A Study on the Performance Assurance in Buildings and Inspection

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Chapter 1

Introduction

In recent times, the multiplicity and high-degree in construction needs allied to the advance of building technology has allowed construction of new forms never seen before. Architectural spaces in large scale as intelligent buildings, marine architecture, atriums and similars are increasing in number. In these new spaces, new building materials and systems have been utilized and, their influence has been a very important factor to the advance of high-technology in building equipment systems. Along with the development of new technology in building equipments, the weight of its cost in the total construction cost has increased. Consequently, improvements in the quality of construction has also been required, not only to protect the owner's interests but also to increase the public benefits through the improvement of reliability from the point of view of the users.

On the other hand, the necessity of carrying out a very effective construction and maintenance process in order to guarantee the performance of the building and building equipment systems has increased.

Furthermore, in Japan, the stock of existent buildings has become very large as a result of an intensive building construction activity so that matters concerning the effective maintenance of the performance of the building stock have also been seriously considered.

The real conditions of existent buildings and the installed building equipments are, in general, unknown. Some studies have been done concerning the reliability of emergency systems in some special buildings [1], which proved that systematic maintenance and periodical inspection are essential to guarantee the good performance of the system.

However, facts have shown the real conditions of some buildings and the consequences they can bring to its users. These facts are represented mainly by fire in buildings where the detection, alarm and/or other fire systems fail to work in an emergency, causing casualties and property damage. Also, the physical failure of building elements like the external walls mortar of some buildings causing death of people walking on the streets, could be avoided if, first, the construction process had been better controlled, and second, if a periodical maintenance of the building had been done.

These are facts that come out to the public due to their serious consequences, however, problems caused by faults during construction and insufficient maintenance of the buildings are present at a larger scale, involving damage not only to public and private property but also to health and welfare of the users at many levels.

A study carried out by the *Group of Study on Countermeasures for Construction Mistakes* [2] showed that, from 166 construction sites inspected by them, 1,074 points were found where rework were required.

According to the data collected during these inspections, the most frequent mistakes were found in plaster/mortar works, followed by wood, glass and interior finishing works. Furthermore, most of the mistakes were pointed out as a result of non-obedience to basic technics in the work, caused by negligence and overlooking. The distribution of the number and percentage of mistakes found is shown in figure 1.1.

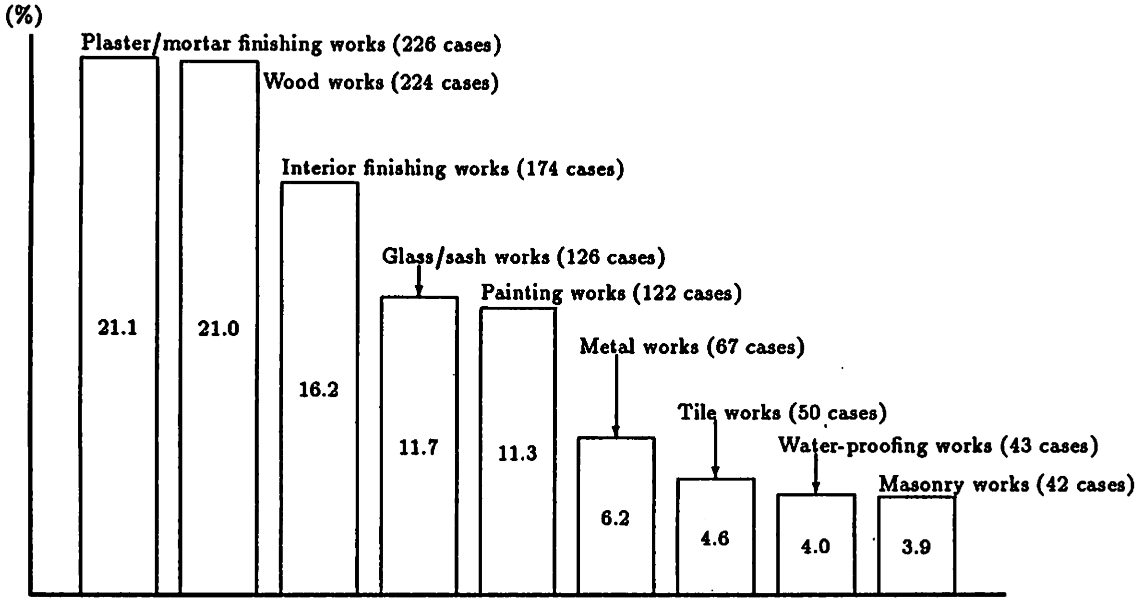


Figure 1.1: Distribution of Inspected Parts and Mistakes Found.

On the other hand, the same Group of Study has investigated the situation of repairing works during the use of the building during an investigation period of 5 years (1976 - 1981) [3] and the origin of their causes were classified as shown in table 1.1.

Table 1.1: Cases of Repairing and Its Cost.

	Origin	Cases (%)	Cost (%)
A	Design	20	28
B	Construction	52	52
C	Maintenance	5	2
D	others	23	18

Some other results of this investigation are presented in figures 1.2 and 1.3.

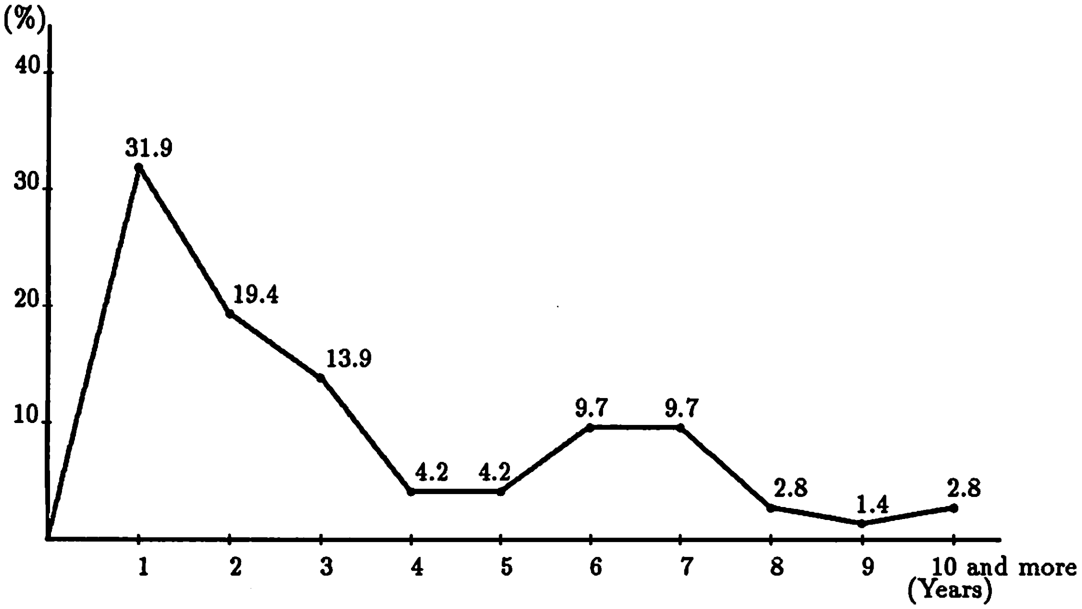
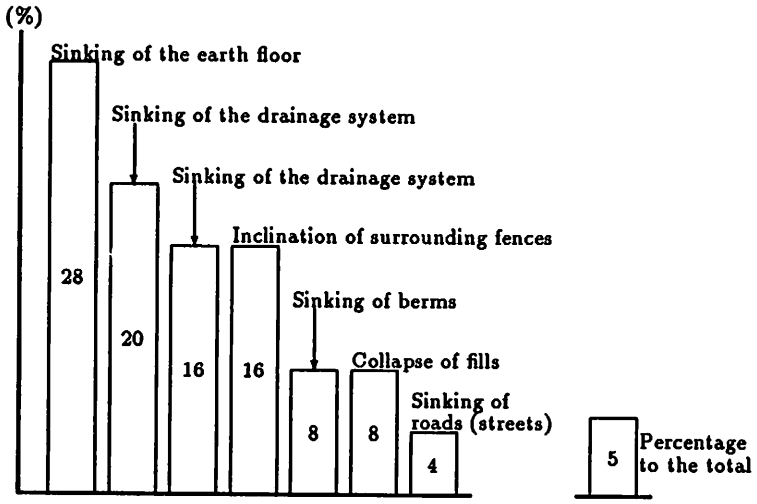


Figure 1.2: Percentage of repairing works versus time after building completion.

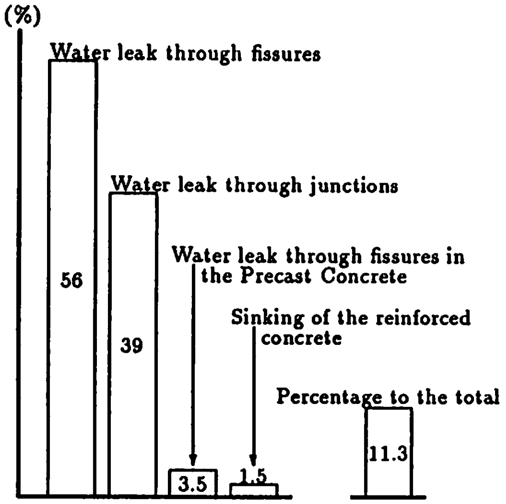
Japan is a country changing continuously, in a very high-pitch, and it has faced many problems related to consequences of its accelerated pace of development. The shortage of laborers has been a very serious matter in this country supported by a very strong industrial economy, where the construction industry plays an important role.

On the other hand, this island nation has faced a mainly social barrier — the difficulty in accepting and understanding different cultures in their island, where, from a general point of view, people with common race and culture has been living isolated during hundreds of years.

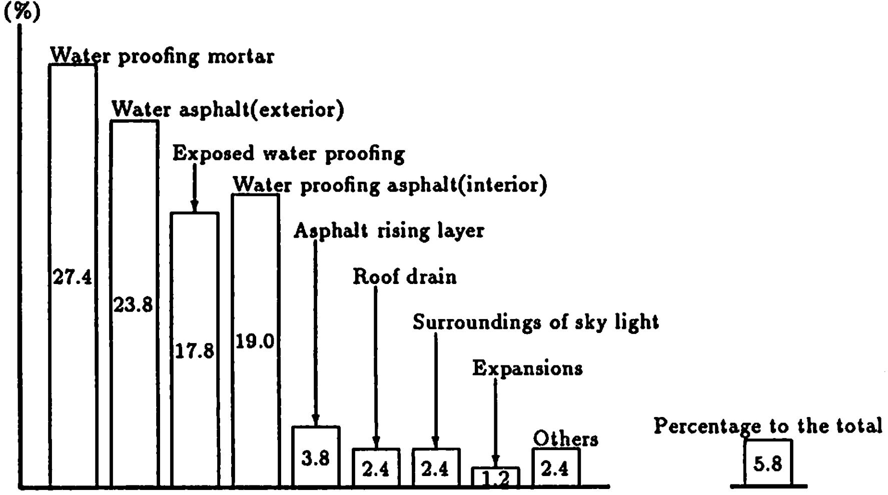
This barrier is also reflected in the international political and economical affairs of this country, where there is a reluctance from the government to take any strong position on the international scene.



(a) Earth works

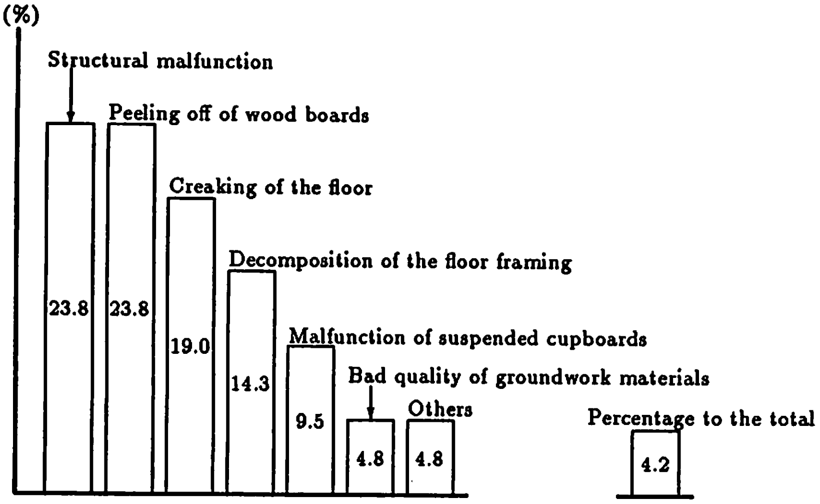


(b) Concrete works

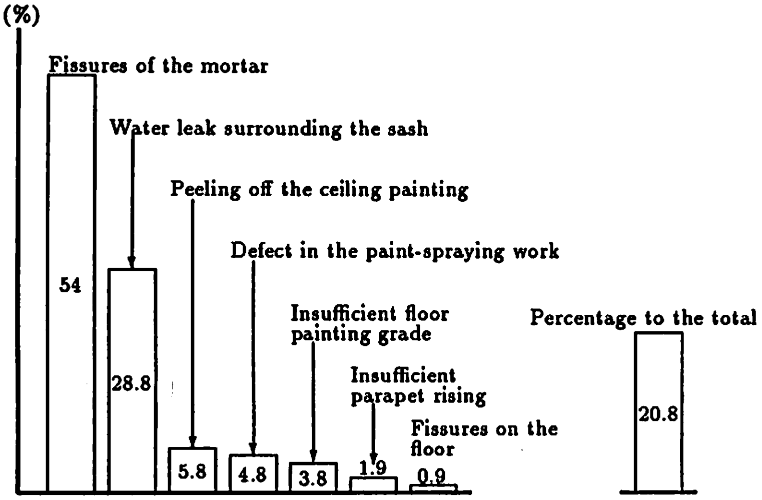


(c) Water-proofing works

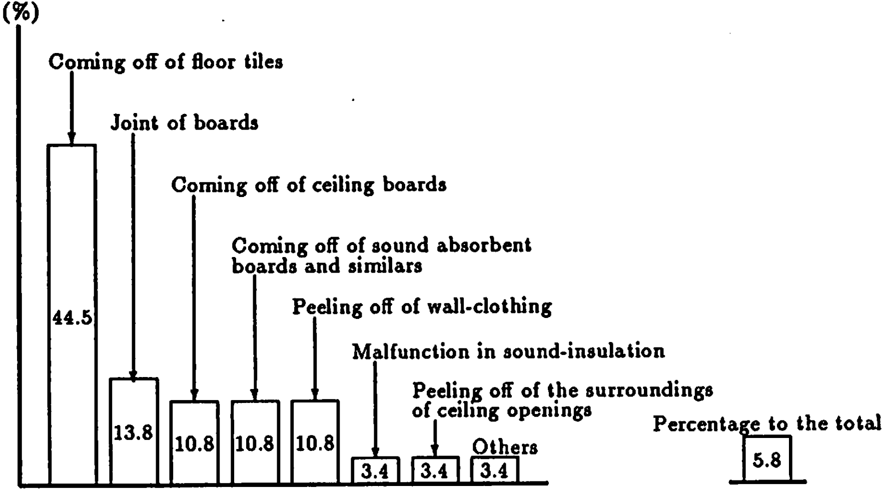
Figure 1.3: Repairing works.



(d) Wood works



(e) Plaster/Mortar works



(f) Interior finishing works

Figure 1.3: (Continued)

In the construction industry field, solutions to the shortage of laborers and the consequent high-cost of the construction has been considered. The introduction of low-cost labor from the neighbor countries and opening of the construction market to foreign design and construction firms seems to be inevitable. Thus, Japanese general contractors are searching also for alternative solutions like the total robotization or the development of new methods of quality assurance of the work at the construction site.

Although efforts have been made to solve the problem in a national basis, pressure by the international community leaded by the United States to relax the Japanese protectionism has also been strong. As a result, Japan is, very carefully and slowly, reconsidering many of the systems on which they work, since the introduction of new members with different cultural background to the Japanese market would generate serious consequences. Particularly in the construction industry, the employment of unqualified laborers at the present Japanese job site, where the works were systematized to be carried out by qualified workers, can result in a deterioration of the final product.

In the building industry field, in particular, the Japanese Building Standard Law has acquired the performance of buildings and building equipment systems through the final inspection of the building at its completion and periodic inspections and tests during the use of the building. However, parallel to the conditions showed above, the importance of the performance assurance has been emphasized more and more in order to satisfy the increasing multiplicity of the building stock, so that time for new considerations about today's building process policy has been driven by necessity.

One of the "considerations" originated a Group of Study in systems adopted by other countries in order to assure the performance of the building and building equipments. The existence of building inspection systems in the United States, some European countries and also some other Asian countries by a third party to guarantee the quality and performance of the work was known. In these countries inspection is required by code or regulations, during construction, at completion, or during the use of the building.

Particularly, interest to deepen the knowledge of the U.S. inspection system in buildings and, to compare and understand better the U.S. and the compatibility to the Japanese systems, including their background, originated an intensive study and discussion by the members of the Group of Study. The formation of a group of study on this matter was first proposed by Mr. Y.Yamanaka, Director of the Building Disaster Prevention Section, Housing Bureau, Ministry of Construction, held in the Japan Building Equipment

Safety Center Foundation and compounded mainly by Mr. Kohei Matsumoto, Chief of the Housing & Building Economy Department, Building Research Institute, Ministry of Construction, Dr. Makoto Tsujimoto, Associated Professor, Department of Engineering, Nagoya University and Mr. Tatsuo Ishii, Technical Chief of Section, Renovation Center, Takenaka Corporation.

The activities of this group consisted first in searching for information based on codes and regulations and, exchange of knowledge and experience concerning the subject among themselves and through explanations by other professionals experienced in construction process abroad. It was clear, from the beginning, that the background conditions that supports the construction system in case of the U.S. and Japan were very different, not only in matters concerning quality of on-site workers, worker's practice, contract system, the design-to-construction process, but also because in the U.S. the systems and practices vary regionally.

After several months of periodical meetings, a better understanding of the system was taken by visits to two main cities in the U.S., in August, 1989, chosen carefully because of the clear difference found in systems adopted by each of them. The visits to the cities of New York and Los Angeles included interviews, hearings and question-answer sections at the respective building departments and some design/construction offices, and visits to construction sites. Furthermore, it resulted in the issue of the report *Building Administration in United States — Permits and Inspections Reports of New York and Los Angeles City* [4], where the details about the systems taken by those cities to administrate the buildings under their legislation can be found besides the schedule and details of the visits.

However, as expected, the information acquired by the previous study and visits to the U.S. were still not enough to clarify certain points considered important by the Group of Study for a better understanding of those systems. After some effort to get further detailed information through contacts with the organizations visited in the U.S., followed by another visit by a member of the Group — Mr. Shigeru Higashi, General Secretary of the Japan Building Equipment Safety Center Foundation to the Department of Building & Safety of Los Angeles City, an official invitation to Building Inspectors of the referred city by the Ministry of Construction of Japan was made, in order to expose the system carried out in that city here, in Japan. In November, 1990, Mr. Warren V. O'Brien, General Manager, and Robert J. Martin, Assistant Deputy Superintendent of Building II of the Department of Building & Safety of the City of Los Angeles visited Japan for this purpose.

This visit consisted of a seminar open to the public and a question-answer section to a particular group, based mainly on questions concerning doubts the former Group of Study had [1].

The building inspection system carried out by the cities of Los Angeles and New York is described in this study based on the collection of information acquired during all the process described above.

This research includes also analysis in the above referred matter, considering the importance of a performance assurance system taking into account the social and economical background of each case. Furthermore, a comparative analysis of the Japanese and the U.S. building process control system and the influence of the mass-production industries' quality control system to the building industry, are also considered.

In general terms, in *Chapter 2* the conceptual and historical aspects of the *"Theory of Performance"* is described and a *"Theory of Performance Assurance"* has been proposed in order to clarify the purpose of this research.

Chapter 3 consists of the discussion of the concepts of Quality Assurance and Quality Control, hereinafter called QA/QC, in general and their application in construction together with the analysis of the feasibility of industrial standards in QA/QC to construction.

In the next chapter –*Chapter 4*– a comparative analysis of QA/QC applied to many fields of construction and the role of building inspections is discussed. Furthermore, concrete examples of building process control and building inspection systems are given based on the information acquired from the Group of Study commented above.

In *Chapter 5*, problems concerning legal responsibility of the professionals involved in the building construction are exposed, emphasis is given to the role of the inspector.

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[1] Details of the contents of these meetings can be found in the *Building Equipments Safety News*, No.66, 3.1991 , published by the Japan Building Equipment Safety Center Foundation.

Chapter 2

Theory of Performance Assurance

2.1 Introduction

In this chapter, the general aspects of the *Theory of Performance* and the *Theory of Performance Assurance* (named here by the researcher) will be discussed. The theory of Performance has been extensively studied along the last thirty years so that its extension is as large as can be imagined, though, here, only the portion that concerns to this research will be mentioned.

On the other hand, the *Performance Assurance* is a subject discussed partially at various fields of the Architecture and Engineering but it will be presented here in a form of a theory formulated by its convenience to this research.

2.2 The Theory of Performance

2.2.1 The development of researches in Performance in Japan

In ancient times, when constructions were all in wood, no performance of a dwelling or other buildings was argued. The materials used to construct the floors, walls, roofs and ceilings were traditionally established and the characteristics of the final construction were known.

Even with the event of reinforced concrete and steel structures, the types of building systems were still limited and its contents, normalized, so that the measurement of its performance was not requested and also the experience acquired from previous construction could always furnish answers to doubts in new ones.

However, when new materials and new construction methods were introduced to the various parts of the buildings, the need of certifying its quality/performance compared to the conventional ones came out. The measurement of the performance of buildings including the conventional systems came up also as a result of the social demand.

The world's technological innovation after the Second World War brought development of new materials and by-products from different fields that hadn't had any relationship with buildings before. They started to be transferred to building materials affecting the order of conventional systems. At that time, special attention was given to researches concerning the performance of building elements – as a result the Theory of Building Elements was developed. This theory consisted of taking into account the building parts like floor, wall, ceiling, etc. and comparing the general performance of each to find the desirable (suitable) level of performance, ignoring the conventional building systematization.

The popularization of new building materials and then the introduction of different kinds of machines at the construction site from the 1950's started a new era where large-sized elements were becoming common at the site — the manipulation of such elements accelerated the phenomenon of prefabrication in this country. As a result, the construction process had to be seriously reconsidered and a comparison of performances of total building systems was driven by necessity. Moreover, as prefabricated dwellings using different building systems came up to the market, not only professionals, but also general consumers had become interested in comparing the new building systems.

During the 50's and 60's, the main subject of study in the field of performance, was the development of testing methods that included the quantification of performance and the establishment of design and production objectives based on this quantification. During the 70's, the researches were directed to the formulation of indicators and information in order to choose the most suitable among the various levels of performance.

2.2.2 Building Performance

a. Definition of Performance

The concept of *Performance* was extensively considered during the 60's in the architectural field, originated from the *theory of choosing materials and construction methods* [5]. Its meaning and its limits, although, haven't been well defined until today.

The word *Function* comes up easily when we think about *performance*. *Function* has an older history than *performance* since it came to the world popularly in the early 19th Century with the concept of Functionalism, first expressed by L.H.Sullivan as "*the form conforms to its function*". However, this word today doesn't express the idea of totality it used to at that time and nowadays it is used to say, for example, "*the function of the partition wall*" or "*the function of the building facilities*", as something partial or material that represents a situation where its use is changed and/or expanded.

The meaning of these words could lead to a very interesting discussion . However, the aim here is a discussion about the concept of the performance in buildings so that the definitions as below will be given but limited to this study.

Performance: *A quantitative and qualitative expression of how much the functions of the building or its parts have been complied with or how much should be considered desirable.* or;

The manner in which or the efficiency with which something reacts or fulfills its intended purpose [1].

Performance is a concept that describes or evaluates a building in a situation where there is a relative relationship between the building and the human being. In other words, it is an information system between the one who produces (constructor) and the one who uses (user), the building being the medium. It is important to clarify that this relationship generally includes the personal value, but here, this item is not considered, as the performance has been defined simply as a qualitative and quantitative expression.

The performance can be classified in many ways, like performance of the material, building elements performance, building facilities performance, performance of the space and building performance. However, it is important to emphasize that the performance of parts like wall insulation or the tightness of a window are just elements that represent parts of the performance of the space or part of the conditions of living for the human being in a building or space .

Function: *It is difficult to fix a clear boundary between performance and function, however, while performance is an expression of the degree of a work, function describes, with more emphasis, the contents of such work.*

Quality: *This word also has many interpretations but here it represents the total evaluation of some properties or performance.* or;

The peculiar property and performance subjected to evaluation in order to define whether the product or service has complied with its usage purpose[2].

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[1] The Random House Dictionary of the English Language, Second Edition, Unabriged.

[2] JIS Z 8101 'The Glossary of Terms used in Quality Control.

Property: *The characteristics which make possible the distinction of one thing from another.*

b. The Concept of Performance in the Architectural Field

Up to this point, the theory of performance, its definition and characteristics were given, and as it could be realized, this theory at its various phases was developed for a better qualification and quantification of building systems in stages which include from the characterization of material to the orientation of building projects.

A characteristic of this theory that has been pointed out as a cause of its partial materialization in such a way that it is still considered not acceptable by some specialists resides on its uncertainty or subjective tendency, or inconsistency; however, the theory allowed the development of the construction products and systems, and the construction industry, in general.

The concept of performance is new in the architectural field, if compared to other engineering fields . For example, the performance for airplanes is determined mainly by its speed/ rising power/ landing extension; for ships, by its speed/ acceleration/ stability/ comfort. In these fields, the concept of performance is so routinized that now it is difficult to point out its performance items to formulate a system. As cars, airplanes, and ships are meanings of transportation, the performance is much clearer and the relationship between the input and output is well defined.

The difficulty in getting hold of performance in buildings resides on the complicated relationship existing between the building — something physical — and the human life, because the first is constructed according to the needs of the second. K.Tatsumi [6] wrote that from the point of view of performance, this relationship has two sides.

> The first: "*... there is a physical face and a sensitive-psychological face in the human life. The point of equilibrium between these two faces depends a lot on the use of the building considered but, in general, in a construction for human beings, of course, the psychological satisfaction will be requested, although, it is extremely difficult to measure in an objective way the functions related to it.*"
>
> The second: "*... the human being has the capacity of producing and changing by himself, his living environment.*" ... "*He can make slight modifications by himself and change his living environment. Also, the physical performance,*

> *previously established by the architect, can be modified by changing the use of the building." ... "These characteristics can be frequently found in buildings due to its long life".*

As shown in the two sides above, the human need in buildings are multiple, changeable along time and require adaptability as well. The third point, which has been considered nowadays, is the psychological one, getting clear due to the development of studies concerning the relationship between human being and building environment in this field.

But, as pointed out before, the total building performance is quite difficult to be determined and its evaluation is also a complex subject that will not be deeply discussed here.

An example of method of performance classification taking in account the building and human needs is given by a report published by the Ministry of Construction titled " *Report on Formulation of a Proposal for Dwellings' Performance Standards*" [7] as follows:

> *The conditions of a specific building will be satisfied through the combination of the performance of space, materials, building equipments and others. For example, the evacuation of a building in case of fire will be determined by many factors like the combustibility and smoke production of finishing materials, the effectiveness of compartmentations (fire-proof, smoke-proof), the position and performance of smoke exhaust systems, the composition of evacuation routes, the performance of fire detection and evacuation leading systems, etc. Even if one of these factors fails on carrying out its performance, the others can cover it so that it is possible to get a satisfactory result as a whole. This is the principle of total evaluation. Generally, the projects are considered from this point of view so that tables have been developed with this purpose.*[3]

The design and/or evaluation of performances have been seen as a matter of the design phase but, actually, the design phase has to be considered only as the preparation phase which will be materialized during the construction phase and performed during the life of the building (maintenance phase). Although, studies concerning the construction and maintenance phases from the point of view of performance and its evaluation are still new, they are considered important subject of study. The performance during the

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[3] See Appendix A — Partial translation of the Performance Systematization [5], Table 1.13(b) -pp.64-70.

construction/maintenance/use should be sufficiently investigated and understood at the design phase.

On the other hand, the performance designed during the design phase should be carried out effectively during the construction/maintenance/use phases.

Many factors are involved in the design of performance, like the interrelationship between functions and performances, and the economical and architectural factors, that can limit the level of performance. But the designed total performance can be obtained if there is a coordination of all the phases and if the performance that could not be achieved completely during the construction would be covered through the maintenance/use phases.

Once the desired building performance is determined, considering all the phases (construction/maintenance/use) and appropriate drawings and specifications are prepared, the construction work can be started.

Most of the performance determined during the design should be assured during the construction phase and systems are organized with this purpose. This is the subject discussed below and in next chapters.

2.3 The Theory of Performance Assurance

The *"theory of performance assurance"* is an idea considered here mainly as something applicable for construction works. This theory takes into account that the criteria for judgment of the performance obtained in the works under construction (having the performance been determined by the architect in the design as a parameter) is totally different from those established for design. For example, basic performance like *" an efficient water supply system"* and *"avoidance of water leakages"* for buildings presents totally different characteristics from the point of view of project (design) but they are members of the same performance parameter, from the point of view of construction —the performance of the plumbing system.

In other words, *" an efficient water supply system"* can be classified, for example, as a performance required for a sufficient everyday water supply and an effective fire protection system, and *"avoidance of leakage"*, a requirement in favor of the durability of the walls and ceilings and consequently, against unexpected damage to the building. But, from the point of view of construction, both are related to the performance of the same construction work. Relationships at this level are presented in figure 2.1, considering the design performance from two others different points of view — Comfortableness and Safety *versus* performance at the construction phase.

Each item of the design performance is satisfied in the construction phase through the guarantee of performance of many construction works. At the same time, many of the design performance also are related to the same work at the construction phase.

As the relationship is multiple and complex the *"theory of performance assurance"* is here considered only as a system for performance assurance of construction works. The sequence of thinking of performance is not the same during the design and during the construction phase, and it will be different also when considering the performance during the use of the building. But the construction phase is essential to meet the total building performance.

2.3.1 Other Considerations Concerning Performance Assurance

Another point to be considered here is that, in principle, during the use of the building, some of the works are kept untouched until a failure or malfunction occurs and others should be checked periodically. In the first group are the structural, plumbing, electrical, piping systems, and in the second, elevators, HVAC, and other mechanical systems in general.

The works included in the first group are those the desired performance should be achieved precisely during construction. Any small mistake during this phase can cause unmeasurable damage to the finished work. In general, the effect of a not-well-done work in this case is not immediate. If the mistake is not found during the installation and before concealment by walls and ceilings, it can cause problems that can vary from a small local damage to the collapse of the structures and loss of money, and sometimes, the worst, loss of lives at an unexpected time. If mistakes are found before the work is concealed, a rework should be done —causing a delay in the construction schedule that costs time and money. Supposing that the mistake is not found or the work is not even checked during the construction, the effect can be worse because the malfunction or fault will come out during the use of the building, responsibilities will be asked and the damaged part of the building should be repaired, becoming costly to the parts involved.

Even for the works of the second group, to which the maintenance during use is a very important factor to acquire good performance, proper attention during its installation phase is required. Generally, they are building service systems and are installed during

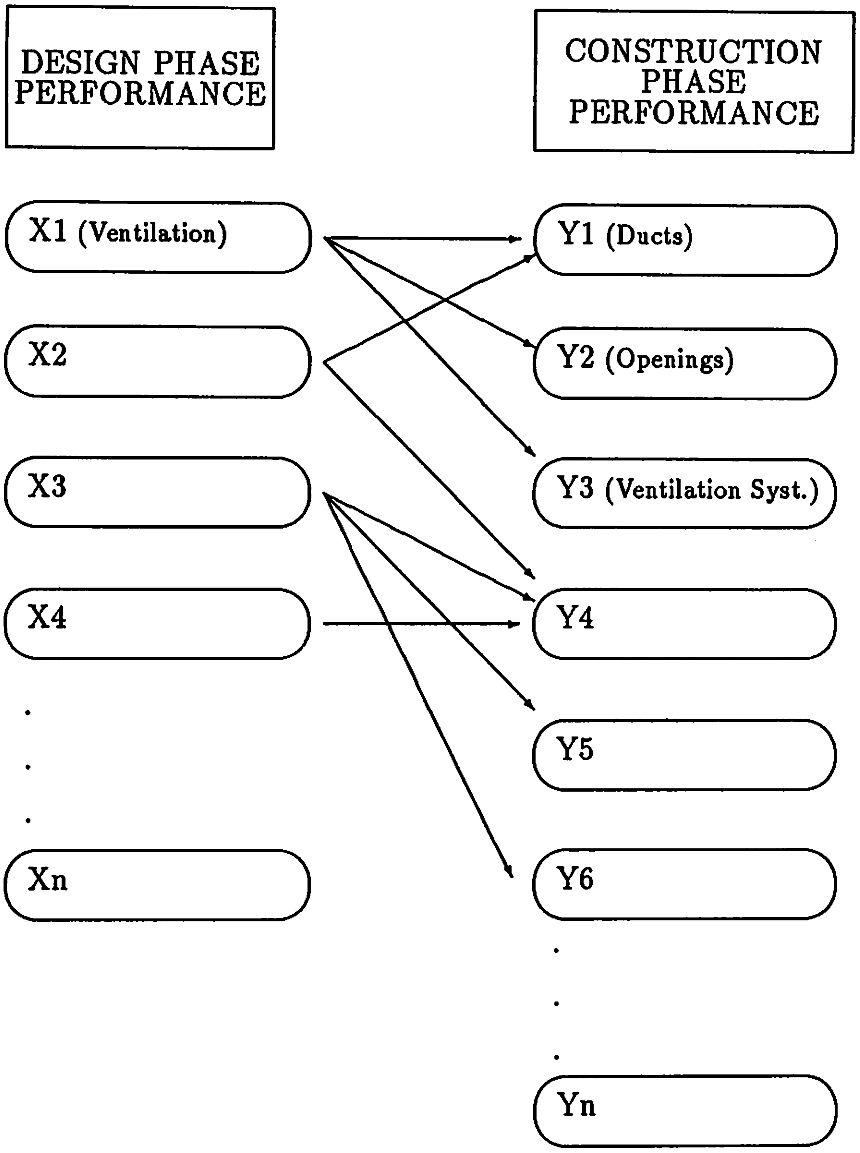

Figure 2.1: Relationship between Performance at the Design and Performance at Construction Phase.

important and have a great influence on the building maintenance phase. Extensive study about the systems to be adopted in order to obtain an optimum performance, either economical or environmental, is an increasing need.

2.4 Conclusions

The performance assurance in the Architectural Field is a never ending discussion, if all the factors, physical, psychological, economical, etc. are taken in to account, so that, at first, a clear definition and distinction of the matter of study was tried here. Then, an explanation of the *theory of performance assurance* is given.

The *theory of performance assurance*, called *theory* just by its convenience, is simply a development of an idea, in a narrow sense, of *how to assure the acquirement of the performance determined in the design phase.* The *alternatives* are shown in the next chapters, always keeping in mind the importance of the construction phase of any project to the acquirement of the desired final product.

Chapter 3

Quality Control / Quality Assurance

3.1 Introduction

The terms quality assurance (QA) and quality control (QC) are frequently used interchangeably. Since QC is a part of QA, maintaining a clear distinction between them is difficult but important. QA consists of all planned and systematic actions necessary to provide adequate confidence that a structure, system or component will perform satisfactory and conform with project requirements. A QA manager and staff are responsible for developing this program and for monitoring the activities within the QA program.

QC consists of specific procedures involved in the quality-assurance process . These procedures include planning, coordinating, checking, reviewing, and scheduling the work. Quality is achieved by individual performing work functions carefully and according to the requirements. Most design-related QA programs and QC activities are covered by a design organization's standard office procedures [8] [9].

There are many attempts to define what is meant by quality and quality in construction. A possible approach is to take one much-quoted definition of quality, put forward for manufacturing industry generally, and identify how far the definition applies to quality in construction.

According to the definition given for manufacturing quality is the sum of [8]:

1. Knowing a customer's needs.

2. Designing to meet them.

3. Faultless construction.

4. Reliable bought-in components and assemblies.
5. Certified instruction manuals.
6. Clear instruction manuals.
7. Suitable packaging.
8. Punctual delivery.
9. Efficient back-up service.
10. Feedback of field experience.

By quality it is meant the right features of any one product, which may be those specified explicitly by a customer, directly or by reference to some acknowledged specification, or may be implicit and mutually understood; and it is also related to consistency. The product or service supplied must not vary, within limits, from an agreed or generally understood "norm".

The quality control is an activity to reach the objectives of an industrial production. It is also an act done in order to put the production in to practice, in an economical way, of products with a stable quality for society.

Quality is important in the following three areas in the operation of a business:

1.Quality of design.
2.Quality of conformance to design.
3.Quality of performance.

The quality of the design of a product is concerned with the stringency of the specifications for manufacture of the product. Generally, the greater the requirement for strength, fatigue resistance, life, function, and interchangeability of a manufactured item, the better the quality of design. Needless to say, the design should be the simplest and least costly which will still meet the customer's preference requirement.

Conformance quality is concerned with how well the manufactured product conforms to the original design requirements - that is, how well quality is controlled from materials procurement through shipment and storage of finished goods. Quality control, as it has been known and used in the past, has been closely associated with conformance quality.

Also, it has been this area where most of the sampling and statistical techniques have been used.

The product is put to work and how it performs depends upon both the quality of design and the quality of conformance. Even if it is the best design possible, poor conformance control can cause poor performance. Conversely, the best conformance control in the world cannot make a product function properly if the design is not right. Thus, a continuing feedback system is necessary for providing quality information to work as a basis for decision making regarding the optimizing of a quality product.

Most of these qualities are what construction's clients require from its designers and manufacturers. Though, in the totality, they are rarely fully achieved, the items should be considered when listing criteria against which to assess — the quality of a construction product or service.

3.2 The development of Quality Control

Here, an introduction to the development QA/QC, its main standards and its application at other fields are made in order to offer an overview of the matter and a better comprehension of its application at the building construction.

3.2.1 In the United States and Europe

The earliest recorded beginning of quality control goes back to 1924 when Dr. Walter A. Shewart of Bell Telephone Laboratories first applied a statistical quality control chart to manufactured product. Later Dr.Shewart authored a book, *"Economic Control of Quality of Manufactured Product"*, published in 1931 [10].

In England, Dr. E.S.Pearson and Dr. J. Neyman defined the theory of hypothetical test and Dr. A. Wald published *"The Application of Statistical Methods to Industrial Standardization and Quality Control"* in 1935, which was adopted later as a British Standard (BS 600).

The early forties saw development and use of sampling tables for acceptance inspection, plus publication of military sampling tables and endorsement of their use by the armed services. The Department of Defense of United States has published several Military Standards and interim standards during this time .

During the World War II and the Korean War the emphasis was on the use of the techniques by the various inspection agencies of DOD. Following the Korean War the emphasis shifted to promotion of the use of quality control techniques by the supplier, accompanied by assurance methods used by the inspection agencies of DOD. Currently, the emphasis on promotion and assurance still holds. To these has been added an emphasis on the quality of design and function which has resulted in a new term – *reliability*. *Reliability* is the quality control of design, development and function.

The 1940's and 50's also saw a significant increase in writings on quality control, both periodicals and books, plus the birth of a national organization in United States, the American Society for Quality Control, in February, 1946.

3.2.2 In Japan

Japan was a nation completely ruined after the war. Almost all of the industrial facilities were destroyed, food, clothing and houses disappeared and Japanese were just before the starving condition.

Among the troubles that General MacArthur found since he disembarked with his force at this period in Japan was the frequent failure in the telephone communication network that disable its efficient use. The cause was not only the effect of the war but defects on the communication facilities and the wide dispersion on its quality level. Realizing the matter, the American Army advised the Japanese electrical communication industries to adopt the modern quality control system and played a leadership role (aiming at modernization). This was the opportunity to the starting of the statistical quality control in Japan, in May, 1946.

The *Union of Japanese Science and Engineering*, JUSE, was formed in 1946 by Kenichi Koyagi, the aim being the reconstruction of Japan. A *Quality Control Research Group* (QCRG) was formed at JUSE and Dr.E. Nishibori gave in 1949 a short course on statistical methods in industry that was followed by several other courses. The first course was given following American and English methods but it was realized that the pure transfer of foreign technics would not be effective and a Japanese method was developed by the members of QCRG.

The next step taken by JUSE was the invitation of a foreign expert (that was done) in 1949 and Dr. W.E.Deming came in 1950 from United States for a conference promoted by JUSE and dedicated to the top management. Conferences were also held in subsequent years and the subject was the responsibility of management or institute constancy of purpose toward service, to improve the system through all stages of production, and to manage the use of statistical quality technology company-wide, from procurement of materials to the consumer, consumer research, innovation, and redesign of product.

Dr. Joseph M.Juran made his first visit to Japan in 1954, at the request of JUSE. His masterful teaching gave to Japanese management new insight into the meaning of quality and management's responsibility to achieve it. Japanese were then given the opportunity to advance from the Statistical Quality Control – which were restricted to actions in the factory – to the origin of the nowadays' Total Quality Control.

The teachings of Dr.Deming and Dr. Juran worked better in Japan due to their effort not to repeat the mistakes made in the U.S. and to the characteristics of the Japanese society. These factors allied to the growth of TQC in Japan created the atmosphere for the development of QC Circles by Dr.K.Ishikawa — one of the founding father of the Japanese miracle.

3.3 The Reliability of the Performance

3.3.1 The Social Background of the Reliability

'Reliability' was first taken as an important matter in the engineering field during the Second World War. At that time, all kinds of weapon systems presented defects not only during its operation but also during transportation and storage. All the countries involved had common problems also with systems that did not perform as expected during the attack or frequently presented short life. This problem was considered very important in the United States and a scientific solution was methodically researched with the cooperation of the army, academic circles and industry. It was the creation of the mother-body of the Reliability Engineering.

At the same time, failures in complex electronic machines were frequent, and the time for repairing and adjusting them was very long so that the period during which the machine was in condition for fully performance was in general short. Its main cause was the reliability of the electronic tubes. The first product developed was a "high-reliability tube", that is nowadays substituted by the semiconductors. Also, in Germany, a mathematical reliability engineering was being applied for the first time in missiles.

After war, the mechanical systems used by men were becoming complex, bigger and popular not only in the military field but also in the civil field, and the need for reliability brought the development of Reliability Engineering and its application in many fields.

In general, the complex mechanical systems are composed by many parts so that even if the probability of defect of each part is low, when a defect occurs, it is frequently necessary to repair or adjust all the system what limits the time during which the system is fully operational.

Big mechanical systems can cause many social and economical problems when a non-predicted stop or decline occurs ; so that the influence of a defect, even an unusual one, cannot be neglected. Today is the 'mass-consuming time' where many of the mechanical systems are used directly by the masses. The masses, constituted by different professions, ages and life-styles without almost no specific knowledge, are consuming many industrialized products. In this situation, there is risk of a serious accident, which could be avoided if consumers had a little knowledge of the equipment. Also, the use of a product under conditions unpredicted during its design occurs. Accidents caused by the misuse by the consumer, supposing some knowledge about the product, are regarded as a deficiency in the design and the responsibility of the producer is asked.

As it can be seen, the complexity, scale and popularization of the system based on the development of the civilization urge the development of technology to control the system from the planning to the production, use and abandonment to assure the bringing of the expected performance into its full play. Or, facing the other way, it can be said that without the development of the Reliability Engineering, the mechanical civilization could not reach today's position.

3.3.2 The Basic Concepts of Reliability

Reliability Engineering, as shown above, has its development mainly in electronic machines so that it is not well established in buildings, not considering the field of building equipments. And, concerning the performance (function) of the building, due to its characteristics, the concrete application is often difficult. However, when the realization of the performance in buildings is considered, many of the suggestions of its posture in relation to the recognition of the basic problems, the introduction of new points of view and the new social requirements are included, so, the basic concepts will be discussed below.

As a concept close to reliability, problems like safety, durability and stability have been discussed up to now in many engineering fields, as well as in the architecture. In opposition to this concept, reliability, when the mechanical system is in a usable condition, has as characteristic the problem of corresponding to the expected functions or not. And, when the function is not corresponded, the restoration of the functions is made by the repairing or changing of the defected part, so that the ease of finding the cause, repairing, changing, etc is a point related to the reliability of the system that should be emphasized.

The concepts of Reliability Engineering are not easy to be accepted direct in buildings because of the unfamiliarity of its terms, although some of these terms and definitions will be given according to the JIS (Japanese Industrial Standards).

Reliability: the representation of the characteristics or the degree of time stability of the systems, equipments and parts' functions; the probability that a determined function of a system, equipment or part to be carried out during the desired period under determined conditions .

Failure: the loss of a determined function.

Maintainability: the representation of the characteristics or the degree of ease of maintenance of repairable systems, equipments and parts; the probability that a repairable system, equipment or part, when the maintenance is done under determined condition, to be maintained in the determined time.

Availability: the probability that a repairable system, equipment or parts maintain the function under determined conditions during a determined time.

As can be seen through the definitions above, in order to take reliability into consideration or to measure the reliability concretely and design, it is necessary to clarify the following items:

1. the subject of the system, equipment or parts.
2. the scope of the conditions of use.
3. the period of use.
4. the determined function.

When the reliability is to be considered, its subject should be clearly determined first. Second, it is necessary to limit the scope of the conditions of use. Factors that can influence the quality of the product are included as conditions of use : the natural environment or inner environment, where the product will be used, as well as the method of use, and the method of maintenance . The fact that the determined function can be performed under any condition is unreal and it is economically unreasonable. And, it is also impossible to consider all the factors during the design. The scope of the conditions to be considered is limited by the objective, the economical and technical conditions. To clarify this scope is important when problems related to failure and responsibility are considered.

The third, the period of use, is in general the consecutive time in years or hours but when it is used intermittently or when a strong action deteriorates its quality, or when there is another scale of measurement that represents better the quantity of use or the level of deterioration, the time scale is not the most reasonable to be considered in reliability.

The fourth, determined function, is not always easy to clarify, depending on the subject. If the subject is a simple component of a system, for example, a lamp, a switch, or a motor, its function is easy to be determined according to the relationship with the other sub-components. However, functions related to the human sensitiveness, as the quality of the sound or image of mechanical systems like stereos and televisions, are so subjective and generally also vague that its precise determination is difficult. Therefore, it becomes impossible to determine physically clearly the conditions to be considered failure or the conditions to be maintained.

3.4 Standards

Many are the standards concerning quality and quality control. Among them the followings can be pointed:

- ISO 900 series —Quality Systems
- BS 5750 - Quality Systems (United Kingdom)
- ANSI/ASQC Z 1-15 - Generic Guidelines for Quality Systems (U.S.A.)
- MIL-Q-9858A - Quality Program Requirements (U.S.A.)
- NF-X-50-110 - Recommendations for a System of Quality Management in Industry (France)
- DIN 55-35 - Basic Elements of Quality Assurance Systems (West Germany)
- CSA Z 299 - Quality Assurance Program Requirements (Canada)

A movement in favor of an international standard for quality assurance putting together the standards already in use in several countries is the origin of the establishment of the technical committee TC 176 for *the standardization in the field of quality assurance* at ISO, in 1980.

Basically, the study was based on an American standard and a British standard. There is not so much difference in the content of the two standards (Z1-15 and BS5750) — the first one is a guideline and the second, a requirement; and the BS 5750 is a multi-level standard, meanwhile Z1-15, is not. This matter will be discussed later in this section.

Here, the aim is to overview the role of quality related ISO standards and its relationship with the others standards shown above.

3.4.1 ISO Standards

The following six standards were enacted as ISO standards after the 5th TC meeting held in October, 1985:

- ISO 8402 - Quality - Vocabulary
- ISO 9000 - Quality management and quality assurance standards - Guidelines for selection and use
- ISO 9001 - Quality systems - Model for quality assurance in design/ development, production, installation and servicing.
- ISO 9002 - Quality systems - Model for quality assurance in production and installation
- ISO 9003 - Quality systems - Model for quality assurance in final inspection and test
- ISO 9004 - Quality management and quality systems elements - Guidelines

where, basically, ISO 9004 was made under the model of ANSI/ASQC; ISO 9001 to 9003, the BS 5750; and ISO 9000 is a guide of how to distinguish the use of ISO 9001 to 9003 and 9004.

ISO 8402 defines *"quality"* as follows:

> *The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs.*

And it presents the difference between *"quality"* and *"grade"*.

Grade: *"An indicator of category or rank related to features or characteristics that cover different sets of needs for products or services intended for the same functional use."*

The following three words are also defined as they are important activities to reach quality:

Quality Management: *"That aspect of the overall management function that determines and implements the quality policy."*

Quality Assurance: *"All those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality."*

Quality Control: *"The operational techniques and activities that are used to fulfill requirements for quality."*

These activities include not only the meaning of achievement, maintenance, but also the meaning of quality improvement through the reduction of defects. Also, as a quality control activity, the establishment of specifications; the design of product, process and service; production; inspection; and the investigation of use are included.

3.4.2 Quality Assurance

In several countries, the words *Quality Control* and *Quality Assurance* are used interchangeably in the industry and business world.

However, TC 176 has defined *Quality Assurance* as above. The quality assurance activities are necessary to guarantee the third party or the client that the quality is ensured. Simple products do not require these activities as the quality can be easily identified. Nevertheless, quality related to resistance, such as strength and plating (gilt, gilding), and quality that is difficult to identify without a destructive test cannot be evaluated only by visual inspection so that the matter should concern the adequacy of its manufacturing process.

Quality assurance is required in those products once a defected part is used a large damage is caused in an irremediable level. The quality of this type of product should be assured before use as the failure during use can not be tolerated. The typical example is the Nuclear Power Facilities. The word *Quality Assurance*, as defined in TC 176, was first used in the nuclear industry from the middle of 60's or early 70's.

Another reason for the definition of quality assurance made by TC 176 is related to the *Product Liability*. When a defective product is pointed out, the maker has to prove to the client and, sometimes, to a third party in court, that the quality of his product is well controlled.

The explanation of the product quality assurance during the manufacturing process by words is not effective. It is necessary to show how quality control is carried out and get the confidence of the public. Hence, it is not essential to explain the design and production process but the control assurance method. This means to show the product, its records and plans; the system and the method of design and manufacturing, tests and inspection carried out – a pursuit of the product and its parts.

3.4.3 The Market Aspects

The contents of quality control activities of industrial products differs slightly, depending on the target. The targets can be two: a particular client, such as an electric power company, that defines the quality standards of the supplied product; or the general public that can not define the quality of products such as cars, cameras, televisions, etc.

In the first case, the product quality is defined by a standard and the standard's quality is not, as principle, a supplier's matter. In the second case, it is not only important to achieve this standard defined by the manufacturer but also to fit it to the consumer's requirements. Generally, in this case, the requirement is included in the price of the product so that the matter is how to ally the product's quality performance to its price.

Table 3.1 shows the characteristics of these two types of products according to its targets.

ISO 9001 to 9003 standards correspond to the second case, here nominated as *"contractual type product"* and ISO 9004, to the first case, the *"market type product"*.

Actually, different factors are working in the quality control activities of the *"contractual type product"* and *"market type product"* though, activities related to procurement, manufacturing and inspection are common . The differences between them are in two points: the establishment of specification and the empirical (actual) proof of the quality control activities. In the *"market type product"*, the quality specification is given by the supplier and in the other case, by the purchaser, so that the quality control activities

Table 3.1: A Comparison of Market Type Product and Contractual Type Product.

Items	Market Type	Contractual Type
Product Planning	Carried out by the supplier	Carried out by the purchaser
Design	Carried out by the supplier	The performance assurance design is carried out by the supplier and the others, by the purchaser
Method of Manufacturing	Carried out by the supplier	It can be defined by the purchaser in the contract
Quality Control Method	Defined independently by the supplier	Some of the quality control elements are pointed by the purchaser
Regulations	Limitations are given by regulations but the quality control is not the subject	Conditions given by regulations are main elements of quality control
Buying and Selling Price	The buying and selling price of each product or its unit price is low	The buying and selling price of each product or its unit price is high
Buying and Selling Units	The number of products sold annually or the buying and selling cases is high	The number of products sold annually or the buying and selling cases is low
The Purchasing Form	The purchaser chooses freely the product among many manufacturers	The purchaser buys according to a contract with a specific supplier based on required quality assurance elements
User	The purchaser is the user of the product	Generally, the purchaser is not the direct user
Damage Influences	Generally, the defective product affects only the purchaser	The defective product affects much people besides the supplier and purchaser
Quality Improvement	The improvement of quality is done based on information gotten in the market	

are significantly different here. These activities are very important for the market type product; however, in the case of the contractual type products, the supplier's sharing is substantially decreased.

On the other hand, if the supplier of a contractual type product has to prove to the purchaser or a third person that the quality control activities are carried out according to the contract, this proof should be achieved. These activities are necessary in market type products if there is an internal auditing, although, in this case as the internal auditing can vary according to the supplier's situation, the external auditing sharing is surely bigger.

Finally, table 3.2 represents the quality control activities in both cases. It can be said that the setting of quality specifications and the external auditing are the non-common points and the major part is common to both.

From this point of view ISO 9001 to 9003 and ISO 9004 standards seem to present a

Table 3.2: Common Items

Type	Product Planning	Quality Control (narrow sense)	Quality Assurance (internal)	Quality Assurance (external)
Contractual	×	O	O	O
Market	O	O	O	×

large overlapping, although their essential difference is *"to whom it is made"*. Therefore, ISO 9001 to 9003 are standards for purchasers and ISO 9004 is a standard for suppliers.

ISO 9001 to 9003 are standards that define concretely which quality control elements should be required and how. The American military standard *MIL-Q-9858 A "Quality Program Requirements"* is also a standard with the same objectives and it defines the quality control activities in order to get the quality desired to the military forces. The *BS 5750 "Quality Systems"* and *CSA Z 299 "Quality Assurance Program Requirements"* are also the same type of standard in favor of purchasers, generally, government agencies, military forces, electric power companies, etc.

On the other hand, besides the processing control and management set by laws and regulations, the market type product is controlled mainly at the supplier's discretion.

However, if a defect is found in the supplier's quality control activities, administrative damages such as the increasing of rework, claims, the loosing of clients, etc. will come up. As this situation increased in recently years, a guideline of these activities was established in 1979 as *ANSI/ASQC Z1-15 "Generic Guidelines for Quality Systems"*. This guide was the first to define a quality guideline for suppliers.

ISO 9004 standard was established taking into account this position, and also adding items not included in contracts between suppliers and purchasers, to it namely, quality cost, market investigation, motivation, etc.

3.5 Application in General:

3.5.1 Nuclear Power Plants

Since the start of mass production, U.S. industry has recognized the necessity of controlling quality during the manufacturing process. Industries found that quality control was necessary to ensure that manufactured parts were within specified dimensional tolerances to achieve interchangeability of parts. It also became apparent that when quality was built into the product it proved to be more reliable and resulted in less returns and recalls due to defects. Good quality control was, thus, economically feasible, and the majority of the larger manufacturers today have implemented some type of quality control program.

This desire for quality was brought to the construction industry and quality control soon became part of power plant construction.

With the advent of nuclear power plant construction in the 1960's, increased emphasis was placed on the control of quality. This occurred because the fuel used in nuclear power plants created a potential hazard to the public. The Federal government realized that, because of this potential hazard, a standard method of controlling quality, along with good assurances that control was maintained, should be incorporated in the licensing requirements for the construction and operation of these nuclear power plants [11].

a. The Federal Regulations

10CFR50. – In discharging its responsibility as a regulatory agency as provided by the Atomic Energy Act of 1954, the *Atomic Energy Commission* (AEC) in 1967 issued the *"General Design Criteria for Nuclear Power Plant Construction"*, published as *Appendix A* to *Title 10 of the Code of Federal Regulations* (10CFR50). This document represented the first attempt to control the design and construction of nuclear powered generating stations. In 1969 the AEC published *Appendix B* to *10CFR50, "Quality Assurance Criteria for Nuclear Power Plants"*. This document has become the cornerstone of the QA requirements which must be rigorously followed by all of the design, construction and operation phases of the nuclear power plant projects. The requirements and responsibilities are delineated in the form of 18 criteria, each of which deals with a particular quality assurance aspect that must be addressed by the QA program of each party involved in the project [12]. The 18 criteria are:

1. Organization
2. Quality Assurance Program
3. Design Control
4. Procurement Document Control
5. Instructions, Procedures, and Drawings
6. Document Control

7. Control of Purchased Material, Equipment, and Services
8. Identification and Control of Materials, Parts, and Components
9. Control of Special Processes
10. Inspection
11. Test Control
12. Control of Measuring and Test Equipment
13. Handling, Storage, and Shipping
14. Inspection, Test, and Operation Status
15. Nonconforming Materials, Parts, or Components
16. Corrective Action
17. Quality Assurance Records
18. Audits

The 18 criteria were brief and general in nature, which left the industry with the task of interpreting their meaning. This task has been accomplished through various codes and standards issued by such organizations as the American National Standards Institute (ANSI), the American Concrete Institute (ACI), and the American Society of Mechanical Engineers (ASME). In addition, Section III of the *ASME Boiler and Pressure Vessel Code for Nuclear Components* has incorporated a requirement that applicants for a *Certificate of Authorization* have a quality assurance program. *NRC Regulatory Guides* have also been issued covering various areas associated with the construction of nuclear power plants. These *Regulatory Guides* outline acceptable methods of implementing specific NRC requirements, and many have utilized the relevant ANSI Standards to meet these requirements by referring to their use in the *Regulatory Guides* [11].

b. The Nuclear Commission

The NRC, established in 1974, is responsible for regulation of the licensing, design, construction, and operation of nuclear power plants. The NRC is responsible for enforcing the requirements of 10CFR50. Two of the primary modes for carrying out this enforcement are through design and licensing review and through actual inspections of construction operations. Before full-scale construction can be commenced on a nuclear project, a construction permit must be issued by the NRC under the Office of Nuclear Reactor Regulation. A review of the licensing process which is required to obtain this permit will be useful in indicating the depth of review and involvement of the NRC and also the time frame which is involved in the process. This licensing process consists of four major steps: (1) the filing and acceptance of the application; (2)the safety, environmental, safeguards, and antitrust reviews of the PSAR (Preliminary Safety Analysis Report) and ER (Environmental Report) by the NRC staff; (3)the safety review conducted by the Advisory Committee on Reactor Safety (ACRS); and (4) the mandatory public hearing by an Atomic Safety and Licensing Board (ASLB).

Upon successful completion of the public hearing, a construction permit can be issued. Inspection during construction and the review for further licensing will be based primary on the PSAR.

A second major area of NRC activities concerns the inspection of nuclear plants that are either operational or being constructed. The NRC inspection program begins with QA planning and extends over the plant's entire lifetime. NRC inspections falls into one of four phases of a nuclear power plant's life. These are: (1) Preconstruction activities, with an emphasis on development of an acceptable QA program; (2)construction activities, including verification of the suitability of materials used, the quality of fabrication, and verification that QA requirements are being met; (3) preoperational testing and startup, including observation of preoperational tests and examination of the organization, personnel, equipment, and procedures that will be used during operation; and (4) operational activities, including periodic inspections to determine whether the plant is operating in accordance with NRC requirements.

QA Programs

Nuclear QA programs are all designed to meet the same requirements, those of 10CFR50, Appendix B, and are therefore frequently similar in some respects. In many instances, the implementation of a QA program will include three levels of activities. These include inspection, surveillance, and auditing. Inspection is generally recognized as a QC function, whereas auditing is considered a QA function. On some sites surveillance is considered to be a function of QC, while on others it is considered a QA activity. The fist level, inspection, includes inspection of materials, fabrication, and site work performed by equipment manufacturers or site constructors. The second level, surveillance, involves a review of the specifications and procedures as well as monitoring of the first level QC. The third level, auditing, involves periodic spot-checks of the first and second level QA/QC programs. This audit function is one of the 18 criteria of 10CFR50, Appendix B, and therefore a requirement that must be met by the utilities.

There is a very broad range in the QA programs on nuclear power plants. The organization of the QA program depends,to a great extent, upon the level of owner involvement during the design, procurement, and construction phases. The level of owner involvement has been generally increasing since the publication of 10CFR50, Appendix B which places ultimate responsibility for quality on the utility.

The steps which are taken to insure quality on a nuclear project are many orders of magnitude greater than those taken in typical commercial and industrial standards. Written procedures and extensive documentation are required on nuclear projects to provide verifiable objective evidence of quality. The depth of inspection on a nuclear project is dramatically different than in typical construction. On a nuclear project, inspections and audits may be performed by site constructors, the utility, consultants, vendors, and regulatory agencies.As it can be seen from these figures, the assurance of acceptable quality on a nuclear power plant can indeed be major undertaking.

3.5.2 Civil Aircraft Industry

A brief description about the maintenance system and its history will be presented here in order to review the concept of reliability in a field where this concept is well defined and developed since failures are frequently linked to costly loss of life and property. [13]

a. Maintenance System and Cost

The air companies keep a very clear system concerning to Preventive Maintenance. The Japan Airlines and the All Nippon Airlines have a complex organization called Maintenance Head Office constituted by an Administrative Office, a Maintenance Office, a Supply Office, a Technical Office, Service Shops, etc. It is a very important and complex organization where the highest position is taken by an executive director or another professional at the same level.

The Maintenance Cost corresponds to 14 to 15 % of the total Administrative Cost.

This rate is variable due to the variations of the fuel price. According to the *Aviation Week* magazine, the above rate, for the five major air companies in U.S.A., is 15.3 %, 13.9 %, 13.1 %, 11.1 % and 10.4 %.

The importance of the maintenance service in the aircraft operation can be seen numerically in table 3.3, for the major airway companies.

Table 3.3: The Proportion of Employees in Major Companies.

Air company	total of employees	maintenance office (%)
Japan Airlines	22,089	4,596 (20.8)
All Nippon Airlines	9,832	2,832 (29.1)
Pan American Airlines	29,964	3,500 (13.1)
British Airways	54,649	14,238 (26.2)
Lufthansa	29,400	8,324 (28.3)
Air France	32,173	8,734 (27.1)
KLM(Netherlands)	17,812	4,215 (23.7)
Transworld	36,549	8,720 (23.9)
United	52,065	6,780 (13.0)
American Airlines	40,134	6,211 (15.5)

The cost of keeping the service standard and the safety standard can be direct or indirect, as shown in table 3.4, where :

Direct cost means the expenses caused directly by the maintenance .

Indirect cost means the expenses caused by the maintenance as administrative cost.

Direct maintenance labor cost is the expense corresponding to the time spent for the maintenance work by the maintenance staff.

Table 3.4: Maintenance Costs.

Maintenance Costs	
direct cost	-direct maintenance labor cost -maintenance material cost -ordered maintenance cost -non direct maintenance labor cost
indirect cost	-indirect maintenance labor cost -other costs

Non direct maintenance labor cost is that spent for the education and waiting time of the staff.

Indirect labor cost is the expenses related to the maintenance of administrative, technical, educational staff.

Other costs include, e.g., real state rental, water-energy fee and others.

The Maintenance Cost / Flying Time has been used as a mean for managing data concerning the efficiency of maintenance. This is a convenient way to compare the conditions of the same type of airplane in different companies, as the Maintenance Cost of each type of airplane can be divided by its flying time, so that the efficiency of the maintenance is obtained. Then, analyzing the proportion of the labor cost and the materials cost in the Maintenance Cost, it is possible to know where the efficiency should be improved.

b. Maintenance Methods

The idea of maintenance has suffered significant changes in the civil aircraft field. And to follow these changes means to reflect about the reliability of the system.

The first generation of maintenance was over at about 1955, the golden age of the propellers, called also the Hard Time (H.T.). During this period, periodic maintenance through inspections from the exterior and interior was thought to be a method to eliminate malfunctions. In addition, a time limit for the airframe, engine and main parts was set, after which a break down inspection and a partial change of parts for new ones should be done. The repeating of this circle was thought to be effective as a Preventive Maintenance. Although, it did not prevent failures as it was expected.

In the second generation, the H.T. and O.C.(On Condition) period, the component parts of the aircraft were divided roughly in airframe, engine and parts where each one was subdivided, for example, the airframe was divided into its main sub-components like main wings, body, flaps, legs, tires, operation cabin, etc. The O.C. is a maintenance method where the inspection of functions of each of the sub-components is carried out attached to the airplane. If the result is in compliance with the standard value, the sub-components are not replaced. The maintenance is a combination of H.T. and O.C. fitted in according to the components characteristics. This method was in use until 1964.

The third maintenance generation is dominated by the Reliability Management. Condition Monitoring (C.M.) was added to the H.T. and O.C. The C.M. monitors the parts needed and analyses its data, collects and analyses the faults found during the operation and each kind of maintenance. Then a feed-back of this information is done to change and improve the maintenance items and the components of the airplane in order to increase the effectiveness of the maintenance. However, these procedures are not restricted to the maintenance area, they are linked to the design, operation, maintenance and improvement as a mean to raise the reliability of the airplanes. The design concept is the safety obtained through (a)the raising of redundancy of the main parts like the engine, landing system and flight control system; (b)the raising of reliability of each part and; (c)the establishment of a reliability system.

In the case of the airframe, a special reliability system was introduced where two design methods were considered. One of them is the design of the structure through the safe-life structure, that means, a design method where the part that can be a cause of lethal accident when broken, is elaborated to a such degree of safety that the probability of failure of the part due to fatigue is minor. When this method is adopted, the airframe becomes extremely heavy and inspection can not be neglected.

As it is very difficult, nowadays, to be absolute sure about the safety against failures caused by fatigue, fissures caused by fatigue cannot be avoided. The second method consists of limiting the damage caused by fatigue to a small area so that it can be found during the inspections before a lethal failure occurs, and countermeasures like reinforcement or replacement of parts can be taken. This is called a fail-safe structure.The inspection points, methods and frequencies are planned during the design phase so that they can be carried out precisely. It is the improvement of reliability through the integration of inspection and design where the maintenance is a part of the reliability system.

In the case of engines, an appropriate, different system is organized. As the problem is the fatigue of the hot section, methods to find easily the limits of fatigue as soon as possible through the periodic inspections in short intervals, providing inspection openings (windows), inspection instruments, etc. have been arranged. The decomposition inspection of the hot section is also done, besides the monitoring, at the same time, of diagnoses (inspection of the quantity and quality of oil, SOAP, flight data monitoring, etc.)

Therefore, the third generation emphasizes the improvement of reliability through the integration of design, operation, maintenance and improvement (repair) and to adopt different methods of maintenance adequate for each part.

c.Aircraft Integrated Data System (AIDS)

AIDS is a system that aims at the analysis of data collected during the flights ; such as flight data, operation data, the conditions of passengers, the conditions of the load, data from the engine, etc. into a computer on board. These data are then transferred to a central computer on the ground to improve the operation and to be used as maintenance data.

There are 9 airplanes out of 40 with this system installed in JAL, so that data can already be collected. If limited to the collection of data to form part of a diagnosis system, AIDS is a convenient system but there are discussable points concerning the surveillance of pilot's flight operation techniques.

3.6 The Industrial Standards Applied to the Construction Industry

In manufacturing industries, normally one firm markets the final product – taking responsibility for design, selection and acceptance testing of bought-in materials and components, production and assembly, internal quality control, packaging, preparation of instruction manuals and technical literature, and provision of follow-up and spare parts services. However, such conditions do not happen in the same way in the construction.

The BS 5750, previously presented above, is the United Kingdom national standard for quality systems. It tells users, and those responsible for managing or assessing a firm's quality arrangements, what is required of a quality-oriented system. It is claimed to be a practical standard of use throughout industry.

The 1984 BSRIA Report, *"The application of BS 5750 to building services"*, examined critically the application of BS5750 to the kinds of quality systems need for the building services industry's clients. It noted that the quality philosophy on which BS 5750 is based can be summarized in three maxims:

- management should be quality conscious,
- formal quality procedures shall be used,
- all transaction should be documented.

While these maxims have universal application, the issue is whether the specifications for the three basic levels of system are sufficiently general to be applicable to the needs of construction, including building services. Also, the difficulty of application of certain requirements are remarkable.

For instance, Part 4 of BS 5750 suggests that the design and development program should contain key events, so that progress reviews can be made, and it should indicate when these reviews should be made. However, these events are still not well defined in the design process of buildings where the design work is divided between many practitioners, what it makes difficult to systematize. The same can be said about the construction process, where construction managers, contractors and subcontractors are involved in the job.

The control of physical and functional tolerances to avoid the use of irrational limits, proposed in Part 4 of BS 5750 is written in terms of engineering manufacture; there is an equal necessity for architects and other designers to take account of the realities of site tolerances and the problem of fitting the standard into the site conditions.

The use of defect data feedback from previous designs is a task much neglected in design and construction. But it is needed and it has been already proved that can be done.

George Atkinson [8] defines the construction's special features as follows:

Construction's special features fall into ten main areas:

(1) *By tradition and convention, design and construction are normally still thought of as separate activities, each practitioner - directly or through a third party - having a separate contractual responsibility to the building owner. Design work is usually split between different practitioners, and may be more or less completed before the organizer of the production process - the builder - is under chosen, responsibility for the process being split between many sub-contractors.*

(2) *Statutory authorities regulate design and construction in many ways and stages during the process, and their requirements may be of a detailed, prescriptive or a functional and general character, and may be followed by examination and, possibly, formal approval of the resulting work.*

(3) *Buildings are mostly 'one-off' products, erected on a piece of ground which, even on an estate, has unique features and may vary in quality every few metres. Testing of prototypes is rare. Even when standard designs are used, details have frequently to be modified to satisfy site, regulatory, or client requirements.*

(4) *Manufactured materials, components, assemblies and mechanical equipment may have been tested and quality assured in the factory; but once brought on the building site they are likely to be handled, stored, assembled and installed under adverse weather and other conditions. Even when quality assured components are used, and care taken in their handling and installation, they may prove incompatible with their neighbors, the resulting chemical or mechanical interactions being a source of trouble.*

(5) *Construction workers move from site to site, and many change employers from one job to the next. Types of work change as a scheme progresses as well as between jobs, as do the size of the workforce and the skills required from it. Employer relations change, as do the coverage, expertise and quality of inspection and supervision. The level of work quality required from an individual operative is unlikely to be defined clearly.*

(6) *Buildings last for decades, more often than for centuries, and parts of a building may have to be replaced at various times, receiving varying degrees of care, maintenance and repair during their life. The consequences of a defective design, selection of an unsuitable component or material, careless installation, inappropriate maintenance or repair, and misuse during occupation may remain latent for many years, and only show up and cause trouble following an exceptional 'overload' like a windstorm or explosion, or be identified as a result of change of ownership or use. Yet the technical requirements of building regulations implicitly assume that a building will remain for ever as built; and the law tends to place all but timeless responsibilities for good performance on the original designer and producer.*

(7) *Supervision and inspection on construction sites are not usually systematic. Site testing of work in progress is rarely undertaken except when sub-standard work is discovered. When it is, rectification is likely to be costly and building completion delayed.*

(8) *When defects are discovered, remedial work is unlikely to be easy for several reasons : it may be difficult to determine the cause of failure, and a wrong diagnosis could well aggravate the problem; and neither the original work nor the changes resulting from the remedial work are likely to be properly recorded systematically. Environmental*

and user conditions vary within a single building so the identification of defective components may prove troublesome; and, as the building is likely to be occupied, remedial work will be difficult to organize.

(9) *Because responsibilities of participants in the process of design, manufacture, assembly and supervision are complex and sometimes ill-defined in contract, when latent defects are discovered it may be necessary for an owner to start litigation to recover the cost of resulting damage. Court procedures then take precedence over unbiased and open fact-finding. Consequently feedback to other designers and producers is restricted.*

(10) *While in traditional construction a degree of robustness and structural redundancy were the norms, this may not be so under new, possibly cost-competitive conditions. A better understanding of how structures perform has enabled designers to work closer to 'limit states' for reasons of efficiency and economy — and, possibly, as displays of technical skill.*

3.7 Conclusions

G.Atkinson's special features, certainly applicable world-wide, reflect the present stage of quality systems at the construction industry and their difficult adaptation to the standards and systems applied in general industry.

Efforts towards an effective application of the QA/QC system have been made in recent years and they have been carried out concretely through improvements, for instance, in construction management and building regulations.

While construction management is an unilateral activity taken by the contractors or construction management firms having as its main purpose cost-saving, quality-effective construction, on the other hand, building regulations, aim basically welfare and safety of the community under its jurisdiction, where also the quality control and quality assurance play an important role.

In the following chapter the practical matters of QA/QC in the construction field will be discussed, as well as their acquirement .

Chapter 4

QA/QC in Buildings and Inspection

4.1 Introduction

The main purpose of inspections in construction is to check if the work is in compliance with established standards, plans and regulations.

Many ways of classifying inspections can be considered, depending on the point of view of: a)who carries it out; b)who pays for it; c)what is it based on; d)who is responsible for it; etc.

The construction inspections can be mainly carried out by government agencies, insurance companies, private agencies, A/E, or contractors/ subcontractors; based on codes and regulations, standards or specifications; according to the interested party of the parties involved, i.e. the owner, the government agency, the contractor or the A/E.

The possible relationships can be expressed as in Figure4.1.

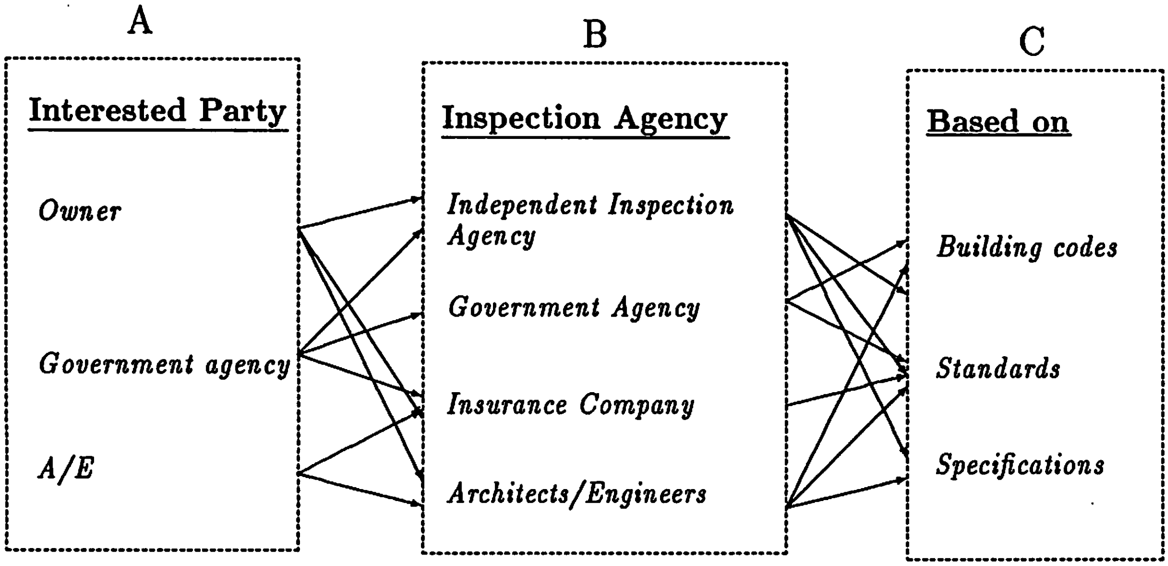

Figure 4.1: Relationships between.

Many of these relationships coexist in the construction site varying according to the policy adopted by the construction manager, the owner, and to the local code requirements.

4.2 A Comparative Analysis of Construction QA/QC

The relationship among property, quality and performance can be defined as *"Considering the physico-chemical property of a product, quality is the property required from the point of view of the purpose and, performance, the quality necessary to observe the functions required by the purpose of the product".* [5]. This relationship can be represented by figure 4.2

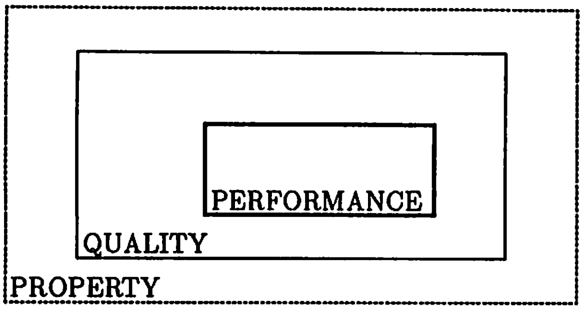

Figure 4.2: Property/Quality/Performance.

In the building construction process, particularly in a narrow meaning limited to construction and inspection, the problems concerning quality are superposed to the ones concerning performance.

The interest is first concentrated on performance as a design condition and when, passing through design and construction management, performance is carried out in practice (quality of product or work), the interest is enlarged to its faults and its assurance, where these last ones are inevitably related to quality.

Matters concerning quality are related first to faulty residential building and more recently, to QA (Quality Assurance), QC (Quality Control), TQC (Total Quality Control) and PL (Product Liability) in the construction industry.

Jack H.Willembrock *et al.* [14] present a comparative analysis of construction QA/QC systems in U.S.A. giving emphasis to the existent difference between the development of QA/QC systems in highway, nuclear power plant and U.S.Navy construction and building construction.

Those aspects of interest to this research are briefly exposed as follows:

The Highway construction has had, since 1976, systems based on a "statistically based QA/QC approach", which resulted from a research sponsored by the Bureau of Public Roads of the U.S. government.

These systems generally attempt to integrate the role of project specifications with the responsibilities of: (1)Process control; (2)final acceptance of phases of construction; and (3) quality assurance. The responsibilities are divided among the various parties involved such as the contractor, the material suppliers, and the highway agency, throughout planning, work procedures and construction management.

The QA/QC in Nuclear construction (as referred to in the former chapter) is based on the quality activities involving 18 criteria, regulated by the Nuclear Regulatory Commission (NRC). In its regulations, the NRC emphasizes that the owner of the utility is ultimately responsible for quality assurance but, through extensive reviews and inspection activities, the NRC determines whether or not QA programs of each parties involved in the construction comply with published guidelines and whether such programs are being properly implemented on the project. QA planning is an activity that occurs throughout the life of a project.

The Navy construction includes projects of piers, airfields, building, roads and other facilities, that support ships, aircraft and shore establishments. The Navy construction contracts are governed by provisions of the Armed Services Procurement Regulation (ASPR), in particular, the quality control is governed by the ASPR Clause 7-602.1, which states:

The Contractor shall (i)maintain an adequate inspection system and perform such inspections as will assure that the work performed under the contract conforms to contract requirements, and (ii)maintain and make available to the Government adequate records of such inspection.

The Navy Contractor Quality Control (CQC) Program, established in 1970, determines that the individual contractor is completely responsible for his work, and as a result, must engage in an active quality control effort. The program also recognizes the importance of good quality control plans and specifications, specific contract requirements for quality control, and active enforcement of contract provisions.

CQC procedures in Navy construction can be divided into contractor related procedures and government related procedures. Contractor procedures govern submittal processing, inspection and testing, and documentation. Corrective actions available to Navy administrators include order to remove and replace defective work, orders to remove incompetent personnel, stop work orders, issuance of unsatisfactory performance appraisals upon completion of work.

While differing in techniques, Navy enforcement, inspection, and surveillance play the same role as nuclear QA, and highway acceptance and testing. Each system recognizes the importance of quality control by the contractor or construction group but also acknowledges the necessity for owner action to ensure that proper QC takes place.

The building construction process begins with the owner who decides when a new facility is needed. An architect is typically retained to design the facility and a contractor is engaged to construct it. During the preliminary design phase the owner, in conjunction with the architect, establishes the quality, budgeting, and time constraints that will govern the project.

The drawings and specifications that the architect develops typically reference well established industry codes and standards in order to define the desired qual-

> ity levels of the various phases of the project. The emphasis on cost and schedule that occurs in a typical building construction project often results in only superficial attention being given to determining if the contractor is meeting the quality requirements . The contractor is typically not directly involved in quality control inspection because the responsibilities for testing are delegated by the owner and architect to an independent testing laboratory. Unless the owner has permanent project engineering staff assigned to the project, the QA/QC responsibilities are usually assumed by the architect under his contract administration function.
>
> Quality control planning for a building construction project often occurs in relation to the development of plans and specifications and the decisions that are made about which parties will be responsible for contract administration and for providing the required testing services.
>
> The primary documents of the QA/QC program are the specifications prepared by the architects that are pointed to be, in many cases, unrealistic, unreasonable and poorly worded, with a tendency for establishing higher quality levels and more stringent requirements than actually required. This occurs due to the assumption that contractors attempt to "get away with" the lowest quality level which is acceptable.
>
> The quality control procedures in the building construction industry are often broadly classified as "field inspection" procedures. These procedures on most projects are the responsibility of a resident engineer or architect. A well defined set of procedures for building construction field inspection or quality control are not typically developed for building construction projects as it is for the other areas pointed above.
>
> Contracts between owners and architects/engineers may specify the frequency of inspections (periodic or continuous), but they usually do not tell the inspector how and what to inspect. These matters are left to the discretion of the inspector, and although he may be guided by industry inspection codes and standards, it is often essentially his own judgment and experience which dictates his procedures.
>
> The greatest criticism of such a loosely defined approach has been that the inspectors often lack the necessary experience and technical qualifications to be left on their own without detailed directions. A good inspector can prevent major construction failures or identify deficiencies whose early correction can prevent costly and time consuming rework. An unqualified inspector can cause unnecessary time delays and adding significantly to contractor and owner costs.

Although Willembrock *et al.* [14] pointed out the difference of QA/QC systems in several areas of the construction, they did not analyze the structure of each regulatory organization. Most of the federal agencies such as NRC and the Army have systematized QA/QC programs developed due to the national importance of its acquirement, that is not the case of civil building construction.

The importance of QA/QC by contractors was emphasized, though the influence of government's agencies to its acquirement was not. The present *state of art* in navy construction as well as in nuclear or highway construction field are consequence of conditions and needs required by the government agencies who are the owners of the projects.

Looking towards the building construction case, the above showed relationship is not always true. Basically, the building owners are people that know little or nothing about construction or the importance of QA/QC during design and construction process so that the hiring of inspection services can be seen just as an increase in construction cost and time-loss for the contractors. That is what actually is happening in many cases, due to the incapability of the inspectors or no communication between inspector and contractor, etc.

Moreover, in the U.S., construction is regulated by building codes enacted in regional basis — by state, county or city governments. While a small number of municipalities write and revise their own code, most jurisdictions adopt one or more of the major model codes. The three major model code writing organizations in the U.S.A. today primarily influence four regions (see Appendix B). This situation makes the unification of QA/QC system by building regulations difficult.

As Willembrock *et al.* [14] assert, the QA/QC system is maybe better performed if taken by the contractors who can control all the construction process and prevent errors to occur. However, building regulations also play an important role in the construction process requiring the minimum level of quality in order to guarantee the safety, health and welfare of the public and the energy conservation policy.

So, building regulations are also a parameter to know the level of development of QA/QC minimum requirements and to clarify the point of equilibrium (balance) between the importance of the government's requirements, and the voluntary efforts by designers and contractors to the acquirement of quality in buildings.

4.3 The Construction Process and Inspections through Building Regulations

By definition, a building code is a "legal document which sets forth requirements to protect the public health, safety and general welfare as they relate to the construction and occupancy of buildings and structures".

The first known building code that included the protection of life as an important factor in constructions was enacted by King Hammurabi , the governor of Babylon in the 18th century B.C., and declares:

> *If a builder has built a house for a man, and his work is not strong, and*

> *if the house he has built falls in and kills the householder, that builder shall be slain.*

After the big fire that destroyed Rome in the first century A.C., the reconstruction of the city by Nero was coordinated by regulations related to construction, sanitation, and utilities. Between the 11th to 12th century, London developed a building code where party wall constructions were set forth, and the use of combustible materials for the roof prohibited, besides other provisions. London suffered from a historical fire in 1666, and as a result, the building code was drastically revised, a new standard for two to four-floor residential buildings, and fireproof structures for external walls of all kinds of constructions were required. Around 1670 the guilds' privilege was abolished and the power of majors and the systems of inspectors and supervisors was established. Since that, many improvements were made until the present building code.

The first building law in record in America was passed in New Amsterdam (New York city today) in 1625 and governed the types and locations of roof covering, a major source of fire transmission through sparks from chimneys.

Historically, administrative regulations are based in two current known as Continental law and Common law. The Continental law is the current found originally in the continental countries of Europe, and the Common law, in England and its successor, the United States.

Both are originated from the fusion of the Roman Law and German Law, though, in the Continental law the influence of the Roman law overwhelms the influence of the German law , and in the Common law, the situation is the opposite.

Rudolf von Ihering (1818 - 1892) said that "Rome has conquered the world three times. First time , by military power, the second, through the religion and last, by the law". The German origin countries were also conquered the three times; however, England was conquered the first two times but escaped from the last one.

Comparing the Continental law and the Common law, it can be said that the basic difference is that the first one gives weight to the abstract theory, on the other hand the Common law gives more importance to the solution of concrete cases, so that concrete judicial experience is taken much more into consideration. Then, while the Continental law has a statute basis concept, the Common law is based in a judicial precedent principle. Furthermore, while the the legal thinking in Continental law is deductive, in Common law is inductive.

Although the building codes basically do not differ in purpose, they present differences related to the posture assumed from the legal or judicial point of view as described above, so that the duties and responsibilities of the building administrative agency and the professionals involved in the construction differ according to the original basis — the Continental or Common law.

Building regulations, in general, regulate buildings throughout its life in the following steps:

1. Prior to the issue of building construction permit (for new buildings, rebuilding, alterations or additions);
2. During construction;
3. At completion of the works;
4. During use of the building; and,
5. At the end of use (demolition).

The first step consists of checking the project's conformity with codes and regulation requirements. When plans are approved, a building construction permit is issued. The construction is started up and building inspections are required in order to assure compliance of the works with the approved plans and the regulations. A final check is carried out at completion of works but before a permit for occupancy is issued.

Building maintenance and building demolition is required by law, essentially to assure the building and life safety.

Many of the factors acting on the two last steps are dominated by the factors of the first three ones. Once the building performance determined in the first step is ensured in the following two steps, troubles during use will not occur if appropriate maintenance procedures are taken and deterioration will be a consequence of other than the construction process at least during the estimated building life.

So, building checks during construction, at completion and during use of the building are important factors to assure the acquirement and maintenance of building performance. These procedures are enforced in many countries in Europe [15] [16] , North America [17] [18], South America [19] and Japan [20] and not only by the building regulations, but also by fire and health-related regulations and codes.

A general flowchart of the procedures necessary to be followed in the U.S. from the design phase till the maintenance phase of the building is illustrated in figure 4.3.

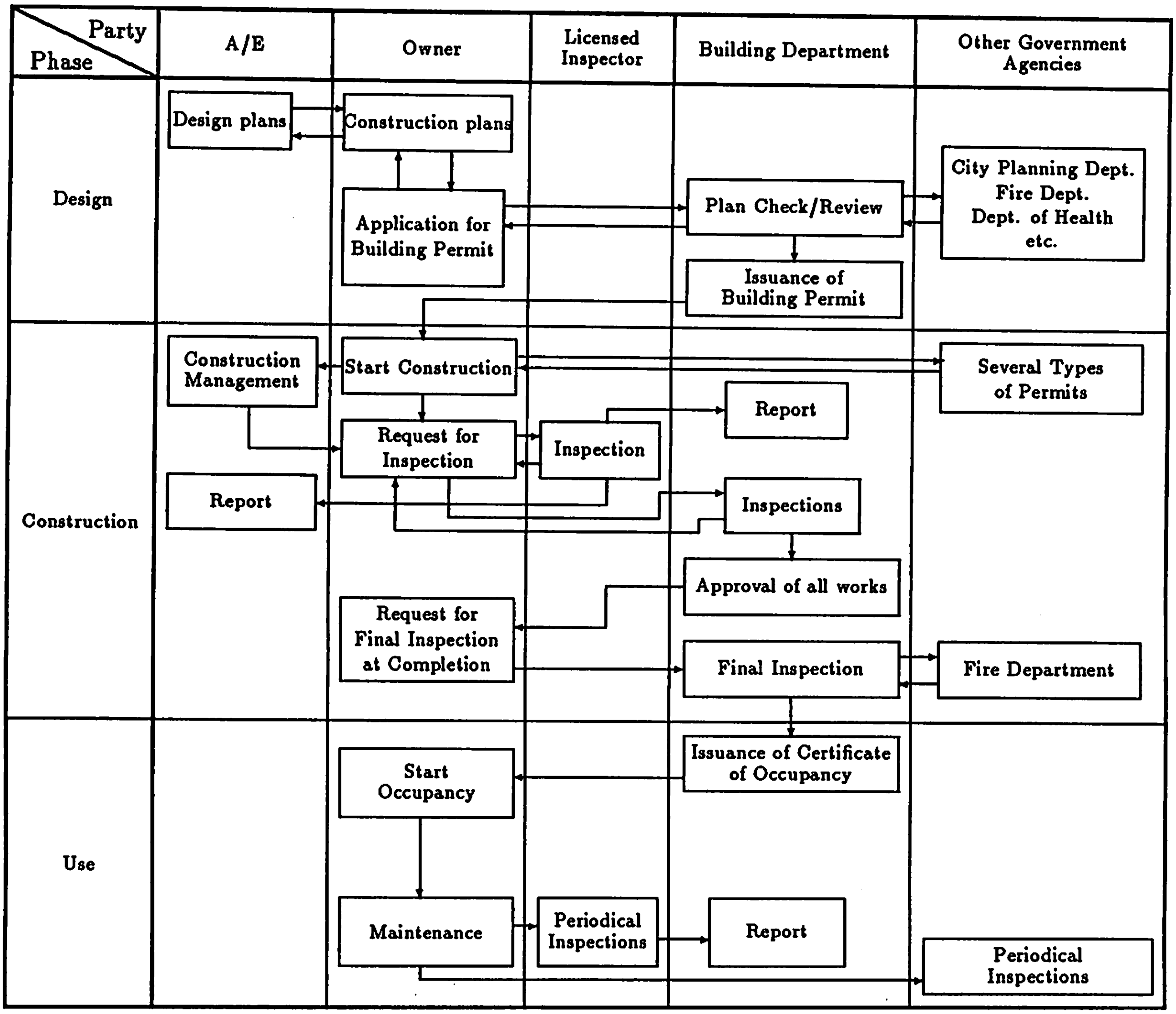

Figure 4.3: Formalities for Building Construction and Maintenance.

4.4 The Inspection System: Case Studies

4.4.1 United States

In the U.S., as mentioned before, codes are enforced in regional basis so that there are differences in their contents. The structure of the inspection system in buildings is not an exception. The difference will be pointed out taking as basis the Building Code of the City of New York [17] and the Building Code of the City of Los Angeles [18].

They were chosen for this study due to their very different characteristics concerning the subject, to the accessibility to the respective codes, and taking into account that New York and Los Angeles present different social-economical backgrounds but, both are considerably large in scale and population.

a. The City of New York

The building code of the city of New York mentions the purpose of the Department inspections in Title 27, Chapter 1, Article 21, Section 27-205 as follows:

> *"The commissioner or his or her authorized representatives, in the discharge of their duties, shall have authority to enter upon and examine and inspect at all reasonable times any building, enclosure, or premises, or any part thereof, or any signs or service equipment attached thereto or contained therein, for the purpose of determining compliance with the provisions of this code and other applicable laws and regulations."*

The Department of Buildings enforces the inspections through the employment of two groups of inspectors aiming at different levels of inspection. One is the group of Department inspectors and the other, composed by inspectors hired by the owner to carry out two kinds of inspections — called Controlled inspections and Semicontrolled inspections. Their duties and responsibilities are defined in the building code, Title 27, Chapter 1, Article 21 and Article 7, Section 27-132 respectively.

The Department's Divisions is shown in figure 4.4.

The Department is mainly responsible for the inspection of the structure in different phases, the plumbing (gas piping and standpipe) system before its concealment by walls and ceilings, and the elevators and similar systems, also in different phases of the construction. The Department should be notified that the work is ready to be inspected at least two working days prior to the desired day of inspection.

The Department of Buildings controls all the inspections during construction, including the controlled inspections, through a Permanent Inspection Record card (See Appendix C) posted in the jobsite, available at any time to be signed by the inspectors after each inspection is done.

The inspection at completion of the building, called Final Inspection, is carried out by the Department inspector and consists of a checking with the approved plans, accompanied

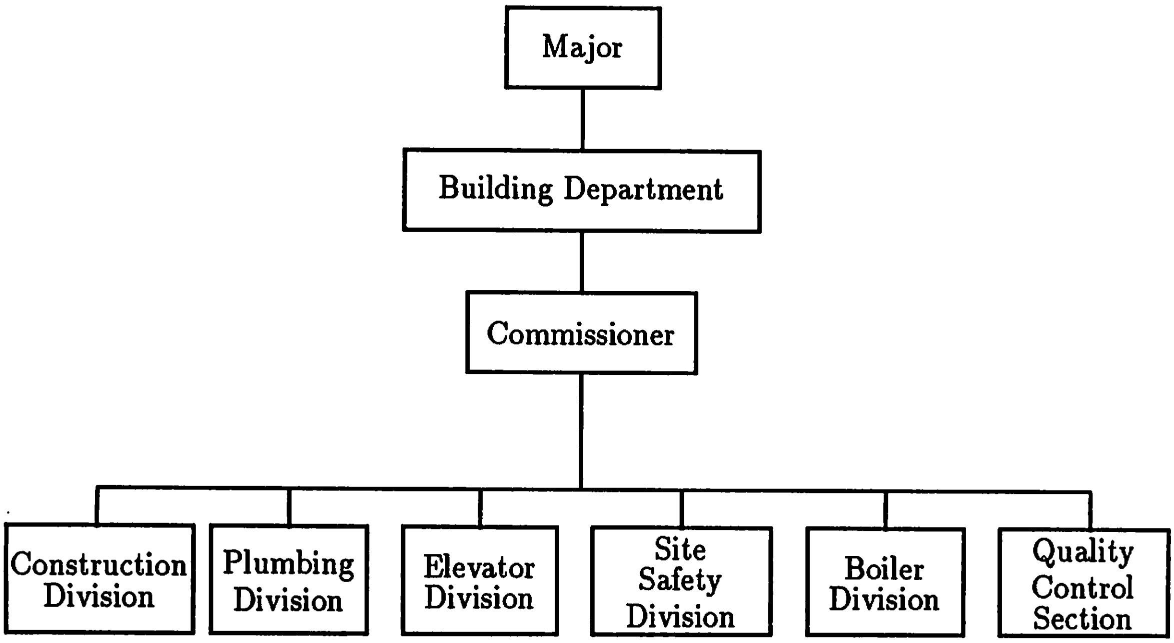

Figure 4.4: New York City Building Department.

by the Superintendent of the Construction.

The inspections during use of the building enforced by the code are periodic inspections carried out by the Department or by an Authorized Agency that submits a report of its result to the Department.

The periodic inspection of elevators, boilers, electrical systems in special cases are carried out by the Department and/or the Authorized Agency , in a yearly or semester basis. The local law also requires periodic inspection of the exterior wall integrity above certain height, carried out by a licensed engineer or registered architect once every 5 years.

Another periodic inspection carried out in the city refers to the fire safety equipment. The Fire Department is responsible for this kind of inspection.

The inspector hired by the owner for the Controlled Inspection should be qualified by the State as a Licensed Professional Engineer or Registered Architect. This qualification is obtained by a person graduated at an engineering college, with 5 years of work experience under orientation of a licensed engineer or architect and after passing a knowledge examination promoted by the State. Generally, a Professional Engineer(P.E.) or Registered Architect (R.A.) works as an inspector in a Testing Laboratory or Authorized Agency that carries out the inspection and testing of materials taken from the site. However, the

P.E. or R.A. are always responsible, personally, for his inspection since the report submitted to the Department of Buildings is stamped by him, personally. The responsibility, in some States, has a time-limited validity but in New York, the inspector is responsible for what he inspected during all his life. The Department inspectors should also have minimum qualifications determined by the City, but they are not liable to the work they inspect.

In practice, there is a shortage of Department Inspectors, and the rotation of inspectors is very fast; generally their experience as city inspectors in the Department is less than two years. The Department pointed that this is a result of a very real fact — that not so many professionals have taken the inspector's job in the Department as a carrier.

This fact has its consequences reflected on the construction site: there are not enough people for field inspection from the Department so that the task of assuring the compliance with codes and regulations is passed to the testing laboratories and their inspectors.

The building code allows Department inspections to be carried out by a controlled inspector and or by the architect or engineer hired or in behalf of the owner, since this person reports and signs the inspection report to the Department, declaring himself responsible for the inspection of the work inspected.

At this point, the necessity of a sophisticated insurance system to support the inspectors' liability should be mentioned.

The insurance companies provide many kind of insurance related to buildings, according to the interested party, which can be the owner, the contractor, the subcontractor, the designer, the inspector and so on.

Generally, each party described above has its own insurance to protect themselves. In case of licensed engineers or architects who work as inspectors, there is one called Professional Liability Insurance in which they are registered personally as they are personally responsible for what they inspect.

b. The City of Los Angeles

The purpose of inspecting buildings in the City of Los Angeles is, as in the City of New York, to protect the health and safety of the citizens and to insure that these buildings are in compliance with the approved plans and other City requirements.

Although the outline of the inspection process does not differ significantly from the system mentioned in the previous case, some very different characteristics can be seen in

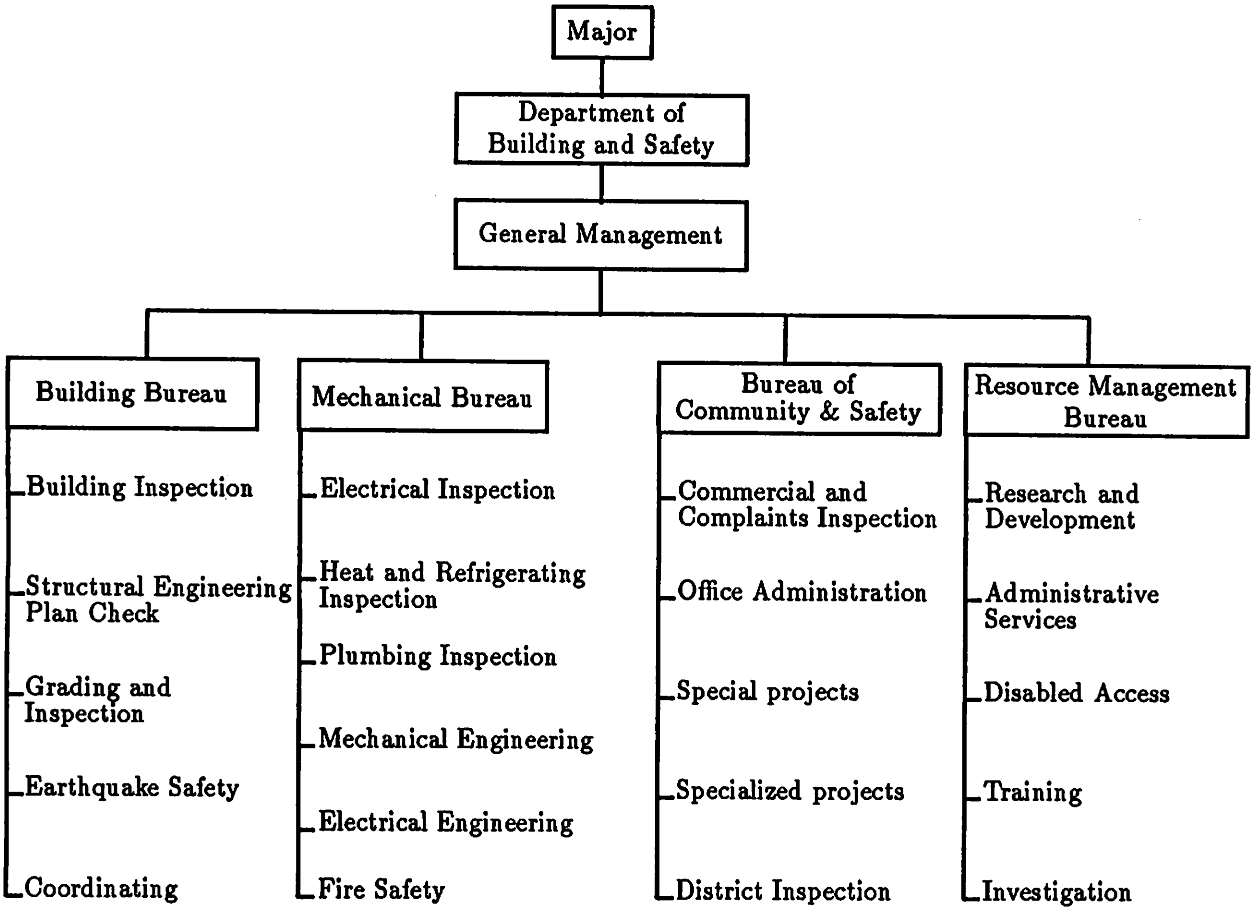

Figure 4.5: Los Angeles Building and Safety Department.

the case of the City of Los Angeles.

The Department's organization is illustrated in figure 4.5.

All construction or work for which a permit is required (works involving amounts higher than 200 dollars) should be subject to inspection by authorized employees of the Department of Building and Safety, and in addition, certain types of construction should have continuous inspection by Registered Deputy Building Inspectors. Prior to the issue of a Certificate of Occupancy, a final inspection should be made by the department of all construction or work for which a permit has been issued.

The process begins with the plan check review. Once the plans are approved, a State License Contractor may obtain a permit and begin the actual installation in whichever discipline he is involved in. Also, the department should be notified when the building or portion thereof is ready for inspection. Most of the department inspection procedures have two steps:

1. Rough Inspection which is inspection of the installation for compliance with the applicable code prior to concealment.
2. Final Inspection is the last inspection of the building which is conducted after the walls and floors and all equipment is in place and operational. This inspection is required prior to occupancy.

The deputy inspector must be present during the execution of all the work he has undertaken to inspect, including:

1. All materials to be used or concealed within such work.
2. Construction.
3. Erection.
4. Placement or use of materials.
5. Observing whether there is compliance with the City code for all work within his scope.

The works inspected by the department's employees and the registered deputy inspector are listed, respectively, in Tables 4.1 and 4.2.

The Rough Inspection is commonly known as Called Inspection as the department is generally notified by telephone calls, at least 24 hours prior to the time desired for the inspection. An inspection card is posted in the jobsite to be signed by the department inspector after the inspection is done (see Appendix C).

The deputy inspector (Registered Deputy Building Inspector)'s employment by the owner, either directly or through the architect or engineering firm in charge of the design of the structure, or through the geologic or soils engineering firm providing technical data for the project or through an independent approved inspection/test firm is required by the Los Angeles Building Code.

The inspector must be approved by, and responsible to, the architect or engineer in responsible charge of the design of the project. However, since this inspector is supplementary to the department inspectors and enforces City ordinance and is licensed by the City, the deputy inspector is also responsible to the City of Los Angeles.

Upon completion of a project, the deputy submits to the Department and to the architect or engineer of record a "Registered Deputy Inspection's Certificate of Compliance"

Table 4.1: Inspection by Department's Employees.

Inspection Types	Inspection During Construction	Inspection at Completion
1. Execution and Fills:	a) Initial Inspection b) Toe Inspection c) Excavation Inspection d) Fill Inspection e) Drainage Device Inspection f) Rough Grading g) Final Inspection	
2. Rough Inspections: (Called Inspections)	a) Footing Excavation b) Forms c) Reinforcing Steel d) Heating & Refrigeration Groundwork e) Electrical Groundwork f) Plumbing Groundwork g) Gas Piping Groundwork h) Rough Plumbing i) Rough Electrical j) Rough Heating & Refrigerating k) Rough Handicapped l) Rough Framing m) Rough Fire Sprinklers n) Insulation o) Exterior Lathing p) Interior Lathing	a) Final Electrical b) Final Gas c) Final Heat. & Refrig. d) Final Fire Sprinkler e) Final Handicapped f) Final Grading g) Final ....

reporting on all work being inspected and approved. Also, regular interim reports are required as work progresses attesting to compliance with the code.

The architect or engineer of record is then required to submit an "Architect or Engineer's Certificate of Compliance" stating to the best of his knowledge that the structure utilizing higher stress or the grading project was constructed or graded in conformity with the approved plans and reports.

Here, also, the insurance system is applied to the inspectors other than those employed by the Department of Building and Safety and the architects and engineers responsible for the construction. The deputy inspectors, generally employed by testing laboratories approved by the city, are liable, despite the insurance is not taken personally but by the laboratories. The architects and engineers are personally liable to the work they coordinate so that they are protected by a Professional Liability Insurance.

The Department of Building and Safety of Los Angeles has faced many problems related to inspection along the years. One of these problems arises from the fact that there are very few available applicants in the workforce who are qualified to come into the city as full inspectors based upon their past experience. In order to solve this problem in

Table 4.2: Inspection by Registered Deputy Inspector.

Inspection Types	Inspection During Construction
1. Special Inspections	a) For use of higher stresses in: 1. Reinforced concrete work. 2. Reinforced masonry work. 3. Welded steel work. b) Under all conditions with the use of: 1. High-strength bolts. 2. Pneumatic mortar. 3. Class B reinforced gypsum concrete. 4. Concrete elements precast at other than jobsite. c) Special conditions of grading & foundation earthwork in hillside area. 1. A contiguous grading area exceeding $60,000ft^2$. 2. An excavated or filled slope steeper than two horizontal to one vertical. 3. An excavated slope exceeding $40ft$ in height and the top of which is within $20ft$ of a property line coterminus with improved private property or public way. 4. Foundation excavations below a one horizontal to on vertical plane inward and down from the property line.
2.Concrete	Concrete ductile moment-resisting space frame over $160ft$ height.
3. Steel	Structural Steel moment-resisting space frame over $160ft$ height.
4. Controlled Activities	a) Required in accordance with regulations promulgated by the superintendent when: 1. The structure is more than 5 stories or $60ft$ in height. 2. The structure exceeds $50,000ft^2$ of ground area or $200,000ft^2$ of total floor area. 3. Nondestructive structural testing methods are utilized. 4. The quality identification marking of the material used are not inspectable after installation. 5. The manner of use of materials precludes full inspection after installation. b) If the superintendent determines the need of inspection in: 1. Unique, novel, or innovative construction. 2. Highly complex or intricate construction. 3. New methods of construction not yet provided for in the rules and regulations.

the early 1960's, a program for training members of the public to be building inspectors has been developed by the Department. This program is known at present as Assistant Inspector Program. With a four-level training and work schedule which combines on-site and classroom experience, the program ensures that the Department has a committed team of inspectors with a broad knowledge of the standards set by codes.

The individual that passes for all the levels and concludes this program is called Building Mechanical Inspector (B.M.I.), and is able to inspect all phases of the construction and conservation of one- or two-family dwellings alone.

The majority of the Department's inspection force have come up through the Assistant Inspector program. This statistic stands at every level including senior inspectors (73%), principal inspectors (71%), and chief inspectors (67%).

Another problem in the inspection is the fact that there are many processes that take place during the construction of a building which continuous inspection is necessary. The department developed the Registered Deputy Inspector Program during the early 1960's, realizing that the continuous inspection by the department would require a significant increase in their workforce, as well as the commitment of limited resource in the city.

The goals of this program were to test and certify a large number of private sector inspectors who would be qualified to perform the highly critical inspections which generally require the continuous presence of a building inspector. This program has increased in scope over the years and continues to be modified as needs arise.

Each applicant is tested by an examining board of city inspectors appointed by the Superintendent of Building. Generally applicants are former journey level building trades craftsmen with a minimum of four years experience consistent with the type of certificate applied for. Others, qualify because they have been a building inspector, have had formal education from a recognized college or national organization or are licensed engineers or architects in the State of California.

Each license must be reexamined every three years. Currently, there are approximately 1,200 licenses in force which are held by 600 people. Many of these individuals work for independent testing laboratories who are also licensed by the City.

The Department issues licenses in the following types of specialties:

1. Reinforced concrete
2. Reinforced masonry
3. Structural steel welding
4. Grading
5. Various controlled activities

Deputy inspectors are required by code to report their work location to the City at least 24 hours prior to starting work. Failure to report is a major violation of their license and may result in the suspension or revocation of his/her license.

During the execution of the work, the deputy inspector should not undertake or engage in any other task or occupation which will interfere with the proper performance of his duties of inspection.

The inspection of buildings during its use is a complex problem in Los Angeles, still to be solved. The codes require buildings to be maintained by the owners but inspection is not required.

The buildings for low-income population (residential type) are the ones requiring maintenance inspection but problems concerning the payment of its cost are still being discussed. A program has been developed to be applied soon for this case and consists of a maintenance inspection every 3 years carried out by the Department but paid by the owner ($30 per unit). The repairing cost has to be also paid by the owner.

The Commercial Buildings are inspected yearly by the Fire Department. They inspect the fire safety, life-safety and proper use of the property. Any violation is reported to the Department of Building and Safety that issues an order after confirming the violation by sending inspectors to the area. The inspectors of the Department of Building and Safety also inspect zoning violations, working together with the Department of Planning.

c. Conclusion

Common points could be seen between these two codes — the plan check, the building permit issue, the inspections during construction and at completion, etc.— but the procedures taken in each of these phases are considered in very different ways.

The reasons can be many, but some of them are very clear, such as the geographical characteristics. New York City is located in a cold region where there is no earthquakes, and as consequence, high-rise buildings were allowed to be built since early times supported by its regional importance as a trade center.

The Department of Buildings of the City of New York carries out plan checks of only specific points, the structural designer is the one responsible for the construction.

However, the Department cares about the maintenance of elevators, boilers, and other building equipment/services besides the maintenance of the integrity of exterior walls of high-rise buildings. The reasons are obvious and typical of this City.

On the other hand, Los Angeles City is in a warm region where, during winter, the population increases significantly due to the migration of people running away from the cold of the north region (generally, homeless people). High-rise buildings have been started up in an accelerated rhythm just in the last ten years. One of the reasons is the typically touristic character of the city — now changing progressively. Another reason remains in the geographical characteristic — the zone is extremely susceptive to earthquakes. Nowadays, the development of earthquake-resistant design systems have stimulated constructions of high-rise buildings together with the development of a new economical situation in L.A.

The Department of Building and Safety of the City of Los Angeles cares about the quality of the structures built in the city in such a way that plan check of high-rise building structures are exhaustively done prior to the issuance of the building permit. Generally, plan checks for this kind of buildings take 8 to 9 months, period during which the plans are checked, given back to the structural designer for corrections and rechecked several times until the final approval by the Department Engineer is given.

In general, while the Department of Buildings of New York lets the construction process to proceed without so much intervention, leaving the matters to be decided between the designer and the owner, the Department of Building and Safety of Los Angeles requires inspections to be done by their employees, without which the work cannot proceed, and for which the owner of the building pays a significant amount of money (the sum of fees paid for plan check until the issue of the building permit and for all the inspection are equivalent to 1% to 1.5% of the total construction cost).

The presence of the department in L.A. is much more outstanding than in New York. In New York, some of the department inspections can be substituted by other kinds of inspections and inspectors (that's what actually occurs); but in L.A. inspection by inspectors other than the city employees are only complementary to their inspection in order to comply with the requirements of the codes and regulations.

4.4.2 Japan

The building construction in Japan is enforced in a national basis by a law called *"Building Standard Law"*. The Building Standard Law is composed by regulations concerning building, zoning, housing and building services. *"Superintendency of Buildings"* is the name of the building authority established in regional basis — Prefectural, Municipal or Town — that enforces the law.

The process that follows the building during its life and includes the design, construction, use and demolition is illustrated in figure 4.6.

The Building Standard Law requires the owner of the building to be constructed to submit an *"application for certificate "* with plans and specifications to the Superintendency of Buildings prior to the starting up of construction. The Superintendency checks the compliance with all regulations related to construction and emits a *" notice of com-*

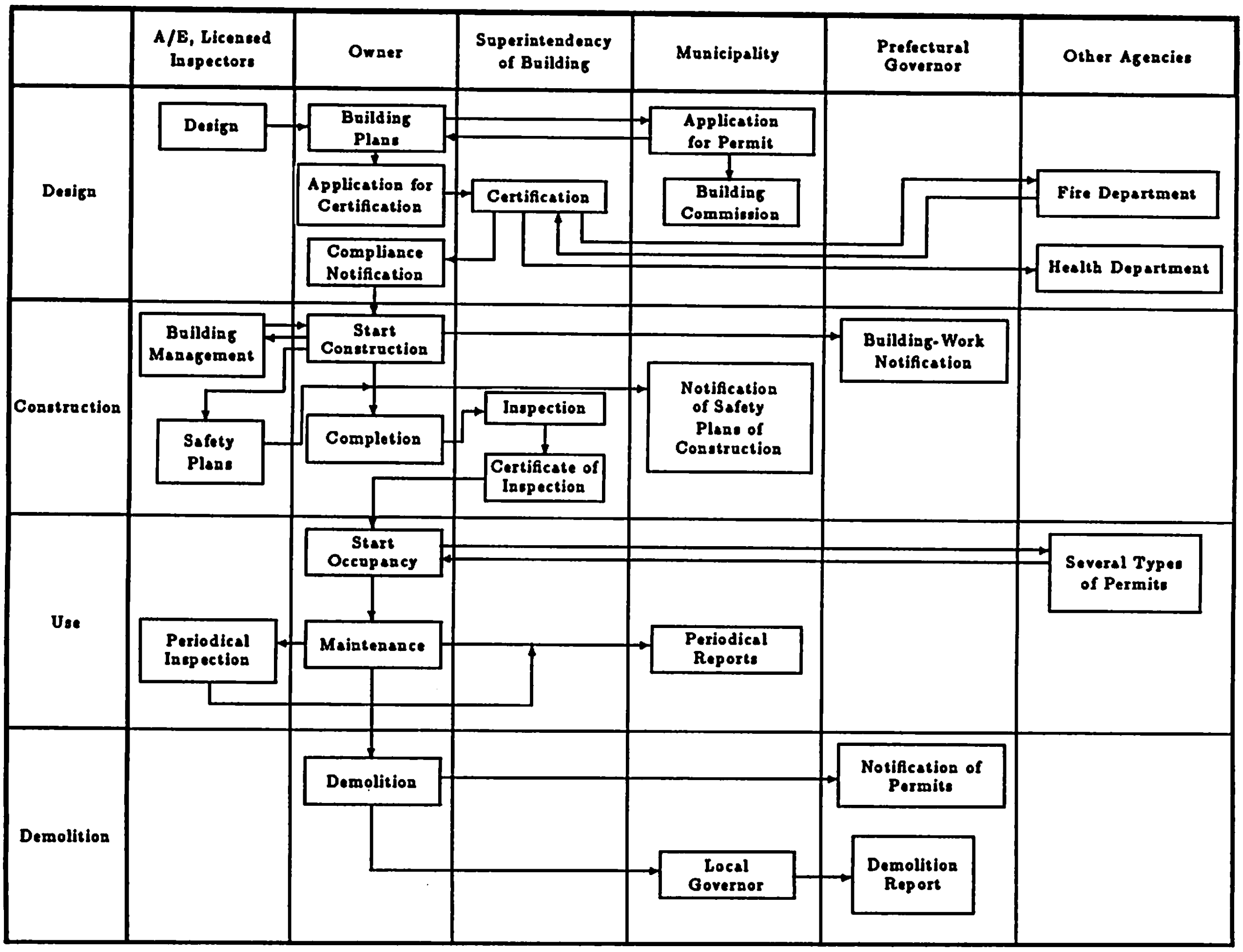

Figure 4.6: Building Activities and Formalities in Japan.

pliance" to the owner when the application is approved.

Generally, only the "*application for certification*" procedure is required by the Superintendency of Buildings, though, in cases where some special limitations or moderations (i.e., construction over the street line, use other than that permitted by zoning, change in the building or occupation rate,etc.) are required by the owner, it is necessary to submit an "*application for permit*". Then, the case is exposed in a public hearing and examined and judged by a Commission of the municipality.

Before starting up, the owner should submit a "*building work notification*" to the Prefectural Governor, that sends it to the Ministry of Construction for statistical data processing. This procedure is followed so that the situation of building activities in the country can be known.

The construction should be carried out according to the approved plans and an ar-

Table 4.3: Inspection in Japan for Health and Building Safety (during construction and completion).

Subject	Regulation	Report to	Contents
· Building-General · Building Equipments · Elevators and Escalators	·Building Code	·Building Official	· Application for building permit. · Inspection and report of work related to building equipments and structure during construction (interim inspection and report). · Notification of the completion followed by the final inspection and the issue of inspection certification.
· Electrical Installations	· Electricity Enterprises Act	· Ministry of International Trade and Industry	· Application for inspection before use.
· Plumbing Installations	· Local Water Supply Act	· Water Service Enterprises Supervisor	· Application for water supply works. · Notification of the completion followed by inspection.
	· Local Sewerage Act	· Sewerage Supervisor	· Notification of completion works followed by inspection and the issue of inspection certificate.
	· Septic Tanks Act	· Prefectural Governor	· Issue of inspection certificate based on the confirmation and notification of the completion of works (Inspection also during construction –dimensions and fulling).
· Gas	· Gas Act	· Gas Service Company	· Application for gas installation works. · Application for gas supply and exhaust system work permit.
· Heating, Ventilation, and Air-Conditioning System	· High Pressure Gas Control	· Prefectural Governor	· Application for final inspection followed by the issue of inspection certificate.
	· Labor's Health and Safety Act	· Chief of Labor Standards Inspection	· Inspection of the boiler and pressured vessel structures and the completed work followed by the issue of inspection certificate.
	· Fire Code	· Prefectural Governor	· Application for oil tank setting permit, inspection during construction, and final inspection followed by the issue of inspection certificate. · Inspection of equipments that use fire (furnaces, cooking ranges, boilers, etc ...).
· Fire Protection System	· Fire Code	· Fire Marshall	· Inspection of fire protection system after the completion of works and the report of test results.

chitect should be the one responsible for the design and construction management of buildings above certain scale.

The Superintendency of Buildings has the authority to require reports from the construction manager, owner, designer or contractor, about the circumstances of the construction or work during construction.

The representative of the Superintendency has the power to enter in the building site to inspect the works related to building, building site, equipments, materials, specifications, and carry out tests and ask questions to the owner, designer or construction manager, in order to certify, inspect, give orders or notices about violations.

Other kinds of inspection are required by law and regulations related to buildings such as Fire Code and Local Sewerage Act (See table 4.3).

The application procedures for additions, alterations and change of use of buildings are the same as for new building construction.

The owner of the building or his representative has to report the completion of the construction within seven days after completion, in order to submit the building to a *"final inspection"* . When compliance to laws and regulations are certified, a *"certificate of final inspection"* is issued by the Superintendency to the owner and the occupation of the building is allowed.

The building site, structure and equipments of some types of buildings determined by the Municipality are required to be inspected periodically by qualified professionals licensed by the Ministry of Construction during use in order to check life safety and fire safety performance, the result having to be reported by the owner or building manager to the Municipality. These inspections during the use of the building are regulated by the Building Standard Law, and several other laws such as Fire Code, Energy Saving Act, Water Service Act, etc. (See table 4.4). The qualified professionals are qualified inspectors or surveyors[1]; or, first-class or second-class architects.

Qualified Professionals

The titles of first-class architect and second-class architect are given to individuals that succeed in examinations promoted by the Ministry of Construction. Those applicant should have one of the following classifications to be eligible :

First-class architect: graduation from a recognized university (except junior college) in Civil Engineering or Architecture and more than two-year experience in building activities; or graduation from a recognized junior college completing three years of study in Civil Engineering or Architecture and more than three-year experience in building activities; or graduation from a recognized junior college or special school in Civil Engineering or Architecture and more than four-year experience in building activities; or four-year experience as second-class architect; or, knowledge and skill superior to the those qualifications cited above, recognized by the Ministry of Construction.

Second-class architect: graduation from a recognized university, college or special school in Architecture; or degree in Civil Engineering and more than one-year experience in building activities; or graduation from a recognized high-school in Civil Engineering

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[1] Determined by Notification No.1825 of the Ministry of Construction (1980) — qualified surveyor of special buildings, qualified inspector for elevators and qualified inspector for building equipments.

or Architecture and more than three-year experience in building activities; or knowledge and skill superior to those qualifications cited above, recognized by the municipalities; or more than seven-year experience in building construction.

4.5 Conclusions

As could be seen, inspection of buildings and building equipments are required by law and regulations, at different levels, either in the U.S. or in Japan. While the purpose of the inspections during construction is to guarantee the acquirement of the performance of works that once concealed in walls or floors and ceilings will be impossible to check, the final inspection aims the checking of the final product. On the other hand, the inspections during use of the building is carried out to guarantee the performance of building systems and equipments for the safety and health of the users.

In the Japanese laws and regulations, great importance is given to the maintenance of building equipments and less, to the inspections during construction. The U.S. counterparts have considered exactly the opposite situation essential.

From this situation, one conclusion can be taken: the understanding of the very different social and cultural background of each country is very important to an effective analysis of the matter.

This analysis will take place in the next chapters, though, it can be said here that the Japanese building construction industry has been strong enough to develop new technologies and control by its own the quality and performance of the buildings, so that these actions frequently have overpassed the minimum conditions required by law.

On the other hand, it is known that the responsibility of professionals is a subject of many disputes in the U.S. construction industry. One of the reasons of the slow development of new construction systems and materials is the high risk these professionals should assume when they employ new technics, systems and materials. The serious consequences this situation can bring is the inhibition of the development of the construction industry as a whole. The liability of professionals and its role in the construction process will be also discussed in the next chapter.

Table 4.4: Inspection in Japan for Health and Building Safety (during the life of the building).

	Subject	Regulation	Cycle	Report to	Application
(1)	Maintenance of buildings Safety-General	Building code			All buildings
	Periodical inspection and report	Building code	1/1 to 3 years	Local Authority	Special constructions like schools, hospitals, markets, public baths, hotels, lodgings, garages, residential buildings $\geq 100m^2$ in area and office building and similar constructions $\geq 5 floors$ and $\geq 1,000m^2$ in area.
	Building Systems -Periodical inspection and report: Emergency Lighting, Ventilation, Water Supply and Drainage, and Smoke Exhausting System	Building code	Once a year	Local Authority	
	Design and Construction Management-General	Building code			Construction work of an extension or/and a remodeling, a big repair, a rearrangement, or changing of use.
(2)	Maintenance of electrical System-General	Electricity Enterprises Act			System with high voltage or a demand $\geq 50kW$ ($20kW$ in case of Theaters, Department stores, Assembly Halls, etc.).
	Installation of Electrical Communication System under supervision of a professional responsible for the terminal	Electrical Communication Enterprises Act			
(3)	Inspection of water Storage tanks facilities	Water Service	Once a year	Local Public Health Center	Tanks with an effective water storage capacity $\geq 10m^3$.
	Maintenance of Septic Tanks for sewage	Septic Tanks Act	Once a year	Prefectural Governor or Local Authority	Building equipped with septic tanks.
	Maintenance of facilities Treatment and Cleaning of waste	Law concerned to treatment and cleaning of waste			Tanks with a treatment capacity for building population ≥ 501 persons.
(4)	Periodical inspection and report	Building code	Once a year	Local Authority	Elevators, Escalators and Dumbwaiters.
(5)	Rationalization of energy in industries, buildings and equipments.	Energy Saving Act			
(6)	Maintenance of boilers	Labor's Health and Safety Act Regulation for safety of boilers and pressured vessels			heat transfer area: $\geq 3m^2$ for steam boilers, $\geq 14m^2$ for hot water boilers, $\geq 30m^2$ for monoflow boilers. (There are cases where the the maintenance is required for heat transfer area values less than above).
	Maintenance of pressured vessels (hot water storage tank, heat exchangers, etc.)	Same as above			Pressured vessels with: gage pressure $\geq 1kgf/cm^2$, Volume $\geq 0.2m^2$
	Inspection of performance of Boilers	Labor's Health and Safety Act Regulation for Safety of boilers and pressured Vessels	Once a year or $\frac{1}{2}$ a year	The Labor Standards Inspection Office	Steam boilers: pressure $\geq 1kg/cm^2$ heat transfer area $\geq 1m^2$ Hot Water Boilers : water head $\geq 10m$ heat transfer area $\geq 8m^2$ Monoflow Boilers: pressure $\geq 10kg/cm^2$ heat transfer are $\geq 10m^2$

(1)= Building, (2)= Electrical installations, (3)= Plumbing installations, (4)= Elevators and Escalators, (5)= Energy, (6)=Heating, Ventilation, and Air Conditioning system.

Table 4.4: (Continued)

	Subject	Regulation	Cycle	Report to	Application
(6)	Inspection of performance of Pressured Vessels	Regulation for Safety of Boilers and Pressured Vessels	Same as above	Same as above	Pressured Vessels with: Gage pressure $\geq 1 kg/cm^2$, Volume $\geq= 0.2 m^3$
	Maintenance of Dangerous Products (Oil Tanks)	Fire Code			Storage or Work with: kerosene or light oil $\geq 500 l$, heavy oil $\geq 2,000 l$, gasoline $\geq 100 l$.
	Maintenance of High Pressure Gas of Refrigeration Machines	High Pressure Gas Control Acts			Refrigeration Machines $\geq 20 t/day$ (approximately $120 Rt/h$), excluding the absorption type.
	Inspection of High Pressure Gas of Refrigeration Machines	Same as above	Once in 3 years	Prefectural Governor	Refrigeration Machines $\geq 20 t/day$ (approximately $40 Rt/h$), excluding the absorption type.
(7)	Maintenance of the Environmental Hygiene of buildings	Law concerned to Hygienic Conditions in Buildings		Local Public Health Center	Theaters, Department Stores , Halls, Offices, $\geq 3,000 m^2$ in area and Schools $\geq 8,000 m^2$ in area.
	Maintenance of the Technical Facilities related to Labor's Health and Safety at workplace	Labor's Health and Safety Act			Workplaces that employ ≥ 50 workers during the regular time.
(8)	Protection of Life Environment and Health of the Population – Special Facilities for Industries and Offices.	Air Pollution Control Act, Vibration Control Act, Noise Control Act, and Water Pollution Prevention Act		City or Prefectural Environmental Pollution Section	
(9)	Fire Extinguishing and Fire Protection in Buildings – Preparation of firefighting plan and implementation of fire prevention management system.	Fire Code		Fire Marshall	For buildings with population ≥ 30 or ≥ 50 persons.
	Inspection and report of Firefighting System: · Alarm System: Automatic Fire Detection Electric Leakage Detection Gas Leakage Detection · Emergency Alarm System · Fire Extinguishing System: Portable Extinguisher and Standpipe, Sprinkler, Water Spray, Foam, Carbon Dioxide, Halogen, Chemical Powder, Fire Hydrant, Water Pumping, Water Sprinkling Connection. · Facilities required for Firefighting : Water Supply Connection Emergency Electric Outlet Wireless Communication Support · Evacuation System : Guiding Illumination Equipment for Evacuation	Fire Code	Once half a year or Once a year	same as above	Buildings $\geq 1,000 m^2$ in area.

(6)=Heating, Ventilation, and Air Conditioning system, (7)=Environmental Hygiene ,
(8)=Environmental Pollution, (9)=Fire Protection and Prevention

Chapter 5

The Professional Liability and Inspection

5.1 Introduction

When faults are found in building constructions, responsibilities are asked for, due to damage caused to property and/or life consequently causing social losses.

Three are the main causes of these faults: a)insufficient specifications; b)failure to follow the specifications during construction and, c)failure to inspect the works according to specifications and standards.

In this chapter, matters concerning liability of professionals in construction – particularly the role of inspections – will be pointed out, together with its situation in relation to construction contracts in the U.S. and Japan. Furthermore, examples of cases of failures in buildings due to faults in the construction phase in the U.S.A. and the situation in Japan will be given.

5.2 Liability

5.2.1 Definitions

Black's Law Dictionary [21] defines *Liability* and to be *Liable* as follows:

Liability: *It has been referred to as of the most comprehensive significance, including almost every character of hazard or responsibility, absolute, contingent, or likely.*

Liable: *1.Bound or obliged in law or equity; responsible; chargeable; answerable; compellable to make satisfaction, compensation, or restitution. Obligated; accountable for or chargeable with. 2.Exposed or subject to a given contingency, risk, or casualty,* *which is more or less probable. Exposed, as to damage, penalty, expense, burden, or anything unpleasant or dangerous. 3.Condition of being bound to respond because a wrong has occurred.*

Furthermore, the following terms and definitions are also helpful here:

Joint Liability: *One wherein joint obliger has right to insist that co-obliger be joined as a codefendant with him, that is, that they be sued jointly.*

Liability Insurance: *is that form of insurance which indemnifies against liability on account of injuries to the person or property of another. It is distinguished from indemnity insurance", and may be issued to cover the liability of, for example, carriers, contractors, employers, landlords, manufacturers, owners, and railroads. Liability insurance may extend to automobiles, elevators, fly wheels-libel, theaters, and, vessels.*

Indemnity Insurance: *is applied to contracts which provide indemnity against loss, and not the contracts which provide for indemnity against liability.*

5.2.2 Japan

As shown in the former chapter, inspections by a third party on behalf of the owner during building construction is not a common practice in Japan. Consequently, claims against faults during construction and after the completion of the work are directed to the responsible for the work – the contractor or the architect/engineer – and concentrated mainly on the first.

Concerning disputes related to faults in construction between the owner and the architect, based on an analysis of data-base made by the Japanese Law Center (Nippon Houritu Sentah), called “LEGALBASE” [22], among the 46,194 judicial precedents stored, only four contain the word ‘architect’. The total number of cases involving indemnity in construction is 44, most of them involving the government, and only two involving “indemnity” and “architect” but none of them involving the responsibility of the architect in matters concerning defects in the design or construction.

The reasons of disputes with government (Superintendency of Buildings) is the arising number of concerted action by local residents against the development of new building projects.

Why are the disputes involving architects and faults in construction very rare in Japan? The reasons are many and very clear when the Japanese society and its construction system is considered. Construction disputes are mainly related to contractors and most of the cases are solved by self-settlement, as settlement through private negotiation allows both sides to save face and maintain a spirit of group harmony and cooperation.

Another factor behind this situation is the architects' position in the society – the non-seeking for the architect's responsibility can also mean that this professional has not been socially recognized.

K.Kashiwagi *et al* [25] state the actual situation of construction contract as follows: *"... the contract itself is governed by the Civil Code, Commercial Code, and various other laws and ordinances relating to private agreements. The Ministry of Construction oversees the implementation of these laws, licenses of contractors, and sets industry standards. In addition, professional and trade organizations such as the Architectural Institute of Japan, the Architectural Association of Japan, the Japan Architects Association, the Japan Society of Civil Engineers, and the Associated General Contractors of Japan, Inc. help determine industry practices."*

Concerning disputes, the same authors say *"... they are almost always settled by the parties themselves. In the event the parties are unable to do so, they may submit the dispute to mediation or arbitration, ... The courts are used only as a last resort for setting construction disputes."*

Legally, according to the Article 638 of the Civil Code [23], the contractor is continuously liable to the construction during a period of five years for "normal" construction (wood) and ten years for "solid" construction (brick/stone masonry, steel, reinforced concrete or reinforced masonry), and five years for foundations. The time is counted from the transference of the product or service . In case of damage or failure of the construction during the above mentioned period due to faults in the construction, the indemnity or repair within one year is required.

For subjects other than construction, the liability period is one year from its delivery or transfer to the orderer. The orderer can seek for repair or indemnity that corresponds to repairing cost within this period, according to Article 637 of the Civil Code.

However, there is an exception to the Article 638 which determines that if, through a contract, the orderer agrees to reduce the liability period to two years, this agreement will be valid and it will not be considered as a violation of the statement of the mentioned article.

In practice, the general contractor is used to making contracts with liability of 2 years, though as they work based on the trust and reputation, they guarantee the ‘after-service’ or repair of faults even after the mentioned period, so that rarely disputes occur.

5.2.3 U.S.A.

The Liability

In the United States, professionals are all liable so that liability insurance is taken by all parties involved in jobs. The professional liability insurance covers liability for errors, omissions, or negligent acts arising from the performance of professional services and the cost of legal defense including investigation, lawsuits, and arbitration. Provision of legal defense is of no little significance since the costs of defense, even in groundless claims, can involve very large amounts of money.

The period of the liability of a professional is variable from state to state. In the city of New York, for example, the architect or engineer is liable for the work they carry out during all their life. Some states have a special statute of limitations for professionals. The Michigan statute [26], asserts that an action against an architect, engineer or surveyor claiming property damage, personal injury or death arising out of a defective or unsafe condition of an improvement to real property, must be started within six years of the time of the injury. Several states have such statutes, with time periods of from six to ten years and also other states can be expected to enact such special protective devices for architects, engineers, contractors, builders and designers.

The insurance companies provide many kinds of insurance related to construction, according to the interested party, which can be the owner, the contractor, the subcontractor, the designer and the inspector. Some of these insurances are Contractor's Liability Insurance (workmen's compensation, employer's liability, public liability, property damage liability, contractual liability, etc), Project and Property Insurance, Owner's Protective Liability Insurance, Professional Liability for Architects and Engineers, etc.

The Disputes

Disputes can be classified mainly into two different types, according to the obligee that can be the owner or a third party (unconnected with the contract for claims of negligence or errors) .

If, today, an architect violates a duty owed to a third person, he may be liable for injury to him even if his contract with the owner exculpates him from liability to the owner. That is, the exculpatory clauses, which comprise a substantial part of the owner-architect contract, will not relieve an architect from his duty to third persons.

The architect, in his basic contract, has a general obligation to follow the construction, to certify the interim payments and to give final approval to the work. On many projects, the architect is required, by separate contract, to have staff on site to solve all problems of interpretation of the contract, to solve conflicts in the drawings and to approve shop drawings, samples, and the like. This supervisory stage of the architect's work is the main source of the third-party suits.

Every architectural contract contains some standard exculpatory language absolving the architect from liability. The American Institute of Architects constantly monitors all suits in the architectural field and publishes the results in the AIA *Building Construction Legal Citator.* The standard contract is valid as between the owner and the architect, so that, as to the owner, the contract prevails, but as to the third person, the duty of due care prevails.

Concerning disputes related to the construction phase, as it was mentioned before, the local department of building and its employees are not liable for the work they approve or inspect. The disputes seeking for responsibilities involve the owner, the designer, the contractor or the inspectors but never the governmental agencies, in case of private properties (the situation may be different if the owner is a governmental agency).

The Inspections

As shown in the former chapter, codes and regulations vary from state to state and municipality to municipality, so that nothing can be taken as a general case. However, inspections of buildings during construction and at completion are required in most of the cases and, generally, inspectors are hired to do the job.

Inspectors, other than government employees, required to inspect the work accomplishment with codes and regulations, specifications and drawings, can be specialized professionals who carry out only inspections (an independent professional or employed by an independent agency) as in the case of the city of Los Angeles, or professionals directly responsible for the design, e.g. the structural engineer, the architect or the residential engineer (who represents the designer/architect or engineer at the jobsite), as in the case of the city of New York . These variations can be found basically according to the requirements adopted by the local government and the contents of the professional services contracts.

Particularly in the case of the city of Los Angeles, when the inspector is hired by an independent inspection agency or laboratory, these agencies or laboratory are liable for the work of their employees, if not, he is personally liable. In the case of the city of New York, two situations are identified: first, where the inspection is carried out by the architect or engineer responsible for the construction and second, where the inspection is carried out by a staff under the supervision of the architect or engineer. In both cases, the responsible architect or engineer is liable for the work, but in the last case, the inspector can be jointly liable, together with the architect or engineer.

Most of the design of a major project is a joint venture by which several architectural and engineering firms combine to do the work. The architect who initiated such joint venture can be liable for the work of the other joint venturer brought into the project, although if a firm does a limited part of the work, it will be liable only for its own work, not for the entire project.

If the inspection agencies and the independent inspection professionals are considered joint venturers carrying out a limited part of the work, their liability will be restricted to their own work.

On the other hand, responsibility is placed on the contractor for supervision and direction of the construction process. However, the architect-engineer should, under the contract, have the opportunity to observe such portions of the work as he may deem necessary before being covered.

Furthermore, the contractor is required to correct all defective work at his own expense, whether observed before the date of substantial completion or within one year thereafter.

As it can be seen, each party involved in the construction has its own duty and responsibilities and the inspection plays a very important role in the process. A well performed inspection, since the specifications and drawings are complete and able to fulfill all the requirements for satisfactory building performance, can reduce the liability of engineers/architects and the owner, under whom the inspectors carry out their job.

Consequences of inadequate or absence of inspections

The following examples [24] of failure was attributable, in part, to inadequate or non-existence of inspection during construction:

> *"8:00 p.m., July 17, 1981.A walkway suspended by steel rods high above the lobby floor of Kansas City's Hyatt Regency Hotel suddenly plunges earthward, bringing instant death to over 100 people. A major design error is later discovered in the way the walkways were supported by the steel rods."*
>
> *"On March 17, 1981, a multi-story condominium under construction in Cocoa Beach, Florida collapses, killing 11 and injuring several. Among the key causes of failure of the concrete-frame building: a design error; and placement of rebars in the wrong position."*
>
> *"Back in 1975, a major portion of a 14-story concrete-frame building under construction on Commonwealth Avenue in Boston collapses, killing several workers. The structural concrete subcontractor and the general contractor later testify they had never seen the architect or the structural engineer – or their representatives – on the building site. The structural concrete contractor also reveals he'd never even spoken with the project architect or structural engineer. No architect or engineer was retained to see that the design was implemented. Among the causes of failure: deficient shoring and reshoring; and design and reinforcing steel deficiencies."*

The above cases have been the most considerable ones in recently years. However, they do not represent the actual situation of consequences of most failures in inspecting construction work, though their existence can not be neglected.

Architect and the inspection responsibility

The scope of architectural and engineering (A & E) services varies widely, depending upon the nature of the project, the planning and programming capabilities of the owner's organization, and with corporate clients or government agencies, the extent to which the owner carries out supervision and inspection functions while the project is under construction. The *Basic Services* as defined by the American Institute of Architect in the *Standard Form of Agreement Between Owner and Architect* [1] are considered to be rendered in five phases:

1) Schematic design phase
2) Design development phase
3) Construction documents phase
4) Bidding or negotiation phase
5) Construction phase

The fifth phase of basic services covers general administration of the construction contract. This function includes the checking of shop drawings and samples, interpretation

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[1] AIA Doc. B141, Clause 1.1.14 at 3(January, 1974).

of the drawings and specifications, review of change orders, approval of certificates for payments to the construction contractor, and making periodic visits to the site for ascertaining whether the work is proceeding in accordance with the construction contract documents. This phase of the basic services is less extensive on much of the work for federal government where construction agencies such as the Army Corps of Engineers, the Naval Facilities Engineering Command, and the General Services Administration are in a position to furnish their own staffs for large portion of this administrative and supervisory activity. The same situation is true for many state public works departments and for some large private corporations that carry on a more or less continuous building program.

H.D.Hauf [27] recommends that the contract between owner and architect should include terms of the referred AIA Agreement concerning services in the construction phase, and *"There should be a clear statement concerning the purpose of the architect's periodic visits to the site. It should be made clear that exhaustive and continuous on-site inspections to check quality of the work are not contemplated and that the architect will not be responsible for construction means, methods, techniques, or sequences. Although the architect will endeavor to guard the owner against defects in the work, he will not assume responsibility for its execution in accordance with the Contract Documents. It is the construction contractor who has made a contract with the owner to so construct the project."*

On the other hand, the services of the architect-engineer firm in this phase may be expanded to include construction management as agent of the owner.

Chapter 6

Conclusion

This research had as objective analyzing the methods used to achieve the performance assurance of the building as a whole in Japan and in the U.S., mainly emphasising the inspection system by a third party during construction and maintenance of buildings.

A *"theory"* has been proposed in *Chapter 2* to make 0 the difference in the concept of performance assurance at design, construction and maintenance phases clear — emphasis given to the construction phase — since once the performance concept is well defined by the architect/designer at the design phase, its acquirement at the construction phase will be crucial for the result of the final product. Furthermore, the concept of the maintenance system, also defined at the design phase should be properly carried out at construction phase in order to be performed adequately during the life of the building.

As could be seen in *Chapter 2*, this philosophy has been emphasized in studies carried out in Japan in the last decades, though it is not reflected in the Japanese laws, codes and regulations. In these documents, which represent in a certain way, the position of the governmental administration, attention is given to the maintenance of equipments and systems installed in buildings (see table 4.4). This situation can be understood when the present construction industry is considered. The development and success of the QA/QC systems in the Japanese industry has been a spot light in a world-wide scale. Attempts have been made by many countries to introduce the Japanese QA/QC system to their industry. Although limitations have been found in the applications of QA/QC systems into the construction field, as shown in *Chapter 3*, the system has been well applied in the case of Japan, where standardization of materials and systems, the uniformity of the level of the laborers, etc. could be achieved. As a result, the high-pitch in which the construction industry by itself has been developed has not required a severe policy from the governmental administration to the control of building construction process.

It is clear that the confidence the governmental administration has in the building designer/contractor is not always positively corresponded by the last ones. Although a *"point of harmony"* has been maintained, exceptions have been raising up gradually. Most of the cases now resulting in a social problem is the situation of the apartment buildings. Maintenance of some minimum performance for safety and healthy conditions of the occupants has not been frequently satisfied due to defects in the building systems (which could be avoided during the construction) and failures in the maintenance.

The opposite situation could be seen in the case of the U.S. where the governmental administration cares a great deal about the acquirement of minimum performance of the final product — the building — by codes and regulations, less emphasis being given to the maintenance phase. One of the reasons can be understood in the explanation of the General Manager of the Department of Building and Safety of Los Angeles city - Mr. W.V. O'brien. According to Mr.O'brien (in the meeting held in the Japan Building Equipment Safety Center Foundation in November, 1990) once the quality of the performance is acquired during the construction phase, the minimum conditions of living of the building is supposed to be kept during its life. Of course, there can be exception (e.g. fire equipments) but in general this situation is accepted as true.

However, he recognizes the importance of inspections during the use of some specific buildings, e.g. apartment buildings for low-income population, where proper maintenance is generally necessary but also neglected. It was also said that the good maintenance of other types of building concerns the interest of owners and tenants because it is directly linked to the good image of the business carried out there. Furthermore, codes and regulations determine that maintenance of buildings and building systems is a duty of the owner. If any trouble or damage to people or other property is caused by the bad or no maintenance practice, the owner will be legally responsible for it.

Only checks of the fire-safety systems are made periodically by the Fire Department, due to its importance to guarantee the safety of the citizens. In New York city, the maintenance of equipments like boilers and pressure vessels are also made due to the same reason.

Although inspections at the construction site by a third person has shown to be effective in the construction process in the U.S., its position has been questioned by designers and contractors. This matter has been already discussed in *Chapter 4* . However, here, the importance of the inspector as an element to reduce the liability of the owner/designer/contractor should be emphasized.

The work of the inspector is crucial to reduce the liability of the parties involved in the construction, independently of to whom the inspection is carried out for. The inspector is a person that, working at the site, can point out mistakes or defects of design and construction direct to the designer or contractor and can prevent future ones to happen. These mistakes, if ignored during construction, would have serious consequences and certainly, responsibility of the parties involved would be asked, i.e., they would be exposed to a higher liability. Another fact that should be understood is the necessity of having a third-person to inspect/judge the work of the others without any direct involvement in the execution of the work, once an intervention by other parties can be taken as an ethical matter. Mainly, the direct intervention of contractors in the work of Unions' laborers is a very delicate matter.

The whole construction process and its system is organized in such a way that duties and responsibilities are previously established, without which a project can not start. Very precise contracts are carefully prepared among the parties involved in the work in order to clarify their duties and responsibilities as discussed in *Chapter 5* .

At present time, in Japan, the construction activities are concentrated mainly on the hands of the general contractors who carry out the whole project from the construction plans to the construction of the building. Consequently, problems raised up after completion due to faults in construction are always directed to the general contractors. In order to maintain their position as *"good corporation"*, they try to cover costs concerning repair of mistakes when the fault is clearly theirs. As the contract between owner and contractor in Japan generally includes the guarantee of the final product within 2 years after the completion of the building, in most of the cases the owner has no way to ask for responsibilities after this period.

The internationalization of the construction industry has been a subject of discussion in the international scene in recent years. The matter mainly consists of two different themes. One is the creation of the European Community without tax-barriers. The paths to the unification of the European market has been coordinated during these last years, where certainly problems concerning the standardization of products and services has been the main subject. Considerations about procedures of the construction process have been also extensively discussed, including duties and responsibilities of the parties involved and the role of inspections.

The second matter concerns the U.S. and Japan commercial affairs. The disequilibrium in the commercial balance between these countries has been increasing in such a way that pressure from the U.S. Government on to the Japanese counterpart to liberate their market to U.S. product and services has been remarkable.

If, on the one hand, the rules of business in the U.S. are very well defined and the investment without questioning its nationality is welcomed at any time, the opposite occurs in Japan.

This can be seen even in the construction market, where although major Japanese general contractors have entered aggressively in the American market, the opposite has not occurred.

In Japan, laws, rules and regulations are obscure; introduction of foreign investments require very careful analysis; concessions are granted only after very strict examinations and can be easily refused. Administrative barriers to the importation of foreign products and services are of great proportion.

However, nowadays, the reasons given by the Japanese Bureaucracy to the non-acceptance of products and services have been contested not only by the U.S. but also internally.

In the construction field, one clear matter concerning this problem can be seen in the difference of policy applied by these countries to judge/approve materials and systems. The Japanese Building Standard Law defines strictly the specifications for each building element or systems which must be followed. However, in the U.S. efforts have been made in order to determine only the level of performance to be achieved by materials and systems. If a system or element submitted to a testing of performance achieves the required level, its use is approved. The inconsistency of the Japanese acceptance system is clear when compared to the concept of its counterpart.

The acceptance of foreign firms of design/construction in Japan requires changes in the present building process control by the government. The existence of a neutral party (a third party) to judge/approve the compliance with codes, regulations, specifications and contract plans can be one of the alternatives to be considered for the near future.

Appendix A

Fire Safety Performance.

(Partial translation of the Performance Systematization [5], Table 1.13(b), pp.64-70.)

Table A.1: Fire Safety Performance

REQUIREMENTS		GIVEN CONDITIONS		BUILDING CONDITIONS				LIFE STYLE	OTHERS
HUMAN	BUILDING	FACTORS OF ACTION	ENVIRONMENTAL	SURROUNDINGS	BUILDING SPACE AND BUILDING ELEMENTS		EQUIPMENTS		
①Basically, do not cause fires. ②Do not cause life losses or phycological/physical damage due to fire.	1. Prevent fire break-outs. ①Do not cause accidental fires. ②If accidental fire occurs, do not leave it to develop.	· Fire, Heat • Possible fire origins: -building equipments -naked lights -others	· The influence of the Humidity is big.		1. The position, shape and size of spaces. 2. Combustibility of finishing materials.	· Space composition that eases the control of fire break-outs. · Design compatible to the space. · Rational planning of waste processing. · Incombustibility of common spaces. · Incombustibility of special parts and materials.		· Control of factors of action: -methods of control fire break-outs. · Control of combustile materials.	
③Do not cause loose of property due to fire. ④Do not cause troubles or/and damage to others people due to fire.	2. Discover, Detect, Alarm, Inform.	· Fire, Heat · Smoke			1. The position, shape and size of spaces.	· Space composition that eases the finding of accidental fires.	· Automatic fire alarm system · Electric leakage system · Emergency alarm system · Fire alarm system	· Notice · Manager's attitude Receive, Confirm, Alert, Inform.	
	3. Prevent inicial development of fire. -Fire Suppression •Considering the room of fire origin, until the flash over.	· Fire, Heat · Smoke · Toxic Gases •Combustible materials Storage goods Building Elements	· Wind speed, Wind direction		1. Size of room of fire origin. 2. Conditions of openings. 3. Combustibility of finishing elements. 4. Fire-resistance of walls, floors, etc.	· Area · Height Burning · Openings Conditions · Quantity · Incombustibility, Smoke generation, etc. · Possibility of simple fire-resistant compartmentation.	· Initial fire suppression system: -fire extinguishers -standpipes -sprinklers -foam extinguishers -CO_2 extinguishers · Systems necessary for fire suppression operation.	· Control of factors of action: -quantity/quality of combustible materials. · Initial suppression operation: -quickness -capability	Evacuation of the room of fire origin is a matter of this phase.
	4. Prevent fire spread development ①Flame spread. ②Smoke spread, smoke exhaust.	· Fire, Heat · Smoke · Toxic Gases	· Wind speed, Wind direction		[Compartment] 1. Size and shape of the space 2. Conditions of openings. 3. Combustibility of building elements. [Building] 4. Size and shape of the space. 5. Opening conditions. 6. Fire Compartmentation (position and performance)	· Openings of surroundings · Quantity · Incombustibility, Smoke generation, etc. · Relationship with the smoke accumulation. · (Same as 3.2) Air supply, Smoke spread and exhaust conditions. · Compartmentation (horizontal, vertical) · Fire Doors · Smoke-proof · Vertical spread prevention through openings, balcony, spandrels · Structures of shafts and ducts.	· Fire suppression system. · Smoke exhaust system.	[Compartment] · Control of factors of action: -quantity/quality of combustible materials. · Closing of openings. [Building] · Closing of fire doors. · Operation of Smoke exhaust systems.	The objective is to enclose the fire in the compartment of origin.

Table A.2: Fire Safety Performance (Continued)

REQUIREMENTS		GIVEN CONDITIONS		BUILDING CONDITIONS				LIFE STYLE	OTHERS
HUMAN	BUILDING	FACTORS OF ACTION	ENVIRONMENTAL	SURROUNDINGS	BUILDING SPACE AND BUILDING ELEMENTS		EQUIPMENTS		
	5. Safe Evacuation. ①Safety ②Evacuation •Discover, Detect, Alarm are prerequisites.	· Fire, Heat · Smoke · Toxic Gases · O_2 less Air			1. Position and composition of evacuation space. 2. Scale and size of evacuation spaces. 3. Fire-resistant, smoke-proof routes. 4. Performance of evacuation routes. 5. Safe Spaces.	· Effective installation of routes and stairs for evacuation (2-ways route) · Evacuation distance. · Width of routes (compatible to population) · Compartmentation · Openability Smoke · Incombustibility Exhaust · Operationability of routes (operation of doors) · Safety of routes (lights, non-slippery stairs, etc.) · Installation of safety space (position and size).	· Evacuation facilities and equipments. · Evacuation conduction assistance system: -communication -signals -illumination, etc. · Smoke Exhaust system. ••<See building requirements>	· Evacuation operation (tenants): -behavior in emergency. -physical resistance. -capabilities. · Manager's dealing: -conduction of evacuation. -operation of systems. -others.	The points in the evacuation from a compartment are the time till commencement of evacuation operation and its easyness. In case of existence of incapable people, a time during which the permanence in the room in safe conditions is possible should be assured.
	6. Prevention of Failure, Possibility of Reusing the building.	· Fire, Heat.			1. Size of space. 2. Condition of openings. 3. Combustibility of building elements. 4. Thermal capacity of building elements. 5. Fire Resistance of Structural parts.	(See 3.1) (See 3.2) (See 3.3) · Columns, beams, structural walls, etc. · Building elements in general (walls, floors, etc)			Burning conditions and fire-resistant structures define together the non-failure conditions. But, generally, this relationship is determined by law.
	7. Rescue, proper suppression (by fire fighters) •the burning conditions are the same of 4.	· Fire, Heat · Smoke · Toxic Gases · O_2 less Air	· Clearances for fire fighters approach.	· Planning to make easy the approach and entrance of fire-fighters. · Water supply	1. Position and shape of the buildings.	· Easy entrance. · Easy fire suppression operation. · Installation of a space to base the operation. · Fire brigade entrance.	· Standpipe · Water Supply and Water Distribution Connections · Emergency Plugs · Emergency Elevator	· Fire-fighting operation, rescue operation. · Smoke exhaust (smoke exhaust vehicle).	
	8. Prevention of fire spread from other buildings. •Fire spread conditions of neighbor buildings is omitted.	· Fire, Heat. •Fire spread conditions of neighbor buildings is omitted.	· Distance among buildings · Existence and performance of fences, trees, etc. to prevent fire spread. · Wind speed and direction. · Humidity and rain.	· Planning of fences and trees as obstacles to fire spread. · Water Supply (tanks)	1. Position of buildings. 2. Fire-Resistance of external building elements. 3. Conditions of internal materials around openings.	· Distance among buildings · Roof: Fire-resistance, incombustibility, flammability, etc. · External walls: Fire resistance. · Openings: Fire-resistance (Installation of fire-doors, storm doors) · Incombustibility of finishing material around the openings susceptible to fire spread.	· Drencher system	· Do not put combustible materials (curtains inclusive) near openings susceptible to fire spread. · Closing of openings. · Fire-fighting operation.	

Appendix B

Approximate Areas of Model Code Influence

(source: Understanding Building Codes and Standards in the United States, National Association of Home Builders, Washington, DC, p.29.)

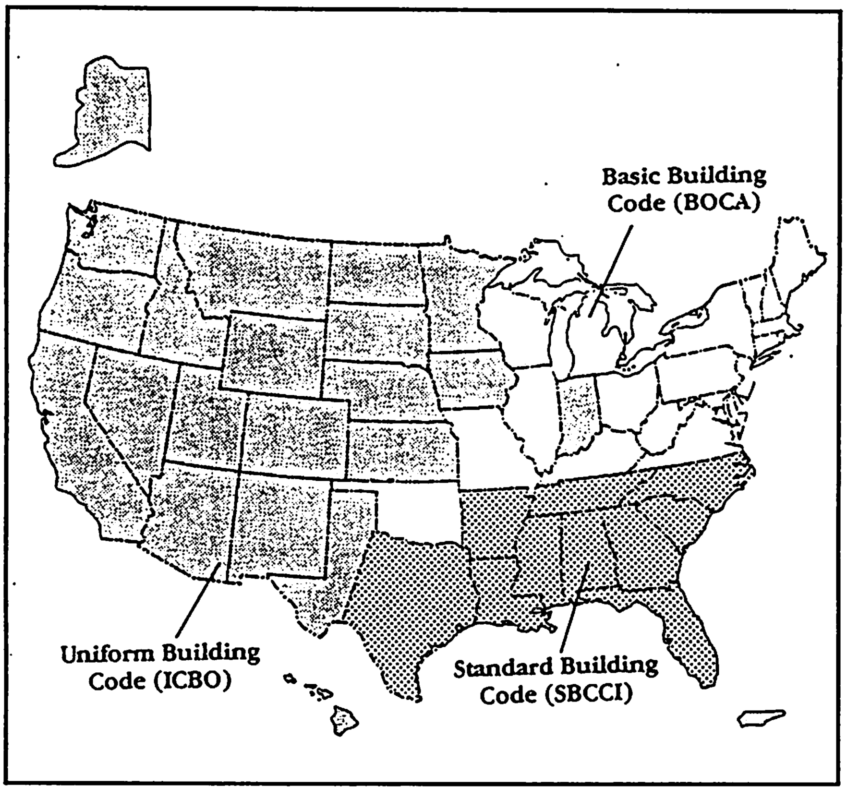
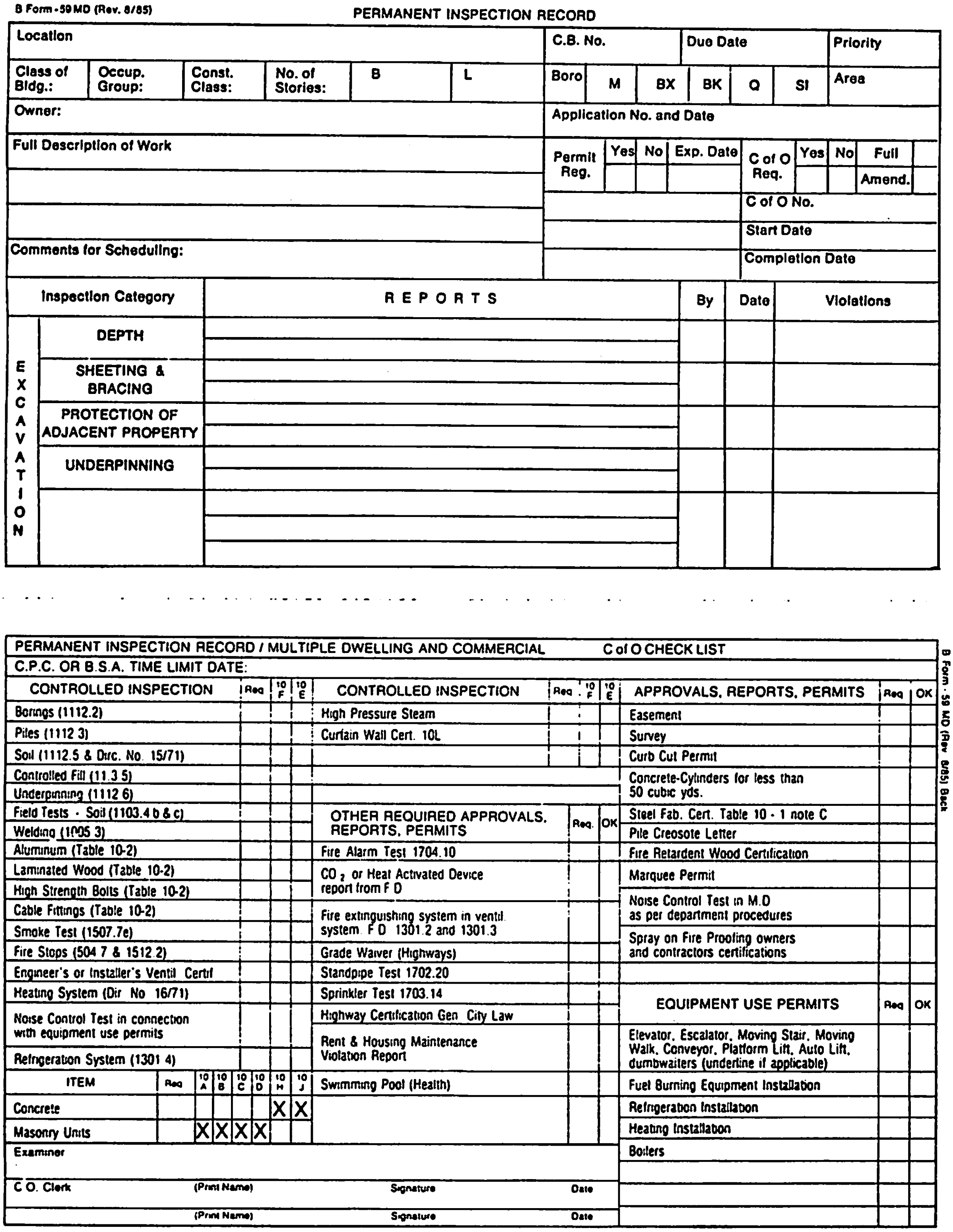


Figure B.1: Approximate Areas of Model Code Influence

Appendix C

Inspection Record Cards



B Form - 59 MD (Rev. 8/85)

PERMANENT INSPECTION RECORD

Location						C.B. No.		Due Date		Priority
Class of Bldg.:	Occup. Group:	Const. Class:	No. of Stories:	B	L	Boro	M	BX	BK	Q	SI	Area

Owner:

Application No. and Date

Full Description of Work

Permit Req.	Yes	No	Exp. Date	C of O Req.	Yes	No	Full	
							Amend.	

C of O No.

Start Date

Completion Date

Comments for Scheduling:

Inspection Category		REPORTS	By	Date	Violations
EXCAVATION	DEPTH				
	SHEETING & BRACING				
	PROTECTION OF ADJACENT PROPERTY				
	UNDERPINNING				

PERMANENT INSPECTION RECORD / MULTIPLE DWELLING AND COMMERCIAL C of O CHECK LIST

C.P.C. OR B.S.A. TIME LIMIT DATE:

CONTROLLED INSPECTION	Req	10 F	10 E
Borings (1112.2)			
Piles (1112 3)			
Soil (1112.5 & Dirc. No. 15/71)			
Controlled Fill (11.3 5)			
Underpinning (1112 6)			
Field Tests - Soil (1103.4 b & c)			
Welding (1005 3)			
Aluminum (Table 10-2)			
Laminated Wood (Table 10-2)			
High Strength Bolts (Table 10-2)			
Cable Fittings (Table 10-2)			
Smoke Test (1507.7e)			
Fire Stops (504 7 & 1512 2)			
Engineer's or Installer's Ventil Certif			
Heating System (Dir No 16/71)			
Noise Control Test in connection with equipment use permits			
Refrigeration System (1301 4)			

ITEM	Req	10 A	10 B	10 C	10 D	10 H	10 J
Concrete						X	X
Masonry Units		X	X	X	X		

CONTROLLED INSPECTION	Req	10 F	10 E
High Pressure Steam			
Curtain Wall Cert. 10L			

OTHER REQUIRED APPROVALS, REPORTS, PERMITS	Req.	OK
Fire Alarm Test 1704.10		
CO_2 or Heat Activated Device report from F D		
Fire extinguishing system in ventil. system F D 1301.2 and 1301.3		
Grade Waiver (Highways)		
Standpipe Test 1702.20		
Sprinkler Test 1703.14		
Highway Certification Gen City Law		
Rent & Housing Maintenance Violation Report		
Swimming Pool (Health)		

APPROVALS, REPORTS, PERMITS	Req	OK
Easement		
Survey		
Curb Cut Permit		
Concrete-Cylinders for less than 50 cubic yds.		
Steel Fab. Cert. Table 10 - 1 note C		
Pile Creosote Letter		
Fire Retardent Wood Certification		
Marquee Permit		
Noise Control Test in M.D as per department procedures		
Spray on Fire Proofing owners and contractors certifications		

EQUIPMENT USE PERMITS	Req	OK
Elevator, Escalator, Moving Stair, Moving Walk, Conveyor, Platform Lift, Auto Lift, dumbwaiters (underline if applicable)		
Fuel Burning Equipment Installation		
Refrigeration Installation		
Heating Installation		
Boilers		

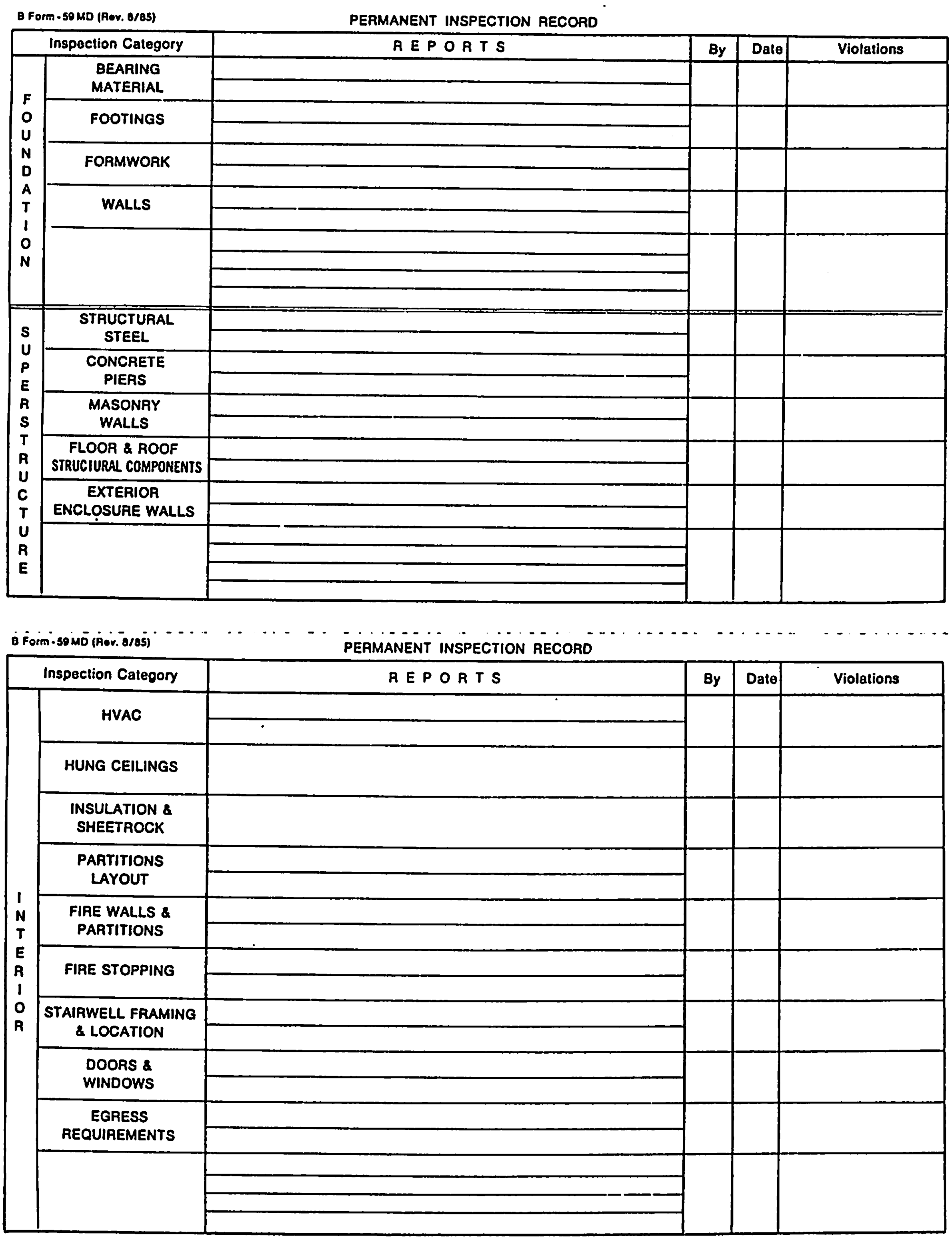
Examiner

C O. Clerk (Print Name) Signature Date

(Print Name) Signature Date

B Form - 59 MD (Rev 8/85) Back

Figure C.1: Permanent Inspection Record Card posted at jobsite: City of New York.



B Form-59MD (Rev. 6/85)

PERMANENT INSPECTION RECORD

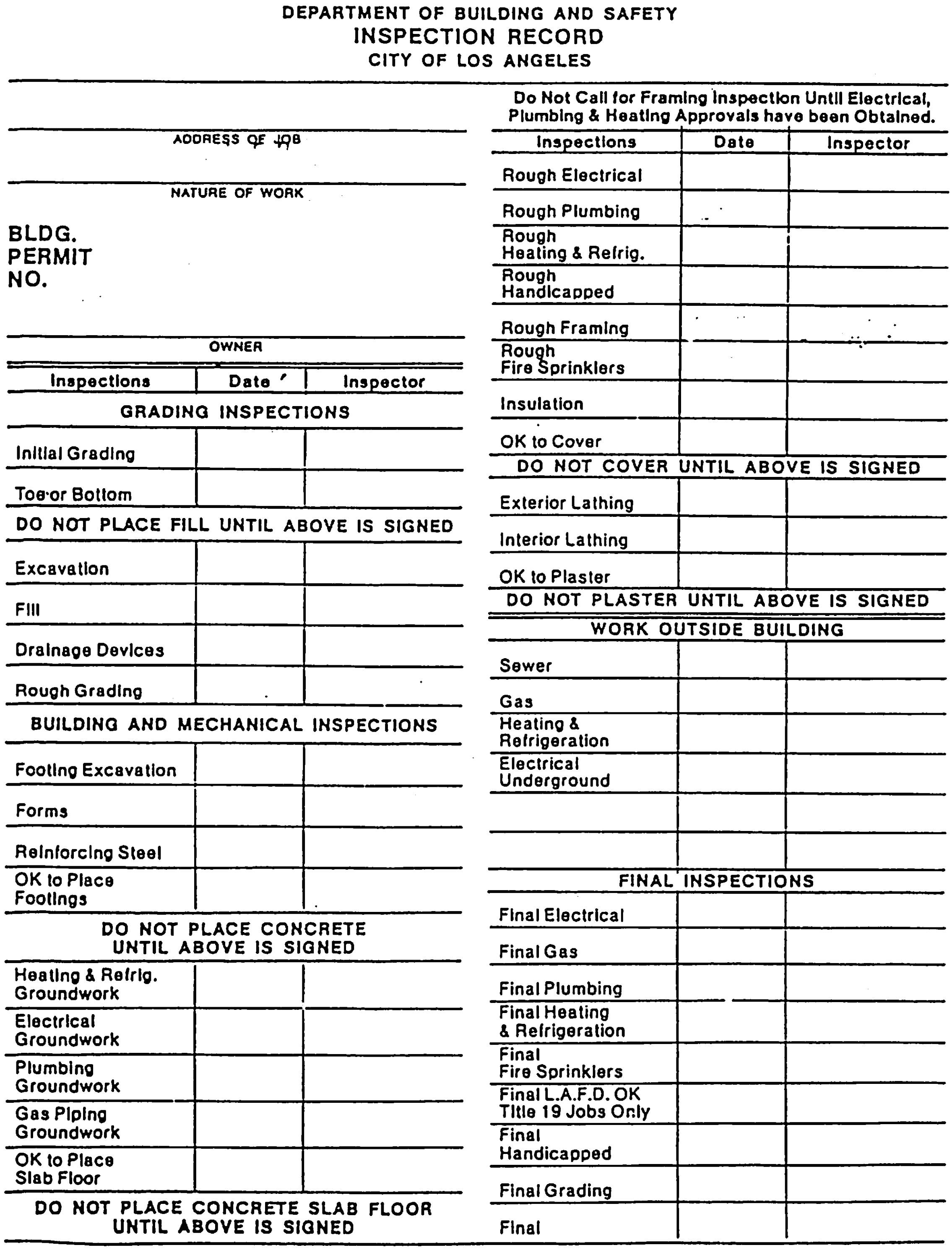
Inspection Category		REPORTS	By	Date	Violations
FOUNDATION	BEARING MATERIAL				
	FOOTINGS				
	FORMWORK				
	WALLS				
SUPERSTRUCTURE	STRUCTURAL STEEL				
	CONCRETE PIERS				
	MASONRY WALLS				
	FLOOR & ROOF STRUCTURAL COMPONENTS				
	EXTERIOR ENCLOSURE WALLS				

B Form-59MD (Rev. 8/85)

PERMANENT INSPECTION RECORD

Inspection Category		REPORTS	By	Date	Violations
INTERIOR	HVAC				
	HUNG CEILINGS				
	INSULATION & SHEETROCK				
	PARTITIONS LAYOUT				
	FIRE WALLS & PARTITIONS				
	FIRE STOPPING				
	STAIRWELL FRAMING & LOCATION				
	DOORS & WINDOWS				
	EGRESS REQUIREMENTS				

Figure C.2: Permanent Inspection Record Card posted at jobsite: City of New York.



DEPARTMENT OF BUILDING AND SAFETY
INSPECTION RECORD
CITY OF LOS ANGELES

ADDRESS OF JOB

NATURE OF WORK

BLDG. PERMIT NO.

OWNER

Inspections	Date	Inspector
GRADING INSPECTIONS		
Initial Grading		
Toe or Bottom		
DO NOT PLACE FILL UNTIL ABOVE IS SIGNED		
Excavation		
Fill		
Drainage Devices		
Rough Grading		
BUILDING AND MECHANICAL INSPECTIONS		
Footing Excavation		
Forms		
Reinforcing Steel		
OK to Place Footings		
DO NOT PLACE CONCRETE UNTIL ABOVE IS SIGNED		
Heating & Refrig. Groundwork		
Electrical Groundwork		
Plumbing Groundwork		
Gas Piping Groundwork		
OK to Place Slab Floor		
DO NOT PLACE CONCRETE SLAB FLOOR UNTIL ABOVE IS SIGNED		

Do Not Call for Framing Inspection Until Electrical, Plumbing & Heating Approvals have been Obtained.

Inspections	Date	Inspector
Rough Electrical		
Rough Plumbing		
Rough Heating & Refrig.		
Rough Handicapped		
Rough Framing		
Rough Fire Sprinklers		
Insulation		
OK to Cover		
DO NOT COVER UNTIL ABOVE IS SIGNED		
Exterior Lathing		
Interior Lathing		
OK to Plaster		
DO NOT PLASTER UNTIL ABOVE IS SIGNED		
WORK OUTSIDE BUILDING		
Sewer		
Gas		
Heating & Refrigeration		
Electrical Underground		
FINAL INSPECTIONS		
Final Electrical		
Final Gas		
Final Plumbing		
Final Heating & Refrigeration		
Final Fire Sprinklers		
Final L.A.F.D. OK Title 19 Jobs Only		
Final Handicapped		
Final Grading		
Final		

Figure C.3: Inspection Record card posted at jobsite: City of Los Angeles.

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