CORRESPONDENCE

A letter from Emeritus Professor F. CAMPUS, late Rector of the University of Liège.

The so-called probabilistic conception or theory of the safety of structures was formally expressed at the Third Congress of the International Association for Bridges and Structural Engineering in Liège, in 1948. The result is to substitute to the traditional "factor of safety" a so-called "probability of failure". This last concept is not so simple as it seems at first glance; it is almost rather ambiguous. The failure under consideration is indeed the impossibility of further service of the structure occurring before the end of the time assigned to the service and this only under mechanical effects. This end of serviceability may result not only of rupture or instability, but also of excessive deformations or cinematic displacements. Therefore, it is not called "probability of rupture".

There is also some ambiguity about the effect of time. Failure may occur at any time, because external forces have reached a statistically abnormal high value. The effects of time and exposure on the mechanical properties or resistance of the structure are rather ignored, except perhaps for shrinkage and creep, and also for fatigue, where it is more a question of repetition and accumulation than of time proper. Nevertheless, the theory goes so far as to define in very general terms an economical optimum for the probability of failure for a given structure and a given time of service. It corresponds to the minimum of a capital which is the sum of three terms:

a) *The initial investment or cost of the structure.*

b) *The capital corresponding to the maintenance costs during the assigned time of service.*

c) *The capital corresponding to the guarantee fees covering the risk of failure during the time assigned to the serviceability, including the reconstruction costs, the indemnities for corporal and material damages, etc.*

The point b) *is naturally dependent on the behaviour of the structure in function of time in the conditions of service, namely the exposure. But in fact, this effect of time is not emphasized, not even about the evolution of mechanical properties.*

In this way, I consider the probabilistic conception of the safety of structures incomplete and therefore somewhat dangerous. Hence my opinion that your new approach to the testing of building materials completes this former conception by assigning sufficient understanding of the changing behaviour of materials under the effects of time and exposure. In other and simpler words, the failure of a structure may result from the decay of the materials, reducing their strength as time goes on, and also their appearance and making them finally unable or unfit for further service before mechanical failure occurs. This is in agreement with the facts.

Indeed, when I consider page 125 of the paper of N. M. PLUM and the appendix, I must remark that the paper does not aim at being only a complement to the probabilistic theory of safety, but at being a complete synthesis in itself.

In this respect, however, I find it somewhat short regarding the question of mechanical safety, namely regarding deformations, on the other hand, the probabilistic theory of safety is definitely short concerning the behaviour and maintenance of the materials. The reason is that the latter was devised by structural engineers, the former by testing engineers. The difference appeared already when, in spring of 1949, on the proposal of Professor Ed. TORROJA, Professor M. ROS and myself came together with him to Paris to discuss these matters. We could agree on the general principles, but Professor ROS and myself were somewhat sceptical on the means. Mr.P.BREDSDORFF declared recently in Paris that the conception he had exposed was an ideal, hence more or less a philosophical matter. Professor TORROJA was not satisfied with that, so he pursued a practical application of the "probability of failure".

It was for this purpose that the "Comité Européen du Béton" was created in 1952, and its Practical Recommendations are based on the concept of "probability of failure". But the way in which this has been applied, although ingenious, is rather below the ideal. In fact, practically, it is equivalent to an improved factor of safety, more flexible, more adaptable. Also more rational, notwithstanding its probabilistic background, just because of this background and the stochastical consideration of the initial properties of the materials.

The principal objection to these Practical Recommendations of the C.E.B. is their shortcomings in respect to the evolution of materials in their lifetime, namely under the effects of exposure. This aspect has been emphasized in the Technical Committee on the Durability of Concrete of RILEM. It seems that C.E.B. and F.I.P. too are now aware of these questions and that modest improvements of the Practical Recommendations of C.E.B. may be expected. They will be very unsatisfactory with regard to the ideal expressed in your paper, according to Mr. BREDSDORFF. But it would already be an improvement for the designing engineers if the philosophy of the probability of failure was completed by the philosophy of the lifetime of materials. To avoid confusions in the minds of structural engineers, it would be very useful to suppress the difference of the notion of time in the two philosophies. The probability of failure of a structure assigns a definite lifetime to the structure under consideration where you have in mind the probable lifetime of any structure under the conditions of service and exposure. As it is merely a question of philosophy, there would be no difficulty to reach agreement on a unique concept. This could be perhaps the task of a small mixed group of members of RILEM, C.E.B. and F.I.P. Anyhow, my opinion is that it is important that your views should not be restricted to the specialists of testing, but become familiar to the designing and the practical engineer. These very general remarks made,

I wish to call the attention on two other points, the first rather general too. I do not agree with your opinion in the second column of page 125 that "the concept of property in the classical materials testing and the modern concept of probability are incompatible". There is not so much new under the sun and I believe that the statistical conception of the properties of materials is classical too. Perhaps it is only a question of words.

Further in table I, page 128, is considered under d*) the sea-water attacks. That seems to me to be a kind of abstract consideration of sea-water action „in se", as it is not in the conditions of natural exposure, where* d) *is inseparable from* e*),* g*),* i*) and other instances, even not prevailing. May I also call the attention on a fact of importance on the effects of natural exposure, namely in sea-water, that is the shape of the structures. Edges and corners, for example, are weak points. So the shape may be of importance for the probable lifetime.*

I agree with Mr. BREDSDORFF that contributions to an ideal may suffer from difficulties to allow practical applications. In this respect however, one should recognize the improvement which may be achieved by very partial and imperfect applications as in the Practical Recommendations of C.E.B. One should no want too much.

Any how I wish to let know my remarks are not criticisms and that I appreciate very much Mr. N. M. PLUM's endeavour.

At a time of great and quick changes in the art of construction, it is useful to emphasize the importancee of thinking.