special concrete nor prestressing tendon.
- Reliability analyses only cover the elements of structures, not the structures as a system.
- Structures to be considered are common building such as offices, apartments, hospitals and public facilities.
- The load characteristics and load parameter taken from available literatures.
- Analysis of partial factor for performance verification mainly deal with the safety and serviceability following European approach, while aspect of durability discussed on the theoretical approach.

1.3.3 Research Methodology

Methodology for this research involves several steps, i.e., data collection, statistical examination, simulation, reliability analysis and calibration. In line with those steps, the literature review and theoretical approach also been performed. Explanation on each step described as follow.

Data Collection;

This research and analysis were based on the data available of concrete strength (f_c'), yield strength of reinforcement (f_y), precision of concrete cover and dimensioning, and also loading for common office building taken from literature. The data collected from several construction sites in Indonesia including apartments, office, hospital and sport facilities for public involving several testing laboratory in Yogyakarta and Jakarta. According to the floor area and budget, those construction project are classified into medium and big project, which the probable quality control system were in the range of good to well controlled.

Statistical Examinations;

The collected data then examined to match the most suitable distribution function. Furthermore, the calculation to determine mean, variance, covariance, standard deviation and other variables will be performed regarding to the distribution function.

Statistical Simulation;

Simulation used in this research is based on Monte Carlo Simulation. The basis of Monte Carlo simulation procedures is the generation of random numbers that are uniformly distributed between 0 and 1. Once it got some realizations u of a uniformly distributed random number U between 0 and 1, it could generate realization x of a uniformly distributed random number X between any two values a and b ($a \le x \le b$) using the following formula:

$$x = a + (b - a)u \qquad (1.1)$$

Since the normal probability distribution play such an important role in structural reliability analysis, the capability to simulate normally distributed random variables is important. To begin, consider a standard normal distribution. To generate a set of standard normal random numbers z_1, z_2 ... z_n, it is need to generate a corresponding set of uniformly distributed random variables $u_1, u_2, \ldots\ldots u_n$, between 0 and 1. Then, for each u_i, it can be generate a value z_i using

$$z_i = \Phi^{-1}(u_i) \tag{1.2}$$

where Φ^{-1} is the inverse of the standard normal cumulative distribution function. The generation of random numbers also can be performed to satisfy the other probability distribution such as normal random numbers, lognormal random numbers and others.

Statistical simulation is used to find the characteristic of strength for several aspects such as beam in flexure, beam in shear, column in compression, and slab in flexure.

Reliability Analysis;

A reliability method serves to decide whether or not a design is judged to be adequately reliable. Reliability methods can be divided broadly into research models, which aim to calculate a precise value of the reliability from probability data, and technical models, which aim to be efficient in practical design decision making. Probability data are assigned, not measured, and there is no "true" reliability. One distinguishes between the theoretical reliability, calculated from a reliability model, and the overall reliability that (in principle) is the observable failure frequency limit of a design. The difference – the adjunct probability of failure – is associated with gross error [3].

Reliability analysis performed using material characteristics, fabrication and statistical characteristics for strength of structural member, and involving loading taken form literature. The loading characteristics based on the study on United States which the Indonesian Loading Code biased from. This because the study on loading characteristics in Indonesia is not yet performed.

From those all steps, the recent conditions of construction industries in Indonesia could be presented, and the reliability analysis will play on the verification for several performances of reinforced concrete structures in Indonesia.

1.4 Expected Outcome

Ones may come with questions related to how far the gap of conditions in Indonesia to apply the performance-based code. By knowing the conditions and level of performances of safety and serviceability of reinforced concrete building, such above question might be answered and many related parties such as owner of buildings, insurance company, and government will have better understanding on managing the benefit and risk of their buildings.