

# URBAN FIRE SAFETY RESEARCH IN CHINA

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## ABSTRACT

*Urban fire research is becoming more and more important for city safety based on the characteristics of city development and current status of urban fire in China. In this paper, the progress of urban fire safety researches, such as dynamics of city fire growth, fire smoke toxicity, movement and its effect on human evacuation, performance-based fire safety design and risk assessment, structure response of building in fire, city fire decision-making system base on GIS and so on in China are introduced.*

## 1. INTRODUCTION

With the rapid development of economy and society in China, urban population, the city zone area and urbanization level increase very quickly. Until 2002, there have been 166 cities, 25.1 percent of all the cities in China, which population exceed 1,000,000 and 279 cities, 42 percent of all the cities in China, which population is 500,000~1,000,000. There are some characteristics of Chinese cities shown as follows:

- Urban scale and urban area are extending constantly;
- Urban population and urban population density are increasing as a whole.

With urban scale expanding, there are some new characteristics of urban building shown as follows (Chen, 2002):

- Transforming from traditional low rise building to high rise or super high building;
- Transforming from traditional single material such as tile to new-style material such as steel;
- Transforming from simple building to large-scale modern building.

As results of the city zone area and urban population density increasing, a great deal of large-scale high rise buildings with complicated functions is booming. Figure.1 shows modern city scene in China. There are some characteristics of urban fire shown as follows (Wang, 2002):

- Many serious fire accidents

It presents upward trend that in an accident the casualty exceeds 10, or death and serious injury exceeds 20, or direct property loss exceeding ¥1,000,000.

- Many public places fire accidents



Fig. 1: Modern city scene in China

Some public places such as emporium, marketplace, hotel, and ballroom usually take place fires and induce serious casualty.

- High fire frequency in private corporation, self-employed individuals and illegal small public place

There is high fire frequency in private corporation, self-employed individuals and illegal small public places, etc.

Figure2 shows the relationship between the direct property loss and the increasing curve of GDP after the Reformation and Opening, which shows that with the development of China economy and urbanization, fire direct property loss and GDP are both increasing. Based on the trend, it is inevitable that there will take place more frequent and more

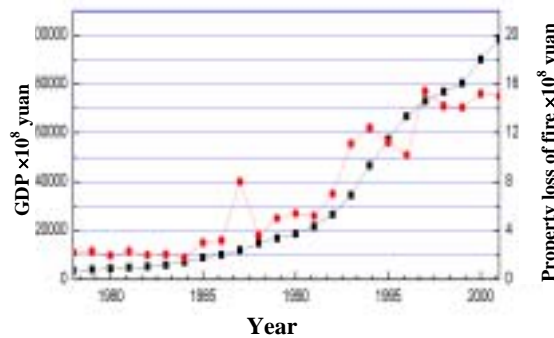


Fig. 2: Fire direct property loss and GDP

serious fires. Fire situation is austere as a whole in China. Fire safety research and fire protection work are still very hard. Making research on fire occurrence, growth characteristic and its spreading rule are essential to reduce urban fire frequency and loss.

## 2. CENTRAL CONTENT OF URBAN FIRE SAFETY RESEARCH

Based on current characteristics of urban fire in China, many researchers have made research on urban fire dynamics evolution mechanism, key technology of urban fire protection, fire safety of urban building structure and urban fire safety engineering theory, etc (shown in Figure3), and achieve some satisfactory results.

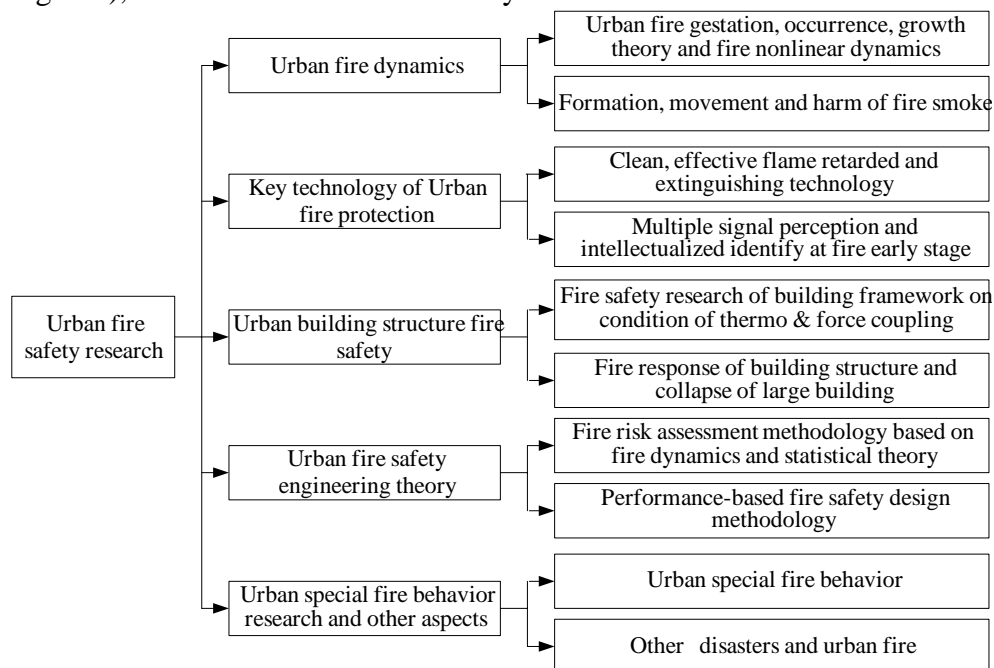


Fig. 3: Urban fire research content

## 2.1 Urban fire dynamics

### 2.1.1 *Urban fire gestation, occurrence, growth theory and fire nonlinear dynamics*

Based on statistical analysis of urban fire (Yang, 2002), the developmental trend and self-organized criticality (Song, 2003) are researched. Some profound researches on theory of urban fire gestation occurrence, growth and building combustible thermal decomposition dynamics (Liu, 2001, 2002) have been achieved. Some given system in fire nonlinear behavior is facilitated. Through establishing proper control equations and numerical equations, numerical solutions which reflect fire nonlinear characteristics are achieved (Weng, 2002, 2002).

### 2.1.2 *Fire characteristics of large space public building*

There are some main research aspects shown as follows: simulation and experiment on combustion characteristics of typical building material in large space public building; characteristics of fire spread and smoke movement in large space building (Li, 2002); experiment and computer simulation about fire spread characteristics and smoke movement characteristics in large space public building (Chow, 2000).

### 2.1.3 *Smoke toxicity and transfer rules of harmful substance*

The main cause of casualty in fire is harmful combustion product. Especially, along with wide using of new building material and decorative material, there are HCN, NO, NO<sub>2</sub> other than CO when new material burning (Qiu, 2001). There are some main research aspects shown as follows: Mechanism of toxic gas generation as typical building material and decorative material burning; harm mechanism to organism; fire smoke movement rules in open, limited and network space and numerical calculation method; chemical dynamics mechanism and spatiotemporal distribution of smoke toxic substance, varied rules of smoke concentration away from fire source; fire smoke movement in high-rise, large space and underground building. These could provide theoretical and technology basis for performance-based fire safety design and effective evacuation (Fang, 2002).

### 2.1.4 *Occupant evacuation in fire*

Based on Chinese characteristics, multi-particle self-driven model, lattice-gas model are conceived to achieve the relation between velocity, density and evacuation capability at egress stairway. Some main research aspects are shown as follows: occupant psychical behavior in fire and evacuation method; time of evacuation and action variety rule with expectation velocity; the influence of fire smoke on occupant evacuation behavior and time (Chen, 2002). These research productions have been applied to many important projects in China.

## 2.2 Key technology protection of urban fire protection

### 2.2.1 *Clean, effective flame retarded and extinguishing technology*

Considering serious harm as flame retarding polymer containing polymer material burning, material structural design at nanoscale and

molecule scale are researched to combine clean flame retarding and nano composite technology to form flame retarding technology of excellent physical and chemical performance (Hu, 2001). Based on molecule design method and some chemical methods such as surfactant, hydrophilic group is inducted into aromatic ring of iron base compound to prepare water-solubility water mist additive. DPIVS diagnostic method of fog field configuration is researched to reveal physical chemistry compound mechanism of multicomponent water mist while extinguishing fire (Wang, 2002).

### ***2.2.2 Multiple signal perception and intellectualized identify at fire early stage***

As we all know, early detection and location of large space building fire is a world difficult problem. Based on researches about early fire characteristics and smoke movement characteristics, considering sense measure and detection identifying model, an technology which has independent intellectual right could realize multiple signal perception and intellectualized identify at fire early stage is achieved.(Cheng, 1999, Zhan, 2000).

## **2.3 Fire safety of urban building framework**

### ***2.3.1 Fire safety research of building framework on condition of thermo & force coupling***

911 World Trade Center collapse event, an exclusive large building collapse as a whole due to fire, provides a new study field to urban fire science. Building and fire study laboratory of National Institute of Standard Technology (NIST) has actualized “World Trade Center and fire safety national study project”. State key laboratory of fire science of China was invited to participate in this project.

At present, Fire safety study of building framework on condition of thermo & force coupling is being researched. The main contents are presented as follows: thermal condition forecast; fire heat transfer to building element on condition of intricate geometry and physical property; performance transformation of building element on condition of heat flux, uneven temperature rise; critical condition and critical mode as building framework destroyed on condition of thermo & force coupling.

### ***2.3.2 Building collapse induced by fire***

Based on coupling of fire dynamics and statistical theory, influencing factors of building collapse induced by fire, fire load statistical analysis result of typical buildings and building fire rules, a simple assessment method of typical building collapse probability induced by fire is presented(Sun,2003).

## **2.4 Urban fire safety engineering theory**

### ***2.4.1 Urban building fire risk assessment methodology and performance-based fire safety design***

Owing to limitation and irrationality of current fire code in modern high rise, large building, fire risk assessment and performance-based fire

safety design methodology are being researched. Based on building fire safety guideline and new progress of fire dynamics and protection technology, a fire risk assessment method which contains survey, analogy, theoretical analysis, simulation experimental study and computer numerical simulation is established.

#### ***2.4.2 Urban fire safety and fire protection engineering information technology, emergency rescue system on condition of urban fatal accident***

In order to put out a fire in time, it is very effective for early extinguishing, reducing disaster loss to establish urban fire geographical information system. Some study contents are presented as follows: urban fire safety geographical information system and database, visual forecasting technique of urban fire safety layout, emergency rescue system and technology of urban fatal fire or explosion accident.

### **2.5 Urban special fire research and other aspects**

#### ***2.5.1 Earthquake disaster and urban fire***

Although violent earthquake can bring disastrous loss, multipoint fire induced by earthquake will spread rapidly to aggravate loss. In order to prevent fire as the second disaster, some main research aspects are presented as follows: mechanism and rule of urban fire cyclone; interactive mechanism and spread mechanism on condition of multipoint fire; urban fire spread prevention technology; urban zone disaster prevention countermeasure; urban fire hazard grade division and integrated technology system of extinguishing and rescue, etc.

#### ***2.5.2 Urban combustible gas leakage and vapor cloud explosion***

Combustible gas pipeline extending all over city and high-pressure oil liquefied gas storage tanks around city are both potential hazard sources to the whole city. In order to prevent great area urban fire induced by leakage of combustible gas pipeline and high-pressure oil liquefied gas storage tanks, leakage mechanism and control technique of urban combustible gas and oil liquefied gas are carried out. Some main research aspects are presented as follows: leakage mechanism and control technique of urban combustible gas; leakage mechanism and control technique of high-pressure oil liquefied gas; vapor cloud and its concentration regularity of distribution after high-pressure oil liquefied gas leakage; flow field, temperature field, concentration field and distribution of impact wave and overpressure after vapor cloud explosion accident (Lin, 2002).

#### ***2.5.3 Urban special fire research***

As today building transforming from traditional low rise building to high rise or super high rise building, underground structure also becomes a trend. Along with appearance of many underground warehouses, shops, amusement buildings and underground traffic, some urban underground fire researches have been commenced. Urban cultural relics fire, vehicle fire are also deserved to research.

### 3. CONCLUSION

Based on current high speed development urbanization and transformation of urban building function and the whole China society, not only current fire code, but also basic aspects of fire safety science have many problems to be resolved. Following control before calamity, portent detection, early detection and rescue, urban fire in China has been controlled within a range of low increase by strengthening fire science and control technology research, fire code, urban building design code.

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