Graphical Fault Tree Analysis for Fatal Falls in the Construction Industry

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1. Introduction
The construction industry has been identified as one of the most hazardous industries in many parts of the world and falls from height are a leading cause of fatalities in the construction industry (Sorock et al., 1993). Comparing to our previous study (Chi et al., 2005) which only identified one primary cause for each fall fatality, the current study coded a maximum of three accident causes for each of 411 work-related fatalities occurring during 2001–2005. Fault tree analysis and Boolean algebra were then applied to present the causal relationships among events and causes that contributed to a construction accident. At the end, the results were presented as graphical fault trees.

2. Method
In Taiwan, the Labor Safety and Health Act requires the employer to report any occupational fatality to the appropriate inspection agency within 24 h. The accident report can be used as legal evidence against the employer for any violation of the Labor Safety and Health Act. Four hundred and eleven work-related accident reports in the Taiwanese construction industry were analyzed in terms of age, gender, experience, falling site, falling height, company size, and the causes for each fatality. Given that most fatal accidents involve multiple events, the current study identified up to three causes for each fatality. The cause of the fall was coded into 3 categories, i.e unsafe behavior, unsafe machines & tools, and unsafe environment. The fault tree analysis were then conducted by identifying multiple cause combinations for each fatality. These multiple cause combinations can be connected by AND-gate (for 2-causes and 3-causes combinations) indicating that these 2 or 3 events contributed simultaneously to these fatal falls. The integration of all possible cause combinations for each falling site can be regarded as the union (connected with an OR-gate) of these cause combinations. Boolean algebra were applied to reduce all possible cause combinations to the ‘smallest’ cut set (Vesely et al., 1981) that could cause the top event to occur. Eventually, all cause combinations associated with each falling site can be simplified and presented in a graphical fault tree diagram.

3. Result and Discussion
Take 98 falls from scaffold cases as an example, 24 cases were caused by 8 single causes, with improper use of PPE (8 cases) as the most frequent single cause. Seventy cases were caused by 23 two-cause combinations with improper scaffolds and improper use of PPE (16 cases) as the most frequent combination. Lastly, four falling from scaffold cases were caused by a three-cause combination. Subsequently, the absorption law was applied to reduce the cause combinations by absorbing a secondary cause with a primary cause. As the result, the original fault tree can be reduced to a logically equivalent fault tree consisting of Minimum Cut Sets (MCS) connected by an OR-gate beneath the top event. Similarly, the same MCS analysis can be applied to other falling sites for further development of prevention measures. Fault trees can be very effective in creating an overview of a complex occurrence and in communicating accident causes and scenarios to construction workers (Svedung and Rasmussen, 2002). To improve effectiveness in communication of accident causation, graphical icons were designed for each falling site scenario and associated accident cause in order to illustrate the fault tree in a graphical manner so that accident causation can be easily understood by construction workers who may not read English (or Chinese).
References


