



Earthquake Resistance Architecture: A Study for the Architectural Design of Buildings in Sismic Zones

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ABSTRACT

In Addressing the role of architects and the architectural aspects of earthquake performance of buildings, this paper has had three objective: First to show that earthquake construction is not merely an engineering activity for structural engineers, it is an activity to be shared by both engineers and architects; Second to demonstrate the role that non computational or architectural aspects plays in determining the earthquake resistance of building, and third to emphasize the need for engineers to understand characteristics of traditional construction and for architects to understand the problem and nature of earthquake effect on building.

Keywords— *Seismo-resistant Architecture, Structural Design, Bricklaying*

I. INTRODUCTION

The earthquake resistance of buildings depends upon three quite different processes in design. There is the overall layout of the building which determines the magnitude of the forces which come onto the building and their distribution: a distribution which is important in the vertical direction in section as well as the horizontal direction in plan. Secondly, there is the ability of the various parts of the building to resist this force, the strength of individual members and the connections between them. Thirdly there are those aspects of construction, which are rarely mentioned at all non-structural or architectural aspects of building,

non-loaded bearing walls and finishes. These may constitute a significant proportion of the mass of the building, their behavior may be quite independent from that of the main structural elements, and may cause serious danger to people or buildings.

For, instance if a seismo-resistant structure or rigid frame is made up of a given number of columns they should all show the seismo-resistant capacity simultaneously during the seismic stage. Otherwise, if owing to any reason, not regard in the Structural Design and Analysis, just part of them act at the beginning of the shake, the will be insufficient and eventually will break own. The remaining ones will fail in turn, brining about the collapse of the building.

II. BASIC PRINCIPLE AND CRITERIA:

The following three basic criteria for Seism resistant Structure Design are –

- a. The seismic coefficient for the various stories of a building increases according to the building height. Consequently, during the architectural design, it is very to place archives, swimming pools, or rooms containing heavy equipment in lower levels.
- b. The resistant elements may be placed with a certain degree of independence from the virtual load.
- c. Seismic forces are proportional to the building weight.

This principle, simple as it may seem, is nevertheless neglected in many building project, even nowadays.

III. STANDERD OF COMPATIBILIZATION OF ARCHITECTURAL AND STRUCTURAL DESIGNS:

The references variables which are to be morphologically compatibilized are considered at the very beginning.

- Flexible floor
- Building Collusion
- Seismic Torsion
- Pseudo resonance
- Sudden flexibility
- Concentred weight
- Short columns
- Tall buildings
- L-U- and T-shaped buildings

Now, the morphological answers for each variable. The following table is a first attempt which would admit an immediate application of the suggested solution.

A. Flexible Floor

This situation arises when at a certain floor; the stiffness of a tall building is considerably reduced in relation to the contiguous floors.

This situation causes a strong concentration of seismic forces on the site, giving rise to dangerous stepping mechanism of the building resistances.

The morphological answer is to avoid this feature in the architectural design. Whenever a floor with large separations between columns is required, it should be the last one or it should be placed outside the towed site, preferably designed as a single level.

B. Building Collision

This phenomenon takes place when there are no joints between contiguous buildings and the collision is produced when the oscillations are not synchronized. This is a completely abnormal situation which must be definitely avoided. The morphological answer is

building separation as current rules specify. It is recommended to take consideration into the design the various functions of the completely separated bodies for the same building in order to prevent building collision to proved a uniform structure and also to avoid sudden stiffness changes in plan and elevation.

C. Seismic Torsion

This effect is produced whenever the stiffness Centre(SC) and Torsion Centre(TC) do not coincide, thus causing additional constraints especially in those elements which are far removed from the SC, which might lead to the stepping of the seismoresistant capacity of the building.

The morphological solution is met by designing buildings with a symmetrical plan and elevation. In addition, the structural and non-structural interacting elements symmetry is required, as well as the functional symmetry of the architectural site.

D. Pseudo-Resonance

This phenomenon arises whenever the period of the building matches the predominant period of the foundation soil. This condition remarkably increases the seismic effects. On the other hand, if the fundamental vibration period of the building depends on its dimensions and structure stiffness, then, the morphological solution is to manipulate these parameters.

E. Sudden Stiffness Changes in Plan and Elevation

This situation can be prevented by using compact, homogeneous spatial shapes in the architectural design. Stiffness-Flexibility

Whenever a rigid or a flexible building is required, i.e. one that can be strained to a certain low or high degree respectively, the common practice is to use for the first case rigid structures such as partition walls made up of reinforced concrete and/or high density and high resistance masonry walls, 0.20m. Thick, and for the second case, the selection is for materials

which are adequate for flexible buildings. Both cases will influence the spatial morphology of such buildings.

F. Concentrated Weight

In most of the current seismoresistant standards, the seismic coefficient increases almost proportionally to the floor level with respect to the ground level. Consequently, in Architectural Design, this principle must be borne in mind, not only to avoid using heavy materials, subfloors, partition walls, coverings, etc., at higher levels, but also to place the sites designed for archives, swimming-pools, or heavy equipment at lower levels. In so doing, two purposes are achieved: firstly, a reduction of the seismic forces, since the seismic coefficient increases at higher levels and secondly, a logical reduction of the seismic shear and moments. The following example clearly illustrates the importance of this later concept.

It presents a six-level construction for comparing the seismic effect caused by a certain P weight, which is firstly placed at the fifth level and then at the first level of the same construction.

The results are conclusive. In the case of P placed at the fifth level, the overturning moment becomes 25 times greater than that for P placed at the first level. Besides, the seismic shear affects to levels 1 up to 5, whereas, in the second case, only the first level is affected but to a lesser extent (5 times less).

G. Short Columns:

Another aspect related to the resistance-stiffness problem is the so-called "Short Column". In this case, the seismic shear increases inversely proportional to the cube of its height for columns of equal cross-sectional area. In addition, this situation worsens for short columns because concrete is unsuitable for resisting strong tangential stresses, thus notably decreasing its ductility. These instances are originated

by a particular feature of masonry which reduces the columns height and consequently, their stiffness becomes greatly increased. This causes the seismic shear to concentrate on the column, which logically cannot resist. The rupture of the resistant elements could make the rest of the elements yield as well, which could in turn bring about the total collapse. This situation can be easily avoided by appropriately designing the shape and location of spaces and openings. On the other hand, when this problem results from differences in elevation between medium-height mezzanines, its elimination is practically impossible. Therefore, these elevation differences must be removed from the seismoresistant architectural design.

IV. TEACHING OF THE SRA TO ARCHITECTS:

The teaching of SRA to architects is focused neither on the seismoresistant structural calculus and optimized design nor on the structural optimization process. It is focused on the responses of the building's morphological and spatial configurations during the architectural design. In fact, the SRA should not be mistaken for the optimized seismoresistant structural design. It rather deals with the solutions from the architecture to seismic constraints. The SRA has established not only its aims, principles and methodology, but also the standards and recommendations for each seismic constraint, in terms of plane, spatial and morphological configurations. The approach presented is a SRA which has facilitated its comprehension and teaching, as well as the training of architects. It does not require thorough understanding of seismoresistant engineering; it does not modify the overall goal of teaching "STRUCTURES" to architects, i.e. the basic Design and Predimensioning of buildings. Figure 1 shows the traditional building design pattern. Figure 2 shows our proposed pattern for building design in seismic zones.



V. BRICKLAYING:

One of the problems of implementing of the Iranian Seismic Code in masonry construction is a lack of specific detailing for reinforcing masonry walls. The bricklayers avoid doing the reinforcement suggested in the Code, because it causes an interruption in brickwork. Different brick or block works practices can, however, be adopted to leave holes which form columns without interrupting the work, one of those is illustrated in.

Hollow Concrete Block:

Perhaps one of the main problems of concrete block masonry is a lack of reinforcement. The reinforcement of a building is important, because of the weaknesses of blocks which are produced without standardization and also because of the necessity of reinforcing masonry buildings to withstand earthquakes. Ordinary concrete blocks are produced by many small individual firms, many of which are in the North. Their quality, because of the scarcity of cement, is not standard. There are a small number of block producing firms which produce blocks for use in joist-block floors/roofs. They are mostly government controlled firms and their quality is based on the Iranian Standard and Industrial Research Institute (ISIRI). Concrete block masonry construction is commonly used with pitched roofs without reinforcements. One of the reasons for the lack of reinforcement of block masonry construction in the country is the difficulty of fulfilling the shuttering requirements for the reinforcement of concrete tie beams and columns. Wood for shuttering is both expensive and scarce. An attractive method of reinforcing masonry construction is to insert steel bars into the block voids as vertical or horizontal reinforcement to be filled with concrete grout to produce reinforced concrete ties inside the walls. U

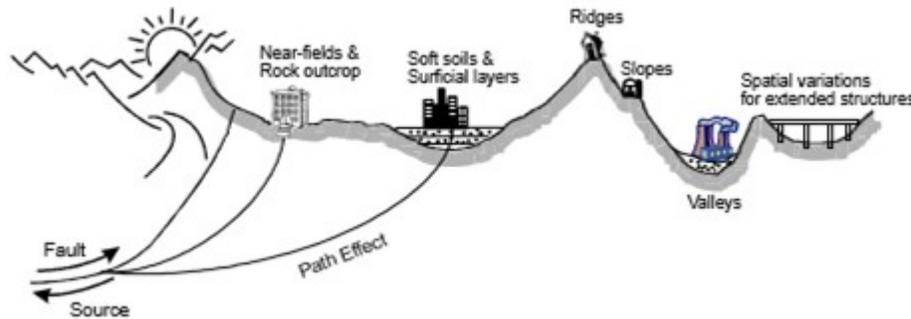
shaped block courses can produce the horizontal reinforced concrete tie beams, if the filled cavity is suitably reinforced. Because shuttering for reinforcement of masonry construction is costly, the use of the concrete blocks can greatly reduce the cost. The concrete block is capable of being installed to form horizontal and vertical reinforced concrete ties, without any use of extra shuttering devices. Illustrates two examples of blocks that could act as reinforcing moulds for masonry construction. The above examples are possible modifications of ordinary two core concrete blocks. Furthermore, it would be better to design and produce three core blocks with indent heads (for vertical reinforcement and also for filling mortar into the vertical gaps); shows the various sizes. The half size blocks helps the laying of the blocks on top of each other and their infilling with concrete into crude shutters. Although this provides a solution which may be adopted, the concrete block is unpopular because of a general desire to expose brickwork.

Another alternative for reinforcing block works is the use of a 'pilaster column'. A pilaster column allows the girder to stop short of the inside of the wall and to rest on the widened portion of the wall and this is shown in Figure 11. The ordinary block of (a) and especial blocks of (b) & (c) form the pilaster column for both masonry construction wall and reinforced concrete frame construction. It should be noted that are introduced for vertical reinforcement which is more crucial, in term of block works without interruption, than the horizontal reinforcement which lies on the block's bed joints.



VI. CHARACTERIZATION OF DESIGN AND GROUND MOTION:

The key issues for specifying a design earthquake or ground motion are: (1) seismic hazard maps (zoning maps), (2) local site effects, (3) near-source effects on horizontal ground motions, and (4) spatial variations of ground motions. There are also other issues related to the effects of the vertical component, energy and duration of ground motions. In conventional



VII. CONCLUSIONS:

This new approach is the result of the building being considered as a whole in which every component interacts with each other during seismic activity. This interaction may be either positive or negative. Consequently, the analysis of such interrelations and their compatibilization from the architectural design viewpoint is required to prevent a decrease of the building seismoresistant capacity. From this global approach to the problem, we have developed a general Theory of Seismoresistant Architecture. Such a theory has got a definition, objectives, basic principles, general methodology and overall criteria of architectural and structural designs compatibilization. This theory pursues that architecture should make its own synthesis facing the seismoresistant demands, and naturally give its answers from morphology. Our General Theory of Seismoresistant Architecture allows architects to assume their responsibility in the seismic problem from the architecture itself (morphology) rather than from the seismoresistant design of structures inherent to seismoresistant engineering. In order to face this approach somewhat alien to the architect, it was necessary to change each and every seismic constraint into morphological constraints of the architectural project. On the other

engineering design – despite a large variability in the ground motion characteristics – a simplified deterministic approach is followed. This procedure is based on a simple parameterization of earthquake magnitude, distance, and site category¹³. Newer research efforts use numerical ground motion models based on seismological theory to analyze the origins of this variability so that the uncertainty in estimating ground motions can be reduced.

hand, the knowledge needed to understand and apply such Seismoresistant Theory is the knowledge which stems from the basic design of seismoresistant structures, a typical aim of teachings of the “Structures” courses in seismic zones. The approach does not require performing structural analysis or complex analytical methods or formulas. It requires, instead, of an adequate selection of contents and their systematic comprehension through concepts

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