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Damage Analysis of Super Large Floating Structure in Airplane Collision

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ABSTRACT

When a super large floating structure, constructed with steel and concrete slabs, is used as an airport, there is a slight possibility for an airplane and engine to drop on it. For designing the super large floating structure, it is important to verify its safety against an airplane collision. In order to clarify the behavior of the deck structure and concrete pavement during collision, numerical calculations are performed utilizing a nonlinear dynamic FEM program. The minimum thickness of the deck plate and concrete pavement, which are necessary to prevent the penetration of the airplane or engine into the deck plate, are shown based on the results of calculation. It is also shown that the concrete pavement is effective to absorb the dynamic energy produced by an airplane collision. As this numerical calculation requires an enormous computing time, it is not economical to apply this at the preliminary structural design stage. So, a simplified model for simulation of the phenomena during an airplane collision is developed to save the computing time.

INTRODUCTION

In the planning of effective utilization of marine space, which has been attracting a great deal of attention recently, the concept of marine airports on large floating structures called Mega-Floats is one with the greatest feasibility. In its structural design, not only environmental external forces such as winds, tides and waves, but also takeoff and landing loads of airplanes are required to be considered. Further, emergency loads such as unusual landing loads or impact loads of an airplane crash need to be investigated.

There are supposed to be 2 types of airplane crash accidents: fuselage or engine.

In this report, the dynamic fracturing behavior in the event that an object crashes vertically onto the deck of the floating structure shown in Fig. 1 was investigated by numerical simulation using the finite element method.

An engine and a fuselage are considered an object. In the case of a fuselage collision, the deformation of the fuselage itself is taken into consideration. Additionally the upper surface of the floating structure deck is supposed to be paved with concrete. The effectiveness of a concrete pavement was also studied because this is expected to reduce the structural damage caused by an airplane crash.

VERIFICATION OF ANALYSIS

To simulate such rapidly occurring phenomena as an impact and a collision, a nonlinear finite element analysis program with explicit integration is commonly used. In this investigation, software program LS-DYNA3D was used.

The authors solved the problem of a double-hull tanker collision (Sano, 1996) and have validated the calculated results with an estimating formula of absorbing collision energy derived from experiments. Kitamura (1996) also validated the results with the program in the stranding of a double-hull tanker. These are the problems related to steel structures under impact but its application to dynamic fracture of concrete is not proved yet. It is then necessary to confirm that the program can give precise outputs for the fracturing behavior of concrete under crash conditions.

Accordingly we simulated the experiment carried out by CRIEPI—Central Research Institute of Electric Power Industry—in which a projectile struck a concrete slab, in order to verify the analytical precision (Ito, 1991). The outline of the CRIEPI experiment is shown in Fig. 2. The projectile, which is a steel round pillar 230 mm in diam and 400 kgf in weight, struck a reinforced concrete slab at a striking velocity of 40 m/s.

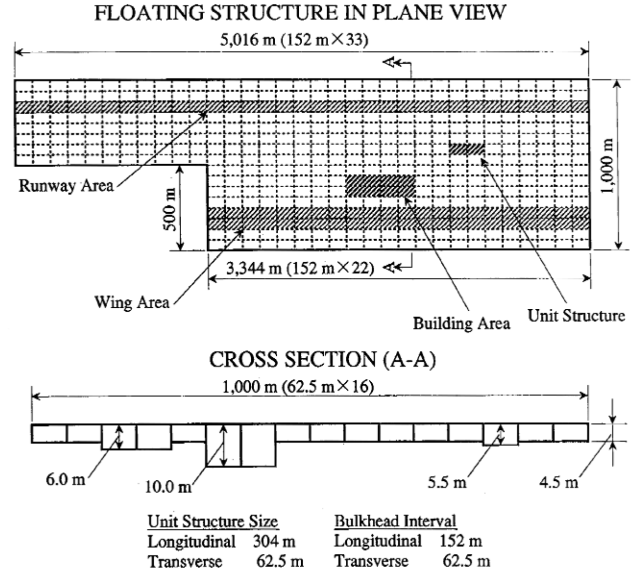

Fig. 1 Floating structure, Mega-Float

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KEY WORDS: Floating structure, marine airport, airplane collision, concrete pavement, collision analysis.