

Chapter 38

Research on the Evolution Processes and Modes of Construction Project Safety Accidents

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Abstract Construction project safety accidents are caused by the complex interaction between a series of inner system factors and outer environment, and will endure a series of processes from the beginning to the end. The causation factors of the construction project accidents, including the human resource, machinery, material, method and environment and the evolution mode of the accidents are analyzed in this paper. The development of construction projects safety accidents is divided into four stages, which are occurrence, preliminary development, evolution and termination. The modes are analyzed and the concept models to describe mechanism of each stage are presented in this paper, which will provide theoretical reference for preventing and dealing with the construction projects safety accidents.

Keywords Construction project • Safety accidents • Evolution • Development • Mechanism

38.1 Introduction

Large scale city construction is in rapid development meanwhile. At the same time, many construction safety accidents happen every year during the construction in China and all over the world. For example, the two famous accidents happened in Shanghai, China of “11.15 Fire Accident in Jiaozhou Road” in 2011 and “Lianhua Hupan Jingyuan Building Collapse Accident” in 2010 have endangered the city public safety greatly and have exerted very bad influence to the public.

The construction project accidents usually happen during the projects construction stage in the construction site, when the project entities come into being. Large varieties and quantities of production factors including human beings, machinery, material,

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method and money are involved and are exposed to all kinds of risks from the nature and social environment, which cause lots of accidents to happen during this stage. Especially for those projects that have large investment scale, long period, complex inner structure, plenty of participants, the accidents will seriously disturb the realization of the project aim, cause serious loss and bad social influence.

This paper will make research on the evolution and development mechanism of construction project safety accidents, divide the stages of the whole process and construct the concept model of the evolution and development mechanism. The mechanism can indicate the inner regular pattern of the accidents, which will be helpful to find out the source the formation pattern, the development power and direction of the accidents.

38.2 The Division of the Evolution Stage of Construction Project Safety Accidents

The processes of the accidents from the beginning to the end can be divided into five stages: formation, occurrence, preliminary development, evolution and end, shown in Fig. 38.1.

The formation of the construction project safety accidents mainly is the result of the interaction of different production factors, including the inner factors and external environment and is a gradual and accumulated process. The burst of the accidents is also the termination of the formation phase. After the occurrence of the accidents, there usually exists a development process in the whole process. In this stage, the accidents strengthen in time continuation, space spread and intensity enhance. If new qualitative changes happen, new accidents happen and the evolution stage begins. Finally, the safety accidents terminate automatically or by man intervening.

38.3 The Formation of the Construction Safety Accidents

38.3.1 Accident-Causing Theory

The accident-causing theory describes the accident mechanism and model extracted from large volume of typical accidents, which reflects the regular pattern of the accident and can provide scientific and complete reference for the analysis and prevention of the accidents [1]. Based on the theory, the practical safety management



Fig. 38.1 The stage division of the construction project safety accidents

work will be improved. Many researchers have published their achievements in the finding of the accidents causing factors from different perspectives. The several typical accident-causing theories include accident causal chain theory, as represented by W.H. Heinrich and Bird and Bird, unexpected energy transfer theory, as represented by Gibson and Hadden, track crossing theory, as represented by W. g. Jonson and Skiba.etc [2–5].

38.3.2 Analysis of Accident Causing Factors

Construction projects, especially large scale construction projects have complex structure and are composed of varieties of factors and interactive sub-systems. At the same time, lots of participants and specialties are involved in the system to handle the complex system, which may cause profit conflict. Sometimes the safety accidents arise because of the profit conflict [6, 7].

The construction projects safety accidents depend not only on the technology level and state, but also on the management level and the physical and psychology state of different production process, different participants and different machines' of the management system. The production factors of human resource, machine, material, method and environment jointly compose the system factors that influence the construction safety accidents.

38.3.2.1 Factor of 'Human Resource'—Quantities of Participants from Different Companies

Construction projects usually involve lots of participants from different companies including owners, constructors, designers, counselors and material suppliers. On one side, the abilities of participants are vital to the success of the project. The hidden safety accidents will increase if the participants lack safety control abilities. On the other side, the benefit conflicts exist between them may cause some participants to damage the project in seeking the biggest profits for themselves. For example, the constructors may choose low quality construction materials for building or less educated technical workers to operate on some special procedures, which both decrease their cost but increase the risk of the projects. All these are direct or indirect factors that can cause safety accidents to occur.

In addition, unlike the fixed construction products, the workers in the construction industry have high mobility comparing to other industries. According to statistics, the workers in the construction industry have lower education level and have more serious employment injuries. All these factors increase difficulty of the safety management of the construction projects.

38.3.2.2 Factors of ‘Machine, material and method’—Lots of Production Factors

1. Two kinds of machinery are involved in the construction field. Some become the components of the entity after construction like the elevator, ventilation equipment, etc.. The others are the tools and equipments used during the construction process, including conveyers like the tower crane, operating tools like the formwork or the scaffold. The machine can bring serious safety accident because of the quality problem of itself or the human’s operation.
2. The materials used in the construction fields are the components of the project entities. They are large in quantities and varieties. Good quality of the material, right choice, strict test and appropriate use of the material will directly affect the safety of the projects.
3. The methods used in the construction projects include the two sides of technology level and the management level. Construction projects have different methods and technology in different process, accidents may happen because of the technology factor, for example, deep foundation excavation, blasting engineering, etc.. Sometimes accidents may happen in process with new technology are firstly used.

On management level, accident may happen because of the lack of safety investment, unhealthy safety management organization, inadequate safety management system, inadequate preparation for new technologies and nonstandard market action.

38.3.2.3 Factor of Complex Environment

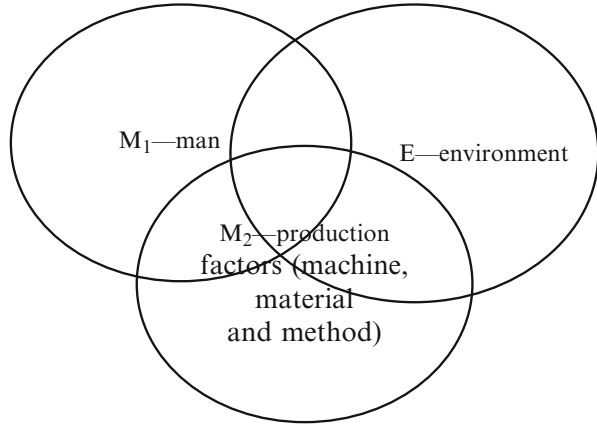
The complex environment refers to not only the natural environment but also the market and social environment. All these environment factors may directly or indirectly cause accidents in the construction project site. For example, the construction standard and policies are still not mature, the standards of design we have now are not fully developed.

The construction projects are carried out in the field. On one side, the engineering projects are exposed to the nature and are easily affected by the natural environment and uncontrollable environment factors. On the other side, the working environment is confined by the gathering of large quantities of man force, material and equipment in narrow field and accidents are easily caused because of that.

38.3.3 Formation Mode and Way of Construction Projects Accidents

Track crossing theory thinks that production system is made of three factors of man, machine and entity. They are in the same environment. The accident happen

Fig. 38.2 Track crossing of the three factors of man, production factors and environment



because of the unsafe action of human beings encounter the unsafe state of the entity (machine or environment). This paper divides the construction accidents causing factors into three categories: man, production factors and environment. The three kinds of factors form the “man—production factors—environment” system. The three sub-systems are interrelated and interactive. This paper applies the assemblage to indicate the formation mode of the construction projects accidents, shown in Fig. 38.2.

The existence of the inner factors like man and production factors and the outside factors will not directly or instantly lead the accidents' to happen but need the other factors to ignite it. The construction accidents are interactive results of kinds of factors. The way to prevent the accidents is to prevent the track crossing of the three factors.

38.4 Evolvement Mode and Rules of Construction Accidents

The evolvement roadmap of the construction project accidents from occurrence to termination is shown in Fig. 38.3.

38.4.1 Occurrence Mode of Construction Projects Accidents

38.4.1.1 Accidents That Happen Suddenly or Gradually

The construction project accidents can be classified as the accidents happen suddenly and the accidents happen gradually. The former accidents happen in very short time and usually have a definite beginning time or short period. The gradually

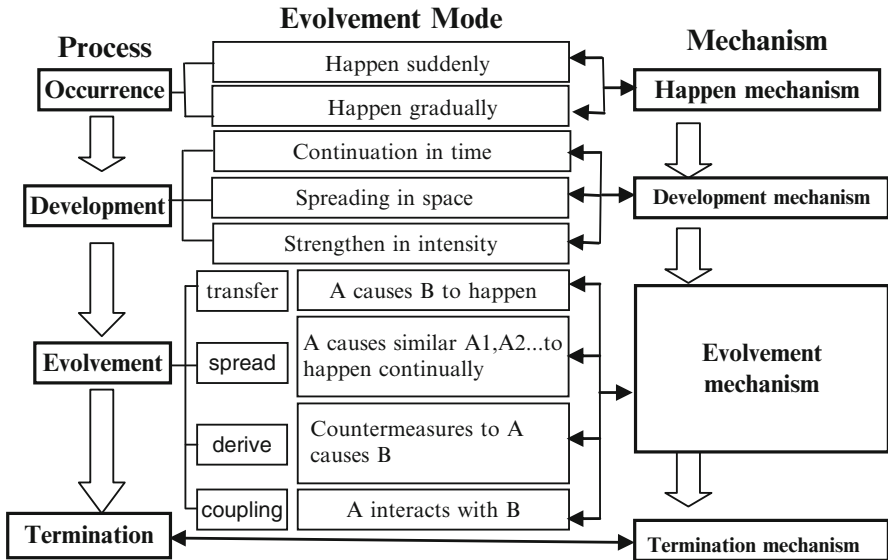


Fig. 38.3 The roadmap of construction project accidents from occurrence to termination

happening accidents cause damage little by little. For example, the accidents like falling from the high altitude, object attack and electric shock injury belong to the former accident, while the accidents like the foundation pit collapse happen after some time's accumulation. Usually the accidents happen gradually leave long time for the people to cope with it while the accidents happen suddenly leave great difficulties for the coping work. The different indication should be payed attention to in different stages and corresponding countermeasures should be adopted to cope with the gradually happened accidents.

38.4.1.2 Accidents That Can Be Fore-Casted or Cannot

The construction projects accidents can be classified as accidents can and cannot be forecasted. The former kind of accidents refers to the accidents which probability can be forecasted by monitor of the sign and causative factor. The accidents can be forecasted are different from the accidents that happen gradually, they are accidents happen suddenly, but there are some signs before they happen and the probability can be forecasted. While the accidents that happen gradually have long accumulation process and have no definite beginning and end time [8].

The mutation theory can be used here to construct the concept model to describe the happen of accidents. The factors of man, machine, material, method and environment can be used as the control variables, the function state of the system can be used as state variables and the mutation potential function can be

constructed, then the mathematic tools can be used to calculate to describe the mechanism, which can be discussed later in other papers.

$$V = f(U_1, U_2)$$

Here, U_1 is the assemble of the system controlling parameter,

$$U_1 = \{M_1(a_1, a_2, \dots a_n), M_2(b_1, b_2, \dots b_n), M_3(c_1, c_2, \dots c_n), M_4(d_1, d_2, \dots d_n), E(e_1, e_2, \dots e_n)\};$$

U_2 is the assemble of the system state parameter, $U_2 = \{N_1, N_2 \dots N_n\}$.

M_1 —Factor of human resource;

M_2 —Factor of machinery;

M_3 —Factor of material;

M_4 —Factor of method;

E —Factor of environment;

38.4.2 Development Mode of the Construction Projects Accidents

The development of the construction projects accidents includes increase in extent and scope. From the perspective of extent, it refers to the intensity strengthening, which increased damage to the supporting body. From the perspective of scope, it refers to the increase of the space. The development mode can be divided into three kinds:

1. Develop during very short time. The formation process of these accidents is very short, and the development process is also very short. This kind of accidents has no big development in the coverage and extent.
2. Develop continually. This kind of accidents has a long last time and has a clear process of development and will increase continually in the damage extent and coverage.
3. Develop dis-continually. This kind of accidents has a clear process of development and evolvement and will increase in the damage extent and coverage, but they don't increase continually, and will enhance after being weak for some time.

38.4.3 Evolvement of Construction Projects Accidents

New qualitative change may occur during the development process of the construction projects accident, which may cause new accidents. The stage with new accidents

emerge is called the evolution stage. The difference between development and evolvement is there is no qualitative change in the former stage but in the latter stage. So the evolvement can be seen as the continuation of the original accidents but also can be seen as the occurrence of new accidents, which relate with the original accidents jointly.

The evolvement is the accidents' development result and it can bring new affect that the original accidents cannot produce, which can be deemed as the evaluation standard of the evolvement. The evolvement modes of the construction projects accidents can be listed as follows:

1. Transferring: New qualitative change may happen during the development process of the construction project accidents and new accidents may emerge.
2. Spreading: The construction project accidents will spread in the scope coverage and the quantities of the supporting body increase. Such as the fire spreads.
3. Deriving: New accidents arise by the countermeasures to cope with the construction projects accidents.
4. Coupling: kinds of factors and subsystems in the accidents interact with each other and cooperate with each other during the evolvement of the construction projects accidents.

38.4.4 Termination of the Construction Projects Accidents

The termination stage follows up with the evolvement stage. It includes the whole process from the weakening of the damage force to the complete end of the accidents. When the accidents don't expand and strengthen in scope and intensity, the termination process can be deemed as beginning. For example, the termination of the fire accident begins as the fire fades and the scope doesn't magnify and it ends as the fire is extinct completely.

38.5 Conclusion

With the larger of the construction projects scale in modern world, the accidents occurrence probability and the damage loss will increase. The construction project accidents causing factors include human resource, machinery, material, method and environment. The accident process can be divided into four phases, which are occurrence, development, evolvement and termination. There exist inner patterns and rules in the accidents evolution. This paper analyses the evolvement modes of each stage and constructs the concept model of the evolvement mechanism. The accidents evolution mechanism and theory will help to provide reference to decrease practical incidence rate and the damage loss, which is especially important in the background of great attention to the public safety today.

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