AN EDUCATIONAL TOOL IN EARTHQUAKE ENGINEERING

Maria de Fátima Farinha
EST-UALG, ICIST

ABSTRACT: One of the main social purposes of education is the transmission of knowledge to the generations that follow, in the most appropriate form. Throughout time, educators have resorted to the technologies at hand, in order to establish the best possible mechanisms for providing knowledge. Increasing ease of access to computers and recent advances seen in information technologies now mean that these can be used as an important tool in education. The work presented in this paper is intended to demonstrate the potential of these systems in the understanding of seismic phenomena and in creating student's awareness of the importance to design structural systems that will perform well under seismic conditions. Animation of vibration modes gives a clear understanding of the structure's behaviour. The main benefits expected include: i) to enhance student's interest in earthquake engineering; ii) to support students' work so that they may be less dependent on physical human presence for tutoring; and iii) to enable students to address more difficult and complex problems.

KEYWORDS: education process, information technology, open and distance learning, earthquake engineering

1. INTRODUCTION

Education is continually changing in keeping with the development of new tools and methods. Purely theoretical education provides the fundamentals but not the right answer to a problem. Nowadays education has to prepare students for practical design and has to give them practical teaching regarding specific design problems in reasonable time.

Computers have played a major and important role in this process. Though initially computers were only looked as the tool that speeds up the mechanical work, they now have a very different scope. For example computer mechanical analysis gives a deeper understanding of the behaviour of a structure. Finite element method (FEM) helps to understand plastic and non-linear behaviour. 3D design is now particularly important: the graphical presentation of results of a phenomenon provides a much better understanding of it.

In recent years learning technology has reached maturity and emerged as a viable educational medium (Timms et al., 1997; Mogey, 1997 and Pavic et al., 1999). Nowadays the field of learning technology offers a wide range of tools and technologies to support education. Computer Assisted Learning (CAL), at its simplest, includes text files that are read via the computer or, at a more advanced level of development, includes complex programmes that present the information using multimedia techniques that interact with the student intelligently. CAL provides several advantages, with emphasis on: I) the large quantity of information that are available; II) the ease and speed of search; III) the diversity of ways in which the information can be presented – text, diagrams, charts, flow-charts, drawings, photographs, video, etc.; and IV) the capacity to provide real-time responses.

Recent studies show that the learning capacity of students supported by multimedia systems is greater than that of students involved in traditional teaching methods. The conclusion of this study is that good students reveal little difference, while weaker students show better results (Issa et al., 1998). The main obstacle to a complete integration of Computer Assisted Learning within the present-day higher education system has essentially to do with economic aspects involving the cost of the equipment and the cost of developing these systems and keeping them in operation.

2. PURPOSE

The main purpose of this work is the development of an animation tool that provides a better understanding of the effect of the seismic phenomenon. At the same time, it is expected to create student's awareness of the importance to design structural systems that will have good performance under earthquake loads.

Although some analysis programmes already covered the animation of vibration modes, the objective was to compile a wide variety of case studies focusing student's attention on the seismic behaviour, with the great advantage of not having to work in real-time.

It was deemed important that all the case studies are based on actual events. So students are closer to professional practice (Petersen and Reynolds, 1999) and to the need, right from the outset, to harmonise the structural design with the architectural design so that the latter would not overly condition the former.

3. SYSTEM ARCHITECTURE

Several buildings with portal frame structure and with a combined wall/portal frame structure, of quite varied height and geometry were analysed.

The response to earthquakes loads were determined by a dynamic analysis programme (SAP 2000, 1997). Seismic activity was quantified by average response spectra defined by the Portuguese code (RSA, 1983). Earthquake loads were considered as acting in the two perpendicular directions in which structures are mainly developed. The vibration modes were calculated and the response to each (modal combination) was determined using the Complete Quadratic Combination (CQC) technique. Taking the Square Root of the Sum of their Squares (SRSS) method the modal results were combined.

The work was undertaken on a personal computer in Windows 98®.

4. VISUALISATION OF RESULTS

Since, within the scope of this paper, it is not possible to present all the case studies, it was decided to present just five cases (Table 1). For each case, the presentation of some of the vibration modes involves a sequence of images taken during the animation.

Table 1

Case study	N° of floors	Layout Area (m^2)	Vibration Modes (Hz)			
			1°	2°	3°	4°
A	10	450	0,565	0,675	0,872	1,872
B	8	230	0,851	0,860	1,120	2,913
C	2	610	2,665	2,707	4,803	9,124
D	7	1280	0,787	1,028	1,498	2,933
E	5	3500	1,333	1,630	1,854	3,571

Case studies A, B and C are three examples of structures that are fairly homogeneous both on plan and in elevation, with a resultant good performance of the structural system under seismic conditions (Figure 1,2,3).

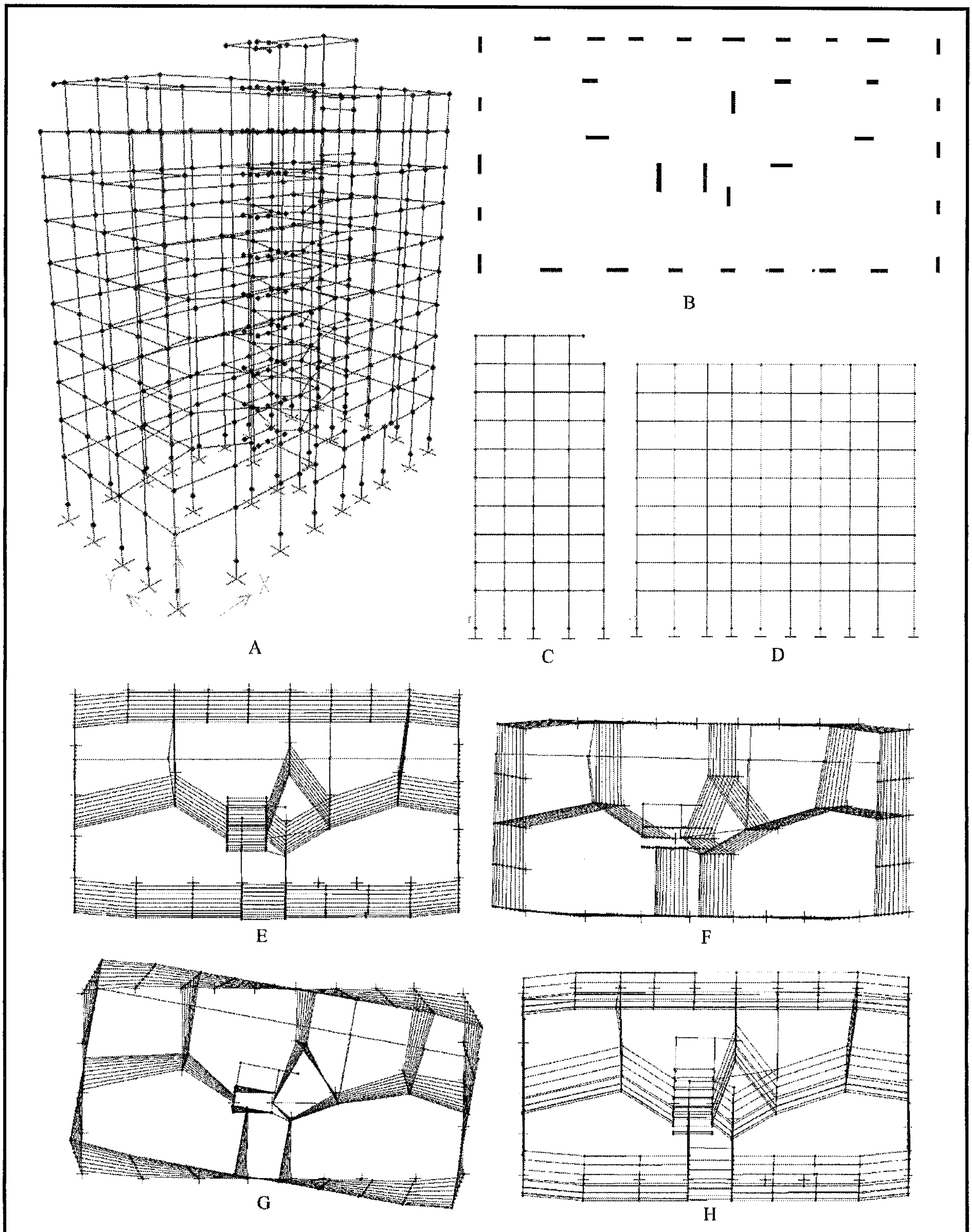

Figure 1. Case study A

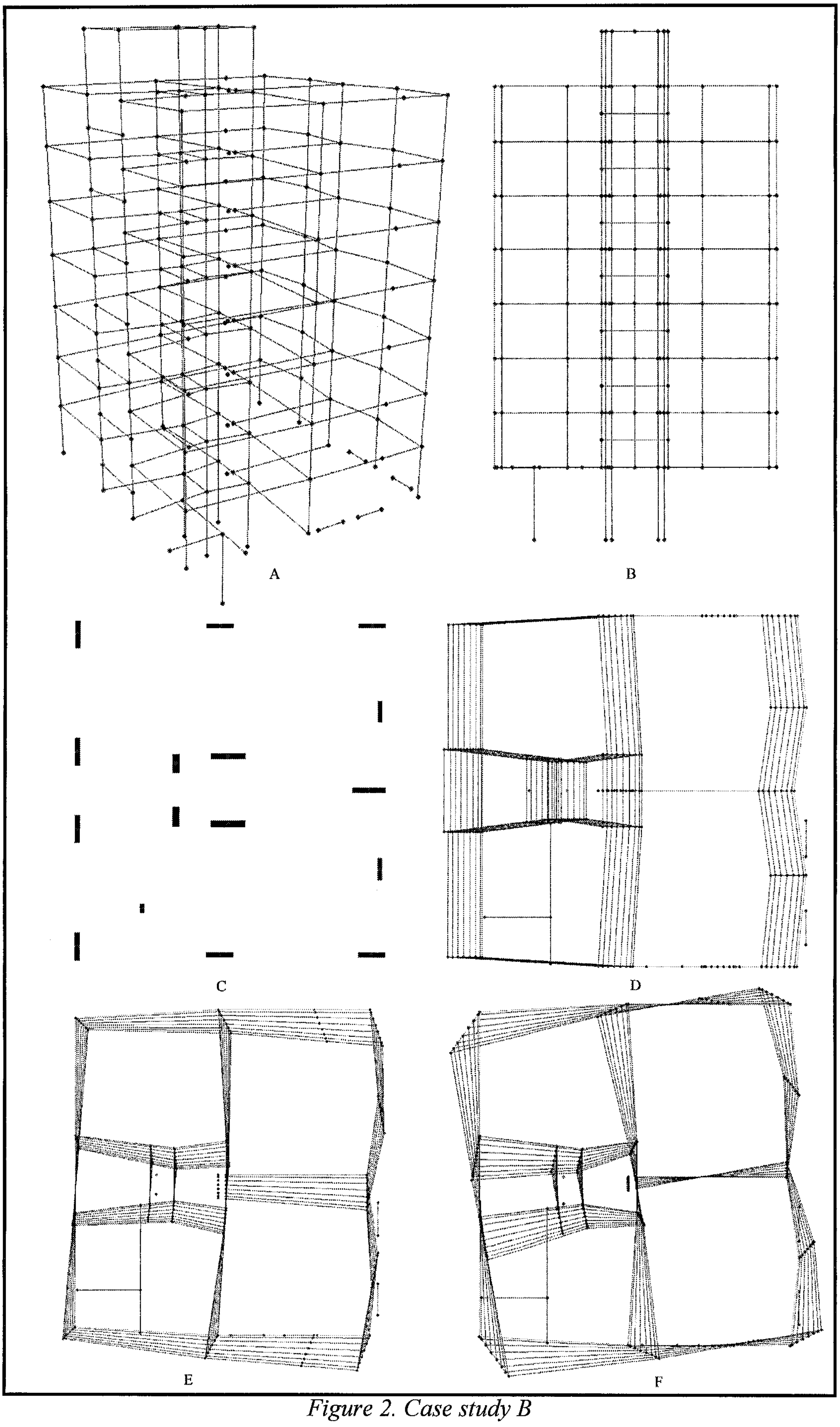

Figure 2. Case study B

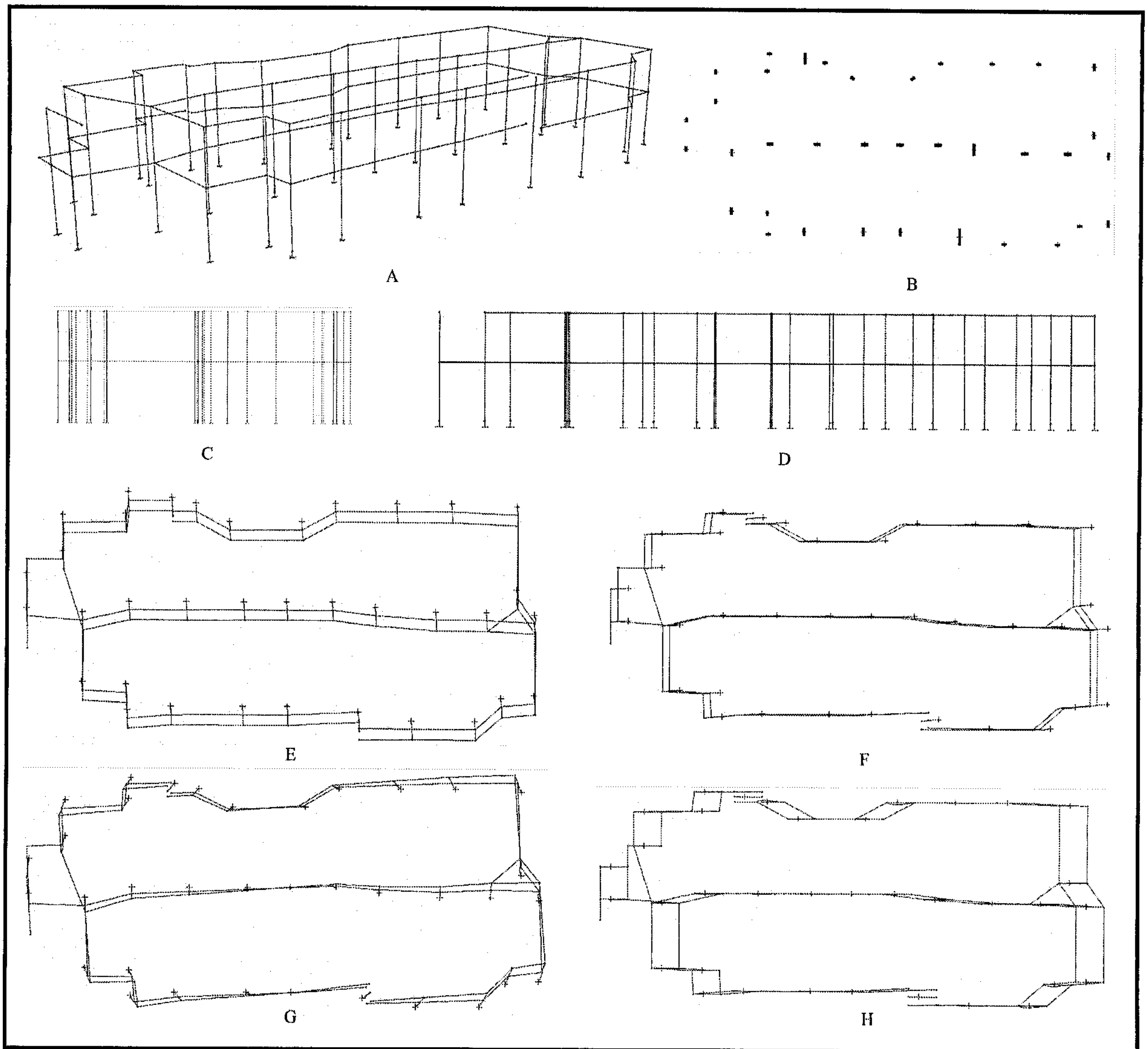

Figure 3. Case study C

In case study D, for architectural reasons, the vertical elements had to be oriented in the direction of the smaller dimension of the building; a very stiff wall element was then conceived along the longer dimension, positioned in the central part on plan, joining both the elevator shafts. As result of this structural solution, the vibration modes performed other than as desirable: the first vibration mode was along the greater dimension of the building on plan and the second vibration mode was along the smaller dimension (Figure 4).

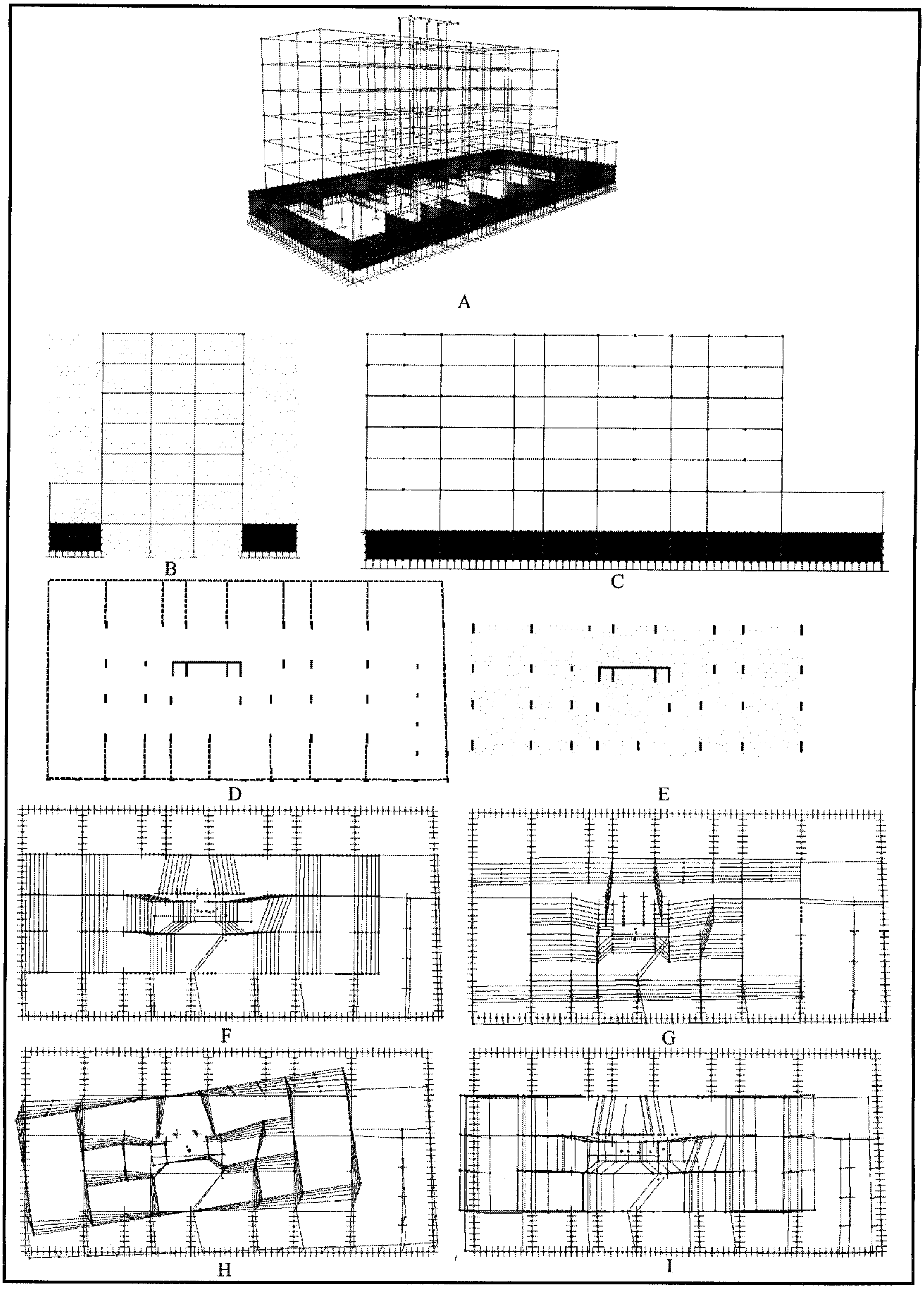

Figure 4. Case study D

Example E refers to a multipurpose building: a car-repair shop, a sales' room, a warehouse and offices, which led to a difficult structural solution with double-height columns and slabs at different heights. These asymmetries of rigidity distribution became perceptible through vibration mode analysis: for example, the first vibration mode already has a component of torsion (Figure 5).

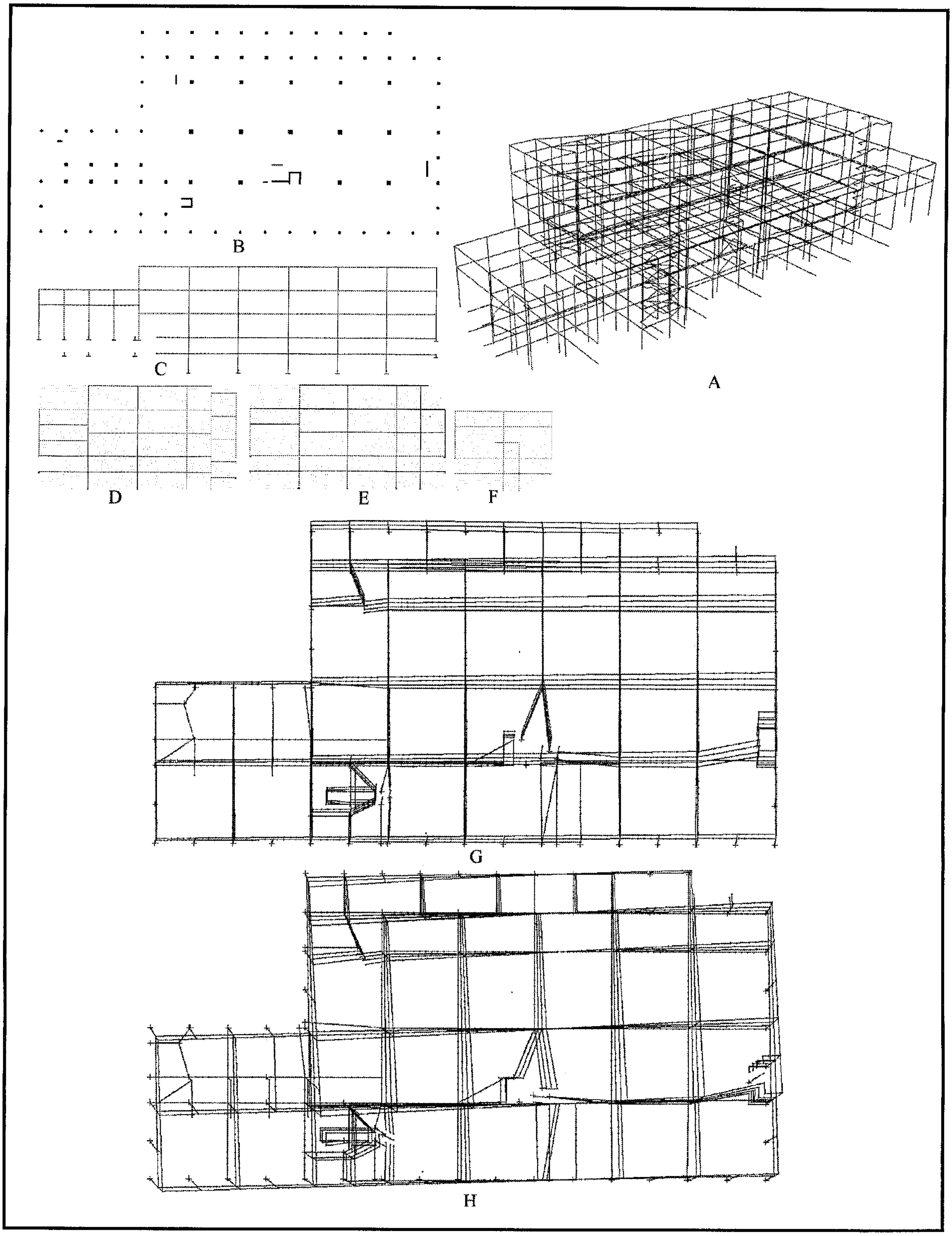

Figure 5. Case study E

4. CONCLUSIONS

The most important aspect for a good seismic performance of a building has to do with the structural system.

The analyses of case studies create student's awareness of the importance of avoiding irregular and complex structural systems. The focus should be on solutions providing (Oliveira, 1989):

- symmetry of mass and rigidity;
- uniform height, with structural continuity and gentle transitions of mass and rigidity;
- uniformity on plan, embracing rectangularity, regularity and redundancy.

This is only possible if, at an early stage of the design process, a frank dialogue is established between the various parties involved, particularly between the architectural team and the structural team.

From a teaching point of view, this is considered to be an effective tool in the creation of student's awareness of the effects that earthquakes have on buildings and of the importance to design structural systems with a good seismic performance. It will be possible to move on to an interactive course in earthquake engineering, complementing the animations with a description and exhaustive explanation of each case. In combination with the development of global communication networks it is also possible to provide an open distance-learning course.

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