THE 5TH ASIAN COMPUTATIONAL FLUID DYNAMICS
BUSAN, KOREA, OCTOBER 27~30, 2003

Characteristics of Smoke Concentration Profiles with Underground Utility Tunnel Fire

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Abstract

Recently, the communication and electrical duct banks as well as various utility lines for urban life are installed in the underground utility tunnel systems. If a fire breaks out in this underground utility tunnel, the function of the city is discontinued and the huge damages can be occurred. The underground utility tunnel systems contain distribution mains for high pressure steam, chilled water, domestic water and compressed air, natural gas and sanitary sewer lines as well as communication and electrical duct banks. Particularly, power cables in underground utility tunnels may overheat and ignite for a variety of reasons. The impact of the resulting fire can cause serious problems for utility companies and their customers. On February 2000, for instance, a fire broke out in the underground utility tunnel in the ground of Yoido, Seoul, Korea. Investigators suspect an overheated amplifier for cable TVs might cause the fire. A cable TV amplifier produces large volumes of heat during its operation so that combustible materials around it could be easily ignited by the heat. In order to avoid this kind of accident, the fiber-optic linear-temperature sensors are recently developed.

Accurate prediction of the fire-induced air velocity, temperature and smoke concentration in underground utility tunnel becomes more important for designing of the efficient fire protection systems. However, it is difficult to handle in case of a fire accident. When a fire breaks out in the cable, the smoke containing poisonous gas will be produced. This poisonous smoke goes through the underground utility tunnel and makes it difficult to extinguish the fire. In order to improve the safety of underground utility tunnel systems and the fire detection, the behaviors of the fire-induced smoke flow and temperature distributions should be investigated. In this study we assumed that the fire is occurred at the contact or connection points of cable.

Numerical calculations are carried out using two different cross-sectional shapes of tunnel, such as rectangular and circular types (see Fig.1). The fire source is modeled as a volumetric heat source. Three-dimensional flow and thermal characteristics in the underground tunnel are solved by means of FVM (Finite Volume Method) using SIMPLE algorithm and standard κ - ε model for Reynolds stress terms. The numerical results of the fire-induced flow characteristics in an underground utility tunnel with different cross-sectional shapes are graphically depicted.

Temperature on the ceiling along the vertical direction of rectangular and cylindrical types decreased at time transit. Also, temperature on the wall along the horizontal direction of rectangular type decreased, while that of cylindrical type increased. The maximum temperature of the rectangular type is greater than that of the cylindrical one. The smoke rises vertically in the rectangular type due to temperature difference. For the case of cylindrical type, however, it flows along the cylindrical wall. The small region of circulation is appeared over the second shelf of the cables and developed to the ceiling wall in the cylindrical type. The distribution of smoke is complicated and formed thickly at the center of ceiling and near heat source in the cylindrical type.

Keywords: *underground utility tunnel systems, volumetric heat source (VHS) model, temperature distribution, smoke concentration.*

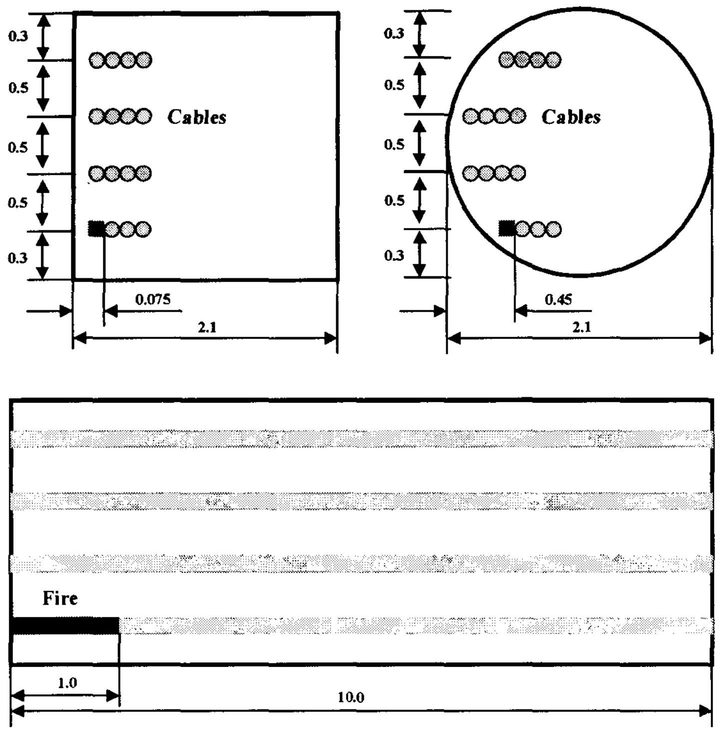

Fig. 1 Schematic diagram of the utility tunnel systems (unit: m) (top: cross-sectional views of rectangular and circular tunnels; bottom: longitudinal cross-section).