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A DIFFERENT PERSPECTIVE ON CONSTRUCTION SAFETY

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Abstract: *Construction safety and quality has been researched from the beginning of time. Engineers were always concerned with the safety and the quality of buildings' construction and the progress in infrastructure resistance has been recorded throughout centuries based on the various discoveries that allowed buildings to survive thousands of years. The buildings are a result of the work done by engineers who know and comply with constructions' rules and regulations. However, is compliance with these rules enough to obtain an overall safety of the building construction?*

Key words: *acceptable safety factor, design guideline, safety concept, cost*

1. Introduction

From the ancient times until the 17th century, empirical design of buildings was based on experience, intuition and great dexterity of our ancestors ingenuity. After the 17th century, the mechanics of constructions witnesses a sharp improvement through the new inventions and works of Gallileo Galilei, Hooke, Bernoulli, Coulomb. The Gothic style represents the climax of the new type of design which defies the laws of gravity, because of the use of stone masonry, where a material resistant only through compression is used.

In the early 19th century, as a result of rapid theoretical development of mathematics and elasticity theories, Navier introduced calculation of the constructions as elastic, homogeneous and isotropic systems, which is allowable on the resistance method. The bearing capacity method (stage breaking) - in its simplistic formulation (or basic stages) of that time, is used for a long time, while in the late 20th century, the method of allowable resistance becomes a universal method calculation.

2. Material and Methods

The most important element in the development of calculating construction methods, is the concept of safety. The first methods used were the deterministic ones (the method of allowing and breaking resistance), in which the basic parameters intervene in the calculation, where actions and applications, resistance and other properties of materials, geometric sizes of structural elements, are considered invariable and with certain values. Thus they obtained structural elements characterized by a sufficient safety, but with a higher consumption of building materials, resulting in structural elements that are oversized, difficult to execute, and with significantly greater execution time.

The practice of using the two methods:

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the allowable resistance and strength and the development of theoretical and experimental knowledge, have led, as a synthesis, to limited states of behavior which makes possible the analysis of building elements and structures for breaking plastic stage (ultimate limit states and load-bearing capacity). Instead, the method of limited state allows the probabilistic safety concept, based on that the probabilistic calculation model, which is closest to the real behavior of structures.

The idea of using probability theory and statistical methods in the study of construction safety, inspired by aircraft manufacturers, was developed from the fifth decade of the last century. We're have to consider the randomness of building material properties, the variability of actions (necessary loads and deformations required) and the outcomes that result, as well as other factors such as variability in size structure and the possibility of different simultaneous actions.

A probabilistic analysis of a structure would require complete coverage of the laws of statistical distribution of permanent and temporary load, required deformations (contraction and slow flow of concrete, temperature variations, irregularities of supports, prestressing) and the laws of distribution of claims from these actions, as well as knowledge of the variability of physico-mechanical properties of materials and the geometric dimensions of sections and structures.

Limited state method provides a constant and consistent safety measure for the entire structure and presents two essential features:

- consideration of the various limited states;
- systematic probability concept of construction safety;

we are able to calculate buildings with an acceptable safety factor

Therefore we are able to calculate buildings with an acceptable safety factor. But what is a safety factor? Is this enough to get the optimal safety?

3. Discussions

Over the life of a building there are many special conditions, therefore the safety of a building should not be seen only in terms of calculation of the resistance structure. Efforts and loads of construction can sometimes be considered by probabilistic methods, and sometimes occur over time.

Determination of stresses building or structure deformations when we known loads and mechanical properties of materials it is not enough to design a building. The overall purpose of the building design is to ensure with an acceptable probability, that the structure designed will behave well throughout the expected life and generally we seek to complete a building with the following objectives:

a) Mechanical resistance and stability

To achieve this, the design engineer must first establish how the construction can be decomposed into simple components, to which can be applied the calculation methods available (static, strength of materials, mechanical of construction and other), and then draw conclusions on the building's behaviour in general. The performance of a building system (concrete, wood, steel) is greatly affected by the environment in which the system is to be placed. More intense requirements are needed in zones of high temperature fluctuations and seasonal changes. These factors includes freeze-thaw, shrink-age cracking, effects of deleterious chemicals and acid rain. Other requirements are needed for concrete placed under water (special structures such as offshore oil platforms).

b) Fire safety;

The main objectives of the fire safety of civil engineering construction are:

- fire prevention or delay the development and spreading: the correct use of combustible materials, using an appropriate partitioning of the building, use of automatic fire extinguishing systems;
- people from the building protection by fire effects: notification in time of the emergency services and clear (secure) the exit routes;
- minimize fire impact by maintaining the structural integrity of the building and ensuring business continuity in the common areas of the building;

To achieve all these objectives, the engineer, starting with the design phase, must exercise fire safety scenarios and on the basis of values and he must obtain combinations of the relationship between fire conditions and performances, in order to achieve well rounded construction fire safety procedures.

c) Hygiene, health and environment;

d) Operating safety;

To achieve operating (optimal) safety, a construction must perform the function for which the construction was made, since the design phase.

e) Protection against noise;

f) Construction must be economic;

The problem of achieving economic construction is one of the most complex challenges. Some aspects of this problem are:

- **Technical conception:** we must take into account the fact that a building also functions as a spatial system mechanism. Considering isolated beams, columns or plane frame systems is artificial and is made only to simplify the calculation methods. For example, structural elements separately calculated that satisfy the resistance condition but assembled, they yielded overall accessibility at lower stress (for stiffening elements of the main beams of a bridge). In other cases, collaboration space provides a stiffening that routinely is disregarded. If in this case we consider this we achieve significant savings. Conception technique can bring savings or expenses to the construction.

- **Load rating:** by using technical instructions, codes of practice, and standards, we secure loads to be considered in the calculations; the engineer needs to know how to choose and treat them with discernment. The role of the design engineer is to truly appreciate the forces and their variety in time. In this way he can rationally and economically design the construction. Exaggerating the importance of loading lead to construction would be an unnecessary expense.

- **Materials:** in most constructions, one of the most significant loads is his own weight. A building is more economical if its own weight is reduced. This is achieved by using materials with low specific gravity but with a high mechanical strength.

- **Time:** time is another factor that civil engineer must take into account from the design, implementation, operation to the documentation phase of a building. In time not only the material properties change but new phenomena, such as: changing natural conditions (pollution), changing geotechnical conditions may occur, which can change the quality of the construction

- **Principal factors affecting cost:** cost of any product is affected by a

variety of factors based on supply and demand. But demand is generated by knowledge and familiarity. A comprehensive awareness of the design engineer and a follow-up of the material behavior will influence the performance of various concrete structures and will always lead to improvement or a better design. The principal factors that affect the production and costing of concrete constructions can be summarized as follows: research and development; performance requirements; codes, standards and engineering specification; selection of material components and the design mixture; quality control and assurance in production.

4. Conclusions

From the above date, the main problem is: in which conditions a construction must be designed, executed and operated to obtain safety and cost-effective procedures. There is a duality between safety and economical concepts. Economics is directly related to utility or cost. What we chose ... safety ... utility ... cost... will constitute a major decision for each investor. Safety factor is specifically related to technological advanced society. In the developed society, the safety coefficients used in the design calculations increase, and this automatically will attract higher final cost of a building (ex. larger sections, stronger foundations).We must also mention that the level of safety that we tend to use, is directly affected by socio-political organization, the level of technical knowledge, the possibility of research, quality control organization, the available materials and constructions skill. By construction safety we mean that capacity of a construction structure to ensure appropriate use in according to the designed outcome, throughout the lifetime of a building. Designed rules do not protect against ethical shortcomings, human error, insufficient technical knowledge, or ethical errors due to poor quality materials, or other similar causes that result in accidents. Somehow these cases can be taken into account by using some statistical methods. One can establish the acceptable probability of failure by comparing it with the accidents' causes presented above. In expert literature, for example, we find that the accidents caused by structure deficiencies do not exceed 10% of all accidents. It is essential to have a thorough understanding of the standards and design codes of the particular zone in which a structural system is to be constructed, whether a building, a bridge, a highway, a tunnel, an offshore platform, or other superstructure or substructure. We can conclude that a better understanding of the problems that can occur and the causes that have generated them, will give designers the opportunity to avoid them and increase safety and quality in construction.

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