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SEISMIC DESIGN CRITERIA FOR EGYPT

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ABSTRACT

Countries like Egypt having low to medium seismicity require great care in estimating seismic hazard levels. The general belief among engineers in Egypt that the country is earthquake-free zone has resulted in buildings designed in most cases for wind loads but without any provisions for seismic action. This paper presents the efforts that have been done during the last few years in order to establish a seismic design criteria for Egypt.

KEYWORDS

Seismic design criteria; seismic hazard, seismic risk, hazard maps, Egypt.

INTRODUCTION

The prevailling knowledge among structural engineers in Egypt since the sixties has resulted in formulating building design codes that do not consider earthquake forces on buildings. This was argued that Egypt is a seismic-hazard free country. A great change in this attitude has been noticed in the eighties since the establishment of the Egyptian Society for Earthquake Engineering (ESEE). This has resulted in formulating the first edition of "Regulations for Earthquake- Resistant Design of Buildings in Egypt " (Sobaih et al., 1988).

SEISMIC HAZARD ASSESSMENT

Seismic hazard assessment has been considered as an essential step towards setting seismic zoning maps for building codes. Although the hazard analysis method was developed particularly for individual sites, it can be systematically applied to a grid of points to obtain regional seismic probability maps. This concept was first introduced by (Cornell, 1968), Milne et al., 1969 and Cornell, 1971). The first hazard map of the United states has been prepared by (Algermissen and Perkins, 1976). Since that time, hazard maps became a main application for many hazard studies (Mihailov, 1978, b, 1982, Olivira et al., 1984, Donovan et al., 1978, Hattori, 1982 and 1988).

Analytical Method

The analytical method to determine seismic hazard at a site has been developed over the past thirty years by different researchers (Cornell, 1968, 1971; Esteva, 1969; Merz and Cornell, 1973). The main idea of the probabilistic hazard analysis is to estimate the probability that a certain peak ground acceleration (PGA) will be exceeded during a known period of time at a certain site. This idea can be acheived through four main steps: Source mechanism, attenuation model, intensity mechanism and occurrence mechanism.

Hazard Maps

Based on the above-mentioned analytical method several hazard maps for peak ground acceleration (PGA) have been prepared for Egypt (Sobaih et al., 1992). Samples of the obtained hazard maps are shown in Fig. 1. These maps thake into consideration all problems pertinent to the current data available in Egypt (Ahmed et al. 1992, Ahmed and Sobaih, 1994).

Seismic Hazard Level

The choice of the exceedance probability for hazard map is a controversial problem. Although an annual exceedance probability of 0.0005 is strongly recommended, only 0.002 is now generally recognized in model codes as a basis for design (Whitman, 1989). The chosen level of hazard should reflect the importance of the structure as well as its expected life-time. Table 1 shows the classification used to develop hazard maps or Egypt according to (Sobaih et al., 1992).

Table 1. Classification of hazard maps (Sobaih et al., 1992)

Map No	Construction Category	Life-time	Importance Factor	Non Exceedance Probability	Hazard Level	Mean Return Period
1	Masonry	50	III	80%	0.0040	250
2	R.C.building	100	III	80%	0.0020*	500
3	R.C.building	100	II	85%	0.0015	667
4	R.C.building	100	I	90%	0.0010	1000
5	Civil structures	200	I	90%	0.0005**	2000
6	N.P.P & Dams	500	I	90%	0.0002	5000

* The current standards for hazard level in the world (Whitman, 1989).
** The recommended standards for hazard leel in the world (Whitman, 1989).

Concept of Design Using Hazard Maps

According to (Whitman, 1989), the design method by using hazard maps follows two approaches. The first approach is called " one level" design method in which a structure is checked against lateral static loads derived from the expected gound acceleration at the site for those cases where " static" design is appropriate as reported by the code . Whenever a dynamic analysis is required by code , the second approach, which is called " two - level " design method, should be applied. In this case the structure is first designed to remain elastic with the expected ground motion during its life- time. Then, after detailing as required by code, is cheched to ensure that collapse will not occur during a higher value of ground motion dervied from assuming a higher non-exceedance probability level than in the first step. Thus, whenever a dynamic analysis is required by code, two levels of hazard should be considered to ensure functioning and survivability of the structure. The hazard analysis methodology is the same for both approaches. However, for Egypt it is more practical to use hazard maps with the first approach. Whenever a detailed dynamic analysis is required, a hazard curve should be obtained for the site by using the probabilistic analytical technique (Ahmed et al., 1992).

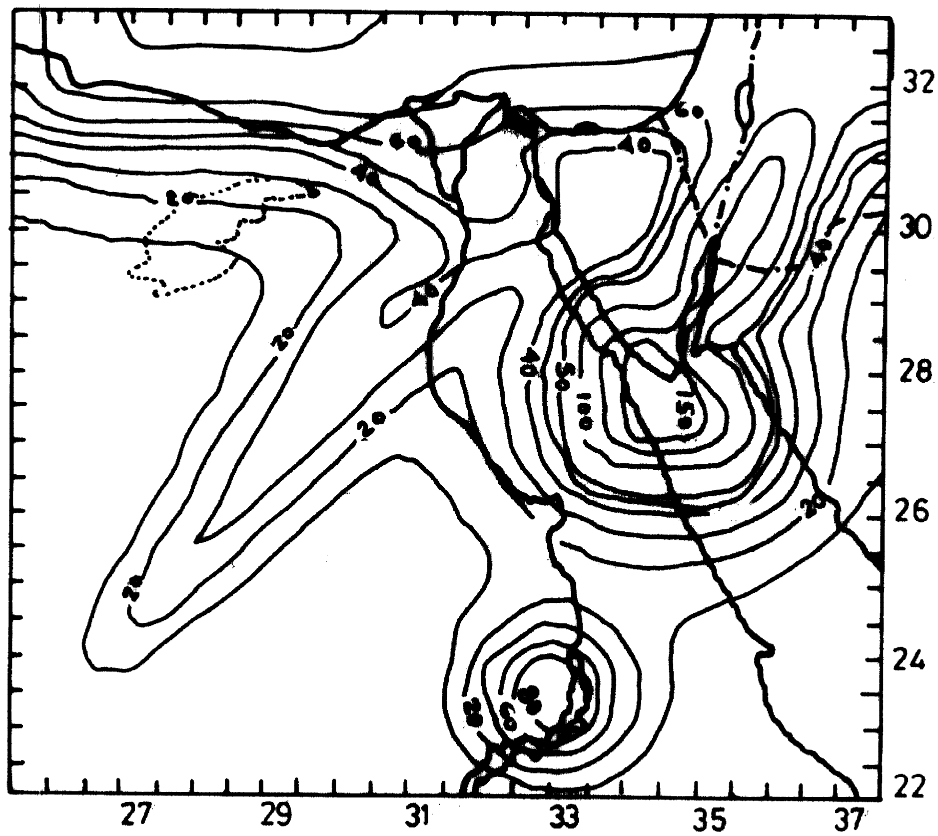


Fig . 1 (a) . Hazard map for exposure period of 100 years and non - exceedanc probability of 90%

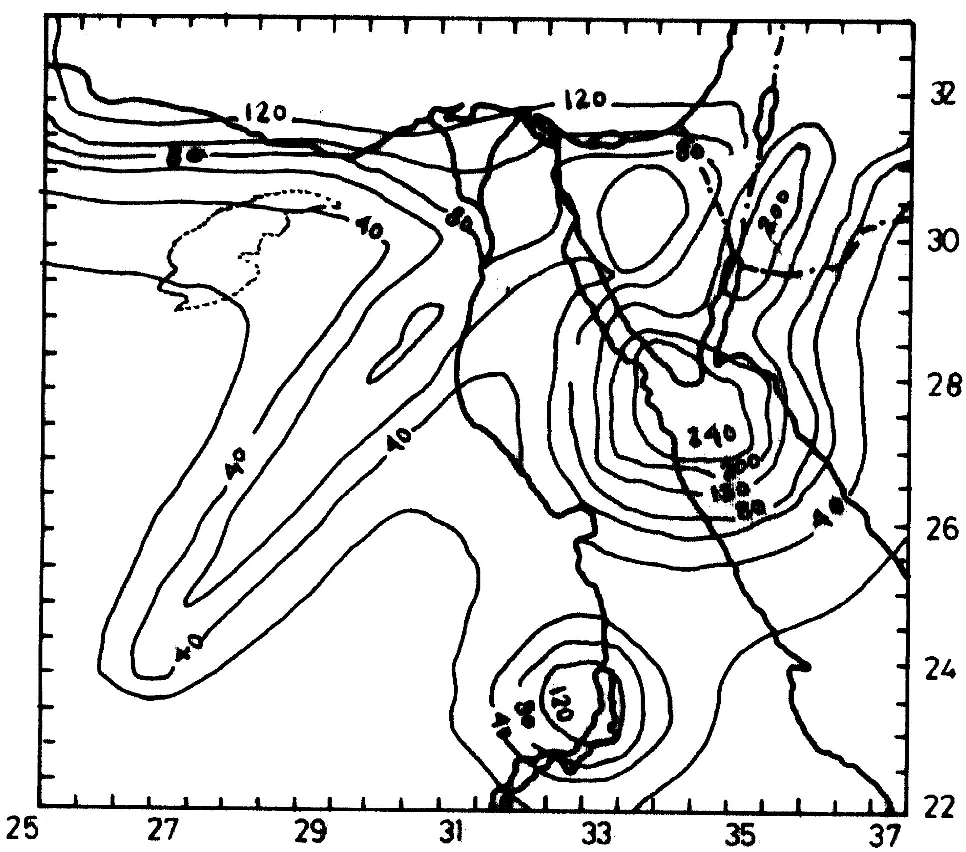


Fig . 1 (b) . Hazard map for exposure period of 500 years and non - exceedanc probability of 90%

SEISMIC DESIGN CODES

In 1988 the Egyptian Society for Earthquake Engineering has developed Regulations for Earthquake-resistant Design of Buidings in Egypt (Sobaih et al., 1988). These regulations give the principles of evaluating seismic actions required for both static and dynamic analyses. It also give values of allowable stresses, requirements for particular elements and allowable deformations (inter-story drift and total deformations).

In order to provide ductility in structural elements minimum requirements for beams, columns and shear walls detailing have been proposed (Sobaih, 1990).

SEISMIC RISK OF EXISTING BUILDINGS

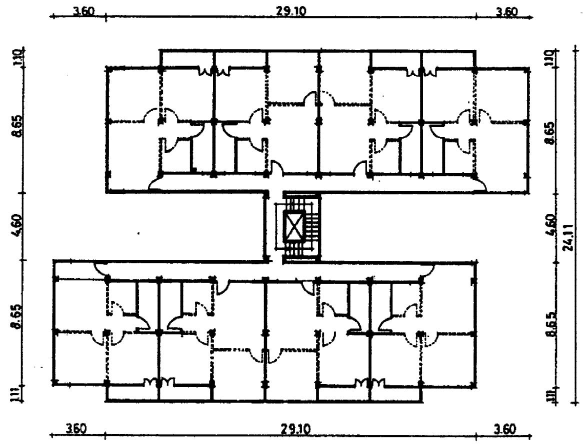
Evaluation of seismic vulnerability of existing reinforced concrete buildings has started in the last decade. A recent method has been proposed (Sobaih et al., 1992). The method has been verified by comparing its results for several buildings that have been subjected to earthquakes in different parts of the World.

A class of buildings is considered for the evaluation of its seismic risk. Six typical designs prepared and constructed on a large scale by the Ministry of Housing in Egypt have been chosen for this purpose, Fig.2. These buildings have five stories and were not designed to resist earthquakes as stipulated by the offical Egyptian Code. The method developed by (Sobaih et al., 1992) has been applied to these buildings for the three soil types described in (Sobaih et al., 1988), i.e., for hard, medium and soft soils, respectively. The results of the seismic risk evaluation are shown in Table 2.

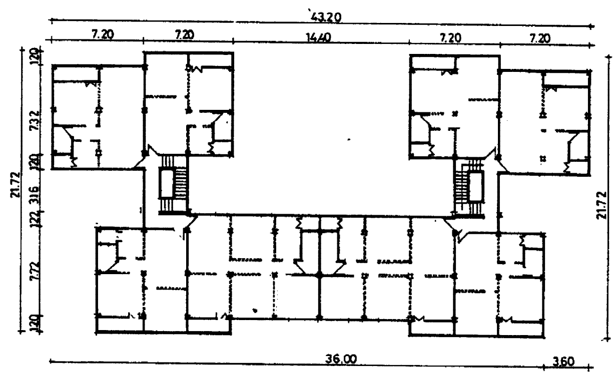
In case of adopting the minimum detailing requirements proposed by (Sobaih, 1990) and reevaluating the seismic risk for these typical buidings it can be easily noted that the risk level is reduced in most cases as shown in Table 3.

Table 2. Seismic risk level in original design

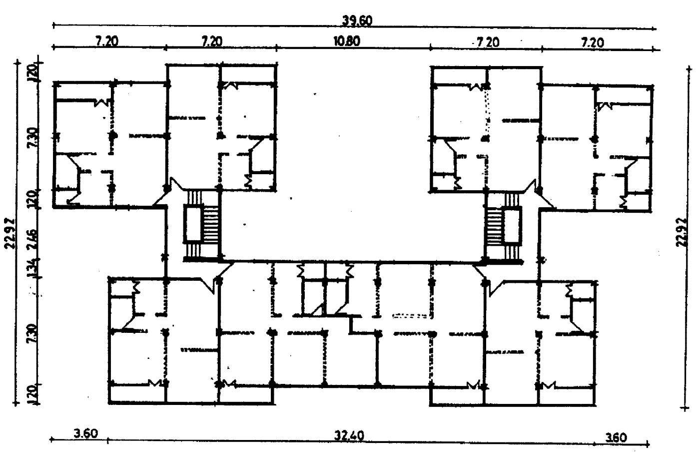
Model	Longitudiual Direction			Transverse Direction		
	Soil I	Soil II	Soil III	Soil I	Soil II	Soil III
A	High	High	High	High	High	High
B	High	High	High	Low	High	High
C	Low	High	High	Low	High	High
D	Low	High	High	High	High	High
E	Low	High	High	Low	High	High
F	Low	High	High	Low	High	High



Model A

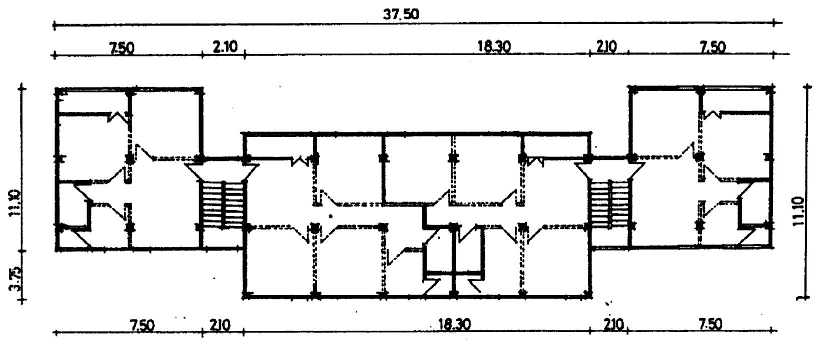


Model B

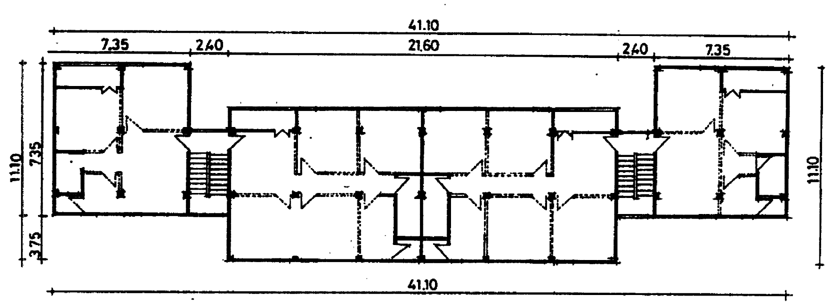


Model C

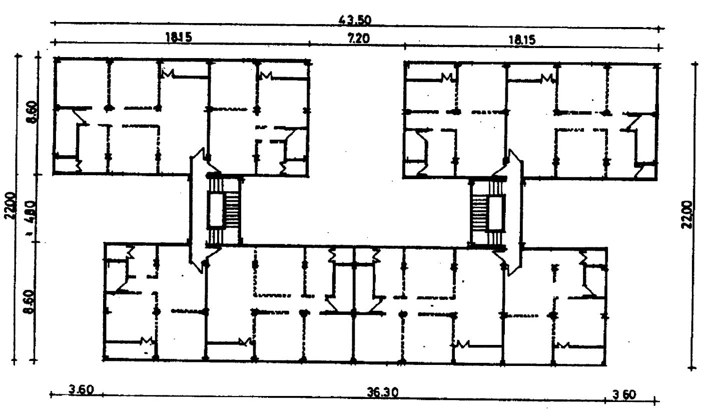
Fig . 2 . Class of buildings considered



Model D



Model E



Model F

Fig . 2 (Cont .) Class of buildings considered

Table 3. Seismic risk level after adopting minimum detailing requirements, (Sobaih, 1990).

Model	Longitudinal Direction			Transverse Direction		
	Soil I	Soil II	Soil III	Soil I	Soil II	Soil III
A	Low	Low	High	Low	Low	High
B	Low	Low	High	Low	Low	High
C	Low	Low	High	Low	Low	High
D	Low	Low	High	Low	Low	High
E	Low	Low	High	Low	Low	Low
F	Low	Low	High	Low	Low	High

CONCLUSIONS

This paper presents the current status of seismic design in Egypt. Basis for seismic hazard assessment, evaluation of seismic actions, and minimum detailing requirements are highlightened. It is shown that although Egypt is generally considered as low to medium seismically hazard country, the current design of buildings leads to high seismic risk in most cases .

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