Transactions of the 17th International Conference on Structural Mechanics in Reactor Technology (SMiRT 17)
Prague, Czech Republic, August 17 –22, 2003
Paper # J04-5

New Aspects on the Resistance of Nuclear Buildings against Aircraft Impact

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ABSTRACT

Since the events of September 11, 2001, there is a new world-wide discussion of the safety of nuclear power plants (npp's) under intentionally forced aircraft impacts. The paper presents a discussion of load functions for different aircrafts and different impact velocities and analyses of a rectangular npp building subjected to these loads. The treated aircrafts are large aircrafts used on intercontinental routes; the impact velocities of the study are varied covering a wide range of possible events. The total impact loads comprise several components with different time characteristic: there are separate load components for fuselage, wings and engines. The considered targets are reinforced concrete walls of safety related npp buildings which are designed for an impact of the above-mentioned military aircraft. The performed nonlinear dynamic analyses show a remarkable potential of reinforced concrete structures to withstand also the impact of large civil aircrafts for which they basically have not been designed.

KEYWORDS: aircraft impact, military aircraft, civil aircraft, impact velocity, nuclear power plant, rectangular building, reinforced concrete, load carrying capacity, nonlinear deformations, punching shear behavior, yielding of reinforcement.

INTRODUCTION

In most countries the load case aircraft impact has not been taken into account up to now. In some countries the resistance of nuclear buildings against aircraft impact has been analysed in the past predominantly for military aircrafts or civil aircrafts of small size. There is one civil aircraft which has been studied in more extension so far: this was a Boeing 707 with approx. 90 tons mass and 102 m/s (230 mph) impact velocity. The load-time function published at first in [1] or slightly differing load functions published later have been adopted for analyses of one npp in the United States and several npp's in Switzerland.

In Germany the design of safety related buildings of npp's licensed after 1973 included the impact of a military aircraft with 20 tons mass and impact velocity 215 m/s. The resulting well-known load-time function with duration 70 ms and peak value 110 MN has been approximately verified by the full-scale aircraft impact test at Albuquerque 1988 [2]. Consequences of these tests and the influence of the load function measured during the tests on the induced vibrations in the interior of a reactor building have been discussed for example in [3].

Since the events of September 11, 2001, there is a new world-wide discussion of the safety of npp's under intentionally forced aircraft impacts. In several countries, the impact load of aircrafts larger than the Boeing 707 treated in [1] are analysed now.

ANALYSES

The paper presents a discussion of load functions for different aircrafts and different impact velocities and analyses of a rectangular npp building subjected to these loads. The treated aircrafts are large aircrafts used on intercontinental routes; the impact velocities of the study are varied covering a wide range of possible events. The total impact loads comprise several components with different time characteristic: there are separate load components for fuselage, wings and engines. The considered targets are reinforced concrete walls of safety related npp buildings which are designed for an impact of the above-mentioned military aircraft. Fig. 1 shows the 3-dimensional computational model, Fig. 2 shows a schematic view of one of the treated load cases giving an excellent impression of the geometric properties aircraft / target.

SUMMARY

The performed nonlinear dynamic analyses show a remarkable potential of reinforced concrete structures to withstand also the impact of large civil aircrafts for which they basically have not been designed. One reason for this potential is the fact that the loaded area and accordingly the critical perimeter for punching shear behaviour in case of a civil aircraft is much larger than in case of a military aircraft. Hence follows that a correspondingly larger part of the impacted building is participating in the load carrying capacity of the reinforced concrete structure. That implies another type of failure of the reinforced concrete structure, which is characterized by bending of the impacted structural member. This failure type is connected with large nonlinear deformations due to cracking and yielding of the reinforcement up to ultimate strain.

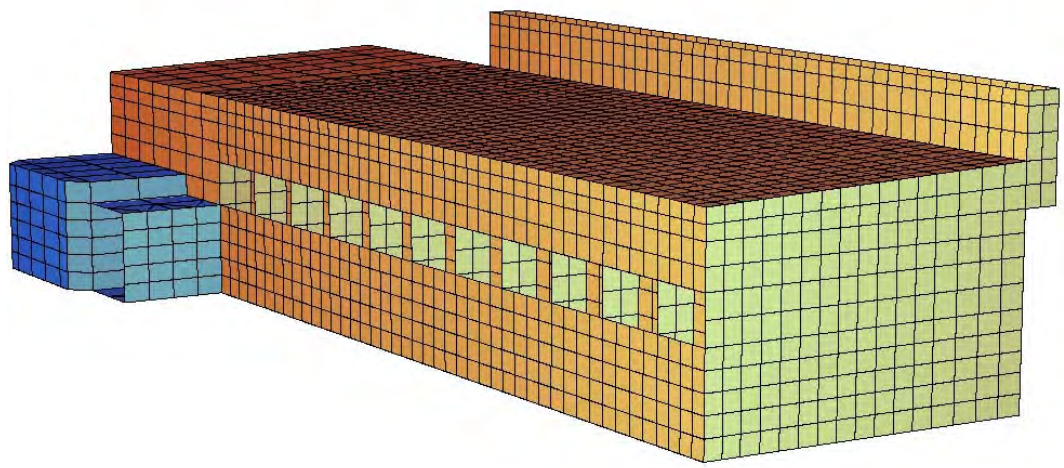

Fig. 1 3-dimensional Finite-Element model for nonlinear analyses

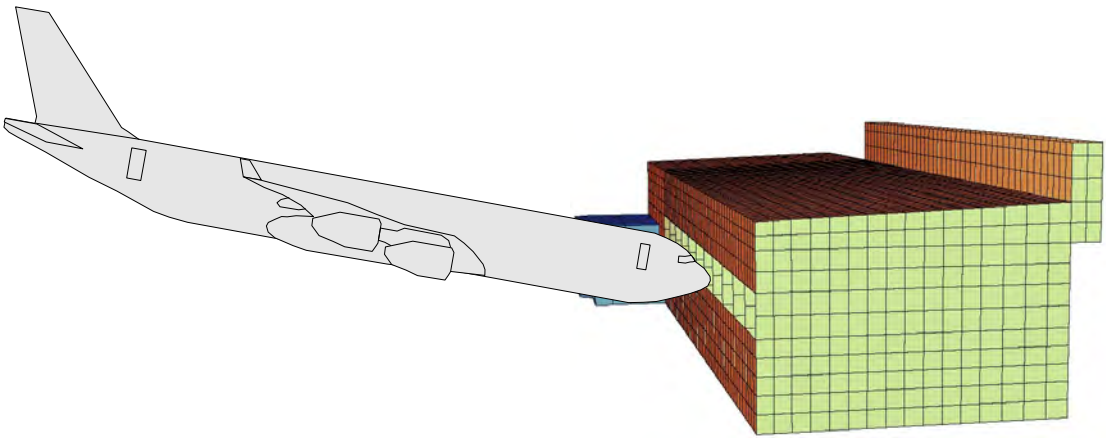

Fig. 2 Schematic view of a large aircraft impacting a nuclear building

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