# Free discussion. First part

## Free Discussion – First Part

In the free discussion to the preceding four contributions, the following persons (listed in alphabetical order) participated

Dr. F. Knoll, Montreal, Canada
Prof. J. Pechar, Prague, Czechoslovakia
Dr. R. Rackwitz, Munich, German Federal Republic
Prof. J. Schneider, Zurich, Switzerland
Prof. C. Turkstra, Montreal, Canada
J. Varsano, Tel-Aviv, Israel
Dr. L.P.C. Yam, London, United Kingdom

Their statements are given below in chronological order:

Pechar: I should like to make some remarks on structural design as a safety measure within an overall safety concept. Sometimes the design problem is simplified to the solution of the safety-cost interaction problem. This simplification is clearly not adequate and acceptable since the notion "safety" does not only cover sufficient bearing capacity and adequate serviceability of structures but also should take into account the influence of structures on the environment and on the user etc. Optimization alone cannot solve the problem. We need probabilistic methods as a tool for improving and quantifying our experience with respect to loads for different structures in different areas for different requirements and conditions and with regard to the behaviour of structures. But design procedures then must be appropriate to their respective task and should take into consideration elastoplastic behaviour of structures, physical and geometrical imperfections (including fabrication and erection tolerances), large deformations etc. and not just only cost-benefit optimization. The limit state design procedure used in Czechoslovakia during the last 12 years seems to correspond quite well to the above mentioned requirements.

Schneider: In preparing the final details for this seminar, I found myself asking "What is the purpose of all this ? Are we on the right track with all these contributions ?" In this context I would like to make some rough, and not very well thought out statements first: The individual wishes to live in his own way. Society, however, lays down certain limitations - unfortunately not the same limitations for everybody. Society also puts financial and other resources into the environment, thus enabling the individual to do, within the given limitations, what he wants, and it is obvious that these resources are limited and differ between different countries. Now life is dangerous and entails risk of life and limb for the individual, who requires society to reduce this risk, although he may voluntarily run much higher personal risks by sports such as mountaineering and other activities. But the reduction of risk is costly and society cannot afford to bring it below a certain level.

We ought then to look for some systematic picture which could be termed the "risk environment" starting with basic risks, such as for example of being killed by hunger, thirst, frost, heat or illness. We there begin to intervene by the distribution of food by means of roads, vehicles, bridges and pipes we build houses to live in, we erect energy plants and distribution systems and provide adequate medical care by setting up hospitals, pharmaceutical industries etc. In doing all this we introduce into the risk environment a multiplicity of additional

hazards which lead to accidents in the home, at work and in traffic, and we cause pollution etc. Among all these additional risks the possibiliy of being killed directly or, in a sense indirectly, by failing structures, is one of our special concerns. This rough outline of a risk environment should in my opinion be developed and also numerically quantified.

Using an adequate definition of "safety" as the requirement to reduce environmental risks to life and limb to a level which can be afforded by society, we could then recognize the problem of optimal safety as a distribution problem: invest the given resources of society adequately in the different areas of the risk environment mentioned above in order to obtain minimum risk.

In doing this, some questions arise: How much can society afford to spend to save the life of one of its members ? How much is society willing to spend ? How should safety measures (i.e. risk-reducing measures) be introduced into the risk environment ? What percentage of the available resources could be allotted to the building industry at large and what proportion would go towards structural safety ? How should structural engineers distribute these resources between the planning, design, execution, maintenance and control of structures ? And, finally, are we actually putting our resources into the most effective place to achieve structural safety.

I admit that this all is very vague, but I think that we should reflect a great deal on these questions. Safety concepts, the theme of our seminar, demand a broader view.

Knoll: Housing and structural work is only a very minor portion of the risk environment. If compared to other risks such as the fire hazard or that of traffic accidents, we see that there is not a very great incentive for society to reduce the frequency of structural failure. We must be conscious of this when thinking about the resources society is prepared to provide for the improvement of structural safety.

Rackwitz: Professor Schneider broadened the subject of this discussion to fields as the general risk environment for human beings and to the value system upon which decisions concerning structural safety should be based. Though such subjects are highly interesting we should restrict our discussion to more technical matters. The selection of a value system is not the domain of engineers nor can they decide on a particular system. But, the engineering profession should explicitly state and then report to the society what its criteria are it is using when developing technical safety measures or "local" optimization within the building sector. A basic need, therefore, is to elaborate an appropriate language for a dialogue between society and engineers.

Knoll: I do not think I agree to limit the discussion to simply technical as everything hangs together. Everybody is involved in affecting structural safety as owner, builder, user or merely by accident.

Turkstra: Melchers has suggested that task simplification might help to prevent errors. However, industrial psychologists have evidence that the converse might be true.

People are motivated by an hierarchy of needs starting with basic requirements for food, shelter and security. When a sufficient level of satisfaction of these needs has been reached, people are motivated by more complex factors including

"self realization" of the need to fulfill one's self image. In other words, people like to have fun.

Psychologists have suggested "job enrichment" by adding responsibilities and greater skill requirements as a basis for better performance.

Varsano: Referring to Prof. Schneider's conclusions I would like to rise the problem of unexpected loads, which could lead to progressive collapse. This problem is well connected with general safety concepts. The question is to what extent is the society ready to take upon itself, the risk of progressive collapse, and what would the economic influence of such requirement be."

Yam: Our study on progressive collapse in the UK is related to unexpected loads due to gas explosions. Safety measures consist of structural and non-structural strategies. On the loading side, pressures due to internal explosion depend on room geometry, arrangement of furniture, venting and ventilation, and are therefore very difficult to predict. On the resistance side, the important factors include continuity at joints and satisfactory layout of the structure on plan to maintain strength in all possible directions after damage. Our study has also shown that the dynamic response is related to the extent of damage and that making some parts of the structure weak helps to prevent progressive collapse.

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