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NUMERICAL INVESTIGATION ON SMOKE MANAGEMENT IN UNDERGROUND BRANCHED TUNNELS

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Abstract:
Soot is perhaps the most harmful element in vehicle tunnels fire as smoke moves harmonize with the way passengers flee. It decreases visibility and can cause suffocation fatalities.
This paper presents an empirical analysis on the effect of removing smoke through different ventilation systems on smoke distribution inside the vehicle tunnel, such as water mist system with transverse ventilation with several extractions of exhaust fans Sustainable human conditions were also tested. FDS 2019 ver. was used to predict temperature, visibility, and concentration of co.
Motivation/Background: Present work to investigate the effect of extracting the smoke by different system of ventilation on smoke spread inside the vehicular tunnel.
Method: By FDS 2019 that used governing equations and naver-stocks equations.
Results: We predicted in this paper smoke spread, temperature distribution, co concentration distribution and visibility.
Conclusions: This study looks at the importance of smoke control generally as well as the smoke control criteria in the automotive tunnel configuration which acknowledged them.
Because the smoke barrier water mist screen with a transverse ventilation device improves the smoke removal technique. FDS is a valuable method for simulating smoke diffusion as well as other effects.

Keywords: Road Tunnel; FDS; Smoke Management; Curtain; Visibility; Water Mist; Velocity.

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1. Introduction

Most regions use building tunnels owing to an rise in traffic as well as the development of the transportation system, smoke, in which it triggers poor visibility and coughing and death, is the main worry throughout the fire around tunnels, which risks the life of citizens residing inside the tube, where approximately 70% of accidents have been triggered through inhalation about a significant quantity of gases[1].

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Understanding which the SMOKE MANAGEMENT will not have to be fire prone, but it is an annuity benefit which offers the potential for recovery and for people in fire resilience to do their work and optimize the period between recovery without significant losses [2]. The airflow device will be developed to avoid temperature build-up outside of an acceptable range throughout the influx of traffic while cars can accumulate in within their tunnel. Unless there is a fire warning, smoke suppression must be tackled to allow quick escape for the major road tunnel.

In the largest cities in the Far East, including Mainland China, Hong Kong and Taiwan, longitudinal ventilation systems are usually built in modern tunnels [3]. Within big cities several tunnels are located, and some of them have a horizontal angle. Yet smoke movement is not completely undermined in tilted tunnels. For other tunnels, the ventilation system was constructed without experimental demonstration based on assumed smoke movement patterns. A scaled model has been used to test Smoke Movement pattern in a tilted tunnel model. Transparent acrylic plastics have been made from a 1/50 tunnel layout 2 m long with adjustable angle to the horizontal. As a heat source combined with burning smoke pellets, tiny 0.097 kW of propanol pool fire have been used. For longitudinal ventilation, an upstream fan was installed. A transformer was used to monitor or change fan speed at different ventilation speeds. Tunnel angle of up to 30 "to horizontal tests were carried out. Also studied was the effect of smoke screens. The smoke motion patterns observed indicate that the form of the booming feather in the tunnel depends on the angle of tilting. Because of gravity, smoke will flow through the tunnel wall. The degree of bending of the pen depends on the position of the pipe. Tunnel sloping to the horizontal would provide greater smoke flow at greater angles. Smoke movement pattern was found to be very different from other design projects for a tilted tunnel with smoke screens. All the results of the observed smoke motion patterns will be recorded in this document, the form of the bouncing plume inside the tunnel depends on the angle tilted. The smoke pen will be bent because of its gravity along the tunnel floor. The angle of bending depends on the slope of the pipe. Thanks to boosting, a larger inclined angle will have a greater amount of smoke in the pipe.

This article discusses work on smoke transmission in a sloped firing tunnel with longitudinal ventilation. Initial review of the numerical equations on soot pad [4]. Numerical calculations were conducted with computational fluid dynamics (CFD). Physical level modeling tests have been performed for essential speed to prevent reverse sheets of 0 °, 3 °, 6 ° and 9 ° horizons for both tunnel configuration setups. The uniform heat release rate Q is a factor and Q 0.12. The research described Q″ below 0.1 as the correlation about critical speed and heat release rate has indeed been calculated. Some of the above-mentioned findings are similar to the tests. A heat release rate of 1/3 demonstrated a difference in non-dimensional critical longitudinal rate in order to avoid back layer. To order to avoid the back in the inclined tunnels, critical speeds are higher than those needed for horizontal tunnels. However, a plausible theoretical model for critical speed in a tilted tunnel will be proposed based on experimental and quantitative tests.

The water flow needed for the proper operation of the Deluge system in tunnels is currently recommended by only few regulatory authorities with jurisdiction. The amount of water needed for a car fire to be correctly suppressed and the threshold at which systems fail to be successful is scarce. This paper seeks to bridge the void in the awareness of tunnel fire suppression; a series of full-scale car fire tests were performed to investigate the efficacy of flood sprinkler systems. The tests were conducted by putting one car under a dilution bucket; the car was set on fire and the

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car's burning behavior was thoroughly tested [5]. Temperatures were measured inside, round and above the car and infrasound camera images were used to obtain the heights of the flames. Two types of car fire removal via the flood system were obtained from this study: incremental and instantaneous. A relation is made between the fire heat release rate and the water flow needed for the water system. It has also been found that a 6.6 mm / min water flow decreases temperature for a large variety of fire sizes in the immediate area of the vehicle.

In recent decades, the use of these tunnels to reduce road jamming has been a significant study as well as layout problem to handling automotive tunnel smoke. Just limited fire may harm for life, resources as well as nature from these passages. As a result, more effective fire prevention strategies have been applied to limit fire hazards to improve protection. major research also displayed that greater 70% of a death in these specific accidents are due to smoke diffusion. n CFD requirements are also used to try out new airflow technologies and to test safety strategies effectiveness through varying fire scenarios. Current work investigates smoke and temperature diffusion via a automotive tunnel during the continuous fuel fire test. For this analysis, a dynamic three-dimensional CFD approach is used to simulate soot movement as a single-phase gas combination while simulating a k omega turbulent formula for the Al-Azhar tunnel literature's actual fire experiment. In Oct 2001, the experiment is performed shortly before the tunnel was opened for general use by vehicles to test the ventilation system to manage burn-generated smoke. Comprehensive soot concentration, temperature and longitudinal velocity contour distributions are given at different real-time counts from the start of fire and at different air ventilation rates to ensure smoke stratification in the early evacuation fire stages. Mathematical international ranges between forecasts and previously reported experimental research. The thesis can be viewed as an empirical approach that could help to better establish smoke control systems and improve ventilation systems in general and vehicle tunnels in particular [6].

Computational models in tilted tunnels at varying angles are using to resolve smoking activity caused by blast, and average temperatures upstream were correctly aligned along the tunnel centerline. The survey shows that in the downstream fireplace outside of only above the fire source the average longitudinal centerline temperature occurs. The interface of upstream smoke layers is virtually paralleling to the horizontally floor while the downward domain of soot sheets parallels to both the inclined tunnel floor was noticed during this basically constant state. Two typical behaviors: Offer the vortexes a steady approach to fire sources and gradually sinks with such a period of time from the fire source and due to the fact that they are very far from the highest degree of the temperature at the top of the dome. Furthermore, when utilizing dimension measurements heat release rate and the average top temperature are known to assess an observational modification [7]. The correlations imply that the equilibrium temperature of the upstream dimensional-free as well as the dimensionless heat discharge intensity is proportionate to 0.56 electricity as the distance to the fire source increases.

2. Materials and Methods

FDS is a handy method to model a fire-induced environment, as it numerically solves a series of the thermal-driven flow Navier-Stokes equations. On the http:/fire.nist.gov/fds/ you can find a summary of the concept, validations and a bibliography of relevant documentation and records. This contains both the DNS model and the LES concept (Large Eddy Simulation). The LES model,

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generally used for the analysis of smoke flow caused by combustion, is chosen. The equations are regulating [8]:
Conservation of mass:

$$\frac{\partial \rho}{\partial t} + \nabla . \rho U = \dot{m}_b'''$$

Conservation of species:

$$\frac{\partial}{\partial t} . (\rho Y_\alpha) + \nabla . \rho Y_\alpha U = \nabla . \rho D_\alpha \nabla Y_\alpha + \dot{m}_\alpha''' + \dot{m}_{b,\alpha}'''$$

Conservation of momentum:

$$\frac{\partial}{\partial t}(\rho U) + \nabla . \rho U U + \nabla p = \rho g + f_b + \nabla . \tau_{ij}$$

Conservation of energy:

$$\frac{\partial}{\partial t}(\rho h_s) + \nabla . \rho h_s U = \frac{Dp}{Dt} + \dot{q}''' - \dot{q}_b''' - \nabla . \dot{q}'' + \varepsilon$$

3. Validation

With the automobile tunnel explosion, experimental research in large size is challenging to do. The testing method for FDS is accomplished using Tiannian Zhou [9] tests on a large tunnel. That fire scale measurement of 1 MW is used in FDS (edition 2019) software to determine the soot activity in vehicle fires in the tunnel. Check experimental variables were max roof temperature, period and intensity of carbon monoxide in a location allocated to Tunnel in Zunyi, Guizou, China. 600 is m the maximum length of that same road tunnel, with a twisted segment of 295 m and a regular portion of 305 m. The tunnel depth is 14 meters and the average height 7 meters to reduce calculations, the exact area is chosen for research and the fire location is placed at 200 meters out and into the ends of the straight road as shown in Figure1.

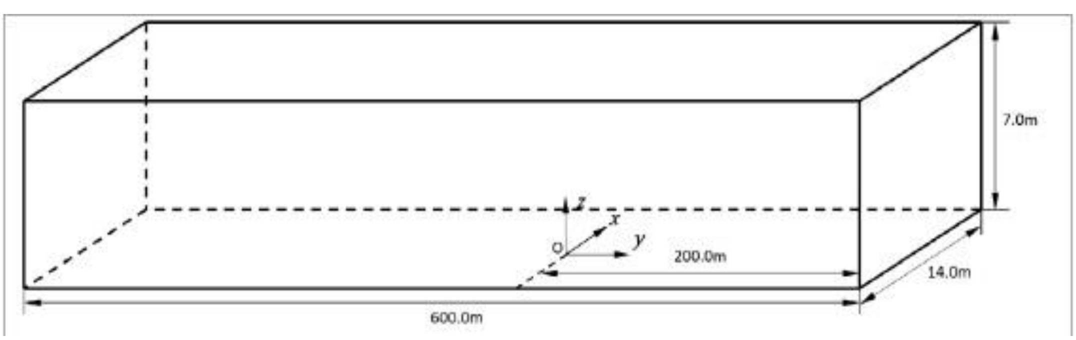

Figure 1: Tunnel in Zunyi, Guizou, China

Confirmation of the mean floor temperature declines as the duration from fire rises. The simulator will accurately forecast the pattern in the temperature of the ceiling as in figure2.

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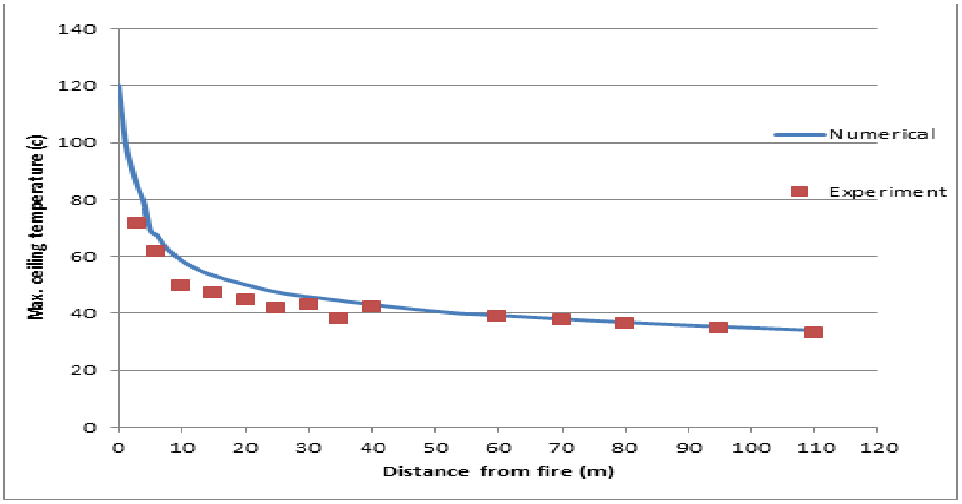

Figure 2: The pattern in the temperature of the ceiling

4. Results and Discussions

A 600 m,5 m height and 10 m width. By using water mist screen and 70 MW three cases will introduce in figure 3, figure 4 and figure 5 below 3,4 and 5 exhaust fans with 140m^3/s for each one besides the ambient temperate is 25 C^0.

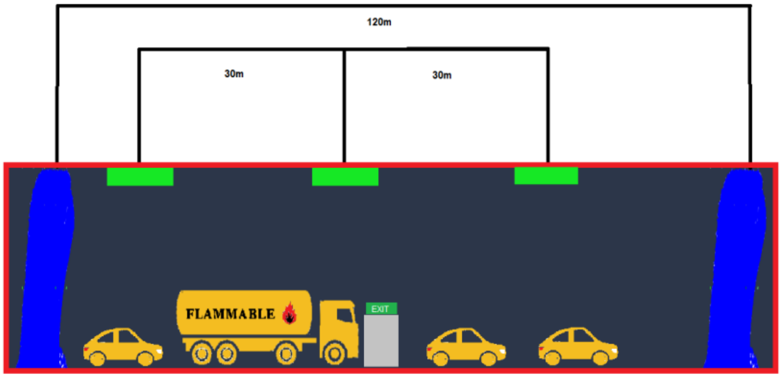

Figure 3: Exhaust fans are used with water mis screen.

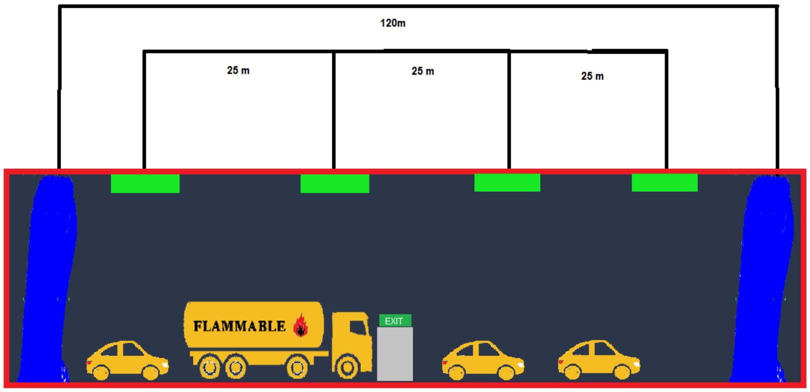

Figure 4: Exhaust fans are used with water mis screen.

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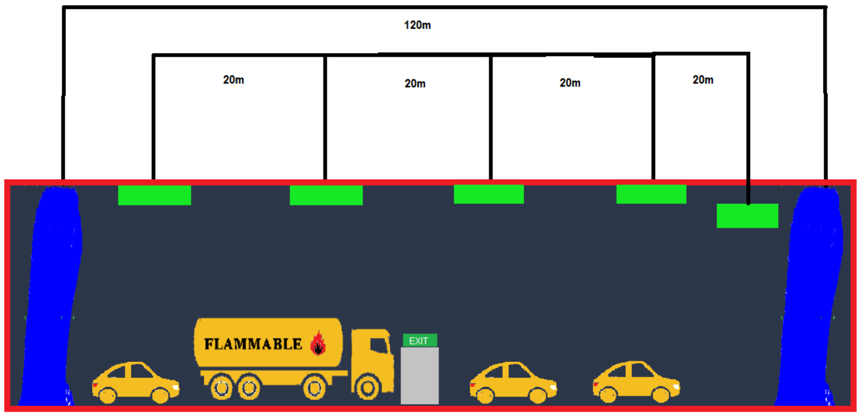

Figure 5: Exhaust fans are used with water mis screen.

4.1. Smoke Spread

Comparison in 300s for the water mist screen confined the smoke between the tow screens in three cases as in figure 6.

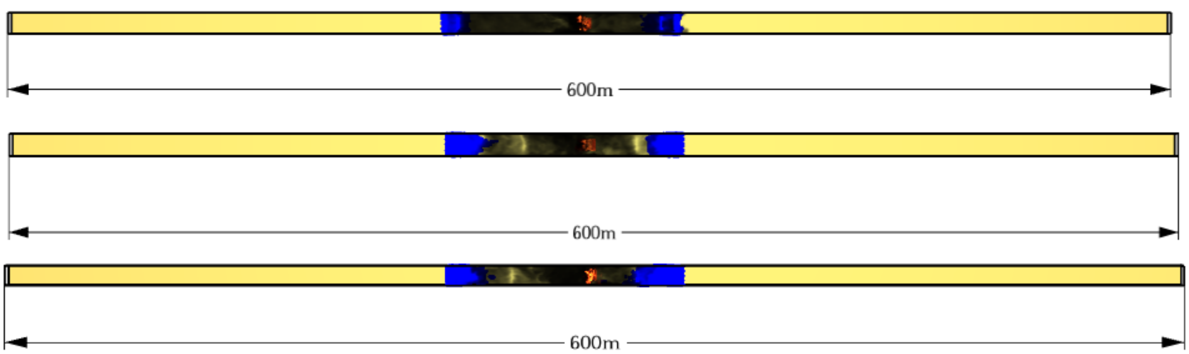

Figure 6: Comparison in 300s for smoke spread

4.2. Visibility Distribution

Comparison in visibility for the three cases by using water mist screen in 300s as in figure 7.

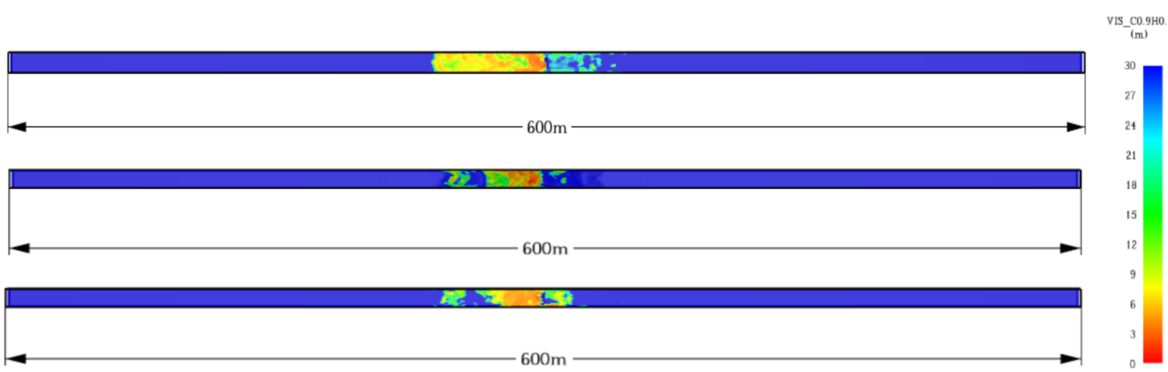

Figure 7: Comparison in 300s for Visibility distribution.

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4.3. Velocity Distribution

Comparison in velocity for the three cases by using water mist screen in 300s as in figure 8.

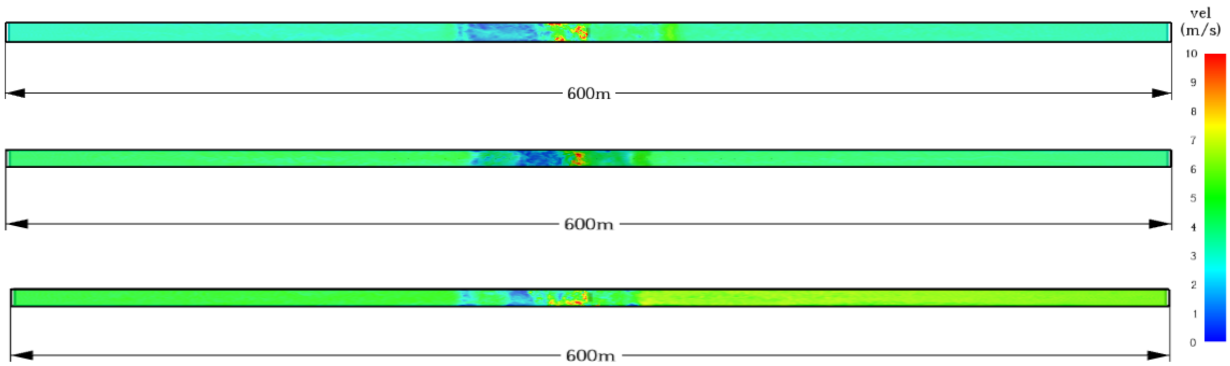

Figure 8: Comparison in 300s for Velocity distribution.

5. Conclusions and Recommendations

The above conclusions could formulate across the basis of the observations reported in either the prior study using a computational check: -

- FDS is a valuable method for simulating smoke diffusion as well as other effects.
- This study looks at the importance of smoke control generally as well as the smoke control criteria in the automotive tunnel configuration which acknowledged them.

Because the smoke barrier water mist screen with a transverse ventilation device improves the smoke removal technique production by 70 MW and has a substantial impact on manufacture of smoke and environmental factors.

Acknowledgements

With the name of GOD, I started this research paper hoping that it accelerates the wheel of progress in this field.
I would like to express my sincere appreciation and infinite thanks to my family, I cannot express; in words; the support of my family. Their insight and wisdom have been invaluable.
Last, but not least, I dedicate this paper to my home country, Egypt

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