Scholars Journal of Engineering and Technology (SJET) **ISSN 2321-435X (Online)**
Sch. J. Eng. Tech., 2015; 3(3B):299-303 **ISSN 2347-9523 (Print)**

(An International Publisher for Academic and Scientific Resources)
www.saspublisher.com

Research Article

Intelligent control of tunnel emergency evacuation signs under fire condition

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Abstract: With the development of traffic cause, tunnel number increased year by year. At the same time, the tunnel fire accidents at home and abroad in recent years has caused a large number of casualties and property losses. The study of tunnel fire evacuation is urgent and necessary. Propose the intelligent control mode of emergency evacuation signs from the perspective of induction of personnel escape. Write a PLC program for 1 km long tunnel as an example. Simulate the emergency evacuation signs' automatic control under the condition of tunnel fire.
Keywords: tunnel fire; PLC; emergency evacuation

INTRODUCTION

With the development of traffic cause, the mileage of traffic tunnels built by various countries in the world increased continuously. Because of the special structure of tunnel space, it is difficult for vehicles and the car personnel to evacuate. In the event of fire, it will be a serious threat to human life and property safety. In recent years, the tunnel fire accidents are common at home and abroad, there are some typical cases: Lin Jia Chuan tunnel fire is on June 12, 1993 [1]; The English Channel tunnel fire is in 1996; Mont Blanc Tunnel fire is in 1999; Salzburg states in Austria Kitts Stanford Huo County mountain tunnel fire is in 2000; Guang Dong Dabaoshan Tunnel fire is in 2008; Shanxi Yanhou Tunnel fire is in 2014; And so on. All have caused great casualties and property losses.

From the statistical data shows that both at home and abroad, the risk of highway tunnel fire is much smaller than the risk of ground vehicle fires, but the consequences of a fire in the tunnel is much more serious. Evacuation is the most serious problem [2]. The tunnel space is narrow and have longer depth. The tunnel is relatively closed and has a few exports and entrances. Once the fire happened, evacuate the personnel is very difficult due to the large concentrations of smoke and low visibility.

The shortage and innovative method of the current emergency evacuation signs:

Many studies have shown that, many victims of tunnel fire are suffocated to death rather than directly burned by fire. This shows the importance of emergency evacuation. The longitudinal size of tunnel is much bigger than the lateral size of tunnel. It needs relatively long time for flames and smokes to spread along the longitudinal. So people in the accident have time for an emergency escape. But our people have less knowledge of reasonable fire evacuation in road tunnel. In the face of tunnel fire, a lot of people's behavior is to stay in the car and to be at a loss. Some people may watch others' behavior in the car and then make a decision. There are also some people who turn around the car and drive to escape. These are the wrong way to escape. The propaganda of tunnel fire safety knowledge should be strengthened [3]. In case a fire occurs in a tunnel, it relies mainly on fire control broadcast and emergency evacuation signs to ensure safe evacuation. However, the current emergency evacuation signs are

always two-way pointed directional signs, as shown in Fig-1.

Fig-1: The current emergency evacuation sign

The right way should be deviating from the point of the fire according to the indication from the emergency evacuation signs and escape to the safe place far away from the fire point. But it is difficult for people to accurately judge the fire point location when fire occurs in reality. If there is no visualized indication from the emergency evacuation signs for people. If the person makes wrong judgment and escape to the fire point, it could lead to serious consequences. Because current emergency evacuation signs are two-way pointed signs and both side of the two-way pointed sign are opened and closed synchronously. People cannot judge the relative position of fire pint according to the emergency evacuation signs. In view of the faultiness of the safe evacuation design, I think it is urgent and necessary to design the intelligent control mode of emergency evacuation signs from the perspective of effective evacuation.

There are two ways for the current emergency evacuation signs to realize the right and left direction light can control to open or close separately. One is the whole evacuation signs can be divided into left and right direction light sign of two separate productions, just physically as a whole. The other one is the left and right direction lights both plus address unit respectively, and then can control on or off according to their independent address coding.

The characteristics of the intelligent control mode is when the tunnel fire, alarm message quickly convey to the remote central controller, system will send the fire point coordinates signals to the scene PLC which controls all the emergency evacuation signs. PLC will execute program to turn off the right direction light of the emergency evacuation signs located on the left side of the fire point. And turn off the left direction light of the emergency evacuation signs located on the right side of the fire point. This can accurately evacuate people to deviate from the fire point and save time for people in danger, and provide the important information of relative position. In case a fire occurs in a tunnel, if people see that the left direction light of the emergency evacuation signs is opened and the right direction light is closed, it means the fire point is on the right. People should evacuate follow the opened left direction light; If people see that the right direction light of the emergency evacuation signs is opened and the left direction light is closed, it means the fire point is on the left. People should evacuate follow the opened right direction light. Personnel can quickly and accurately determine the direction of escape according to the information given by emergency evacuation signs. It is very meaningful to emergency evacuation in fire conditions.

The PLC program of 1 km long tunnel

In this paper, write PLC program of 1 km long tunnel as an example. According to the highway tunnel design specification, the distance between emergency evacuation signs should not be more than 50m. This tunnel takes 50m for the interval. Assume that the coordinate of the tunnel entrance is K000. Install a group of emergency evacuation sign in each interval of 50m for the 1 km long tunnel. There are a total of 19 groups. Each group contains a left sign direction arrow and a right sign direction arrow. There are a total of 38 direction arrows. The serial number of each direction

arrow is L1, L2, L3, L4…L36, L37, L38 from small to big coordinate. The first group includes L1 and L2; The second group includes L3 and L4; …The 19th group includes L37 and L38. Each position coordinate of direction arrow is listed below: The coordinate of L1, L2 is 50; The coordinate of L3, L4 is 100; The coordinate of L5, L6 is 150; The coordinate of L7, L8 is 200; The coordinate of L9, L10 is 250; The coordinate of L11, L12 is 300; The coordinate of L13, L14 is 350; The coordinate of L15, L16 is 400; The coordinate of L17, L18 is 450; The coordinate of L19, L20 is 500; The coordinate of L21, L22 is 550; The coordinate of L23, L24 is 600; The coordinate of L25, L26 is 650; The coordinate of L27, L28 is 700; The coordinate of L29, L30 is 750; The coordinate of L31, L32 is 800; The coordinate of L33, L34 is 850; The coordinate of L35, L36 is 900; The coordinate of L37, L38 is 950.

The initial state is that all the 38 direction arrows (19 groups of emergency evacuation signs) are open, as shown in Fig-2.

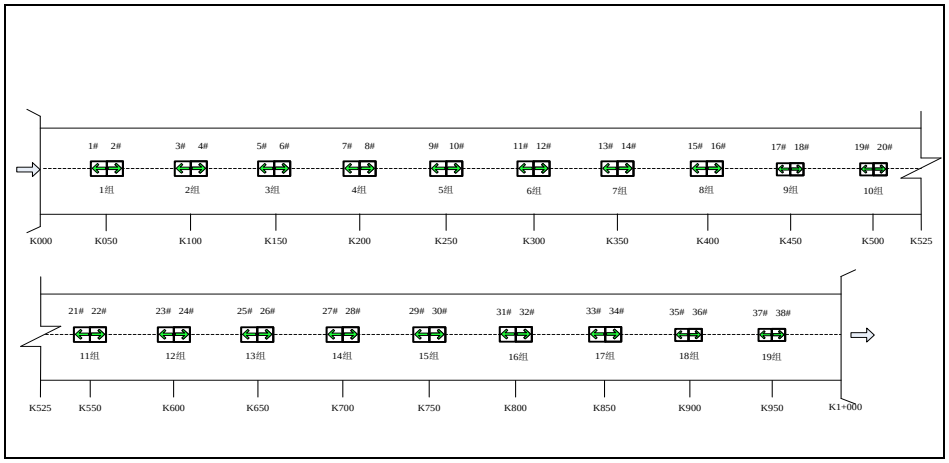

Fig-2: The initial state of emergency evacuation signs

When give the coordinate of fire address, it can be affirmed that the coordinate of fire is between group n and group n+1 (The coordinate of fire is bigger than the coordinate of group n, and smaller than the coordinate of group n+1.). Execute the following command: Close the even number of direction arrows which number is less than 2n (2n, 2n-2×1, 2n-2×2, 2n-2×3, …2n-2(n-1)); Close the uneven number of direction arrows which number is more than 2n (2n+1+2×0, 2n+1+2×1, 2n+1+2×2, 2n+1+2×3, …35, 37); And the rest of direction arrows keep opening.

For example, the coordinate x of fire address is K380, the coordinate of fire point is between 7th group and 8th group of emergency evacuation signs. Then the Number 2, 4, 6, 8, 10, 12, 14 direction arrow will be shut down. The Number 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37 direction arrow will be shut down. And the rest of direction arrows of emergency evacuation signs will keep opening, as shown in figure 3.

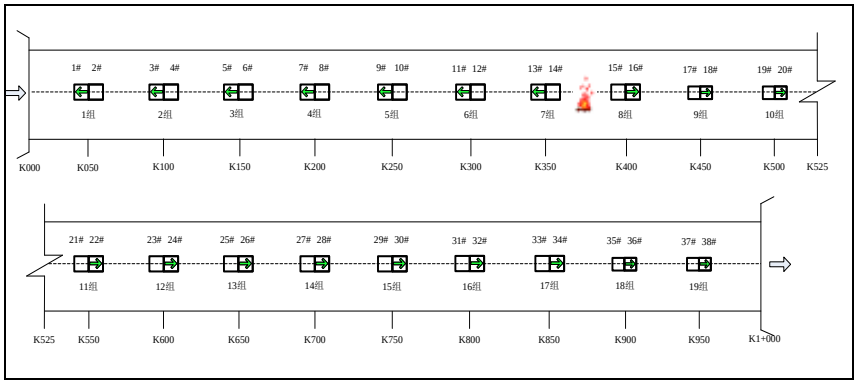

Fig-3: The state of emergency evacuation signs when the coordinate of fire is K380

PROCEDURES AND SIMULATION:

In the program, "Mileage "signifies the coordinate of fire address. "iCounterX "signifies that fire is between which two groups. The program is shown as follows.

```
IF Mileage>0 THEN
Var2 :=Mileage/50;
iCounterX := REAL_TO_INT(Var2);(*Judge the
position*)
var1 := iCounterA MOD 2;
iCounterB :=iCounterX*2;
iCounterA :=iCounterA+1;
IF iCounterA=39 THEN
   iCounterA   :=1;
END_IF;
IF iCounterA <= iCounterB THEN IF Var1 <>0
   THEN IntArray[iCounterA] :=0; ELSE
IntArray[iCounterA] :=1;
      END_IF;
ELSE IntArray[iCounterA] :=1;
   END_IF;
IF iCounterA >iCounterB THEN IF Var1 =0
   THEN IntArray[iCounterA] :=0;
END_IF; END_IF;(*Execute control commands*)
END_IF;
%QX0.0 :=IntArray[1]; (*Assign a physical address*)
%QX0.1 :=IntArray[2];
%QX0.2 :=IntArray[3];
%QX0.3 :=IntArray[4];
%QX0.4 :=IntArray[5];
%QX0.5 :=IntArray[6];
%QX0.6 :=IntArray[7];
%QX0.7 :=IntArray[8];
%QX1.0 :=IntArray[9];
%QX1.1 :=IntArray[10];
%QX1.2 :=IntArray[11];
%QX1.3 :=IntArray[12];
%QX1.4 :=IntArray[13];
%QX1.5 :=IntArray[14];
%QX1.6 :=IntArray[15];
%QX1.7 :=IntArray[16];
%QX24.0 :=IntArray[17];
%QX24.1 :=IntArray[18];
%QX24.2 :=IntArray[19];
%QX24.3 :=IntArray[20];
%QX24.4 :=IntArray[21];
%QX24.5 :=IntArray[22];
%QX24.6 :=IntArray[23];
%QX24.7 :=IntArray[24];
%QX25.0 :=IntArray[25];
%QX25.1 :=IntArray[26];
%QX25.2 :=IntArray[27];
%QX25.3 :=IntArray[28];
%QX25.4 :=IntArray[29];
%QX25.5 :=IntArray[30];
%QX25.6 :=IntArray[31];
%QX25.7 :=IntArray[32];
%QX48.0 :=IntArray[33];
%QX48.1 :=IntArray[34];
%QX48.2 :=IntArray[35];
%QX48.3 :=IntArray[36];
%QX48.4 :=IntArray[37];
```

%QX48.5 :=IntArray[38]; (*To assign physical address*)

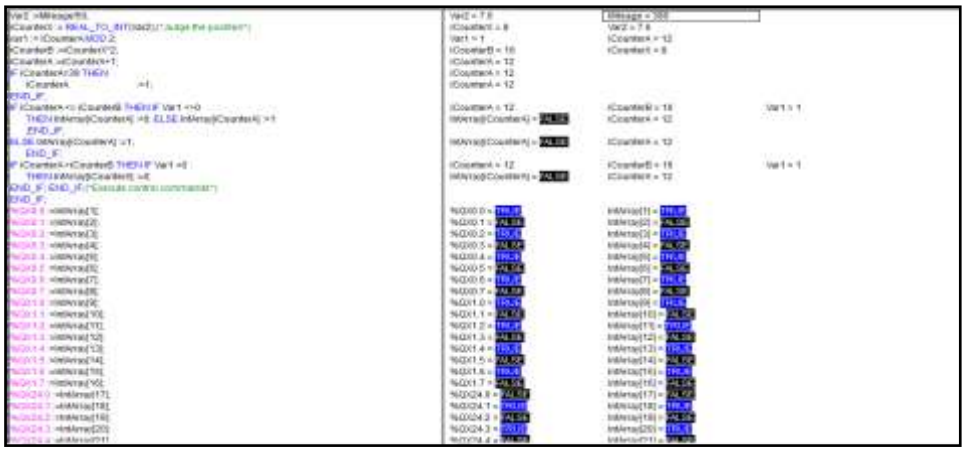

Fig-4: The program and simulation

If the coordinate x of fire address is K380, the simulation results are shown in figure 5.

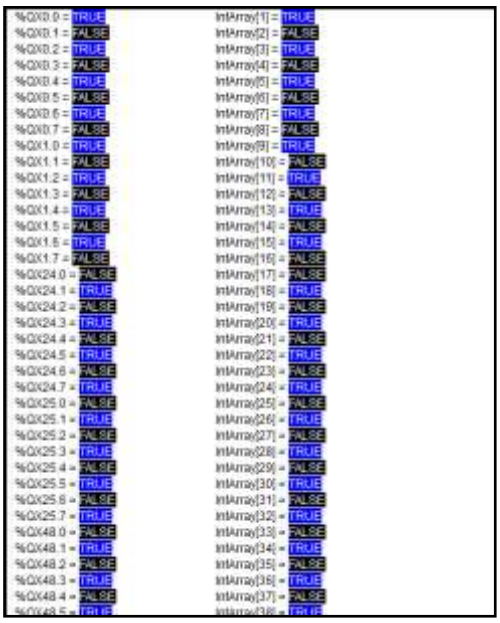

Fig-5: The simulation result when the coordinate of fire is K380

CONCLUSION AND RECOMMENDATION:

When the fire happened, automatic fire alarm system will send the detected fire signal to control center. After receiving the fire signal, the system will automatically run the evacuation procedure according to the tunnel fire location information. The state of the corresponding emergency evacuation signs will be adjusted. The program will shut down the direction arrow of emergency evacuation signs that is pointing to the direction of fire source. And guide people to escape in the safe direction. This provides a safe, accurate and rapid evacuation method for the affected people in tunnel under fire condition.

REFERENCES

1. Li YZ, Gong X, Chen CK; Study on the Performance-based Safe Evacuation Design in Tunnel Fires. Journal of Disaster Prevention and Mitigation Engineering, 2006; 26(4): 409-413.
2. Yan W; A Lesson Learnt From the Fire Disaster in the Santiago Channel. Journal of Chinese People's Armed Police Force Academy, 2010; 6:20.
3. Zhou J, Jiang X, Chen D; Investigation and analysis on human evacuation psychological behavior in road tunnel fire. Fire Science and Technology, 2014; 7.