

Residential Electrical Fire in Shenzhen: Data Analysis and Possible Solution

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Abstract— This paper presents the data analysis of electrical fire incidents in Shenzhen, China. A detailed examination of 3192 electrical fire incidents from 2014 to 2018 is presented. Time distribution and spatial distribution of electrical fires in residential buildings are reported. The analysis of this study indicates that the prevention of electrical fires in urban villages is of great significance. Moreover, installing arc fault detection devices is necessary to reduce electrical fires. The results presented in this paper can be beneficial to policymakers for electrical fire prevention.

Index Terms— Fire incident, Urban village, Electrical fire

I. INTRODUCTION

An electrical fire has always been a critical issue that attracts significant social concern [1]. It can cause serious threats to human life and property. Fire risk is associated with various factors, such as the age of houses, economic level, weather conditions, social behavior, etc [2]. Statistics analysis based on fire event data is an effective approach to study the influence of these factors that affect fire risk [3, 4]. In the past years, fire research based on statistical analysis has been conducted in both urban and rural areas [5-8]. For cities, like Shenzhen, due to its rapid growth of urbanization, many high-rise buildings have been constructed recently. Meanwhile, urban villages that provide shelter for migrant workers are quite prevalent in this city. The situation of fire risk in Shenzhen might be different from that of the rural areas and typical urbanized cities. Moreover, there has been less research focusing on the analysis of the fire data that occurred in residential buildings, even though more and more fire incidents occurred in residential buildings, especially in the economically developed areas.

With the collected data of the residential fire incidents in Shenzhen, this paper analyzes the factors that influence the fire risk in a city. The fire incidents data in Shenzhen from 2014 to 2018 is collected for analysis. The time distribution and spatial distribution as well as the causes of the electrical fire in the residential building are evaluated. This paper presents some

statistical correlation for people to learn from actual events [9]. The results of the paper could be used for policy formulation and allocation of fire prevention resources.

II. RESIDENTIAL ELECTRICAL FIRES IN SHENZHEN

In the period from 2014 to 2018, 8,875 fire incidents occurred in Shenzhen, leading to 64 deaths, 106 injuries, and direct property losses of 118.491 million yuan. Among them, 3,192 were electrical fires resulting in 21 deaths, 35 injuries, and direct property losses of 53.901 million yuan. Electrical fires accounted for 35.97% of the total fires. Though there is a downward trend in the total fire incidents from 2014 to 2018, as can be seen from Table 1, the proportion of electrical fires has increased every year.

Table 1. Electrical fire incidents in Shenzhen from 2014 to 2018

| Year | Electrical fire | Total fires | Electrical fire/Total fires (%) | Losses due to electrical fire (million) | Injuries due to electrical fire | Deaths due to electrical fires |
|------|-----------------|-------------|---------------------------------|---|---------------------------------|--------------------------------|
| 2014 | 623 | 2025 | 30.77 | 11806.6 | 6 | 1 |
| 2015 | 529 | 1775 | 29.80 | 14250.3 | 5 | 3 |
| 2016 | 591 | 1549 | 38.15 | 12021.8 | 12 | 8 |
| 2017 | 812 | 2063 | 39.36 | 9326.7 | 7 | 5 |
| 2018 | 637 | 1463 | 43.54 | 6184.7 | 5 | 4 |

The electrical fire incidents from 2014 to 2018 are shown in Table 2. It can be seen that residential and dormitory electrical fires account for a very large proportion in terms of number, casualties, and economic losses. Among all the electrical fires, there are 1755 residential electrical fires, accounting for 54.98% of the total electrical fire incidents. Losses due to residential electrical fires are 12.7929 million yuan, accounting for 23.87% losses of total electrical fires. Most injuries and deaths caused by electrical fires are in residential buildings (91.43% of the injuries, and 85.71% of deaths). Therefore, it is very necessary to study the characteristics of residential electrical fires.

Table 2. Distribution of fire incidents in Shenzhen from 2014 to 2018 by types of building

| Location | Number | Losses (thousand) | Injuries | Deaths |
|----------------------|--------|-------------------|----------|--------|
| Residential building | 1755 | 12792.9 | 32 | 18 |
| Factory, warehouse | 525 | 24292.9 | 1 | 1 |
| Market | 139 | 2337.6 | 0 | 0 |
| Restaurant | 97 | 561.7 | 0 | 0 |
| Entertainment venues | 20 | 871.3 | 0 | 2 |
| School | 9 | 22.8 | 0 | 0 |
| Hospital | 6 | 6.2 | 0 | 0 |
| Other | 641 | 12710 | 2 | 0 |
| Total | 3192 | 53595.4 | 35 | 21 |
| Residential/total | 54.98% | 23.87% | 91.43% | 85.71% |

III. RESIDENTIAL ELECTRICAL FIRE CHARACTERISTICS ANALYSIS

1) Spatial distribution of residential electrical fires

By analyzing the residential electrical fire distribution we can find out the districts in which the residential electrical fire is prone to happen thus more attention can be paid and more fire prevention resources can be allocated in that area.

From Table 3 we can see, the number of residential electrical fires in Baoan, Longgang, and Futian District is relatively high. The number of electrical fires is 398, 286, and 267 respectively in these three districts, accounting for 22.68%, 16.30%, and 15.21% of the total residential electrical fires in Shenzhen. Since the residential electrical fires in these three districts accounted for more than half of the total number of residential electrical fires. To effectively reduce the residential electrical fire accidents in Shenzhen, much more attention should be paid to these three districts.

Table 3. Spatial distribution of fire incidents in Shenzhen from 2014 to 2018

| District | Number | Proportion | Losses (thousand) | Injuries | Deaths |
|-----------|--------|------------|-------------------|----------|--------|
| Futian | 267 | 15.21% | 1580.2 | 8 | 3 |
| Nanshan | 134 | 7.64% | 1670.4 | 0 | 0 |
| Luohu | 132 | 7.52% | 2230.2 | 2 | 3 |
| Longgang | 286 | 16.30% | 2221.1 | 9 | 0 |
| Baoan | 398 | 22.68% | 2965.8 | 7 | 9 |
| Longhua | 197 | 11.23% | 1312.1 | 0 | 1 |
| Guangming | 165 | 9.40% | 470.6 | 2 | 0 |
| Pingshan | 100 | 5.70% | 127.5 | 3 | 2 |
| Yantian | 46 | 2.62% | 164.5 | 1 | 0 |
| Dapeng | 30 | 1.71% | 50.5 | 0 | 0 |
| Total | 1755 | 100.00% | 12792.9 | 32 | 18 |

2) Classification of the residential electrical fire

Residential buildings in Shenzhen can be divided into three categories: urban village buildings, commercial residential buildings, and dormitory buildings (mainly corporate dormitories). The electrical fire data of urban villages building, commercial residential buildings, and dormitory buildings from 2014 to 2018 are shown in Table 4. Among them, 1,186 fires occurred in urban villages building, results in 11 deaths, 29 injuries, and 7.5112 million yuan losses. The high incidence of electrical fires in urban village buildings is caused by the following reasons:

- Buildings in the urban villages are mostly old buildings with low fire resistance levels
- The electrical power lines in the urban villages are installed irregularly all over the villages without proper planning
- The population density in the buildings of the urban villages is extremely high, and the electricity loading often exceeds the design capacity of the power lines.
- Residents in the buildings of the urban villages are mostly migrant workers, their weak awareness of electrical safety might lead to electrical fires

It is found that 327 electrical fires occurred in the commercial residential building, leading to 7 deaths, 2 injuries, and 3.790,800 million yuan economic losses. Usually, commercial residential buildings have reasonable layouts. They are designed properly, and constructed properly as well. The electrical wiring and equipment in the commercial residential building are relatively new, so the fire risk in the commercial residential building is relatively small. However, due to its large number of flats, the consequences of a fire in such a building can be serious. Therefore, fire prevention in commercial residential buildings is also worth noting.

It also is found that 245 electrical fires occurred in the dormitory buildings. One person was injured in the fire, and the economic loss due to the fires is 1.6909 million yuan. Although the layout of the dormitory is reasonable, problems such as insufficient awareness of the electrical safety of employees, illegal use of electrical appliances, electrical wiring, and old equipment might also be the reason for the electrical fire.

Table 4. Distribution of fire incidents in residential buildings

| Types | Number | Financial Losses (thousand) | Injuries | Deaths |
|---------------------------------|----------|-----------------------------|----------|--------|
| Urban villages building | 1186 | 7511.2 | 29 | 11 |
| Commercial residential building | 324 | 3590.8 | 2 | 7 |
| Dormitory buildings | 245(127) | 1690.9 | 1 | 0 |

3) Time distribution of the residential electrical fire

A. Distribution of residential electrical fire incidents by year:

Table 5 shows yearly electrical fire incidents in residential buildings from 2014 to 2018. From the table, we can see that the electrical fires have slowly increased in the past five years. In 2017, the situation of electrical fires was the most severe. There were 458 electrical fire incidents in residential buildings, 4 people were killed and 6 people were injured by the fires. The economic loss was 3.0799 million yuan.

Table 5. Losses due to electrical fires in residential buildings

| Year | Number | Losses (thousand) | Deaths | Injuries |
|------|--------|-------------------|--------|----------|
| 2014 | 317 | 1787.8 | 1 | 5 |
| 2015 | 291 | 4218.8 | 1 | 5 |
| 2016 | 307 | 2053.3 | 8 | 11 |
| 2017 | 458 | 3079.9 | 4 | 6 |
| 2018 | 382 | 1653.1 | 4 | 5 |

B. Distribution of residential electrical fire incidents by season:

As for the seasonal distribution of electrical fires in residential buildings, it is found that 523 electrical fires occurred in the first quarter, 436 electrical fires occurred in the second quarter, 396 electrical fires occurred in the third quarter, and 400 electrical fires occurred in the fourth quarter. The risk of electrical fires in the first quarter is relatively high. This might be because the temperature in the first quarter may be relatively low and dry. More heating devices and electrical appliances are used. The utilization of such devices increases the chance of an electrical fire.

C. Distribution of residential electrical fire incidents by month:

From the monthly distribution of electrical fires in residential buildings in Shenzhen, we can see the risk of an electrical fire in January is the highest, with 191 electrical fires happened. In February, April, and September, the risk for electrical fires was also relatively high, with 172, 171, and 152 respectively. The electrical fires risk in urban village building is relatively high and are relatively relevant with month. There are more electrical fires in January and February. The time distribution of electrical fires in commercial residential buildings and dormitory buildings is relatively stable without obvious time characteristics.

Table 6. Distribution of electrical fire incidents by month

| Month | Type of residential building | | | Total |
|-------|------------------------------|----------------------------------|-------------|-------|
| | Urban villages buildings | Commercial residential buildings | Dormitories | |
| 1 | 133 | 34 | 24 | 191 |
| 2 | 129 | 27 | 16 | 172 |
| 3 | 93 | 40 | 25 | 158 |
| 4 | 115 | 35 | 21 | 171 |
| 5 | 104 | 24 | 31 | 159 |
| 6 | 67 | 23 | 22 | 112 |
| 7 | 77 | 16 | 25 | 118 |
| 8 | 79 | 25 | 14 | 118 |
| 9 | 106 | 29 | 17 | 152 |
| 10 | 102 | 34 | 14 | 150 |
| 11 | 91 | 16 | 13 | 120 |
| 12 | 90 | 21 | 23 | 134 |
| Total | 1186 | 324 | 245 | 1755 |

D. Distribution of residential electrical fire incidents by hour:

From the hourly distribution of electrical fires in residential buildings, we can conclude that the electrical fires in urban village buildings are found to occur mainly in 9:00-11:00 and 17:00-20:00. This might be because more electrical appliances for dining are used during that period and electrical fires are more likely to occur. Electrical fires in commercial residential buildings are found to occur mainly between 16:00-23:00; electrical fires in dormitories do not show a strong correlation with time.

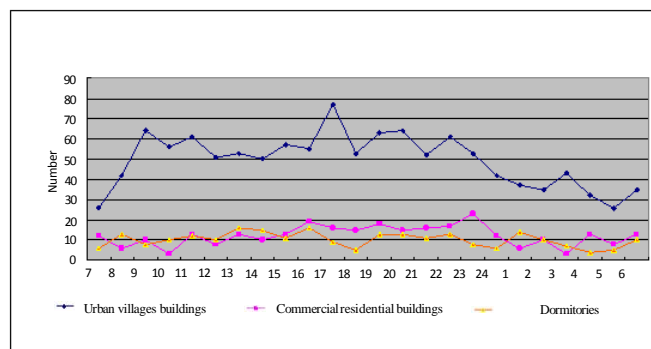


Figure 1. Distribution of residential electrical fire incidents by hour

IV. CAUSES OF ELECTRICAL FIRE INCIDENTS

Analyzing the causes of electrical fires has a significant role in fire prevention and reduction. As can be seen from Table 7, the causes of fires in residential buildings can be divided into three categories, that is, supply circuit failures, electrical equipment failures, and fires caused by heating appliances. Among them, supply circuit failures are responsible for 58.46% of the total residential electrical fires, electrical equipment failures for 28.66%, and fires due to heating appliances for 4.58%. Among the causes of the supply circuit failures, short circuit faults are the most prominent cause that leads to electrical fires in residential buildings. Most of the electrical fires can essentially be attributed to arc faults. When a short circuit, overload, poor contact, or leakage current occurs in the electrical circuit or an electrical appliance, arcing will be generated in the circuit in the form of the series arc, parallel arc or carbonized paths. Thus, the detection of arc faults can be effectively used as an early warning method for preventing electrical fires.

Table 7. Causes of electrical fire incidents in residential buildings

| Causes of electrical fires | | Number | Losses (thousand) | Injuries | Deaths |
|-----------------------------------|-----------------|--------|---------------------|----------|--------|
| Electrical circuit failures | Short circuit | 745 | 5612.7 | 8 | 9 |
| | Open circuit | 4 | 4.5 | 0 | 0 |
| | Overload | 35 | 70.2 | 0 | 0 |
| | Leakage current | 8 | 6.2 | 3 | 0 |
| | Poor contact | 22 | 140.5 | 2 | 3 |
| | Other | 212 | 2121.7 | 4 | 0 |
| Electrical equipment failures | | 503 | 3690.9 | 8 | 0 |
| Fire caused by heating appliances | | 80 | 272.2 | 0 | 2 |
| Other | | 146 | 923 | 7 | 4 |
| Total | | 1755 | 12841.9 | 32 | 18 |

1) Short circuit

Short circuits in the supply circuits are mainly caused by two reasons. One is the mechanical damage, the other is the insulation degradation due to overheating, water immersion, mold growth, and sunlight radiation. When a short circuit fault occurs in a circuit or equipment, the current in the circuit will suddenly increase, resulting in high temperature or arc, which will eventually lead to an electrical fire.

2) Overload



Figure 2. Combusting of insulation material due to overload

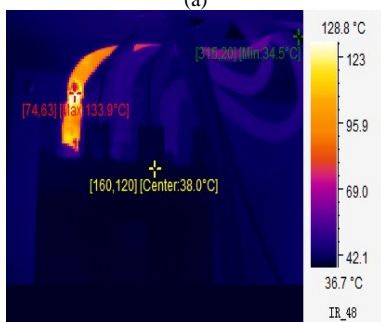
Electrical insulation for the supply circuit can be made with neoprene, natural rubber, polyethylene and other carbon-high polymer organic materials, which are thermally unstable. If the current passing through the electrical circuit exceeds its capacity, the temperature of the electrical wire will rise significantly, causing the electrical wire or surrounding combustibles to burn. Overload is an important factor causing electrical fires. It can not only directly cause a fire, but also damage the insulation material of the circuit, and resulting in a short circuit, poor contact, leakage current and other faults. The main causes of overload are:

- 1) connecting many loads in a circuit, causing overload of the electrical wire
- 2) Unproper selection of the cross-sectional area of conductors
- 3) Electrical appliances working in the fault conditions

3) Poor contact



(a)



(b)

Figure 3. High temperature due to poor contact. (a) Poor contact point. (b) The result obtained by infrared temperature measurement.

If the connection between two wires or the connection between the wire and electrical equipment is not good, the contact resistance will be very large. When the circuit is

energized, high temperature and electric arc are generated at the contact, igniting the insulating layer of the circuit or the nearby combustible materials. The fire due to poor contact is easy to ignore and difficult to prevent.

4) Leakage current

When the insulation materials of the electrical wire are degraded due to environmental influences or natural aging. Leakage current from the conductor will flow to grounded objects. If the leakage current exceeds a certain value, it can ignite surrounding combustible materials thus cause an electric fire.

5) Failure of electrical equipment

When electrical equipment is used for a long time, its wiring or others suffers from aging. The short circuit, leakage, overload, poor contact might happen. Sometimes, unproper use of the electrical equipment will lead to overloading of the appliances. All these factors might result in an electrical fire.

V. CONCLUSIONS

As a fast-developing city, electricity demand keeps increasing. As a result, the number of electrical fires is increased year by year. Among them, residential electrical fires account for more than half of the total number of electrical fires. From 2014-2018, the number of deaths caused by electrical fires in residential buildings accounted for 85.71% of the total deaths from electrical fires. Preventing electrical fires in residential buildings can significantly reduce fire risk, especially in reducing casualties.

Residential electrical fires in Shenzhen are distributed relatively even in terms of time. The figure in the first quarter was just slightly higher than other quarters. From the monthly distribution, the fire risk in January is the highest. From the hourly distribution, electrical fire mainly occurs during dinner time. In contrast to the time distribution, the spatial distribution in Shenzhen shows a strong regional correlation. Residential electrical fires in the three districts of Baoan, Longgang, and Futian District accounted for 54.19 percent of the residential electrical fires in the whole city. The residential electrical fires in the city are mainly concentrated in urban villages (fires in urban villages accounted for 67.58% of all residential electrical fires in ShenZhen). Possible reasons for this situation may be the aging of buildings, lacking of proper management, lacking of electrical fire awareness from the resident.

After analyzing and summarizing the causes of electrical fires, it can be seen that although there are various causes of electrical fires, the fires are essentially due to: arcs or dangerous high temperatures of electrical equipment.

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