1115

E L C A L A P

BERLIN 1975

International seminar on extreme load conditions and limit analysis procedures for structural reactor safeguard and containment structures. Berlin (F.R. Germany), 8-11 September 1975
CEA-CONF--3457

FR7602783

STUDY ON THE PERFORATION OF REINFORCED CONCRETE SLABS BY RIGID MISSILES

GENERAL INTRODUCTION

Contribution by : R. GUERAUD (EDF - SEPTEN) *
A. SOKOLOVSKY (CEA - DSN) **

* ELECTRICITE DE FRANCE - Service Etudes et Projets Thermiques et Nucléaires

** COMMISSARIAT A L'ENERGIE ATOMIQUE - Département de Sûreté Nucléaire

Nuclear plants under design or in construction, the number and power of which are growing, are becoming inseparable from the industrial and human surroundings. These surroundings include some sources of hazard. The design and construction of these power plants are therefore subjected to given safety requirements. To implement these requirements it is necessary to analyse the risk sources, to estimate the importance of these risks and to infer suitable design characteristics capable of reducing if not abolishing the vulnerability of the power plant.

Among hazards likely to set safety problems, those which affect us more specifically in this brief introduction involve various missiles such as aircraft, splinters of turbogenerators, etc...

Results of statistical investigations relating to falls of various missiles and subsequent use of probabilistic methods allow these hazards and their importance to be grasped and supply basic assumption for the computation of essential protective devices.

When the occurrence of the impact of a given missile on a building has to be studied the problem may be roughly devided in two parts :

- Study of the stability of the building as a whole ;

- Study of the local resistance against perforation at the impact point.

.../...

In the same way, in order to simplify the approach to these questions, missiles were classified into two categories :

- So called "Soft missiles", i.e, those which suffer very large deformations during the impact, absorbing a good deal of their kinetic energy. In general such missiles, of which the impact area is large, affect the whole of the structure and are studied in connection with the first problem.

This is mostly the case for large aircraft.

- So called "rigid missiles", i.e, ones which hardly lose their shape during the shock, their impact area being rather small. Such missiles belong to the studies connected with the second problem.

This is, e.g, the case of turbine disc fragments.

The first problem raises certain difficulties. Nevertheless we have at our disposal computation codes which enable us to investigate the transient dynamic reponse of the structure and to determine the effects induced in the structure. This question will not be dealt with here.

The second problem is more difficult to solve because no very satisfactory computation process exists, as far as we know. Finite elements codes of course exist - M. GOLDSTEIN will show what can be done with them - as well as finite differences codes - However if he wishes to bring into play this kind of code the user comes up against one great difficulty which is to choose a law of transient dynamic behaviour in such a heterogeneous body as reinforced concrete. Indeed according to the intensity of the shock the material may be entirely fractured or reduced to powder, dislocated or broken up into bloks more or less overlapping and still capable of appreciable resistance.

As far as we know there exists at present no algrithm able to show a realistic picture of these complex phenomena.

The impact of a missile against a reinforced concrete wall also yields secondary missiles, the emission of which may be a source of hazard and must be investigated with special care.

In order to compute the penetration or the perforation limit the literature contains some formulae such as those of :

- PETRY (modified)

- B.R.L. (Ballistic Research Laboratory)

- U.S Army Corps of Engineers

- H.N - N.D.R.C. (National Defense Research Committee).

.../...

These formulae worked out after military tests were carried out within velocity and missile mass ranges quite different from those encountered in our investigations. In some cases if one or another of these formulae is applied in order to compute the protective thickness needed against such missiles as ours the spread of values obtained can amount to a ratio of one to twelve.

This could be explained perhaps if is recalled that the authors of these formulae were working towards another end. Some were considering the aspect of attack and perforation, others were concentrating on the aspect of defense and protection of staff, even the avoidance of secondary missile projection.

Such scattering of the results is very serious for us because it may result in either under-shielding or over-shielding, which latter would burden the economy unnecessarily.

On the other hand it is clear that simple extrapolation of existing data is not always realistic.

We have therefore entered upon a series of studies and tests.

A first series of tests, initiated by Electricité de France (EDF) and executed by the Centre Expérimental du Bâtiment et des Travaux Publics (CEBTP), had an exploratory aim.

We felt that it would be useful first to fix our opinion about the worth of the known formulae as fast as possible, hence without complicated equipment. The results of these tests form the subject of the paper to be submitted by M. KAVIRCHINE and M. ASTRUC.

However it may be observed that during such tests the velocity of the missiles is relatively low (about 30 $m.s^{-1}$) and if an investigation on similarity between the real case and its reduced model is carried out by means of shock dynamics it may be shown that there are grounds for keeping the same velocity value in both cases. It may be that extrapolation of these results to the higher-velocity range would be critical.

A second series of tests, also ordered by EDF from the Direction Centrale du Génie Militaire, brings into play more ample facilities as described in the paper of Colonel FIQUET and Commandant DACQUET.

Nevertheless the tests, which likewise have to be completed as rapidly as possible, are performed with existing and hence limited means. Since our wish was to obtain missile velocities between 90 $m.s^{-1}$ and 170 $m.s^{-1}$, which is low on military standards, a mortar was set in action. Such a choice having been made, the corresponding missile masses were found to lie between 160 kg and 300 kg.

Now our feeling is that these tests are sufficiently numerous and important to back up our theoretical investigations carried out independently.

Another experimental programme was carried out as part of a vast study undertaken by the Commissariat à l'Energie Atomique (CEA) with some assistance from EDF. The paper of M. GOLDSTEIN, M. BERRIAUD and M. LABROT is devoted to this work.

The experiments connected with this programme were performed on a reduced scale keeping the similarity with the Military Engineers tests as pointed out above. The results will consequently give us a better grasp of the laws of similarity and we hope to be able to extrapolate experimental data of this kind over real missiles impinging on a large power plant.

In addition these experiments are compared with results of finite elements computation code in the hope of adjusting a law of behaviour in the case of reinforced concrete.

In any case our experimental programme is not finished. Consequently no final conclusion will be inferred and experimental results only will be submitted further on.