# AN OUTLINE OF EARTHQUAKE PROTECTION CRITERIA FOR A DEVELOPING COUNTRY.

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CONTENTS.-



ABSTRACT.-

Analysis is made of the economic and technological characteristics of a developing country influencing seismic protection criteria, mainly : scarcity of capital, high rate of interest, preferential assignments of investment, protection of the basic sources of production, lack of production alternatives, the low level of general education, the inferior quality of materials, and inferior technology.

The quality of a completed structure is mostly affected by construction technique which in a developing country is often inferior. Inspection, therefore, requires special importance. To overcome the adverse effects of underdevelopment in construction, greater safety factors in design and preference for simple and unsophisticated structural solutions are recommended.

The essential aspects of earthquake engineering and the consequences of destructive earthquakes are reviewed from the standpoint of Engineering Practice, Legislation and Planning, Seismic Consciousness and Emergency Measures.

The conclusion is drawn that greater safety in the design for earthquake protection should be recommended.

The paper considers Chilean experience mainly, but the conclusions are generalized to include other developing countries.

## 1.- EARTHQUAKE ENGINEERING AND ITS PLACE IN THE SOCIO-ECONOMIC STRUCTURE OF A DEVELOPING COUNTRY.-

A number of countries with varying stages of development are located in very active seismic zones of the world. The conditions of underdevelopment bring certain specific characteristics to the problem of seismic

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protection, which will be analysed.

In a developing country there is a shortage of capital, resulting from low incomes as well as small capacity and reluctance to save. Therefore, the current interest rates,and especially the shadow rates, are significantly higher than in fuller developed countries with their well organized and generously provided capital markets. The difference could easily be from 50% to 100% higher. The shortage of capital induces the developing countries to assign preference to investments in installations capable of producing basic goods and services. Luxury items and non-essential goods are given low priority. Preferential urgency is given, therefore, to public works and other investments, which make up the basic infrastructure, also to high demand consumer goods industries and to various capital products, especially those related to the construction industry.

The high value of capital, the protection of the basic production sources, and the lack of production alternatives in case of failure, as in an earthquake, are factors which point toward a need for greater seismic protection in a developing country than in a developed country.

It is not improbable that all the main units of a basic industry could be concentrated in a single location at a given moment, which presents a high seismic risk. This situation exists in Chile, for instance, where the only steel mill is located at Huachipato.

The low level of general education, which is an additional characteristic of underdevelopment, is paired with the lack of precision and responsibility in the execution of the work. Mortar joints in brickwork masonry are not uniform, beads in welding are irregular, etc. The quality of workmanship, without adequate supervision, is generally poor.

The inferiority of materials is another factor which should be considered. Quite often, bricks are not quality controlled and have erratic properties. Lumber is not treated and is cut in non-uniform dimensions, to mention a few examples. Labor and construction techniques are, therefore, critically affected by underdevelopment of adequate materials standards.

These last two factors, namely, the low level of education and the inferior quality of materials, which hinder the proper execution of the construction, lead to the conclusion that the structural solutions should be of simple execution, with a minor degree of sophistication, employing larger safety factors in the design, when compared with technology applicable to more fully developed countries. It should be pointed out that the shortage of adequate materials or specialized labor cannot be solved by importation from abroad, because the restriction of imports due to the shortage of foreign currency is essential.

Damage produced by destructive earthquakes can be extremely significant and critical to the whole welfare and economy of a developing country. The earthquake of 1960 in the South of Chile, produced losses estimated at

US $500,000,000., a figure higher than 50% of the National Budget for that year and 12% of the Gross National Product. Such a high percentage of destruction is not conceivable in a developed country and it hampers considerably the progress of a developing nation.

It should be kept in mind that the Chilean territory since the Spanish Conquest has suffered approximately 50 destructive earthquakes in different parts of its territory, some of them followed by severe tsunamis. The destruction caused by the most recent earthquakes studied systematically (1939, 1958, 1960, 1965), amounted each time to several percentage units of the national capital existing at the time. Therefore, it is not adventurous to state, that in approximately 400 years, the earthquakes have made it necessary to replace the capital at least twice as rapidly as would have been normal without these catastrophes. Without the seismic destruction, the present Chilean capital would be considerably stronger than it is today. These harsh economic effects do not consider the loss in human life, which besides its severe impact upon the community , has also harmed the national productive capacity, which has not been evaluated.

The earthquake of January 24, 1939 that destroyed the towns of Chillán, Concepción, Cauquenes and other intermediate cities, caused the loss of approximately 40,000 lives, which represented at the time 8 per 1000 of the country's population. What has happened in Chile, should be equivalent to the situation in other developing countries with similar general seismic conditions. It points out the compelling need for seismic protection and to take advantage of world-wide knowledge in the field of earthquake engineering.

The development of earthquake engineering should be included in the general national planning, taking into consideration its socio-economic implications and the available resources. Due consideration should be given in the codes to the previous conclusion that a larger safety factor be provided in the design.

To analyze the essential aspects of earthquake engineering and the effects of destructive earthquakes, the subject has been divided in four basic factors, namely : Engineering Practice, Legislation and Planning, Seismic Consciousness and Emergency Measures.

The analysis of these factors which does not pretend to be exhaustive, has been based on our Chilean experience. It is believed nevertheless, that the views we are presenting are valid for other developing areas as well.

## 2.- EARTHQUAKE ENGINEERING AND THE CONSEQUENCES DERIVED FROM DESTRUCTIVE EARTHQUAKES.

2.1. Subdivided into :

- 2.1.1 Design
- 2.1.2 Construction
- 2.1.3 Training of Professionals and Technicians
- 2.1.4 Training of Craftsmen
- 2.1.5 Research

## 2.1.1. DESIGN.

A cause of the bad results observed in several developing countries has been the defective designs performed by professionals insufficiently experienced. In some zones of moderate seismic activity, the respective codes specify very low seismic coefficientes. Therefore, the design for lateral forces is very often controlled by wind loads, while concepts such as relative rigidity, horizontal torsion, etc. are prone to be overlooked. When a destructive earthquake occurs, these defects in design are made evident. In other cases, foreign designs without proper consideration to earthquake resistance are brought into the developing country, with the consequent latent danger.

A good design requires close colaboration between the architect and the structural engineer. This is valid not only for high-rise buildings but also for minor structures. It is frequently seen, that in houses damaged by an earthquake, a small architectural modification that would have amounted to the simple relocation of doors and windows in a wall, would have considerable improved the seismic resisting capacity of the structure.

The relatively high ratio between tha cost of the project and the cost of manual labor, in a developing country, together with the shortage of technicians of intermediate level, such as design draftsmen, sometimes produces a tendency in the designer to develop plans insufficiently detailed, with incomplete specifications, leaving many details to be resolved on site. This method, when carefully handled is not a bad solution. Carried to extremes, however, it has not only the inconvenience that the details can be badly resolved in the field, but lack of foresight makes it necessary at times to chip out walls and slabs to install pipes, ducts, and fixtures not sufficiently contemplated and detailed on the drawings. This is not only detrimental to the resistance of the directly affected structural elements, but also it may endanger the resistance of neighboring elements.

Another frequent cause of bad results in our country has been the lack of details for connecting joints. For example, crossing and overlapping of reinforcing bars in tie beams in reinforced concrete construction, woodwork in roofing and partitions and their connection to the main resisting structure, anchorage of various elements, etc.,are details that are too often missing from the drawings. The advantages of including this type of details in the drawings is obvious. Another example of the Chilean practice relates to chimneys in dwellings. Details are too often overlooked on the drawings, leaving construction entirely to the field. Across the world, chimneys are very vulnerable to earthquake damage. A great part of these omissions can be corrected if the design engineer participates in the inspection at different stages of construction.

## 2.1.2. CONSTRUCTION.

Subdivided into :

2.1.2.1. Construction Materials
2.1.2.2. Labor
2.1.2.3. Types of Construction
2.1.2.4 Inspection During Construction

2.1.2.1. CONSTRUCTION MATERIALS.

Includes herein are : steel, concrete, reinforced concrete, wood, masonry and adobe. For the first three mentioned materials, international quality standards are reached in general. Wood has often not been adequately submitted to treatment and preservation to make it a reliable construction material in most developing countries. Brick and masonry, due to local conditions and the lack of quality control, are very different in quality in various regions of the world. In the case of Chile with existing codes, we find very erratic qualities for brick and masonry, especially in rural and suburban areas. To this, we should add the great variation in the quality of mortars due to the lack of water control.

Adobe construction, based on mud, will be discussed as a method of construction later on.

2.1.2.2. LABOR.

The abundance of unskilled labor, which is reflected in the types of construction adopted, is one of the characteristics of a developing country.

Among the factors that influence the construction of an earthquake resistant structure, labor is a characteristic condition, as mentioned earlier. Sometimes, it is possible to overcome its consequences. Such is the case, for example, in certain types of pre-fabricated housing units, with all utilities included, where the erection labor required can be performed under controlled conditions by unskilled labor. At the shop or site where the different components are fabricated, it is possible to establish the quality control systema required for work of this type.

2.1.2.3. TYPES OF CONSTRUCTION.

Subdivided into :

Steel Structures
Reinforced Concrete Structures
Brick Masonry
Concrete Block Masonry
Wood Construction
Adobe Construction
Mud and Stone Construction

STEEL CONSTRUCTION.

Frequently, this type of structure is less economical than reinforced concrete, not only because of the high cost of steel shapes, which in general are imported, but also because of the lack of special elements, that would provide the correct architectural solution for finishings, which are not available on the local markets. Steel structures are only used in the construction of large high-rise buildings. Competitive limits in height for structural steel over reinforced concrete are found at a considerably larger number of stories than in advanced nations where structural steel is more readily available. For industrial structures, on the other hand, steel structures have been gaining in use due to the advantages this material presents in large spans and for ease of expansion or modifications to the plant.

REINFORCED CONCRETE STRUCTURES.

It is interesting to note the development that reinforced concrete has followed in Chile in the construction of high-rise buildings. The present Chilean Seismic Code is better suited for low buildings than it is for high-rise structures. In buildings of 15 or more stories designed to comply with this code, the shear forces at the base are such as to require the use of rigid walls to absorb the lateral forces. These walls or vertical diaphragms materialize on the exterior facades or the elevator shafts and stairwells.This type of buildings has shown its capability of resisting earthquakes such as experienced in Chile.

Recent studies in the use of reinforced concrete for high-rise buildings, mainly in the U.S.A., seem to favor structures with rigid frames with special requirements for the joints to assure adequate ductility. We do not believe that this type of structure will gain great popularity in this country where it is likely that reinforced concrete structures based on rigid walls will continue to be used. They are easier to build than structures with ductile rigid frames, which require a highly refined treatment of all details and particularly severe inspection conditions. This is also certainly valid in other developing countries and points to the preference for simple and unsophisticated solutions.

BRICK MASONRY.

The behaviour of brick masonry framed within reinforced concrete columns and bond beams have, in general, been satisfactory. It is beyond our economic capabilities and that of other developing countries to adopt the system generally used in California, e.g. based on a thin wall of reinforced concrete covered on either side with small brick masonry. It is true that this method of construction provides a higher degree of seismic protection than does our reinforced masonry construction.

CONCRETE BLOCK MASONRY.

In many zones of the world, concrete blocks have been considered as a mere substitute for clay bricks. This is without doubt an erroneous concept since the correct utilization of concrete block masonry requires an adequately sized horizontal mesh type reinforcement and reinforced concrete or grout-filled cells, distributed throughout the walls. The Uniform Building Code, for example, should be critically analyzed to determine if its reinforcement requirements are adequate from the technical and economical point of view of the country. If a certain type of construction, such as reinforced brick masonry is permitted in a given code, it would be logical to accept reinforced concrete block masonry as an alternative solution, reinforced in such a way as to provide the same degree of safety required for the reinforced brick masonry.

WOOD CONSTRUCTION.

Some of the problems that have occurred in wood construction are the following :

a) Due to the lack of adequate treatment, the structures are attacked by moths, termites and humidity.
b) Unseasoned lumber (as commonly sold in Chile) shrinks approximately 3% on drying and often breaks the connections.
c) Connections, with given exceptions are not properly designed nor controlled. Nails are used extensively in preference to bolts, screws and connectors.
d) It is vulnerable to fire, a hazard accompanying an earthquake.

Nevertheless, the seismic behavior of wood construction, in general, has proven to be satisfactory, according to our Chilean experience and confirmed in many other seismic areas, both developing and developed.

ADOBE CONSTRUCTION.

Various methods of adobe construction are used in different parts of the world. This type of construction has been employed extensively in Chile for rural and suburban housing and it will continue to be used in many developing countries, not because it is good, but because it is available within the economic restrictions imposed on such a country. It is understood that this material does not in itself have the necessary qualities to provide a seismic resistant construction and it has three serious disadvantages. It is weak, brittle and heavy. When combined with a braced wood frame, as has been used extensively in Chile, it can provide structures with a certain degree of seismic protection. This in itself is a wood house clad with adobe. The effectiveness of this construction, greatly dependent on the state of preservation of the wood, has been put to test in a number of Chilean earthquakes, demonstrating that buildings do not collapse, but crack extensively requiring a high cost of repair due to re-application of plaster. It is difficult to combine a basically rigid, weak material (adobe) with a basically flexible, strong material (wood) and make the latter brace the former without damage to the adobe.

MUD AND STONE CONSTRUCTION.

This construction is certainly the lowest in the resistant scale and it is only mentioned here because there is still a considerable number of people who live in this type of house. When the roof is built-up with a heavy layer mud, this type of dwelling presents a considerable risk to the life of its occupants in an earthquake of even moderate intensity. Construction of this type should be condemned and it should be the responsability of the respective governments to develop other more adequate systems based on locally available materials, keeping in mind the social and economic conditions of its inhabitants.

2.1.2.4. INSPECTION DURING CONSTRUCTION.

Inspection is a difficult problem to deal with even in a developed country, and is particularly critical in a developing area, due to the lack of resources and qualified personnel in sufficient numbers. The classical problem here is how to inspect a job under construction in a remote area in a proper manner, when professionals trained for these functions are non-existent. In general, there are two possible solutions :

a) Increase the technical capacity of the local authorities by hiring skilled technicians, and
b) Contract the services of the design engineer to provide the job inspection.

The second choice has quite often been followed in this country .

The value of inspection cannot be overemphasized because of its irreplaceable function. Inspection capability is affected by underdeveloped conditions, but certainly in a minor degree when compared with labor. Permanent inspection during construction is one of the most efficient tools to overcome the adverse effects of labor underdevelopment. In the construction field, good inspection can be obtained at a small capital investment, since it only consists of wages without cost of materials and, therefore, yields a high return on the investment.

2.1.3. TRAINING OF PROFESSIONALS AND TECHNICIANS.

It should be required that the universities and similar institutions in developing countries promote training programs in geophysics, seismology and especially in earthquake engineering. These programs should be planned and maintained at the different levels that the degree of development requires.

Although recognized courses in these disciplines are in progress in many countries, there are a great number of active professionals and technicians in the engineering field that need to be informed through post-graduate courses, conferences and seminars. A conference such as 4WCEE, in which we are presently participating, is designed with this as its most important purpose, calling upon world-wide scientific and engineering experts to exchange knowledge.

2.1.4. TRAINING OF CRAFTSMEN

It has been stated that there is an abundance of relatively inexpensive and unskilled labor in developing countries. The development that we speak of here, entails not only the technical skills to do the more complicated work but also to be able to responsibly guide the manner in which the work is performed. This is, it is true, an educational problem that is deep rooted in underdeveloped areas.

2.1.5. RESEARCH.

The question of how much research and at what level it should be conducted in a developing country, has been brought forward on many occasions. In this respect, two points of view have been expressed that are valid in earthquake engineering. Some maintain that the scientific and technological gap is so considerable that it is unlikely that first class technologies will be attained in a developing country and, therefore, we will have to settle for intermediate technologies. Others maintain. and whose views we support, that we cannot accept to be second class scientists or engineers. If a second-class technology were the acceptable objective, the "brain drain" as it is sometimes referred to, would continue to the U.S.A. and other highly developed centers. What has to be done is to select the technological areas that are not properly developed and are of high local interest, and work intensively on them and obtain a degree of excellence in these technologies.

Certain areas of research are indicated, defining hereto three types of priority, A, B, C, in a decreasing order. The estimated priorities refer to the bulk of the construction projects and should by all means be altered for special cases of exceptional importance. The assignement of preferencial rating in different areas is not easy, therefore no attempt has been made to indicate the order of priority within each category.

PRIORITY "A" RESEARCH

Regional seismicity (Macroregionalization)
Seismic stations
Geology and geotechnics
Study of codes, regulations and ordinances
Soil mechanics (First rank industries, buildings and engineering projects)
Study of destructive earthquakes
Survey of damage, relationship between damage, types of structures and soils.
Seismic resistance of housing
Seismic resistance of important civil works and industrial buildings
Seismic safety of essential services
Repair methods for damaged structures

PRIORITY "B" RESEARCH

Near surface geology
Microregionalization
Properties of materials and structural elements
Methods of construction
Seismic resistance of common industrial buildings
Earthworks and rock embankments

PRIORITY "C" RESEARCH

Dynamic properties of soils
Dynamic properties of structures and local construction methods
New materials
Soil structure interaction
Behavior of shear wall building

Several of these lines of research are being followed at this time in Chile even though early results are not expected in all areas.

## 2.2. PLANNING AND LEGISLATION.

### 2.2.1. STANDARDS.

Seismic regulations should be developed considering the social, technical and economic realities of each country. It is not possible to import a foreign code from a country with a greater degree of development. This not only applies to seismic codes but also to steel and reinforced concrete regulations, for example. Undoubtedly, the fundamental precepts of all the regulations should be the same, but codes should be adapted to local conditions. Seismic codes should consider regional seismicity which may differ considerably from the conditions of the country whose standard is adopted. The situation in certain developing countries where local seismic regulations have been prepared and where it might be possible to choose a foreign code, (such as the German DIN or USA codes), for steel or reinforced concrete structures, is not recommended. The suitability of different requirements become awkward and can easy lead to confusion and unforeseen stuations. It should be observed, however, that materials will perform in accordance with their basic properties and how they are used in a structure, regardless of what code may be used as a design basis.

In this country, a new Seismic Design Code will, in the near future, replace many articles in the General Construction Ordinances which have been a guide for more than 35 years. Although it must be recognized that in the light of the present state of advancement in earthquake engineering, the Ordinances have been inadequate in many respects; it is no less true that it has been based on the national reality and has provided the definitive characteristics of our types of construction. The results of the experience have shown to be satisfactory.

Earlier in this paper it was stated that, in order to compensate for the adverse effects of underdevelopment, it was necessary to increase the safety factors of the design. The quantification of these considerations and procedures of application should be specifically stated in the General Construction Ordinance.

To increase the safety factors does not mean an increase in the seismic coefficients nor necessarily a decrease in allowable stresses. It can and should mean specific recommendations in the structural organization of construction, the establishment of more severe requirements for joints of structural elements, an increase of minimum dimensions, the setting of higher limits for minimum percentages of steel in reinforced concrete, stricter conditions for concrete cold joints, etc.

The effect of a seismic regulation in the decrease of losses can be felt only on a long range basis, as older construction is replaced or diminished in importance percentage-wise to the total investment. The experience of the 1960 earthquakes in Chile indicated that the losses in housing reached an 18% of the total housing investment in the affected area (approximately US $ 300,000,000.). It has been estimated that the losses would have increased to 24% (US $ 400,000,000,) if the 1940 Ordinances had not existed. If, on the other hand, all of the housing units had conformed to the then applicable Ordinances, it is estimated that the losses would have been limited to 9% (US $ 100,000,000.). These figures lead to the conclusion that research and code development much more than pays for itself. It is worthwhile to note in this case, that wood construction is predominant in the south of Chile and that its seismic behavior has been good; the percentage of destruction in other zones where brick and adobe are predominant would have been considerably higher had the Seismic Ordinances not existed. It was noted that some of the damage was due to omissions in the Ordinances. No provisions for minimum distance between adjacent buildings, specifications for wood construction, slide hazard conditions, etc., are included in our present Ordinances. The 9% loss previously estimated could have been appreciably reduced by correcting these omissions.

The Low Cost Housing Ordinance in force in this country since 1943 deserves special comment. Due to successive modifications incorporated in order to reduce costs, but without using an overall criteria, a situation has arisen which could lead to unsafe conditions. It is highly recommended that this Ordinance be restudied wholly and analyzed as to whether desviations from the General Construction Ordinance mean real economies that justify the lower resistance permitted by the Low Cost Housing Ordinance. Specifically, such requirements as the elimination of columns and the lowering of minimum dimensions of structural elements and the minimum percentages of reinforcing bars for concrete members, should be critically examined.

### 2.2.2. SEISMIC LEGISLATION

In a country where inevitably every few years a destructive earthquake occurs with considerable property damage, it is convenient to have a pre-established legal procedure that would permit effective and rapid help to those areas damaged. A provision in which 2% of the National Budget is allocated to public disasters, which is often used to relieve the consequences of a destructive earthquake, exists in this country. In another line of thinking, an official organization would be in order to assign and distribute certain funds in a regular way to promote and encourage education and practice oriented measures conducive to adequate seismic protection in accordance with pre-established policies. The direct beneficiaries could be the universities and the municipalities.

Urban development, city planning and remodeling should be continued while also considering seismic risks. The need to protect construction investments requires a careful selection of appropriate sites, considering such factors as poor soils, slide hazards, exposure to eventual tsunamis, etc., allocating zones not suitable for construction (as being too great a risk) to open green areas. In the remodelling of cities, these factors should also be considered, giving priority to replacement of public buildings and housing that present greater risks.

## 2.3. SEISMIC CONSCIOUSNESS

Under this title, are grouped all of the non-specialized educational actions that help make people aware of seismic risks. Included herein are not only those actions intended to preserve human lives directly, but also to protect against property losses. Due to the lack of a seismic consciousness, existing buildings are modified, cutting openings through walls, executing extensions, etc., or after a great earthquake, repairs are made to damaged structures without consulting technically qualified people or the proper authorities.

This education should begin at Primary School level with general notions on the cause of earthquakes and their principal effects and it should certainly reach adults by means of the press, radio and television. This idea has been adopted in Chile where presently the Primary School teachers are being prepared and it is estimated that whithin 5 years the experience will reach all the schools in this country. In this sense, the Japanese experience is interesting where it has been seen that in teaching children, this knowledge is passed on to adults through family contacts. In that country, a group of regulations have been established aimed at the public in general, tending to prevent loss of lives in a great earthquake, recommending ways to take cover and pointing out the importance of fire prevention in order to avoid a major disaster.

It is recommended that in public buildings of certain importance, priorities be given, in accordance with the structural characteristics, to the safer locations (or the unsafe locations) in order to govern the behavior of the building's ocuupants, with consideration of panic hazards attendant to large gatherings at the time of an earthquake.

The recognition that a zone that has been affected in the past by a destructive earthquake, is most likely exposed to future seismic activity and that its construction should have adequate protection, requires a seismic consciousness of the public.

A development which has contributed in a significant manner to raise the level of construction via seismic engineering practice in advanced nations has been the acceptance of the earthquake insurance by the community. This insurance attracts public interest by justifying lower premiums for safer constructions. It is to the insurance company's interest to reduce the seismic risk, helping in this way to improve the earthquake resistant buildings. In some countries, notably New Zealand, it is the government that underwrites the earthquake insurance as well as makes and enforces the construction codes.

## 2.4. EMERGENCY MEASURES.

If planned preventive measures have not been taken, a destructive earthquake may create a chaotic situation bringing with it serious damage and loss of life.

It is indispensable that a responsible organization be in charge of emergency measures with the necessary authority to mobilize the existing means and resources, with the participation of the armed forces, police, fire brigades and civil defense. First aid, medical equipment, pre-established lines of communication,.scheduling of emergency work crews to inmediately repair the essential services are some of the factors that should be foreseen jointly with other problems resulting from the emergency.

In order to take adequate action promptly on the inspection, demolition and repairs works, certain criteria, organizations and experienced personnel should be available, selecting beforehand those who can be relied upon to take charge of these functions that too often have been improvised, sometimes causing damage and unnecessary demolition.

An Emergency Office under the Ministry of the Interior, has been organized in Chile, that is responsible for the designation of area chiefs, the receiving and distribution of help, the supervision of demolition, temporary reconstruction, re-establishment of communications, repairs to water and power systems, etc. A National Emergency Plan has been created which was applied in the Taltal 1966 and Tocopilla 1967 earthquakes and demonstrated its efficiency.

A Seismic Risk Committee also exists and is composed of geologists, seismologists, soil mechanic specialists, structural engineers and various State and University organizations. The Committee's principal functions is to collect all information necessary for seismic, geological, soil, structural, damage, etc. studies. In the event of a destructive earthquake, a study group coordinated by this Committee, can inmediately move to the damaged zone. In this Committee's first publication, we find damage evaluation surveys, degrees of intensity, geological and soil effects, etc. The Seismic Risk Committee works in close contact with the Emergency Office in the case of a destructive earthquake.

## 3. CONCLUSION

To begin, the characteristics of underdevelopment were emphasized : shortage of capital, high interest rates, preferential assignments of investments, protection of basic production sources, lack of production alternatives, on the one hand, low level of general education and inferior quality of materials on the other. The first five considerations point to a greater degree of safety required for the design. The last two adverse factors hinder the proper execution of construction.

. The conclusion can be no other than, taking into account the first considerations we must find ways to overcome the adverse effects of the latter. The most efficient way to reduce the seismic risk is to rely on good seismic structures. To have them built, we have to go through the stages of design, construction and inspection. The design is the least affected of these three stages, by the conditions of underdevelopment. In general, it is not difficult for engineers in developing countries to be well informed on the best seismic design practices. The shortage of intermediate level technical personnel, such as design draftsmen, that we have in Chile, is a sympton of underdevelopment that can surely be appreciated in other developing countries.

Labor and construction methods are factors most affected by underdevelopment. This is confirmed in the numerous reports on damage caused by destructive earthquakes observed in developing countries where it is frequently mentioned that construction methods, too frequently, have not matched design procedures.

Focusing in a global manner on the execution of a seismic structure in a developing country, the disadvantages of underdevelopment can be overcome to some extent by some compensating means in design. It is recommended that the regulations of developing countries include some means to surmount the unfavorable effects previously mentioned of underdevelopment by requiring greater factors of safety in design. This increased safety does not necessarily imply higher seismic coefficients or lower allowable stresses, but does imply a group of measures that will guarantee among other conditions, that the elements be constructed with a minimum of complications, that is to say with fewer potential defects, with less sophisticated solutions, and with better connections between resisting elements, etc. As an example, let us consider the problems derived from cold joints in reinforced concrete structures. Due to faulty and careless construction procedures, quite often after a big destructive earthquake, a large crack appears on the joint surface. Would it not be logical then to assume, that these joints are not being designed or executed correctly? This condition could be improved by requiring that 45° dowels sufficiently anchored be located reinforcing the potential weakened joint section.

As basic factors of the earthquake resistant capacity of a structure, resistance and ductility must be mentioned. In a developing country, emphasis should be placed on resistance rather than ductility. The latter implies a more sophisticated concept harder to achieve, and demands careful labor and strict inspection. This statement certainly has greater validity in reinforced concrete than in steel structures, and in no way is intended to minimize the importance of ductility. The above mentioned considerations are directed to the great quantity of construction that is taking place in developing countries under routine conditions and obviously does not apply to the exceptional cases.

Inspection, also affected by underdeveloped conditions, constitutes an irreplaceable phase of the construction job. Adequate control can and must overcome the adverse effects of underdeveloped labor and construction methods. The training of competent inspectors is an investment offering great financial returns, and contributes significantly to the achievement of seismic resistant structures.