

# Measures of Improving on Railway Intersection Traffic Safety and Research on Frame Bridge Design Technique

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**Abstract:** This essay analyses causes of railway intersection traffic accidents and summarizes the main factors of affecting intersection safety, and then studies out measures of improving on the railway intersection traffic safety. On the basis of comparatively analyzing railway intersection safety situations and current researches in China and abroad, the essay systematically analyses safety of railway intersections and their effect factors through people, cars, geometric characteristics of intersections, safe guard, management and environment. Using flyover structure can overcome problems of intersection traffic safety. The styles of flyover can be sorted into two: over or under cross the road. Over bridge have disadvantages of large investment, occupying more area, and terrain delimitation, so under crossing bridge is mostly used. The author analyzed the design of under crossing frame bridge through studying structure size, structure stress, structure reinforcement assembly, and developed a computer software of orthogonal or oblique crossing frame bridge with one hole, two holes, three holes or four holes. The software can do parameters input, finite element analysis, and structure reinforcement assembly according to the size of frame bridge structure. It also can automatically draw the plane of structures, and produce detail drawings of reinforcement steel bars. Application of the software can improve bridge design efficiently and shorten the design period.

**Keywords:** railway intersection; causes of intersection accidents; measures of intersection safety; under crossing frame bridge structure; reinforcement assembly calculation

## 1. Overview

As economy booming and local infrastructure constructing, road and railway cross with each other frequently. There are two styles of crosses: level and flyover. As to the level crossing (the intersection), safety issues become more severe. The management of intersections involves many departments. And it is a complex system which is made up of people, vehicles, equipment, environment, and so on. The intersection is not only a weak link of railway transport safety, but also a dangerous district of railway transport. The accidents of railway intersection can not only cause interruption of railway transport having severe effects to traffic system, but also result in the loss of lives and properties. For example, there were 729 traffic accidents in 2004 and the number of casualty was 513. Trains were interrupted for 2292 hours. The direct economic loss was more than 1200 million yuan<sup>[1,2]</sup>. In order to decrease railway intersection traffic accidents completely, only we should do is to change intersections to flyover structure.

## 2. Causes of Intersection Accidents

Accidents of railway intersection are stochastic and the reasons are complicated, so we can mainly analyze the causes through analyzing effects of the factors of people, cars, intersections and environment to intersections.

### 2.1. Factors of People

Among the factors of intersection safety accidents, Factor of people is the main reason. The reasons caused the collisions at the railway intersection are various, but the most of the reasons are that pedestrians and drivers are in fluky psychology when they pass through the crossings. In recent years more than 90 percent of intersection accidents caused by drivers who violate traffic regulations, lack security awareness, operate wrong or bad technique and other factors. According to statistics, in 2005, 81 percent of the intersection traffic accidents were caused by drivers who did not comply with traffic rules and illegally occupy the crossings, which had resulted in serious traffic accidents with casualties and economic loss.

### 2.2. Factors of Vehicles

On the road there are so many bad condition vehicles: broken down, discarded and under technology standard. In addition, there are lots of various tumbrels running on the roads of city and countryside. According to statistics, 14 percent of the intersection traffic accidents happened is due to the vehicles malfunctioned when they passed the crossing, such as flameout, brake failure.

### 2.3. Factors of Safety Management

Setting Crossings is convenient for the public to travel. Crossings are open free to the society and provide with significant social welfare. Crossings would be a special

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本论文得到校课题资金《地铁站场CAD系统的研究》的资助。

kind of public facility with double attributes: railway production and social commonweal. The special attributes of crossings determine that only the departments of Railway is in charge of setting crossings, maintaining and disposing of accidents. However, Railway departments have no power to deal with and coordinate in many issues. Railway departments have concerned about the safety of crossings all along. In order to reinforce the safety management of railway crossings, every province and city have established safety management committees which are composed of railway, highway, public security and local departments. But still it is necessary for all the departments to cooperate smoothly with effort, lead the traffic control methods into the safety management, give more publicity to crossing safety, and improve road traffic conditions.

## **2.4. Factors of Setting Crossings**

When setting crossings, road gradient, straight degree, railway crossing angle, number of railway tracks crossing a road, and width of a road are directly related to railway intersection safety. On both sides of intersections of road are mostly with a certain slope, in addition the surfaces are bumpy because of the tracks, which are very likely to result in flameout or fall of pedestrians.

## **2.5. Factors of Equipments**

Crossing safety devices and equipments are intended to prevent accidents, yet the types and installation position also play a great role in crossing safety. According to investigations, different crossings actually have great different incidence rates even though they likewise have been installed red flash lights. The incidence rate in countryside is lower than cities. Red flash lights in cities cannot effectively be warning indicators to avoid accidents; however, most of the victims are local people who are familiar with the crossing. In addition, the warning effect of the red flash light in the intersection is not obvious among other city lights.

## **2.6. Factors of Environment**

The crossing visibility of overlooking from the road cannot be a negligible quantity. If there is no enough range of visibility, drivers cannot drive safely and steadily through crossing. Other factors, such as too many high buildings and high trees, and poor lighting, can probably obstruct drivers' view so as to influence crossing safety. Some measures, such as installation of protective door or traffic signal lamp in some crossings, publicities about crossing safety of some public service organizations, shut-up of some crossing, and renovation of railway lines, should be taken to reduce traffic accidents.

## **3. Measures of Reducing Intersection Accidents**

Safety precautions can be taken effectively in many as-

pects of equipments, management, education and law to vigorously enhance crossing security and eliminate hidden dangers of railroad crossings, according to the safety analysis above and the prevention principle of accidents. Consequently late-model crossings can accommodate to the increasing need of railway transportation development.

### **3.1. Railway Intersection Equipments**

The railway intersection equipments are the defense line of ceasing the accidents. With the increasing of motor vehicles, train's speed and train's density, traditional warning and preventable equipments have many limitations. The railway department should press on with developing new warning and preventable equipments. Through the modern communication and information technologies, train's running status (including speed, distance to intersection, and the arrival time) are instantaneously digitally demonstrated which makes the passing pedestrian and drivers to obtain intuitively the train's running situation and make a quick decision.

### **3.2. Safety Management**

Intersection travelling is a complex and dynamic system which involves road traffic system and rail transportation system. To ensure crossing safety, it needs a concerted effort from the railroad, the local authority, the municipal administration, and the traffic control department, and it is necessary to introduce the methods and rules of road crossings into railway crossing management. Also the safety management pattern should include many interrelated departments. In addition, it is vital to normalize the driving system and improve the driving environment of intersections.

### **3.3. Education and Legal System**

According to the statistics, the reason of more than 98 percent of intersection traffic accidents is that the motor vehicle violates regulations to get over intersections. The most effective method is to use the means of negativity-reinforcement, which namely introduces the local traffic control to the railway intersection management and attracts drivers' attentions, who attempt to get over.

Railway intersection is not only an important portion of railway transportation, but also a special extension part of road transit. Therefore, in order to guarantee this "part" safe and prevent accidents, it is necessary to strengthen the comprehensive management which includes railway departments and other local concerned departments. This is not only the key to solve the intersection problems, but also a way to enhance the security reliability and to strengthen safety management. Moreover, it is a joint response to strengthen foundation and face social work.

### 3.4. Changing Intersection to Flyover Structure

The prior consideration is changing intersections to flyover structure in order to accelerate the “removing, merging and changing” work on intersections. It is a main measure to prevent intersection accidents completely.

## 4. Solutions of Intersection Traffic Safety

There are two styles of flyover: over cross the road and under cross the road. Over bridge have disadvantages of large investment, much area occupation, and much terrain limitation, so over bridge is generally not be adopted. At present, under crossing frame bridge is adopted to solve the insecurity risks of intersection in most situations. According to the width and grade of the road, there are four forms of under crossing frame bridge: one hole, two holes, three holes, and four holes<sup>[2]</sup>.

### 4.1. Principles of Choosing the Structure Size of Frame Bridge

#### 4.1.1. Choice of Structure Types

At present in China three types of frame bridge is mainly adopted in main structure: one hole, two holes and three holes. The aperture (net width) size and net height should accommodate to the conditions of road traffic; and be considered comprehensively with use, nature, and volume of traffic from long-term development and overall situation.

The net height of a bridge should be considered by “Highway Engineering Technical Standards”, which is said that the bridge hole which the motor vehicles pass through should not less than 5 meters in height. Considering differences in construction and road surface thickness requirements, bridge height should be designed 5.3 meters.

#### 4.1.2. Choice of Sections

After the type and the size are determined, it needs to further choose section size of each component in the structure.

If the span ranges from 5.0 to 6.0 meters, the thickness of the top tray should be 0.5 to 0.6 m. If the span is from 8.0 to 10.0 m, then the thickness of the top tray should be 0.7 to 0.8 m. If the span is from 12.0 to 16.0 m, then the thickness of the top tray should range from 0.9 to 1.2 m.

The thickness of the baseplate can be slightly larger than the thickness of top tray. Generally the thickness of the baseplate is 0.1 to 0.2 m, which is larger than the thickness of top tray.

The thickness of side wall and midboard can adopt the same thickness. Generally the thickness is 0.7 to 0.8 times of the top tray. Meanwhile the convenience of handing reinforcement and stamping concrete should be considered.

In short, the reasonable proportion of the component section size should make the amount of the concrete and

reinforcement economical and convenient to construct.

### 4.2. Crossing Design Theory

The frame bridge structure size and design load, ground conditions are directly linked with traffic. There are single hole, double or three-hole and four holes during the design of span.

#### 4.2.1. Design Load

The design load includes main forces and additional forces. The main forces include dead load and live load. The dead load includes structural weight, lateral pressure of soil, shrinkage of concrete, and effects of creep. The live load includes live load and walloping of a train, soil pressure generated by live load of highway, and live load of pavement. The additional forces include a train's braking force and influence of temperature changes. The calculation of each load is not described here<sup>[2]</sup>.

#### 4.2.2. Calculate Internal Force

The internal force of a frame structure is calculated by the elastic foundation theory, considering the influence of the deformation (subsidence, rotation) which is caused by the frame floor load on the elastic foundation. The calculation of the beam of elastic foundation adopts the theory of a common deformation<sup>[2,3]</sup>.

### 4.3. Design Principles

The design and programming of frame bridge are carried out according to planks finite element theory [2-6]. Details can be referred from [2-6].

### 4.4. Functions of the Software

The functions of the software include dividing structural units, calculating loads, calculating structure internal force, assembling structure reinforcement. Users only need to enter some data of structure size, loads, material properties and other parameters. Then the program can automatically calculate structure internal force and the reinforced areas required by control sections. In addition, it can implement structure reinforcement assembly which includes choosing the diameters of basic reinforcements and supplementary reinforcements, and their amounts. And it will generate automatically the drawings of structure reinforcement assembly and the tables of reinforcement amounts.

### 4.5. Other Factors Taken into Account

When the under crossing frame bridge structures are in the areas which have a lot of rain, there may be unusable natural drainage condition. So pumps will be needed to discharge the water out lest affecting the traffic.

In the soft foundation area, because the foundation bearing capacity is lesser, frame bridge jacking construction technology will be used only after reinforcing the foundation.

If the underground water level is high and the working

pit is deep in the soil, it have to consider strengthening working pits and promptly eliminating working pits' water during construction<sup>[2]</sup>.

According to the actual site situation, some reinforcement measures should be adopted in the construction of the railway line, such as using rail, i-section, beam, bridge type shield or grille nets. Meanwhile, measures of reducing soil resistance should be taken.

## 5. Conclusions

Analyzing the factors of railway intersection safety is very important to reduce traffic accidents, safeguard the people's lives and properties, and improve road and rail operation efficiency.

Through the analysis, the best way is to adopt under crossing frame bridge structure to solve safety problems, which is a economical and reasonable method.

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