Tunnel Ventilation Numerical Simulation based on Fluent

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Abstract

With the aid of Fluent software, three-dimensional numerical simulation is carried out for ventilation during short-distance construction stage of the main tunnel assisted by 2# inclined shaft in the tunnel of Liupan Mountain. Thus, the velocity and pressure distribution in the tunnel wind field are obtained. Then, analysis is conducted based on results of numerical simulation and construction situation, providing basis and reference for ventilation design in actual projects.

Keywords

Fluent, Ventilation Simulation, Ventilation Design.

1. Background of the project

Liupan Mountain Tunnel in Dongshanpo Village-Maojiagou Village Expressway is located in the Ningxia Hui Autonomous Region. When the construction goes to K11+900, 2# inclined shaft should be excavate to assist the construction of main tunnel. Considering the length of 2# inclined shaft, the distance for blind heading is as long as 3422m. With the long distance of blind ventilation, and 9.3% longitudinal slope of the inclined shaft, many problems occur, such as low efficiency of transportation, incomplete combustion of tail gas and lampblack, and serious contamination. Therefore, ventilation design should be made in particular. For this purpose, this paper employs Fluent software to carry out the ventilation simulation during short-distance construction stage of the main tunnel assisted by inclined shaft, which provides basis and reference for ventilation design in projects.

2. Ventilation simulation during short-distance construction stage of the main tunnel assisted by inclined shaft

As shown in Fig. 1, when the construction reaches the intersection of the inclined shaft and the main tunnel, the enclosed area of arch-formed section of the completed tunnel in the fresh air channel is about 12m2. The fan is installed in the inclined shaft about 30m away from the intersection. A multi-speed axial-flow fan is installed to blow air toward small mileage of the main tunnel. And the jet fans are adopted to conduct stream guidance for short distance, with the maximum ventilating distance of 200m.

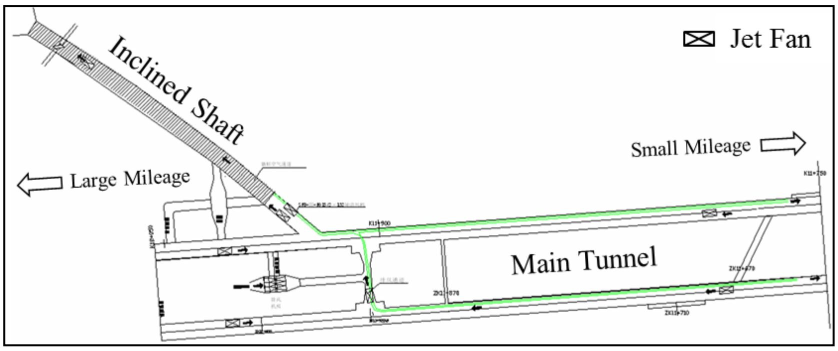
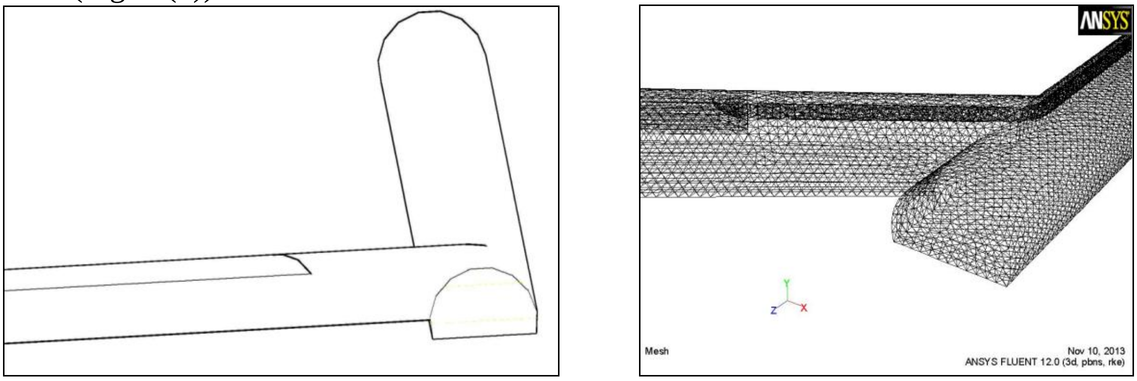


Fig. 1 Layout drawing of Ventilation during short-distance construction stage of the main tunnel assisted by inclined shaft

2.1 Modeling, meshing and parameter setting.

Combined with the actual construction, AutoCAD is chosen to establish a geometric model according to the actual size (Figure 2 (a)), to avoid the possible size effect on the results. Import the 3D model built in AutoCAD into Gambit, divide the model with tetrahedron mesh and import the divided model into Fluent (Fig. 2 (b)).



(a) Three-dimensional modeling in CAD (b) Import into Fluent for parameter setting

Fig. 2 Modeling with software

Set the inlet of the air pipe to be the boundary condition for entrance speed, determine the wind speed at the inlet to be 30.18m/s according to the type of fan in use. Set the outlet of air pipe and entrance of the inclined shaft to be pressure intensity outlets and exert wall boundary conditions to other sides. Calculate with standard law of wall.

Apply gravity acceleration of 9.8m/s^2 to -Y direction, and solve the three-dimensional N-S equation with the method of limited volume with separated implicit expression. Model is used for turbulent model and SIMPLE algorithm is adopted to solve the coupling problem of pressure and velocity.

2.2 The velocity distribution in the wind field.

As the model is large and the overall display is not good, we choose to examine the key parts we are studying. The face of the main tunnel, intersection of inclined tunnel and main tunnel, and entrance of inclined tunnel are chosen to show their velocity vector diagrams when the wind speed is faster than 0.25 m/s, as shown in Fig. 3 (a), Fig. 4 (a) and Fig. 5 (a). It can be seen from the figures that the wind speed in the wind tunnel is higher and becomes lower long the air pipe; while the wind speed in the tunnel is generally low, and only increase obviously near the outlet. The wind speed in the tunnel is more than 0.25m/s, in line with the air health standard for construction section of the tunnel.

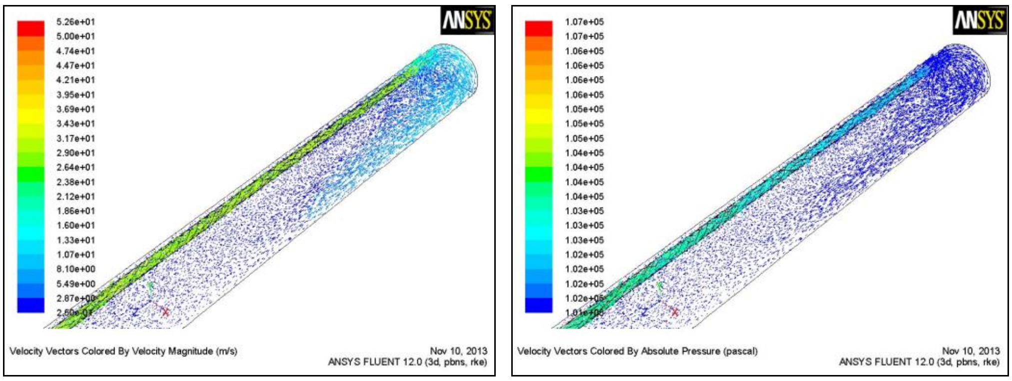


Fig.3 Velocity vector diagram (> 0.25m/s) and pressure intensity vector diagram near the face of the main tunnel

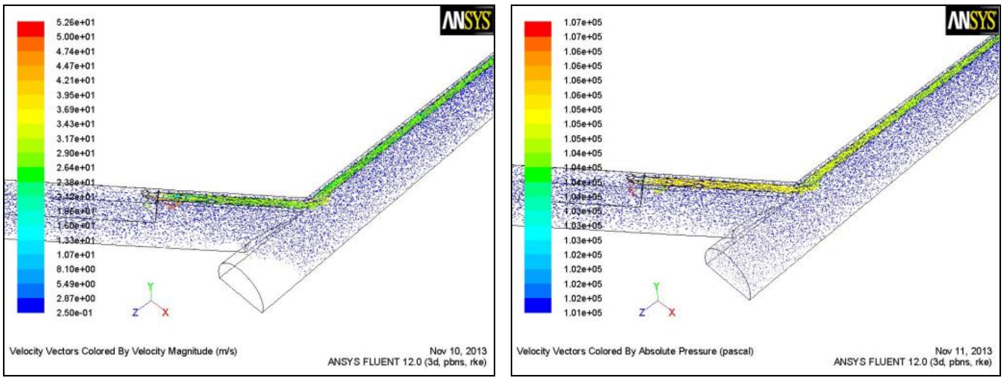


Fig.4 Velocity vector diagram (> 0.25m/s) and pressure intensity vector diagram near diagram the intersection of the inclined tunnel and the main tunnel

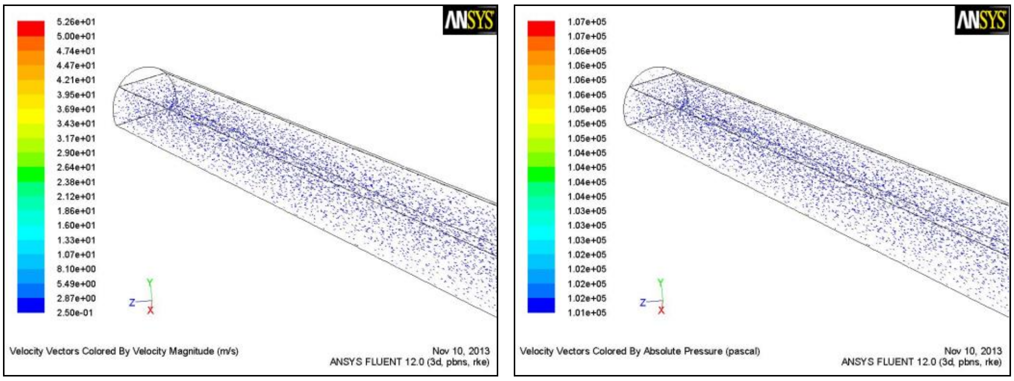


Fig.5 Velocity vector diagram (> 0.25m/s) and pressure intensity vector diagram near the entrance of the inclined tunnel

2.3 Pressure intensity distribution in the wind field.

As shown in Fig. 3 (b), Fig. 4 (b) and Fig. 5 (b), the pressure intensity vector diagrams of the face of the main tunnel, intersection of inclined tunnel and main tunnel, and entrance of inclined tunnel can be seen. It is found that the air pressure intensity in the air pipe is large and drops significantly along the pipe, and that the air pressure intensity in the tunnel remains basically the same, about 1 atmospheric pressure, in accord with the air health standard for construction section of the tunnel.

3. Conclusion

Through the ventilation simulation during short-distance construction stage of the main tunnel assisted by 2# inclined shaft in the tunnel of Liupan Mountain. It is found that:

(1) The wind speed in the tunnel retains 0 ~ 21.0 m/s; the pressure intensity is 1.01×10^5 ~ 1.02×10^5 Pa;

(2) Due to viscous force of fluid, the wind speed near the inner wall of the tunnel reaches the minimum. Especially at the intersection of the inclined tunnel and the main tunnel, the wind speed near the inner wall of the tunnel is less than 0.25m/s. However, little influence is exerted on overall tunnel ventilation.

(3) At the location near the face of the tunnel, the wind speed along the air pipe to the outlet is big, while the wind speed toward the entrance of inclined tunnel drops gradually.

In general, the wind speed in the tunnel is basically above 0.25m/s, and the pressure intensity is about 1 atmospheric pressure, which is in accordance with the requirement of ventilation in the tunnel construction. Thus, the ventilation design is reasonable.

References

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