

DISCUSSION BY F. NOVOA M. (I)

to the Paper N° 283, A Rational Approach to Seismic Design Standards for Structures, by N.M. Newmark and W.J. Hall.

- A) This paper must be heartily welcome as a most important contribution and guide to the field. It is not by chance, nor for reasons of vogue that the method by the authors (1), as soon as published, was adopted by us as the basis for our specifications for the high voltage electrical equipment (see 2 and 3).

We emphatically agree with the authors on the basic function of the Specifications, as this is particularly important in our special field, where the tendency to develop equipment for different conditions on standard elements has been established for the last one or two decades.

We have been trying to guide the composition and design of earthquake resistant equipment through a simplified analysis which has brought satisfactory explanation to the observed facts of experience with the equipment up to 220 kV (see 3 and 4).

In this simplified analysis and the results of several recent studies (see, by ex., 5 and 6), we can see the germs of a more developed earthquake analysis, applicable not only to the more complicated electrical equipment necessary for more than 220 kV, but also to several industrial installations.

The analysis would consist in the separate consideration of the design earthquake, as a transient random signal, and of the structural arrangement as a graph of transfer functions, each representing the single elements, with feedback loops representing the couplings. This kind of analysis would left in front of the designer the essential characteristics of his chosen structural arrangement, before confusing them with the random characteristics of the signal (see also the discussion to 6)

Do the authors have a view on this specific matter?.

- B) In our simplified analysis, much importance is given to the fact that a sufficiently rigid element will not have a response higher than that of the ground, nor represent an amplification of the ground excitation when employed as a support for another oscillator. From our experience, and considering the elastic design spectrum in (1), we have chosen a natural frequency of 15 Hz to define such a rigid element or support.

(I) Author of Paper N° 69.

From the new design spectrum in fig. 1 and Table 1, we can see that the authors define a "faring frequency" of 20 to 40 Hz. As the matter is most important from the economical point of view, we would like to know the opinion of the authors.

It is perhaps interesting to add, that our experience seems to indicate that even lower frequencies than 15 Hz have not yet been detected to give significant amplification. Some other facts, as the absence of failures on higher modes, when these could have got amplification on account of critical natural frequencies (see, by ex., that the failures observed in ref. 5 correspond only to the fundamental mode of the towers), could also serve as a corroboration.

- C) The selection of a 1.0 g earthquake we understand it corresponds to the maximum credible earthquake. We are not, however, very surprised by the increase in intensity it represents for the design, which we suppose provoked by the San Fernando earthquake. This, because, in spite not having yet registered very great intensities, we have already noticed that the statistical breakage of capacitor columns in Concepción, 1960 (see case a in ref. 3), demand a maximum ground acceleration of 0,7 to 0.85 g to be explained. with a 7.5 Richter earthquake at 90 km distance. We are investigating, however, the ground there, to try to detect any local amplification, if present.

References.

- (1) See ref. 1 of the Paper.
- (2) F. Novoa : Earthquakes and the Substation Equipment Arrangement and Specification, CIGRE 1970, report 23-02.
- (3) F. Novoa : Earthquake analysis and Specification of the HV Electrical Equipment, 5 WCEE, paper N° 69.
- (4) F. Novoa : Further remarks to (3).
- (5) T. Konno, E. Kimura : Earthquake Effects on Steel Tower Structures Atop Building, 5 WCEE, paper N° 21, and discussion by F. Novoa.
- (6) H. Sato, K. Suzuki : On the Response Analysis of the Structure System subjected to Multi-seismic Motions, 5 WCEE, paper N° 19, and discussion by F. Novoa.