Learning engineering from breakdown cases

Learning Engineering from Breakdown Cases

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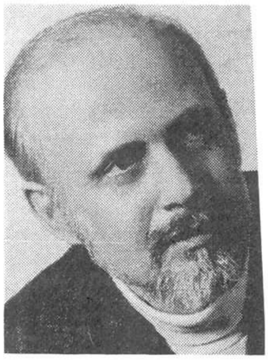

Summary:

Engineering decision making processes are not always rational. Intuition, feeling, common sense and other forms of pre-rational mechanisms are used as well. They are based on knowledge accumulated while "being-in-the-world", and particularly during breakdowns. Studies of engineering disciplines are predominantly theoretical and students have few opportunities to learn from experiences or breakdowns. It is proposed that information technology, particularly virtual reality and multimedia, would allow them to share the experience of those few that had such opportunities. An electronic publication is presented, that uses breakdown cases to convey structural engineering knowledge of earthquake resistant design of reinforced concrete structures. It based on more than 500 commented and classified digitised images. The system proved efficient and was found to complement the related theoretical knowledge.

Keywords: education, earthquake engineering, multimedia, case-based iearning, breakdown

Most of engineer's work is founded on solid mathematical and mechanical foundations, however, particularly during conceptual design process, more primal decision making mechanisms such as "feeling", intuition, insight and common sense also take place. They are not learned as much in school as in the everyday life - as Martin Heidegger would have put it - while "being in the world". Buildings like the one in Fig. 1 (right) are not designed because of experiences such as in Fig. 1(left). But buildings such as the one in Fig. 2 *are* designed and can fail (as shown in Fig.3) but no "feeling" speaks against them.

Experienced engineers are gaining the "feeling" during their whole career. Psychologists and philosophers claim that learning is most efficient when things go wrong - while real life problems are being solved. Teaching of young engineers should reflect that. Studying and experiencing failures provides valuable lessons in general.

We propose (1) that some engineering topics can be efficiently learned from breakdowns, that (2) such learning also contributes to the pre-rational knowledge, feeling, intuition and that (3) hypermedia can be used to implement it. We prove the hypotheses with a system to teach earthquake engineering - EASY.

Earthquake engineering is a particular well-suited topic to implement these concepts. Fortunately for the general population, but unfortunately for the structural engineers, earthquakes happen very rarely. Additionally, the effects that the earthquakes have on buildings are extremely difficult to model in a laboratory. It is therefore very important to be able to share the "in-the-world" experience of those that have seen what earthquakes do to engineering built structures.

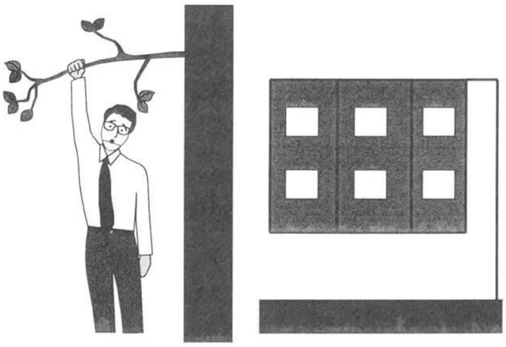

Figure 1: Not applying common sense experience (left) to engineering design(right).

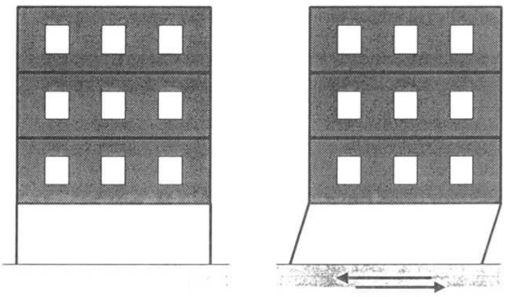

Figure 2: Typical soft storey structure.

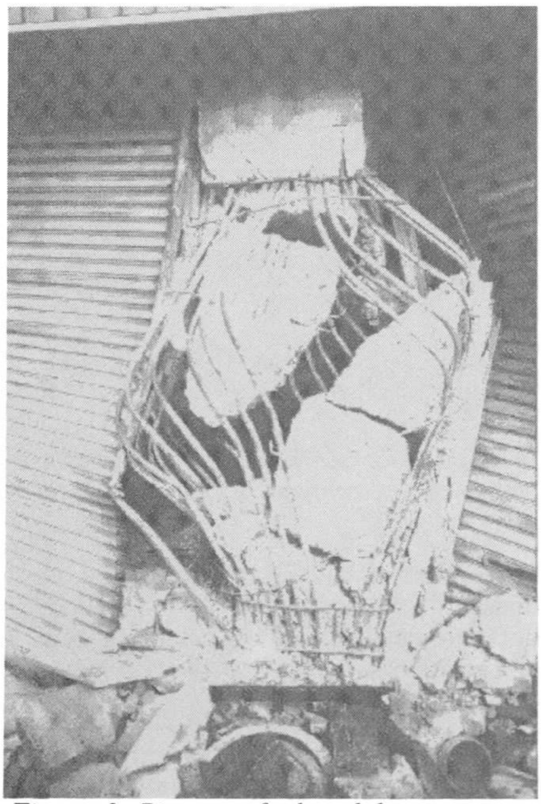

Figure 3: Picture of a breakdown.

A system has been created that structures a lot of the knowledge related to earthquake engineering around the failures and breakdowns. It uses hypermedia to show the breakdown realistically, triggers interest and the natural curiosity and offers hyperlinks that lead the exploratory mind of a student to informal and formal knowledge about earthquake safe design. It is available on the Web at

http://www.ikpir.fagg.uni-lj.si/easy/.

The system implements the idea of breakdown oriented learning and models the learning process into four steps:

Breakdown: The breakdown is shown as a color image of a collapsed structure or detail (as in Fig. 3). It captures student's attention and triggers the "will to meaning". Hundreds of pictures are available that show collapsed structures and details of structural elements.
Rationalization: A lot of structured information about a slide is given, both structured in various classifications, as well as in the form of unstructured comments. Explanations for the failure of this particular building or element are given.
Generalization: Failures have been classified into nearly 20 failure types. In depth explanations are provided on how and why such a failure type occurs. Hyperlinks lead to other slides that show the same type of failure or are similar to the examined one by one of the criteria. By following them, students gain a more general view on the topics and can explore the more general views on the problems of earthquake resistant design.
Conceptualization: Hyperlinks to textbooks and into the related building code are provided. More formal, higher level models related to the original breakdown are shown. Formal knowledge from the domain of structural dynamics as well as recipes from building codes are given.

Ever since visiting the earthquake sites and taking photographs it has been intuitively that structuring engineering knowledge around breakdown cases could be a useful and attractive approach. It was well accepted by students and educators. This paper, post-festum, provides the rationalisation: why it works. And hopefully eases the development of similarly conceived systems for example related to the fire safety, general structural safety etc.