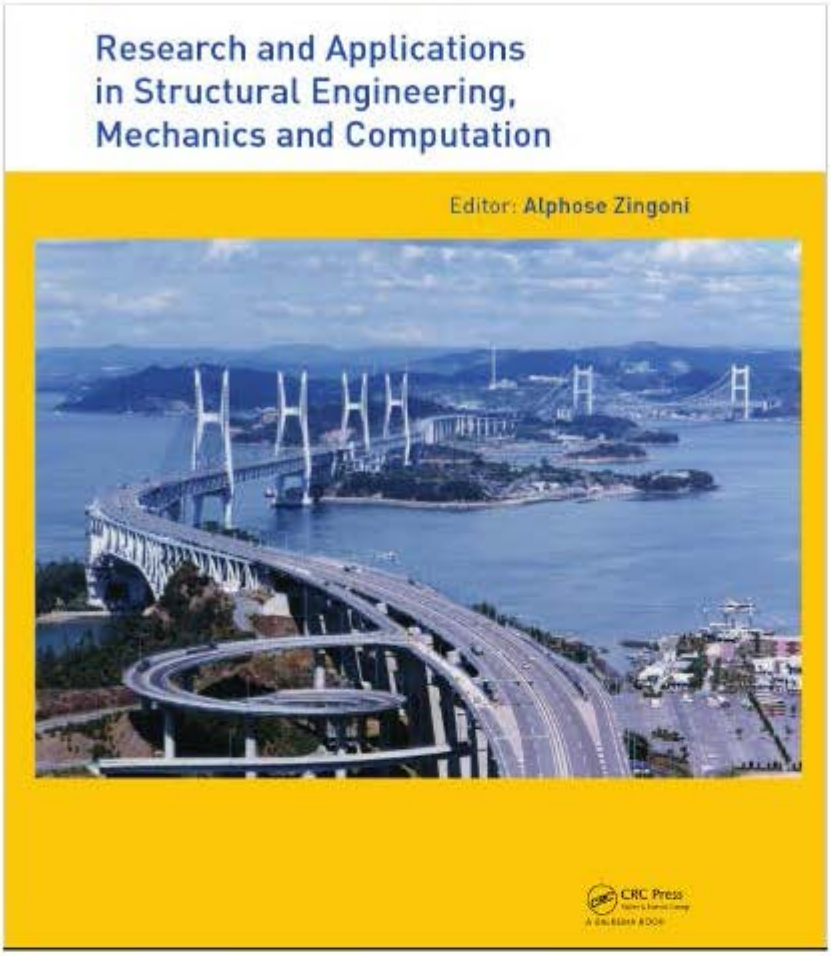

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Computational modelling of reinforced concrete wall subjected to transformer tank rupture

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ABSTRACT: Transformer is one of the vital equipment to provide reliable electricity. The worst of the transformer explosion may lead to the major blackout. Transformer explosion maybe due to, lack of maintenance or the problems inside itself. In the past, transformers were adjacent to each other and without a wall in between at substation. Nowadays, constructing reinforced concrete wall between transformers is in practice as protection precaution. Finite Element Method (FEM) software is used due to the capability of analyzing and simulating reinforced concrete structure subjected to high rate and short duration dynamic loading. The simulation results reveal the crack propagation behavior is identical for the different blast modes. The cracks start to occur at the bottom of the wall on the transformer side. Later follows with the crack propagations on the other side at about one third of the wall height in the curve shape.

1 INRODUCTION

Electric substation is the place where transformers are installed in order to transform the electric voltage from high to low level or otherwise before can be distributed to the respective customer. Typically, there are more than one transformers operating at one time to supply the electricity. These transformers are located adjacent to each other within the required distance. As a protection precaution, a wall is constructed in between the transformers. For comparison, in Brazil initially substations were operating for some years without a wall in between transformer (Duarte, 2004). Probably due to transformer fire at one of the substation, the firewall is constructed later. In the studies revealed, the wall can start to collapse after just one hour. In fact, the wall is designed for 4 hours fire resistance. This is because, the energy releases by the transformer explosion and the subsequent effect of fire did not take into consideration during the design stage.

This study presents the simulation result of the potential damage of the reinforced concrete wall due to transformer tank rupture. Three blast modes based on the point of transformer tank rupture are used for the modeling. Although, there is no direct experimental result available yet to validate the numerical result, the previous field test provided indirect result for the comparison.

2 TRANSFORMER TANK RUPTURE

In general, transformer explosions are originated from broken-down insulations, which may be caused by over load switching, lightning surges, deterioration of insulations, low level and moisture or acid contamination in the transformer oil. Inside the transformer, with the high temperature and energy released by the arc, the insulation oil will be decomposed to highly explosive gasses, mainly Hydrogen and Acetylene. This decomposition process will generate pressure inside the transformer tank until the tank cannot withstand and the tank rupture will be occurred(Surasit, 2008, Chille et al., 1998, GexCon, 2007).

According to the investigation report of Power Transformer Tank Rupture and Mitigation by the task force of IEEE Power Transformer Subcommittee, when the explosion happens, transformer is able to release arc energy between 1 MJ up to 147 MJ (IEEE, 2010). In the research works done by Sergi, it is discovered, for a 100 MJ electrical arc inside the oil, the first MJ creates 2.3m^3, of explosive gas. The other 99 MJ add only 2m^3. Obviously any electrical arc is very dangerous whatever its energy (SERGI, 2008).

The point of tank rupture will be varies for each transformer, normally occurred at the weakest point of the rectangular tank (IEEE, 2010), which is can be at; main cover to tank wall flange-welded joint;