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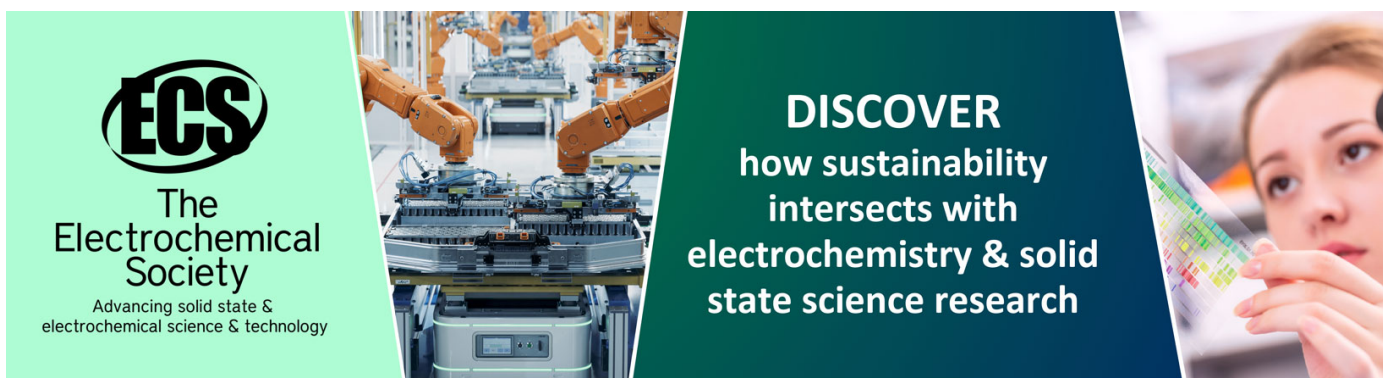
## Construction Site Safety Management Research Based on SEM

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# Construction Site Safety Management Research Based on SEM

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**Abstract.** The construction project provides a large number of employment opportunities for the construction workers, and the health of the construction workers is closely related to the safety management of the construction site. This paper first designs construction workers' health and construction site safety management measurement scale by using literature analysis and group interview. After that, through the structural equation model(SEM), the author reveals the path between the construction workers' health and construction site safety management of the labors and contractors. According to the results of the discussion, the construction workers' physical health and the safety technology management are the core of construction site safety management.

## 1. Introduction

The safety and quality of construction has always been the core concern of construction and its related industries. The construction technologies are complicated and industrialization is improved, and the safety management measures at construction sites are also continuously updated. However, the safety accidents caused by low education and insufficient knowledge of construction workers are numerous<sup>[1]</sup>. Therefore, the safety management of construction site and the health of labor are important topics in civil engineering.

This paper aims to study the following research questions: (1) the effect of construction workers' health on the construction site safety management; (2) the effect of construction site safety management on construction workers' health. The main process for discussing these questions unfolds as follows. Firstly, this paper reviews the literature, including construction workers' health, and construction site safety management. Secondly, reasonable hypothesis and theoretical model are put forward. Thirdly, the research methods are discussed, including the process of data collection, variables and their measurement. Fourth, it analyzes the first-order path of construction workers' health and construction site safety management. Finally, conclusions and recommendations are made.

## 2. Theory

The health management of construction industry mainly includes health environment and safety management system(HSE) and occupational health and safety (OHS). This paper refers to the research results of Zhu<sup>[1]</sup> on the division of construction workers' health, including construction workers' mental health, construction workers' physical health and construction workers' working environmental health.

Construction site safety management covers a wide range. In this paper, the safety management of construction site only includes safety management measures related to labors, such as construction



safety inspection. This paper draws on the research results of Huang<sup>[3]</sup> on the construction site safety management, including safety system, agency and technology management.

The conceptual framework was shown in figure1. The framework illustrated the interaction between construction workers' health and construction site safety management. We reviewed the relevant literature and proposed eighteen hypotheses to be tested in this framework in the next section.

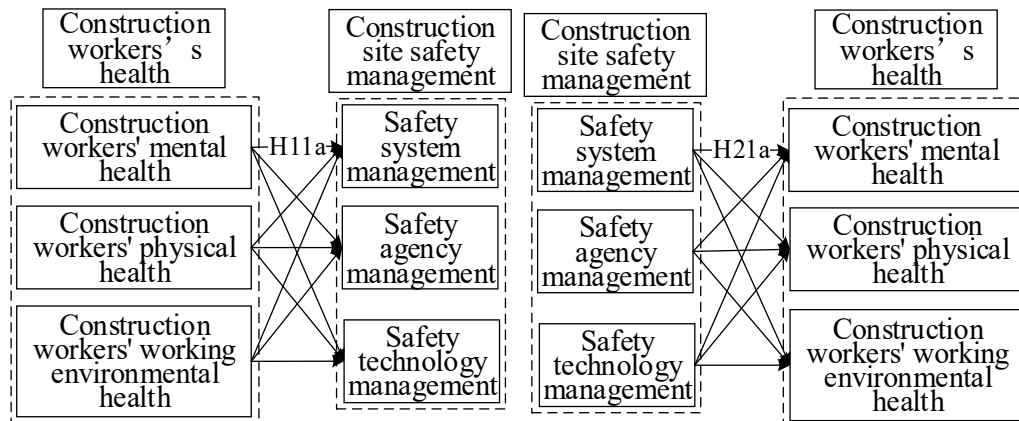


Figure1 The conceptual model of the study

### 3. Hypothesis development

The construction site safety facilities are performed by the labors under the command of the contractor's project manager. The strength of safety measures and the degree of wear over time are greatly affected by the psychological activities and personal behavior of the construction labors. At the same time, the main protection object of construction site safety measures is construction workers. Sherratt<sup>[4]</sup> believes that improving the safety awareness of construction personnel is the most urgent in the construction site safety management. Ma<sup>[5]</sup> believes that helping the construction workers to establish a complete character can effectively improve the site safety level. Zhang<sup>[6]</sup> proposed to use intelligent safety helmet to detect and evaluate the unsafe behavior of workers in order to contribute to the safety management of construction site. Hence, we propose the following hypotheses.

Hypothesis 1. Construction workers' health are positively associated with construction site safety management

Hypothesis 11. Construction workers' mental health are positively associated with construction site safety management

Hypothesis 11a/b/c. Construction workers' mental health are positively associated with safety system/agency/technology management

Hypothesis 12. Construction workers' physical health are positively associated with construction site safety management

Hypothesis 12a/b/c. Construction workers' physical health are positively associated with safety system/agency/technology management

Hypothesis 13. Construction workers' working environmental health are positively associated with construction site safety management

Hypothesis 13a/b/c. Construction workers' working environmental health are positively associated with safety system/agency/technology management

Hypothesis 2. Construction site safety management are positively associated with construction workers' health

Hypothesis 21. Construction site safety system management are positively associated with construction workers' health

Hypothesis 21a/b/c. Construction site safety system management are positively associated with construction workers' mental/physical/working environment health

Hypothesis 22. Construction site safety agency management are positively associated with construction workers' health

Hypothesis 22a/b/c. Construction site safety agency management are positively associated with construction workers' mental/physical/working environment health

Hypothesis 23. Safety technology management are positively associated with construction workers' health

Hypothesis 23a/b/c. Construction site safety technology management are positively associated with construction workers' mental/physical/working environment health

## 4. Research design

### 4.1. Method

Structural equation model (SEM) is a typical method to study the relationship between potential factors. The model contains observable variables and latent variables that can not be directly observed. It can deal with multiple dependent variables at the same time and overcome the disadvantage of only one dependent variable in linear correlation analysis. SEM also can reflect all the data objectively and systematically, which reduce the deficiency of the questionnaire method that more qualitative than quantitative. By introducing the first-order dimension to study the causal structure contact and intensity between the second-order constructs, we can obtain the mathematical model and quantitative law behind the subjective value, so as to innovate and analysis the construction workers' health and site safety management.

### 4.2. Survey and data collection

In this paper, SEM is used to verify the research hypothesis. Respondents filled in the questionnaire according to the actual situation of the project and the compliance degree of the questionnaire items. We have done the following to ensure the questionnaire scientific and data reliability. Firstly, we choose the project that has the cooperation relation with the research group as the investigation object, and through literature investigation and group discusses to design initial measuring scale. Secondly, analyzing and discussing the measurement items of each variable one by one, questionnaire was distributed on a small scale within the team, and according to the questionnaire test results improvement. Thirdly, the questionnaire is distributed and consulted by ten experts, and the final formal questionnaire is formed according to the expert opinion. Fourthly, every researcher has been involved in questionnaire design, so they are all very familiar with the content and objectives. A total of 357 questionnaires were distributed in electronic form and 323 were recovered, with a total recovery rate of 90.48%. In this paper, 298 valid questionnaires were obtained after excluding missing answers, selecting neutral options and answering time within two minutes.

### 4.3. Variables and measures

This paper uses Likert 5 scale to measure the three variables that construction workers' health and site safety management. Each item was rated on a five-point (ranging from 1 for "strongly disagree" to 5 for "strongly agree"). The items and their inspection parameters are listed in table1. SPSS 24.0 was used to descriptive statistical analysis the collected data. KMO is the reliability measurement index of the scale, and Cronbach's  $\alpha$  is the measurement index of internal consistency of the scale. By calculating the questionnaire data to meet the requirements of  $KMO > 0.6$  and Cronbach's  $\alpha > 0.7$ , the statistical data can be used for factors analysis. The absolute value of the statistical skewness  $\leq 3$ , and the absolute value of the kurtosis  $\leq 8$ , all of which meet the requirements, indicating that the data are multivariate normal distribution, which lays a foundation for the subsequent path analysis.

Table1 Variables and their reliability and validity tests

| Dimension                                | Element variable                                   | Measurement items                                           | Cronbach's $\alpha$ | KMO  |
|------------------------------------------|----------------------------------------------------|-------------------------------------------------------------|---------------------|------|
| Construction workers' health             | Construction workers' mental health                | Construction workers' bad ideology                          | 0.79                | 0.83 |
|                                          |                                                    | Construction workers' bad mentality                         |                     |      |
|                                          |                                                    | Construction workers overworked                             |                     |      |
|                                          |                                                    | Poor interpersonal relationships among construction workers |                     |      |
|                                          | Construction workers' physical health              | Construction workers site physical examination a            | 0.78                |      |
|                                          |                                                    | Bad dormitory environment for construction workers          |                     |      |
|                                          |                                                    | Cleaning and disinfection of workers' living areas          |                     |      |
|                                          |                                                    | Cleaning and sanitation of workers' canteens                |                     |      |
|                                          | Working environmental health                       | Environmental temperature in construction operations        | 0.64                |      |
|                                          |                                                    | Environmental humidity in construction operations           |                     |      |
| Construction lighting at night           |                                                    |                                                             |                     |      |
| Use of construction protective equipment |                                                    |                                                             |                     |      |
| Safety system management                 | Safety management production responsibility system | 0.78                                                        |                     |      |
|                                          | Safety education training system                   |                                                             |                     |      |
|                                          | Safety management process inspection system        |                                                             |                     |      |
|                                          | Safety management rework system.                   |                                                             |                     |      |
| Construction site safety management      | Safety agency management                           | Institutional setup                                         | 0.72                |      |
|                                          |                                                    | Safety Risk Manager Qualification                           |                     |      |
|                                          |                                                    | Safety contingency plans                                    |                     |      |
|                                          |                                                    | Closed management                                           |                     |      |
|                                          | Safety technology management                       | Construction equipment                                      | 0.78                |      |
|                                          |                                                    | External lift                                               |                     |      |
|                                          |                                                    | Foundation pit support                                      |                     |      |
|                                          |                                                    | Formwork engineering                                        |                     |      |
|                                          |                                                    | Institutional setup                                         |                     |      |

## 5. Discussion

Parametric statistics reach significant level( $|t| > 1.96$  or  $P < 0.05$  is deemed that the hypothesis is holds). Estimates (factor load) reflects the degree of direct effect between potential variables. The hypotheses test results of the theoretical model in this study are shown in table2.

Table2 First order factor path analysis

| Hypothesis | Path                                                                 | Estimates | S.E.  | C.R.   | P     | Hypothesis Supported |
|------------|----------------------------------------------------------------------|-----------|-------|--------|-------|----------------------|
| H11a       | Construction workers' mental health → Safety system management       | 0.338     | 0.108 | 3.491  | ***   | YES                  |
| H11b       | Construction workers' mental health → Safety agency management       | 0.119     | 0.108 | 1.241  | 0.214 | NO                   |
| H11c       | Construction workers' mental health → Safety technology management   | 0.223     | 0.083 | 2.315  | **    | YES                  |
| H12a       | Construction workers' physical health → Safety system management     | 0.637     | 0.115 | 5.292  | ***   | YES                  |
| H12b       | Construction workers' physical health → Safety agency management     | 0.331     | 0.099 | 3.242  | **    | YES                  |
| H12c       | Construction workers' physical health → Safety technology management | 0.457     | 0.081 | 4.183  | ***   | YES                  |
| H13a       | Construction work's environmental health → Safety system management  | -0.016    | 0.127 | -0.167 | 0.867 | NO                   |
| H13b       | Construction work's environmental health → Safety agency management  | 0.184     | 0.147 | 1.698  | 0.09  | NO                   |

| Hypothesis | Path                                                                    | Estimates | S.E.  | C.R.   | P     | Hypothesis Supported |
|------------|-------------------------------------------------------------------------|-----------|-------|--------|-------|----------------------|
| H13c       | Construction work's environmental health → Safety technology management | 0.329     | 0.121 | 2.831  | **    | YES                  |
| H21a       | Safety system management → Construction workers' mental health          | 0.573     | 0.184 | 4.285  | ***   | YES                  |
| H21b       | Safety system management → Construction workers' physical health        | 0.668     | 0.163 | 4.937  | ***   | YES                  |
| H21c       | Safety system management → Construction work's environmental health     | 0.076     | 0.13  | 0.634  | 0.526 | NO                   |
| H22a       | Safety agency management → Construction workers' mental health          | -0.394    | 0.293 | -2.199 | **    | YES                  |
| H22b       | Safety agency management → Construction workers' physical health        | -0.338    | 0.236 | -2.049 | **    | YES                  |
| H22c       | Safety agency management → Construction work's environmental health     | 0.045     | 0.239 | 0.241  | 0.809 | NO                   |
| H23a       | Safety technology management → Construction workers' mental health      | 0.588     | 0.263 | 3.246  | **    | YES                  |
| H23b       | Safety technology management → Construction workers' physical health    | 0.569     | 0.213 | 3.387  | ***   | YES                  |
| H23c       | Safety technology management → Construction work's environmental health | 0.432     | 0.233 | 2.122  | *     | YES                  |

\*  $p < 0.05$ \*\*  $p < 0.01$ \*\*\*  $p < 0.001$ 

## 6. Conclusion

Based on the background of construction safety in China, this paper studies the interaction between construction workers' health and construction site safety management. According to the study findings, the positive effect of construction workers' health on site safety management is mainly manifested in technology management, and construction workers' physical health has the most significant positive effect on site safety management. The positive effect of construction site safety management on the construction workers' health is mainly manifested in construction workers' mental and physical health, and safety technology management has the most significant positive effect on construction workers' health. Therefore, the contractor should pay more attention to the construction workers' physical health and the application of safety technology management.

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