Study on Risk of Accident by Heatstroke in Construction Industry of Japan

Hiroyuki Wariishi and Takehiro Tanaka

School of Architecture, Toyo University, 2100 k ujirai , Kawagoe-shi,Saitama,350-8585,Japan;whtaan@nifty.com, tanaka@toyo.jp

Abstract

This is the study on safety and quality improvement technique for construction and maintenance of building facilities. In this paper, the tendency of accidents in building facilities for the past ten years and the occurrence condition of fatalities disaster by heatstroke in construction in Japan is summarized. Finally the countermeasures and experiment for heatstroke are proposed

Introduction

Very little research has been conducted in fields such as safety activities, training/exercises, danger/risk prevention measures and analysis/evaluation methods for the building industry. The current state of safety/danger in building facilities is also not been fully comprehended.

Mortality in the construction industry is increasing in comparison with other industries. Also, it has been found out that the number of heatstroke cases has increased due to ageing among constructors on one hand, and global warming under the influence of abnormal weather and other factors on the other hand.

The purpose of the present study was to examine safety and quality improvement techniques for the construction and maintenance of building facilities. The tendency for accidents to occur in building facilities during the past ten years and the occurrence of heatstroke leading to fatalities in the construction industry in Japan is summarized in the paper. The rainy season particular to Japan and the summer season also appear have some impact

An experiment on heatstroke was carried out by measuring environmental parameters in summer at several points in Toyo University campus recording data on temperature, humidity, Wet Bulb Globe Temperature (WBGT), the sky percentage, etc. Finally countermeasures for heatstroke are proposed.

Recent Tendency - Accidents in Building Facilities

Transitions in the number of fatalities in all industries, the construction industry and works related to building facilities for ten years from 2004 to 2013 is shown in Fig. 1 and the transitions in casualties in Fig. 2. Fig. 1 was constructed using yearly data on statistics of occupational accidents "Fatal accidents according to the type of works/Conditions classified according to types of accidents in the construction industry" of The Japan Construction Occupational Safety and Health Association. In these data "Building Facilities" in the categories of Construction works and "Utility Construction Works (electro-communication, machinery and others)" are distinguished as two different types of works, but they were added in the present study as they represent works related to building facilities.

Fig. 2 was constructed using yearly data from the statistics of occupational accidents "Occurrences of life-threatening disasters according to types of industries and accidents (fatal accidents and four days-off or longer) of the Japan Advanced Information Center of Safety and Health in the Japan Industrial Safety and Health Association. In the data "Works on Building Facilities" under the category of Construction Works and "other construction work (electro-communication, machinery and equipment installation, and other construction works)" are distinguished as two different types of works, but they were added in this study as they represent works related to building facilities.

According to the data, the number of fatalities in all industries declined gradually from 1,600s in 2004 to 1,000s in 2013. A sharp fall was observed in 2009 and 2011, which can be attributed to economic slowdown in the construction industry as a result of the Lehman Shock in September 2008 and the Great East Japan Earthquake in March 2011.

The number of fatalities in the construction industry dropped below 400 for the first time in 2009, whereas no big difference was seen for works related to building facilities where the trend continues to be almost leveling off.

The number of fatalities in the construction industry accounts for about 34% of the total number of fatalities in all industries, out of which nearly 20% is represented by works related to building facilities. Fatalities in works related to building facilities comprise nearly 7% of total fatalities in all industries.

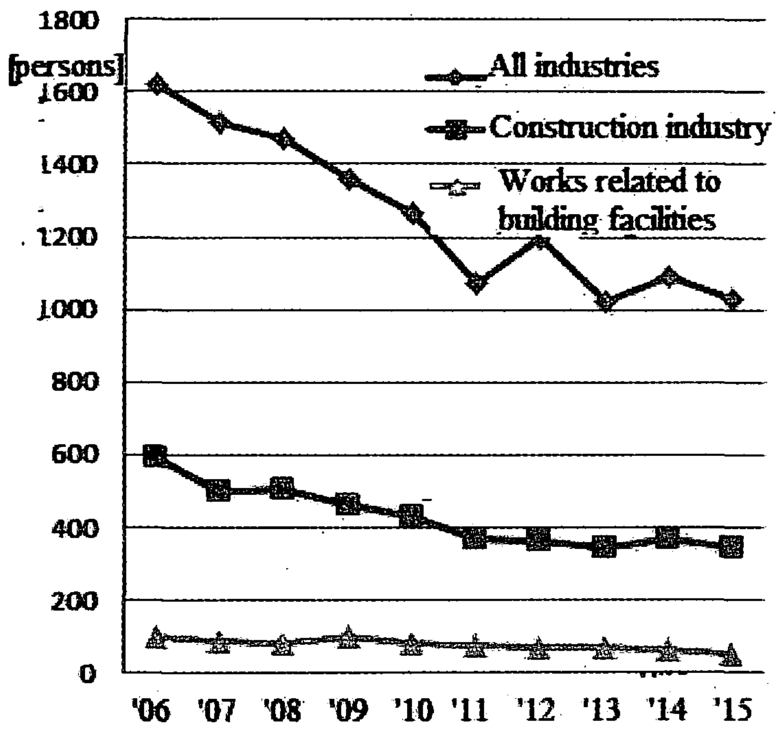

Fig. 1. Transitions of no. of fatalities, 2006 - 2015

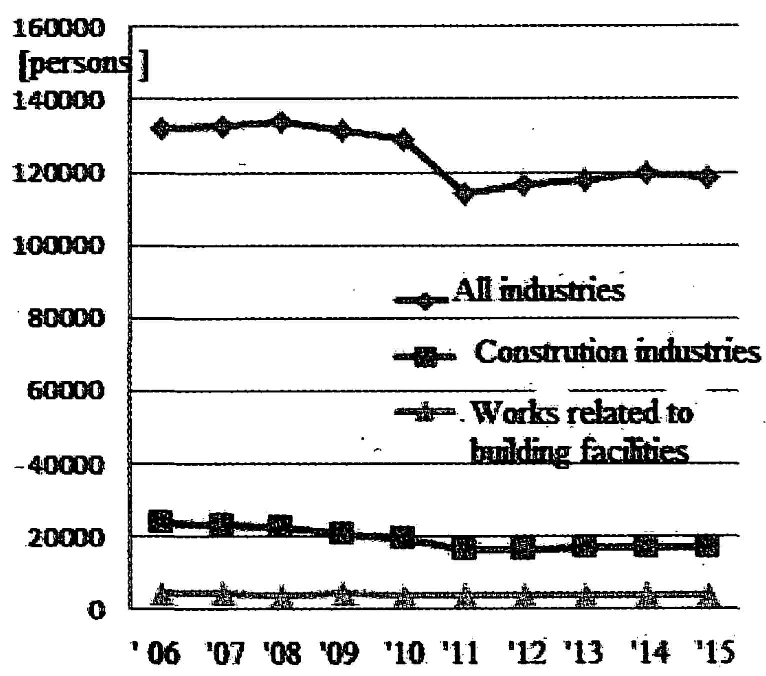

Fig. 2. Transitions of no. of casualties, 2006 - 2015

As for number of casualties, that of the construction industry accounts for about 16% of the total number in all industries, out of which nearly 19% is represented by works related to building facilities. Causalities in works related to building facilities comprise nearly 3% of the total casualties in all industries. The proportion of causalities in the construction industry to those in all industries is about 16% whereas the proportion of fatalities in the construction industry to those in all industry is 34%, suggesting that accidents in the construction industry are more likely to lead to fatal disasters.

Heatstroke-Related Fatal Workplace Accidents

Change in death toll from heatstroke (1998-2013)

As for the number of deaths caused by heatstroke at work from 1998, the largest number was 47 cases registered in 2010, followed by the second largest of 30 cases in 2013. The number of heatstroke victims in other years stood mostly around 20.

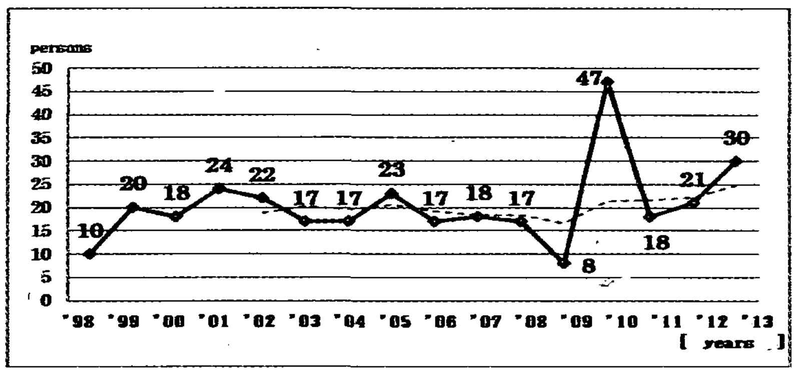

Fig. 3. Death toll from heatstroke (1998-2013)

Heatstroke deaths by industry (2010-2013)

According to data on the occurrence of fatal heatstroke accidents by industry during the past four years (2010-2013), most accidents occurred in the construction industry which was followed by the manufacturing industry.

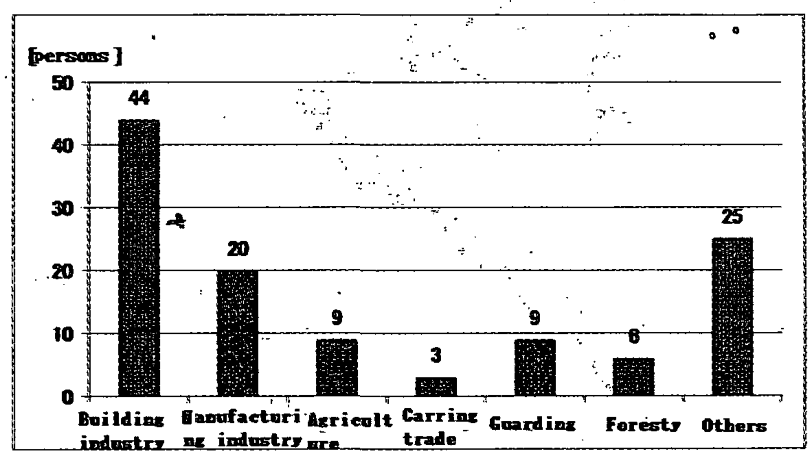

Fig. 4. Heatstroke deaths by industry (2010-2013 total)

Heatstroke

Heatstroke is a generic term for physical disorders which occur when the water and sodium balance in the body system fails or when the body is no longer able to regulate its internal temperature in a climate of high temperature and high humidity.

Its symptoms include dizziness, faint, muscle pains/cramps, excessive perspiration, headache, indisposition, nausea, vomiting, fatigue, consciousness disorder, convulsion, limb movement disorder and hyperthermia.

Heatstroke prevention measures

1. Lowering wet bulb globe temperature (WBGT)
   Efforts should be made to decrease WBGT in the workplace by taking the following measures.
   a. Place a shield between heat source and workers to block the heat in the workplace

where a measured WBGT value has exceeded or will possibly exceed its standard value (hereafter, a hot and humid workplace).

b. Install a roof to easily block direct sunlight and reflection off surrounding wall and ground in a hot and humid outdoor workplace.

c. Equip a hot and humid workplace with proper ventilation or an air-conditioning facility. The facility installed in a hot and humid indoor workplace should have a dehumidifying function. When water is sprinkled in an ill-ventilated hot and humid workplace, precautions should be taken to ensure humidity is not raised.

Body Temperature and Heatstroke Symptoms and Factors

When it is predicted that WBGT will exceed its reference value according to a WBGT forecast or heatstroke information service, the WBGT should be measured during work using the following formulae:

a. Indoors, and outdoors with little solar radiation

WBGT = 0.7 × (natural wet-bulb temp.) + 0.3 × (black-bulb temp.) (1)

b. Outdoors with solar radiation

WBGT = 0.7× (natural wet-bulb temp.) + 0.2 × (black-bulb temp.) + 0.1 × (dry-bulb temp.) (2)

Even if the WBGT cannot be measured, dry-bulb temperature and relative humidity should be referred to in evaluating heat stress.

Experiment Outline

Survey outline

In the study, an experiment was conducted on heatstroke at a hypothetical building construction and maintenance site. A construction field was reproduced in which experimental devices were installed. Measurement points surveyed are outlined in the Table. Owing to lack of space, only the survey of July 22 is reviewed in this paper.

Table. Survey Outline

Measurement points (Surface coverings)	1. Steel plate 2. Asphalt
Measurement items	Temperature and humidity, radiant temperature, WBGT, black-bulb temperature
Measurement period	July 22 (Wed.) to July 25 (Sat.) 2015
Height of measurement point	Temperature: 0.1, 0.5, 1.2 and 1.8 m Humidity: 1.5 m Heatstroke prevention meter: 1.0 m

Experimental results on Temperature

Temporal changes in the temperature measured at the 1.8 m-high level and at the 0.1 m-high level are shown in Fig. 5 and Fig. 6, respectively. The followings are findings obtained by this survey.

a. The temperature is higher at a point 0.1 m above the surface in both asphalt and steel plate cases all along. This can be attributed to high radiant heat of asphalt and steel plate surfaces.

b. According to Figure 6, the temperature of asphalt is higher than that of steel plate after 12:00. This is possibly because the specific heat of asphalt (0.92 kJ/kgK) is higher than that of steel (0.46 kJ/kgK), it retains the heat after 14:00 until 18:00.

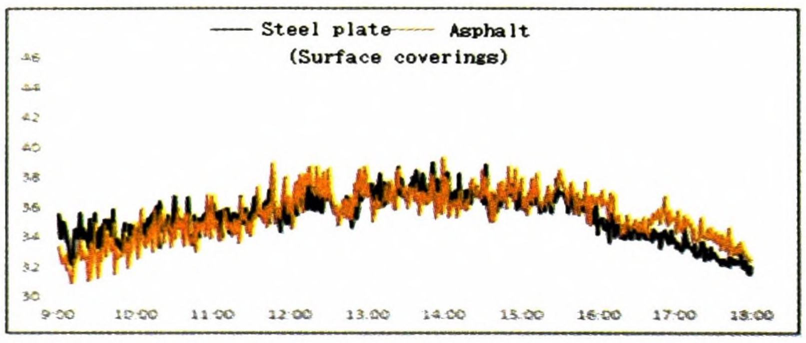

Fig. 5. Temporal change in temperature (h=1.8m, 7/22)

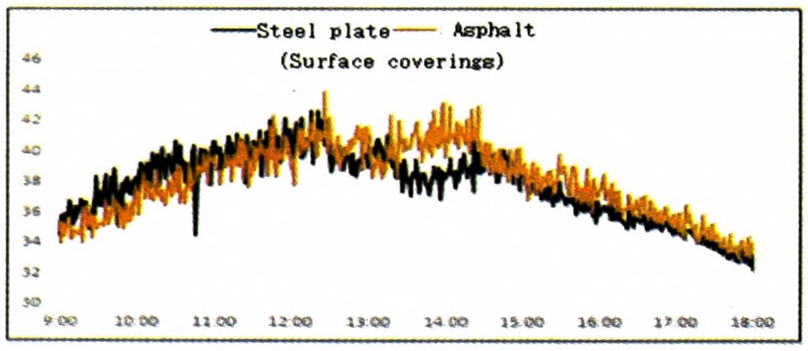

Fig. 6. Temporal change in temperature (h=0.1m, 7/22)

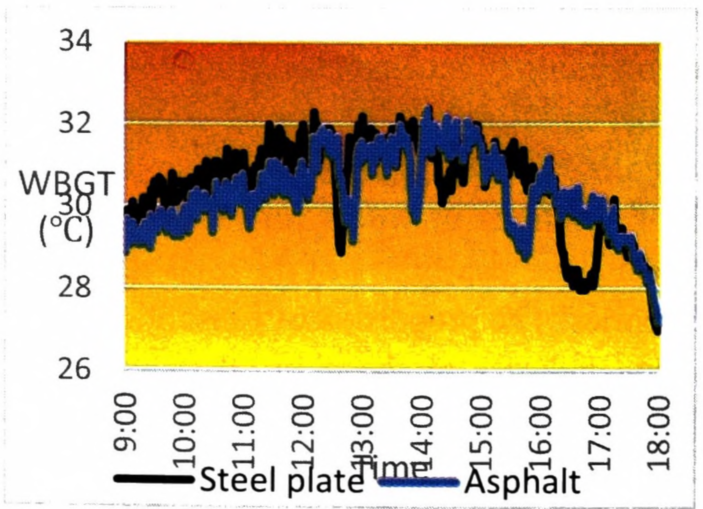

Fig. 7. Temporal change in the WBGT (July 22)

Observations on WBGT

No big differences were observed in WBGT. But as Fig. 7 and the Table illustrates, the index mostly stayed above the stern warning level. But the WBGT abruptly decreased. This may be because humidity changed substantially and lowered the WBGT.

Examinations of experimental results

Where temperature is concerned, higher values were exhibited by asphalt. But no big differences were detected between steel plate and asphalt in terms of WBGT. As the Table however indicates, it should be cautioned that the risk of heatstroke reached the stern warning level in both cases. Therefore, heatstroke prevention measures must be taken as circumstances demand.

Summary and Future Issues

In this paper, the tendency of heatstroke-induced accidents in the workplace was reviewed. Also, an experiment conducted on heatstroke at a hypothetical building construction and maintenance site was reported.

As future tasks, various heatstroke related issues will be addressed through analyses of changes in heatstroke risk and experimental results, on the basis of substantiated data about heatstroke mechanism and prevention measures taken in the workplace by referring to the WBGT standard level.

References

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